

AMI-Based Load Research – KIUC Demonstration

Confirming the Value of AMI

INITIAL FINDINGS | NOVEMBER 15 2013



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The National Rural Electric Cooperative Association

NRECA is the national service organization for more than 900 not-for-profit rural electric cooperatives and public power districts providing retail electric service to more than 42 million consumers in 47 states and whose retail sales account for approximately 12 percent of total electricity sales in the United States.

NRECA's members include consumer-owned local distribution systems — the vast majority — and 66 generation and transmission (G&T) cooperatives that supply wholesale power to their distribution cooperative owner-members. Distribution and G&T cooperatives share an obligation to serve their members by providing safe, reliable and affordable electric service.

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NRECA's Cooperative Research Network™ (CRN) manages an extensive network of organizations and partners in order to conduct collaborative research for electric cooperatives. CRN is a catalyst for innovative and practical technology solutions for emerging industry issues by leading and facilitating collaborative research with co-ops, industry, universities, labs, and federal agencies.

CRN fosters and communicates technical advances and business improvements to help electric cooperatives control costs, increase productivity, and enhance service to their consumer-members. CRN products, services and technology surveillance address strategic issues in the areas:

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- Consumer Energy Solutions
- Generation & Environment
- Grid Analytics
- Next Generation Networks
- Renewables
- Resiliency
- Smart Grid

CRN research is directed by member advisors drawn from the more than 900 private, not-for-profit, consumer-owned cooperatives who are members of NRECA.

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FOREWORD

The National Rural Electric Cooperative Association (NRECA) has organized the NRECA-U.S. Department of Energy (DOE) Smart Grid Demonstration Project (DE-OE0000222) to install and study a broad range of advanced Smart Grid technologies in a demonstration that involves 23 electric cooperatives in 11 states. For purposes of evaluation, the technologies deployed have been classified into three major sub-classes, each consisting of four technology types, the status of which have been reported in the Interim Technology Report of April 2013:

Enabling Technologies:	Advanced Metering Infrastructure Meter Data Management Systems Telecommunications Supervisory Control and Data Acquisition
Demand Response:	In-Home Displays & Web Portals Demand Response Over AMI Prepaid Metering Interactive Thermal Storage
Distribution Automation:	Renewables Integration Smart Feeder Switching Advanced Volt/VAR Control Conservation Voltage Reduction

To demonstrate the value of implementing the Smart Grid, NRECA has prepared a series of single-topic studies to evaluate the merits of project activities. The study designs have been developed jointly by NRECA and DOE. This document is the initial report on one of those topics, based upon the progress of the activity to date. The project team will be monitoring the progress of the various cooperative activities during the remaining term of the demonstration to close identified information gaps and identify additional information that will be of benefit to the merit evaluation. This document and the other single-topic studies then will be updated, as appropriate, for consideration in the final Technology Performance Report at the close of the Smart Grid Demonstration Project.

DISCLAIMER

The views as expressed in this publication do not necessarily reflect the views of the U.S. Department of Energy or the United States Government.

AMI-Based Load Research – KIUC Demonstration

1. INTRODUCTION

The Kauai Island Utility Cooperative (KIUC) has begun a first-ever formal Load Research Study for the cooperative's electric system, using the newly installed Advanced Metering Infrastructure (AMI) system developed in association with the National Rural Electric Cooperative Association (NRECA) under the Smart Grid Demonstration Project. The Load Research Study is being undertaken for engineering and regulatory purposes, and will form the basis for certain rate studies expected to be filed with the Hawaii Public Utilities Commission in the near future. The value of an AMI system in providing robust statistical information on electric loads with a high degree of confidence is being demonstrated through this formal load research program, now underway. This report describes the development of the AMI system, the background for load research activities, the initial sense of accomplishment from the use of the system, and the expectations for accomplishing a robust evaluation of system load characteristics.

2. THE AMI-BASED LOAD RESEARCH PROGRAM

2.1 Research Objectives

The advent of AMI has been expected to provide a vastly improved foundation for electric utility system load research. The NRECA Smart Grid Demonstration Project included installation of advanced metering at nearly every one of the traditionally metered locations throughout the KIUC service territory. This installation was especially timely from the standpoint of providing an advantageous platform for demonstrating the value of AMI in completing a load research study.

Until such time as the AMI system was installed, for rates and tariff development, KIUC had relied on sample data from comparable utilities or limited information from uniquely placed monitoring equipment. Pressure had been placed by the Hawaii Public Utilities Commission (HPUC), particularly at the urging of the Hawaii Consumer Advocate during the last KIUC rate case, for KIUC to undertake a utility system-specific load research study. That study was intended to provide detailed information on electric usage characteristics among and within KIUC's consumer classes of service—residential, small and large commercial, and industrial. Estimates at the time indicated that such a load research study, using traditional sampling and individually installed meters, would require hundreds of thousands of dollars to complete. In addition, updating research results would require similar levels of effort.

The AMI system installed at KIUC was investigated as a means, among the many potential uses of AMI information, of accomplishing a load research program in a cost-effective manner. Using AMI-installed equipment for data gathering and analysis provides for ready availability of the requisite sample information, data accumulation and analysis using equipment already installed, and load research statistics that can be updated easily. The information provided can be of such detail as to fully satisfy regulatory requirements and monitor the impacts of alternative rate structures and consumer response.

2.2 Project Characteristics

The AMI installation was undertaken at KIUC for a variety of reasons. Those reasons included providing (1) remote monitoring for reduced meter reading expenses, (2) engineering data for feeder load analysis, (3) consumer energy use characteristics associated with on-site solar hot water heating and photovoltaic (PV) installations, (4) limiting cycle billing adjustments from staggered meter reads, (5) remote cutoff and reconnection, (5) monitoring of load control impacts, and (6) routinely detailed demand and energy use statistics of individual load centers and aggregate loads. The AMI installation project included a radio transmission system for communications between the utility and the metering equipment, and installation of data collection software that would adequately provide for initiation of signals out from the cooperative and data transmission back from the individual metering points.

Once the installation was nearly complete, KIUC began the specific load research study using the AMI system. A contract was prepared for SAIC to help set up the study, provide expertise in customer class identification and sample selection, and initiate the data gathering. NRECA was involved early in the contracting process, supporting the use of the AMI system in that fashion and coordinating with SAIC on the information gathered and application of the results.

2.3 Development and Implementation

SAIC designed the KIUC load research program, which included consideration of sharing information on the undertaking with NRECA by supplying periodic information during the year-long research. SAIC's efforts have included collecting preliminary load data from KIUC from which to evaluate the level of detail required within existing consumer classes to form a statistically relevant programmatic data collection.

The load research program directed by SAIC was initiated in early summer 2013 with the anticipation of data collection through a complete one-year cycle, beginning with historical data from the time of the first AMI meter data availability through late spring 2014.

2.4 Evaluation Criteria – Effectiveness

KIUC has demonstrated the effectiveness of using AMI for the load research program, in that the vast reach of a broad-based installation across virtually the entire consumer base provides for essentially unlimited data sources. The primary limitation to use of the aggregate data is the sheer volume of information available, such that slightly different sampling techniques are required compared to traditional methods. The advantages are clear, in that all meters are available, and random tests can be performed to validate the sample selection by identifying variances and deviations. A comparison of difficulties in load research by traditional sampling and metering approaches shows in stark relief the advantages of advanced metering infrastructure. Information on unique sites that reflects implementation of distributed generation sources and load management programs from readily accessible AMI data provides additional benefits in rate setting for special incentive programs, as well as traditional cost-of-service studies.

2.5 Regulatory Acceptance and Justification

KIUC is now able to provide evidence of the end-use load characteristics of a variety of consumers throughout the system, fully responding to the regulatory request for utility-specific load research. No longer will proxy data be required, nor will significantly disruptive and expensive research programs be required for rate structure updates or revisions to cost-of-service allocations. Questions as to the efficacy of incentive programs can be accomplished routinely by aggregating data from those locations at which programs were applied and via continuous monitoring of consumer response.

As the load research program at KIUC has been initiated only recently and will be underway over the next several months to collect 12 months of data, the final results will not be available until early spring 2014. As a result, the regulatory acceptance of the load research findings will be addressed in more detail following Consumer Advocate and HPUC staff review of the load research program and results at KIUC.

3. THEORETICAL BASIS OF LOAD RESEARCH

3.1 Value and Applications of Load Research

“Load Research” has been defined as “(a)n activity embracing the measurement and study of the characteristics of electric loads to provide a thorough and reliable knowledge of trends, and general behavior of the load characteristics of the customers serviced by the electrical industry. Simply put, Load Research allows utilities to study the ways their customers use electricity, either in total or by individual end uses.”¹ The information obtained through load research provides the knowledge of electric use patterns and characteristics that the electric utility requires to effectively meet the service requirements that provide consumer and utility value.

A number of functional areas of the electric utility operation depend on this knowledge and the load research products to perform effectively. These include the following:

- ◆ Generation – Net system output analysis, production cost and system model development, capacity planning, and load duration curves;
- ◆ Electric Choice – Load profiling, forecasting, settlement accounting, program and project evaluation;
- ◆ Distribution – Substation load analysis, transformer sizing, circuit load studies, load management, and loss studies;
- ◆ Marketing – Individual customer analysis, customer class analysis, on-peak demand, load studies, demographic studies, and major account demand analysis;
- ◆ Rates and Pricing – 8,760 class demand studies, billing determinants, allocation schedules, sample design and management, class and system peak analysis, and major account demand analysis; and
- ◆ Other – Demand-side management, weather normalization, and product development.

¹ AEIC. “*Why Electric Utilities Need Load Research*,” a Load Research Primer for Electric Utility Leaders.

