# Behind the Meter Battery Energy Storage System M&V Study

# Study Results Report with Addendum 1

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# REVISION HISTORY

| DRAFT | DATE |
|---|---|
| FIRST DRAFT | 2/8/2018 |
| REVIEW COMMENTS | 4/2/2018 |
| SECOND DRAFT | 7/9/2018 |
| THIRD DRAFT (WITH ADDENDUM 1) | 6/24/2019 |
| FOURTH DRAFT (WITH ADDENDUM 1) | 7/9/2019 |
| FIFTH DRAFT (WITH ADDENDUM 1) | 8/1/2019 |

# 1.0 Executive Summary

## 1.1 Synopsis

The 30kW/60kWh & 250kW/500kWh Energy Storage Systems (ESS) are being evaluated as a Demand Response Load shedding system for commercial customers. In addition to Demand Response, the systems shift load from on-peak time periods to off-peak time periods. The ESS functions by supplementing grid supplied electricity with a battery and inverter system. When facility load approaches a pre-determined threshold for each utility meter, the ESS supplements the load in order to minimize the facility's on-peak and non-coincident demand charges on a monthly basis.

Overall, the financial savings to the customer has been significant and has met with expectations after the planned 16 week analysis term. The capability as a Demand Response asset has demonstrated potential. After the planned eight (8) simulated test events the actual performance was mixed with the systems responding well by meeting the projected curtailment on some occasions but on other occasions it appeared there was no response. Once it becomes a financial benefit, we feel that the system will perform.

## 1.2 Project Background

San Diego Gas & Electric (SDG&E) approached Information & Energy Services, Inc. through the *Emerging Technologies (ET)* program to perform a measurement & verification (M&V) study of a new battery based load shedding system for commercial customers. The objective of this study was to evaluate the demand response capability of the energy storage system. In addition to peak load shaving capability, IES was to demonstrate the impact of the energy storage system on the utilities circuit levels and the customers' bill/economics were studied. Please see Table 1 below showing the people involved in the M&V process.

**Table 1: Process Participants**

| Name | Role | Organization |
|---|---|---|
| Kate Zeng | Manager, Emerging Technologies Program | SDG&E |
| Christopher Roman | Project Manager, ET Program | SDG&E |
| Mike Rogers, P.E., C.E.M. | Professional Engineer | IES |
| James Bottomley, C.E.M. | Mechanical Engineer | IES |
| Jase Zappel, LEED Green Associate | Energy Analyst & Technical Writer | IES |
| Mike King | Field Support | IES |
| Erin Broderick | Utility Analyst & Technical Writer | IES |
| Ryan Tandy | Mechanical Engineer | IES |
| Chad Koster | Facilities Director | Poway USD |
| Lindsey Danner | Energy Manager | Grossmont UHSD |
| Dave Margolius | Product Manufacturer Liaison | Vendor |

## 1.3 Results

### 1.3.1 Peak-Shaving Strategy

The Peak-Shaving strategy employed by the Vendor's ESS and software resulted in reduced on-peak and Non-Coincident demand charges compared to what the utility customer would have been charged under the existing rate structure if the ESS had not been installed. The vendor has a Power Efficiency Agreement (PEA) with each customer, stating what percentage of the calculated financial savings the customer will return to the Vendor. This savings share percentage is agreed upon by the customer and the Vendor prior to system installation, in exchange the ESS is installed at no cost to the customer.

This study evaluated the financial performance of a fleet of twenty-seven (27) ESSs compared to the projected financial savings as provided by the Vendor prior to implementation. The test fleet consists of twenty-seven (27) ESSs installed at a mix of elementary, middle, and high schools across two (2) school districts located in the SDG&E service territory. Of these only twenty (20) were installed in time to include results in this report. The remaining seven (7) will be evaluated in 2018 and results compiled in an addendum to this report. The delay between the current twenty (20) systems and the remaining seven (7) systems was due to the vendor waiting for SGIP incentive funding prior to construction of each system.

The twenty (**20)** ESSs in the initial test fleet (Group 1) represent **4.46 MW** of total energy storage capacity. Overall the financial savings achieved for the Utility Company Customers were **91% of the pre-project estimated savings**, over an analysis period of roughly **5 months** from February to June, 2017. The analysis resulted in a **total estimated reduction of $225,808** in Utility Company Demand Charges, which was shared by the Vendor and the School Districts (Customers) who operate the public schools used to host the study. The split is determined by the PEAs between the Vendor and the Customers, and based on this the **Customers retained a total of $64,924 without any capital expenditure**. The Analysis of **fleet state of charge** showed that approximately **3,000 kW** of dispatch-able demand would be available for a 2-hour curtailment event, or half that amount for a 4-hour event.

Table 2 below shows a summary of the financial savings resulting from this group of test sites after the 16+ week analysis term.

**Table 2: Summary of Financial Savings Compared to Projections**

| # | School District | System Name | System Size kW | System Size kWh | Analysis Period (Mo.) | Max. Recorded Reduction (kW) | Cumulative Bill Reduction | Portion Customer Keeps | Cumulative Customer Value (Present) | Customer Target Value (Present) | % Customer Target Value Achieved (Present) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Grossmont | East County ROP | 30 | 60 | 5 | 10.5 | $ 806 | 30% | $ 242 | $ 759 | 32% |
| 2 | Grossmont | El Capitan HS | 250 | 500 | 5 | 142.4 | $ 8,084 | 35% | $ 2,829 | $ 5,029 | 56% |
| 3 | Grossmont | Foothill School | 60 | 120 | 5 | 25.6 | $ 2,829 | 20% | $ 566 | $ 874 | 65% |
| 4 | Grossmont | Grossmont HS | 250 | 500 | 5 | 120.1 | $ 12,222 | 40% | $ 4,889 | $ 5,889 | 83% |
| 5 | Grossmont | Mt Miguel HS | 250 | 500 | 5 | 85.5 | $ 9,553 | 45% | $ 4,299 | $ 7,444 | 58% |
| 6 | Grossmont | Santana HS 1 | 250 | 500 | 5 | 91.2 | $ 12,218 | 30% | $ 3,878 | $ 3,929 | 99% |
| 7 | Grossmont | Santana HS 2 | 250 | 500 | 5 | 188.7 | $ 19,478 | 30% | $ 6,105 | $ 4,419 | 138% |
| 8 | Poway | Black Mountain | 250 | 500 | 5 | 110.8 | $ 12,972 | 25% | $ 3,243 | $ 3,243 | 100% |
| 9 | Poway | Del Norte HS B | 500 | 1000 | 5 | 337.8 | $ 43,110 | 25% | $ 10,778 | $ 9,355 | 115% |
| 10 | Poway | Del Norte HS A | 60 | 120 | | 62.7 | | | | | |
| 11 | Poway | Del Sur ES | 250 | 500 | 5 | 118.1 | $ 14,520 | 25% | $ 3,630 | $ 3,405 | 107% |
| 12 | Poway | Garden Road ES | 60 | 120 | 5 | 30.6 | $ 3,666 | 25% | $ 916 | $ 1,200 | 76% |
| 13 | Poway | Mesa Verde MS | 250 | 500 | 5 | 120.4 | $ 14,078 | 25% | $ 3,519 | $ 3,718 | 95% |
| 14 | Poway | Midland ES | 250 | 500 | 5 | 96.6 | $ 11,378 | 25% | $ 2,844 | $ 2,712 | 105% |
| 15 | Poway | Park Village ES | 250 | 500 | 5 | 95.9 | $ 9,750 | 25% | $ 2,438 | $ 2,867 | 85% |
| 16 | Poway | Stone Ranch ES | 250 | 500 | 5 | 97.3 | $ 10,889 | 25% | $ 2,722 | $ 3,143 | 87% |
| 17 | Poway | Westwood ES | 250 | 500 | 5 | 102.4 | $ 10,008 | 35% | $ 3,503 | $ 3,653 | 96% |
| 18 | Poway | Willow Grove ES | 250 | 500 | 5 | 130.7 | $ 10,992 | 25% | $ 2,748 | $ 3,643 | 75% |
| 19 | Poway | Highland Ranch | 250 | 500 | 5 | 95.6 | $ 9,611 | 35% | $ 3,364 | $ 3,689 | 91% |
| 20 | Poway | District Office | 250 | 500 | 4 | 95.4 | $ 9,645 | 25% | $ 2,411 | $ 2,103 | 115% |
| **TOTAL** | | | **4.46 MW** | | | | **$ 225,809** | | **$ 64,924** | **$ 71,072** | **91%** |

**Notes:**

1. Santana HS (both): The customer share of savings was changed from 40% to 30% on 3/10/2017, this is reflected in monthly calculations.
2. Black Mountain MS: This site was not part of the original project projections, therefore no target value is available.
   Due to lack of available target value, it was assumed that Black Mountain MS achieved 100% of the target value, i.e. the Customer Target Value was assumed to be equal to the Cumulative Customer Value, for purposes of averaging.
3. The Del Norte A & B systems are shown as a combined value because the Billing Statements from the Vendor were initially combined.

On average, the actual ESS performance met with the manufacturer's projected performance estimates within a reasonable margin. The larger 250 kW system was more likely than the smaller systems to meet or exceed the performance estimate.

### 1.3.2 Demand Response

This study evaluated the Vendors Energy Storage Systems as a potential load shedding asset for Demand Response (DR). A total of eight (8) simulated demand response events were called in July through October, during summer on-peak hours and the curtailment was measured using the Utility Company billing meter for each Customer site. Curtailment projections were provided by the Vendor "on the fly" when each simulated event was called and are shown in the summary table below. The system's design lends itself to power resiliency because the ability to respond extremely quickly to changes in the electric grid and should be an ideal candidate for use in an Automated Demand Response setting. Table 3 below summarizes the load shedding achieved by the test fleet of twenty (20) Energy Storage Systems over the eight (8) simulated DR events.

**Table 3: Demand Response Testing Summary**

| # | District | System Name | System Size | DR-1 7/27/2017 | DR-2 8/15/2017 | DR-3 8/16/2017 | DR-4 10/10/2017 | DR-5 10/11/2017 | DR-6 10/20/2017 | DR-7 10/24/2017 | DR-8 10/25/2017 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Notification Type | | | | | | | |
| | | | | Day-Ahead | Day-Ahead | Same-Day | 30-Minute | Same-Day | Same-Day | 30-Minute | Same-Day |
| | | | | Simulated Event Duration (hrs.) | | | | | | | |
| | | | | 2 | 4 | 2 | 2 | 4 | 2 | 2 | 4 |
| | | | | Avg. Curtailment vs. 10-in-10 baseline (kW) / Apparent Event Participation (Yes/No) | | | | | | | |
| 1 | GUHSD | East County REC | 30 kW / 60 kWh | -1.3 / NO | 9.6 / YES | 18.2 / YES | 1.2 / NO | 3.6 / YES | 13.0 / YES | -8.0 / NO | -13.1 / NO |
| 2 | GUHSD | El Capitan HS | 250 kW / 500 kWh | 29.5 / YES | 30.6 / YES | 21.2 / YES | -3.9 / NO | 50.1 / NO | 172.0 / YES | 57.2 / YES | 2.5 / NO |
| 3 | GUHSD | Foothill Adult | 60 kW / 120 kWh | -20.8 / NO | 24.0 / YES | 21.0 / YES | 8.8 / NO | 12.4 / YES | 41.4 / YES | -10.2 / YES | -27.2 / NO |
| 4 | GUHSD | Grossmont HS | 250 kW / 500 kWh | 53.3 / YES | 69.7 / YES | 37.5 / YES | -11.3 / NO | 130.0 / YES | 241.0 / YES | -61.6 / NO | -58.9 / NO |
| 5 | GUHSD | Mt Miguel HS | 250 kW / 500 kWh | -61.5 / NO | 14.6 / NO | -67.6 / NO | -1.8 / NO | 45.8 / NO | 186.1 / YES | 32.8 / NO | -113.2 / NO |
| 6 | GUHSD | Santana HS 1 | 250 kW / 500 kWh | 13.4 / YES | -1.3 / YES | 19.4 / YES | 35.9 / NO | 72.2 / YES | 150.6 / YES | -19.9 / NO | -44.9 / NO |
| 7 | GUHSD | Santana HS 2 | 250 kW / 500 kWh | 6.0 / YES | 14.8 / YES | -3.8 / YES | 41.1 / NO | 63.9 / YES | 116.1 / YES | 11.7 / YES | -37.7 / NO |
| 8 | PUSD | Black Mountain MS | 250 kW / 500 kWh | -11.0 / NO | 9.1 / YES | -2.9 / YES | 14.5 / NO | 68.4 / YES | 236.7 / YES | 9.4 / YES | -8.7 / NO |
| 9 | PUSD | Del Norte HS A | 60 kW / 120 kWh | 22.8 / YES | 212.2 / YES | 185.5 / YES | -10.0 / NO | 232.5 / YES | 219.6 / YES | -54.9 / NO | 8.1 / NO |
| 10 | PUSD | Del Norte HS B | 500 kW / 1000 kWh | -10.6 / NO | -0.3 / NO | 0.9 / NO | -1.6 / NO | 4.4 / NO | -1.5 / NO | -4.1 / NO | -1.1 / NO |
| 11 | PUSD | Del Sur ES | 250 kW / 500 kWh | 26.7 / YES | 58.1 / YES | 72.2 / YES | -4.2 / NO | 90.5 / YES | 163.3 / YES | -19.6 / NO | -15.7 / NO |
| 12 | PUSD | Garden Road ES | 60 kW / 120 kWh | -17.0 / NO | 13.3 / NO | 7.9 / NO | -1.3 / NO | 4.7 / NO | 20.9 / NO | -26.6 / NO | -15.7 / NO |
| 13 | PUSD | Mesa Verde MS | 250 kW / 500 kWh | 10.4 / YES | 84.5 / YES | 74.4 / YES | -7.9 / NO | 43.7 / YES | 141.3 / YES | -17.6 / NO | -5.5 / NO |
| 14 | PUSD | Midland ES | 250 kW / 500 kWh | 24.4 / YES | 108.1 / NO | 122.5 / YES | -1.0 / NO | 8.5 / YES | 115.8 / YES | -47.0 / NO | -47.1 / NO |
| 15 | PUSD | Park Village ES | 250 kW / 500 kWh | -2.3 / YES | 137.8 / YES | 126.3 / YES | 32.4 / NO | 105.4 / YES | 175.4 / YES | -34.7 / NO | -41.4 / NO |
| 16 | PUSD | Stone Ranch ES | 250 kW / 500 kWh | 5.3 / YES | 49.0 / YES | 59.4 / YES | -23.8 / NO | 104.1 / YES | 180.3 / YES | -39.6 / NO | -1.3 / NO |
| 17 | PUSD | Westwood ES | 250 kW / 500 kWh | 21.2 / YES | 134.3 / YES | 132.9 / YES | -1.0 / NO | 84.7 / YES | 177.9 / YES | -41.0 / NO | -57.1 / NO |
| 18 | PUSD | Willow Grove ES | 250 kW / 500 kWh | 0.3 / YES | 125.3 / YES | 119.5 / YES | -18.8 / NO | 69.9 / YES | 166.8 / YES | -85.5 / YES | -33.4 / NO |
| 19 | PUSD | Highland Ranch ES | 250 kW / 500 kWh | 0.2 / YES | 30.0 / YES | 60.9 / YES | 8.9 / NO | 22.8 / YES | 96.8 / YES | -33.6 / NO | -30.3 / NO |
| 20 | PUSD | PUSD Dist. Office | 250 kW / 500 kWh | 35.5 / YES | 37.2 / YES | 92.5 / YES | 48.2 / NO | 51.2 / YES | 123.4 / YES | -21.2 / NO | -21.6 / NO |

**Notes:**

PURPLE TEXT = Day-Ahead Notification given prior to simulated DR event.

BLUE TEXT = Same-Day Notification given prior to simulated DR event.

ORANGE TEXT = 30-Minute Notification given prior to simulated DR event.

| | DR-1 | DR-2 | DR-3 | DR-4 | DR-5 | DR-6 | DR-7 | DR-8 |
|---|---|---|---|---|---|---|---|---|
| Total kW Curtailed / GCN Projection | 124.5 / 630 | 1160.6 / 1170 | 1097.9 / N/A | 104.4 / N/A | 1268.8 / 1300 | 2736.9 / 2550 | -414.0 / 1450 | -563.3 / 1600 |

| | |
|---|---|
| Average kW Curtailed | 689.5 |
| Typical kW Curtailed | 1,175.8 |
| Max kW Curtailed | 2,736.9 |

Table 3 above shows poor performance compared to expectations. Since the ESSs were verified in manual tests to be able to discharge at the stated kW value it must be concluded that the control system either was not being triggered to respond to the simulated event or that the control algorithm opted for by the Vendor heavily prioritizes peak shifting over demand response curtailment. For example in four (4) out of the eight (8) total simulated DR events (#1, #4, #7, & #8) there was essentially no curtailment or there was 'negative' curtailment, i.e. the simulated event day had a demand that was higher than the 10-in-10 baseline. These instances of the ESS fleet not being triggered to respond to simulated DR events can be attributed to one or more of a number of potential reasons listed below:

1. Notification method was via email.
    a. This method required human intervention to command ESSs to respond to events. A fully automated DR response would be the most practical system.
    b. This may explain non-performance on the 30-min notification DR event simulations.
2. ESSs frequently re-charged during a DR simulation.
    a. This reduced the average curtailment achieved, even in cases where the ESS had discharged during the beginning of a simulation.
    b. It is not understood why the Vendors control algorithm would allow the ESS to re-charge during a DR event.
3. Vendor / Aggregator may have not been fully ready to participate in Demand Response testing.
    a. Despite claims that they were ready and able to do the testing, the results speak for themselves. This is a new technology and the operations team at the Vendor are potentially still working the kinks out.
4. Peak shifting prioritized over demand response.
    a. The financial alignment of the vendor would suggest that it is more advantageous to focus on the monthly NC and on-peak load shifting since that is what generates profit for the vendor.
    b. At the time when DR event simulations were conducted there was no financial benefit to the vendor to respond to the test events. In addition, if responding to a simulated DR event caused the ESS to be unable to respond to a facility peak then that scenario could potentially cause a reduction in profit. For this reason it may be possible that a more limited response to simulations was favored by the vendor.
    c. During real DR events a similar limited response may be selected by the vendor in order to preserve their ability to shift peak loads. All of the risk involved with participation in a DR program would fall on the customer not the Vendor / Aggregator.

The average curtailment over the eight (8) simulated DR events was a disappointing **689.5 kW**. As a kind of a 'best-case scenario' of what can be expected we can look at the average curtailment achieved in the three (3) most consistent test events. A 'best case' average curtailment figure for the 4.46 MW fleet is **1,175.8 kW**. This average includes both 4-hour and 2-hour simulations. **The highest curtailment achieved in any of the test events was 2,736.9 kW averaged over 2-hours.** For this event the Vendor projected the curtailment would be 2,550 kW, which was accurate to within approximately **7%** in this case an over estimate.

It should be noted that in almost all cases the ESS was observed to re-charge itself during the simulated DR events. When the ESS re-charges, it creates a facility peak during the DR event and if this were to happen during any real DR events, the cost will be significant enough to overshadow the peak-shaving financial benefits that the system may have accrued during a given month. In many instances the ESS appeared to be operating as if it were a normal day during the DR event simulations, i.e. the systems frequently did not appear to be operating in a manner that would maximize DR reduction during a test event.

While the potential capability as a short term load shedding device has been demonstrated via manual commands sent to the units, there will still need to be additional work done by the vendor to fine-tune the control algorithm if the fleet is going to be an effective resource for grid resiliency and to maximize the load shedding potential of the fleet. The total available energy stored in the fleet was analyzed to determine the average available capacity by time of day. Please see Figure 1 below which shows the potential available capacity in terms of kW available for a 2-hour duration curtailment.

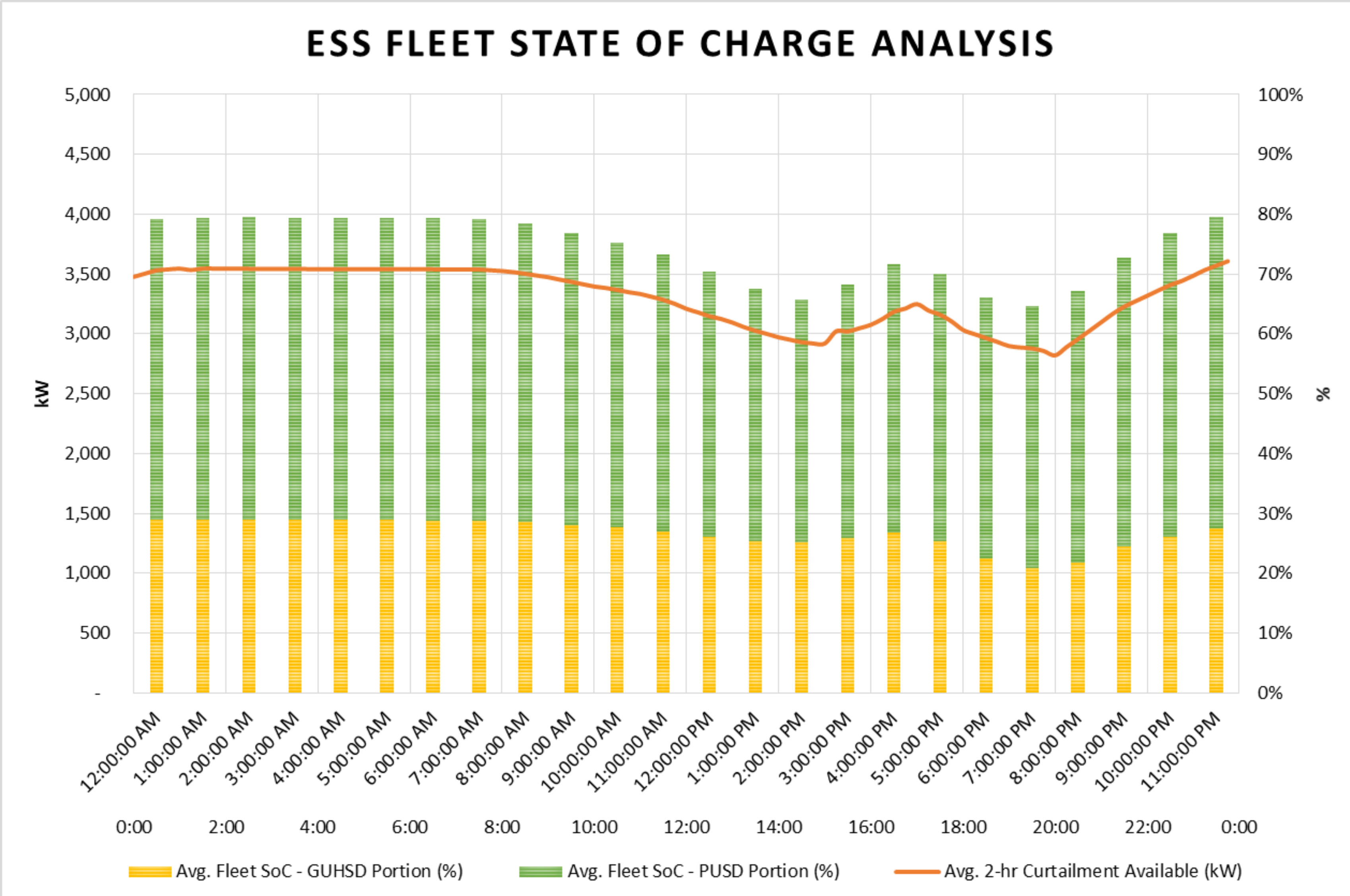


**Figure 1: ESS Average Fleet State of Charge**

# 2.0 Technology Overview

### 2.1 Energy Storage Systems

An *Energy Storage System* (ESS) in this study refers to a battery-inverter system which is used to provide electric power to a facility during "high-demand" periods, in an attempt to avoid peak-demand[1] and non-coincident[2] demand charges. The system's lithium ion battery re-charges during off-peak periods when the facility load is lowest. Energy consumed at night has a higher GHG factor than energy consumed during the day due to the high percentage of solar energy in the mix in the specific utility area of San Diego, CA.

Additionally, the ESS can be called upon to function as a load-shedding asset for Demand Response purposes. The systems investigated in this report use an internet connected controller to recognize the optimized peak load level and react accordingly by supplementing the utility provided power when the facility load approaches this level.

*Battery Energy Storage System Vendors*

1. Engie Storage
2. Stem
3. Schneider Electric
4. RES Group
5. AES Energy Storage
6. NEC Energy Solutions
7. Aggreko
8. Others

The technology being evaluated is a specific product from one of the vendors in the market. The equipment installed at each site consisted of a lithium-ion battery bank, inverter/charger, metering and internet connected control box, AC & DC contactors, and an air conditioning unit to maintain batteries at optimum temperature for longevity and performance. Equipment is packaged into a sturdy outdoor rated enclosure. Each system was installed in parallel with the utility meter and was connected to the site's existing main service panel. When the system is discharging, the site obtains energy simultaneously from the battery bank and from the utility grid. The lithium-ion Batteries are re-charged from the utility grid or renewable resources (if available). Please see Figure 2 below which depicts the

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[1] On-Peak Demand Charges: Utility Company charges resulting from the monthly maximum electric demand which occurred between the hours of 11:00 AM and 6:00 PM Weekdays from May 1st thru October 31st and between 5:00 PM and 8:00 PM Weekdays all other months.

[2] Non-Coincident Demand Charges: Utility Company charges resulting from the monthly maximum electric demand, regardless of the time of day this demand occurred.

connection between the power grid and the ESS in terms of the GHG emissions cycle.

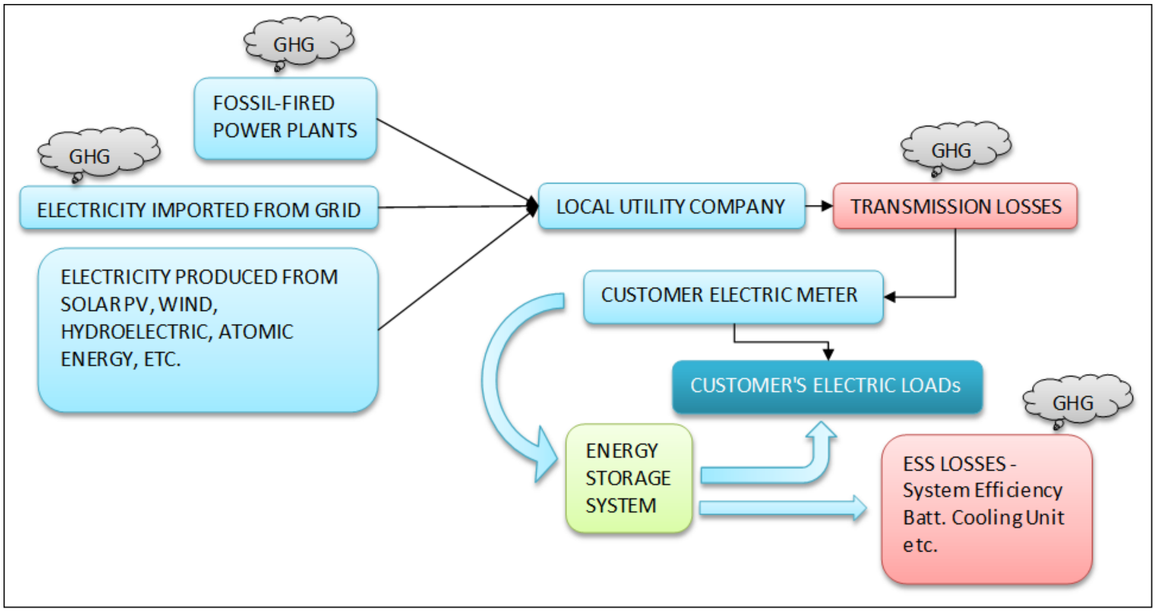


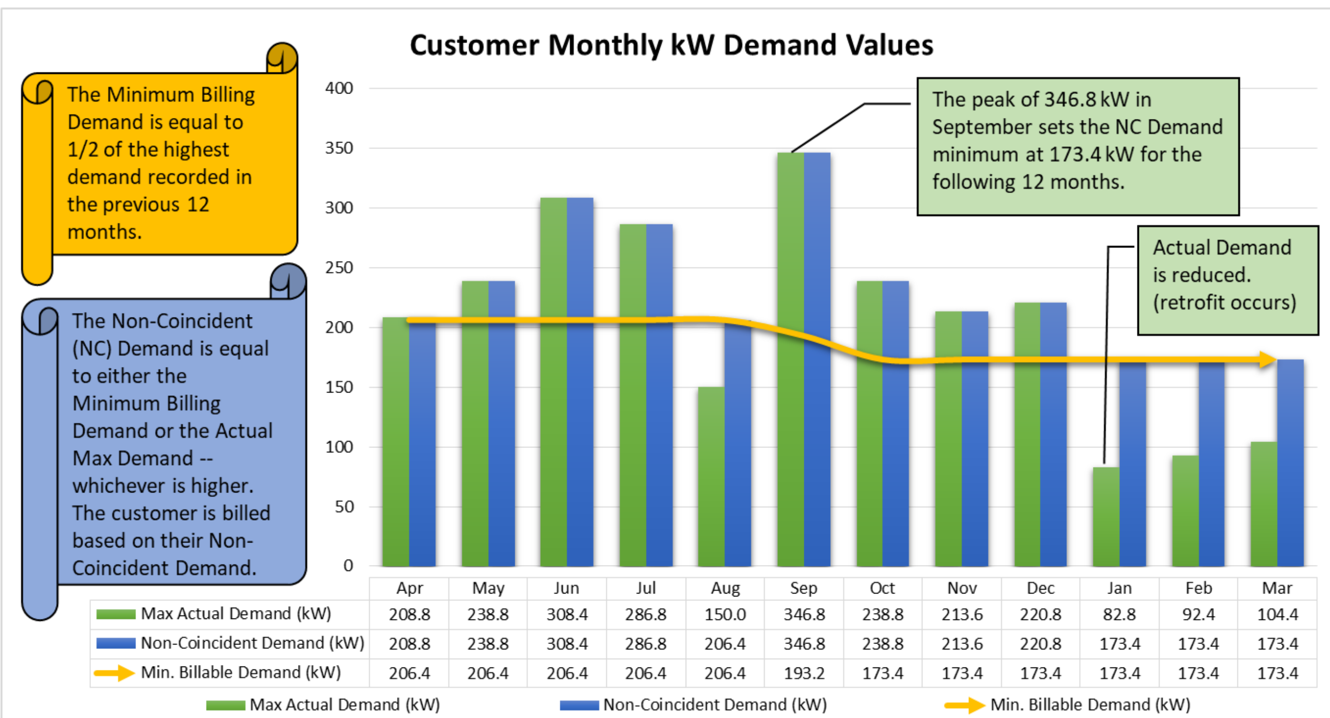

**Figure 2: ESS Cycle Showing GHG Interactions**

Technically speaking, the ESS is capable of providing emergency backup power during a utility outage, if it were interconnected at a critical load panel. Under the current UL certifications, ESSs are required to power down in the event of a grid outage. None of the systems evaluated in this study are interconnected in a way that would be used to provide backup power to the site, this is due to both regulatory stipulations found in the CPP-D electric schedule, and also because the customer did not specify this need at the time of installation. Section 20 of the CPP-B tariff states: “In no event shall the customer operate its own generation in parallel with the Utility electric system during Utility service interruptions” [1]. Evaluation of the ESS as a back-up power supply or UPS device was not in the scope of this study.

System data was analyzed for trends on charge/discharge cycling, power resiliency, and utility peak savings. The collected data show that the controller discharges energy whenever the site electric load approaches a “set-point” level, in an attempt to prevent the utility metered load from exceeding the targeted maximum value. The target value is specific for each site and is determined by the Vendors controller, the value may change over time to reflect changes in site load or other factors as determined necessary by the Vendor.

The Vendors Software ESS aims to provide useable electric power to a facility during On-Peak periods, strategically reducing the need to purchase electricity from the utility company during these more-expensive peak periods. The system’s lithium ion battery would charge during the least expensive “Off Peak” periods, typically occurring at night. The battery’s stored energy would then be used (discharged) to strategically offset facility peak demand, both Non-Coincident and On-Peak.

The systems investigated in this report use an onboard controller to instantly recognize the facilities electric demand and compares this value to a pre-determined cutoff. If the facility demand approaches the cutoff then the inverter system is engaged to supplement the facility load such that the utility metered portion does not exceed the cutoff value. The cutoff value is determined by the Vendor and is adjusted frequently based on several factors. Ratchet charges from the utility company based on historical maximum facility demand levels were not taken into account when determining the cutoff. Many of the sites in the study had recent lighting upgrades which lowered the site demand, this resulted in ratchet charges that were not taken into account in billing statements from the Vendor to their customers. An example of how ratchet charges work is shown in Figure 3 below. Please note that this is a general example of a ratchet charge, and does not include any actual customer data.




| | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Jan | Feb | Mar |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Max Actual Demand (kW) | 208.8 | 238.8 | 308.4 | 286.8 | 150.0 | 346.8 | 238.8 | 213.6 | 220.8 | 82.8 | 92.4 | 104.4 |
| Non-Coincident Demand (kW) | 208.8 | 238.8 | 308.4 | 286.8 | 206.4 | 346.8 | 238.8 | 213.6 | 220.8 | 173.4 | 173.4 | 173.4 |
| Min. Billable Demand (kW) | 206.4 | 206.4 | 206.4 | 206.4 | 206.4 | 193.2 | 173.4 | 173.4 | 173.4 | 173.4 | 173.4 | 173.4 |

**Figure 3: Ratchet Charges Illustrated**

### 2.2 SGIP Requirements

ESSs such as the type evaluated in this study are eligible for the CPUC's Self-Generation Incentive Program (SGIP). The eligibility requirements as stated in the CPUC Handbook [1] are as follows:

- ESS must be capable of discharging at least once per day.
    - *ESS is software limited to 2 full discharge-charge cycles per day. The systems are capable of a full discharge in a 2-hour period.*
- ESS is required to discharge a minimum of 130 full discharges per year.
    - *Analysis of the discharge cycles over the 3-month period from May 1st, 2017 to July 31st, 2017 showed that the ESS systems achieved 20 full discharge cycles. At this rate the minimum number of cycles will not be met.*
- ESS must be permanently installed.
    - *All electrical connections are industry standard for permanent equipment and the units are mounted on concrete foundations poured for the purpose.*
- ESS must be utility interconnected.
    - *All systems in this fleet received permission to operate (PTO) letters from the local electric utility company (SDG&E).*
- 100% of incentive rate eligibility for systems with a stored energy discharge duration of less than 2 hours at full rated capacity.
    - *ESS will discharge for 2 hours at full load.*
- 100% of incentive rate eligibility for systems with a stored energy capacity of less than 2 MWh.
    - *The largest ESS in this fleet is rated at 1,000 kWh.*
- All technologies must be certified for safety by a nationally recognized testing laboratory.
    - *The batteries used in the ESS meet UL 1973 and UL 1642. The inverter used in the ESS meets UL 1741 and IEEE 1546-ETL.*
- The ESS must maintain a round trip efficiency equal to or greater than 69.6% in the first year of operation in order to achieve a ten-year average round trip efficiency of 66.5%
    - *The vendor stated round-trip system efficiency is 94% average, with 88.4% minimum efficiency. Efficiency at Full Load is given as 86%.*
    - *Analysis of the round trip efficiency of the entire fleet over the whole testing period showed an average efficiency of 93%. This average is weighted by kWh. Round trip efficiency varied from system to system between 69% and 98%.*
- ESS projects funded through SGIP are eligible to provide DR services and participate in DR programs.

- *The energy storage systems evaluated are capable of providing load reduction for DR purposes, although currently lacking a functional automated notification method or connection to the ADR server for Automated Demand-Response participation in the Utility's program offerings.*

### 2.3 30 kW / 60 kWh System

One of the Vendors energy management systems is the 30 kW / 60 kWh. This energy storage system is designed to discharge energy at a max rate of 30 kW and is capable of discharging at max capacity at least once a day. In addition, this system will provide 60 kWh of energy storage capacity. This system operates at 480 VAC, 60 Hz, 3 phase, and this operation range matches the same power requirements for utility meters. Each energy storage module comes with a Controller which operates at 120V, 60 Hz. Multiple units can be installed together to create a larger system. This was done at several of the test sites to create a 60 kW / 120 kWh system.

Each ESS module is equipped with Samsung lithium-ion batteries for charging and discharging energy. The roundtrip efficiency of these Samsung batteries is 86% at full load. For the 30 kW / 60 kWh system, each battery is rated to store 71 kWh, but the charge and discharge is designed to operate within a 5% to 95% storage capacity. The module is rated for 5,260 full charge/discharge cycles over a 10-year life. After 10 years, the batteries should be replaced. Additionally, each battery can charge to 95% capacity in 2 hours, and it can discharge to 5% in the same amount of time. For daily operation, each battery is limited to 2 full charge/discharge cycles per day by the software controller.

The ESS module and controller is compact: The unit weighs 1,600 lbs. and has a footprint of 8.83 square feet. The controller is less than a square foot which allows for wall mounting. Typically, for economic purposes, these components would be mounted near the site utility meter. All of the Vendors ESS are equipped with the proprietary Software which is used to determine when the system charges or discharges the batteries, and at what rate it does so. This software communicates with controller via cellular connectivity.

Please see Figure 4 below for a simplified diagram of the ESS.

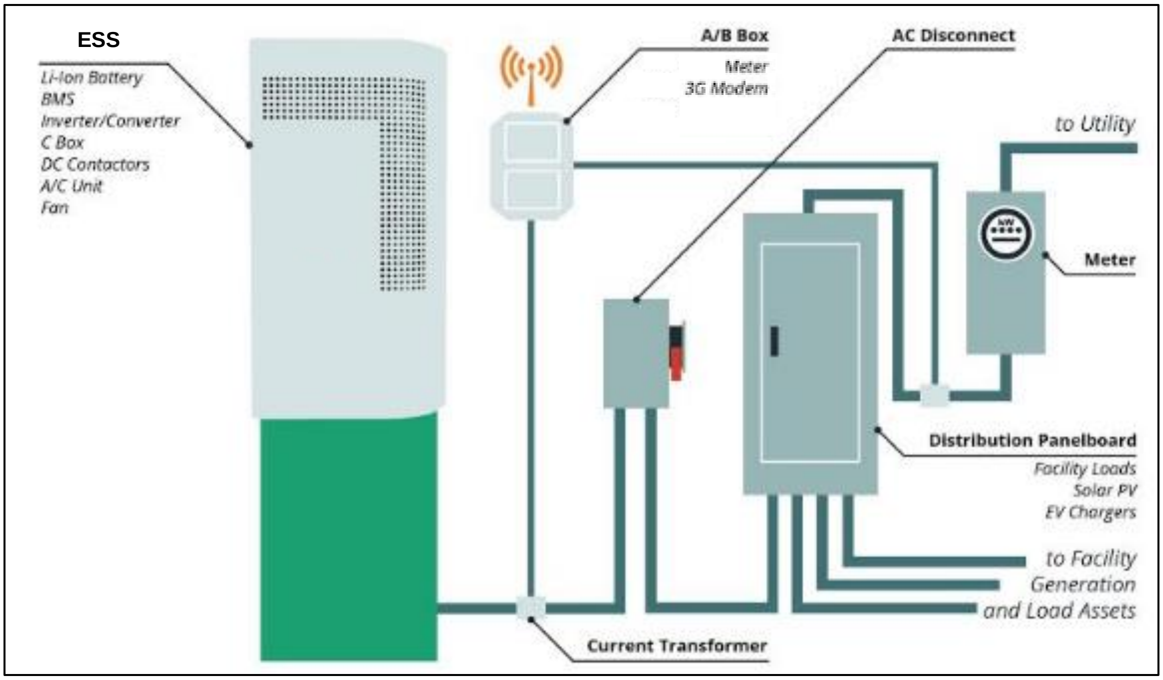



**Figure 4: System Diagram**

### 2.4 250 kW / 500 kWh System

The Vendor also offers energy storage systems for sites with energy requirements higher than those served by the 30 kW model. The larger ESS is rated at 250 kW / 500 kWh and like the smaller system, multiple units can be combined to form an even larger ESS. The 250 kW system is the most prevalent type used throughout this study and is sized for facilities such as larger schools, hospitals, office buildings and the like.

This system operates at 480 VAC, 60 Hz and 3 phase, and this operation range matches the same power requirements for utility meters. Each energy storage module comes with a Controller which operates at 120V, 60 Hz.

Please see Figure 5 below, showing a typical ESS.  This is a 250 kW / 500 kWh model.

**Figure 5: 250kW/500kWh Battery Energy Storage System**

The main difference between the 30 kW / 60 kWh and the 250 kW / 500 kWh systems is the battery capacity. The total capacity of the 250 kW / 500 kWh is 572 kWh, but to avoid overloading, the batteries should be kept between 5% and 95% capacity. At 95% capacity, the battery will store 543 kWh for discharging. The charge/discharge rate and cycles per day are the same for both systems.  The re-charge time at full load is given as 2 hours.  In this system there are a total of 572 kWh of battery capacity installed, giving a 14.4% excess capacity above the stated capacity of 500 kWh.

The main similarities between the 30 kW / 60 kWh system and 250 kW / 500 kWh are the software, module configuration and controller. The software and controller is identical, regardless of the size system used.

Please refer to Figure 6 below for a visual representation of the software interface used to keep track of the ESS performance by the customer. The energy performance being assessed in Figure 2 is for a 250 kW / 500 kWh system at a middle school site in San Diego, CA. This interface can be viewed by logging into the Vendor website and selecting the site.

**Figure 6: ESS Software Interface**

Figure 5 can be viewed within the website application, and the user may adjust the time period under observation to keep track of performance over time. This website application shows the demand reduction, peak shaving, performance, energy production and savings.

### 2.5 Description of Incumbent Technology

The incumbent technology was analyzed at public school district customer sites which did not currently utilize any other battery load shedding systems on the same meter as the technology under evaluation. Please note that in this study one site does utilize TES on a separate utility meter.

# 3.0 Evaluation Methodology

## 3.1 Study Goals

The field study initially had an initial duration targeted at 16-weeks of evaluation. The actual length of the study was considerably longer including the planning, construction, metering Cx, peak-savings evaluation, and demand response simulation portions. The project began in July 2015, with evaluation of installed systems beginning in the February 2017 billing cycle. Reporting on the project took place in February 2018. The project timeline is shown below in Figure 7 below.

| July 2015 – January 2016 | March 1, 2016 | June 2016 – Feb. 2017 | Feb. 2017 – June 2017 | July 2017 – October 2017 |
|---|---|---|---|---|
| M&V Plan & Revisions | M&V Contract Execution | Installation & Metering Cx | Peak Savings Evaluation | DR Simulations |

**Figure 7: Project Timeline (Group 1)**

The peak-savings analysis portion of this study was conducted using **20 weeks** of collected data to evaluate a combined **4.46 MW** of battery type Energy Storage Systems.

Each site was to be monitored with respect to utility metered electrical load, from utility provided electrical data; as well as data provided directly from the Energy Storage System's on-board metering. The performance of the 30 kW / 60 kWh & 250 kW / 500 kWh systems was evaluated for a period of at least 16-weeks (20-weeks in most cases), using 15-minute interval data and monthly billing data. The performance was evaluated for several criteria including:

- Demand Response Effectiveness (response time & actual load shed)
    - Individual System and Fleet-Wide State of Charge (SoC)
        - *How actionable are the Vendor provided day-ahead and hour-ahead Dispatchable Demand Capacity notifications. Prior to a DR event, the Vendor will calculate how much Dispatchable Demand Capability is available to the utility company, the accuracy of this estimate will be analyzed.*
    - CBP 10-in-10 Baseline
- On a monthly basis, how effective are the systems at reducing facility on-peak and non-coincident demand charges
    - How much is money saved
    - Was the correct peak shaved

### 3.2 Measurement & Verification Overview

IES subscribes to using industry standard M&V protocols that have been developed in response to the need for reliable and consistent measurement practices. The following reference is used for the development of M&V procedures for this project:

- U.S. Department of Energy. 2002. *International Performance Measurement & Verification Protocol (IPMVP)*.

The IPMVP protocols have defined four M&V options (Options A through D) that meet the needs of a wide range of evaluations and provide suggested procedures for baseline development and post-retrofit verification. These M&V options are flexible and reflect the considerations previously mentioned. Please see Table 4 on the following page for an overview of these options.

**Table 4: Measurement & Verification Options**

| M&V Option | Calculation Method | Typical Applications |
|---|---|---|
| ***Option A: Partially Measured Retrofit Isolation*** | | |
| Savings are determined by partial field measurement of the energy use of the system(s) to which an ECM was applied, separate from the energy use of the rest of the facility. Measurements may be either short-term or continuous.<br>Partial measurement means that some but not all parameter(s) may be stipulated, if the total impact of possible stipulation error(s) is not significant to the resultant savings. Careful review of ECM design and installation will ensure that stipulated values fairly represent the probable actual value. | Engineering calculations using short term or continuous post-retrofit measurements and stipulations. | Lighting retrofit where power draw is measured periodically. Operating hours of the lights are assumed to be one half hour per day longer than store open hours. |
| ***Option B: Retrofit Isolation*** | | |
| Savings are determined by field measurement of the energy use of the systems to which the ECM was applied, separate from the energy use of the rest of the facility. Short-term or continuous measurements are taken throughout the post-retrofit period. | Engineering calculations using short term or continuous measurements | Application of controls to vary the load on a constant speed pump using a variable speed drive. Electricity use is measured by a kWh meter installed on the electrical supply to the pump motor. In the base year this meter is in place for a week to verify constant loading. The meter is in place throughout the post-retrofit period to track variations in energy use. |
| ***Option C: Whole Facility (Bill Comparison)*** | | |
| Savings are determined by measuring energy use at the whole facility level. Short-term or continuous measurements are taken throughout the post-retrofit period. | Analysis of whole facility utility meter or sub-meter data using techniques from simple comparison to regression analysis. | Multifaceted energy management program affecting many systems in a building. Energy use is measured by the gas and electric utility meters for a twelve month base year period and throughout the post-retrofit period. |
| ***Option D: Calibrated Simulation (Calibrated Building Modeling)*** | | |
| Savings are determined through simulation of the energy use of components or the whole facility. Simulation routines must be demonstrated to adequately model actual energy performance measured in the facility. This option usually requires considerable skill in calibrated simulation. | Energy use simulation, calibrated with hourly or monthly utility billing data and/or end- use metering. | Multifaceted energy management program affecting many systems in a building but where no base year data are available. Post-retrofit period energy use is measured by the gas and electric utility meters. Base year energy use is determined by simulation using a model calibrated by the post-retrofit period utility data. |

IES selected a combination of Option B and Option C to most accurately evaluate the financial benefits to the Customer and the Demand Response capabilities of the retrofit equipment. Measurements will be recorded on a 15-minute basis by the unit's on-board metering equipment, and are compiled and transmitted electronically to IES by the Vendor on a monthly basis. A sample of the units had additional sub-meters installed by IES to verify accuracy. Table 5 below summarizes the methods IES selected for use in this study.

**Table 5: Measurement & Verification Option Selected**

| # | Emerging Technology Description | Option A | Option B | Option C | Option D |
|---|---|---|---|---|---|
| 1 | Battery Energy Storage System | | X | X | |

Prior to starting the study, the manufacturer had already selected appropriate testing sites based on the sites' willingness to participate, then gained approval from SDG&E. The sites are qualified based on their locations and the fact that the sites do not currently utilize any other battery load shedding systems. The test sites are located within the Grossmont Union High School District and the Poway Unified School District, in the SDG&E service territory. The sites are a mix of Elementary, Middle, and High Schools, with on district support facility (office) and one Adult School. Each site has between one and two energy storage units installed, the smallest size system is 30 kW and the largest system is 500 kW.

### 3.3 Metering Plan

The Vendor provided the following data points as metered at each ESS unit:

- Building Load
- Battery State of Charge (SoC)
- kW Discharge
- kW Charge
- Calculated baseline (CBL)

The data collected by the Vendor are provided electronically in 15-minute intervals in Microsoft Excel format, following each event and regularly on monthly intervals.

IES also utilized the following information from each applicable utility meter, as provided by SDG&E:

- On-grid demand kW (15-minute interval data)
- Monthly billing history (full history showing demand charges, peak demand, etc.)

SDG&E provided both historical and current data for all meters at all test sites, as well as the circuit level data showing distribution to the group of sites, in order to obtain a complete picture of the electric consumption, demand, and billing for each site as well as the combined impact of all systems included in the study.

Each site was monitored with respect to utility metered electrical load, from the utility provided electrical data as well as data provided directly from the ESS system. The performance of the 30 kW / 60 kWh & 250 kW / 500 kWh systems was evaluated for a period of **20-weeks** with **15-minute** interval and monthly billing data. From these data IES calculated the financial benefits attained via peak shaving and the technology's effectiveness as a power resiliency asset.

### 3.4 Metering Verification Plan

As shown in Table 2 of Section 1, the scope of the study includes a total of twenty (20) systems (Group 1). The sample of sub-metered units includes fifteen (15) of these to show that the measurements are repeatable over multiple test sites, and to validate the data provided by the Vendor. A statistically valid sample with over 80% confidence and 20% precision was undertaken for each system size. A statistically valid sample of the 20 systems included in the study includes the units listed in Table 6 below.

**Table 6: Systems with IES Sub-Metering Installed**

| IES SUB-METERING SUMMARY | | | System Size | |
|---|---|---|---|---|
| # | School District | System Name | kW | kWh |
| 1 | Grossmont | East County ROP | 30 | 60 |
| 2 | Grossmont | El Capitan HS | 250 | 500 |
| 3 | Grossmont | Foothill School | 60 | 120 |
| 4 | Grossmont | Mt Miguel HS | 250 | 500 |
| 5 | Grossmont | Santana HS 1 | 250 | 500 |
| 6 | Grossmont | Santana HS 2 | 250 | 500 |
| 7 | Poway | Black Mountain | 250 | 500 |
| 8 | Poway | Del Norte HS B | 500 | 1000 |
| 9 | Poway | Del Norte HS A | 60 | 120 |
| 10 | Poway | Garden Road ES | 60 | 120 |
| 11 | Poway | Stone Ranch ES | 250 | 500 |
| 12 | Poway | Westwood ES | 250 | 500 |
| 13 | Poway | Willow Grove ES | 250 | 500 |
| 14 | Poway | Highland Ranch | 250 | 500 |
| 15 | Poway | District Office | 250 | 500 |

An evaluation of the Vendors metering system's electrical metering accuracy was performed by installing revenue grade electrical metering systems on **15 of the 20 test systems**. On this sample of the units, IES measured the following data points directly at the point of connection between the ESS and the sites' electrical distribution gear:

- kW input or output from the system, 3-phase total and per phase (at a 15-minute frequency)
- kVAR input or output from the system, 3-phase total and per phase (at a 15-minute frequency)
- kVA input or output from the system, 3-phase total and per phase (at a 15-minute frequency)
- Power Factor, 3-phase total and per phase (at a 15-minute frequency)
- Peak Power Demand
- Current, 3-phase total and per phase (at a 15-minute frequency)
- Voltage, 3-phase total and per phase (at a 15-minute frequency)
- Power Frequency, Hz (at a 15-minute frequency)
- Import & Export Accumulated Energy (kWh, kVARh, kVAh)

Please see Figure 8 below, which shows a screen capture taken from the IES sub-metering data collection server. This data was collected at PUSD - Del Norte High School (System B) in the month of March 2017.

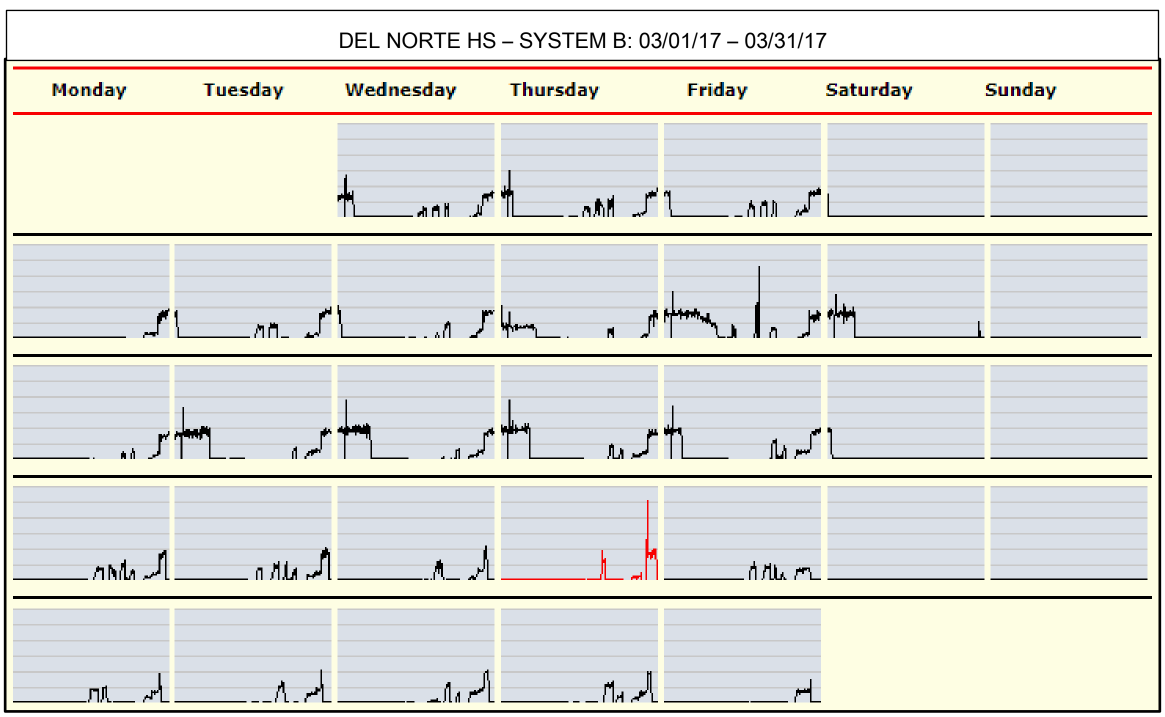



**Figure 8: IES Daedalus Software Interface**

Real-Time Commissioning was performed by IES technicians with assistance from the Vendors operations team. In each commissioning test the ESS was commanded to charge and discharge at various levels, with readings from the IES installed sub-meter and the ESS on-board metering system being compared in real-time.

Utility meter data provided by SDG&E was used in the evaluation. Please note that all of the systems shown in Table 2 of Section 1 are included in the study. The data used for analysis was provided directly from the ESS's metering for each system, in addition to SDG&E's meter data.

## 3.5 DR Event Simulation Methodology

### 3.5.1 Scope of Testing

The Demand Response (DR) testing portion of the M&V study consisted of a series of **eight (8) simulated DR events**. DR event simulations started on 6/29/2017. The simulated DR events will consist of the following notification types and durations as shown in Table 7 below.

**Table 7: Simulated Demand Response Event Scope**

| |
|---|
| One (1) event with a day-ahead notification and a 2-hour duration. The starting time shall be between 11:00 AM and 4:00 PM on the event day. |
| One (1) event with a day-ahead notification and a 4-hour duration. The starting time shall be between 11:00 AM and 2:00 PM on the event day. |
| Two (2) events with a same-day notification and a 2-hour duration each. The starting time shall be between 11:00 AM and 4:00 PM on the event day. |
| Two (2) events with a same-day notification and a 4-hour duration each. The starting time shall be between 11:00 AM and 2:00 PM on the event day. |
| Two (2) events with a 30-minute notification and a 2-hour duration each. The starting time shall be between 11:00 AM and 4:00 PM on the event day. |

The simulated DR events were called by Information & Energy Services Inc. (IES) via email message sent to the project stakeholders: the Vendor, the school districts, and SDG&E. The simulated DR event notifications were restricted to weekdays between Tuesday and Friday, between the months of June and October, 2017. Each of the eight (8) simulated DR events were called for all twenty (20) of the sites in the Group 1 test fleet, as listed in Table 2 of Section 1.

### 3.5.2 Notifications

All simulated event notifications were sent via email, this method was selected Notification for day-ahead simulated DR events was sent by 3:00 pm on the weekday previous to the event day. Notification for same-day DR event simulations was sent by 9:00 am on the event day. Notification for 30-minute notification events was sent 30 minutes prior to the event start time. A sample of the notification email that was sent to project stakeholders is shown in **Appendix C**.

### 3.5.3 Vendor Availability Forecasting

The Vendor provided their forecasted available capacity on an event by event basis. This forecasted capacity was provided to IES via email in response to each event notification. IES used the Vendor forecast for analysis where applicable.

### 3.5.4 DR Baselines and Curtailment Analysis

Using the 15-minute Vendor and SDG&E electric meter data already being collected continuously, simulated DR event day data was analyzed to determine the potential load shedding capabilities available to utility operators. These event day data are compared to the following customer specific baseline types found in the current DR product offerings:

- For CBP: 10-in-10 day baseline as shown in Item 5.b. on CPUC sheet #27962-E and Day-of adjusted 10-in-10 baseline as shown in Item 5.c. on CPUC sheet #27963-E
- For CPP-D: Vendor determined Capacity Reservation
- Measured baseline as if the ESS was not installed. Calculated as Actual Utility Meter kW plus ESS supplied kW, based on recorded data.

The available SDG&E DR product offerings are used for this analysis. The product offerings currently are **CBP Day-Ahead, CBP Day-Of, & CPP-D**. All terms and conditions listed in the DR offerings and rate tariffs are replicated as closely as necessary to perform the analysis for simulated DR events.

IES used a total of eight (8) simulated DR events to evaluate the responsiveness and effectiveness of battery energy storage as a demand response asset. The ability for the ESS units to provide energy at any given time is independent of the season, weather variations, time of day, and building conditions was verified. Additionally, ESSs' performance was tested by simulating multiple DR events in a short time frame, such as two events on consecutive days. No more than one event may be called within a 24-hour period. Since the test sites are mostly primary schools, they are unoccupied or very lightly occupied through most of the summer months. IES collected most of the demand response test data in October once classes had resumed.
The Simulated DR Event dates and details are recorded in Figure 9, shown on the following page.

| | |
|---|---|
| **Event Date:** | 7/27/2017 |
| **Event Start Time:** | 1:00 PM (local) |
| **Event Duration:** | 2-hours |
| **Notification Type:** | Day-Ahead |
| **Notified On:** | 7/26/2017 8:00 AM (PDT) |

| | |
|---|---|
| **Event Date:** | 8/15/2017 |
| **Event Start Time:** | 2:00 PM (local) |
| **Event Duration:** | 4-hours |
| **Notification Type:** | Day-Ahead |
| **Notified On:** | 8/14/2017 2:30 PM (PDT) |

| | |
|---|---|
| **Event Date:** | 8/16/2017 |
| **Event Start Time:** | 12:00 PM (local) |
| **Event Duration:** | 2-hours |
| **Notification Type:** | Same Day |
| **Notified On:** | 8/16/2017 10:55 AM (PDT) |

| | |
|---|---|
| **Event Date:** | 10/10/2017 |
| **Event Start Time:** | 2:30 PM (local) |
| **Event Duration:** | 2-hours |
| **Notification Type:** | 30-MINUTE |
| **Notified On:** | 10/10/2017 2:00 PM (PDT) |

| | |
|---|---|
| **Event Date:** | 10/11/2017 |
| **Event Start Time:** | 12:00 PM (local) |
| **Event Duration:** | 4-hours |
| **Notification Type:** | Same Day |
| **Notified On:** | 10/11/2017 8:45 AM (PDT) |

| | |
|---|---|
| **Event Date:** | 10/20/2017 |
| **Event Start Time:** | 1:30 PM (local) |
| **Event Duration:** | 2-hours |
| **Notification Type:** | Same Day |
| **Notified On:** | 10/20/2017 8:16 AM (PDT) |

| | |
|---|---|
| **Event Date:** | 10/24/2017 |
| **Event Start Time:** | 11:45 AM (local) |
| **Event Duration:** | 2-hours |
| **Notification Type:** | 30-minute |
| **Notified On:** | 10/24/2017 11:15 AM (PDT) |

| | |
|---|---|
| **Event Date:** | 10/25/2017 |
| **Event Start Time:** | 11:45 AM (local) |
| **Event Duration:** | 4-hours |
| **Notification Type:** | same-day |
| **Notified On:** | 10/25/2017 8:00 AM (PDT) |

**Figure 9: DR Event Log**

# 4.0 Findings

### 4.1 Effects on Utility Demand Baseline

Utility companies charge customers on a baseline plus demand rate. Maintaining a steady demand of power yields a lower utility rate, so the Vendor's software utilizes energy storage to flatten the load curve. During peaks in demand, the controller software unloads power to the site to maintain a steady baseline. Utility companies rely on supplying a site with a baseline amount of energy. When a site demands more electricity than the baseline load, utility companies will charge for that demand because on an aggregate level as the load increases the utility is forced to bring additional generation resources online, these being the most costly and least efficient to operate. Accordingly, this electricity is more expensive. Efficiency of a natural gas power plant is on the order of 30-40% [3] compared to an average operating round-trip efficiency of 93% for this ESS. Also, an ESS can be installed in a period of less than a year which is much faster than a new power plant can be constructed.

In practice, the utility rates are set by the highest amount of energy demanded by a site. This means utility companies charge customers based on the max amount of kW, or instantaneous amount of energy, with the total kWh of energy used making up a minor portion of the total utility bill. With the help of the software, the controller is designed to charge the batteries when facility demand is at its lowest, and discharge when facility demand is highest. The purpose of the controller is to lower the demand peak to reduce utility charges on a monthly basis.

The performance of the fleet of twenty (20) ESSs was analyzed over a five (5) month period which included the February, March, April, May, and June 2017 billing statements. The analysis period was roughly from the second week in February 2017 through the second week in July 2017. The planned analysis period was to last a minimum of sixteen (16) weeks, the actual analysis period was approximately twenty (20) weeks.

Overall, the performance met pre-project expectations within 91% for demand or load shifting. This is shown in Table 8 below, and Table 2 on page 7.

**Table 8: Load Shifting Performance Summary**

| # | School District | System Name | System Size kW | System Size kWh | Analysis Period (Mo.) | Max. Recorded Reduction (kW) | Cumulative Bill Reduction | Portion Customer Keeps | Cumulative Customer Value (Present) | Customer Target Value (Present) | % Customer Target Value Achieved (Present) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Grossmont | East County ROP | 30 | 60 | 5 | 10.5 | $ 805.56 | 30% | $ 241.67 | $ 759.00 | 32% |
| 2 | Grossmont | El Capitan HS | 250 | 500 | 5 | 142.4 | $ 8,084.13 | 35% | $ 2,829.44 | $ 5,028.77 | 56% |
| 3 | Grossmont | Foothill School | 60 | 120 | 5 | 25.6 | $ 2,829.34 | 20% | $ 565.87 | $ 873.92 | 65% |
| 4 | Grossmont | Grossmont HS | 250 | 500 | 5 | 120.1 | $ 12,221.97 | 40% | $ 4,888.79 | $ 5,888.50 | 83% |
| 5 | Grossmont | Mt Miguel HS | 250 | 500 | 5 | 85.5 | $ 9,553.03 | 45% | $ 4,298.86 | $ 7,443.75 | 58% |
| 6 | Grossmont | Santana HS 1 | 250 | 500 | 5 | 91.2 | $ 12,218.41 | 30% | $ 3,878.25 | $ 3,928.63 | 99% |
| 7 | Grossmont | Santana HS 2 | 250 | 500 | 5 | 188.7 | $ 19,477.58 | 30% | $ 6,104.64 | $ 4,419.00 | 138% |
| 8 | Poway | Black Mountain | 250 | 500 | 5 | 110.8 | $ 12,972.23 | 25% | $ 3,243.06 | $ 3,243.06 | 100% |
| 9 | Poway | Del Norte HS B | 500 | 1000 | 5 | 337.8 | $ 43,110.15 | 25% | $10,777.54 | $ 9,355.10 | 115% |
| 10 | Poway | Del Norte HS A | 60 | 120 | | 62.7 | | | | | |
| 11 | Poway | Del Sur ES | 250 | 500 | 5 | 118.1 | $ 14,519.74 | 25% | $ 3,629.94 | $ 3,404.58 | 107% |
| 12 | Poway | Garden Road ES | 60 | 120 | 5 | 30.6 | $ 3,665.94 | 25% | $ 916.48 | $ 1,199.69 | 76% |
| 13 | Poway | Mesa Verde MS | 250 | 500 | 5 | 120.4 | $ 14,077.57 | 25% | $ 3,519.39 | $ 3,717.92 | 95% |
| 14 | Poway | Midland ES | 250 | 500 | 5 | 96.6 | $ 11,377.81 | 25% | $ 2,844.45 | $ 2,711.67 | 105% |
| 15 | Poway | Park Village ES | 250 | 500 | 5 | 95.9 | $ 9,750.04 | 25% | $ 2,437.51 | $ 2,867.08 | 85% |
| 16 | Poway | Stone Ranch ES | 250 | 500 | 5 | 97.3 | $ 10,888.84 | 25% | $ 2,722.21 | $ 3,143.33 | 87% |
| 17 | Poway | Westwood ES | 250 | 500 | 5 | 102.4 | $ 10,008.17 | 35% | $ 3,502.86 | $ 3,652.54 | 96% |
| 18 | Poway | Willow Grove ES | 250 | 500 | 5 | 130.7 | $ 10,992.29 | 25% | $ 2,748.07 | $ 3,643.13 | 75% |
| 19 | Poway | Highland Ranch | 250 | 500 | 5 | 95.6 | $ 9,610.60 | 35% | $ 3,363.71 | $ 3,689.00 | 91% |
| 20 | Poway | District Office | 250 | 500 | 4 | 95.4 | $ 9,645.20 | 25% | $ 2,411.30 | $ 2,103.17 | 115% |
| | **TOTAL** | | **4.46 MW** | | | | **$ 225,808.59** | | **$64,924.05** | **$71,071.83** | **91%** |

As Table 8 shows, some systems out performed their projected target over the first 5 months, while others under-performed. One trend that may be noted in the table is the tendency for the smaller 30 kW / 60 kWh ESS to underperform compared to projections, while the larger 250 kW / 500 kWh was more likely to achieve the expected savings. However, the smaller ESS also tended to be installed at sites with reduced a reduced maximum demand and therefore reduced demand charges overall. Due to the smaller maximum demand, the ESS had a diminished potential to perform financially. A more accurate finding may be that for a potential customer to consider an ESS as a feasible option the site's maximum demand should be at least 200 kW and not have ratchet charges. The sites which underperformed either have a maximum demand below 200 kW or ratchet charges.

ESS Efficiency is another consideration when reviewing the performance of the test sites. A marked trend of the smaller sized systems (single & double 30 kW / 60 kWh) was reduced performance compared to the larger sized systems (single & double 250 kW / 500 kWh) as shown above in Table 8 – Performance Summary. The system efficiency was also analyzed and a correlation between system size and efficiency is also noted, specifically the smaller systems achieved a round trip efficiency of between 69%-86% while the larger system achieved a much higher round-trip efficiency of between 92%-98%. Please see Table 9 below summarizing the round-trip efficiency by system type. The average round-trip efficiency is 93.4% over the fleet of 20 units. The 250 kW / 500 kWh achieved an average round-trip efficiency of 94.5%.

**Table 9: Efficiency Summary by Type**

| ESS EFFICIENCY SUMMARY: by System Type | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| # | Qty. of Type in Study | System Base Type | System Type kW | System Type kWh | Total kWh Consumed | Total kWh Discharged | Total kWh Lost | Efficiency (Avg.) (%) |
| 1 | 1 | Single GS 30-60 | 30 | 60 | 3,046 | 2,215 | 830 | 73% |
| 2 | 3 | Double GS 30-60 | 60 | 120 | 19,024 | 14,562 | 4,462 | 77% |
| 3 | 15 | Single GS 250-500 | 250 | 500 | 353,958 | 334,610 | 19,348 | 95% |
| 4 | 1 | Double GS 250-500 | 500 | 1000 | 47,959 | 44,671 | 3,288 | 93% |
| | TOTAL | | | | 423,986 | 396,058 | 27,928 | 93% |

Please note that the average round-trip efficiency value shown in Table 9 is weighted by Total kWh.

**Appendix B** contains the site-by-site summaries of the monthly peak shaving and financial performance analysis. These tables show the On-Peak and Non-Coincident demand savings in each billing period. The achieved demand reduction amounts were typically 50% or less than the rated kW of the ESS, and performance month-over-month was inconsistent. A customer site with a higher overall baseline demand is more likely to achieve a consistent reduction month-over month. The Energy Storage Systems installed at sites with consistently high daytime demand were the best performers and frequently exceeded the pre-project savings estimates.

Figure 10 on the following page depicts the maximum monthly Non-Coincident demand at one of the High Schools included in the study.

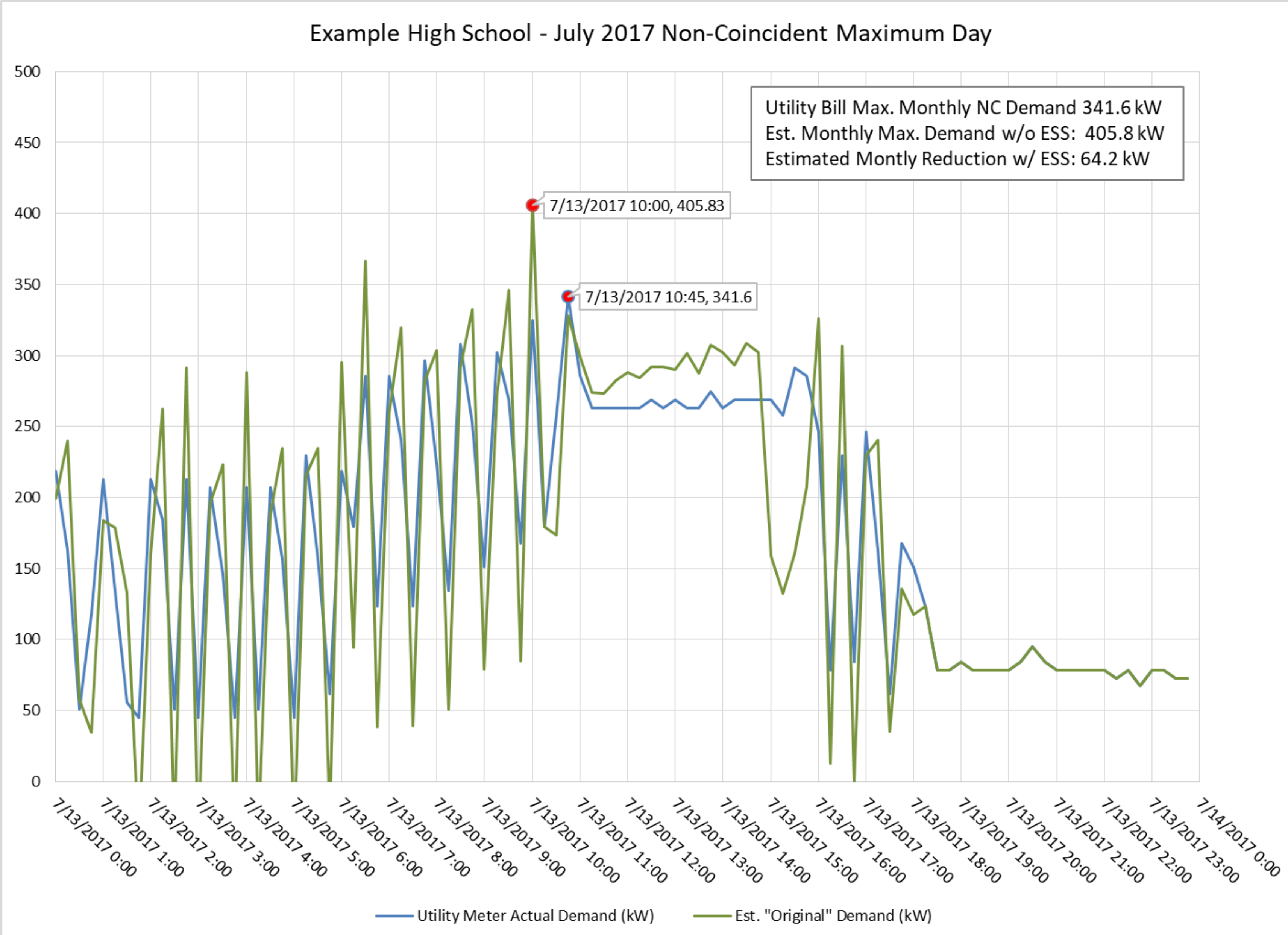



**Figure 10: Non-Coincident Demand Maximum Day**

As shown in Figure 10, the actual Non-Coincident demand at the utility meter was 341.6 kW. In this example, the figure only shows the maximum day. The blue line is the actual demand, or the demand seen by the utility meter.  The green line is the estimated “original” demand, or the demand as if the ESS were not installed. This is calculated as the actual demand plus the inverter output at any given time. The Non-Coincident demand savings is calculated on a monthly basis as the difference between the maximum estimated “original” demand and the actual Non-Coincident demand each month. In this example the estimated “original” monthly maximum demand was 405.8 kW, therefore the ESS was able to reduce this customer’s demand by 64.2 kW in the example from July 2017 at one of the test sites.  The monthly savings and kW reduction summaries from all the test sites over the full analysis term are included in **Appendix B.**

It is important here to draw the distinction between maximum monthly demand and utility company defined Non-Coincident demand with a ratchet charge.  A ratchet charge occurs when the monthly maximum demand is less than half of the maximum demand in the previous 12 months. If this occurs then the Non-Coincident demand is the higher of the two values.  The Vendor were apparently unaware of ratchet charges and accordingly their billing statements to customers did not account for the ratchet charge and ESS units did not optimize their charging and discharging patterns to take this into account.

In the above example the monthly Non-Coincident demand savings are calculated as the NC demand reduction multiplied by the NC demand rate, which in this example was $23.89/kW as specified in the customer’s applicable rate tariff.  The NC savings resulting from the ESS this month was a total of $1,534.38 for this customer site.  Of this total the customer retains 45% or $690.47 plus the savings from the On-Peak demand reduction as discussed in detail below.

In addition to Non-Coincident demand, the utility company bills on the basis of On-Peak demand. Figure 11 below shows a day with the actual monthly maximum On-Peak demand at the same site as the previous example.

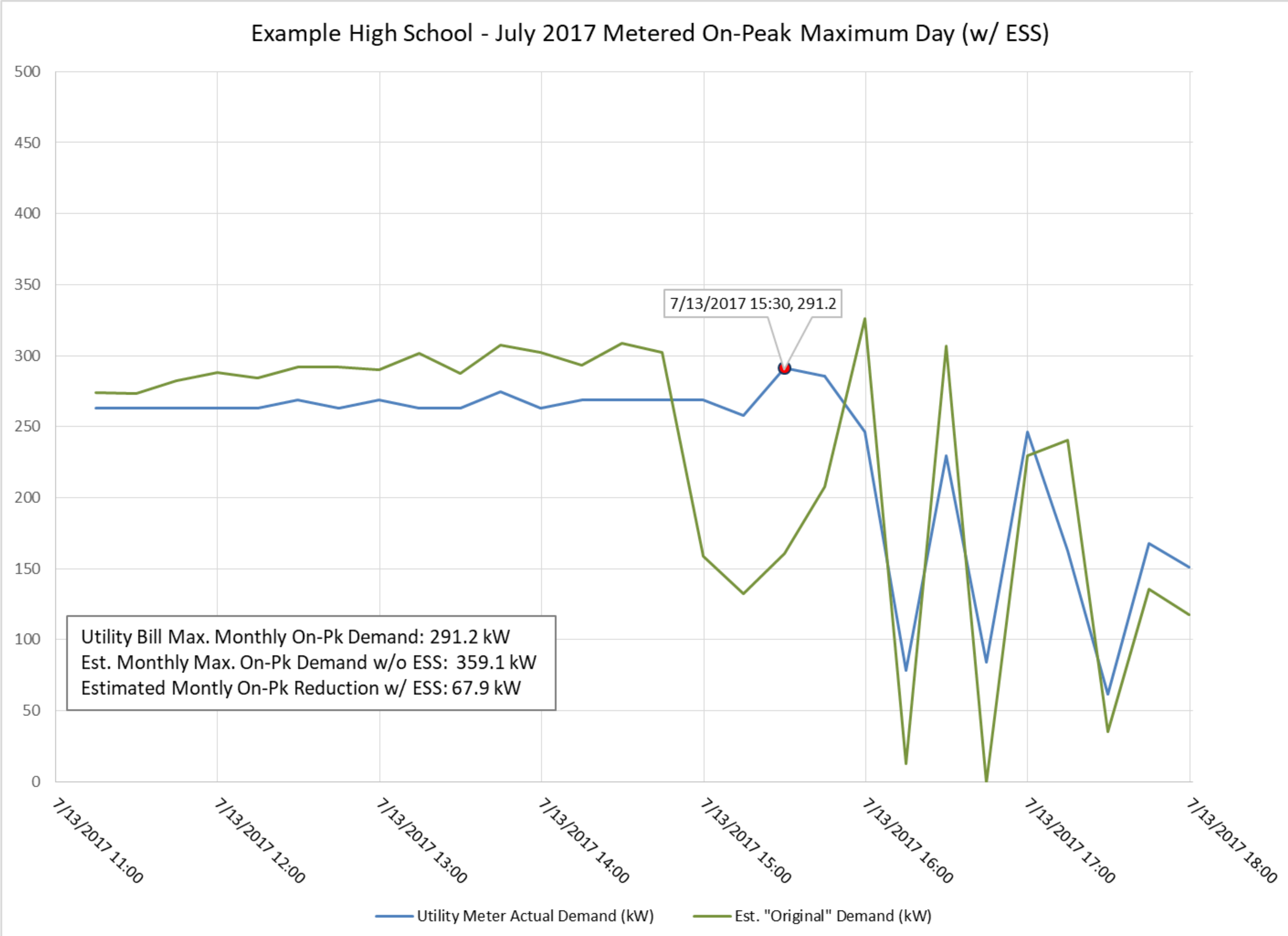



**Figure 11: Actual On-Peak Demand Maximum Day**

In Figure 11 above please note that the maximum monthly On-Peak demand recoded by the utility meter was 291.2 kW, in this example (blue line). The Figure above only shows the On-Peak period of the day in which the maximum actual On-Peak demand occurred.

In Figures 11 and 12, just like in Figure 10, the blue line represents the actual demand as seen by the utility meter, while the green line represents the estimated “original” demand, or the demand that the facility would have been billed for if the ESS had not been installed.

Figure 12 below shows the day on which the estimated “original” On-Peak demand would have occurred if the ESS had not been installed.

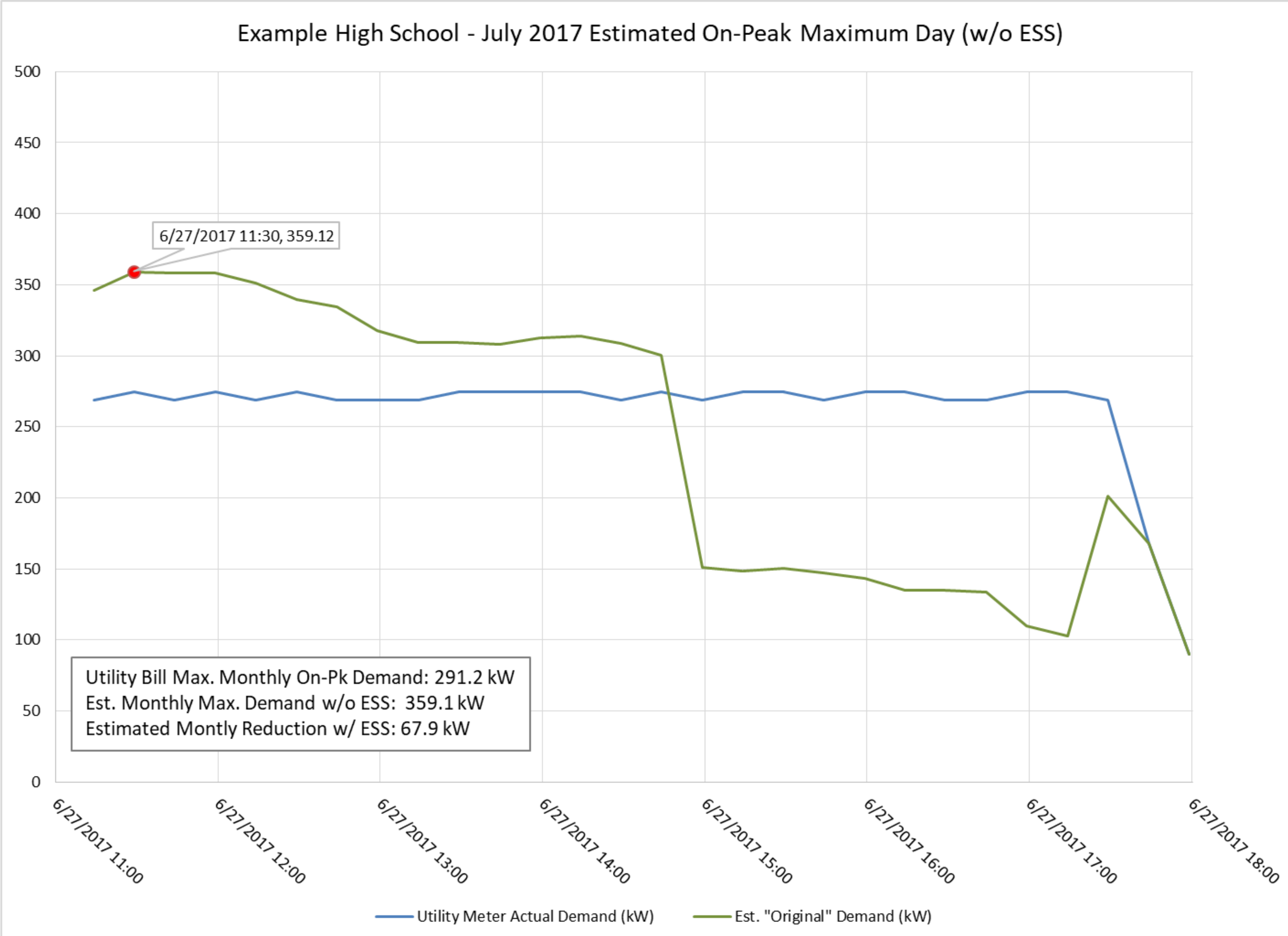



**Figure 12: Original On-Peak Demand Maximum Day**

In Figure 12 above please note that the monthly maximum "original" On-Peak demand would have been 359.1 kW (green line), if the ESS had not been installed. Therefore in the example above, the On-Peak demand was reduced by a total of 67.9 kW, from 359.1 kW to 291.2 kW.

In the above example the monthly On-Peak demand savings are calculated as the On-Peak demand reduction multiplied by the On-Peak demand rate, which in this example was $9.93/kW for July which is a summer month. The On-Peak savings resulting from the ESS this month was a total of $674.41 for this customer site, as compared to $1,534.38 for the NC demand portion of the bill. Note that the NC demand portion is the factor that drives the overall cost of the customer bill.

Based on the PEA between the customer and the Vendor, 45% of the saving s are retained by the customer, which works out to $303.48 customer savings. In total this month the example customer site retained $993.96 which would have otherwise been paid to the utility company.

Overall the host customers' financial savings were substantial and are shown in Table 8 on page 30 of this report.

### 4.2 Demand Response Effects

Eight (8) simulated demand response events were called and the load profiles on those days were analyzed to determine the performance of the ESS as a demand response asset. The key findings of this portion of the study are as follows:

- Substantial potential as a demand response asset was demonstrated.
    - Technical performance of batteries and inverters was good.
    - Software performed poorly or was not utilized in a manner to affect load shedding at the test sites in response to the simulated event times/dates.
- DR Performance of the test fleet was not consistent from site to site or between simulated events.
- The system's software algorithm was clearly not optimized for a demand response situation:
    - Frequently the ESS was observed to re-charge during simulated events.
    - Discharge strategy frequently appeared to be the normal daily strategy during simulated events.
- Event duration had little effect on curtailment due to inconsistent performance.

- Approximately 25% of the total capacity was curtailed on the three (3) most consistent event simulations, including four and two-hour events.
- The highest performing simulation resulted in an average 2.7 MW curtailment over the 2-hour event.
- Load shedding predictions from the Vendor were reasonably accurate for two of the events with better performance.

The above findings should not be interpreted as a failure of the ESS as a demand response asset, instead minor adjustments to the control algorithm are all that are needed. The capability of the ESS to discharge on cue and instantly replace a portion of the electricity needs of a customer were demonstrated on an individual basis, however the fleet's performance during the simulated events was not consistent.

Table 10 below catalogs the instances in which an ESS was observed to re-charge batteries during a simulated DR event.

**Table 10: ESS Re-Charging During Simulated Demand Response Events**

| # | District | System Name | System Size | DR-1 | DR-2 | DR-3 | DR-4 | DR-5 | DR-6 | DR-7 | DR-8 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 7/27/2017 | 8/15/2017 | 8/16/2017 | 10/10/2017 | 10/11/2017 | 10/20/2017 | 10/24/2017 | 10/25/2017 |
| 1 | GUHSD | East County REC | 30 kW / 60 kWh | YES | YES | NO | YES | YES | YES | NO | YES |
| 2 | GUHSD | El Capitan HS | 250 kW / 500 kWh | NO | YES | NO | NO | NO | YES | NO | YES |
| 3 | GUHSD | Foothill Adult | 60 kW / 120 kWh | YES | YES | YES | YES | YES | YES | NO | YES |
| 4 | GUHSD | Grossmont HS | 250 kW / 500 kWh | NO | YES | NO | YES | YES | YES | NO | YES |
| 5 | GUHSD | Mt Miguel HS | 250 kW / 500 kWh | NO | NO | NO | NO | NO | YES | NO | YES |
| 6 | GUHSD | Santana HS 1 | 250 kW / 500 kWh | NO | YES | NO | YES | YES | YES | NO | YES |
| 7 | GUHSD | Santana HS 2 | 250 kW / 500 kWh | NO | YES | YES | YES | YES | YES | NO | YES |
| 8 | PUSD | Black Mountain MS | 250 kW / 500 kWh | NO | YES | YES | YES | YES | YES | NO | YES |
| 9 | PUSD | Del Norte HS A | 60 kW / 120 kWh | NO | YES | NO | YES | YES | YES | NO | YES |
| 10 | PUSD | Del Norte HS B | 500 kW / 1000 kWh | NO | YES | NO | NO | YES | YES | NO | NO |
| 11 | PUSD | Del Sur ES | 250 kW / 500 kWh | NO | YES | NO | YES | YES | YES | NO | NO |
| 12 | PUSD | Garden Road ES | 60 kW / 120 kWh | NO | YES | YES | NO | YES | YES | YES | YES |
| 13 | PUSD | Mesa Verde MS | 250 kW / 500 kWh | YES | YES | NO | YES | YES | YES | YES | YES |
| 14 | PUSD | Midland ES | 250 kW / 500 kWh | NO | YES | NO | NO | NO | YES | NO | YES |
| 15 | PUSD | Park Village ES | 250 kW / 500 kWh | NO | YES | NO | YES | YES | YES | NO | YES |
| 16 | PUSD | Stone Ranch ES | 250 kW / 500 kWh | NO | YES | NO | NO | YES | YES | NO | YES |
| 17 | PUSD | Westwood ES | 250 kW / 500 kWh | NO | YES | NO | YES | YES | YES | NO | YES |
| 18 | PUSD | Willow Grove ES | 250 kW / 500 kWh | NO | YES | YES | NO | YES | YES | YES | YES |
| 19 | PUSD | Highland Ranch ES | 250 kW / 500 kWh | NO | YES | YES | YES | YES | YES | NO | YES |
| 20 | PUSD | PUSD Dist. Office | 250 kW / 500 kWh | NO | YES | NO | NO | NO | YES | NO | NO |

In Table 10 please note the frequency at which re-charging during a simulated event occurred. The ESSs re-charged batteries based on the normal operation mode wherein the batteries are re-charged as soon after discharging as the facility load will permit, regardless of the simulation, i.e. no difference from a normal day.

Using the average efficiency of the ESS (see Section 4.3) it is possible to calculate the energy impacts in kWh for each of the simulated DR events. Please see Table 11 on the following page which shows the curtailment energy provided for each simulated DR event, as well as the rebound energy kWh wasted for re-charging.

**Table 11: ESS Re-Charging Rebound Energy Consumption**

| # | District | System Name | System Size | DR-1 7/27/2017 | DR-2 8/15/2017 | DR-3 8/16/2017 | DR-4 10/10/2017 | DR-5 10/11/2017 | DR-6 10/20/2017 | DR-7 10/24/2017 | DR-8 10/25/2017 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Notification Type | Day-Ahead | Day-Ahead | Same-Day | 30-Minute | Same-Day | Same-Day | 30-Minute | Same-Day |
| | | | Simulated Event Duration (hrs.) | 2 | 4 | 2 | 2 | 4 | 2 | 2 | 4 |
| | | | Curtailment vs. 10-in-10 baseline (kWh) / Energy Waste (kWh) | | | | | | | | |
| 1 | GUHSD | East County REC | 30 kW / 60 kWh | -2.6 / NA | 38.4 / 10.5 | 36.4 / 9.9 | 2.4 / NA | 14.4 / 3.9 | 26.0 / 7.1 | -16.0 / NA | -52.4 / NA |
| 2 | GUHSD | El Capitan HS | 250 kW / 500 kWh | 59.0 / 3.7 | 122.4 / 7.6 | 42.4 / 2.6 | -7.8 / NA | 200.4 / NA | 344.0 / 21.5 | 114.4 / 7.1 | 10.0 / NA |
| 3 | GUHSD | Foothill Adult | 60 kW / 120 kWh | -41.6 / NA | 96.0 / 30.2 | 42.0 / 13.2 | 17.6 / NA | 49.6 / 15.6 | 82.8 / 26.1 | -20.4 / -6.4 | -108.8 / NA |
| 4 | GUHSD | Grossmont HS | 250 kW / 500 kWh | 106.6 / 7.0 | 278.8 / 18.4 | 75.0 / 5.0 | -22.6 / NA | 520.0 / 34.3 | 482.0 / 31.8 | -123.2 / NA | -235.6 / NA |
| 5 | GUHSD | Mt Miguel HS | 250 kW / 500 kWh | -123.0 / NA | 58.4 / NA | -135.2 / NA | -3.6 / NA | 183.2 / NA | 372.2 / 25.3 | 65.6 / NA | -452.8 / NA |
| 6 | GUHSD | Santana HS 1 | 250 kW / 500 kWh | 26.8 / 0.8 | -5.2 / -0.2 | 38.8 / 1.2 | 71.8 / NA | 288.8 / 8.6 | 301.2 / 8.9 | -39.8 / NA | -179.6 / NA |
| 7 | GUHSD | Santana HS 2 | 250 kW / 500 kWh | 12.0 / 0.5 | 59.2 / 2.5 | -7.6 / -0.3 | 82.2 / NA | 255.6 / 10.7 | 232.2 / 9.8 | 23.4 / 1.0 | -150.8 / NA |
| 8 | PUSD | Black Mountain MS | 250 kW / 500 kWh | -22.0 / NA | 36.4 / 1.4 | -5.8 / -0.2 | 29.0 / NA | 273.6 / 10.3 | 473.4 / 17.7 | 18.8 / 0.7 | -34.8 / NA |
| 9 | PUSD | Del Norte HS A | 60 kW / 120 kWh | 45.6 / 3.1 | 848.8 / 58.2 | 371.0 / 25.4 | -20.0 / NA | 930.0 / 63.8 | 439.2 / 30.1 | -109.8 / NA | 32.4 / NA |
| 10 | PUSD | Del Norte HS B | 500 kW / 1000 kWh | -21.2 / NA | -1.2 / NA | 1.8 / NA | -3.2 / NA | 17.6 / NA | -3.0 / NA | -8.2 / NA | -4.4 / NA |
| 11 | PUSD | Del Sur ES | 250 kW / 500 kWh | 53.4 / 4.1 | 232.4 / 18.0 | 144.4 / 11.2 | -8.4 / NA | 362.0 / 28.0 | 326.6 / 25.3 | -39.2 / NA | -62.8 / NA |
| 12 | PUSD | Garden Road ES | 60 kW / 120 kWh | -34.0 / NA | 53.2 / NA | 15.8 / NA | -2.6 / NA | 18.8 / NA | 41.8 / NA | -53.2 / NA | -62.8 / NA |
| 13 | PUSD | Mesa Verde MS | 250 kW / 500 kWh | 20.8 / 1.4 | 338.0 / 23.0 | 148.8 / 10.1 | -15.8 / NA | 174.8 / 11.9 | 282.6 / 19.2 | -35.2 / NA | -22.0 / NA |
| 14 | PUSD | Midland ES | 250 kW / 500 kWh | 48.8 / 3.6 | 432.4 / NA | 245.0 / 18.2 | -2.0 / NA | 34.0 / 2.5 | 231.6 / 17.2 | -94.0 / NA | -188.4 / NA |
| 15 | PUSD | Park Village ES | 250 kW / 500 kWh | -4.6 / -0.1 | 551.2 / 13.2 | 252.6 / 6.1 | 64.8 / NA | 421.6 / 10.1 | 350.8 / 8.4 | -69.4 / NA | -165.6 / NA |
| 16 | PUSD | Stone Ranch ES | 250 kW / 500 kWh | 10.6 / 0.6 | 196.0 / 10.7 | 118.8 / 6.5 | -47.6 / NA | 416.4 / 22.8 | 360.6 / 19.7 | -79.2 / NA | -5.2 / NA |
| 17 | PUSD | Westwood ES | 250 kW / 500 kWh | 42.4 / 2.9 | 537.2 / 37.3 | 265.8 / 18.5 | -2.0 / NA | 338.8 / 23.5 | 355.8 / 24.7 | -82.0 / NA | -228.4 / NA |
| 18 | PUSD | Willow Grove ES | 250 kW / 500 kWh | 0.6 / 0.0 | 501.2 / 21.3 | 239.0 / 10.2 | -37.6 / NA | 279.6 / 11.9 | 333.6 / 14.2 | -171.0 / -7.3 | -133.6 / NA |
| 19 | PUSD | Highland Ranch ES | 250 kW / 500 kWh | 0.4 / 0.0 | 120.0 / 5.8 | 121.8 / 5.9 | 17.8 / NA | 91.2 / 4.4 | 193.6 / 9.3 | -67.2 / NA | -121.2 / NA |
| 20 | PUSD | PUSD Dist. Office | 250 kW / 500 kWh | 71.0 / 4.1 | 148.8 / 8.6 | 185.0 / 10.6 | 96.4 / NA | 204.8 / 11.8 | 246.8 / 14.2 | -42.4 / NA | -86.4 / NA |
| **TOTAL KWH CURTAILED / KWH WASTED PER EVENT** | | | | 498.0 / 32.0 | 4104.8 / 266.7 | 2326.8 / 154.5 | 0.0 / 0.0 | 4655.2 / 274.1 | 5435.0 / 330.5 | 156.6 / 8.8 | 0.0 / 0.0 |

**Notes:**

PURPLE TEXT = Day-Ahead Notification given prior to simulated DR event.

BLUE TEXT = Same-Day Notification given prior to simulated DR event.

ORANGE TEXT = 30-Minute Notification given prior to simulated DR event.

NA = Not Applicable because the system did not respond to the DR simulated event.

Figure 13 below shows the Actual Metered Demand, the “original” demand, the 10-in-10 day baseline demand and the ESS battery state of charge during DR event simulation #6 at one of the test sites (Black Mountain Middle School). This event was selected because it demonstrated the highest overall performance out of all the simulations. The specific test site is shown here because in this case it demonstrates good performance and has a well-defined load shape showing a clear response to the demand response simulation. The load profile for each test site, during each simulated event are shown in **Appendix D.**

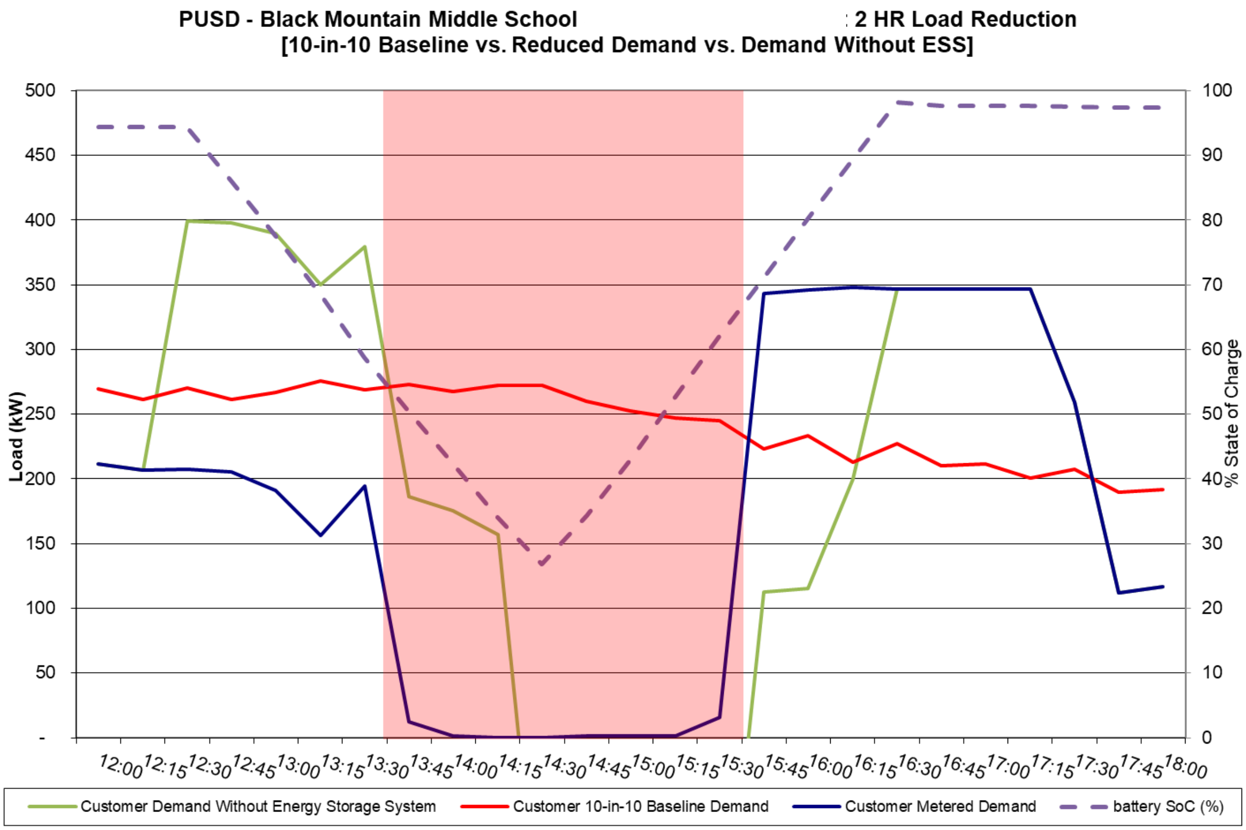



**Figure 13: Black Mountain Middle School – Simulated DR Event Test #6**

Although the curtailment at this site was quite good (an average of 236.7 kW over 2-hours) we can see that the battery begins re-charging as soon as it reaches a 25% state of charge (dashed purple line). This is typical behavior for the control algorithm, but in this case, it occurs during the DR event simulation which was a common occurrence.

The green line in Figure 13 above shows what the site’s demand would have been if the ESS were not installed. The blue line shows the actual utility metered demand. Please note that the ESS begins supplementing the site’s load prior to the start time of the simulated event as shown by the shaded region between 1:30 PM and 3:30 PM.

This demonstrates that while it would be technically possible to improve the DR performance with relatively simple modifications to the control algorithm, the concern exists that unless the vendor's business model is properly aligned with the DR program, the vendor would not be able to risk the financial savings generated from the peak-reduction to fully participate in DR. The tuning of the DR response algorithm would be a delicate balancing act since any failure to be ready to reduce a facilities peak could cause the vendor to miss an opportunity to create financial savings and cause the NC demand to be higher for 12 months.

As a contrast to the clear response to a DR event simulation shown in Figure 13 above, Figure 14 below shows a system at a test site that did not show a response to a specific event.

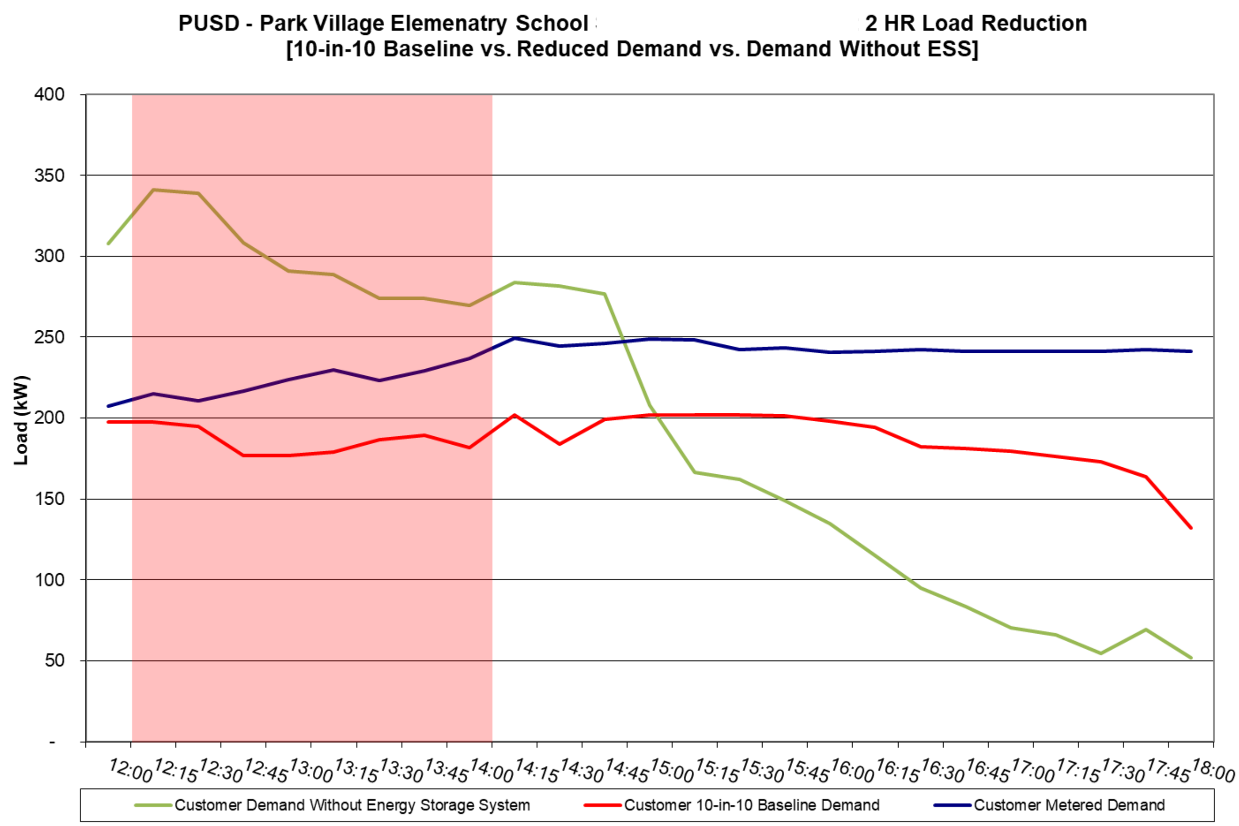



**Figure 14: Park Village Elementary School – Simulated DR Event Test #7**

In Figure 14 above please note that the 2-hour simulated DR event was called for the hours between noon and 2:00 PM. The load shape in this case does not show a pronounced reduction during the hours of the simulation, instead this is the load shape of a typical daily operation. The actual metered demand is higher than the

10-in-10 day baseline demand resulting in no DR reduction at all, even when the ESS is has successfully reduced the actual demand compared to the “original” demand as shown by the relative position of the green and blue lines respectively.

One likely reason why this site’s ESS did not appear to participate in the DR event Simulation is that this event (#7) was one of the two simulations with only 30-minute notification provided. The majority of the systems similarly did not appear to participate in this simulation as well as the prior simulation with 30-minute notification. The email notification method was intended as an expedient notification method for use during this study only and is not intended to simulate actual practice. If the technology is to be integrated with the utility systems in the future then the automated notification method would be substantially different and is not evaluated in this study.

Overall the ESS was demonstrated to have significant load shedding capability, and is functionally sound and furthermore does not present a serious hazard to occupants or interconnected equipment. Minor optimization of the control routine for DR is recommended.

### 4.3 ESS Round-Trip Efficiency Analysis

The round-trip electrical efficiency of the ESS was evaluated as part of this M&V study. The kWh consumed by the ESS over the study period was totaled and this total was compared to the total kWh exported by the ESS, the difference being waste. Energy waste factors include charging circuit efficiency, inverter efficiency, cooling system & associated fans, ancillary loads such as the system controller all contribute to system losses. The vendor stated round-trip system efficiency is 94% average, with 88.4% minimum efficiency. Efficiency at Full Load is given as 86% by the vendor. The kWh weighted average efficiency was measured as 93.4% over the study period and meets the vendor claims.

One trend that is apparent in Tables 9 and 12 is the difference between the average round-trip efficiency of the smaller size ESS compared to the larger size ESS. The 60 kW / 120 kWh is made up of two 30 kW / 60 kWh units connected in parallel. The average efficiency of the 60 kW / 120 kWh is 76.5% which is lower than the vendor statement but higher than the SGIP minimum. The 500 kW / 1000 kWh is made up of two 250 kW / 500 kWh units, which were the most common type deployed in this study. The average round trip efficiency of the 250 kW / 500 kWh was measured to be 94.5% over the entire study period, this meets the vendors claimed efficiency.

The efficiency measured more than satisfies the SGIP requirement of 69.6% round trip efficiency in the first year and 66.5% over 10 years. The duration of the study was not long enough to comment on long term efficiency, but the battery manufacturer's warranty is sufficient to preclude premature battery failure within the SGIP minimum time period.

Please see Table 12 below, showing the average round-trip efficiency over the entire M&V study period for each ESS.

**Table 12: ESS Average Round-Trip Efficiency**

| ESS EFFICIENCY SUMMARY: by System | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| # | School District | System Name | System Size kW | System Size kWh | Total kWh Consumed | Total kWh Discharged | Total kWh Lost | Efficiency (%) |
| 1 | Grossmont | East County ROP | 30 | 60 | 3,046 | 2,215 | 830 | 73% |
| 2 | Grossmont | El Capitan HS | 250 | 500 | 21,391 | 20,056 | 1,335 | 94% |
| 3 | Grossmont | Foothill School | 60 | 120 | 6,030 | 4,131 | 1,899 | 69% |
| 4 | Grossmont | Grossmont HS | 250 | 500 | 23,618 | 22,058 | 1,559 | 93% |
| 5 | Grossmont | Mt Miguel HS | 250 | 500 | 29,123 | 27,145 | 1,978 | 93% |
| 6 | Grossmont | Santana HS 1 | 250 | 500 | 27,992 | 27,160 | 831 | 97% |
| 7 | Grossmont | Santana HS 2 | 250 | 500 | 22,639 | 21,687 | 952 | 96% |
| 8 | Poway | Black Mountain | 250 | 500 | 19,714 | 18,975 | 739 | 96% |
| 9 | Poway | Del Norte HS B | 500 | 1000 | 47,959 | 44,671 | 3,288 | 93% |
| 10 | Poway | Del Norte HS A | 60 | 120 | 6,765 | 5,813 | 952 | 86% |
| 11 | Poway | Del Sur ES | 250 | 500 | 23,240 | 21,442 | 1,798 | 92% |
| 12 | Poway | Garden Road ES | 60 | 120 | 6,229 | 4,618 | 1,611 | 74% |
| 13 | Poway | Mesa Verde MS | 250 | 500 | 24,270 | 22,619 | 1,650 | 93% |
| 14 | Poway | Midland ES | 250 | 500 | 25,256 | 23,384 | 1,872 | 93% |
| 15 | Poway | Park Village ES | 250 | 500 | 24,905 | 24,308 | 597 | 98% |
| 16 | Poway | Stone Ranch ES | 250 | 500 | 26,006 | 24,585 | 1,421 | 95% |
| 17 | Poway | Westwood ES | 250 | 500 | 20,146 | 18,746 | 1,400 | 93% |
| 18 | Poway | Willow Grove ES | 250 | 500 | 25,702 | 24,608 | 1,094 | 96% |
| 19 | Poway | Highland Ranch | 250 | 500 | 18,814 | 17,910 | 904 | 95% |
| 20 | Poway | District Office | 250 | 500 | 21,142 | 19,926 | 1,216 | 94% |
| | **TOTAL** | | 4460 | 8920 | 423,986 | 396,058 | 27,928 | 93% |

### 4.4 Discharge Cycle Analysis

To receive SGIP incentives there is a requirement that the ESS completes 130 full discharge cycles per year [2]. The SGIP handbook defines a full discharge cycle as the total incentivized capacity of the ESS in terms of kWh, and the discharge is not required to be done all at once. The annual total kWh discharged is the value measured. In other words, the ESS must discharge 130 times the kWh capacity of the ESS every year. An analysis of the total discharge cycles was performed over the 3-month period from May 1, 2017 to July 31, 2017. The individual system values are summarized in Table 13 on the following page.

