Integration of Energy Management, Electrical Submetering and Time Sensitive Pricing in a Large Residential Community Utilizing Wireless Communications: Phase 3

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ABSTRACT

In this paper, we present the third phase, which includes project results which were unavailable in 2008, of a demonstration project in which advanced metering and communications technology, time-sensitive pricing, sensors and control systems were combined cost-effectively in a unique way to enable multifamily apartment residents, owners, the utility grid and society to achieve reduced energy consumption and demand, and take full advantage of incentives available offered by the New York State Energy Research and Development Authority (NYSERDA). Along the way, a number of significant barriers were overcome. Specifically, the project involves a 37 building garden apartment complex covering over 60 acres in Queens, New York, where a project team of consultants and technology vendors integrated an advanced 2-way wireless data communications system, electrical submetering, a 3-period time-of-use rate, apartment temperature sensors, boiler control and room air conditioner controls. The installation addressed the unique barriers of garden apartment complexes by consolidating data from all 930 individual apartments and 33 utility master-meters. In addition, the apartment meters use a color-coded LED display to inform residents of the TOU price period, temperature sensors transmit information to the boiler control system and integrated controls enable control of room air conditioner units during hot summer days. Original projected reductions in apartment sector electric consumption and demand were 20% and an overall building heating fuel consumption of 10%. Actual results will be documented in this paper. Additional incentives are also anticipated from the New York State Independent System Operator (NYISO) for demand response activities, such as critical day load curtailments. This NYSERDA project is serving as a model for integrating multiple energy and demand reduction measures in multifamily buildings, especially garden apartment complexes, which have entailed significant barriers to energy savings measures, particularly electrical submetering, in the past.

Background

With the increasing cost of energy, difficulty in siting power generation, environmental concerns and uncertain fuel supplies, there has been a renewed interest in reducing energy consumption, especially wasteful practices. Both New York State and New York City have recently announced significant energy and greenhouse gas reduction targets. During the past 30 years, New York State Energy Research and Development Authority (NYSERDA) has spearheaded efforts to address this issue in the multifamily residential sector in New York, a major – but underserved – sector. A significant component of the multifamily sector includes

master metered buildings[1] containing over four hundred thousand apartments. Accordingly, there has been an emphasis to develop advanced electrical submetering technologies as well as demonstration projects to encourage the widespread implementation of electrical submetering. These programs were also designed to demonstrate that submetering brings about modifications in tenant behavior to encourage conservation as well as to address barriers to implementation. More recently, several case studies have utilized NYSERDA, utility and the New York State Independent System Operator (NYISO) incentives to augment submetering with measures that achieve additional savings in innovative ways, providing benefits to all stakeholders.

Electrical submetering was reinstated in New York State by the Public Service Commission (PSC) during 1979 in an effort to promote conservation and decrease dependency on foreign oil. Most of the large multifamily residential buildings under the jurisdiction of various New York agencies, namely, the New York State Division of Housing and Community Renewal (DHCR) and the New York City Department of Housing Preservation and Development (HPD) were constructed as master metered buildings during the 1950s and 1960s due to the lower construction costs and the relatively low cost of electricity. In order to ensure that the submetering equipment available to these supervised buildings was both reliable and accurate, the New York State Energy Research and Development Authority (NYSERDA), in association with DHCR, initiated the "Demonstration of New Submetering Technologies" Project in 1980[2]. The first meaningful program within New York State designed to promote the implementation of electrical submetering was by the Consolidated Edison Company of New York (Con Edison)[3] from 1990-1995. The program achieved moderate success but did not meet the full expectations which were anticipated at the inception of this program due to the myriad of barriers to implementation which were encountered while the program was conducted. When New York State began deregulation of electricity in 1995, NYSERDA[4] was assigned to oversee research, development and deployment of energy conservation programs which were previously the responsibility of separate utilities within the State. In its new role, NYSERDA concluded that for submetering to be successfully implemented, it would be necessary to identify barriers

[1] Master-metered buildings are defined as those with one (or more) utility meters measuring and billing for only the whole building but not each individual apartment. Submetering (or sometimes referred to as checkmetering) is a process whereby meters are installed for each apartment in either the apartment or a common area that enables the building owner to meter and allocate utility electric charges to individual apartment residents in proportion to their actual consumption rather than apartment size or shares in a Cooperative.