The Load Research Committee of the Association of Electric Illuminating Companies (AEIC) identifies the value proposition of AMI in the following categories and activities (**Table 1**):²

Table 1. Value of AMI

Category	Activity
System Analysis and Rates – Electric	<ul style="list-style-type: none"> ◆ Main Rate Case ◆ Real-time Pricing (design and implementation)
System Analysis and Rates – Gas	<ul style="list-style-type: none"> ◆ Main Rate Case
Electric Choice/Deregulation	<ul style="list-style-type: none"> ◆ Load Profiles ◆ Energy procurement for basic service ◆ Hourly energy market price calculations
Load Management	<ul style="list-style-type: none"> ◆ Transformer Study ◆ Load Response Programs
Data Warehousing/Data Access	<ul style="list-style-type: none"> ◆ Meter data management ◆ Interval data distribution (for fee)
Forecasting	<ul style="list-style-type: none"> ◆ Air conditioning ◆ Residential and commercial
New Technology	<ul style="list-style-type: none"> ◆ New meter testing and support
Intellectual Capital	<ul style="list-style-type: none"> ◆ Subject matter expertise ◆ Consulting
Settlement	<ul style="list-style-type: none"> ◆ Shadow settlements ◆ Estimate peak contributions for ISO installed capacity markets ◆ Estimate hourly loads for ISO energy markets
Market Research Support	<ul style="list-style-type: none"> ◆ End use analysis ◆ Conditional demand analysis ◆ Rate evaluation ◆ Sales analysis (unbilled revenue) ◆ Ad hoc data request
Customer Service Support	<ul style="list-style-type: none"> ◆ Billing determinants ◆ Reporting and analysis of customers' interval data ◆ Revenue protection investigations
Asset Management/Optimization/Acquisition	<ul style="list-style-type: none"> ◆ Generation ◆ Transmission ◆ Distribution

Through its various categories, activities, and applications of the knowledge obtained, load research contributes value to the utility, both strategically and financially. This value can be identified by the contribution of load research information to the financial parameters associated with system operations and revenue collection. The value is the portion of a measurable event that either increases revenue or produces real savings. This being the case, the continuity of the load research information is important, and gaps in knowledge, or failure to recognize changes in usage characteristics, can lead to failures in recognizing impending or actual losses of the savings or revenues.

² AEIC. *Load Research Value Calculation*, January 9, 2007.

3.2 Load Research Approach

A wide range of source data is available on the fundamentals of load research using “Smart Grid” technologies. This is now well known throughout the industry, and includes extensive work by the Electric Power Research Institute (EPRI) and others, such as AEIC’s National Load Research Committee. For example, AEIC has provided a primer on why load research is important for electric utilities, and EPRI conducted a workshop in October 2010 for its members to identify how “...broad application of Smart Grid or AMI could both increase the need for and reduce the cost of acquiring high-quality load research data.”³ The concern at that time was that much of the load shapes that the industry had developed in years past and remained in use were perhaps no longer accurate representations of system characteristics. The cost of collecting data at the end-use level was considered quite expensive, due to special metering requirements.

The abstract of the EPRI workshop proceedings described a situation in which utilities and operating organizations sought better load shape information, and the deployment of smart meters presented both opportunities and challenges—the opportunity being the ability to capture system-wide load shape information without the need for the special metering. However, the widespread coverage of smart metering and the immense amount of data available required “rigorous” data collection and sampling procedures to obtain the requisite and relevant information at the “required levels of precision.” Also, while smart meters provided premises-level data, additional research was needed to clarify whether the metering could be used to identify the impact on load shapes of new technologies, response to dynamic pricing, information feedback, and demand response programs.

3.3 Historical Methods of Load Research

Electric utilities have been conducting load research almost since the inception of the electric system through monitoring or recording of metered delivery by using strip chart recordings of voltage and current for motor loads and other devices. The so-called “modern era” of load research began with the introduction of demand recorders that used magnetic tape cartridges to record data pulses from a special meter that replaced the normal billing meter. The cartridges were collected and downloaded to mini-computers that translated the pulse data into time-series interval measurements of power. Similar systems were used for demand recording of large commercial and industrial loads. Later evolution of the systems provided for devices that delivered load data via telephonic system, hand-held recorders (the “automated meter reading” or AMR), radio, and power line carrier signals over the distribution network. These later systems provided greater capability than demand and energy recorders, and subsequent systems have expanded upon those capabilities, ultimately to provide “two-way” communications for delivery and receipt of information.

³ *End-Use Load Research in a Smart Grid World*. EPRI Abstract. September 23, 2010.

4. ENABLING TECHNOLOGY OF AMI-BASED LOAD RESEARCH

4.1 The KIUC AMI System

KIUC initially started looking at an AMI system in 2008 and, with the assistance of Power Systems Engineering, developed a business case for the implementation of an AMI. Once the business case was presented and accepted, KIUC enlisted the assistance of Katama Technologies to develop a Request for Proposal (RFP) to determine the requirements and selection criteria for an AMI system. In 2009, KIUC selected the Landis+Gyr Gridstream®, based on a radio frequency (RF) mesh network, and was ready to proceed with implementation when federal stimulus funding became available. An RFP meeting the requirements for stimulus funding was prepared in 2011 with the assistance of the NRECA National Consulting Group and supplied to vendors.

4.2 AMI Selection Criteria of KIUC

KIUC and its consultants conducted a very rigorous proposal evaluation of the vendor offerings. **Table 2** reflects the range of considerations used in evaluating the offerings; this resulted in the selection of an L&G system.

Table 2. KIUC Vendor Evaluation – Technical Specifications

Section	Technical Specification Requirement	Weight
6	General System Requirements	40
7	AMI Server Hardware and Software	40
8	Load Control Hardware and Software Requirements	10
9	WAN/Backhaul Communications	5
10	Fixed Network LAN Communications	20
11	Residential Electric Meters	20
12	Commercial and Industrial (C/I) Electric Meters	20
13	Load Management Hardware	10
14	Electric Grid Management Applications	15
15	System Administration and Security	20
16	Documentation	5
17	Quality Assurance, Testing and System Acceptance	10
18	Vendor Support and Training	15
19	Implementation Roles and Requirements	5

The initial system implementation plan included seven collectors, 106 standard routers, and 29,630 electric meters; equipment installations were chosen strategically per design, so that the system implementation would not disrupt KIUC’s normal operating procedures. The functionality included capability for in-home displays, home area networks, dynamic pricing, and selective load control.

4.3 Installation and Operation Issues and Actions

Overall, KIUC has been very pleased with the decision to go with Landis+Gyr for its AMI metering system (**Figure 1**). While it did encounter “bumps in the road” throughout the installation process, L&G and its deployment contractor were very prompt and competent in addressing the issues. The equipment is working as expected, and KIUC is excited to be the leader in the State of Hawaii in Smart Meter deployment. KIUC also is working on the rollout of a web portal to provide members with detailed usage from their smart meters.

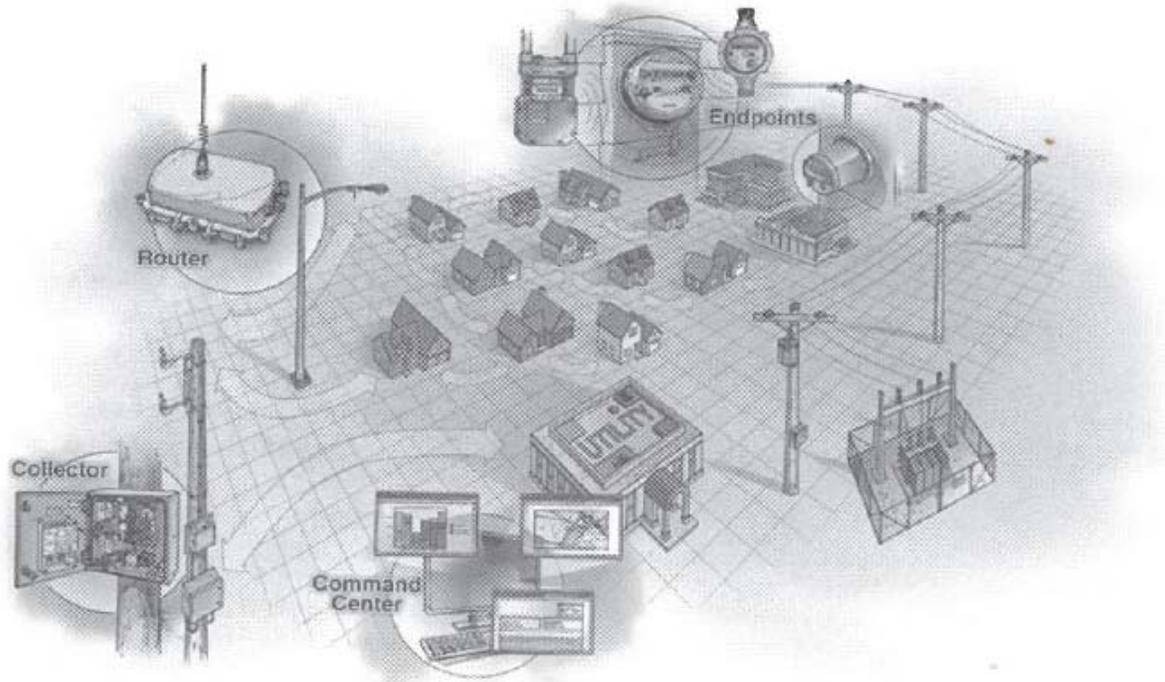


Figure 1. Landis+Gyr RF Mesh Network

5. AMI-BASED LOAD RESEARCH PROGRAM NOW UNDERWAY AT KIUC

The sequence of events for development of the load research study by SAIC is straightforward:

Sample Selection → Metering Info → Data Analysis → Reporting

Implementation of the AMI and the prevalence of the pre-existing interval metering simplified the process of sample selection, but only somewhat, in that a representative sample was still necessary for class load estimates. The ability to cost-effectively increase sample sizes, both to achieve greater precision and allow for sub-sampling, was a key benefit of the AMI metering. For example, given the large variability of loads in the Large Commercial and Large Power classes and their size relative to the other classes, the team decided simply to sample all customers in these classes (i.e., achieving what is commonly referred to as a “census” for these classes).