Table 13: ESS Discharge Cycle Analysis

| ESS Discharge/Re-Charge Cycle Analysis Summary (5/1/2017 to 7/31/2017) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| # | School District | System Name | System Size kW | kWh | Total kWh Discharged | Discharge Cycles Achieved | Discharge Cycles Required | % |
| 1 | Grossmont | East County ROP | 30 | 60 | 1,076 | 18 | 33 | 55% |
| 2 | Grossmont | El Capitan HS | 250 | 500 | 4,972 | 10 | 33 | 30% |
| 3 | Grossmont | Foothill School | 60 | 120 | 2,649 | 22 | 33 | 67% |
| 4 | Grossmont | Grossmont HS | 250 | 500 | 12,015 | 24 | 33 | 73% |
| 5 | Grossmont | Mt Miguel HS | 250 | 500 | 10,520 | 21 | 33 | 64% |
| 6 | Grossmont | Santana HS 1 | 250 | 500 | 10,988 | 22 | 33 | 67% |
| 7 | Grossmont | Santana HS 2 | 250 | 500 | 7,658 | 15 | 33 | 47% |
| 8 | Poway | Black Mountain | 250 | 500 | 8,033 | 16 | 33 | 49% |
| 9 | Poway | Del Norte HS B | 500 | 1000 | 19,348 | 19 | 33 | 59% |
| 10 | Poway | Del Norte HS A | 60 | 120 | 1,550 | 13 | 33 | 39% |
| 11 | Poway | Del Sur ES | 250 | 500 | 2,207 | 4 | 33 | 13% |
| 12 | Poway | Garden Road ES | 60 | 120 | 1,863 | 16 | 33 | 47% |
| 13 | Poway | Mesa Verde MS | 250 | 500 | 8,400 | 17 | 33 | 51% |
| 14 | Poway | Midland ES | 250 | 500 | 11,490 | 23 | 33 | 70% |
| 15 | Poway | Park Village ES | 250 | 500 | 15,673 | 31 | 33 | 96% |
| 16 | Poway | Stone Ranch ES | 250 | 500 | 10,339 | 21 | 33 | 63% |
| 17 | Poway | Westwood ES | 250 | 500 | 10,303 | 21 | 33 | 63% |
| 18 | Poway | Willow Grove ES | 250 | 500 | 15,177 | 30 | 33 | 93% |
| 19 | Poway | Highland Ranch | 250 | 500 | 10,318 | 21 | 33 | 63% |
| 20 | Poway | District Office | 250 | 500 | 15,097 | 30 | 33 | 92% |
| | **TOTAL** | | 4460 | 8920 | 179,676 | 20 | 33 | 62% |

The 3-month discharge cycle analysis period starting May 1, 2017 was selected to ensure that all 20 units were fully installed, online, and software was operating normally. The initial part of the study was not used for this analysis. Compliance with this SGIP requirement is estimated to result in the ESS being exercised unnecessarily and would result in added inefficiency (due to system round-trip efficiency) and unneeded cycles of the batteries, reducing system lifespan.

Over this period of 3 months we can expect a quarter of the 130 cycles to have occurred, or 32.5 full discharge cycles. One discharge cycle is defined as the total incentivized kWh, which for this fleet is 8,920 kWh. Based on the analysis performed, a total of 179,676 kWh was discharged from the ESS fleet over the 3-month period. As shown in Table 13 above, this is equivalent to 20 full discharge cycles and makes up only 62% of the pro-rated minimum requirement.

### 4.5 Financial Analysis

Equipment purchase, installation, warranty and maintenance are no cost to the customer, instead the Vendor splits the savings with the customer over a 10-year period. This means there is no initial cost, and the customer will immediately start seeing savings after installation. This Vendor offers no initial cost through the PEA or Shared Savings Plan. Through the PEA, customers share a percentage of the monthly savings, based on initial costs, expected future savings, utility rates & taxes, and other factors. This program period is 10 years, in which period the company expects to earn back expenditures and make a profit. However, the life of the Samsung batteries is roughly 10 years, so a customer can choose to either enter the program again and share savings or pay for a new installation. Either way, the batteries would need to be replaced after the 10-year period.

### 4.6 Critical Peak Pricing Program (CPP-D) and Capacity Bidding Program (CBP) Discussion

The Critical Peak Pricing Program (CPP-D) and the Capacity Bidding Program (CBP) are two demand response programs offered by SDG&E. CPP-D is a commodity tariff applied as the default commodity rate for customers receiving bundled service on a commercial or industrial rate schedule whose maximum monthly demand is greater than 20 kW for twelve consecutive months (e.g. schedule AL-TOU) [1]. With CPP-D a customer pays an additional commodity charge called an event day adder as well as the regular commodity charge whenever a CPP event is called [1]. For periods when an event is not being called, the customer pays only the normal commodity rate as shown in the tariff [1]. Under CPP-D a customer has the option to reserve a level of generation capacity specified in kW that would protect that portion of their load from the CPP event day adder [1]. The customer must pay a monthly Capacity Reservation Charge for 12 months for each kW of reserved capacity [1]. By default the capacity reservation level is set at 50% of the customer's CPP Maximum Summer demand [1].

By contrast, the CBP program is a voluntary demand response program in which participants can earn incentives for reducing demand when called upon. The amount of the incentive varies by time of day, month, and if the notification is given on the same day as the event or on the previous day [4]. This program is also open to aggregators, such as the Vendor in this case, to combine ESS assets located at various sites into one generation system [4]. To utilize the CBP, an aggregator will submit a monthly 'Load Reduction Nomination' in which they specify the amount of load reduction and mix of 'Products' available for the coming month no later than 15 days prior to the start of each operational month [4]. The multiple products that the program participant can choose from are shown below in Table 14 [4].

**Table 14: Capacity Bidding Program (CBP) Products**

| Day-Ahead Products | Hours | Minimum Duration per Event | Maximum Duration per Event | Maximum Cumulative Event Duration Per Operational Month | Maximum Events Per Day |
|---|---|---|---|---|---|
| 2 to 4 hours | 11am to 7pm | 2 hours | 4 hours | 24 | 1 |
| 2 to 4 hours | 1pm to 9pm | 2 hours | 4 hours | 24 | 1 |

| Day-Of Products | Hours | Minimum Duration per Event | Maximum Duration per Event | Maximum Cumulative Event Duration Per Operational Month | Maximum Events Per Day |
|---|---|---|---|---|---|
| 2 to 4 hours | 11am to 7pm | 2 hours | 4 hours | 24 | 1 |
| 2 to 4 hours | 1pm to 9pm | 2 hours | 4 hours | 24 | 1 |

The incentive rates available per kW of reduction bid are shown below in Table 15 [4].

**Table 15: Capacity Bidding Program (CBP) Rates**

Capacity Incentive, Day-Ahead Program Option ($/kW-month):

| Product | Hours | May | Jun | Jul | Aug | Sep | Oct |
|---|---|---|---|---|---|---|---|
| 2 to 4 hours | 11am to 7pm | 2.86 | 7.61 | 16.51 | 20.41 | 13.52 | 4.10 |
| 2 to 4 hours | 1pm to 9pm | 3.43 | 9.13 | 19.81 | 24.49 | 16.22 | 4.91 |

Capacity Incentive, Day-Of Program Option ($/kW-month):

| Product | Hours | May | Jun | Jul | Aug | Sep | Oct |
|---|---|---|---|---|---|---|---|
| 2 to 4 hours | 11am to 7pm | 3.26 | 8.66 | 18.81 | 23.24 | 15.40 | 4.66 |
| 2 to 4 hours | 1pm to 9pm | 3.87 | 10.30 | 22.35 | 27.63 | 18.30 | 5.54 |

Because of the variety of different products and choices available to a CBP program participant, Table 16 was prepared as a guide to assist a School-District with ESS assets to make the most of the CBP program. The recommended Load Reduction Nomination of 25% of the ESS's inverter capacity is made based on performance observations, and is contingent on the vendor fixing the manual DR notification issues and associated lack of reliable curtailment. The Vendor is also an Aggregator.

**Table 16: Capacity Bidding Program (CBP) Product Selection Guide**

| | |
|---|---|
| **Direct Participation or Aggregator?** | **Aggregator** |
| **Day-Ahead Program or Day-Of Program?** | **Day-Of Program** |
| **11:00AM to 7:00PM window or 1:00PM to 9:00PM window?** | **11:00AM to 7:00PM** |
| **Load Reduction Nomination** | **25% of ESS Output (kW)** |

### 4.7 Technical Incentive (TI) Program Analysis

A hypothetical analysis of the potential incentives available under the Technical Incentive (TI) Program was conducted. The current TI Program incentive rate is $200.00 per kW available for automated demand response (ADR) curtailment [5]. Only curtailment which has been verified and is available for ADR (compatible with Open-ADR standard) is eligible for this inventive [5]. Supposing that the systems will be set up for ADR, we analyzed the peak curtailment demonstrated in any DR event simulation for each system to determine the maximum potential incentive each would hypothetically be eligible for under the TI Program. Results for each system size are summarized in Table 17 below.

**Table 17: Technical Incentive (TI) Program Analysis**

| System Size | Estimated Potential Technical Incentive |
|---|---|
| 30 kW / 60 kWh | $ 3,640 |
| 60 kW / 120 kWh | $ 4,447 |
| 250 kW / 500 kWh | $ 32,669 |
| 500 kW / 1000 kWh | $ 46,500 |

### 4.8 Market Analysis

The demand for clean energy increases with a market that values reducing emissions and carbon footprint. To compliment this trend, the market must find ways to provide clean energy options for residential and commercial purposes. For example, electric car sales have increased 59% year-over-year with 12,000 total electric cars sold in 2016. [6]. However, these sales could have been much higher if the market can supply the resources necessary to own an electric car. Another clean energy with high market potential is the solar panel market, and this market is expected to increase the amount of solar power to the United States' grid by 94% from 7.5 gigawatts to 14.5 gigawatts by 2016. [7]. With an increase in energy supplied to the grid and increase in needs for on-site power applications, battery storage is a logical solution to meet these market needs. With the United States as one of the top consumers of energy in the world, improving the battery storage market is vital to the United States to provide grid-energy to everyone without increasing utility costs or oversizing equipment.

Even though the need for battery storage options is necessary, the market has not been able to meet full potential due to a deficient market structure. However, the push for energy storage is expected to increase significantly by 2020. According to energystorage.com, "the energy storage market is set to 'explode' to an annual installation size of 6 gigawatts (GW) in 2017 and over 40 GW by 2022 – from an initial base of only 0.24 GW installed in 2012 and 2013." [8]. Now, an EPA rating for electric vehicles is 30 kilowatt-hours (kWh) per 100 miles. [9]. If the average person typically drives between 10,000 to 15,000 miles a year and there are over 12,000 electric vehicles in the United States sold, then the energy demand for electric cars is 3.6 GW to 5.4 GW per year. This shows that if there are 6 GW that are expected to be installed by 2017 and the need in 2016 is about 5 to 6 GW already, it is evident that the demand for more battery stations are needed.

Currently, there are three levels of electric vehicle charging stations: AC Level 1, AC Level 2, and DC Fast Charging. AC Level 1 charging is a residential application that provides 120 volts at 15 amps, which will charge a battery electric vehicle in 12 to 20 hours and hybrid vehicles in 8 to 10 hours. [10]. AC Level 2 can be either a residential or commercial application that provides 240 volts at 30 to 70 amps, which will charge a battery electric vehicle in 4 to 7 hours and hybrid vehicles in 3 to 5 hours. [10]. In order to use AC Level 2 charging for home application, additional power requirements are needed to meet the voltage and current levels that typical homes cannot provide. Most homes do not have the spare panel capacity to provide even an additional 30 amp 240 volt service for a Level 2 charger and would require a second electric service to the home as well as sub-panel upgrades.

This introduces a new market need for not only home charging stations but also for residential battery storage, especially for homes with solar panels or some other form of power generation. DC Fast charging is a commercial application that provides 480 volts, which will charge a battery electric vehicle in 10 to 30 minutes and hybrid vehicles in 5 to 20 minutes. [10]. This also introduces a need for battery storage in the commercial spectrum.

The overall need for battery storage is growing each year. According to the Department of Energy, The United States currently uses about 4 trillion kilowatt-hours of power per year. [11]. "U.S. electricity demand is expected to increase at a rate of 1% each year through 2035, at which point the country is expected to consume 5,021 billion kilowatt-hours of electricity." [11]. With this increase in power demand, the electric grid will need to be able to provide an additional 250 GW in order to meet energy needs of 2035. Now, this can be achieved with different types of systems to make up the 250 GW, including systems such as: solar, wind, geothermal, hydroelectric, nuclear, turbine, and many other. However, many of these systems have certain complications. For instance, solar power only generates electricity when the sun is out. Another example would be wind power, where the generation of electricity is dependent on the wind's ability to rotate the turbine blades. One last example would be hydroelectric, where the dependent for electricity would be the flow of a river or dam. These examples are great options for creating renewable energy, but the problem remains to be the inability to control the generation of power. In addition, problems can occur in non-renewable methods of generation as well. Most non-renewable systems can be easily fluctuated to control the power needed, but these systems require non-renewable resources that can cost money and create a carbon footprint, depending on the system used. In all cases, these challenges can be resolved with the use of battery storage technology in combination with renewable and non-renewable power generation.

Battery storage technology has been used to store and distribute on-site electricity. There are battery storage options in the residential and commercial applications. For residential storage options, the most common type of storage is the use of lithium-iron-phosphate, and two of the top products in the United States is the Tesla Powerwall and the Iron Edison LiYFePO4. [12]. Many of these systems, provided with the right inverter and energy management system, can operate at a high efficiency and generate around 3-6 usable kWh. [12]. In the commercial sector, there are various sizes of battery storage to meet the company's needs. However, most of these residential and commercial battery storage devices are used in conjunction with some type of energy generation system, typically solar. According to greentechmedia.com, the U.S. Energy market grew 243% in 2015. [13]. "The 112 megawatts deployed in the fourth quarter 2015 represented more than the total of all storage deployments in 2013 and 2014 combined." [13]. This website also claims by 2020 the U.S. battery market is projected to be worth $2.5 billion and add 1.7 GW to the grid. [13]. Lithium-ion battery storage will continue to be a major seller in the market, but steady-state systems may become a major seller as well.

If a company is known for paying a fortune in utility bills, a combined on-site power generation, battery storage and energy management system would be an ideal solution and could provide tax benefits, depending on the location of the company. Utility rates are highest during peak hours, and most market energy management systems will be able to provide power from solar and save this energy to be provided during hours which utility rates and usage is highest. This will reduce costs and provide energy when energy is needed the most.

## 5.0 Conclusion

The ESS was evaluated from initial installation through the first 5 months of operation, with a sample size of 20 units having a total fleet capacity of 4.46 MW which were installed in 2017 at a mix of Elementary, Middle, and High Schools located in the wider San Diego area. The systems were demonstrated to be safe and effective at reducing electric demand at the utility meter and resulted in an estimated $225,809 total reduction in billed demand charges over the analysis period. Based on a savings agreement with the technology vendor, the utility end customers retained $64,924 of this amount and did not expend any funds to purchase, install, or maintain the systems. The overall performance of the ESSs was positive, and over the evaluation period achieved 91% of the manufacturer's pre-project performance estimate (pro-rated for length of time evaluated).

The performance as a DR asset was tested and found to have significant potential if the control algorithm is optimized for the task. The manufacturer reports that currently the control system is being optimized to work with sites also incorporating solar PV electricity generating systems.

Further study of this emerging technology is recommended after adjustments to the control system are completed. An additional seven (7) ESSs are planned for this M&V evaluation, which is scheduled to take place in 2018. An addendum to this report will contain any updates to these findings.

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# Addendum 1

**Addendum 1 Synopsis**

The 60 kW / 120 kWh, 90 kW / 180 kWh, 120 kW / 240 kWh & 250 kW / 500 kWh Energy Storage Systems (ESS) are being evaluated as a Demand Response Load shedding system for commercial customers. In addition to Demand Response, the systems do a 'peak-shaving' strategy whereby the most expensive peak loads are mitigated to some degree by shifting peak loads to off peak times. The ESS functions by supplementing grid supplied electricity with a battery and inverter system. When facility load approaches a pre-determined threshold for each utility meter, the ESS supplements the load in order to minimize the facility's on-peak and non-coincident or maximum demand charges on a monthly basis.

In this addendum to the main report produced in July 2018, results from evaluation of seven (7) of the original 27 systems are reported. This addendum was needed because of a delay in constructing the final seven (7) systems as a result of rebate constraints.

There were several differences between the first group (Group 1) of test sites and the second (Group 2). The primary difference between Group 1 and Group 2, was that of the Second Group, five (5) out of (7) systems were connected to utility accounts which also had solar PV systems installed, changing the customer load profile. Additionally, these systems were placed on the GALDGRC2 rate tariff that has demand charges that are less than half of the ALTOUCP2 rate tariff that was used for Group 1 test sites. One of the Group 2 test sites is on an OLTOUCP2 (outdoor lighting) rate tariff that does not have demand charges, and therefore does not generate financial savings - although it does accomplish peak shaving.

The vendor had no way of anticipating these changes at the time Power Efficiency Agreements (PEAs) were drawn up and savings projections were calculated (in 2015). Therefore, the savings projections calculated by the vendor in 2015 were not met by the Group 2 test systems.

**Project Background (Addendum 1)**

San Diego Gas & Electric (SDG&E) approached Information & Energy Services, Inc. through the *Emerging Technologies (ET)* program to perform a measurement & verification (M&V) study of a new load shedding system for commercial customers. The objective of this study was to evaluate the demand response capability of the energy storage system.

This addendum to the main report briefly describes the results from the Group 2 test sites and explores the interaction between peak shaving strategy used by the ESS and the solar PV generation systems installed on the same accounts.

Please see Table A1 below, which lists the people involved in the M&V process.

**Table A18: Key Process Participants**

| Name | Role | Organization |
|---|---|---|
| Kate Zeng | Manager, Emerging Technologies Program | SDG&E |
| Christopher Roman | Project Manager, ET Program | SDG&E |
| Mike Rogers, P.E., C.E.M. | Professional Engineer | IES |
| James Bottomley, E.I.T | Mechanical Engineer | IES |
| Jase Zappel, PMP, LEED GA | Energy Analyst & Technical Writer | IES |
| Mike King | Field Support | IES |
| Erin Broderick | Utility Analyst & Technical Writer | IES |
| Ryan Tandy, E.I.T. | Mechanical Engineer | IES |
| Lindsey Danner | Energy Manager | Grossmont UHSD |
| Robin Schucker | Product Manufacturer Liaison | Vendor |

## Addendum 1 Results

### Peak-Shaving Strategy

For both Group 1 and 2, the Peak-Shaving strategy employed by the Vendor ESS and software resulted in reduced on-peak and non-coincident or maximum demand charges compared to what the utility customer would have been charged under the existing rate structure if the ESS had not been installed.

The results of this portion of the study (Group 2) were significantly reduced financial performance compared to Group 1. This was primarily due to the DGR rate tariff used on Group 2, compared to the ALTOU rate tariff used on Group 1. The Vendor has a Power Efficiency Agreement (PEA) with the school district customer, stating what percentage of the calculated financial savings the customer will return to the Vendor. The customer and vendor agreed on this savings share percentage prior to system installation; in exchange the ESS was installed at no cost to the customer.

This study evaluated the financial performance of a fleet of twenty-seven (27) ESSs compared to the projected financial savings as provided by the Vendor to the customers prior to implementation. The test fleet consists of twenty-seven (27) ESSs installed at a mix of elementary, middle, and high schools across two (2) school districts located in the SDG&E service territory. Of these, only twenty (20) were installed in time to include results in the main Results Report (July 2018).

This addendum covers the remaining seven (7) systems, which had construction completion dates between May and November of 2018. The delay between the first twenty (20) systems and the remaining seven (7) systems was due to the vendor waiting for SGIP incentive funding prior to construction of each system.

The seven **(7)** ESSs in the second test fleet (Group 2) represent **880 kW** of total energy storage capacity. Overall the financial savings achieved for the Utility Company Customers were **20% of the pre-project estimated savings**, over an analysis period of roughly **4 to 5 months** (each system) using data collected between July 2018 and March 2019. The analysis resulted in a **total estimated reduction of $21,729** in Utility Company Demand Charges, which was shared by the Vendor and the School District (Customer) who operates the public schools used to host the study.

The split is determined by the PEAs between the Vendor and the Customer, and based on these the **Customers retained a total of $7,178 without any capital expenditure**. The simulation of **Demand Response** events showed that up to **180 kW** of dispatch-able demand might be available for a 2-hour curtailment event out of the 570 kW participating in the simulations, or approximately **30%** of the fleet capacity.

Table A2 below shows a summary of the financial savings resulting from this group of test sites after the 16+ week analysis term.

**Table A19: Summary of Financial Savings Compared to Projections**

| # | School District | System Name | Rare Tariff | System Size kW | System Size kWh | Analysis Period (Mo.) | Max. Recorded Reduction (kW) | Cumulative Bill Reduction | Portion Customer Keeps | Cumulative Customer Value (Present) | Customer Target Value (Present) | % Customer Target Value Achieved (Present) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Grossmont | Grossmont HS #3 | ALTOUCP2 | 90 | 180 | 5 | 75.0 | $ 7,158.77 | 25% | $ 1,789.69 | $ 2,504.79 | 71% |
| 2 | Grossmont | West Hills HS | GALDGRC2 | 250 | 500 | 4 | 222.6 | $ 5,406.08 | 40% | $ 2,162.43 | $ 11,290.40 | 19% |
| 3 | Grossmont | Monte Vista HS #1 | GALDGRC2 | 120 | 240 | 4 | 41.7 | $ 1,195.53 | 35% | $ 418.44 | $ 3,503.03 | 12% |
| 4 | Grossmont | Monte Vista HS #2 | GALDGRC2 | 120 | 240 | 4 | 74.2 | $ 1,929.37 | 35% | $ 675.28 | $ 3,276.47 | 21% |
| 5 | Grossmont | El Cajon Valley HS #1 | GALDGRC2 | 120 | 240 | 5 | 77.3 | $ 2,831.83 | 30% | $ 849.55 | $ 3,274.00 | 26% |
| 6 | Grossmont | El Cajon Valley HS #2 | GALDGRC2 | 120 | 240 | 5 | 96.0 | $ 3,207.18 | 40% | $ 1,282.87 | $ 10,563.33 | 12% |
| 7 | Grossmont | El Cajon Valley HS #3 | OLTOUCP2 | 60 | 120 | 4 | 42.2 | $ - | 15% | $ - | $ 919.55 | 0% |
| | **TOTAL** | | | **880 kW** | | | | **$ 21,728.76** | | **$ 7,178.26** | **$ 35,331.58** | **20%** |

On average, the actual ESS performance was significantly less than the manufacturer's projected performance estimates. When the vendor originally planned the systems, there were no solar PV systems and different rate tariffs in place at several project locations. Therefore, it is not surprising that the projections were not met.

## Demand Response

This study evaluated the Battery Energy Storage Systems as a potential load shedding asset for Demand Response (DR). A total of eight (8) simulated demand response events were called in September and October 2018 during summer on-peak hours, and the curtailment was measured using the data collected by the systems' on board controllers. Curtailment projections were provided by the vendor for each test event and were considered to be conservative based on the available capacity and considering the building load, which could be negative during part or all of an event. Despite this, the projections were more than 20% different than the actual curtailment on five (5) out of eight (8) simulations.

The system's design lends itself to power resiliency because of the ability to respond extremely quickly to changes in the electric grid, and should be an ideal candidate for use in an Automated Demand Response setting if the right pricing cues can be determined to align the vendors interests with those of the utility.

Table A3 below summarizes the load shedding achieved by the test fleet of five (5) Energy Storage Systems over the eight (8) simulated DR events.

**Table A20: Demand Response Testing Summary**

| DR-1<br>9/6/2018 | DR-2<br>9/20/2018 | DR-3<br>9/27/2018 | DR-4<br>10/4/2018 | DR-5<br>10/9/2018 | DR-6<br>10/10/2018 | DR-7<br>10/17/2018 | DR-8<br>10/19/2018 |
|---|---|---|---|---|---|---|---|
| **Notification Type** | | | | | | | |
| 30-Minute | Day-Ahead | Day-Ahead | Same-Day | Day-Ahead | Day-Ahead | Day-Ahead | Day-Ahead |
| **Simulated Event Duration (hrs.)** | | | | | | | |
| 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| **Maximum Potential kW Curtailment** | | | | | | | |
| 450 | 330 | 450 | 450 | 450 | 450 | 330 | 330 |
| **Total kW Curtailed / Vendor Projection** | | | | | | | |
| 168.7 / 90 | 102.0 / 115 | 77.5 / 70 | 79.8 / 65 | 182.1 / 140 | 137.1 / 140 | 36.1 / 50 | 56.5 / 80 |

Table 3 above shows poor performance compared to expectations. Since the ESSs were verified in manual tests to be able to discharge at the stated kW value it must be concluded that either the solar PV is generating most of or all the facility load, or the control system was not being triggered to respond to the simulated event or that the control algorithm opted for by the Vendor heavily prioritizes peak shifting over demand response curtailment.

For example in the very first DR simulation on 9/6/2018 we saw strong participation from three (3) of the five (5) included systems which implemented a very simple control strategy of setting the Calculated Threshold value to 1 or zero (some very low positive number) which caused the systems to discharge their batteries rapidly for the duration of the event, at which point the Calculated Threshold was changed back to the previous value and the system would re-charge after the event was completed.

This resulted in very favorable performance on the systems where this strategy was employed. This can be seen in Event #1, Grossmont HS #3, Monte Vista HS #2, and El Cajon Valley HS #1 in Table A4 on the following page.

**Table A21: Demand Response Testing Results**

| ENGIE ESS: DR EVENT SIMULATION (GROUP 2 SITES) | | | | | | EVENT #1 | | EVENT #2 | | EVENT #3 | | EVENT #4 | | EVENT #5 | | EVENT #6 | | EVENT #7 | | EVENT #8 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| # | School District | System Name | Rare Tariff | System Size | | 9/6/2018 | | 9/20/2018 | | 9/27/2018 | | 10/4/2018 | | 10/9/2018 | | 10/10/2018 | | 10/17/2018 | | 10/19/2018 | |
| | | | | | | kW | kWh | kW | kWh | kW | kWh | kW | kWh | kW | kWh | kW | kWh | kW | kWh | kW | kWh |
| 1 | Grossmont | Grossmont HS #3 | ALTOUCP2 | 90 | 180 | 74.1 | 148.3 | 34.5 | 68.9 | 33.6 | 67.2 | 14.1 | 28.1 | 30.1 | 60.3 | 23.9 | 47.7 | 1.9 | 3.8 | -11.0 | -22.1 |
| 2 | Grossmont | West Hills HS | GALDGRC2 | 250 | 500 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3 | Grossmont | Monte Vista HS #1 | GALDGRC2 | 120 | 240 | 0.0 | 0.0 | 0.0 | 0.0 | -3.0 | -6.0 | 0.1 | 0.1 | 2.7 | 5.3 | 3.2 | 6.4 | 4.0 | 7.9 | 4.5 | 9.0 |
| 4 | Grossmont | Monte Vista HS #2 | GALDGRC2 | 120 | 240 | 48.3 | 96.5 | 16.4 | 32.8 | 8.6 | 17.3 | 11.6 | 23.1 | 29.3 | 58.6 | 38.5 | 77.0 | 9.9 | 19.8 | 36.8 | 73.5 |
| 5 | Grossmont | El Cajon Valley HS #1 | GALDGRC2 | 120 | 240 | 45.6 | 91.3 | 26.2 | 52.4 | 26.1 | 52.3 | 36.0 | 72.0 | 75.2 | 150.5 | 39.9 | 79.9 | 20.3 | 40.6 | 26.3 | 52.6 |
| 6 | Grossmont | El Cajon Valley HS #2 | GALDGRC2 | 120 | 240 | 0.3 | 0.7 | 24.9 | 49.9 | 12.1 | 24.3 | 18.1 | 36.2 | 44.8 | 89.5 | 31.6 | 63.2 | 0.0 | 0.0 | 0.0 | 0.0 |
| 7 | Grossmont | El Cajon Valley HS #3 | OLTOUCP2 | 60 | 120 | 0.4 | 0.7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **ACHIEVED CURTAILMENT** | | | | | | **168.7 kW** | | **102.0 kW** | | **77.5 kW** | | **79.8 kW** | | **182.1 kW** | | **137.1 kW** | | **36.1 kW** | | **56.5 kW** | |
| *VENDOR PROJECTED CURTAILMENT* | | | | | | *90 kW* | | *115 kW* | | *70 kW* | | *65 kW* | | *140 kW* | | *140 kW* | | *50 kW* | | *80 kW* | |

The following simulated DR events saw the vendor employ a different control strategy, which reduced the Calculated Threshold at the start of the event, but not the same extreme reduction all the way to zero. This strategy did result in a reduction of building load that was higher than it would have been on other days, but did not consistently result in the system discharging during the events, i.e. the level of participation was typically diminished. It should be noted that the vendor was hampered in driving the systems to maximum performance because they were not allowed to discharge if the customer meter was net negative at the time, or if that discharge would cause the customer utility meter to go net negative. This was a factor that reduced performance on several occasions for several of the systems. Specifically for Monte Vista HS #1 system the solar generation prevented the participation completely for half of the events and on the others only a small curtailment was possible starting after 6:00 PM. This was also noted at El Cajon Valley HS #2 system, during 3 of the simulations net negative building load either diminished the curtailment possible or prevented it entirely. The maximum potential kW curtailment after removing the systems with net negative load at the time of the event is shown in Table 3 on the previous page.

The average curtailment over the eight (8) simulated DR events was a disappointing **105 kW**. The theoretical maximum curtailment over a 2-hour window for the test fleet is 570 kW. As a kind of a ‘best-case scenario’ we can look at maximum curtailment achieved in the series of test events. After removing the system which was net negative at the time, a ‘best case’ curtailment figure for the remaining 450 kW in the fleet was **182.1 kW averaged over 2-hours.** For this event the Vendor projected the curtailment would be 140 kW, which was accurate to within approximately 30%, in this case an under estimate. A 30% difference between the projection and the actual curtailment is considered a poor level of accuracy, and the projections were sometimes above and sometimes below the actual curtailment.

In many instances the ESS appeared to be operating as if it were a normal day during the DR event simulations, i.e. the systems frequently did not appear to be operating in a manner that would maximize DR reduction during a test event. Because of this appearance, we evaluated by comparing the performance of two test events to the performance of other days in the same week as the test event. Test Events #2 and #4 were selected for this comparison.

As we can see in Table A5 below, the performance on the test event days was significantly higher than the load shedding during the same time periods on the comparison days. Therefore the DR curtailment strategy employed by the vendor did in fact produce results.

**Table A22: Demand Response Day Comparison to Non-DR Days**

| ENGIE ESS: COMPARISON DAYS TO DR EVENT SIM | | | | | | EVENT #2 | | COMPARISON | | EVENT #4 | | COMPARISON | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| # | School District | System Name | Rare Tariff | System Size | | 9/20/2018 | | 9/18/2018 | | 10/4/2018 | | 10/5/2018 | |
| | | | | | | kW | kWh | kW | kWh | kW | kWh | kW | kWh |
| 1 | Grossmont | Grossmont HS #3 | ALTOUCP2 | 90 | 180 | 34.5 | 68.9 | 25.7 | 51.4 | 14.1 | 28.1 | 5.0 | 10.0 |
| 2 | Grossmont | West Hills HS | GALDGRC2 | 250 | 500 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3 | Grossmont | Monte Vista HS #1 | GALDGRC2 | 120 | 240 | 0.0 | 0.0 | -1.1 | -2.3 | 0.1 | 0.1 | 0.0 | 0.0 |
| 4 | Grossmont | Monte Vista HS #2 | GALDGRC2 | 120 | 240 | 16.4 | 32.8 | 0.0 | 0.0 | 11.6 | 23.1 | 1.2 | 2.3 |
| 5 | Grossmont | El Cajon Valley HS #1 | GALDGRC2 | 120 | 240 | 26.2 | 52.4 | 13.6 | 27.2 | 36.0 | 72.0 | 23.2 | 46.4 |
| 6 | Grossmont | El Cajon Valley HS #2 | GALDGRC2 | 120 | 240 | 24.9 | 49.9 | 0.0 | 0.1 | 18.1 | 36.2 | 1.4 | 2.8 |
| 7 | Grossmont | El Cajon Valley HS #3 | OLTOUCP2 | 60 | 120 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.8 | 3.7 |
| ACHIEVED CURTAILMENT | | | | | | 102.0 kW | | 38.2 kW | | 79.8 kW | | 32.6 kW | |

The potential capability as a short term load shedding device has been demonstrated via manual commands sent to the units demonstrating the theoretical (nameplate) performance is possible when no other factors (low building loads) are present. However, there will still need to be additional work done by the vendor to optimize performance of the control algorithm if the fleet is going to be an effective resource for grid resiliency and to maximize the load shedding potential of the fleet. In order to better align the utility's needs with that of the vendor, changes to the pricing cues given in the existing rate tariff or DR program rules will likely need to be made.

The total available energy stored in the Group 2 systems at the end of each test event was analyzed to determine the remaining available capacity. Please see Table A6 below, which shows the potential available capacity after each test event ended was quite high. As an outlier to the rest of the systems, it should be noted that for Events #7 & #8, the Grossmont HS system began the event in a very low state of charge, and in Event #8 re-charged from 16% up to 26% during the test which is not representative.

**Table A23: Remaining State of Charge after Simulations Ended**

| ENGIE ESS: Remaining SoC After Test Event | | | | | EVENT #1 | EVENT #2 | EVENT #3 | EVENT #4 | EVENT #5 | EVENT #6 | EVENT #7 | EVENT #8 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| # | School District | System Name | System Size | | % of Charge Remaining | % of Charge Remaining | % of Charge Remaining | % of Charge Remaining | % of Charge Remaining | % of Charge Remaining | % of Charge Remaining | % of Charge Remaining |
| 1 | Grossmont | Grossmont HS #3 | 90 | 180 | 28% | 59% | 59% | 79% | 71% | 79% | 16% | 26% |
| 2 | Grossmont | West Hills HS | 250 | 500 | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| 3 | Grossmont | Monte Vista HS #1 | 120 | 240 | 98% | 96% | 99% | 97% | 96% | 96% | 71% | 70% |
| 4 | Grossmont | Monte Vista HS #2 | 120 | 240 | 71% | 89% | 87% | 93% | 83% | 76% | 91% | 77% |
| 5 | Grossmont | El Cajon Valley HS #1 | 120 | 240 | 73% | 84% | 80% | 74% | 24% | 75% | 83% | 83% |
| 6 | Grossmont | El Cajon Valley HS #2 | 120 | 240 | 98% | 91% | 93% | 93% | 84% | 81% | 91% | 85% |
| 7 | Grossmont | El Cajon Valley HS #3 | 60 | 120 | 95% | 97% | 97% | 98% | 97% | 96% | 97% | 97% |
| ACHIEVED CURTAILMENT (kW) | | | | | 168.7 | 102.0 | 77.5 | 79.8 | 182.1 | 137.1 | 36.1 | 56.5 |

**Appendix 1A** contains the site-by-site summaries of the monthly peak shaving and financial performance analysis. These tables show the On-Peak and Non-Coincident or Maximum demand savings in each billing period. Financial performance of systems listed with a GALDGRC2 rate tariff is based on 'grandfathering' rates shown in the DGR rate tariff book. The OL-TOU rate tariff does not have demand charges, accordingly the El Cajon Valley HS #3 system does not generate any financial savings.

**Appendix 1B** contains the system performance details recorded by the on board controller during each simulated DR event.

The achieved demand reduction amounts were typically less than 30% of the rated kW of the ESS, and performance was inconsistent. Performance was also diminished because the systems were limited to discharge up to the net building load only, i.e. not allowed to produce a net negative effect on the meter. This is compounded by the solar PV systems which frequently are producing the entire facility load or more during the on-peak period between 4:00 PM and 6:00 PM. This artificial constraint based on interconnection rules was a factor that diminished performance measured by this study.

**Addendum 1 Conclusion**

For this Addendum, the final seven (7) of the original fleet of 27 energy storage systems was evaluated from initial installation through the first 4 to 5 months of operation. The sample size of seven (7) units having a total fleet capacity of 880 kW which were installed in 2018 at High Schools located in the wider San Diego area. The systems were demonstrated to be safe and mildly effective at reducing electric demand at the utility meter and resulted in an estimated $21,729 total reduction in billed demand charges over the analysis period.

Based on a savings agreement with the technology vendor, the utility end customer (School District) retained $7,178 of this amount and did not expend any funds to purchase, install, or maintain the systems. It should be noted that this School District reports that they did not receive a billing statement from the vendor since July of last year, potentially being done as an end of year true-up payment rather than a monthly invoice as previously.

The overall performance of the ESSs was mildly positive, and over the evaluation period achieved 20% of the manufacturer's pre-project performance estimate (pro-rated for length of time evaluated). The shortfall was due to the change in billing rate tariff and installation of solar PV generation systems, which were not known at the time the projections were made. The performance as a DR asset was tested and found to have potential if the control algorithm were optimized for the task.

## Addendum Appendix 1A

*Site Specific Monthly Peak-Shaving Analysis Summaries*

| # | School District | System Name | Rare Tariff | System Size kW | System Size kWh | Analysis Period (Mo.) | Max. Recorded Reduction (kW) | Cumulative Bill Reduction | Portion Customer Keeps | Cumulative Customer Value (Present) | Customer Target Value (Present) | % Customer Target Value Achieved (Present) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Grossmont | Grossmont HS #3 | ALTOUCP2 | 90 | 180 | 5 | 75.0 | $ 7,158.77 | 25% | $ 1,789.69 | $ 2,504.79 | 71% |
| 2 | Grossmont | West Hills HS | GALDGRC2 | 250 | 500 | 4 | 222.6 | $ 5,406.08 | 40% | $ 2,162.43 | $ 11,290.40 | 19% |
| 3 | Grossmont | Monte Vista HS #1 | GALDGRC2 | 120 | 240 | 4 | 41.7 | $ 1,195.53 | 35% | $ 418.44 | $ 3,503.03 | 12% |
| 4 | Grossmont | Monte Vista HS #2 | GALDGRC2 | 120 | 240 | 4 | 74.2 | $ 1,929.37 | 35% | $ 675.28 | $ 3,276.47 | 21% |
| 5 | Grossmont | El Cajon Valley HS #1 | GALDGRC2 | 120 | 240 | 5 | 77.3 | $ 2,831.83 | 30% | $ 849.55 | $ 3,274.00 | 26% |
| 6 | Grossmont | El Cajon Valley HS #2 | GALDGRC2 | 120 | 240 | 5 | 96.0 | $ 3,207.18 | 40% | $ 1,282.87 | $ 10,563.33 | 12% |
| 7 | Grossmont | El Cajon Valley HS #3 | OLTOUCP2 | 60 | 120 | 4 | 42.2 | $ - | 15% | $ - | $ 919.55 | 0% |
| **TOTAL** | | | | **880** | **kW** | | | **$ 21,728.76** | | **$ 7,178.26** | **$ 35,331.58** | **20%** |

### Grossmont High School

| # | System Name | Rate | System Size kW | System Size kWh | Start Date | End Date | Bill Month | NC kW Reduction | On-Pk kW Reduction | Customer Bill Reduction | Portion Customer Keeps | Customer Value |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Grossmont HS #3 | ALTOUCP2 | 90 | 180 | 8/21/2018 | 9/16/2018 | September | 29.3 | -12.1 | $ 414.30 | 25% | $ 103.58 |
| 2 | Grossmont HS #3 | ALTOUCP2 | 90 | 180 | 9/17/2019 | 10/15/2018 | October | 72.2 | 75.0 | $ 2,763.24 | 25% | $ 690.81 |
| 3 | Grossmont HS #3 | ALTOUCP2 | 90 | 180 | 10/16/2018 | 11/14/2018 | November | 54.5 | 6.1 | $ 1,243.95 | 25% | $ 310.99 |
| 4 | Grossmont HS #3 | ALTOUCP2 | 90 | 180 | 11/15/2018 | 12/16/2018 | December | 44.5 | 37.2 | $ 1,546.21 | 25% | $ 386.55 |
| 5 | Grossmont HS #3 | ALTOUCP2 | 90 | 180 | 12/17/2018 | 1/16/2019 | January | 24.2 | 41.5 | $ 1,191.07 | 25% | $ 297.77 |
| **AVERAGE** | | | | | | | | **44.9** | **29.5** | **$1,431.75** | | **$ 357.94** |
| **TOTAL** | | | | | | | | | | **$ 7,158.77** | | **$ 1,789.69** |

## West Hills High School aka Health Occupation Center

| # | System Name | Rate | System Size kW | System Size kWh | Start Date | End Date | Bill Month | MAX kW Reduction | On-Pk kW Reduction | Customer Bill Reduction | Portion Customer Keeps | Customer Value |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | West Hills HS | GALDGRC2 | 250 | 500 | 11/8/2018 | 12/9/2018 | December | 96.2 | 128.2 | $1,254.64 | 40% | $ 501.86 |
| 2 | West Hills HS | GALDGRC2 | 250 | 500 | 12/10/2018 | 1/9/2019 | January | 96.2 | 128.2 | $1,254.64 | 40% | $ 501.86 |
| 3 | West Hills HS | GALDGRC2 | 250 | 500 | 1/10/2019 | 2/7/2019 | February | 80.6 | 56.2 | $1,019.91 | 40% | $ 407.96 |
| 4 | West Hills HS | GALDGRC2 | 250 | 500 | 2/8/2019 | 3/5/2019 | March | 142.5 | 222.6 | $1,876.89 | 40% | $ 750.76 |
| **AVERAGE** | | | | | | | | **103.9** | **133.8** | **$1,351.52** | | **$ 540.61** |
| **TOTAL** | | | | | | | | | | **$5,406.08** | | **$2,162.43** |

## Monte Vista High School

| # | System Name | Rate | System Size kW | System Size kWh | Start Date | End Date | Bill Month | MAX kW Reduction | On-Pk kW Reduction | Customer Bill Reduction | Portion Customer Keeps | Customer Value |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Monte Vista HS #1 | GALDGRC2 | 120 | 240 | 8/22/2018 | 9/23/2018 | September | 25.9 | 5.2 | $ 329.75 | 35% | $ 115.41 |
| 2 | Monte Vista HS #1 | GALDGRC2 | 120 | 240 | 9/24/2018 | 10/23/2018 | October | 15.4 | 15.4 | $ 227.14 | 35% | $ 79.50 |
| 3 | Monte Vista HS #1 | GALDGRC2 | 120 | 240 | 10/24/2018 | 11/22/2018 | November | 41.7 | 2.5 | $ 516.92 | 35% | $ 180.92 |
| 4 | Monte Vista HS #1 | GALDGRC2 | 120 | 240 | 11/23/2018 | 12/23/2018 | December | 8.9 | 22.0 | $ 121.72 | 35% | $ 42.60 |
| **AVERAGE** | | | | | | | | **23.0** | **11.3** | **$ 298.88** | | **$ 104.61** |
| **TOTAL** | | | | | | | | | | **$ 1,195.53** | | **$ 418.44** |

| # | System Name | Rate | System Size kW | System Size kWh | Start Date | End Date | Bill Month | MAX kW Reduction | On-Pk kW Reduction | Customer Bill Reduction | Portion Customer Keeps | Customer Value |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Monte Vista HS #2 | GALDGRC2 | 120 | 240 | 8/22/2018 | 9/23/2018 | September | -1.5 | 15.5 | $ 20.98 | 35% | $ 7.34 |
| 2 | Monte Vista HS #2 | GALDGRC2 | 120 | 240 | 9/24/2018 | 10/23/2018 | October | 37.4 | 48.2 | $ 580.38 | 35% | $ 203.13 |
| 3 | Monte Vista HS #2 | GALDGRC2 | 120 | 240 | 10/24/2018 | 11/22/2018 | November | 32.0 | 34.1 | $ 478.03 | 35% | $ 167.31 |
| 4 | Monte Vista HS #2 | GALDGRC2 | 120 | 240 | 11/23/2018 | 12/23/2018 | December | 65.8 | 74.2 | $ 849.98 | 35% | $ 297.49 |
| **AVERAGE** | | | | | | | | **33.4** | **43.0** | **$ 482.34** | | **$ 168.82** |
| **TOTAL** | | | | | | | | | | **$ 1,929.37** | | **$ 675.28** |

## El Cajon Valley High School

| # | System Name | Rate | System Size kW | System Size kWh | Start Date | End Date | Bill Month | MAX kW Reduction | On-Pk kW Reduction | Customer Bill Reduction | Portion Customer Keeps | Customer Value |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | El Cajon Valley HS #1 | GALDGRC2 | 120 | 240 | 6/29/2018 | 7/30/2018 | July | 14.2 | 7.5 | $ 192.98 | 30% | $ 57.89 |
| 2 | El Cajon Valley HS #1 | GALDGRC2 | 120 | 240 | 7/31/2018 | 8/28/2018 | August | 77.3 | 57.3 | $ 1,091.97 | 30% | $ 327.59 |
| 3 | El Cajon Valley HS #1 | GALDGRC2 | 120 | 240 | 8/29/2018 | 9/27/2018 | September | 0.0 | 0.0 | $ - | 30% | $ - |
| 4 | El Cajon Valley HS #1 | GALDGRC2 | 120 | 240 | 9/28/2018 | 10/29/2018 | October | 62.5 | 62.5 | $ 923.87 | 30% | $ 277.16 |
| 5 | El Cajon Valley HS #1 | GALDGRC2 | 120 | 240 | 10/30/2018 | 11/28/2018 | November | 51.1 | -3.6 | $ 623.01 | 30% | $ 186.90 |
| **AVERAGE** | | | | | | | | **41.0** | **24.7** | **$ 566.37** | | **$ 169.91** |
| **TOTAL** | | | | | | | | | | **$ 2,831.83** | | **$ 849.55** |

| # | System Name | Rate | System Size kW | System Size kWh | Start Date | End Date | Bill Month | MAX kW Reduction | On-Pk kW Reduction | Customer Bill Reduction | Portion Customer Keeps | Customer Value |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | El Cajon Valley HS #2 | GALDGRC2 | 250 | 500 | 6/29/2018 | 7/30/2018 | July | 64.8 | 96.0 | $ 1,036.89 | 40% | $ 414.76 |
| 2 | El Cajon Valley HS #2 | GALDGRC2 | 250 | 500 | 7/31/2018 | 8/28/2018 | August | 57.0 | 52.1 | $ 830.22 | 40% | $ 332.09 |
| 3 | El Cajon Valley HS #2 | GALDGRC2 | 250 | 500 | 8/29/2018 | 9/27/2018 | September | 57.5 | 48.9 | $ 828.18 | 40% | $ 331.27 |
| 4 | El Cajon Valley HS #2 | GALDGRC2 | 250 | 500 | 9/28/2018 | 10/29/2018 | October | -0.8 | -0.8 | $ (11.20) | 40% | $ (4.48) |
| 5 | El Cajon Valley HS #2 | GALDGRC2 | 250 | 500 | 10/30/2018 | 11/28/2018 | November | 41.5 | 6.2 | $ 523.09 | 40% | $ 209.24 |
| **AVERAGE** | | | | | | | | **44.0** | **40.5** | **$ 641.44** | | **$ 256.57** |
| **TOTAL** | | | | | | | | | | **$ 3,207.18** | | **$ 1,282.87** |

| # | System Name | Rate | System Size kW | System Size kWh | Start Date | End Date | GCN Bill Month | MAX kW Reduction | On-Pk kW Reduction | Customer Bill Reduction | Portion Customer Keeps | Customer Value |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | El Cajon Valley HS #3 | OLTOUCP2 | 60 | 210 | 7/31/2018 | 8/28/2018 | August | 1.7 | 3.8 | $ - | 15% | $ - |
| 2 | El Cajon Valley HS #3 | OLTOUCP2 | 60 | 120 | 8/29/2018 | 9/27/2018 | September | 4.4 | 42.2 | $ - | 15% | $ - |
| 3 | El Cajon Valley HS #3 | OLTOUCP2 | 60 | 120 | 9/28/2018 | 10/29/2018 | October | 2.6 | 9.1 | $ - | 15% | $ - |
| 4 | El Cajon Valley HS #3 | OLTOUCP2 | 60 | 120 | 10/30/2018 | 11/28/2018 | November | 9.6 | 9.5 | $ - | 15% | $ - |
| **AVERAGE** | | | | | | | | **4.6** | **16.2** | **$ -** | | **$ -** |
| **TOTAL** | | | | | | | | | | **$ -** | | **$ -** |

## Addendum Appendix 1B

*Demand Response Simulation Details*

| DR-1<br>9/6/2018 | DR-2<br>9/20/2018 | DR-3<br>9/27/2018 | DR-4<br>10/4/2018 | DR-5<br>10/9/2018 | DR-6<br>10/10/2018 | DR-7<br>10/17/2018 | DR-8<br>10/19/2018 |
|---|---|---|---|---|---|---|---|
| **Notification Type** | | | | | | | |
| **30-Minute** | **Day-Ahead** | **Day-Ahead** | **Same-Day** | **Day-Ahead** | **Day-Ahead** | **Day-Ahead** | **Day-Ahead** |
| **Simulated Event Duration (hrs.)** | | | | | | | |
| **2** | **2** | **2** | **2** | **2** | **2** | **2** | **2** |
| **Maximum Potential kW Curtailment** | | | | | | | |
| **450** | **330** | **450** | **450** | **450** | **450** | **330** | **330** |
| **Total kW Curtailed / Vendor Projection** | | | | | | | |
| 168.7 / 90 | 102.0 / 115 | 77.5 / 70 | 79.8 / 65 | 182.1 / 140 | 137.1 / 140 | 36.1 / 50 | 56.5 / 80 |

| **ENGIE ESS: DR EVENT SIMULATION (GROUP 2 SITES)** | | | | | | **EVENT #1** | | **EVENT #2** | | **EVENT #3** | | **EVENT #4** | | **EVENT #5** | | **EVENT #6** | | **EVENT #7** | | **EVENT #8** | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **#** | **School District** | **System Name** | **Rare Tariff** | **System Size** | | **9/6/2018** | | **9/20/2018** | | **9/27/2018** | | **10/4/2018** | | **10/9/2018** | | **10/10/2018** | | **10/17/2018** | | **10/19/2018** | |
| | | | | | | **kW** | **kWh** | **kW** | **kWh** | **kW** | **kWh** | **kW** | **kWh** | **kW** | **kWh** | **kW** | **kWh** | **kW** | **kWh** | **kW** | **kWh** |
| 1 | Grossmont | Grossmont HS #3 | ALTOUCP2 | 90 | 180 | 74.1 | 148.3 | 34.5 | 68.9 | 33.6 | 67.2 | 14.1 | 28.1 | 30.1 | 60.3 | 23.9 | 47.7 | 1.9 | 3.8 | -11.0 | -22.1 |
| 2 | Grossmont | West Hills HS | GALDGRC2 | 250 | 500 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3 | Grossmont | Monte Vista HS #1 | GALDGRC2 | 120 | 240 | 0.0 | 0.0 | 0.0 | 0.0 | -3.0 | -6.0 | 0.1 | 0.1 | 2.7 | 5.3 | 3.2 | 6.4 | 4.0 | 7.9 | 4.5 | 9.0 |
| 4 | Grossmont | Monte Vista HS #2 | GALDGRC2 | 120 | 240 | 48.3 | 96.5 | 16.4 | 32.8 | 8.6 | 17.3 | 11.6 | 23.1 | 29.3 | 58.6 | 38.5 | 77.0 | 9.9 | 19.8 | 36.8 | 73.5 |
| 5 | Grossmont | El Cajon Valley HS #1 | GALDGRC2 | 120 | 240 | 45.6 | 91.3 | 26.2 | 52.4 | 26.1 | 52.3 | 36.0 | 72.0 | 75.2 | 150.5 | 39.9 | 79.9 | 20.3 | 40.6 | 26.3 | 52.6 |
| 6 | Grossmont | El Cajon Valley HS #2 | GALDGRC2 | 120 | 240 | 0.3 | 0.7 | 24.9 | 49.9 | 12.1 | 24.3 | 18.1 | 36.2 | 44.8 | 89.5 | 31.6 | 63.2 | 0.0 | 0.0 | 0.0 | 0.0 |
| 7 | Grossmont | El Cajon Valley HS #3 | OLTOUCP2 | 60 | 120 | 0.4 | 0.7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **ACHIEVED CURTAILMENT** | | | | | | **168.7 kW** | | **102.0 kW** | | **77.5 kW** | | **79.8 kW** | | **182.1 kW** | | **137.1 kW** | | **36.1 kW** | | **56.5 kW** | |
| *VENDOR PROJECTED CURTAILMENT* | | | | | | *90 kW* | | *115 kW* | | *70 kW* | | *65 kW* | | *140 kW* | | *140 kW* | | *50 kW* | | *80 kW* | |

Notes:

| | Start | End | Projected kW |
|---|---|---|---|
| 9/6/2018 Event # 1 | 16:00 | 18:00 | 90 |
| 9/20/2018 Event # 2 | 16:00 | 18:00 | 115 |
| 9/27/2018 Event # 3 | 15:00 | 17:00 | 70 |
| 10/4/2018 Event # 4 | 16:00 | 18:00 | 65 |
| 10/9/2018 Event # 5 | 16:00 | 18:00 | 140 |
| 10/10/2018 Event # 6 | 16:00 | 18:00 | 140 |
| 10/17/2018 Event # 7 | 16:00 | 18:00 | 50 |
| 10/19/2018 Event # 8 | 16:00 | 18:00 | 80 |

## Grossmont High School

## Simulated DR Event #1

**DR Event #1**

| Time/Date | Calculated Threshold (kW) | Battery SoC (%) | System Output (kW) | System Output (kWh) | |
|---|---|---|---|---|---|
| 9/6/18 16:00 | 205.97 | | | | |
| 9/6/18 16:15 | 1.00 | 97% | 85.65 | 21.41 | |
| 9/6/18 16:30 | 1.00 | 86% | 87.85 | 21.96 | |
| 9/6/18 16:45 | 1.00 | 76% | 87.67 | 21.92 | |
| 9/6/18 17:00 | 1.00 | 64% | 87.70 | 21.92 | |
| 9/6/18 17:15 | 1.00 | 52% | 59.57 | 14.89 | |
| 9/6/18 17:30 | 1.00 | 44% | 59.68 | 14.92 | |
| 9/6/18 17:45 | 1.00 | 38% | 68.06 | 17.02 | |
| 9/6/18 18:00 | 1.00 | 28% | 56.95 | 14.24 | |
| **Average kW Curtailed over 2-hr event -->** | | | **74.14** | 148.28 | <-- Total kWh Curtailed |

## Simulated DR Event #2

**DR Event #2**

| Time/Date | Calculated Threshold (kW) | Battery SoC (%) | System Output (kW) | System Output (kWh) | |
|---|---|---|---|---|---|
| 9/20/18 16:00 | 174.94 | | | | |
| 9/20/18 16:15 | 54.81 | 95% | 59.89 | 14.97 | |
| 9/20/18 16:30 | 55.92 | 88% | 54.00 | 13.50 | |
| 9/20/18 16:45 | 55.62 | 81% | 54.84 | 13.71 | |
| 9/20/18 17:00 | 54.81 | 74% | 56.37 | 14.09 | |
| 9/20/18 17:15 | 54.81 | 64% | 11.78 | 2.94 | |
| 9/20/18 17:30 | 54.81 | 62% | 12.63 | 3.16 | |
| 9/20/18 17:45 | 54.81 | 61% | 14.13 | 3.53 | |
| 9/20/18 18:00 | 54.81 | 59% | 11.97 | 2.99 | |
| **Average kW Curtailed over 2-hr event -->** | | | **34.45** | 68.90 | <-- Total kWh Curtailed |

## Simulated DR Event #3

**DR Event #3**

| Time/Date | Calculated Threshold (kW) | Battery SoC (%) | System Output (kW) | System Output (kWh) | |
|---|---|---|---|---|---|
| 9/27/18 15:00 | 174.94 | | | | |
| 9/27/18 15:15 | 174.94 | 88% | 0.40 | 0.10 | |
| 9/27/18 15:30 | 174.94 | 88% | 0.10 | 0.02 | |
| 9/27/18 15:45 | 174.94 | 88% | 0.00 | 0.00 | |
| 9/27/18 16:00 | 174.94 | 88% | 53.65 | 13.41 | |
| 9/27/18 16:15 | 67.58 | 81% | 40.87 | 10.22 | |
| 9/27/18 16:30 | 67.58 | 74% | 50.74 | 12.69 | |
| 9/27/18 16:45 | 67.58 | 67% | 64.58 | 16.15 | |
| 9/27/18 17:00 | 67.58 | 59% | 58.33 | 14.58 | |
| **Average kW Curtailed over 2-hr event -->** | | | **33.58** | 67.17 | <-- Total kWh Curtailed |

## Simulated DR Event #4

**DR Event #4**

| Time/Date | Calculated Threshold (kW) | Battery SoC (%) | System Output (kW) | System Output (kWh) |
|---|---|---|---|---|
| 10/4/18 16:00 | 174.94 | | | |
| 10/4/18 16:15 | 67.58 | 96% | 17.92 | 4.48 |
| 10/4/18 16:30 | 67.58 | 91% | 37.66 | 9.41 |
| 10/4/18 16:45 | 67.58 | 87% | 31.02 | 7.75 |
| 10/4/18 17:00 | 67.58 | 83% | 24.68 | 6.17 |
| 10/4/18 17:15 | 67.58 | 80% | 1.23 | 0.31 |
| 10/4/18 17:30 | 67.58 | 79% | 0.00 | 0.00 |
| 10/4/18 17:45 | 67.58 | 79% | 0.02 | 0.01 |
| 10/4/18 18:00 | 67.58 | 79% | 0.00 | 0.00 |
| **Average kW Curtailed over 2-hr event -->** | | | **14.07** | 28.13 <-- Total kWh Curtailed |

*Note: curtailment occurred during first hour of simulated event only.*

## Simulated DR Event #5

**DR Event #5**

| Time/Date | Calculated Threshold (kW) | Battery SoC (%) | System Output (kW) | System Output (kWh) |
|---|---|---|---|---|
| 10/9/18 16:00 | 174.94 | | | |
| 10/9/18 16:15 | 69.37 | 94% | 32.71 | 8.18 |
| 10/9/18 16:30 | 69.37 | 90% | 29.86 | 7.47 |
| 10/9/18 16:45 | 61.52 | 87% | 35.39 | 8.85 |
| 10/9/18 17:00 | 0.00 | 82% | 86.55 | 21.64 |
| 10/9/18 17:15 | 59.59 | 72% | -0.20 | -0.05 |
| 10/9/18 17:30 | 54.60 | 72% | -2.75 | -0.69 |
| 10/9/18 17:45 | 53.82 | 71% | 0.69 | 0.17 |
| 10/9/18 18:00 | 0.00 | 71% | 58.94 | 14.74 |
| **Average kW Curtailed over 2-hr event -->** | | | **30.15** | 60.30 <-- Total kWh Curtailed |

*Note: curtailment occurred during first hour of simulated event with a final push in last 15-minutes.*

## Simulated DR Event #6

**DR Event #6**

| Time/Date | Calculated Threshold (kW) | Battery SoC (%) | System Output (kW) | System Output (kWh) |
|---|---|---|---|---|
| 10/10/18 16:00 | 174.94 | | | |
| 10/10/18 16:15 | 69.37 | 96% | 24.97 | 6.24 |
| 10/10/18 16:30 | 69.37 | 93% | 22.87 | 5.72 |
| 10/10/18 16:45 | 69.37 | 91% | 19.44 | 4.86 |
| 10/10/18 17:00 | 38.22 | 88% | 68.88 | 17.22 |
| 10/10/18 17:15 | 60.90 | 80% | -1.43 | -0.36 |
| 10/10/18 17:30 | 54.88 | 80% | -1.01 | -0.25 |
| 10/10/18 17:45 | 52.57 | 79% | -0.75 | -0.19 |
| 10/10/18 18:00 | 0.00 | 79% | 57.90 | 14.47 |
| **Average kW Curtailed over 2-hr event -->** | | | **23.86** | 47.72 <-- Total kWh Curtailed |

*Note: curtailment occurred during first hour of simulated event with a final push in last 15-minutes.*

## Simulated DR Event #7

**DR Event #7**

| Time/Date | Calculated Threshold (kW) | Battery SoC (%) | System Output (kW) | System Output (kWh) | |
|---|---|---|---|---|---|
| 10/17/18 16:00 | 120.99 | | | | |
| 10/17/18 16:15 | 64.56 | 22% | 28.56 | 7.14 | |
| 10/17/18 16:30 | 67.69 | 18% | 23.78 | 5.95 | |
| 10/17/18 16:45 | 73.03 | 14% | 14.05 | 3.51 | |
| 10/17/18 17:00 | 72.61 | 12% | 11.16 | 2.79 | |
| 10/17/18 17:15 | 67.66 | 11% | -11.27 | -2.82 | |
| 10/17/18 17:30 | 64.14 | 12% | -9.56 | -2.39 | |
| 10/17/18 17:45 | 68.08 | 13% | -20.81 | -5.20 | |
| 10/17/18 18:00 | 66.45 | 16% | -20.62 | -5.16 | |
| **Average kW Curtailed over 2-hr event -->** | | | **1.91** | 3.82 | <-- Total kWh Curtailed |

*Note: Curtailment occurred during first hour of simulated event, with re-charging during second hour.*

## Simulated DR Event #8

**DR Event #8**

| Time/Date | Calculated Threshold (kW) | Battery SoC (%) | System Output (kW) | System Output (kWh) | |
|---|---|---|---|---|---|
| 10/19/18 16:00 | 128.15 | | | | |
| 10/19/18 16:15 | 87.02 | 16% | 12.09 | 3.02 | |
| 10/19/18 16:30 | 89.11 | 14% | 1.58 | 0.40 | |
| 10/19/18 16:45 | 92.35 | 14% | -2.56 | -0.64 | |
| 10/19/18 17:00 | 88.73 | 14% | 0.53 | 0.13 | |
| 10/19/18 17:15 | 83.28 | 14% | -31.84 | -7.96 | |
| 10/19/18 17:30 | 82.72 | 18% | -33.32 | -8.33 | |
| 10/19/18 17:45 | 82.72 | 22% | -31.25 | -7.81 | |
| 10/19/18 18:00 | 52.64 | 26% | -3.63 | -0.91 | |
| **Average kW Curtailed over 2-hr event -->** | | | **-11.05** | -22.10 | <-- Total kWh Curtailed |

*Note: There was no discernable participation. System re-charged during event.*

## West Hills High School aka Health Occupation Center

West Hills HS aka Health OCC – installation was completed after summer utility season ended & DR testing had been concluded. This system could not be included in DR simulations.

## Monte Vista High School #1

## Simulated DR Event #1

**DR Event #1**

| Time/Date | Calculated Threshold (kW) | Battery SoC (%) | System Output (kW) | System Output (kWh) | |
|---|---|---|---|---|---|
| 9/6/18 16:00 | 108.50 | | | | |
| 9/6/18 16:15 | 68.80 | 98% | 0.00 | 0.00 | |
| 9/6/18 16:30 | 68.80 | 98% | 0.00 | 0.00 | |
| 9/6/18 16:45 | 68.80 | 98% | 0.00 | 0.00 | |
| 9/6/18 17:00 | 68.80 | 98% | 0.00 | 0.00 | |
| 9/6/18 17:15 | 68.80 | 98% | 0.00 | 0.00 | |
| 9/6/18 17:30 | 68.80 | 98% | 0.00 | 0.00 | |
| 9/6/18 17:45 | 68.80 | 98% | 0.00 | 0.00 | |
| 9/6/18 18:00 | 68.80 | 98% | 0.00 | 0.00 | |
| **Average kW Curtailed over 2-hr event -->** | | | **0.00** | 0.00 | <-- Total kWh Curtailed |

*Note: Net-negative building load prevented participation.*

## Simulated DR Event #2

**DR Event #2**

| Time/Date | Calculated Threshold (kW) | Battery SoC (%) | System Output (kW) | System Output (kWh) |
|---|---|---|---|---|
| 9/20/18 16:00 | 108.50 | | | |
| 9/20/18 16:15 | 68.80 | 96% | 0.00 | 0.00 |
| 9/20/18 16:30 | 68.80 | 96% | 0.00 | 0.00 |
| 9/20/18 16:45 | 68.80 | 96% | 0.00 | 0.00 |
| 9/20/18 17:00 | 68.80 | 96% | 0.00 | 0.00 |
| 9/20/18 17:15 | 68.80 | 96% | 0.00 | 0.00 |
| 9/20/18 17:30 | 68.80 | 96% | 0.00 | 0.00 |
| 9/20/18 17:45 | 68.80 | 96% | 0.00 | 0.00 |
| 9/20/18 18:00 | 68.80 | 96% | 0.00 | 0.00 |
| **Average kW Curtailed over 2-hr event -->** | | | **0.00** | 0.00 <-- Total kWh Curtailed |

*Note: Net-negative building load prevented participation.*

## Simulated DR Event #3

**DR Event #3**

| Time/Date | Calculated Threshold (kW) | Battery SoC (%) | System Output (kW) | System Output (kWh) |
|---|---|---|---|---|
| 9/27/18 15:00 | 79.12 | | | |
| 9/27/18 15:15 | 79.12 | 94% | 21.79 | 5.45 |
| 9/27/18 15:30 | 79.12 | 91% | 4.82 | 1.21 |
| 9/27/18 15:45 | 79.12 | 90% | -42.92 | -10.73 |
| 9/27/18 16:00 | 79.12 | 97% | -7.64 | -1.91 |
| 9/27/18 16:15 | 9.32 | 99% | 0.00 | 0.00 |
| 9/27/18 16:30 | 9.32 | 99% | 0.00 | 0.00 |
| 9/27/18 16:45 | 9.32 | 99% | 0.00 | 0.00 |
| 9/27/18 17:00 | 9.32 | 99% | 0.00 | 0.00 |
| **Average kW Curtailed over 2-hr event -->** | | | **-2.99** | -5.99 <-- Total kWh Curtailed |

*Note: System re-charged during event.*

## Simulated DR Event #4

**DR Event #4**

| Time/Date | Calculated Threshold (kW) | Battery SoC (%) | System Output (kW) | System Output (kWh) |
|---|---|---|---|---|
| 10/4/18 16:00 | 160.76 | | | |
| 10/4/18 16:15 | 19.65 | 97% | 0.00 | 0.00 |
| 10/4/18 16:30 | 19.65 | 97% | 0.00 | 0.00 |
| 10/4/18 16:45 | 19.65 | 97% | 0.00 | 0.00 |
| 10/4/18 17:00 | 19.65 | 97% | 0.00 | 0.00 |
| 10/4/18 17:15 | 19.65 | 97% | 0.00 | 0.00 |
| 10/4/18 17:30 | 19.65 | 97% | 0.00 | 0.00 |
| 10/4/18 17:45 | 19.65 | 97% | 0.00 | 0.00 |
| 10/4/18 18:00 | 19.65 | 97% | 0.57 | 0.14 |
| **Average kW Curtailed over 2-hr event -->** | | | **0.07** | 0.14 <-- Total kWh Curtailed |

*Note: Net-negative building load prevented appreciable participation.*

## Simulated DR Event #5

**DR Event #5**

| Time/Date | Calculated Threshold (kW) | Battery SoC (%) | System Output (kW) | System Output (kWh) |
|---|---|---|---|---|
| 10/9/18 16:00 | 160.76 | | | |
| 10/9/18 16:15 | -86.75 | 96% | 0.00 | 0.00 |
| 10/9/18 16:30 | -69.20 | 96% | 0.00 | 0.00 |
| 10/9/18 16:45 | -49.27 | 96% | 0.00 | 0.00 |
| 10/9/18 17:00 | -45.78 | 96% | 0.00 | 0.00 |
| 10/9/18 17:15 | -36.39 | 96% | 0.00 | 0.00 |
| 10/9/18 17:30 | -24.52 | 96% | 0.00 | 0.00 |
| 10/9/18 17:45 | -9.26 | 96% | 1.09 | 0.27 |
| 10/9/18 18:00 | 0.00 | 96% | 20.13 | 5.03 |
| **Average kW Curtailed over 2-hr event -->** | | | **2.65** | 5.30 <-- Total kWh Curtailed |

*Note: Net-negative building load prevented appreciable participation until 18:00.*

## Simulated DR Event #6

**DR Event #6**

| Time/Date | Calculated Threshold (kW) | Battery SoC (%) | System Output (kW) | System Output (kWh) |
|---|---|---|---|---|
| 10/10/18 16:00 | 160.76 | | | |
| 10/10/18 16:15 | -74.83 | 97% | 0.00 | 0.00 |
| 10/10/18 16:30 | -71.46 | 97% | 0.00 | 0.00 |
| 10/10/18 16:45 | -50.28 | 96% | 0.00 | 0.00 |
| 10/10/18 17:00 | -32.23 | 96% | 0.00 | 0.00 |
| 10/10/18 17:15 | -13.84 | 96% | 0.00 | 0.00 |
| 10/10/18 17:30 | -0.25 | 96% | 0.00 | 0.00 |
| 10/10/18 17:45 | 0.00 | 96% | 4.22 | 1.05 |
| 10/10/18 18:00 | 0.00 | 96% | 21.46 | 5.36 |
| **Average kW Curtailed over 2-hr event -->** | | | **3.21** | 6.42 <-- Total kWh Curtailed |

*Note: Net-negative building load prevented appreciable participation until 18:00.*

## Simulated DR Event #7

**DR Event #7**

| Time/Date | Calculated Threshold (kW) | Battery SoC (%) | System Output (kW) | System Output (kWh) |
|---|---|---|---|---|
| 10/17/18 16:00 | 160.77 | | | |
| 10/17/18 16:15 | -27.45 | 72% | 0.00 | 0.00 |
| 10/17/18 16:30 | -31.17 | 72% | 0.00 | 0.00 |
| 10/17/18 16:45 | -12.33 | 72% | 0.00 | 0.00 |
| 10/17/18 17:00 | 18.45 | 72% | 0.00 | 0.00 |
| 10/17/18 17:15 | 19.80 | 72% | 0.00 | 0.00 |
| 10/17/18 17:30 | 18.70 | 72% | 0.00 | 0.00 |
| 10/17/18 17:45 | 9.86 | 72% | 16.06 | 4.01 |
| 10/17/18 18:00 | 19.80 | 71% | 15.55 | 3.89 |
| **Average kW Curtailed over 2-hr event -->** | | | **3.95** | 7.90 <-- Total kWh Curtailed |

*Note: Net-negative building load prevented appreciable participation until 18:00.*

## Simulated DR Event #8

**DR Event #8**

| Time/Date | Calculated Threshold (kW) | Battery SoC (%) | System Output (kW) | System Output (kWh) |
|---|---|---|---|---|
| 10/19/18 16:00 | 160.77 | | | |
| 10/19/18 16:15 | -51.79 | 72% | 0.00 | 0.00 |
| 10/19/18 16:30 | -44.17 | 72% | 0.00 | 0.00 |
| 10/19/18 16:45 | -41.44 | 72% | 0.00 | 0.00 |
| 10/19/18 17:00 | -28.06 | 72% | 0.00 | 0.00 |
| 10/19/18 17:15 | -17.63 | 72% | 0.00 | 0.00 |
| 10/19/18 17:30 | -8.34 | 72% | 2.41 | 0.60 |
| 10/19/18 17:45 | 2.87 | 72% | 19.30 | 4.82 |
| 10/19/18 18:00 | 18.99 | 70% | 14.46 | 3.62 |
| **Average kW Curtailed over 2-hr event -->** | | | **4.52** | 9.04 <-- Total kWh Curtailed |

*Note: Net-negative building load prevented appreciable participation until 18:00.*

## Monte Vista High School #2

### Simulated DR Event #1

**DR Event #1**

| Time/Date | Calculated Threshold (kW) | Battery SoC (%) | System Output (kW) | System Output (kWh) | |
|---|---|---|---|---|---|
| 9/6/18 16:00 | 208.90 | | | | |
| 9/6/18 16:15 | 0.00 | 97% | 0.28 | 0.07 | |
| 9/6/18 16:30 | 0.00 | 97% | 14.97 | 3.74 | |
| 9/6/18 16:45 | 0.00 | 96% | 25.52 | 6.38 | |
| 9/6/18 17:00 | 0.00 | 93% | 36.53 | 9.13 | |
| 9/6/18 17:15 | 0.00 | 90% | 54.48 | 13.62 | |
| 9/6/18 17:30 | 0.00 | 85% | 73.04 | 18.26 | |
| 9/6/18 17:45 | 0.00 | 78% | 79.61 | 19.90 | |
| 9/6/18 18:00 | 0.00 | 71% | 101.62 | 25.41 | |
| **Average kW Curtailed over 2-hr event -->** | | | **48.26** | 96.51 | <-- Total kWh Curtailed |

### Simulated DR Event #2

**DR Event #2**

| Time/Date | Calculated Threshold (kW) | Battery SoC (%) | System Output (kW) | System Output (kWh) | |
|---|---|---|---|---|---|
| 9/20/18 16:00 | 208.90 | | | | |
| 9/20/18 16:15 | 143.24 | 95% | 0.00 | 0.00 | |
| 9/20/18 16:30 | 143.24 | 95% | 0.00 | 0.00 | |
| 9/20/18 16:45 | 143.24 | 95% | 17.42 | 4.35 | |
| 9/20/18 17:00 | 143.24 | 93% | 29.75 | 7.44 | |
| 9/20/18 17:15 | 143.24 | 89% | 0.11 | 0.03 | |
| 9/20/18 17:30 | 143.24 | 89% | 0.00 | 0.00 | |
| 9/20/18 17:45 | 143.24 | 89% | 0.00 | 0.00 | |
| 9/20/18 18:00 | 143.24 | 89% | 83.88 | 20.97 | |
| **Average kW Curtailed over 2-hr event -->** | | | **16.40** | 32.79 | <-- Total kWh Curtailed |

### Simulated DR Event #3

**DR Event #3**

| Time/Date | Calculated Threshold (kW) | Battery SoC (%) | System Output (kW) | System Output (kWh) | |
|---|---|---|---|---|---|
| 9/27/18 15:00 | 153.79 | | | | |
| 9/27/18 15:15 | 153.79 | 94% | 28.28 | 7.07 | |
| 9/27/18 15:30 | 153.79 | 92% | 20.28 | 5.07 | |
| 9/27/18 15:45 | 153.79 | 90% | 5.45 | 1.36 | |
| 9/27/18 16:00 | 153.79 | 88% | 11.30 | 2.82 | |
| 9/27/18 16:15 | 57.40 | 87% | 0.04 | 0.01 | |
| 9/27/18 16:30 | 57.40 | 87% | 0.00 | 0.00 | |
| 9/27/18 16:45 | 57.40 | 87% | 0.13 | 0.03 | |
| 9/27/18 17:00 | 57.40 | 87% | 3.72 | 0.93 | |
| **Average kW Curtailed over 2-hr event -->** | | | **8.65** | 17.30 | <-- Total kWh Curtailed |

### Simulated DR Event #4

**DR Event #4**

| Time/Date | Calculated Threshold (kW) | Battery SoC (%) | System Output (kW) | System Output (kWh) | |
|---|---|---|---|---|---|
| 10/4/18 16:00 | 160.41 | | | | |
| 10/4/18 16:15 | 97.68 | 94% | 0.00 | 0.00 | |
| 10/4/18 16:30 | 97.68 | 94% | 0.00 | 0.00 | |
| 10/4/18 16:45 | 97.68 | 94% | 0.13 | 0.03 | |
| 10/4/18 17:00 | 97.68 | 94% | 6.63 | 1.66 | |
| 10/4/18 17:15 | 97.68 | 93% | 0.38 | 0.10 | |
| 10/4/18 17:30 | 97.68 | 93% | 0.00 | 0.00 | |
| 10/4/18 17:45 | 97.68 | 93% | 0.08 | 0.02 | |
| 10/4/18 18:00 | 97.68 | 93% | 85.29 | 21.32 | |
| **Average kW Curtailed over 2-hr event -->** | | | **11.56** | 23.13 | <-- Total kWh Curtailed |

## Simulated DR Event #5

**DR Event #5**

| Time/Date | Calculated Threshold (kW) | Battery SoC (%) | System Output (kW) | System Output (kWh) | |
|---|---|---|---|---|---|
| 10/9/18 16:00 | 160.41 | | | | |
| 10/9/18 16:15 | 3.61 | 95% | 0.00 | 0.00 | |
| 10/9/18 16:30 | 0.00 | 95% | 0.81 | 0.20 | |
| 10/9/18 16:45 | 0.00 | 95% | 23.41 | 5.85 | |
| 10/9/18 17:00 | 0.00 | 93% | 45.38 | 11.35 | |
| 10/9/18 17:15 | 46.62 | 89% | 13.44 | 3.36 | |
| 10/9/18 17:30 | 67.03 | 88% | 9.97 | 2.49 | |
| 10/9/18 17:45 | 51.28 | 87% | 40.94 | 10.24 | |
| 10/9/18 18:00 | 0.00 | 83% | 100.59 | 25.15 | |
| **Average kW Curtailed over 2-hr event -->** | | | **29.32** | 58.64 | <-- Total kWh Curtailed |

## Simulated DR Event #6

**DR Event #6**

| Time/Date | Calculated Threshold (kW) | Battery SoC (%) | System Output (kW) | System Output (kWh) | |
|---|---|---|---|---|---|
| 10/10/18 16:00 | 167.95 | | | | |
| 10/10/18 16:15 | -3.20 | 96% | 26.96 | 6.74 | |
| 10/10/18 16:30 | 0.00 | 94% | 72.07 | 18.02 | |
| 10/10/18 16:45 | 0.00 | 87% | 13.58 | 3.39 | |
| 10/10/18 17:00 | 0.00 | 85% | 46.72 | 11.68 | |
| 10/10/18 17:15 | 43.86 | 81% | 27.55 | 6.89 | |
| 10/10/18 17:30 | 69.24 | 78% | 9.64 | 2.41 | |
| 10/10/18 17:45 | 80.76 | 77% | 15.55 | 3.89 | |
| 10/10/18 18:00 | 0.00 | 76% | 95.84 | 23.96 | |
| **Average kW Curtailed over 2-hr event -->** | | | **38.49** | 76.98 | <-- Total kWh Curtailed |

## Simulated DR Event #7

**DR Event #7**

| Time/Date | Calculated Threshold (kW) | Battery SoC (%) | System Output (kW) | System Output (kWh) | |
|---|---|---|---|---|---|
| 10/17/18 16:00 | 168.06 | | | | |
| 10/17/18 16:15 | 32.69 | 98% | 0.00 | 0.00 | |
| 10/17/18 16:30 | 41.25 | 98% | 0.00 | 0.00 | |
| 10/17/18 16:45 | 41.58 | 98% | 5.53 | 1.38 | |
| 10/17/18 17:00 | 49.15 | 97% | 14.40 | 3.60 | |
| 10/17/18 17:15 | 61.01 | 96% | 23.66 | 5.92 | |
| 10/17/18 17:30 | 77.95 | 93% | 14.47 | 3.62 | |
| 10/17/18 17:45 | 94.17 | 92% | 8.86 | 2.22 | |
| 10/17/18 18:00 | 97.20 | 91% | 12.25 | 3.06 | |
| **Average kW Curtailed over 2-hr event -->** | | | **9.90** | 19.79 | <-- Total kWh Curtailed |

## Simulated DR Event #8

**DR Event #8**

| Time/Date | Calculated Threshold (kW) | Battery SoC (%) | System Output (kW) | System Output (kWh) | |
|---|---|---|---|---|---|
| 10/19/18 16:00 | 168.06 | | | | |
| 10/19/18 16:15 | 10.86 | 96% | 11.70 | 2.93 | |
| 10/19/18 16:30 | 0.45 | 94% | 26.40 | 6.60 | |
| 10/19/18 16:45 | 0.00 | 92% | 45.20 | 11.30 | |
| 10/19/18 17:00 | 0.00 | 88% | 66.09 | 16.52 | |
| 10/19/18 17:15 | 72.06 | 82% | 13.08 | 3.27 | |
| 10/19/18 17:30 | 86.58 | 80% | 18.32 | 4.58 | |
| 10/19/18 17:45 | 98.06 | 79% | 19.52 | 4.88 | |
| 10/19/18 18:00 | 38.92 | 77% | 93.87 | 23.47 | |
| **Average kW Curtailed over 2-hr event -->** | | | **36.77** | 73.54 | <-- Total kWh Curtailed |

## El Cajon Valley High School #1

### Simulated DR Event #1

**DR Event #1**

| Time/Date | Calculated Threshold (kW) | Battery SoC (%) | System Output (kW) | System Output (kWh) | |
|---|---|---|---|---|---|
| 9/6/18 16:00 | 89.00 | | | | |
| 9/6/18 16:15 | 1.00 | 99% | 13.77 | 3.44 | |
| 9/6/18 16:30 | 1.00 | 97% | 18.10 | 4.53 | |
| 9/6/18 16:45 | 1.00 | 96% | 23.30 | 5.83 | |
| 9/6/18 17:00 | 1.00 | 94% | 34.20 | 8.55 | |
| 9/6/18 17:15 | 1.00 | 91% | 48.28 | 12.07 | |
| 9/6/18 17:30 | 1.00 | 86% | 74.64 | 18.66 | |
| 9/6/18 17:45 | 1.00 | 79% | 65.18 | 16.29 | |
| 9/6/18 18:00 | 1.00 | 73% | 87.54 | 21.89 | |
| | **Average kW Curtailed over 2-hr event -->** | | **45.63** | 91.25 | <-- Total kWh Curtailed |

### Simulated DR Event #2

**DR Event #1**

| Time/Date | Calculated Threshold (kW) | Battery SoC (%) | System Output (kW) | System Output (kWh) | |
|---|---|---|---|---|---|
| 9/6/18 16:00 | 89.00 | | | | |
| 9/6/18 16:15 | 1.00 | 99% | 13.77 | 3.44 | |
| 9/6/18 16:30 | 1.00 | 97% | 18.10 | 4.53 | |
| 9/6/18 16:45 | 1.00 | 96% | 23.30 | 5.83 | |
| 9/6/18 17:00 | 1.00 | 94% | 34.20 | 8.55 | |
| 9/6/18 17:15 | 1.00 | 91% | 48.28 | 12.07 | |
| 9/6/18 17:30 | 1.00 | 86% | 74.64 | 18.66 | |
| 9/6/18 17:45 | 1.00 | 79% | 65.18 | 16.29 | |
| 9/6/18 18:00 | 1.00 | 73% | 87.54 | 21.89 | |
| | **Average kW Curtailed over 2-hr event -->** | | **45.63** | 91.25 | <-- Total kWh Curtailed |

### Simulated DR Event #3

**DR Event #3**

| Time/Date | Calculated Threshold (kW) | Battery SoC (%) | System Output (kW) | System Output (kWh) | |
|---|---|---|---|---|---|
| 9/27/18 15:00 | 93.01 | | | | |
| 9/27/18 15:15 | 93.01 | 98% | 0.00 | 0.00 | |
| 9/27/18 15:30 | 93.01 | 98% | 29.59 | 7.40 | |
| 9/27/18 15:45 | 93.01 | 95% | 43.58 | 10.90 | |
| 9/27/18 16:00 | 93.01 | 92% | 51.73 | 12.93 | |
| 9/27/18 16:15 | 66.07 | 87% | 12.68 | 3.17 | |
| 9/27/18 16:30 | 66.07 | 86% | 16.63 | 4.16 | |
| 9/27/18 16:45 | 66.07 | 83% | 28.51 | 7.13 | |
| 9/27/18 17:00 | 66.08 | 80% | 26.40 | 6.60 | |
| | **Average kW Curtailed over 2-hr event -->** | | **26.14** | 52.28 | <-- Total kWh Curtailed |

### Simulated DR Event #4

**DR Event #4**

| Time/Date | Calculated Threshold (kW) | Battery SoC (%) | System Output (kW) | System Output (kWh) | |
|---|---|---|---|---|---|
| 10/4/18 16:00 | 165.23 | | | | |
| 10/4/18 16:15 | 111.04 | 98% | 34.29 | 8.57 | |
| 10/4/18 16:30 | 111.04 | 95% | 43.35 | 10.84 | |
| 10/4/18 16:45 | 111.04 | 91% | 44.14 | 11.03 | |
| 10/4/18 17:00 | 111.04 | 87% | 39.09 | 9.77 | |
| 10/4/18 17:15 | 111.04 | 83% | 26.46 | 6.62 | |
| 10/4/18 17:30 | 111.04 | 80% | 32.68 | 8.17 | |
| 10/4/18 17:45 | 111.04 | 77% | 32.52 | 8.13 | |
| 10/4/18 18:00 | 111.04 | 74% | 35.55 | 8.89 | |
| | **Average kW Curtailed over 2-hr event -->** | | **36.01** | 72.02 | <-- Total kWh Curtailed |

## Simulated DR Event #5

**DR Event #5**

| Time/Date | Calculated Threshold (kW) | Battery SoC (%) | System Output (kW) | System Output (kWh) | |
|---|---|---|---|---|---|
| 10/9/18 16:00 | 165.23 | | | | |
| 10/9/18 16:15 | 65.05 | 79% | 85.31 | 21.33 | |
| 10/9/18 16:30 | 55.34 | 71% | 93.75 | 23.44 | |
| 10/9/18 16:45 | 51.72 | 61% | 99.54 | 24.89 | |
| 10/9/18 17:00 | 39.05 | 52% | 95.49 | 23.87 | |
| 10/9/18 17:15 | 57.87 | 42% | 80.33 | 20.08 | |
| 10/9/18 17:30 | 71.36 | 35% | 52.38 | 13.10 | |
| 10/9/18 17:45 | 76.67 | 29% | 47.84 | 11.96 | |
| 10/9/18 18:00 | 76.93 | 24% | 47.23 | 11.81 | |
| **Average kW Curtailed over 2-hr event -->** | | | **75.23** | 150.47 | <-- Total kWh Curtailed |

## Simulated DR Event #6

**DR Event #6**

| Time/Date | Calculated Threshold (kW) | Battery SoC (%) | System Output (kW) | System Output (kWh) | |
|---|---|---|---|---|---|
| 10/10/18 16:00 | 165.23 | | | | |
| 10/10/18 16:15 | 50.38 | 96% | 0.00 | 0.00 | |
| 10/10/18 16:30 | 46.54 | 96% | 1.17 | 0.29 | |
| 10/10/18 16:45 | 0.00 | 96% | 55.31 | 13.83 | |
| 10/10/18 17:00 | 0.00 | 91% | 92.54 | 23.13 | |
| 10/10/18 17:15 | 64.43 | 82% | 21.33 | 5.33 | |
| 10/10/18 17:30 | 71.46 | 80% | 10.44 | 2.61 | |
| 10/10/18 17:45 | 52.41 | 79% | 40.90 | 10.22 | |
| 10/10/18 18:00 | 0.00 | 75% | 97.82 | 24.46 | |
| **Average kW Curtailed over 2-hr event -->** | | | **39.94** | 79.88 | <-- Total kWh Curtailed |

## Simulated DR Event #7

**DR Event #7**

| Time/Date | Calculated Threshold (kW) | Battery SoC (%) | System Output (kW) | System Output (kWh) | |
|---|---|---|---|---|---|
| 10/17/18 16:00 | 162.60 | | | | |
| 10/17/18 16:15 | -12.71 | 96% | 0.00 | 0.00 | |
| 10/17/18 16:30 | -7.30 | 96% | 3.67 | 0.92 | |
| 10/17/18 16:45 | 2.40 | 95% | 22.20 | 5.55 | |
| 10/17/18 17:00 | 20.38 | 93% | 25.97 | 6.49 | |
| 10/17/18 17:15 | 36.40 | 91% | 22.18 | 5.54 | |
| 10/17/18 17:30 | 45.24 | 89% | 31.11 | 7.78 | |
| 10/17/18 17:45 | 59.29 | 86% | 27.19 | 6.80 | |
| 10/17/18 18:00 | 67.23 | 83% | 30.21 | 7.55 | |
| **Average kW Curtailed over 2-hr event -->** | | | **20.32** | 40.63 | <-- Total kWh Curtailed |

## Simulated DR Event #8

**DR Event #8**

| Time/Date | Calculated Threshold (kW) | Battery SoC (%) | System Output (kW) | System Output (kWh) | |
|---|---|---|---|---|---|
| 10/19/18 16:00 | 162.60 | | | | |
| 10/19/18 16:15 | -6.45 | 95% | 4.96 | 1.24 | |
| 10/19/18 16:30 | 0.00 | 94% | 4.67 | 1.17 | |
| 10/19/18 16:45 | 0.00 | 94% | 31.22 | 7.81 | |
| 10/19/18 17:00 | 0.00 | 91% | 41.68 | 10.42 | |
| 10/19/18 17:15 | 48.73 | 87% | 13.75 | 3.44 | |
| 10/19/18 17:30 | 63.77 | 85% | 10.54 | 2.63 | |
| 10/19/18 17:45 | 75.17 | 84% | 7.47 | 1.87 | |
| 10/19/18 18:00 | 0.00 | 83% | 95.94 | 23.98 | |
| **Average kW Curtailed over 2-hr event -->** | | | **26.28** | 52.56 | <-- Total kWh Curtailed |

## El Cajon Valley High School #2

### Simulated DR Event #1

**DR Event #1**

| Time/Date | Calculated Threshold (kW) | Battery SoC (%) | System Output (kW) | System Output (kWh) | |
|---|---|---|---|---|---|
| 9/6/18 16:00 | 208.6 | | | | |
| 9/6/18 16:15 | 98.2 | 98% | 0.00 | 0.00 | |
| 9/6/18 16:30 | 98.2 | 98% | 0.00 | 0.00 | |
| 9/6/18 16:45 | 98.2 | 98% | 0.00 | 0.00 | |
| 9/6/18 17:00 | 98.2 | 98% | 0.00 | 0.00 | |
| 9/6/18 17:15 | 98.2 | 98% | 0.00 | 0.00 | |
| 9/6/18 17:30 | 98.2 | 98% | 0.00 | 0.00 | |
| 9/6/18 17:45 | 98.2 | 98% | 0.00 | 0.00 | |
| 9/6/18 18:00 | 98.2 | 98% | 2.78 | 0.70 | |
| **Average kW Curtailed over 2-hr event -->** | | | **0.35** | 0.70 | <-- Total kWh Curtailed |

*Note: There was no discernable participation.*

### Simulated DR Event #2

**DR Event #2**

| Time/Date | Calculated Threshold (kW) | Battery SoC (%) | System Output (kW) | System Output (kWh) | |
|---|---|---|---|---|---|
| 9/20/18 16:00 | 208.60 | | | | |
| 9/20/18 16:15 | 98.20 | 96% | 0.00 | 0.00 | |
| 9/20/18 16:30 | 98.20 | 96% | 0.00 | 0.00 | |
| 9/20/18 16:45 | 98.20 | 96% | 0.00 | 0.00 | |
| 9/20/18 17:00 | 98.20 | 96% | 1.66 | 0.42 | |
| 9/20/18 17:15 | 98.20 | 96% | 12.42 | 3.11 | |
| 9/20/18 17:30 | 98.20 | 95% | 45.78 | 11.44 | |
| 9/20/18 17:45 | 98.20 | 93% | 60.32 | 15.08 | |
| 9/20/18 18:00 | 98.20 | 91% | 79.27 | 19.82 | |
| **Average kW Curtailed over 2-hr event -->** | | | **24.93** | 49.86 | <-- Total kWh Curtailed |

*Note: Net-negative building load prevented appreciable participation until 17:00.*

### Simulated DR Event #3

**DR Event #3**

| Time/Date | Calculated Threshold (kW) | Battery SoC (%) | System Output (kW) | System Output (kWh) | |
|---|---|---|---|---|---|
| 9/27/18 15:00 | 208.60 | | | | |
| 9/27/18 15:15 | 208.60 | 97% | 19.38 | 4.84 | |
| 9/27/18 15:30 | 98.20 | 96% | 29.92 | 7.48 | |
| 9/27/18 15:45 | 208.60 | 94% | 9.86 | 2.46 | |
| 9/27/18 16:00 | 98.20 | 94% | 7.22 | 1.81 | |
| 9/27/18 16:15 | 98.20 | 93% | 1.37 | 0.34 | |
| 9/27/18 16:30 | 98.20 | 94% | 2.84 | 0.71 | |
| 9/27/18 16:45 | 98.20 | 93% | 8.63 | 2.16 | |
| 9/27/18 17:00 | 98.20 | 93% | 17.96 | 4.49 | |
| **Average kW Curtailed over 2-hr event -->** | | | **12.15** | 24.29 | <-- Total kWh Curtailed |

## Simulated DR Event #4

**DR Event #4**

| Time/Date | Calculated Threshold (kW) | Battery SoC (%) | System Output (kW) | System Output (kWh) | |
|---|---|---|---|---|---|
| 10/4/18 16:00 | 369.40 | | | | |
| 10/4/18 16:15 | 75.81 | 98% | 0.00 | 0.00 | |
| 10/4/18 16:30 | 75.81 | 98% | 16.87 | 4.22 | |
| 10/4/18 16:45 | 75.81 | 97% | 30.58 | 7.64 | |
| 10/4/18 17:00 | 75.81 | 96% | 39.93 | 9.98 | |
| 10/4/18 17:15 | 75.81 | 94% | 0.24 | 0.06 | |
| 10/4/18 17:30 | 75.81 | 94% | 6.87 | 1.72 | |
| 10/4/18 17:45 | 75.81 | 93% | 11.71 | 2.93 | |
| 10/4/18 18:00 | 75.81 | 93% | 38.40 | 9.60 | |
| **Average kW Curtailed over 2-hr event -->** | | | **18.08** | 36.15 | <-- Total kWh Curtailed |

## Simulated DR Event #5

**DR Event #5**

| Time/Date | Calculated Threshold (kW) | Battery SoC (%) | System Output (kW) | System Output (kWh) | |
|---|---|---|---|---|---|
| 10/9/18 16:00 | 369.40 | | | | |
| 10/9/18 16:15 | -0.99 | 96% | 1.11 | 0.28 | |
| 10/9/18 16:30 | -2.98 | 96% | 14.46 | 3.62 | |
| 10/9/18 16:45 | -1.25 | 95% | 16.49 | 4.12 | |
| 10/9/18 17:00 | 0.00 | 94% | 31.71 | 7.93 | |
| 10/9/18 17:15 | 26.35 | 93% | 27.64 | 6.91 | |
| 10/9/18 17:30 | 22.80 | 91% | 68.19 | 17.05 | |
| 10/9/18 17:45 | 0.00 | 88% | 92.23 | 23.06 | |
| 10/9/18 18:00 | 0.00 | 84% | 106.32 | 26.58 | |
| **Average kW Curtailed over 2-hr event -->** | | | **44.77** | 89.54 | <-- Total kWh Curtailed |

## Simulated DR Event #6

**DR Event #6**

| Time/Date | Calculated Threshold (kW) | Battery SoC (%) | System Output (kW) | System Output (kWh) | |
|---|---|---|---|---|---|
| 10/10/18 16:00 | 369.40 | | | | |
| 10/10/18 16:15 | -5.56 | 96% | 0.00 | 0.00 | |
| 10/10/18 16:30 | -6.51 | 96% | 8.60 | 2.15 | |
| 10/10/18 16:45 | -7.05 | 96% | 15.57 | 3.89 | |
| 10/10/18 17:00 | 0.00 | 95% | 61.79 | 15.45 | |
| 10/10/18 17:15 | 0.00 | 92% | 79.35 | 19.84 | |
| 10/10/18 17:30 | 0.00 | 89% | 87.65 | 21.91 | |
| 10/10/18 17:45 | 0.00 | 85% | 0.00 | 0.00 | |
| 10/10/18 18:00 | 0.00 | 81% | 0.00 | 0.00 | |
| **Average kW Curtailed over 2-hr event -->** | | | **31.62** | 63.24 | <-- Total kWh Curtailed |

## Simulated DR Event #7

**DR Event #7**

| Time/Date | Calculated Threshold (kW) | Battery SoC (%) | System Output (kW) | System Output (kWh) | |
|---|---|---|---|---|---|
| 10/17/18 16:00 | 369.00 | | | | |
| 10/17/18 16:15 | -87.07 | 96% | 0.00 | 0.00 | |
| 10/17/18 16:30 | -82.40 | 96% | 0.00 | 0.00 | |
| 10/17/18 16:45 | -68.07 | 96% | 0.00 | 0.00 | |
| 10/17/18 17:00 | -25.88 | 96% | 0.00 | 0.00 | |
| 10/17/18 17:15 | -0.44 | 96% | 0.00 | 0.00 | |
| 10/17/18 17:30 | 16.62 | 96% | 0.00 | 0.00 | |
| 10/17/18 17:45 | 29.79 | 93% | 0.00 | 0.00 | |
| 10/17/18 18:00 | 34.11 | 91% | 0.00 | 0.00 | |
| **Average kW Curtailed over 2-hr event -->** | | | **0.00** | 0.00 | <-- Total kWh Curtailed |

*Note: Net-negative building load prevented appreciable participation in first half of event only.*

## Simulated DR Event #8

**DR Event #8**

| Time/Date | Calculated Threshold (kW) | Battery SoC (%) | System Output (kW) | System Output (kWh) | |
|---|---|---|---|---|---|
| 10/19/18 16:00 | 369.00 | | | | |
| 10/19/18 16:15 | -68.63 | 96% | 0.00 | 0.00 | |
| 10/19/18 16:30 | -64.12 | 96% | 0.00 | 0.00 | |
| 10/19/18 16:45 | -52.67 | 96% | 0.00 | 0.00 | |
| 10/19/18 17:00 | -32.13 | 96% | 0.00 | 0.00 | |
| 10/19/18 17:15 | -13.18 | 95% | 0.00 | 0.00 | |
| 10/19/18 17:30 | 0.02 | 92% | 0.00 | 0.00 | |
| 10/19/18 17:45 | 0.00 | 89% | 0.00 | 0.00 | |
| 10/19/18 18:00 | 0.00 | 85% | 0.00 | 0.00 | |
| **Average kW Curtailed over 2-hr event -->** | | | **0.00** | 0.00 | <-- Total kWh Curtailed |

*Note: Net-negative building load prevented appreciable participation in first half of event only.*

## El Cajon Valley High School #3

## Simulated DR Event #1

**DR Event #1**

| Time/Date | Calculated Threshold (kW) | Battery SoC (%) | System Output (kW) | System Output (kWh) | |
|---|---|---|---|---|---|
| 9/6/18 16:00 | 60.00 | | | | |
| 9/6/18 16:15 | 0.00 | 96% | 0.31 | 0.08 | |
| 9/6/18 16:30 | 0.00 | 95% | 0.53 | 0.13 | |
| 9/6/18 16:45 | 0.00 | 95% | 0.43 | 0.11 | |
| 9/6/18 17:00 | 0.00 | 95% | 0.30 | 0.08 | |
| 9/6/18 17:15 | 0.00 | 95% | 0.33 | 0.08 | |
| 9/6/18 17:30 | 0.00 | 95% | 0.31 | 0.08 | |
| 9/6/18 17:45 | 0.00 | 95% | 0.36 | 0.09 | |
| 9/6/18 18:00 | 0.00 | 95% | 0.32 | 0.08 | |
| **Average kW Curtailed over 2-hr event -->** | | | **0.36** | 0.72 | <-- Total kWh Curtailed |

*Note: This account is on rate tariff OLTOUCP2, and appears to serve sports field lighting only, based on available information. El Cajon Valley High School System #3 was removed from DR testing after the first event because it does not have any consistent load on the meter during the day.*

## Appendix A

*Test Site Summaries*

A total of **20** Energy Storage Systems are included in the test fleet for evaluation as part of this M&V study (Group 1). At the **18** test sites, a total of **24** individual 30 kW / 60 kWh & 250 kW / 500 kWh units were evaluated (4 of the ESSs consist of two ESS units in parallel). The test sites are located within the Grossmont Union High School District and the Poway Unified School District, in the SDG&E service territory. The test sites are listed in Table 18 below.

**Table 24: List of Energy Storage Systems Evaluated, Group 1**

| # | District | Facility | kW | kWh |
|---|---|---|---|---|
| 1 | Grossmont | East County ROP | 30 | 60 |
| 2 | Grossmont | El Capitan HS | 250 | 500 |
| 3 | Grossmont | Foothill School | 60 | 120 |
| 4 | Grossmont | Grossmont HS | 250 | 500 |
| 5 | Grossmont | Mt Miguel HS | 250 | 500 |
| 6 | Grossmont | Santana HS 1 | 250 | 500 |
| 7 | Grossmont | Santana HS 2 | 250 | 500 |
| 8 | Poway | Black Mountain | 250 | 500 |
| 9 | Poway | Del Norte HS B | 500 | 1000 |
| 10 | Poway | Del Norte HS A | 60 | 120 |
| 11 | Poway | Del Sur ES | 250 | 500 |
| 12 | Poway | Garden Road ES | 60 | 120 |
| 13 | Poway | Mesa Verde MS | 250 | 500 |
| 14 | Poway | Midland ES | 250 | 500 |
| 15 | Poway | Park Village ES | 250 | 500 |
| 16 | Poway | Stone Ranch ES | 250 | 500 |
| 17 | Poway | Westwood ES | 250 | 500 |
| 18 | Poway | Willow Grove ES | 250 | 500 |
| 19 | Poway | Highland Ranch | 250 | 500 |
| 20 | Poway | District Office | 250 | 500 |

# Grossmont Union High School District

## East County Regional Education Center

***Site Summary***

East County Regional Education Center is approximately 30,000 square foot adult education center serving students in San Diego, CA as part of the Grossmont Union High School District. The center features a single story building housing a computer lab, administrative offices, and classrooms.

***HVAC***

The site is conditioned by 24 single zone roof top package units of various sizes.

***Lighting***

Lighting at the center consists primarily of 32w T8 linear fluorescent lamps with electronic ballast. Offices and classrooms utilize recessed 2'x4' fixture of the two and three lamp variety. Exterior fixtures include parking lot poles with 500W lamps, Building light was a mixture of surface mounted flood and decorative compact fluorescent fixtures.

***Energy Storage System***

The Vendor installed a 30 kW / 60 kWh battery load shedding system located at the north side of the center's property in December of 2016.

***IES Sub-Metering***

IES's role is to provide a third party verification of the amount of electricity used and shed by the school, as well as provide analysis of current (w/ ESS) vs historical electrical use.

***Sub-Metering System***

An IES metering system was installed in August of 2016 and is located within the main electrical room next to the Fire Riser room. The system consists of an Obvius Aquisuite data gathering unit and Veris bi-directional power meter. The data gathering server is located in the main building network closet. The data is transferred to the IES servers to be monitored and stored. This system began receiving and recording data in August of 2016.

***Utility Baseline***

East County Regional Education Center operates with one electric meter that the ESS is installed on.  In FY 2015, total electric consumption costs were $55,110 at an average rate of $0.27/kWh.

The Figure 15 below depicts interval data for an average weekday during both summer and winter months.

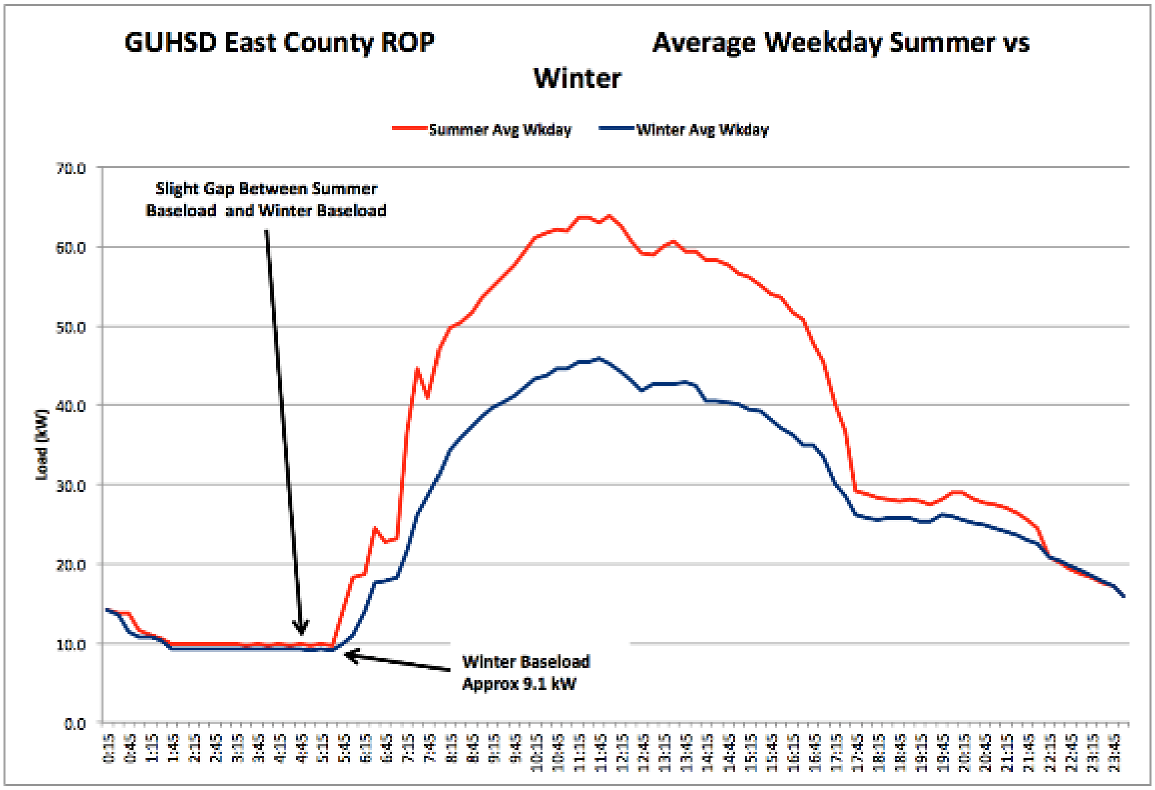


**Figure 15: Average Weekday Summer vs. Winter**

## El Capitan High School

### *Site Summary*

El Capitan High School is a 175,565 square foot high school serving students in Grossmont Union High School District. Established in 1959, the school has undergone numerous rounds of construction. Buildings in the high school include: building 300 (Music), 500, 800, 900, 1000, 1200, 1300 (Industrial Arts) and 1700 (Science). There are 10 portables on site. The site also includes a large gym with male and female locker rooms. Additionally, there is an administration building and custodial buildings on campus.

The school operates on a traditional school calendar with the school year starting after Labor Day and ending in mid-June. Winter Break lasts the final two weeks of December. Spring Break is a one-week break occurring between March and April. General hours are 7:10 am - 2:20 pm Monday through Friday. Buildings are occupied 9 hours a day, 185 days per year. The gym is an exception that operates over 4,162 hours a year. The pool is filtered 24-7 and its pump speed complies with six hour turnover rate requirements.

Figure 16 below shows the overall campus layout. In this view north is to the right.

**Figure 16: School Layout**

***HVAC***

A variety of HVAC Equipment heats and/or cools each of the buildings surveyed. In buildings 300, 400, 500 (library) and 1300, four pipe air handler units with hot and chilled water coils provide the heating and cooling for the spaces. The controls for these spaces are pneumatic temperature controls and the schedule controlled by the Honeywell WEBs-AX energy management system. The central plant for these buildings consists of an air cooled chiller mounted on the north end of the Gymnasium. The plants typical hours of operation are 9.5 hours per day 200 days per year for an annual hours of operation of 1,900 hours per year.

The new Science building, a portion of building 200, buildings 600, 700, 800, 900, 1000, 1100, 1200, 1500, 1800 and 1900 are heated and cooled by single zone roof mounted packaged gas/electric units. The units are relatively new with average efficiency ratings of approximately 13 SEER. The units are controlled by the Honeywell WEBs-AX energy management system. The rooftop typical hours of operation are 95 hours per day 190 days per year for an annual hours of operation of 1,800 hours per year.

Additional cooling consists of a few window units for cooling of small spaces in permanent structures. The portable classrooms are conditioned by 35 wall mount heat pumps controlled by programmable thermostats. The controls have an extended limit from adjusting temperatures and tend to have extended runtime according to facility personnel. The portable classrooms according to facility staff typically are enabled 11 hours per day 200 days per year for a total annual enabled hours of 2,200 per year.

### *Lighting*

Indoor lighting at El Capitan was recently upgraded to LED, with both 2'x4' and 2'x2' LED recessed troffer retrofit fixtures and LED tubes replacing the existing T8 lighting. Some T8 lighting remains in pendant and strip mount fixtures. The new LED troffer retrofits include onboard lighting controls to reduce runtime. Additionally, the high bay gym lighting has been replaced with Cree LED high bay fixtures.

Outdoor lighting at El Capitan was also recently upgraded to LED, with fixtures ranging from mini-wall packs to canopy lighting to pole lighting and sconces using a variety of new LED fixtures and LED lamps.

### *Other Systems*

The buildings surveyed have a wide variety of plug load equipment, including computers, printers, and other office and classroom plug load equipment. There is a 10-lane competition swimming pool on campus with a circulation pump equipped with controls to allow it to modulate to maintain the correct flow rate.

### *Energy Storage System*

The Vendor installed a 250 kW / 500 kWh battery load shedding system in July of 2016.

### *IES Sub-Metering*

IES's role is to provide a third party verification of the amount of electricity used and shed by the school, as well as provide analysis of current (w/ ESS) vs historical electrical use.

### *Sub-Metering System*

An IES metering system was installed in August of 2016 and is located within the North electrical block house, nearest the transformer. The system consists of an Obvius Aquisuite data gathering unit and Veris bi-directional power meter. The data gathering server communicates wirelessly with the power meter and is located in the 700 Building network closet. The data is transferred to the IES servers to be monitored and stored. This system began receiving and recording data in August of 2016.

### *Utility Baseline*

El Capitan HS operates with one electric meter that the ESS is installed on. In FY 2015, electric consumption costs for this meter were $173,008 at an average rate of $0.29/kWh.

Figure 17 below depicts interval data for an average weekday during both summer and winter months for this meter.