[2] Demonstration of New Submetering Technologies Report (NYSERDA Report 86-8), published October 1986 by Hirschfeld & Stone Consulting Engineers. The major results of this study were:

a. State of New York adopted ANSI C-12.1 as the standard for submetering equipment;

b. The conservation benefit of submetering was quantified at between 18% to 26% of the electrical usage in the apartment sector of master metered buildings;

c. Power line carrier (PLC) technologies were demonstrated as viable techniques for communicating submetering data in residential buildings.

[3] Con Edison funded the Submetering in Residential Buildings Program during 1990 through 1995. The program was conducted by Xenergy, Applied Energy Group and Herbert E. Hirschfeld, P. E. Under this program, feasibility evaluations, educational meetings as well as financial incentives were available to participating residential buildings during the evaluation of and implementation of electrical submetering.

[4] New York State Energy Research & Development Authority (NYSERDA) was assigned by The New York State Public Service Commission as responsible state agency and initiated a system benefits charge (SBC) collected by the utilities to fund NYSERDA's role.

and devise means for overcoming them. To achieve this goal, NYSERDA sponsored the "Facilitating Submetering Implementation" Program[5].

Two major barriers which were identified and subsequently addressed by actions were:

- The PSC initially required approval by the majority of shareholders or apartment owners in cooperatives and condominiums for submetering to proceed. Due to the lack of involvement by the majority of shareholders or apartment owners in these type residential buildings, it became very difficult to meet this voting requirement. The PSC subsequently amended this in 1996 to require approval of only a majority of shareholders or apartment owners that actually participate in the voting process.

Figure 1. Georgetown Mews Complex

- A lack of understanding of the submetering process, submetering technologies and impact on residents regarding the installation of submetering equipment complicated the evaluation process by building owners and/or Boards of Directors. To address this lack of educational material, NYSERDA funded the development of the Residential Electrical Submetering Manual[6] and contracted for the development of the website www.submeteronline.com.

In 1999 NYSERDA followed this with the "Submetering in Multifamily Buildings" Program which provided technical assistance to residential buildings during their evaluation of electrical submetering[7]. Broadening the program to reflect more advanced metering options, NYSERDA then developed the Comprehensive Energy Management (CEM) Program which provided similar technical assistance to residential buildings as well as financial incentives to offset advanced metering (including submetering) implementation costs. These incentives generally covered 50% of implementation costs for Fair Market buildings and 60% of implementation costs for Affordable Housing [8]buildings. Under the CEM program, the submetering equipment which was eligible for financial incentives was required to meet the NYSERDA's newly developed specifications for Advanced Metering equipment, which included providing for transmission of interval master-meter data to a NYSERDA data collection center.

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[5] Facilitating Submetering Implementation, NYSERDA Report #96-7 conducted May 1996 by Herbert E. Hirschfeld, P. E., Howard Schechter, Ruth Lerner, Joseph S. Lopes and Fredric Goldner.

[6] Residential Electrical Submetering Manual, published by NYSERDA in October 1997 by Hirschfeld, Schechter, Lerner and Lopes.

[7] Submetering Multifamily Buildings Program was conducted between 1999 and 2002 by Herbert E. Hirschfeld, P.E. The services provided included:

a. Preparation of Electrical Submetering Technical/Economic Feasibility Evaluations;
b. Meeting with building owners, Boards of Directors and residents for educational purposes;
c. Assist residential buildings obtain regulatory approval from such agencies as PSC, DHCR and HPD.

[8] Generally speaking, Affordable Housing represents either low income or subsidized housing while Fair Market represents the balance of housing types.

