CFAES OHIO STATE UNIVERSITY EXTENSION

Peak Demand Energy in Agriculture

CASE STUDY: BFEM SWINE FARM DEMAND ENERGY MONITORING

THE OHIO STATE UNIVERSITY
COLLEGE OF FOOD, AGRICULTURAL, AND ENVIRONMENTAL SCIENCES

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OSU Office of Outreach and Engagement

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On Farm Research Collaborations

Special appreciation is expressed to the six farms who cooperated in this study by permitting the energy monitoring of their facilities, and by furnishing information on their farming operations. The names of farms collaborating in the on-farm research have been coded to protect their identity.

Study Design

Background

While most traditional residential accounts are based only on total energy usage, commercial accounts are charged for both total energy usage and the peak amount of power, called demand, used over a short time period. High demand charges can dramatically increase electricity prices for many commercial electrical consumers. On some farms, the demand charges based on 15 minutes of peak usage can account for roughly 50 percent of the farms monthly electricity bill. While demand charges are often significant, few consumers understand the costs, how they are calculated, and how the timing of their electrical usage can impact the electric bill.

As agricultural operations have become more sophisticated and automated, the electrical demands of many farms has increased. In 2014, the agricultural sector consumed 1,714 trillion BTU of energy with electricity representing 17 percent of the total energy consumed. Energy inputs are important to agriculture, as electricity costs average 1-6 percent of total expenses for farm businesses. According to the United States Department of Agriculture Economic Research Service (USDA-ERS), from the period 2012 – 2019, the operating profit margin ratio of U.S. farms ranged from a high of 18% (2013) to a low of 6% (2016). The operating profit margin ratio is one measure of farm profitability. Generally speaking, a farm with an operating profit margin ratio greater than 20% is considered positive. An operating profit margin ratio below 20% indicated potential vulnerability to changing market conditions.

We believe the equipment and technologies evaluated will have applicability in ventilated swine and dairy barns across the United States. The 2017 Census of Ag data indicate that 3,600 of 66,000 US swine producers account for 52.7 million of an estimated 72.3 million pigs in inventory at a given time. Annual U.S. pig production will top 139 million pigs in 2020 and would have been near that in 2019 it appears when all calculations are completed[1]. In addition, there are approximately 34,187 licensed dairy farms in the U.S. with over 9 million head of dairy cattle. Table 1 provides a list of the states in the midwest representing 18,425 licensed dairy farms accounting for just over

Table 1: Potential for Widespread Adoption of Energy Management Strategies on Swine and Dairy Farms

State	Licensed Dairy Farms	Head of Swine
Indiana	965	4,050,000
Illinois	600	5,350,000
Iowa	1,120	22,800,000
Kentucky	540	410,000
Michigan	1,520	1,190,000
Minnesota	2,980	8,500,000
Ohio	2,200	2,950,000
Wisconsin	8,500	305,000
Total	**18,425**	**45,555,000**

[1] Census of Agriculture (2017). United States Summary and State Data. Available at: https://www.nass.usda.gov/Publications/AgCensus/2017/Full_Report/Volume_1,_Chapter_1_US/st99_1_0017_0019.pdf

one-half (54%) of U.S. milk production[2]. As a result of this study, the economic impact and potential for widespread adoption of new energy management strategies and technologies on swine and dairy farms is significant.

Project Objective

The purpose of this on-farm research project was to better understand the electrical demand on livestock farms, and identify management strategies and equipment farmers can implement to promote long-term sustainability for their farm. Understanding peak demand charges and energy management strategies in agriculture is a complex issue. As a result, our project partners were strategically selected around four critical disciplines including energy, swine production, dairy production, and electrical engineering. In total, over 29 project partners contributed to the project including Extension professionals, swine and dairy farmers, the OSU College of Food, Agricultural, and Environmental Sciences, the Ohio Agricultural Research and Development Center, and faculty and students in the OSU College of Computer and Electrical Engineering.

The overriding objective of the agricultural energy management program was to identify energy management strategies to minimize costs and foster long-term sustainability. To enable this objective, we installed advanced energy metering equipment in agricultural facilities to track electric demand profiles and monitor energy use power quality to gain knowledge about energy usage patterns. Specifically, we collected energy usage data for individual operational loads allowing our team to investigate energy use of specific operations and how they contribute to the farms overall peak demand charges. The detailed energy data helps to answer questions about energy usage, peak demand trends, and power quality that will ultimately inform solutions farmers can implement to reduce energy cost. Study results were used to develop Extension outreach materials to disseminate the research findings to agricultural producers and stakeholders throughout Ohio and beyond to encourage the adoption of energy management best-practices.

In total, the peak demand energy in agriculture research project included six research farms including three swine facilities and three dairy facilities that were enrolled in the project to install advanced energy meters to collect energy data. This case study investigates the results from energy data collected at the BFEM Swine Farm, which was one of the six research sites.

Research Site - BFEM Farms

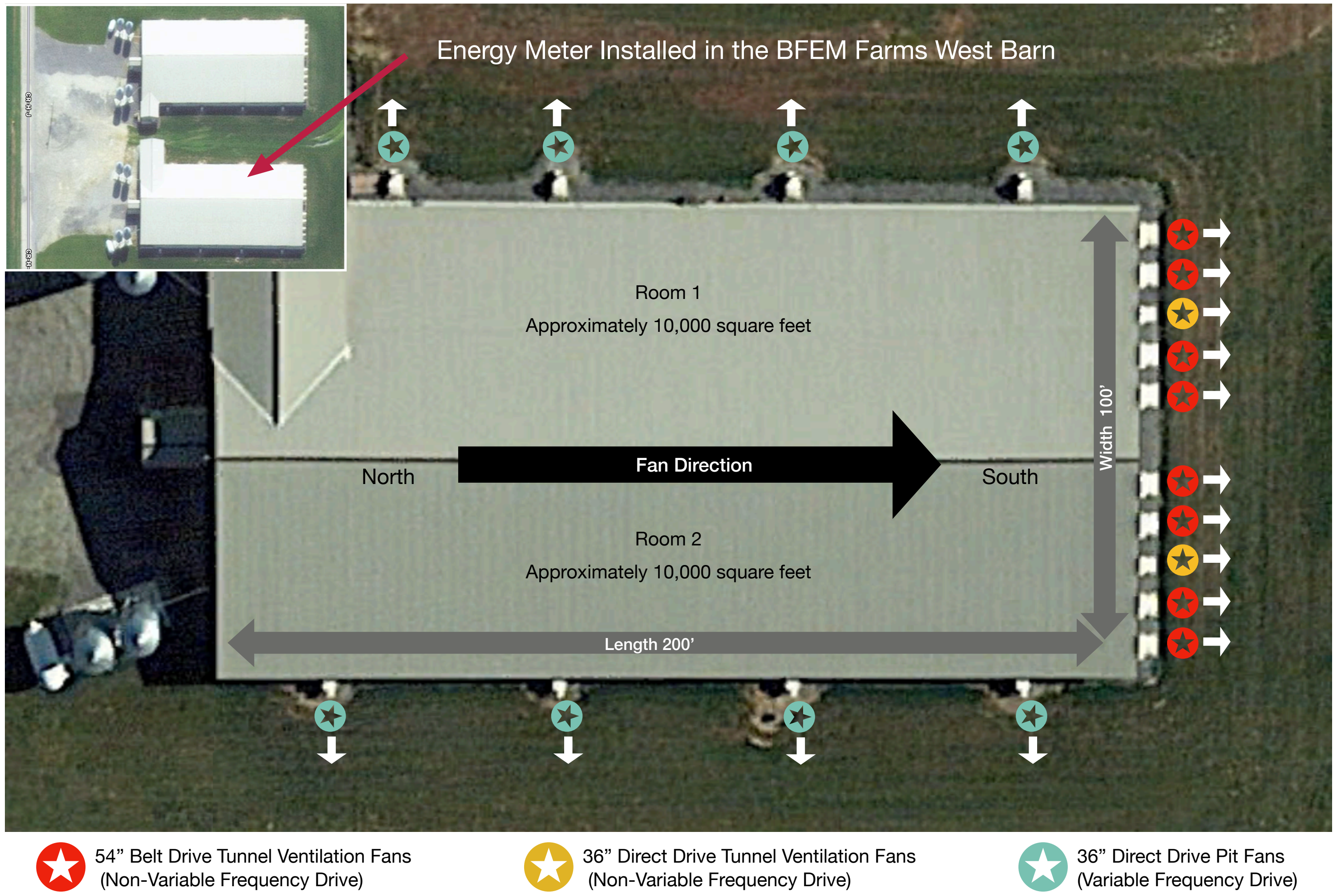
As part of the Ohio State University Extension agricultural energy management research project, this case study report is specifically focused on data collected from the BFEM farm. The BFEM farm participated in a two-year Ohio State University Extension on-farm research project to measure peak energy demand. BFEM farms is a family-owned farm located just outside of Wauseon in Fulton County, Ohio. The farm manages a total of 1,000 acres consisting of corn, soybeans, barley, wheat, and operates two separate 2,400 double-wide tunnel ventilated swine wean-to-finishing barns. Fulton County is a strong agricultural county ranking 15th in total agricultural receipts for the state of Ohio. Based on the 2017 USDA Census Data, nearly

[2] USDA NASS (2019). Milk Production Report. Available at: https://downloads.usda.library.cornell.edu/usda-esmis/files/h989r321c/44558m869/j3860f20k/mkpr0319.pdf

75 percent of the 260,288 total acres in Fulton County are involved in farming. Fulton County agriculture generates a total of $173 million in cash farm receipts with $123 million from crop enterprises and $50 million from livestock annually. When comparing market value of livestock production across Ohio's 88 counties, Fulton County ranks 3rd in beef cattle, 28th in hogs, and 32nd in dairy[3].

As illustrated in Image A, the BFEM Farms research site consists of two wean-to-finishing barns. Constructed in 2013, the two 2,400 head double-wide barns are roughly 100' wide by 200' long. Each barn is divided into two rooms that are 10,000 square feet each and includes a dividing wall in the pit that keeps the air spaces in each room separate. Each room has four 54" belt drive tunnel ventilation fans, a 36" direct drive tunnel ventilation fan, and four 36" variable frequency drive pit fans. As a result, each barn has a total of eight 54" fans, two 36" direct drive fans, and eight 36" direct drive variable frequency drive fans.

Image A: Overview of BFEM Farms 2,400 Swine Wean-to-Finish Swine Barn(s).



The two BFEM Farms wean-to-finish barns receive new pigs at approximately 10 pounds and feed them to a weight of roughly 280 pounds before loading them out to market. The east and west barns operate on separate cycles and have different weight pigs occupying them throughout the year. When new pigs are brought in, the barn is filled over the course of a couple days. After approximately 147 days, the heaviest group of pigs are identified and loaded out. Over a period of five weeks, additional loads are taken out as the barn is emptied before being cleaned for the next cycle of pigs is received.

The BFEM wean-to-finish barns are designed with a mechanical tunnel ventilation system that uses a series of single speed fans controlled by temperature set-points programed in the controller to staging fans up and down in a stair step pattern. The BFEM has an AP Cumberland Expert VT-110 controller dedicated to managing the ventilation and feed auger systems in each room on their farm (Image B). In collaboration with the swine integrator, BFEM Farms estimate

[3] Census of Agriculture (2017). United States Summary and State Data. Available at: www.nass.usda.gov/Publications/AgCensus/2017/Full_Report/Volume_1,_Chapter_1_US/usv1.pdf

the number and weight of the hogs occupying each room of their barns to adjust temperature settings in the controllers to maintain minimum ventilation requirements. When the air temperature exceeds the individual staged set-point, the fans automatically turn on and often run continuously throughout the summer to provide airflow and comfort to the hogs. It is not uncommon for all five fan stages to operate during the spring and fall months, but generally not on a continual basis.

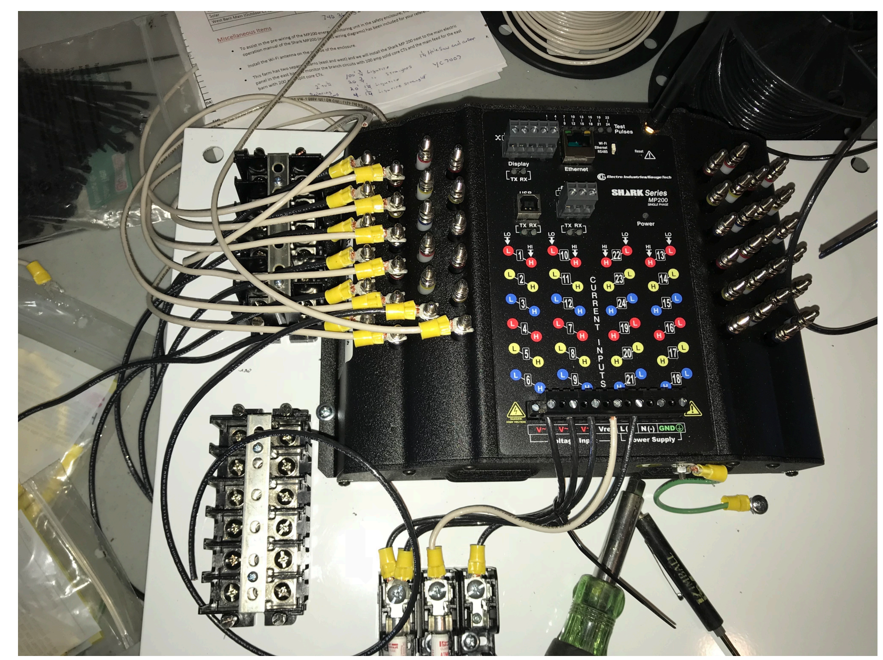
While both barns are on the same utility account and meter, our research study only collected energy data from the west barn. However, the design and operation of the BFEM Farm is consistent with many modern wean-to-finish barns throughout the midwest. Additional details regarding the specific facility processes within the west barn that were monitored is further described in the equipment installation section of this case study.

Equipment Installation

At the BFEM farm, we measured the main electric service feed to the west barn as well as 15 individual electrical circuits with large electric loads that were critical to the farms day-to-day operations. To meet the research needs of this study, the project team selected the Electro Industries Shark MP200 energy metering system (Image C). The MP200 is a multifunction energy meter capable of recording energy usage data for up to eight, three phase circuits or up to 24 single phase circuits. The meter complies with requirements of IE C62053-22 (Class 0.5%) and ANSI C12.20 (Class 0.5%) with accuracy of +/- 0.5% or better for voltage and current, and 0.5% for power and energy functions. While the meter can be configured with a network for real time data, internet was not available at the BFEM farm. As a result, we upgraded the

Image B: Image of AP Cumberland Expert VT-110 controllers.

Image C: Installing the Shark MP 200 Energy Meter on the backing plate with disconnect fuses and shorting blocks.



Photos by: Eric Romich, OSU Extension Field Specialist.

Image D

Image E

Image F

Image G

Images F - I: Preparing the Shark MP 200 Energy Meter for installation by mounting it on a backing plate with disconnect fuses and shorting blocks.

Photos by: Eric Romich, OSU Extension Field Specialist.

memory to 32 MB of storage providing enough capacity to store up to 6 months of trending historical data-logs before the research team had to conduct a physical data download.

The meter which measures 7.6” (L) x 11.28” (W) x 4.36” (H) was mounted on a backing plate and wired to disconnect fused and shorting blocks (Image C) before being installed in a National Electrical Manufacturers Association (NEMA) Type 1 safety enclosure box (Image D).

A combination of solid-core and split-core current transformers (Images E - G) were installed on each of the individual electrical circuits to monitor electrical activity of specific farm operations including:

- Main Service Feed
- 36” Pit Fans and 36” Direct Drive Fan (Room 1)
- 36” Pit Fans and 36” Direct Drive Fan (Room 2)
- 54” Belt Drive Fans 1 and 2 (Room 1)
- 54” Belt Drive Fans 1 and 2 (Room 2)
- 54” Belt Drive Fans 4 and 5 (Room 1)
- 54” Belt Drive Fans 4 and 5 (Room 2)
- Feed Augers (Room 1)
- Feed Augers (Room 2)
- Heaters (Room 1)
- Heaters (Room 2)
- Curtains and Misters (Room 1)
- Curtains and Misters (Room 2)
- Water Pump
- Baseboard Heater
- Pressure Washer

The complexity of the installation, configuration, and ongoing monitoring of this utility-grade metering equipment required training of our research team. Upon the completion of training, we configured the MP200 to collect data points on 5 minute block windows with a 15 minute rolling demand window. The meter profiles were set to collect readings for voltage, current, frequency, kWh, kW, kVAR, kVA and PF using the configured demand features over the averaging period. OSU purchased the equipment and covered the cost of assembling the energy meters, fuses, and shorting blocks in the safety enclosure for the BFEM farm. The total cost for monitoring equipment was roughly $3,300. In addition, BFEM farms hired a licensed electrician to complete the installation of the energy meter and current transformers on site.

The equipment utilized for this research study was highly accurate with numerous advanced features contributing to a higher overall installation cost. However, there is a growing variety of more simplified cost effective energy loggers available to interested farmers that can be purchased for between $60 and $400. Many of these systems communicate directly with a local network and display real time energy usage statistics to a computer screen or smartphone device.

Timeline

The equipment was installed on the morning of April 10, 2018 (Image J). Following the installation, the research team monitored and calibrated the equipment for several weeks. Data collection for the BFEM farm officially started on May 1, 2018. A software update was completed in December 2018 which allowed the meters to collect demand profile data on 5-minute intervals to calculate a 15-minute rolling demand. The data presented in this case study is a 12 month window from January to December 2019.

Image J: Installation of safety enclosure box, MP 200 meter, and the current transformers at the main electric panel of the east barn.

Photos by: Eric Romich, OSU Extension Field Specialist.

Study Results

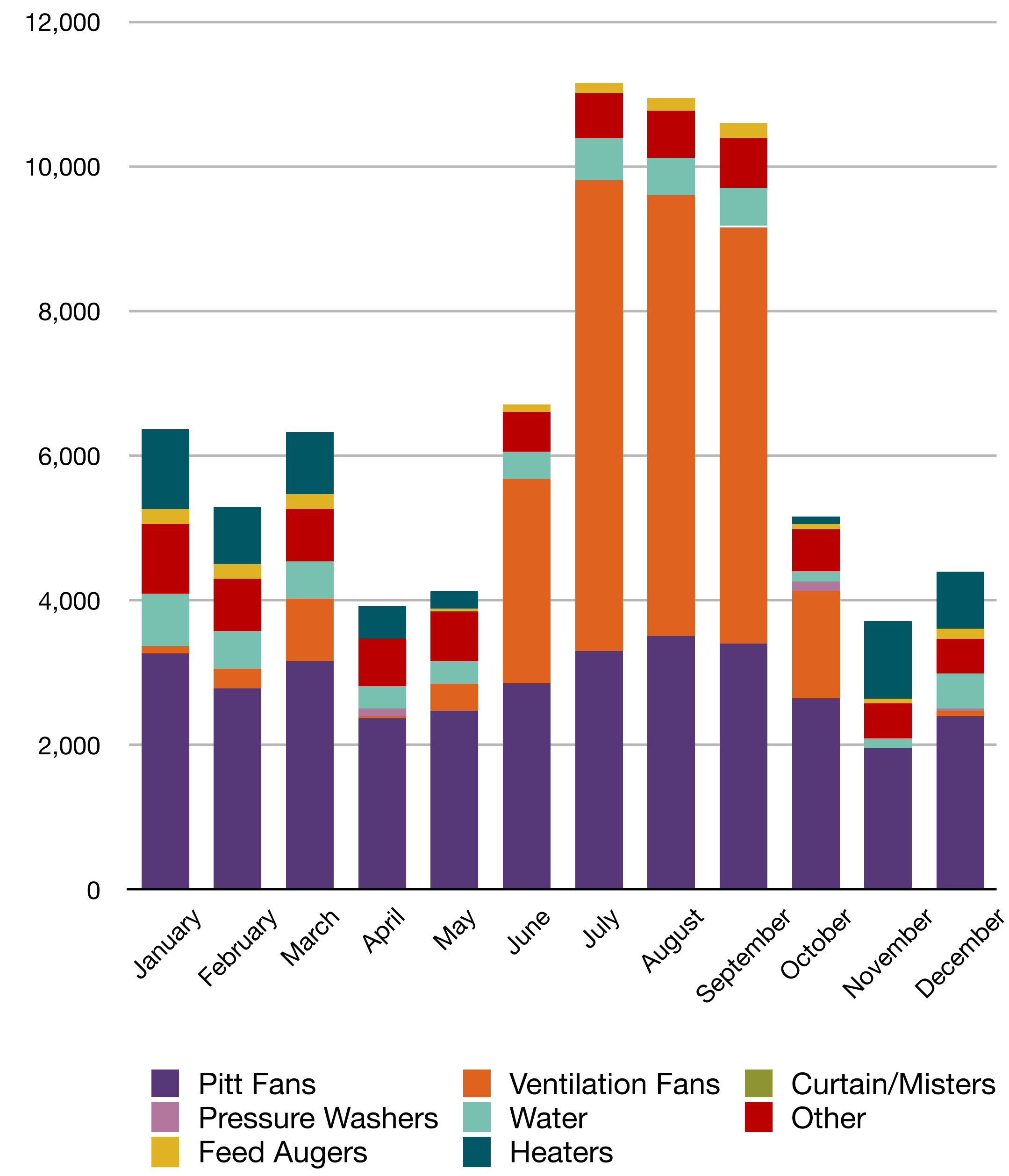
Electric Use by Operation

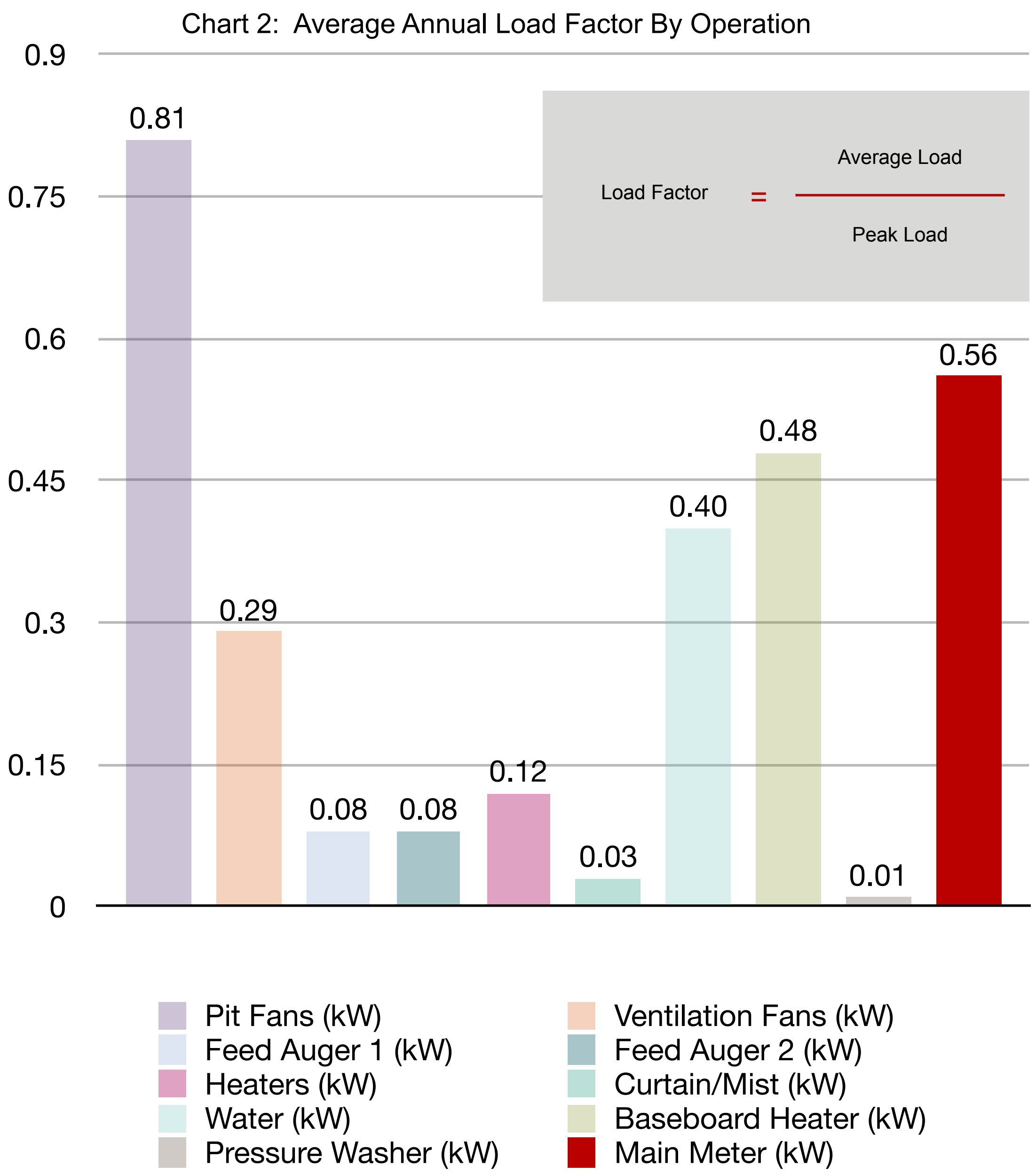
In our study we installed current transformers to monitor energy use, demand, and power quality on 15 individual operations. For this report, we have condensed the data into eight separate categories including: ventilation fans, pitt fans, feed augers, heaters, water pump, pressure washer, curtains/misters, and other. We collected energy usage data on each of the operations over a 12 month period from January to December 2019.

Over the 12 month period, the BFEM farm west feeder/finishing barn used 78,730 kWh of energy for the swine operations. On average, the farm used 6,561 kWh per month, including the minimum of 3,715 kWh used in November 2019 and a maximum of 11,149 kWh in July 2019. The pit fans represent the largest and most consistent load source accounting for 34,142 kWh or 43% of the annual energy usage. Tunnel ventilation fans were the second largest consumer of energy using 24,343 kWh or 31% of the total energy use over the 12 month period. Combined, the pit and ventilation fans loads used 58,485 kWh or 74% of the total energy use over the 12 month period. As illustrated in Chart 1, during the months between June and September the ventilation fans accounted for over 84% of the total energy consumption, including 88% in both July and August.

Combined, the "other" loads not metered accounted for 10% of the total energy use over the 12 month period. While this category represents the balance of miscellaneous electrical loads not metered with a current transformer, it is estimated that most of the usage in this category is for lighting. Finally the water pump and heaters both accounted for 7% of the total energy use over the 12 month period, followed by 2% for feed auger motors. Unlike the ventilation fans which used more energy in the summer and heaters which experienced increased usage in the winter months, energy consumption from the feed and water operations was very consistent over the 12 month period.

Chart 1: Monthly Energy Use (kWh) by Operation - 2019





Load Factor

We calculated the monthly load factor on each of the operations monitored over a 12 month period from January to December 2019. Load factor is a metric used to indicate if a customers electric use over a period of time is reasonably stable, or consistent. Load factor is the ratio of a facility's average demand, compared to the measured peak demand. A load factor of "one" is perfect and indicates consistent use of electricity over the billing period, while a lower factor suggests greater variation in usage and peak demand spikes.

In most cases, there is adequate information on a monthly utility bill to calculate the load factor for the farms main meter. As described above, this is a useful metric to help understand how efficiently the farm is using energy. The energy meters used in this study collected the energy usage, average demand, and peak demand for each individual operation. As a result, the study team was able to calculate the load factor for each individual operation to assess how efficiently specific operations used energy. This detailed level of data is extremely helpful to identify which operations contribute the greatest to the farms overall peak demand cost.

