# Smart grid appliances case study: anatomy of a demonstration pilot

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## Keywords

## Abstract

Creating customer value from the Smart Grid has been an overarching goal of the utility industry. Many Smart Meter business cases included undefined customer benefits associated with having the added intelligence of a Smart Meter. In this "Grid Smart Appliance" demonstration project, Glasgow Electric Plant Board (GEPB), Tennessee Valley Authority (TVA), and General Electric (GE) have joined forces to examine what those benefits might include. This project is being implemented in phases and involves the instrumentation of 30 homes (20-test and 10-control) in the GEPB service territory. The loads under monitor include heating, ventilation and air conditioning (HVAC), domestic hot water heater (DHW), electric clothes washer (Washer), electric clothes dryer (Dryer), Dishwasher, Range, Refrigerator, and the home's internal temperature.

**Phase I.** In early 2012, customers were recruited for the project using new appliances as an incentive to participate. The customers existing appliances were isolated and instrumented to begin securing 15-minute baseline appliance usage information. Baseline information was collected for approximately three months (Phase I).

**Phase II.** In early June 2012, a new Energy Smart/Grid Smart/GE appliance bundle was installed in 20 of the homes (Phase II). This included the installation of the GE Nucleus™ home energy management system. The GE's Nucleus™ energy manager, in conjunction with a smart meter, provides near-real-time home electricity consumption information to help consumers identify ways to view their usage, manage their electricity costs, and actively reduce their electricity usage.

**Phase III.** Beginning in the September 2012, the project began investigating a series of residential customer offerings allowing the utility and customers to modify their appliance usage using the built-in control technology of the appliances. In this phase, Time-of-Use (TOU) rates and Demand Response (DR) events were implemented for the 30 customers. For both the TOU rates and the DR events, only the weekdays were affected. The TOU rates breakdown as such:

- 00:00–14:00 is a low period charged at $0.10/kWh.
- 14:00–18:00 is a high period charged at $0.20/kWh.
- 18:00–24:00 is a low period charged at $0.10/kWh.

The DR events were called during the weekdays from 2 pm–6 pm which coincides with the high period of the TOU rates. During these events, appliances are prompted to shed their usage. Customers had the ability to override these events.

This paper compares, contrasts and highlights the appliance usage characteristics observed in Phase I and Phase II of the project. The conference presentation will update this paper with the results from the Phase III activities that are designed to take advantage of the built-in control technology to modify the appliance usage in accordance with utility price signalling and need. This analysis is currently on-going and is subject to client review prior to publication.

## Introduction

Glasgow Electric Plant Board (GEPB) is located in Glasgow, Kentucky serving approximately 7,200 members located in Barren County, Kentucky. GEPB has 171 miles of line serving 5,300 residential members and has been participating in advanced metering programs since 2009. These metering programs have allowed GEPB to evaluate residential load profiles. One such project is the Google PowerMeter Project[1] which involved installation of "smart" meters on all individual residential homes in the GEPB area of service. These smart meters provide hourly and daily energy information viewable on an energy information dashboard.

In 2011, GEPB launched the "Grid Smart Appliance" Demonstration Project with TVA and General Electric (GE). The project provides demand response enabled residential appliance bundles including the "GE Nucleus™" home energy management system to a small sample of residential customers in the GEPB region for a minimum of two years. As an participation incentive, the program participants are being allowed to keep the ENERGY STAR appliances at the conclusion of the project. The ENERGY STAR appliance bundle includes: refrigerator, dishwasher, electric clothes washer, electric clothes dryer, range/oven, and GeoSpring Hybrid water heater.

The demonstration project is examining residential customer behavioral responses to utility changes occurring over a two year period. In the two year period, multiple phases will ensue. Each of these phases incorporate small changes to the aforementioned appliances that include new appliance installation, time of use price signals, demand response signals and HVAC control. Throughout the project, quantitative data are being captured and analyzed to better understand the customer's response. Overall, the project has four objectives:

1. Measuring the baseline energy of residential appliances;

2. Measuring the impact on energy and demand profiles of selected appliances resulting from replacing the appliances with the GE ENERGY STAR Bundle;

3. Determining the ability and the willingness of residential homeowners to modify load based on information provided by the utility; and

4. Examining consumer sentiment regarding perceived benefits of modifying their behavior.

The project includes 20 households as an experimental "test" group with 10 additional households used as a control group. Certain project requirements were established in order to participate in the program. These requirements are listed below.

- To be within the TVA territory;

- Internet Broadband connection;

- Seasoned household appliances (minimum 8–10 years old);

- Already have an electric water heater or heat pump;

- Be representative of "Middle Class America";

- Participate in "incentive only[2]" program to save energy/reduce peak loads;

- Allow personal energy use data become a part of data based for analysis;

- Forego any major building/HVAC upgrades during the evaluation period;

- Participate in surveys and interviews regarding appliances and home energy equipment;

- Allow AMI meter with Zigbee 1.0 Home Area Network to be installed;

- The general locations of homes to be reasonable clustered to reduce project costs;

- Allow a quality energy audit to be performed on the residence prior to start;

- Have been in home at least one full year;

- Wait one full year of test time before conducting major upgrades to building shell;

- Continue on pilot program after completing building upgrades;

- Have key appliances on dedicated circuits to allow of ease of monitoring; and

- Allow the home to be well instrumented to document energy usage.

Due to the numerous requirements established and self selection, the 20 households are viewed as a large "focus group". The project has been divided into multiple phases with phases one and two complete. Phase one started in TVA Fiscal Year (FY) week 9 (March 1st, 2012) and continued to FY week 23 (June 2nd, 2012). Data collected during Phase I established a baseline for the existing appliances for each of the 20 homes. During FY weeks 23 and 24, all homes received new GE ENERGY STAR appliances and therefore the data during those two weeks is not analyzed in the Phase I and Phase II comparison. Phase II launched during FY week 25 (June 17) and continued through FY week 35 (September 2). Data collected after week 35 is considered Phase III and includes price and control signals sent to the appliances and the consumer. During Phase III, control signals are being sent to the appliances, typically between the hours of 2 pm and 6 pm on weekdays, with the consumers being rewarded $1 for not overriding the event. During the course of the project a number of customer meetings have been held to explain the importance of time differentiated appliance usage to help educate the consumer. While this paper focuses on the results of Phase I and Phase II, we plan to present the more interesting Phase III results at the conference.

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1. http://www.nytimes.com/2009/02/10/technology/companies/10grid.html?partner=permalink&exprod=permalink&_r=0

2. Not to participate in any active load management outside of the project.

## Overall Findings

The following findings focus on the twenty "test" group homes that were monitored and received new GE ENERGY STAR appliances. For the twenty "test" homes, the average daily usage (in kWh) was calculated for all appliances installed. The following figure shows the average daily usage for the appliance bundle in kWh for each phase, as well as percent reduction within the bar chart. With the exception of the dishwasher, each appliance shows reduction in energy usage during Phase II.

Figure 1 shows the modest usage associated with the dish washer, range and washer. The dryer, refrigerator and water heater dominate the usage of the appliance bundle. Please note, the highest consuming device in the home is the HVAC system. The figure shows the very dramatic reduction in energy associated with the installation of the GeoSpring Hybrid water heater (71.4 % reduction in use) and the new refrigerators (33.1 % reduction in use) with the dryer, range and washer showing modest reductions in average daily use. The only anomaly concerning the new appliances was the dishwasher, which had a slight increase in energy consumption of 7.4 %. Two primary drivers for this increase were identified. During Phase II, 19 out of the 20 homes witnessed an increase in the number of total runs of the dish washer.

The following sections examine the performance of each of the appliances.

### ELECTRIC WATER HEATER PERFORMANCE

Major energy reductions in water heating were expected with the installation of the heat pump water heater, however, the increases were higher than anticipated in all 20 homes. Figure 2 shows a comparison of pre and post-installation of the GeoSpring Hybrid water heater.