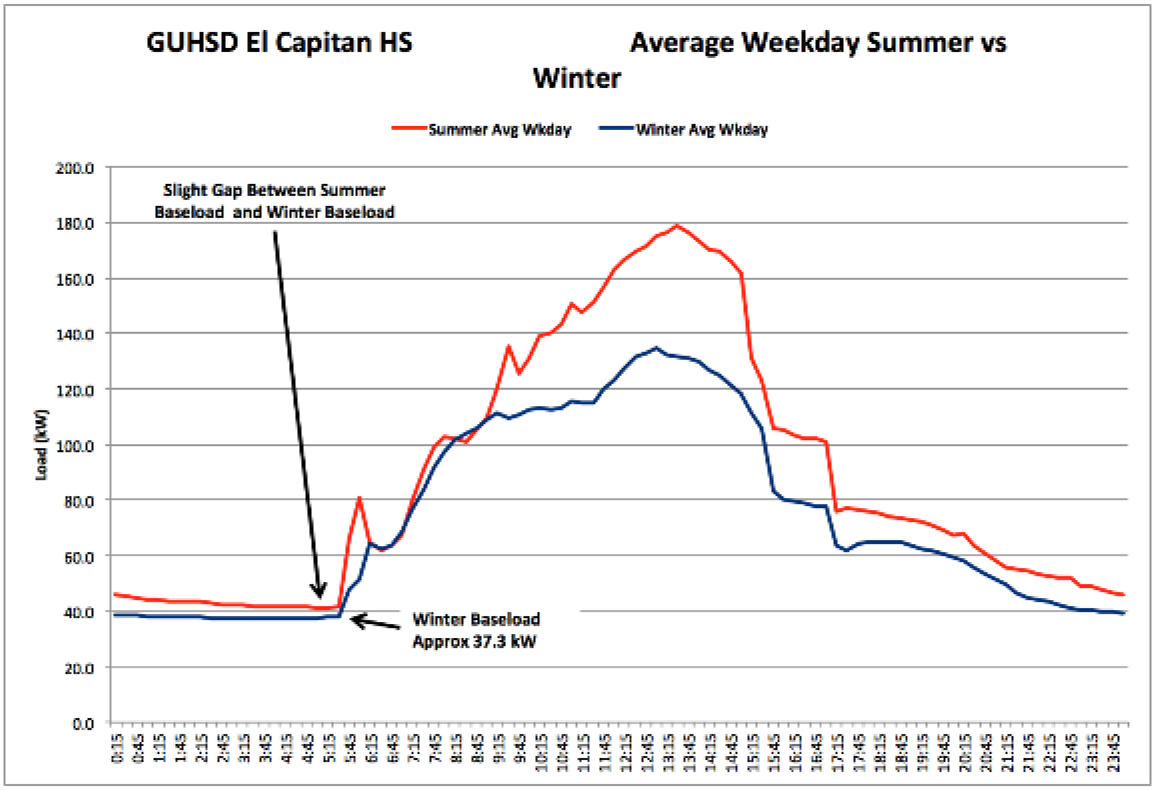


**Figure 17: Average Weekday Summer vs. Winter**

## Foothill Adult School

***Site Summary***

Foothills Adult Education Center is approximately 40,000 square foot adult education center serving students in San Diego, CA as part of the Grossmont Unified School District. The center features three single story buildings and two modular buildings. The main building housing a computer lab, administrative offices, classrooms, Parent Education building, and a Child Care building.

***HVAC***

The main building is conditioned by four multi zone units of various sizes mounted on the roof top. The Parent Education building is conditioned by two single zone roof top package units. The Child Care building is conditioned by two ground mount units. The larger modular building is conditioned by two wall mounted heat pumps. The smaller modular building is conditioned by one wall mounted heat pump.

***Lighting***

Lighting at the center consists primarily of 32w T8 linear fluorescent lamps with electronic ballast. Offices and classrooms utilize recessed 2’x4’ fixture of the two and three lamp variety. Exterior fixtures include parking lot poles with 500W lamps, Building lighting is a mixture of roof mounted flood and compact fluorescent fixtures.

***Energy Storage System***

The Vendor installed a 60 kW / 120 kWh battery load shedding system located at the north side of the center’s Main building in December of 2016.

***IES Sub Metering***

IES’s role is to provide a third party verification of the amount of electricity used and shed by the school, as well as provide analysis of current (w/ ESS) vs historical electrical use.

***Sub-Metering System***

An IES metering system was installed in August of 2016 and is located by the exterior wall adjacent to the battery system. The system consists of an Obvius Aquisuite data gathering unit and Veris bi-directional power meter. The data gathering server is located in a nearby telephone network room that is accessed from the exterior of the building. The data is transferred to the IES servers to be monitored and stored. This system began receiving and recording data in October of 2016.

***Utility Baseline***

Foothill operates with one electric meter that the ESS is installed on. In FY 2015, electric consumption costs for this meter were $115,252 at an average rate of $0.24/kWh.

Figure 18 below depicts interval data for an average weekday during both summer and winter months for this meter.

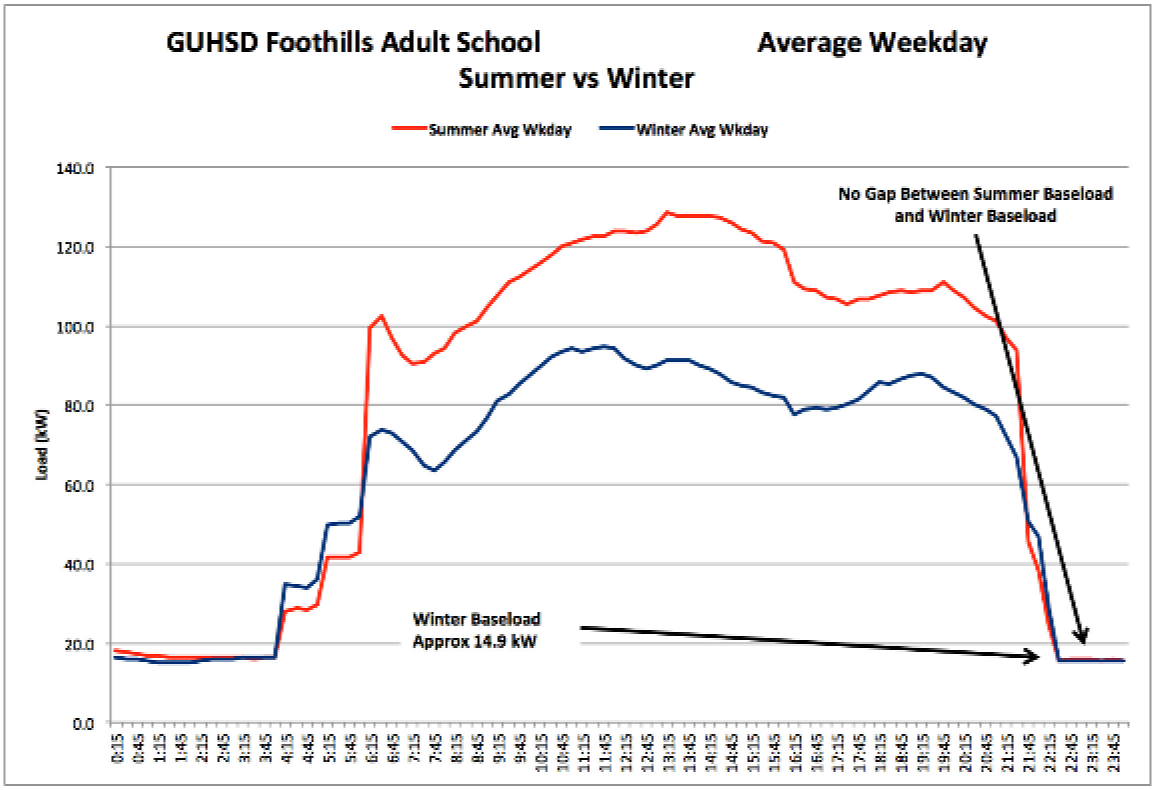


**Figure 18: Average Weekday Summer vs. Winter**

## Grossmont High School

### *Site Summary*

Grossmont HS is located in Grossmont, CA. The school serves over 2,300 students. The high school opened in 1922 and operates on a traditional school calendar. The campus totals 255,457 square feet and includes the District Office for GUHSD.

The school operates on a tradition school calendar with the school year starting after Labor Day and ending in mid-June. Winter break is a two-week break at the end of December. Spring break is a one week break in late March/April. School hours are 7:00am 2:30pm Monday Friday. In general the spaces are occupied approximately 9 hours per day 185 days per year with the exception being the gymnasium. The gymnasium is used very extended hours throughout the year with an hours of operation for lighting and other ventilation equipment in excess of 4,162 hours annually. The pool is constantly being filtered on a 24/7 basis following a sequence of operation for the pump speed to conform with the health code requirements of six hour turnover rates.

Figure 19 below shows the campus layout.


**Figure 19: School Layout**

***HVAC***

The campus HVAC is a mixture of different systems as a result of the original construction of the campus and phased in modernization projects. The buildings #200, 300, 500 (Band), 900 (old CDC), 955 (Band), a portion of the 1200 (PE Bldg.), 1400 (Humanities), District Office are all conditioned by single zone roof mounted packaged gas/electric units. The typical classrooms are conditioned by a rooftop unit with a nominal capacity of between 4 to 5 tons. The units are in adequate condition not requiring their replacement. The HVAC serving all permanent structures are controlled by the campus EMS, a Honeywell WEBs-AX system.

The portable classrooms are controlled by stand-alone programmable thermostats. The portable classrooms according to facility staff typically are enabled 11 hours per day 200 days per year for a total annual enabled hours of 2,200 per year.

***Lighting***

Indoor lighting at Grossmont HS was recently upgraded to LED, with both 2’x4’ and 2’x2’ LED recessed troffer retrofit fixtures and LED tubes replacing the existing T8 lighting. Some T8 lighting remains in pendant and strip mount fixtures. The old gym has 36 4-lamp F96T8s in pendent-strip fixtures in it which have not been upgraded. The new LED troffer retrofits include onboard lighting controls to reduce runtime.

Outdoor lighting at Grossmont HS was also recently upgraded to LED, with fixtures ranging from mini-wall packs to canopy lighting to pole lighting and sconces using a variety of new LED fixtures and LED lamps.

***Other Systems***

The site has numerous computer loads, with many left on- though it was the end of the school day when we audited. There were two vending machines or glass faced coolers throughout the campus that were accounted for. The campus has a 25 yard pool with a circulation pump system equipped with controls to allow it to modulate to maintain the correct flow rate of six hour turnover whenever the swimming pool is occupied as directed by County Health Codes.

***Renewable Systems***

There is a small roof mounted solar PV system located on the Building 900 (Old CDC) on Campus.

***Energy Storage System***

The Vendor installed a 250 kW / 500 kWh battery load shedding system in July of 2016.

***Utility Baseline***

IES looked at two meters at Grossmont HS, of which the ESS is installed on one.  In FY 2015, electric consumption costs for these meters was $367,416 at an average rate of $0.23/kWh.

Figures 20 and 21 on the following page display interval data for an average weekday during both summer and winter months for the two meters.

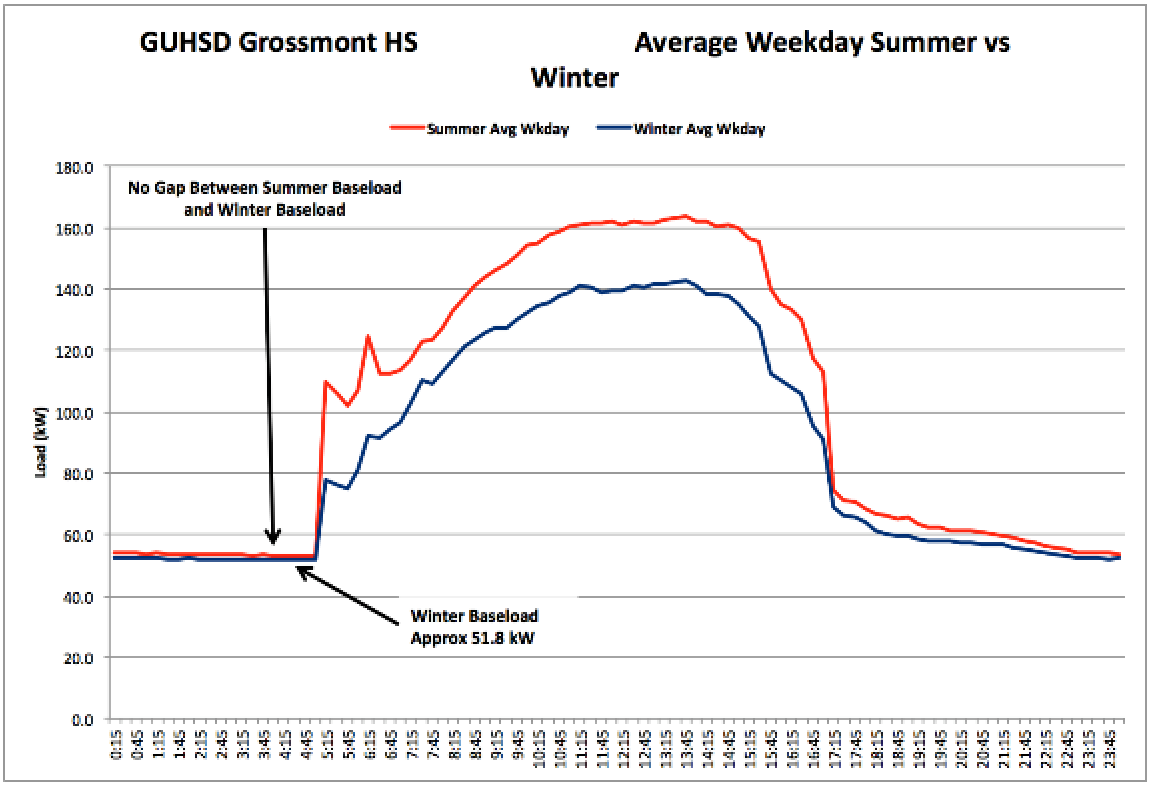


**Figure 20: GROSSMONT HS 1 - Average Weekday Summer vs. Winter**

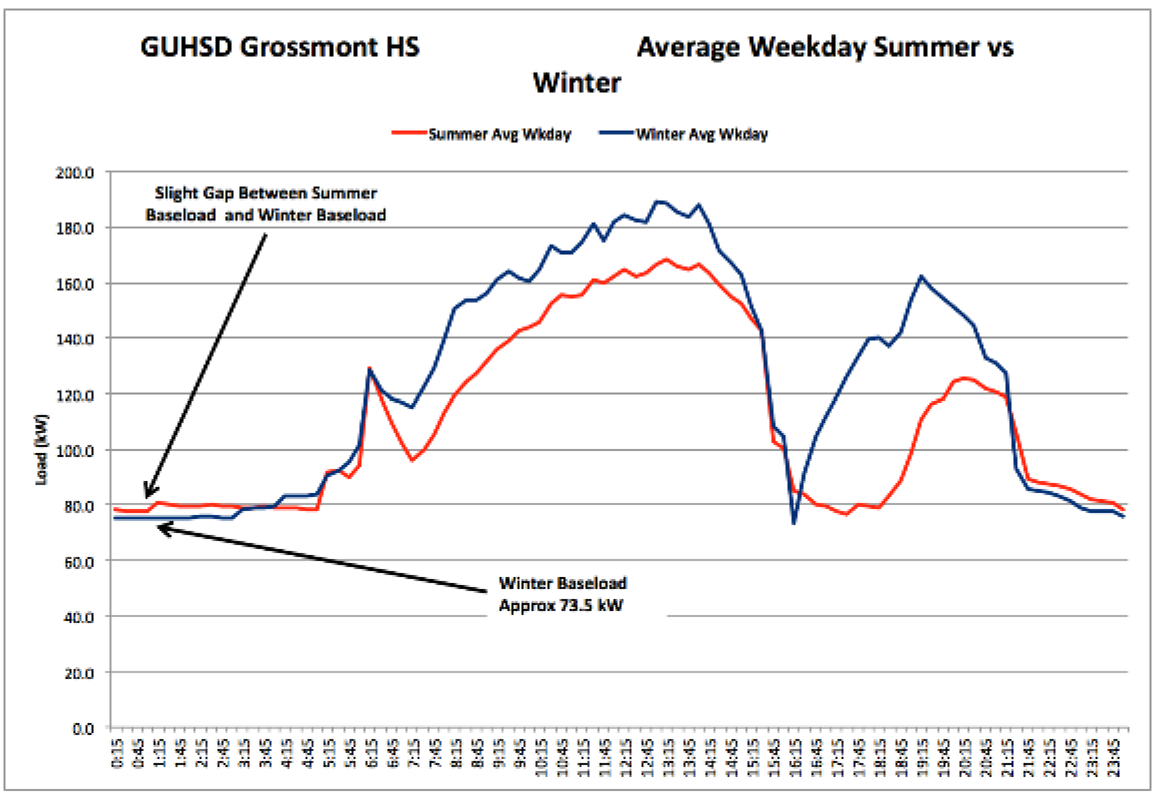


**Figure 21: GROSSMONT HS 2 - Average Weekday Summer vs. Winter**

## Mt. Miguel High School

### *Site Summary*

Mount Miguel High School is an 187,302 square foot high school serving over 1,500 students in Grossmont Union High School District. Buildings on campus include the 100, 200 (including the library), 300 and 700 (including a kitchen and band room) wings, buildings 500, 600 and 900, the gym and locker rooms, and an administration building.

The school operates on a traditional school calendar with the school year starting after Labor Day and ending in mid-June. Winter break is a two-week break at the end of December. Spring break is a one-week break in late March/April. School hours are 7:00am – 2:30pm Monday – Friday. In general the spaces are occupied approximately 9 hours per day 185 days per year with the exception being the gymnasium. The gymnasium is used very extended hours throughout the year with an hours of operation for lighting and other ventilation equipment in excess of 4,162 hours annually. The pool is constantly being filtered on a 24/7 basis following a sequence of operation for the pump speed to conform with the health code requirements of six hour turnover rates.

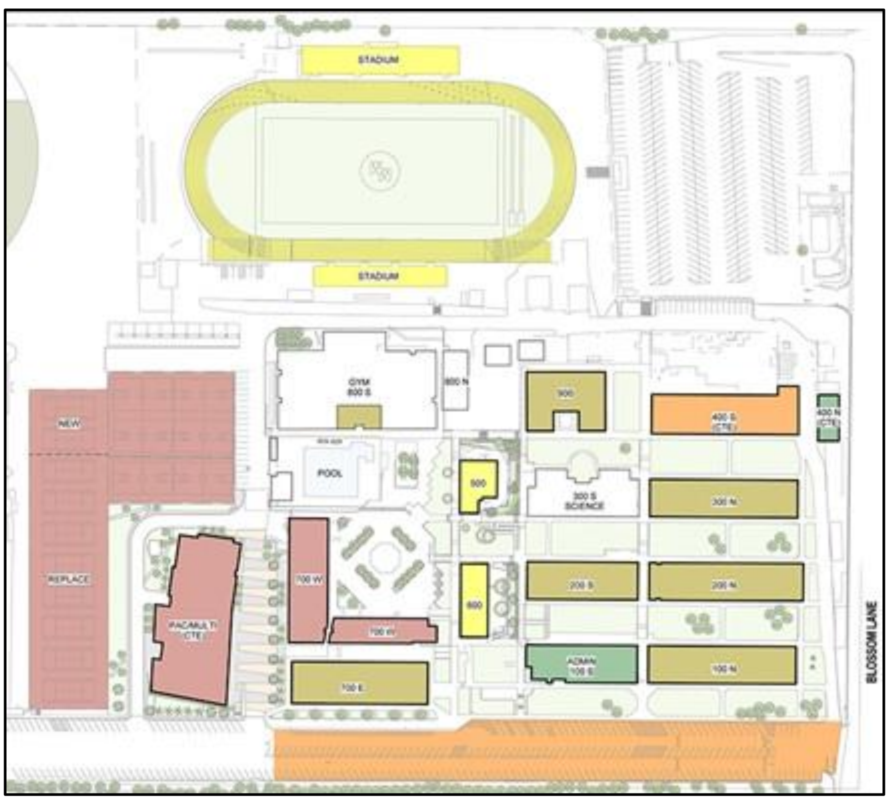


**Figure 22: School Layout**

***HVAC***

The campus has gone through an early construction followed by recent phases of modernization of the campus with most of the campus having newer HVAC for heating and cooling of the buildings. In buildings 100N, 100S, 200N, 200S, 300N, 300S, a portion of the 400 building, 500, 60, 700N, 700S and 900 are heated and cooled by single zone roof mounted packaged gas/electric units. Building 800 has no cooling with only limited heating. All HVAC units are controlled by an energy management system. The rooftop packaged units typical hours of operation are 9.5 hours per day 190 days per year for an annual hours of operation 1,800 hours per year.

***Lighting***

Indoor lighting at Mt. Miguel was recently upgraded to LED, with both 2’x4’ and 2’x2’ LED recessed troffer retrofit fixtures and LED tubes replacing the existing T8 lighting. Some T8 lighting remains in pendant and strip mount fixtures. The new LED troffer retrofits include onboard lighting controls to reduce runtime. Additionally, the high bay gym lighting has been replaced with Cree LED high bay fixtures.

Outdoor lighting at Mt. Miguel was also recently upgraded to LED, with fixtures ranging from mini-wall packs to canopy lighting to pole lighting and sconces using a variety of new LED fixtures and LED lamps.

***Other Energy Consuming Systems***

The site has numerous computer loads, with many left on- though it was the end of the school day when audited. The campus has a 25 yard pool with a circulation pump system equipped with controls to allow it to modulate to maintain the correct flow rate of six hour turnover whenever the swimming pool is occupied as directed by County Health Codes.

***Energy Storage System***

The Vendor installed a 250 kW / 500 kWh battery load shedding system in June of 2016.

***IES Sub-Metering***

IES’s role is to provide a third party verification of the amount of electricity used and shed by the school, as well as provide analysis of current (w/ ESS) vs historical electrical use.

***Sub-Metering System***

An IES metering system was installed in June of 2016 and is located at the electrical pad near the ESS unit. The system consists of an Obvius Aquisuite data gathering unit and Veris bi-directional power meter. The data gathering server communicates wirelessly with the power meter and is located in a nearby building network closet. The data is transferred to the IES servers to be monitored and stored. This system began receiving and recording data in July of 2016.

***Utility Baseline***

Mt. Miguel operates with one electric meter that the ESS is installed on. In FY 2015, electric consumption costs for this meter were $293,976 at an average rate of $0.23/kWh.

Figure 23 depicts interval data for an average weekday during both summer and winter months for this meter.

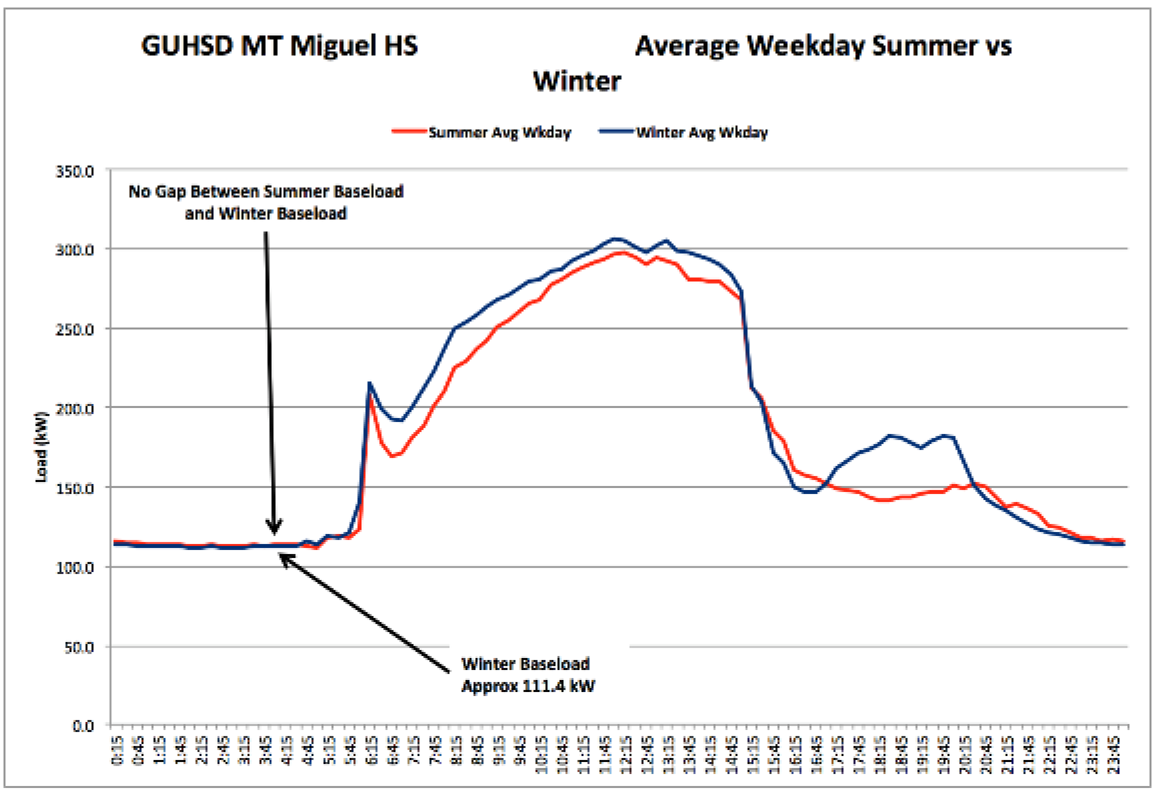


**Figure 23: Average Weekday Summer vs. Winter**

## Santana High School

### *Site Summary*

Santana High School is a 149,979 square foot high school serving over 1,500 students in Grossmont Union High School District. The site has classroom multiple wings, labeled: 100, 200, 300, 700 and 800. Buildings 400 and 500 are smaller, all-purpose areas, and building 600 is a media center and cafeteria. On site there is an admin building, a library, a gym, locker rooms, an auto shop, an auto body yard, and a large cement quad.

The school operates on a traditional school calendar with the school year staring after Labor Day and ending in mid-June. Winter break is a two-week break at the end of December. Spring break is a one week break in late March/April. School hours are 7:00am - 2:36pm Monday-Friday. In general the spaces are occupied approximately 9 hours per day 185 days per year with the exception being the gymnasium. The gymnasium is used very extended hours throughout the year with an hours of operation for lighting and other ventilation equipment in excess of 4,162 hours annually. The pool is constantly being filtered on a 24/7 basis following a sequence of operation for the pump speed to conform with the health code requirements of six hour turnover rates.

Figure 24 below shows the campus layout.


**Figure 24: School Layout**

### *HVAC*

HVAC at Santana High School has been recently modified from its original construction. In buildings 600 and in the gym, four pipe air handler units with hot and chilled water coils provide the heating and cooling for the spaces. The locker rooms are heating only. The controls for these spaces are pneumatic temperature controls and the schedule controlled by the Honeywell WEBs-AX energy management system.

The central plant for these buildings consists of an air cooled chiller mounted at the Southeast corner of the gym. The plants typical hours of operation are 9.5 hours per day 200 days per year for an annual hours of operation of 1,900 hours per year.

Buildings 100, 200, 300, 400, 500, 700, 800 and the science building are heated and cooled by single zone roof mounted packaged gas/electric units. The units are relatively new with average efficiency ratings of approximately 13 SEER. The units are controlled by the Honeywell WEBSs-AX energy management system. The rooftop packaged units typical hours of operation are 9.5 hours per day 190 days per year for an annual hours of operation of 1,800 hours per year.

The site's HVAC is made up of a chilled water system in the gym, as well as a heating plant serving the locker rooms. Window AC units serve areas throughout. Rooftop package units are located on the administration building. The 1600 building g is served by four air-handling units, and the 600 building features a multi-zone unit.

### *Lighting*

Indoor lighting at Santana was recently upgraded to LED, with both 2'x4' and 2'x2' LED recessed troffer retrofit fixtures and LED tubes replacing the existing T8 lighting. Some T8 lighting remains in pendant and strip mount fixtures. The new LED troffer retrofits include onboard lighting controls to reduce runtime. Additionally, the high bay gym lighting has been replaced with Cree LED high bay fixtures.

Outdoor lighting at Santana includes a wide variety of lighting and has not been converted to LED. High pressure sodium lights are present in pole mounted fixtures. 250 watt metal halide pole mounted fixtures are also present, in addition to 100 watt metal halide wall packs. CFL wall packs are also used. 60 watt incandescent fixtures are found in downlights and jelly jars around campus.

### *Other Systems*

The site has numerous computer loads, with many left on- though it was the end of the school day when we audited.  There were two vending machines or glass faced coolers throughout the campus that were accounted for. The campus has a 25 yard pool with a circulation pump equipped with controls to allow it to modulate to maintain the correct flow rate.

***Energy Storage System***

The Vendor installed two (2) 250 kW / 500 kWh battery load shedding systems in July of 2016.

***IES Sub-Metering***

IES's role is to provide a third party verification of the amount of electricity used and shed by the school, as well as provide analysis of current (w/ ESS) vs historical electrical use.

***Sub-Metering System***

Two (2) IES metering systems were installed in July of 2016 and are located within the North and South electrical block houses respectively.  Each system consists of an Obvius Aquisuite data gathering unit and Veris bi-directional power meter. The data gathering servers communicate via cellular modem. The data is transferred to the IES servers to be monitored and stored. These systems began receiving and recording data in July of 2016.

***Utility Baseline***

IES looked at two meters at Santana HS, of which there is an ESS is installed on both.  In FY 2015, electric consumption costs for these meters was $161,274 at an average rate of $0.26/kWh.

Figures 25 and 26 depict interval data for an average weekday during both summer and winter months for the two meters.

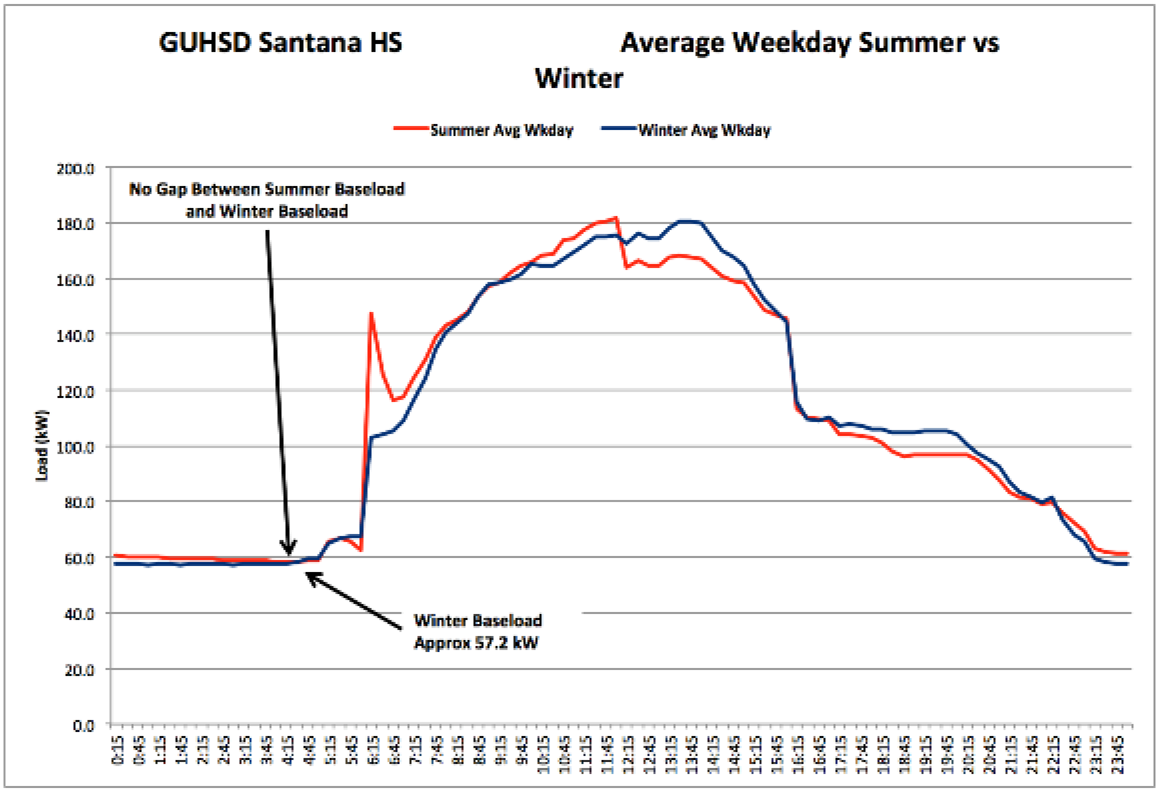


Figure 25: SANTANA HS 1 - Average Weekday Summer vs. Winter

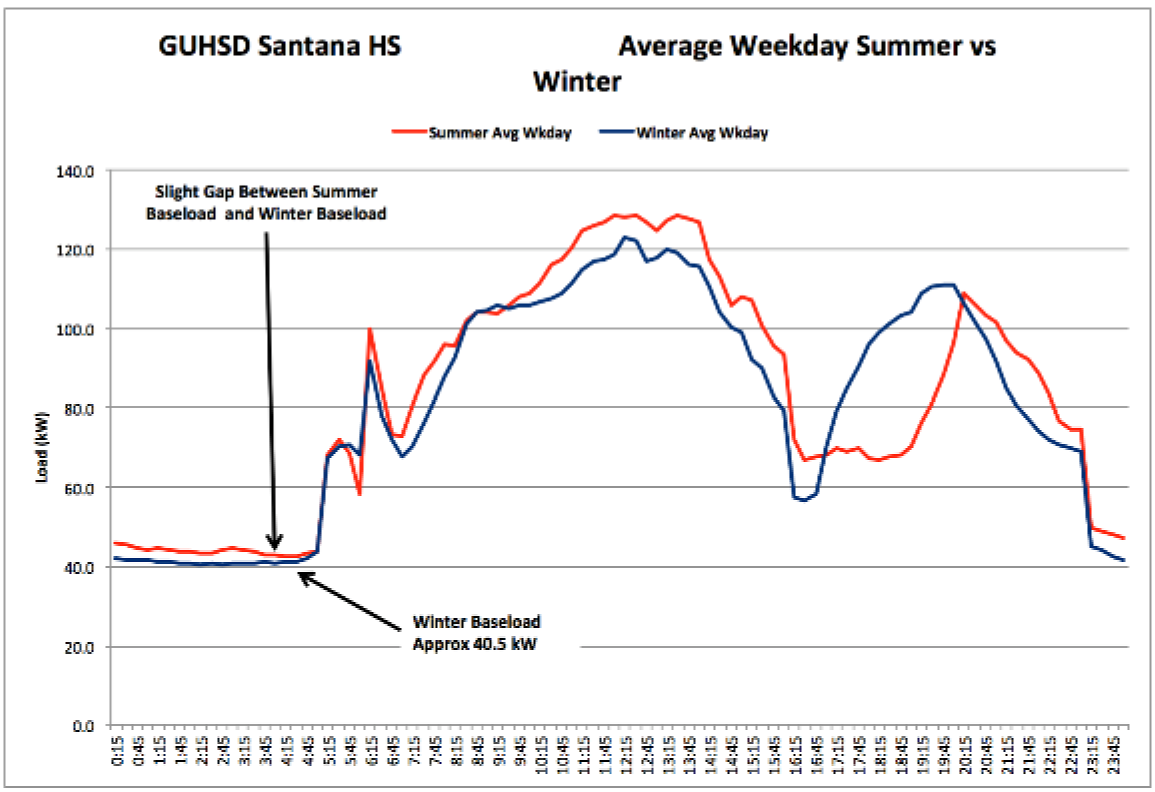


Figure 26: SANTANA HS 2 - Average Weekday Summer vs. Winter

## Poway Unified School District

### Black Mountain Middle School

#### *Site Summary*

Black Mountain is a 93,000 square foot middle school serving students in San Diego, CA. as part of the Poway Unified School District. The school features several single story buildings a library, computer lab, administrative offices, classrooms and other structures. There is a county-owned gymnasium/ theatre attached at the north end of campus.

#### *HVAC*

The site has a central plant on the west side of the school feeding several constant speed/ constant volume UMP air handling units throughout the campus. Newer modular classrooms use new rooftop package units, along with the new classroom buildings at the southern portion of campus for a total 347 tons. Automated Logic thermostats control these units. A large Ajax boiler was also present that supplies heating hot water to all the classrooms conditioned by the UMP's.

#### *Lighting*

Lighting at the school consists of 32w T8 linear fluorescent lamps with electronic ballast. Offices and classrooms utilize a three lamp variety, while the hallways use a two-lamp fixture. Assorted rooms have solar tubes.

Exterior fixtures include twenty-two parking lot pole lamps (250w LPS), 100w metal halide poles, 100w metal halide wall packs, 50w metal halide wall boxes, and six 150w metal halide fixtures in the lunch trap area.

#### *Other Systems*

There are miscellaneous loads throughout the buildings. The site has numerous computers in the computer labs which were in standby. Windows were observed to be double pane. A vending machine is in the lunch trap that is uncontrolled.

#### *Energy Storage System*

The Vendor installed a 250 kW / 500 kWh battery load shedding system located at the far west side of the school's property in June of 2016.

#### *IES Sub Metering*

IES's role is to provide a third party verification of the amount of electricity used and shed by the school. As well as analysis of current (w/ ESS) vs historical electrical use.

### *Sub-Metering System*

An IES metering system was installed in June of 2016 and is located within the main electrical distribution enclosure. The system consists of an Obvius Aquisuite data gathering unit and Veris bi-directional power meter. The data gathering server communicates wirelessly with the power meter and is located in the adjacent custodial office / storage room. The data is transferred to the IES servers to be monitored and stored. This system began receiving and recording data in December of 2016.

### *Utility Baseline*

IES looked at two meters at Black Mountain MS, of which the ESS is installed on one.

Figures 27 and 28 depict interval data for an average weekday during both summer and winter months for the two meters.

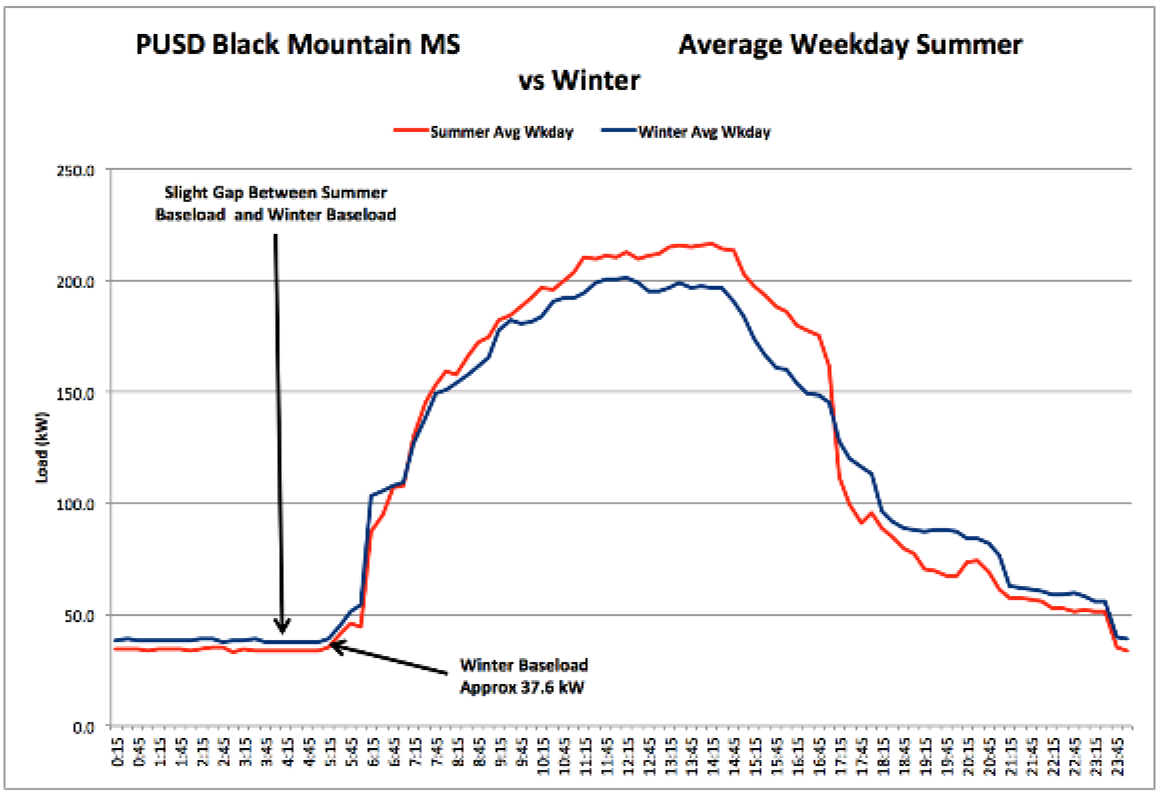


**Figure 27: BLACK MOUNTAIN MS 1 - Average Weekday Summer vs. Winter**

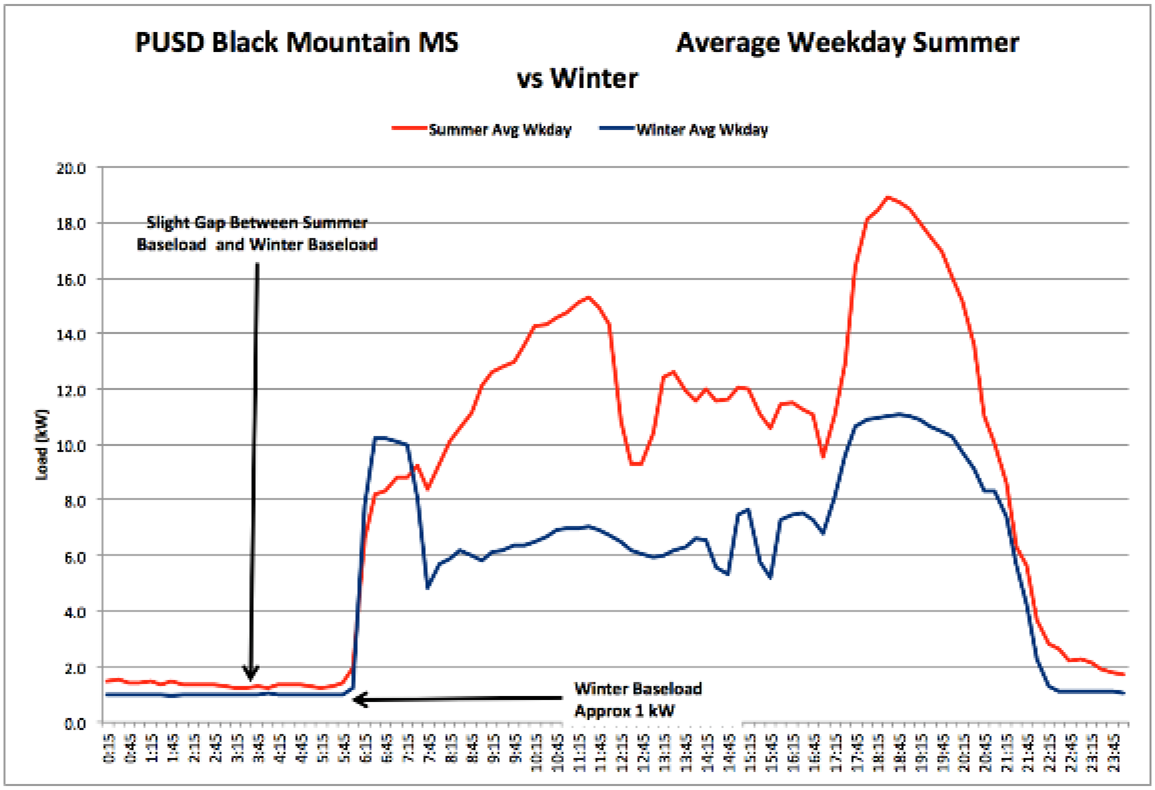


**Figure 28: BLACK MOUNTAIN MS 2 - Average Weekday Summer vs. Winter**

## Del Norte High School

### *Site Summary*

Del Norte High School is a 204,159 square foot High School serving students in Poway Unified School District. Multiple buildings are arranged in a circular formation, including many performing arts buildings (music, theatre, etc.), a gym, an aquatic center featuring pool, a library (second floor of administration building), three snack shacks, multiple admin offices and of course classrooms. Steel structures holding metal seam roofs cover many of the exterior walkways between the buildings.

Figure 29 below shows an overall layout of the campus.


**Figure 29: School Layout**

***HVAC***

Del Norte High School is primarily cooled and heated by a central chiller/ boiler plant. The central plant consists of a pre-fabricated enclosure with chiller and pumps. The chilled water system consists of two Carrier 350-ton centrifugal chillers equipped with VFD's to optimize the low cooling load performance.

On the airside the needs of the school are met with UMP air handlers and fan coil units. The UMP fan coils (8.5 tons or less) are located throughout the majority of the buildings with the Buildings or Zones A2, A3, M and N supplied by either slightly larger FCU's and/or VAV air handlers.

In addition to the VAV air handlers being equipped with VFD's, each of the FCU's has a VFD that is used for the purpose of balancing the system as can be seen on the front of the FCU pictured above.

Additional HVAC on the campus includes the six heat pumps listed in the above table that serve small zones that are either used sparingly or for off hour operation. The

HVAC equipment and all parameters (temperatures, scheduling, central plant sequence of operation, etc. are controlled by a full DDC Alerton control system.

***Lighting***

Lighting is primarily 4 foot T8 32 one 800 series linear fluorescent lamps in the classrooms. The majority of the fluorescent lighting throughout the campus is controlled by occupancy sensors. The Gymnasium is illuminated by 400-watt metal halide high bays. Lighting in the theater is from a combination of halogen lighting fixtures. Additional lighting on the perimeter of the building is provided by compact fluorescent down lights. The halogens are all controlled by a dimming control system. Throughout the interior of the campus are both MR16 halogens and compact fluorescents.

Exterior lights consist primarily of high pressure sodium (HPS) fixtures of all types, including flood lights, down lights, hallway wall packs, and pole lighting throughout the campus and parking lots. All exterior lighting appeared to be controlled by a combination photocell and time clock.

***Other Systems***

There are miscellaneous loads throughout the buildings. The site has numerous computers that are controlled to shut off via a central server. There is a full production kitchen on site with walk-in coolers and freezers in additional to numerous other reach-in coolers and freezers and other commercial cooking equipment. As with the time of construction of the facility the windows and insulation all meet current building codes such as double pane windows.

***Energy Storage System***

The Vendor installed one (1) 60 kW / 120 kWh ESS and one (1) 500 kW / 1000 kWh system. Both systems were installed in July of 2016.

***IES Sub Metering***

IES's role is to provide a third party verification of the amount of electricity used and shed by the school. As well as analysis of current (w/ ESS) vs historical electrical use.

***Sub-Metering System***

Two (2) IES metering systems were installed in July of 2016 and are located at the electrical service enclosures nearest the kitchen loading dock and the performing arts building respectively. Each system consists of an Obvius Aquisuite data gathering unit and Veris bi-directional power meter. The data gathering servers communicate via cellular modem. The data is transferred to the IES servers to be monitored and stored. These systems began receiving and recording data in September of 2016.

***Utility Baseline***

IES looked at two meters at Del Norte, of which an ESS is installed on both. In FY 2015, electric consumption costs for these meters was $545,222 at an average rate of $0.25/kWh.

The following charts depicts interval data for an average weekday during both summer and winter months for the two meters.

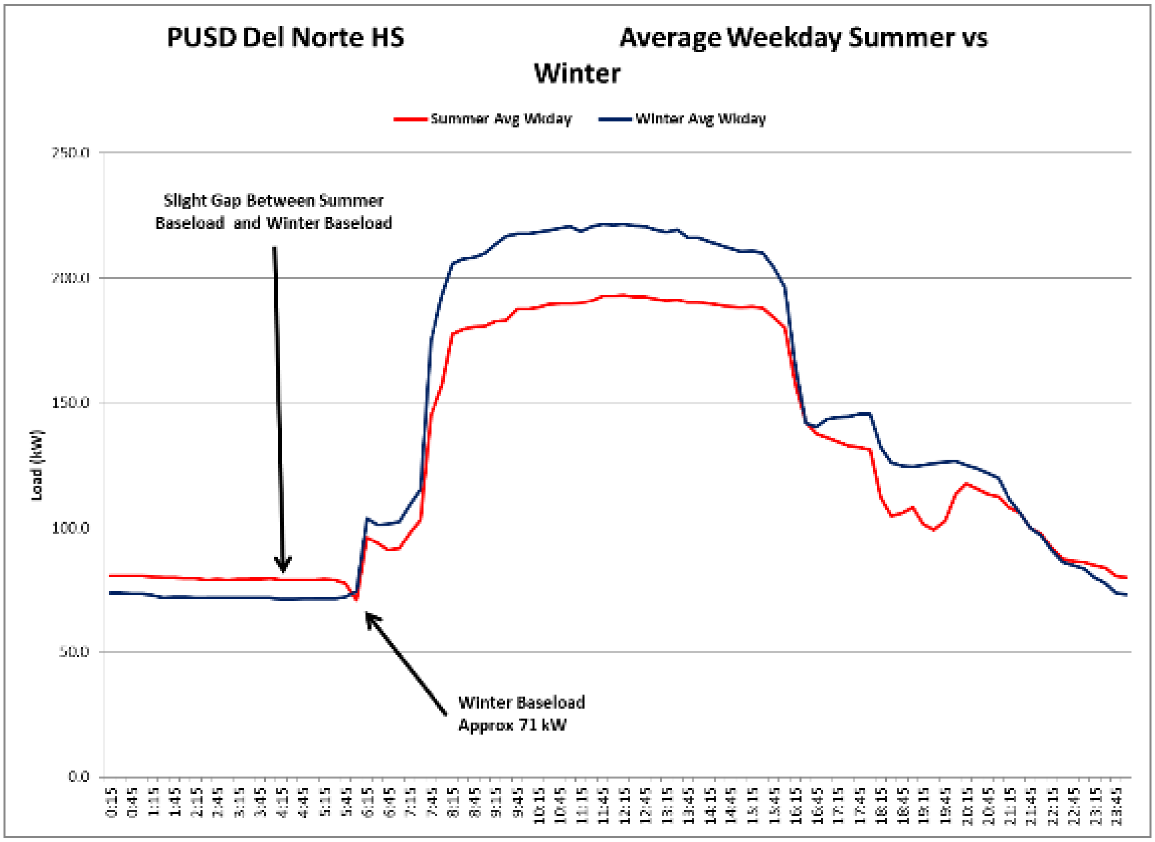


**Figure 30: DEL NORTE HS 1 - Average Weekday Summer vs. Winter**

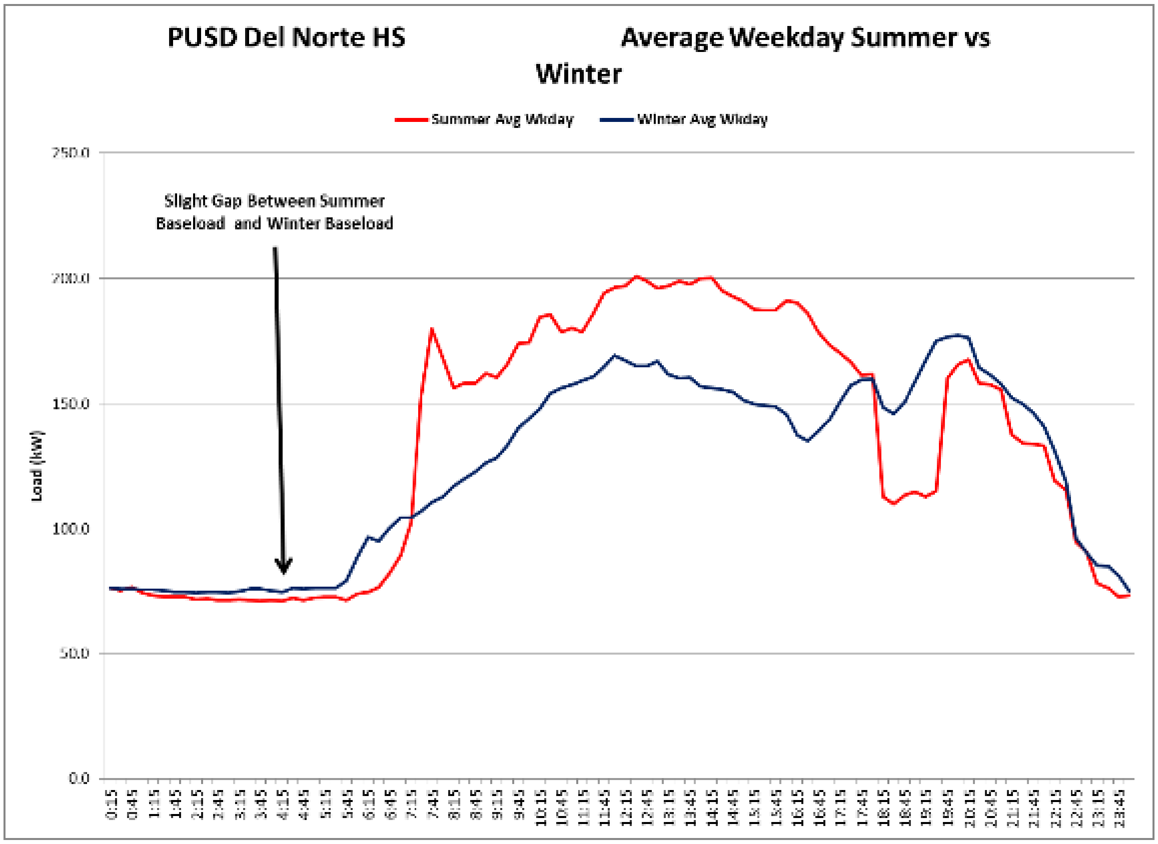


**Figure 31: DEL NORTE HS 2 - Average Weekday Summer vs. Winter**

## Del Sur Elementary School

***Site Summary***

Del Sur is a two story Elementary School in Poway Unified School District. This modern construction features a unique indoor layout for a southern California elementary school. The two-story building holds the majority of the classrooms, with a kindergarten wing in the back of the school near the lobby.

Figure 32 below shows the overall layout of the school.

**Figure 32: School Layout**

***HVAC***

The HVAC is provided by a ChilPak pre-packaged central plant which consists of two Smardt centrifugal chillers each with two Turbocor TT-300 60-ton oil free/ magnetic bearing centrifugal compressors. The associated cooling tower consists of one EVAPCO single cell tower with a 25 hp tower fan equipped with a variable frequency drive. Additional cooling is a small Carrier split system thought to be cooling a small data room.

The air side consists of a combination of air handlers and fan coil units manufactured from United Metal Products (UMP). The typical unit that serves the classrooms is a UMP model #CAH-IDM-4, which is a 5 ton unit with a 1.5 hp supply fan. The central plant and air handler equipment is all controlled by a full DDC Alerton control system. The central plant is enabled Mon to Fri from 6:30 am to 5:45 pm and on Sat from 8:30 am until 3:00 pm. The classrooms are scheduled to be enabled Mon to Fri at either 6:00 am or 6:30 am depending on which grouping of rooms and all disabled at 5:45 pm. The MPR is enabled Mon to Fri from 6:30 am to 5:45 pm and on Sat from 8:00 am to 2:30 pm. The ESS and Preschool is enabled Mon to Fri from 5:30 am to 5:45 pm.

***Lighting***

Interior classroom and other select area lighting consists of linear fluorescent T8 lamps and fixtures. The upstairs have natural light from Solatube skylights. The MPR is illuminated primarily by 500-watt Halogens that according to the lead custodian are enabled approximately 12 hours per day. Watt Stopper relay panels enable/disable the classroom in addition to the corridors and stairwells. According to facility staff the system enables the lighting from roughly dawn to dusk and later.

The exterior lighting consists of 250-watt HPS for the parking lots on 40-foot poles with shorter poles containing 100-watt HPS lamps. From interval data analysis it is evident that the exterior lighting ran throughout the night (dusk to dawn) at some times throughout the year and was disabled at other parts of the year. The controls for the lighting consist of a combination photocell and time clock. Additional exterior lighting is both 18-watt and 26-watt compact fluorescents in a double and single lamp respectively.

***Other Systems***

There are miscellaneous loads throughout the buildings. The site has numerous computers. The kitchen has a walk-in cooler with 3 evaporator fans rated at 115 volt and 2 amps. Standard commercial kitchen equipment such as coolers, reach-in freezers and cooking equipment are throughout the kitchen. Windows were observed to be double pane. A solar PV system on the south facing portion of the roof was sized at about 50 kW from the inverter and the number of panels would be offsetting approximately 100,000 kWh annually.

***Energy Storage System***

The Vendor installed a 250 kW / 500 kWh battery load shedding system located at the far west side of the school’s property in December of 2016.

***Utility Baseline***

Del Sur operates with one electric meter that the ESS is installed on. In FY 2015, electric consumption costs for this meter were $203,087 at an average rate of $0.29/kWh.

Figure 33 depicts interval data for an average weekday during both summer and winter months for this meter.

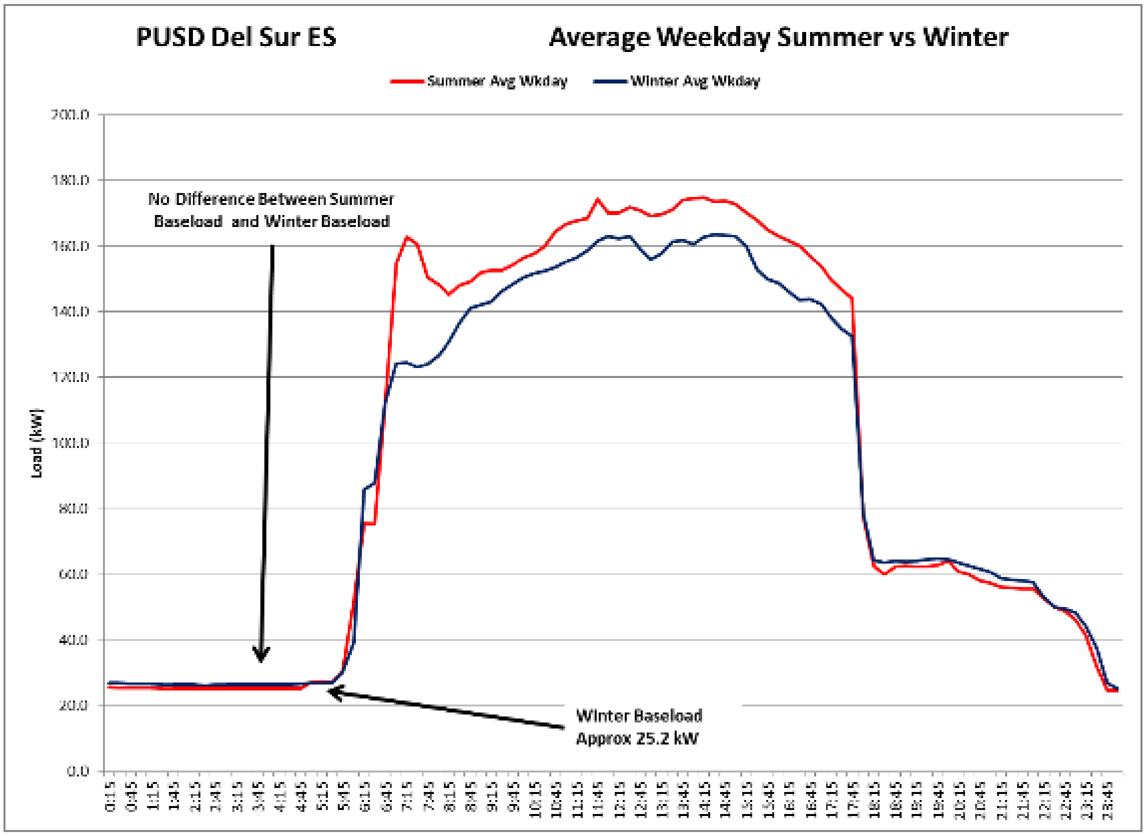


**Figure 33: Average Weekday Summer vs. Winter**

## PUSD District Office

### *Site Summary*

Poway Unified School District Office is approximately 125,000 square foot facility serving Poway Unified Schools located in North San Diego County, CA. The District Office houses many of the districts resource teams. The District Office consist of a single 2 story building featuring training rooms, conference rooms and office space.

### *HVAC*

The site is conditioned by approximately 30 single zone roof top package units and 3 multi zone ground mount units.

### *Lighting*

Interior lighting at the District office consists of 32w T8 linear fluorescent lamps with electronic ballast in a recessed 2'x4' fixture as well as a variety of surface mount compact fluorescent fixtures. Exterior fixtures include parking lot pole lamps and building surface mount compact fluorescent fixtures.

### *Energy Storage System*

The Vendor installed a 250 kW / 500 kWh battery load shedding system located at the north side of the District office in December of 2016.

***IES Sub Metering***
IES's role is to provide a third party verification of the amount of electricity used and shed by the school, as well as analysis of current (w/ ESS) vs historical electrical use.

***Sub-Metering System***
An IES metering system was installed in June of 2016 and is located within the main electrical distribution enclosure. The system consists of an Obvius Aquisuite data gathering unit and Veris bi-directional power meter. The data is transferred to the IES servers to be monitored and stored. This system began receiving and recording data in January of 2017.

***Utility Baseline***
IES looked at one meter at the District Office, on which the ESS is installed.

Figure 34 depicts interval data for an average weekday during both summer and winter months for the meter.

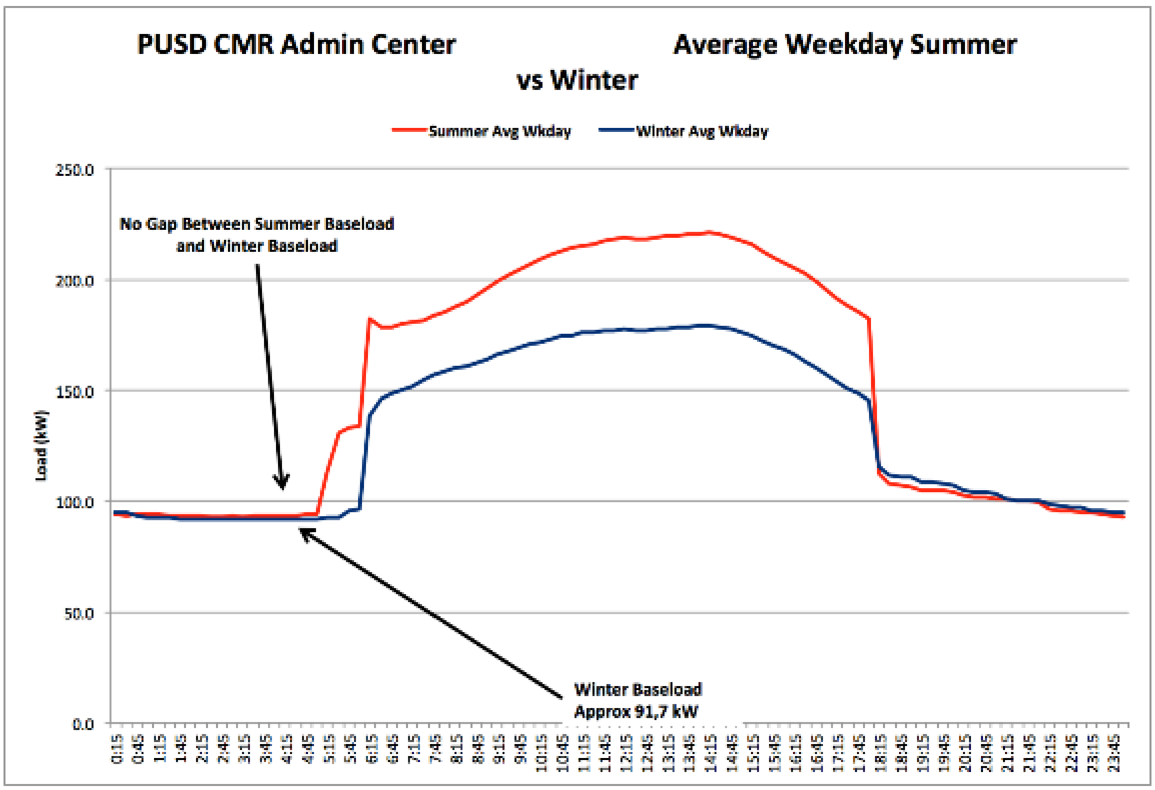


**Figure 34: Average Weekday Summer vs. Winter**

## Garden Road Elementary School

### *Site Summary*

Garden Road is an elementary school in Poway Unified School District. There is an administration space, multipurpose room with small kitchen and stage area, one portable and one ESS building. Permanent classrooms are laid out in different branching wings. The Library houses the LRC with computers.

Figure 35 below shows the overall layout of the campus.

**Figure 35: School Layout**

### *HVAC*

Classrooms are conditioned by Trane package units from 1997. Coils on these units are in poor shape. Two split units by Trane and Fujitsu (one for server room, one for communications room) were found on rooftops. Alerton thermostats are in use throughout the campus. Bard heat pump units are used for the ESS portable building.

### *Lighting*

Interior lights are 841 series 32 watt T8 in offices, the MPR, LRC and classrooms. Corner mounted occupancy sensors were in use.
Exterior wall packs include CFLs and HPS lamps. Parking lot lighting is low pressure sodium (LPS). Exterior lights are on time clock, from 4:45 pm to 11:45 pm and from 5:00 am to 7:00 am.

### *Other Systems*

Computers in LRC may shut off, staff not sure. There was no solar onsite. A small kitchen was found with no walk-ins.

***Energy Storage System***

The Vendor installed a 60 kW / 120 kWh battery load shedding system on one of the site's meters in January of 2017.

***IES Sub Metering***

IES's role is to provide a third party verification of the amount of electricity used and shed by the school, as well as analysis of current (w/ ESS) vs historical electrical use.

***Sub-Metering System***

An IES metering system was installed in July of 2016 and is located at the south side of Building D at the main electrical distribution enclosure. The system consists of an Obvius Aquisuite data gathering unit and Veris bi-directional power meter. The data gathering server communicates via cellular modem. The data is transferred to the IES servers to be monitored and stored.

***Utility Baseline***

IES looked at two meters at Garden Road, of which the ESS is installed on one. In FY 2015, electric consumption costs for this meter were $87,931 at an average rate of $0.26/kWh.

Figures 36 and 37 depict interval data for an average weekday during both summer and winter months for the meters.

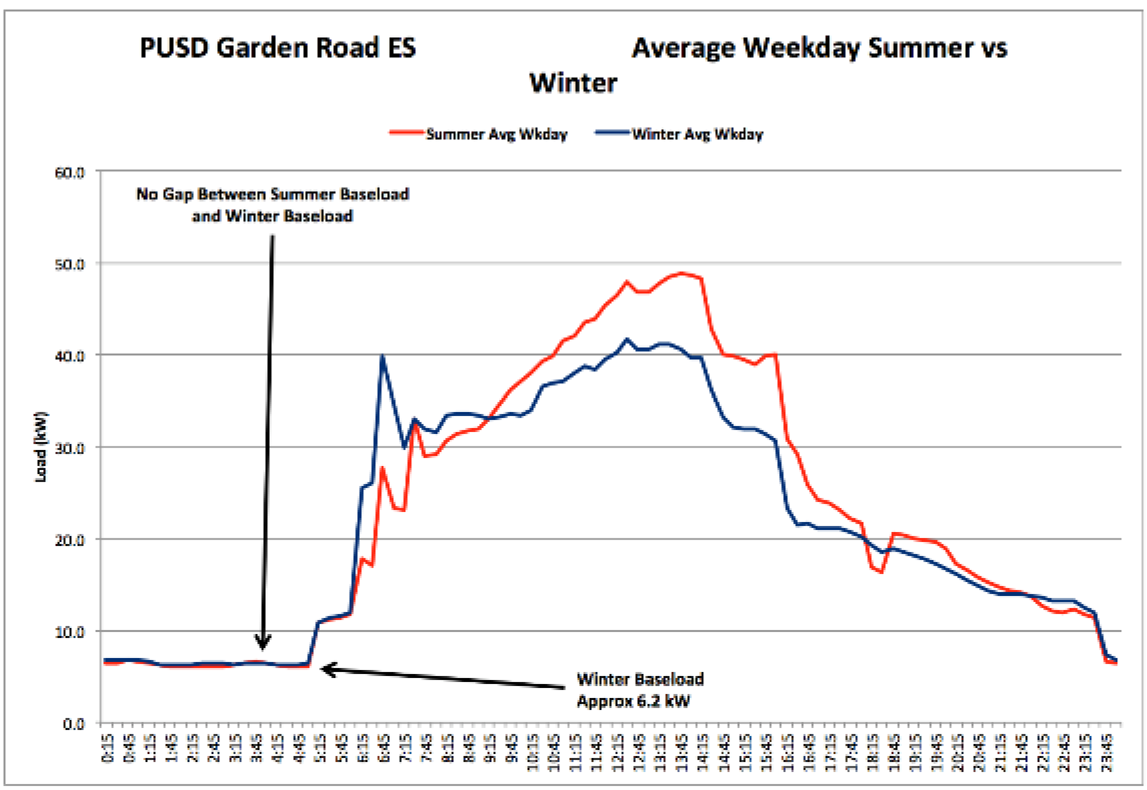


**Figure 36: GARDEN ROAD ES 1 - Average Weekday Summer vs. Winter**

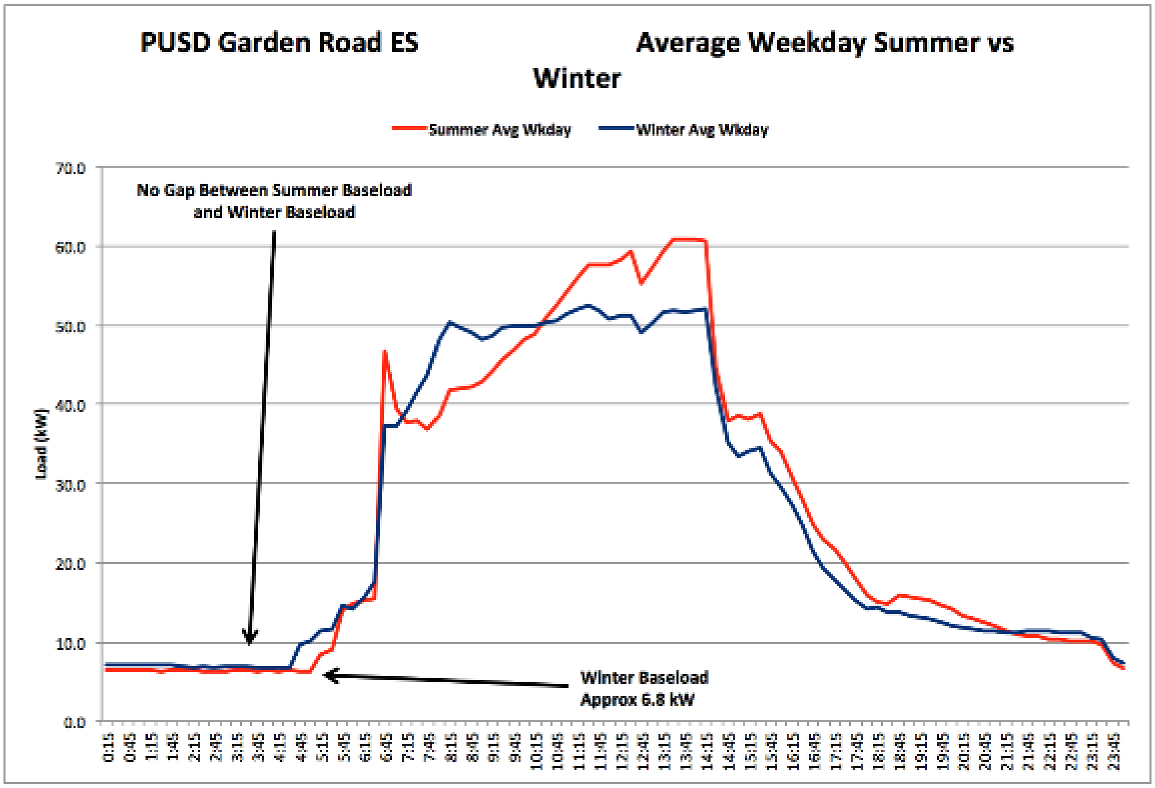


**Figure 37: GARDEN ROAD ES 2 - Average Weekday Summer vs. Winter**

## Highland Ranch Elementary School

### *Site Summary*

Highland Ranch is a 44,626 square foot Elementary School serving students in Poway Unified School District. Permanent classrooms and offices surround a central resources room, and a newer two story MPR is on the north edge of the campus.

Figure 38 shows a general overview of the school.

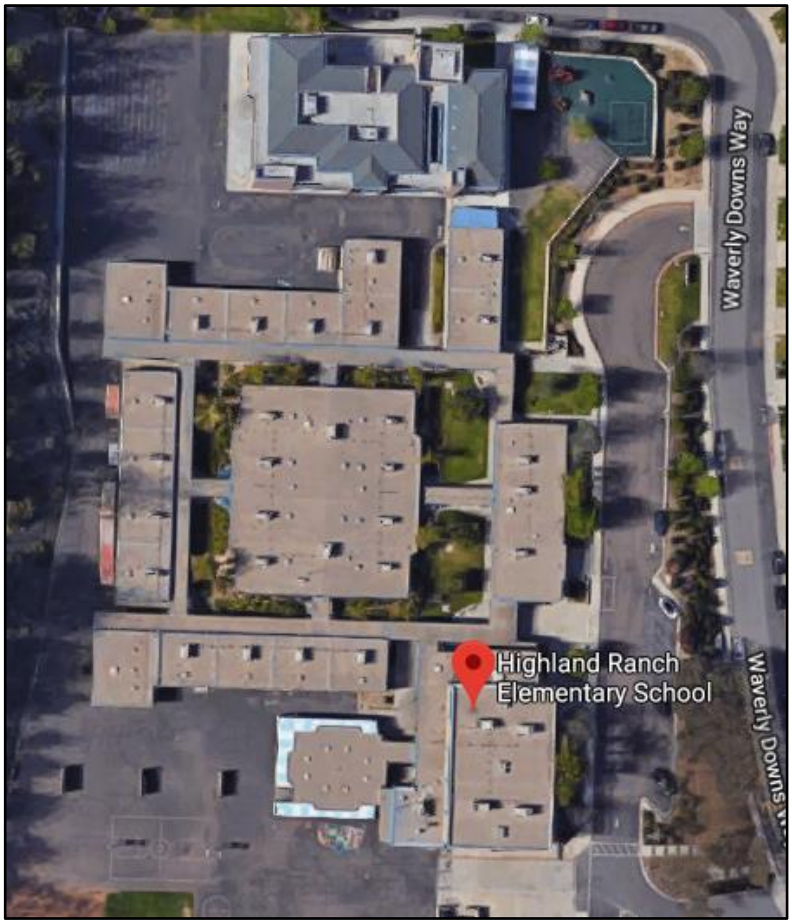


**Figure 38: Site Overview**

### *HVAC*

Lennox and Trane package units are in use throughout most of the campus, serving all classrooms. An EMI split system serves the campus' data center. Alerton thermostats control these units. The portables on campus feature wall mount heat pump units controlled by thermostats and twist timers.

***Lighting***

Lighting at the school is made up of 28-watt T8 fluorescent fixtures. Occupancy sensors control these fixtures in classrooms. The MPR features T5 High Output fixtures.

Mostly 13-watt and 18-watt one-lamp compact fluorescent (CFL) fixtures. 100-watt metal halide fixtures were observed around the campus. 150-watt, 100-watt and 70-watt high-pressure sodium (HPS) fixtures are used in parking, security and wall pack fixtures, respectively.

***Other Systems***

There are miscellaneous loads throughout the buildings.  The site has numerous computers that are controlled to shut off via a central server. A small kitchen features a normal sized reach-in refrigerator.

***Energy Storage System***

The Vendor installed a 250 kW / 500 kWh battery load shedding system on one of the sites meters in March of 2017.

***IES Sub Metering***

IES's role is to provide a third party verification of the amount of electricity used and shed by the school, as well as analysis of current (w/ ESS) vs historical electrical use.

***Sub-Metering System***

An IES metering system was installed in January of 2017 and is located at the east side of the campus, near the main electrical distribution enclosure. The system consists of an Obvius Aquisuite data gathering unit and Veris bi-directional power meter. The data gathering server communicates via cellular modem. The data is transferred to the IES servers to be monitored and stored. This system began receiving and recording data in January of 2017.

***Utility Baseline***

IES looked at two meters at Highland Ranch, on which the ESS is installed on one. In FY 2015, electric consumption costs for this meter were $79,358 at an average rate of $0.20/kWh.

Figures 39 and 40 depict interval data for an average weekday during both summer and winter months for the meters.

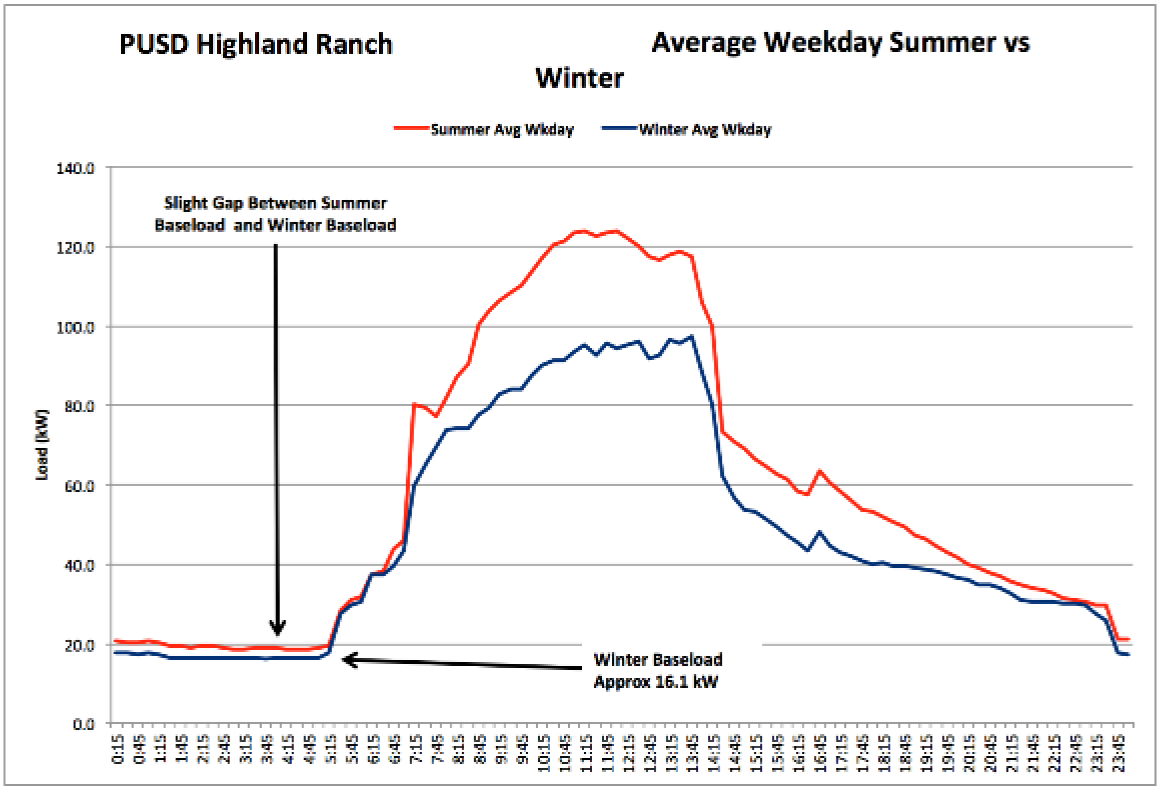


Figure 39: HIGHLAND RANCH ES 1 - Average Weekday Summer vs. Winter

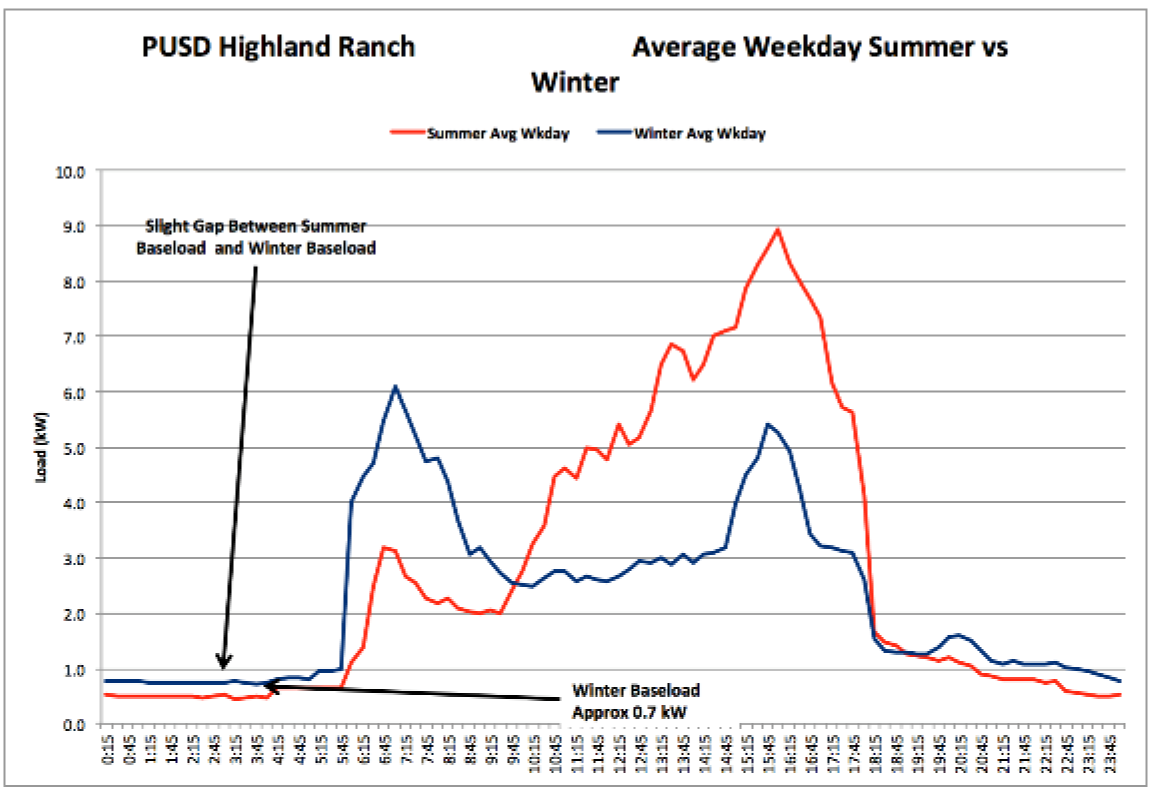


Figure 40: HIGHLAND RANCH ES 2 - Average Weekday Summer vs. Winter

## Mesa Verde Middle School

### *Site Summary*

Mesa Verde Middle School serves students in Poway Unified School District. It is a sprawling Campus featuring multiple classroom pods, loosely connected by exterior hallways. The Campus features a music and performance room, large gym, science rooms, computer labs and administrative offices.

Figure 41 below shows the overall layout of the campus.


**Figure 41: Site Overview**

### *HVAC*

The site has two central plants consisting of a 125-ton chiller in one and a 175-ton air-cooled chiller in the second. Each plant has a single Rite heating hot water boiler. The central plants are not cross connected, therefore each plant has to run to supply their specific loads. Carrier packaged units are used for various locations on Campus.

***Lighting***

Lighting at the school is made up of 28-watt T8 fluorescent fixtures, though some T12 fixtures were spotted around campus. Occupancy sensors control fixtures in most classrooms. High Bay T5 fixtures are used in the gymnasium.

Exterior lights are mostly 13-watt, 18-watt and 32-watt one- and two-lamp compact fluorescent (CFL). All exterior lighting appeared to be controlled by a combination photocell and time clock. Ground mount 100-watt metal halide fixtures were observed in the campus center with 150-watt high pressure sodium (HPS) pole lamps used in the parking lot.

***Other Systems***

There are miscellaneous loads throughout the buildings. The site has numerous computers that are controlled to shut off via a central server. Walk-in refrigerators were found in the Kitchen. Windows were observed to be double pane.

***Energy Storage System***

The Vendor installed a 250 kW / 500 kWh battery load shedding system on one of the sites meters in December of 2016.

***Utility Baseline***

Mesa Verde operates with one electric meter that the ESS is installed on. In FY 2015, electric consumption costs for this meter were $166,653 at an average rate of $0.17/kWh.

Figure 42 depicts interval data for an average weekday during both summer and winter months for this meter.

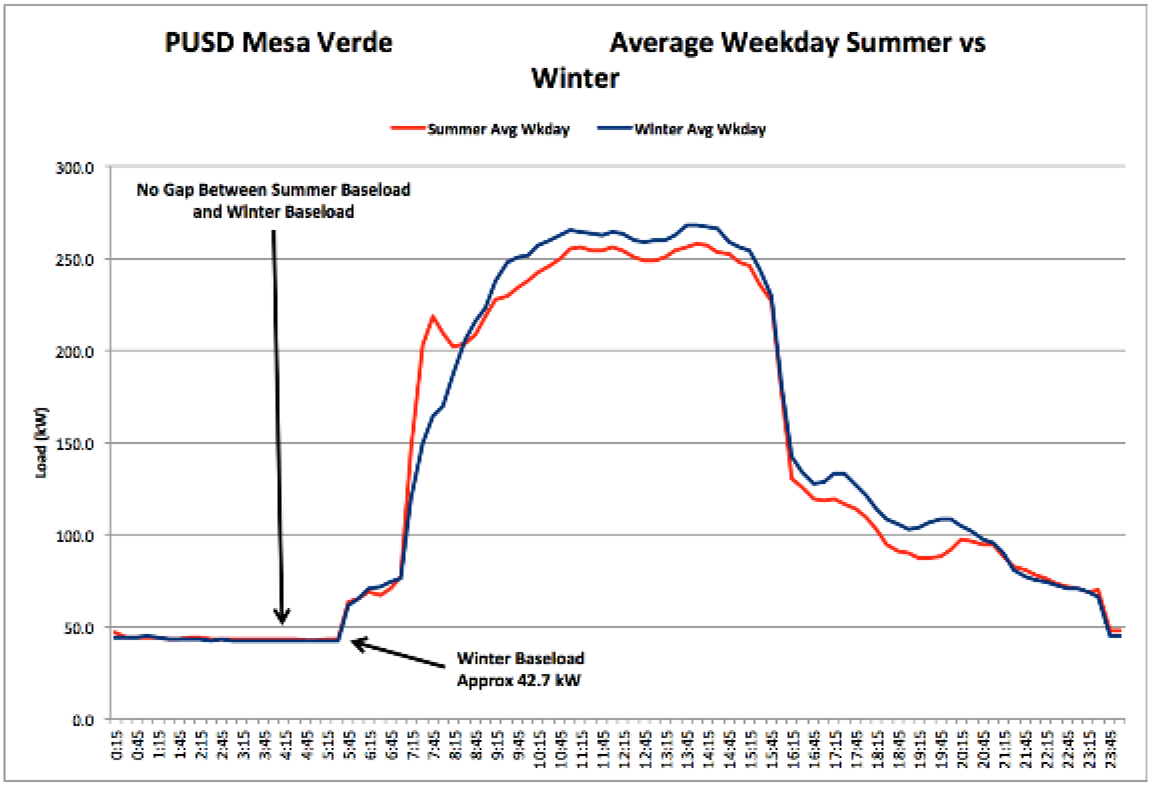


**Figure 42: Average Weekday Summer vs. Winter**

## Midland Elementary School

***Site Summary***

Midland Elementary is the oldest school in the Poway Unified School District with original construction in 1925. The campus was completely rebuilt in 2006. It features multiple buildings, including two story buildings, featuring offices, a library, multipurpose room, computer labs, and classrooms.

Figure 43 below shows the overall layout of the school.

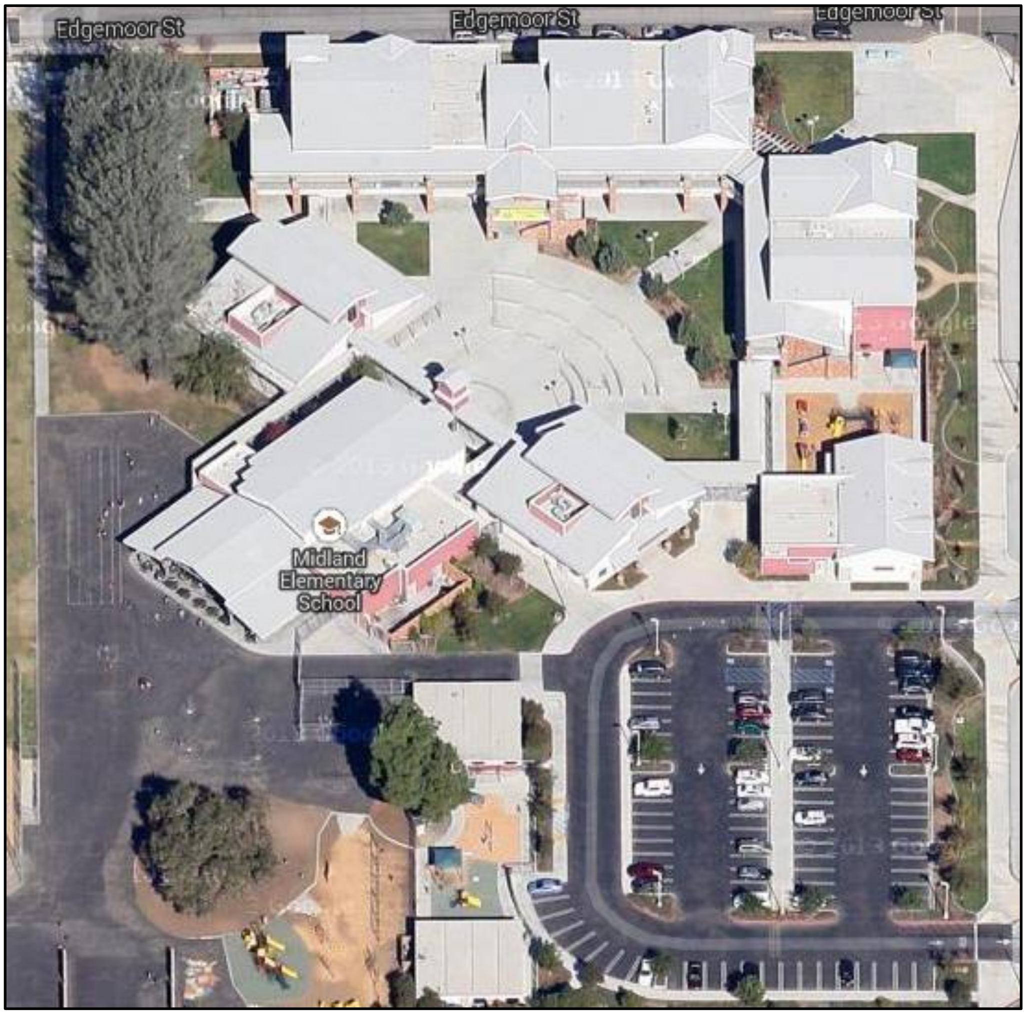


**Figure 43: School Layout**

***HVAC***

The site has a central plant which runs from 4:00am to 4:00pm according to EMS schedules. Two Trane 70-ton (model #RTAA070A) air cooled chillers provide the cooling to the portion of the campus (wings D, E & F) that are cooled by the central plant. The remaining portion of the campus (Admin, MPR and Library) are conditioned by Trane rooftop Packaged units that range in size from 4 to 17.5 tons each. The portable classroom are conditioned by wall mount 3.5 ton heat pump units.

***Lighting***

Interior lighting is served by 32-watt T8 linear fluorescents, primarily in a three-lamp configuration. The library uses one- and two-lamp CFL fixtures, as well as metal halide (MH) up-lights. The MPR is illuminated by a fluorescent T5 high output lighting system. Much of the lighting on campus is controlled by occupancy sensors.

Exterior lighting at the site is served by metal halide poles throughout the campus courtyard. Wall pack and canned compact fluorescent (CFL) are in use throughout the exterior hallways. The lunch trap also utilizes a high-pressure sodium (HPS) up-lamp fixture.

***Other Systems***

There are miscellaneous loads throughout the buildings. The site has numerous computers loads, with computers being enabled at approximately 6:00 am according to District IT staff. A small kitchen features typical commercial cooking equipment.

***Energy Storage System***

The Vendor installed a 250 kW / 500 kWh battery load shedding system on one of the sites meters in October of 2016.

***Utility Baseline***

Midland operates with one electric meter that the ESS is installed on. In FY 2015, electric consumption costs for this meter were $81,422 at an average rate of $0.18/kWh.

Figure 44 depicts interval data for an average weekday during both summer and winter months for this meter.

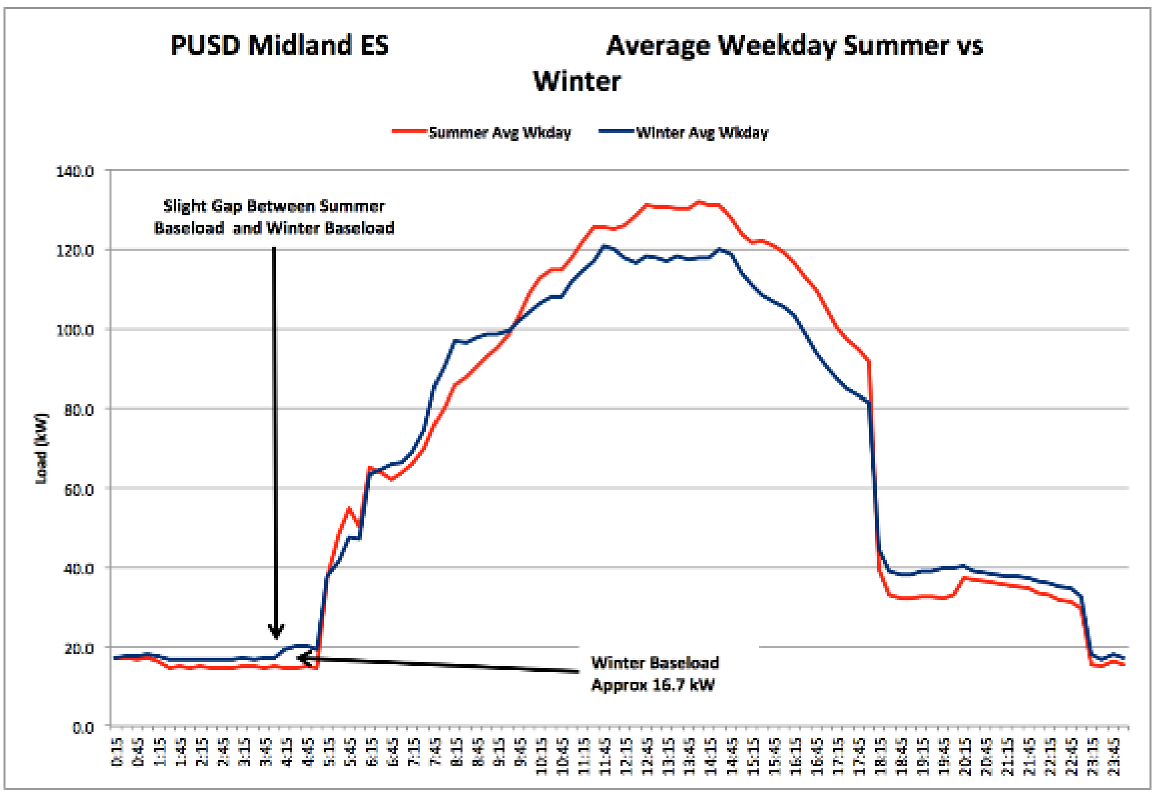


**Figure 44: Average Weekday Summer vs. Winter**

## Park Village Elementary School

***Site Summary***

Park Village Elementary serves students in Poway Unified School District. The Campus is spread out and features numerous permanent classrooms, an MPR, library/resource center, administrative offices and a small kitchen. Portable classrooms were also observed.

Figure 45 below shows a general overview of the campus.

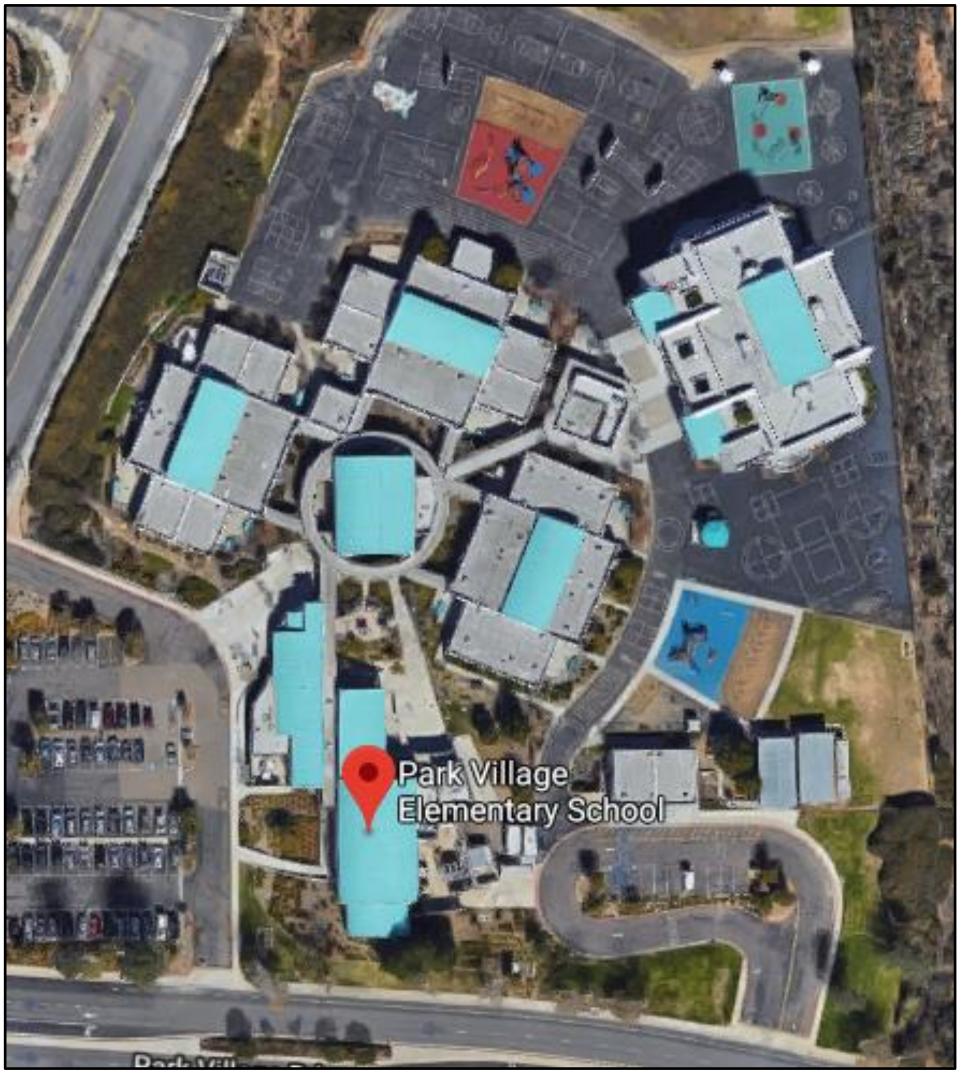


**Figure 45: School Overview**

***HVAC***

The facility is primarily cooled by two small central plants (upper & lower) that were modernized with the last two years approximately. Each plant contains two Carrier 80 ton air-cooled chillers. Each chiller is served by a single variable speed 15 hp chilled water pump. The heating is provided by one heating hot water boiler in each plant. The chilled water and heating hot water is distributed to air handlers in each standard pod building. The new K Building is conditioned by four Trane Intellipak units located on the roof. The HVAC is all controlled by Alerton DDC with the exception of portable classroom which are conditioned by stand-alone T-Stats.

***Lighting***

Currently the 4-foot T8 linear recessed fluorescent fixtures used throughout the building contain three-lamp 841 series 32w T8 lamps; the fixtures consume 89watts per fixture. These are controlled by occupancy sensors. Portables on Campus still use T12 fixtures.

Currently the exterior portion of Campus are served by 18-, 26- and 42-watt CFL fixtures. Metal halide security fixtures are also in use, along with 90-watt two-lamp low-pressure sodium parking lot pole lights.

***Other Systems***

There are miscellaneous loads throughout the buildings. The site has numerous computers that are controlled to shut off via a central server. Older transformers were located in classroom wings. A small kitchen features a normal sized reach-in refrigerator. Windows were observed to be double pane.

***Energy Storage System***

The Vendor installed a 250 kW / 500 kWh battery load shedding system on one of the sites meters in October of 2016.

***Utility Baseline***

IES looked at one meter at Park Village, on which the ESS is installed.

Figure 46 depicts interval data for an average weekday during both summer and winter months for the meter.

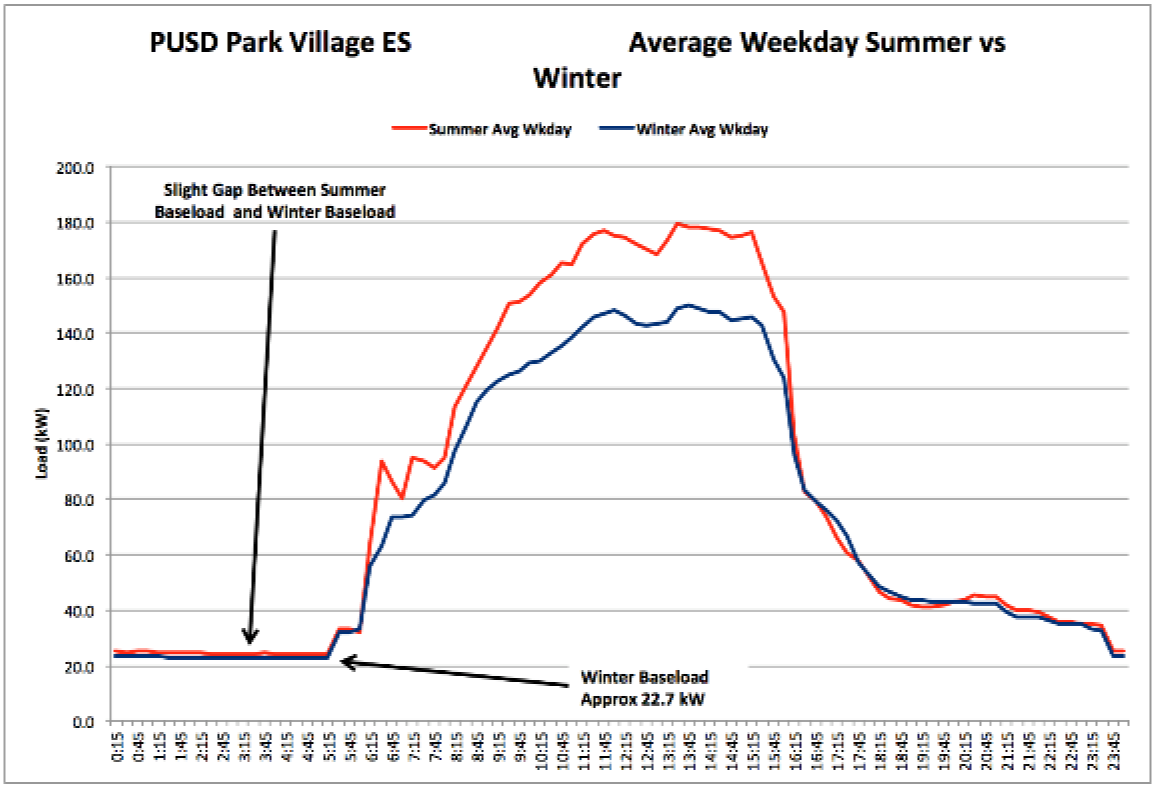


**Figure 46: Average Weekday Summer vs. Winter**

## Stone Ranch Elementary School

### *Site Summary*

Stone Ranch is an 80,362 sq-ft campus that features multiple classroom buildings behind a main building featuring Administrative Offices, an MPR, Library and Offices. The site also features 19 portable classrooms.

Figure 47 below shows a general overview of the campus.

**Figure 47: School Layout**

***HVAC***

Trane high efficiency gas/electric package units are in use for the permanent buildings. The units range in size from 3 to 10 tons each. A full Alerton DDC system controls all aspects of the permanent buildings HVAC. Portables are served by 3.5 ton wall mount heat pumps. Portables use occupancy based thermostats that allow the units to go to an unoccupied set-point if the room is vacant for a predetermined period of time.

***Lighting***

Lighting at the school is made up of primarily T8 linear fluorescent fixtures. The MPR main floor is illuminated with 4-foot T5 high output fixtures with 50-watt bulbs. The library and office hall is lit by compact fluorescent lamps with 2 x 13-watt lamps and 1 x 13-watt lamps respectively. The majority of the campus interior lighting is controlled by occupancy sensors.

Exterior lights are mostly 13-watt and 18-watt one- and two-lamp compact fluorescent (CFL). Two-lamp 32-watt T8 fixtures light the exterior canopies. Uplights (shown below) are used in front of the school and under the lunch trap. LPS Parking Pole lights containing 2 x 90-watt lamps are used in the parking lot. The exterior lighting is controlled by a schedule with a photocell to fine-tune the schedule.

***Other Systems***

There are miscellaneous loads throughout the buildings. The site has numerous computers that are controlled to shut off via a central server. A small kitchen features a normal sized reach-in refrigerator. Windows were observed to be double pane. According to District Office the PC are enabled 1st thing 6AM and off at 6PM.

***Energy Storage System***

The Vendor installed a 250 kW / 500 kWh battery load shedding system on one of the sites meters in March of 2017.

***IES Sub Metering***

IES's role is to provide a third party verification of the amount of electricity used and shed by the school, as well as analysis of current (w/ ESS) vs historical electrical use.

***Sub-Metering System***

An IES metering system was installed in November of 2016 and is located at the east side of the campus, near the main electrical distribution enclosure. The system consists of an Obvius Aquisuite data gathering unit and Veris bi-directional power meter. The data gathering server communicates via cellular modem. The data is transferred to the IES servers to be monitored and stored. This system began receiving and recording data in November of 2016.

***Utility Baseline***

Stone Ranch operates with one electric meter that the ESS is installed on. In FY 2015, electric consumption costs for this meter were $164,091 at an average rate of $0.33/kWh.

Figure 48 depicts interval data for an average weekday during both summer and winter months for this meter.

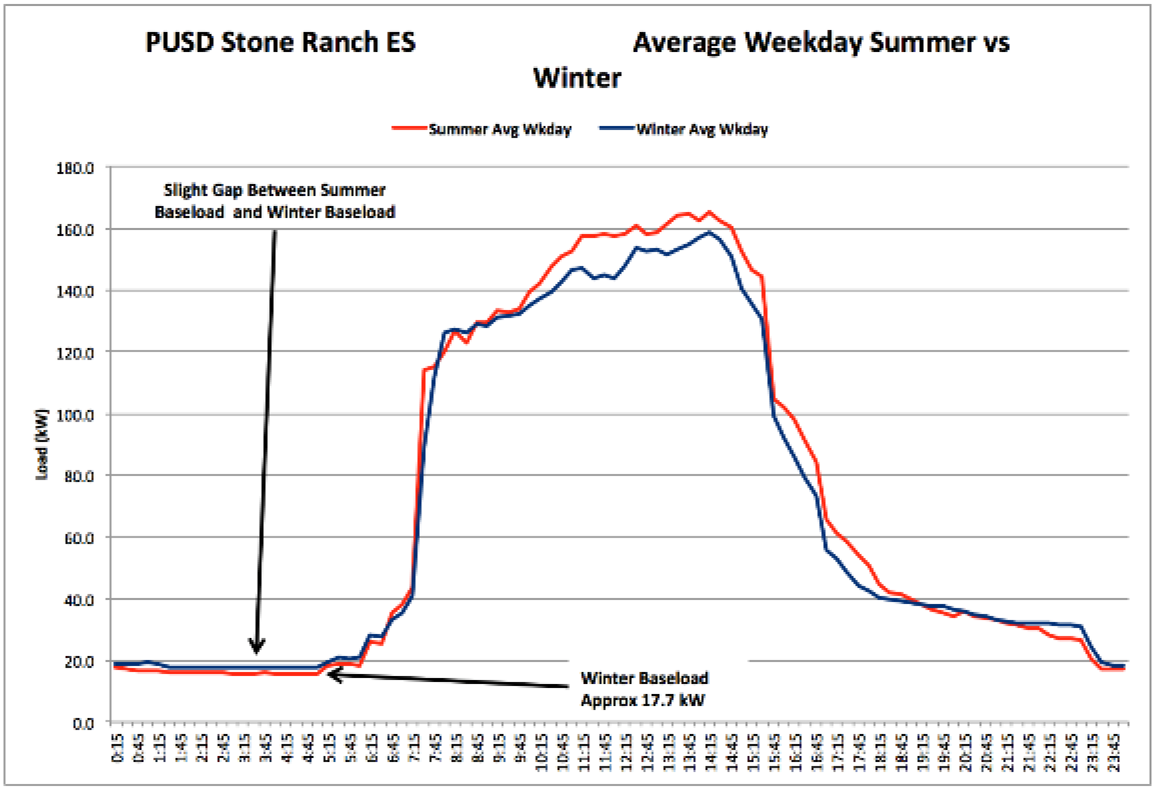


**Figure 48: Average Weekday Summer vs. Winter**

## Westwood Elementary School

### *Site Summary*

Westwood Elementary School serves students in Poway Unified School District. The school is arranged in a “circle” of permanent classrooms surrounding a central resource room. The site also has an MPR, administrative offices and portable classrooms.

Figure 49 below shows a general overview of the campus.


**Figure 49: Site Overview**

***HVAC***

The site has a central plant featuring a Carrier water cooled chiller and cooling tower, along with a Raypak boiler. UMP air handling units and multi-zone units deliver on the air side. Two split units are located on the roof and serve the data room and kitchen. Wall mount heat pumps are used for the portable classrooms and are controlled by programmable thermostats and twist timers.

***Lighting***

Lighting at the school is made up of 28-watt T8 fluorescent fixtures. Occupancy sensors control these fixtures in classrooms. Interior CFL fixtures using two 26watt lamps are also in many inside areas.

Exterior lighting consists of 7- and 26-watt CFL lamps in wall pack fixtures. Ground mount high-pressure sodium fixtures (50-watt) are used on Campus grounds, along with pole mounted 70-watt HPS fixtures.

***Other Systems***

There are miscellaneous loads throughout the buildings.  The site has numerous computers that are controlled to shut off via a central server. A small kitchen features a normal sized reach-in refrigerator.  Windows were observed to be double pane.

***Energy Storage System***

The Vendor installed a 250 kW / 500 kWh battery load shedding system on one of the sites meters in November of 2016.

***IES Sub Metering***

IES's role is to provide a third party verification of the amount of electricity used and shed by the school, as well as provide analysis of current (w/ ESS) vs historical electrical use.