Data would thus be available for purposes of analyses as well as designing load profile, load reduction/curtailment, and time sensitive pricing programs to further expand the energy conservation capabilities associated with submetering. This requirement was generally not a problem for large residential or high-rise buildings with a relatively high ratio of apartments to building master meters. However, in garden-apartment type complexes, where multiple low-rise buildings are spread out over a large geographical area and which comprise a significant percentage of building types within New York State, there is a relatively low ratio of apartments to building master meters and multiple utility owned building master meters. In such instances, building to building communications becomes more problematic, and the number of communication devices (modems, DSL lines, etc) increases substantially, thereby increasing submetering implementation and monthly operating costs significantly for these types of buildings in order to comply with NYSERDA eligibility requirements and receive incentive funding[9].

As a result of this significant cost barrier, the percentage of submetering implementation in garden apartment complexes has remained low and NYSERDA has continued to fund research for solutions which address these issues and improve the ability of these buildings to proceed with implementation. It was under the NYSERDA CEM Program that technical assistance and incentive funding was made available to Georgetown Mews, the garden-apartment type residential building complex which is the subject of this paper. The evaluation of this demonstration project was separately funded by NYSERDA R&D[10].

Building Complex Description

Georgetown Mews (pictured) is a cooperative complex, consisting of thirty seven (37) 2-story low-rise (garden type) residential buildings with a total of 930 apartments occupying approximately sixty (60) acres in Kew Gardens Hills, Queens, New York. This residential complex is master metered by thirty three (33) individual utility (Con Edison) owned utility meters and contains sixteen (16) individual boiler rooms located throughout the complex which provide hot water to the buildings for apartment space heating and domestic hot water (DHW). Apartment cooling is

Figure 2. Site Map

[9] The utilization of conventional electro-mechanical meters which require on-site manual readings represent an alternative solution for submetering garden-apartment complexes; however, because these installations are ineligible to receive NYSERDA incentives for failure to meet the advanced metering requirements, many garden-apartment type complexes are reluctant to proceed with submetering. Additionally, the lack of advanced metering precludes time sensitive pricing and limits participation in New York State Independent System Operator (ISO) load curtailment (ICAP) programs.

[10] Contract for "Load Management Demonstration in Multifamily Housing" awarded to Herbert E. Hirschfeld, P. E.

facilitated by resident owned through-the-wall air conditioners of varying size and capacities. This complex is subdivided into four sections which are separated by streets which support significant traffic (refer to Figure 2).

Approximately 85% of the apartments are occupied by shareholders, with the balance occupied by rent stabilized apartments under the jurisdiction of the Office of Rent Administration of DHCR. Georgetown Mews Owners Corporation owns the apartments occupied by the rent stabilized tenants.

Problem Statement and Proposed Solution

As previously mentioned, many residential buildings throughout New York State have been unable to cost-effectively implement existing submetering technologies due to inherent communications limitations and their associated high cost. This is often the case in garden type apartment complexes which are usually spread out over substantial areas, often with varying topographies, separated by streets and clusters of trees, and frequently contain numerous utility owned master meters. Furthermore, without two-way communications as required for transmitting submetering data, there is no reliable means to effectuate central load control of individual apartment heating and air conditioning equipment. Additionally, if existing apartment air conditioners cannot be centrally (or fleet) controlled, there is no mechanism to effectuate widespread demand control and the ability to participate in an effective load curtailment program. Finally, reliable communications is required to transmit and collect submetering data in short enough time intervals to facilitate time sensitive pricing.

Figure 3. Cable Interconnects and Network Node

With the use of advanced metering currently employed by buildings which participate in the NYSERDA CEM program there is a requirement to remotely retrieve all master meter(s) interval data, as well as individual apartment submeter(s) data. To satisfy this NYSERDA requirement, in such a multi building complex with a multitude of utility meters, typically requires complex communications systems, via either numerous DSL or phone lines, with associated monthly charges which can adversely affect the economic benefit of implementation. It should be noted that failure to meet these NYSERDA CEM requirements precludes the buildings from receiving incentives predicated on advanced metering criteria, thereby serving as a disincentive to implement submetering.