The load research is proceeding in steps, which include the following:

- ◆ Selecting sample consumers that are sufficiently representative to ensure precision of class load estimates;
- ◆ Capturing hourly or sub-hourly sample loads;
- ◆ Validation of the data collected;
- ◆ Reporting the class loads and load detail; and
- ◆ Supporting downstream analysis with the load information.

A sample design was prepared with the goal of maximizing precision with the sample size constraints that made use of data from a specified time period of metered data. Stratified sampling segmented the consumers into homogenous groups to improve precision, using one of

the more common stratification variables of billed energy. The strata boundaries then were determined by statistical methods, and samples allocated across the strata, followed by simple random sampling to capture sufficiently large sub-samples. The sample selection was determined using load data from January 2012. AMI-based load data from March 2013 then were received and processed.

The validation step is fundamentally a review of the recorded data for erroneous and/or missing values, which may be replaced with estimates in some instances. If certain samples are suspicious and unexplained, they may be substituted out and replaced with those of higher confidence.

Class load estimation is derived from the weighted mean across the strata of the hourly loads, followed by determination of class peak loads and identification of class loads during the system peak hour. Sample billing data obtained through July 2013 proved useful for “expansion” to full class representation, and system peak information was made available to SAIC for determination of system peak timing and benchmarking to ensure the representativeness of the load estimates.

The load research plan anticipated a November 1, 2012 to October 31, 2013 test-year period for the load research and will be used to produce estimated class loads, including coincident and non-coincident class peak loads and load profiles. In addition, a series of benchmarking analyses will be performed to ascertain the reasonableness of the resulting class loads as compared to known system-level load data and class billing determinants.

Once the complete year of load research data has been collected, SAIC will revise the data sets and calculations developed over the course of the year and make necessary adjustments based on subsequent decisions with respect to stratification, sampling, or other issues.

5.1 Initial Findings

The initial findings reflect some typical load behaviors, including volatile intra-day loads, a high variance across the months, and numerous meters with zero usage in early March. Some examples of residential meter profiles are shown in Figures 2–4.⁴

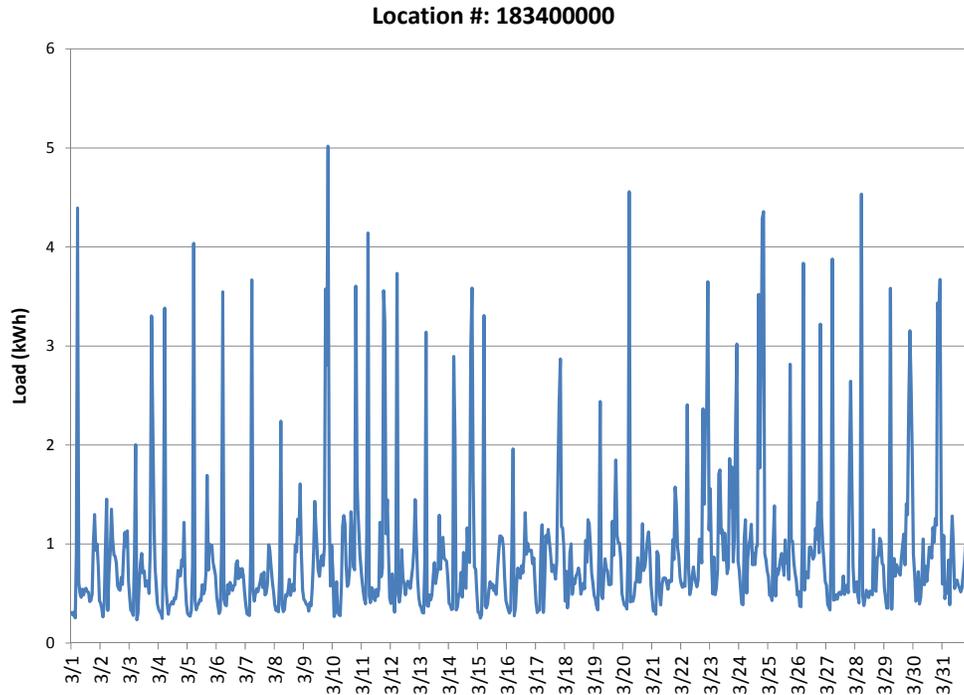


Figure 2. Residential Meter Profile – Example 1

⁴ In the examples, the Y-axis is marked as kWh; however, as the data are given on an hourly basis, the data are kWh/hr, or simply kilowatts.

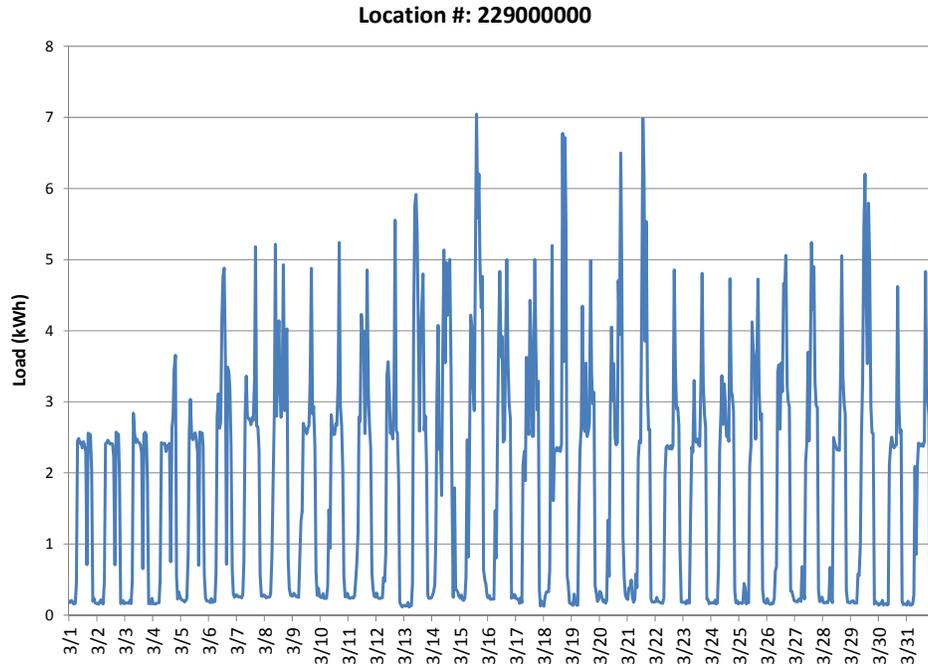


Figure 3. Residential Meter Profile – Example 2

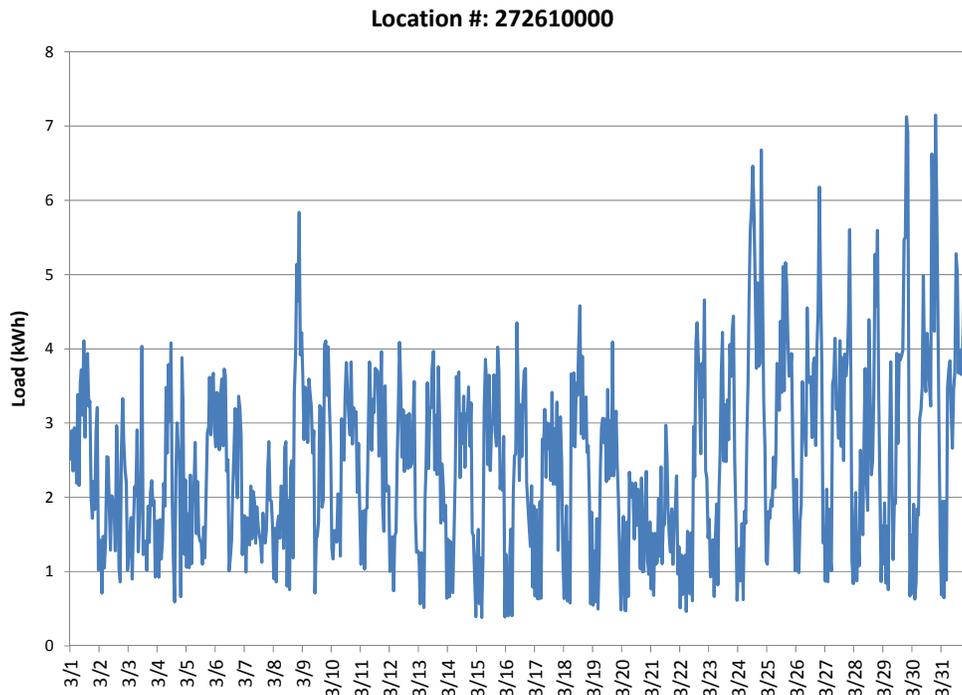


Figure 4. Residential Meter Profile – Example 3

In a few cases, unusual residential load patterns were observed, such as periodic low loads, periodic spikes, and periodic zero loads. However, these were largely observed to be functions of typical vacation home occupancy patterns, responses to weather conditions, and other explainable events and conditions (**Figures 5–7**).