Percent reduction could not be calculated for Home 11 because there was no baseline data on energy usage of the water heater during Phase I. The energy reduction ranges from

**Table 1. Project Phases.**

| Project Phases |
| --- |
| Phase 1: March 1, 2012 – June 2, 2012 |
| Installation Period: June 3, 2012 – June 16, 2012 |
| Phase 2: June 17, 2012 – September 2, 2012 |
| Phase 3: September 3, 2012 – Current |

60–84 % which is substantially above the expected savings of approximately 50–60 %. The inordinately large increase is believe to be associated with having all hot water consuming appliances, i.e., washer and dishwasher, changed out to more energy (and water) efficient models.

The top part of Figure 3 presents the average daily use (Sunday through Saturday) of the water heater during Phase I (left hand graph) and Phase II (right hand graph). The dashed lines are each individual home with the solid line representing the average of all 20 homes in the test group. The graph in the top left hand corner shows the high variability encountered in the Phase I homes. During Phase I, the average daily usage ranged from a low of approximately 3 kWh/day to a high of nearly 20 kWh/day. The overall average of Phase I was 7.2 kWh/day. In contrast, the water heat use during Phase II was much lower and consistent averaging just over 2 kWh/day. On the bottom of the figure are the average hourly demands during the average weekday. Once again, the individual homes are presented as dashed lines with the average presented as the solid line. The water heater shows a lot of diversity with the standard Phase I water heater ranging to a high in excess of 4 kW in the early morning hours. In contrast, the Phase II heat pump water heater shows very low load and little diversity.

In Figure 4 we take the average profiles from the bottom of Figure 3 and plot them on the same axis. In addition, we in-
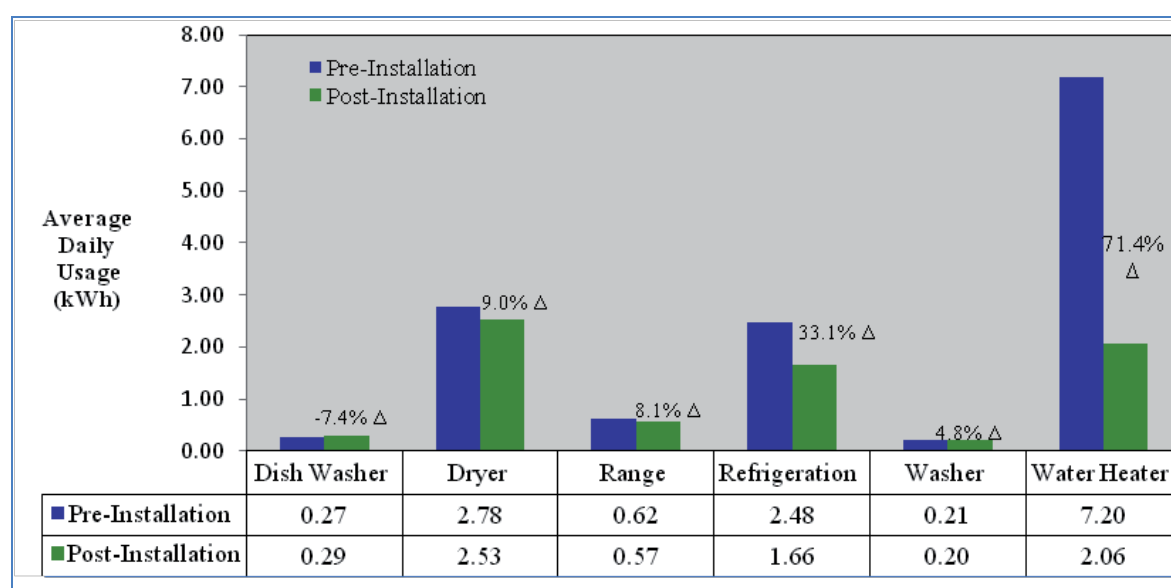


| | Dish Washer | Dryer | Range | Refrigeration | Washer | Water Heater |
| --- | --- | --- | --- | --- | --- | --- |
| Pre-Installation | 0.27 | 2.78 | 0.62 | 2.48 | 0.21 | 7.20 |
| Post-Installation | 0.29 | 2.53 | 0.57 | 1.66 | 0.20 | 2.06 |

*Figure 1. Average Daily Usage of Pre and Post Appliance Installation for all 20 Homes.*
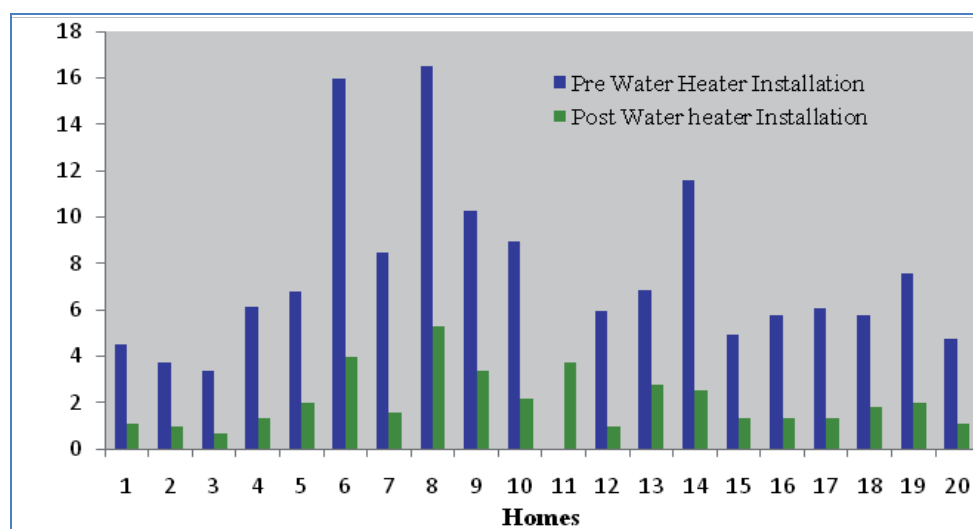
Figure 2. Pre and Post Water Heater Energy Usage for all 20 Homes – Daily Use (kWh).

clude preliminary results for Phase III. The figure clearly shows an improved appliance load factor and a significant reduction in early morning peak demand. The average diversified demand displays a four-fold decrease from 0.8 kW/customer to less than 0.2 kW/customer. The Phase III load shows active control during the late morning and afternoon periods followed by periods of payback.

### PRIMARY REFRIGERATOR PERFORMANCE

Figure 5 highlights the refrigerator performance. The top of the figure presents the Phase I and Phase II average daily usage plots. Once again, each individual house is plotted as a dashed lines with the average across the 20 households plotted as the solid line. The range of daily use during Phase I is quite diverse ranging from a low of just over 1.5 kWh/day to a high of just under 4 kWh/day. The average use was approximately 2.5 kWh/day. The new ENERGY STAR refrigerators installed and operating during Phase II show a much narrower band of use ranging from less than 1.5 kWh/day to just over 2 kWh/day. The average in Phase II was 1.66 kWh day a reduction of 1/3 of the Phase I use. The bottom part of the figure presents the average hourly demand on weekdays. Here again, there is substantial diversity shown in the Phase I refrigerators when compared to Phase II refrigerators.

In Figure 6 we plot the average profiles from the bottom of Figure 5 on the same axis. The dramatic reduction in load is very evident. On a diversified basis the refrigerator load is reduced to under 0.1 kW. In addition, we have added the load performance of the refrigerator under Phase III control to the figure. In Phase III we are actively reducing the refrigerator usage during the utility's late afternoon peak.

### DISHWASHER PERFORMANCE

Figure 7 and Figure 8 show the modest usage of the dishwasher. The average daily use of the dishwasher (excluding the draw on the electric hot water heater) is less than 0.5 kWh/day. The individual customers dishwasher usage is highly variable in both the Phase I and Phase II periods. There seems to

be a conscious decision to defer dishwasher runs until the late evening period during Phase II and Phase III. This is likely the result of the general education of the homeowner to be more cognizant of the importance of time differentiated energy use in the home.