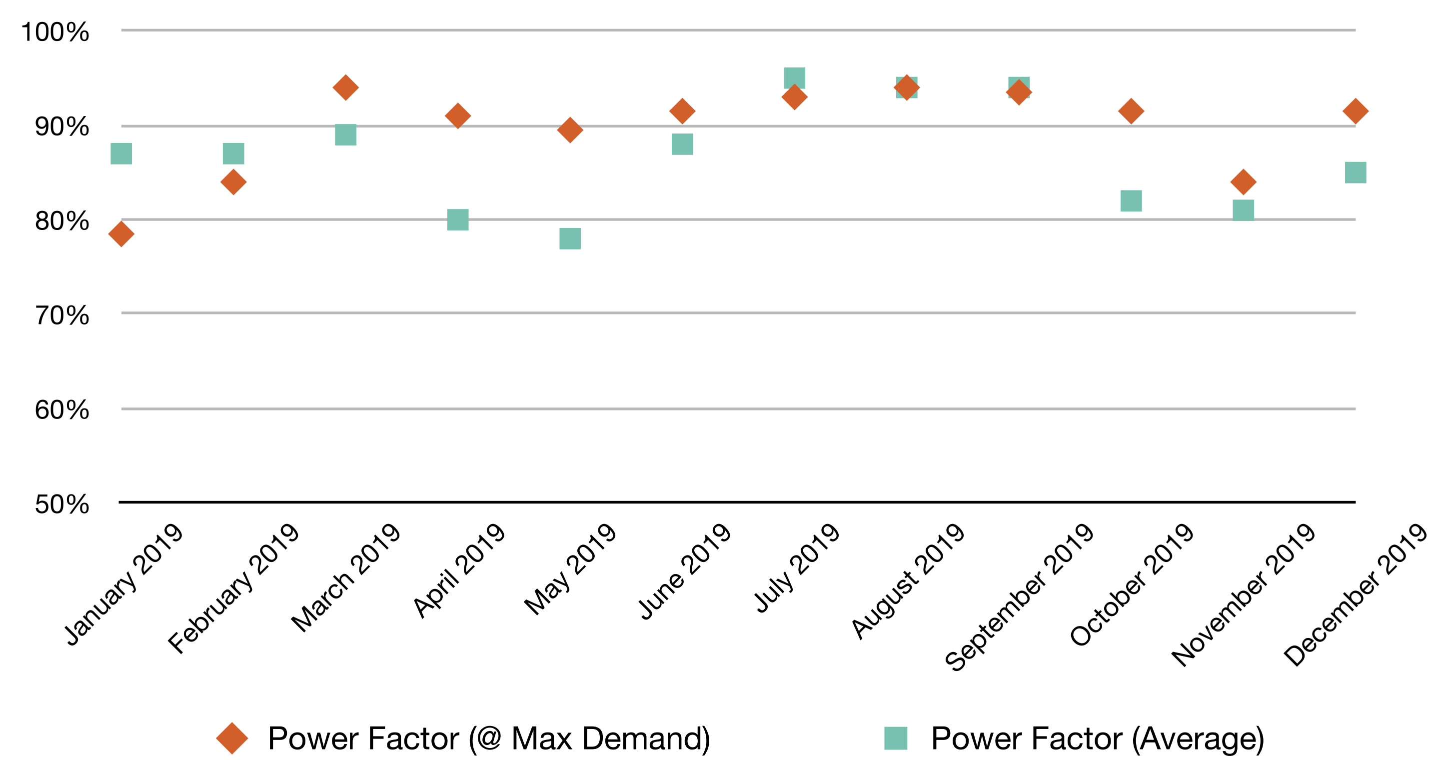
As illustrated in Chart 2, the average load factor for the BFEM farm over the study period was 0.56. When investigating individual operations, the pressure washer had the lowest 12-month average load factor of 0.01. This is not surprising because the pressure washer operations only occurs a couple times per year when the barns are emptied and cleaned in preparation for a new load of hogs. While a low load factor is often an indication of a load that contributes to peak demand, in this case there is no correlation because other operational loads (ventilation fans, heaters, feed augers, and water pumps) do not need to run when the barn is empty and the pressure washer is in use for cleaning. The next lowest load factors were the curtains and misters which ranged from 0.01 to 0.06 with a 12-month average of 0.03, followed by the feed auger motors that ranged from 0.02 to 0.14 with a 12-month average of 0.08. Again, while the low load factor indicates inefficient, or sporadic use of energy, there is minimal savings opportunities because these operations use smaller motors and typically contribute less than 5% of the total peak demand. The pit fans have a very good load factor ranging from 0.69 to 0.96 with a 12-month average of 0.81. This indicates an efficient use of energy that will not trigger unnecessary peak demand spikes. In comparison, the tunnel ventilation fans had a much lower load factor ranging from 0.01 to 0.81 with a 12-month average of 0.29. The primary difference is that the pit fans are operated by variable frequency drive motors, while the tunnel ventilation fans are staged motors that are either on at 100%, or off. This suggest making efficiency upgrades to the tunnel ventilation fan operations has excellent potential for peak demand reduction.

Power Factor

Power factor is the ratio between real power and apparent power (Power Factor = Real Power / Apparent Power), typically expressed as a percentage. In general, low power factor is bad, requiring more electricity to be fed into the system with no additional energy benefit to the system or consumer. Simply put, it is a cost with no benefit. Many utility providers consider the power factor of your facility in calculating your monthly billing demand charges. While each rate structure is unique, many utilities require commercial customers to maintain a power factor of 90% or greater to avoid additional charges. In some cases, these additional charges can have a significant impact on your overall delivery charges.

Some utilities will consider the average power factor over the billing period while others will use the power factor recorded during the time window that the peak demand was established. Chart 3 illustrates the power factor data for the BFEM farm and shows the monthly data for both the average monthly power factor and the power factor at the time of the monthly peak demand. Over the analysis period, the average monthly power factors were below 90% during nine of the 12 months. When assessing the power factor at the time of the monthly peak demand, the power factors were below 90% during four of the 12 months.

Chart 3: BFEM Monthly Power Factor



Energy Consumption vs. Peak Demand

Charts 4 and 5 below summarize the share of total energy use for each function and the share of peak demand for each function. When comparing the overall contributions by operation, ventilation fans are the largest contributor to peak demand (kW) at 41% while only accounting for 31% of the total energy use (kWh). Conversely, the pit fans are the second largest contributor to the overall peak demand at 27%, however, they represent the greatest total energy usage (kWh) at 43%. The high energy (kWh) consumption is because the pit fans often run continuously to maintain air quality. However, because the pit fans are operated by a variable frequency drive, the impact to the peak demand is minimized. The feed auger motors, heaters, and pressure washers all have a larger contributor to the overall peak demand compared to energy consumption. This suggest these operations require larger motor loads that do not run for a very long period of time compared to other operations on the farm. Finally, the contributions from the water pump and other loads remain fairly consistent between both the total energy use (kWh) and the peak demand (kW). The next section will further analyze the peak demand trends and financial implications analysis section which drills down into the details of the demand impacts.

Chart 4: 2019 Share of Total Energy Use (kWh) by Operation

Chart 5: 2019 Share of Peak Demand Contribution by Operation

Peak Demand Analysis

Peak Demand Trends

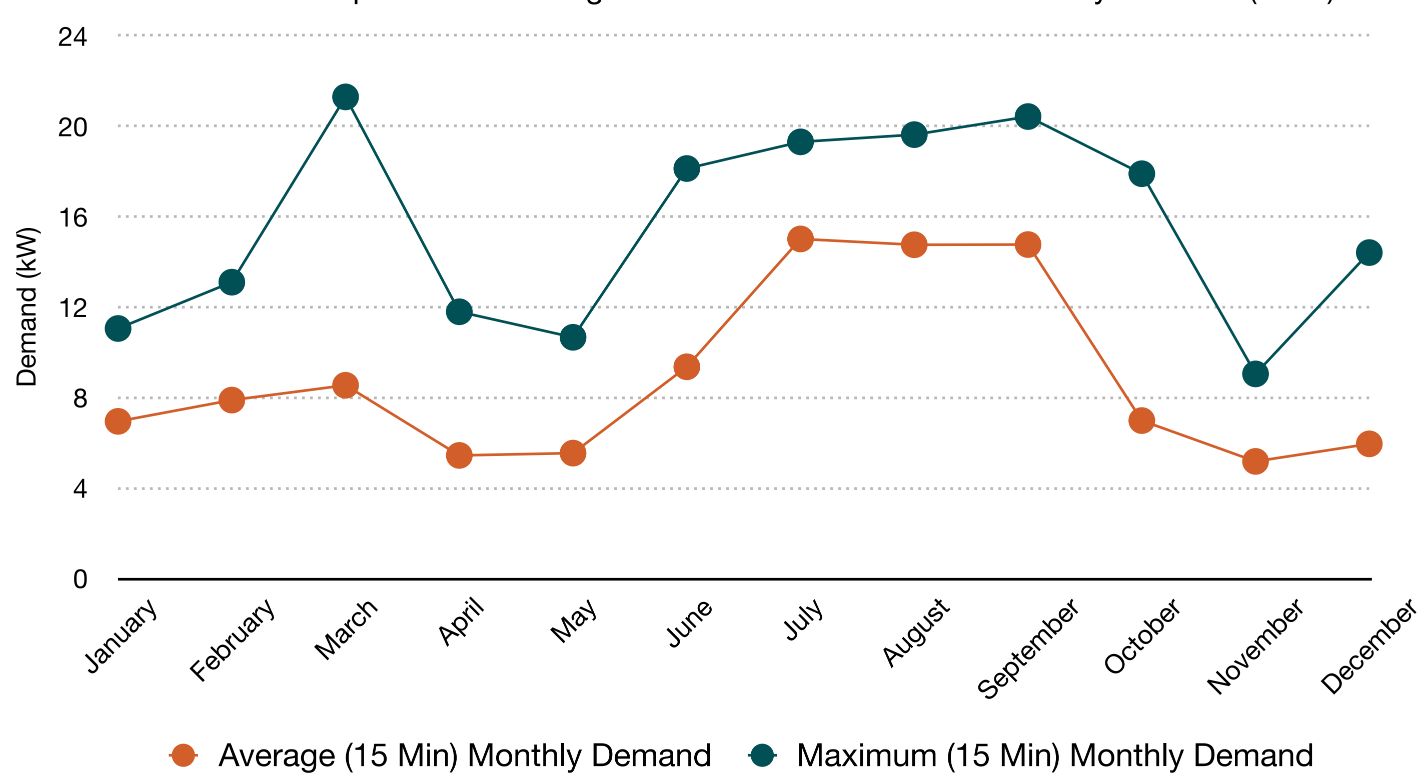
In this section we analyze the peak demand trends for the BFEM farm. It is important to reflect on the difference between energy consumption and peak demand. Most consumers are familiar with energy consumption, which is the total amount of energy measured in kilowatt hours (kWh) that you use over a period of time, or billing period. In comparison, energy demand charges are based on the maximum amount of electricity drawn from an electric power system at a single point in time, generally measured in megawatts (MW) or kilowatts (kW). While demand charges are based on your peak usage in a specific period in time, it is not necessarily an instantaneous peak. Instead, most utilities will measure a monthly peak demand as a rolling average over a specific time interval, typically 15 or 30-minute intervals. Data for the BFEM farm is calculated on a 15-minute rolling demand window

When comparing the monthly 15-minute demand average to the maximum monthly 15-minute demand, there is a considerable difference. For example as illustrated in Chart 6, over the analysis period the maximum monthly demand is 88 percent greater than the average monthly demand. This indicates that most of the time the farm requires an average of 7 kW less electrical demand to operate the facility than the energy actually used to set the monthly maximum demand.

Chart 6 also suggests there is a seasonal impact to the energy demand on the farm, as both the average monthly demand is higher in the summer months and lower from October through May. To better understand the variation of seasonal peak demand trends, it is important to consider what contributes to monthly demand charges.

Chart 7 illustrates the maximum monthly demand of each specific operation. It is important to remember that this is likely to be slightly different from the maximum demand contribution of each operation during the 15 minute window

Chart 6: Comparison of Average and Maximum 15 Minute Monthly Demand (2019)



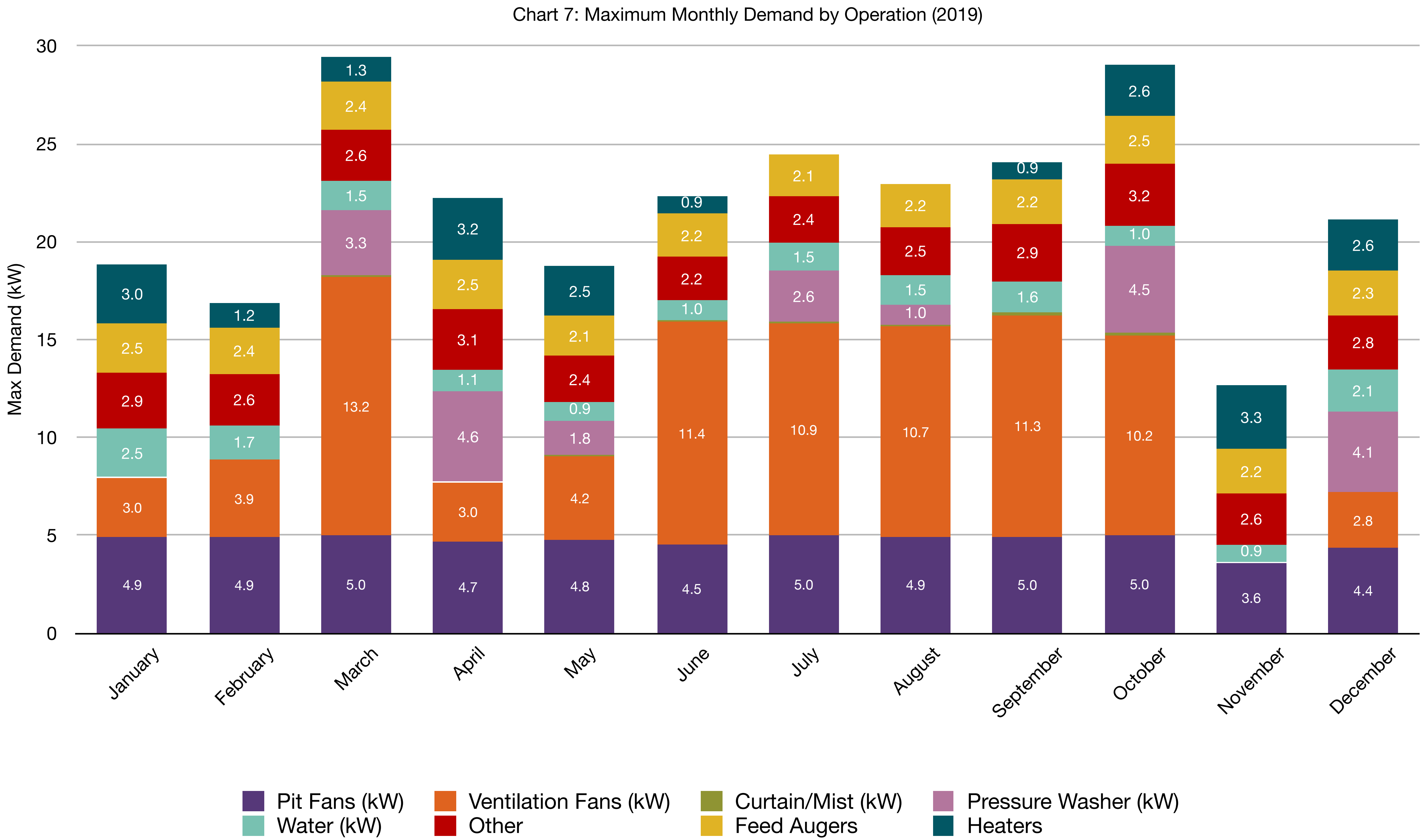
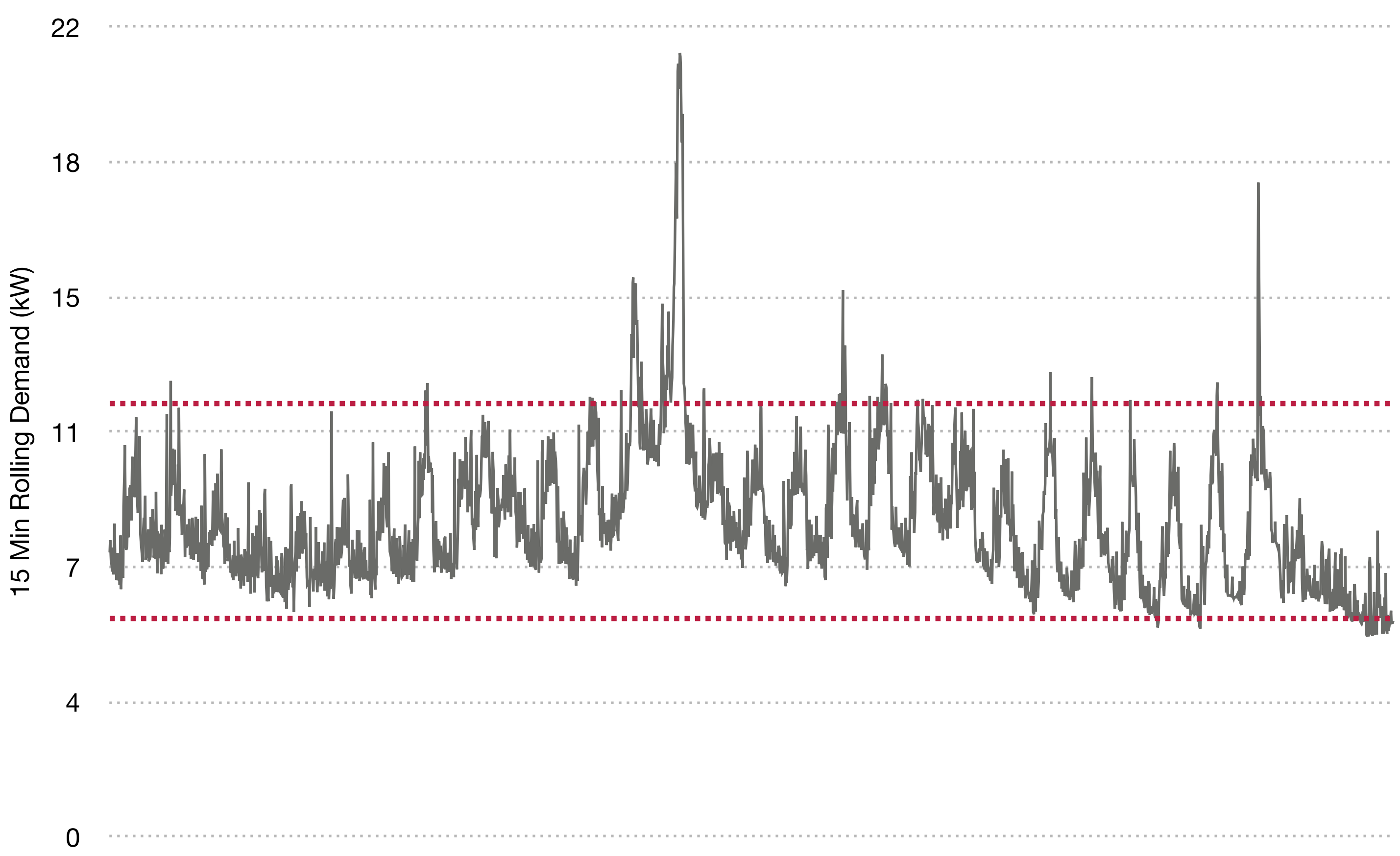


Chart 7: Maximum Monthly Demand by Operation (2019)
Max Demand (kW)
30
25
20
15
10
5
0
January
February
March
April
May
June
July
August
September
October
November
December
4.9
3.0
2.5
2.9
2.5
3.0
4.9
3.9
1.7
2.6
2.4
1.2
5.0
13.2
3.3
1.5
2.6
2.4
1.3
4.7
3.0
4.6
1.1
3.1
2.5
3.2
4.8
4.2
1.8
0.9
2.4
2.1
2.5
4.5
11.4
1.0
2.2
2.2
0.9
5.0
10.9
2.6
1.5
2.4
2.1
4.9
10.7
1.0
1.5
2.5
2.2
5.0
11.3
1.6
2.9
2.2
0.9
5.0
10.2
4.5
1.0
3.2
2.5
2.6
3.6
0.9
2.6
2.2
3.3
4.4
2.8
4.1
2.1
2.8
2.3
2.6
Pit Fans (kW)
Ventilation Fans (kW)
Curtain/Mist (kW)
Pressure Washer (kW)
Water (kW)
Other
Feed Augers
Heaters

that the monthly max demand was established. For example, in July the pressure washer had a maximum demand of 2.6 kW, however it did not contribute to the maximum monthly 15-minute peak demand window because it was used when the stage fans were off and therefore the overall peak demand was lower. As shown in Chart 7, the ventilation fans make a significant contribution to the overall peak demand in the summer months, however contribute less in the winter months. The heaters had a variation in monthly peak demand typically contributing more in the winter months. While the heaters in the tunnel rooms did not operate in the summer, for some reason, the baseboard electric heater in the office did turn on for a short period in June. Pit fans remain consistent due to the variable frequency drive controls. Finally, the peak demand contributions from feed auger motors, water pump, and other operations appear to be relatively consistent from month to month. The highest total monthly peak demand was in March of 2019.

As illustrated in Chart 8, the maximum 15-minute monthly demand of 21.3 kW was set in March 2019, which was the largest demand recorded at the BFEM farm during the 12-month study period. As outlined by the red dotted lines in Chart 8, most of the month the total operating demand was within a range of 6 kW and 12 kW, with several spikes over 15 kW. When analyzing specific operational electric loads, there were obvious differences between their average demand and the peak demand (kW) patterns which contributed to the high demand spikes.

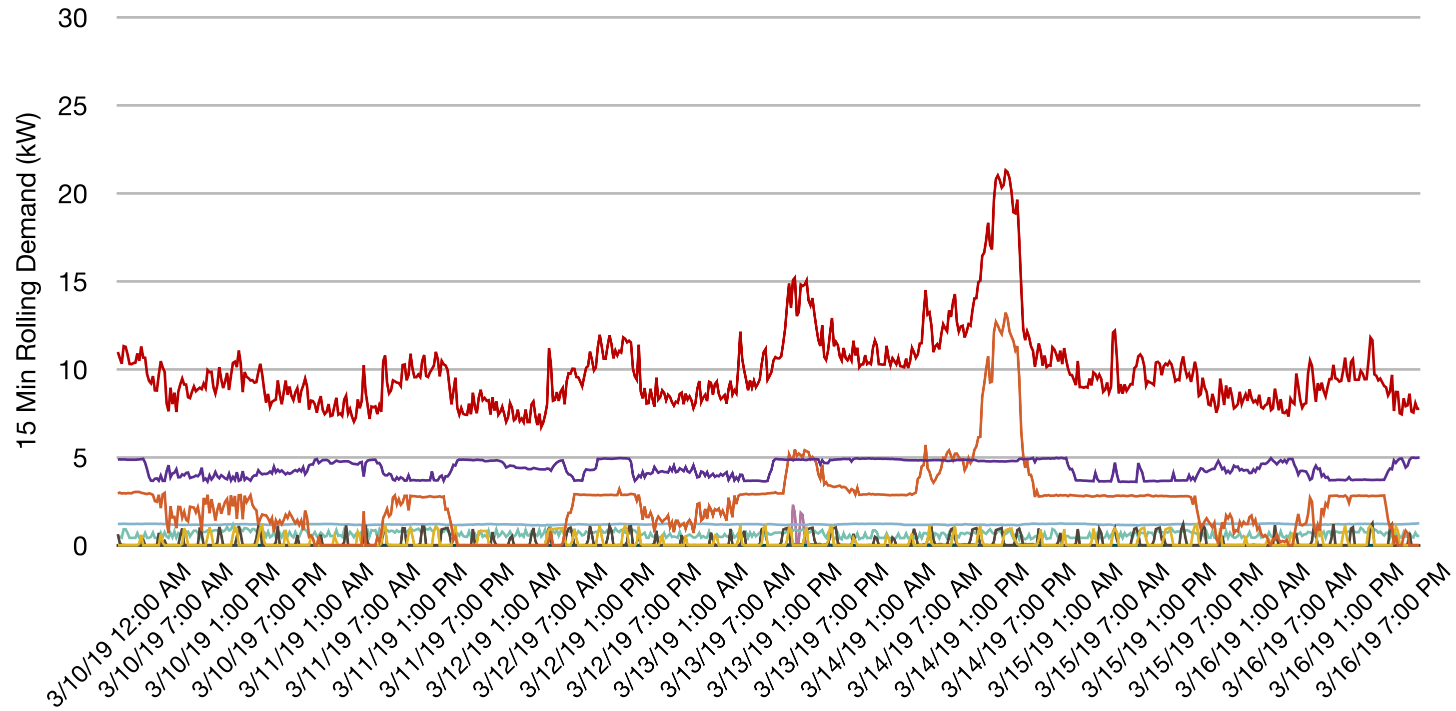
Chart 8: BFEM 15-Minute Maximum Demand - March 2019



As shown in Chart 9, electric demand loads associated with water pump and baseboard heater in the office maintain consistent usage patterns throughout the day contributing an average of .64 kW and 1.18 kW respectively. Pit fans also present a consistent usage pattern, ranging from 3.6 kW to 4.9 kW and an average of 4.3 kW throughout the week. Because the pit fans represent both a large and consistent demand load, they essentially set a plateau in the load profile that additional peak demand spikes from other operations build from.

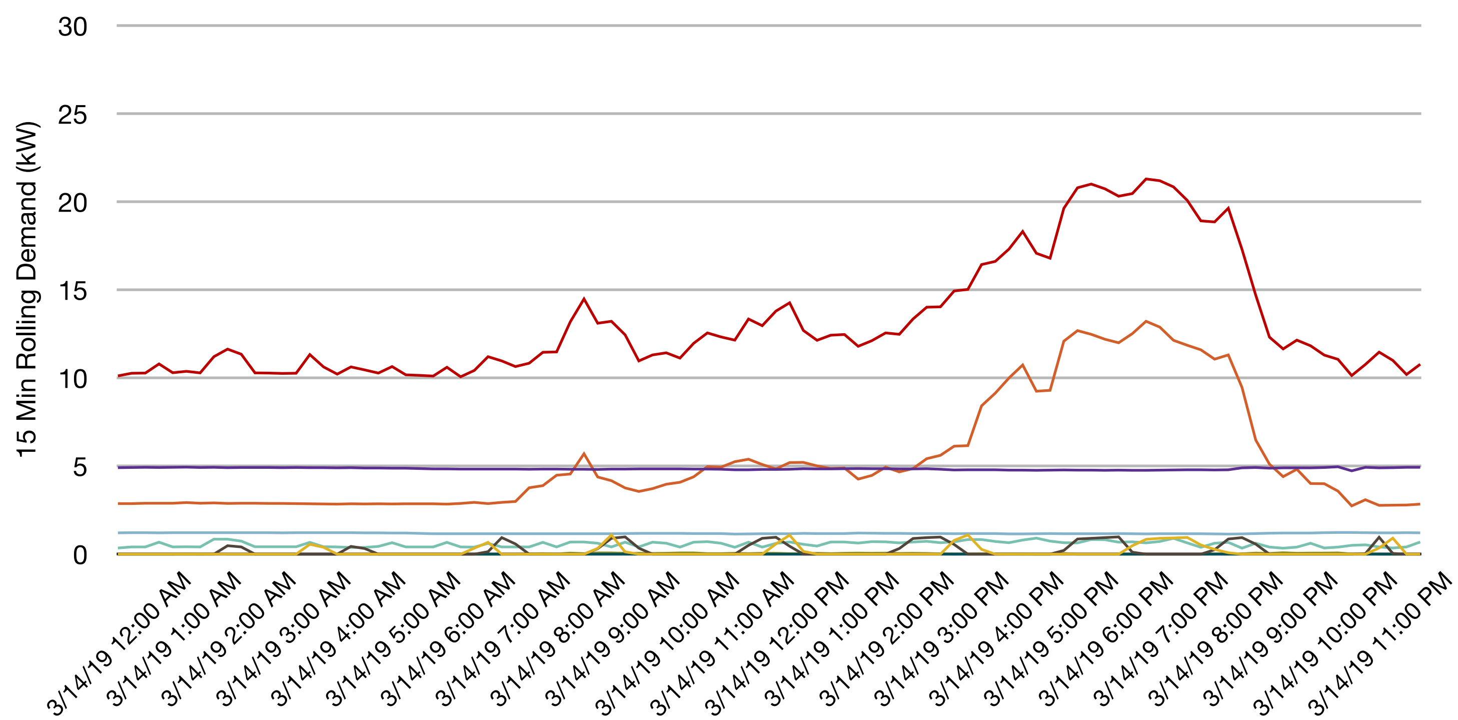
Ventilation fans are often the largest operational contributor to the overall peak demand and drive the overall peak demand profile. For example, eight out of the 12 months the ventilation fans contributed over 36% to the monthly peak demand, including six months which actually contributed to over 50% of the monthly peak demand. Ventilation fans are controlled by

Chart 9: BFEM Swine 15-Minute Demand Profile: Peak Week - March 2019



a thermostat setting which triggers separate stages of required ventilation. While the ventilation fans tend to run sporadically in the spring and fall, in the summer months they are more consistent and rarely shut down. Ventilation fans are critical motor loads essential to animal comfort and therefore they offer little opportunity to adjust through load shifting. Finally, the feed auger motor operations are more randomized as the hogs eat throughout the day, which contributes to minor spikes in the total peak demand.

Chart 10: BFEM Swine 15-Minute Demand Profile: Peak Day - March 14, 2019



As illustrated in Chart 10, the maximum 15-minute monthly demand was set on March 14th at 6:45 p.m., when the electrical loads of critical operations overlapped due to the random nature of their process. For example, during the March 14th at 6:45 p.m. peak demand window the pit fans peaked at 4.76 kW, the ventilation fans at 13.22 kW, the feed augers at 0.84 kW, water pump at 0.64 kW, the baseboard heater at 1.15 kW, while miscellaneous loads contributed 0.68 kW to the total demand. This peak demand event could have been avoided if all 5 stages of ventilation fans were not operating at full capacity. Additional ventilation requirements were staged on over a 5 hour period during a warm afternoon. As the additional ventilation stages were shut off, the barns total peak demand was quickly reduced from 21.3 kW to 14.7 kW.

Financial Implications

Based on the analysis period, the 15-minute monthly demand charges at the BFEM farm accounted for a minimum of 31 percent, a maximum of 46 percent, and a 12-month average of 38 percent of the total electric bill. In comparison, the 12-month average of energy generation charges were 56 percent, while cost recovery charges or riders represented an average of 6 percent of the total electric bill charges (Chart 11). When put in monetary terms, the 15-minute monthly demand charges at the BFEM farm accounted for a minimum of $125, a maximum of $295, and a 12-month average of $216 of the total electric bill.