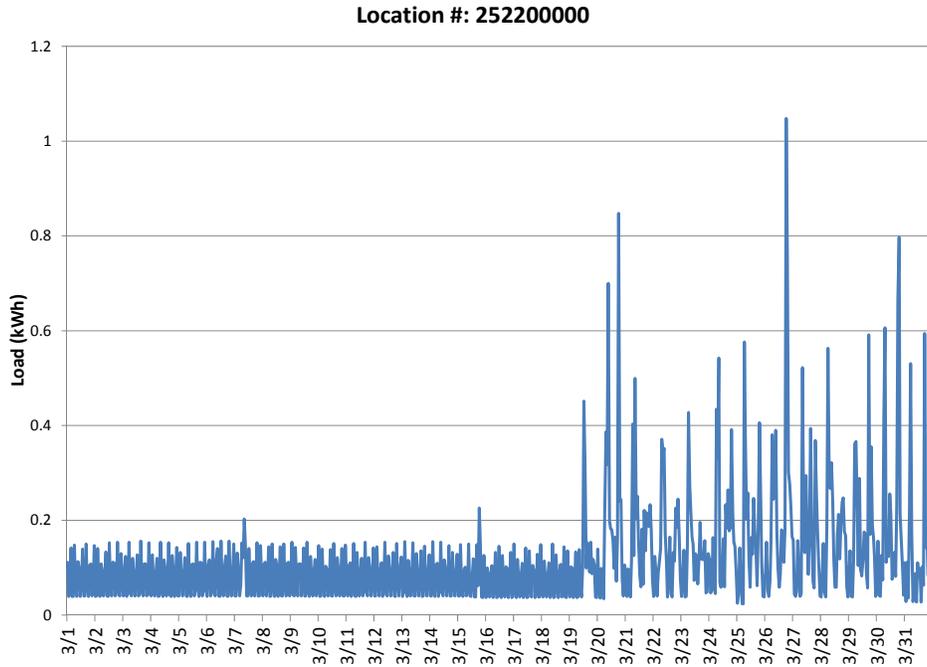


Figure 5. Residential Meter Profile – Example 4 (Periodic Low Loads)

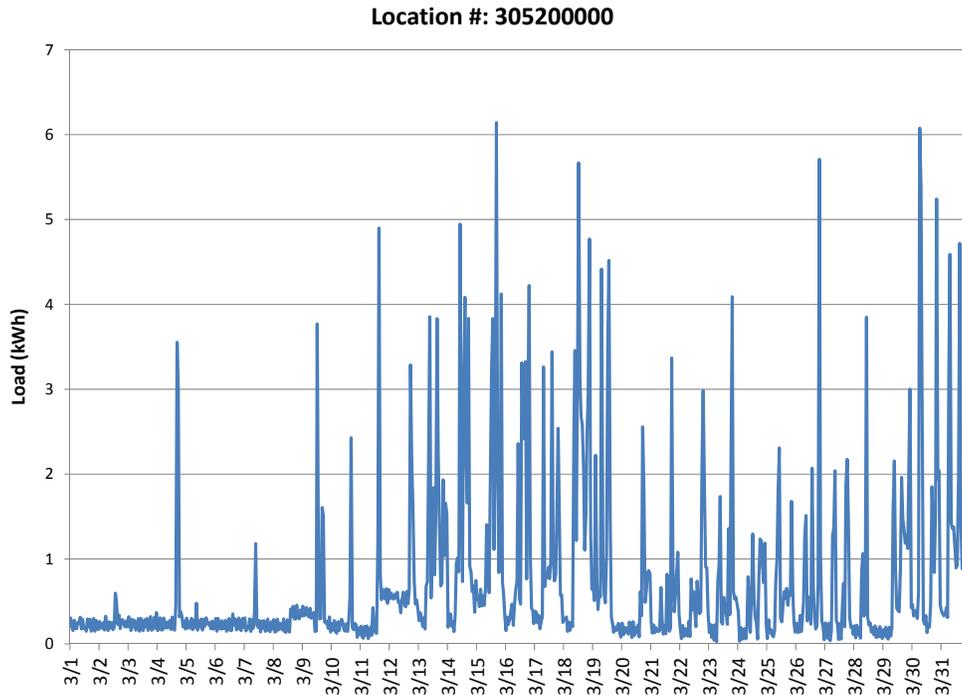


Figure 6. Residential Meter Profile – Example 5 (Periodic Low Loads)

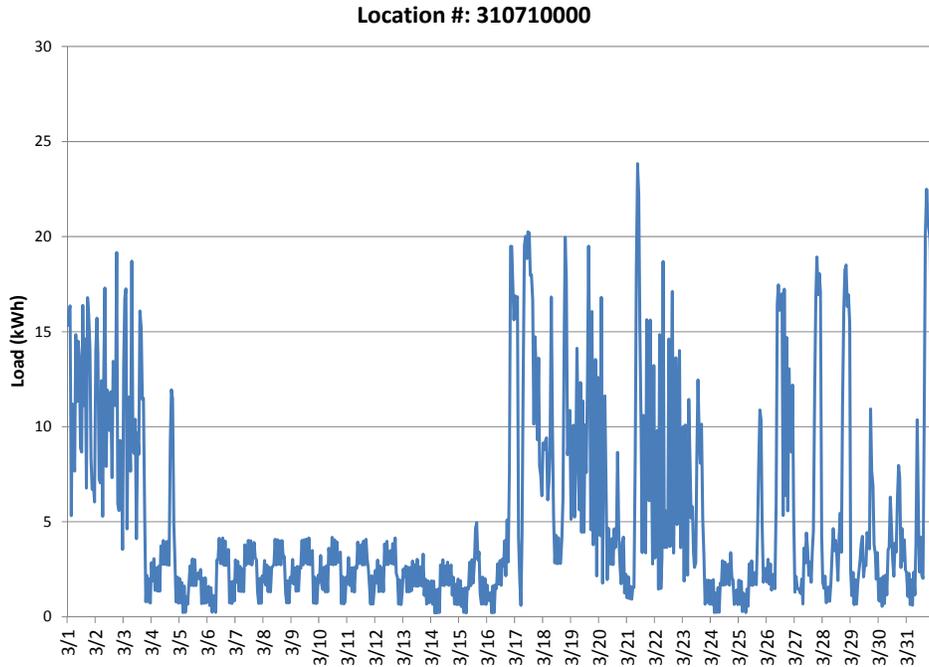


Figure 7. Residential Meter Profile – Example 6 (Periodic Low Loads)

Similar patterns emerged from the Small Commercial data set, with typical profiles and occasional periodic low loads (**Figures 8 and 9**).

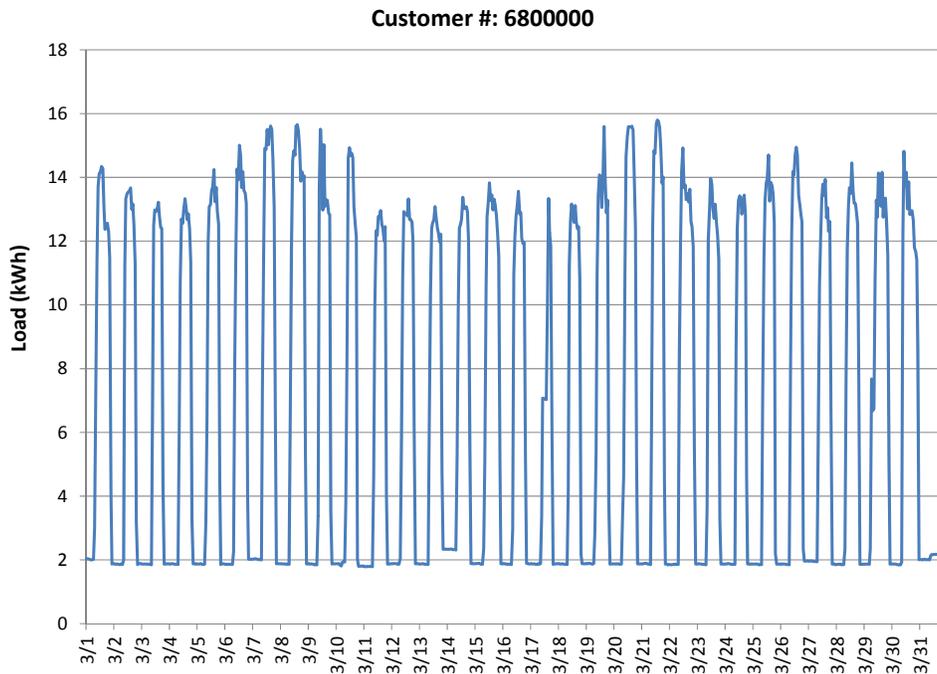


Figure 8. Small Commercial Meter Profile – Example 1

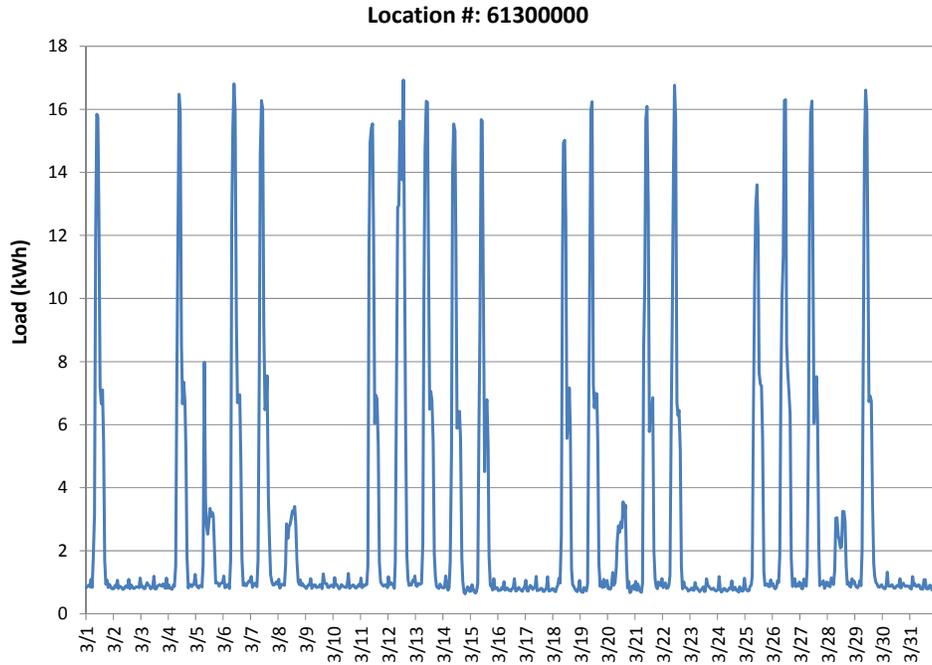


Figure 9. Small Commercial Meter Profile – Example 2

With Large Power, for which all metered consumers are included in the data set, an example of a periodic zero load reading was identified, calling for further investigation (Figure 10).