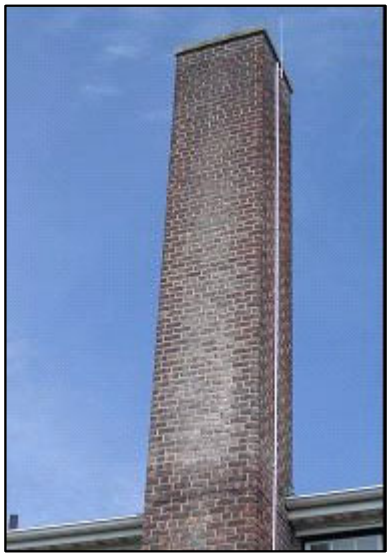
The integrated system proposed and subsequently installed[11] at Georgetown Mews to address these issues consisted of an Intech 21 web enabled building-to-building communications

[11] Installation commenced in June 2007 and completion to date includes:
a. Communication system comprising directional antennas, multidirectional antennas for each of the four building sectors, interconnecting cabling as required, all network nodes and 4 DSL lines/associated servers
b. All apartment submeters

system (utilizing custom directional and multi-directional antennas and interconnecting cabling and network nodes – refer to Fig. 3, 4, and 5) that successfully transmits individual apartment submetering data in 15-minute time intervals. This eliminated the need for multiple communications systems to satisfy each of the 33 utility master metered buildings, reducing the system to only four sections (See Figure 2 – Site Plan) with each section being provided with a separate DSL communications sub-system which will greatly reduce the monthly maintenance costs for this submetering system.

Figure 4. Directional Antenna

Figure 5. Multi-directional Antenna



Individual submeters were installed inside each apartment at additional cost, as opposed to adjacent to dedicated apartment circuit breakers in the basement area. This allowed it to take full advantage of an integral apartment temperature sensor which would be utilized to develop control algorithms to optimize the heating distribution system, which includes 16 individual boiler rooms, at Georgetown Mews.

The 16 existing boiler controls were replaced by an Intech 21 controller (refer to Fig. 6), which is also compatible with the installed communications network, and can be operated based on control algorithms derived from input from the individual apartment temperature sensors as opposed to only the ambient temperature.

Figure 6. Replacement Heat Controller

In addition, each of the individual apartment submeters with integral temperature sensors contains three color LEDs depicting each of the three time periods which pertain to the time of use pricing schedule (refer to Fig 7). The red light depicts a Peak Pricing Period (most expensive electricity); the yellow light depicts a Shoulder Pricing Period (moderately expensive electricity) and the green light depicts an Off-Peak Pricing Period (least expensive electricity). The LEDs provide indication to the apartment resident which pricing period is in effect to assist him/her in modifying his/her usage

c. All advanced master meters in parallel with utility master meters (in lieu of KYZ pulses)
d. All replacement boiler controllers compatible with communications system
e. The website and associated software programming
f. 32 out of 40 fleet controlled air conditioning units compatible with communication system

patterns in accordance with the schedule depicted in Figure 8. The intent of the LED feature is to provide a signal to the apartment resident to alert him/her which will provide the incentive to reduce peak usage and shift the overall demand to Off-Peak periods, thereby saving the apartment resident some money and working toward eliminating the threat of power outages caused by excessive peak demands on the utility grid.

Figure 7. Typical apartment submeter with LED lights

To satisfy one of several NYSERDA project objectives, Intech 21 and Islandaire jointly developed and provided 40 individual through-the-wall room air conditioners which can be centrally (fleet) controlled utilizing the installed communications network.

The air conditioner control and communications module package, which is installed as part of the chassis, was developed by Intech 21 and includes a multitude of capabilities to provide maximum flexibility in applying various control strategies. For example, the ability to control the compressor separately from the air conditioner recirculation blower and the ability to remotely adjust the thermostat setting to effectuate fleet load control, reduce usage and demand and minimize tenant inconvenience were also primary design objectives of this project. This concept provides both the management and the individual apartment resident the ability to use the internet to control the operation of the individual air conditioners.