While it is helpful to review the overall demand cost, metering individual processes on the farm allowed us to better understand which operations are contributing most to the peak demand cost. As illustrated in Table 2, ventilation fans often contribute the most to overall demand cost with a maximum monthly demand cost of $183 and an average monthly demand cost of $89 per month. The pit fans represents the second greatest impact to the total monthly demand cost with a maximum monthly demand of $66 and an average monthly demand cost of $58 per month. Next, feed auger motors and the water pump accounted for the third highest contribution to the total monthly demand cost with a maximum monthly demand cost of $62 and an average monthly demand cost of $31 per month. Finally, the pressure washer operations which are used to clean and sanitize the barn, only contributed to the monthly15-minute peak demand window during two of the 12 months over the analysis period. The pressure washer contributed $60 to the monthly demand cost in April and $38 in December. Due to the seasonal nature of ventilation fans and water pump operations, they have the greatest variation in cost. The demand cost for these operations is significantly higher in the summer when the animals are in need of additional water and ventilation to keep cool.

Chart 11: Monthly Comparison of Generation and Demand Cost

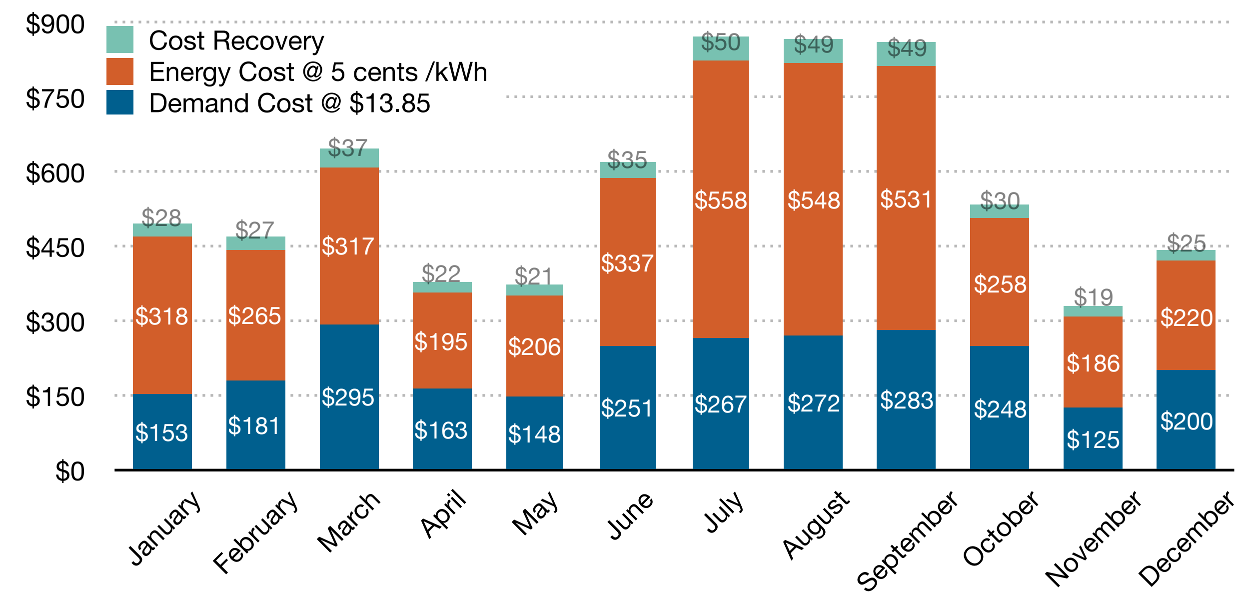


Table 2: Estimated Demand Cost by Operation During Monthly 15-Minute Peak Demand

Date	Pit Fans	Ventilation Fans	Feed & Water	Heating	Pressure Washer	Other Loads	Total Demand
1/30/19 3:15 PM	$47	$0	$62	$16	$0	$28	$153
2/3/19 3:45 PM	$60	$96	$13	$0	$0	$12	$181
3/14/19 6:45 PM	$66	$183	$21	$16	$0	$9	$295
4/10/19 4:15 PM	$47	$0	$13	$0	$60	$43	$163
5/31/19 4:30 PM	$59	$54	$21	$0	$0	$14	$148
6/23/19 7:15 PM	$59	$144	$35	$0	$0	$13	$251
7/21/19 7:00 AM	$60	$139	$37	$0	$0	$32	$267
8/27/19 8:30 AM	$64	$138	$39	$0	$0	$31	$272
9/23/19 8:15 AM	$65	$138	$44	$0	$0	$37	$283
10/3/19 3:45 PM	$66	$139	$31	$0	$0	$12	$248
11/12/19 9:00 AM	$38	$0	$27	$32	$0	$28	$125
12/26/19 3:30 PM	$60	$38	$27	$16	$38	$21	$200
Note:	Demand charges are seasonally adjusted ranging from $12.02 to a high of $14.45 per kW. This table uses an average demand cost of $13.85 which represents charges from both transmission and distribution demand charges, but excludes cost recovery fees.						

Observations

When reviewing the data, a key observation is related to the significant decrease of demand charges in November, December, January, and February. This suggests there is a connection between demand charges and seasonal operations. Chart 12 compares the maximum daily temperature from the weather station at the Ohio Agricultural Research and Development Station in Custar, Ohio to the total daily maximum peak demand of the BFEM farm. The total daily peak demand profile for the farm closely reflects the profile trends of the maximum daily temperature, suggesting that temperature has a direct influence on peak demand cost. Select processes monitored on the farm that could be influenced by temperature include pit fans, tunnel ventilation fans, feed auger motors, and water pump operations.

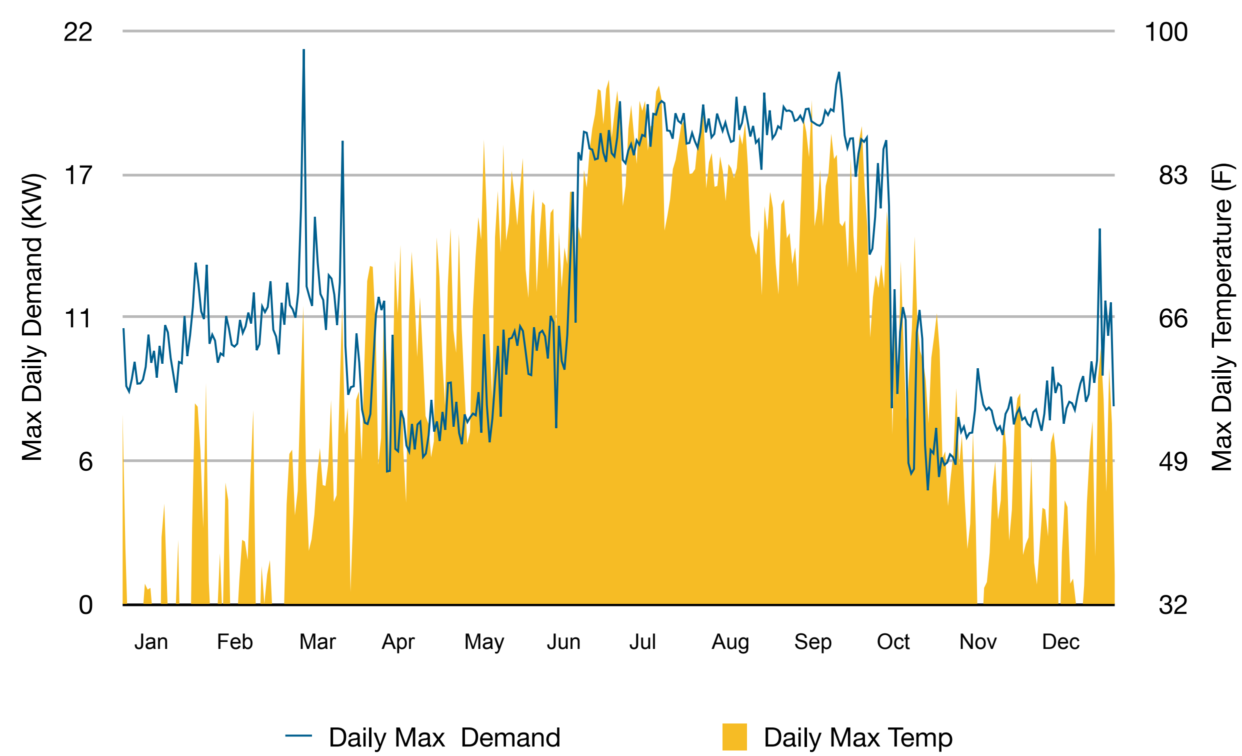
While it appears the feed and water consumption is higher in the summer months and drops off in September, these operations are not controlled by a thermostat and are more related to animal weight and behavior. Based on the load profile in Chart 13 for the feed auger motors and pressure washer, it appears the hogs were loaded out to market in early April when feed auger motors stopped running and the barn was empty while being cleaned with the pressure washer before the next load of pigs came in in late April. This cycle appears again in mid October. This is a useful reminder that the production cycles of a hog barn will unintentionally influence the peak demand data. For example, looking at Chart 12 you would expect the demand to be higher in April and May due to high temperatures triggering additional ventilation fan loads. However, as we just discussed, the barn was empty in April and the pigs were smaller in May after the new load of animals was received.

As illustrated by the load profiles in Chart 12, the ventilation fans are thermostat controlled and therefore appear to be directly linked to the maximum daily temperature.

Based on this observation, it is important to review the controller stage settings to determine if they are properly calibrated and not unnecessarily adding additional ventilation stages. However, it is equally important to maintain the required ventilation needs to meet animal comfort and production goals. Chart 14 combines the pit fans and tunnel ventilation fans to compare fan motor loads to the total peak demand load for the farm. As illustrated in Chart 14, the combined fan loads directly influence the total peak demand for the farm throughout the year.

While the ventilation fans drive the overall demand trends, the feed auger motors often influence the maximum monthly demand spike. Further investigation of the peak demand profile for the feed auger motors found that in most cases the feed auger motors in the east and west rooms are staggered, meaning that their peak demand contributions do not overlap because they do not operate at the same time. In fact, over the 12 month

Chart 12: Impact of Temperature and Electric Demand



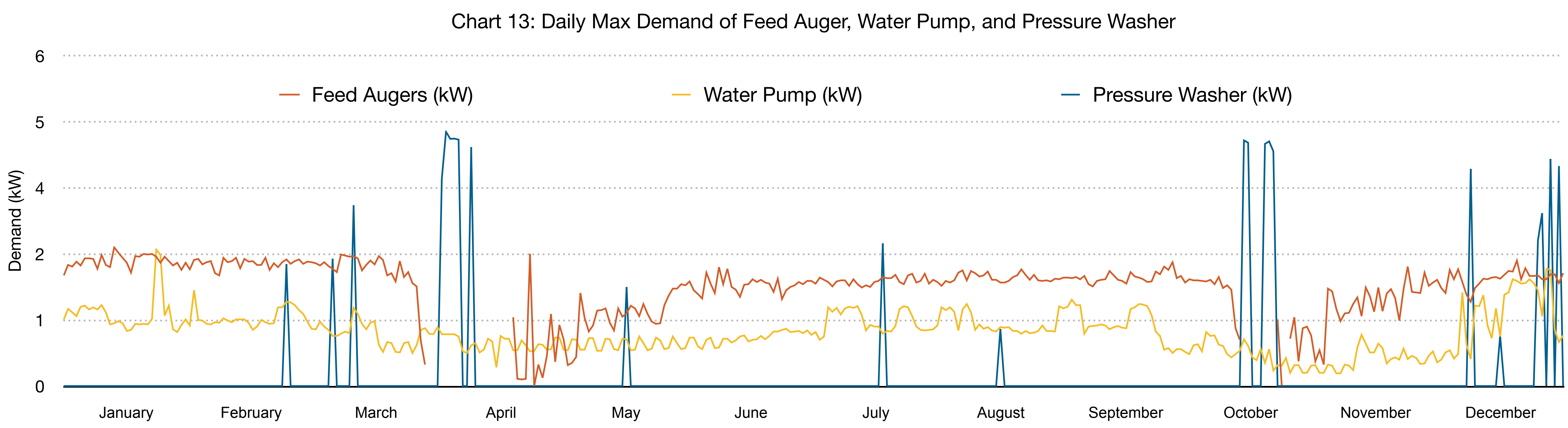


Chart 13: Daily Max Demand of Feed Auger, Water Pump, and Pressure Washer
Feed Augers (kW)
Water Pump (kW)
Pressure Washer (kW)
Demand (kW)
6
5
4
2
1
0
January
February
March
April
May
June
July
August
September
October
November
December

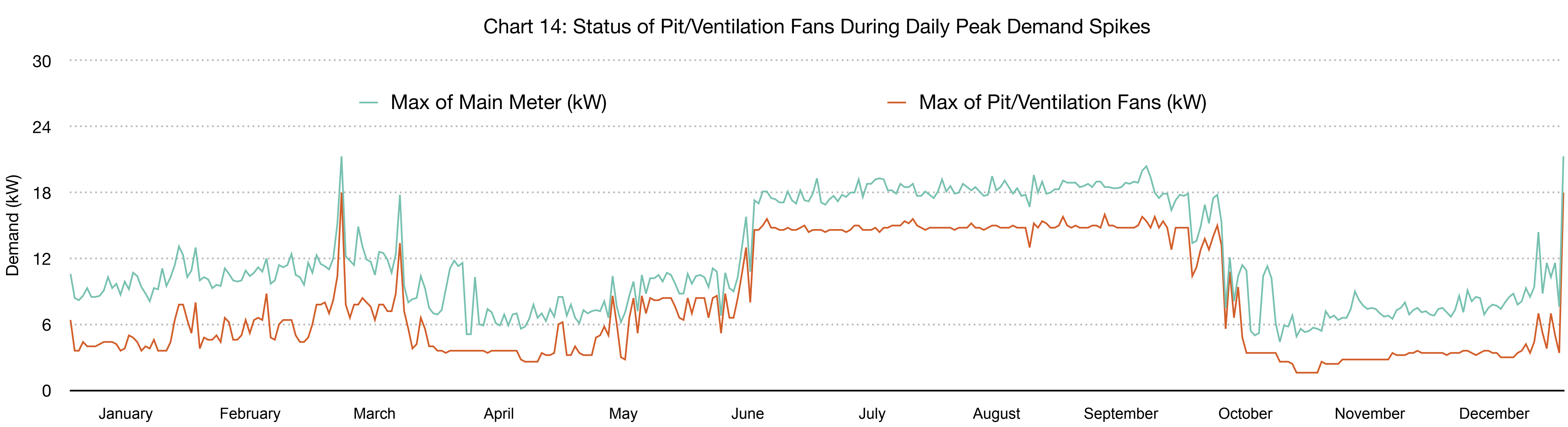


Chart 14: Status of Pit/Ventilation Fans During Daily Peak Demand Spikes
Max of Main Meter (kW)
Max of Pit/Ventilation Fans (kW)
Demand (kW)
30
24
18
12
6
0
January
February
March
April
May
June
July
August
September
October
November
December

Image K: (left) is and example of a feed auger motor in the east room used to pull feed into the barn.

Photos by: Eric Romich, OSU Extension Field Specialist.

analysis period the feed auger motors in the east and west rooms were operating in unison for only 5% of the time. Over the 12-month analysis period, there were 35,050 recorded 15-minute demand time intervals (events) and 99% of the recorded events had a demand of less than 18 kW. When analyzing the 215 demand events over 18 kW, we found the feed auger motors (Image K) in both the east and west rooms were operating concurrently 66% of the time for demand events over 18 kW.

In summary, larger ventilation fan loads which are influenced by temperature drive the overall demand trends for the farm. However, the actual monthly peak demand is often set when the feed auger motors from both rooms randomly run simultaneously. While individually the maximum peak demand load from the feed auger motors in one room of the tunnel ventilated barn is not excessively large, it could have a multiplier effect if the farm has more than one barn on site powered from the same electric meter. For example, on average the maximum demand from the feed auger motors in one room is 1.3 kW, adding $18 to the BFEM farms monthly demand[4]. While we are only metering one barn for this study, the BFEM farms has two double wide tunnel barns and if all four rooms (two from each barn) have the feed auger operations running simultaneously, this could have a multiplier effect unnecessarily adding $72 to the BFEM farms monthly demand charges.

[4] Based on a demand cost of $13.85 per kW.

Closing Thoughts

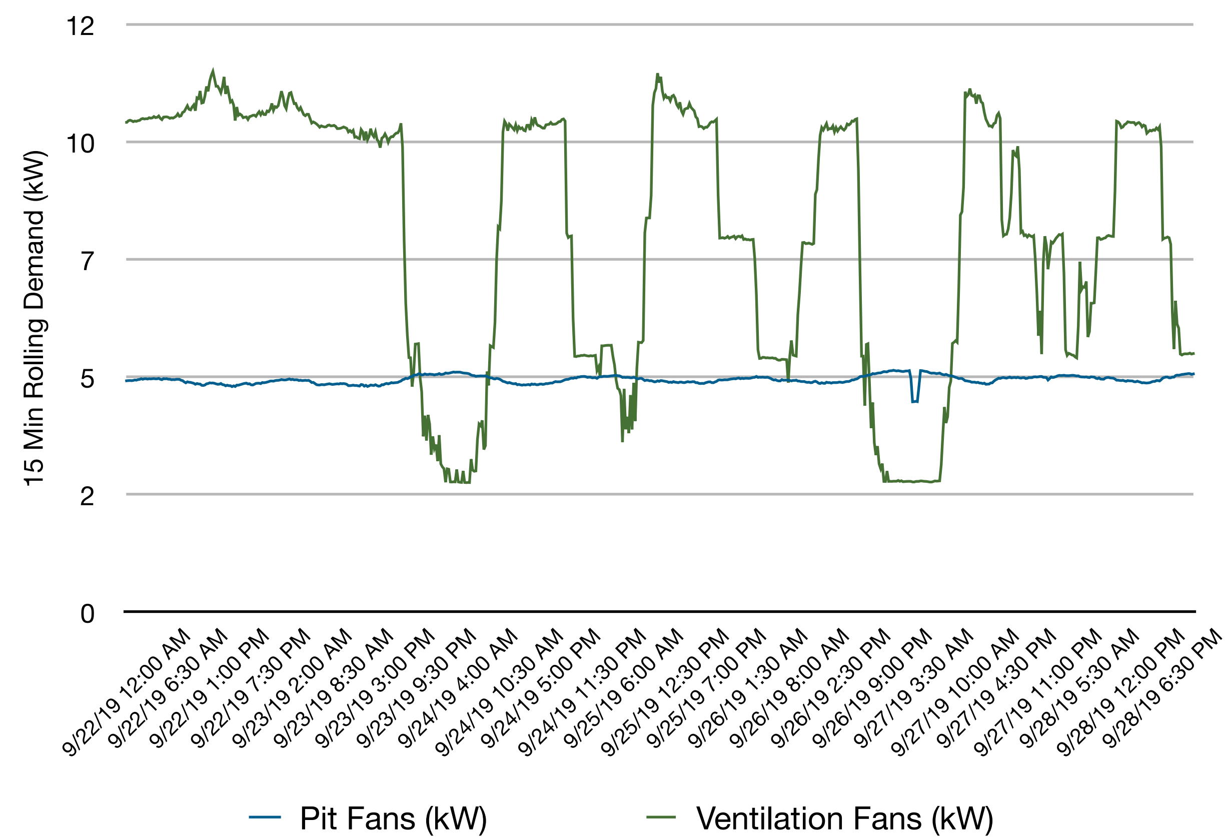
Summary of Results and Recommendations

When combining the pit fans and tunnel ventilation fans, fan motors accounted for 74% of the total energy use and 68% of the total peak demand over the analysis period. Although both the pit fans and tunnel ventilation fans are designed to maintain air quality to ensure animal comfort, health, and superior productivity, they operate in a very different manner and have very distinct impacts to energy and peak demand. Compared to the tunnel ventilation fans, the pit fans run more frequently and consume more energy over the course of the year. For example, in 2019 the pit fans consumed a total of 34,142 kWh compared to the tunnel ventilation fans which consumed only 24,343 kWh during the same time period. However, the tunnel ventilation fans set a maximum monthly demand of 13.2 kW compared to a maximum of 5 kW for the pit fans. As a result, despite using less energy than the pit fans, the tunnel ventilation fans annual demand cost was $387 more compared to the pit fans[5].

This is due to the design of the mechanical tunnel ventilation system which uses single speed fans that are often belt driven, and controlled by a temperature driven controller. Traditional tunnel barn ventilation strategies employ fans staging up and down in a stair step pattern typically set three to five degrees apart (Chart 15). In this type of system, operators calculate the number and weight of the hogs occupying the building to assign minimum ventilation requirements. Because of this design strategy, barns often climb in temperature significantly before maximum ventilation is achieved or many fans turn on at one time, which creates high motor loads. In comparison, the pit fans which are typically used for air quality and minimum ventilation are controlled by a variable speed drive control. The variable frequency drive system allows the fans to operate in a range from 10% to 100% capacity, which in turn flattens the load profile and minimizes peak demand spikes (Chart 15).

During the hot summer months of June, July, and August, all stages of the tunnel ventilation fans tend to run at full capacity all day and most of the night, limiting the potential for demand reduction and cost savings. However, during the other nine months out of the year there could be an opportunity to reduce the farms peak demand with the use of high efficiency direct drive electronically commutated (EC) motors on ventilation

Chart 15: Comparison of Fan Demand Profiles - September 2019



[5] Based on a demand cost of $13.85 per kW.

fans and sensor-driven smart controls. Similar to a variable speed drive controller, EC motors use integrated electronics to continuously monitor motor functions and automatically adjust the control input to align fan speed to match the demand, maintaining efficiency throughout the operable speed range (Image L and M). While belt-driven fans experience large declines in efficiency at part load, electronically commutated EC motors maintain efficiency at various speeds and part-load operation.

A review of the tunnel ventilation fans operation during the study period showed promising opportunity for demand reduction with EC drive motors in conjunction with smart control strategies, especially in the spring and winter months. This is due to relatively low ventilation requirements with a few spikes due to warm temperatures. For example, when filtering the tunnel ventilation demand loads to only investigate 15-minute demand events over 7.5 kW, there were 4,998 events in the summer months of June, July, and August that were over 7.5 kW, including a maximum demand of 11.4 kW. In comparison, during the spring months of March, April, and May, there were only 22 events that recorded a demand spike over 7.5kW including a maximum demand of 13.2 kW. While both the pit fans and tunnel ventilation fans are essential operations required to maintain animal comfort and production, there are opportunities to reduce both energy consumption and peak demand contributions through improved design and energy efficiency.

Image L: is and example of an electronically commutated (EC) drive stir fan motor.

Image M: is and example of a variable speed drive (VSD) power unit designed to operate in extreme environments.

Photos by: Eric Romich, OSU Extension Field Specialist.

Tips to Start Energy Management on Your Farm

Depending upon farm size, energy consumption can contribute significantly to total operating costs. This study documented that there may be opportunities to reduce energy costs by adjusting the operating time of certain loads. Farm operations interested in investigating energy consumption and costs savings strategies can get started by following the five steps of the on-farm energy management process flow outlined in Chart 16.

The first step to the on-farm energy management process is to understand historical energy trends by first investigating your electric rate sheet to understand how you are billed for electricity and then gathering historical usage data from past bills or by contacting your utility provider. This will require dedicating time to reading electric bills, locating and reading your rate sheet, and discussing questions with your utility provider. Using the energy data collected, develop a historical baseline data log with monthly kilowatt demand, kilowatt hours used, load factor, and power factor for the

Chart 16: On-Farm Energy Management Process Flow

Step 1: Understanding Historical Energy Trends

- Investigate your electric rate sheet to understand energy cost, tariff data, and how you are billed for electricity
- Gather historical usage data from bills or by contacting your utility provider
- Develop historical baseline data log with monthly kWh, kW, and Power Factor
- Develop energy flow diagram that identifies large motor loads, essential operations, and non-essential operations

Step 2: Farm Energy Assessment

- Discuss the goals of the energy assessment with the farms's key staff
- Analyze the major energy consumption data with relevant personnel
- Sketch a drawling of the site with equipment inventory and usage information (motor size, run time, frequency, importance)
- Identify the main energy consuming operations to be evaluated during the energy review

Step 3: Energy Monitoring

- Decide if energy meters will have to be installed or if usage trends can be estimated based on existing data
- Determine what type of equipment and instrumentation is required to collect the energy usage data
- Conduct detailed energy monitoring of large motor loads from targeted operations
- Organize all energy usage data into a centralized database to compare with baseline data

Step 4: Analysis and Planning

- Assess energy consumption by operation type, by major items of process equipment, by end-use, time-of-day, and time-of-season
- Based on the load profile data, investigate energy conservation opportunities, load shifting, energy efficiency technologies, and alternative generation
- Estimate the economic return of the associated recommendations and rank the value of energy management corrective actions

Step 5: Implementation

- Identify energy efficiency funding programs (loan and/or grant) from utility providers, state, and federal government.
- Outline and prioritize energy management procedures based on energy savings and economic return
- Implement energy management strategy
- Conduct ongoing monitoring and verification of energy and cost savings

Image N: (below) is and example of tunnel ventilation fans classified as essential motor loads that cannot be manipulated or shifted because it is required to maintain animal health, comfort, and productivity.

Image O: (right) is an example of a pressure washer used for cleaning and sanitation of the barn and miscellaneous farm equipment. This is classified as a non-essential motor load because it could be shifted to preform the same function at a different time without negatively impacting the operations.

Photos by: Eric Romich, OSU Extension Field Specialist.

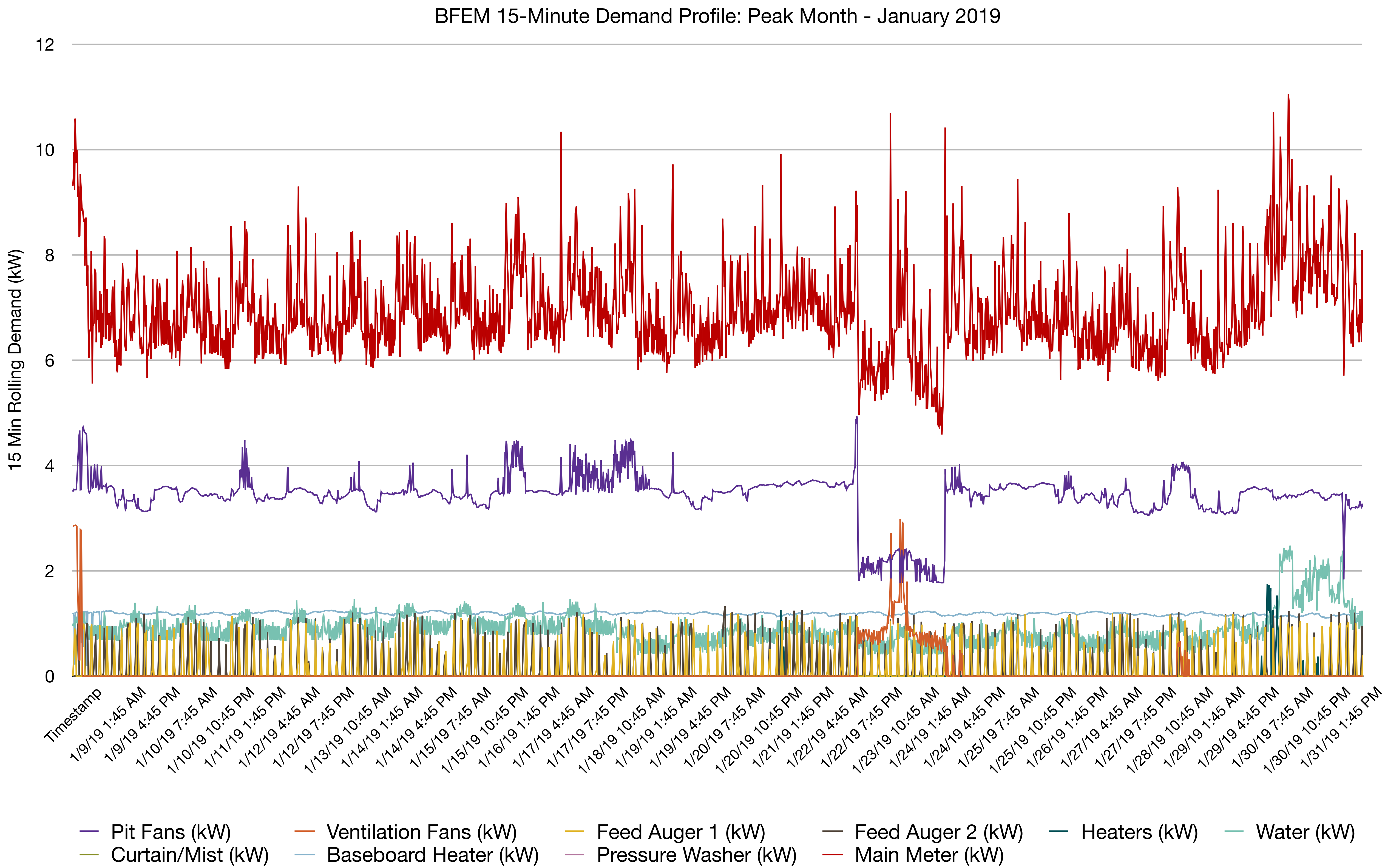
farm. Finally, use the historical baseline data and your knowledge of the farm operation to draft an energy flow diagram that identifies large motor loads, essential operations, and non-essential operations. While all the motors are in some way essential, motor loads that could be operated at a different time of day, or night to reduce overall load would be classified as non-essential (Image N and O).