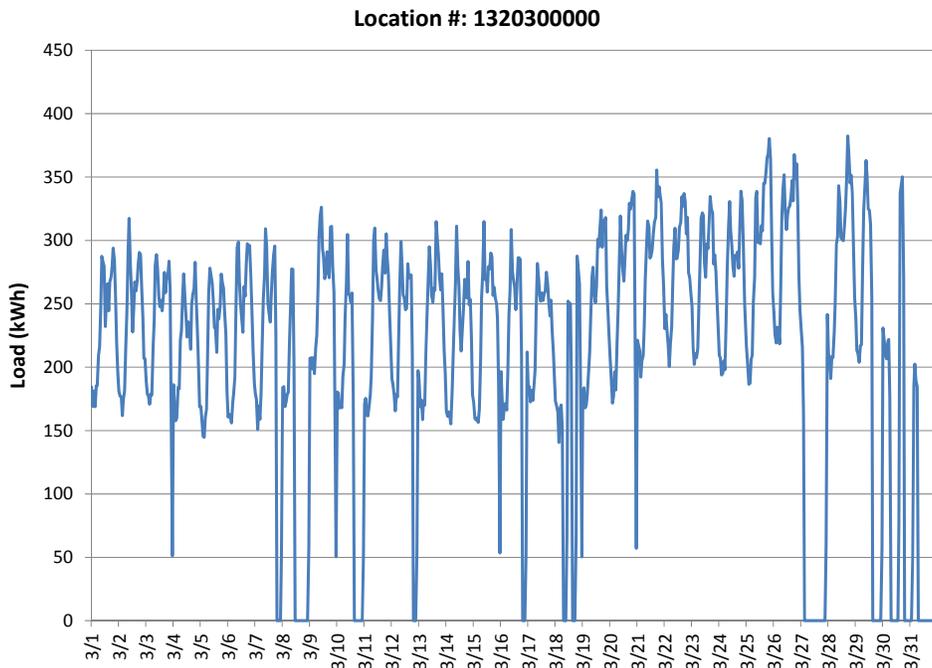


Figure 10. Large Power Meter Profile Example

5.2 Conclusions from Initial Sampling and Selection

The conclusions drawn from the AMI-based data set are that the data appear remarkably clean and generally error free. Most locations follow sensible patterns, with typical weather variability and day-type patterns (especially the non-residential classes). Some locations reflect unusual operations, such as periodically unoccupied rental or condominium housing, intermittently higher-demand appliances or other end uses, and commercial facilities with odd hours.

The availability of data from the AMI system across nearly all consumers provides the opportunity to sample and identify anomalies—patterns that may not be recognized easily by traditional sampling and recording systems. Deriving sample data from an AMI system has allowed for larger samples than otherwise could be achieved cost-effectively and the ability to more easily identify and exclude samples containing invalid data without sacrificing precision.

Aside from a few minor clean-up issues, the estimated class loads are expected to be representative and reasonable. From the information available to date, the system load profiles for March 2013 are shown in **Figures 11–15** (excluding, in the case of the System Load Profile, certain non-metered loads and losses).