***Sub-Metering System***

An IES metering system was installed in October of 2016 and is located at the west side of the campus, near the main electrical distribution enclosure. The system consists of an Obvius Aquisuite data gathering unit and Veris bi-directional power meter. The data gathering server communicates via cellular modem. The data is transferred to the IES servers to be monitored and stored. This system began receiving and recording data in October of 2016.

***Utility Baseline***

Westwood ES operates with one electric meter that the ESS is installed on. In FY 2015, electric consumption costs for this meter were $117,076 at an average rate of $0.21/kWh.

Figure 50 depicts interval data for an average weekday during both summer and winter months for this meter.

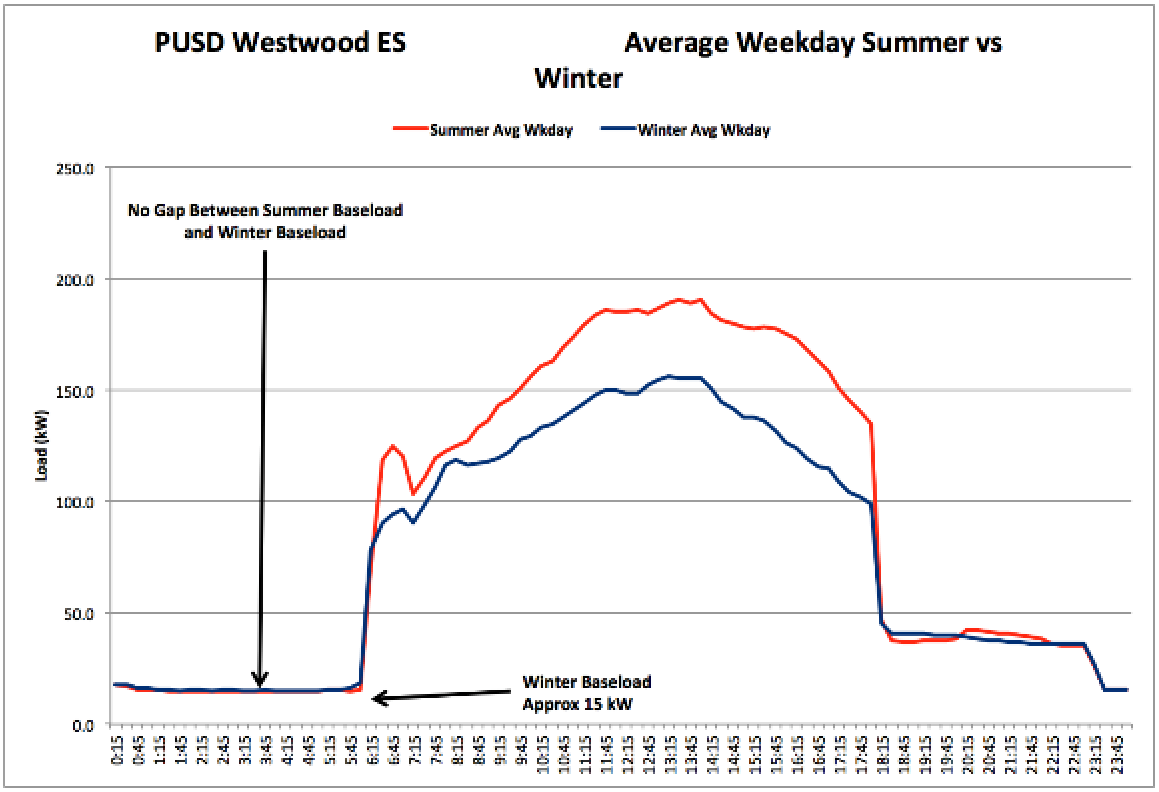


**Figure 50: Average Weekday Summer vs. Winter**

## Willow Grove Elementary School

### *Site Summary*

Willow Grove is an elementary school serving Poway Unified School District. The school features a large building out front, which holds administrative offices, a health center, the central plant and maintenance yard, MPR room and library. This building separates the parking lot from the rest of campus, which consists of permanent classroom buildings connected by steel exterior walkways surrounding a central yard.

Figure 51 below shows the general layout of the campus.

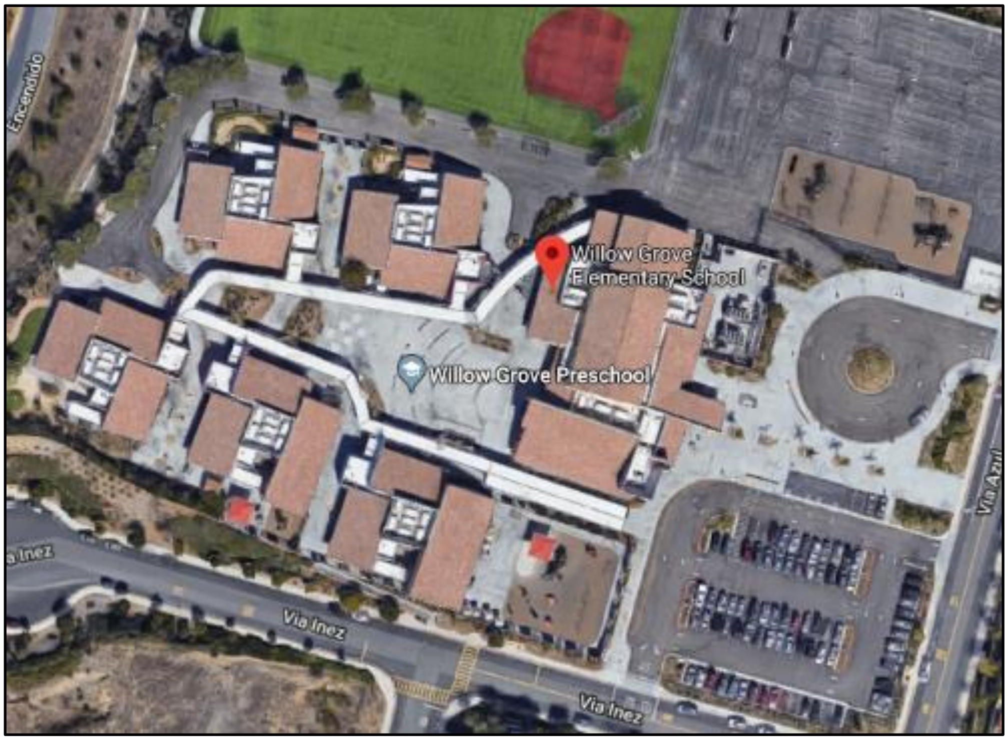


**Figure 51: School Overview**

***HVAC***

The site’s central plant consists of a LAARS boiler, two Carrier chillers and B&G chilled water pumps. The plant feeds UMP constant volume air handling units throughout the campus.  Two Trane package units serve the large front-facing building.

***Lighting***

Three lamp 32-watt T8 linear fluorescent fixtures are used throughout most of the interior areas. 2-foot T8 fixtures are also in use throughout areas of certain classrooms and the administration building.

Outdoor hallways are lit by box and canned CFL fixtures. Low pressure sodium parking lot pole fixtures serve the parking lot.

***Other Systems***

There are miscellaneous loads throughout the buildings.  The site has numerous computers that are controlled to shut off via a central server. A small kitchen features a normal sized reach-in refrigerator.  Windows were observed to be double pane.

***Energy Storage System***

The Vendor installed a 250 kW / 500 kWh battery load shedding system on one of the sites meters in November of 2016.

*IES Sub Metering*

IES's role is to provide a third party verification of the amount of electricity used and shed by the school, as well as provide analysis of current (w/ ESS) vs historical electrical use.

*Sub-Metering System*

An IES metering system was installed in November of 2016 and is located at the north-east corner of the campus, near the main electrical distribution enclosure. The system consists of an Obvius Aquisuite data gathering unit and Veris bi-directional power meter. The data gathering server communicates via cellular modem. The data is transferred to the IES servers to be monitored and stored. This system began receiving and recording data in November of 2016.

*Utility Baseline*

Willow Grove ES operates with one electric meter that the ESS is installed on. In FY 2015, electric consumption costs for this meter were $192,242 at an average rate of $0.37/kWh.

Figure 52 depicts interval data for an average weekday during both summer and winter months for this meter.

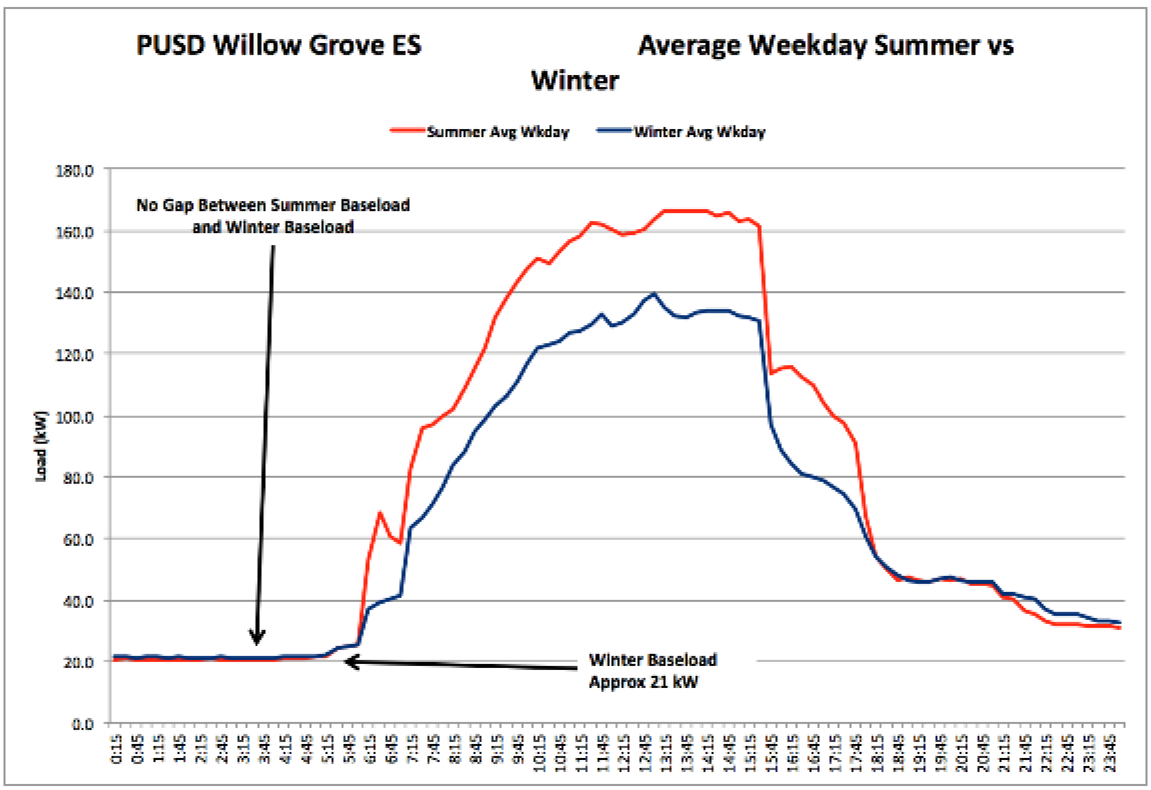


**Figure 52: Average Weekday Summer vs. winter**

## Appendix B

### *SDG&E FUNDING PASS-THROUGH INFORMATION*

*Appendix A contains project information relating to the SDG&E funding contribution to improve savings splits in favor of the host customers (school districts), and pass-through of that funding to the Vendor.*

The contractual shared savings-split amount between the Vendor and the host customers (Grossmont Union High School District & Poway Unified School District) are shown below in Table A-1 and Table A-2.

<u>Please note that Table A-3 and Table A-4 show the contractual savings splits AFTER the SDG&E contribution of $150,000 ($75,000 per school district).</u> SDG&E is contributing a total of $150,000 toward project implementation costs which will be applied as a buy-down against equipment costs. Based on the shared-savings model of the project, a buy-down improves the shared-savings-split in favor of the school district customers. The Vendor has modified the shared savings split on selected sites (highlighted) in order to maximize total financial benefits for the school districts. <u>Table A-5 and Table A-6 show the contractual savings splits BEFORE the SDG&E contribution.</u>

SDG&E will contribute $75,000 toward the project mobilization costs on behalf of the Grossmont Union High School District, which is currently structured to be applied to two of the 28 planned systems: the El Capitan High School #1 system and the Mt Miguel High School system. This changed the savings-split at El Capitan High School #1 from 25% to 35%, and the savings-split at Mt Miguel High School from 30% to 45%. Please see Table A-1 below summarizing the effects of the SDG&E contribution on behalf of the Grossmont Union High School District. According to the Vendor the $75,000 contribution will save the school district a total of $188,220 over the lifetime of the project.

**Table A-1: Effects of SDG&E Contributions on Behalf of Grossmont Union High School District**

| GROSSMONT UHSD | SAID (Last 4) | Size (kWh) | Increased Funding | Increase in Split | Increased Amount Yr. 1 | Increased Amount 10-Year |
|---|---|---|---|---|---|---|
| El Capitan HS | 4692 | 500 | $37,500 | 10% | $4,214 | $75,681 |
| Mt. Miguel HS | 2705 | 500 | $37,500 | 15% | $7,011 | $112,539 |
| Total | - | 1,000 | $75,000 | - | $11,225 | $188,220 |

SDG&E will contribute $75,000 toward the project mobilization costs on behalf of the Poway Unified School District, which is currently structured to be applied to three of the 31 planned systems: the Westwood Elementary system, the Highland

Ranch Elementary system, and the District Office system. This changed the savings-split at Westwood Elementary School from 25% to 35%. The savings split at Highland Ranch Elementary School changed from 23% to 35%. The savings-split at the District Office changed from 0% to 25%, meaning that without the SDG&E contribution the study would have included one fewer system as the school district would not have had a system installed at the District Office. Please see Table A-2 below summarizing the effects of the SDG&E contribution on behalf of the Poway Unified School District. According to the Vendor $75,000 contribution will save the school district a total of $145,078 over the lifetime of the project.

**Table A-2: Effects of SDG&E Contributions on Behalf of Poway Unified School District**

| POWAY USD | SAID (Last 4) | Size (kWh) | Increased Funding | Increase in Split | Increased Amount Yr. 1 | Increased Amount 10-Year |
|---|---|---|---|---|---|---|
| District Office | - | 500 | $30,000 | 25% | $6,310 | $79,367 |
| Highland Ranch ES | - | 500 | $22,500 | 10% | $2,719 | $34,203 |
| Westwood ES | - | 500 | $22,500 | 10% | $2,505 | $31,508 |
| Total | - | 1,500 | $75,000 | - | $9,752 | $145,078 |

**Table A-3: Grossmont Union High School District – Post SDG&E Contribution Shared Savings Split**

| Grossmont USD | SAID | Meter | kW | kWh | Demand Savings | Savings Share | Year-1 Value to District |
|---|---|---|---|---|---|---|---|
| Grossmont UHSD Monte Vista HS 1 | 80511897 | 6581739 | 250 kW | 500 kWh | $30,026 | 35% | $10,509 |
| Grossmont UHSD Santana HS 1 | 308393053 | 6581271 | 250 kW | 500 kWh | $31,429 | 40% | $12,572 |
| Grossmont UHSD El Cajon HS 2 | 398819355 | 6691709 | 500 kW | 1,000 kWh | $63,380 | 40% | $25,352 |
| Grossmont UHSD El Capitan HS 1 | 1034394692 | 6583847 | 250 kW | 500 kWh | $34,483 | 35% | $12,069 |
| Grossmont UHSD Foothill School | 1061581245 | 6579953 | 60 kW | 120 kWh | $10,487 | 20% | $2,097 |
| Grossmont UHSD EL Cajon HS 1 | 3437870377 | 6691708 | 250 kW | 500 kWh | $26,192 | 30% | $7,857 |
| Grossmont UHSD Monte Vista HS 2 | 4425520881 | 6581742 | 250 kW | 500 kWh | $28,084 | 35% | $9,829 |
| Grossmont UHSD Santana HS 2 | 4813176175 | 6581594 | 250 kW | 500 kWh | $35,352 | 40% | $14,141 |
| Grossmont UHSD Grossmont HS 3 | 4961106752 | 6584838 | 250 kW | 500 kWh | $24,046 | 25% | $6,011 |
| Grossmont UHSD East County ROP | 6137866889 | 6691261 | 30 kW | 60 kWh | $6,072 | 30% | $1,821 |
| Grossmont UHSD Health Occ. | 7315392858 | 6685774 | 750 kW | 1,500 kWh | $84,678 | 40% | $33,871 |
| Grossmont UHSD Mt Miguel HS | 7473572705 | 6695339 | 250 kW | 500 kWh | $39,700 | 45% | $17,865 |
| Grossmont UHSD El Cajon HS 3 | 8440363457 | 6686234 | 120 kW | 240 kWh | $18,391 | 15% | $2,759 |
| Grossmont UHSD Grossmont HS 4 | 9723643748 | 6580381 | 250 kW | 500 kWh | $35,331 | 40% | $14,132 |
| TOTAL | | | | | | | $170,887 |

**Table A-4: Poway Unified School District – Post SDG&E Contribution Shared Savings Split**

| Poway USD | SAID | Meter | kW | kWh | Demand Savings | Savings Share | Year-1 Value to District |
|---|---|---|---|---|---|---|---|
| Poway - Bernardo Heights MS | 803558876 | 06561784 | 250 kW | 500 kWh | $67,462 | 40% | $27,057 |
| Poway - Bernardo Heights MS 2 | 1340039500 | 6687828 | 250 kW | 500 kWh | $40,408 | 25% | $10,102 |
| Poway - Del Norte HS B | 1576838466 | 6584448 | 60 kW | 120 kWh | $11,462 | 25% | $2,866 |
| Poway - Del Norte HS A | 7803723594 | 0699985 | 500 kW | 1,000 kWh | $78,347 | 25% | $19,587 |
| Poway - Del Sur ES | 2498304191 | 6583771 | 250 kW | 500 kWh | $32,684 | 25% | $8,171 |
| Poway - Garden Road ES | 8143567513 | 6687920 | 60 kW | 120 kWh | $11,517 | 25% | $2,879 |
| Poway - Highland Ranch ES | 9375705855 | 6581790 | 250 kW | 500 kWh | $25,296 | 35% | $8,854 |
| Poway - Mesa Verde MS | 1815037990 | 6692126 | 250 kW | 500 kWh | $35,692 | 25% | $8,923 |
| Poway - Midland ES | 9404859604 | 6694771 | 250 kW | 500 kWh | $26,032 | 25% | $6,508 |
| Poway - Park Village ES | 4299823960 | 6694785 | 250 kW | 500 kWh | $27,524 | 25% | $6,881 |
| Poway - Stone Ranch ES | 2330937607 | 6697543 | 250 kW | 500 kWh | $30,176 | 25% | $7,544 |
| Poway - Westwood ES | 6228361711 | 6691201 | 250 kW | 500 kWh | $25,046 | 35% | $8,766 |
| Poway - Willow Grove ES | 9570864997 | 6583906 | 250 kW | 500 kWh | $34,974 | 25% | $8,743 |
| Poway - District Office | 4829544581 | 6691168 | 250 kW | 500 kWh | $25,238 | 25% | $6,310 |
| TOTAL | | | | | | | $133,190 |

**Table A-5: Grossmont Union High School District –Shared Savings Split Without SDG&E Contribution**

| Grossmont USD | SAID | Meter | Savings Share |
|---|---|---|---|
| Grossmont UHSD Monte Vista HS 1 | 80511897 | 6581739 | 35% |
| Grossmont UHSD Santana HS 1 | 308393053 | 6581271 | 40% |
| Grossmont UHSD El Cajon HS 2 | 398819355 | 6691709 | 40% |
| Grossmont UHSD El Capitan HS 1 | 1034394692 | 6583847 | 25% |
| Grossmont UHSD Foothill School | 1061581245 | 6579953 | 20% |
| Grossmont UHSD EL Cajon HS 1 | 3437870377 | 6691708 | 30% |
| Grossmont UHSD Monte Vista HS 2 | 4425520881 | 6581742 | 35% |
| Grossmont UHSD Santana HS 2 | 4813176175 | 6581594 | 40% |
| Grossmont UHSD Grossmont HS 3 | 4961106752 | 6584838 | 25% |
| Grossmont UHSD East County ROP | 6137866889 | 6691261 | 30% |
| Grossmont UHSD Health Occ. | 7315392858 | 6685774 | 40% |
| Grossmont UHSD Mt Miguel HS | 7473572705 | 6695339 | 30% |
| Grossmont UHSD El Cajon HS 3 | 8440363457 | 6686234 | 15% |
| Grossmont UHSD Grossmont HS 4 | 9723643748 | 6580381 | 40% |

**Table A-6: Poway Unified School District –Shared Savings Split Without SDG&E Contribution**

| Poway USD | SAID | Meter | Savings Share |
|---|---|---|---|
| Poway - Bernardo Heights MS | 803558876 | 06561784 | 40% |
| Poway - Bernardo Heights MS 2 | 1340039500 | 6687828 | 25% |
| Poway - Del Norte HS B | 1576838466 | 6584448 | 25% |
| Poway - Del Norte HS A | 7803723594 | 06699985 | 25% |
| Poway - Del Sur ES | 2498304191 | 6583771 | 25% |
| Poway - Garden Road ES | 8143567513 | 6687920 | 25% |
| Poway - Highland Ranch ES | 9375705855 | 6581790 | 25% |
| Poway - Mesa Verde MS | 1815037990 | 6692126 | 25% |
| Poway - Midland ES | 9404859604 | 6694771 | 25% |
| Poway - Park Village ES | 4299823960 | 6694785 | 25% |
| Poway - Stone Ranch ES | 2330937607 | 6697543 | 25% |
| Poway - Westwood ES | 6228361711 | 6691201 | 25% |
| Poway - Willow Grove ES | 9570864997 | 6583906 | 25% |
| Poway - District Office | 4829544581 | 6691168 | - |

# Appendix C

*Site Specific Monthly Analysis Summaries*

| # | School District | System Name | System Size kW | System Size kWh | Analysis Period (Mo.) | Max. Recorded Reduction (kW) | Cumulative Bill Reduction | Portion Customer Keeps | Cumulative Customer Value (Present) | Customer Target Value (Present) | % Customer Target Value Achieved (Present) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Grossmont | East County ROP | 30 | 60 | 5 | 10.5 | $ 805.56 | 30% | $ 241.67 | $ 759.00 | 32% |
| 2 | Grossmont | El Capitan HS | 250 | 500 | 5 | 142.4 | $ 8,084.13 | 35% | $ 2,829.44 | $ 5,028.77 | 56% |
| 3 | Grossmont | Foothill School | 60 | 120 | 5 | 25.6 | $ 2,829.34 | 20% | $ 565.87 | $ 873.92 | 65% |
| 4 | Grossmont | Grossmont HS | 250 | 500 | 5 | 120.1 | $ 12,221.97 | 40% | $ 4,888.79 | $ 5,888.50 | 83% |
| 5 | Grossmont | Mt Miguel HS | 250 | 500 | 5 | 85.5 | $ 9,553.03 | 45% | $ 4,298.86 | $ 7,443.75 | 58% |
| 6 | Grossmont | Santana HS 1 | 250 | 500 | 5 | 91.2 | $ 12,218.41 | 30% | $ 3,878.25 | $ 3,928.63 | 99% |
| 7 | Grossmont | Santana HS 2 | 250 | 500 | 5 | 188.7 | $ 19,477.58 | 30% | $ 6,104.64 | $ 4,419.00 | 138% |
| 8 | Poway | Black Mountain | 250 | 500 | 5 | 110.8 | $ 12,972.23 | 25% | $ 3,243.06 | $ 3,243.06 | 100% |
| 9 | Poway | Del Norte HS B | 500 | 1000 | 5 | 337.8 | $ 43,110.15 | 25% | $10,777.54 | $ 9,355.10 | 115% |
| 10 | Poway | Del Norte HS A | 60 | 120 | | 62.7 | | | | | |
| 11 | Poway | Del Sur ES | 250 | 500 | 5 | 118.1 | $ 14,519.74 | 25% | $ 3,629.94 | $ 3,404.58 | 107% |
| 12 | Poway | Garden Road ES | 60 | 120 | 5 | 30.6 | $ 3,665.94 | 25% | $ 916.48 | $ 1,199.69 | 76% |
| 13 | Poway | Mesa Verde MS | 250 | 500 | 5 | 120.4 | $ 14,077.57 | 25% | $ 3,519.39 | $ 3,717.92 | 95% |
| 14 | Poway | Midland ES | 250 | 500 | 5 | 96.6 | $ 11,377.81 | 25% | $ 2,844.45 | $ 2,711.67 | 105% |
| 15 | Poway | Park Village ES | 250 | 500 | 5 | 95.9 | $ 9,750.04 | 25% | $ 2,437.51 | $ 2,867.08 | 85% |
| 16 | Poway | Stone Ranch ES | 250 | 500 | 5 | 97.3 | $ 10,888.84 | 25% | $ 2,722.21 | $ 3,143.33 | 87% |
| 17 | Poway | Westwood ES | 250 | 500 | 5 | 102.4 | $ 10,008.17 | 35% | $ 3,502.86 | $ 3,652.54 | 96% |
| 18 | Poway | Willow Grove ES | 250 | 500 | 5 | 130.7 | $ 10,992.29 | 25% | $ 2,748.07 | $ 3,643.13 | 75% |
| 19 | Poway | Highland Ranch | 250 | 500 | 5 | 95.6 | $ 9,610.60 | 35% | $ 3,363.71 | $ 3,689.00 | 91% |
| 20 | Poway | District Office | 250 | 500 | 4 | 95.4 | $ 9,645.20 | 25% | $ 2,411.30 | $ 2,103.17 | 115% |
| | **TOTAL** | | **4.46 MW** | | | | **$ 225,808.59** | | **$64,924.05** | **$71,071.83** | **91%** |

**Notes:**

1. Santana HS (both): The customer share of savings was changed from 40% to 30% on 3/10/2017, this is reflected in monthly calculations.
2. Black Mountain MS: This site was not part of the original project projections, therefore no target value is available.
   Due to lack of available target value, it was assumed that Black Mountain MS achieved 100% of the target value, i.e. the Customer Target Value was assumed to be equal to the Cumulative Customer Value, for purposes of averaging.
3. The Del Norte A & B systems are shown as a combined value because the Billing Statements from the Vendor were initially combined.

| # | School District | System Name | Billing Type | System Size kW | System Size kWh | Start Date | End Date | GCN Bill Month | NC kW Reduction | On-Pk kW Reduction | Customer Bill Reduction | Portion Customer Keeps | Customer Value |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Grossmont | East County ROP | Bundled | 30 | 60 | 3/1/2017 | 3/30/2017 | February | 0.0 | 0.1 | $ 0.76 | 30% | $ 0.23 |
| 2 | Grossmont | East County ROP | Bundled | 30 | 60 | 3/31/2017 | 5/2/2017 | March | 6.5 | 6.6 | $ 227.81 | 30% | $ 68.34 |
| 3 | Grossmont | East County ROP | Bundled | 30 | 60 | 5/2/2017 | 6/1/2017 | April | 6.8 | 10.5 | $ 273.68 | 30% | $ 82.10 |
| 4 | Grossmont | East County ROP | Bundled | 30 | 60 | 6/1/2017 | 6/30/2017 | May | 8.6 | 8.6 | $ 299.70 | 30% | $ 89.91 |
| 5 | Grossmont | East County ROP | Bundled | 30 | 60 | 6/30/2017 | 8/1/2017 | June | 0.1 | 0.1 | $ 3.62 | 30% | $ 1.08 |
| **(AVERAGE) or TOTAL** | | | | | | | | | **4.4 (Avg)** | **5.2 (Avg)** | **$ 805.56** | | **$ 241.67** |

| # | District | System Name | Billing Type | System Size kW | System Size kWh | Start Date | End Date | GCN Bill Month | NC kW Reduction | On-Pk kW Reduction | Customer Bill Reduction | Portion Customer Keeps | Customer Value |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Grossmont | El Capitan HS | Bundled | 250 | 500 | 2/7/2017 | 3/9/2017 | February | 0.0 | 48.7 | $ 368.67 | 35% | $ 129.04 |
| 2 | Grossmont | El Capitan HS | Bundled | 250 | 500 | 3/10/2017 | 4/10/2017 | March | 19.1 | 65.1 | $ 960.60 | 35% | $ 336.21 |
| 3 | Grossmont | El Capitan HS | Bundled | 250 | 500 | 4/10/2017 | 5/10/2017 | April | 93.4 | 142.4 | $ 3,748.68 | 35% | $ 1,312.04 |
| 4 | Grossmont | El Capitan HS | Bundled | 250 | 500 | 5/10/2017 | 6/9/2017 | May | 46.0 | 79.0 | $ 1,937.31 | 35% | $ 678.06 |
| 5 | Grossmont | El Capitan HS | Bundled | 250 | 500 | 6/9/2017 | 7/10/2017 | June | 10.8 | 78.6 | $ 1,068.86 | 35% | $ 374.10 |
| **(AVERAGE) or TOTAL** | | | | | | | | | **33.8 (Avg)** | **82.8 (Avg)** | **$ 8,084.13** | | **$ 2,829.44** |

| # | District | System Name | Billing Type | System Size kW | System Size kWh | Start Date | End Date | GCN Bill Month | NC kW Reduction | On-Pk kW Reduction | Customer Bill Reduction | Portion Customer Keeps | Customer Value |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Grossmont | Foothill School | Bundled | 60 | 120 | 2/1/2017 | 3/5/2017 | February | 10.1 | 2.9 | $ 268.68 | 20% | $ 53.74 |
| 2 | Grossmont | Foothill School | Bundled | 60 | 120 | 3/6/2017 | 4/4/2017 | March | 3.5 | -2.2 | $ 68.54 | 20% | $ 13.71 |
| 3 | Grossmont | Foothill School | Bundled | 60 | 120 | 4/4/2017 | 5/4/2017 | April | 25.2 | 25.6 | $ 880.30 | 20% | $ 176.06 |
| 4 | Grossmont | Foothill School | Bundled | 60 | 120 | 5/4/2017 | 6/5/2017 | May | 21.1 | 21.1 | $ 735.10 | 20% | $ 147.02 |
| 5 | Grossmont | Foothill School | Bundled | 60 | 120 | 6/5/2017 | 7/5/2017 | June | 25.2 | 25.2 | $ 876.72 | 20% | $ 175.34 |
| **(AVERAGE) or TOTAL** | | | | | | | | | **17 (Avg)** | **14.5 (Avg)** | **$ 2,829.34** | | **$ 565.87** |

| # | District | System Name | Billing Type | System Size kW | System Size kWh | Start Date | End Date | GCN Bill Month | NC kW Reduction | On-Pk kW Reduction | Customer Bill Reduction | Portion Customer Keeps | Customer Value |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Grossmont | Grossmont HS | Bundled | 250 | 500 | 2/15/2017 | 3/19/2017 | February | 89.8 | 8.4 | $ 2,265.24 | 40% | $ 906.10 |
| 2 | Grossmont | Grossmont HS | Bundled | 250 | 500 | 3/20/2017 | 4/19/2017 | March | 81.5 | 24.0 | $ 2,179.87 | 40% | $ 871.95 |
| 3 | Grossmont | Grossmont HS | Bundled | 250 | 500 | 4/19/2017 | 5/18/2017 | April | 116.6 | 14.4 | $ 3,005.29 | 40% | $ 1,202.12 |
| 4 | Grossmont | Grossmont HS | Bundled | 250 | 500 | 5/18/2017 | 6/19/2017 | May | 120.1 | 120.1 | $ 4,174.09 | 40% | $ 1,669.63 |
| 5 | Grossmont | Grossmont HS | Bundled | 250 | 500 | 6/19/2017 | 7/19/2017 | June | 27.7 | -7.8 | $ 597.48 | 40% | $ 238.99 |
| **(AVERAGE) or TOTAL** | | | | | | | | | **87.1 (Avg)** | **31.8 (Avg)** | **$ 12,221.97** | | **$ 4,888.79** |

| # | District | System Name | Billing Type | System Size kW | System Size kWh | Start Date | End Date | GCN Bill Month | NC kW Reduction | On-Pk kW Reduction | Customer Bill Reduction | Portion Customer Keeps | Customer Value |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Grossmont | Mt Miguel HS | Bundled | 250 | 500 | 2/22/2017 | 3/23/2017 | February | 85.5 | 8.0 | $ 2,102.64 | 45% | $ 946.19 |
| 2 | Grossmont | Mt Miguel HS | Bundled | 250 | 500 | 3/24/2017 | 4/25/2017 | March | 80.3 | 67.5 | $ 2,427.30 | 45% | $ 1,092.29 |
| 3 | Grossmont | Mt Miguel HS | Bundled | 250 | 500 | 4/25/2017 | 5/24/2017 | April | 37.8 | 37.8 | $ 1,278.40 | 45% | $ 575.28 |
| 4 | Grossmont | Mt Miguel HS | Bundled | 250 | 500 | 5/24/2017 | 6/23/2017 | May | 45.4 | 45.4 | $ 1,535.90 | 45% | $ 691.16 |
| 5 | Grossmont | Mt Miguel HS | Bundled | 250 | 500 | 6/23/2017 | 7/25/2017 | June | 64.2 | 67.9 | $ 2,208.79 | 45% | $ 993.96 |
| **(AVERAGE) or TOTAL** | | | | | | | | | **62.6 (Avg)** | **45.3 (Avg)** | **$ 9,553.03** | | **$ 4,298.86** |

| # | District | System Name | Billing Type | System Size kW | System Size kWh | Start Date | End Date | GCN Bill Month | NC kW Reduction | On-Pk kW Reduction | Customer Bill Reduction | Portion Customer Keeps | Customer Value |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Grossmont | Santana HS 1 | Bundled | 250 | 500 | 2/7/2017 | 3/9/2017 | February | 69.1 | 57.4 | $ 2,127.26 | 40% | $ 850.90 |
| 2 | Grossmont | Santana HS 1 | Bundled | 250 | 500 | 3/10/2017 | 4/10/2017 | March | 87.9 | 51.1 | $ 2,540.54 | 30% | $ 762.16 |
| 3 | Grossmont | Santana HS 1 | Bundled | 250 | 500 | 4/10/2017 | 5/10/2017 | April | 86.6 | 86.6 | $ 3,011.54 | 30% | $ 903.46 |
| 4 | Grossmont | Santana HS 1 | Bundled | 250 | 500 | 5/10/2017 | 6/9/2017 | May | 91.2 | 91.2 | $ 3,168.72 | 30% | $ 950.62 |
| 5 | Grossmont | Santana HS 1 | Bundled | 250 | 500 | 6/9/2017 | 7/11/2017 | June | 38.3 | 42.0 | $ 1,370.35 | 30% | $ 411.10 |
| **(AVERAGE) or TOTAL** | | | | | | | | | **74.6 (Avg)** | **65.7 (Avg)** | **$ 12,218.41** | | **$ 3,878.25** |

**Note:**

Customer Share of savings changed from 40% to 30% on 3/10/2017

| # | District | System Name | Billing Type | System Size kW | System Size kWh | Start Date | End Date | GCN Bill Month | NC kW Reduction | On-Pk kW Reduction | Customer Bill Reduction | Portion Customer Keeps | Customer Value |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Grossmont | Santana HS 2 | Bundled | 250 | 500 | 2/7/2017 | 3/9/2017 | February | 71.4 | 114.1 | $ 2,613.72 | 40% | $ 1,045.49 |
| 2 | Grossmont | Santana HS 2 | Bundled | 250 | 500 | 3/10/2017 | 4/9/2017 | March | 66.2 | 58.9 | $ 2,067.93 | 30% | $ 620.38 |
| 3 | Grossmont | Santana HS 2 | Bundled | 250 | 500 | 4/10/2017 | 5/9/2017 | April | 177.0 | 66.6 | $ 5,021.38 | 30% | $ 1,506.41 |
| 4 | Grossmont | Santana HS 2 | Bundled | 250 | 500 | 5/10/2017 | 6/8/2017 | May | 140.5 | 82.3 | $ 4,287.63 | 30% | $ 1,286.29 |
| 5 | Grossmont | Santana HS 2 | Bundled | 250 | 500 | 6/9/2017 | 7/10/2017 | June | 144.9 | 188.7 | $ 5,486.93 | 30% | $ 1,646.08 |
| **(AVERAGE) or TOTAL** | | | | | | | | | **120 (Avg)** | **102.1 (Avg)** | **$ 19,477.58** | | **$ 6,104.64** |

**Note:**

Customer Share of savings changed from 40% to 30% on 3/10/2017

| # | District | System Name | Billing Type | System Size | | Start Date | End Date | GCN Bill Month | NC kW Reduction | On-Pk kW Reduction | Customer Bill Reduction | Portion Customer Keeps | Customer Value |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | kW | kWh | | | | | | | | |
| 1 | Poway | Black Mountain | Bundled | 250 | 500 | 2/7/2017 | 3/9/2017 | February | 110.8 | 34.6 | $ 2,977.20 | 25% | $ 744.30 |
| 2 | Poway | Black Mountain | Bundled | 250 | 500 | 3/10/2017 | 4/9/2017 | March | 86.6 | 26.4 | $ 2,321.97 | 25% | $ 580.49 |
| 3 | Poway | Black Mountain | Bundled | 250 | 500 | 4/10/2017 | 5/9/2017 | April | 103.2 | 108.6 | $ 3,643.19 | 25% | $ 910.80 |
| 4 | Poway | Black Mountain | Bundled | 250 | 500 | 5/10/2017 | 6/9/2017 | May | 94.2 | 78.7 | $ 3,114.71 | 25% | $ 778.68 |
| 5 | Poway | Black Mountain | Bundled | 250 | 500 | 6/10/2017 | 7/10/2017 | June | 23.5 | 33.1 | $ 915.16 | 25% | $ 228.79 |
| **(AVERAGE) or TOTAL** | | | | | | | | | **83.7 (Avg)** | **56.3 (Avg)** | **$ 12,972.23** | | **$ 3,243.06** |

| # | District | System Name | Billing Type | System Size | | Start Date | End Date | GCN Bill Month | NC kW Reduction | On-Pk kW Reduction | Customer Bill Reduction | Portion Customer Keeps | Customer Value |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | kW | kWh | | | | | | | | |
| 1 | Poway | Del Norte HS A | Direct Acces | 60 | 120 | 2/6/2017 | 3/8/2017 | February | 0.0 | 27.4 | $ 207.66 | 25% | $ 51.92 |
| 2 | Poway | Del Norte HS A | Direct Acces | 60 | 120 | 3/9/2017 | 4/6/2017 | March | 0.0 | 0.0 | $ - | 25% | $ - |
| 3 | Poway | Del Norte HS A | Direct Acces | 60 | 120 | 4/7/2017 | 5/8/2017 | April | 0.0 | 17.0 | $ 169.20 | 25% | $ 42.30 |
| 4 | Poway | Del Norte HS A | Direct Acces | 60 | 120 | 5/9/2017 | 6/7/2017 | May | 62.7 | 45.5 | $ 2,002.86 | 25% | $ 500.72 |
| 5 | Poway | Del Norte HS A | Direct Acces | 60 | 120 | 6/8/2017 | 7/9/2017 | June | 0.0 | 0.0 | $ - | 25% | $ - |
| **(AVERAGE) or TOTAL** | | | | | | | | | **12.5 (Avg)** | **18 (Avg)** | **$ 2,379.72** | | **$ 594.93** |

| # | District | System Name | Billing Type | System Size | | Start Date | End Date | GCN Bill Month | NC kW Reduction | On-Pk kW Reduction | Customer Bill Reduction | Portion Customer Keeps | Customer Value |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | kW | kWh | | | | | | | | |
| 1 | Poway | Del Norte HS B | Direct Access | 500 | 1000 | 2/6/2017 | 3/8/2017 | February | 228.6 | 222.4 | $ 7,286.00 | 25% | $ 1,821.50 |
| 2 | Poway | Del Norte HS B | Direct Access | 500 | 1000 | 3/9/2017 | 4/6/2017 | March | 337.8 | 226.0 | $ 9,989.99 | 25% | $ 2,497.50 |
| 3 | Poway | Del Norte HS B | Direct Access | 500 | 1000 | 4/7/2017 | 5/8/2017 | April | 214.0 | 77.7 | $ 5,883.76 | 25% | $ 1,470.94 |
| 4 | Poway | Del Norte HS B | Direct Access | 500 | 1000 | 5/9/2017 | 6/7/2017 | May | 200.1 | 163.1 | $ 6,575.94 | 25% | $ 1,643.98 |
| 5 | Poway | Del Norte HS B | Direct Access | 500 | 1000 | 6/8/2017 | 7/9/2017 | June | 315.6 | 318.0 | $ 10,994.75 | 25% | $ 2,748.69 |
| **(AVERAGE) or TOTAL** | | | | | | | | | **259.2 (Avg)** | **201.4 (Avg)** | **$ 40,730.44** | | **$ 10,182.61** |

| | | | | System Size | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| # | District | System Name | Billing Type | kW | kWh | Start Date | End Date | GCN Bill Month | NC kW Reduction | On-Pk kW Reduction | Customer Bill Reduction | Portion Customer Keeps | Customer Value |
| 1 | Poway | Del Sur ES | Bundled | 250 | 500 | 2/6/2017 | 3/8/2017 | February | 116.0 | 114.6 | $ 3,711.38 | 25% | $ 927.84 |
| 2 | Poway | Del Sur ES | Bundled | 250 | 500 | 3/9/2017 | 4/6/2017 | March | 113.2 | 24.2 | $ 2,958.98 | 25% | $ 739.74 |
| 3 | Poway | Del Sur ES | Bundled | 250 | 500 | 4/7/2017 | 5/8/2017 | April | 118.1 | 99.0 | $ 3,910.42 | 25% | $ 977.61 |
| 4 | Poway | Del Sur ES | Bundled | 250 | 500 | 5/9/2017 | 6/7/2017 | May | 97.7 | 110.2 | $ 3,525.74 | 25% | $ 881.44 |
| 5 | Poway | Del Sur ES | Bundled | 250 | 500 | 6/8/2017 | 7/9/2017 | June | 11.9 | 11.9 | $ 413.23 | 25% | $ 103.31 |
| **(AVERAGE) or TOTAL** | | | | | | | | | **91.4 (Avg)** | **72 (Avg)** | **$ 14,519.74** | | **$ 3,629.94** |

| | | | | System Size | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| # | District | System Name | Billing Type | kW | kWh | Start Date | End Date | GCN Bill Month | NC kW Reduction | On-Pk kW Reduction | Customer Bill Reduction | Portion Customer Keeps | Customer Value |
| 1 | Poway | Garden Road ES | Direct Acces | 60 | 120 | 2/9/2017 | 3/13/2017 | February | 11.6 | 9.6 | $ 357.89 | 25% | $ 89.47 |
| 2 | Poway | Garden Road ES | Direct Acces | 60 | 120 | 3/14/2017 | 4/12/2017 | March | 30.3 | 9.8 | $ 816.66 | 25% | $ 204.17 |
| 3 | Poway | Garden Road ES | Direct Acces | 60 | 120 | 4/13/2017 | 5/11/2017 | April | 27.6 | 27.6 | $ 959.79 | 25% | $ 239.95 |
| 4 | Poway | Garden Road ES | Direct Acces | 60 | 120 | 5/12/2017 | 6/12/2017 | May | 13.4 | 13.4 | $ 466.79 | 25% | $ 116.70 |
| 5 | Poway | Garden Road ES | Direct Acces | 60 | 120 | 6/13/2017 | 7/12/2017 | June | 30.6 | 30.6 | $ 1,064.80 | 25% | $ 266.20 |
| **(AVERAGE) or TOTAL** | | | | | | | | | **22.7 (Avg)** | **18.2 (Avg)** | **$ 3,665.94** | | **$ 916.48** |

| | | | | System Size | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| # | District | System Name | Billing Type | kW | kWh | Start Date | End Date | GCN Bill Month | NC kW Reduction | On-Pk kW Reduction | Customer Bill Reduction | Portion Customer Keeps | Customer Value |
| 1 | Poway | Mesa Verde MS | Direct Access | 250 | 500 | 2/7/2017 | 3/9/2017 | February | 79.2 | 106.1 | $ 2,743.79 | 25% | $ 685.95 |
| 2 | Poway | Mesa Verde MS | Direct Access | 250 | 500 | 3/10/2017 | 4/9/2017 | March | 80.8 | 43.4 | $ 2,309.04 | 25% | $ 577.26 |
| 3 | Poway | Mesa Verde MS | Direct Access | 250 | 500 | 4/10/2017 | 5/9/2017 | April | 120.4 | 87.2 | $ 3,843.41 | 25% | $ 960.85 |
| 4 | Poway | Mesa Verde MS | Direct Access | 250 | 500 | 5/10/2017 | 6/8/2017 | May | 88.5 | 90.9 | $ 3,099.61 | 25% | $ 774.90 |
| 5 | Poway | Mesa Verde MS | Direct Access | 250 | 500 | 6/9/2017 | 7/10/2017 | June | 36.4 | 116.0 | $ 2,081.72 | 25% | $ 520.43 |
| **(AVERAGE) or TOTAL** | | | | | | | | | **81 (Avg)** | **88.7 (Avg)** | **$ 14,077.57** | | **$ 3,519.39** |

| # | District | System Name | Billing Type | System Size kW | System Size kWh | Start Date | End Date | GCN Bill Month | NC kW Reduction | On-Pk kW Reduction | Customer Bill Reduction | Portion Customer Keeps | Customer Value |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Poway | Midland ES | Direct Access | 250 | 500 | 2/13/2017 | 3/15/2017 | February | 62.9 | 46.8 | $ 1,896.73 | 25% | $ 474.18 |
| 2 | Poway | Midland ES | Direct Access | 250 | 500 | 3/16/2017 | 4/16/2017 | March | 90.9 | 35.9 | $ 2,498.97 | 25% | $ 624.74 |
| 3 | Poway | Midland ES | Direct Access | 250 | 500 | 4/17/2017 | 5/15/2017 | April | 91.2 | 96.6 | $ 2,966.03 | 25% | $ 741.51 |
| 4 | Poway | Midland ES | Direct Access | 250 | 500 | 5/16/2017 | 6/14/2017 | May | 35.2 | 35.2 | $ 1,222.47 | 25% | $ 305.62 |
| 5 | Poway | Midland ES | Direct Access | 250 | 500 | 6/15/2017 | 7/16/2017 | June | 80.2 | 80.8 | $ 2,793.60 | 25% | $ 698.40 |
| **(AVERAGE) or TOTAL** | | | | | | | | | **72.1 (Avg)** | **59.1 (Avg)** | **$ 11,377.81** | | **$ 2,844.45** |

| # | District | System Name | Billing Type | System Size kW | System Size kWh | Start Date | End Date | GCN Bill Month | NC kW Reduction | On-Pk kW Reduction | Customer Bill Reduction | Portion Customer Keeps | Customer Value |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Poway | Park Village ES | Direct Access | 250 | 500 | 2/7/2017 | 3/9/2017 | February | 45.5 | 21.0 | $ 1,275.09 | 25% | $ 318.77 |
| 2 | Poway | Park Village ES | Direct Access | 250 | 500 | 3/10/2017 | 4/9/2017 | March | 23.0 | 0.0 | $ 563.44 | 25% | $ 140.86 |
| 3 | Poway | Park Village ES | Direct Access | 250 | 500 | 4/10/2017 | 5/9/2017 | April | 83.9 | 86.8 | $ 2,946.38 | 25% | $ 736.59 |
| 4 | Poway | Park Village ES | Direct Access | 250 | 500 | 5/10/2017 | 6/8/2017 | May | 72.2 | 95.9 | $ 2,751.07 | 25% | $ 687.77 |
| 5 | Poway | Park Village ES | Direct Access | 250 | 500 | 6/9/2017 | 7/10/2017 | June | 51.8 | 92.1 | $ 2,214.06 | 25% | $ 553.52 |
| **(AVERAGE) or TOTAL** | | | | | | | | | **55.3 (Avg)** | **59.2 (Avg)** | **$ 9,750.04** | | **$ 2,437.51** |

| # | District | System Name | Billing Type | System Size kW | System Size kWh | Start Date | End Date | GCN Bill Month | NC kW Reduction | On-Pk kW Reduction | Customer Bill Reduction | Portion Customer Keeps | Customer Value |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Poway | Stone Ranch ES | Bundled | 250 | 500 | 2/7/2017 | 3/8/2017 | February | 41.8 | 16.5 | $ 1,149.87 | 25% | $ 287.47 |
| 2 | Poway | Stone Ranch ES | Bundled | 250 | 500 | 3/9/2017 | 4/6/2017 | March | 93.0 | 37.2 | $ 2,561.87 | 25% | $ 640.47 |
| 3 | Poway | Stone Ranch ES | Bundled | 250 | 500 | 4/7/2017 | 5/8/2017 | April | 97.3 | 85.9 | $ 3,265.79 | 25% | $ 816.45 |
| 4 | Poway | Stone Ranch ES | Bundled | 250 | 500 | 5/9/2017 | 6/7/2017 | May | 74.3 | 74.3 | $ 2,582.22 | 25% | $ 645.55 |
| 5 | Poway | Stone Ranch ES | Bundled | 250 | 500 | 6/8/2017 | 7/9/2017 | June | 33.1 | 50.5 | $ 1,329.09 | 25% | $ 332.27 |
| **(AVERAGE) or TOTAL** | | | | | | | | | **67.9 (Avg)** | **52.9 (Avg)** | **$ 10,888.84** | | **$ 2,722.21** |

| # | District | System Name | Billing Type | System Size kW | System Size kWh | Start Date | End Date | GCN Bill Month | NC kW Reduction | On-Pk kW Reduction | Customer Bill Reduction | Portion Customer Keeps | Customer Value |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Poway | Westwood ES | Direct Acces | 250 | 500 | 2/6/2017 | 3/8/2017 | February | 52.8 | -31.9 | $ 1,053.73 | 35% | $ 368.81 |
| 2 | Poway | Westwood ES | Direct Acces | 250 | 500 | 3/9/2017 | 4/6/2017 | March | 67.8 | 30.4 | $ 1,891.54 | 35% | $ 662.04 |
| 3 | Poway | Westwood ES | Direct Acces | 250 | 500 | 4/7/2017 | 5/8/2017 | April | 102.4 | 85.9 | $ 3,389.94 | 35% | $ 1,186.48 |
| 4 | Poway | Westwood ES | Direct Acces | 250 | 500 | 5/9/2017 | 6/7/2017 | May | 68.3 | 68.3 | $ 2,372.72 | 35% | $ 830.45 |
| 5 | Poway | Westwood ES | Direct Acces | 250 | 500 | 6/8/2017 | 7/9/2017 | June | 33.5 | 46.7 | $ 1,300.25 | 35% | $ 455.09 |
| **(AVERAGE) or TOTAL** | | | | | | | | | **65 (Avg)** | **39.9 (Avg)** | **$ 10,008.17** | | **$ 3,502.86** |

| # | District | System Name | Billing Type | System Size kW | System Size kWh | Start Date | End Date | GCN Bill Month | NC kW Reduction | On-Pk kW Reduction | Customer Bill Reduction | Portion Customer Keeps | Customer Value |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Poway | Willow Grove ES | Bundled | 250 | 500 | 1/31/2017 | 3/2/2017 | February | 62.4 | 31.7 | $ 1,768.10 | 25% | $ 442.02 |
| 2 | Poway | Willow Grove ES | Bundled | 250 | 500 | 3/3/2017 | 4/2/2017 | March | 82.2 | 118.6 | $ 2,913.20 | 25% | $ 728.30 |
| 3 | Poway | Willow Grove ES | Bundled | 250 | 500 | 4/3/2017 | 5/2/2017 | April | 0.0 | 86.5 | $ 886.91 | 25% | $ 221.73 |
| 4 | Poway | Willow Grove ES | Bundled | 250 | 500 | 5/3/2017 | 6/1/2017 | May | 79.7 | 130.7 | $ 3,294.58 | 25% | $ 823.65 |
| 5 | Poway | Willow Grove ES | Bundled | 250 | 500 | 6/2/2017 | 7/2/2017 | June | 37.0 | 119.2 | $ 2,129.50 | 25% | $ 532.38 |
| **(AVERAGE) or TOTAL** | | | | | | | | | **52.3 (Avg)** | **97.4 (Avg)** | **$ 10,992.29** | | **$ 2,748.07** |

| | | | | System Size | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **#** | **District** | **System Name** | **Billing Type** | **kW** | **kWh** | **Start Date** | **End Date** | **GCN Bill Month** | **NC kW Reduction** | **On-Pk kW Reduction** | **Customer Bill Reduction** | **Portion Customer Keeps** | **Customer Value** |
| 1 | Poway | Highland Ranch | Direct Acces | 250 | 500 | 3/13/2017 | 4/10/2017 | March | 28.6 | 2.9 | $ 723.55 | 35% | $ 253.24 |
| 2 | Poway | Highland Ranch | Direct Acces | 250 | 500 | 4/11/2017 | 5/10/2017 | April | 60.6 | 84.6 | $ 2,353.33 | 35% | $ 823.66 |
| 3 | Poway | Highland Ranch | Direct Acces | 250 | 500 | 5/11/2017 | 6/11/2017 | May | 95.6 | 74.3 | $ 3,104.79 | 35% | $ 1,086.68 |
| 4 | Poway | Highland Ranch | Direct Acces | 250 | 500 | 6/12/2017 | 7/11/2017 | June | 12.8 | 33.2 | $ 652.81 | 35% | $ 228.48 |
| 5 | Poway | Highland Ranch | Direct Acces | 250 | 500 | 7/12/2017 | 8/9/2017 | July | 80.0 | 79.6 | $ 2,776.12 | 35% | $ 971.64 |
| **(AVERAGE) or TOTAL** | | | | | | | | | **49.4 (Avg)** | **48.7 (Avg)** | **$ 9,610.60** | | **$ 3,363.71** |

| | | | | System Size | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **#** | **District** | **System Name** | **Billing Type** | **kW** | **kWh** | **Start Date** | **End Date** | **GCN Bill Month** | **NC kW Reduction** | **On-Pk kW Reduction** | **Customer Bill Reduction** | **Portion Customer Keeps** | **Customer Value** |
| 1 | Poway | District Office | Direct Acces | 250 | 500 | 4/11/2017 | 5/10/2017 | April | 68.7 | 63.7 | $ 2,337.32 | 25% | $ 584.33 |
| 2 | Poway | District Office | Direct Acces | 250 | 500 | 5/11/2017 | 6/11/2017 | May | 47.8 | 49.1 | $ 1,674.07 | 25% | $ 418.52 |
| 3 | Poway | District Office | Direct Acces | 250 | 500 | 6/12/2017 | 7/11/2017 | June | 90.3 | 95.4 | $ 3,190.48 | 25% | $ 797.62 |
| 4 | Poway | District Office | Direct Acces | 250 | 500 | 7/12/2017 | 8/9/2017 | July | 66.9 | 78.5 | $ 2,443.34 | 25% | $ 610.83 |
| **(AVERAGE) or TOTAL** | | | | | | | | | **68.4 (Avg)** | **71.7 (Avg)** | **$ 9,645.20** | | **$ 2,411.30** |

# Appendix D

*Sample DR Simulated Event Notification*

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**DEMAND RESPONSE SIMULATION**

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To Whom It May Concern,

This letter serves as notification of a Simulated Demand Response Event for the schools and education support facilities listed below.
The Simulated Demand Response Event is scheduled to occur at the date and time shown below.
This simulation is for the purpose of evaluating the Demand Response capabilities of the Energy Storage Systems (ESS) installed at the sites listed.

**No action is required on the part of the school site staff, please continue to operate your buildings as you normally would.**

| | |
|---|---|
| **Event Date:** | x/xx/2017 |
| **Event Start Time:** | 0:00 PM (local) |
| **Event Duration:** | 2-hours |
| **Notification Type:** | Day-Ahead |
| **Notified On:** | x/xx/2017 0:00 PM |

List of Sites included in this Demand Response Simulated Event is shown below.

| District | Site Common Name |
|---|---|
| GUHSD | East. Co. Regional Ed. Center |
| GUHSD | El Capitan High School |
| GUHSD | Foothills Adult School |
| GUHSD | Grossmont High School |
| GUHSD | Mount Miguel High School |
| GUHSD | Santana High School (2 systems) |
| PUSD | Black Mountain Middle School |
| PUSD | Del Norte High School (2 systems) |
| PUSD | Del Sur Elementary School |
| PUSD | Garden Road Elementary School |
| PUSD | Mesa Verde Elementary School |
| PUSD | Midland Elementary School |
| PUSD | Park Village Elementary School |
| PUSD | Stone Ranch Elementary School |
| PUSD | Westwood Elementary School |
| PUSD | Willow Grove Elementary School |
| PUSD | Highland Ranch Elementary School |
| PUSD | District Office (Ave of Science) |

Thank you for your assistance in this evaluation study of the ESS's being performed for SDG&E.

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# Appendix E

*Demand Response Simulation Charts*

| # | District | System Name | System Size | DR-1 7/27/2017 | DR-2 8/15/2017 | DR-3 8/16/2017 | DR-4 10/10/2017 | DR-5 10/11/2017 | DR-6 10/20/2017 | DR-7 10/24/2017 | DR-8 10/25/2017 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Notification Type | | | | | | | |
| | | | | Day-Ahead | Day-Ahead | Same-Day | 30-Minute | Same-Day | Same-Day | 30-Minute | Same-Day |
| | | | | Simulated Event Duration (hrs.) | | | | | | | |
| | | | | 2 | 4 | 2 | 2 | 4 | 2 | 2 | 4 |
| | | | | Avg. Curtailment vs. 10-in-10 baseline (kW) / Apparent Event Participation (Yes/No) | | | | | | | |
| 1 | GUHSD | East County REC | 30 kW / 60 kWh | -1.3 / NO | 9.6 / YES | 18.2 / YES | 1.2 / NO | 3.6 / YES | 13.0 / YES | -8.0 / NO | -13.1 / NO |
| 2 | GUHSD | El Capitan HS | 250 kW / 500 kWh | 29.5 / YES | 30.6 / YES | 21.2 / YES | -3.9 / NO | 50.1 / NO | 172.0 / YES | 57.2 / YES | 2.5 / NO |
| 3 | GUHSD | Foothill Adult | 60 kW / 120 kWh | -20.8 / NO | 24.0 / YES | 21.0 / YES | 8.8 / NO | 12.4 / YES | 41.4 / YES | -10.2 / YES | -27.2 / NO |
| 4 | GUHSD | Grossmont HS | 250 kW / 500 kWh | 53.3 / YES | 69.7 / YES | 37.5 / YES | -11.3 / NO | 130.0 / YES | 241.0 / YES | -61.6 / NO | -58.9 / NO |
| 5 | GUHSD | Mt Miguel HS | 250 kW / 500 kWh | -61.5 / NO | 14.6 / NO | -67.6 / NO | -1.8 / NO | 45.8 / NO | 186.1 / YES | 32.8 / NO | -113.2 / NO |
| 6 | GUHSD | Santana HS 1 | 250 kW / 500 kWh | 13.4 / YES | -1.3 / YES | 19.4 / YES | 35.9 / NO | 72.2 / YES | 150.6 / YES | -19.9 / NO | -44.9 / NO |
| 7 | GUHSD | Santana HS 2 | 250 kW / 500 kWh | 6.0 / YES | 14.8 / YES | -3.8 / YES | 41.1 / NO | 63.9 / YES | 116.1 / YES | 11.7 / YES | -37.7 / NO |
| 8 | PUSD | Black Mountain MS | 250 kW / 500 kWh | -11.0 / NO | 9.1 / YES | -2.9 / YES | 14.5 / NO | 68.4 / YES | 236.7 / YES | 9.4 / YES | -8.7 / NO |
| 9 | PUSD | Del Norte HS A | 60 kW / 120 kWh | 22.8 / YES | 212.2 / YES | 185.5 / YES | -10.0 / NO | 232.5 / YES | 219.6 / YES | -54.9 / NO | 8.1 / NO |
| 10 | PUSD | Del Norte HS B | 500 kW / 1000 kWh | -10.6 / NO | -0.3 / NO | 0.9 / NO | -1.6 / NO | 4.4 / NO | -1.5 / NO | -4.1 / NO | -1.1 / NO |
| 11 | PUSD | Del Sur ES | 250 kW / 500 kWh | 26.7 / YES | 58.1 / YES | 72.2 / YES | -4.2 / NO | 90.5 / YES | 163.3 / YES | -19.6 / NO | -15.7 / NO |
| 12 | PUSD | Garden Road ES | 60 kW / 120 kWh | -17.0 / NO | 13.3 / NO | 7.9 / NO | -1.3 / NO | 4.7 / NO | 20.9 / NO | -26.6 / NO | -15.7 / NO |
| 13 | PUSD | Mesa Verde MS | 250 kW / 500 kWh | 10.4 / YES | 84.5 / YES | 74.4 / YES | -7.9 / NO | 43.7 / YES | 141.3 / YES | -17.6 / NO | -5.5 / NO |
| 14 | PUSD | Midland ES | 250 kW / 500 kWh | 24.4 / YES | 108.1 / NO | 122.5 / YES | -1.0 / NO | 8.5 / YES | 115.8 / YES | -47.0 / NO | -47.1 / NO |
| 15 | PUSD | Park Village ES | 250 kW / 500 kWh | -2.3 / YES | 137.8 / YES | 126.3 / YES | 32.4 / NO | 105.4 / YES | 175.4 / YES | -34.7 / NO | -41.4 / NO |
| 16 | PUSD | Stone Ranch ES | 250 kW / 500 kWh | 5.3 / YES | 49.0 / YES | 59.4 / YES | -23.8 / NO | 104.1 / YES | 180.3 / YES | -39.6 / NO | -1.3 / NO |
| 17 | PUSD | Westwood ES | 250 kW / 500 kWh | 21.2 / YES | 134.3 / YES | 132.9 / YES | -1.0 / NO | 84.7 / YES | 177.9 / YES | -41.0 / NO | -57.1 / NO |
| 18 | PUSD | Willow Grove ES | 250 kW / 500 kWh | 0.3 / YES | 125.3 / YES | 119.5 / YES | -18.8 / NO | 69.9 / YES | 166.8 / YES | -85.5 / YES | -33.4 / NO |
| 19 | PUSD | Highland Ranch ES | 250 kW / 500 kWh | 0.2 / YES | 30.0 / YES | 60.9 / YES | 8.9 / NO | 22.8 / YES | 96.8 / YES | -33.6 / NO | -30.3 / NO |
| 20 | PUSD | PUSD Dist. Office | 250 kW / 500 kWh | 35.5 / YES | 37.2 / YES | 92.5 / YES | 48.2 / NO | 51.2 / YES | 123.4 / YES | -21.2 / NO | -21.6 / NO |

**Notes:**

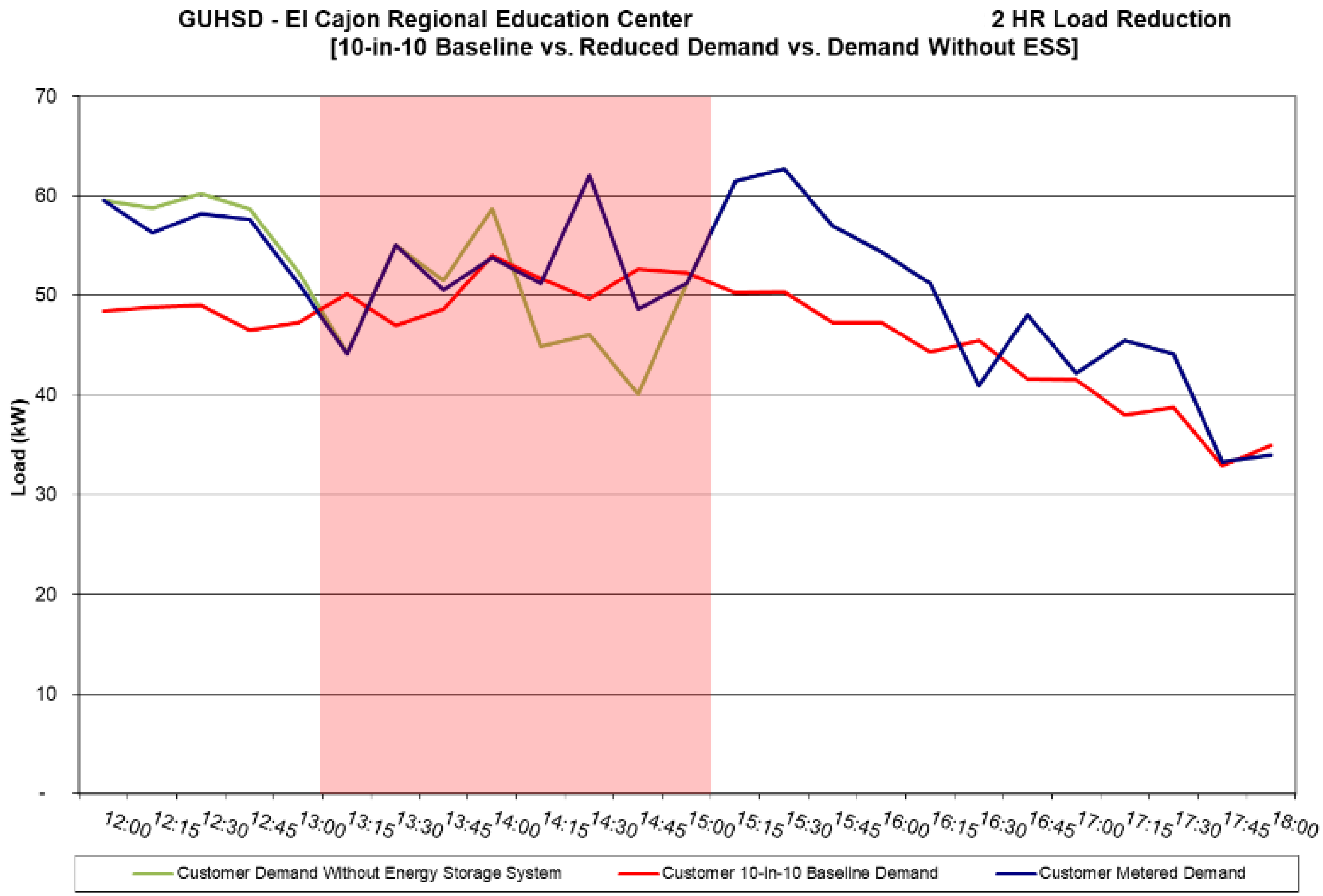
PURPLE TEXT = Day-Ahead Notification given prior to simulated DR event.

BLUE TEXT = Same-Day Notification given prior to simulated DR event.

ORANGE TEXT = 30-Minute Notification given prior to simulated DR event.

***GUHSD - East County Regional Education Center***

*Simulated DR Event #1*



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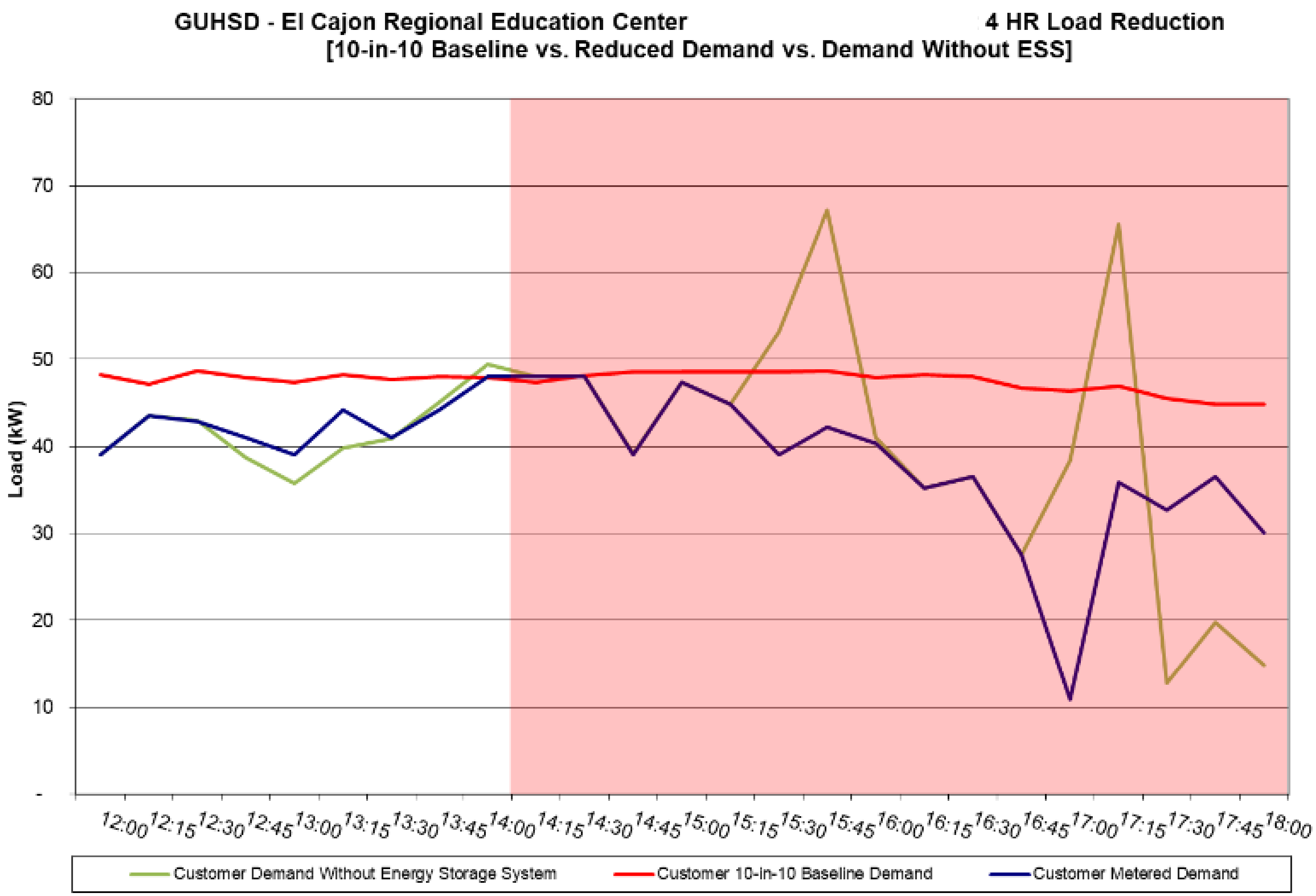

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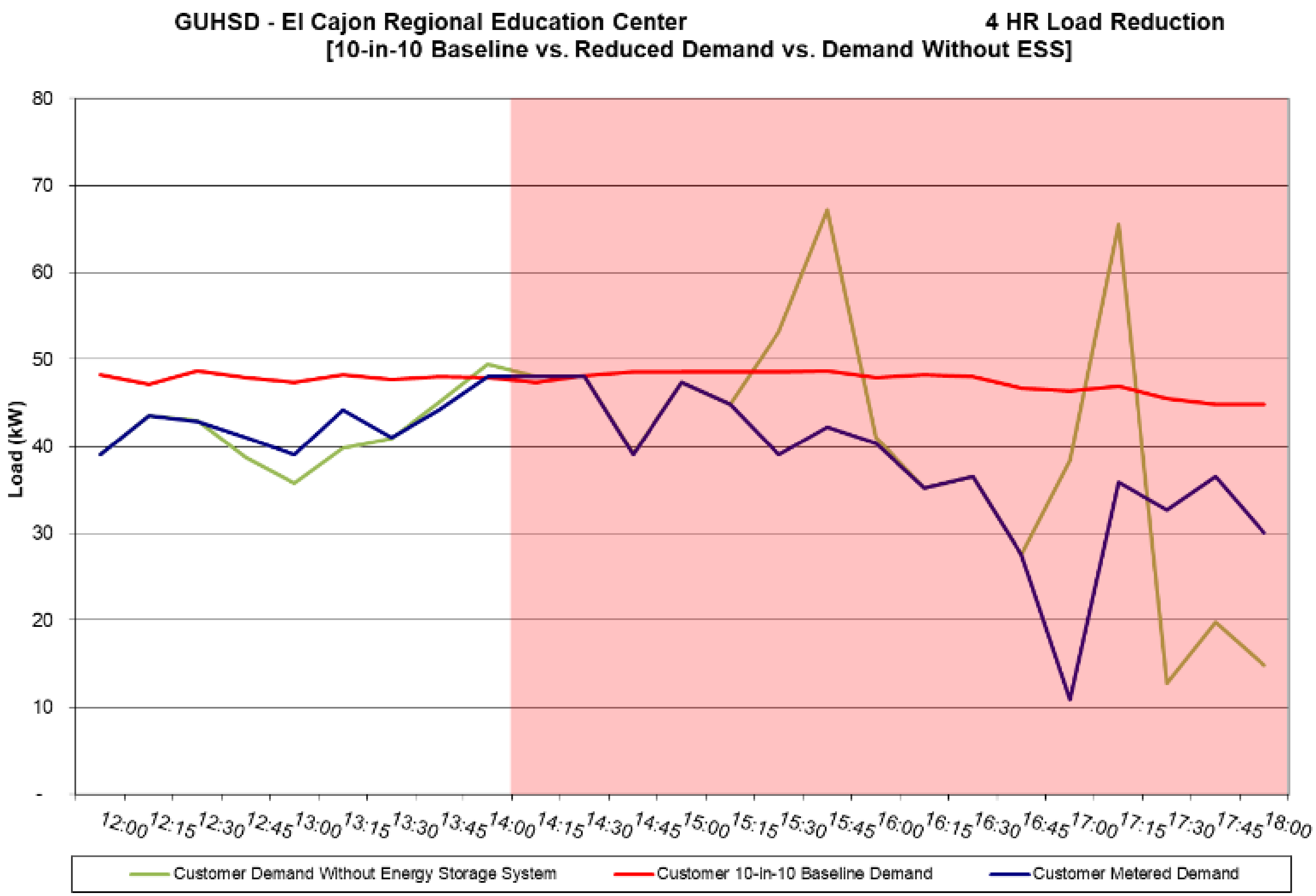

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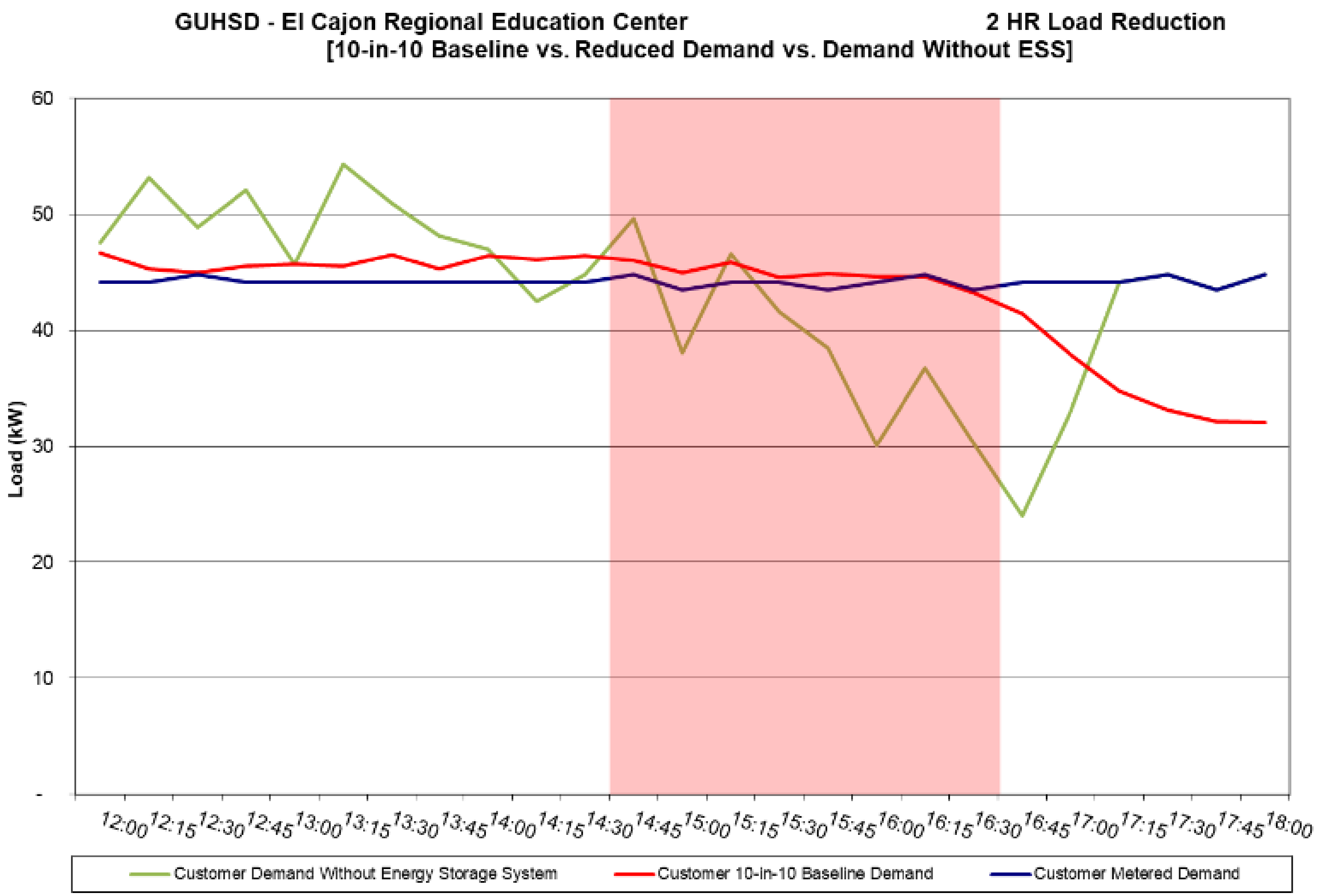

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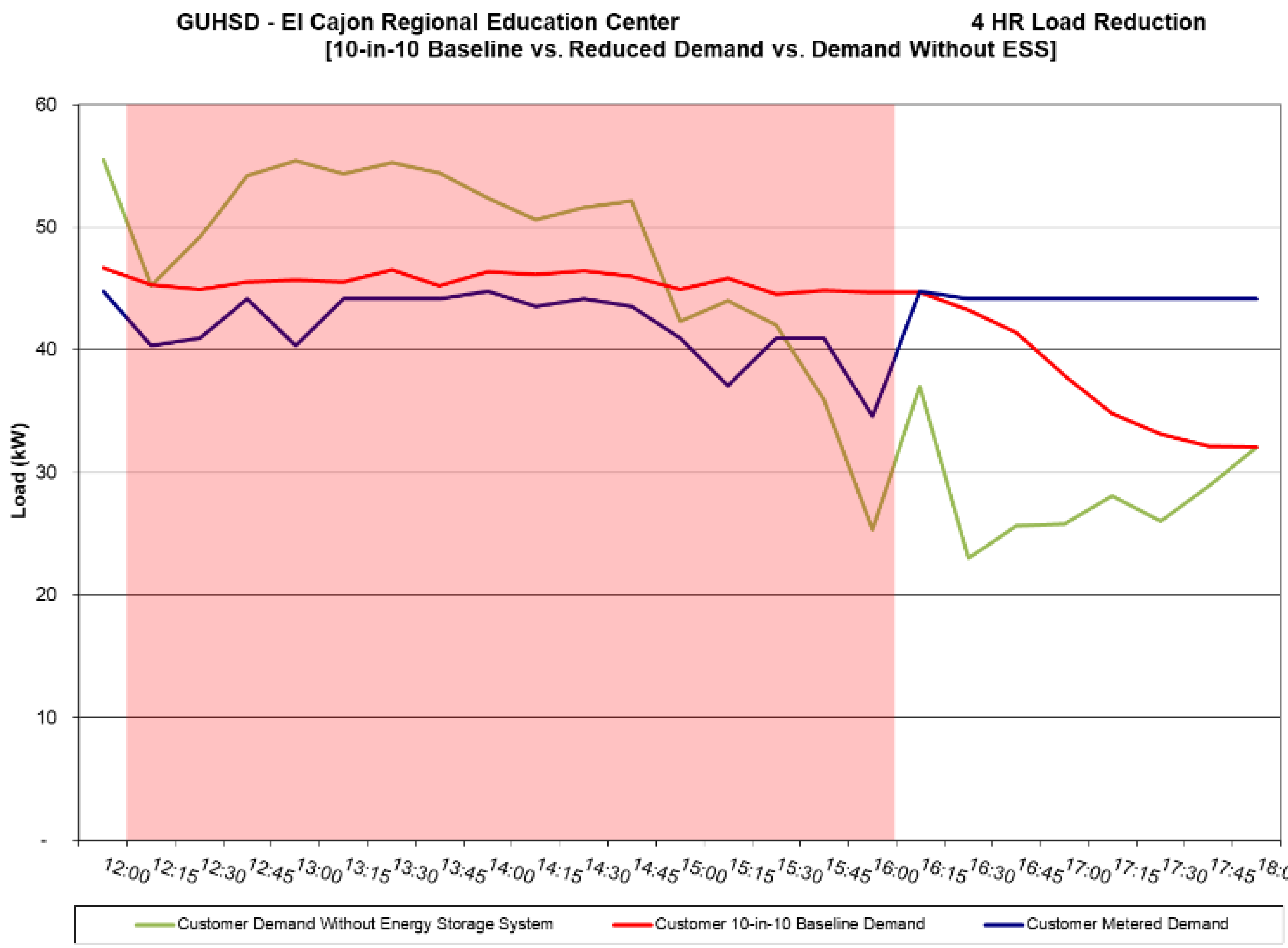
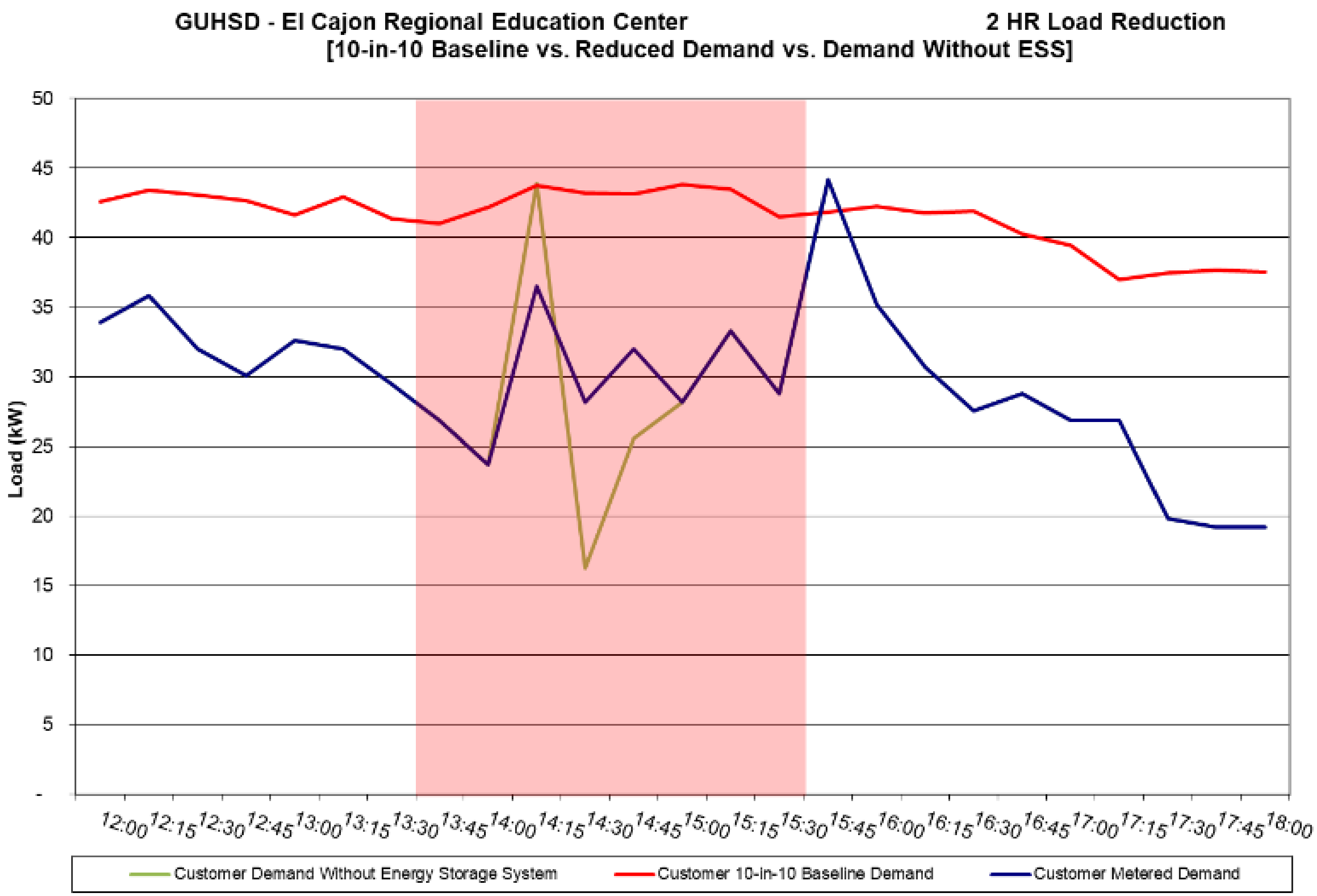


*Simulated DR Event #6*



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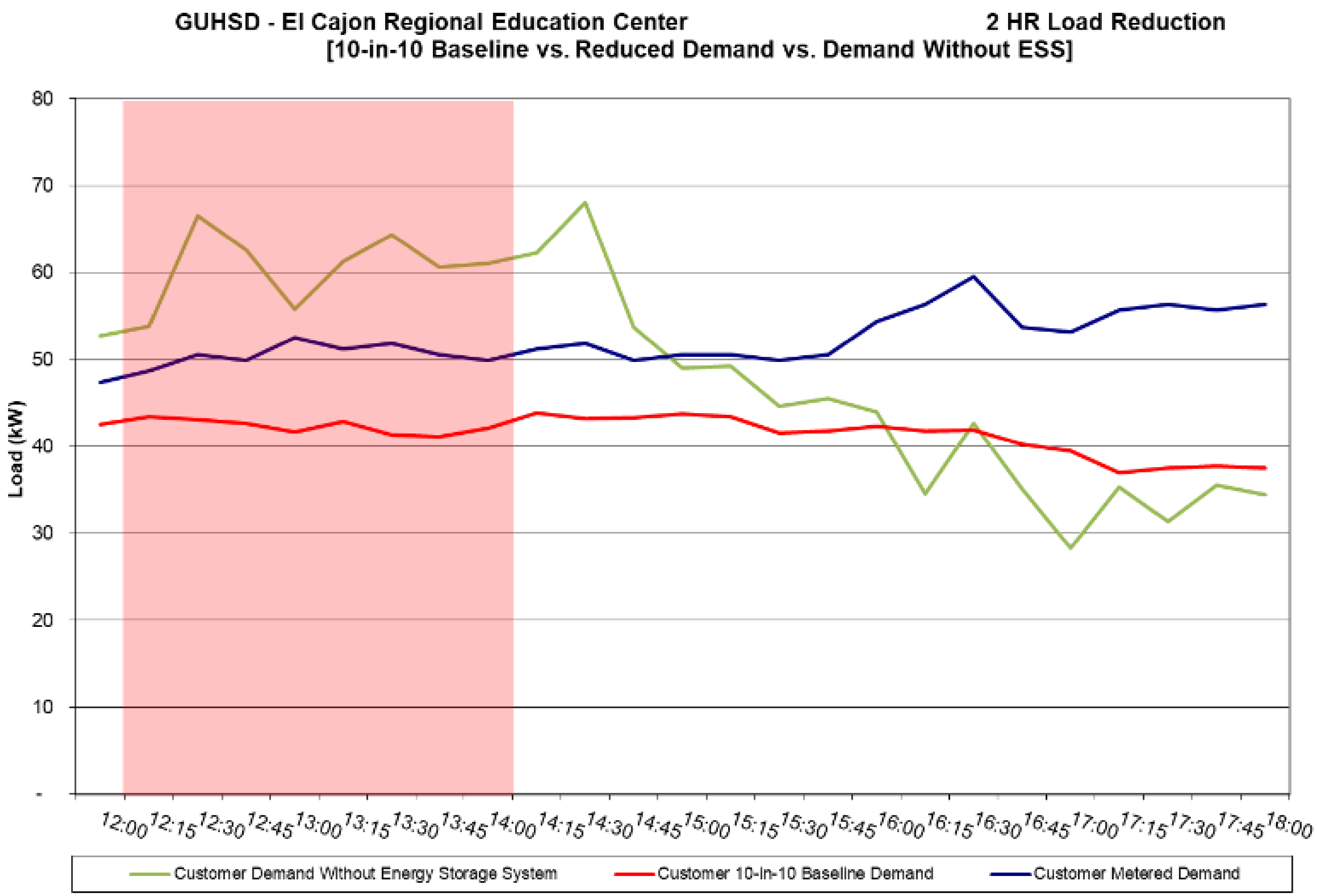
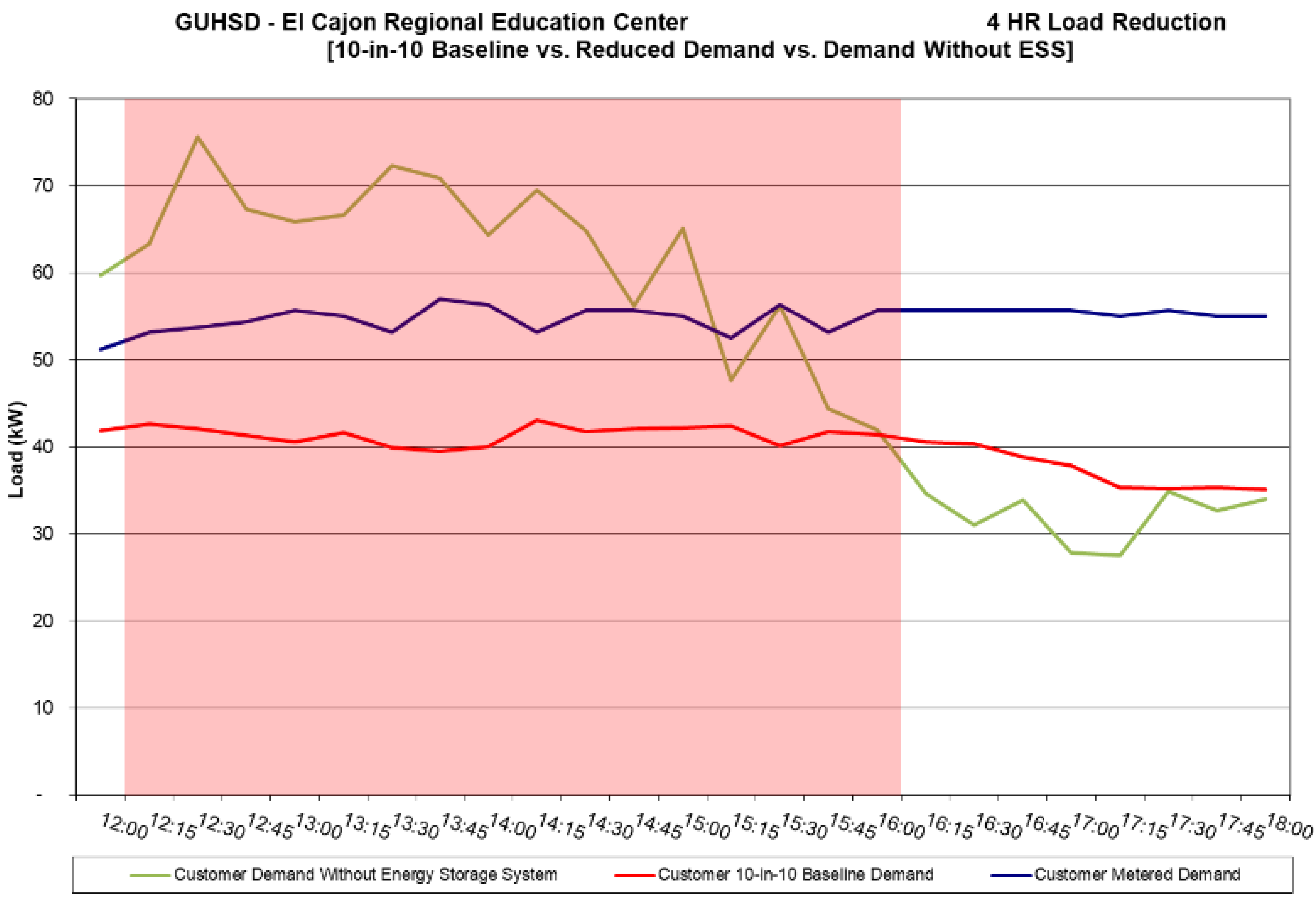
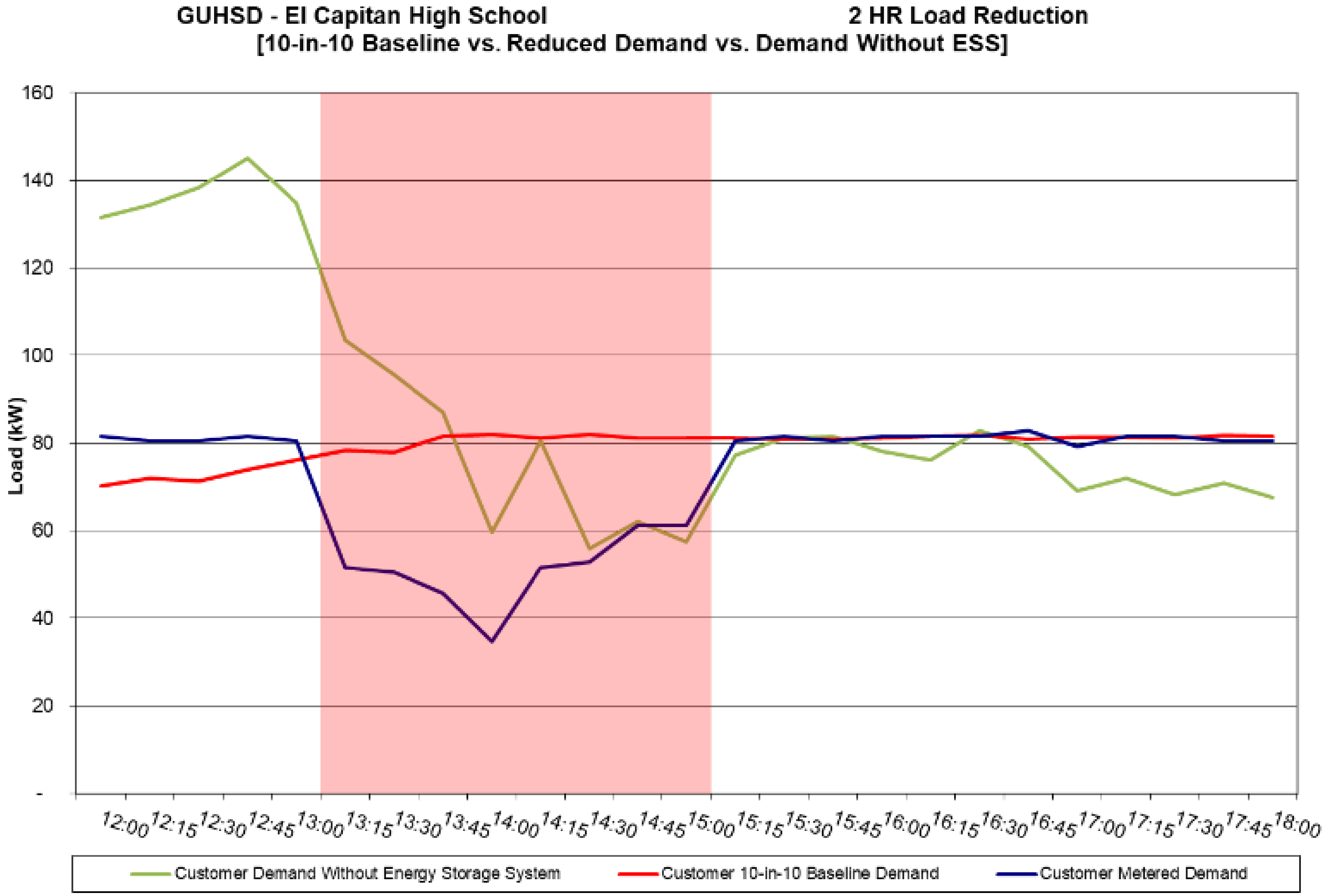


*Simulated DR Event #8*



***GUHSD - El Capitan High School***

*Simulated DR Event #1*



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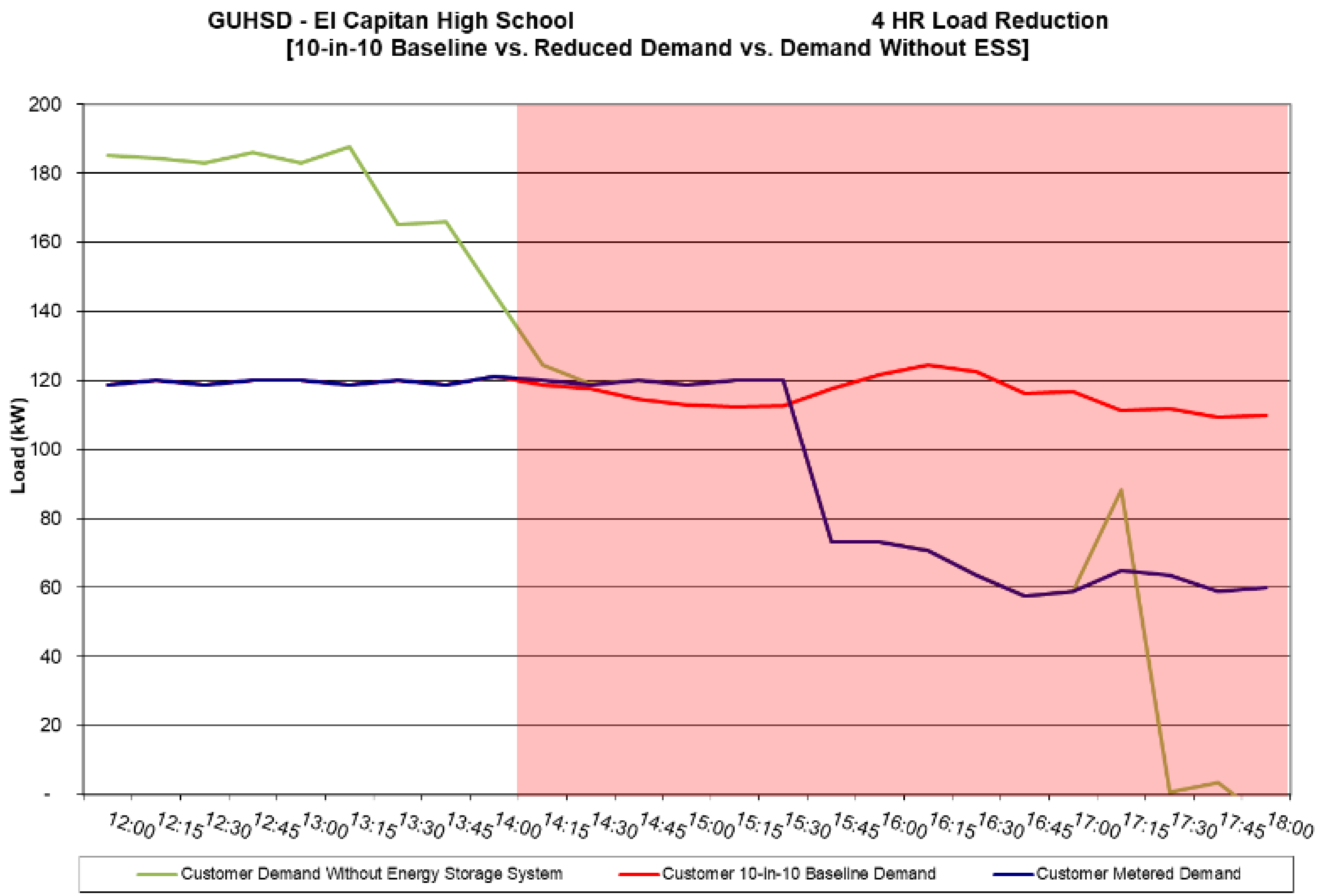

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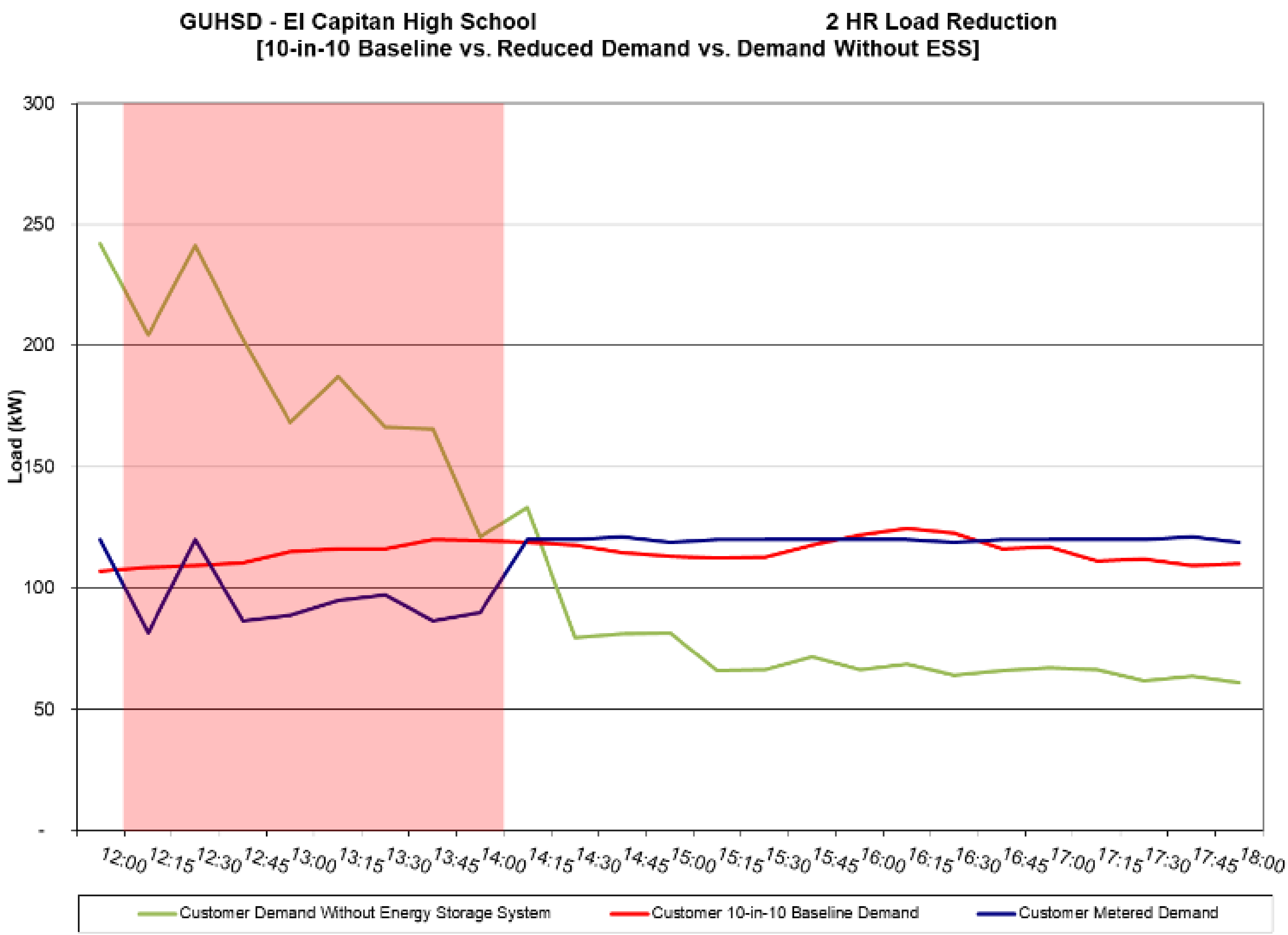

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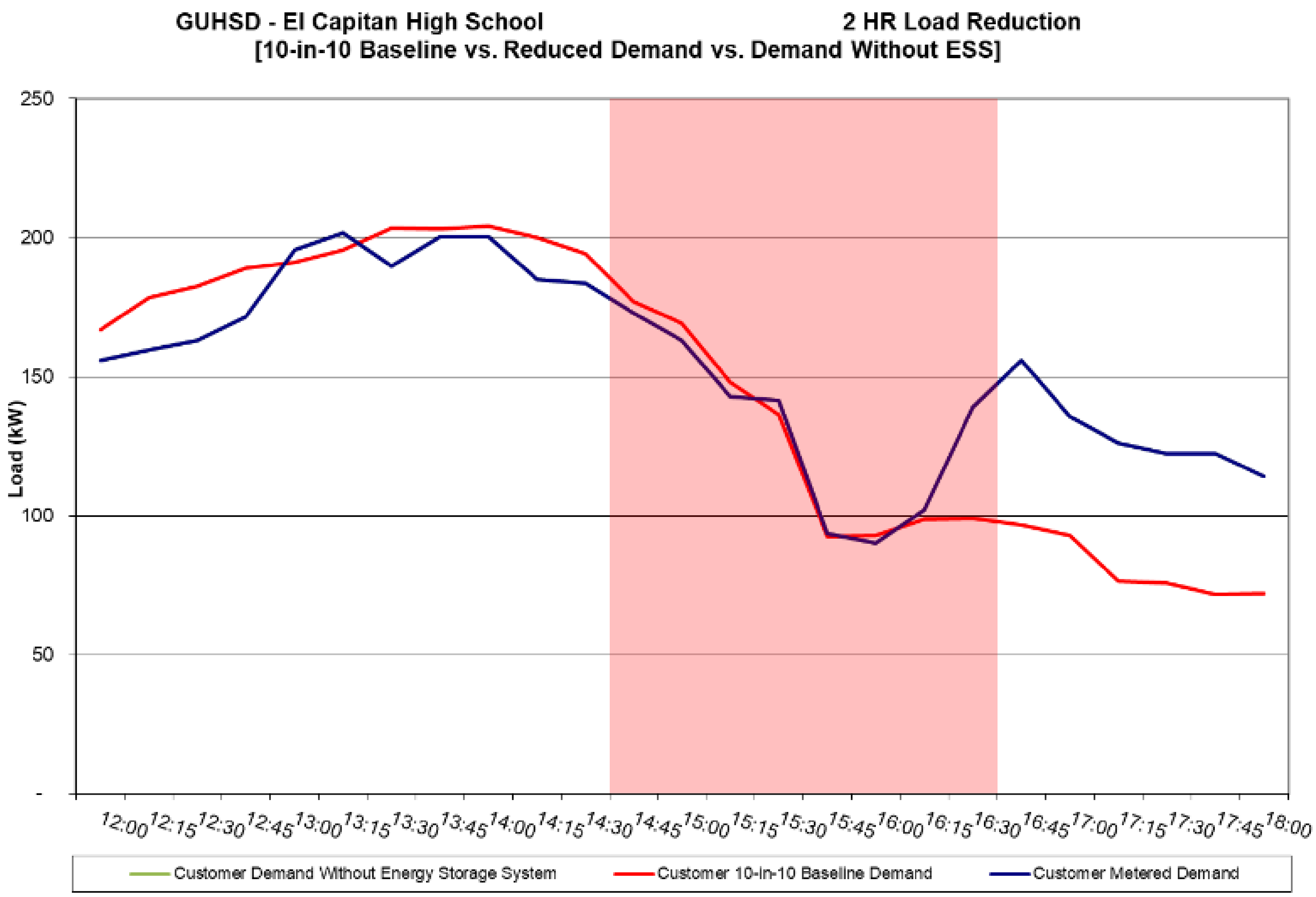

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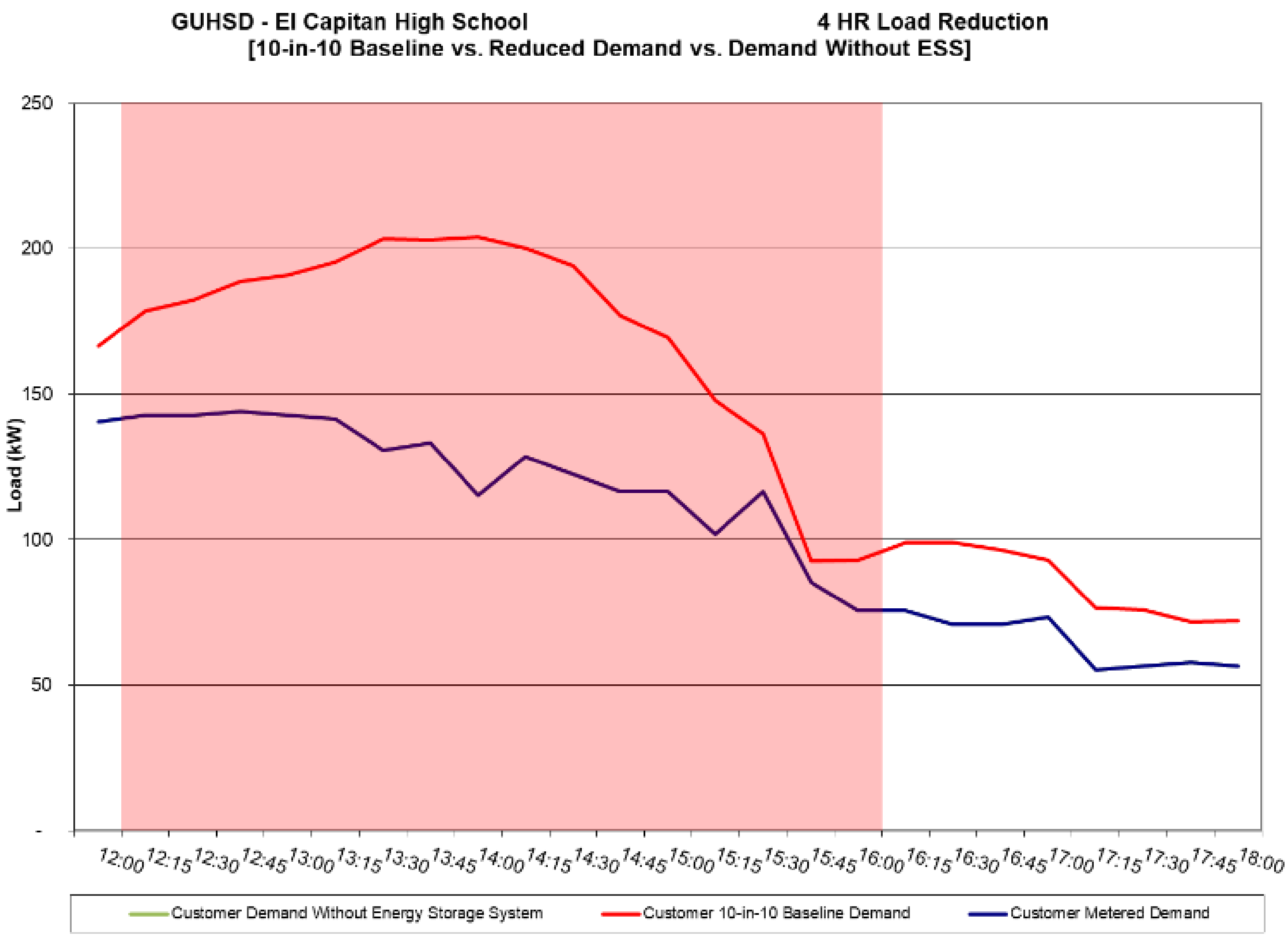