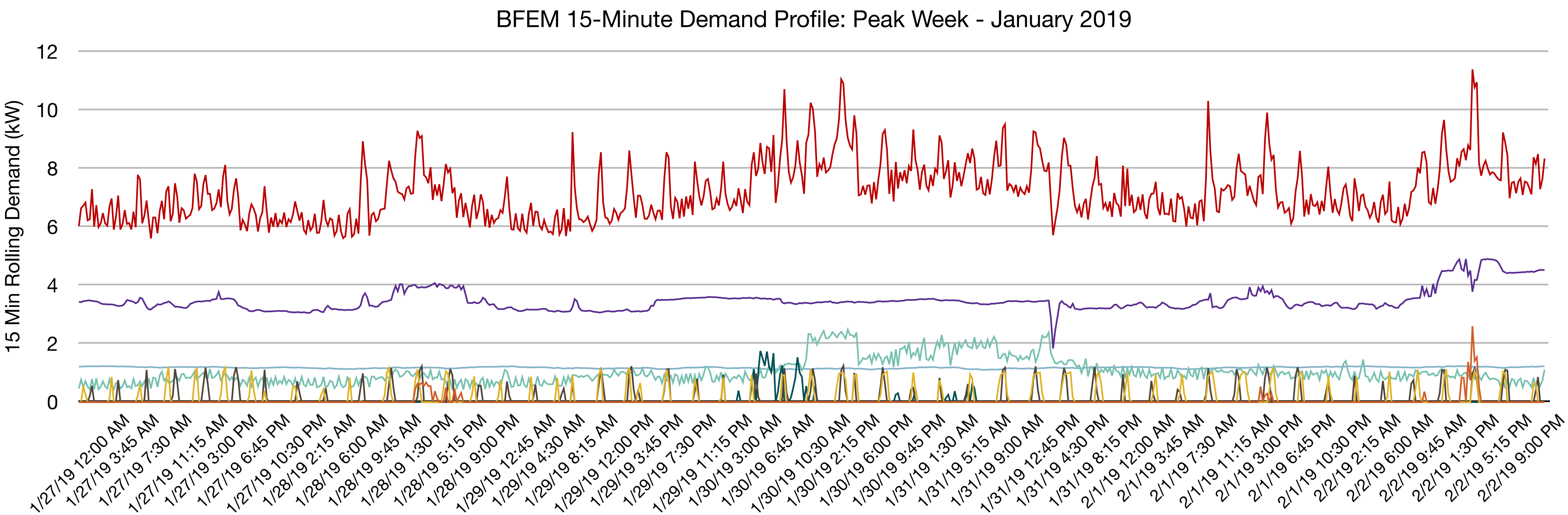
Using the historical energy trends data from the first step, you should assess energy consumption patterns to gain a clearer understanding of which farm operations to concentrate on first. This farm energy assessment process can also help clarify the level of urgency for the farms energy cost and help establish the farms energy management goals to produce significant energy savings. Once these steps are completed, you can begin the third step of energy monitoring. First decide if energy meters will have to be installed to collect usage data and look for savings based on how and when you use electricity on your farm, or if usage trends can be estimated based on existing data. While the monitoring equipment used in this study was very complex, there are other options that are much more affordable and will provide a basic level of analysis. For example, equipment to collect detailed energy usage and peak demand data tends to be more affordable, while equipment to collect more detailed power quality data tends to be more expensive. Determining what type of equipment and instrumentation is required to collect the energy usage data will be largely dependent on the inventory of essential and non-essential motor loads, and the information you are interested in learning.

The final steps include analysis and planning and implementation. Based on the load profile data, investigate energy conservation opportunities, load shifting, energy efficiency technologies, and alternative generation and estimate the economic return of the associated recommendations. Based on the energy savings and economic return, rank the value of energy management corrective actions. Identify energy efficiency funding programs and start implementing energy management strategies based on the ranked value. Conduct ongoing monitoring and verification after energy conservation strategies are completed, to reassess and verify the expected energy savings. The measured results should determine if the goal of the farm energy management program was achieved.

Appendix - Detailed Demand Profile Charts

JANUARY 2019




BFEM 15-Minute Demand Profile: Peak Week - January 2019
15 Min Rolling Demand (kW)
0
2
4
6
8
10
12
1/27/19 12:00 AM
1/27/19 3:45 AM
1/27/19 7:30 AM
1/27/19 11:15 AM
1/27/19 3:00 PM
1/27/19 6:45 PM
1/27/19 10:30 PM
1/28/19 2:15 AM
1/28/19 6:00 AM
1/28/19 9:45 AM
1/28/19 1:30 PM
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1/29/19 12:45 AM
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1/30/19 2:15 PM
1/30/19 6:00 PM
1/30/19 9:45 PM
1/31/19 1:30 AM
1/31/19 5:15 AM
1/31/19 9:00 AM
1/31/19 12:45 PM
1/31/19 4:30 PM
1/31/19 8:15 PM
2/1/19 12:00 AM
2/1/19 3:45 AM
2/1/19 7:30 AM
2/1/19 11:15 AM
2/1/19 3:00 PM
2/1/19 6:45 PM
2/1/19 10:30 PM
2/2/19 2:15 AM
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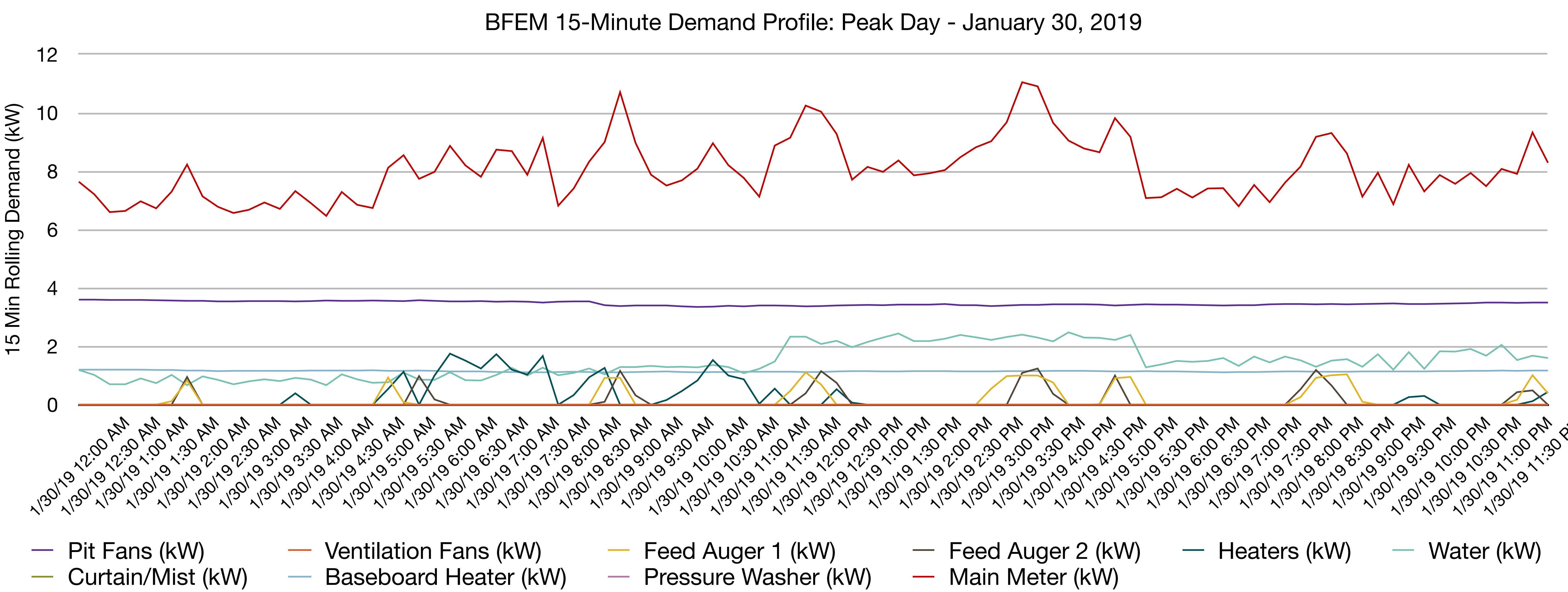
2/2/19 9:00 PM


BFEM 15-Minute Demand Profile: Peak Day - January 30, 2019
15 Min Rolling Demand (kW)
0
2
4
6
8
10
12
1/30/19 12:00 AM
1/30/19 12:30 AM
1/30/19 1:00 AM
1/30/19 1:30 AM
1/30/19 2:00 AM
1/30/19 2:30 AM
1/30/19 3:00 AM
1/30/19 3:30 AM
1/30/19 4:00 AM
1/30/19 4:30 AM
1/30/19 5:00 AM
1/30/19 5:30 AM
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1/30/19 9:30 AM
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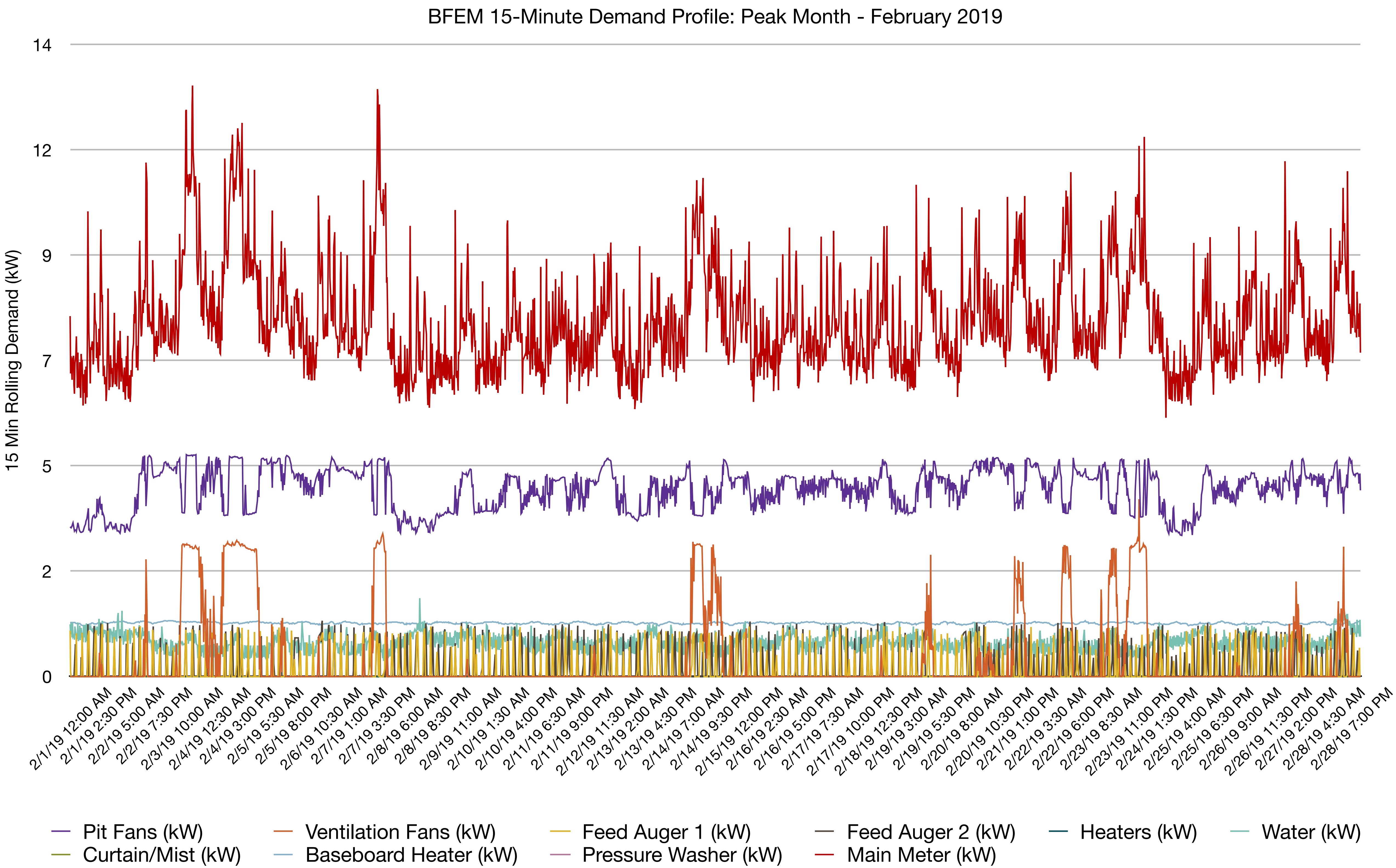
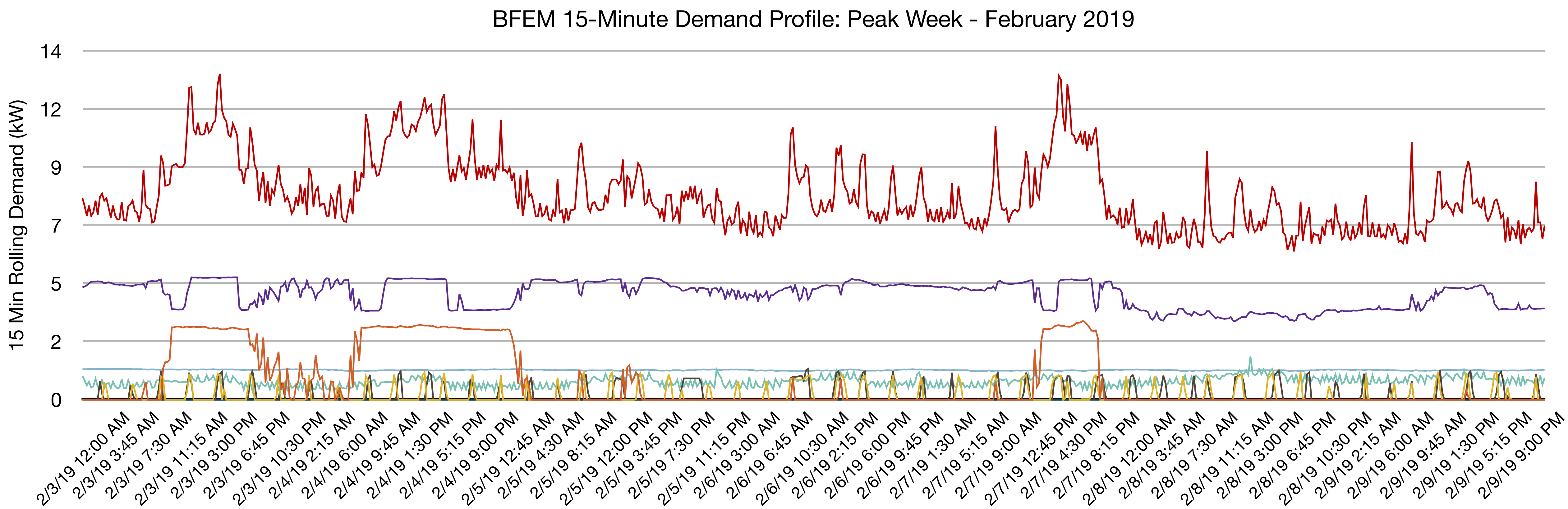
1/30/19 6:00 PM
1/30/19 6:30 PM
1/30/19 7:00 PM
1/30/19 7:30 PM
1/30/19 8:00 PM
1/30/19 8:30 PM
1/30/19 9:00 PM
1/30/19 9:30 PM
1/30/19 10:00 PM
1/30/19 10:30 PM
1/30/19 11:00 PM
1/30/19 11:30 PM
Pit Fans (kW)
Ventilation Fans (kW)
Feed Auger 1 (kW)
Feed Auger 2 (kW)
Heaters (kW)
Water (kW)
Curtain/Mist (kW)
Baseboard Heater (kW)
Pressure Washer (kW)
Main Meter (kW)

FEBRUARY 2019




BFEM 15-Minute Demand Profile: Peak Week - February 2019
15 Min Rolling Demand (kW)
14
12
9
7
5
2
0
2/3/19 12:00 AM
2/3/19 3:45 AM
2/3/19 7:30 AM
2/3/19 11:15 AM
2/3/19 3:00 PM
2/3/19 6:45 PM
2/3/19 10:30 PM
2/4/19 2:15 AM
2/4/19 6:00 AM
2/4/19 9:45 AM
2/4/19 1:30 PM
2/4/19 5:15 PM
2/4/19 9:00 PM
2/5/19 12:45 AM
2/5/19 4:30 AM
2/5/19 8:15 AM
2/5/19 12:00 PM
2/5/19 3:45 PM
2/5/19 7:30 PM
2/5/19 11:15 PM
2/6/19 3:00 AM
2/6/19 6:45 AM
2/6/19 10:30 AM
2/6/19 2:15 PM
2/6/19 6:00 PM
2/6/19 9:45 PM
2/7/19 1:30 AM
2/7/19 5:15 AM
2/7/19 9:00 AM
2/7/19 12:45 PM
2/7/19 4:30 PM
2/7/19 8:15 PM
2/8/19 12:00 AM
2/8/19 3:45 AM
2/8/19 7:30 AM
2/8/19 11:15 AM
2/8/19 3:00 PM
2/8/19 6:45 PM
2/8/19 10:30 PM
2/9/19 2:15 AM
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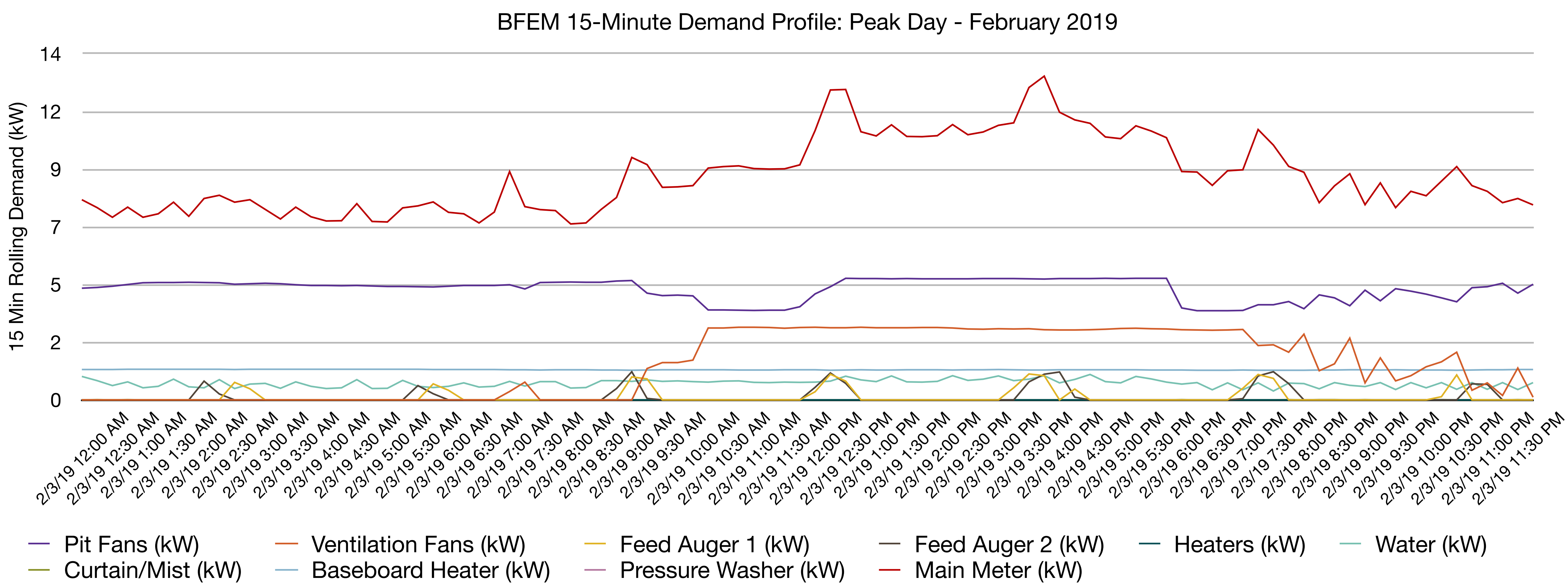
2/9/19 1:30 PM
2/9/19 5:15 PM
2/9/19 9:00 PM


BFEM 15-Minute Demand Profile: Peak Day - February 2019
15 Min Rolling Demand (kW)
14
12
9
7
5
2
0
2/3/19 12:00 AM
2/3/19 12:30 AM
2/3/19 1:00 AM
2/3/19 1:30 AM
2/3/19 2:00 AM
2/3/19 2:30 AM
2/3/19 3:00 AM
2/3/19 3:30 AM
2/3/19 4:00 AM
2/3/19 4:30 AM
2/3/19 5:00 AM
2/3/19 5:30 AM
2/3/19 6:00 AM
2/3/19 6:30 AM
2/3/19 7:00 AM
2/3/19 7:30 AM
2/3/19 8:00 AM
2/3/19 8:30 AM
2/3/19 9:00 AM
2/3/19 9:30 AM
2/3/19 10:00 AM
2/3/19 10:30 AM
2/3/19 11:00 AM
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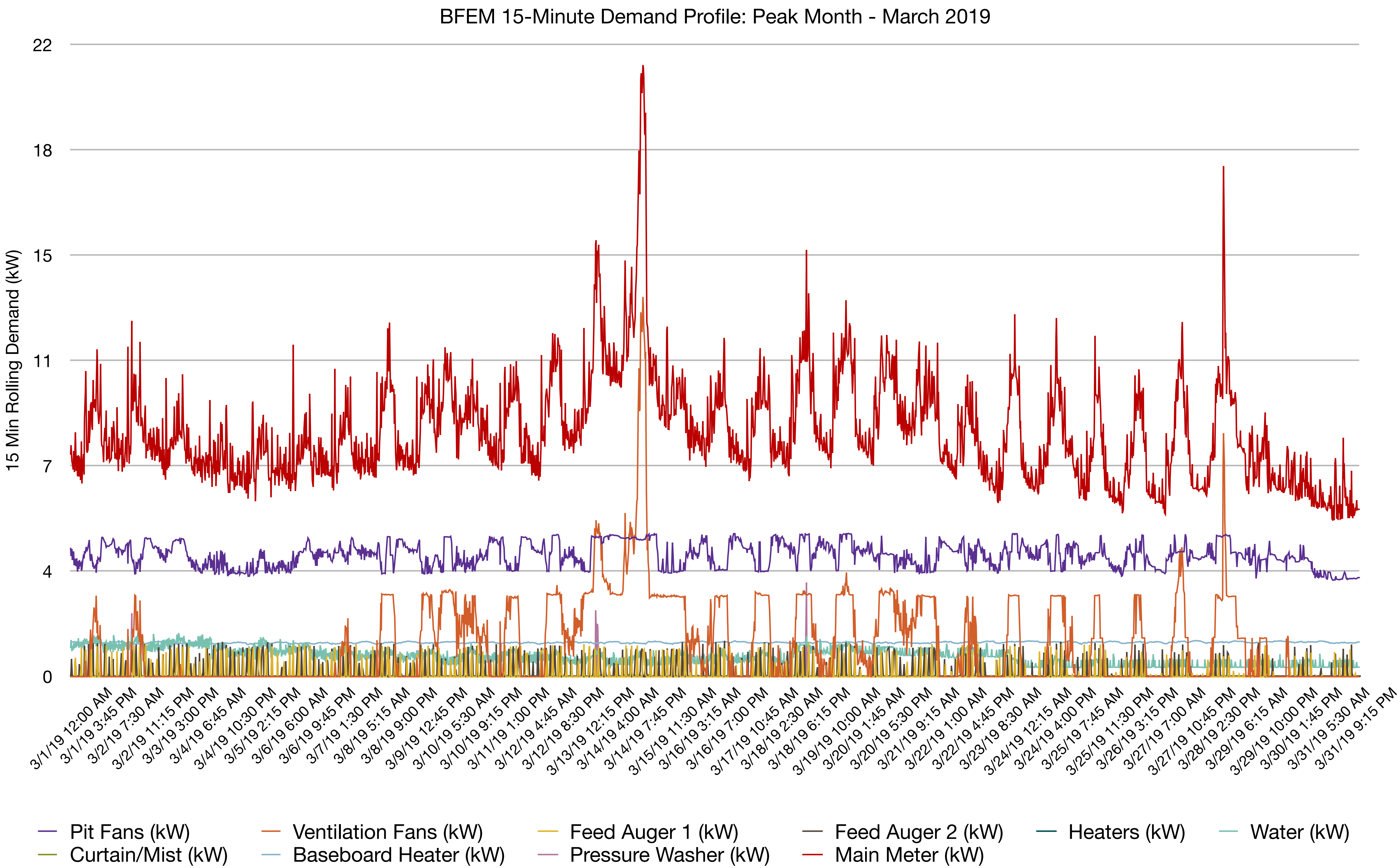
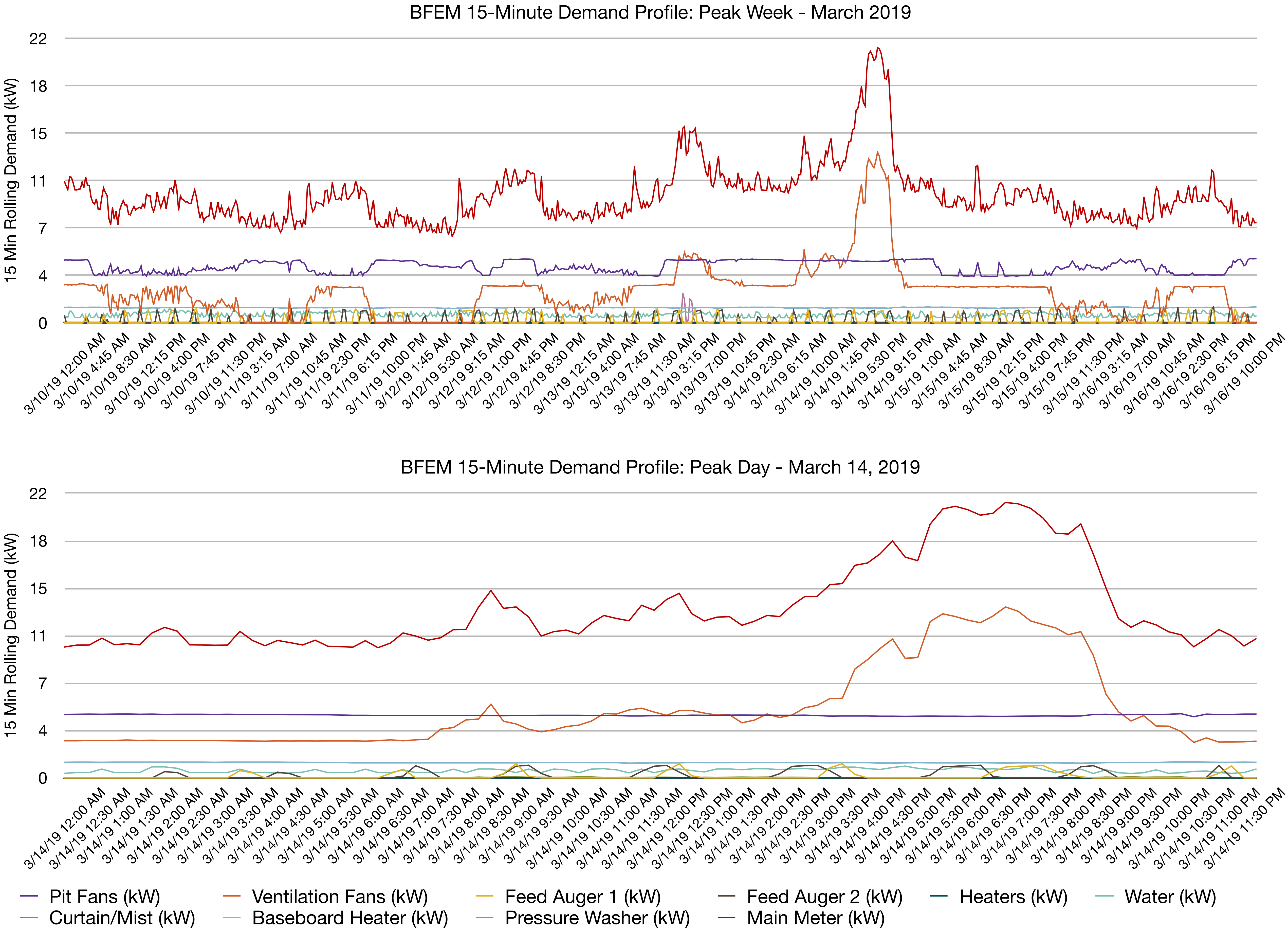
2/3/19 8:00 PM
2/3/19 8:30 PM
2/3/19 9:00 PM
2/3/19 9:30 PM
2/3/19 10:00 PM
2/3/19 10:30 PM
2/3/19 11:00 PM
2/3/19 11:30 PM
Pit Fans (kW)
Ventilation Fans (kW)
Feed Auger 1 (kW)
Feed Auger 2 (kW)
Heaters (kW)
Water (kW)
Curtain/Mist (kW)
Baseboard Heater (kW)
Pressure Washer (kW)
Main Meter (kW)