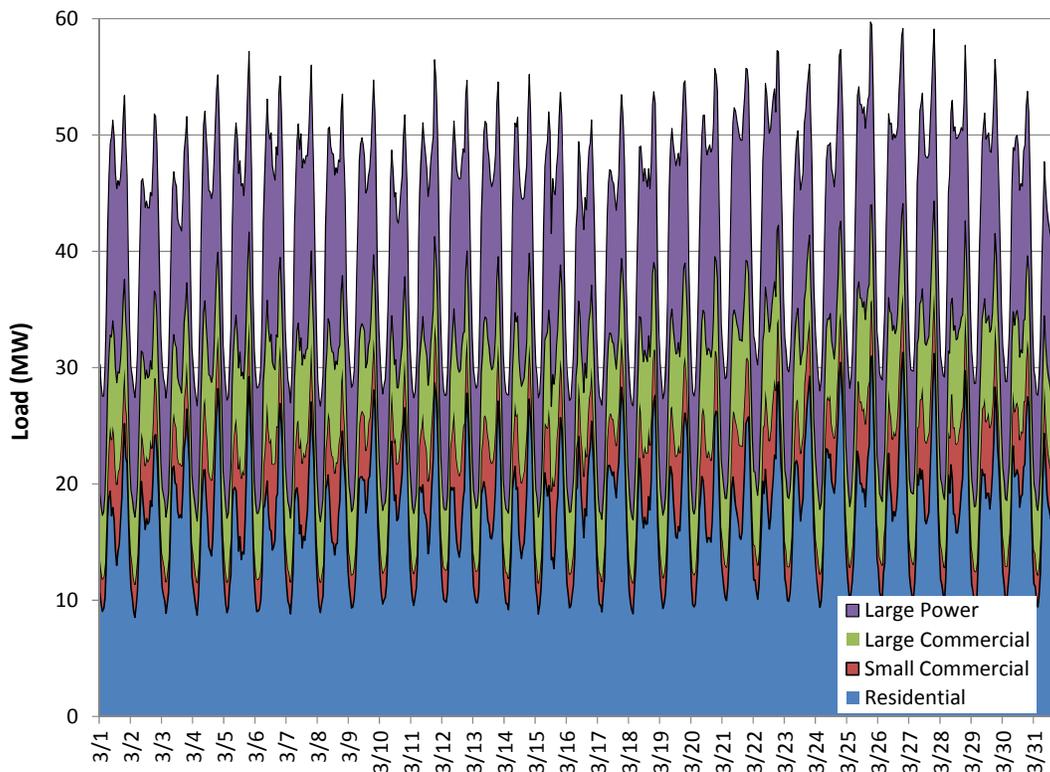


Figure 11. Partial System Load Profile – March 2013

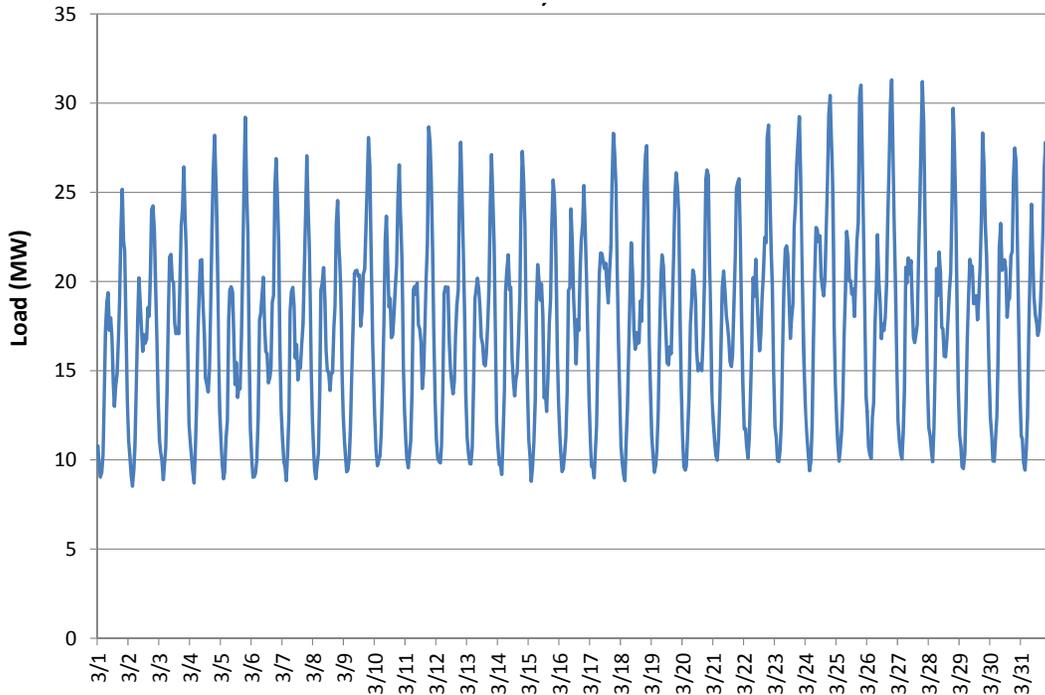


Figure 12. Residential Load Profile – March 2013

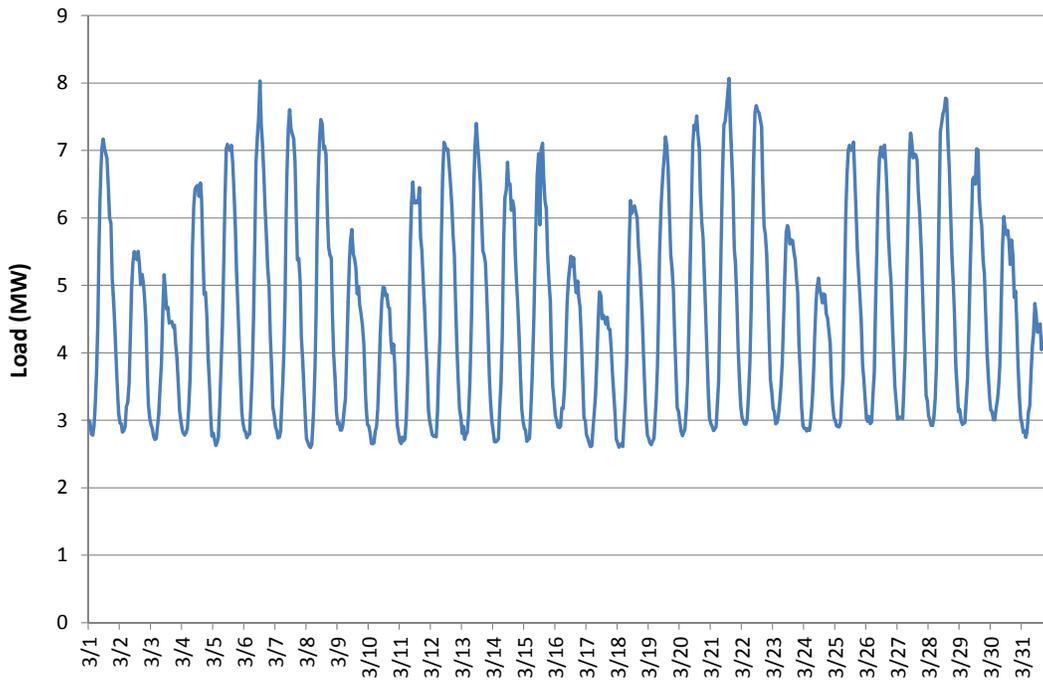


Figure 13. Small Commercial Load Profile – March 2013

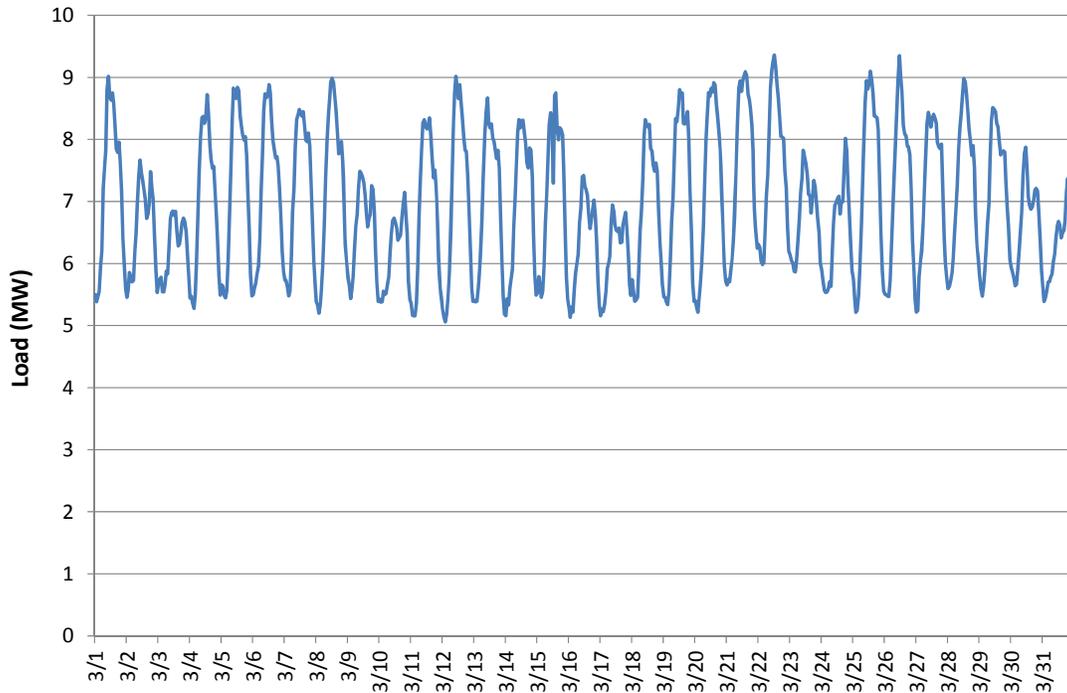


Figure 14. Large Commercial Load Profile – March 2013

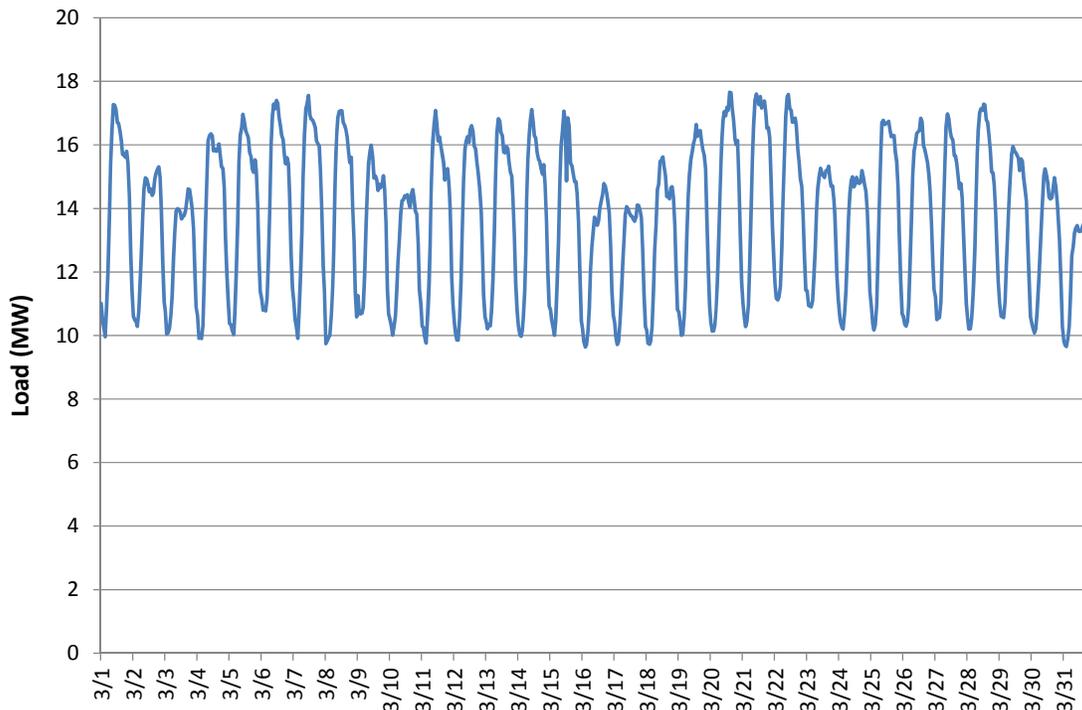


Figure 15. Large Power Load Profile – March 2013

Figures 16–19 depict the estimated load profiles of the Residential, Small Commercial, Large Commercial, and Large Power classes on the system peak day, illustrating the differences in contribution to the system peak relative to the class loads in question, which is of significant interest in cost-of-service calculations.

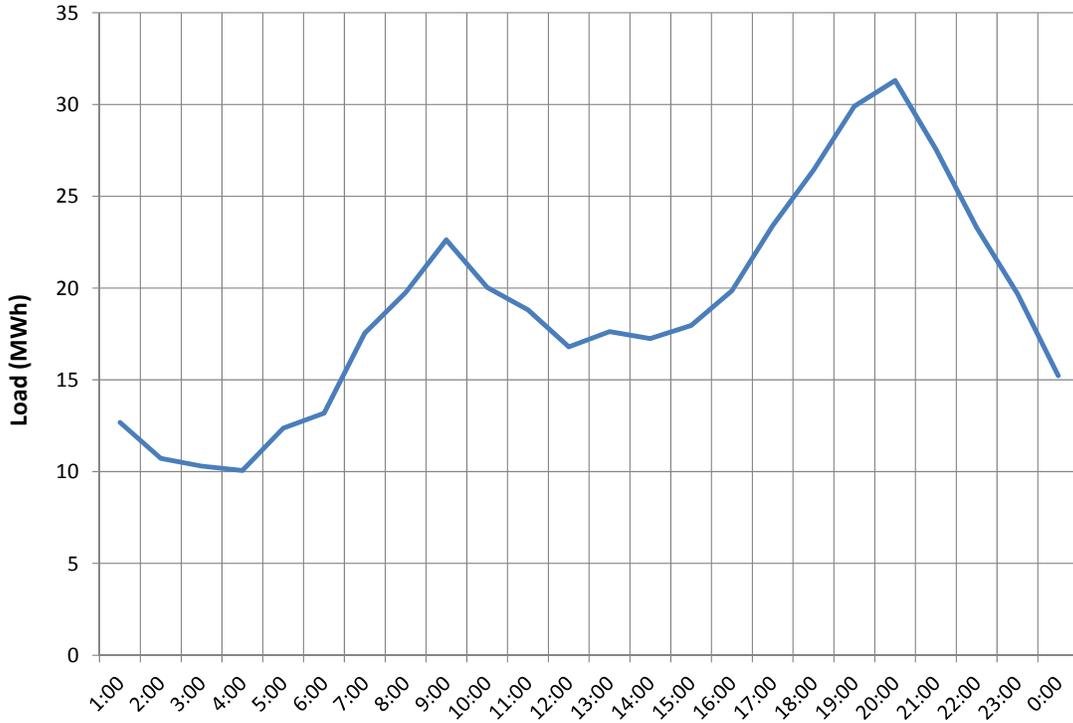


Figure 16. System Peak Day Load Profile – Residential (Mar-13)