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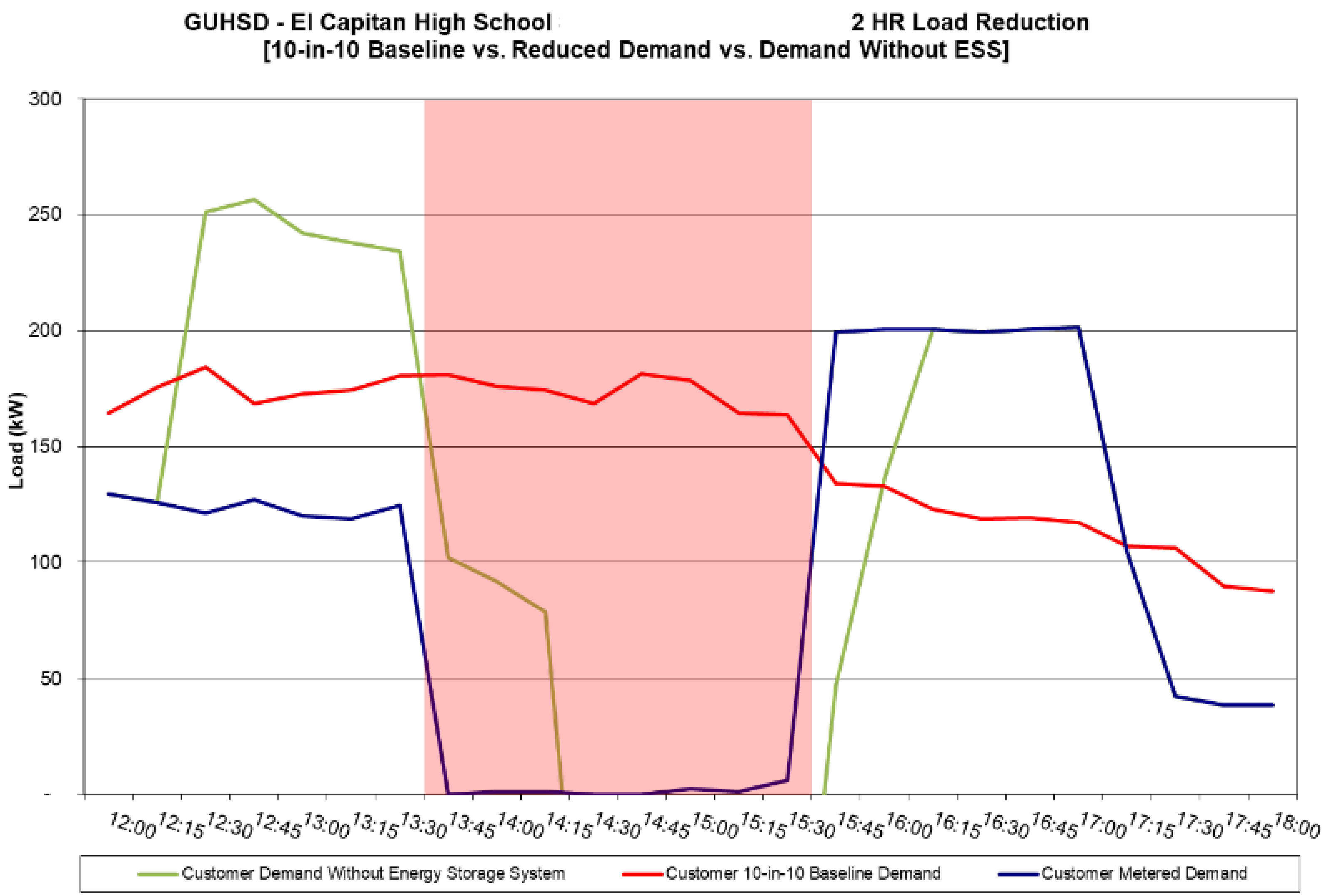
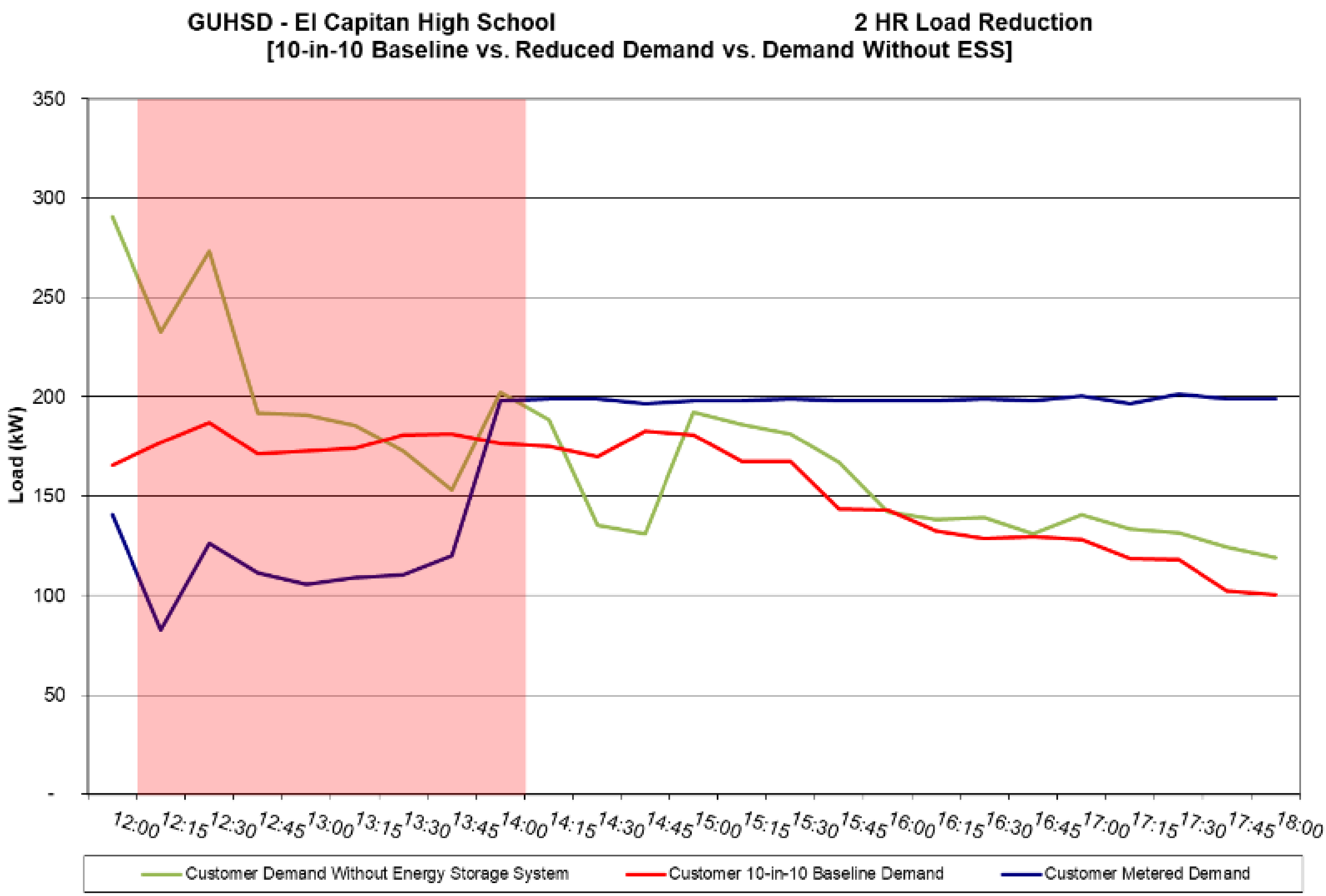
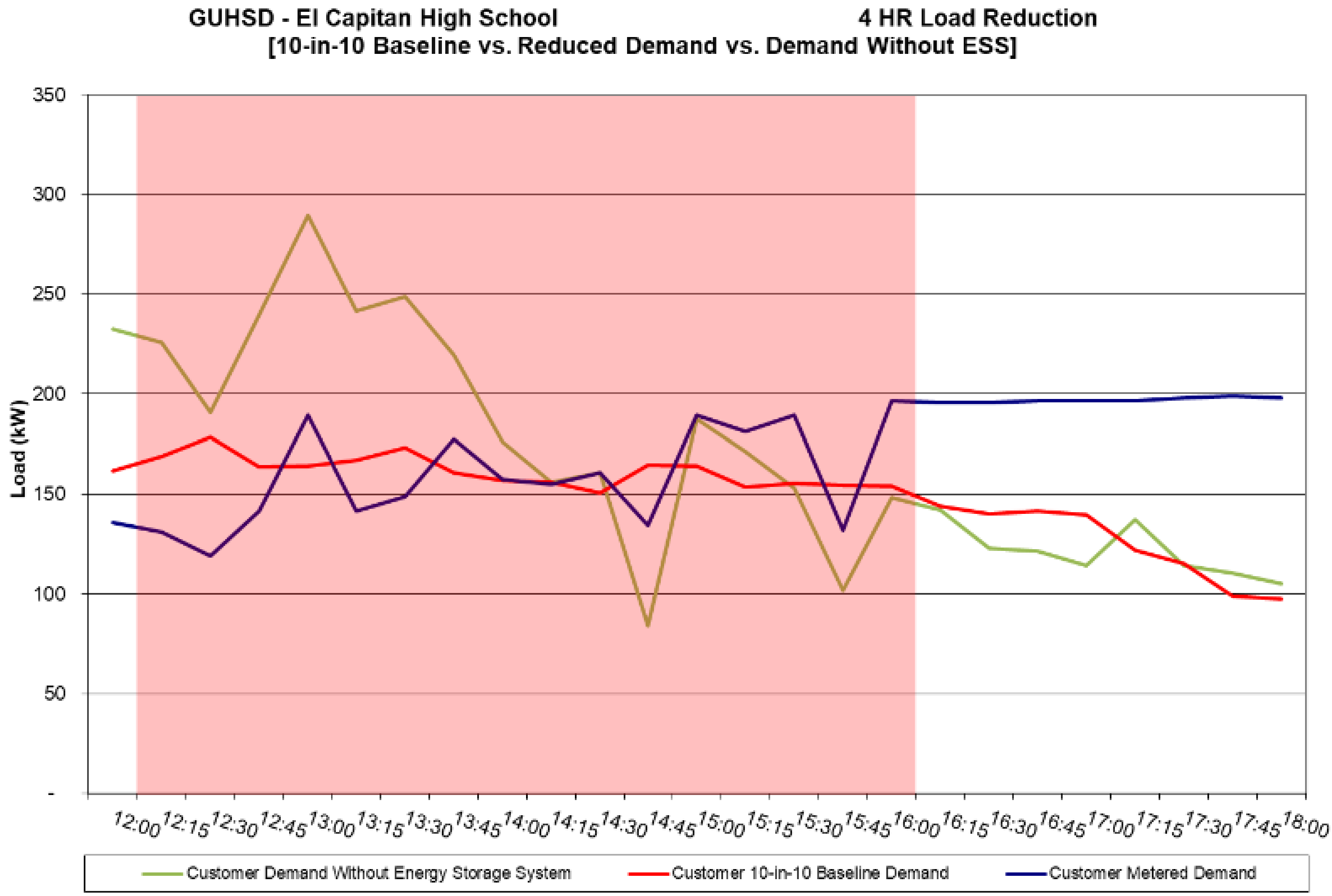