MARCH 2019



BFEM 15-Minute Demand Profile: Peak Month - March 2019
15 Min Rolling Demand (kW)
22
18
15
11
7
4
0
3/1/19 12:00 AM
3/1/19 3:45 PM
3/2/19 7:30 AM
3/2/19 11:15 PM
3/3/19 3:00 PM
3/4/19 6:45 AM
3/4/19 10:30 PM
3/5/19 2:15 PM
3/6/19 6:00 AM
3/6/19 9:45 PM
3/7/19 1:30 PM
3/8/19 5:15 AM
3/8/19 9:00 PM
3/9/19 12:45 PM
3/10/19 5:30 AM
3/10/19 9:15 PM
3/11/19 1:00 PM
3/12/19 4:45 AM
3/12/19 8:30 PM
3/13/19 12:15 PM
3/14/19 4:00 AM
3/14/19 7:45 PM
3/15/19 11:30 AM
3/16/19 3:15 AM
3/16/19 7:00 PM
3/17/19 10:45 AM
3/18/19 2:30 AM
3/18/19 6:15 PM
3/19/19 10:00 AM
3/20/19 1:45 AM
3/20/19 5:30 PM
3/21/19 9:15 AM
3/22/19 1:00 AM
3/22/19 4:45 PM
3/23/19 8:30 AM
3/24/19 12:15 AM
3/24/19 4:00 PM
3/25/19 7:45 AM
3/25/19 11:30 PM
3/26/19 3:15 PM
3/27/19 7:00 AM
3/27/19 10:45 PM
3/28/19 2:30 PM
3/29/19 6:15 AM
3/29/19 10:00 PM
3/30/19 1:45 PM
3/31/19 5:30 AM
3/31/19 9:15 PM
Pit Fans (kW)
Ventilation Fans (kW)
Feed Auger 1 (kW)
Feed Auger 2 (kW)
Heaters (kW)
Water (kW)
Curtain/Mist (kW)
Baseboard Heater (kW)
Pressure Washer (kW)
Main Meter (kW)


BFEM 15-Minute Demand Profile: Peak Week - March 2019
15 Min Rolling Demand (kW)
22
18
15
11
7
4
0
3/10/19 12:00 AM
3/10/19 4:45 AM
3/10/19 8:30 AM
3/10/19 12:15 PM
3/10/19 4:00 PM
3/10/19 7:45 PM
3/10/19 11:30 PM
3/11/19 3:15 AM
3/11/19 7:00 AM
3/11/19 10:45 AM
3/11/19 2:30 PM
3/11/19 6:15 PM
3/11/19 10:00 PM
3/12/19 1:45 AM
3/12/19 5:30 AM
3/12/19 9:15 AM
3/12/19 1:00 PM
3/12/19 4:45 PM
3/12/19 8:30 PM
3/13/19 12:15 AM
3/13/19 4:00 AM
3/13/19 7:45 AM
3/13/19 11:30 AM
3/13/19 3:15 PM
3/13/19 7:00 PM
3/13/19 10:45 PM
3/14/19 2:30 AM
3/14/19 6:15 AM
3/14/19 10:00 AM
3/14/19 1:45 PM
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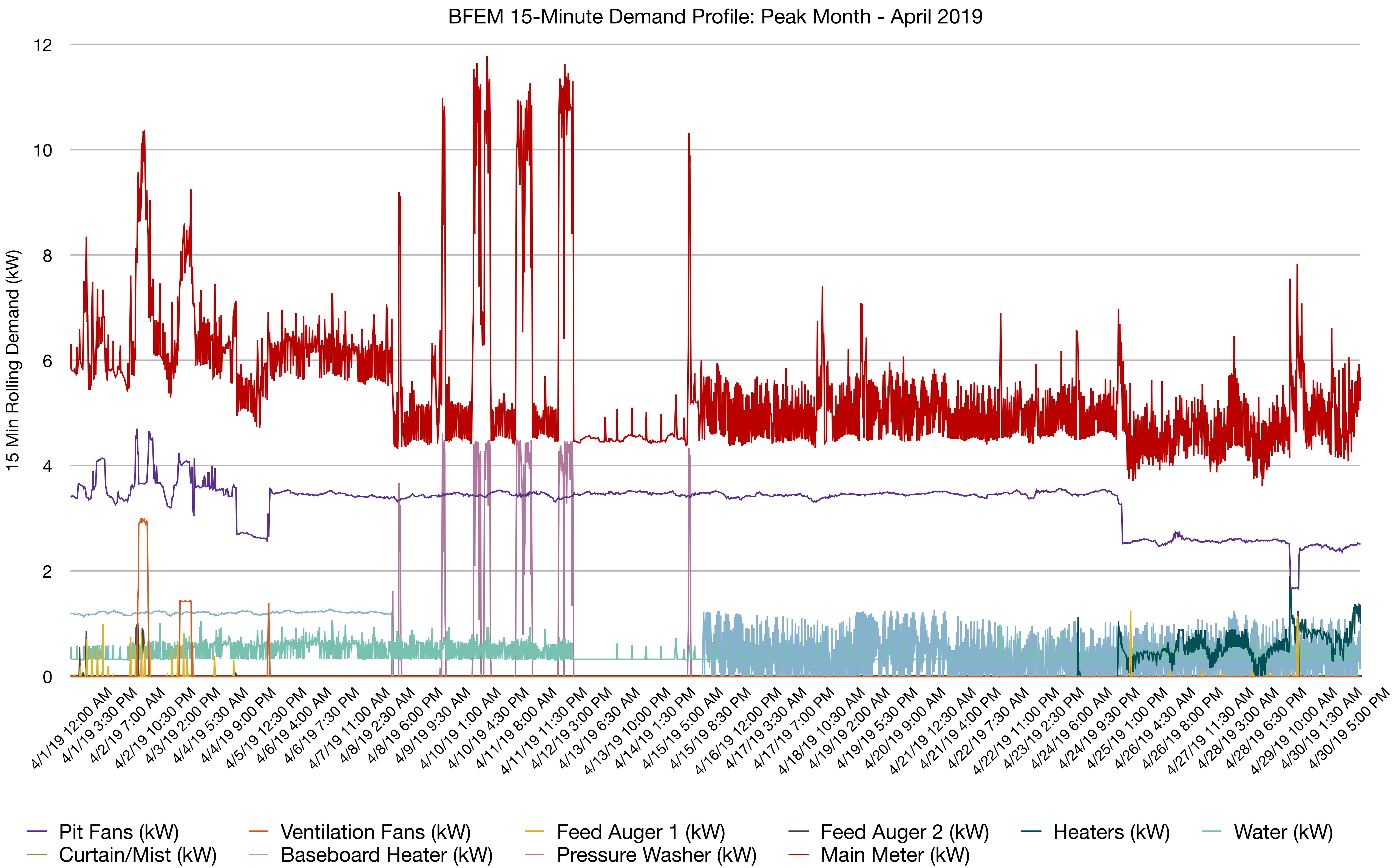
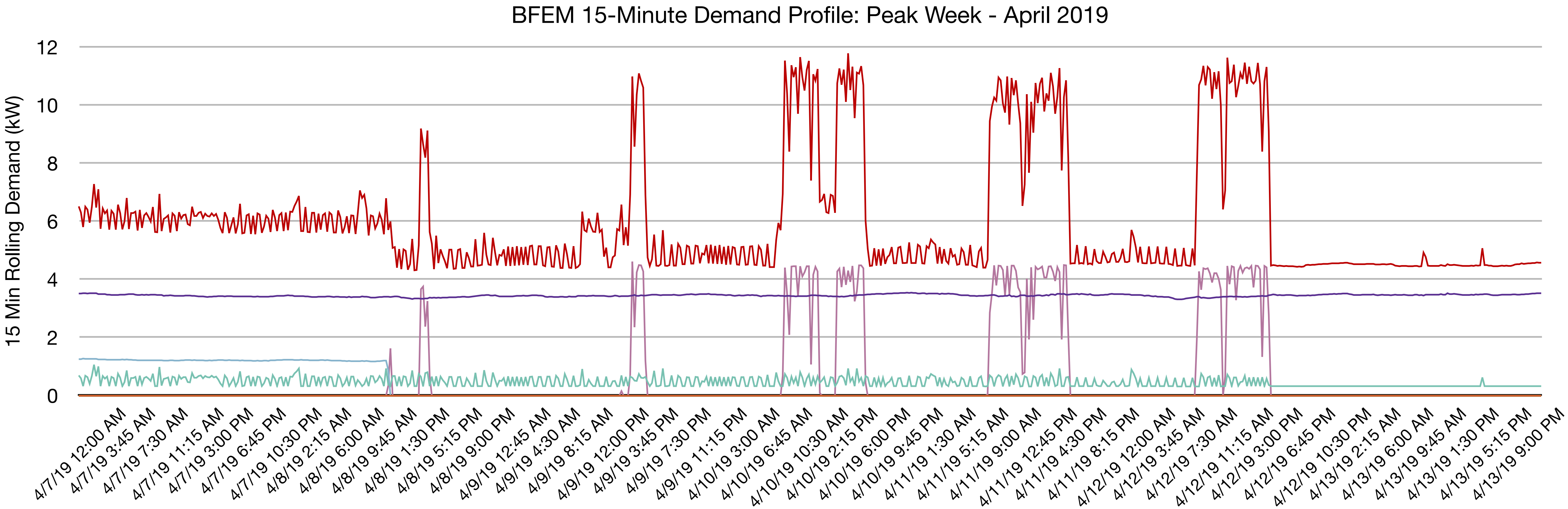
3/14/19 9:15 PM
3/15/19 1:00 AM
3/15/19 4:45 AM
3/15/19 8:30 AM
3/15/19 12:15 PM
3/15/19 4:00 PM
3/15/19 7:45 PM
3/15/19 11:30 PM
3/16/19 3:15 AM
3/16/19 7:00 AM
3/16/19 10:45 AM
3/16/19 2:30 PM
3/16/19 6:15 PM
3/16/19 10:00 PM
BFEM 15-Minute Demand Profile: Peak Day - March 14, 2019
15 Min Rolling Demand (kW)
22
18
15
11
7
4
0
3/14/19 12:00 AM
3/14/19 12:30 AM
3/14/19 1:00 AM
3/14/19 1:30 AM
3/14/19 2:00 AM
3/14/19 2:30 AM
3/14/19 3:00 AM
3/14/19 3:30 AM
3/14/19 4:00 AM
3/14/19 4:30 AM
3/14/19 5:00 AM
3/14/19 5:30 AM
3/14/19 6:00 AM
3/14/19 6:30 AM
3/14/19 7:00 AM
3/14/19 7:30 AM
3/14/19 8:00 AM
3/14/19 8:30 AM
3/14/19 9:00 AM
3/14/19 9:30 AM
3/14/19 10:00 AM
3/14/19 10:30 AM
3/14/19 11:00 AM
3/14/19 11:30 AM
3/14/19 12:00 PM
3/14/19 12:30 PM
3/14/19 1:00 PM
3/14/19 1:30 PM
3/14/19 2:00 PM
3/14/19 2:30 PM
3/14/19 3:00 PM
3/14/19 3:30 PM
3/14/19 4:00 PM
3/14/19 4:30 PM
3/14/19 5:00 PM
3/14/19 5:30 PM
3/14/19 6:00 PM
3/14/19 6:30 PM
3/14/19 7:00 PM
3/14/19 7:30 PM
3/14/19 8:00 PM
3/14/19 8:30 PM
3/14/19 9:00 PM
3/14/19 9:30 PM
3/14/19 10:00 PM
3/14/19 10:30 PM
3/14/19 11:00 PM
3/14/19 11:30 PM
Pit Fans (kW)
Ventilation Fans (kW)
Feed Auger 1 (kW)
Feed Auger 2 (kW)
Heaters (kW)
Water (kW)
Curtain/Mist (kW)
Baseboard Heater (kW)
Pressure Washer (kW)
Main Meter (kW)

APRIL 2019



BFEM 15-Minute Demand Profile: Peak Month - April 2019
15 Min Rolling Demand (kW)
0
2
4
6
8
10
12
4/1/19 12:00 AM
4/1/19 3:30 PM
4/2/19 7:00 AM
4/2/19 10:30 PM
4/3/19 2:00 PM
4/4/19 5:30 AM
4/4/19 9:00 PM
4/5/19 12:30 PM
4/6/19 4:00 AM
4/6/19 7:30 PM
4/7/19 11:00 AM
4/8/19 2:30 AM
4/8/19 6:00 PM
4/9/19 9:30 AM
4/10/19 1:00 AM
4/10/19 4:30 PM
4/11/19 8:00 AM
4/11/19 11:30 PM
4/12/19 3:00 PM
4/13/19 6:30 AM
4/13/19 10:00 PM
4/14/19 1:30 PM
4/15/19 5:00 AM
4/15/19 8:30 PM
4/16/19 12:00 PM
4/17/19 3:30 AM
4/17/19 7:00 PM
4/18/19 10:30 AM
4/19/19 2:00 AM
4/19/19 5:30 PM
4/20/19 9:00 AM
4/21/19 12:30 AM
4/21/19 4:00 PM
4/22/19 7:30 AM
4/22/19 11:00 PM
4/23/19 2:30 PM
4/24/19 6:00 AM
4/24/19 9:30 PM
4/25/19 1:00 PM
4/26/19 4:30 AM
4/26/19 8:00 PM
4/27/19 11:30 AM
4/28/19 3:00 AM
4/28/19 6:30 PM
4/29/19 10:00 AM
4/30/19 1:30 AM
4/30/19 5:00 PM
Pit Fans (kW)
Ventilation Fans (kW)
Feed Auger 1 (kW)
Feed Auger 2 (kW)
Heaters (kW)
Water (kW)
Curtain/Mist (kW)
Baseboard Heater (kW)
Pressure Washer (kW)
Main Meter (kW)


BFEM 15-Minute Demand Profile: Peak Week - April 2019
15 Min Rolling Demand (kW)
0
2
4
6
8
10
12
4/7/19 12:00 AM
4/7/19 3:45 AM
4/7/19 7:30 AM
4/7/19 11:15 AM
4/7/19 3:00 PM
4/7/19 6:45 PM
4/7/19 10:30 PM
4/8/19 2:15 AM
4/8/19 6:00 AM
4/8/19 9:45 AM
4/8/19 1:30 PM
4/8/19 5:15 PM
4/8/19 9:00 PM
4/9/19 12:45 AM
4/9/19 4:30 AM
4/9/19 8:15 AM
4/9/19 12:00 PM
4/9/19 3:45 PM
4/9/19 7:30 PM
4/9/19 11:15 PM
4/10/19 3:00 AM
4/10/19 6:45 AM
4/10/19 10:30 AM
4/10/19 2:15 PM
4/10/19 6:00 PM
4/10/19 9:45 PM
4/11/19 1:30 AM
4/11/19 5:15 AM
4/11/19 9:00 AM
4/11/19 12:45 PM
4/11/19 4:30 PM
4/11/19 8:15 PM
4/12/19 12:00 AM
4/12/19 3:45 AM
4/12/19 7:30 AM
4/12/19 11:15 AM
4/12/19 3:00 PM
4/12/19 6:45 PM
4/12/19 10:30 PM
4/13/19 2:15 AM
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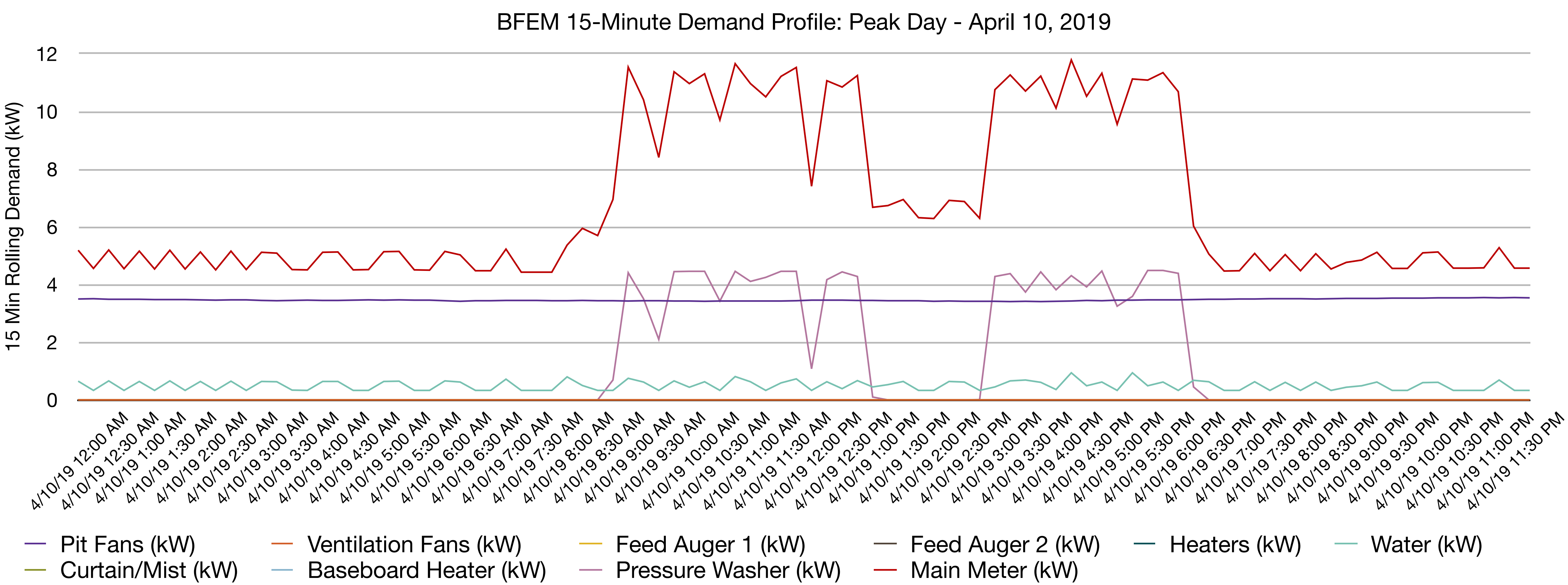
4/13/19 9:00 PM


BFEM 15-Minute Demand Profile: Peak Day - April 10, 2019
15 Min Rolling Demand (kW)
0
2
4
6
8
10
12
4/10/19 12:00 AM
4/10/19 12:30 AM
4/10/19 1:00 AM
4/10/19 1:30 AM
4/10/19 2:00 AM
4/10/19 2:30 AM
4/10/19 3:00 AM
4/10/19 3:30 AM
4/10/19 4:00 AM
4/10/19 4:30 AM
4/10/19 5:00 AM
4/10/19 5:30 AM
4/10/19 6:00 AM
4/10/19 6:30 AM
4/10/19 7:00 AM
4/10/19 7:30 AM
4/10/19 8:00 AM
4/10/19 8:30 AM
4/10/19 9:00 AM
4/10/19 9:30 AM
4/10/19 10:00 AM
4/10/19 10:30 AM
4/10/19 11:00 AM
4/10/19 11:30 AM
4/10/19 12:00 PM
4/10/19 12:30 PM
4/10/19 1:00 PM
4/10/19 1:30 PM
4/10/19 2:00 PM
4/10/19 2:30 PM
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4/10/19 3:30 PM
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4/10/19 4:30 PM
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4/10/19 5:30 PM
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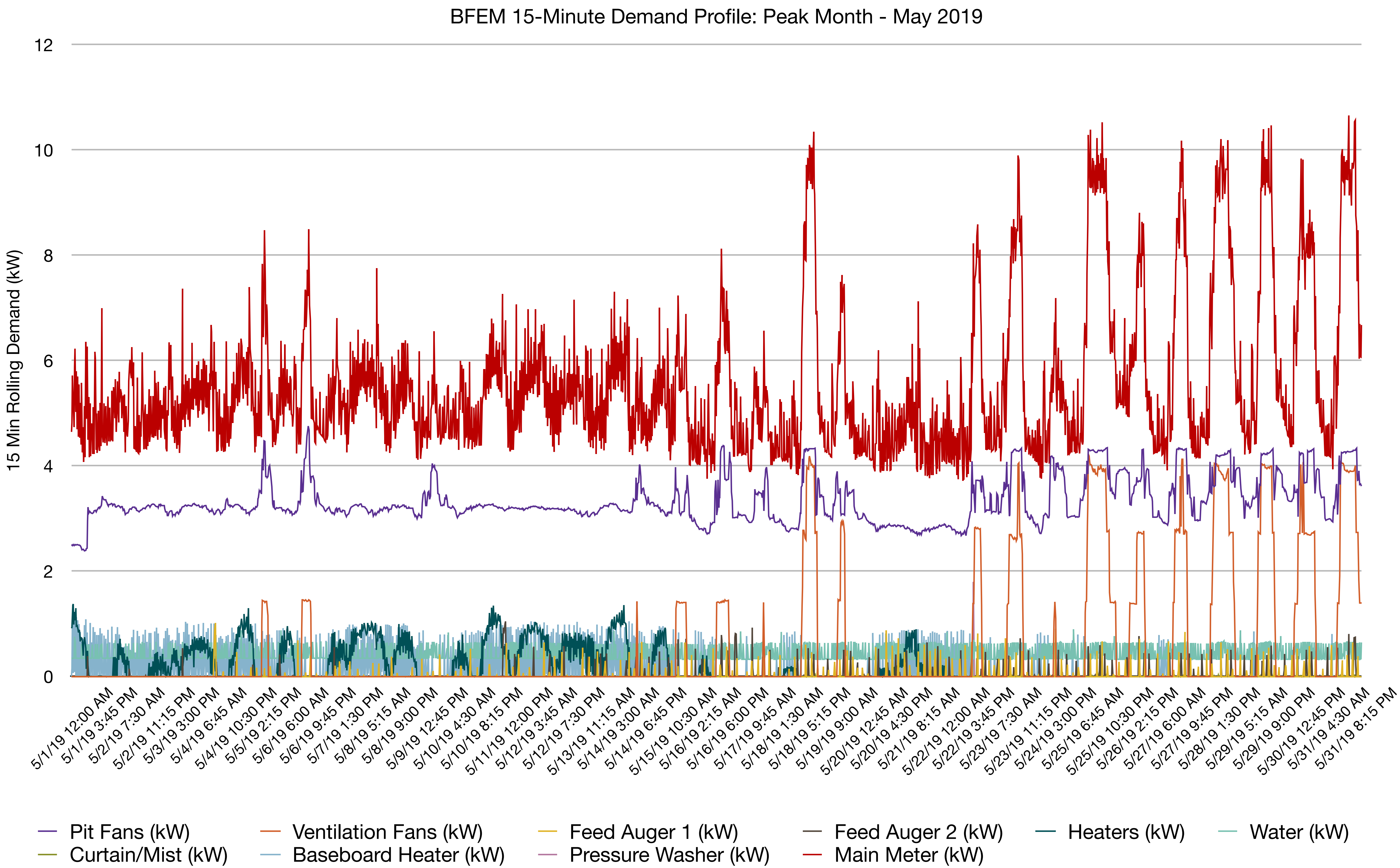
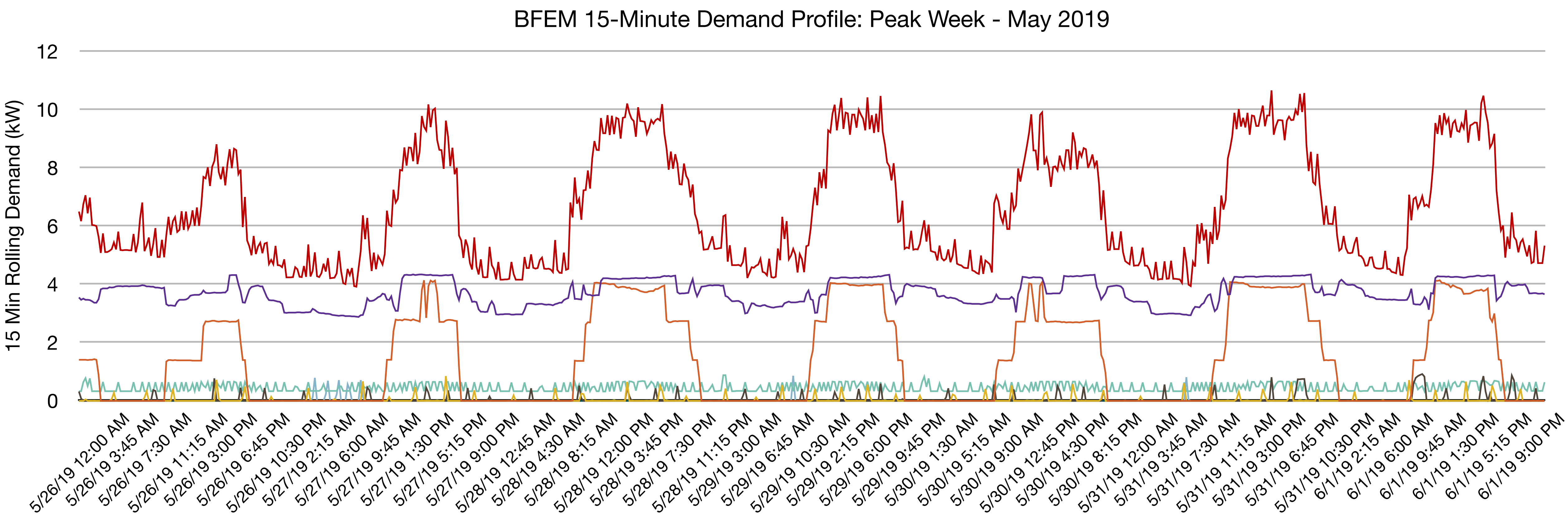
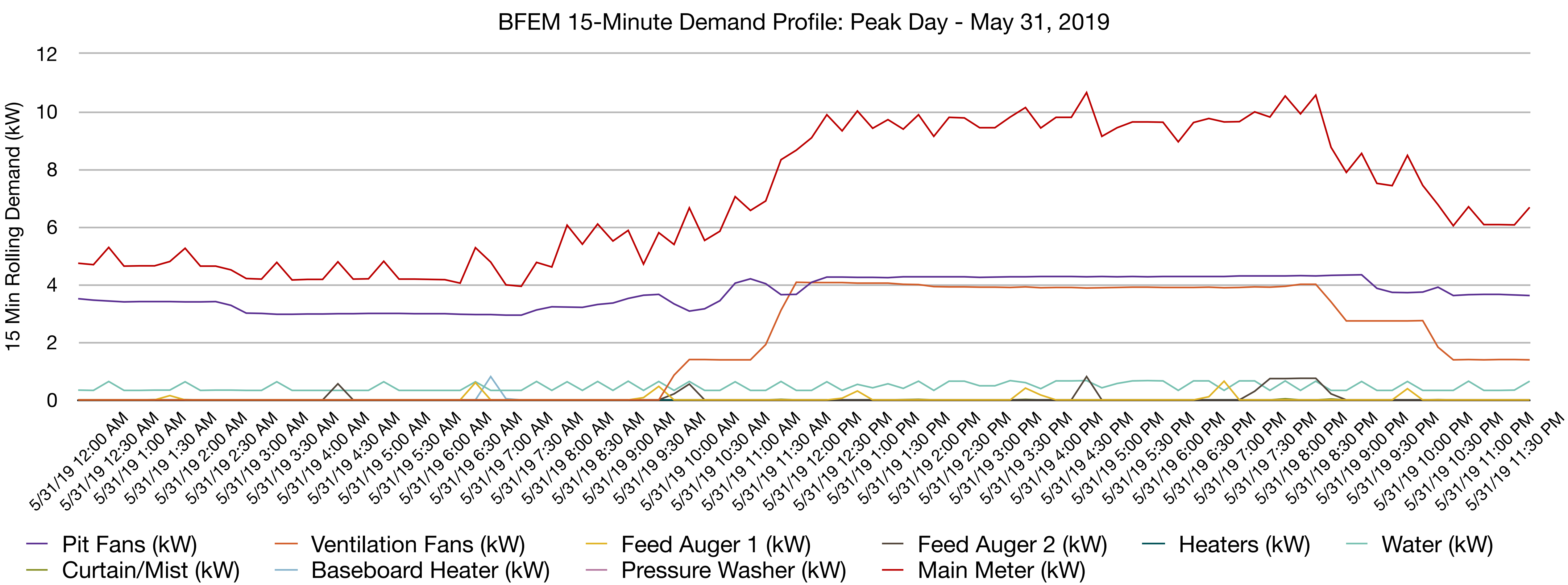
4/10/19 6:30 PM
4/10/19 7:00 PM
4/10/19 7:30 PM
4/10/19 8:00 PM
4/10/19 8:30 PM
4/10/19 9:00 PM
4/10/19 9:30 PM
4/10/19 10:00 PM
4/10/19 10:30 PM
4/10/19 11:00 PM
4/10/19 11:30 PM
Pit Fans (kW)
Ventilation Fans (kW)
Feed Auger 1 (kW)
Feed Auger 2 (kW)
Heaters (kW)
Water (kW)
Curtain/Mist (kW)
Baseboard Heater (kW)
Pressure Washer (kW)
Main Meter (kW)