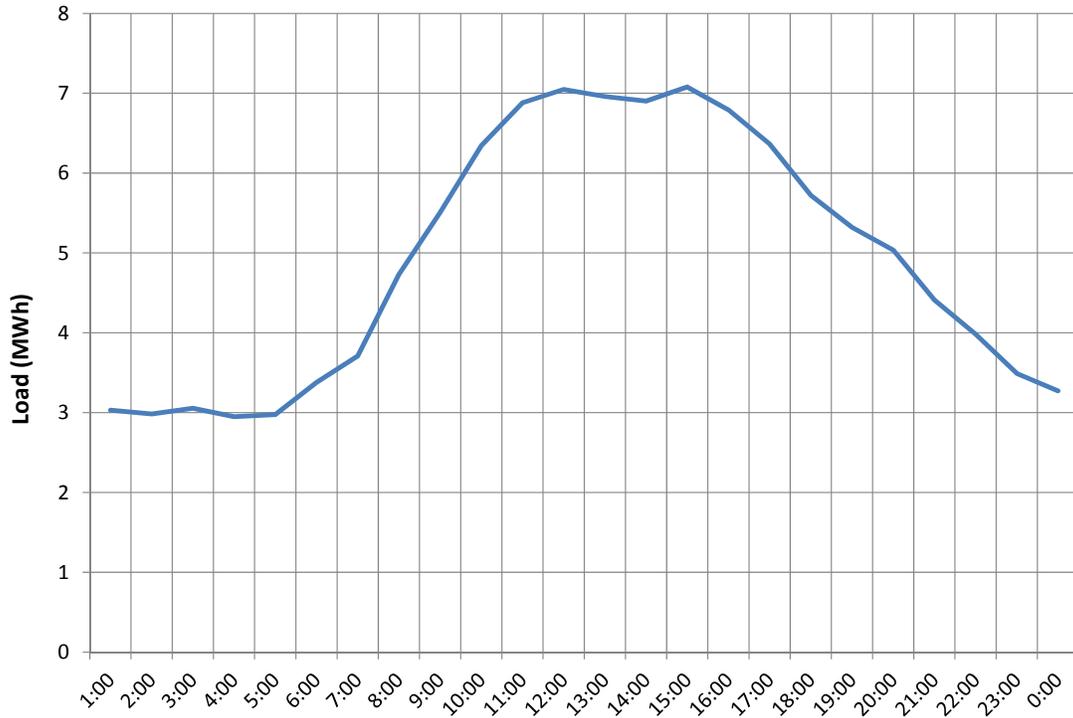


Figure 17. Peak Day Load Profile – Small Commercial (Mar-13)

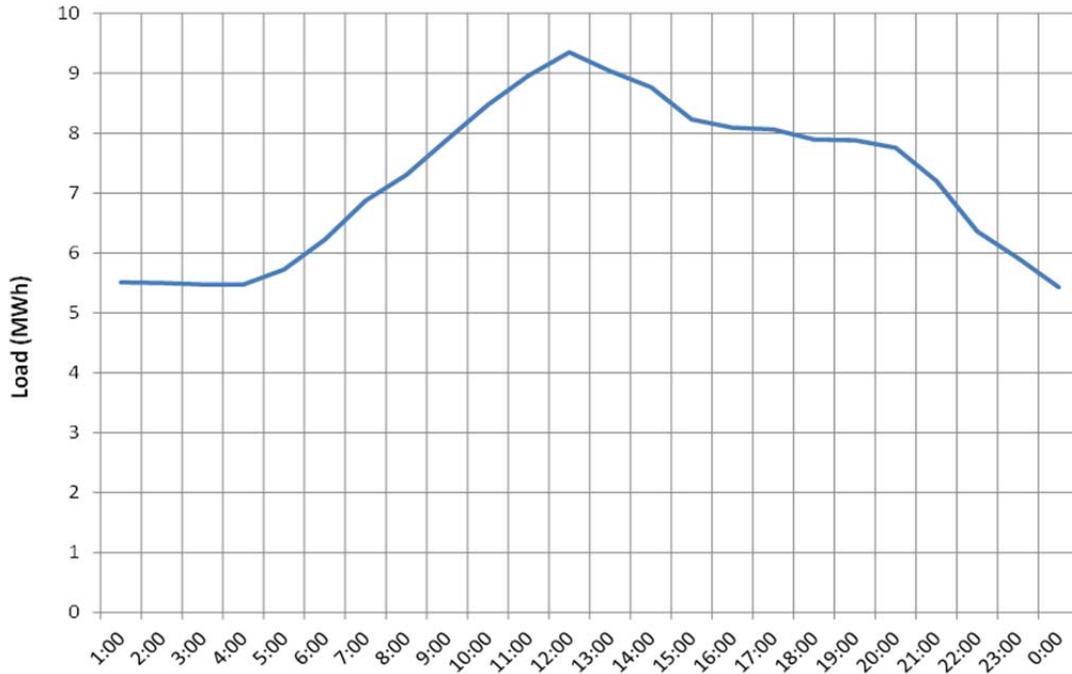


Figure 18. Peak Day Load Profile – Large Commercial (Mar-13)

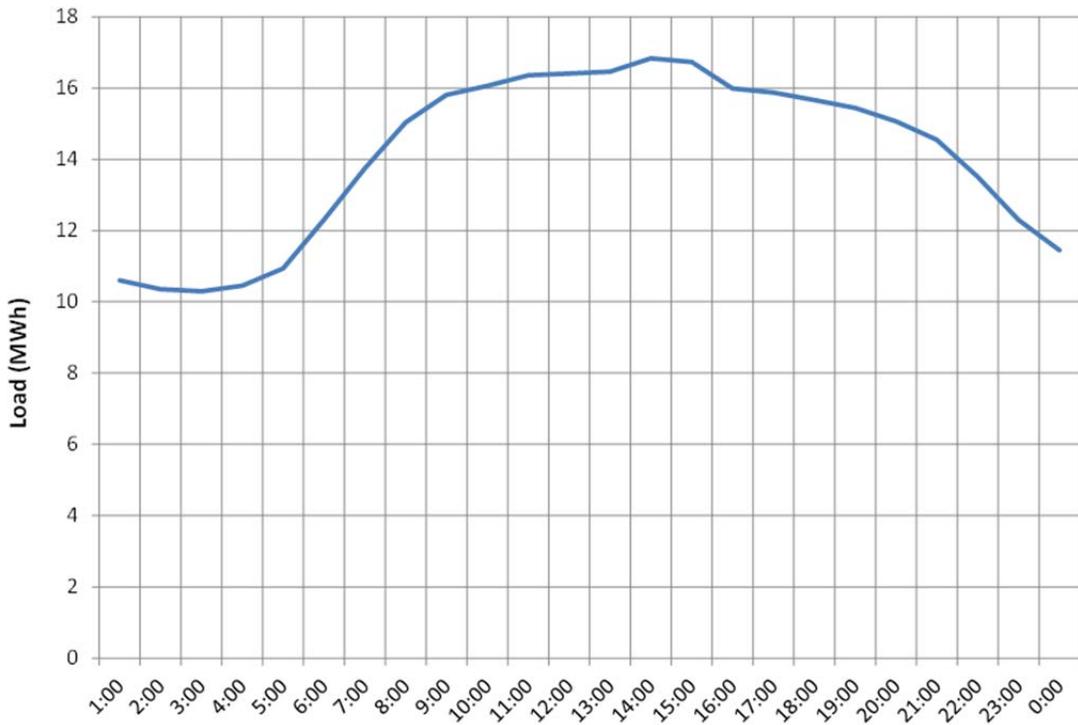


Figure 19. Peak Day Load Profile – Large Power (Mar-13)

5.3 Approach to Net Metered Loads

The AMI-based load research provides an opportunity to examine additional categories of load behaviors, such as net metered consumers providing a portion of their own generation requirements. Evaluation is continuing on how best to treat the net metered loads versus generation, but information is now available to monitor those loads effectively.

For example, some average net load and generation profiles of net metering consumers on the KIUC system are available from March 2013 (**Figures 20–23**). The data represent net delivered and net received energy, rather than the full load requirements and total generation of the net metering customers.