### ELECTRIC RANGE PERFORMANCE

Figure 9 and Figure 10 present the energy and demand characteristics of the electric range. Here again, there is high diversity in the usage of this appliance. The average daily use is less than 1 kWh/day with a not surprising concentration of use in the early morning and early evening hours. The average weekday use peaks at the 6 pm to 7 pm dinner period. The average profiles for all three phases are very similar.

### CLOTHES WASHER PERFORMANCE

Figure 11 and Figure 12 present the energy and demand characteristics of the clothes washer, exclusive of the demand on the electric hot water heater. Here again, the clothes washer shows a lot of diversity with nearly flat usage throughout the week. The average daily use is under 0.25 kWh. The washer profile in Phase II and Phase III shows a distinct increase in usage in the morning and evening and a reduction during the afternoon hours. Once again, we speculate that this is an attempt by these consumers to move load off of the afternoon and early evening periods in anticipation of future time-of-use pricing.

### ELECTRIC CLOTHES DRYER PERFORMANCE

Figure 13 and Figure 14 present the energy and demand characteristics of the electric clothes dryer. The diversity of use of the twenty customers is variable enough to show a relatively flat usage throughout the week with a slight increase in usage during Sunday (Day of Week = 1) and Saturday (Day of Week = 7). Examining the average weekday load profiles, there seems to be intentional effort by the consumers to shift load from the afternoon and evening weekday period to the late morning period.
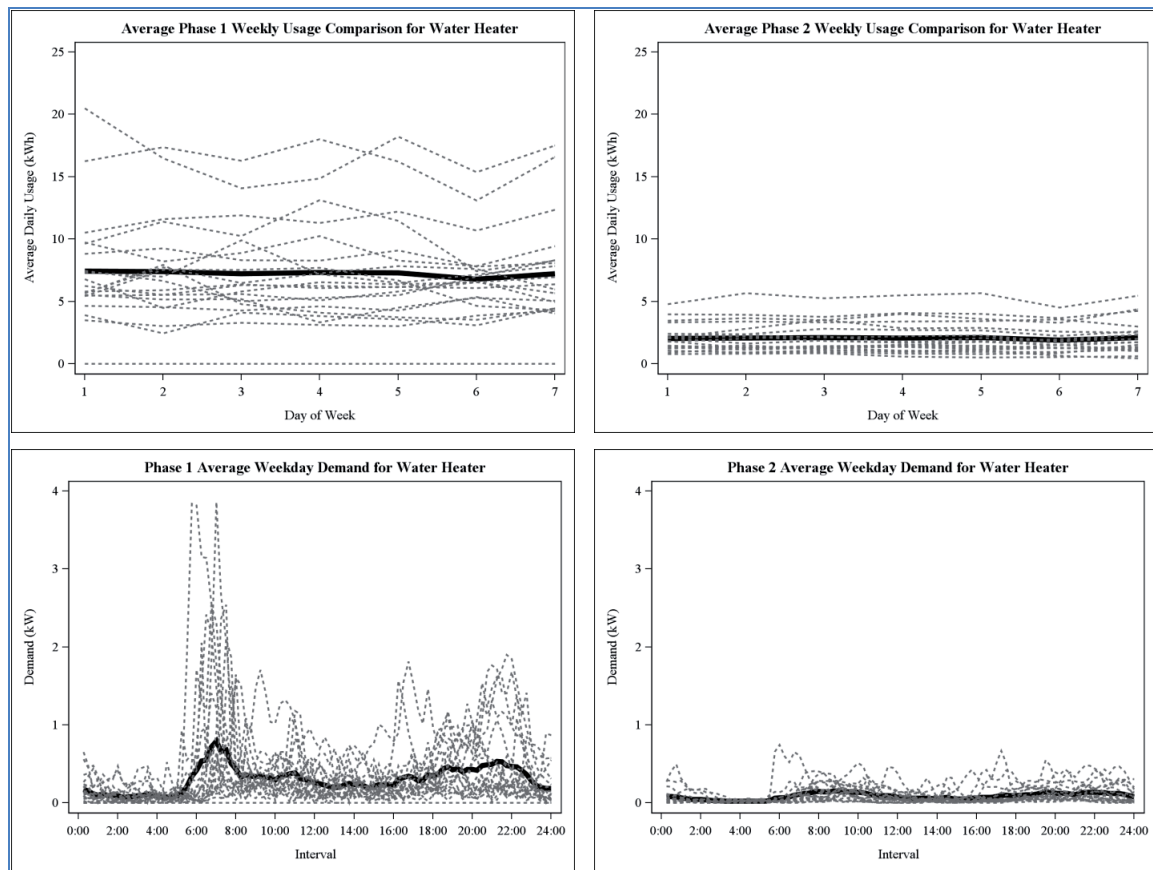
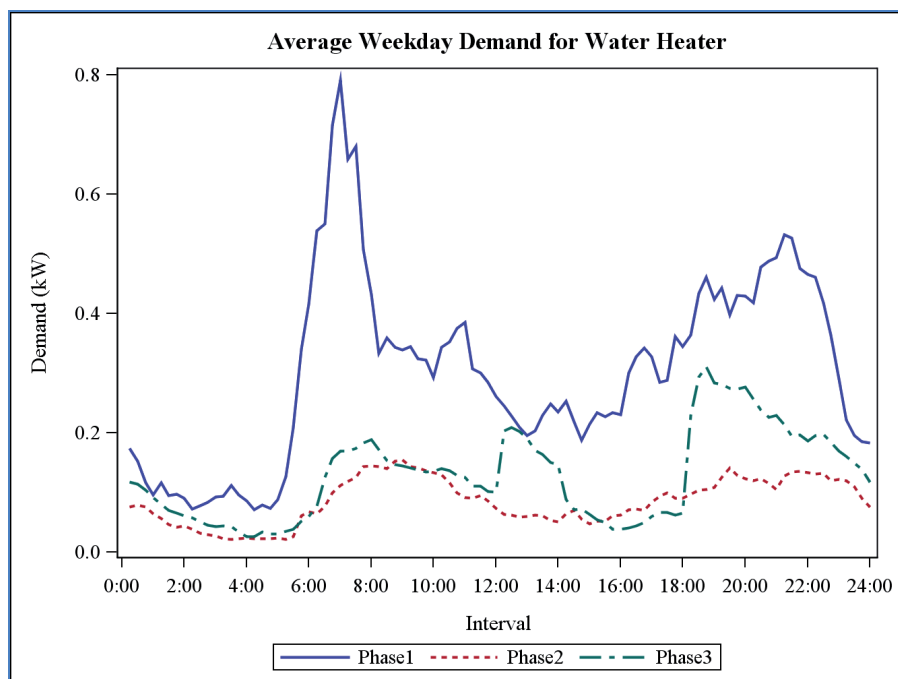*Figure 3. Water Heating Profiles Average Daily Use and Average Weekday Demand.*