MAY 2019

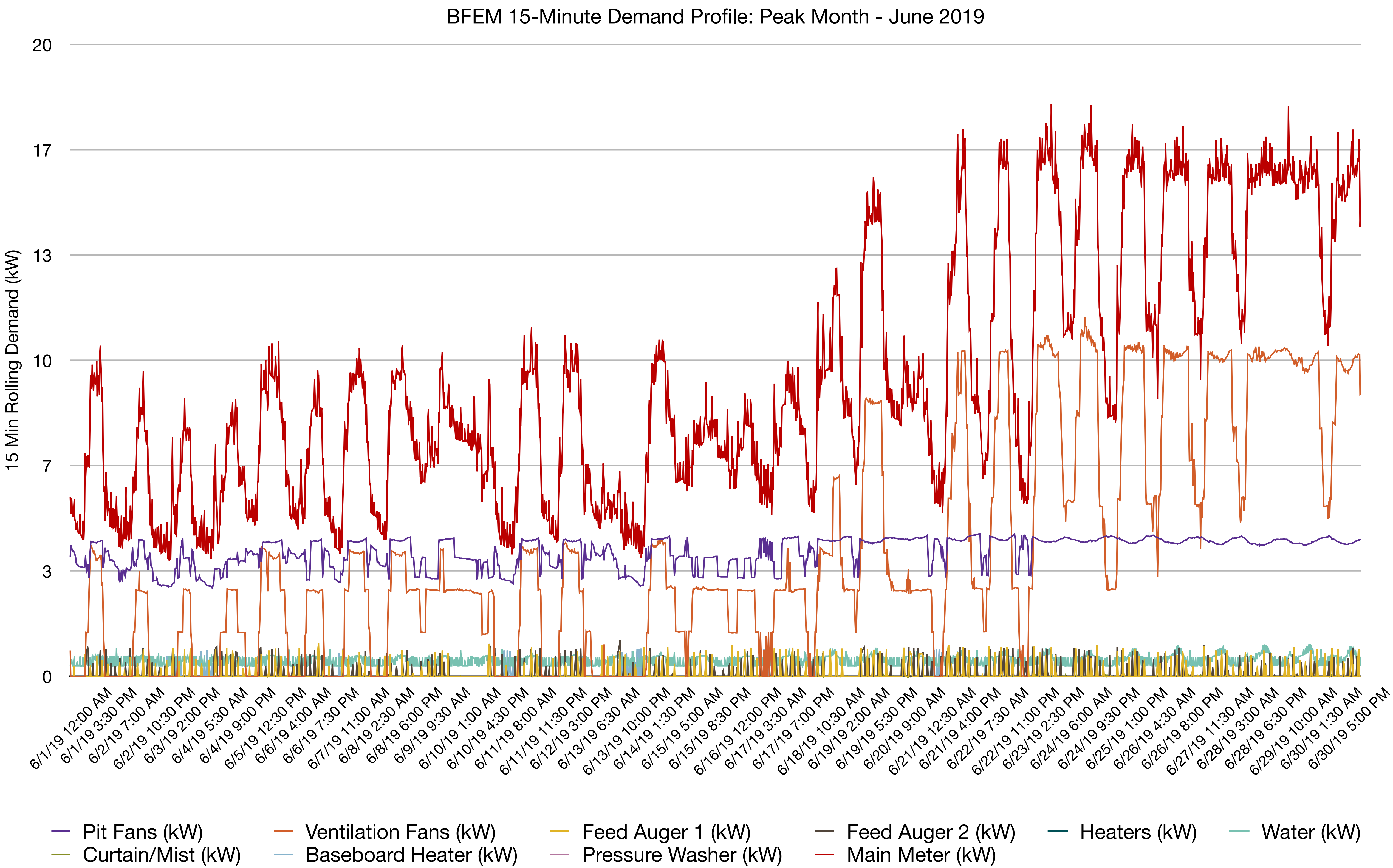


BFEM 15-Minute Demand Profile: Peak Month - May 2019
15 Min Rolling Demand (kW)
12
10
8
6
4
2
0
5/1/19 12:00 AM
5/1/19 3:45 PM
5/2/19 7:30 AM
5/2/19 11:15 PM
5/3/19 3:00 PM
5/4/19 6:45 AM
5/4/19 10:30 PM
5/5/19 2:15 PM
5/6/19 6:00 AM
5/6/19 9:45 PM
5/7/19 1:30 PM
5/8/19 5:15 AM
5/8/19 9:00 PM
5/9/19 12:45 PM
5/10/19 4:30 AM
5/10/19 8:15 PM
5/11/19 12:00 PM
5/12/19 3:45 AM
5/12/19 7:30 PM
5/13/19 11:15 AM
5/14/19 3:00 AM
5/14/19 6:45 PM
5/15/19 10:30 AM
5/16/19 2:15 AM
5/16/19 6:00 PM
5/17/19 9:45 AM
5/18/19 1:30 AM
5/18/19 5:15 PM
5/19/19 9:00 AM
5/20/19 12:45 AM
5/20/19 4:30 PM
5/21/19 8:15 AM
5/22/19 12:00 AM
5/22/19 3:45 PM
5/23/19 7:30 AM
5/23/19 11:15 PM
5/24/19 3:00 PM
5/25/19 6:45 AM
5/25/19 10:30 PM
5/26/19 2:15 PM
5/27/19 6:00 AM
5/27/19 9:45 PM
5/28/19 1:30 PM
5/29/19 5:15 AM
5/29/19 9:00 PM
5/30/19 12:45 PM
5/31/19 4:30 AM
5/31/19 8:15 PM
Pit Fans (kW)
Ventilation Fans (kW)
Feed Auger 1 (kW)
Feed Auger 2 (kW)
Heaters (kW)
Water (kW)
Curtain/Mist (kW)
Baseboard Heater (kW)
Pressure Washer (kW)
Main Meter (kW)


BFEM 15-Minute Demand Profile: Peak Week - May 2019
15 Min Rolling Demand (kW)
12
10
8
6
4
2
0

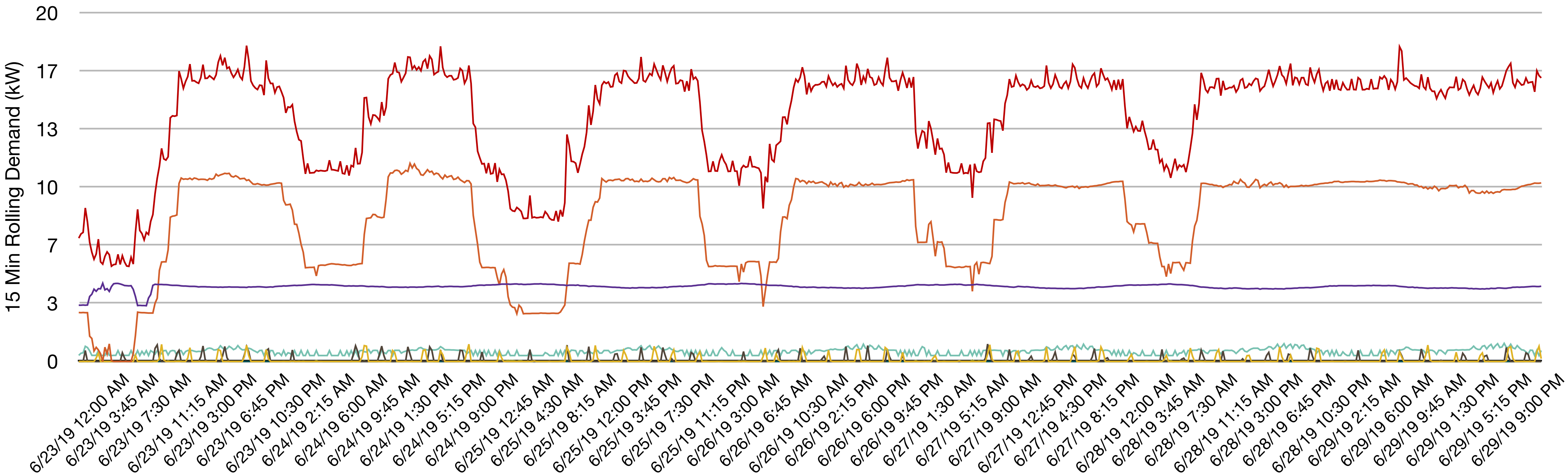

BFEM 15-Minute Demand Profile: Peak Day - May 31, 2019
15 Min Rolling Demand (kW)
12
10
8
6
4
2
0
Pit Fans (kW)
Ventilation Fans (kW)
Feed Auger 1 (kW)
Feed Auger 2 (kW)
Heaters (kW)
Water (kW)
Curtain/Mist (kW)
Baseboard Heater (kW)
Pressure Washer (kW)
Main Meter (kW)

JUNE 2019

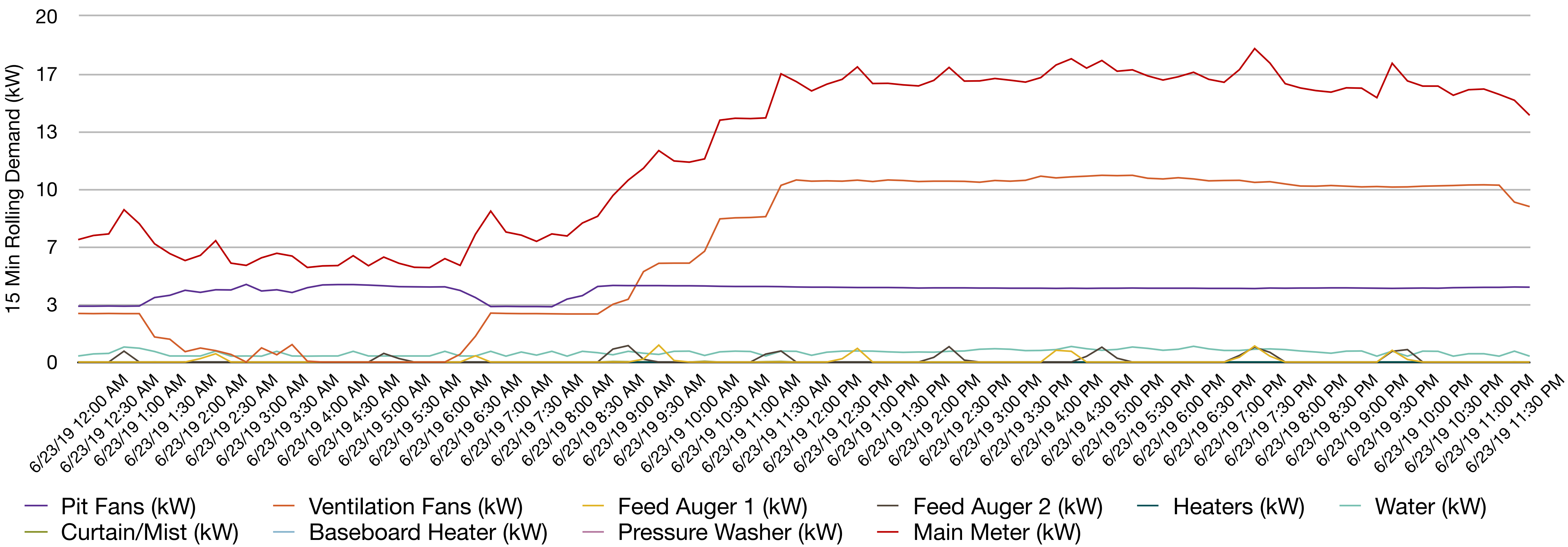


BFEM 15-Minute Demand Profile: Peak Month - June 2019
15 Min Rolling Demand (kW)
20
17
13
10
7
3
0
6/1/19 12:00 AM
6/1/19 3:30 PM
6/2/19 7:00 AM
6/2/19 10:30 PM
6/3/19 2:00 PM
6/4/19 5:30 AM
6/4/19 9:00 PM
6/5/19 12:30 PM
6/6/19 4:00 AM
6/6/19 7:30 PM
6/7/19 11:00 AM
6/8/19 2:30 AM
6/8/19 6:00 PM
6/9/19 9:30 AM
6/10/19 1:00 AM
6/10/19 4:30 PM
6/11/19 8:00 AM
6/11/19 11:30 PM
6/12/19 3:00 PM
6/13/19 6:30 AM
6/13/19 10:00 PM
6/14/19 1:30 PM
6/15/19 5:00 AM
6/15/19 8:30 PM
6/16/19 12:00 PM
6/17/19 3:30 AM
6/17/19 7:00 PM
6/18/19 10:30 AM
6/19/19 2:00 AM
6/19/19 5:30 PM
6/20/19 9:00 AM
6/21/19 12:30 AM
6/21/19 4:00 PM
6/22/19 7:30 AM
6/22/19 11:00 PM
6/23/19 2:30 PM
6/24/19 6:00 AM
6/24/19 9:30 PM
6/25/19 1:00 PM
6/26/19 4:30 AM
6/26/19 8:00 PM
6/27/19 11:30 AM
6/28/19 3:00 AM
6/28/19 6:30 PM
6/29/19 10:00 AM
6/30/19 1:30 AM
6/30/19 5:00 PM
Pit Fans (kW)
Ventilation Fans (kW)
Feed Auger 1 (kW)
Feed Auger 2 (kW)
Heaters (kW)
Water (kW)
Curtain/Mist (kW)
Baseboard Heater (kW)
Pressure Washer (kW)
Main Meter (kW)

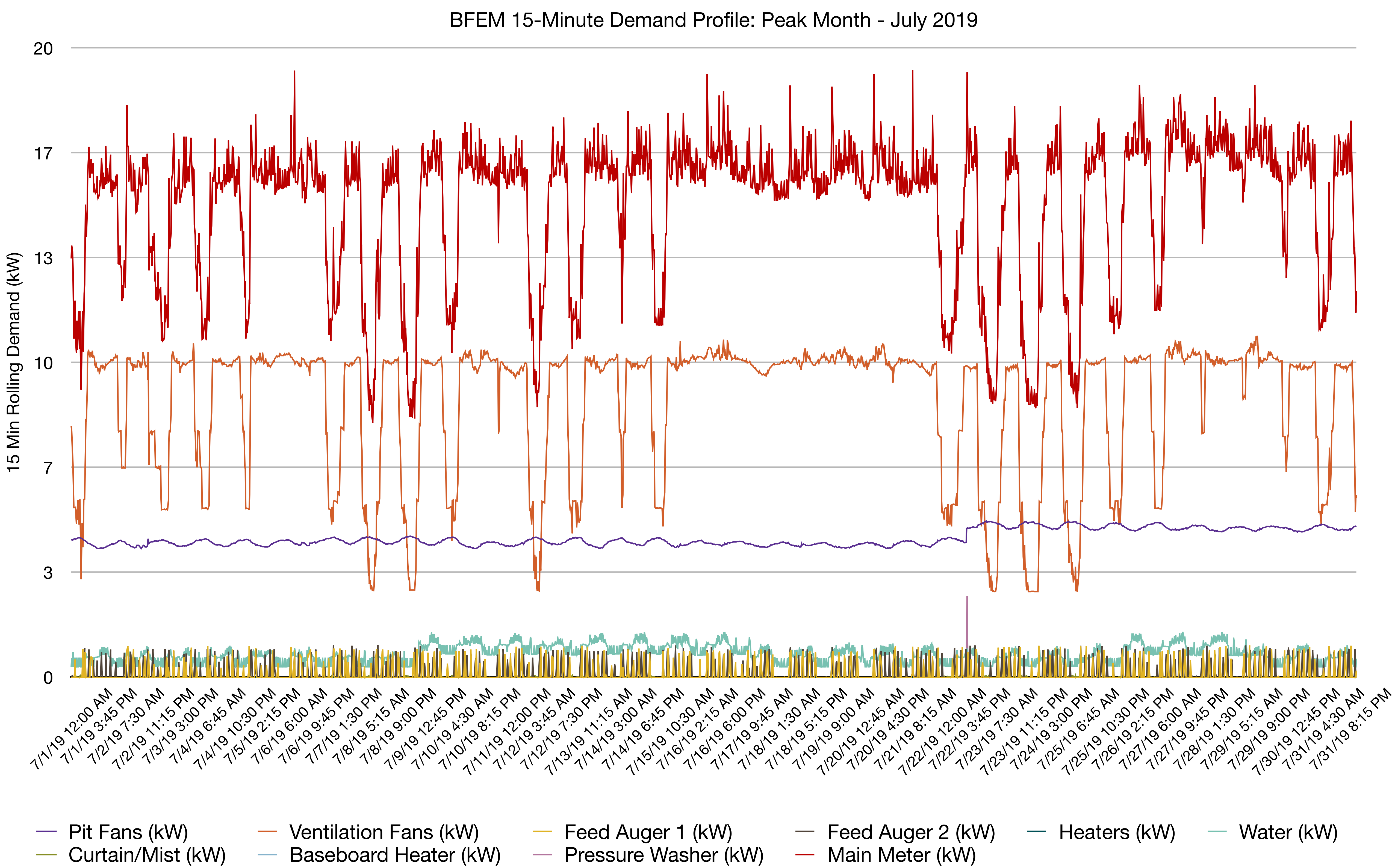
BFEM 15-Minute Demand Profile: Peak Week - June 2019



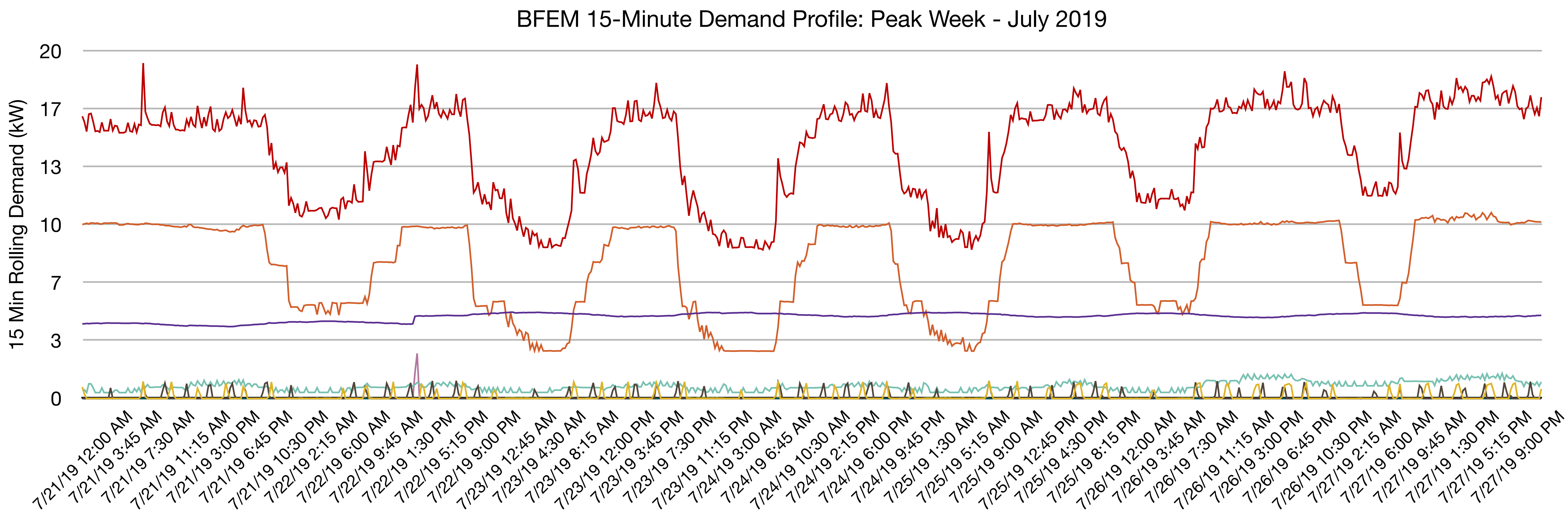
BFEM 15-Minute Demand Profile: Peak Day - June 23, 2019

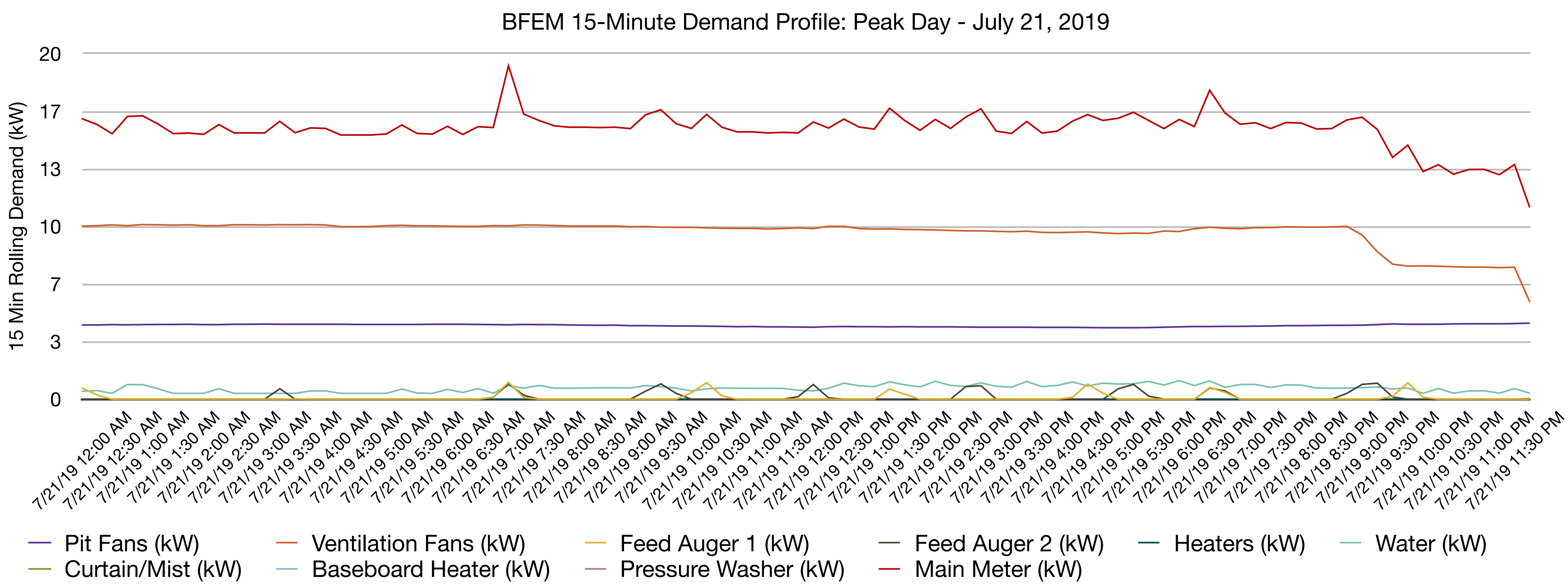


JULY 2019

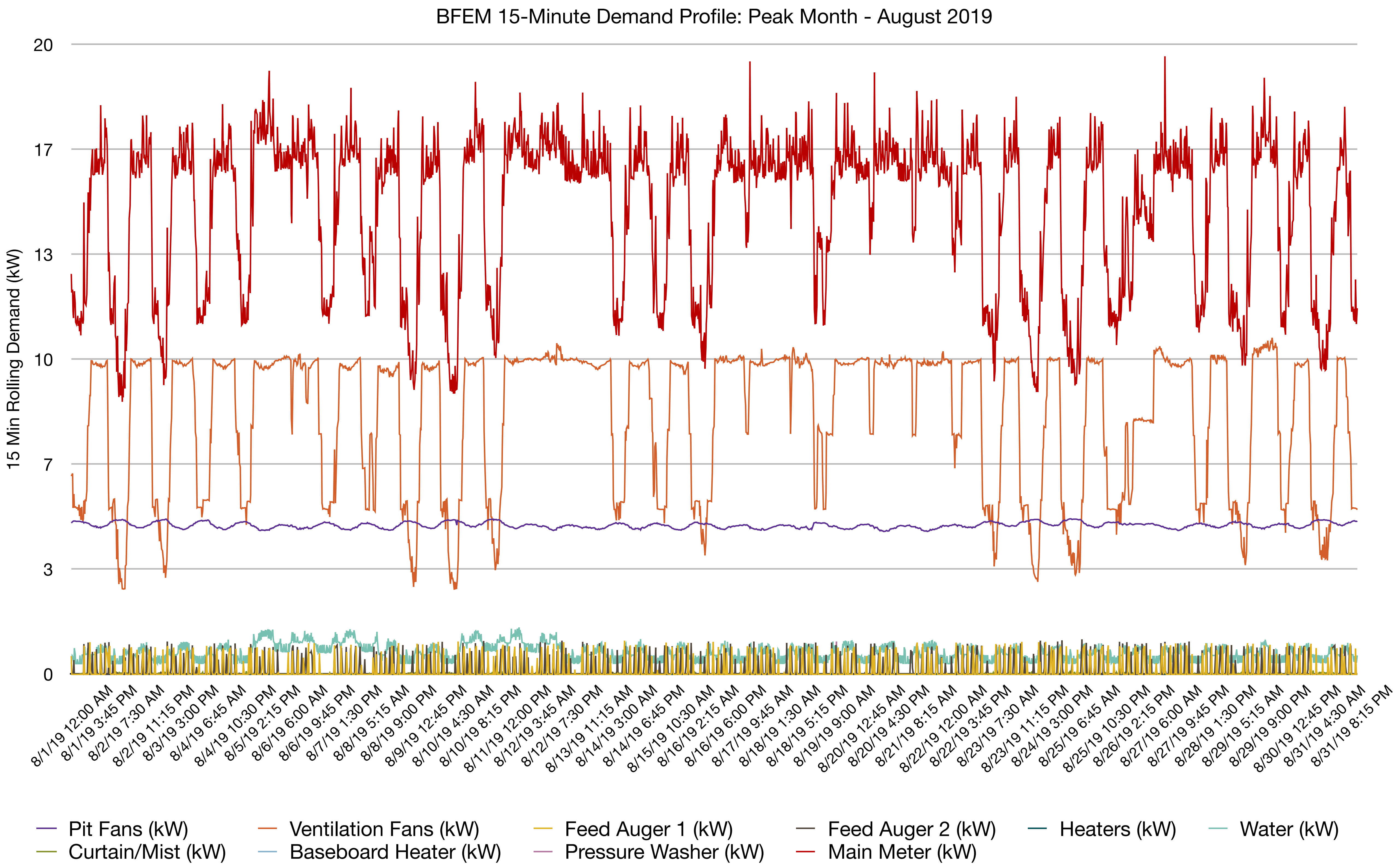


BFEM 15-Minute Demand Profile: Peak Month - July 2019
15 Min Rolling Demand (kW)
20
17
13
10
7
3
0
7/1/19 12:00 AM
7/1/19 3:45 PM
7/2/19 7:30 AM
7/2/19 11:15 PM
7/3/19 3:00 PM
7/4/19 6:45 AM
7/4/19 10:30 PM
7/5/19 2:15 PM
7/6/19 6:00 AM
7/6/19 9:45 PM
7/7/19 1:30 PM
7/8/19 5:15 AM
7/8/19 9:00 PM
7/9/19 12:45 PM
7/10/19 4:30 AM
7/10/19 8:15 PM
7/11/19 12:00 PM
7/12/19 3:45 AM
7/12/19 7:30 PM
7/13/19 11:15 AM
7/14/19 3:00 AM
7/14/19 6:45 PM
7/15/19 10:30 AM
7/16/19 2:15 AM
7/16/19 6:00 PM
7/17/19 9:45 AM
7/18/19 1:30 AM
7/18/19 5:15 PM
7/19/19 9:00 AM
7/20/19 12:45 AM
7/20/19 4:30 PM
7/21/19 8:15 AM
7/22/19 12:00 AM
7/22/19 3:45 PM
7/23/19 7:30 AM
7/23/19 11:15 PM
7/24/19 3:00 PM
7/25/19 6:45 AM
7/25/19 10:30 PM
7/26/19 2:15 PM
7/27/19 6:00 AM
7/27/19 9:45 PM
7/28/19 1:30 PM
7/29/19 5:15 AM
7/29/19 9:00 PM
7/30/19 12:45 PM
7/31/19 4:30 AM
7/31/19 8:15 PM
Pit Fans (kW)
Ventilation Fans (kW)
Feed Auger 1 (kW)
Feed Auger 2 (kW)
Heaters (kW)
Water (kW)
Curtain/Mist (kW)
Baseboard Heater (kW)
Pressure Washer (kW)
Main Meter (kW)