*Simulated DR Event #7*

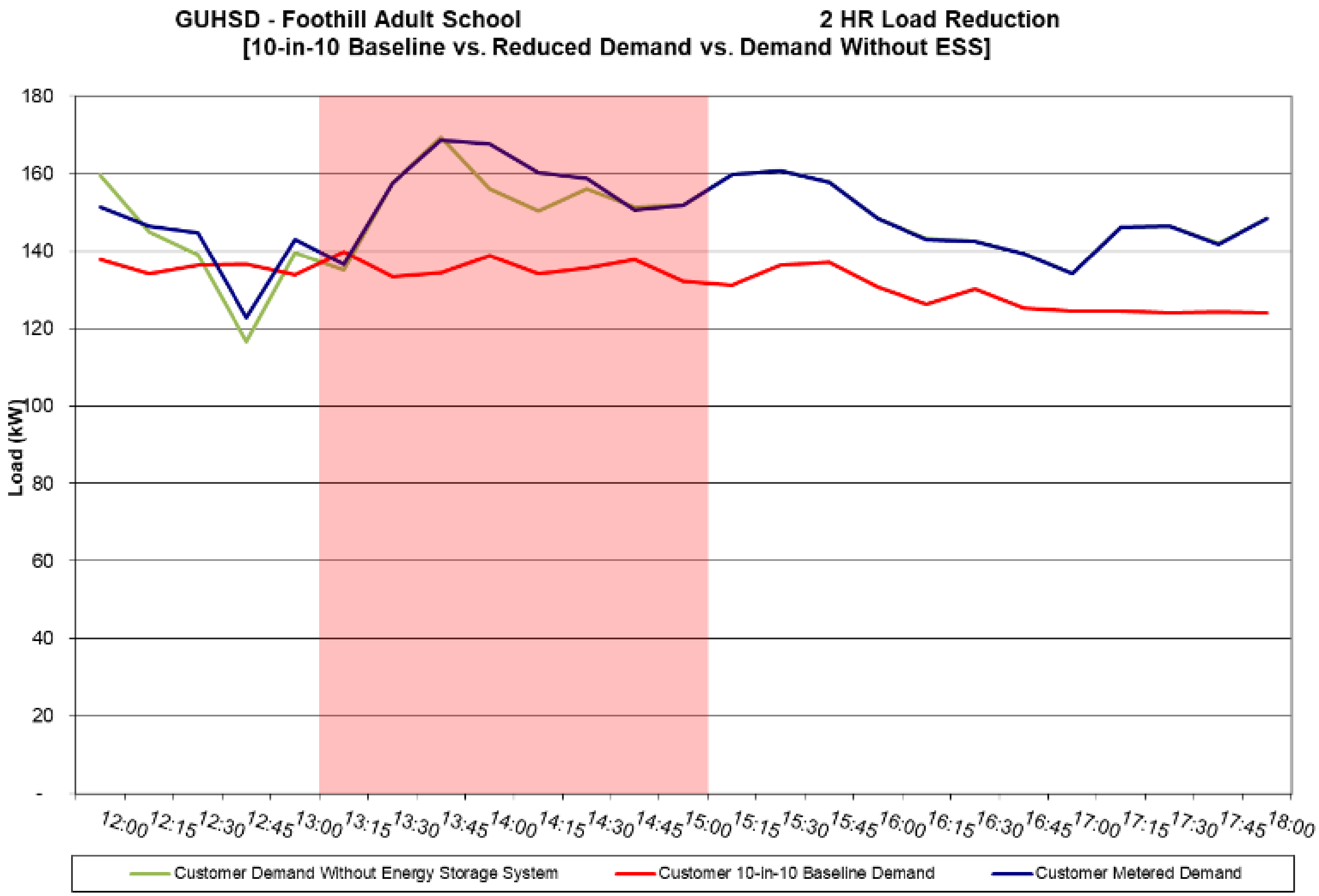


*Simulated DR Event #8*

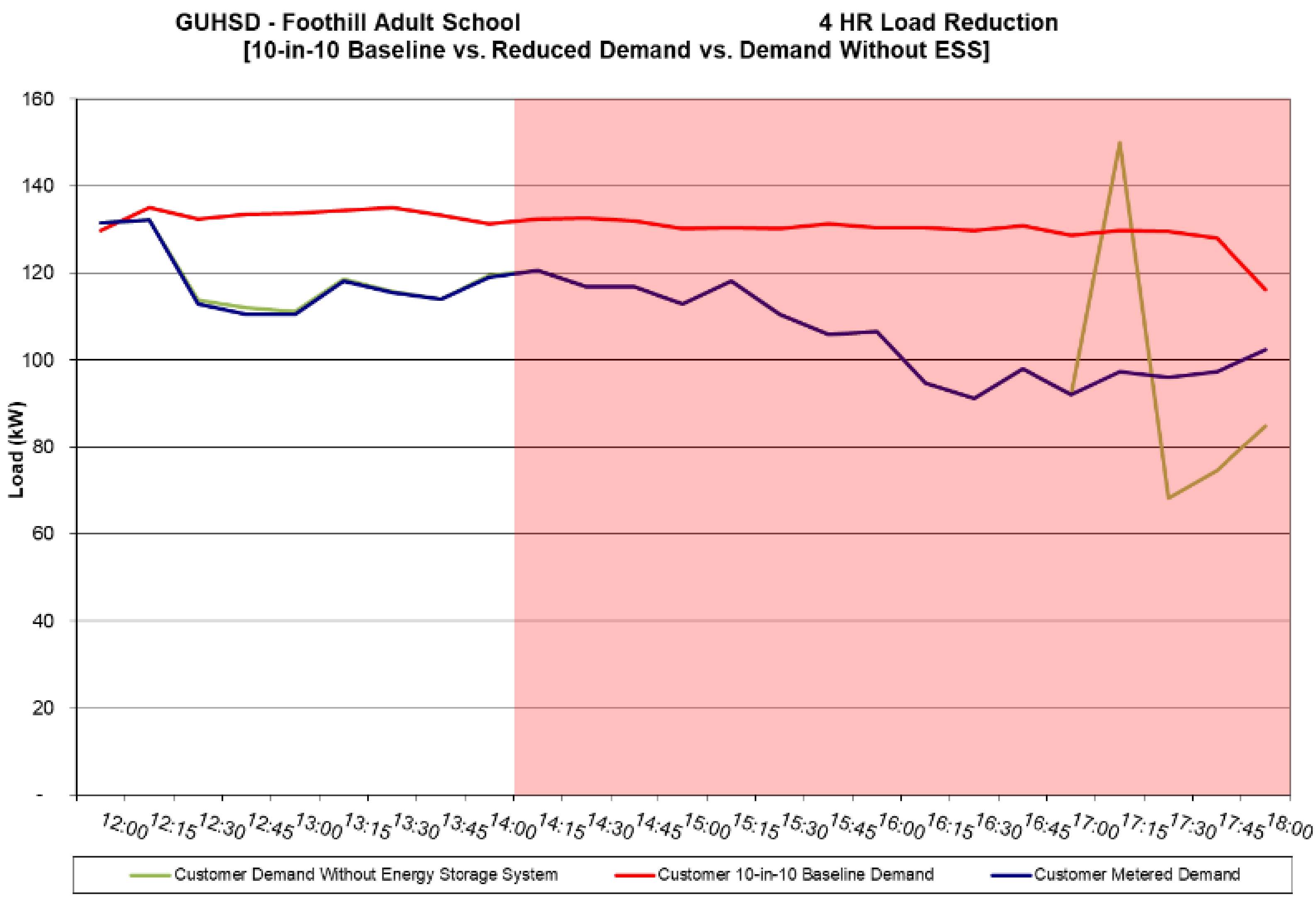


***GUHSD – Foothill Adult School***

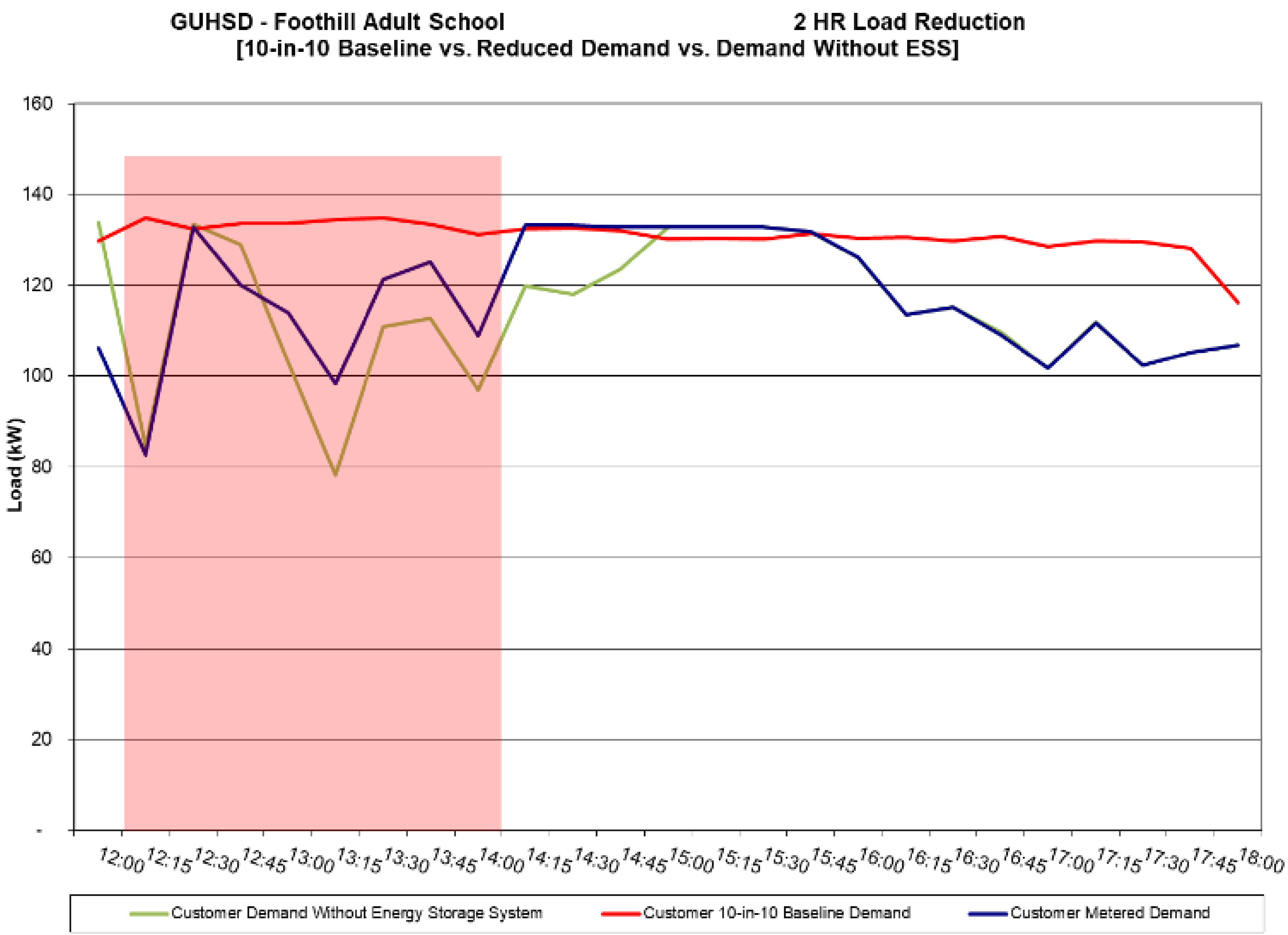
*Simulated DR Event #1*



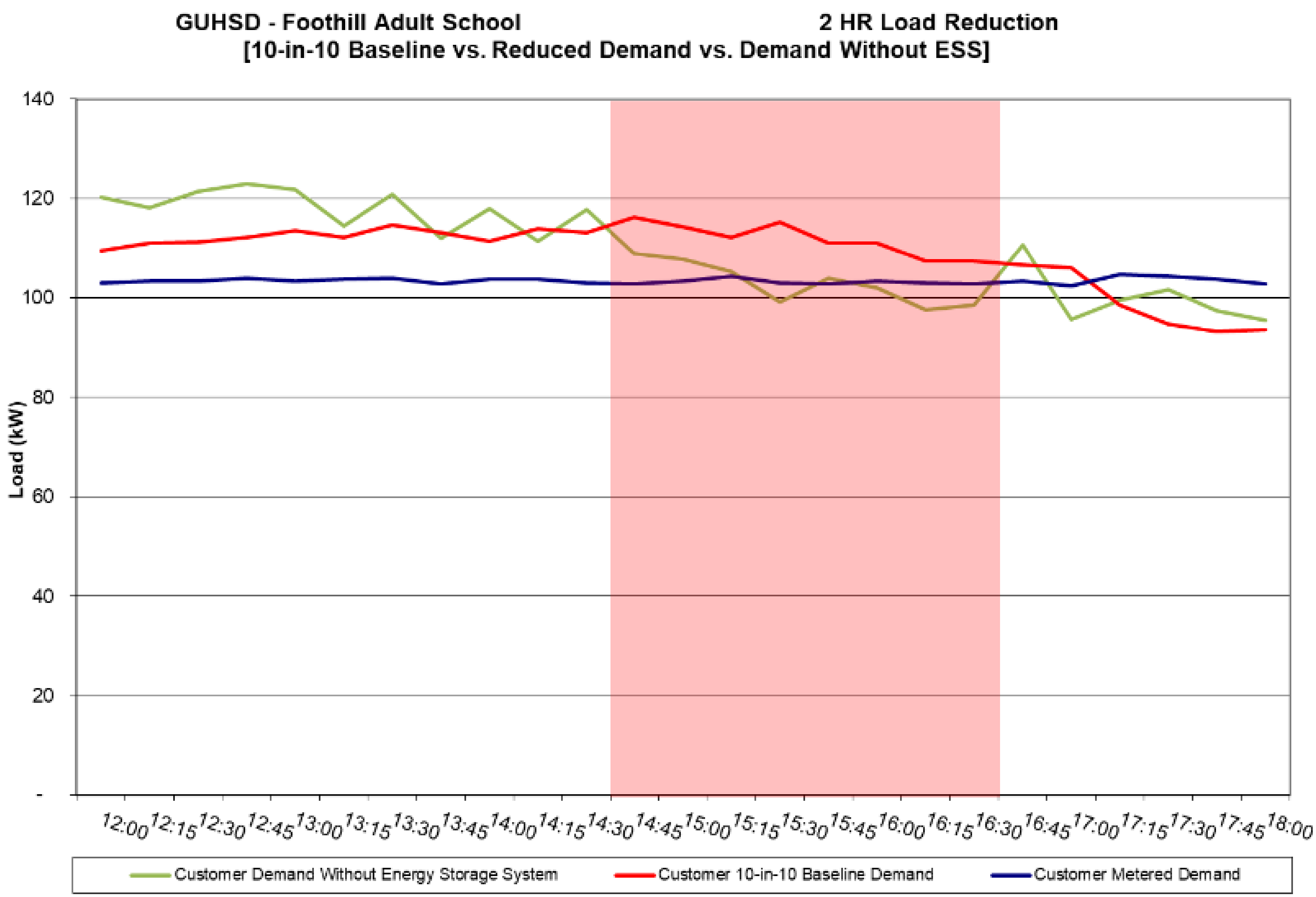
*Simulated DR Event #2*



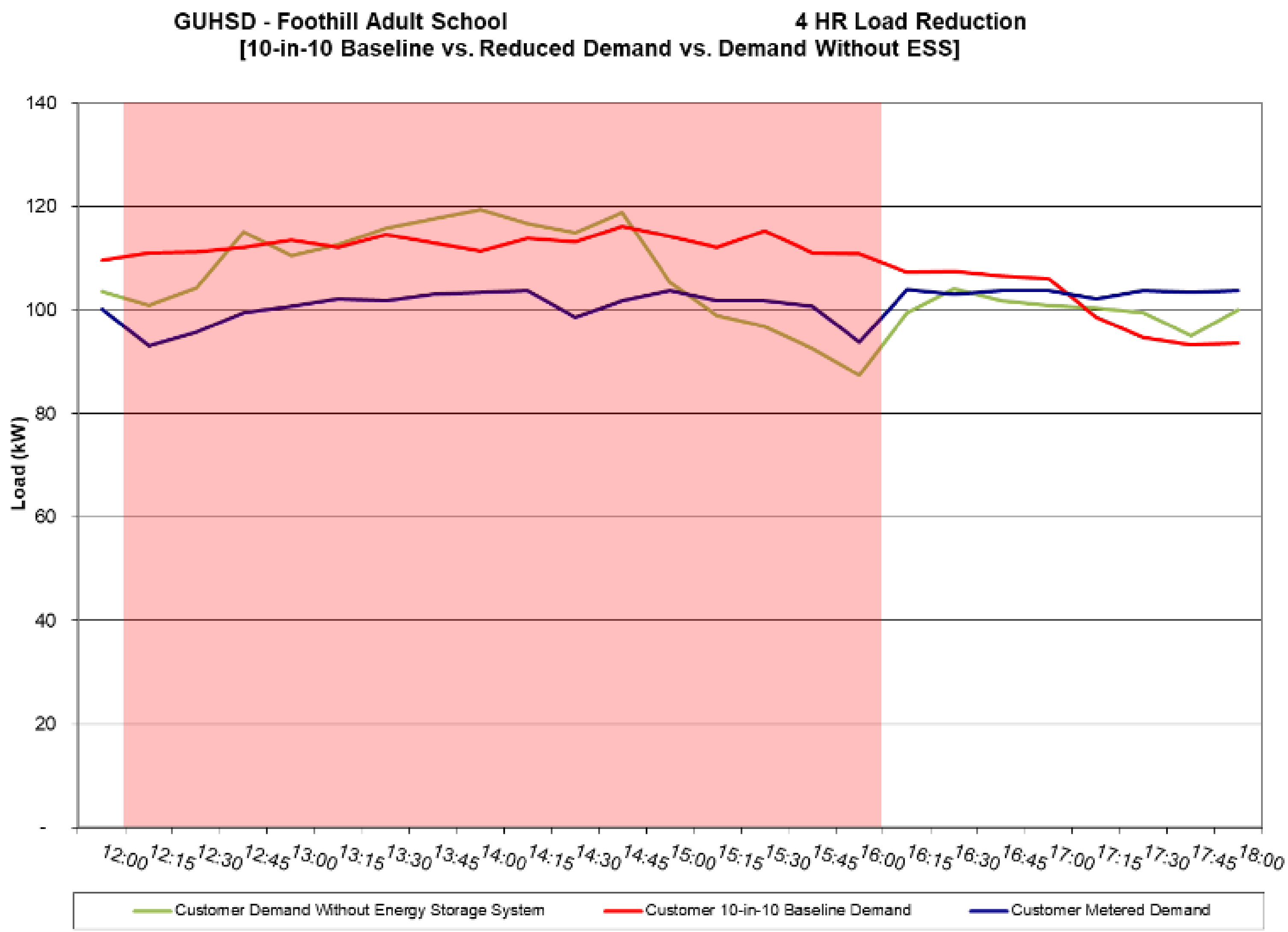
*Simulated DR Event #3*



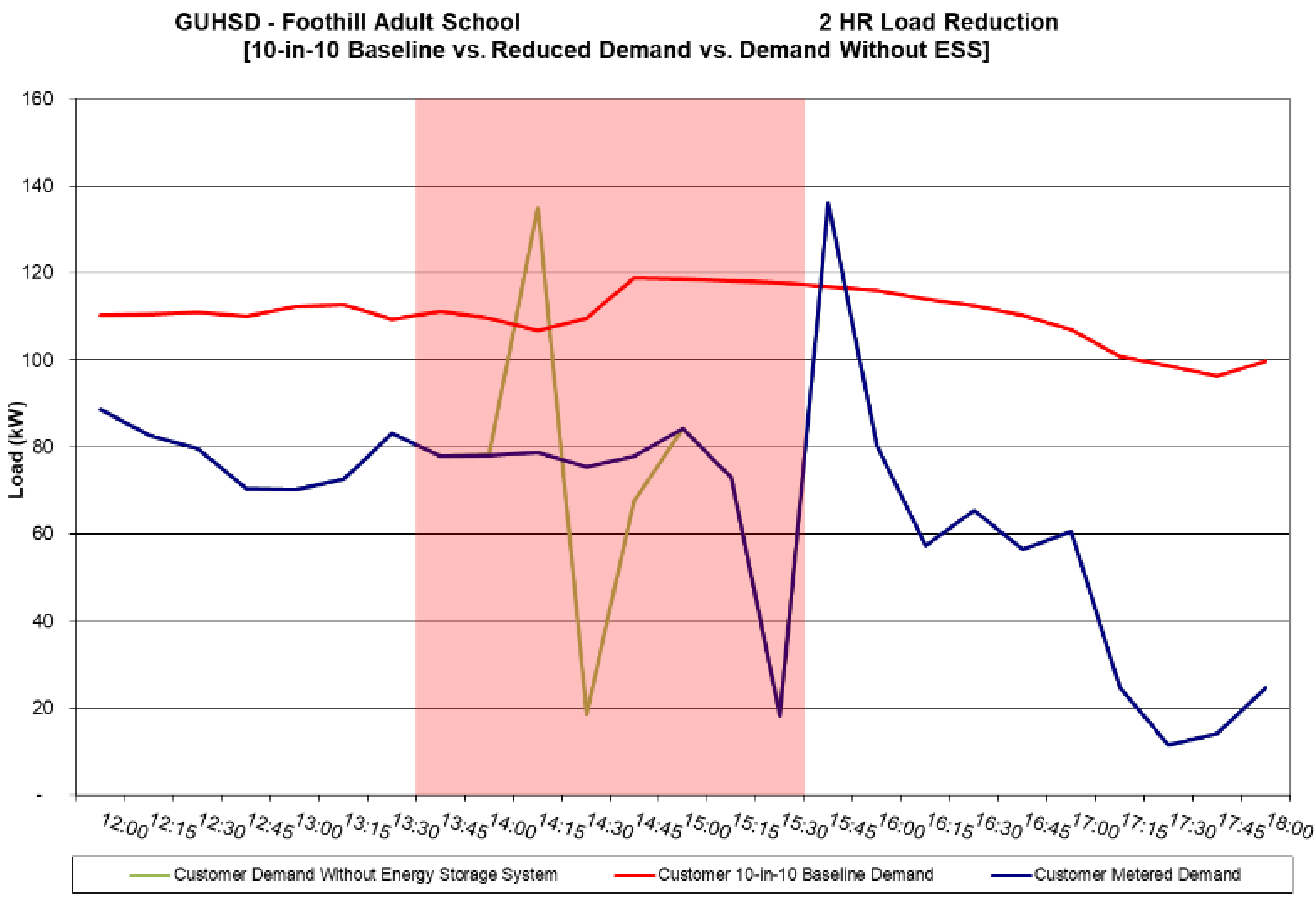
*Simulated DR Event #4*



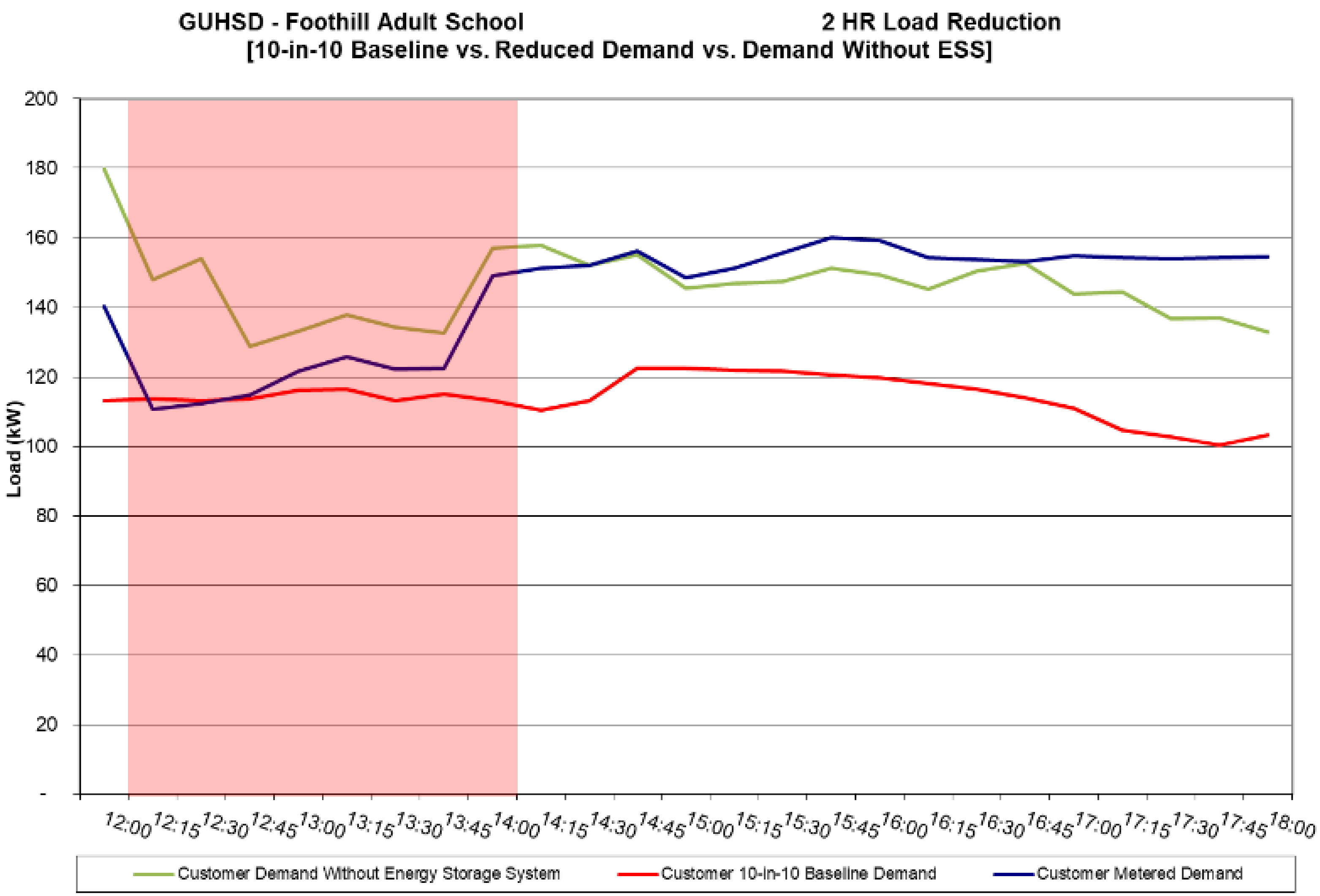
*Simulated DR Event #5*



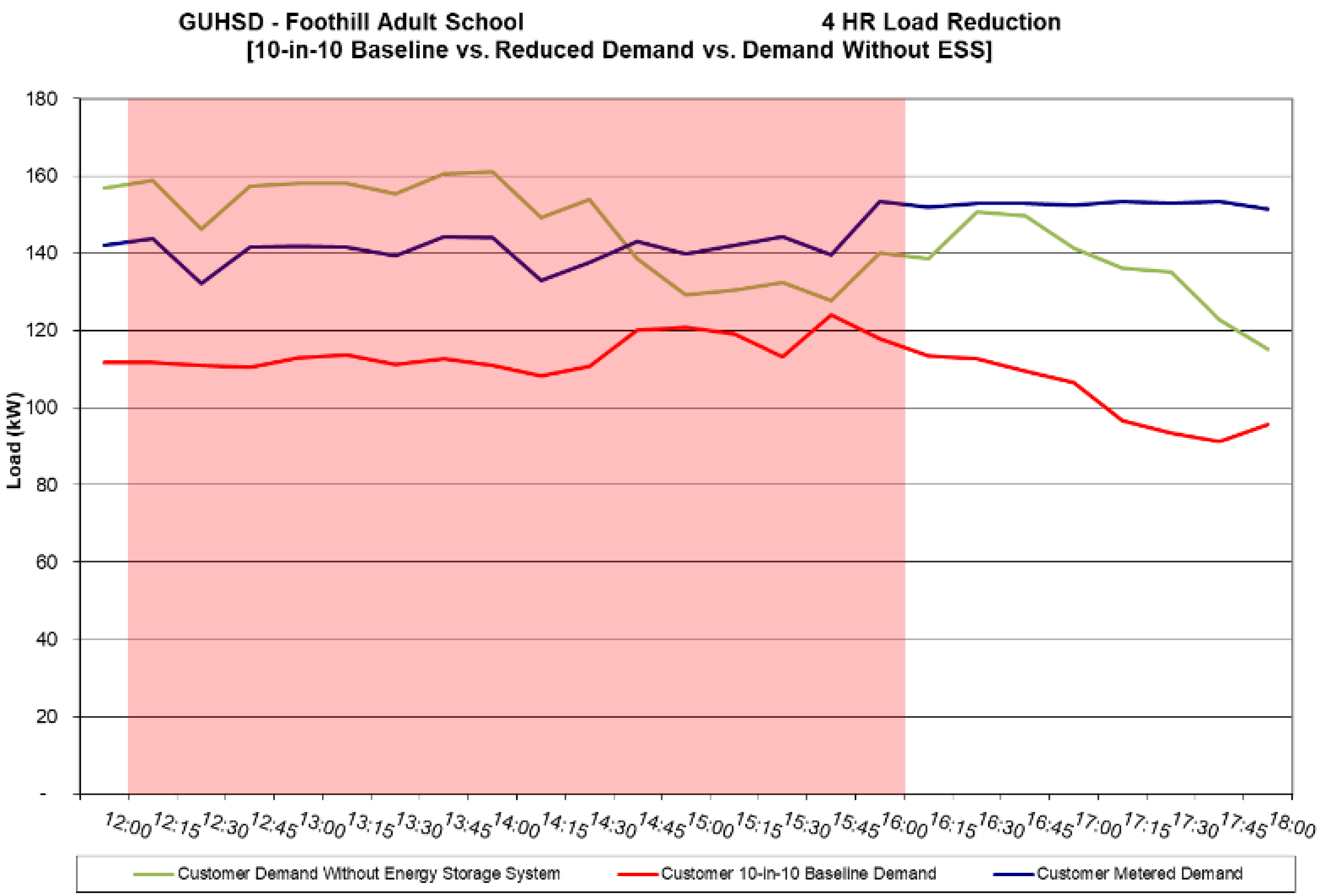
*Simulated DR Event #6*



*Simulated DR Event #7*

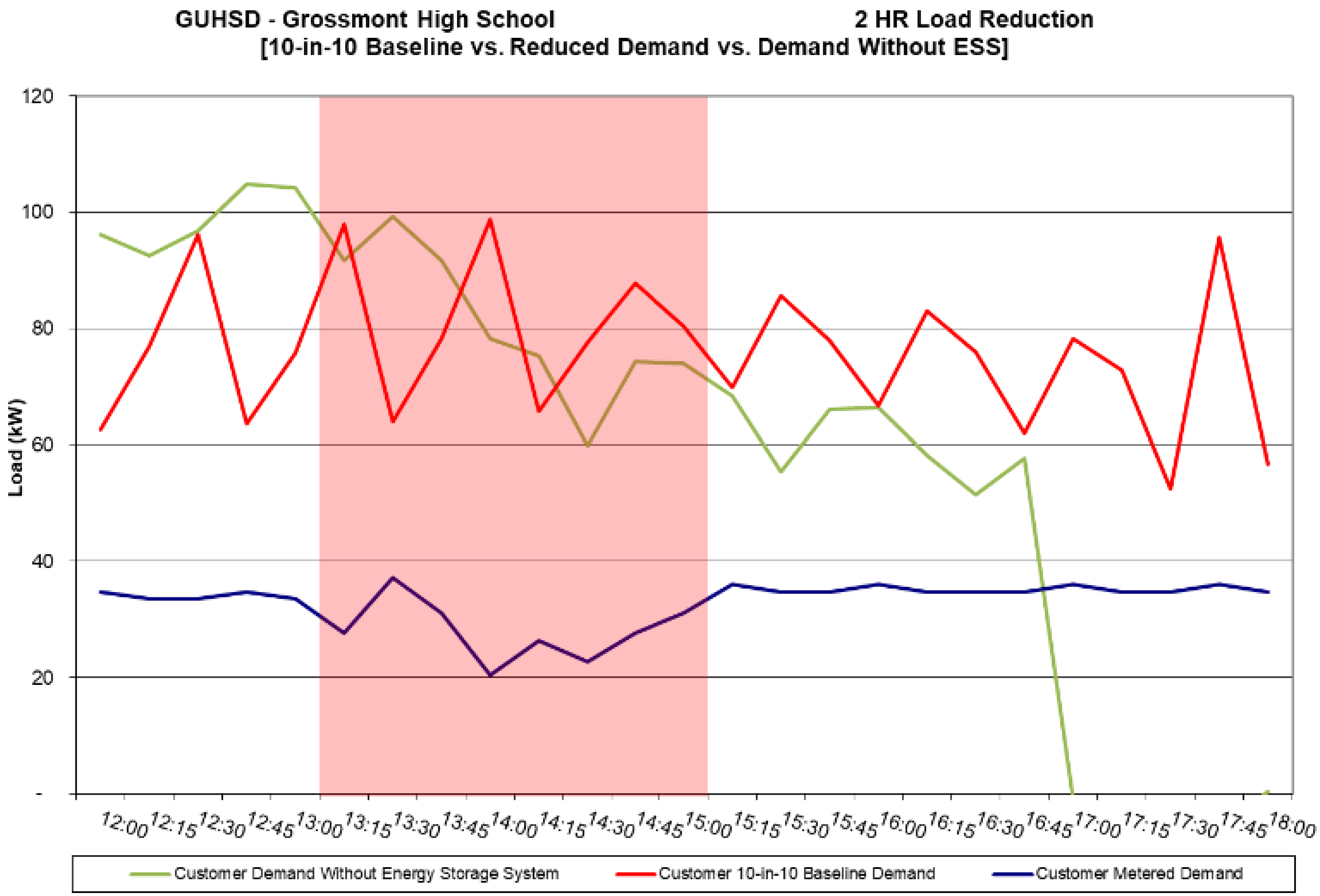


*Simulated DR Event #8*

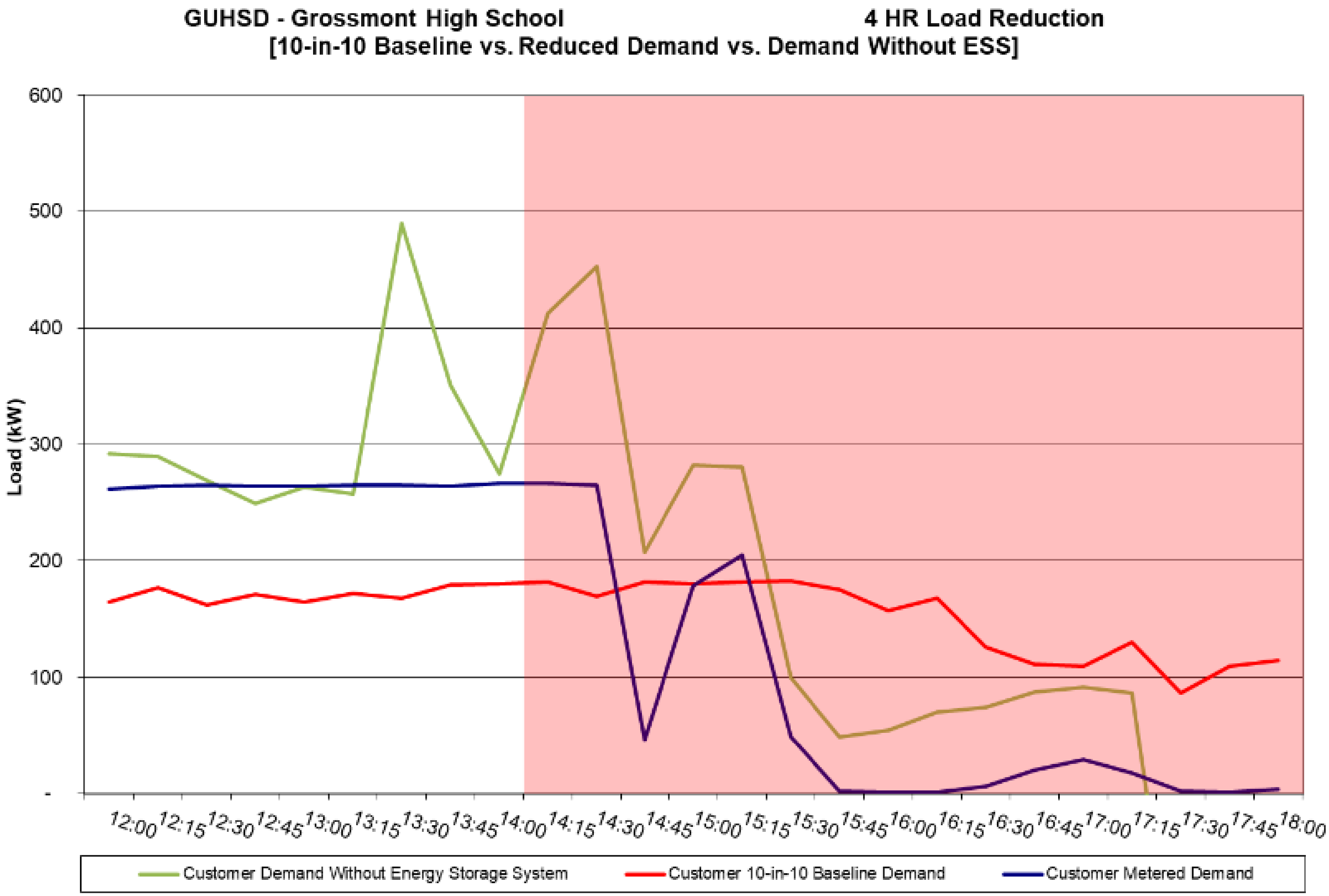


***GUHSD – Grossmont High School***

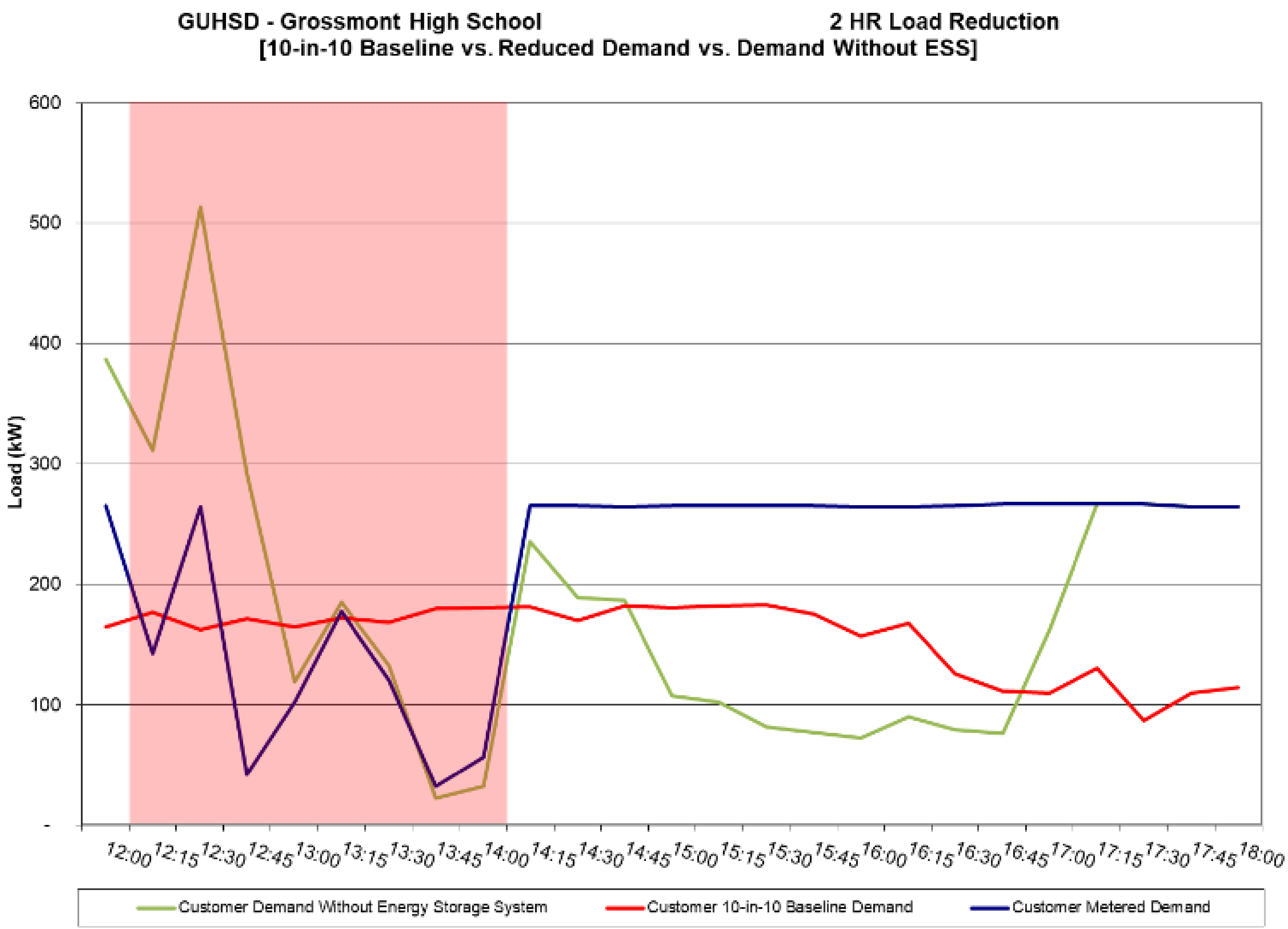
*Simulated DR Event #1*



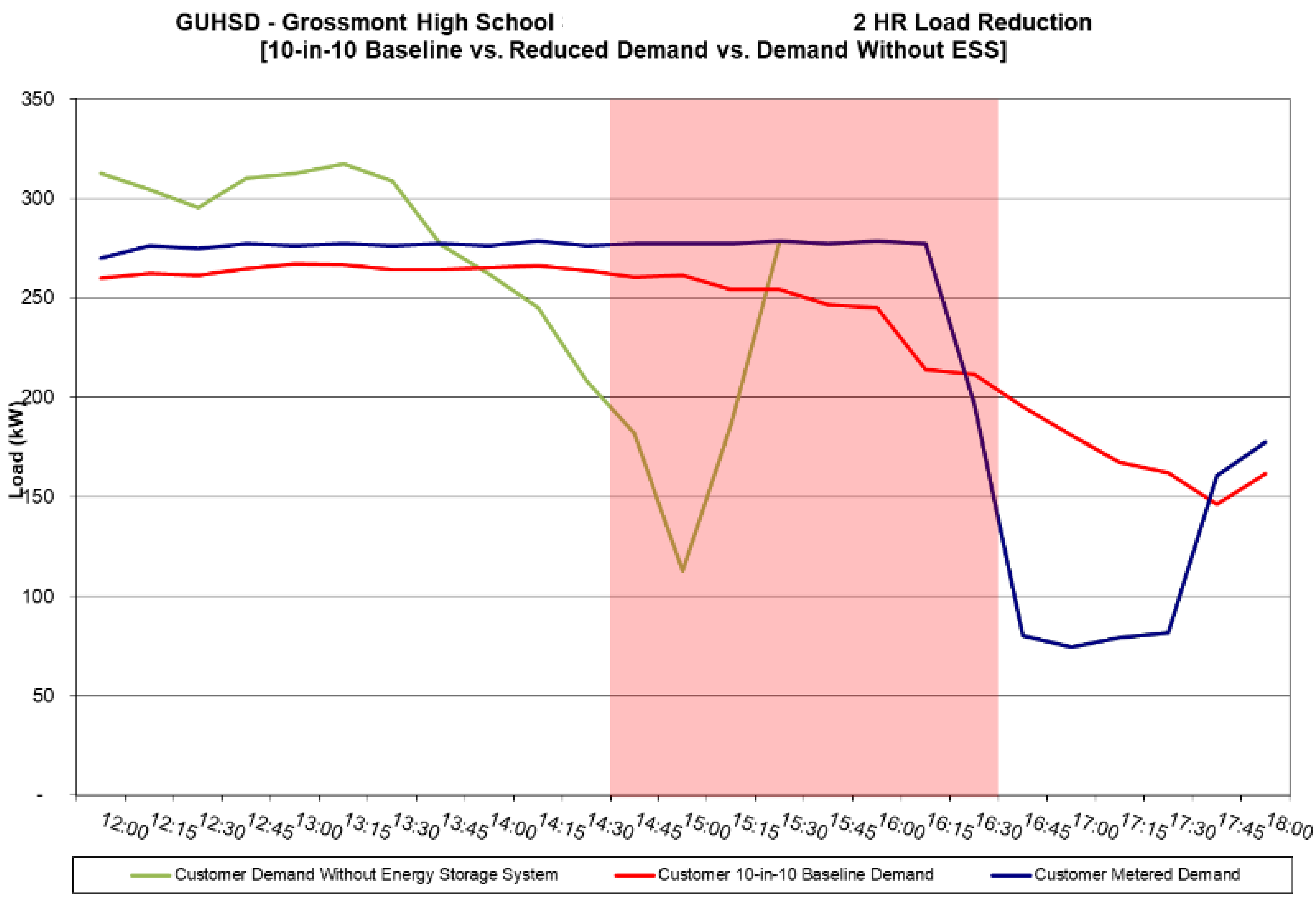
*Simulated DR Event #2*



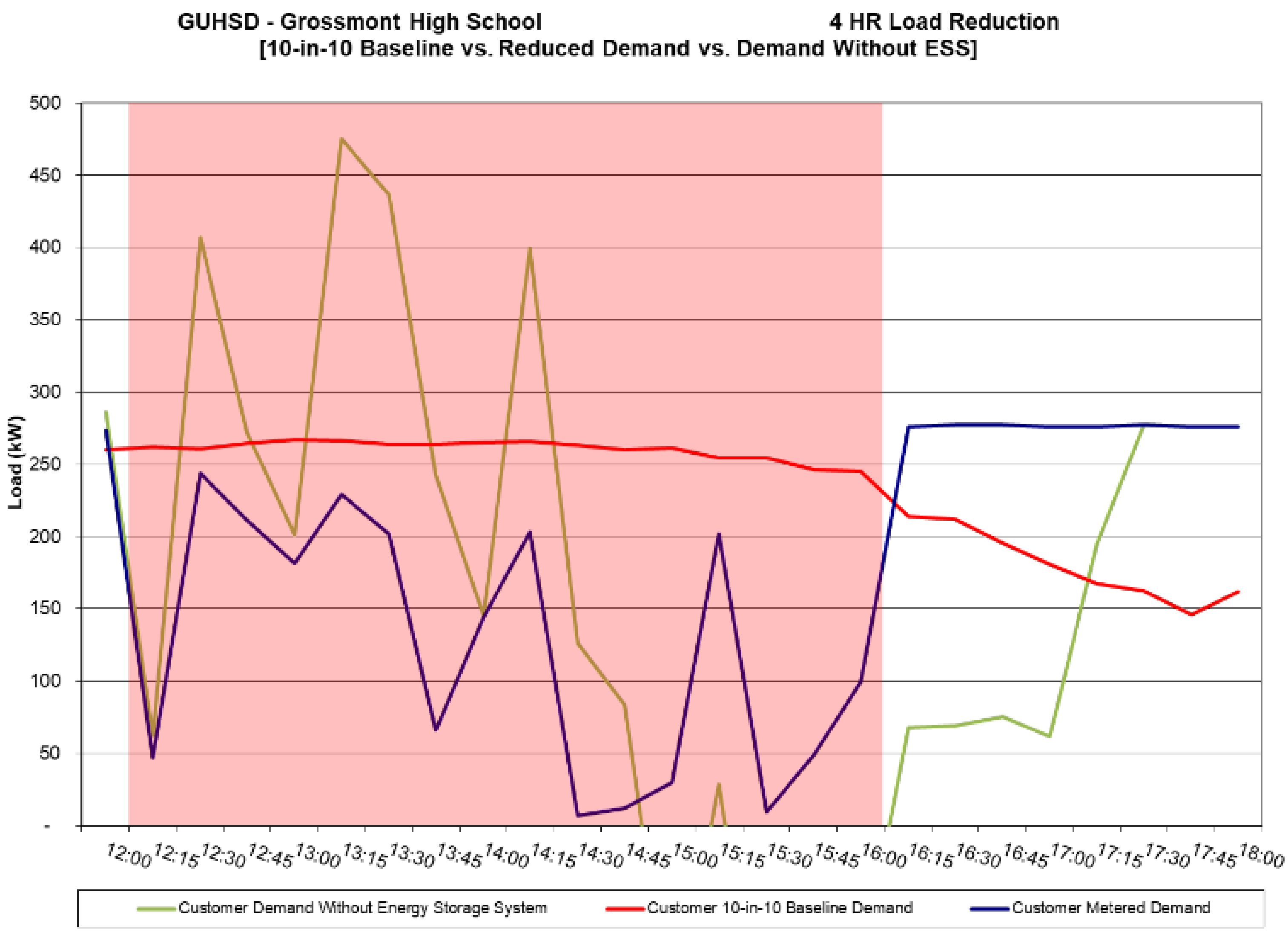
*Simulated DR Event #3*



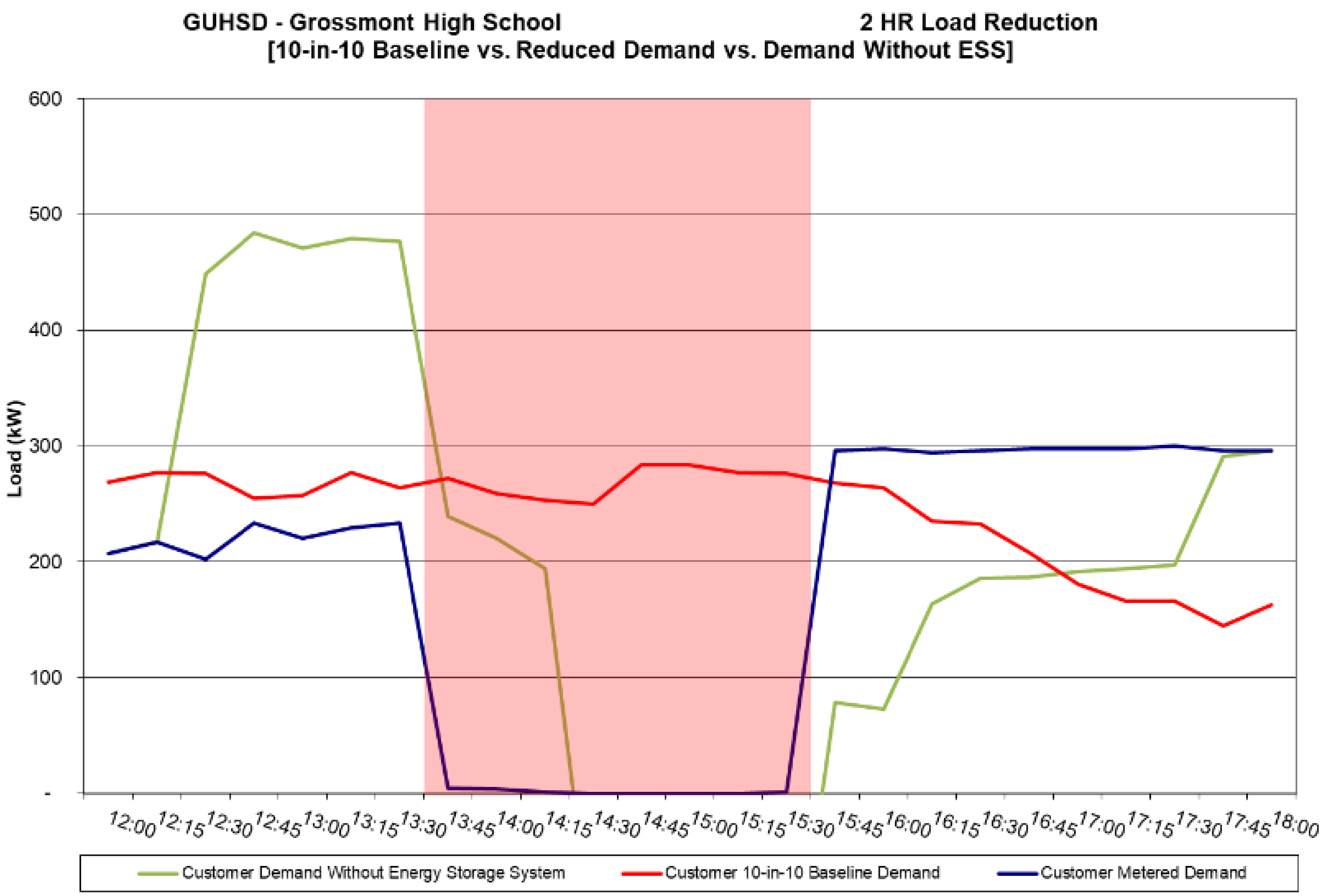
*Simulated DR Event #4*



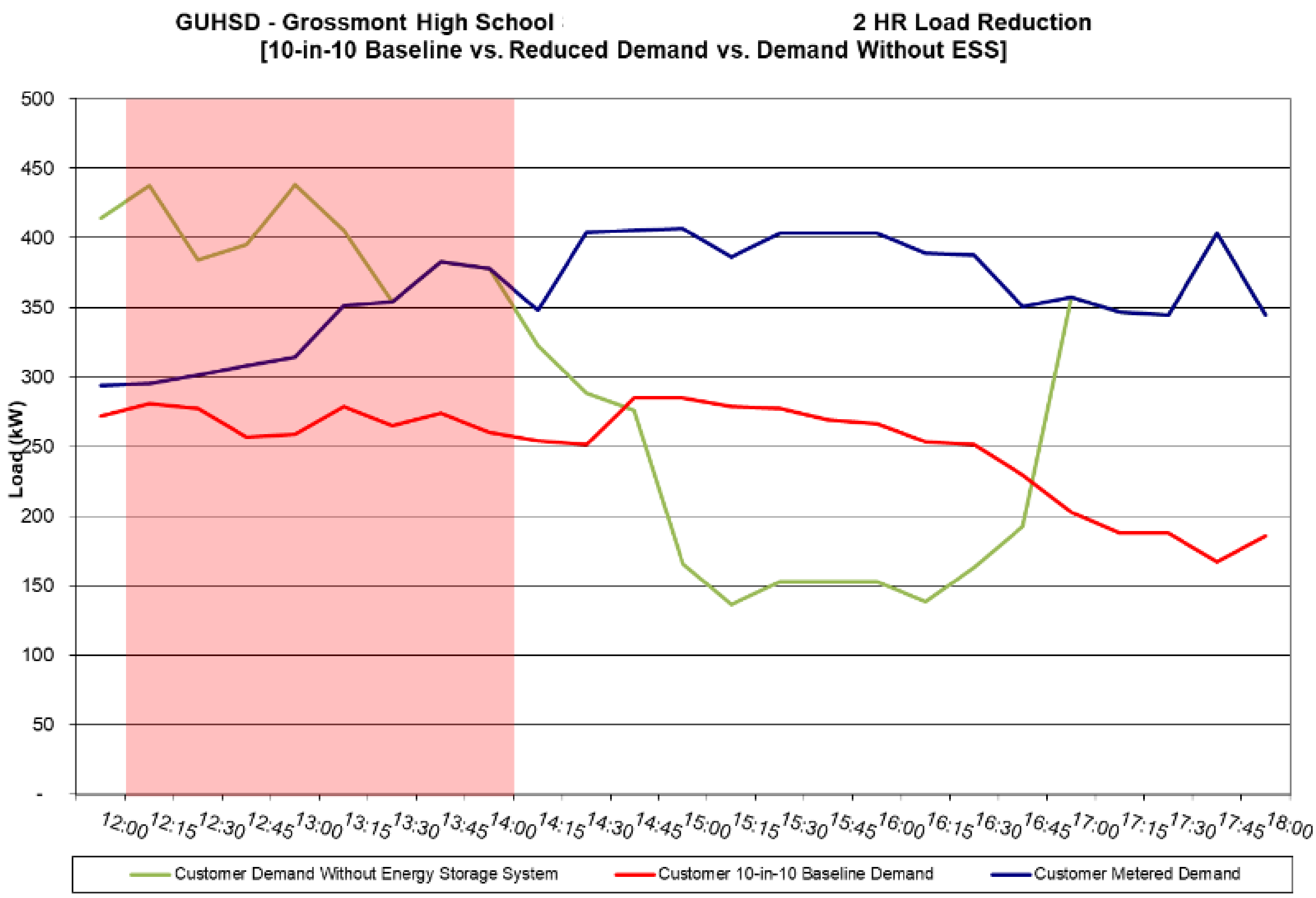
*Simulated DR Event #5*



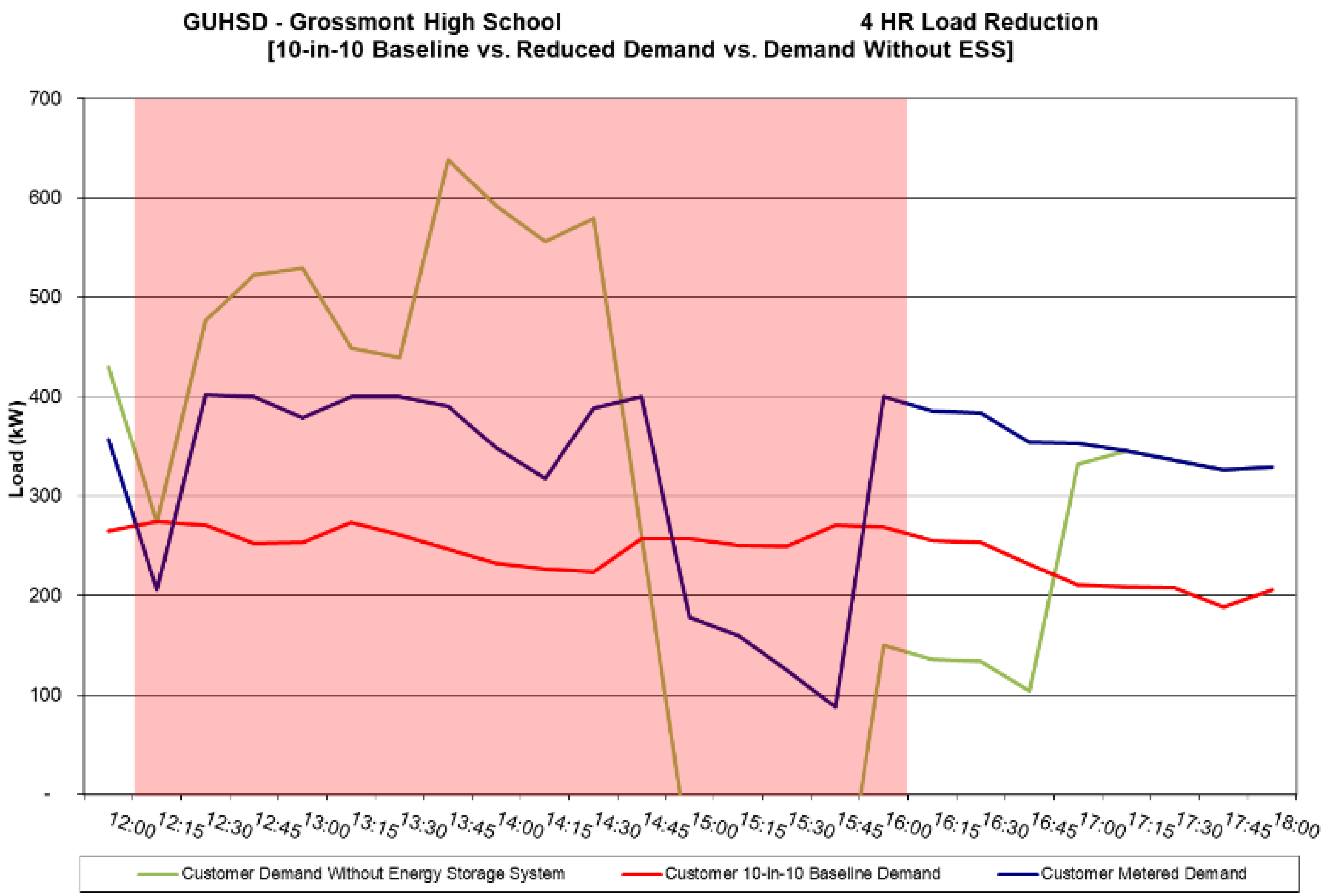
*Simulated DR Event #6*



*Simulated DR Event #7*

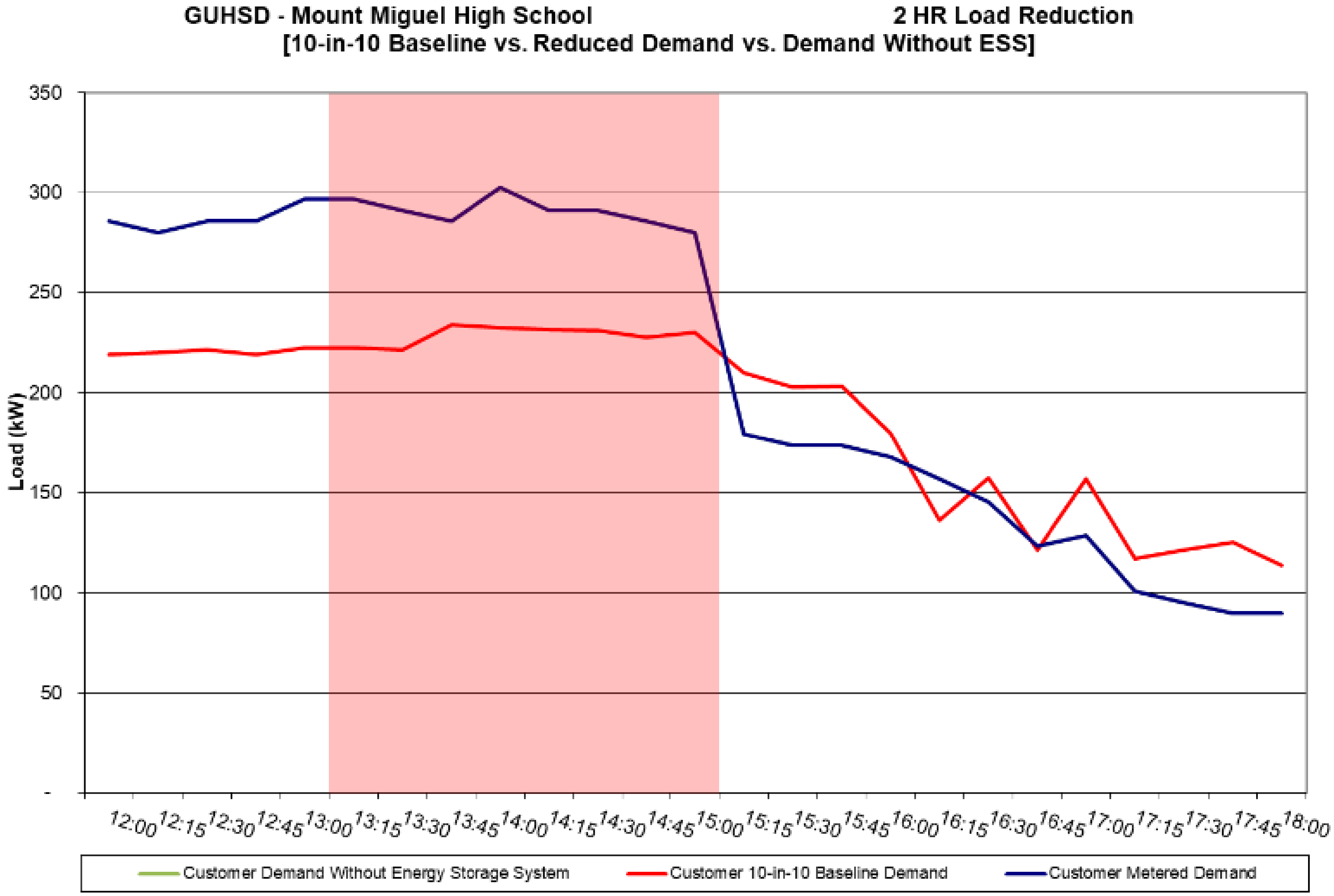


*Simulated DR Event #8*

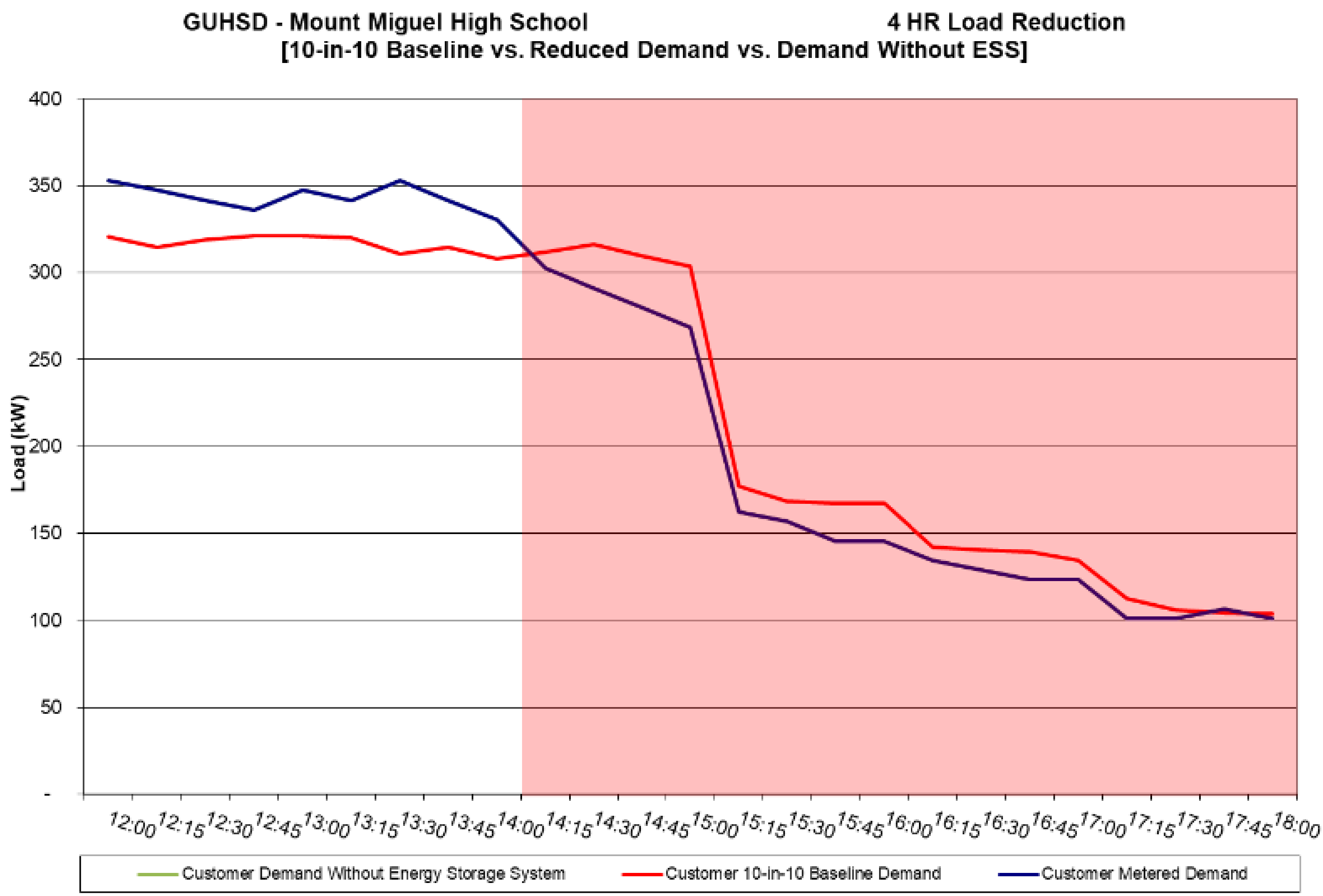


***GUHSD – Mount Miguel High School***

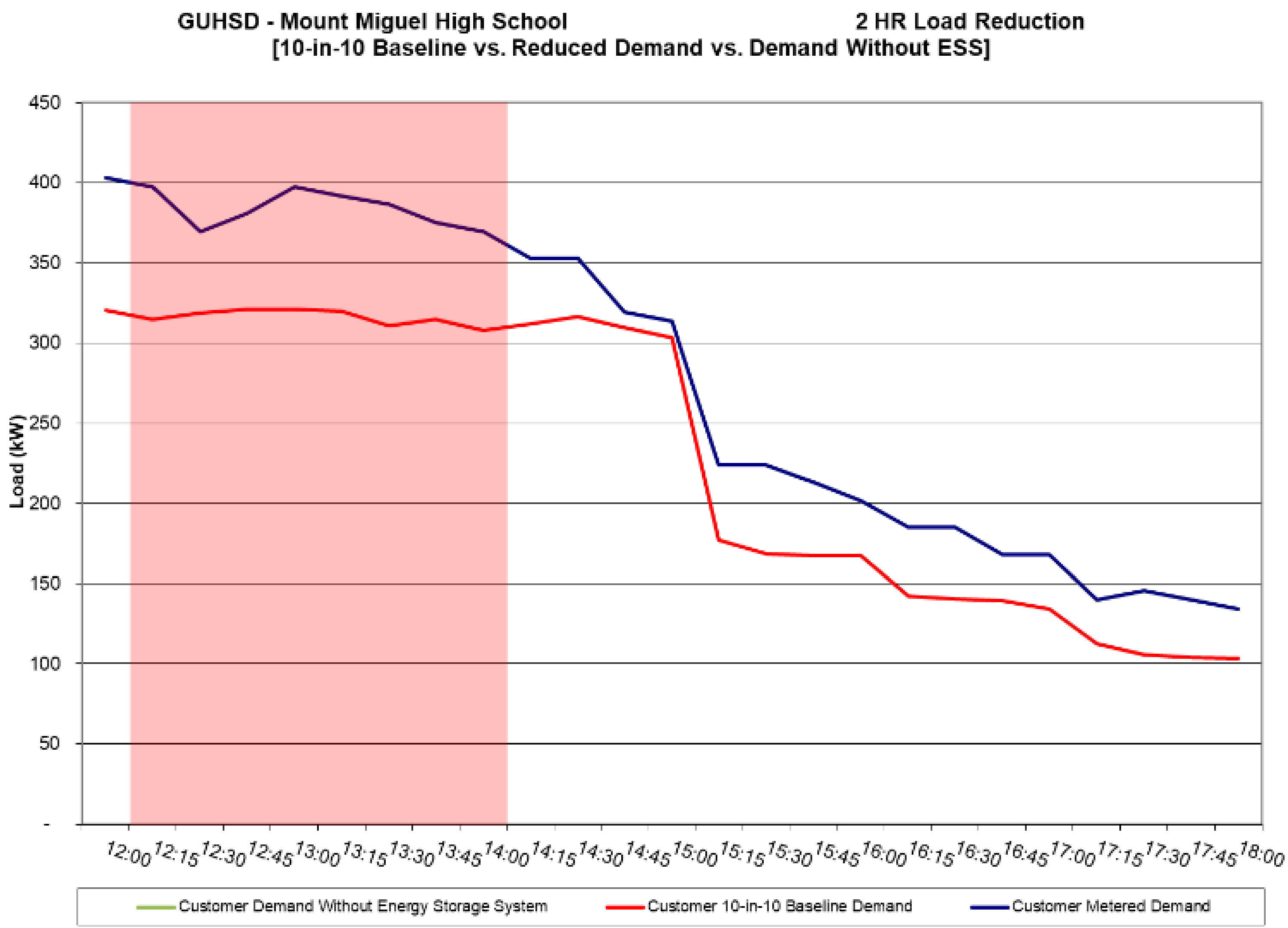
*Simulated DR Event #1*



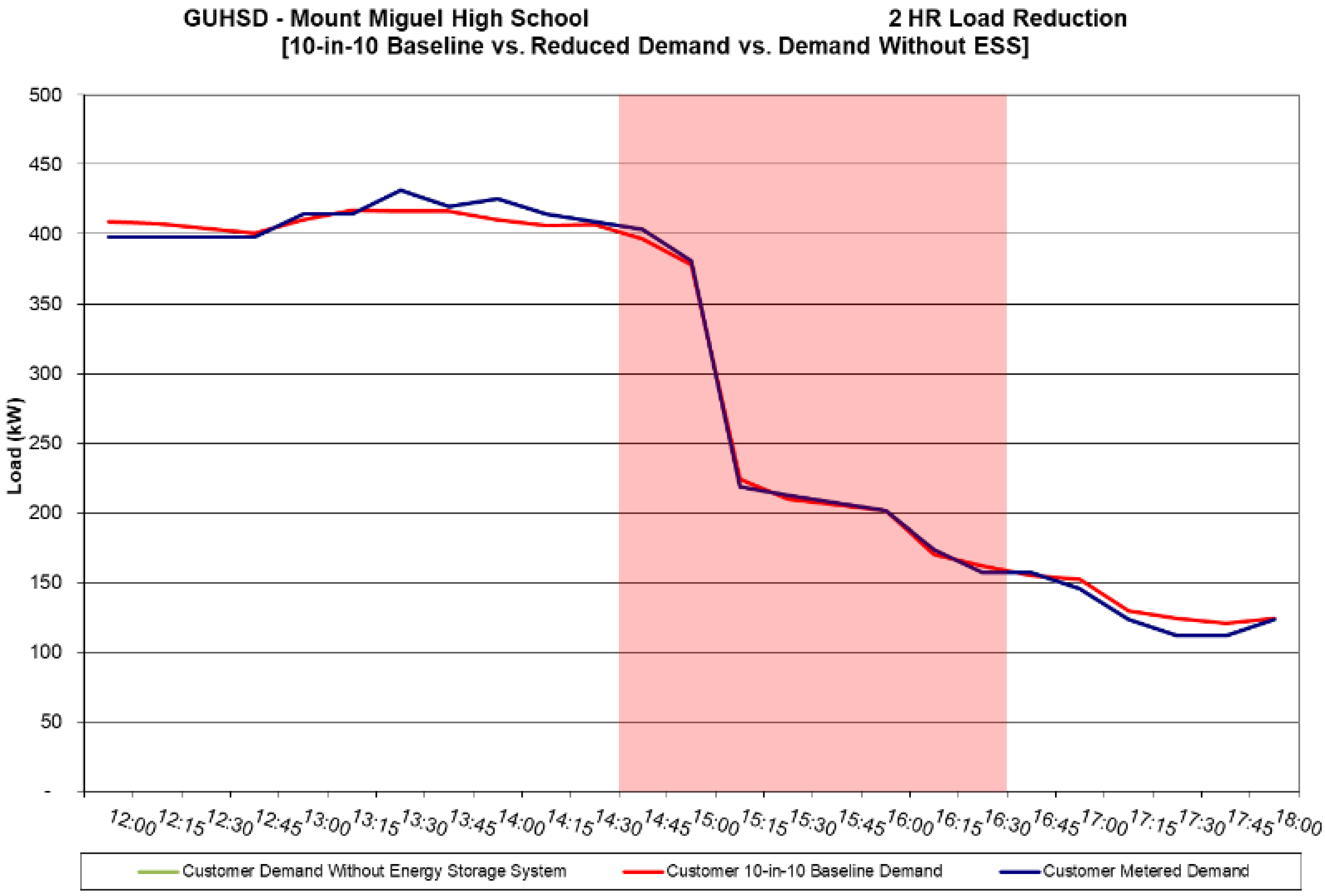
*Simulated DR Event #2*



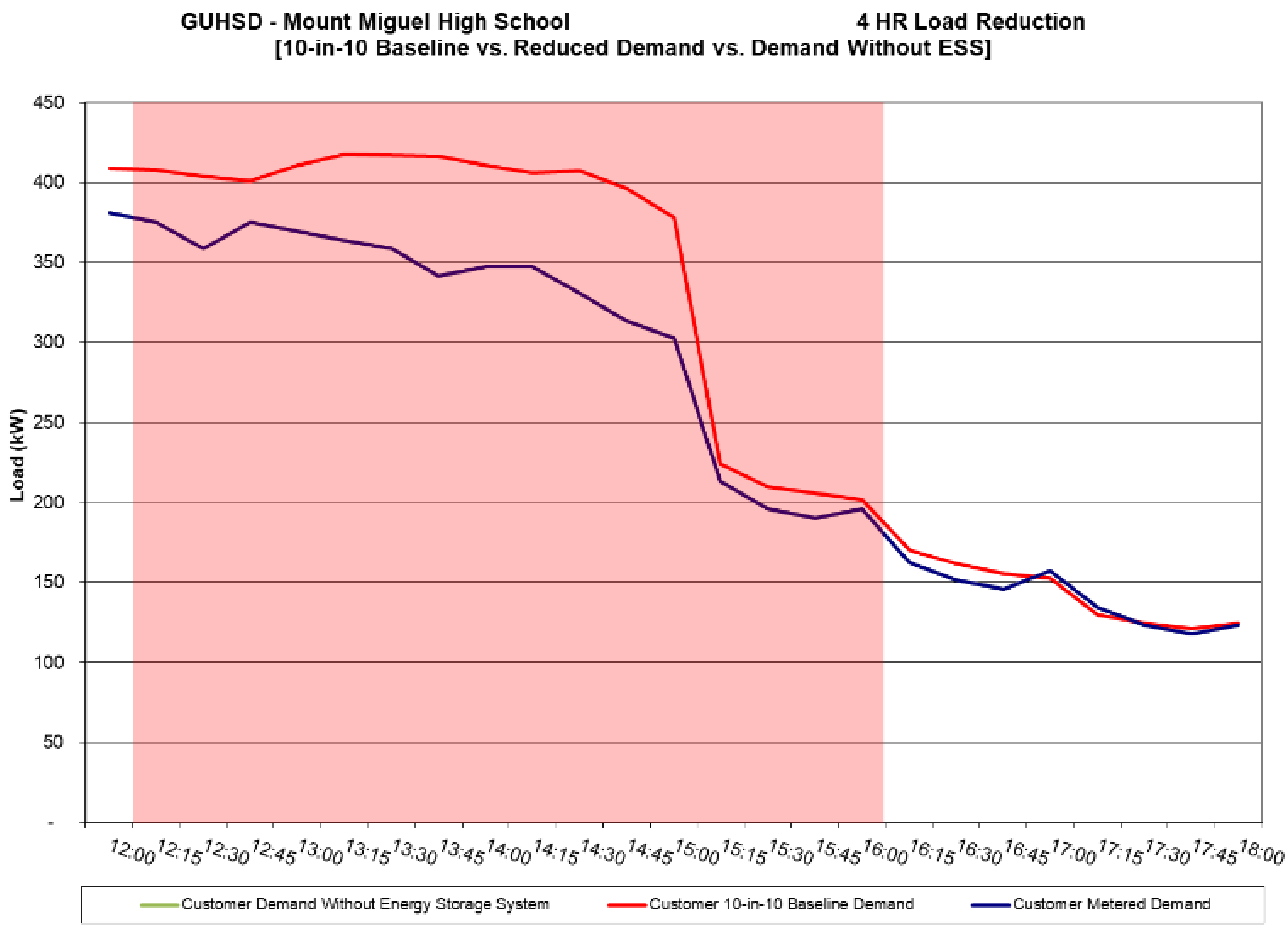
*Simulated DR Event #3*



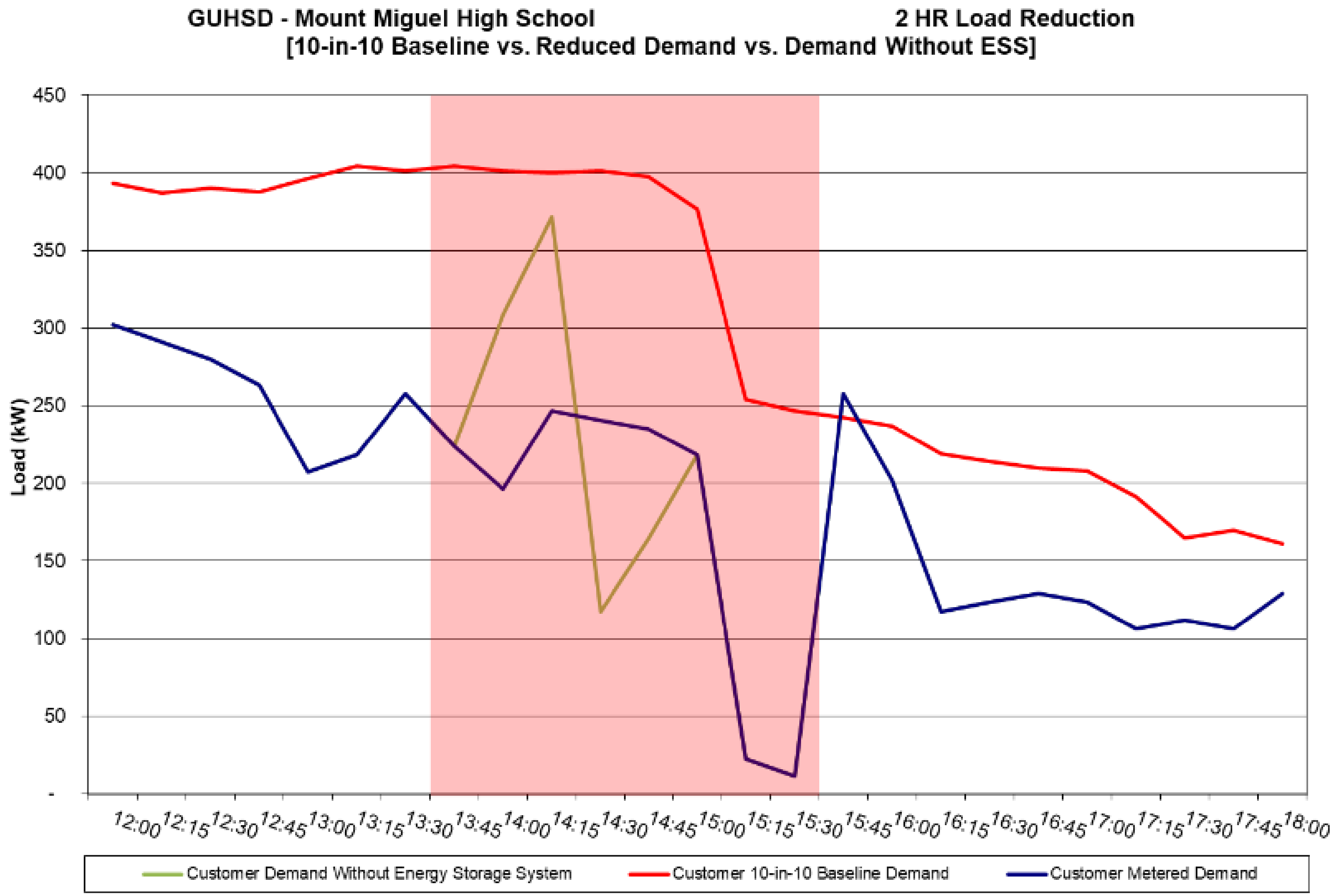
*Simulated DR Event #4*



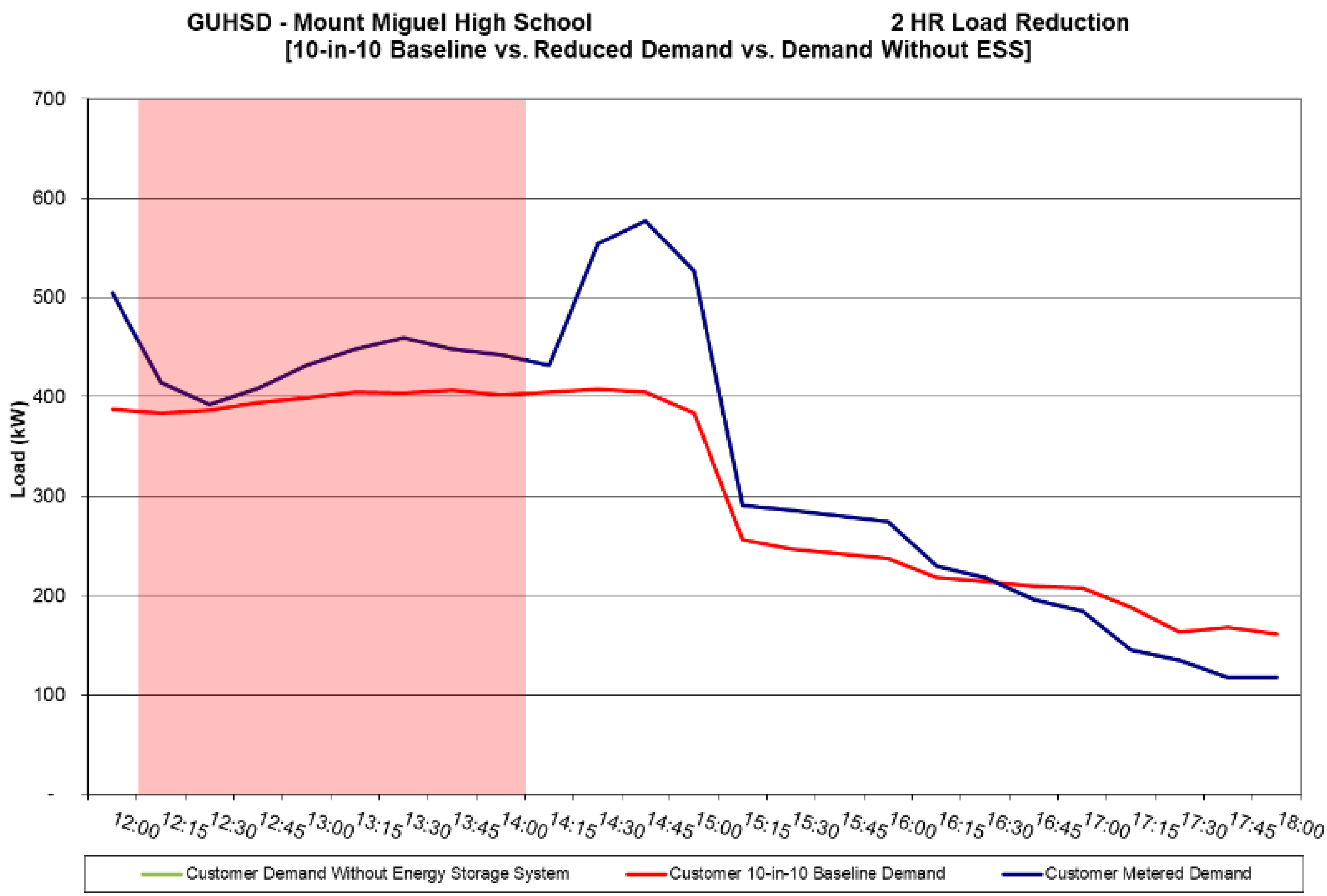
*Simulated DR Event #5*



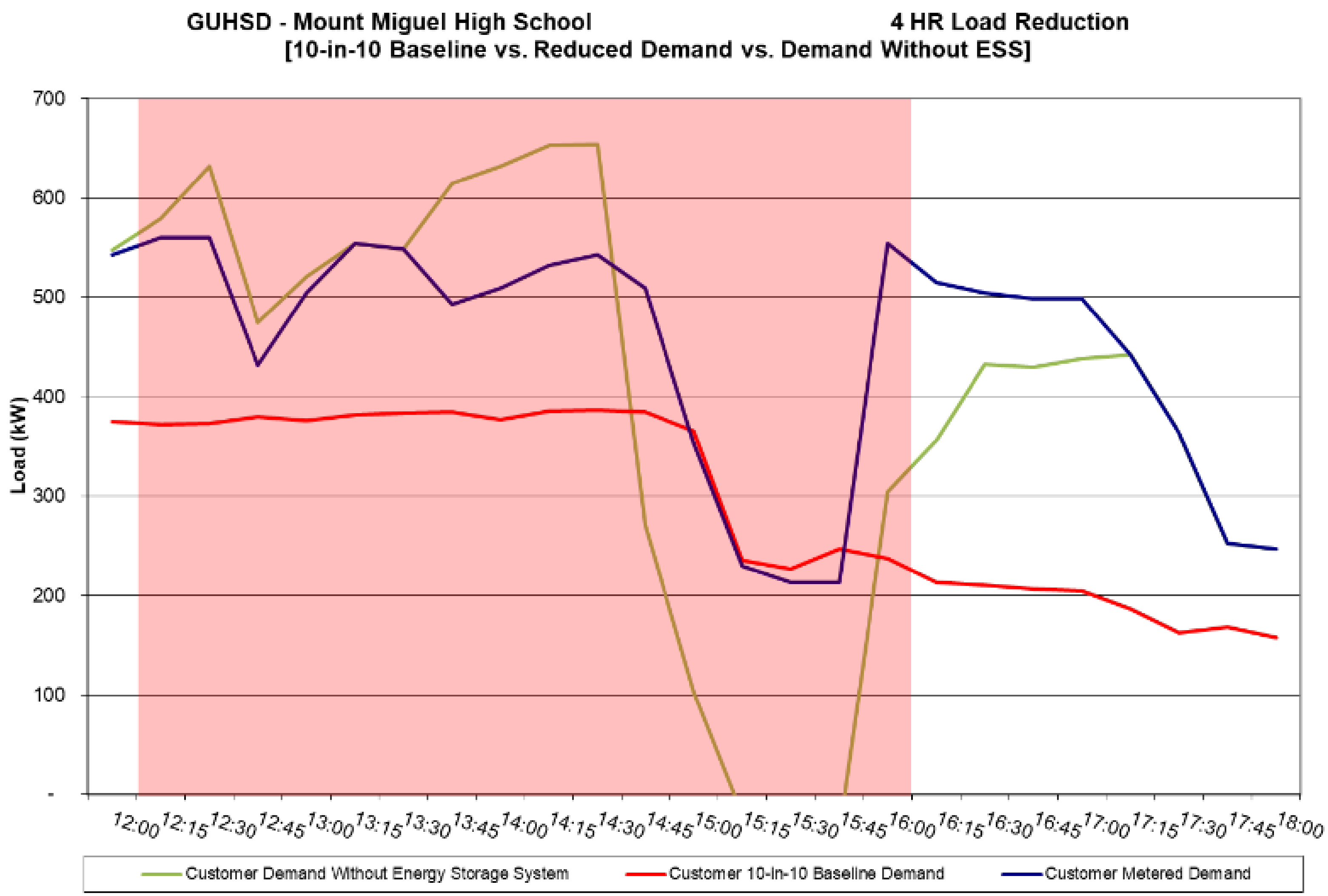
*Simulated DR Event #6*



*Simulated DR Event #7*

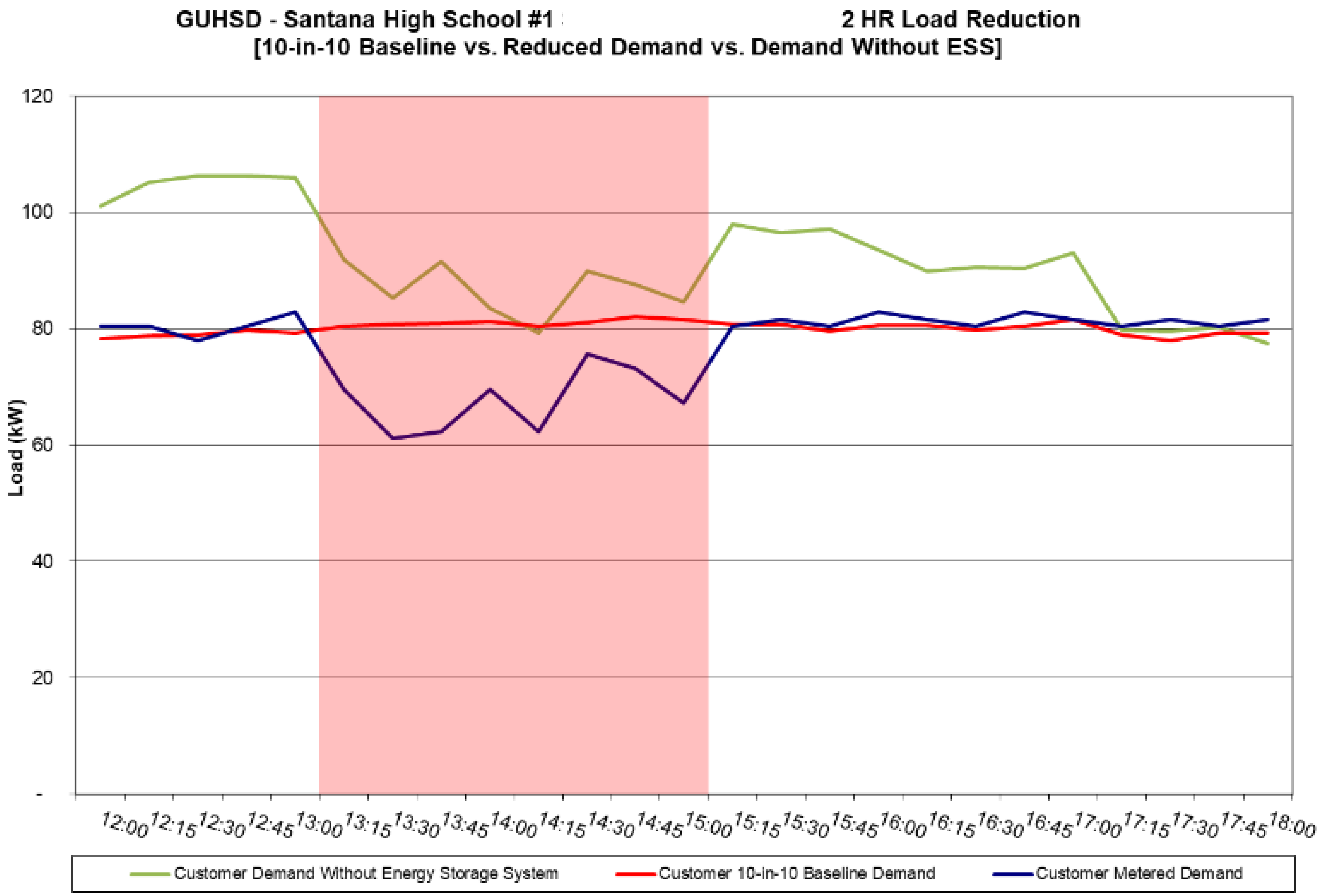


*Simulated DR Event #8*

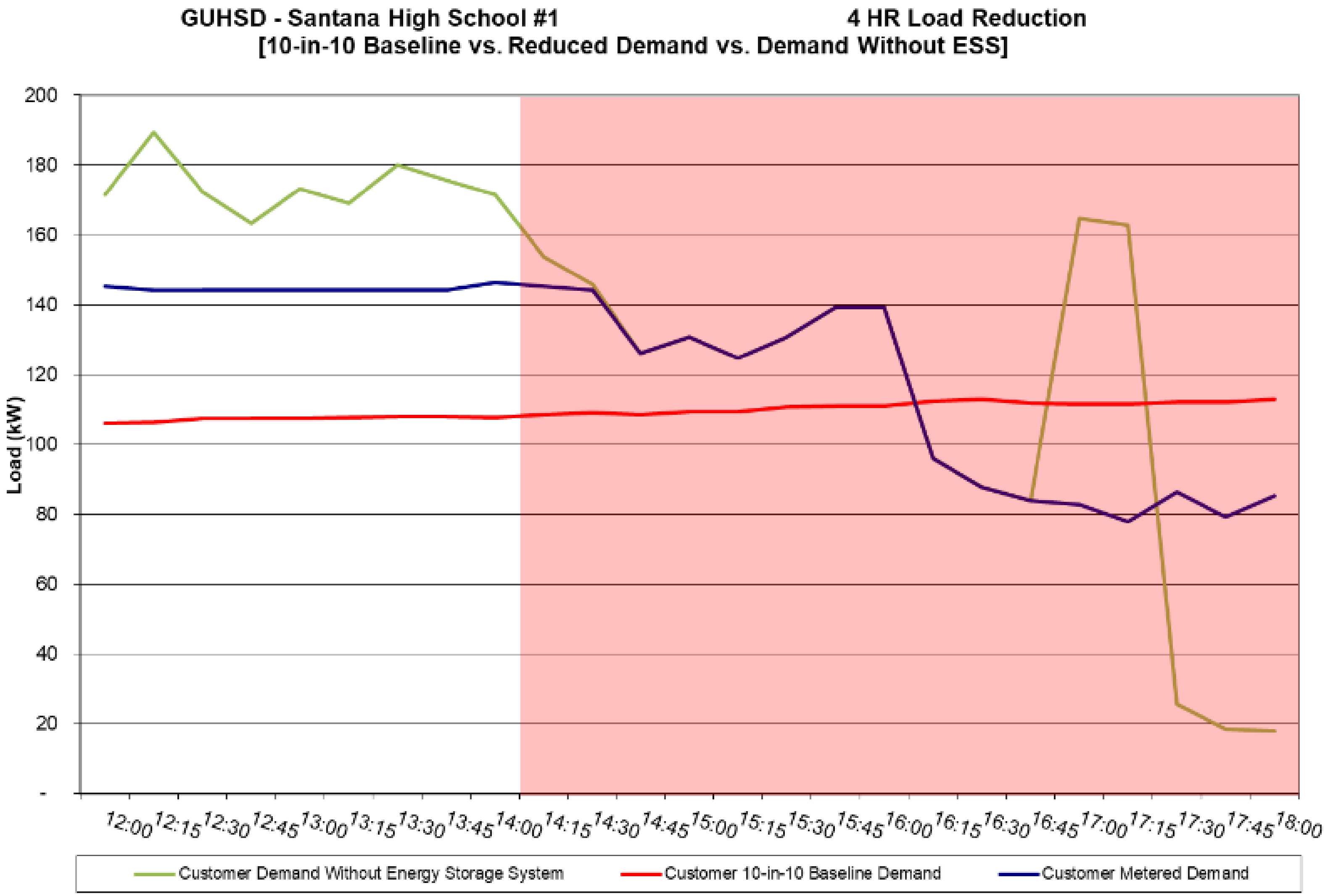


***GUHSD – Santana High School 1***

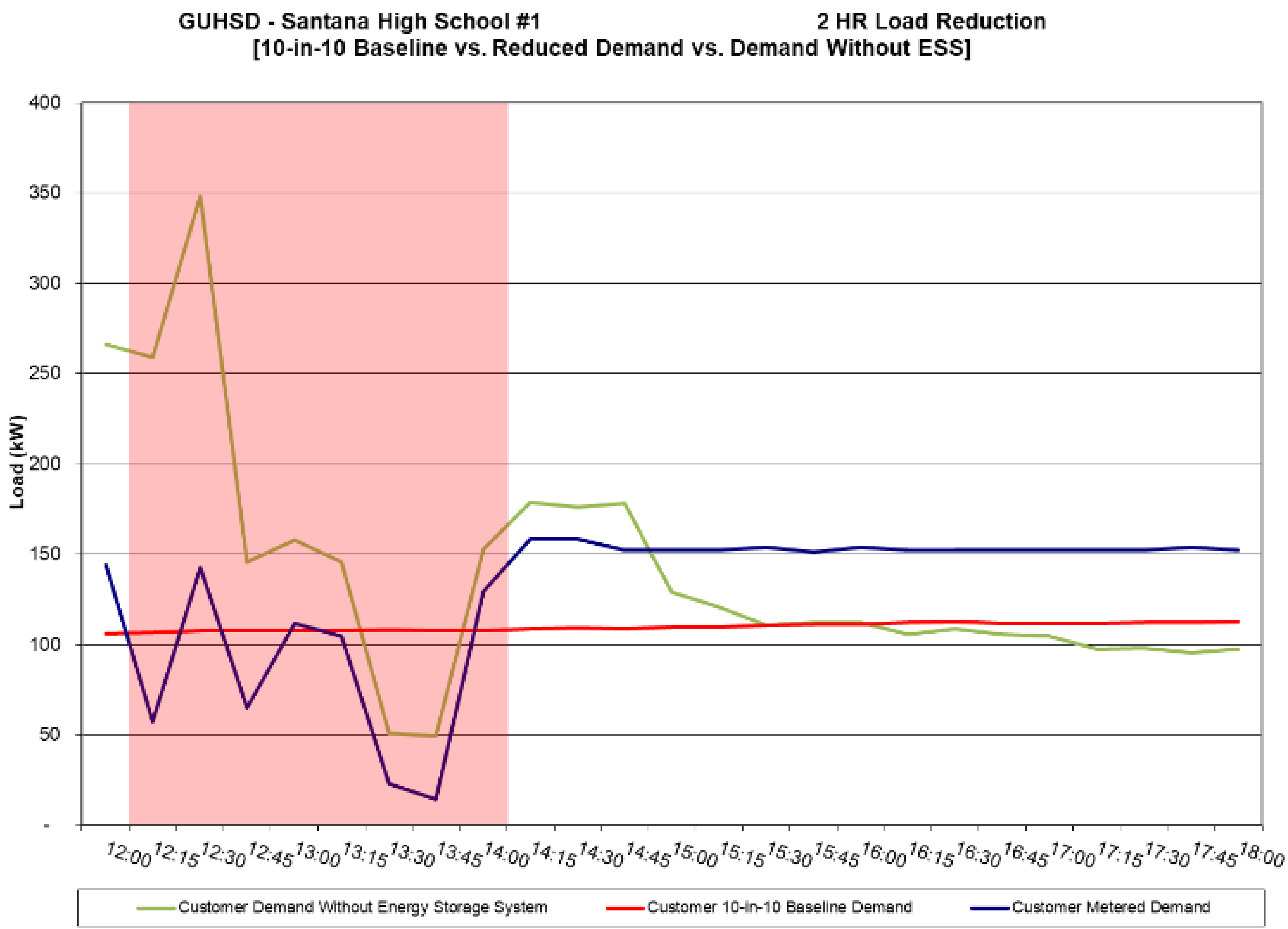
*Simulated DR Event #1*



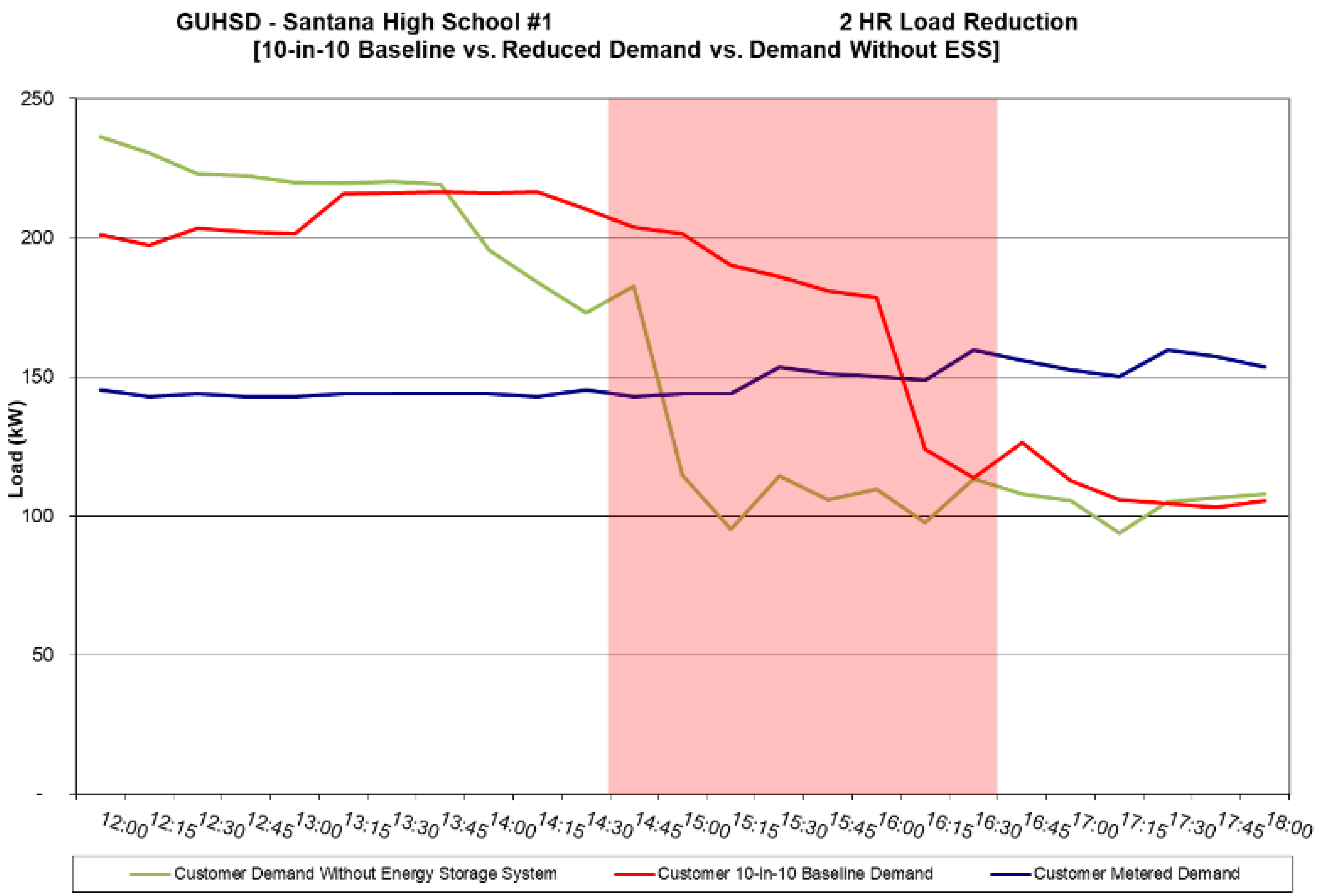
*Simulated DR Event #2*



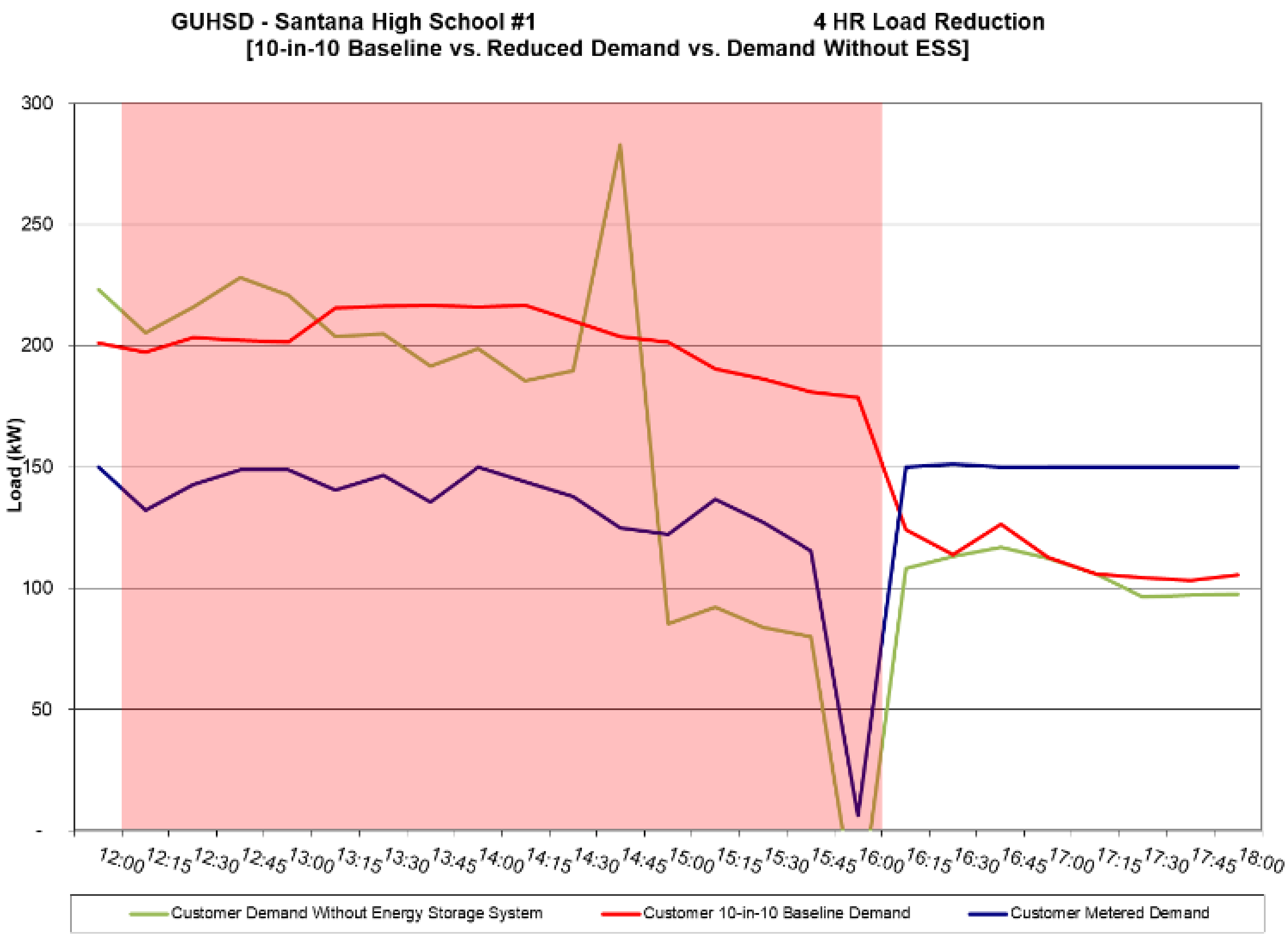
*Simulated DR Event #3*



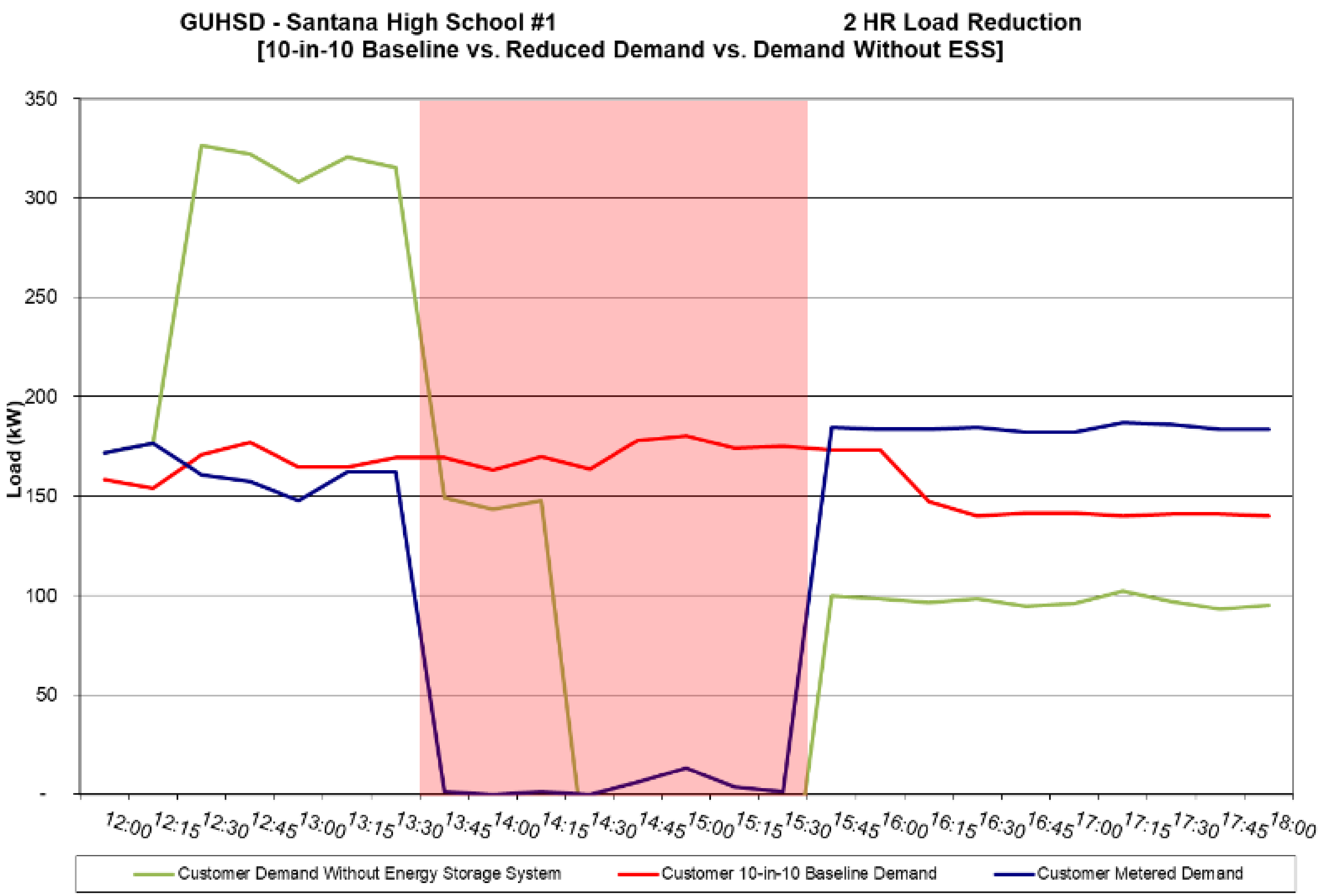
*Simulated DR Event #4*



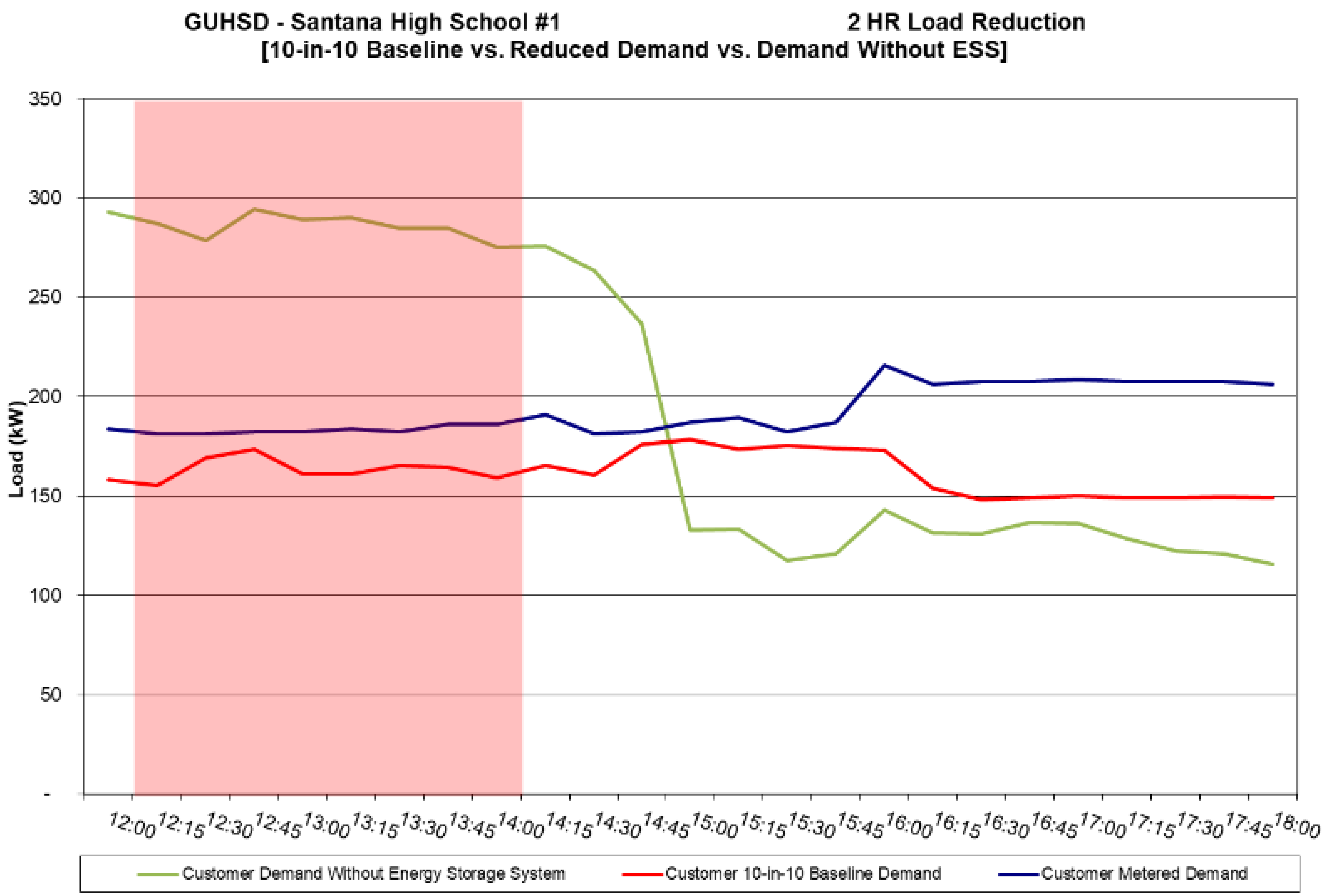
*Simulated DR Event #5*



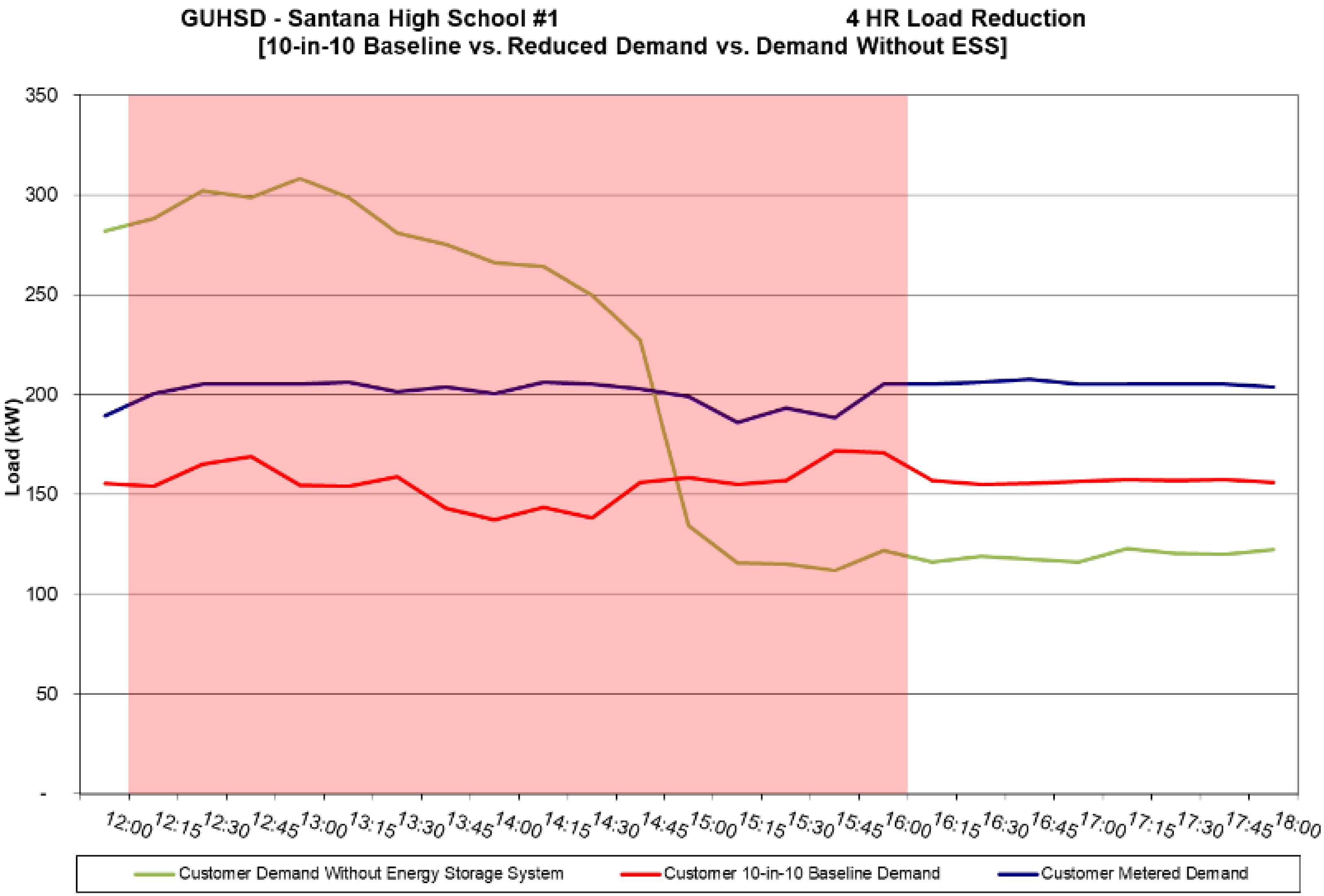
*Simulated DR Event #6*



*Simulated DR Event #7*

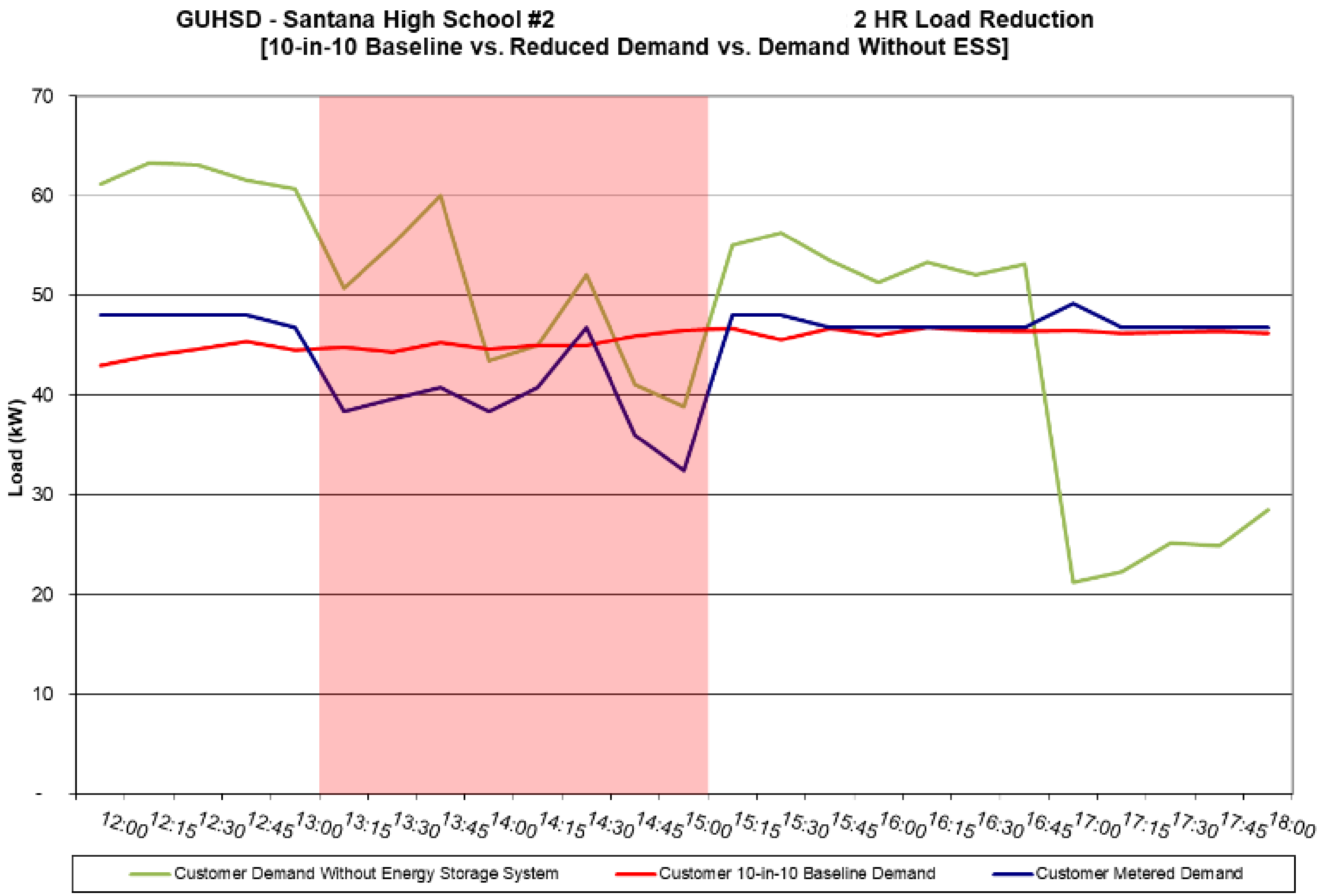


*Simulated DR Event #8*

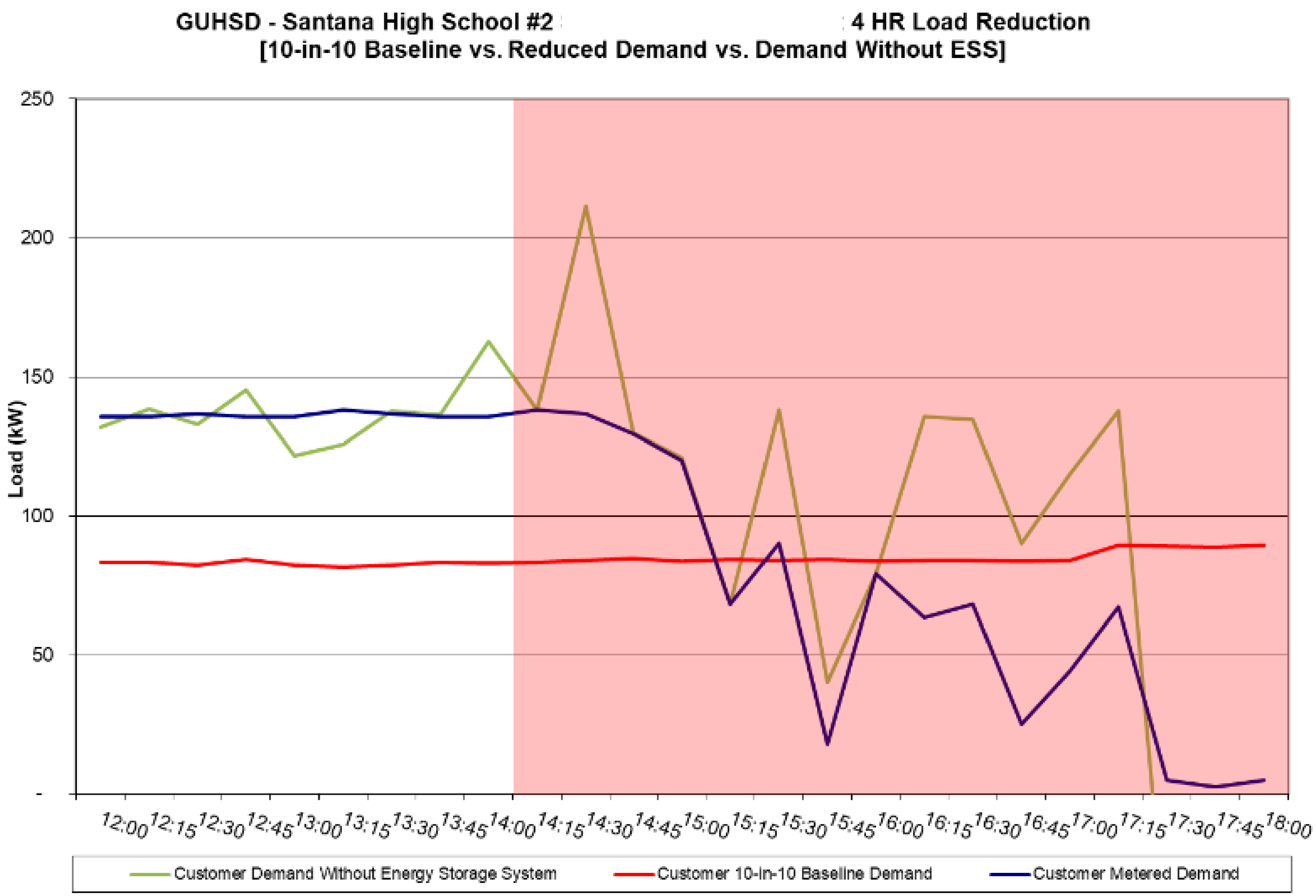


***GUHSD – Santana High School 2***

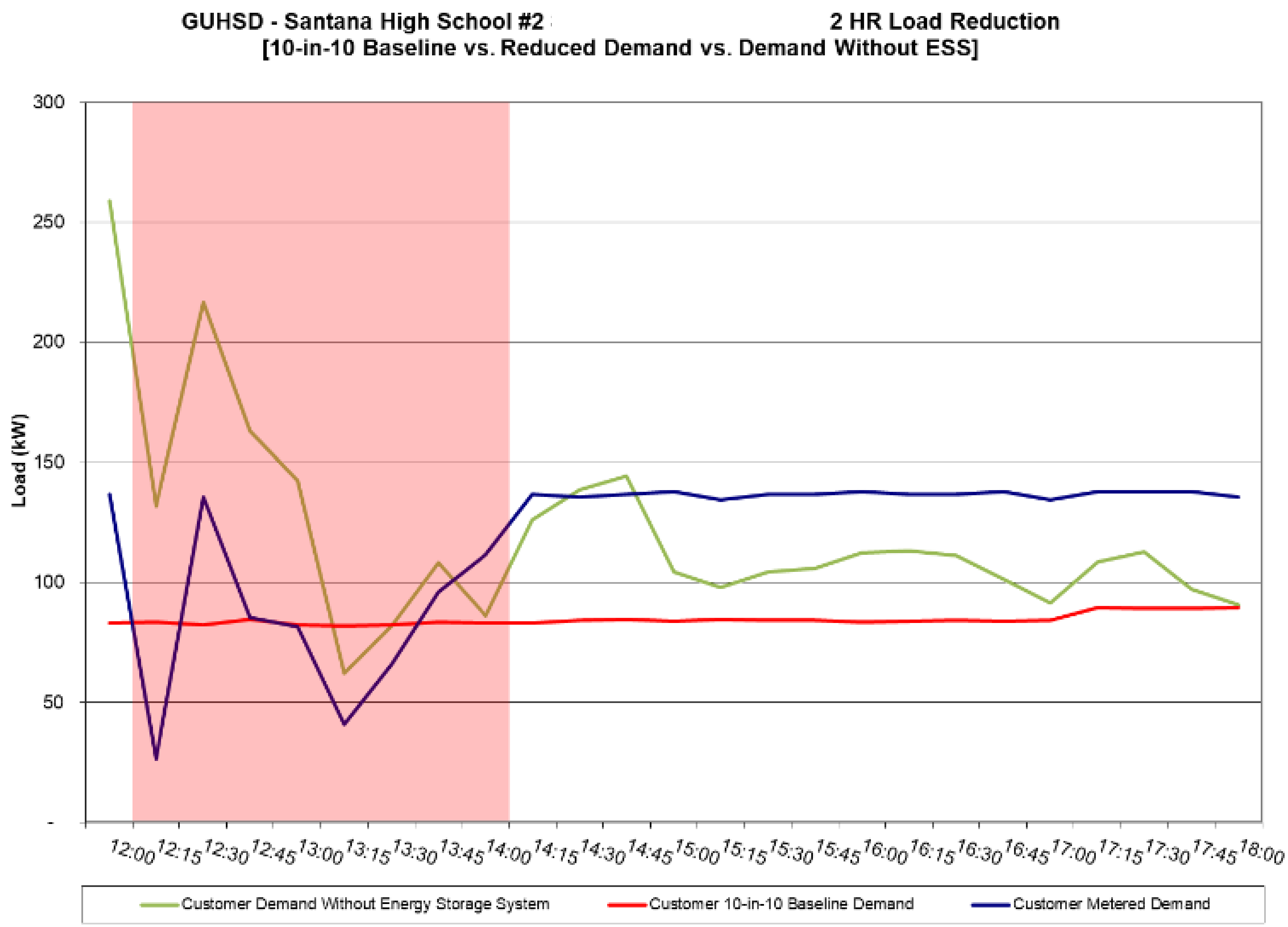
*Simulated DR Event #1*



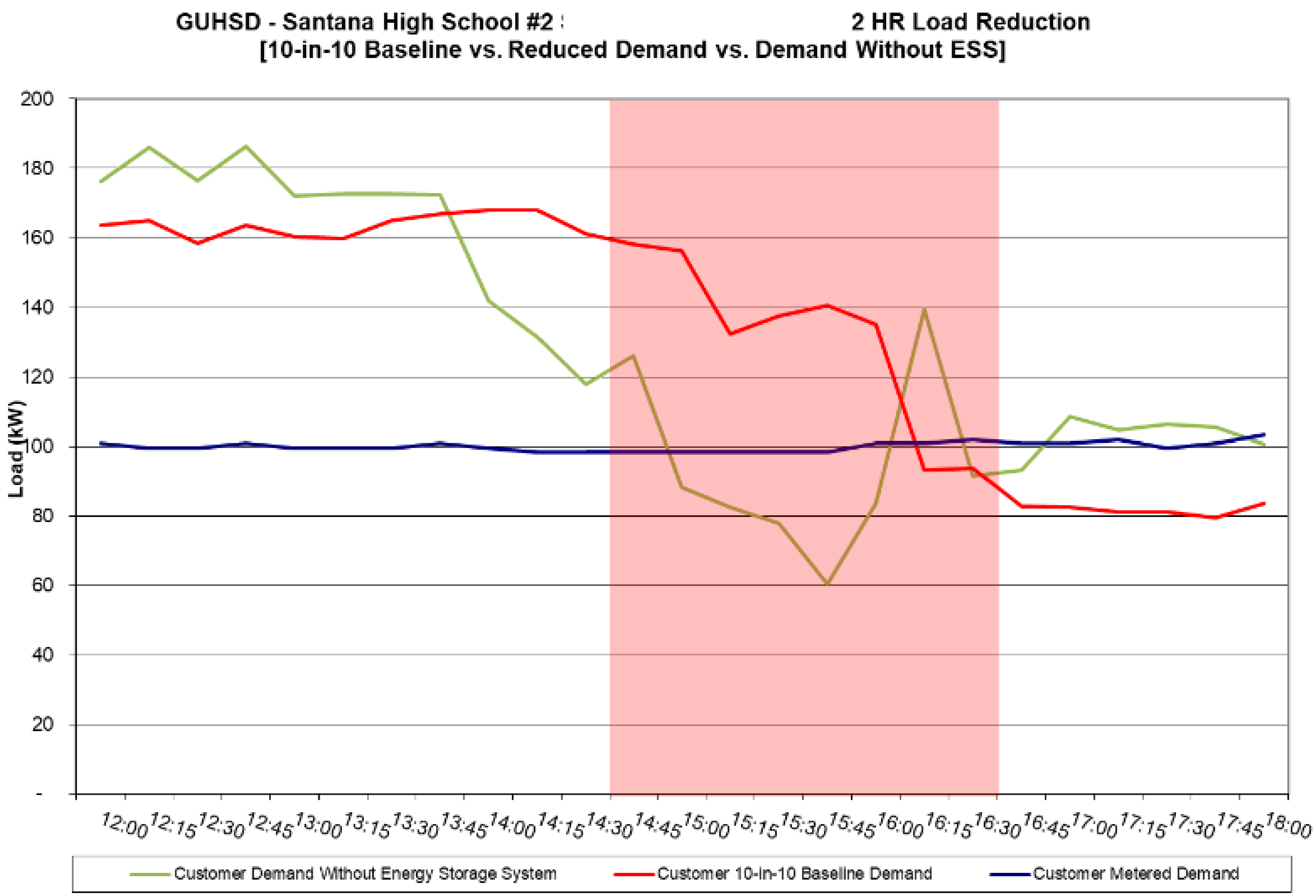
*Simulated DR Event #2*



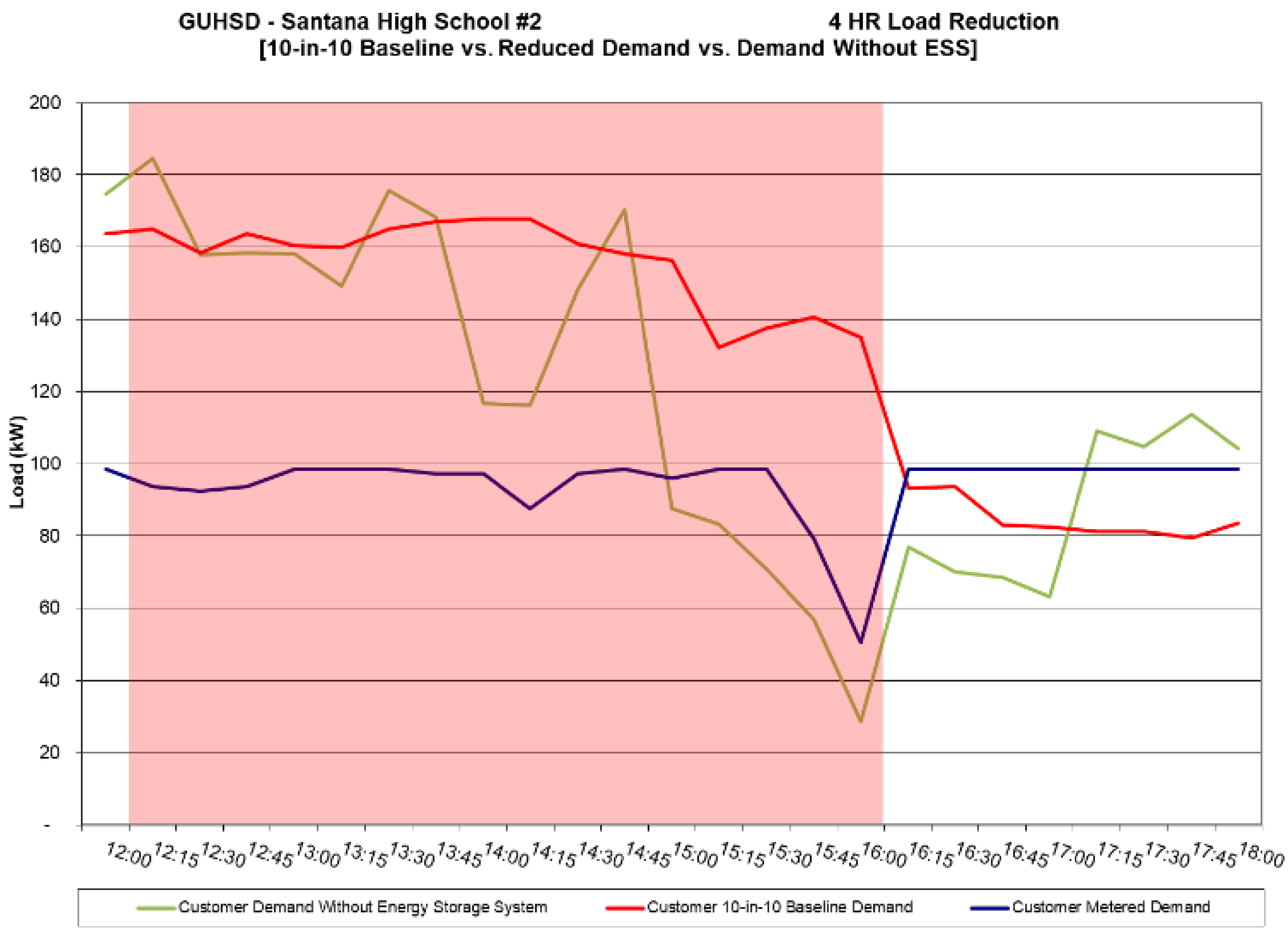
*Simulated DR Event #3*



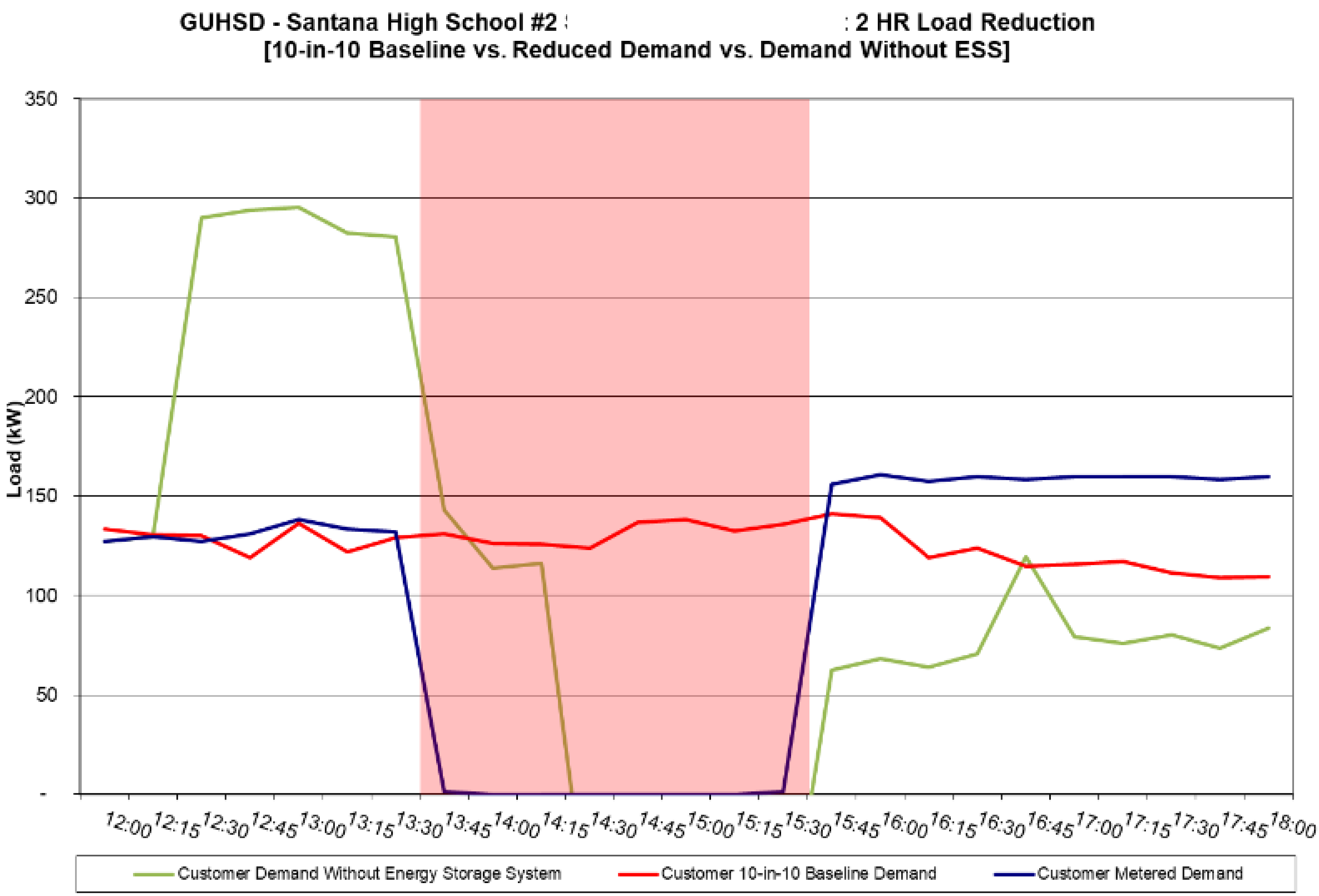
*Simulated DR Event #4*