*Figure 4. Water Heater Average Weekday Load − Phase I versus Phase II versus Phase III.*
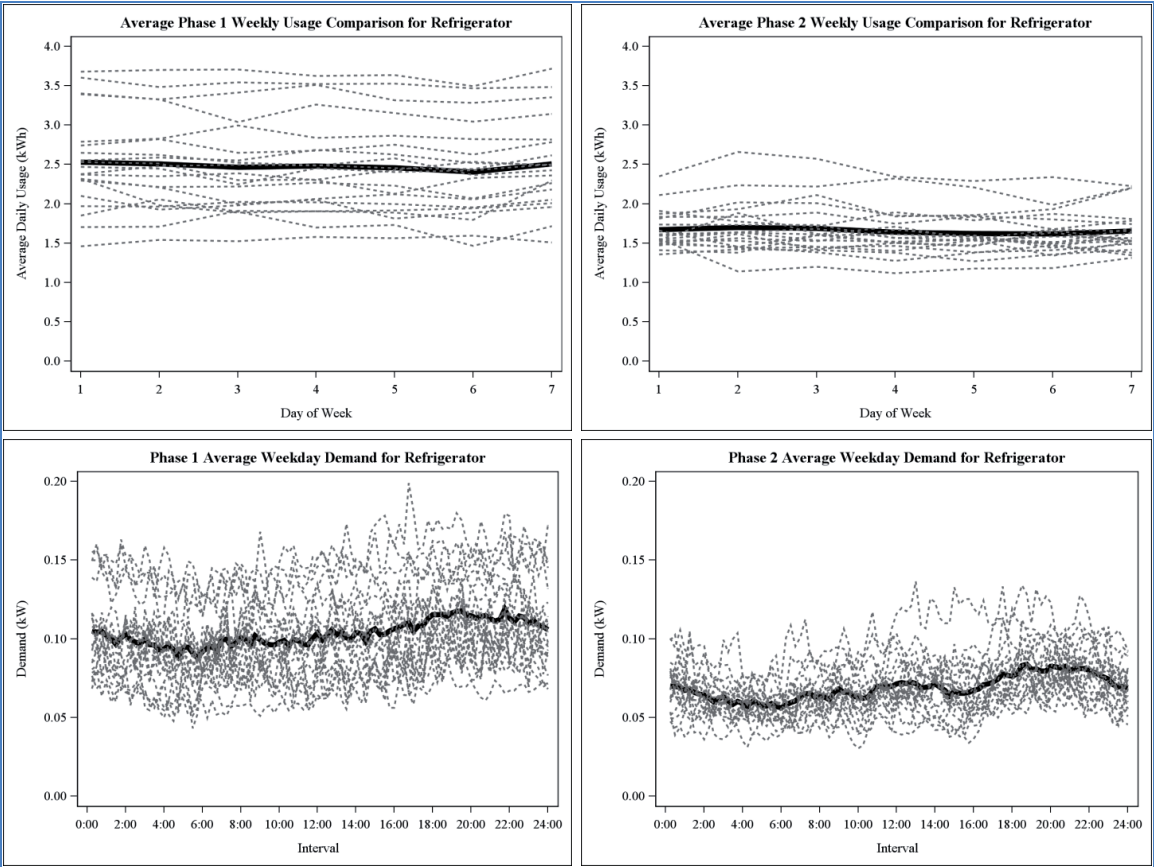
*Figure 5. Refrigerator Profiles Average Daily Use and Average Weekday Demand.*
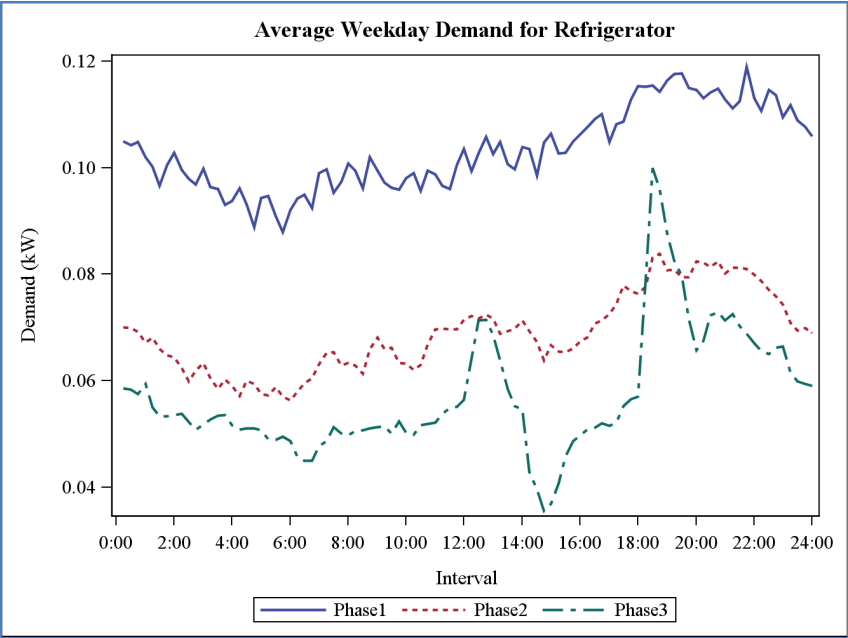


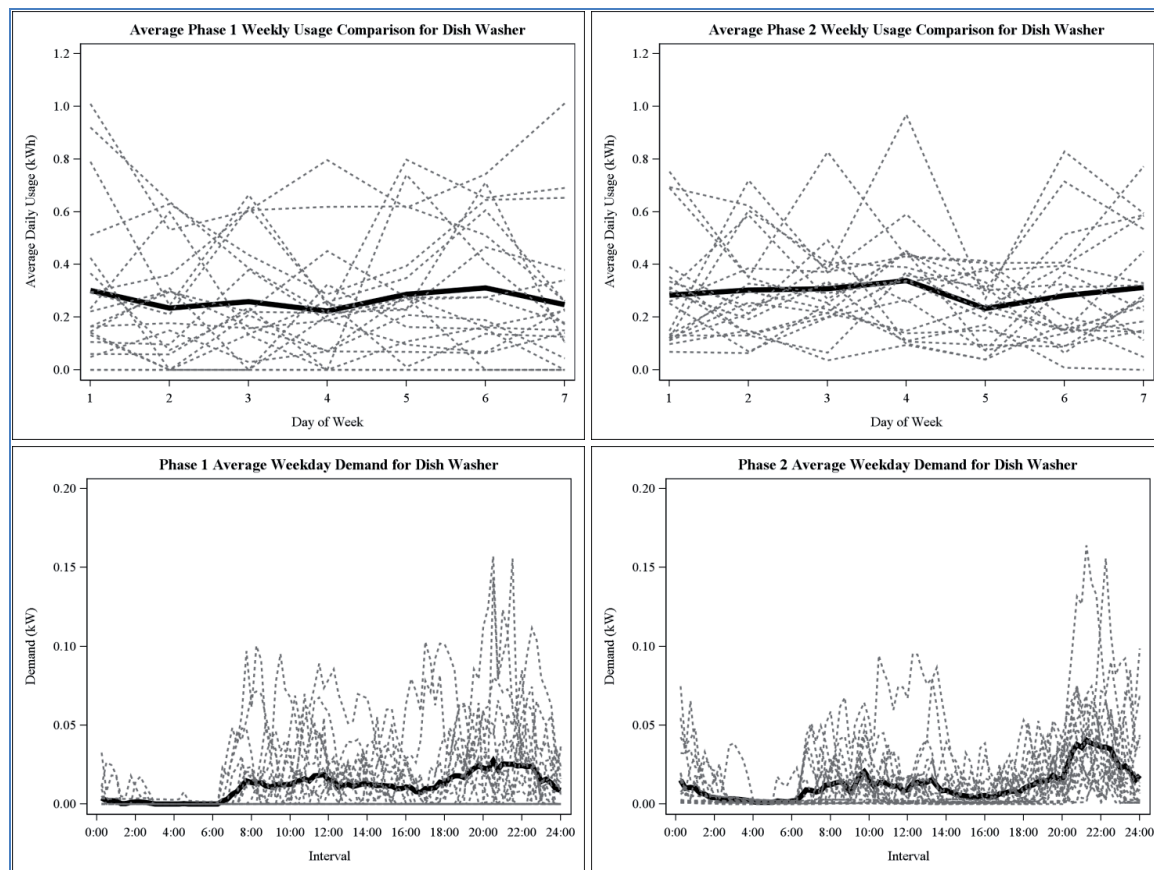*Figure 6. Refrigerator Average Weekday Load – Phase I versus Phase II versus Phase III.*

Figure 7. Dishwasher Average Daily Use (kWh) and Average Hourly Demand (kW).



Figure 8. Dishwasher Average Weekday Load − Phase I versus Phase II versus Phase III.