Overcoming Barriers

As indicated, a retrofit project like this encountered a number of significant barriers that had to be overcome before successful implementation. Getting this project off the ground while addressing these barriers involved about three years of effort, and culminated in an atypically short implementation period of only 6 months for actual installation, excluding the air conditioners, which are planned for the 2010 summer season. These barriers included:

Economic Cost-Effectiveness Justification

As mentioned, the data communications system, configured for the building complex, combined wireless data communications, consolidation of the 33 master-metered data nodes into four networked nodes, and incorporating additional energy and cost-saving features, including temperature monitoring for boiler control and associated fuel and operational savings, time-sensitive pricing, and capability for load control to take advantage of incentives for demand response improved the cost-effectiveness considerably. In order to take full advantage of NYSERDA incentives for advanced metering, rather than use conventional electro-mechanical meters installed in each building basement capable of only submetering (which would preclude any non-submetering features and associated savings and not qualify for NYSERDA incentives), a more advanced (and NYSERDA-qualified) system was installed, with meters in each apartment that incorporated temperature sensors and LEDs that signaled residents as to the time-

of-use rate price level. The temperature sensors provide operational savings since building complex-wide temperature monitoring can be done from a central location by operations staff.

NYSERDA deployment funds paid for a significant share of meters, data communications, boiler control equipment and associated installation under their deployment initiative. NYSERDA R&D funds covered communications enhancements, meter upgrades to include LED TOU signals, time-of-use billing and the air conditioner control capability. The time-of-use rate and billing system adopted for the project was already developed through an earlier NYSERDA R&D project with Clinton Hill Apartments in Brooklyn, NY, in which a three-tier time-of-use rate (refer to Fig. 8) was applied and associated time-of-use billing system developed[12].

The savings associated with reduced energy consumption and demand anticipated for submetering and boiler control, plus additional savings associated with the TOU rate and potential for demand response from air conditional control, combined with the cost savings from operational efficiencies from the temperature monitoring and project installation funding from NYSERDA, ensured that the project was cost-effective, with a short enough payback period to satisfy all stakeholders.

Figure 8. TOU Rate and Period Description

[12] The three-tier, or "Traffic Light" rate concept was developed by Joseph S. Lopes of Applied Energy Group, Inc. for the Clinton Hill Project (NYSERDA Agreement 7572 – 2003-2007). It applies a fixed price ratio of peak to shoulder to off-peak period usage of 3 to 2 to 1, respectively, for allocating total energy costs based on peak period of 2-6 pm weekdays, shoulder period of 10am-2pm and 6-10pm weekdays and 6-10pm weekends, with all other hours off-peak. As described, an additional critical peak period of 6-10pm for peak during likely summer critical days may be applied to the Georgetown Mews project.

Regulatory Barriers

Approximately 85% of the apartments are occupied by shareholders of the Cooperative. The balance of the apartments are owned by the Georgetown Mews Owners Corporation and occupied by rent-stabilized tenants. Institution of submetered billing for the rent-stabilized apartments requires regulatory approval from both the PSC and DHCR. In order to avoid the lengthy DHCR approval process, it was decided to exclude the rent-stabilized tenants from the submetering process[13]. Also, excluding the rent-stabilized tenants from the submetering process eliminates significant opposition and actions which substantially delays the implementation process. Occupants of these apartments will not be billed for electric charges until the apartment is sold and becomes a shareholder-occupied apartment.

Resident and Political Opposition

It is common practice for residents who oppose submetering to reach out to their local politicians in an attempt to derail the process. Their objections, however, are often based on misconceptions and self-interest. Many of the politicians do not fully understand what submetering is (and its benefits) and are generally motivated by their obligation to satisfy their voting constituents. In the appearance of acting on the behalf of their constituents, these politicians involve other regulatory organizations who are intimidated and obligated to further investigate specific applications which, in turn, further delays the approval process. These actions often create substantial delays which, in combination with internal pressures exerted by residents who are opposed, may discourage owners and Boards of Directors from proceeding with the implementation.

In order to overcome typical misconceptions and minimize opposition at Georgetown Mews, an educational and outreach campaign was conducted by the Board of Directors, management and building consultant that included a series of meetings with representatives of the State Assembly, State Senate, City Council and Congress. An additional workshop was conducted for all the shareholders and informational materials were prepared and disseminated to all shareholders. NYSERDA participated in the process.