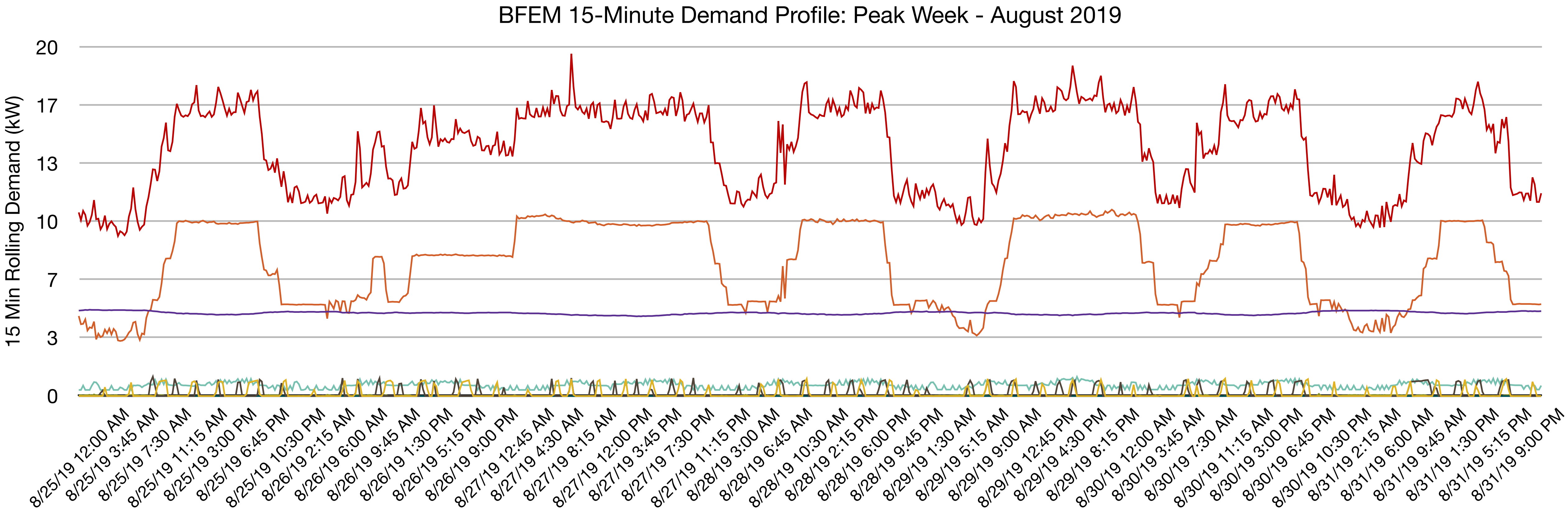

BFEM 15-Minute Demand Profile: Peak Week - July 2019
15 Min Rolling Demand (kW)
20
17
13
10
7
3
0
7/21/19 12:00 AM
7/21/19 3:45 AM
7/21/19 7:30 AM
7/21/19 11:15 AM
7/21/19 3:00 PM
7/21/19 6:45 PM
7/21/19 10:30 PM
7/22/19 2:15 AM
7/22/19 6:00 AM
7/22/19 9:45 AM
7/22/19 1:30 PM
7/22/19 5:15 PM
7/22/19 9:00 PM
7/23/19 12:45 AM
7/23/19 4:30 AM
7/23/19 8:15 AM
7/23/19 12:00 PM
7/23/19 3:45 PM
7/23/19 7:30 PM
7/23/19 11:15 PM
7/24/19 3:00 AM
7/24/19 6:45 AM
7/24/19 10:30 AM
7/24/19 2:15 PM
7/24/19 6:00 PM
7/24/19 9:45 PM
7/25/19 1:30 AM
7/25/19 5:15 AM
7/25/19 9:00 AM
7/25/19 12:45 PM
7/25/19 4:30 PM
7/25/19 8:15 PM
7/26/19 12:00 AM
7/26/19 3:45 AM
7/26/19 7:30 AM
7/26/19 11:15 AM
7/26/19 3:00 PM
7/26/19 6:45 PM
7/26/19 10:30 PM
7/27/19 2:15 AM
7/27/19 6:00 AM
7/27/19 9:45 AM
7/27/19 1:30 PM
7/27/19 5:15 PM
7/27/19 9:00 PM


BFEM 15-Minute Demand Profile: Peak Day - July 21, 2019
15 Min Rolling Demand (kW)
20
17
13
10
7
3
0
7/21/19 12:00 AM
7/21/19 12:30 AM
7/21/19 1:00 AM
7/21/19 1:30 AM
7/21/19 2:00 AM
7/21/19 2:30 AM
7/21/19 3:00 AM
7/21/19 3:30 AM
7/21/19 4:00 AM
7/21/19 4:30 AM
7/21/19 5:00 AM
7/21/19 5:30 AM
7/21/19 6:00 AM
7/21/19 6:30 AM
7/21/19 7:00 AM
7/21/19 7:30 AM
7/21/19 8:00 AM
7/21/19 8:30 AM
7/21/19 9:00 AM
7/21/19 9:30 AM
7/21/19 10:00 AM
7/21/19 10:30 AM
7/21/19 11:00 AM
7/21/19 11:30 AM
7/21/19 12:00 PM
7/21/19 12:30 PM
7/21/19 1:00 PM
7/21/19 1:30 PM
7/21/19 2:00 PM
7/21/19 2:30 PM
7/21/19 3:00 PM
7/21/19 3:30 PM
7/21/19 4:00 PM
7/21/19 4:30 PM
7/21/19 5:00 PM
7/21/19 5:30 PM
7/21/19 6:00 PM
7/21/19 6:30 PM
7/21/19 7:00 PM
7/21/19 7:30 PM
7/21/19 8:00 PM
7/21/19 8:30 PM
7/21/19 9:00 PM
7/21/19 9:30 PM
7/21/19 10:00 PM
7/21/19 10:30 PM
7/21/19 11:00 PM
7/21/19 11:30 PM
Pit Fans (kW)
Ventilation Fans (kW)
Feed Auger 1 (kW)
Feed Auger 2 (kW)
Heaters (kW)
Water (kW)
Curtain/Mist (kW)
Baseboard Heater (kW)
Pressure Washer (kW)
Main Meter (kW)

AUGUST 2019



BFEM 15-Minute Demand Profile: Peak Month - August 2019
15 Min Rolling Demand (kW)
20
17
13
10
7
3
0
8/1/19 12:00 AM
8/1/19 3:45 PM
8/2/19 7:30 AM
8/2/19 11:15 PM
8/3/19 3:00 PM
8/4/19 6:45 AM
8/4/19 10:30 PM
8/5/19 2:15 PM
8/6/19 6:00 AM
8/6/19 9:45 PM
8/7/19 1:30 PM
8/8/19 5:15 AM
8/8/19 9:00 PM
8/9/19 12:45 PM
8/10/19 4:30 AM
8/10/19 8:15 PM
8/11/19 12:00 PM
8/12/19 3:45 AM
8/12/19 7:30 PM
8/13/19 11:15 AM
8/14/19 3:00 AM
8/14/19 6:45 PM
8/15/19 10:30 AM
8/16/19 2:15 AM
8/16/19 6:00 PM
8/17/19 9:45 AM
8/18/19 1:30 AM
8/18/19 5:15 PM
8/19/19 9:00 AM
8/20/19 12:45 AM
8/20/19 4:30 PM
8/21/19 8:15 AM
8/22/19 12:00 AM
8/22/19 3:45 PM
8/23/19 7:30 AM
8/23/19 11:15 PM
8/24/19 3:00 PM
8/25/19 6:45 AM
8/25/19 10:30 PM
8/26/19 2:15 PM
8/27/19 6:00 AM
8/27/19 9:45 PM
8/28/19 1:30 PM
8/29/19 5:15 AM
8/29/19 9:00 PM
8/30/19 12:45 PM
8/31/19 4:30 AM
8/31/19 8:15 PM
Pit Fans (kW)
Ventilation Fans (kW)
Feed Auger 1 (kW)
Feed Auger 2 (kW)
Heaters (kW)
Water (kW)
Curtain/Mist (kW)
Baseboard Heater (kW)
Pressure Washer (kW)
Main Meter (kW)


BFEM 15-Minute Demand Profile: Peak Week - August 2019
15 Min Rolling Demand (kW)
20
17
13
10
7
3
0
8/25/19 12:00 AM
8/25/19 3:45 AM
8/25/19 7:30 AM
8/25/19 11:15 AM
8/25/19 3:00 PM
8/25/19 6:45 PM
8/25/19 10:30 PM
8/26/19 2:15 AM
8/26/19 6:00 AM
8/26/19 9:45 AM
8/26/19 1:30 PM
8/26/19 5:15 PM
8/26/19 9:00 PM
8/27/19 12:45 AM
8/27/19 4:30 AM
8/27/19 8:15 AM
8/27/19 12:00 PM
8/27/19 3:45 PM
8/27/19 7:30 PM
8/27/19 11:15 PM
8/28/19 3:00 AM
8/28/19 6:45 AM
8/28/19 10:30 AM
8/28/19 2:15 PM
8/28/19 6:00 PM
8/28/19 9:45 PM
8/29/19 1:30 AM
8/29/19 5:15 AM
8/29/19 9:00 AM
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8/29/19 8:15 PM
8/30/19 12:00 AM
8/30/19 3:45 AM
8/30/19 7:30 AM
8/30/19 11:15 AM
8/30/19 3:00 PM
8/30/19 6:45 PM
8/30/19 10:30 PM
8/31/19 2:15 AM
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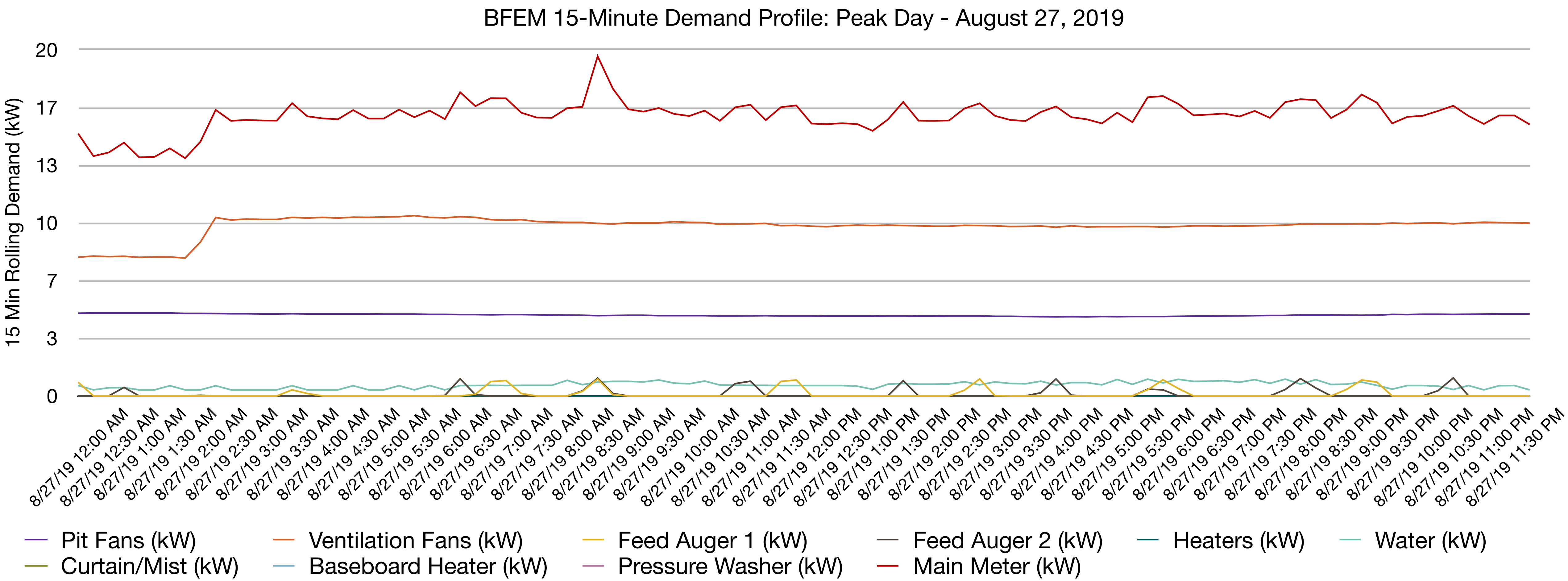
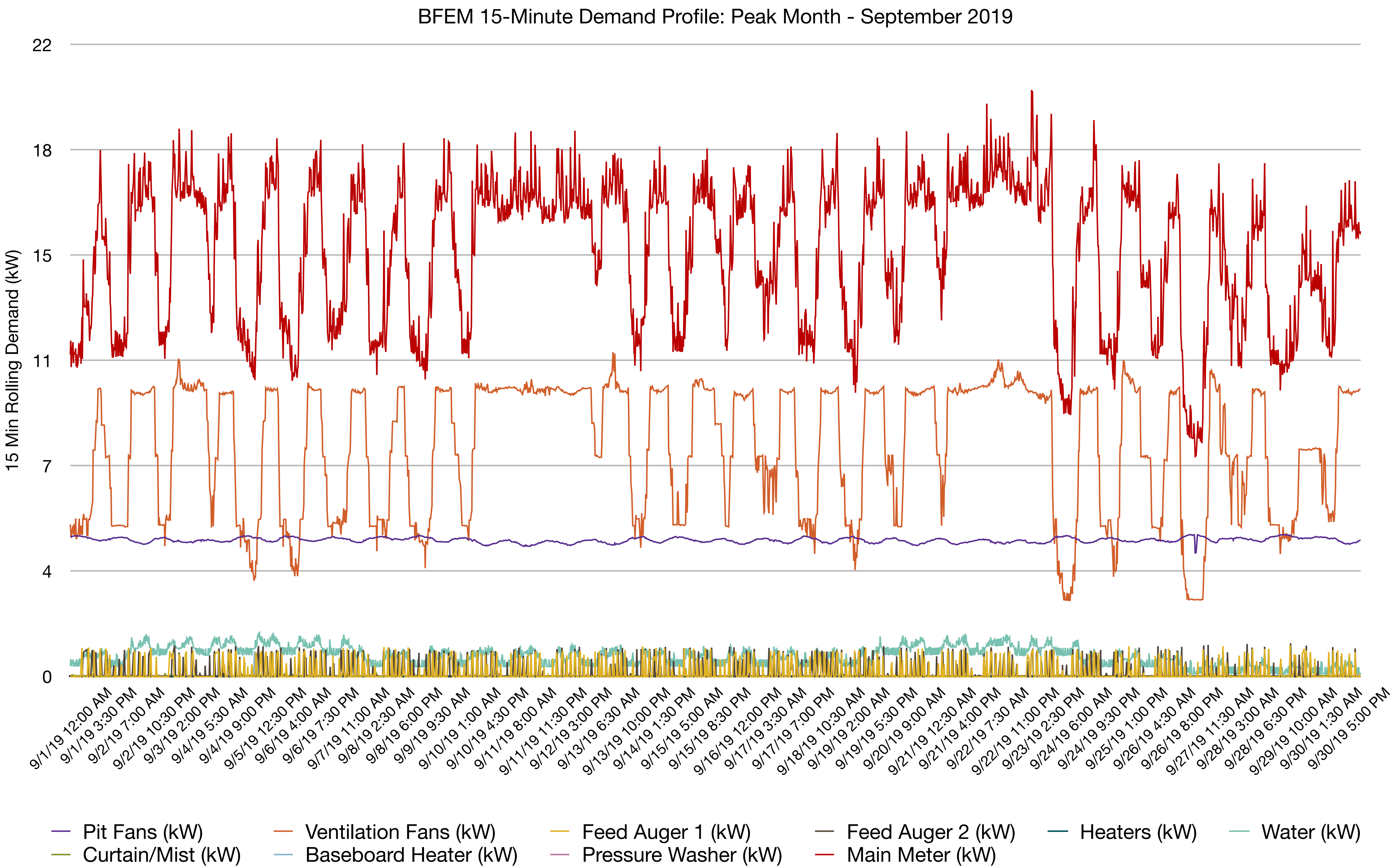
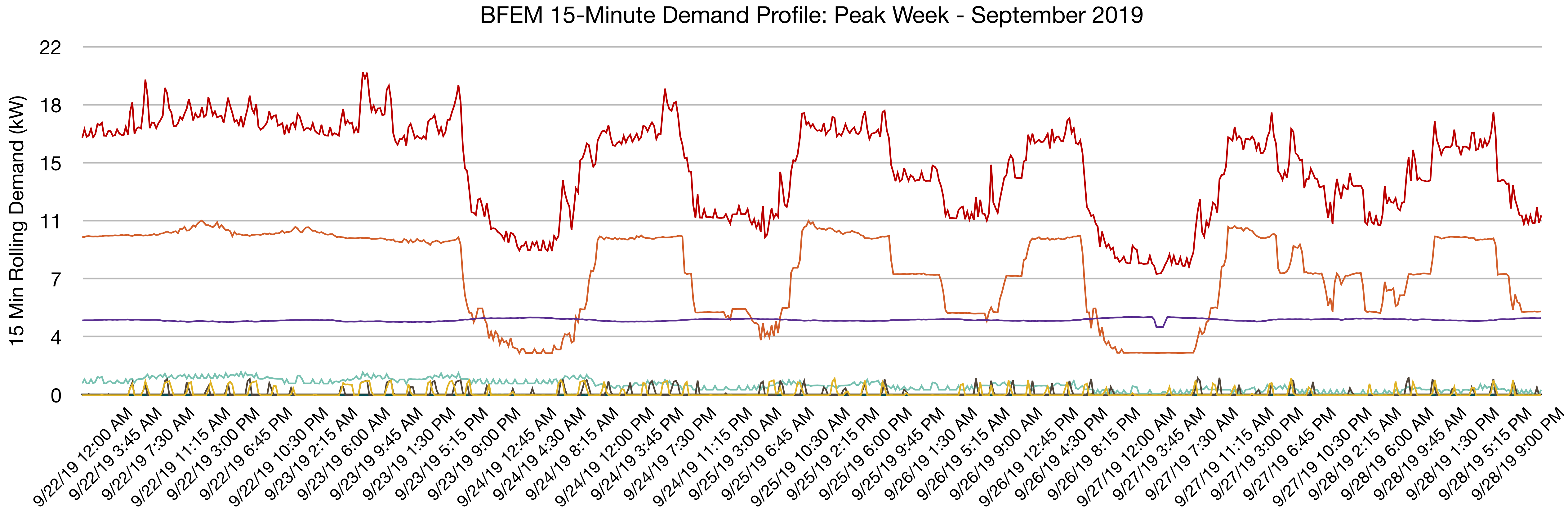
8/31/19 9:00 PM


BFEM 15-Minute Demand Profile: Peak Day - August 27, 2019
15 Min Rolling Demand (kW)
20
17
13
10
7
3
0
8/27/19 12:00 AM
8/27/19 12:30 AM
8/27/19 1:00 AM
8/27/19 1:30 AM
8/27/19 2:00 AM
8/27/19 2:30 AM
8/27/19 3:00 AM
8/27/19 3:30 AM
8/27/19 4:00 AM
8/27/19 4:30 AM
8/27/19 5:00 AM
8/27/19 5:30 AM
8/27/19 6:00 AM
8/27/19 6:30 AM
8/27/19 7:00 AM
8/27/19 7:30 AM
8/27/19 8:00 AM
8/27/19 8:30 AM
8/27/19 9:00 AM
8/27/19 9:30 AM
8/27/19 10:00 AM
8/27/19 10:30 AM
8/27/19 11:00 AM
8/27/19 11:30 AM
8/27/19 12:00 PM
8/27/19 12:30 PM
8/27/19 1:00 PM
8/27/19 1:30 PM
8/27/19 2:00 PM
8/27/19 2:30 PM
8/27/19 3:00 PM
8/27/19 3:30 PM
8/27/19 4:00 PM
8/27/19 4:30 PM
8/27/19 5:00 PM
8/27/19 5:30 PM
8/27/19 6:00 PM
8/27/19 6:30 PM
8/27/19 7:00 PM
8/27/19 7:30 PM
8/27/19 8:00 PM
8/27/19 8:30 PM
8/27/19 9:00 PM
8/27/19 9:30 PM
8/27/19 10:00 PM
8/27/19 10:30 PM
8/27/19 11:00 PM
8/27/19 11:30 PM
Pit Fans (kW)
Ventilation Fans (kW)
Feed Auger 1 (kW)
Feed Auger 2 (kW)
Heaters (kW)
Water (kW)
Curtain/Mist (kW)
Baseboard Heater (kW)
Pressure Washer (kW)
Main Meter (kW)

SEPTEMBER 2019




BFEM 15-Minute Demand Profile: Peak Week - September 2019
15 Min Rolling Demand (kW)
22
18
15
11
7
4
0
9/22/19 12:00 AM
9/22/19 3:45 AM
9/22/19 7:30 AM
9/22/19 11:15 AM
9/22/19 3:00 PM
9/22/19 6:45 PM
9/22/19 10:30 PM
9/23/19 2:15 AM
9/23/19 6:00 AM
9/23/19 9:45 AM
9/23/19 1:30 PM
9/23/19 5:15 PM
9/23/19 9:00 PM
9/24/19 12:45 AM
9/24/19 4:30 AM
9/24/19 8:15 AM
9/24/19 12:00 PM
9/24/19 3:45 PM
9/24/19 7:30 PM
9/24/19 11:15 PM
9/25/19 3:00 AM
9/25/19 6:45 AM
9/25/19 10:30 AM
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9/25/19 9:45 PM
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9/26/19 5:15 AM
9/26/19 9:00 AM
9/26/19 12:45 PM
9/26/19 4:30 PM
9/26/19 8:15 PM
9/27/19 12:00 AM
9/27/19 3:45 AM
9/27/19 7:30 AM
9/27/19 11:15 AM
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9/27/19 6:45 PM
9/27/19 10:30 PM
9/28/19 2:15 AM
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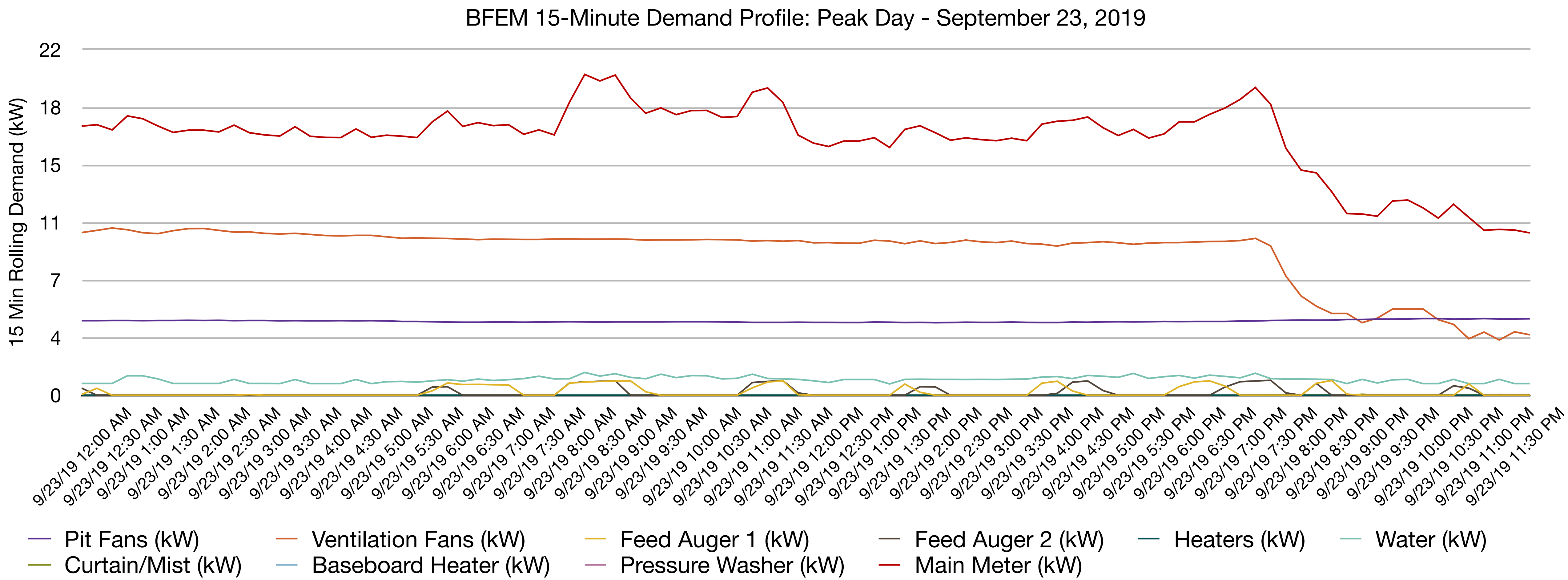
9/28/19 9:00 PM


BFEM 15-Minute Demand Profile: Peak Day - September 23, 2019
15 Min Rolling Demand (kW)
22
18
15
11
7
4
0
9/23/19 12:00 AM
9/23/19 12:30 AM
9/23/19 1:00 AM
9/23/19 1:30 AM
9/23/19 2:00 AM
9/23/19 2:30 AM
9/23/19 3:00 AM
9/23/19 3:30 AM
9/23/19 4:00 AM
9/23/19 4:30 AM
9/23/19 5:00 AM
9/23/19 5:30 AM
9/23/19 6:00 AM
9/23/19 6:30 AM
9/23/19 7:00 AM
9/23/19 7:30 AM
9/23/19 8:00 AM
9/23/19 8:30 AM
9/23/19 9:00 AM
9/23/19 9:30 AM
9/23/19 10:00 AM
9/23/19 10:30 AM
9/23/19 11:00 AM
9/23/19 11:30 AM
9/23/19 12:00 PM
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9/23/19 1:00 PM
9/23/19 1:30 PM
9/23/19 2:00 PM
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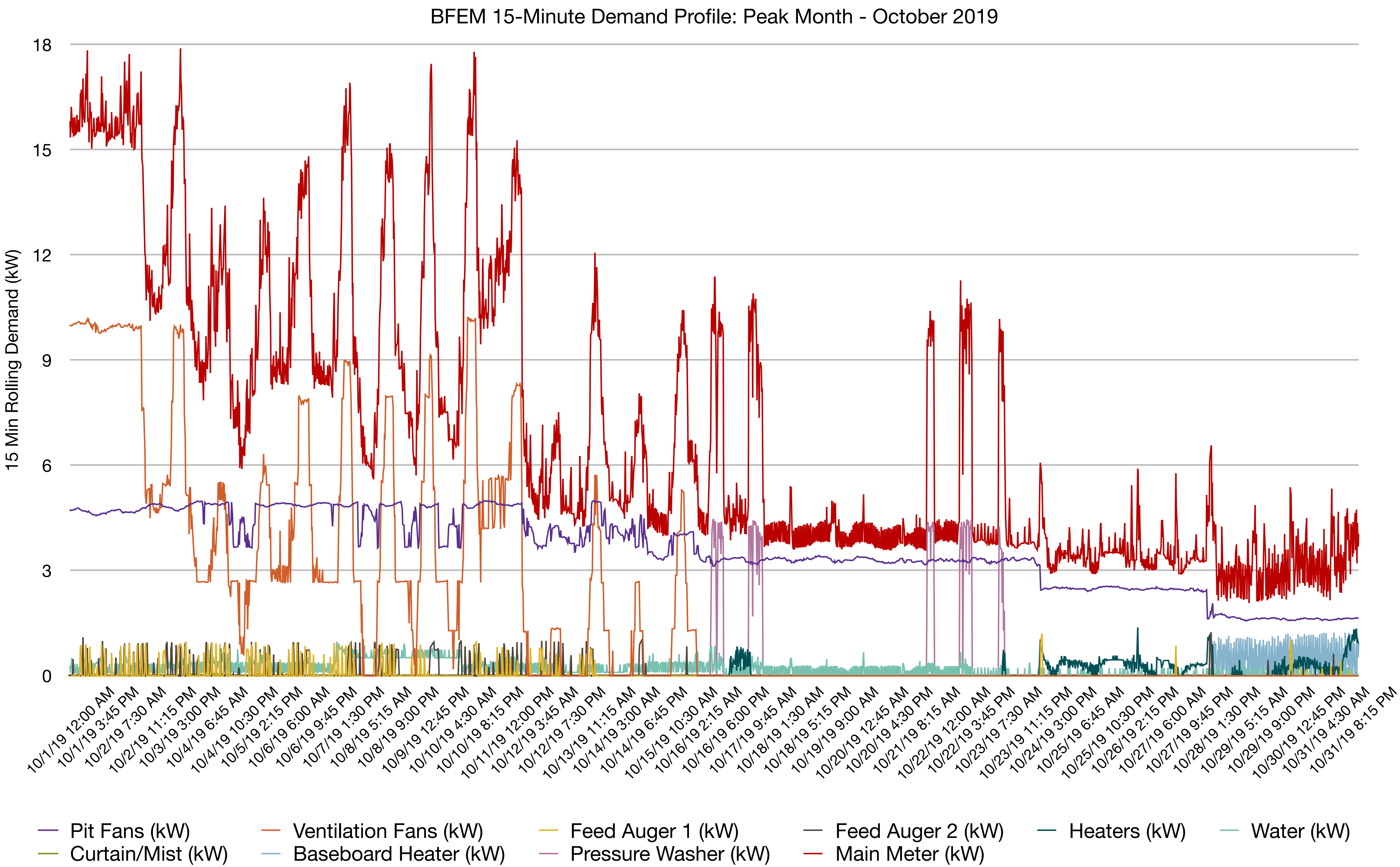
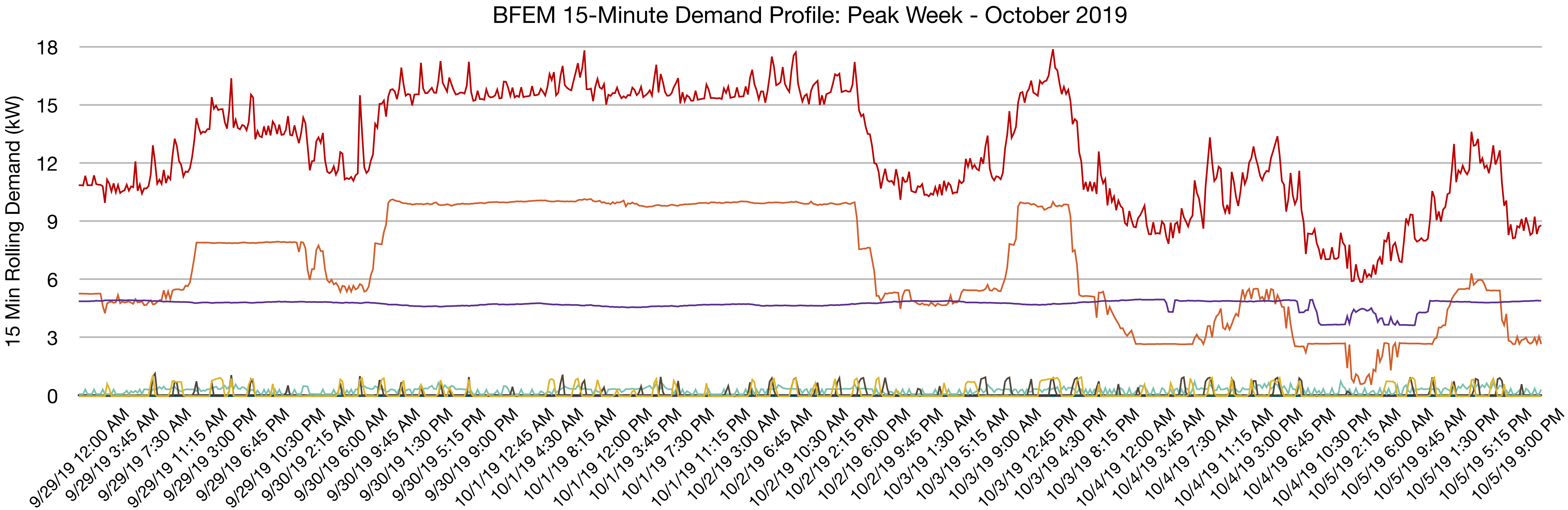
9/23/19 3:00 PM
9/23/19 3:30 PM
9/23/19 4:00 PM
9/23/19 4:30 PM
9/23/19 5:00 PM
9/23/19 5:30 PM
9/23/19 6:00 PM
9/23/19 6:30 PM
9/23/19 7:00 PM
9/23/19 7:30 PM
9/23/19 8:00 PM
9/23/19 8:30 PM
9/23/19 9:00 PM
9/23/19 9:30 PM
9/23/19 10:00 PM
9/23/19 10:30 PM
9/23/19 11:00 PM
9/23/19 11:30 PM
Pit Fans (kW)
Ventilation Fans (kW)
Feed Auger 1 (kW)
Feed Auger 2 (kW)
Heaters (kW)
Water (kW)
Curtain/Mist (kW)
Baseboard Heater (kW)
Pressure Washer (kW)
Main Meter (kW)