*Figure 9. Electric Range/Oven Average Daily Use (kWh) and Average Hourly Demand (kW).*



*Figure 10. Electric Range/Oven Average Weekday Load – Phase I versus Phase II versus Phase III.*

Figure 11. Clothes Washer Average Daily Use (kWh) and Average Hourly Demand (kW).
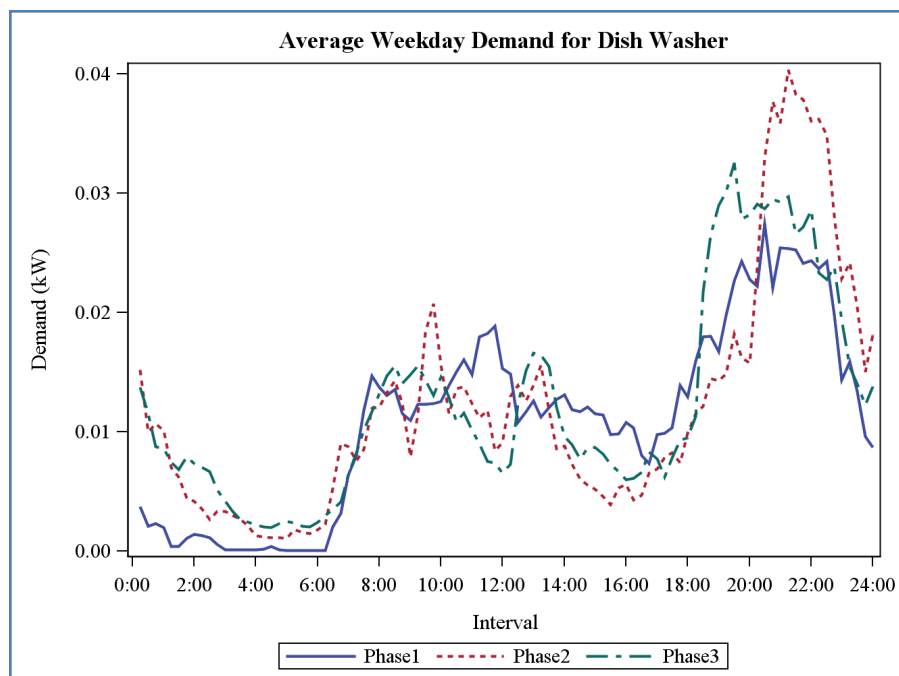


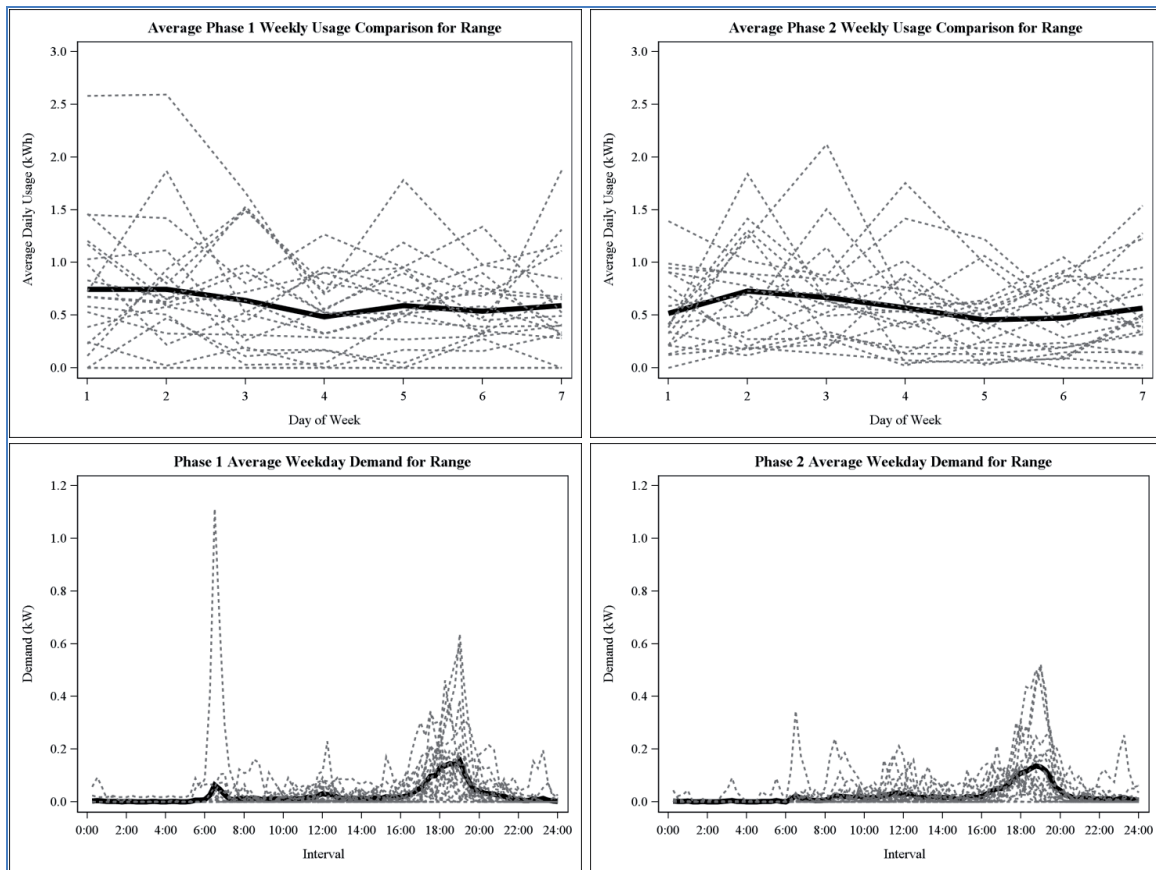Figure 12. Clothes Washer Average Weekday Load – Phase I versus Phase II versus Phase III.