These efforts, which occurred over a three year period, were critical in achieving shareholder approval and cooperation during both the voting and installation process, which required access to apartments for the one-time installation of the apartment submeter, which is often a protracted process. In retrospect, the efforts to address the technical requirements of this project are dwarfed by the effort required to obtain approval and cooperation, which was aided by experience in previous projects – some successful and some not.

Project Monitoring and Verification and Applicability

This NYSERDA project is intended to collect data on electric consumption (energy and demand), heating consumption (fuel oil), and assess the impacts, cost reduction and overall cost-effectiveness in order to provide an example case study for similar installations. Data collected

[13] Rent-stabilized tenants will not be billed for electric charges. Bills for the rent-stabilized apartments will be the responsibility of the owner of these apartments, the Georgetown Mews Owners Corp., which charges rent that includes electric, which is not based on actual usage.

by the metering reading and billing company is formatted in Excel spreadsheets and forwarded to the office of Herbert E. Hirschfeld, P. E. for inputting into FASER® software program, sorting and analyses. The results can then be transferred for utilization by the several hundred thousand apartments in New York State which are similar to those in Georgetown Mews.

When the project was conceived Georgetown Mews consumed over 5 million kWh annually and had a peak demand of 2,000 KW. It was anticipated that as a result of conducting this project, that both the electrical usage and demand would be reduced by approximately 20%. These projections were based on prior projects and case studies conducted by Herbert E. Hirschfeld, P. E. during the past 30 years. The results of this project to date as referenced in the Results and Conclusions section below indicates that to a substantial extent, the project goals are attainable.

When the project was conceived, Georgetown Mews consumed over 1 million gallons of heating oil annually which should be reduced by approximately 10% as a result of this project. This anticipated reduction in fuel consumption is predicated on similar results achieved by utilizing this identical heat controller in other residential buildings in New York, including the New York City Housing Authority.

These annual reductions in energy costs should justify the implementation of these conservation measures. The economics can be further improved by incentives available from Georgetown Mews' participation in NYISO Curtailment programs, as well as Con Edison Peak Load Reduction programs, once the fleet-controlled air conditioner load control is installed and operational.

Results and Conclusions

Analyses of data collected up to March 26, 2010 were conducted by utilizing Faser® software[14] to calculate the cost avoidance, reduction in adjusted electrical consumption (kWh) and demand (KW). These values for the most recent twelve (12) monthly utility billing periods are as follows: cost avoidance was $170,803 which represents 14.99% of the adjusted electric cost; reduction in adjusted electrical usage was 709,511 kWh which represents 14.68% of the total adjusted electric usage and the reduction in demand was 2,687.1 KW which represents 19.4% of the total demand.

These results would have improved significantly if all 930 apartments paid for their electricity; however, since the residents of the 137 sponsor owned apartments did not pay for their electricity (the sponsor did), they did not contribute to the conservation achieved by this residential complex. In fact, monthly comparisons between the 137 sponsor owned apartments and the 793 shareholder occupied apartments (who paid for their electricity) consistently showed that the sponsor owned (non-shareholder) apartments consumed approximately 30% to 50% more electricity per billing period than the shareholder owned apartments[15], proving again that submetering is a most effective energy conservation measure.

[14] Faser® software was originally developed by Omnicomp and designed to analyze utility billing data correcting for variations in weather factors (CDD, HDD), utility costs and billing periods to enable comparisons between current year to adjusted baseline year. This software program has been utilized by Herbert E. Hirschfeld, P.E. for over 20 years.