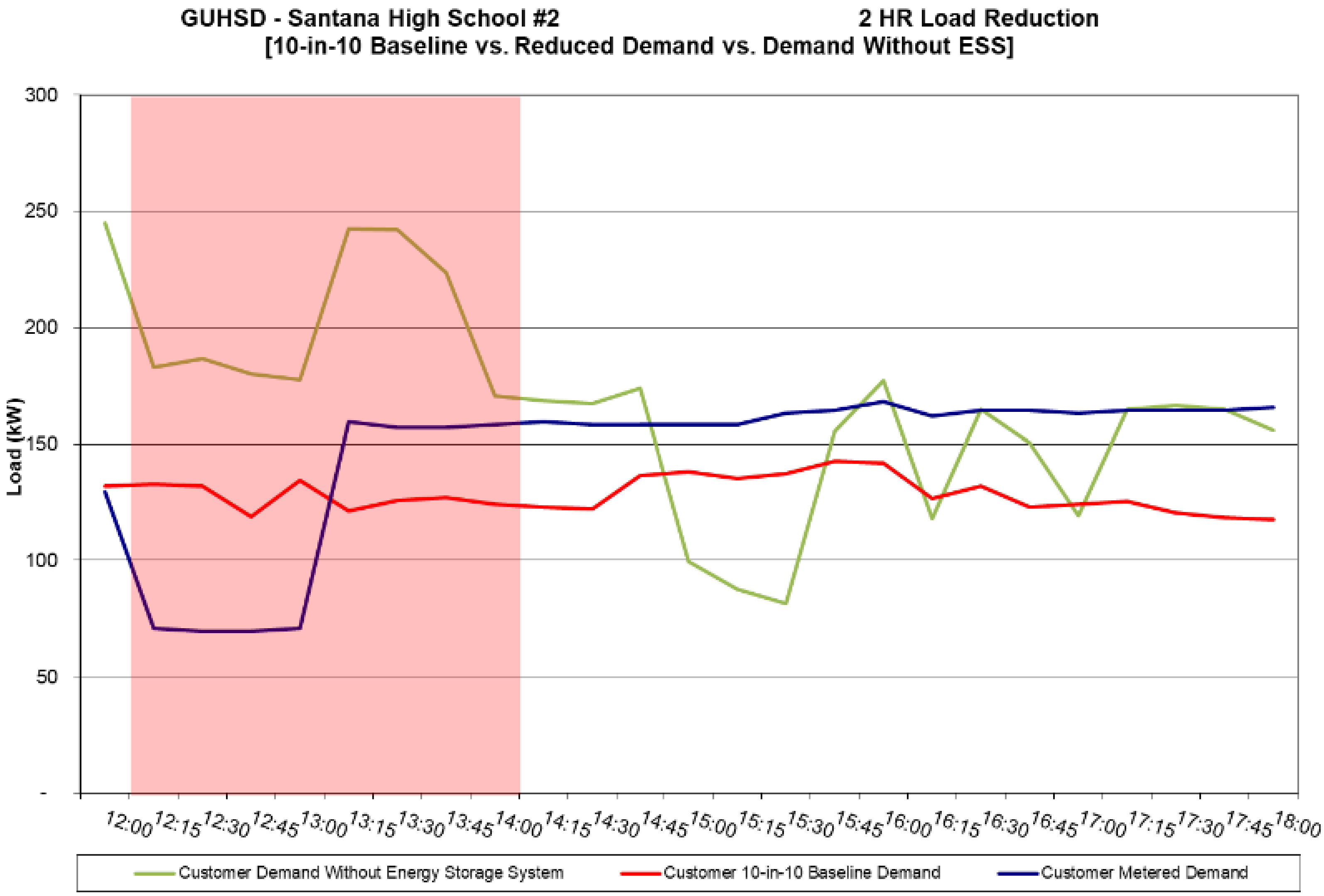
*Simulated DR Event #5*



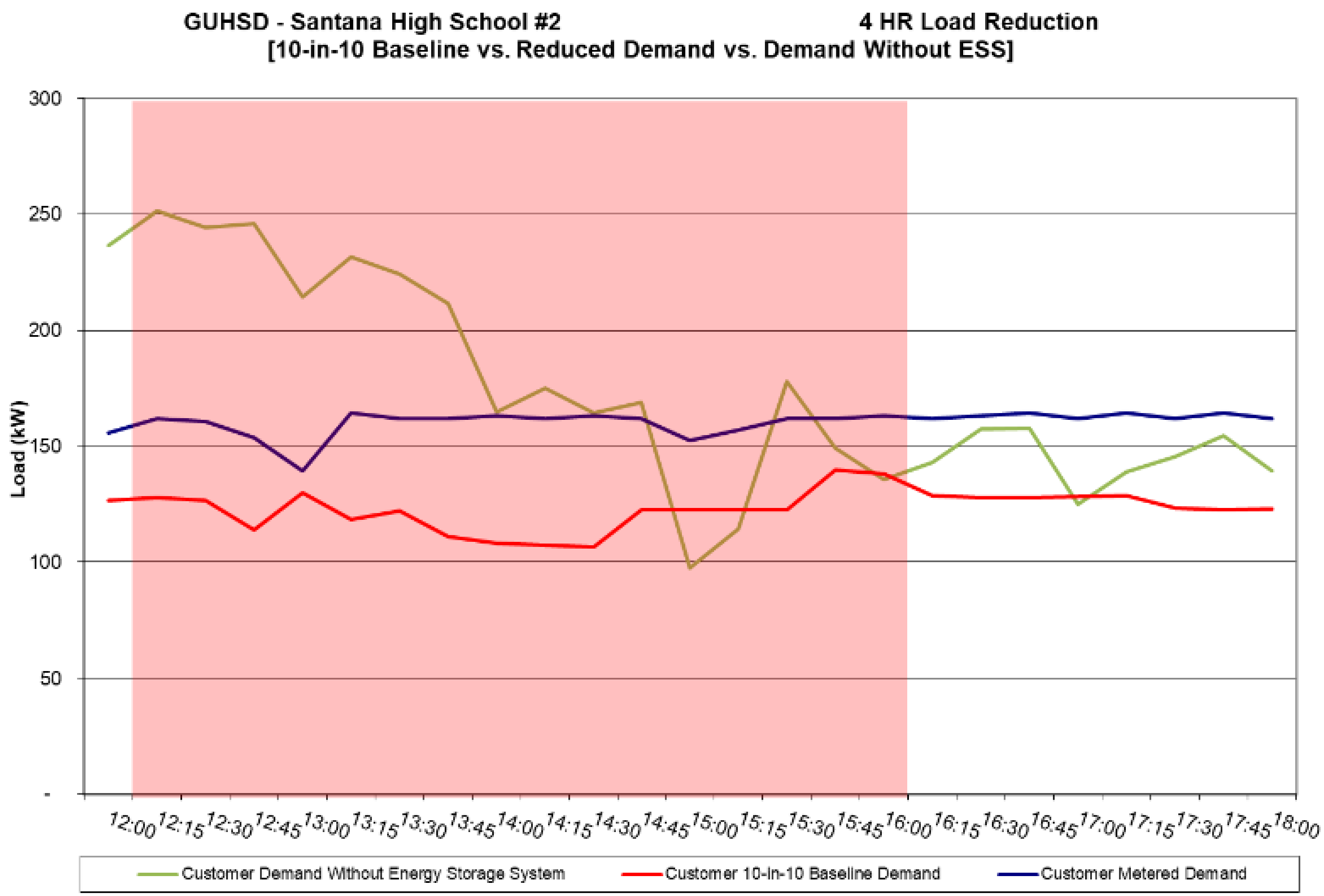
*Simulated DR Event #6*



*Simulated DR Event #7*

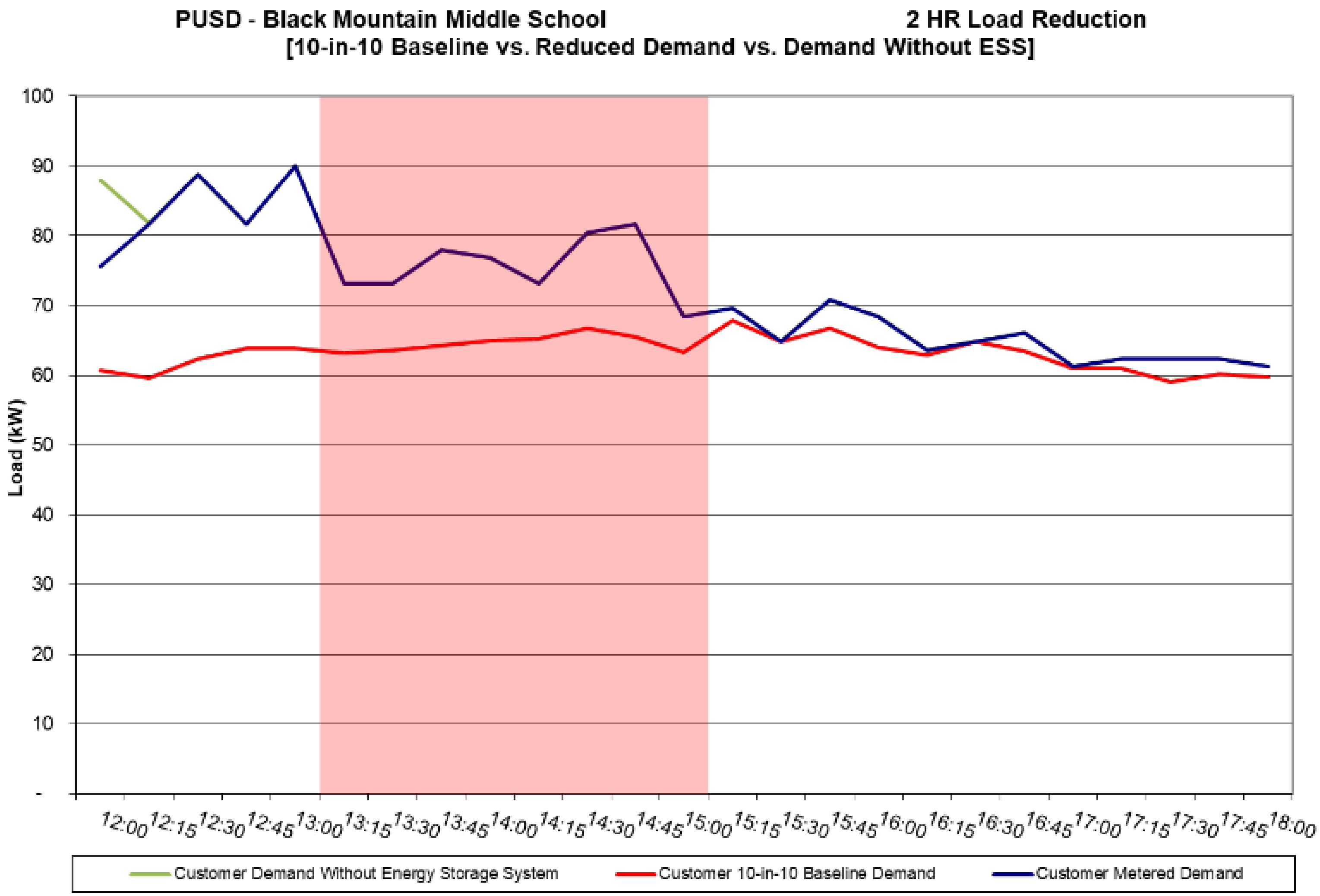


*Simulated DR Event #8*

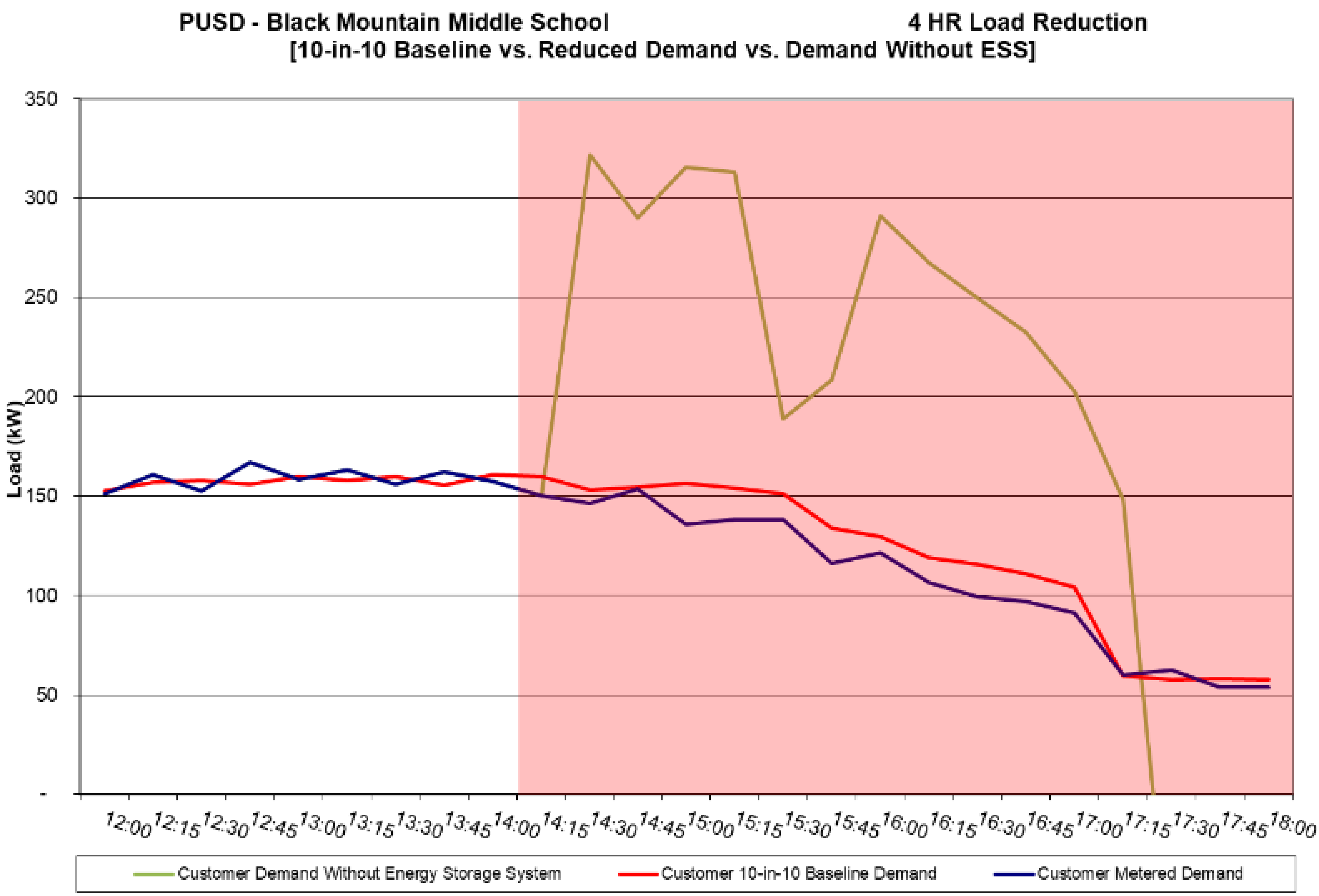


***PUSD – Black Mountain Middle School***

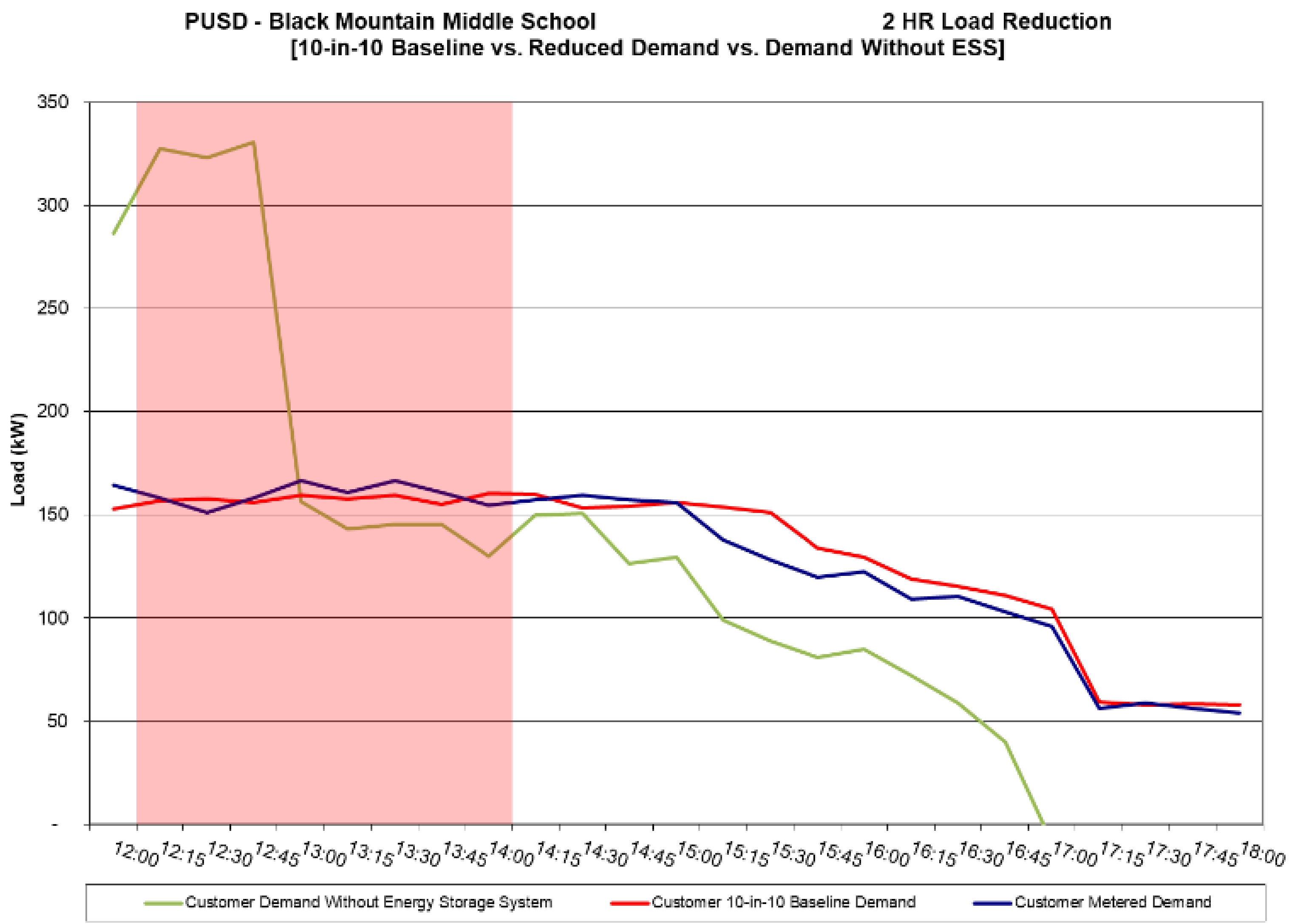
*Simulated DR Event #1*



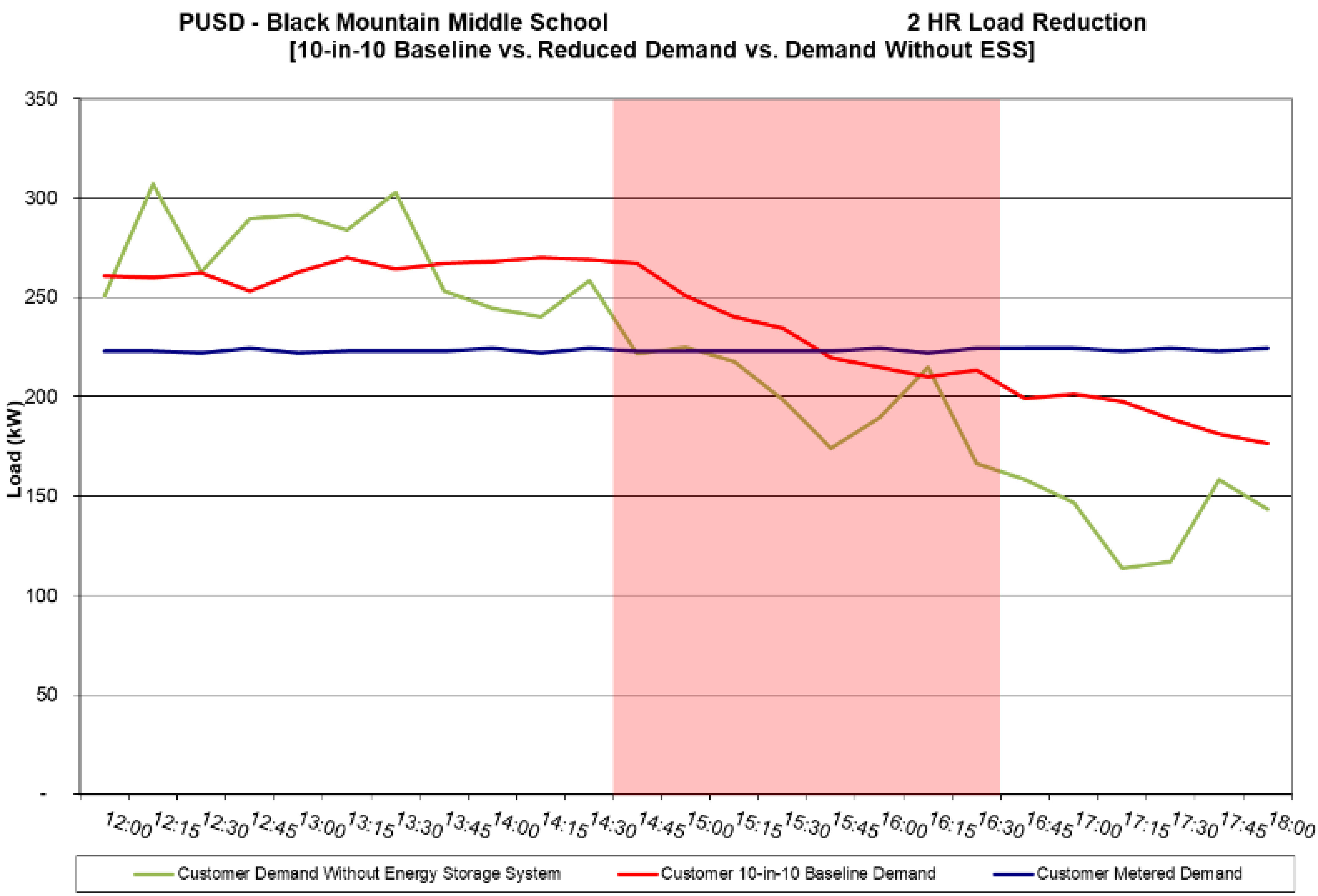
*Simulated DR Event #2*



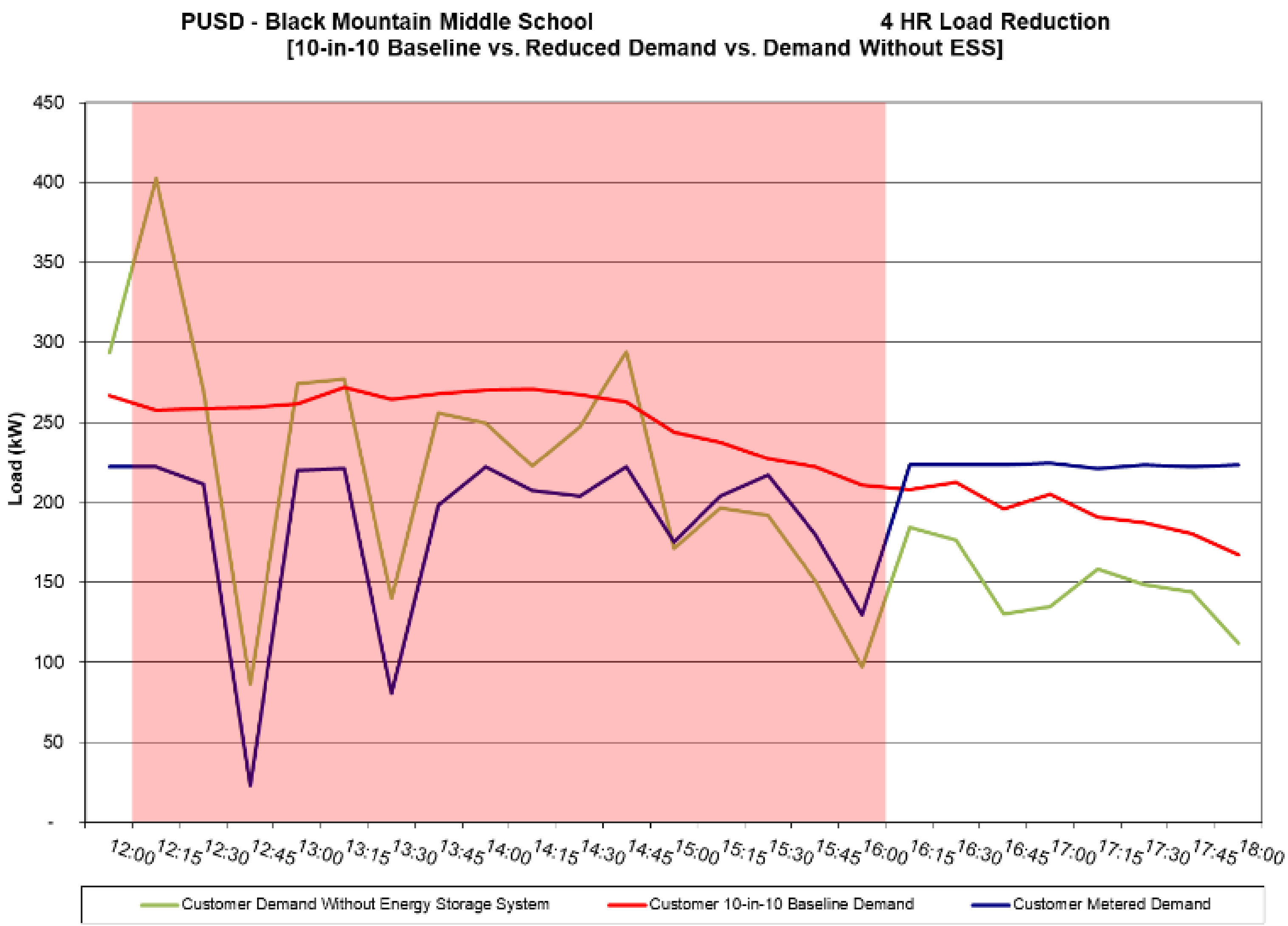
*Simulated DR Event #3*



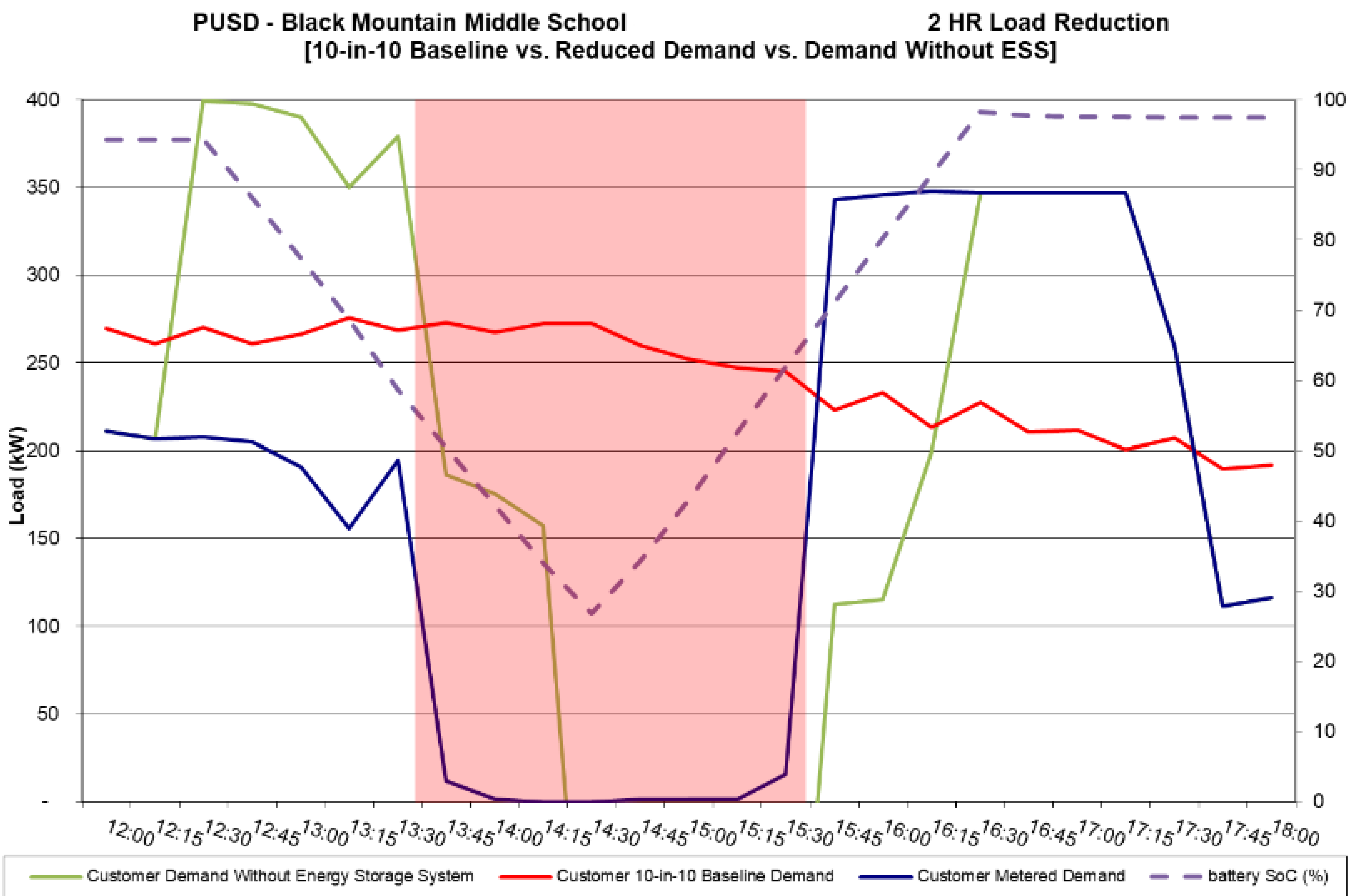
*Simulated DR Event #4*



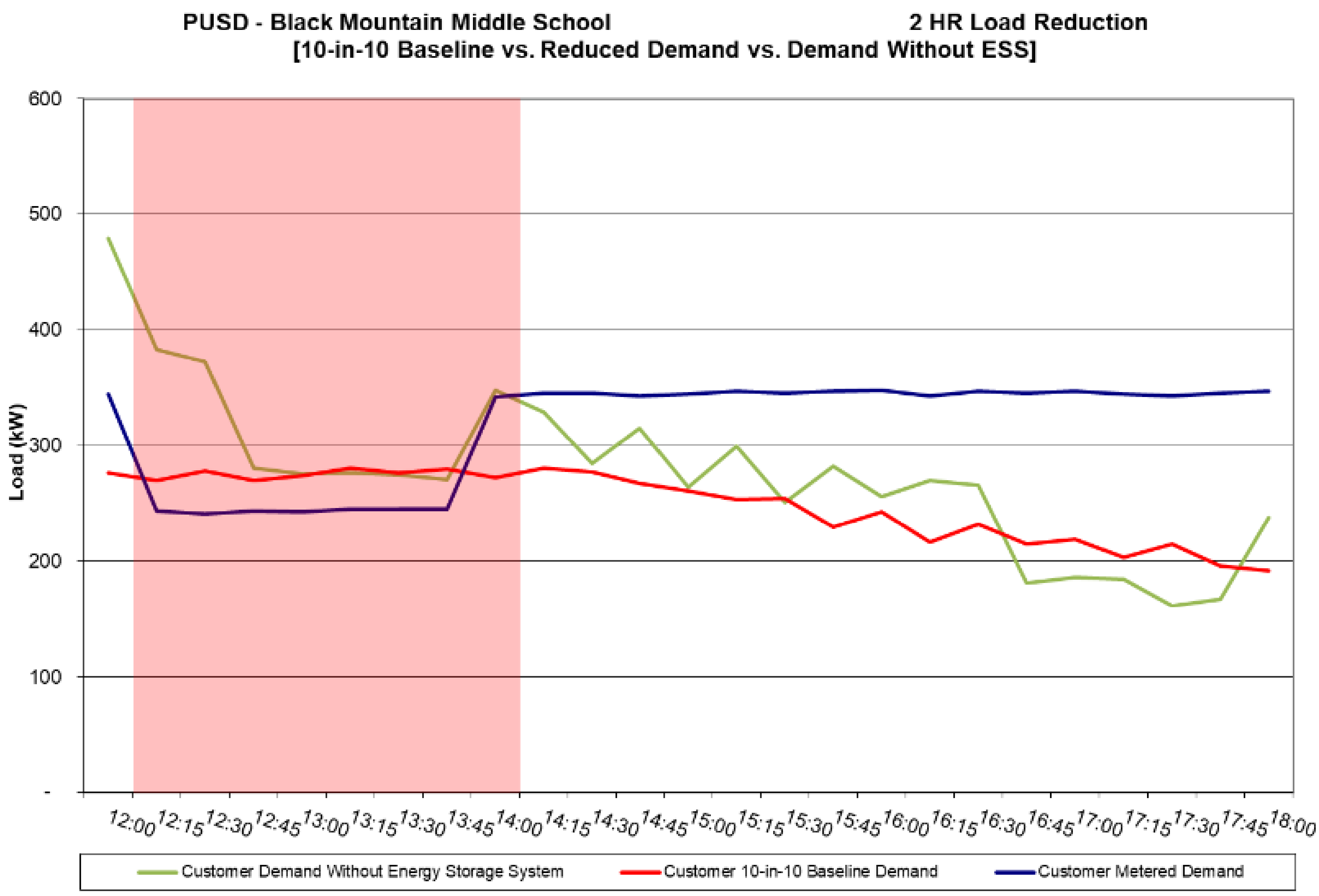
*Simulated DR Event #5*



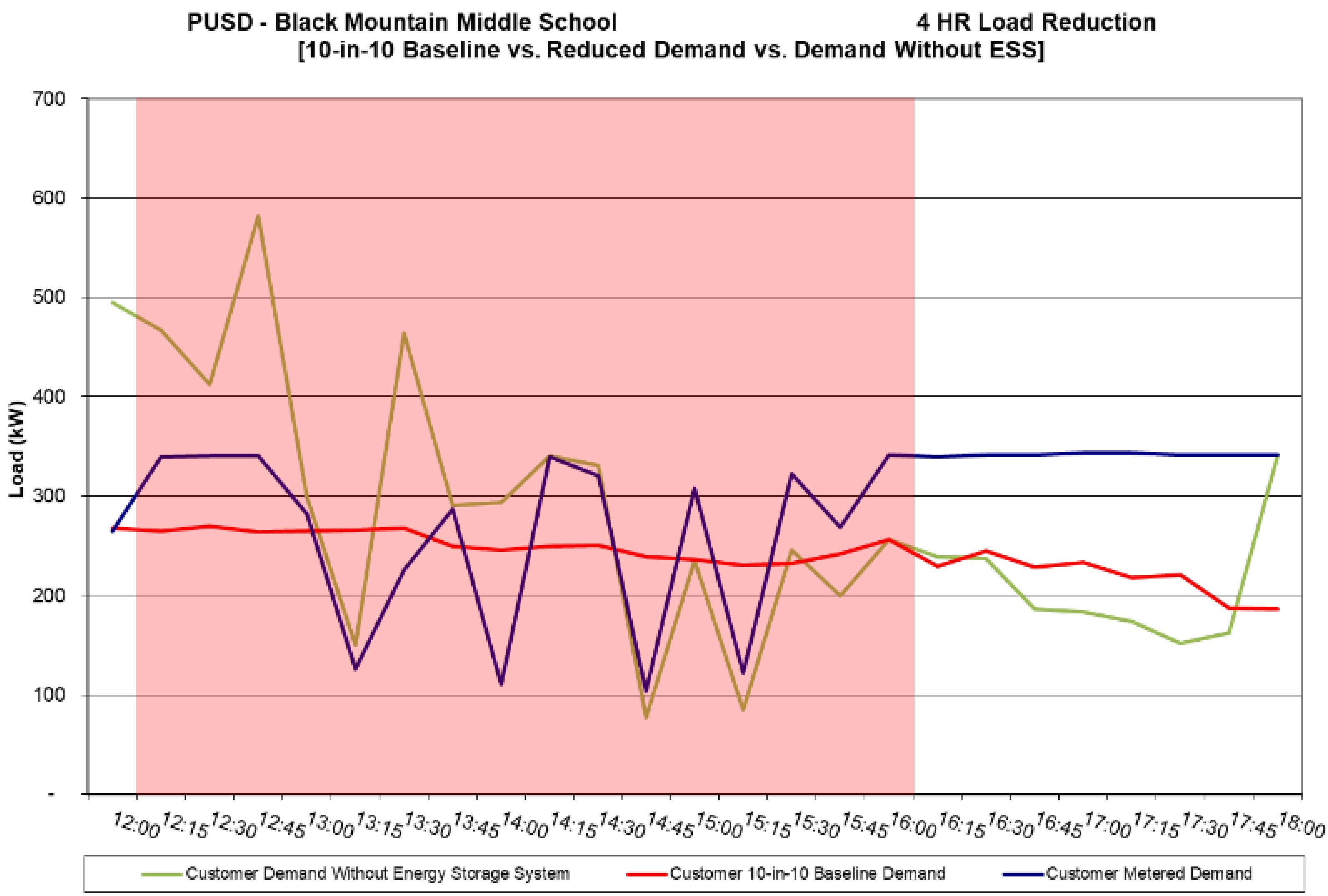
*Simulated DR Event #6*



*Simulated DR Event #7*

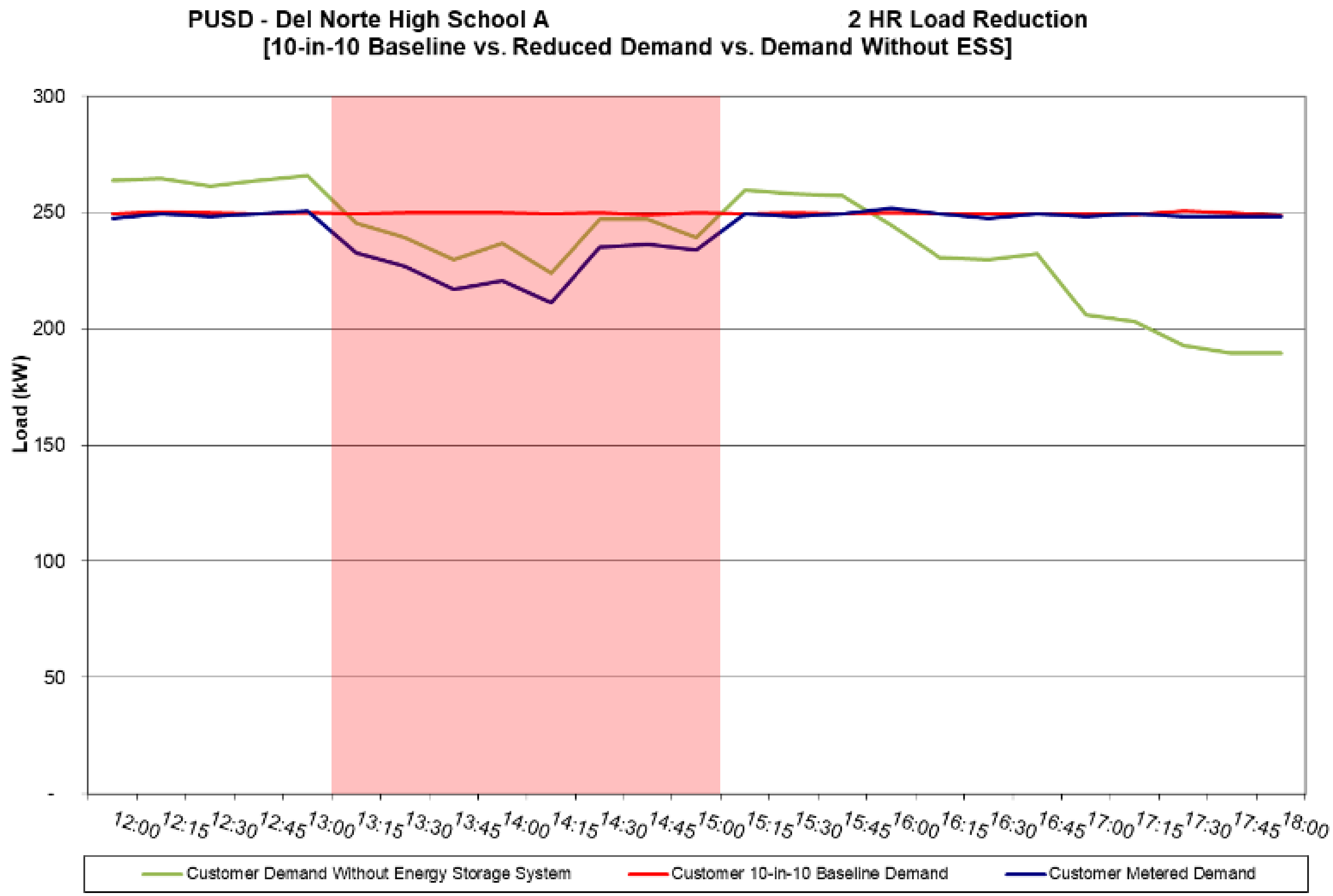


*Simulated DR Event #8*

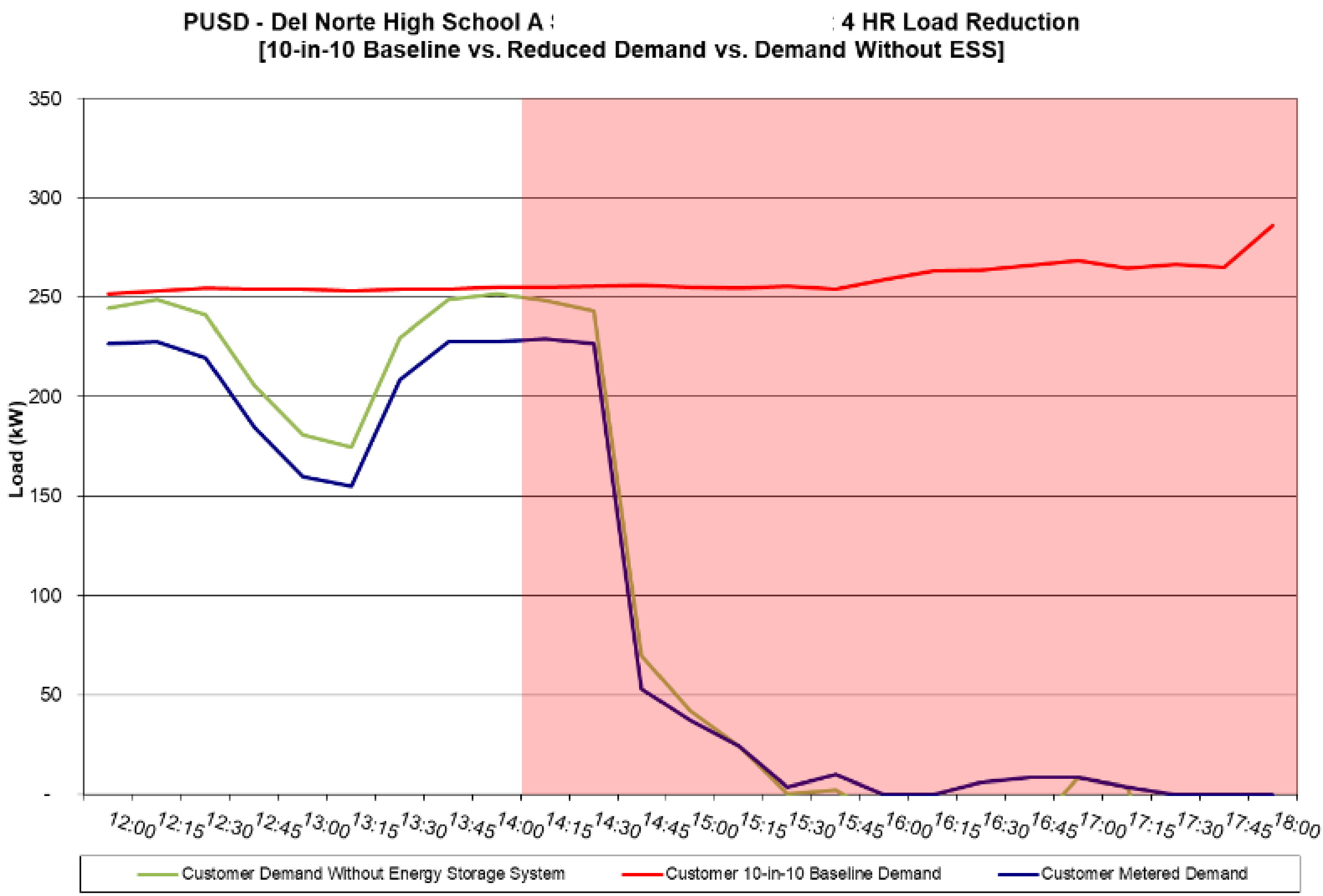


*PUSD – Del Norte High School A*

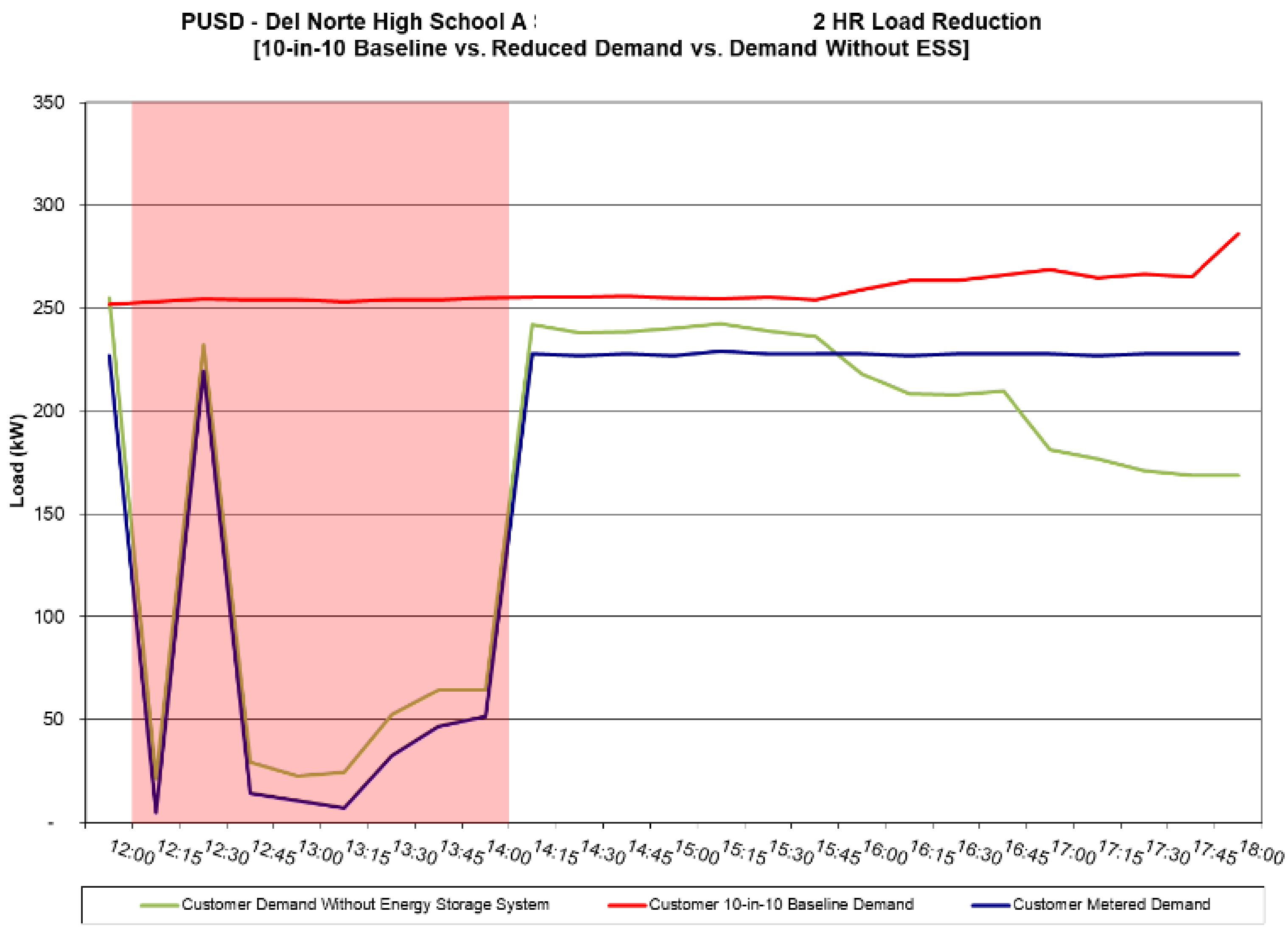
*Simulated DR Event #1*



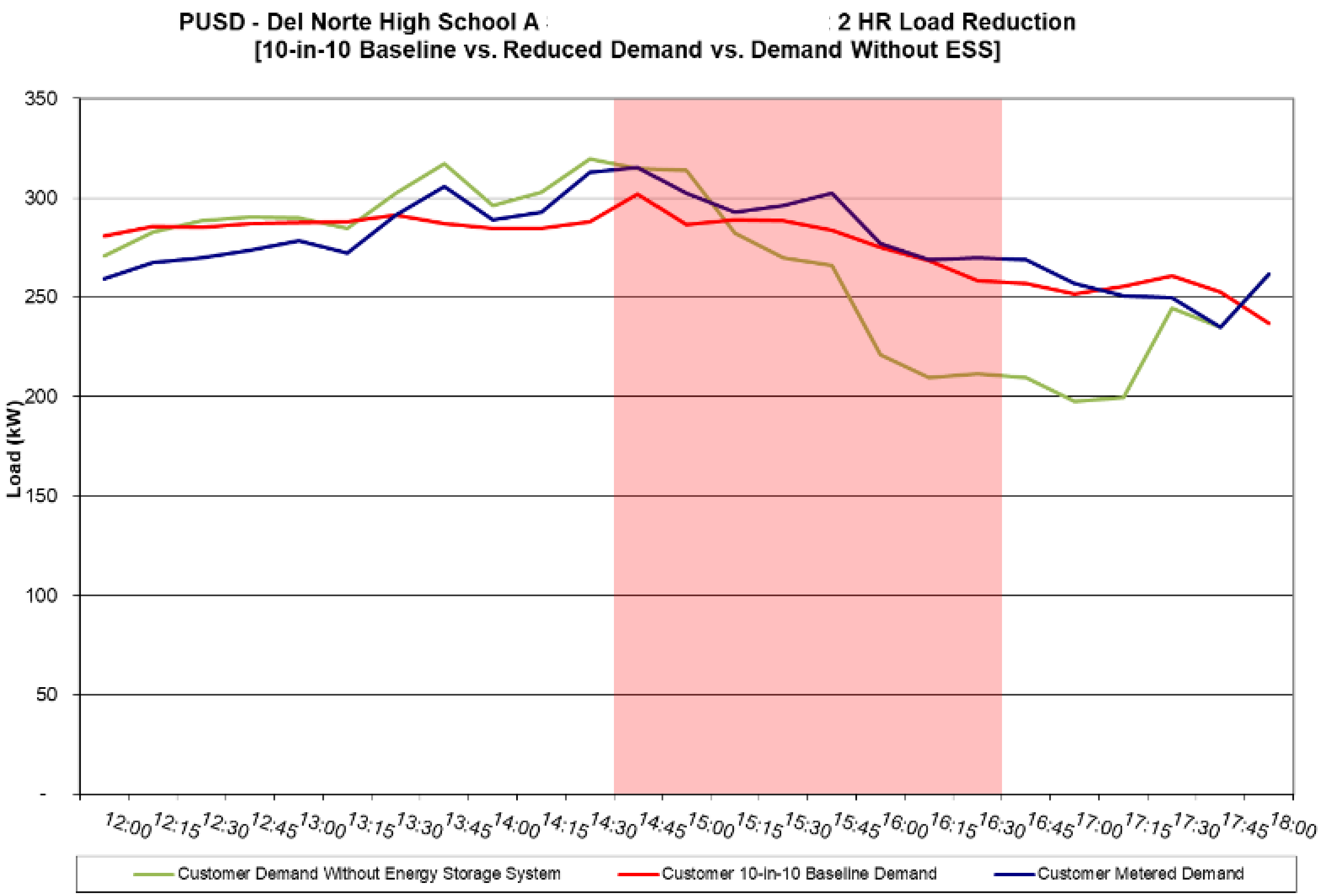
*Simulated DR Event #2*



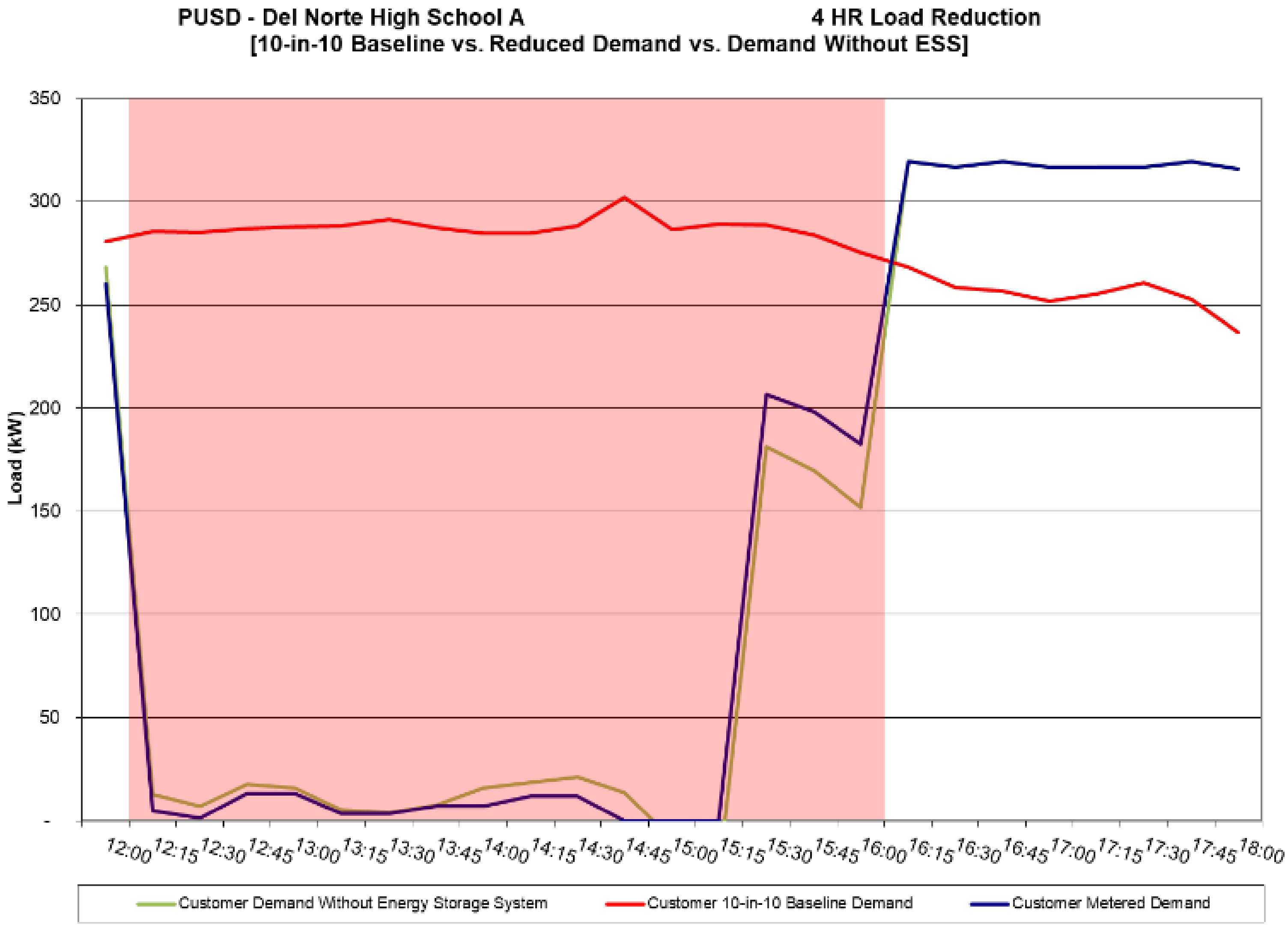
*Simulated DR Event #3*



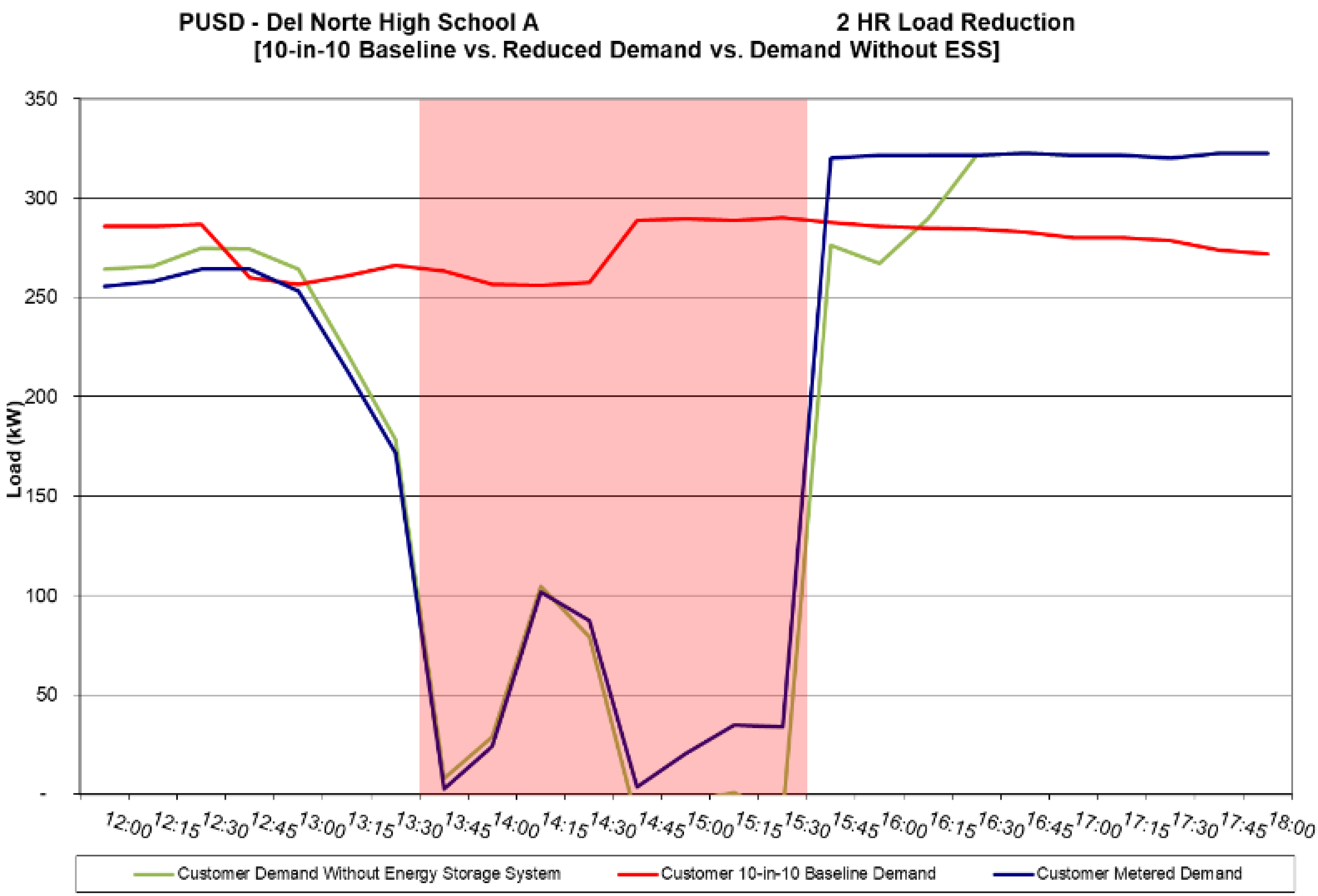
*Simulated DR Event #4*



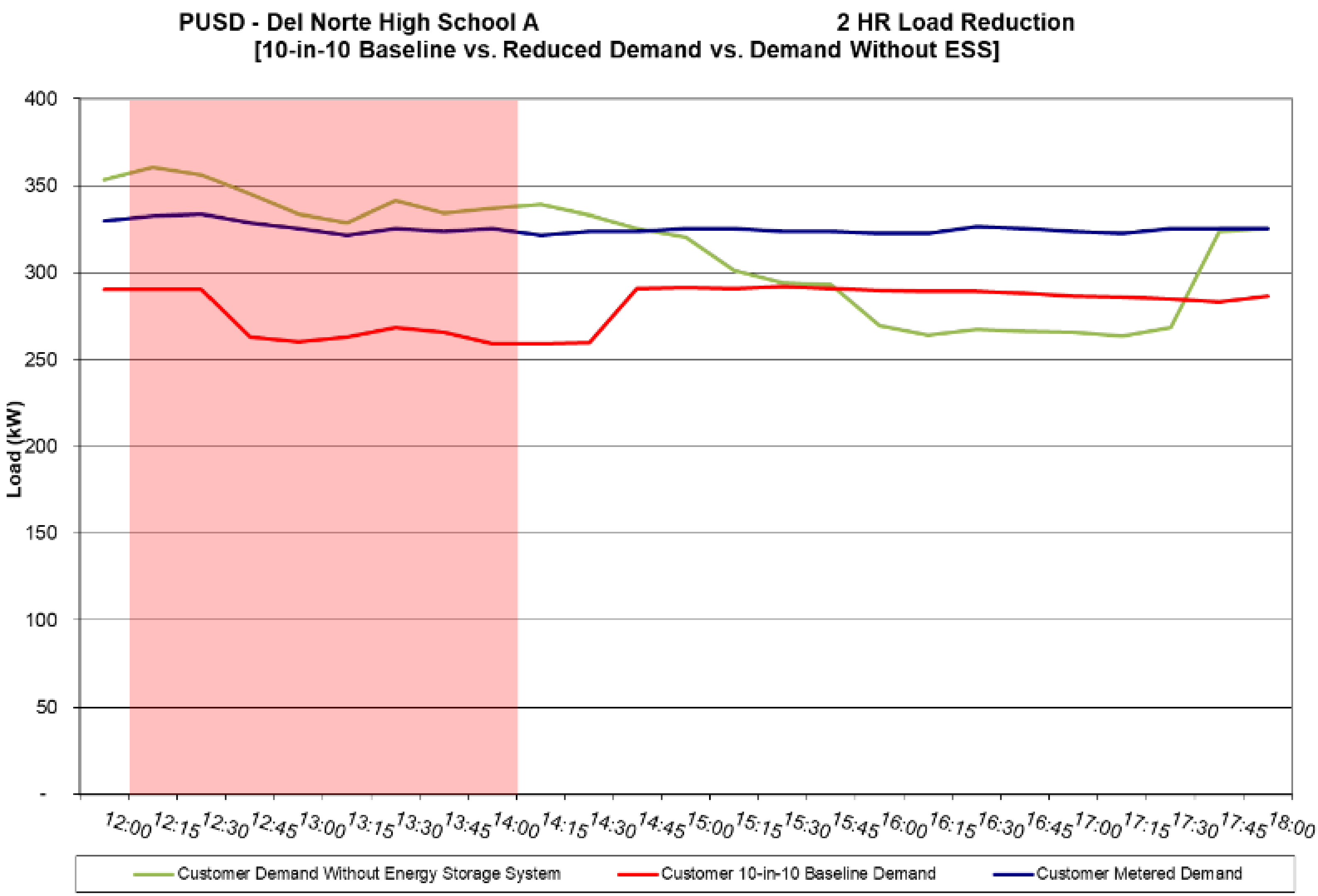
*Simulated DR Event #5*



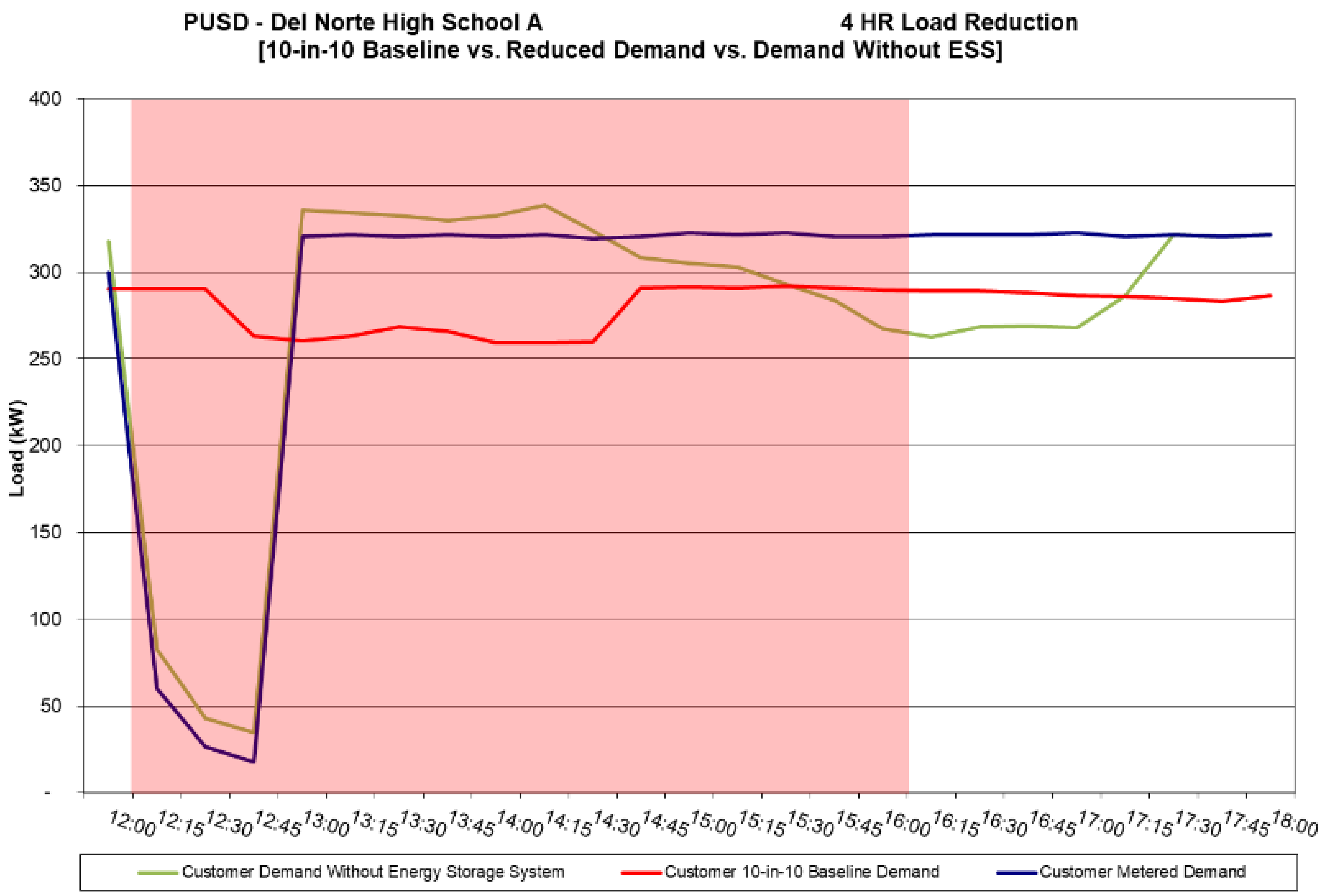
*Simulated DR Event #6*



*Simulated DR Event #7*

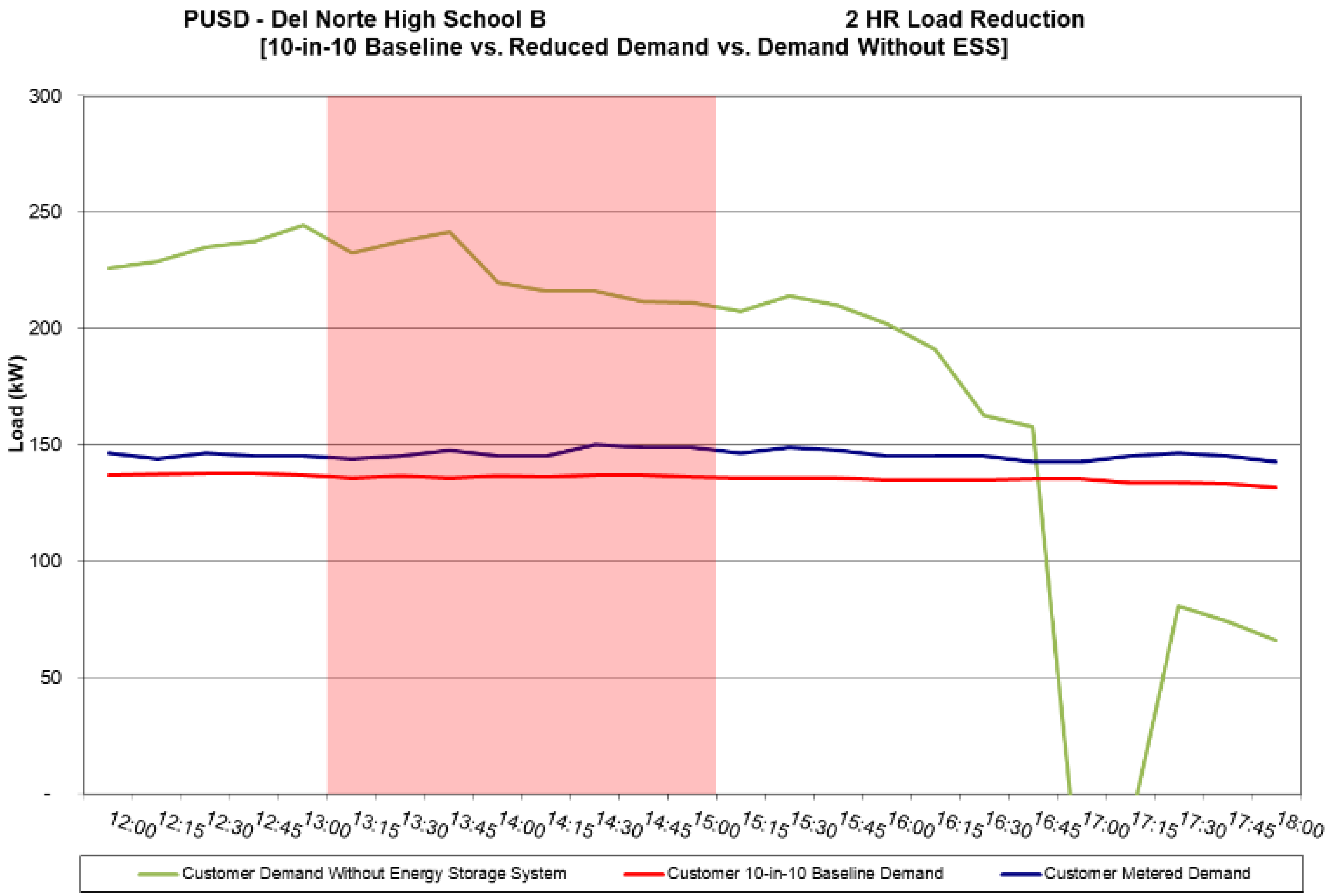


*Simulated DR Event #8*

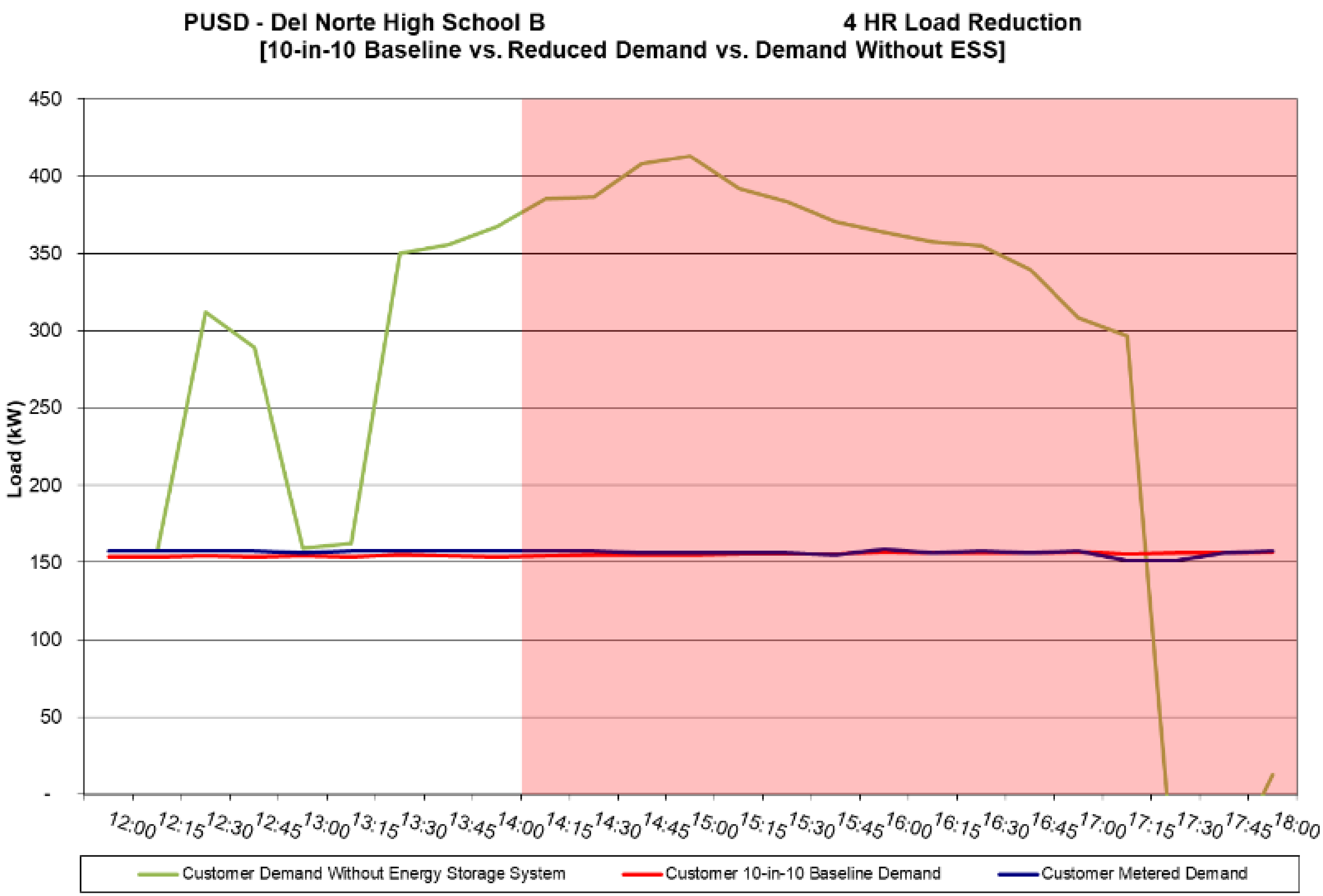


***PUSD – Del Norte High School B***

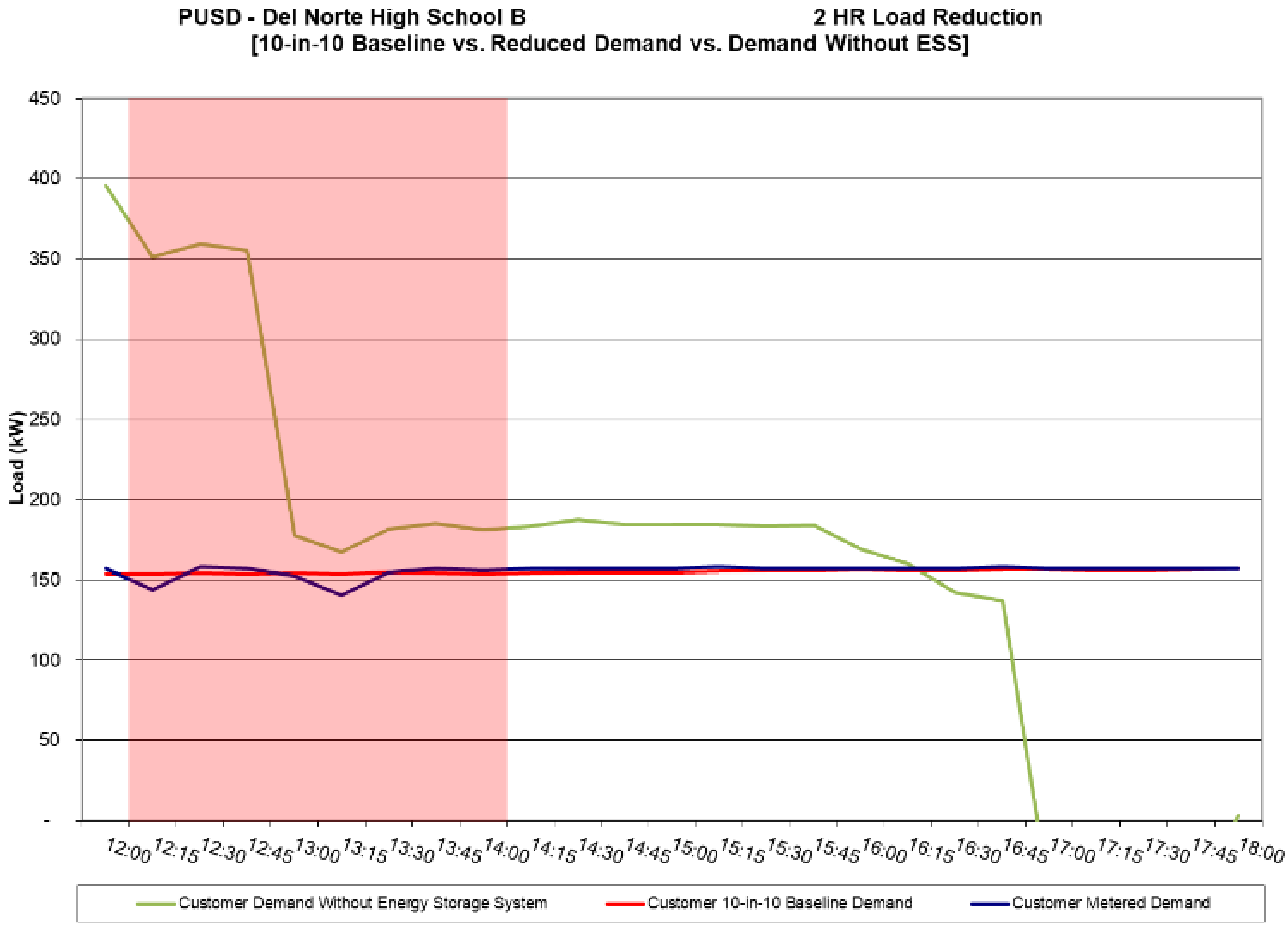
*Simulated DR Event #1*



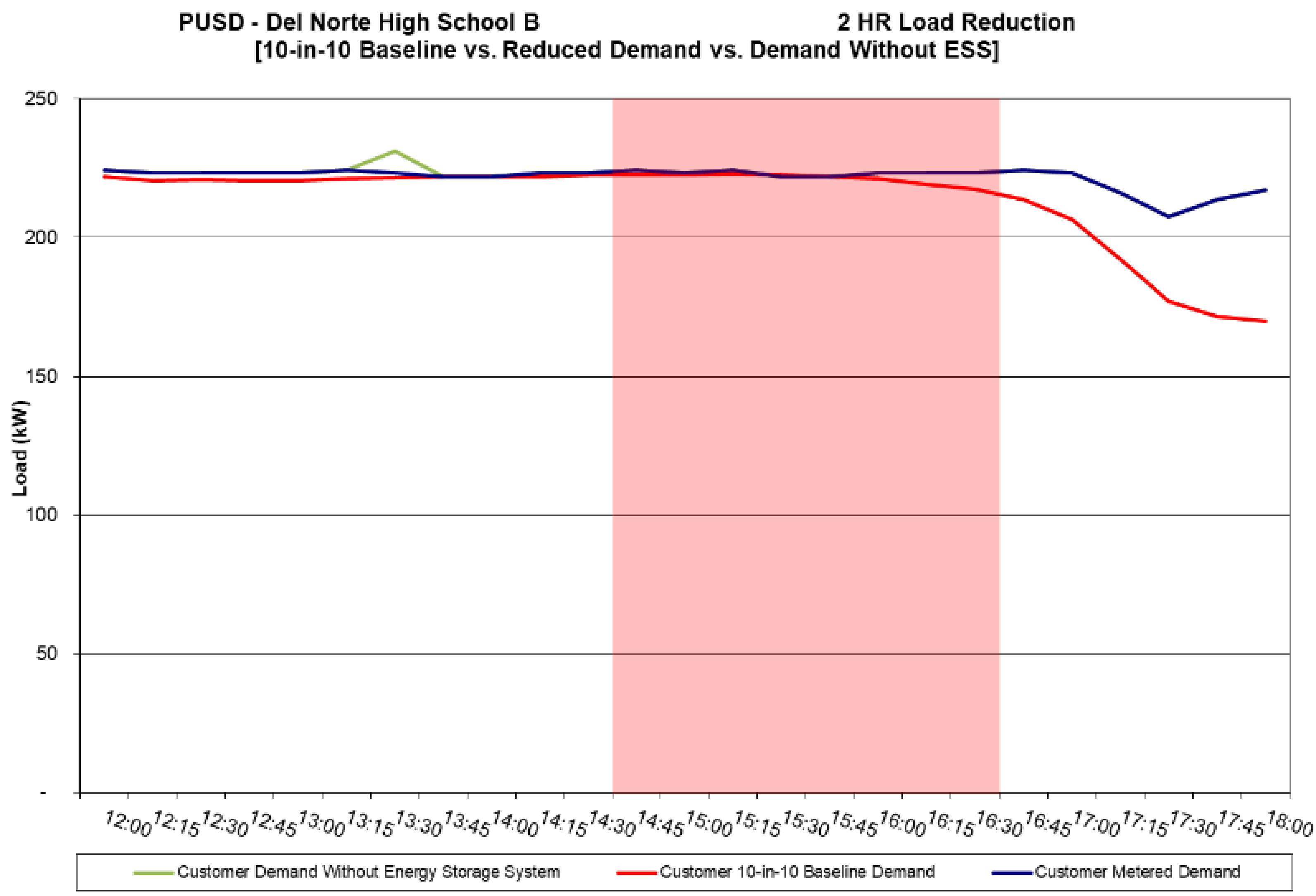
*Simulated DR Event #2*



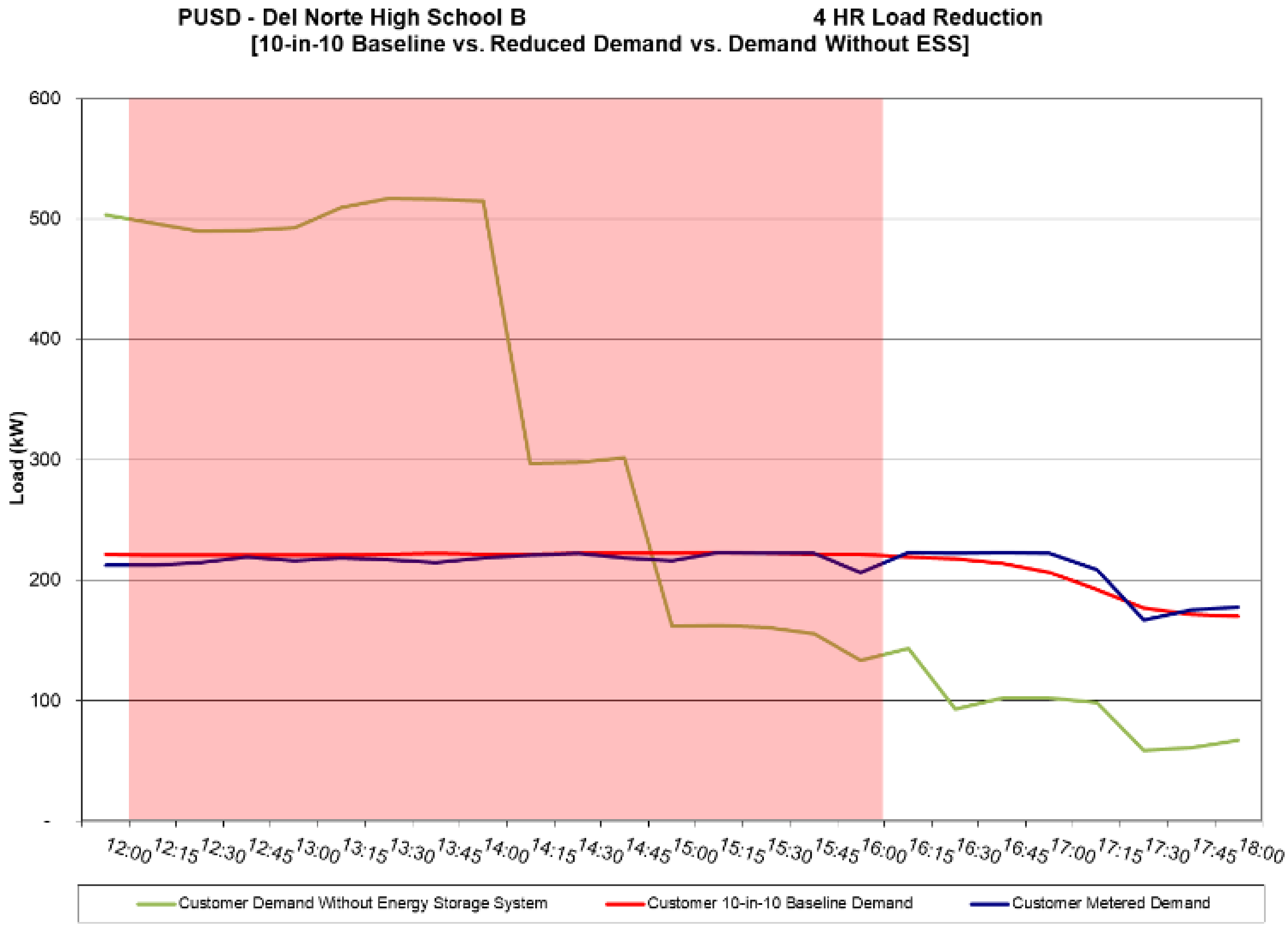
*Simulated DR Event #3*



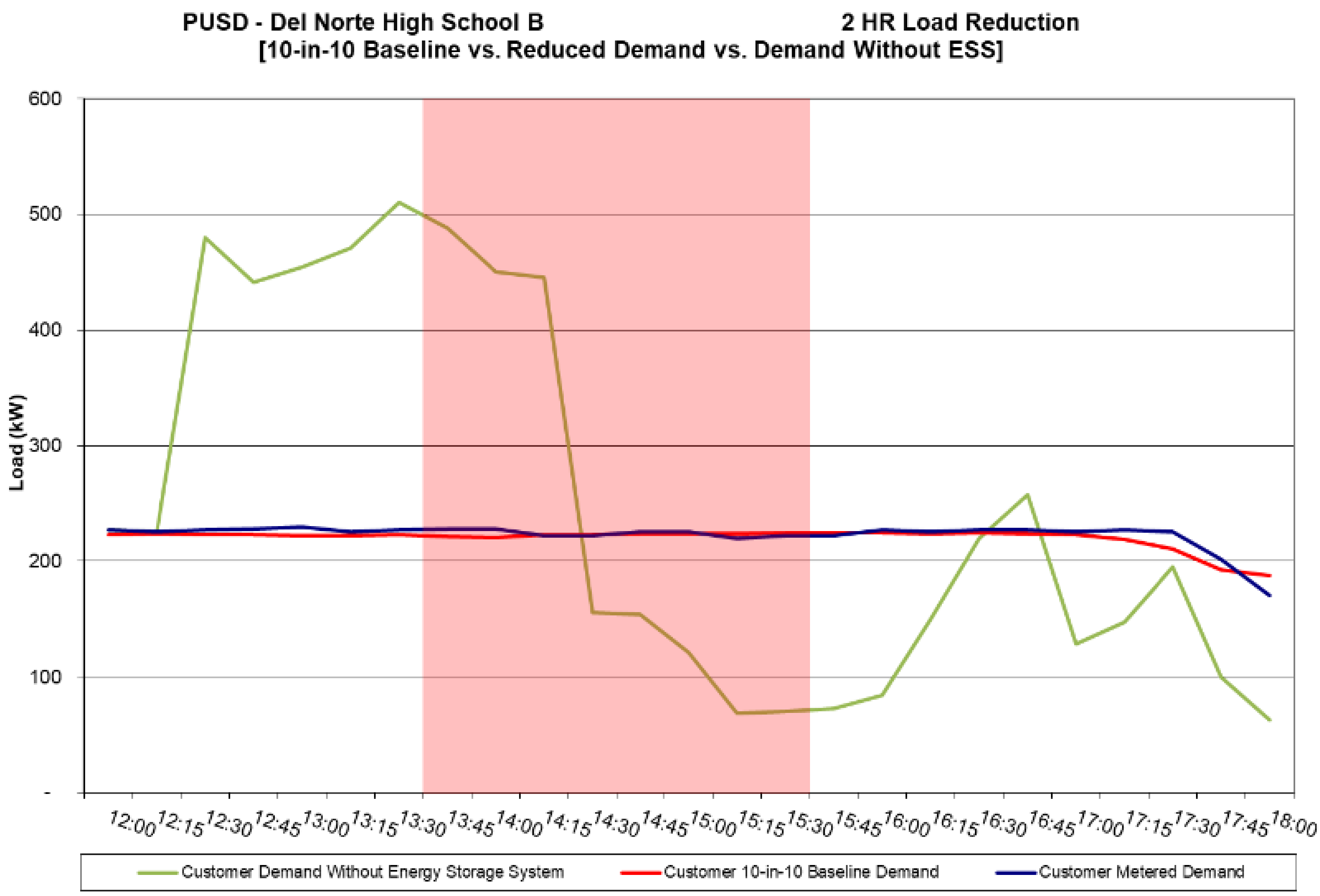
*Simulated DR Event #4*



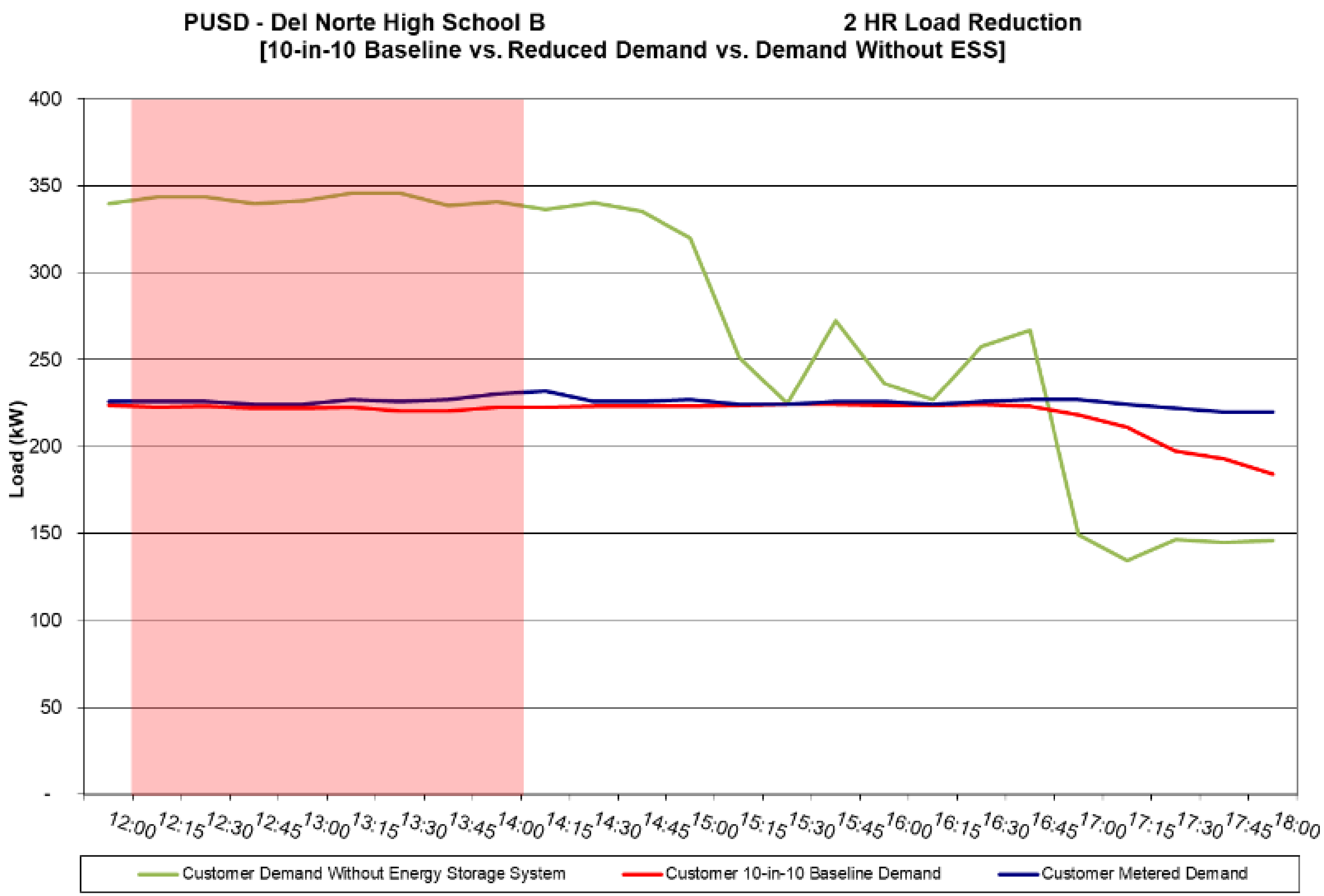
*Simulated DR Event #5*



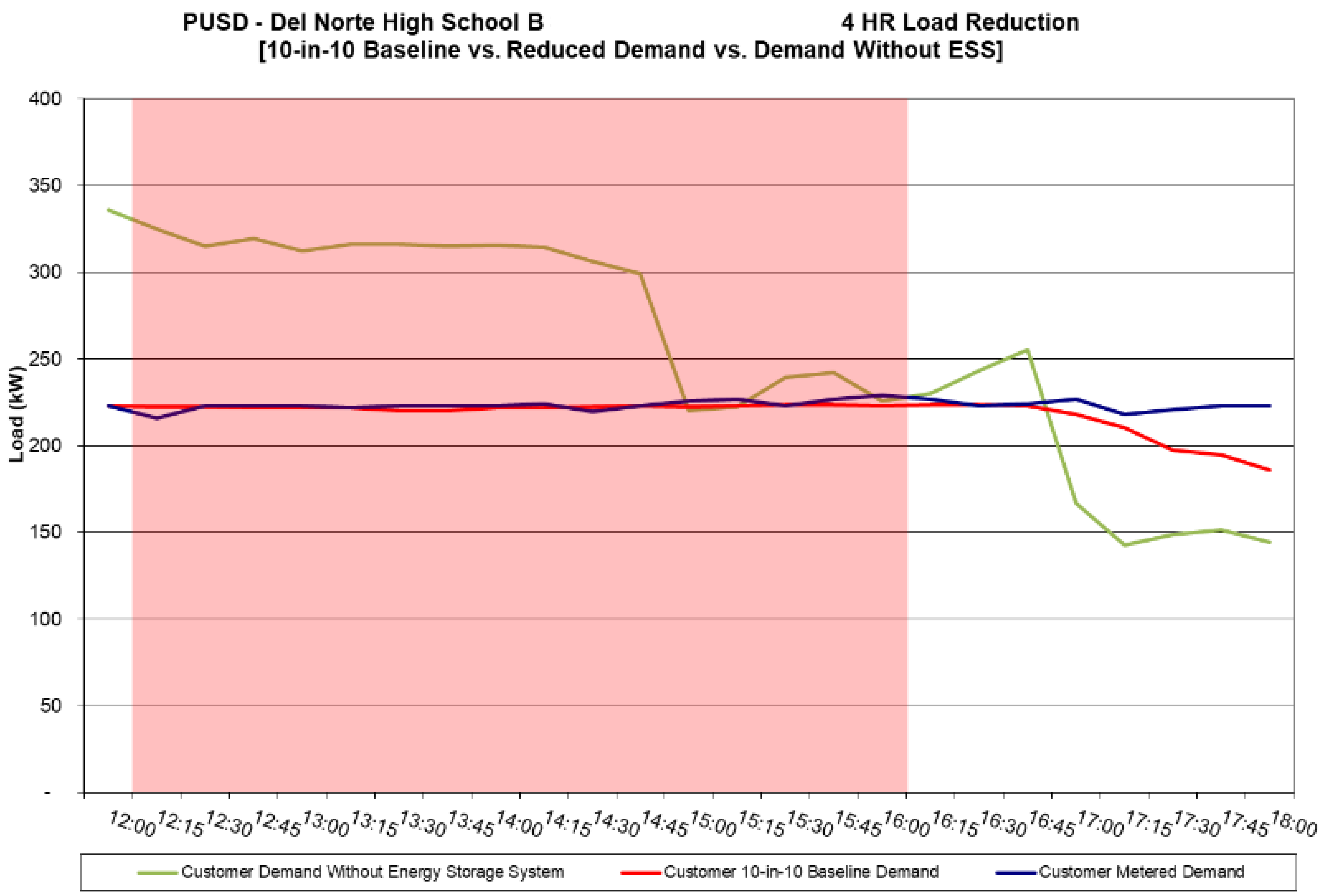
*Simulated DR Event #6*



*Simulated DR Event #7*

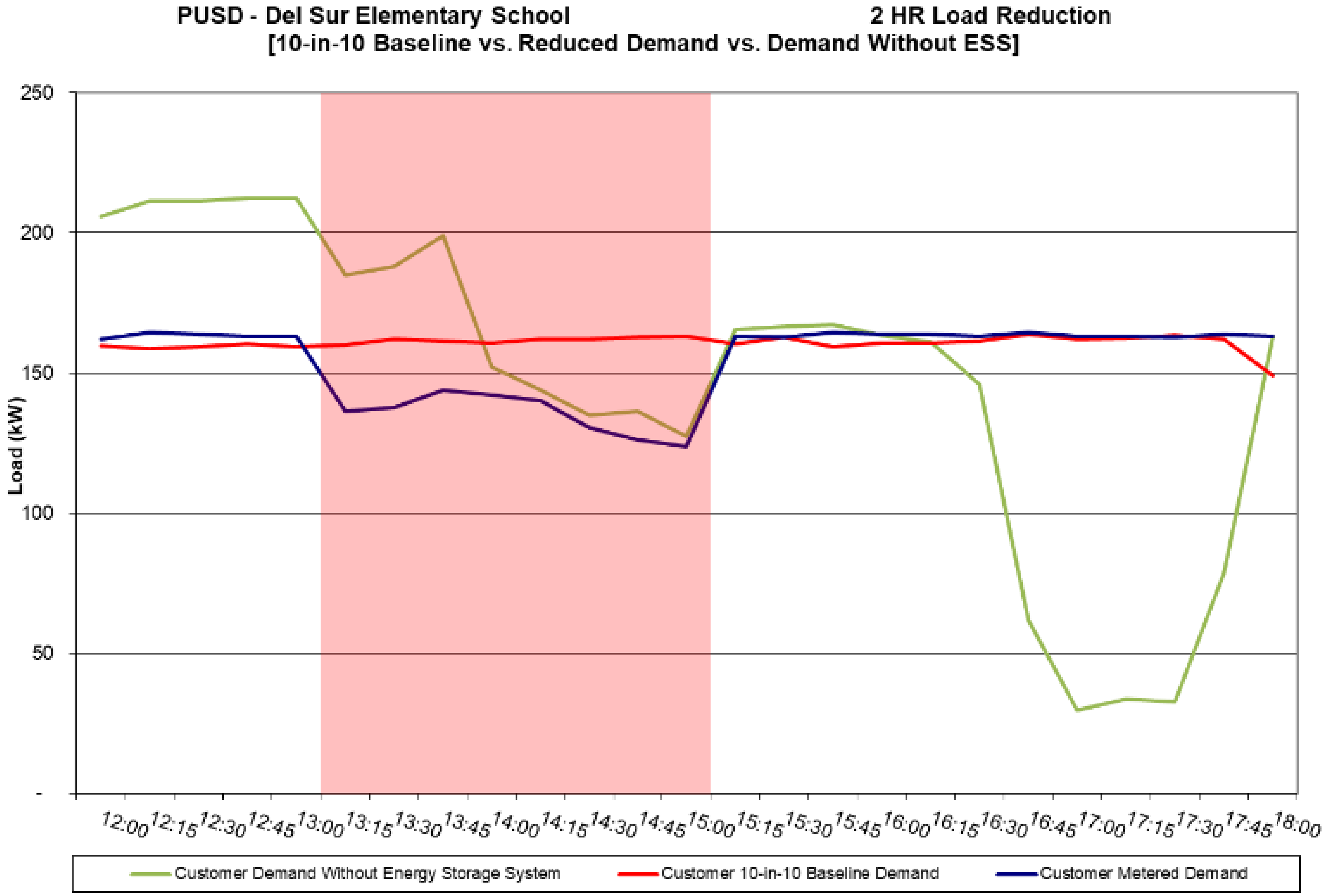


*Simulated DR Event #8*

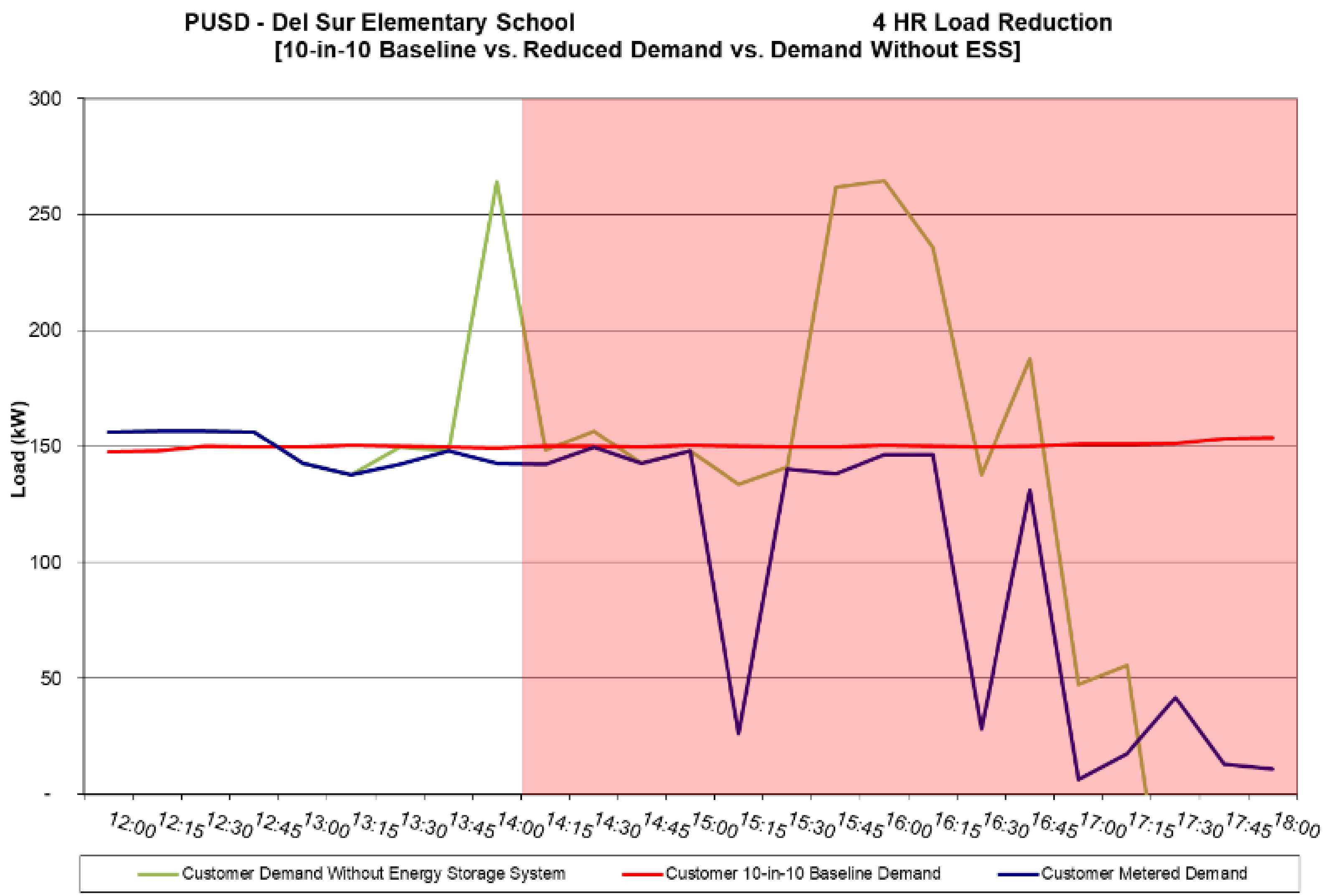


***PUSD – Del Sur Elementary School***

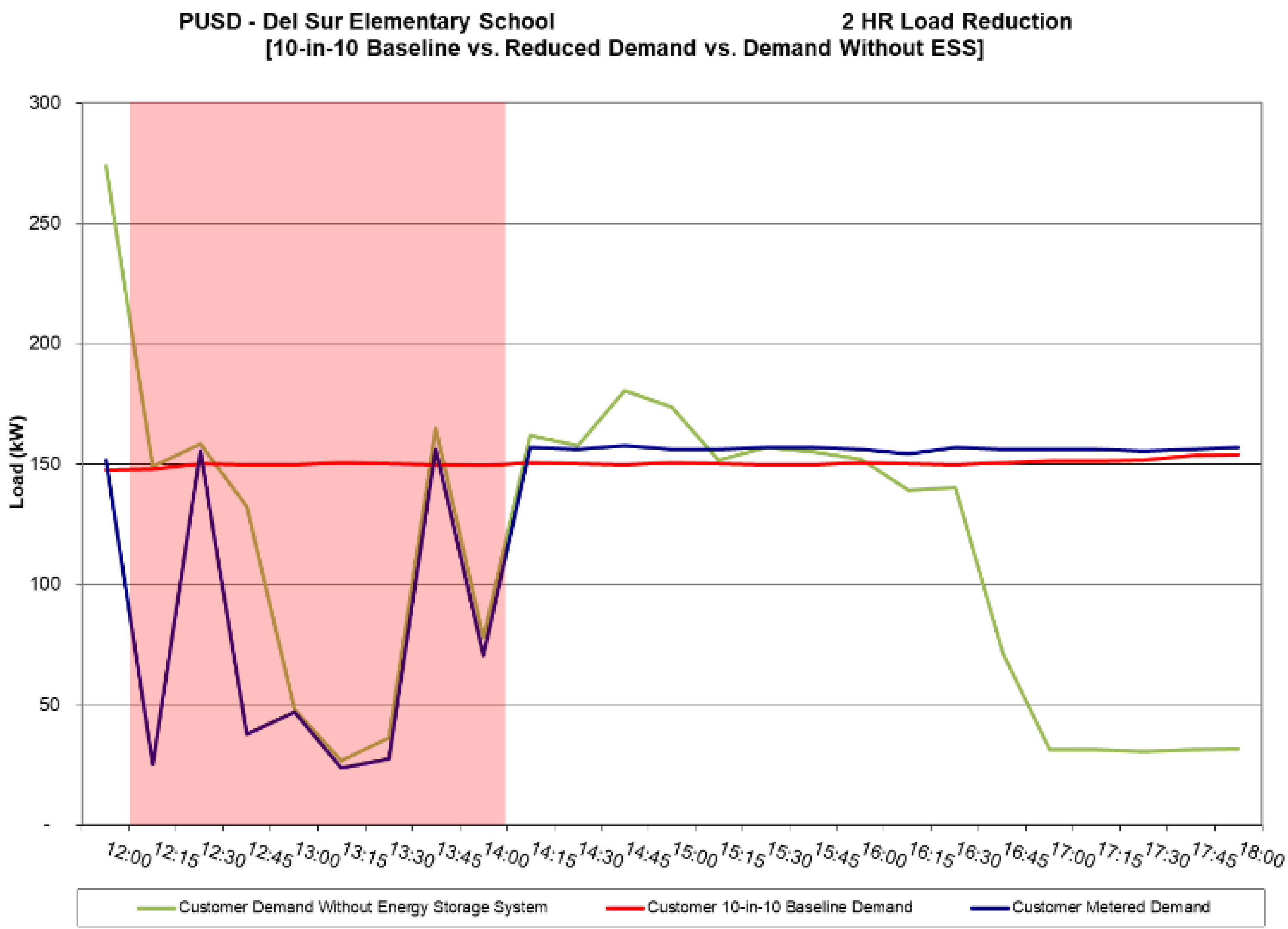
*Simulated DR Event #1*



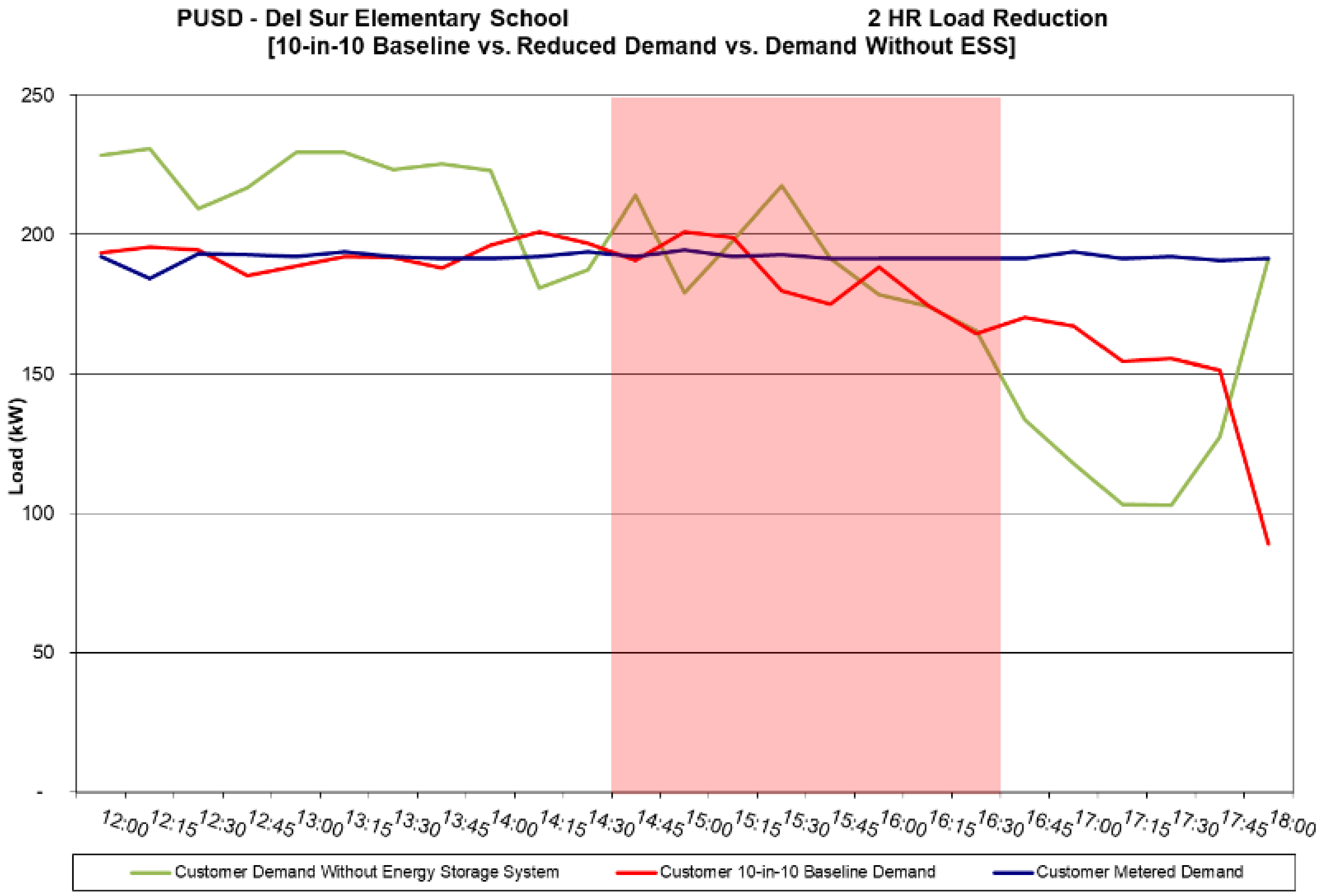
*Simulated DR Event #2*



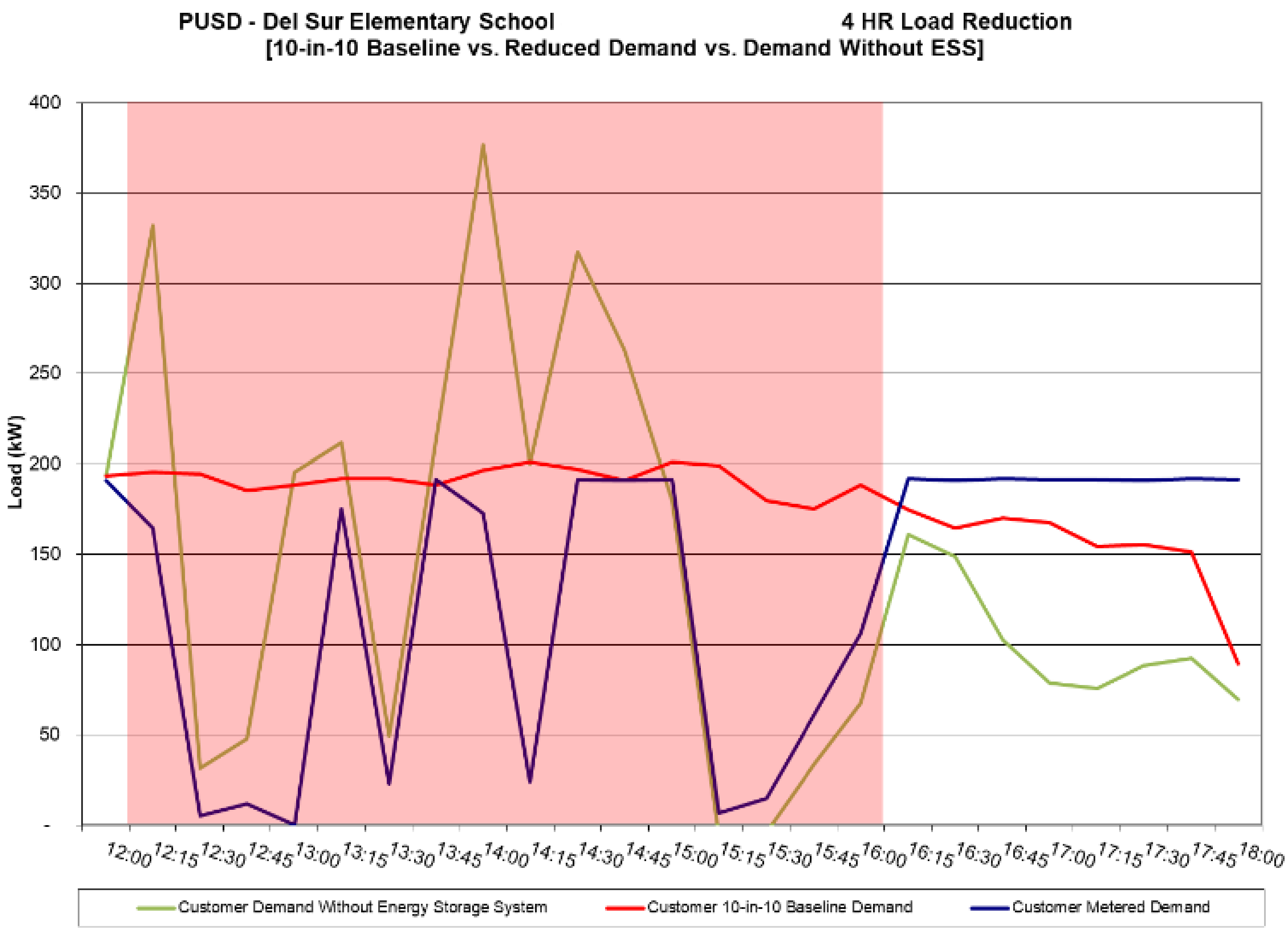
*Simulated DR Event #3*



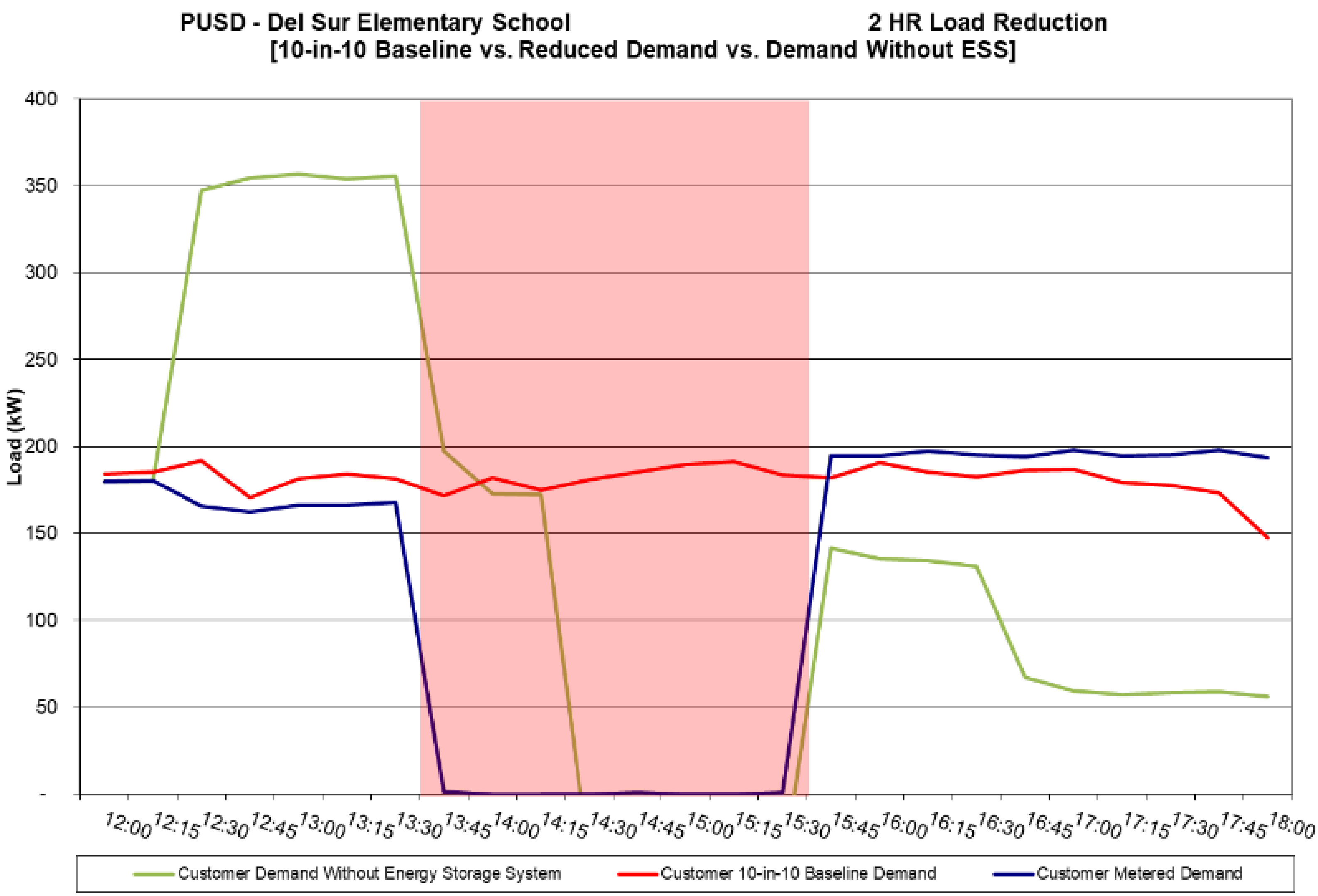
*Simulated DR Event #4*



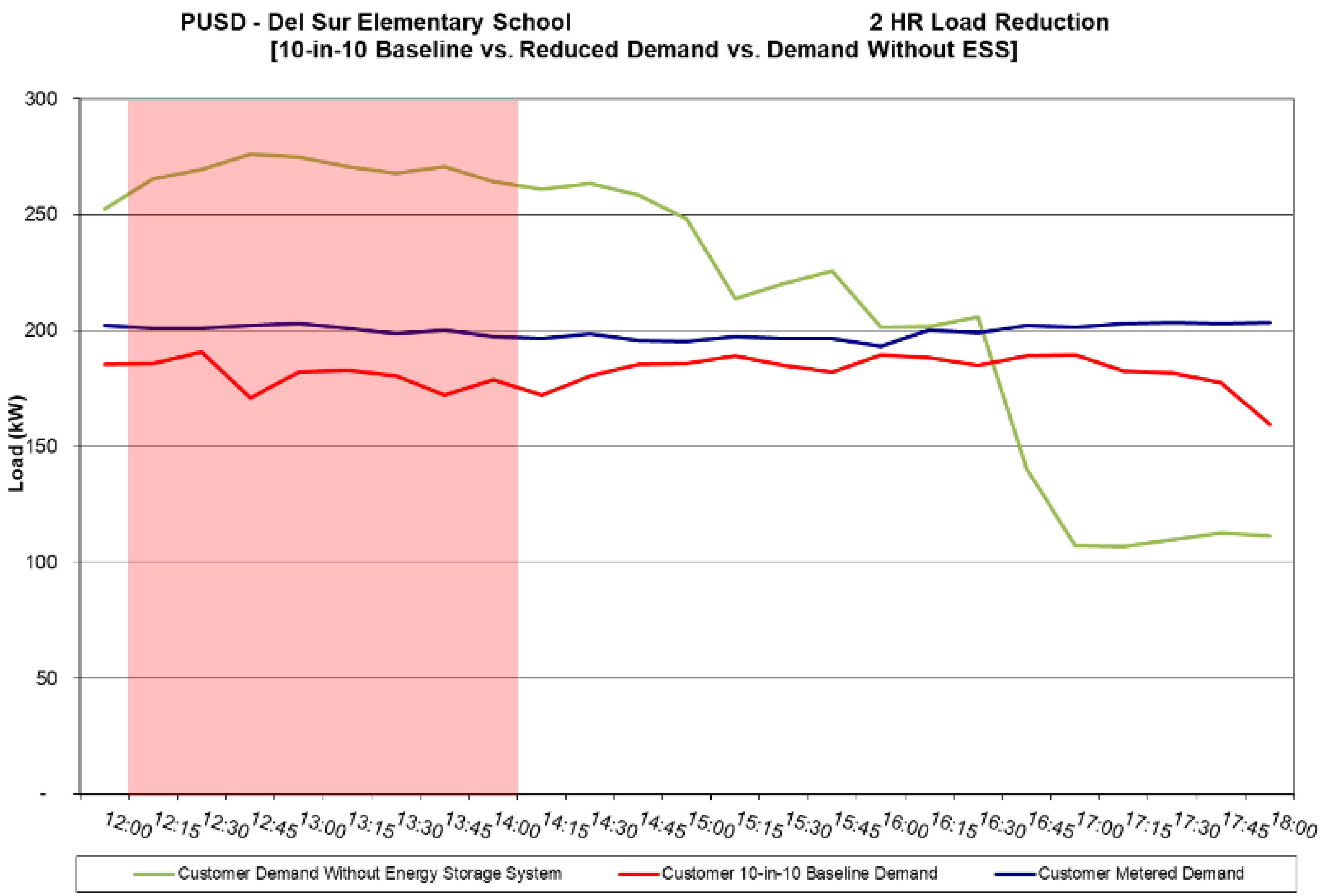
*Simulated DR Event #5*



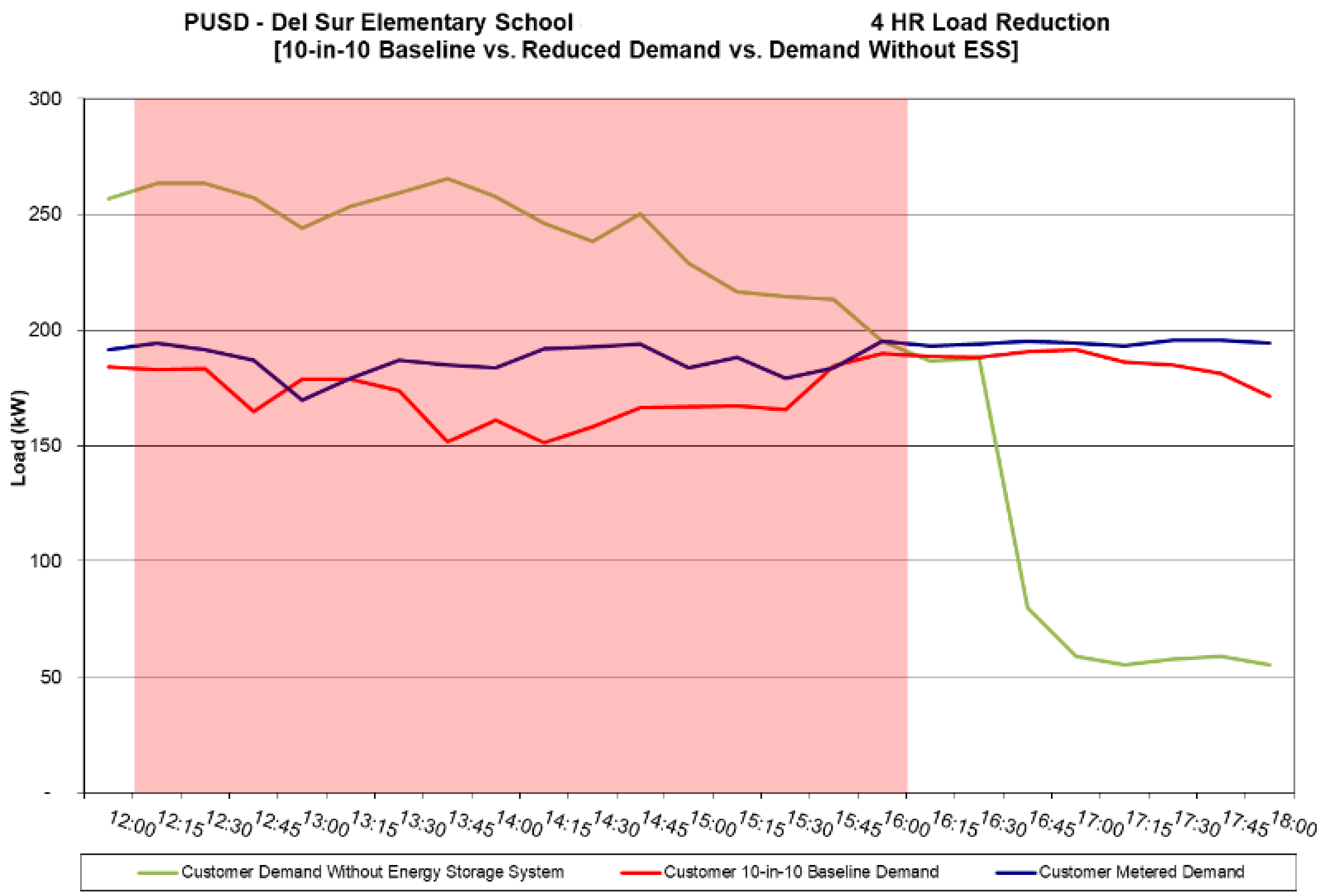
*Simulated DR Event #6*



*Simulated DR Event #7*

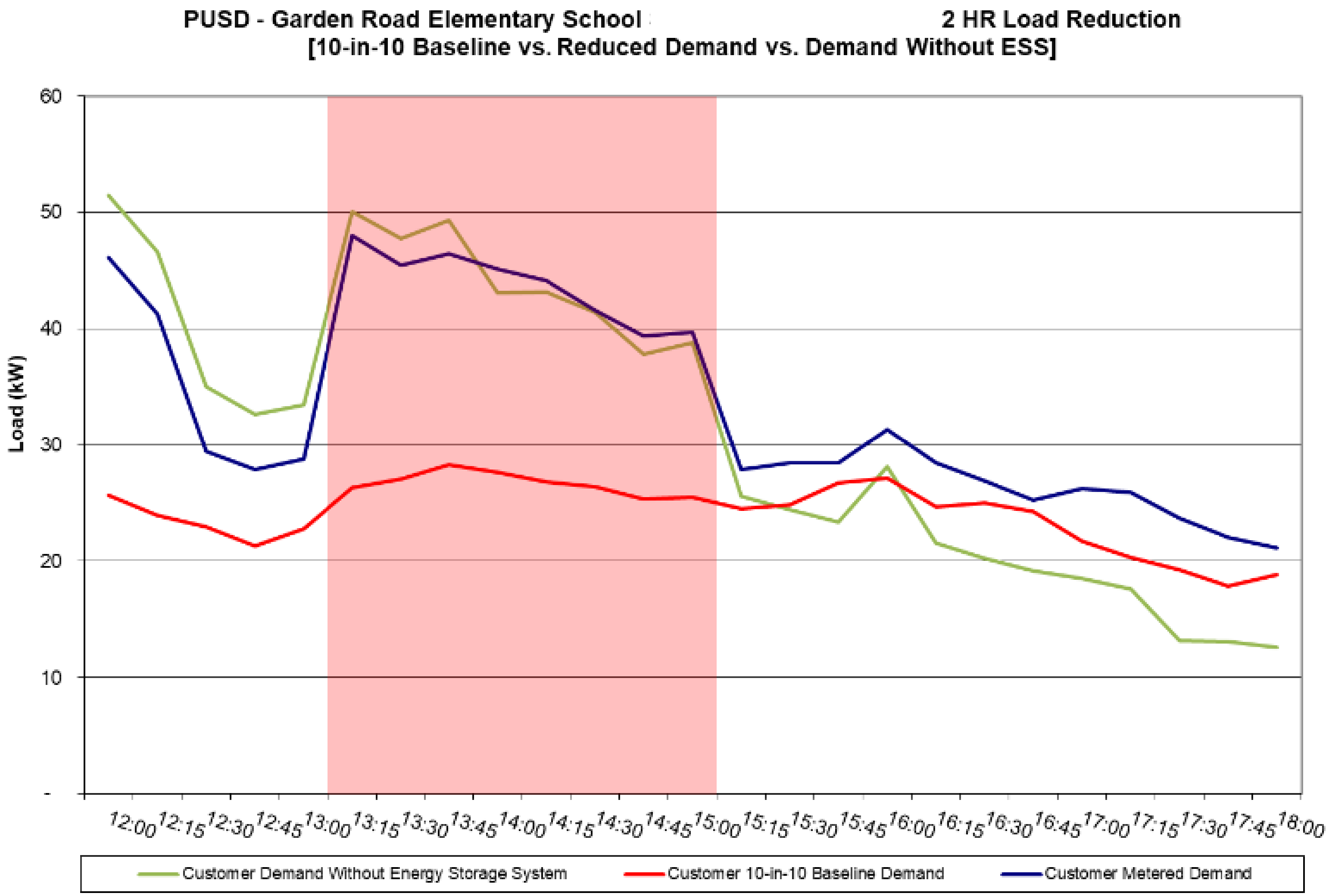


*Simulated DR Event #8*

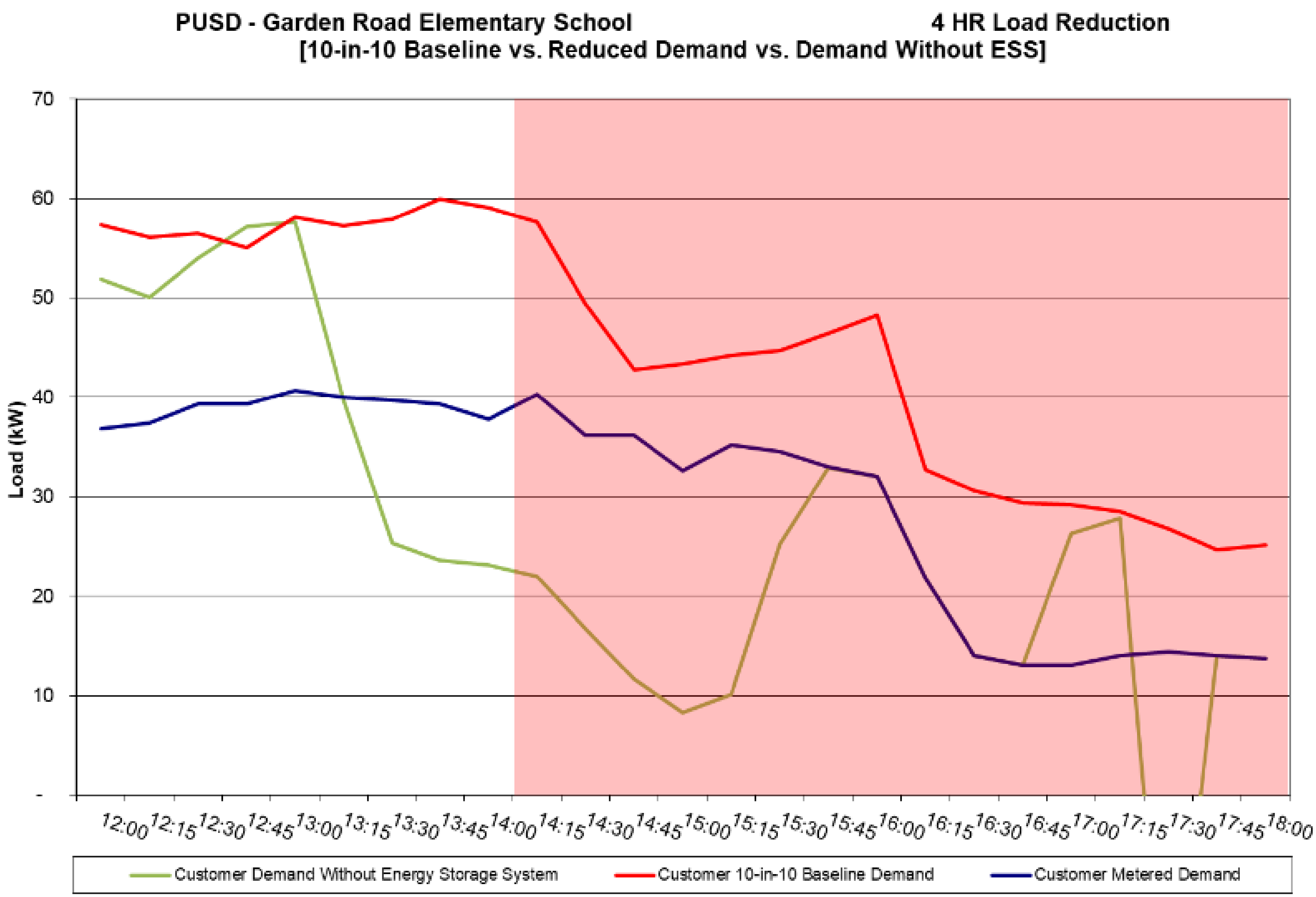


***PUSD – Garden Road Elementary School***

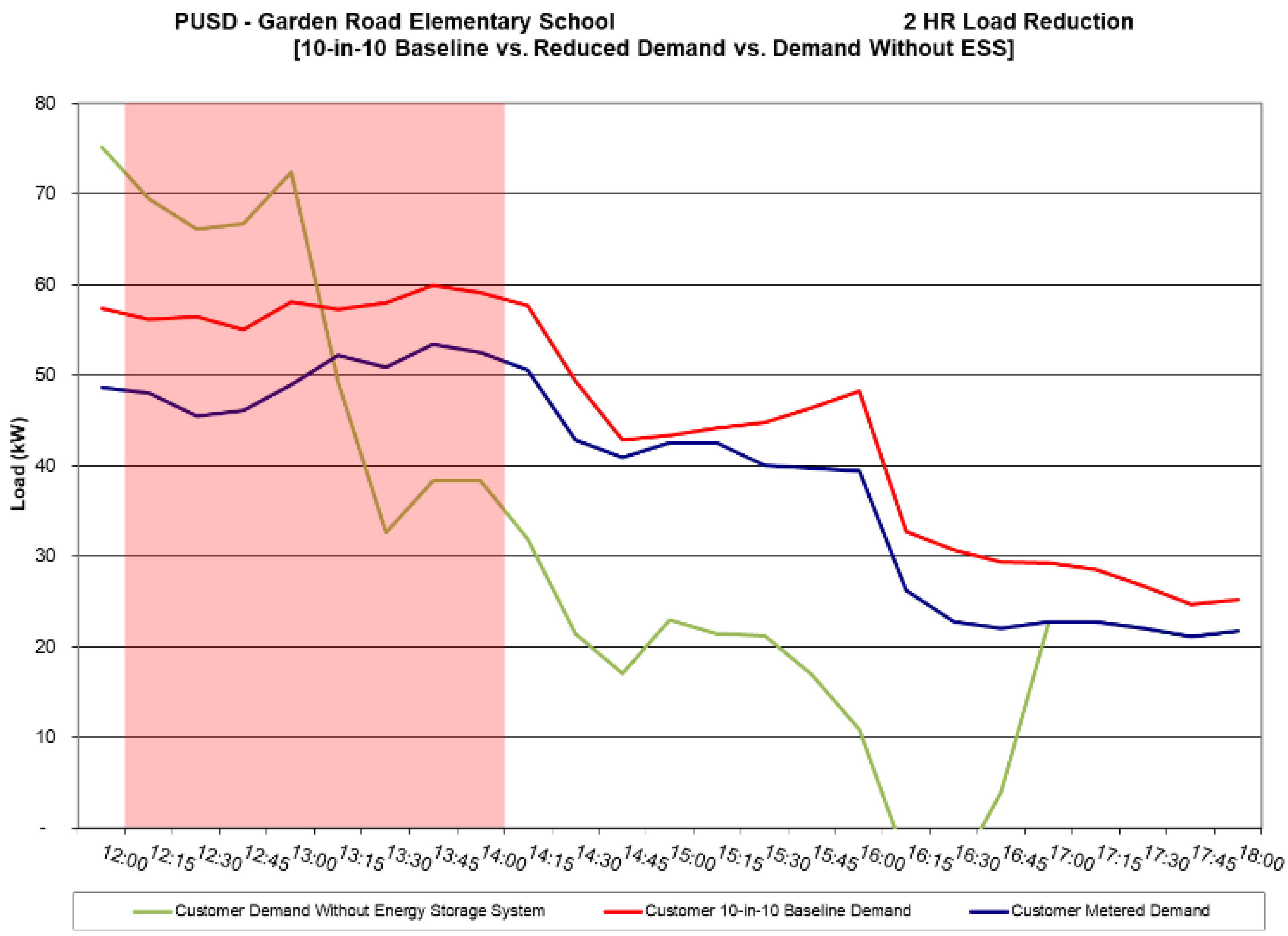
*Simulated DR Event #1*



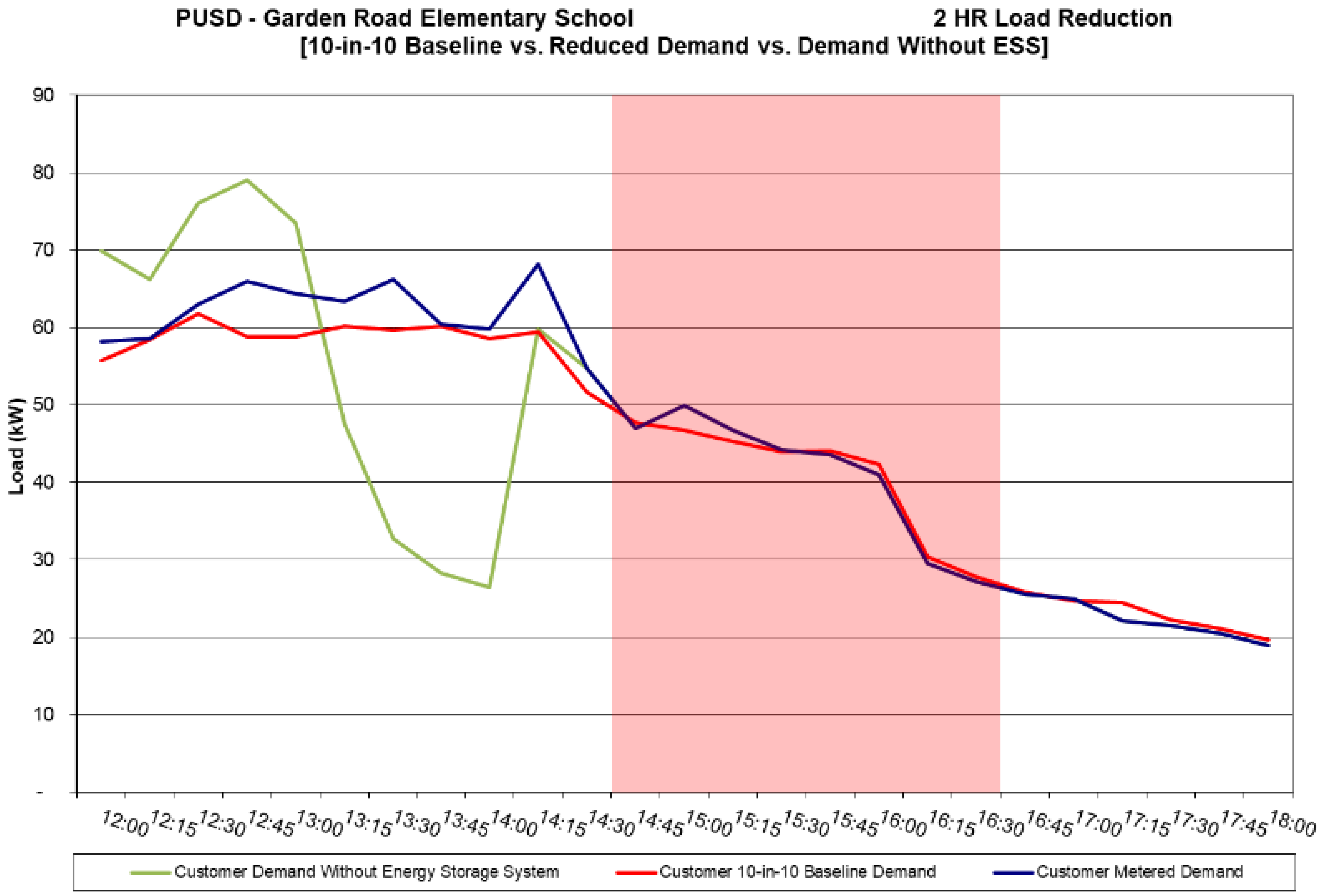
*Simulated DR Event #2*