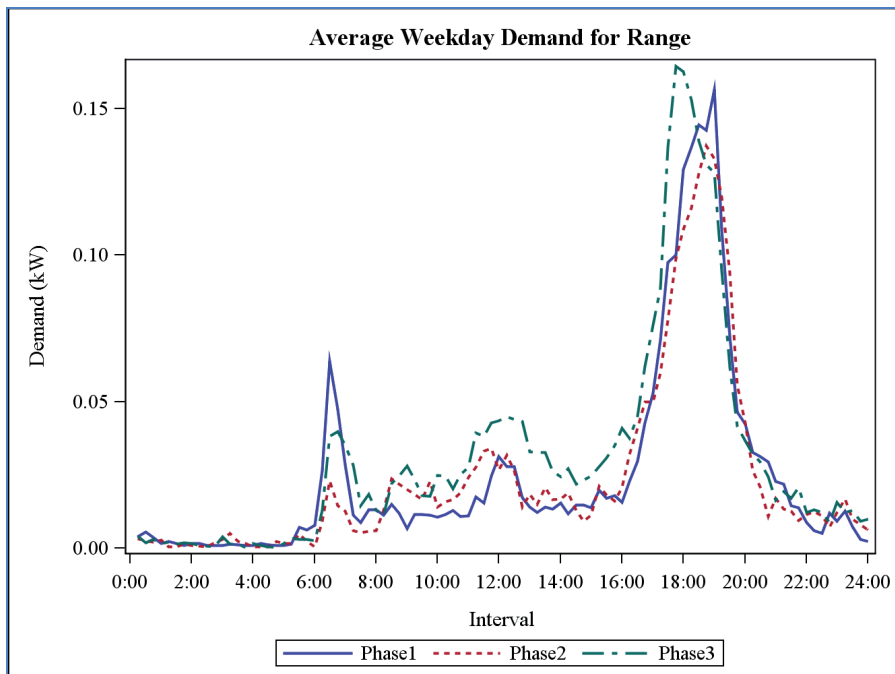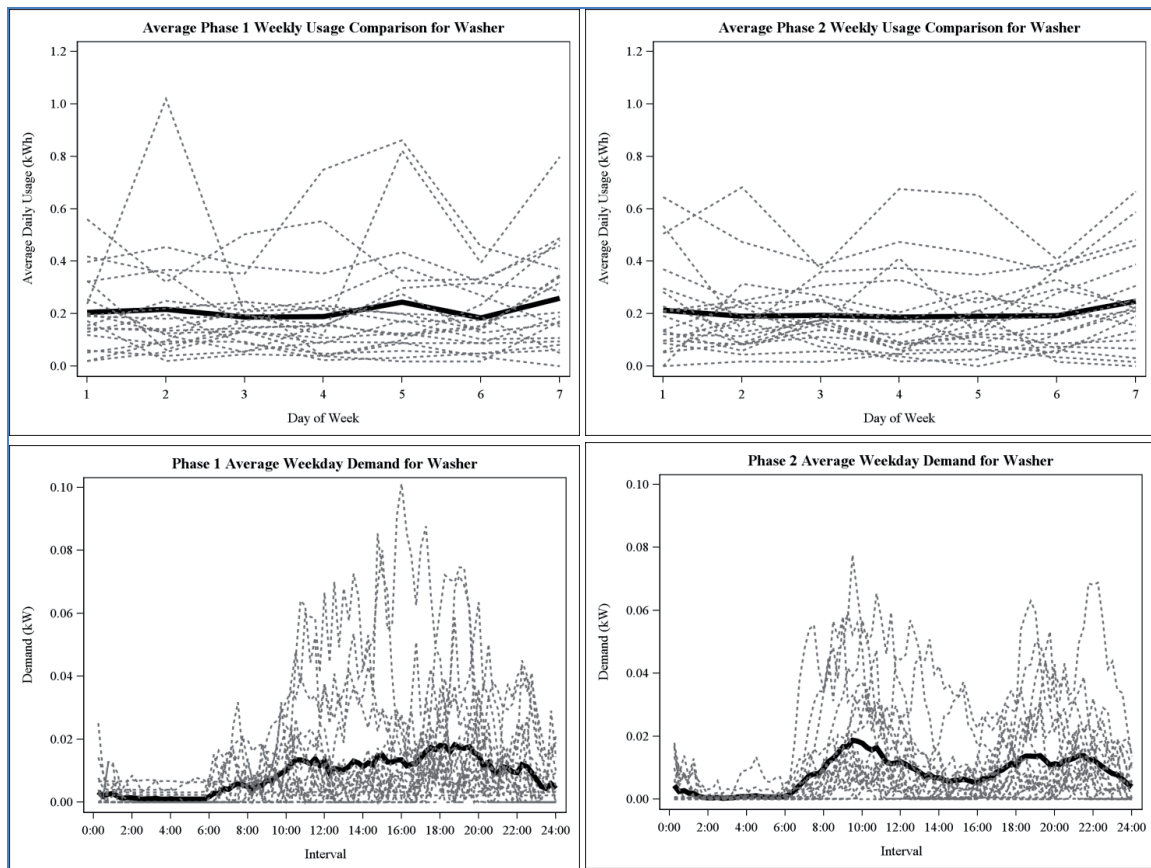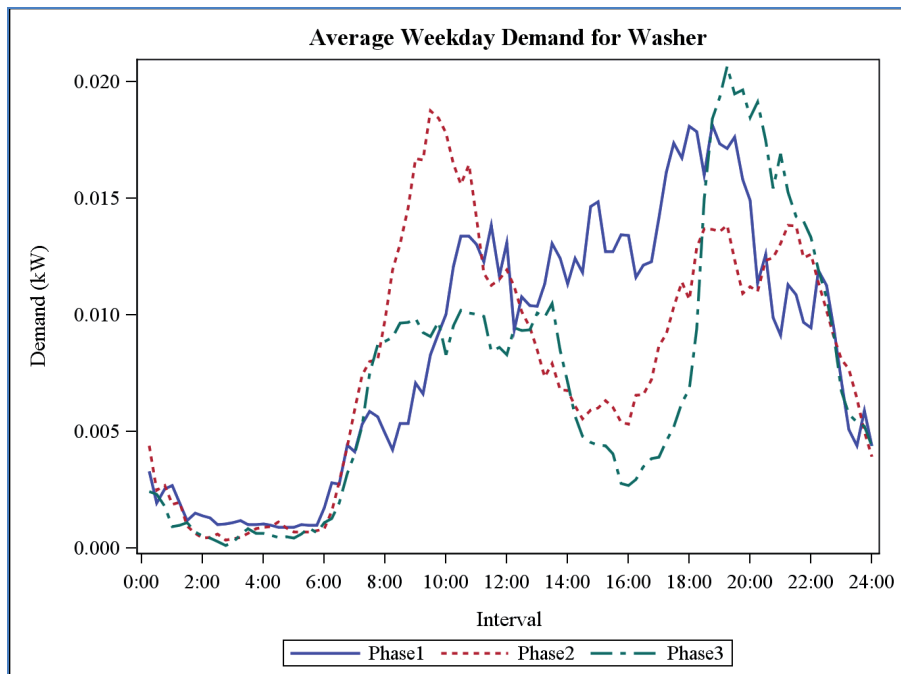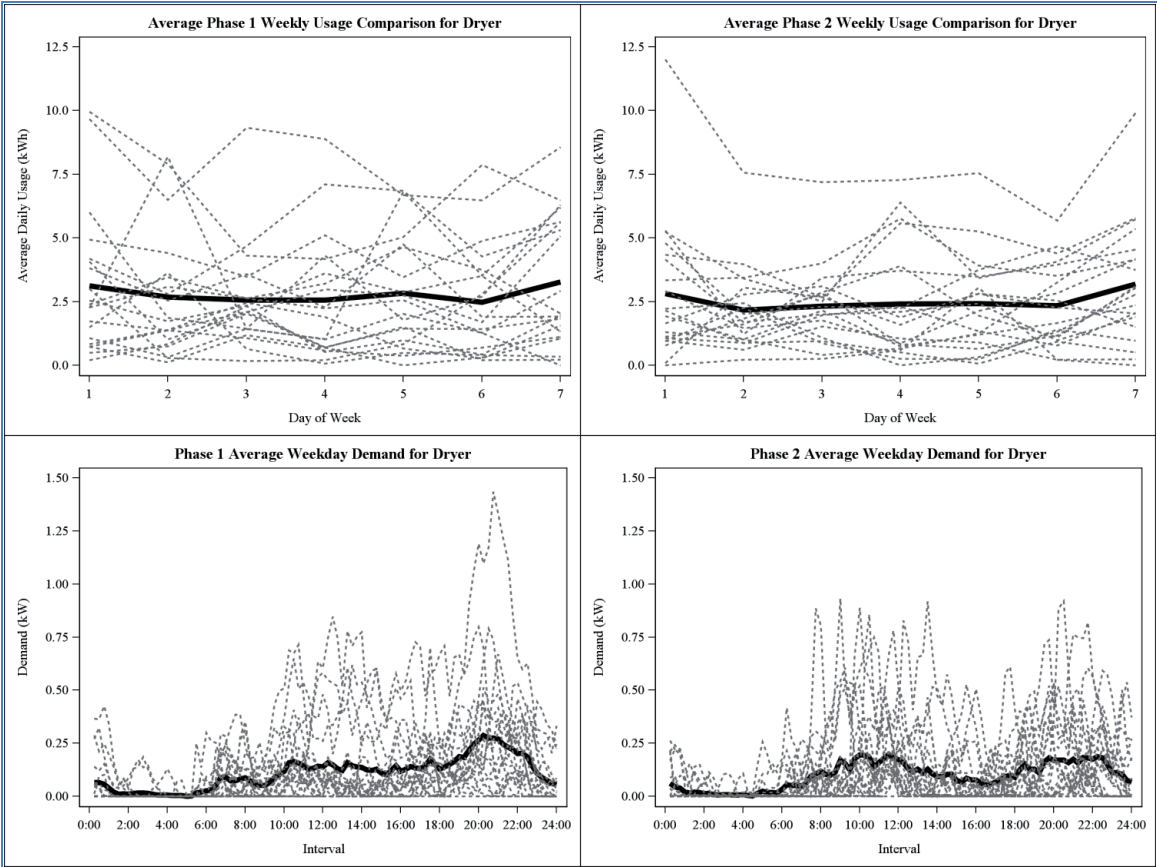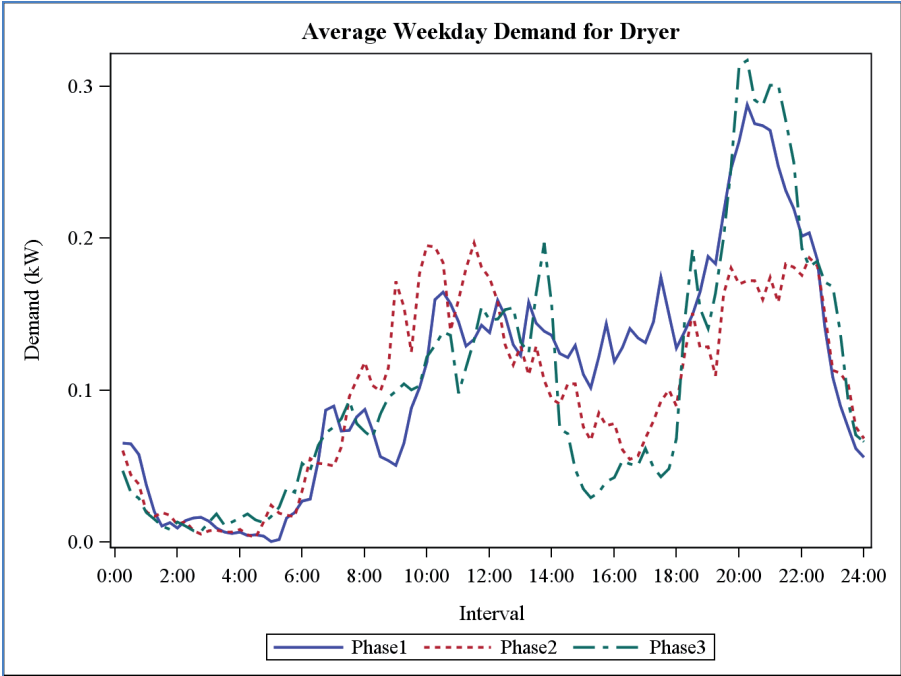Figure 13. Electric Clothes Dryer Average Daily Use (kWh) and Average Hourly Demand (kW).