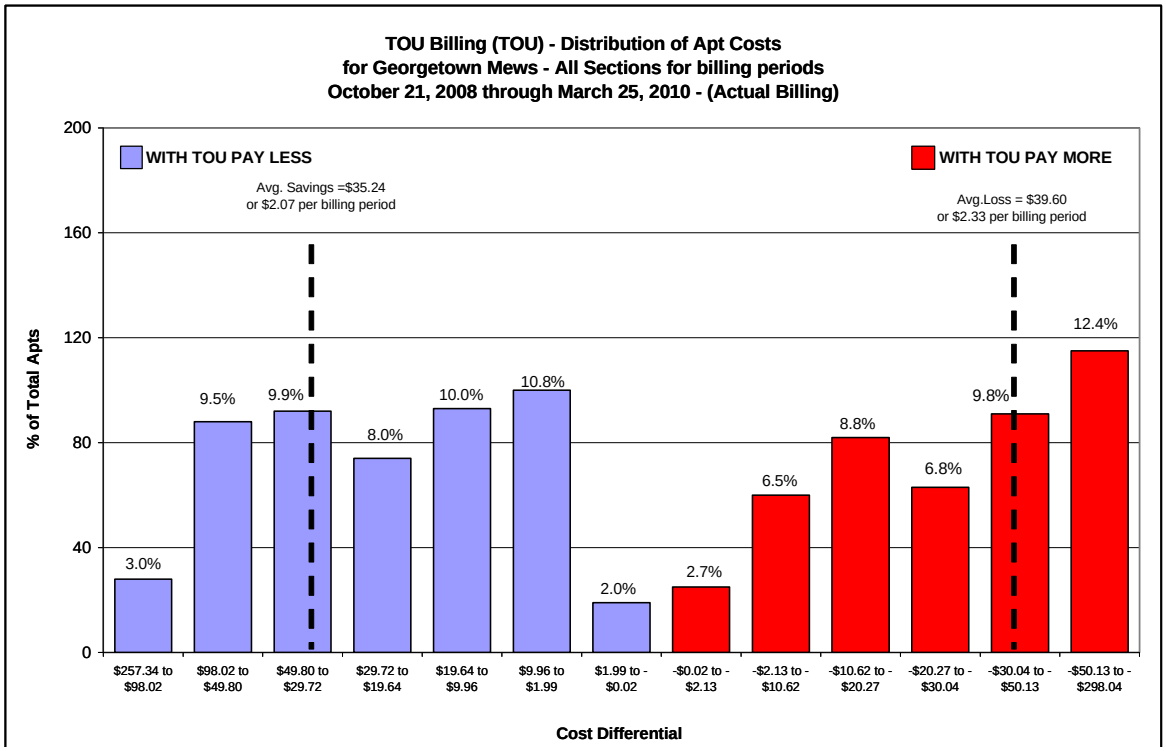
[15] The meter reading/billing organization provided excel spreadsheets detailing each apartment's electric usage and associated billing cost. Shareholder apartments and non-shareholder apartments were identified to enable comparisons to be made for each billing period. Example: for the 2/25/10 to 3/26/10 billing period the average usage

Further analyses of the collected data, obtained as excel spreadsheets, also confirmed earlier findings by this author that in residential buildings the top 10% user apartments consume approximately 25% of the total electricity consumed by the apartments. The bottom 70% user apartments consume approximately 50% of the total electricity consumed by the apartments, proving that the majority of apartments benefit from submetering.[16]

The utilization of the 3 step TOU schedule provided these findings: the average benefit to apartments which benefited under TOU saved approximately 3% to 4% on their electric bill while the average additional cost for apartments which did not benefit under TOU was between 3% and 4%.[17] (Refer to figures 9 and 10)

The significance of this is that with this manageable spread in savings and additional costs, building management was able to deal with TOU billing without jeopardizing the submetering process. While these values were relatively small, the TOU billing utilizing the LEDs probably increased the residents' awareness of the fact that they were paying for their electricity and improved the benefits attributed to submetering.[18]

Figure 9. TOU Impact



for the non-shareholder apartments was 277.3 kWh while the average usage for the shareholder apartments was 213.2 kWh.

[16] Data provided in excel spreadsheets were sorted by usage depicted that 53% of the apartments benefited from TOU billing while 47% of the apartments paid more as the result of TOU billing.