OCTOBER 2019





BFEM 15-Minute Demand Profile: Peak Week - October 2019
15 Min Rolling Demand (kW)
18
15
12
9
6
3
0
9/29/19 12:00 AM
9/29/19 3:45 AM
9/29/19 7:30 AM
9/29/19 11:15 AM
9/29/19 3:00 PM
9/29/19 6:45 PM
9/29/19 10:30 PM
9/30/19 2:15 AM
9/30/19 6:00 AM
9/30/19 9:45 AM
9/30/19 1:30 PM
9/30/19 5:15 PM
9/30/19 9:00 PM
10/1/19 12:45 AM
10/1/19 4:30 AM
10/1/19 8:15 AM
10/1/19 12:00 PM
10/1/19 3:45 PM
10/1/19 7:30 PM
10/1/19 11:15 PM
10/2/19 3:00 AM
10/2/19 6:45 AM
10/2/19 10:30 AM
10/2/19 2:15 PM
10/2/19 6:00 PM
10/2/19 9:45 PM
10/3/19 1:30 AM
10/3/19 5:15 AM
10/3/19 9:00 AM
10/3/19 12:45 PM
10/3/19 4:30 PM
10/3/19 8:15 PM
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10/4/19 3:45 AM
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10/4/19 10:30 PM
10/5/19 2:15 AM
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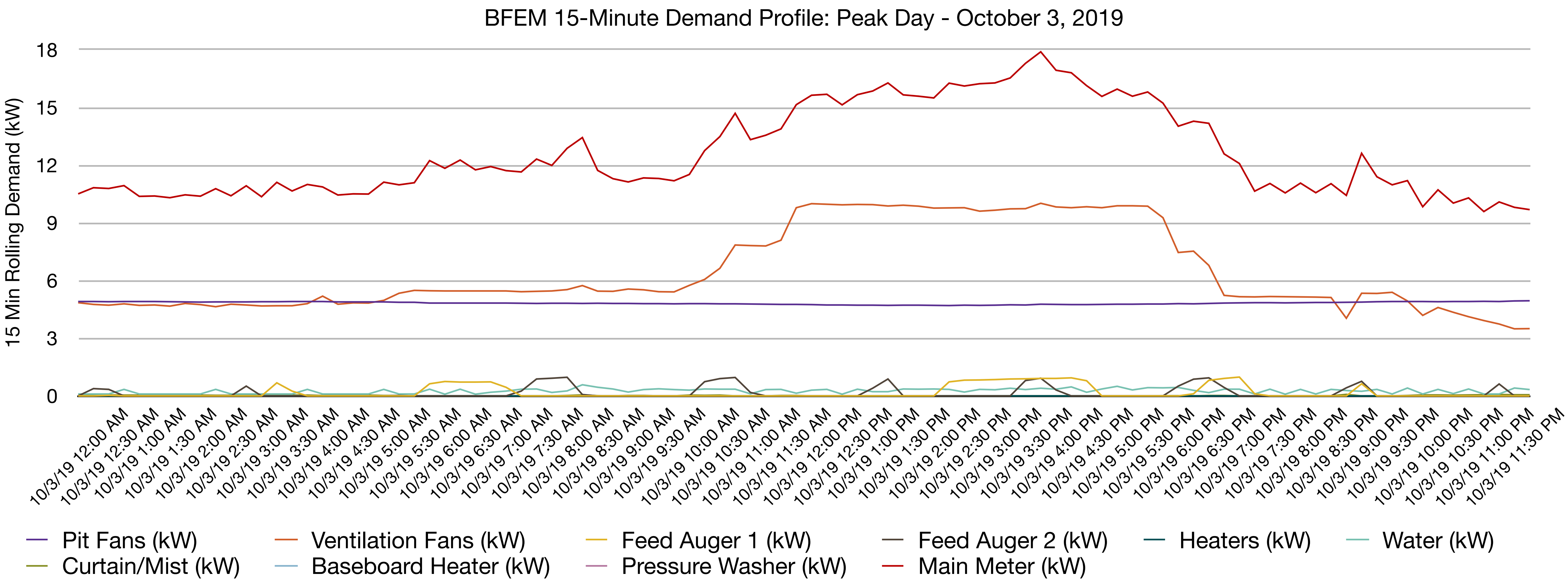
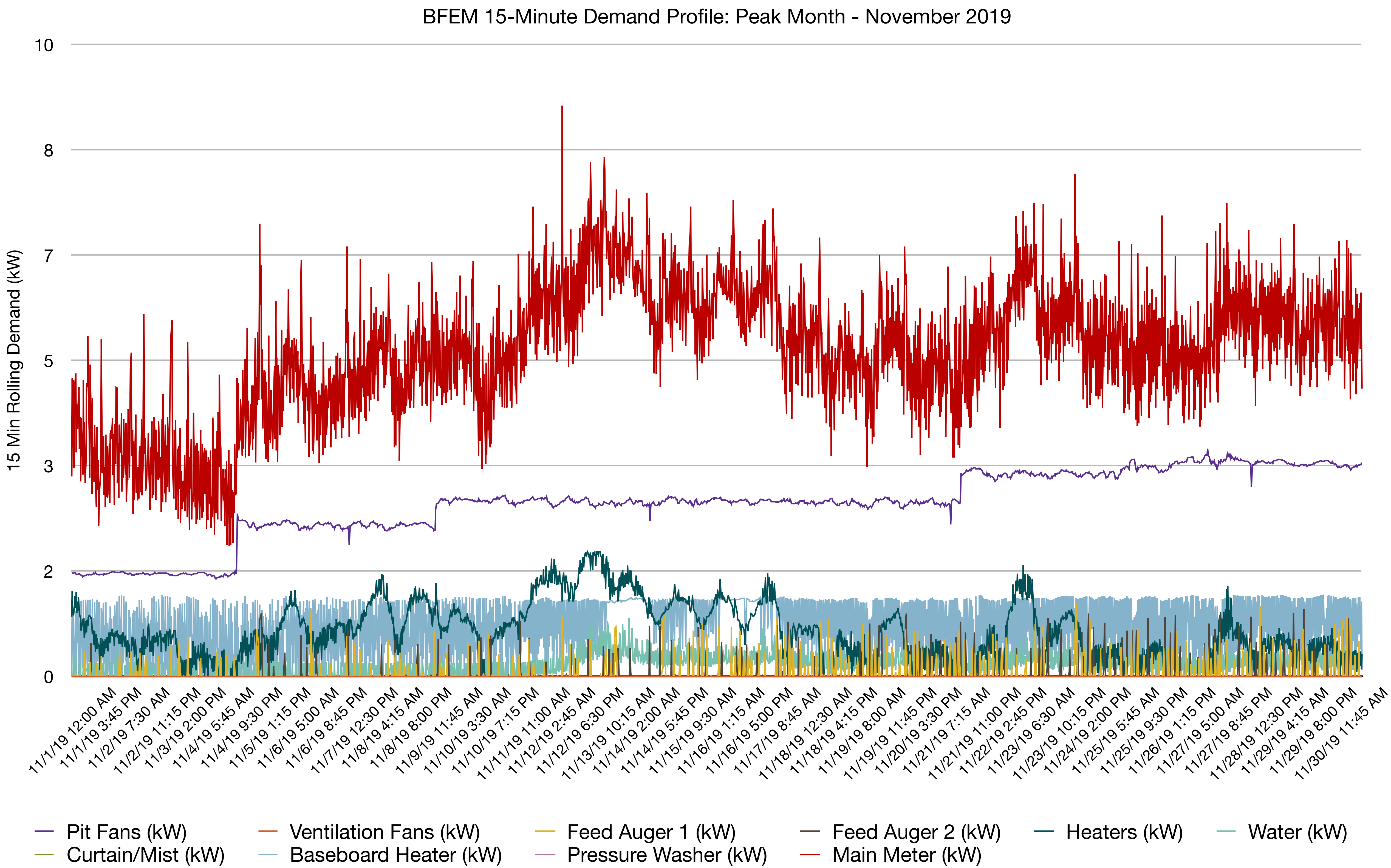
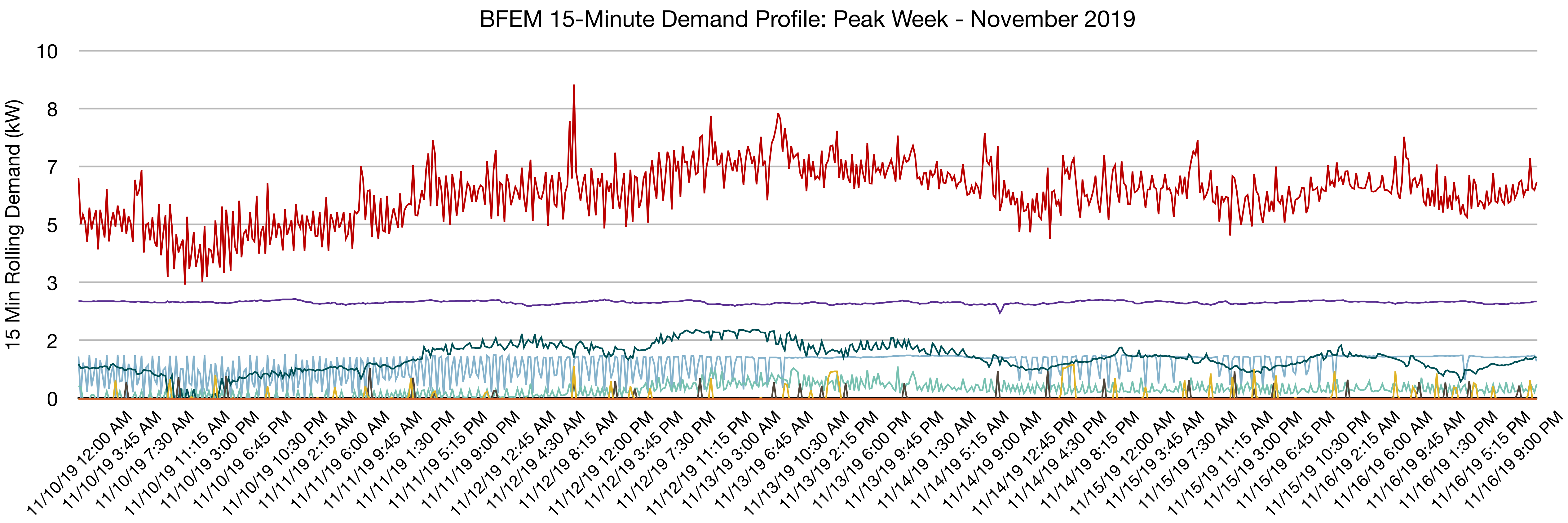
10/5/19 9:00 PM



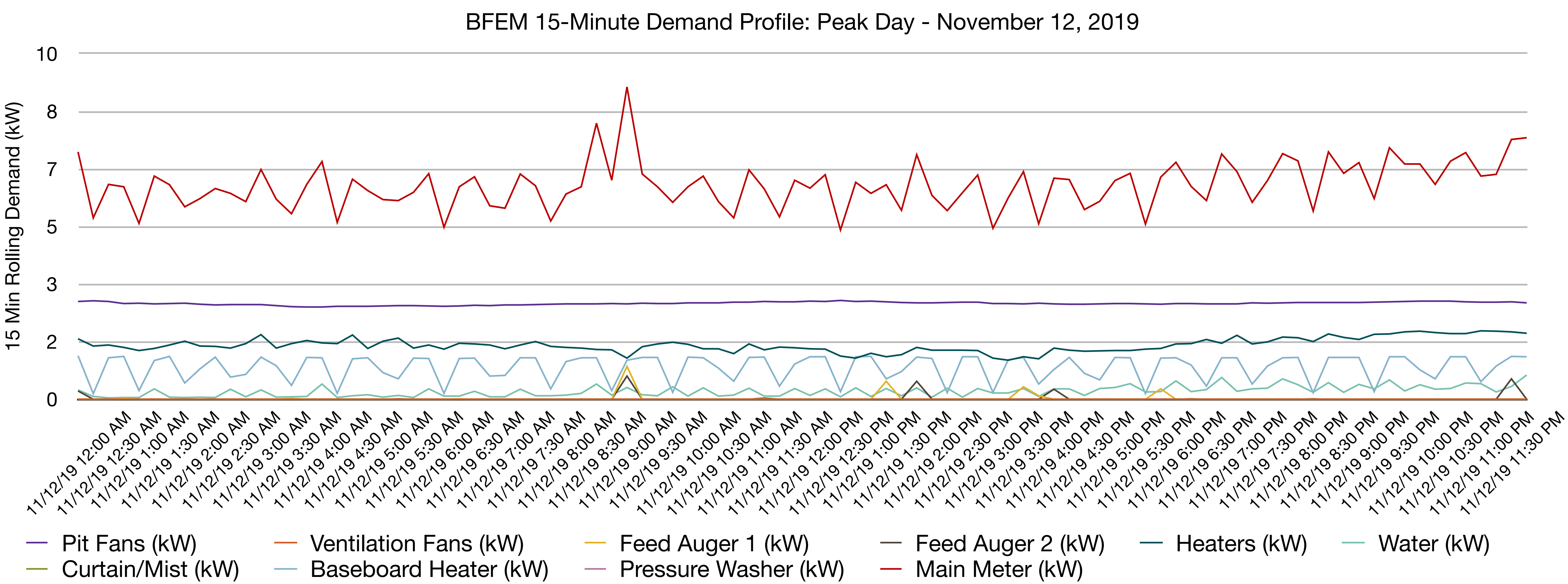
BFEM 15-Minute Demand Profile: Peak Day - October 3, 2019
15 Min Rolling Demand (kW)
18
15
12
9
6
3
0
10/3/19 12:00 AM
10/3/19 12:30 AM
10/3/19 1:00 AM
10/3/19 1:30 AM
10/3/19 2:00 AM
10/3/19 2:30 AM
10/3/19 3:00 AM
10/3/19 3:30 AM
10/3/19 4:00 AM
10/3/19 4:30 AM
10/3/19 5:00 AM
10/3/19 5:30 AM
10/3/19 6:00 AM
10/3/19 6:30 AM
10/3/19 7:00 AM
10/3/19 7:30 AM
10/3/19 8:00 AM
10/3/19 8:30 AM
10/3/19 9:00 AM
10/3/19 9:30 AM
10/3/19 10:00 AM
10/3/19 10:30 AM
10/3/19 11:00 AM
10/3/19 11:30 AM
10/3/19 12:00 PM
10/3/19 12:30 PM
10/3/19 1:00 PM
10/3/19 1:30 PM
10/3/19 2:00 PM
10/3/19 2:30 PM
10/3/19 3:00 PM
10/3/19 3:30 PM
10/3/19 4:00 PM
10/3/19 4:30 PM
10/3/19 5:00 PM
10/3/19 5:30 PM
10/3/19 6:00 PM
10/3/19 6:30 PM
10/3/19 7:00 PM
10/3/19 7:30 PM
10/3/19 8:00 PM
10/3/19 8:30 PM
10/3/19 9:00 PM
10/3/19 9:30 PM
10/3/19 10:00 PM
10/3/19 10:30 PM
10/3/19 11:00 PM
10/3/19 11:30 PM
Pit Fans (kW)
Ventilation Fans (kW)
Feed Auger 1 (kW)
Feed Auger 2 (kW)
Heaters (kW)
Water (kW)
Curtain/Mist (kW)
Baseboard Heater (kW)
Pressure Washer (kW)
Main Meter (kW)

NOVEMBER 2019



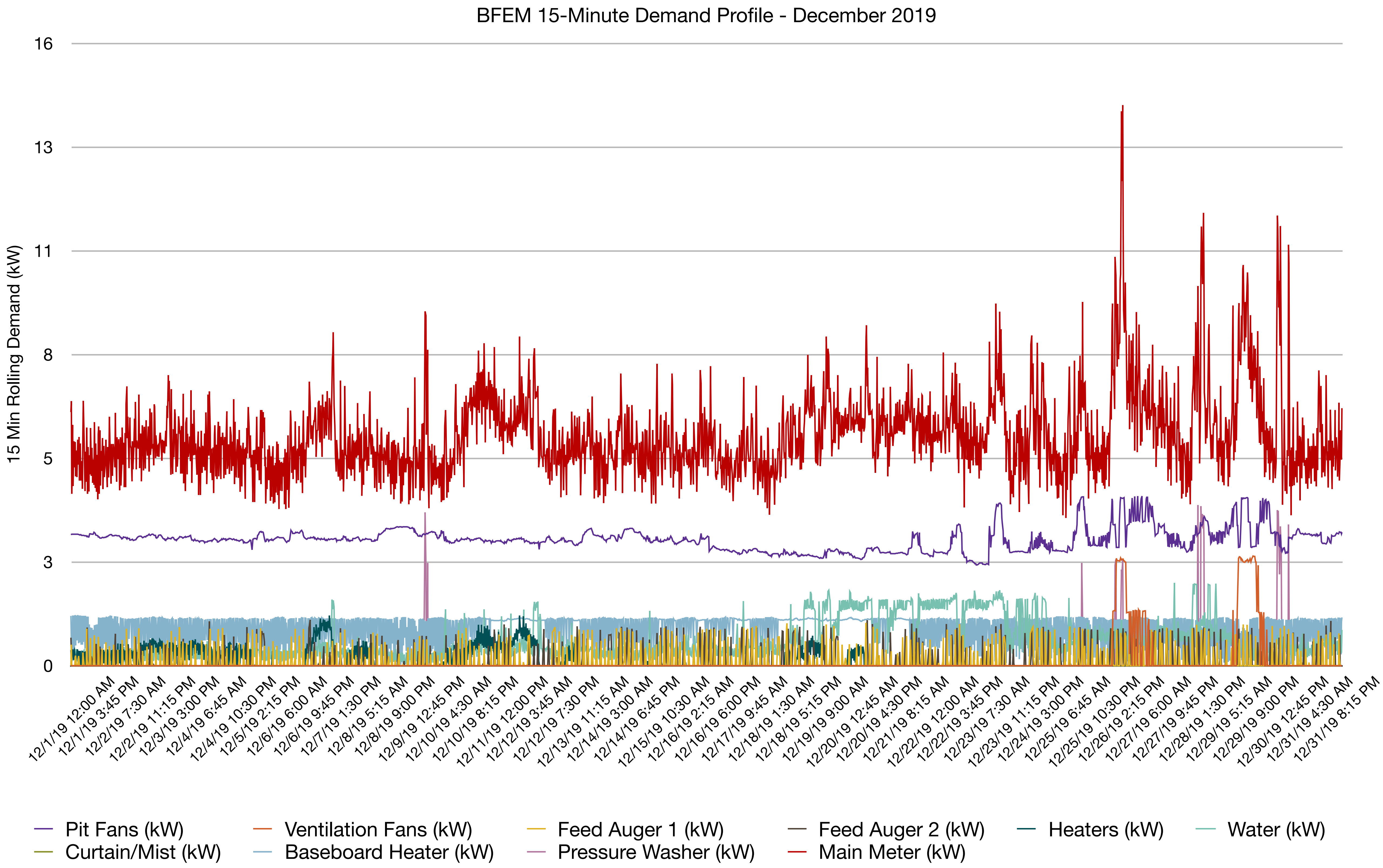


BFEM 15-Minute Demand Profile: Peak Week - November 2019
15 Min Rolling Demand (kW)
0
2
3
5
7
8
10

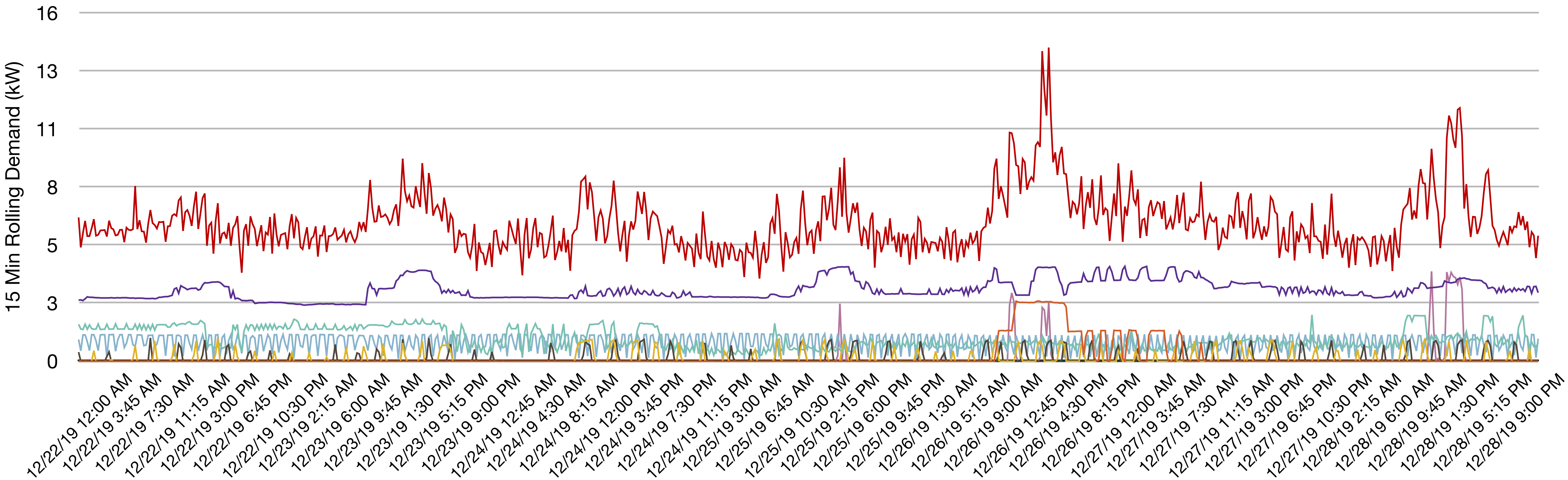


BFEM 15-Minute Demand Profile: Peak Day - November 12, 2019
15 Min Rolling Demand (kW)
0
2
3
5
7
8
10
Pit Fans (kW)
Ventilation Fans (kW)
Feed Auger 1 (kW)
Feed Auger 2 (kW)
Heaters (kW)
Water (kW)
Curtain/Mist (kW)
Baseboard Heater (kW)
Pressure Washer (kW)
Main Meter (kW)

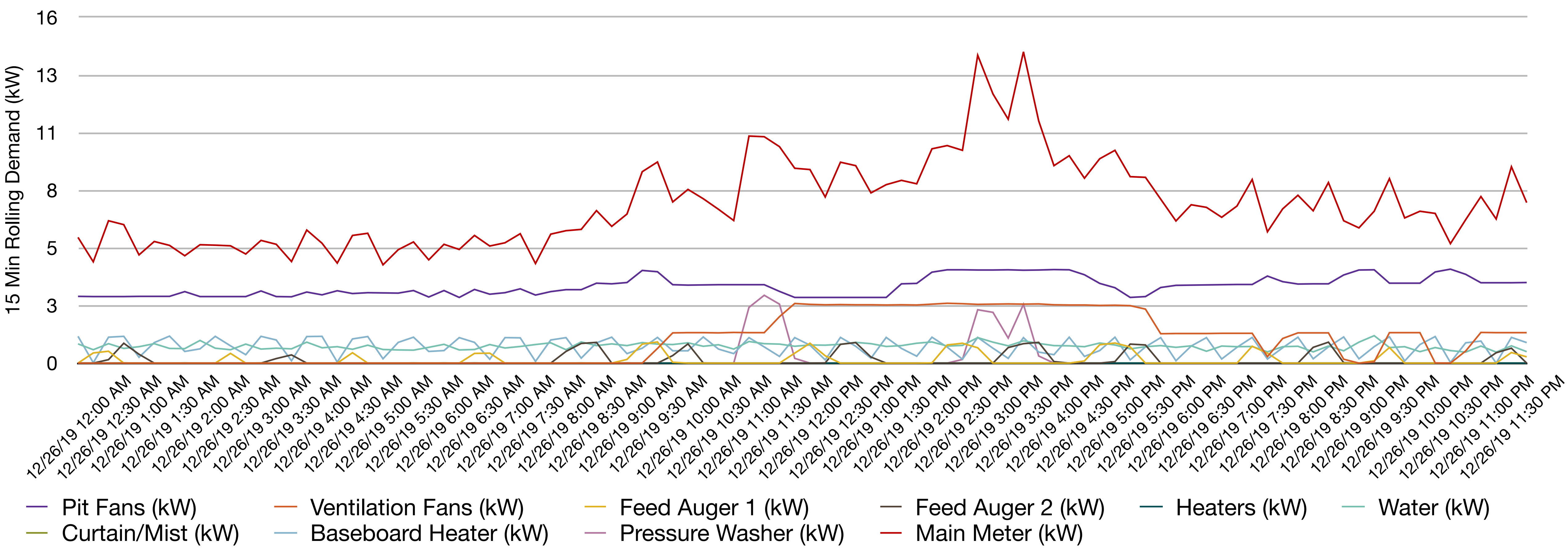
DECEMBER 2019



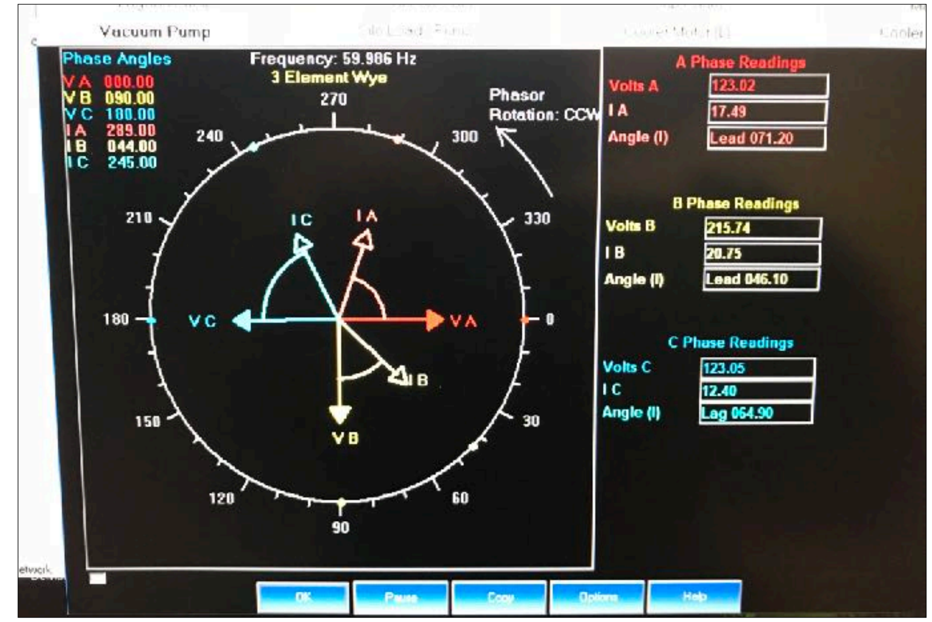
BFEM 15-Minute Demand Profile: Peak Week - December 2019



BFEM 15-Minute Demand Profile: Peak Day - December 26, 2019




COMMUNICATOR
Professional Mode
DEWALT


Vacuum Pump
Phase Angles
VA 000.00
VB 090.00
VC 180.00
IA 289.00
IB 044.00
IC 245.00
Frequency: 59.986 Hz
3 Element Wye
Phasor Rotation: CCW
A Phase Readings
Volts A 123.02
IA 17.49
Angle (I) Lead 071.20
B Phase Readings
Volts B 215.74
IB 20.75
Angle (I) Lead 046.10
C Phase Readings
Volts C 123.05
IC 12.40
Angle (I) Lag 064.90


HOMAN
419-925-4349