Figure 14. Electric Clothes Dryer Average Weekday Load – Phase I versus Phase II versus Phase III.

**Table 2. Summary of Phase 1 Average Weekly Usage by Home.**

| Home | Number of Weeks | Average Weekly Use (kWh) | Dish Washer | Clothes Dryer | Electric Range | Refrigerator | Clothes Washer | Water Heater | Total Appliance Bundle Use | HVAC | Heat and Fans | Non-HVAC Use | Other Unmetered Use | Appliance Bundle Percent of Non-HVAC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 14 | 114.7 | 0.7 | 5.7 | 4.0 | 10.3 | 0.4 | 30.5 | 51.6 | 28.7 | 8.5 | 77.5 | 25.9 | 66.6% |
| 2 | 14 | 274.0 | 1.4 | 7.0 | 6.9 | 12.6 | 0.7 | 24.4 | 53.0 | 51.2 | 12.0 | 210.8 | 157.8 | 25.1% |
| 3 | 14 | 101.7 | 0.8 | 5.1 | 1.1 | 13.4 | 0.4 | 23.1 | 44.0 | 23.1 | 6.4 | 72.3 | 28.3 | 60.8% |
| 4 | 14 | 372.8 | 1.9 | 19.0 | 4.4 | 13.9 | 1.4 | 41.8 | 82.4 | 93.2 | 20.1 | 259.6 | 177.1 | 31.7% |
| 5 | 14 | 240.5 | 3.4 | 23.4 | 7.1 | 13.5 | 1.1 | 43.5 | 92.1 | 59.3 | 16.3 | 164.9 | 72.8 | 55.8% |
| 6 | 12 | 595.5 | 0.0 | 55.3 | 6.4 | 24.3 | 3.0 | 112.5 | 201.5 | 199.3 | 1.2 | 395.0 | 193.5 | 51.0% |
| 7 | 12 | 193.4 | 2.0 | 21.9 | 4.4 | 19.7 | 1.7 | 58.9 | 108.5 | 24.9 | 0.0 | 168.5 | 60.0 | 64.4% |
| 8 | 12 | 373.0 | 1.1 | 44.2 | 2.4 | 16.5 | 1.9 | 113.9 | 180.1 | 78.4 | 13.4 | 281.2 | 101.1 | 64.0% |
| 9 | 10 | 402.5 | 3.2 | 34.5 | 7.4 | 18.5 | 3.4 | 69.5 | 136.6 | 117.4 | 23.2 | 261.9 | 125.3 | 52.1% |
| 10 | 11 | 354.8 | 2.5 | 31.1 | 4.0 | 17.5 | 1.2 | 61.0 | 117.3 | 80.2 | 14.6 | 260.1 | 142.8 | 45.1% |
| 11 | 11 | 434.0 | 5.2 | 16.5 | 5.5 | 21.8 | 2.8 | 0.0 | 51.6 | 83.9 | 32.6 | 317.4 | 265.8 | 16.3% |
| 12 | 11 | 188.3 | 1.0 | 4.3 | 1.0 | 16.1 | 0.7 | 40.7 | 63.7 | 50.8 | 19.9 | 117.6 | 53.8 | 54.2% |
| 13 | 11 | 336.7 | 0.6 | 16.8 | 0.0 | 14.5 | 1.1 | 45.4 | 78.4 | 133.3 | 17.4 | 186.0 | 107.6 | 42.2% |
| 14 | 10 | 286.8 | 1.3 | 28.3 | 5.4 | 22.6 | 3.4 | 77.1 | 138.1 | 52.3 | 14.9 | 219.6 | 81.5 | 62.9% |
| 15 | 10 | 229.4 | 2.2 | 12.5 | 9.5 | 13.4 | 1.1 | 32.2 | 70.8 | 66.2 | 16.3 | 146.9 | 76.1 | 48.2% |
| 16 | 10 | 338.9 | 0.8 | 9.9 | 2.3 | 23.7 | 0.9 | 39.0 | 76.5 | 104.3 | 17.2 | 217.5 | 141.0 | 35.2% |
| 17 | 10 | 101.5 | 0.8 | 6.6 | 0.0 | 16.5 | 0.3 | 39.8 | 64.0 | 4.4 | 2.0 | 95.1 | 31.1 | 67.3% |
| 18 | 9 | 225.8 | 4.1 | 19.4 | 2.7 | 16.0 | 1.2 | 37.3 | 80.7 | 75.6 | 0.0 | 150.3 | 69.5 | 53.7% |
| 19 | 9 | 228.9 | 2.8 | 8.3 | 4.2 | 15.2 | 1.3 | 49.4 | 81.3 | 50.6 | 14.3 | 164.0 | 82.7 | 49.6% |
| 20 | 8 | 204.7 | 0.0 | 6.4 | 4.2 | 11.7 | 0.6 | 31.9 | 54.7 | 50.6 | 18.6 | 135.5 | 80.8 | 40.4% |
| Minimum | | 101.5 | 0.0 | 4.3 | 0.0 | 10.3 | 0.3 | 0.0 | 44.0 | 4.4 | 0.0 | 72.3 | 25.9 | 16.3% |
| Average | | 279.9 | 1.8 | 18.8 | 4.1 | 16.6 | 1.4 | 48.6 | 91.4 | 71.4 | 13.4 | 195.1 | 103.7 | 46.8% |
| Maximum | | 595.5 | 5.2 | 55.3 | 9.5 | 24.3 | 3.4 | 113.9 | 201.5 | 199.3 | 32.6 | 395.0 | 265.8 | 67.3% |