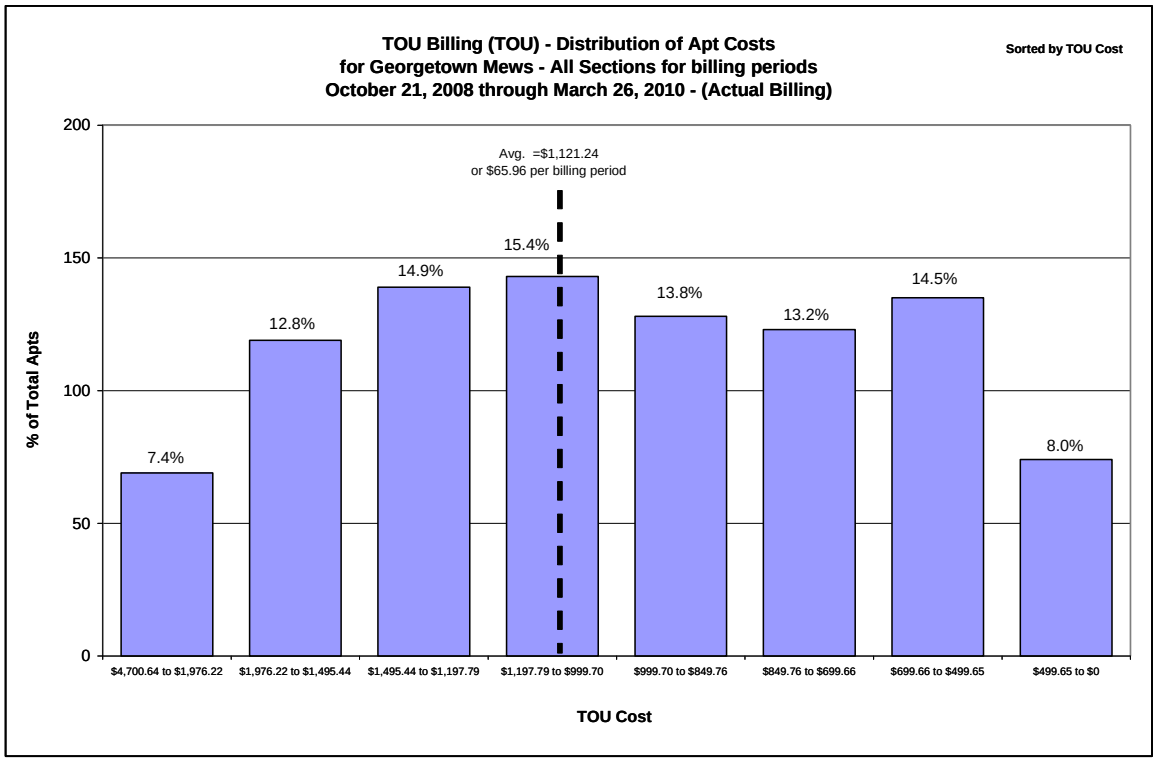
[17] Data from excel spreadsheets were imported into graphics to depict distribution of apartments which benefited and which did not benefit from TOU billing. A graph detailing this distribution for the billing periods October 21, 2008 through March 26, 2010 is included as Figures 9 and 10.

[18] This observation was discussed during several meetings with the building complex's Board of Directors who stated that they were more aware of the submetering process due to the lights which emanate from the submeter's LEDs.

To date, there has been no evaluation regarding the fleet controlled air conditioners as only forty a/c units are to be installed and are scheduled for operation and evaluation during the summer of 2010. The savings in fuel have yet to be quantified, although the buildings' operations personnel have utilized the web enabled system to monitor the apartments' temperatures and adjust the heating system operation accordingly. Additionally, utilization of the Internet has improved management's response to resident heat complaints and the monitoring of heating system operation, resulting in a reduction in building operations and maintenance costs.

It should also be noted that this author has recently completed a similar project in a 42 building all-electric residential complex, located in Manhattan, N.Y., utilizing the basic wireless communications and submetering technology which will be tied into fleet control of heat pumps and is scheduled to install 200 fleet controlled air conditioners in another building utilizing the identical submetering communications system. These projects demonstrate the transferability of the original project evaluated in this study.

Figure 10. TOU Billing Distribution



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