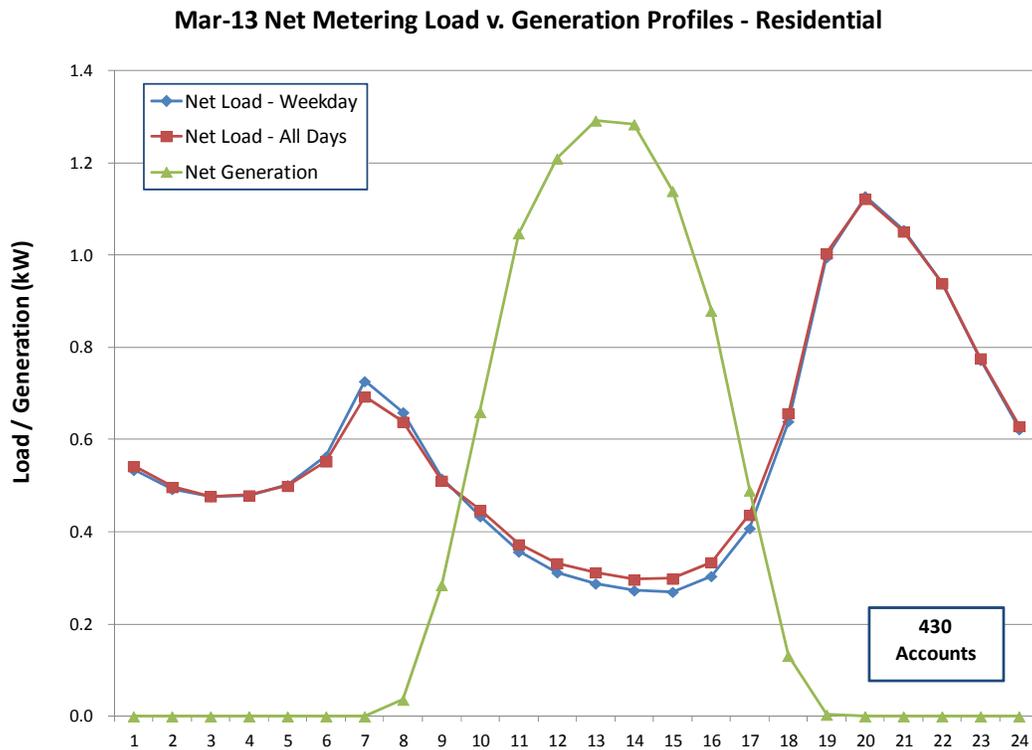


Figure 20. Net Metering Load vs. Generation Profiles – Residential

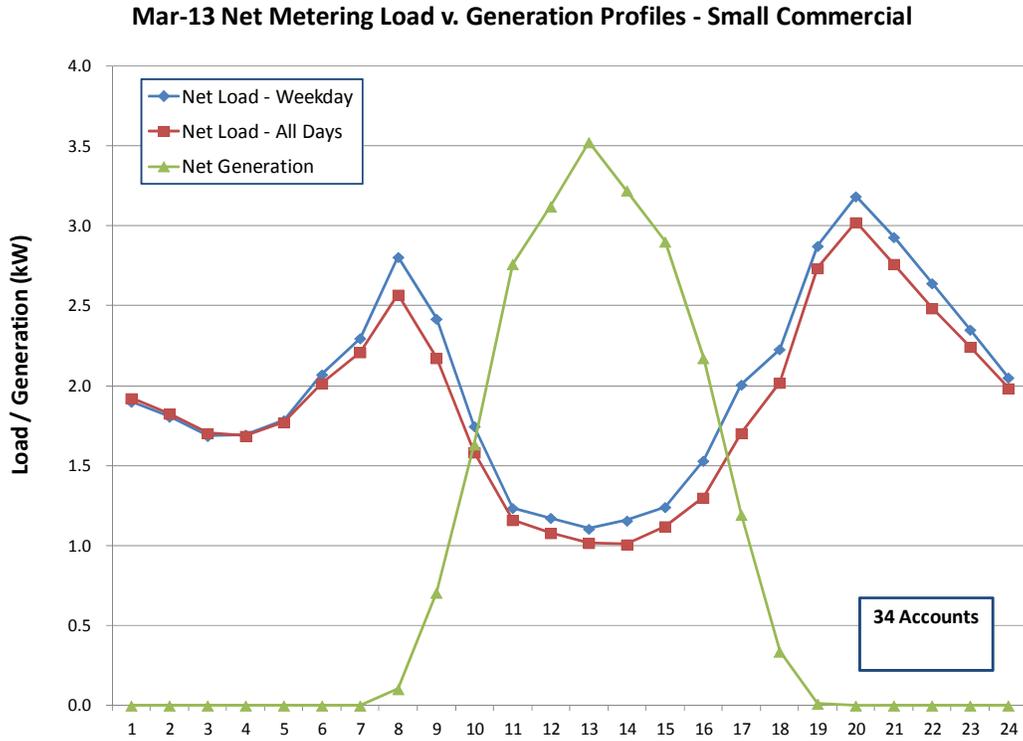


Figure 21. Net Metering Load vs. Generation Profiles – Small Commercial

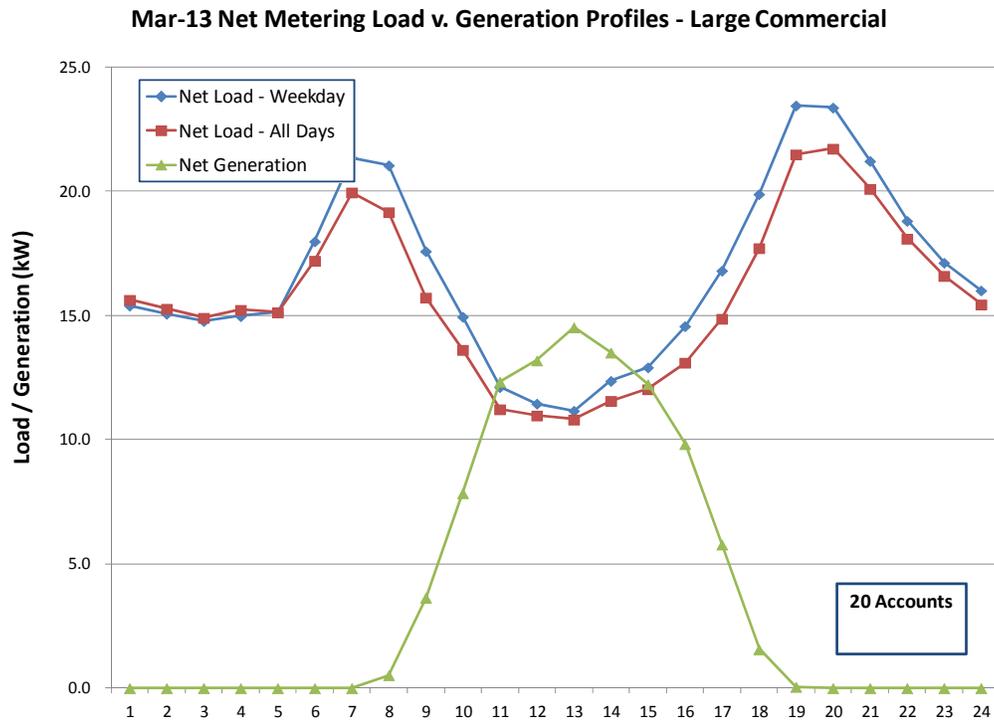


Figure 22. Net Metering Load vs. Generation Profiles – Large Commercial

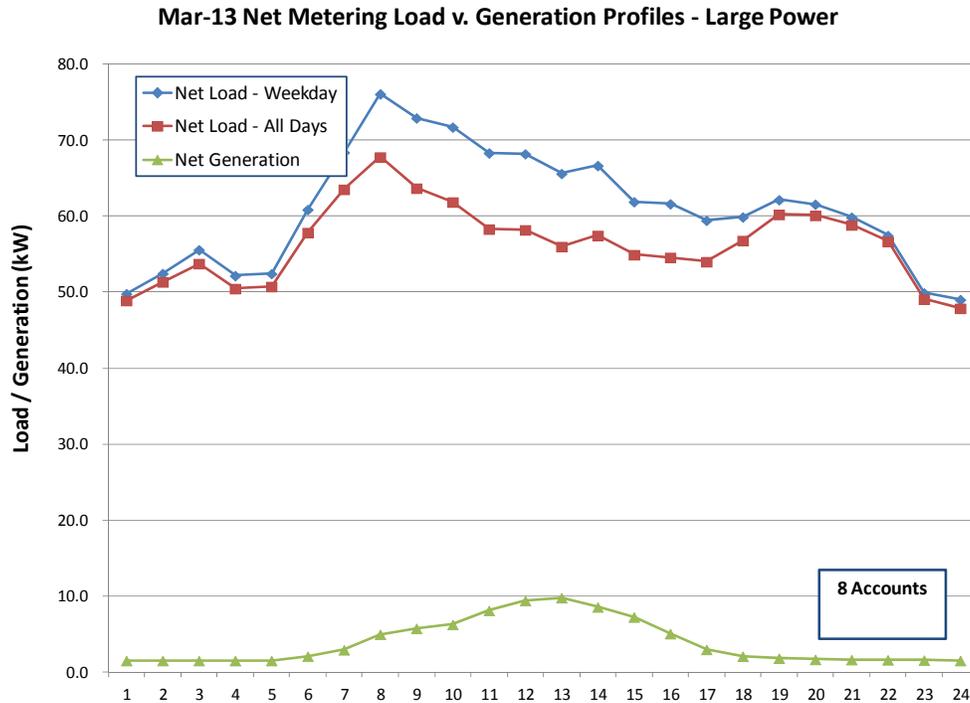


Figure 23. Net Metering Load vs. Generation Profiles – Large Power

5.4 Next Steps in KIUC AMI-Based Load Research

Over the next few months, SAIC and KIUC will be working together to finalize the data collection and address additional issues related to completing the load research study, including the following:

- ◆ Implement a process for estimating the non-metered loads on the system;
 - ◆ Obtain and process the balance of the additional months of data for the test period under examination:
 - Adjust data to be transferred, as appropriate;
 - Capture contiguous months (and further interval analysis);
 - Continue provision of system/billing data;
 - ◆ Implement decided approach on migrating locations;
 - ◆ Implement decided approach on NEM/Q loads vs. generation; and
- Continue load data validation.

5.5 Full-Period Data Analysis Issues

With the KIUC load research program continuing to evolve over the test period analysis, issues with data will continue to be identified and reported. Findings associated with multiple-month data collection will be cited in SAIC's update, which will be provided to KIUC and NRECA at year end, with the results to be included in the revised and final KIUC demonstration documentation.

6. CONCLUSIONS TO DATE FROM THE SMART GRID AMI-BASED LOAD RESEARCH DEMONSTRATION

To date, the KIUC AMI-Based Load Research Demonstration has shown that the AMI system has provided remarkably clean and generally error-free data, reflecting the integrity of the AMI system and data collection protocols and communications network. A quite comprehensive set of profiles for the initial month examined suggests that a full-year data set will be reasonable and fully representative of load class contributions to serve as a basis for rate studies and other purposes. Based on these findings, a preliminary determination may be made that an AMI-based system provides a better design for obtaining the requisite data than traditional equipment. The research objective of demonstrating the use of the AMI system for load research has been partially met through the initial work, and full-period data analysis and reporting will provide the balance of the investigative results.

The AMI system has allowed KIUC to avoid incremental costs in acquiring the load data, and the system has shown overall integrity and provides data uniquely associated with the KIUC consumer base on which it may rely. The ability to create a sample from a relatively unlimited database of recorded metering information has been useful for the sampling design. Further work on collection should add to the identification of anomalous results and the opportunity to understand unique features of the KIUC load requirements, including such factors as net metering circumstances and other non-utility generation. Furthermore, the opportunity to selectively identify unusual and anomalous load and investigate the causes and impacts will provide for improved operating efficiencies.

7. RECOMMENDATIONS FOR FURTHER STUDY

Pending the completion of the 12-month data analysis and reporting, and the results of regulatory acceptance of the research findings, several factors in the application of the AMI system for load research may be worthwhile candidates for further study. These include the following:

- ◆ The impact and effect of metering “opt-outs” and the impact on derived load characteristics for the system;
- ◆ Comparison with more traditional systems, such as PLC-based data collection, for data integrity and data continuity; and
- ◆ The value of periodic repetition of the sampling and the appropriate time frame for re-examination.