**Table 3. Summary of Phase II Average Weekly Usage by Home.**

| Home | Number of Weeks | Average Weekly Use (kWh) | Dish Washer | Clothes Dryer | Electric Range | Refrigerator | Clothes Washer | Water Heater | Total Appliance Bundle Use | HVAC | Heat and Fans | Non-HVAC Use | Other Unmetered Use | Appliance Bundle Percent of Non-HVAC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 13 | 172.2 | 1.1 | 4.8 | 5.0 | 11.1 | 0.3 | 9.6 | 32.0 | 89.7 | 18.6 | 64.0 | 32.0 | 50.0% |
| 2 | 13 | 384.3 | 1.4 | 14.3 | 5.2 | 13.7 | 1.4 | 7.9 | 44.0 | 157.5 | 31.3 | 195.4 | 151.4 | 22.5% |
| 3 | 13 | 144.4 | 1.5 | 6.7 | 2.9 | 12.0 | 0.5 | 5.8 | 29.4 | 74.6 | 10.9 | 58.8 | 29.5 | 49.9% |
| 4 | 13 | 559.8 | 1.8 | 15.8 | 3.9 | 10.9 | 1.1 | 11.6 | 45.2 | 260.6 | 50.0 | 249.2 | 204.0 | 18.1% |
| 5 | 13 | 340.9 | 3.9 | 11.9 | 5.7 | 11.6 | 0.9 | 14.9 | 48.9 | 177.7 | 26.4 | 136.9 | 87.9 | 35.8% |
| 6 | 13 | 707.5 | 2.3 | 57.0 | 6.2 | 16.9 | 3.4 | 31.2 | 117.0 | 363.4 | 0.0 | 344.1 | 227.1 | 34.0% |
| 7 | 13 | 264.7 | 1.3 | 17.6 | 2.1 | 13.8 | 1.5 | 16.8 | 53.1 | 161.9 | 0.0 | 102.8 | 49.8 | 51.6% |
| 8 | 13 | 431.7 | 2.4 | 30.6 | 4.0 | 10.0 | 1.9 | 41.4 | 90.2 | 194.5 | 30.0 | 207.2 | 117.0 | 43.6% |
| 9 | 13 | 454.1 | 3.4 | 28.5 | 6.7 | 11.6 | 2.0 | 24.7 | 77.0 | 207.1 | 37.4 | 209.6 | 132.6 | 36.7% |
| 10 | 13 | 553.4 | 1.9 | 23.4 | 4.8 | 13.5 | 1.3 | 18.7 | 63.6 | 220.2 | 34.9 | 298.4 | 234.8 | 21.3% |
| 11 | 13 | 624.9 | 4.5 | 32.5 | 6.8 | 10.9 | 4.0 | 24.9 | 83.6 | 221.3 | 66.6 | 336.9 | 253.3 | 24.8% |
| 12 | 13 | 390.3 | 0.9 | 4.3 | 0.9 | 10.1 | 0.3 | 8.4 | 25.0 | 226.1 | 73.5 | 90.6 | 65.6 | 27.5% |
| 13 | 13 | 578.2 | 2.0 | 15.1 | 2.5 | 11.5 | 0.8 | 20.5 | 52.3 | 337.2 | 42.2 | 198.8 | 146.4 | 26.3% |
| 14 | 13 | 446.2 | 2.1 | 25.8 | 6.0 | 14.4 | 2.8 | 24.6 | 75.7 | 239.9 | 49.1 | 157.3 | 81.6 | 48.1% |
| 15 | 13 | 444.8 | 2.0 | 13.7 | 4.6 | 10.4 | 1.5 | 10.9 | 43.1 | 256.6 | 36.1 | 152.1 | 109.0 | 28.4% |
| 16 | 13 | 382.2 | 0.6 | 12.6 | 0.8 | 11.2 | 0.9 | 10.8 | 37.0 | 168.4 | 24.3 | 189.5 | 152.4 | 19.6% |
| 17 | 13 | 254.5 | 1.7 | 5.5 | 1.2 | 16.0 | 0.5 | 12.5 | 37.5 | 151.3 | 22.6 | 80.5 | 43.0 | 46.6% |
| 18 | 13 | 315.0 | 2.9 | 18.1 | 2.9 | 10.7 | 1.5 | 16.7 | 52.9 | 187.8 | 0.0 | 127.2 | 74.4 | 41.6% |
| 19 | 13 | 331.1 | 2.5 | 11.0 | 2.4 | 10.4 | 1.1 | 15.7 | 43.1 | 123.7 | 30.1 | 177.3 | 134.1 | 24.3% |
| 20 | 13 | 380.7 | 1.0 | 9.4 | 2.4 | 11.5 | 0.9 | 10.3 | 35.5 | 209.0 | 50.2 | 121.4 | 85.9 | 29.2% |
| Minimum | | 144.4 | 0.6 | 4.3 | 0.8 | 10.0 | 0.3 | 5.8 | 25.0 | 74.6 | 0.0 | 58.8 | 29.5 | 18.1% |
| Average | | 408.0 | 2.1 | 17.9 | 3.8 | 12.1 | 1.4 | 16.9 | 54.3 | 201.4 | 31.7 | 174.9 | 120.6 | 31.1% |
| Maximum | | 707.5 | 4.5 | 57.0 | 6.8 | 16.9 | 4.0 | 41.4 | 117.0 | 363.4 | 73.5 | 344.1 | 253.3 | 51.6% |

## Summary

Table 2 and Table 3 summarize the average weekly usage of each home and appliance. The tables identify the home, the number of weeks of data collected during the period, the average weekly usage of the home, the average weekly usage of each monitored appliance, the total average weekly usage of the appliance bundle, the metered HVAC use, the residual (or unmetered) use and the percentage of use the appliance bundle is of the total non-HVAC use. The tables display the high variability of usage associated with individual customer appliance usage. As an example, during Phase I, the percentage of non-HVAC usage attributed to the appliance bundle ranged from a low of 24 % to a high of nearly 70 %. During Phase II, the percentage of non-HVAC usage attributed to the appliance bundle ranged from a low of 29 % to a high of just over 60 %. The following summarizes the appliance usage across our sample of homes:

- Dishwasher Usage: For every household the dishwasher is a minor energy user ranging from a low of zero usage per week to just over 5 kWh/week;

- Dryer Usage: Dryer has the propensity to be a significant energy user with average weekly usage ranging from a low under 5 kWh to a high more than 11 times this minimum amount;

- Electric Range Usage: The electric range/oven shows modest use range from very low to just under 10 kWh/week;

- Refrigerator Usage: The refrigerator showed more variability in Phase I when compared to Phase II when the usage was in the range from a low of 10 kWh/week to just under 17 kWh/week;

- Clothes Washer Usage: The electric loading of this appliance showed minor use never exceeding 4 kWh/week;

- Water Heater Usage: Water heater usage was very variable ranging up to nearly 114 kWh/week during Phase I. In Phase II, the average weekly use ranged from a low of just under 6 kWh/week to over 40 kWh/week.

- HVAC Usage: The HVAC was the highest energy user in the home ranging from a low of 75 kWh/week to over 360 kWh/week during Phase II.

- Heat and Fan Usage: Heat and fans range from zero (gas heated homes) to more than 70 kWh/week in Phase II;

- Other Unmetered[3] use ranged from a low in the mid-20 kWh/week to a high over 250 kWh/week. This, once again, shows the high variability of non-appliance bundle usage associated with our sample homes.

- The final column calculates the appliance bundle as a percentage of the non-HVAC measured use. In Phase I there were 11 customers where this percentage was greater than 50 %. In contrast, during Phase II only 2 customers had their combined appliance bundle use at or above 50 %.

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3. Other unmetered use excludes the appliance bundle and the usage associated with the HVAC.