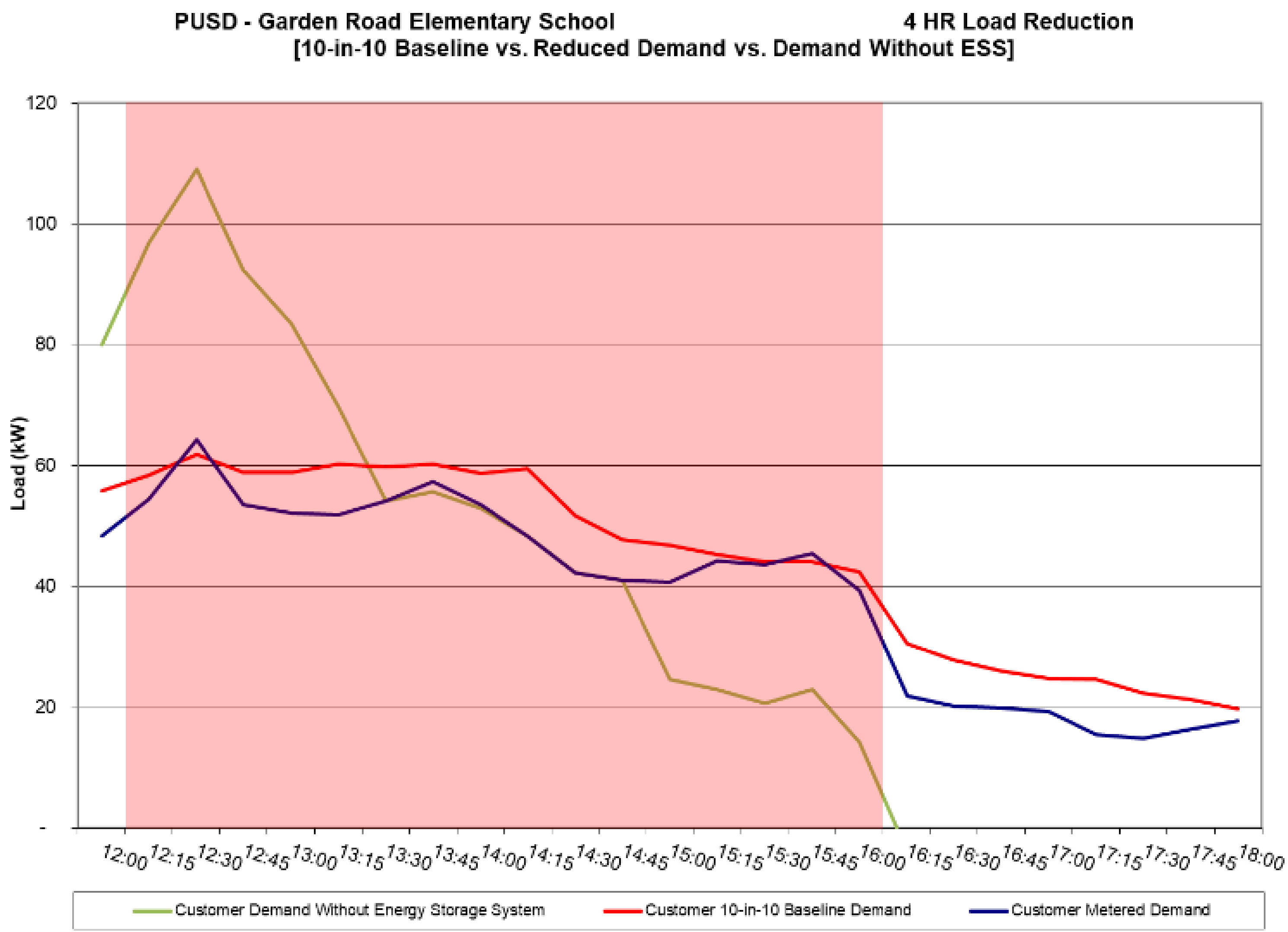
*Simulated DR Event #3*



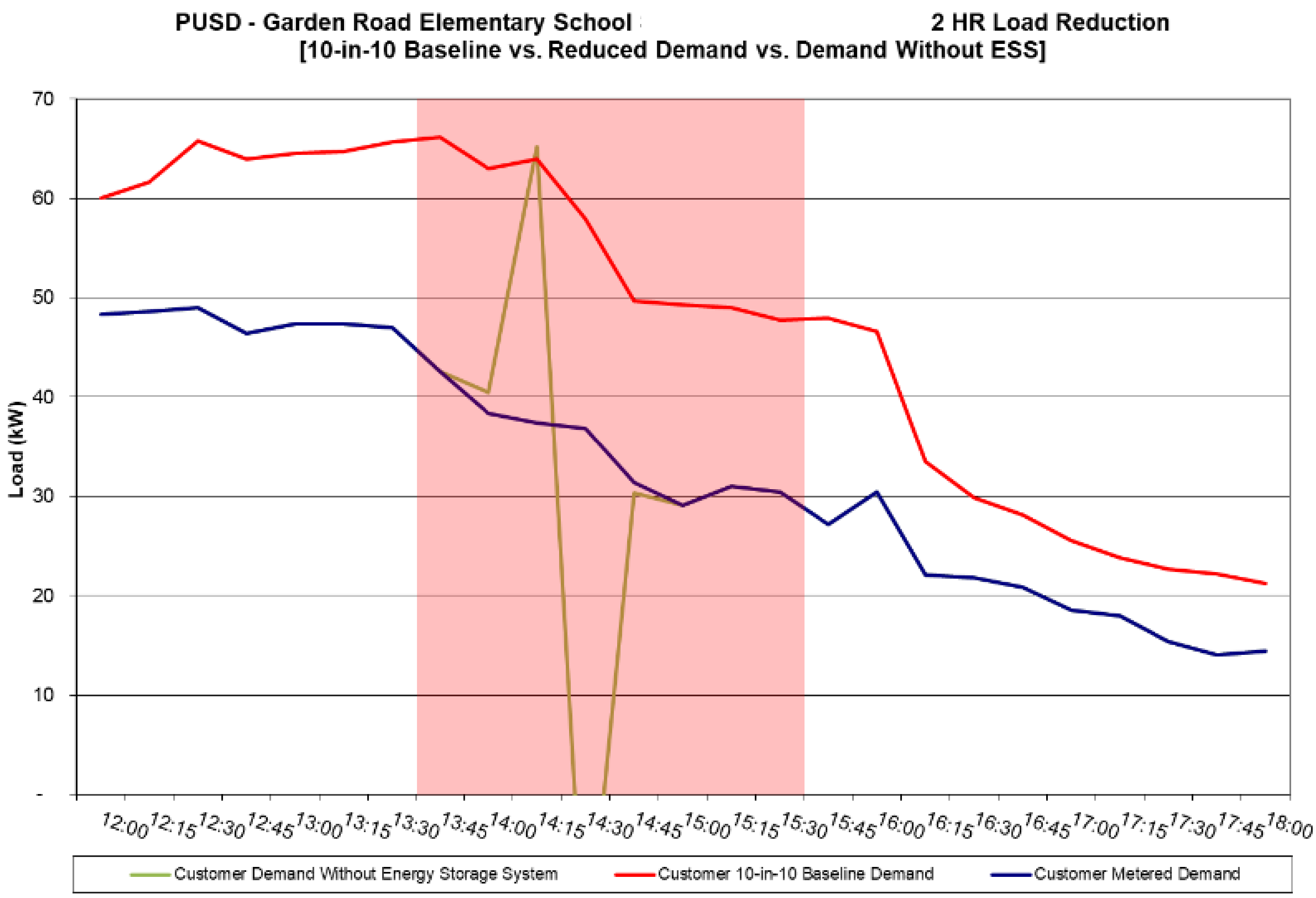
*Simulated DR Event #4*



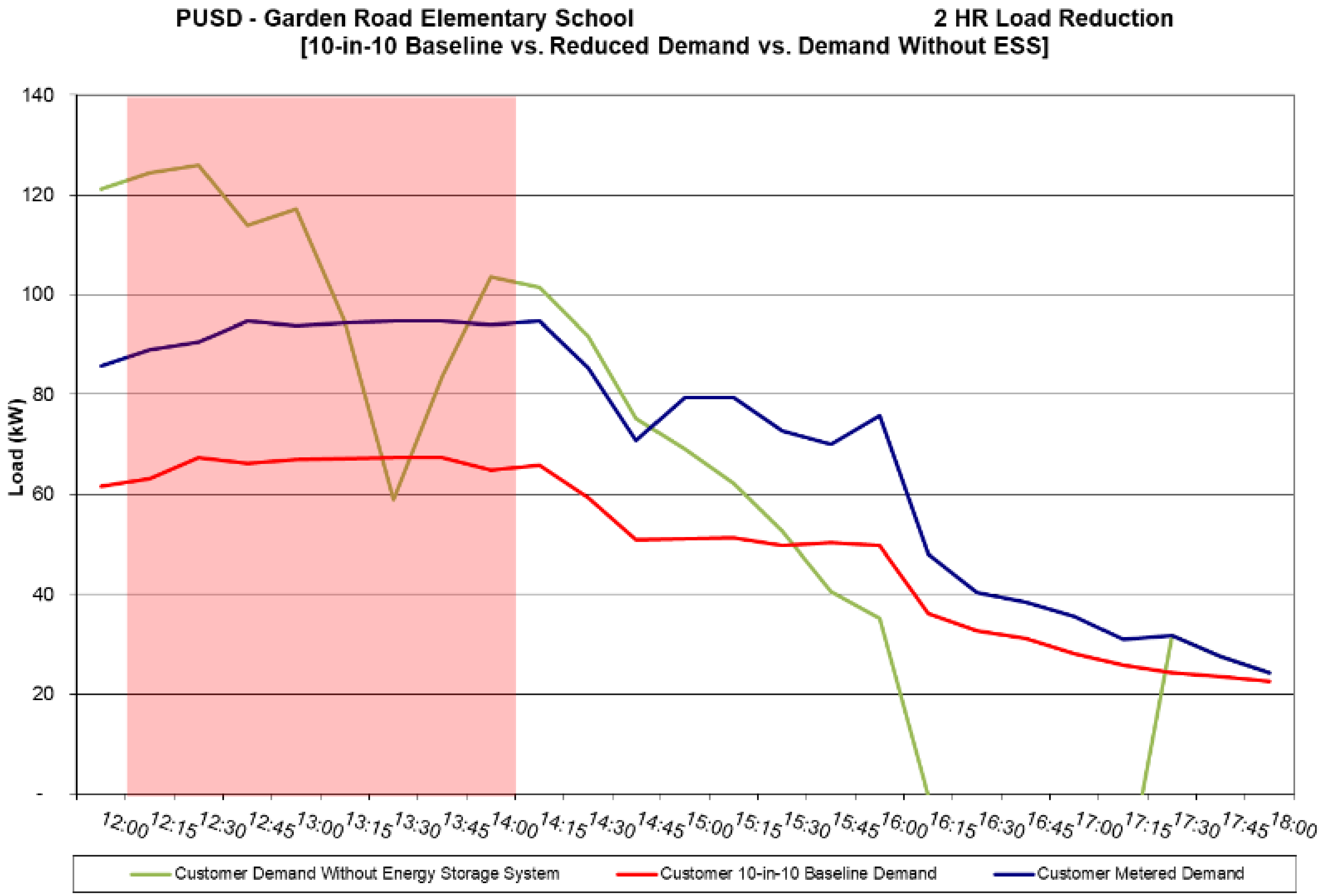
*Simulated DR Event #5*



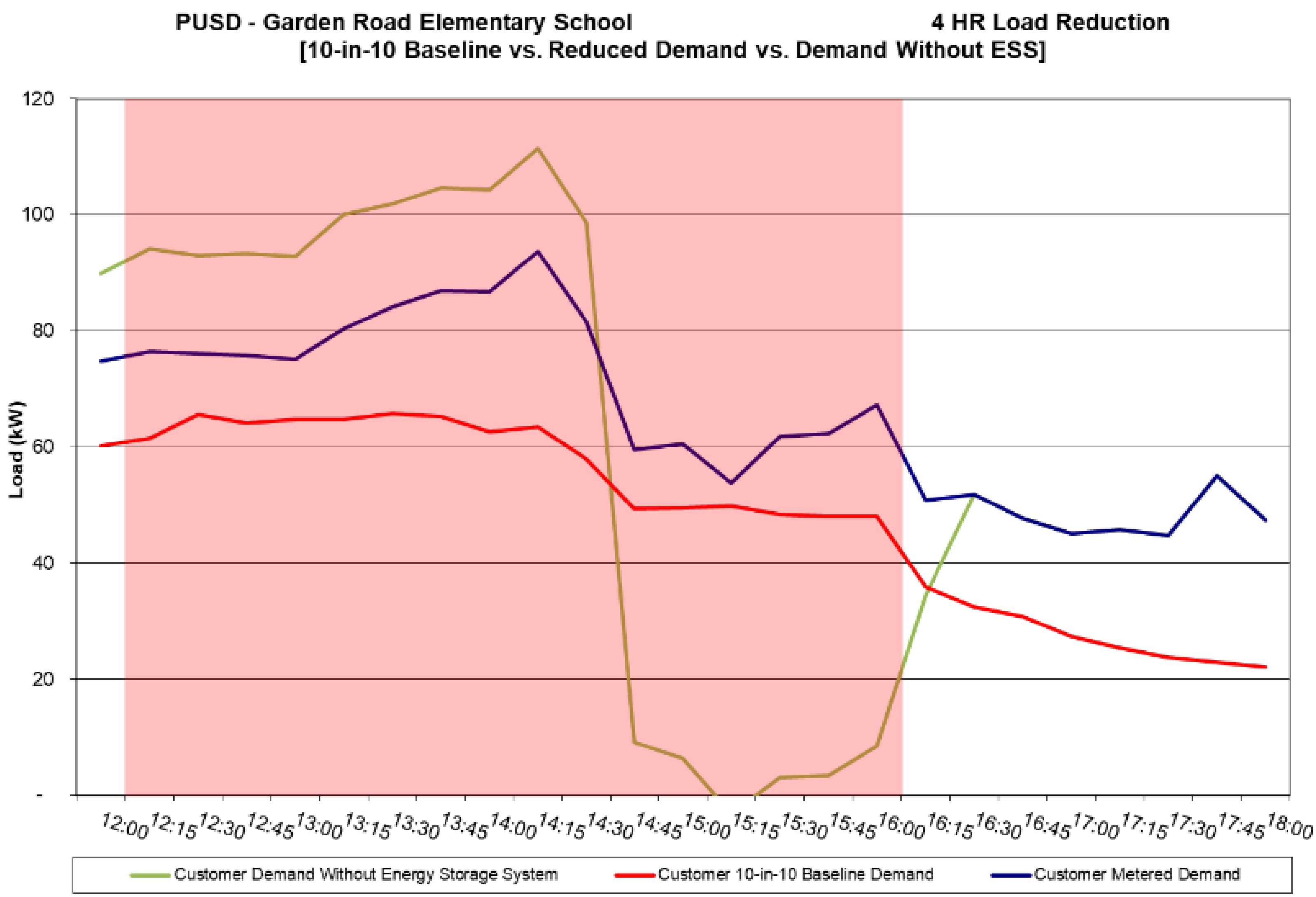
*Simulated DR Event #6*



*Simulated DR Event #7*

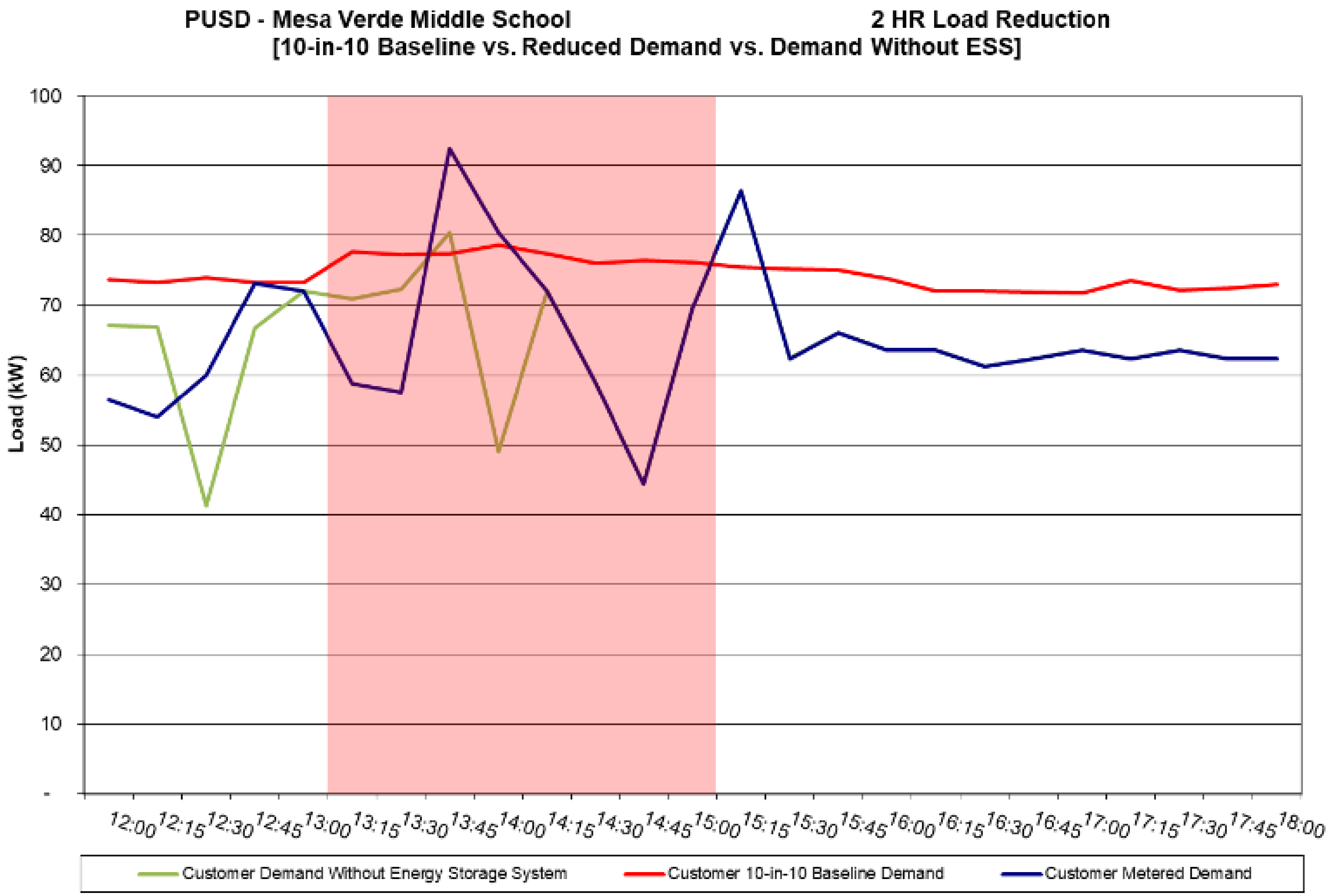


*Simulated DR Event #8*

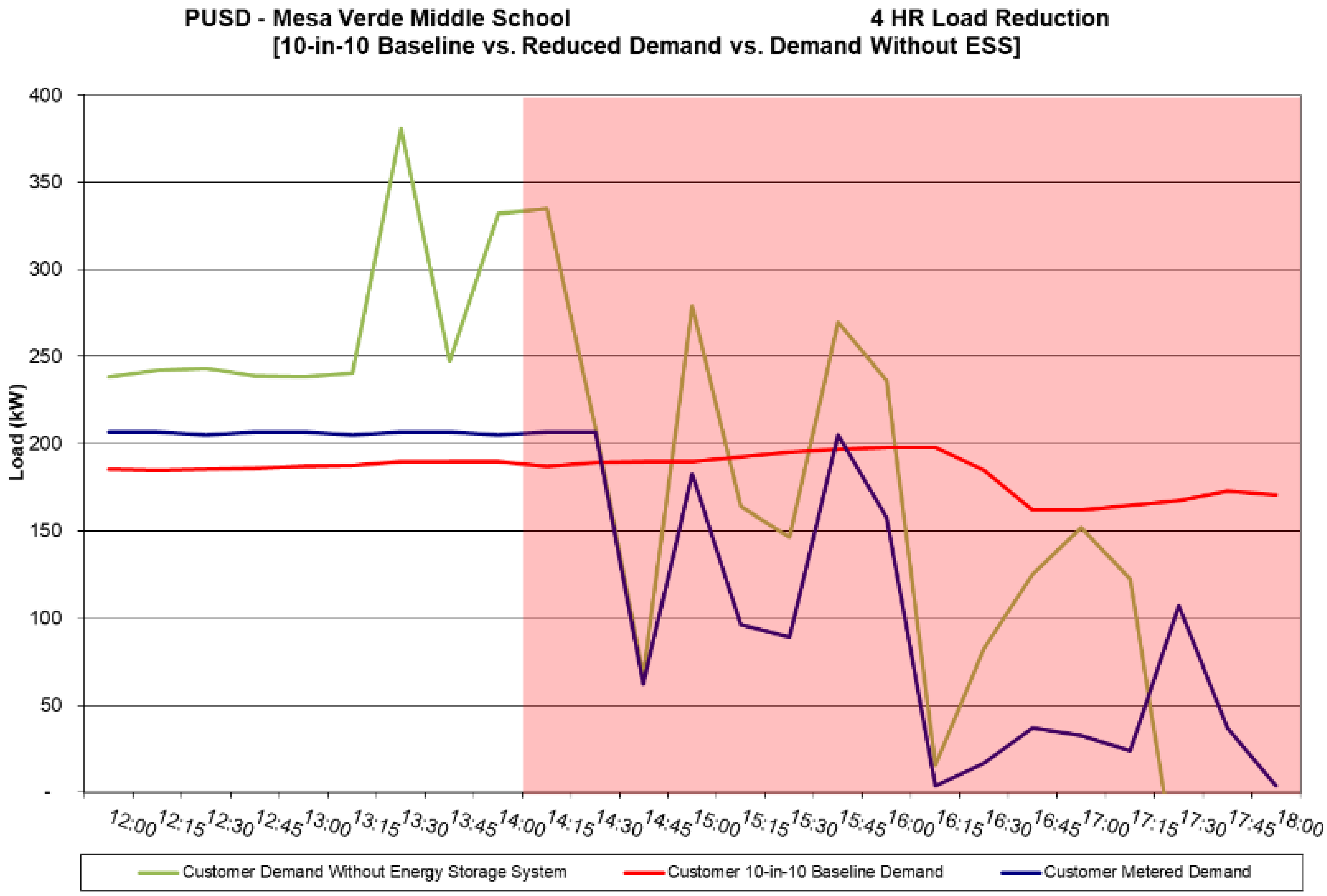


***PUSD – Mesa Verde Middle School***

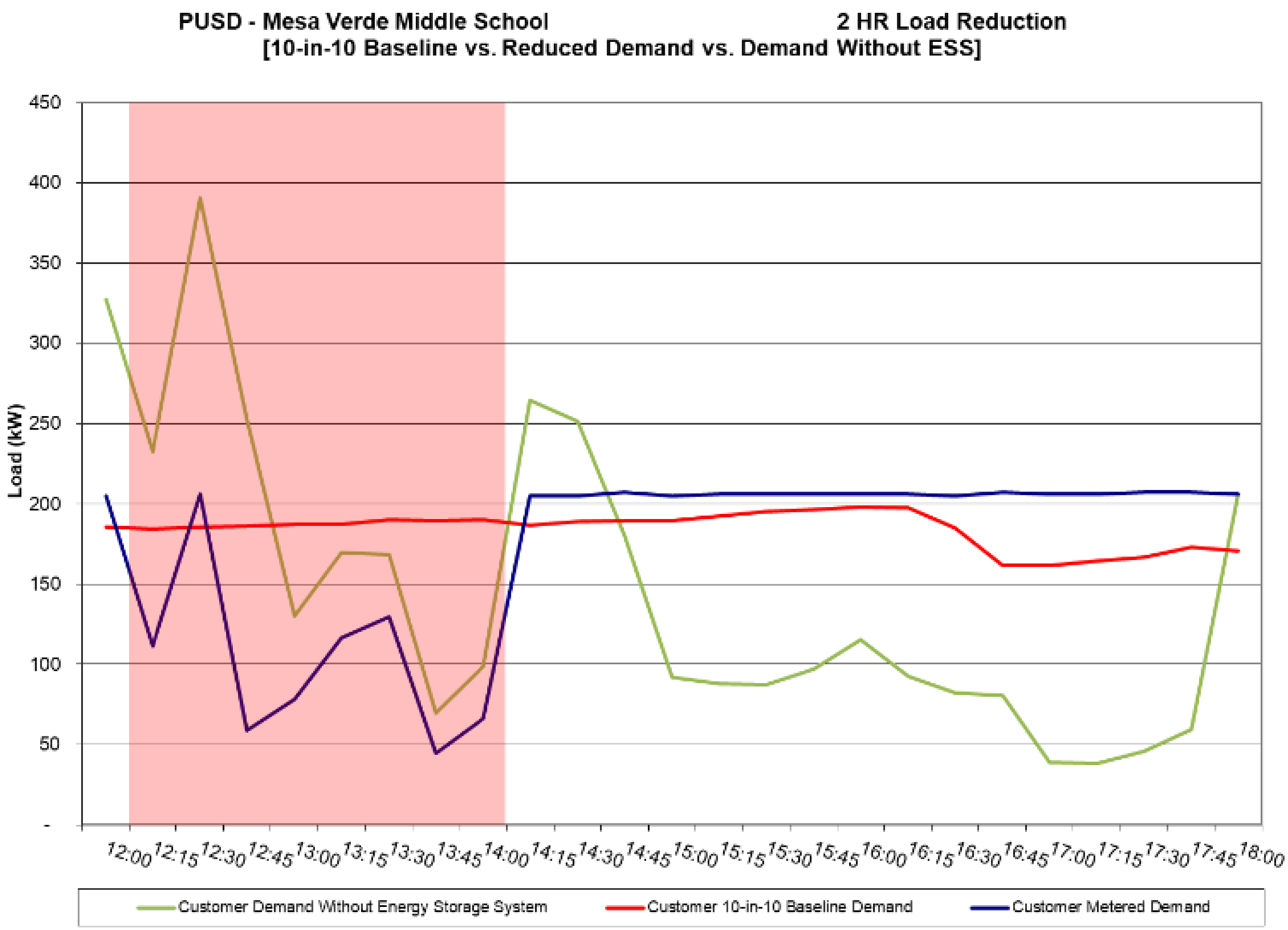
*Simulated DR Event #1*



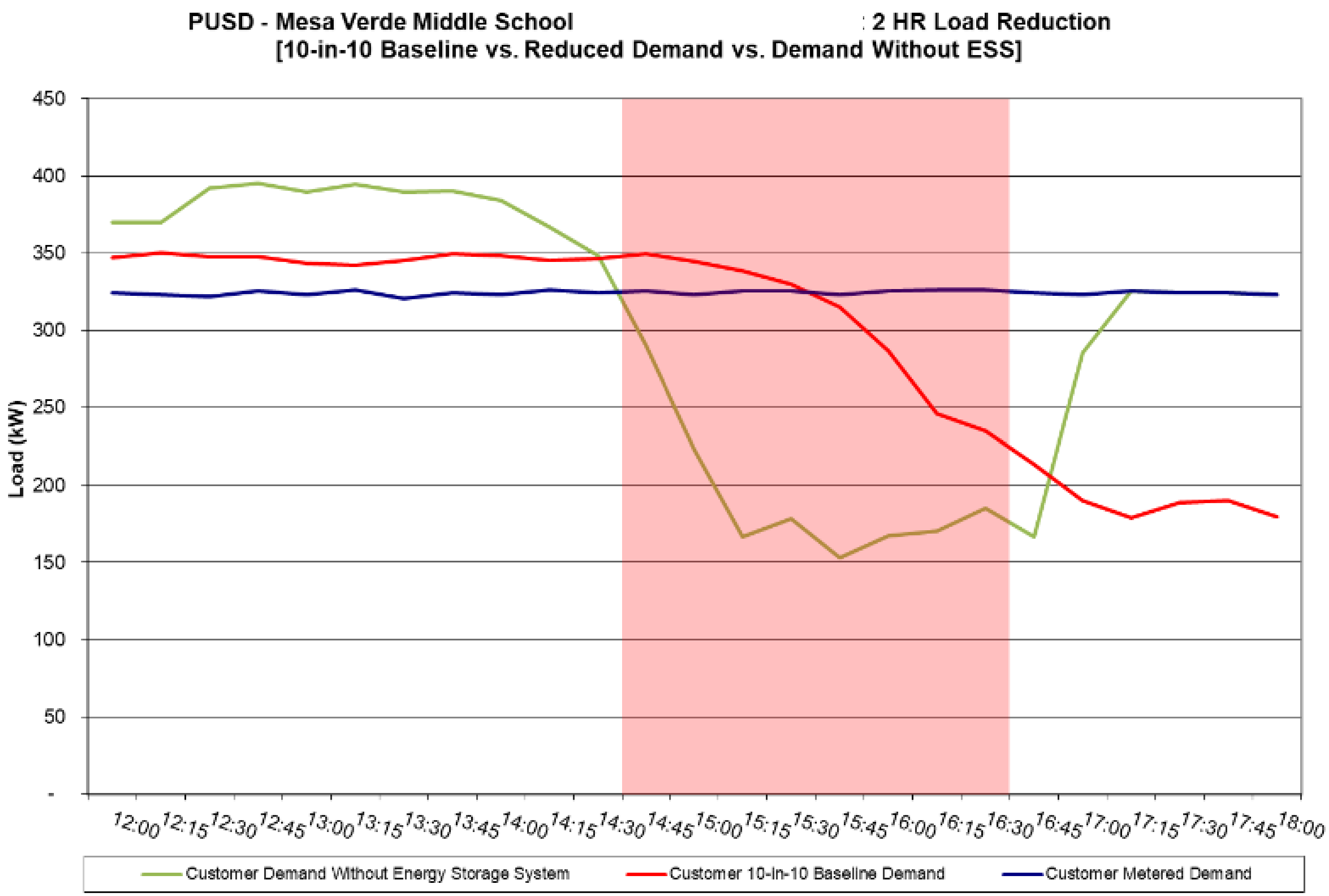
*Simulated DR Event #2*



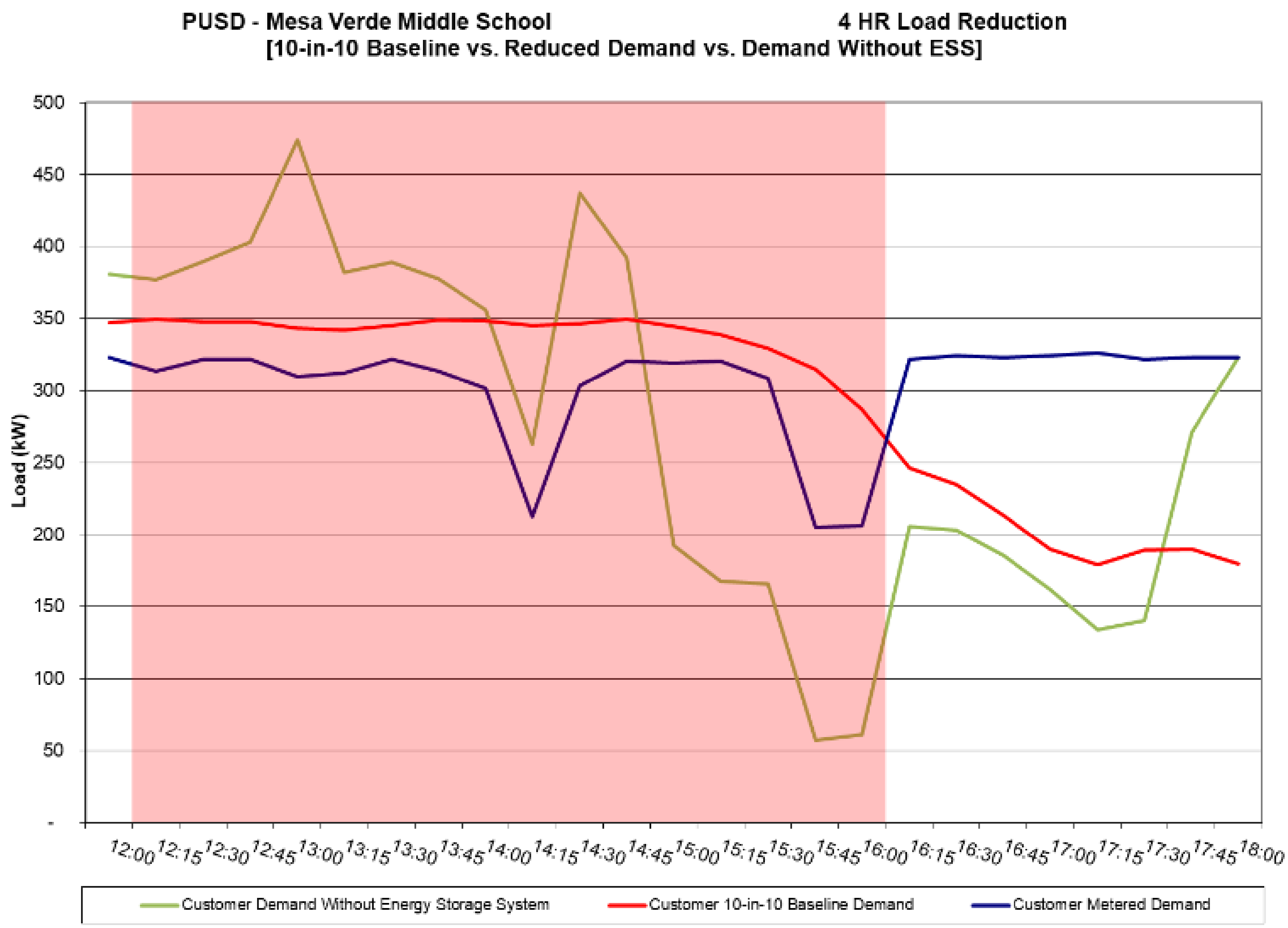
*Simulated DR Event #3*



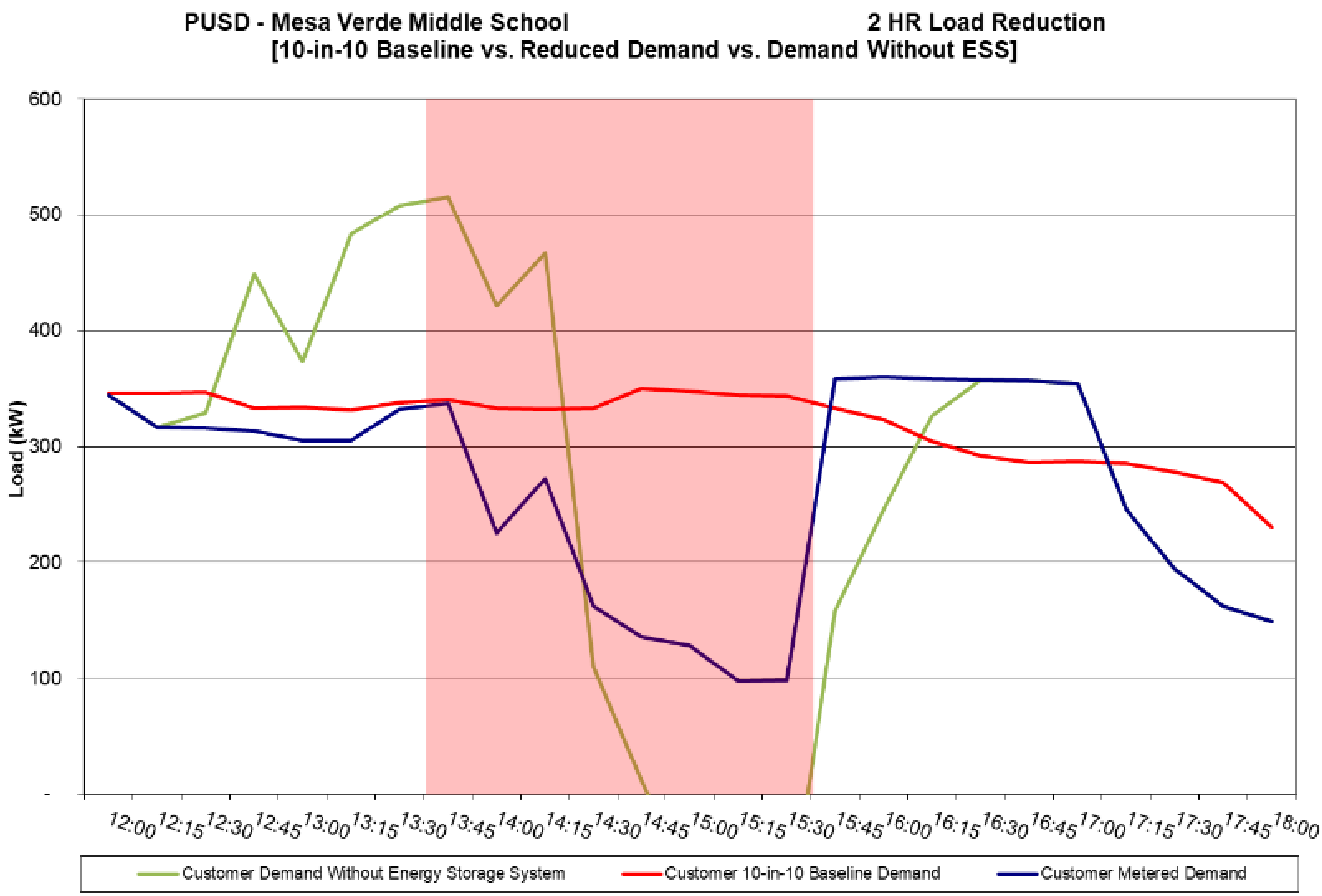
*Simulated DR Event #4*



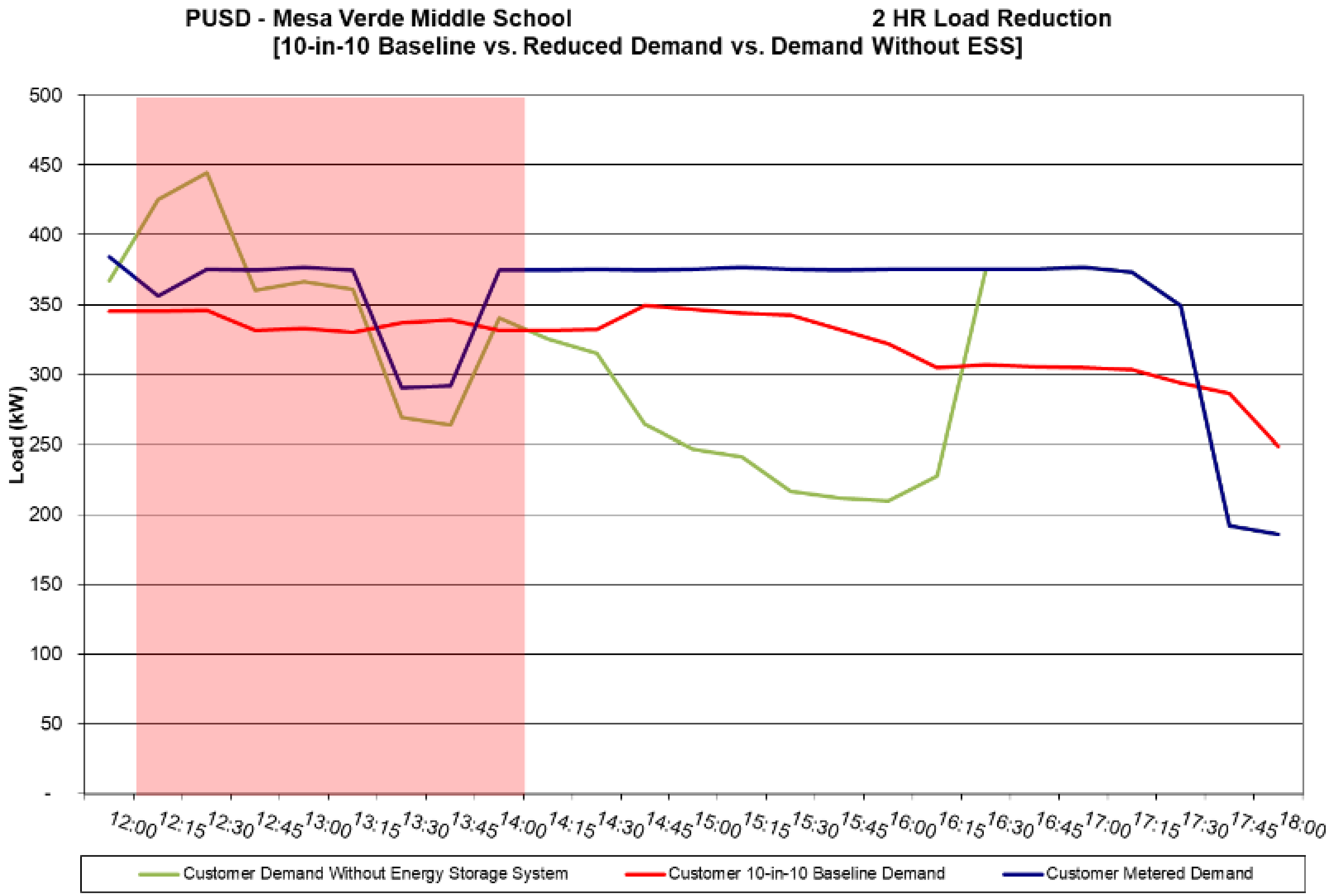
*Simulated DR Event #5*



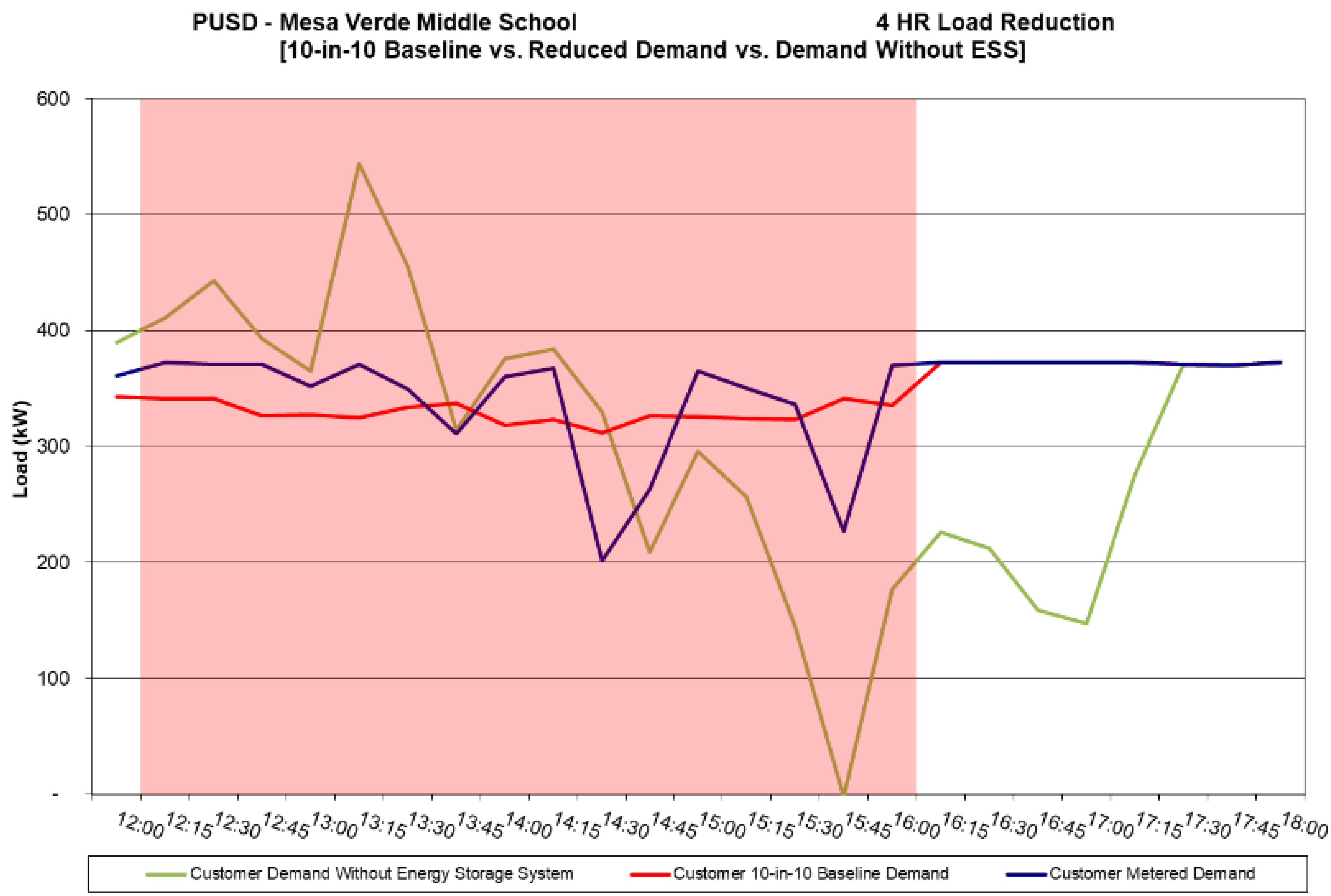
*Simulated DR Event #6*



*Simulated DR Event #7*

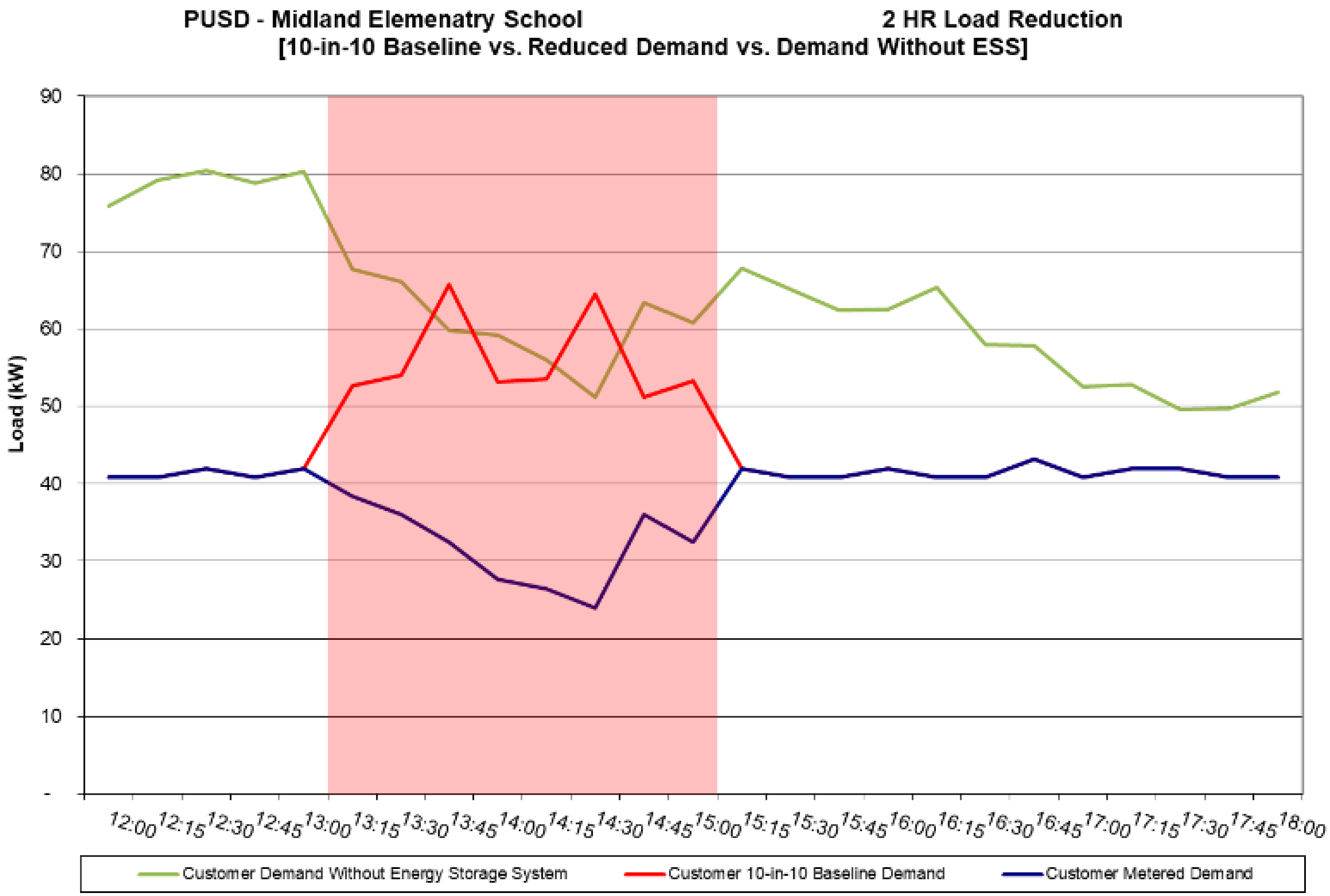


*Simulated DR Event #8*

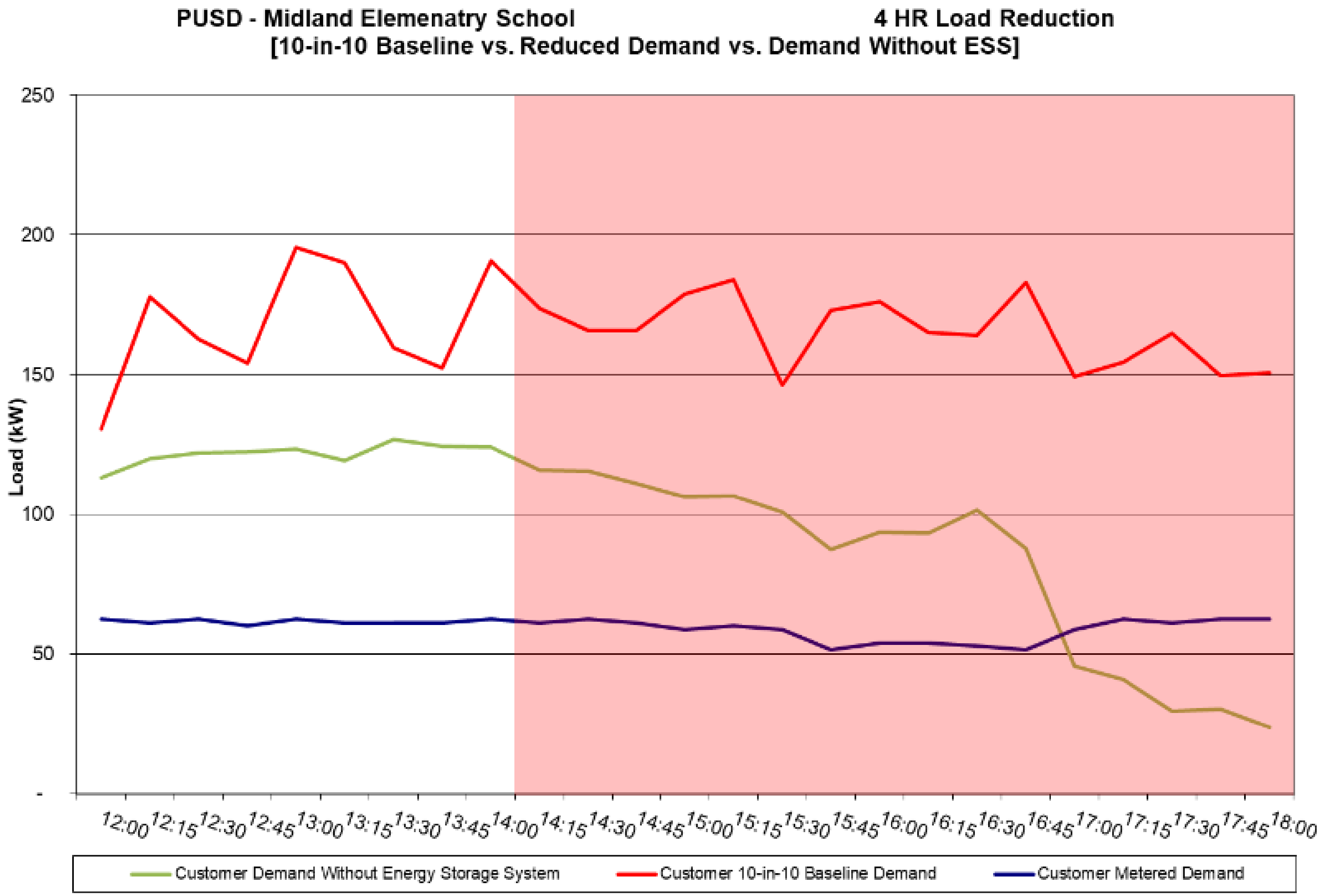


***PUSD – Midland Elementary School***

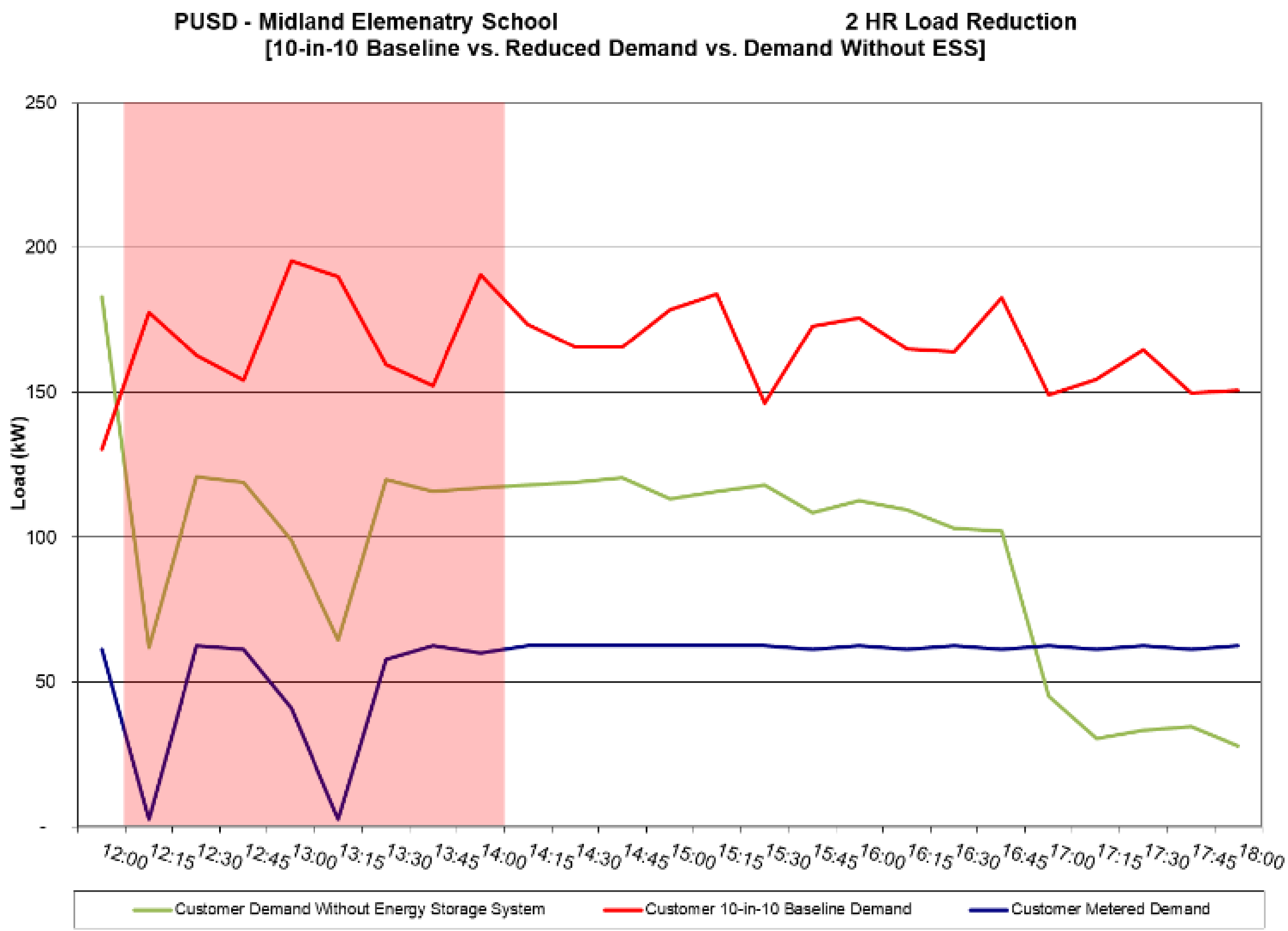
*Simulated DR Event #1*



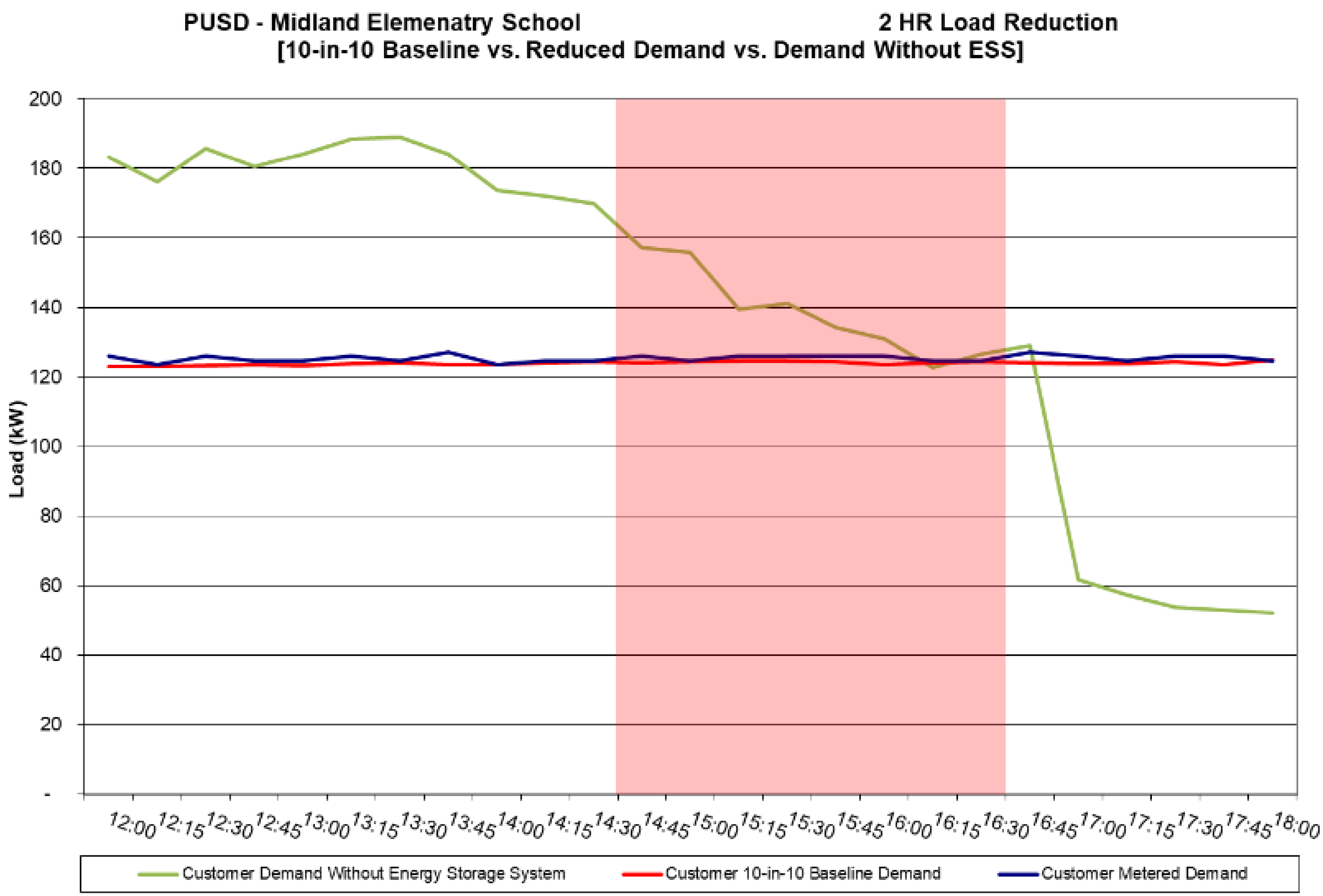
*Simulated DR Event #2*



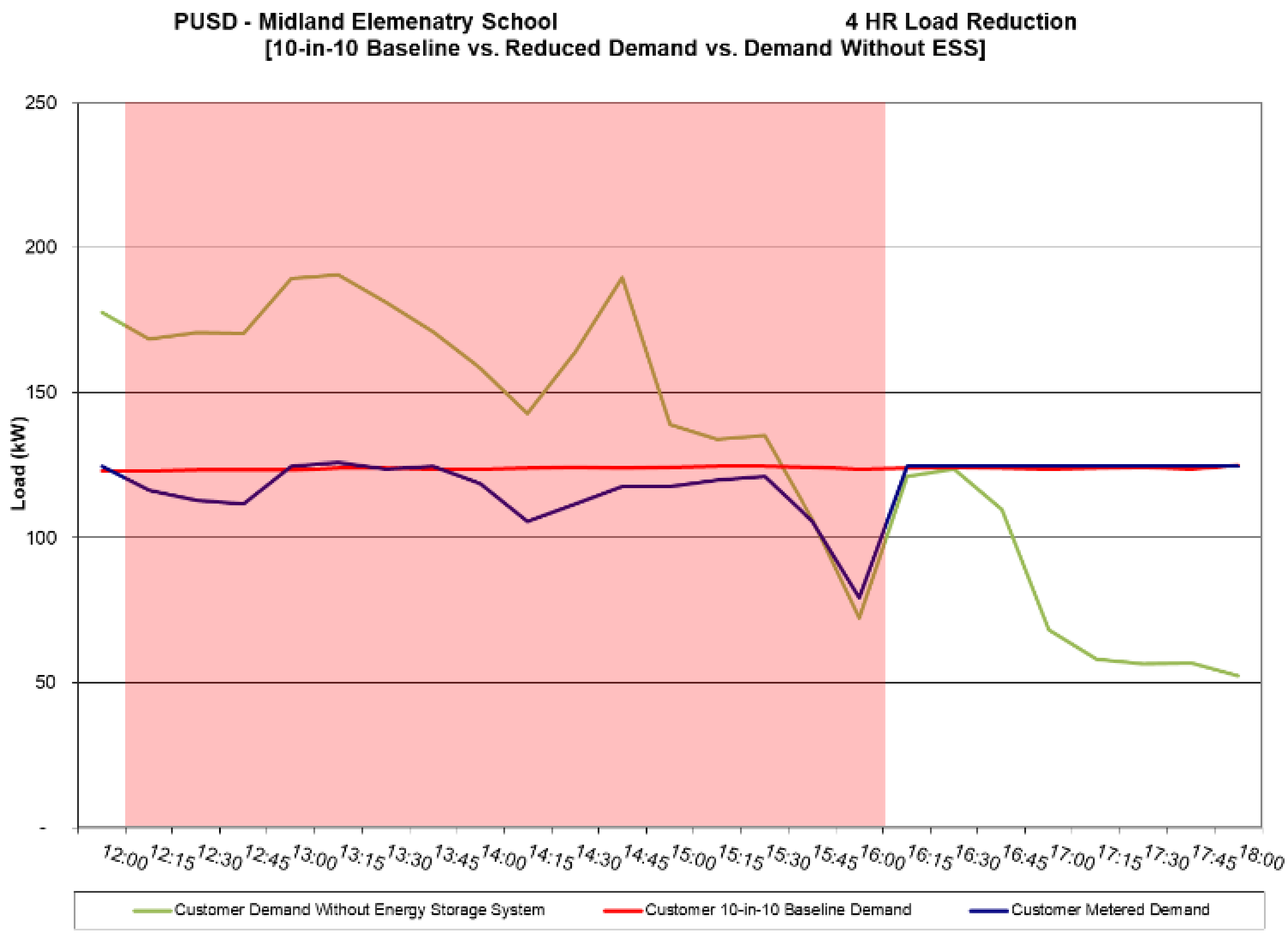
*Simulated DR Event #3*



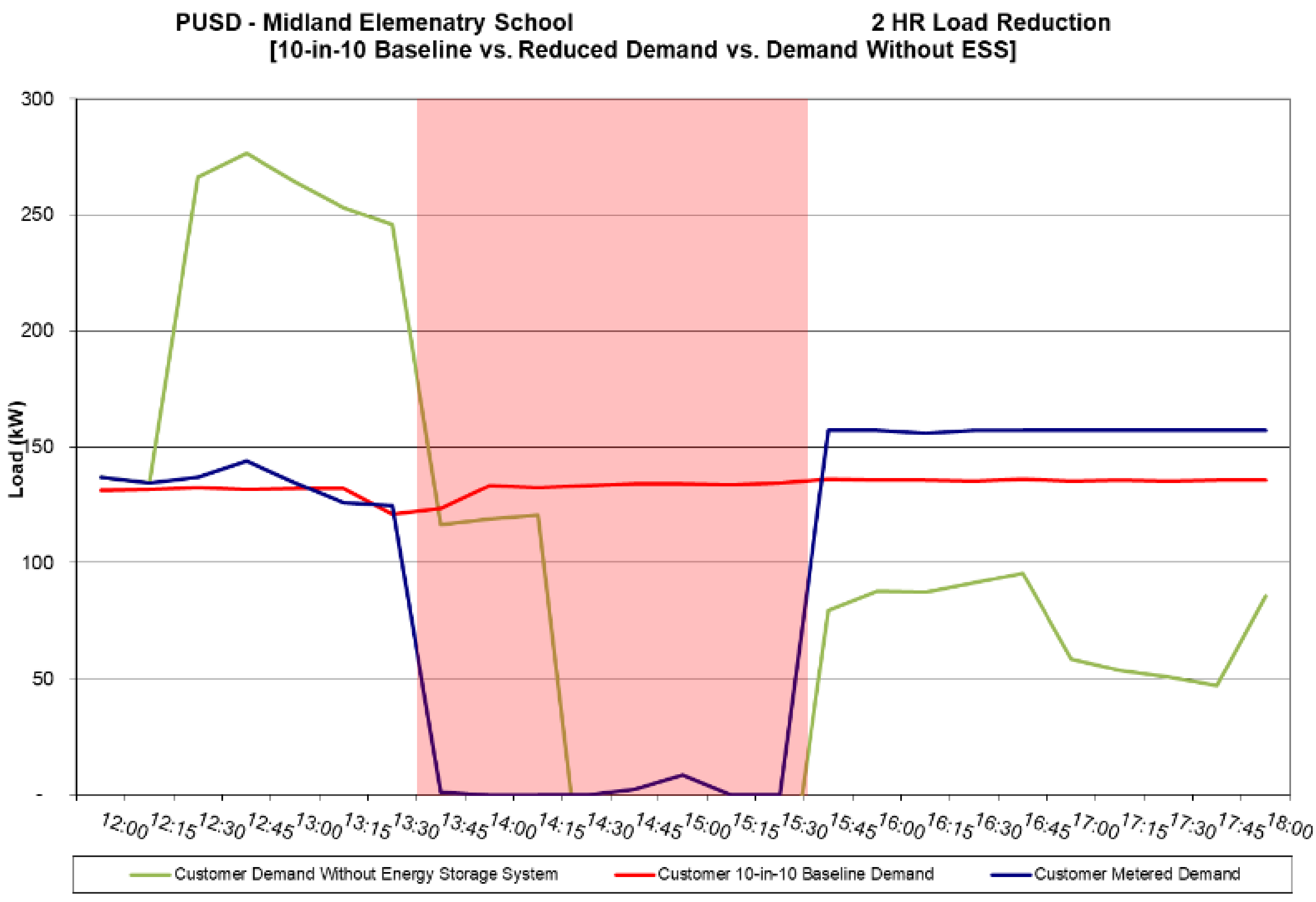
*Simulated DR Event #4*



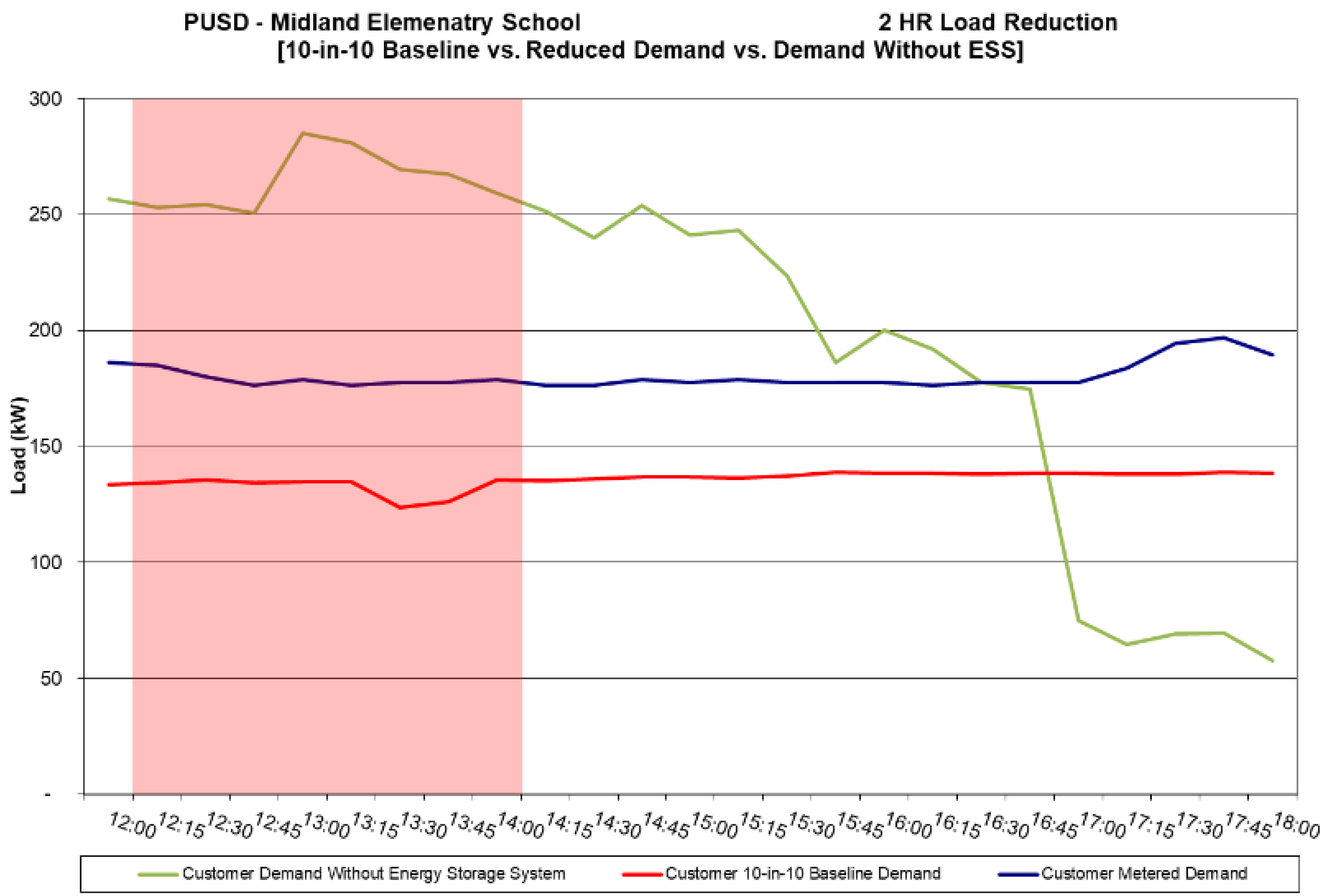
*Simulated DR Event #5*



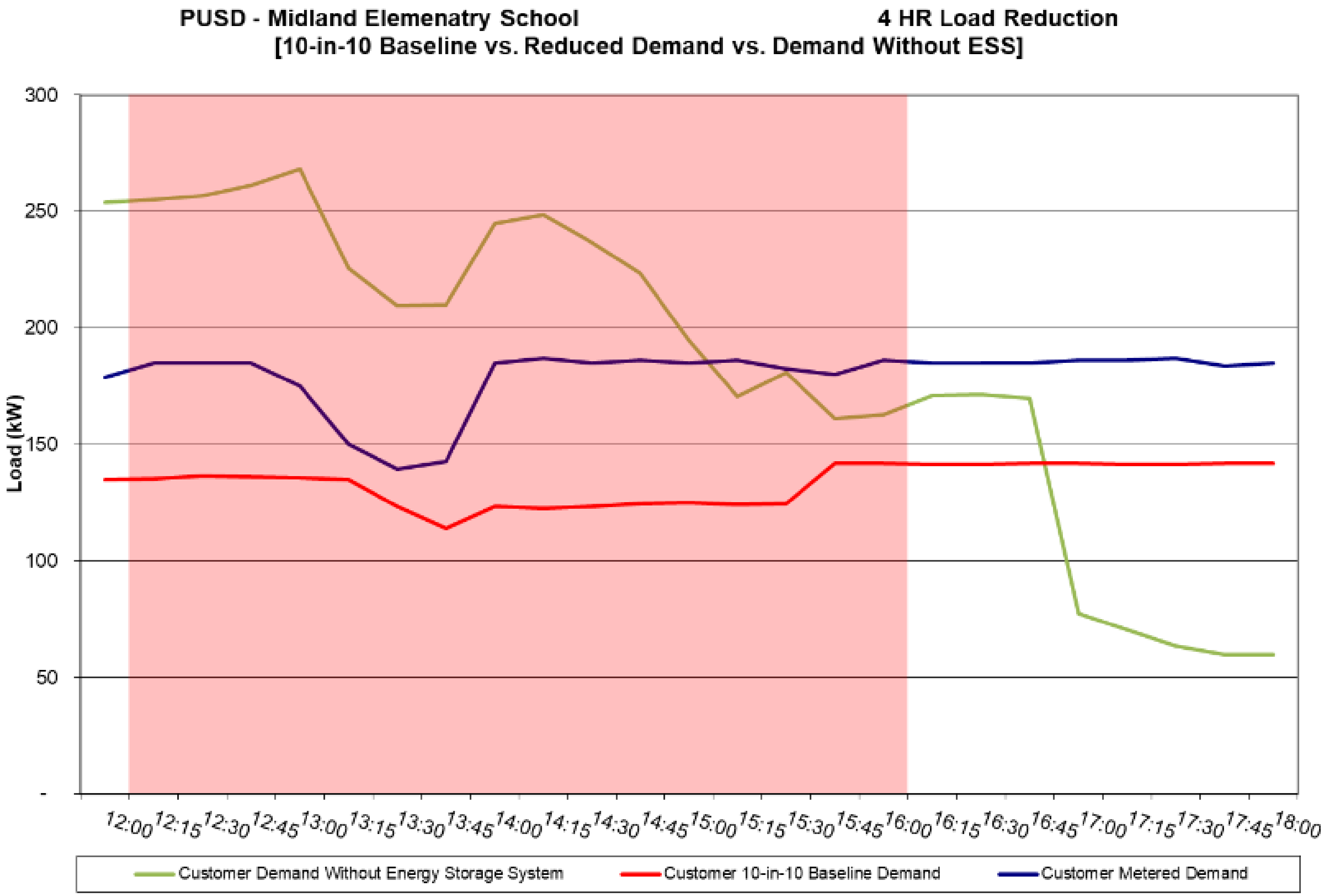
*Simulated DR Event #6*



*Simulated DR Event #7*

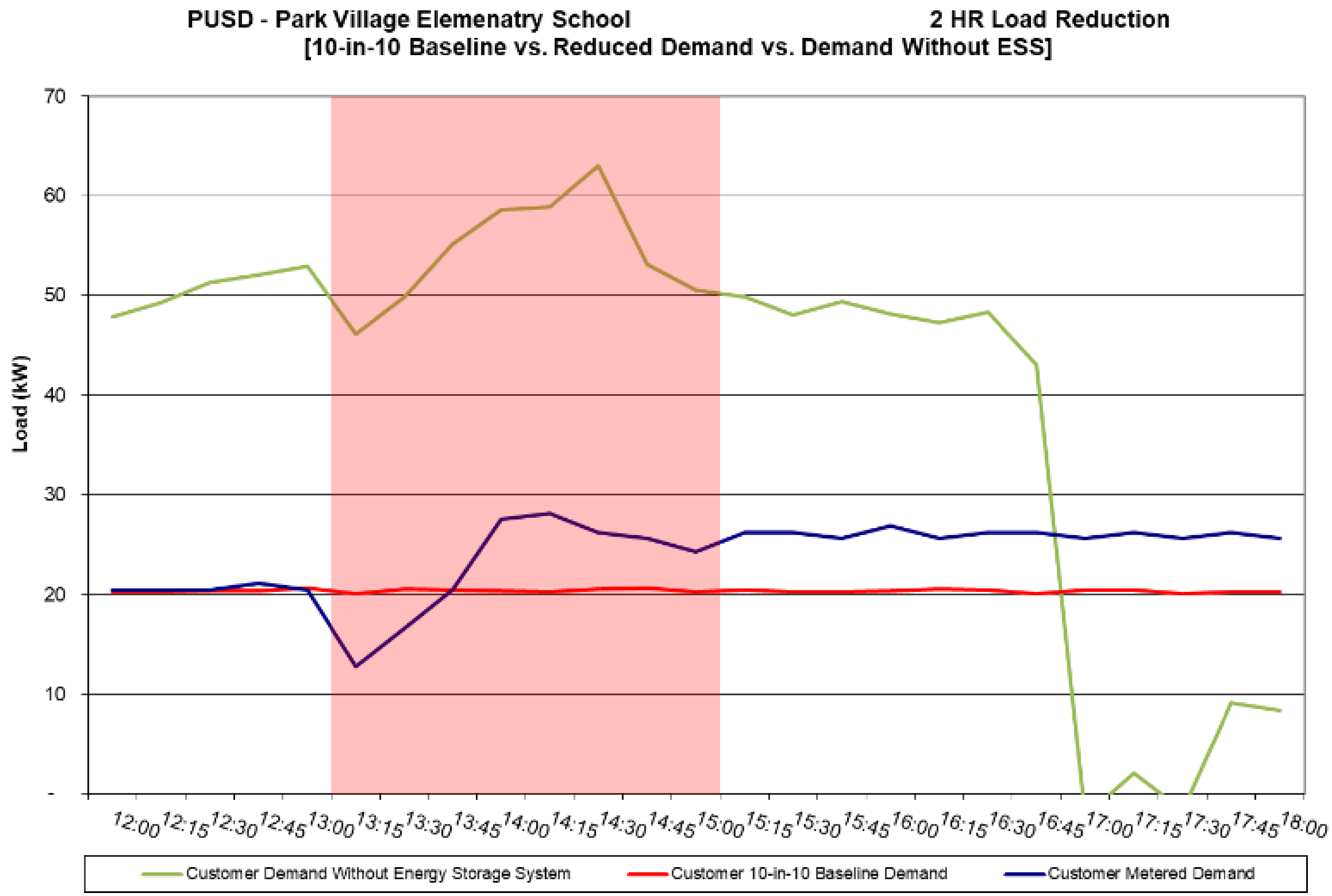


*Simulated DR Event #8*

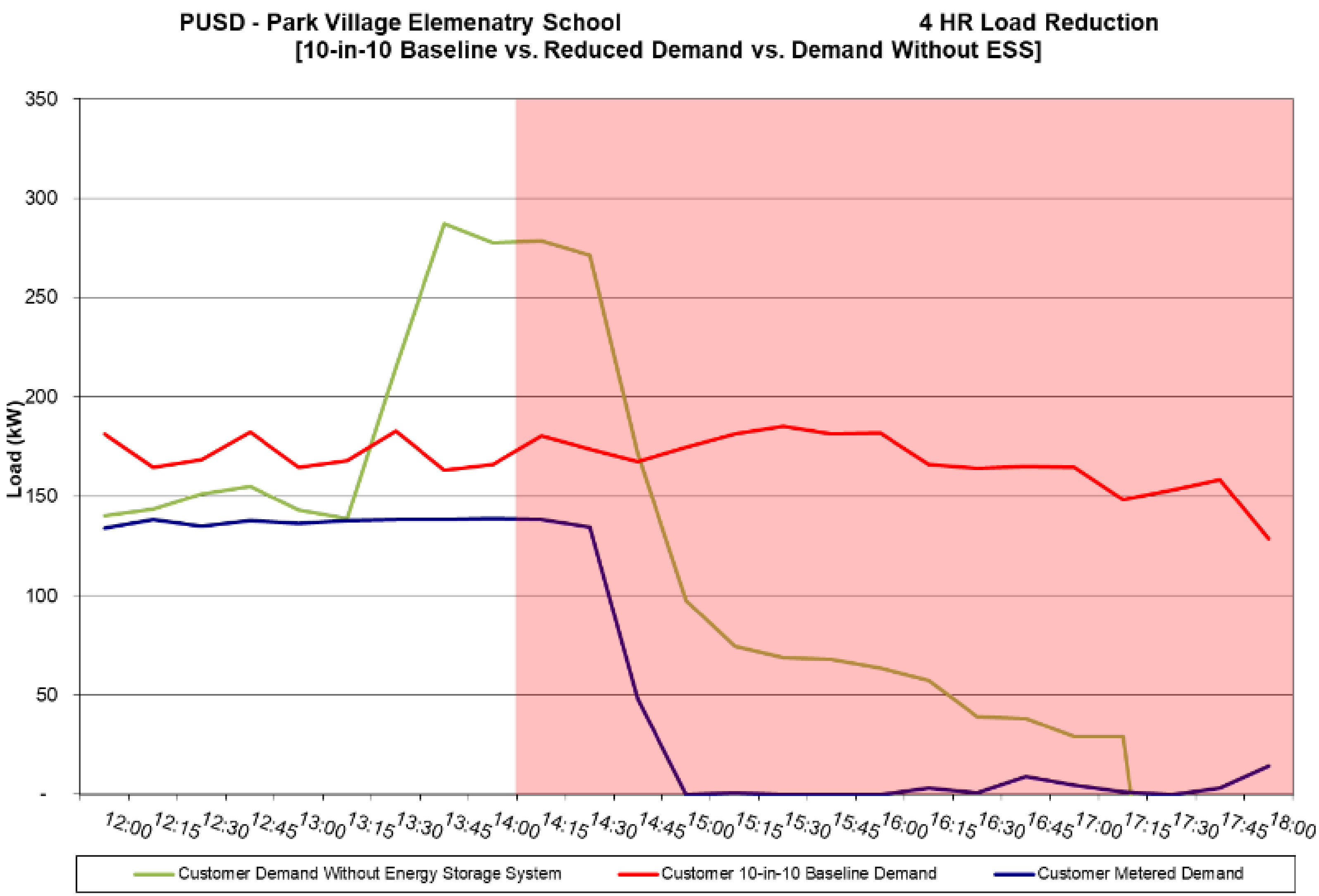


***PUSD – Park Village Elementary School***

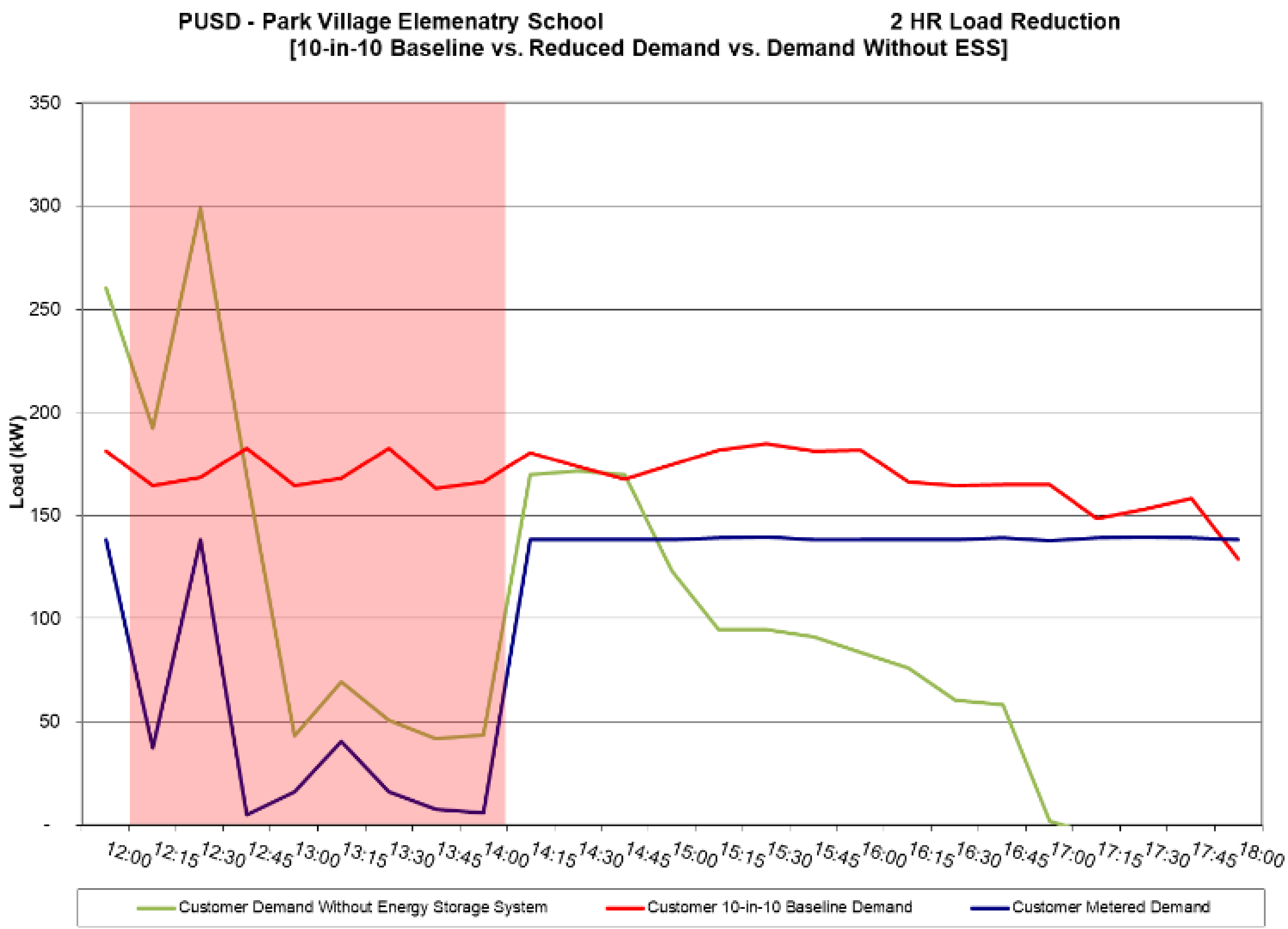
*Simulated DR Event #1*



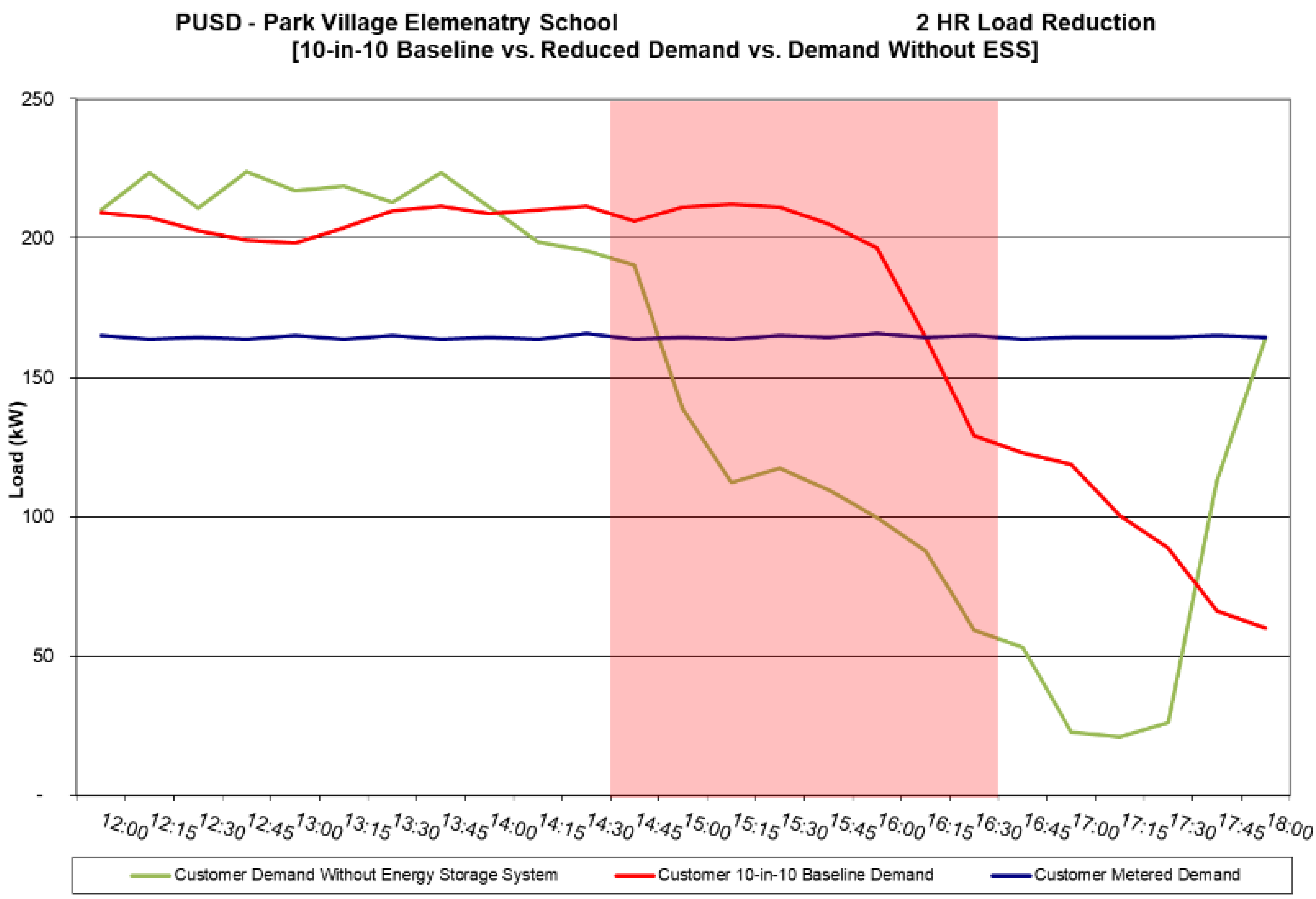
*Simulated DR Event #2*



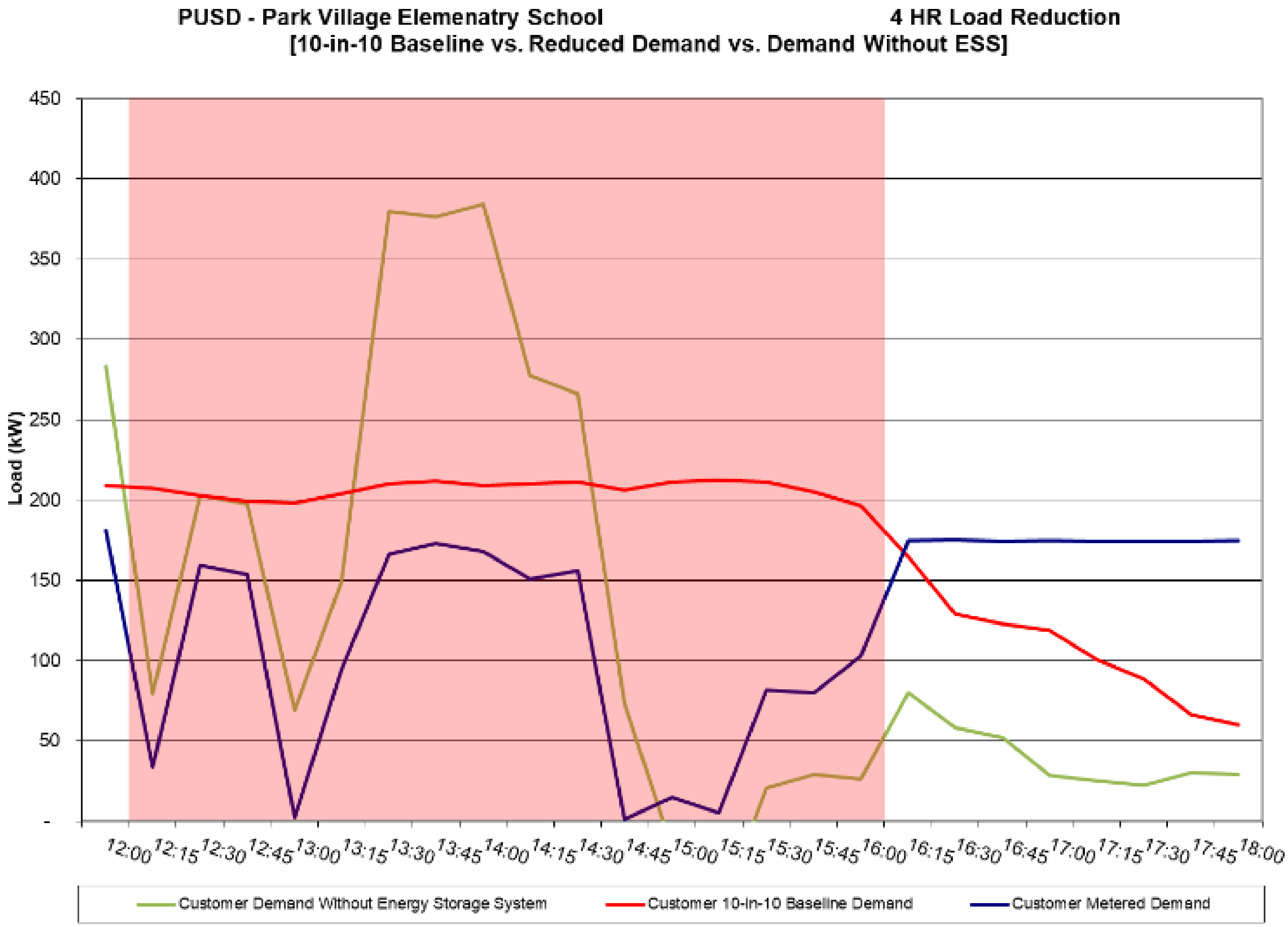
*Simulated DR Event #3*



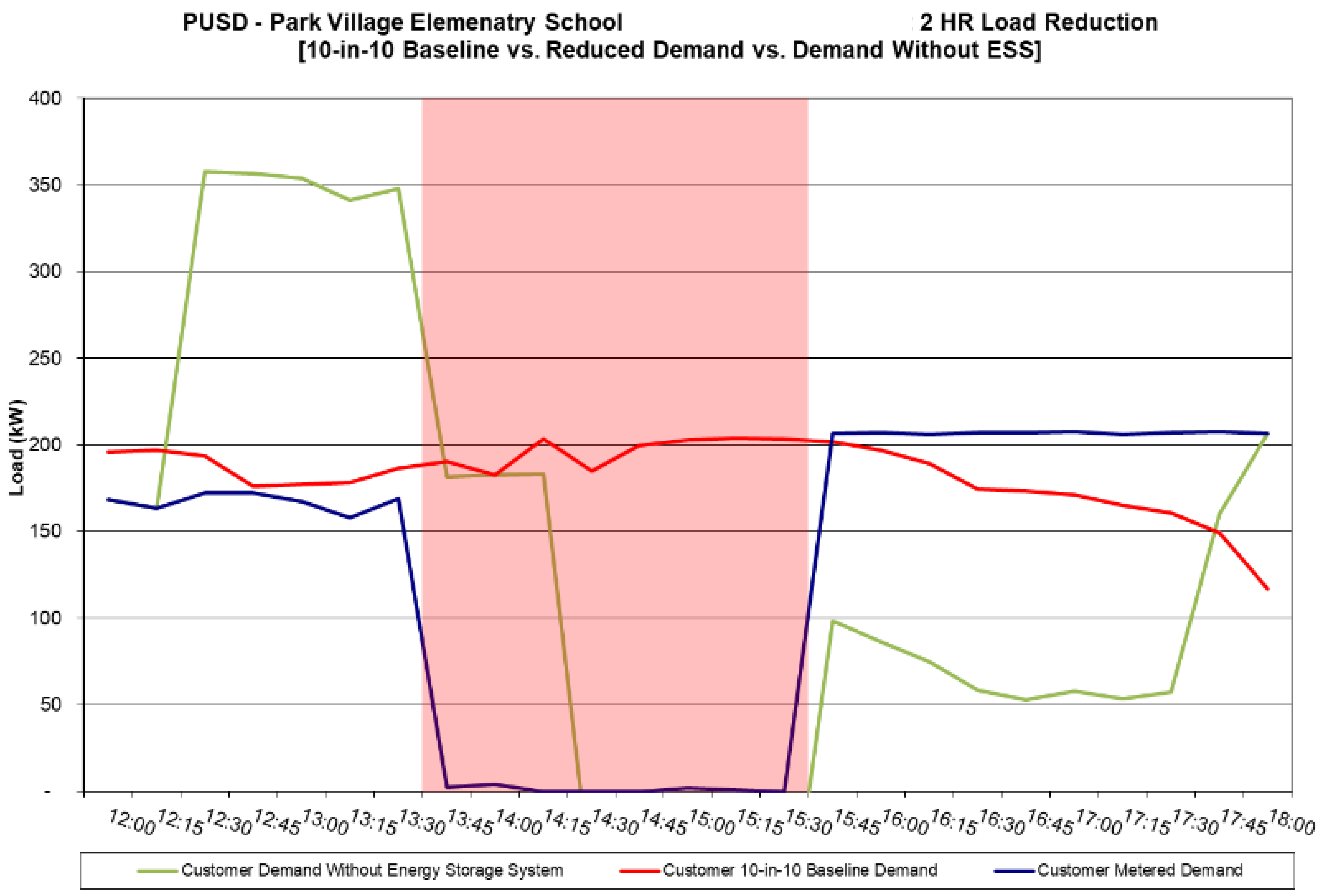
*Simulated DR Event #4*



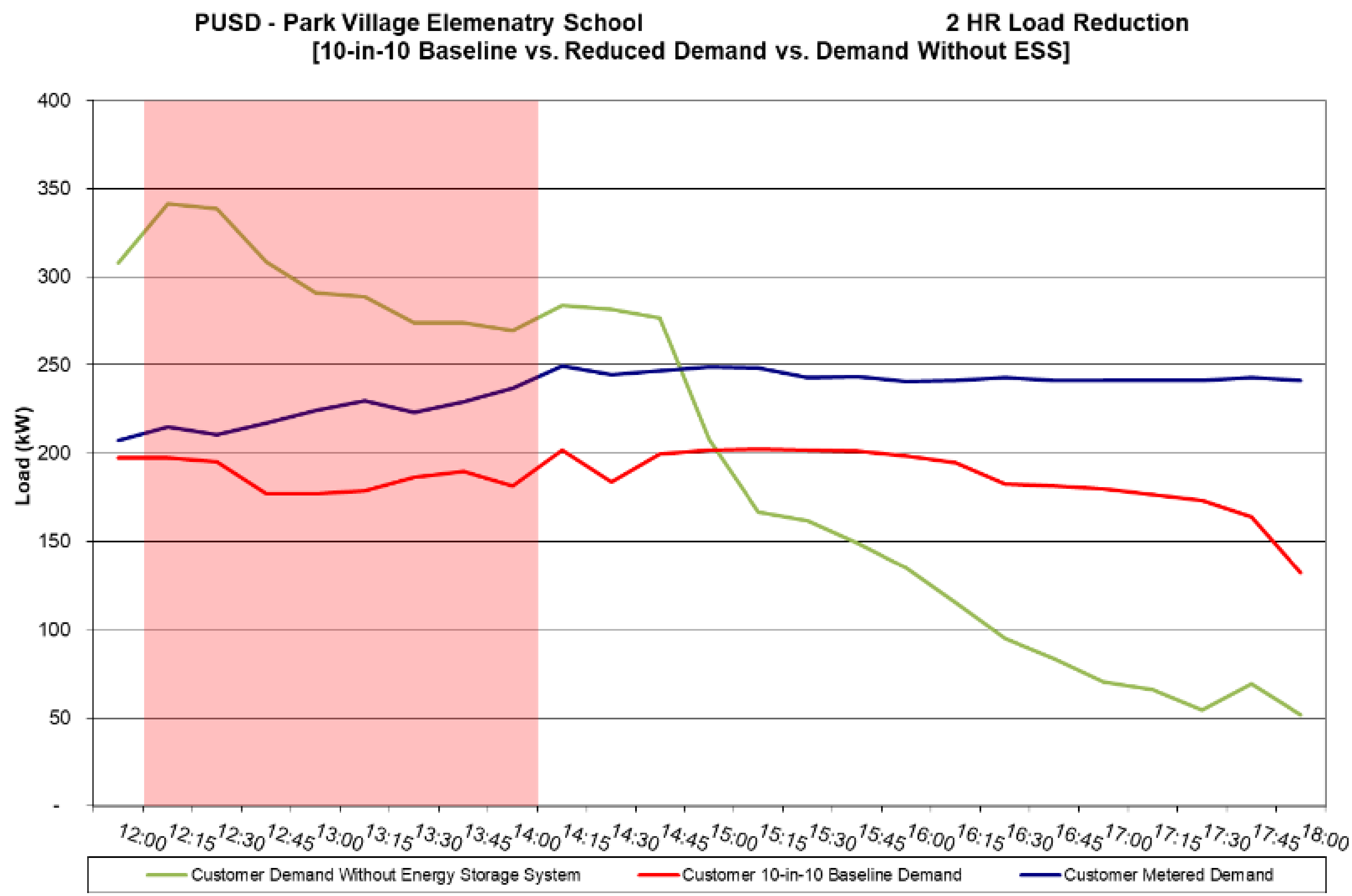
*Simulated DR Event #5*



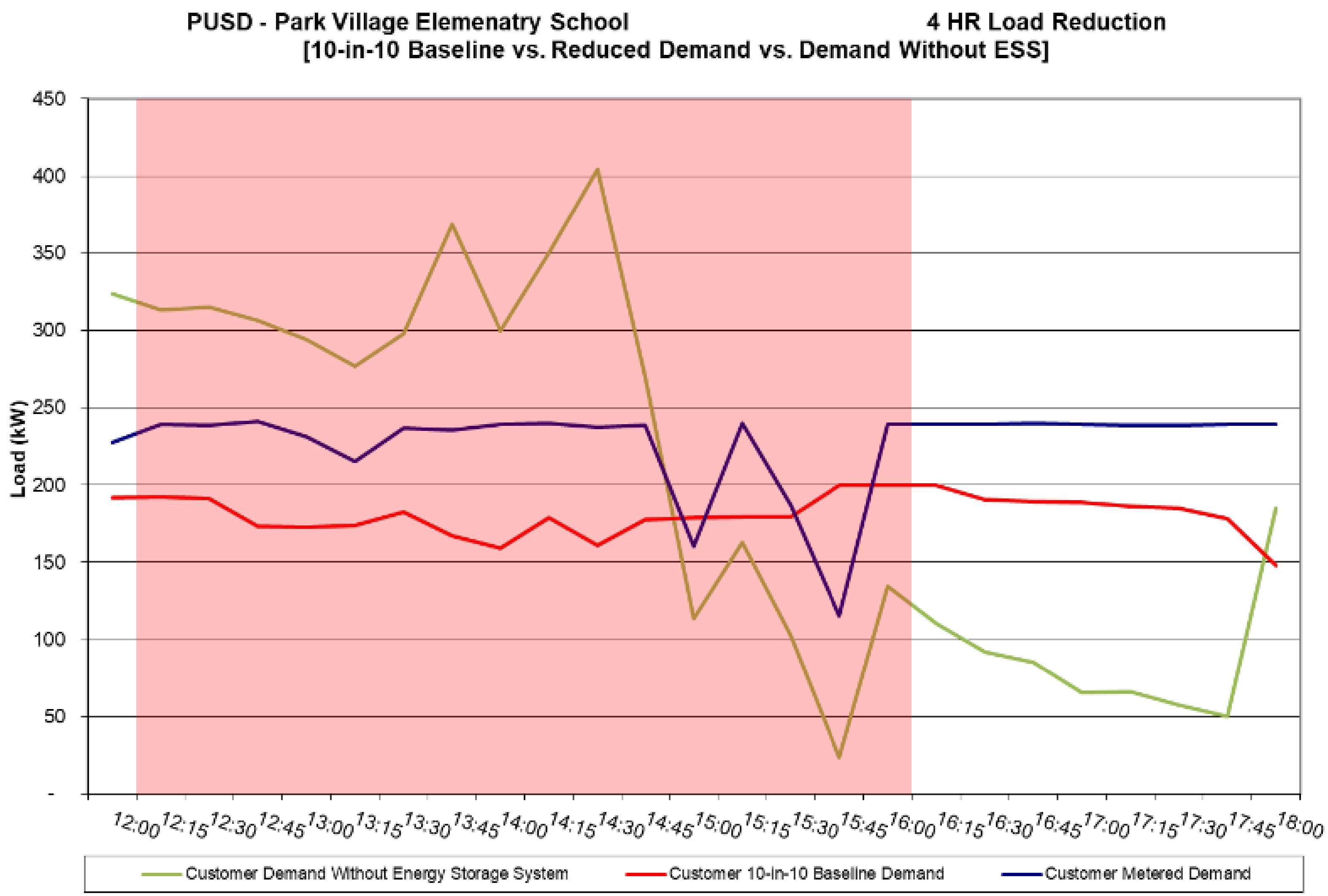
*Simulated DR Event #6*



*Simulated DR Event #7*

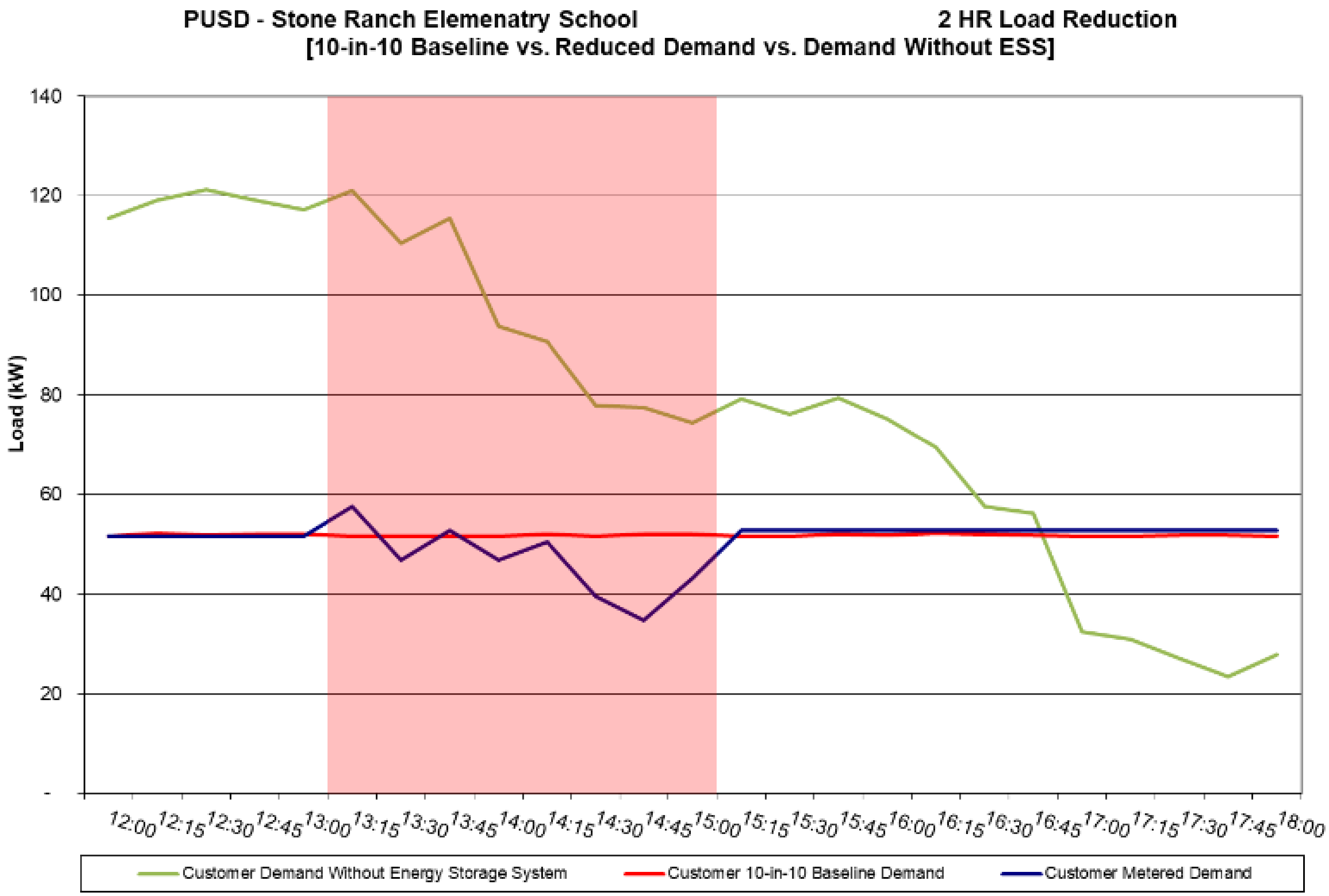


*Simulated DR Event #8*

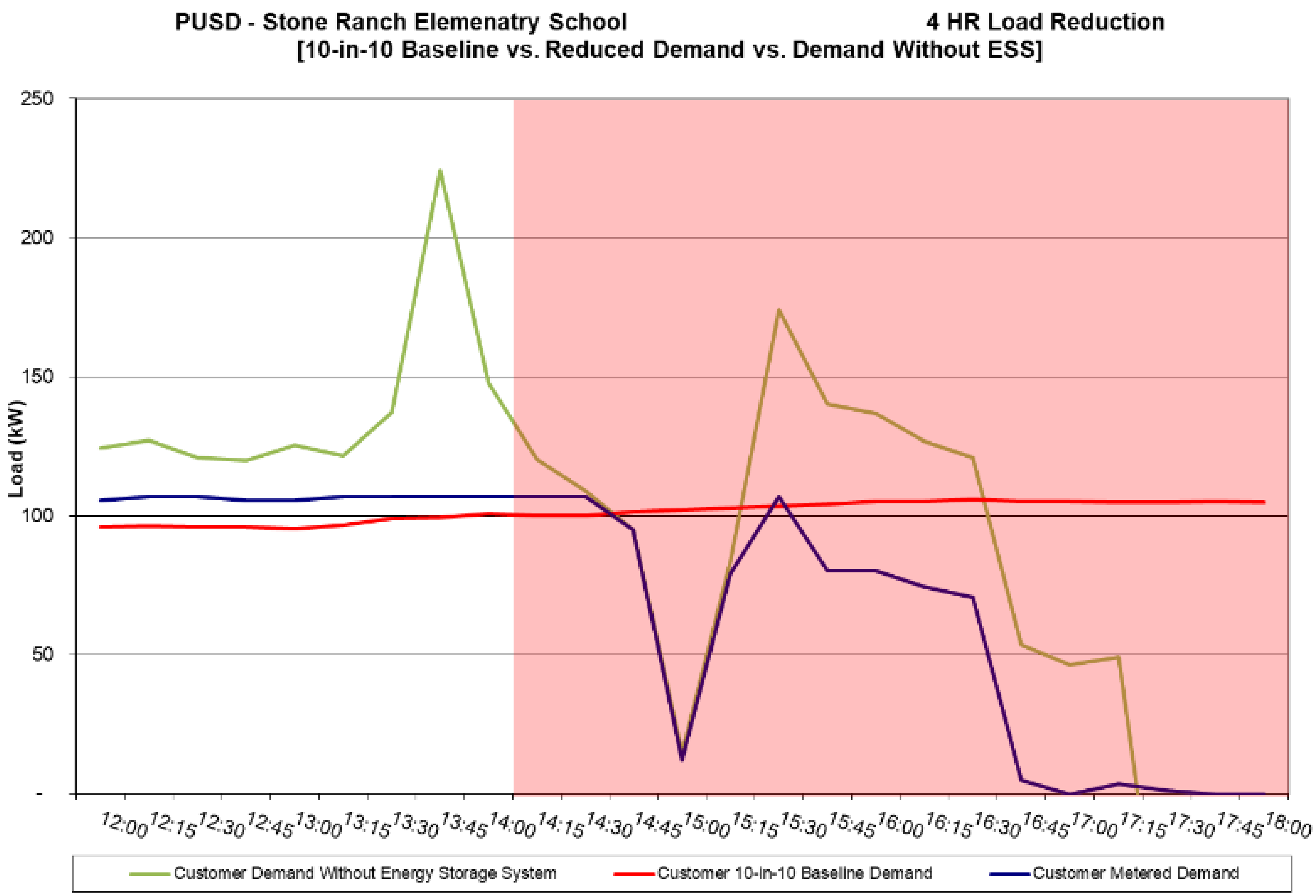


***PUSD – Stone Ranch Elementary School***

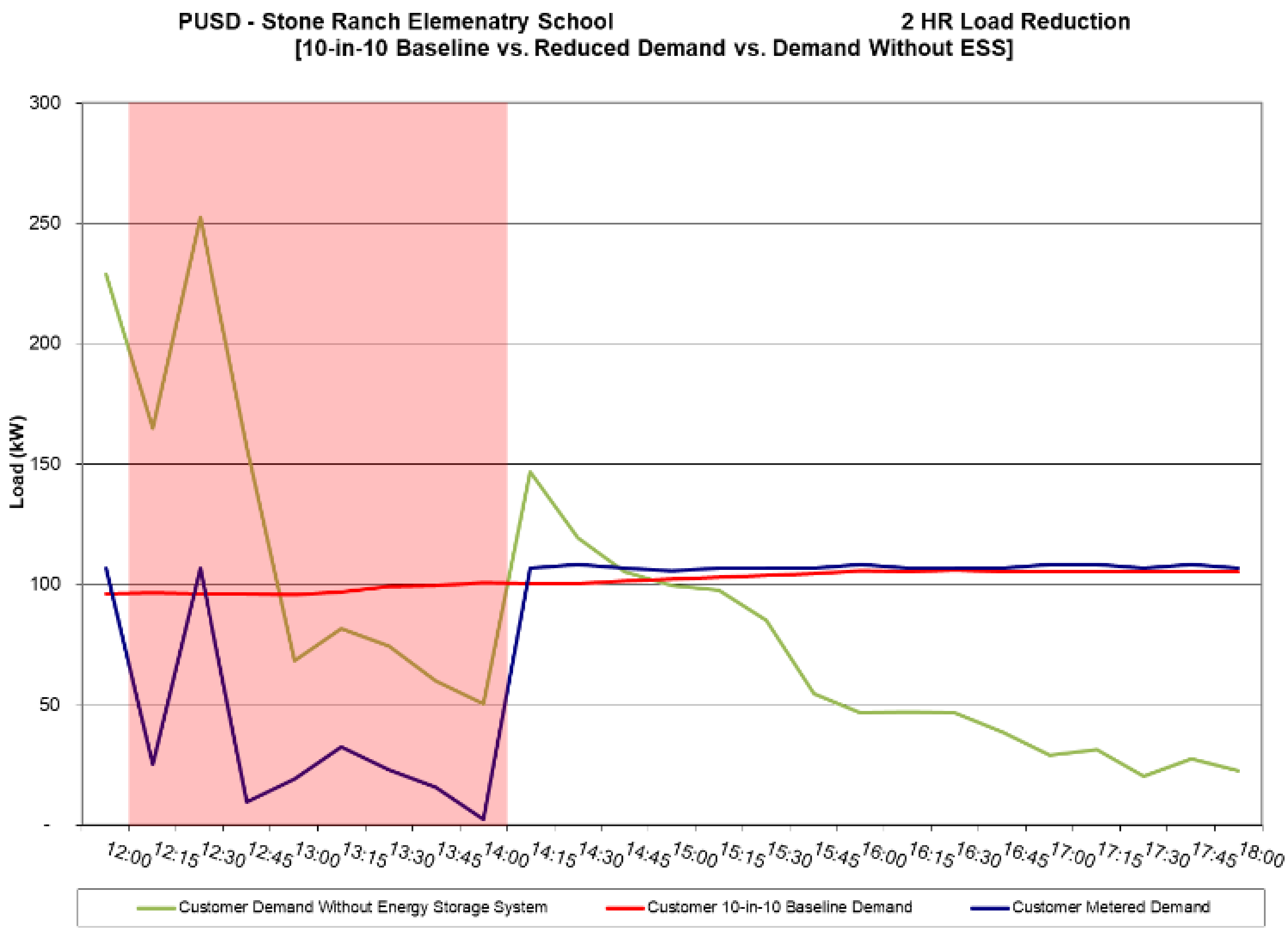
*Simulated DR Event #1*



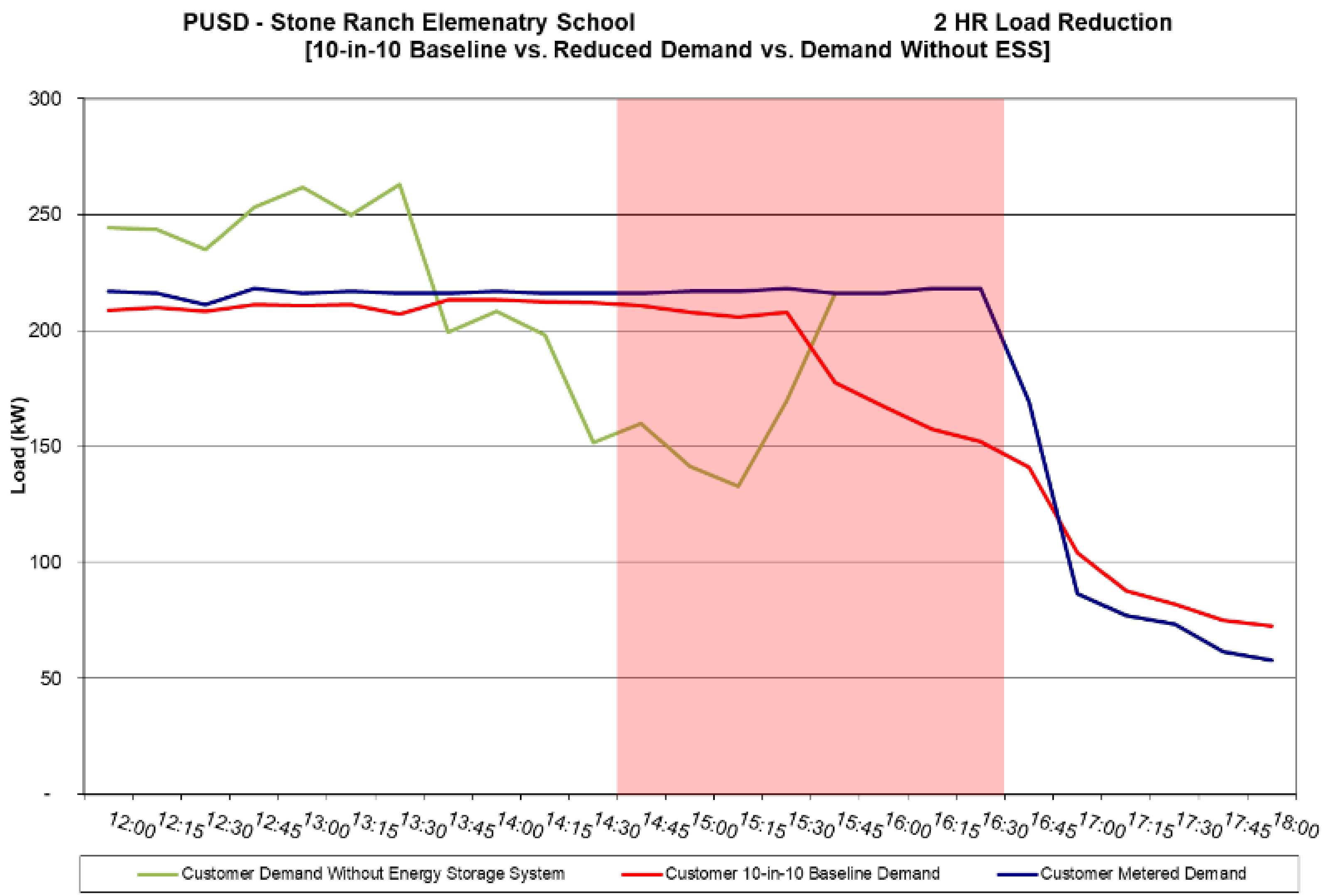
*Simulated DR Event #2*



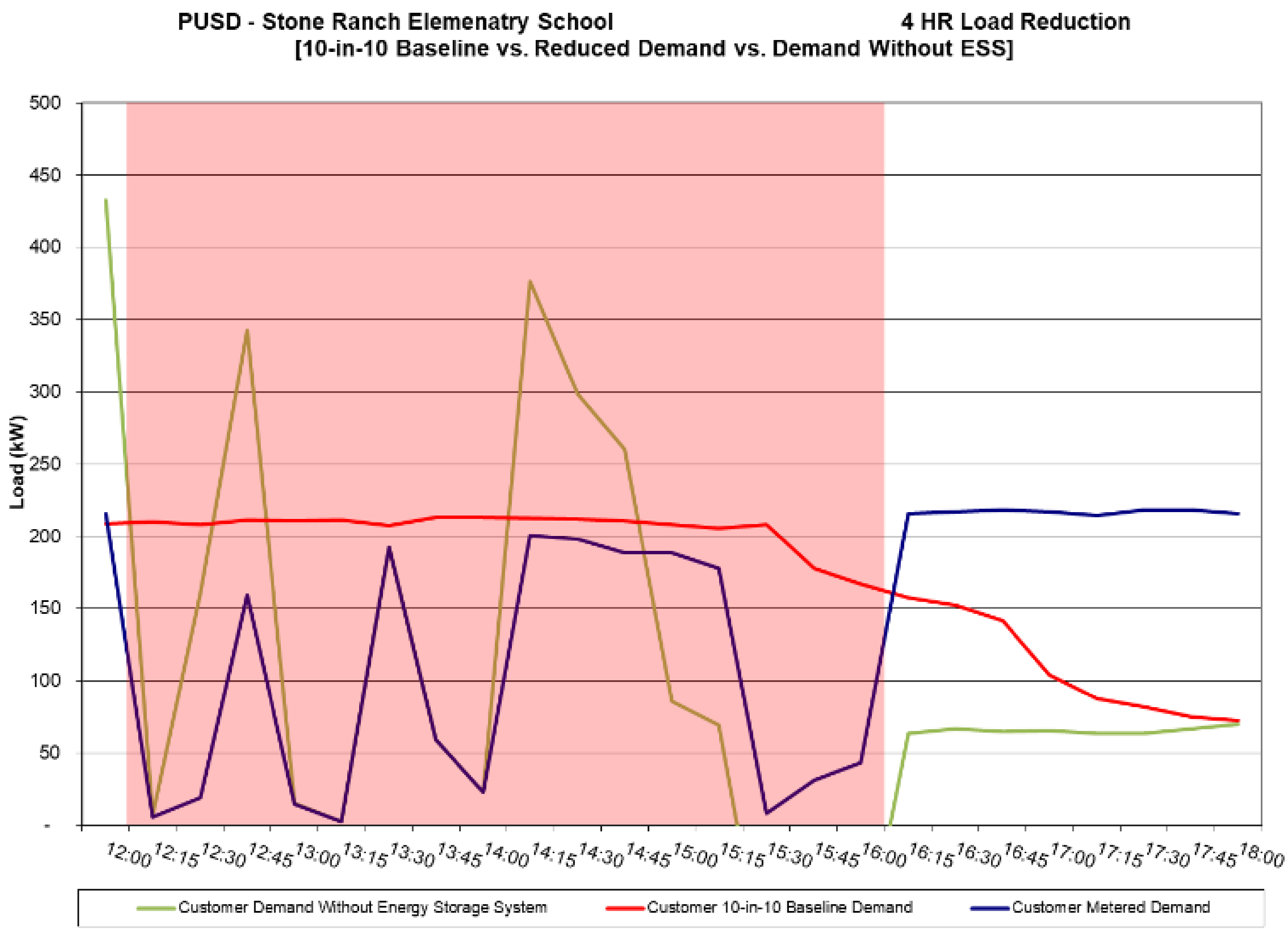
*Simulated DR Event #3*



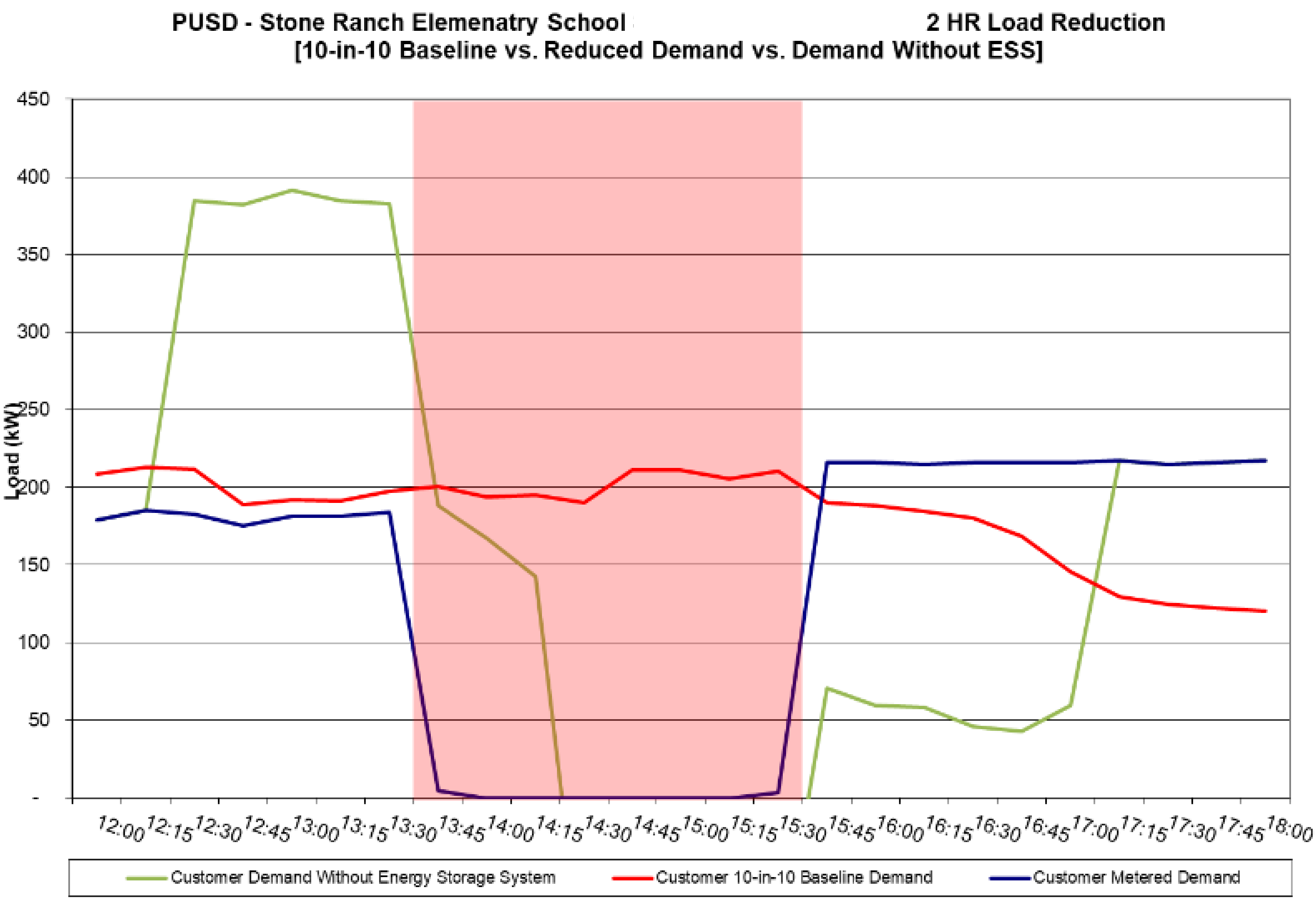
*Simulated DR Event #4*



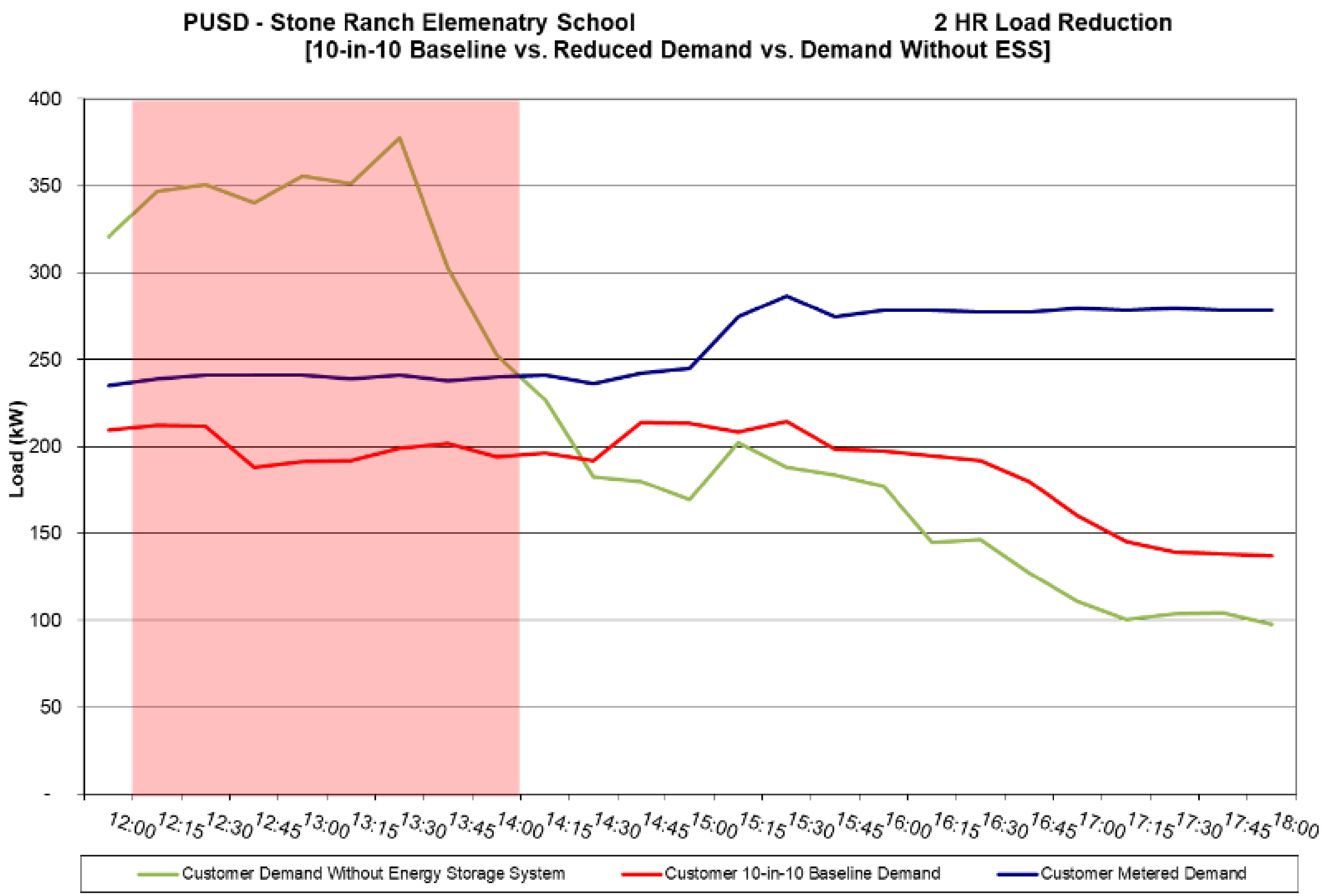
*Simulated DR Event #5*



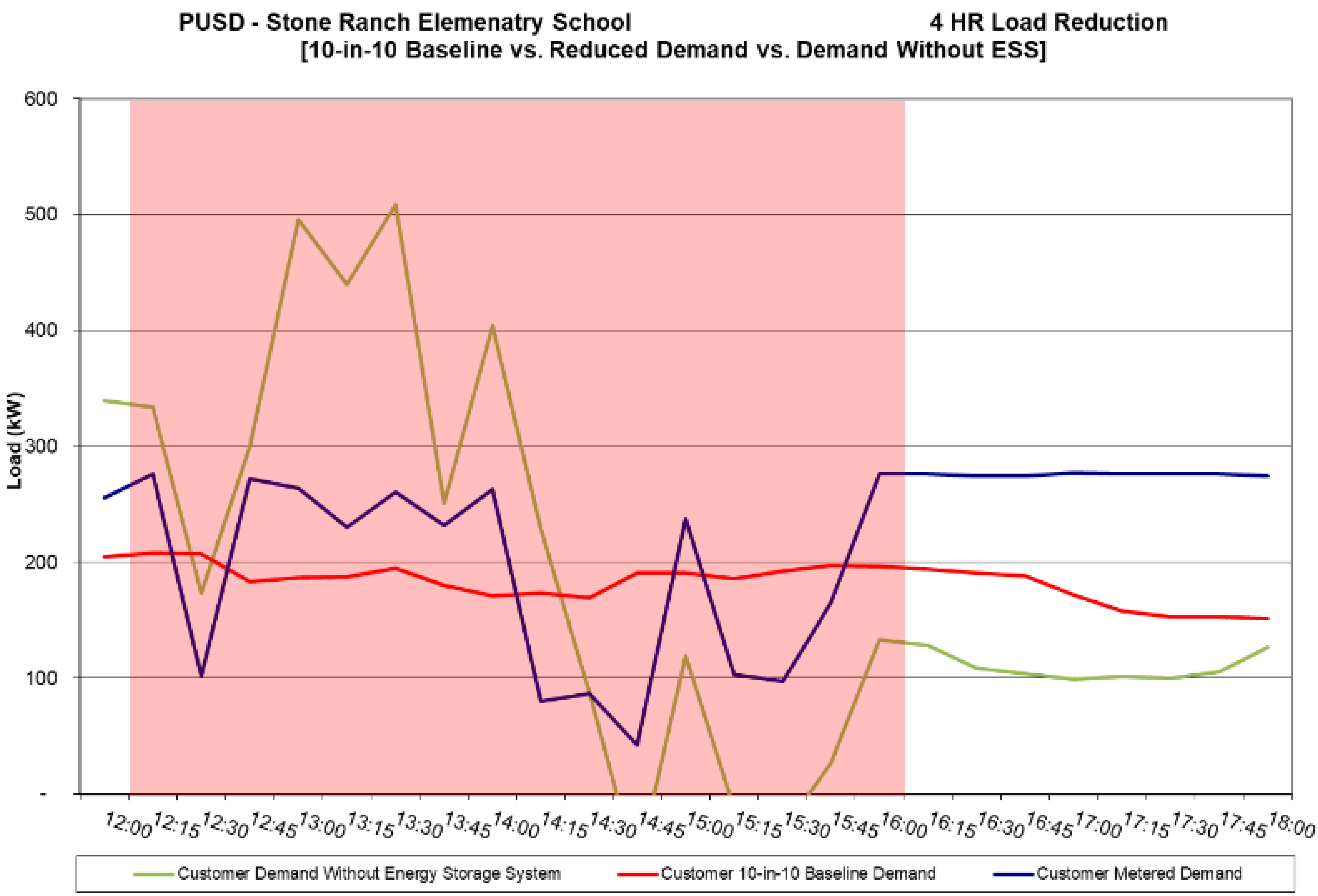
*Simulated DR Event #6*



*Simulated DR Event #7*

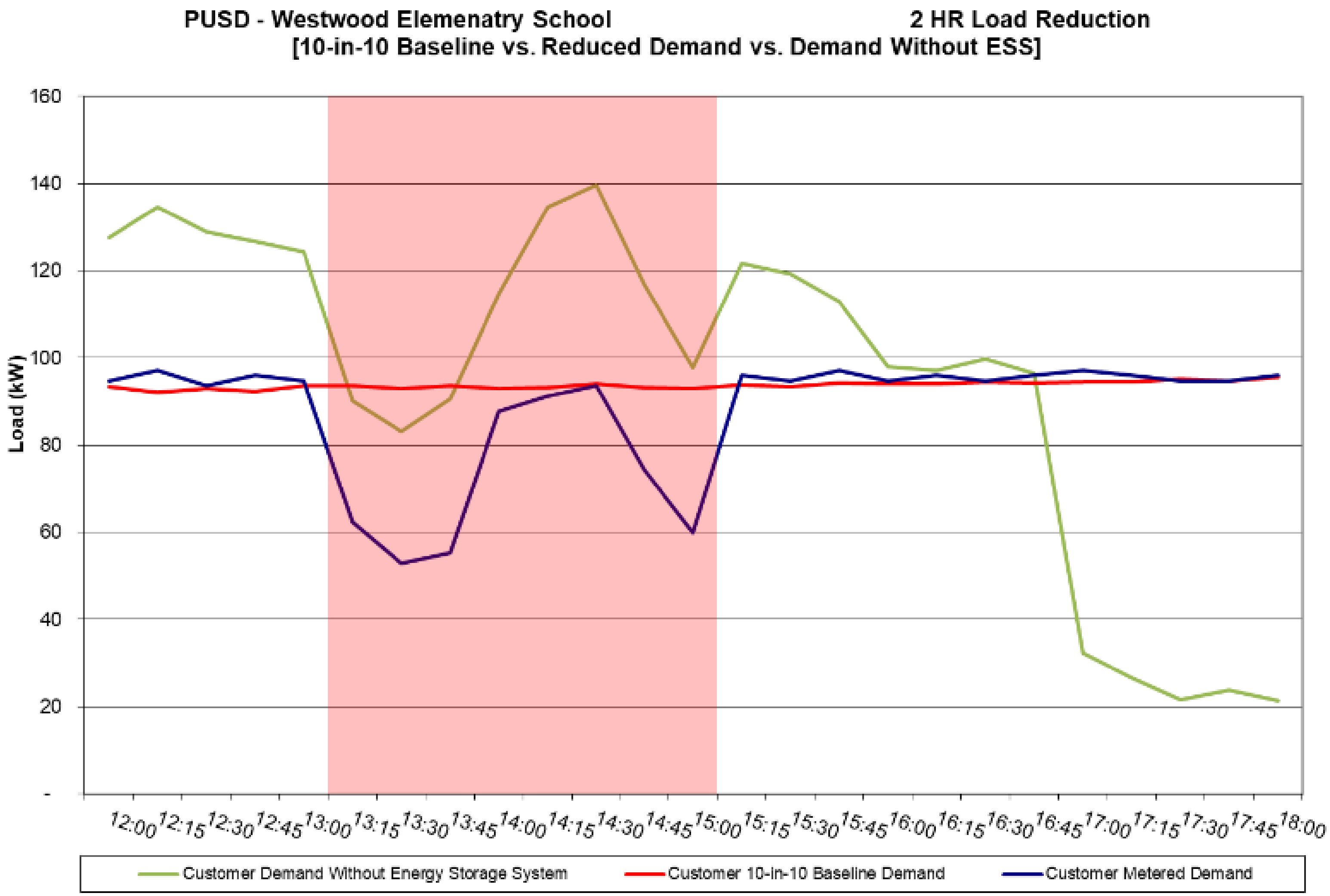


*Simulated DR Event #8*

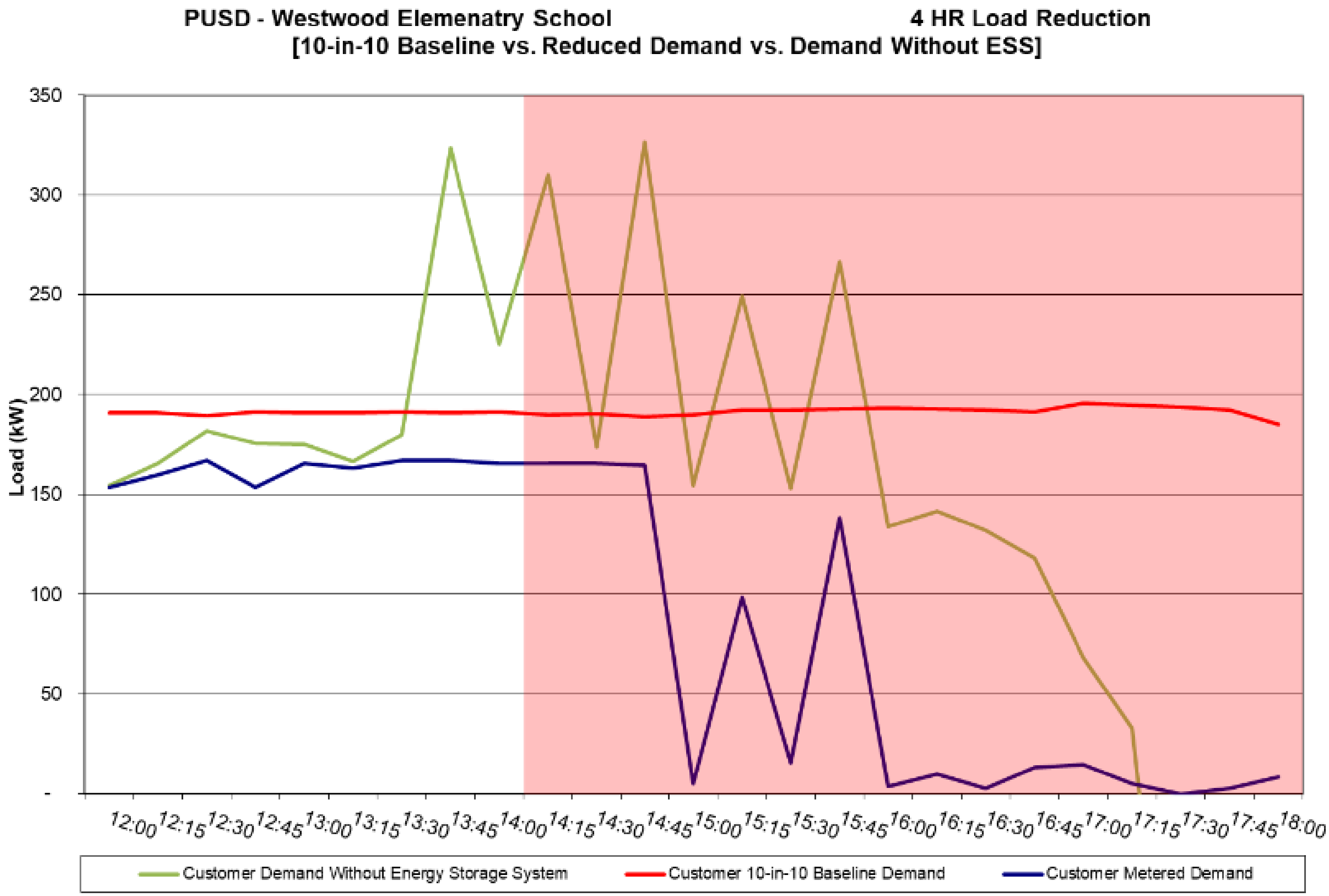


***PUSD – Westwood Elementary School***

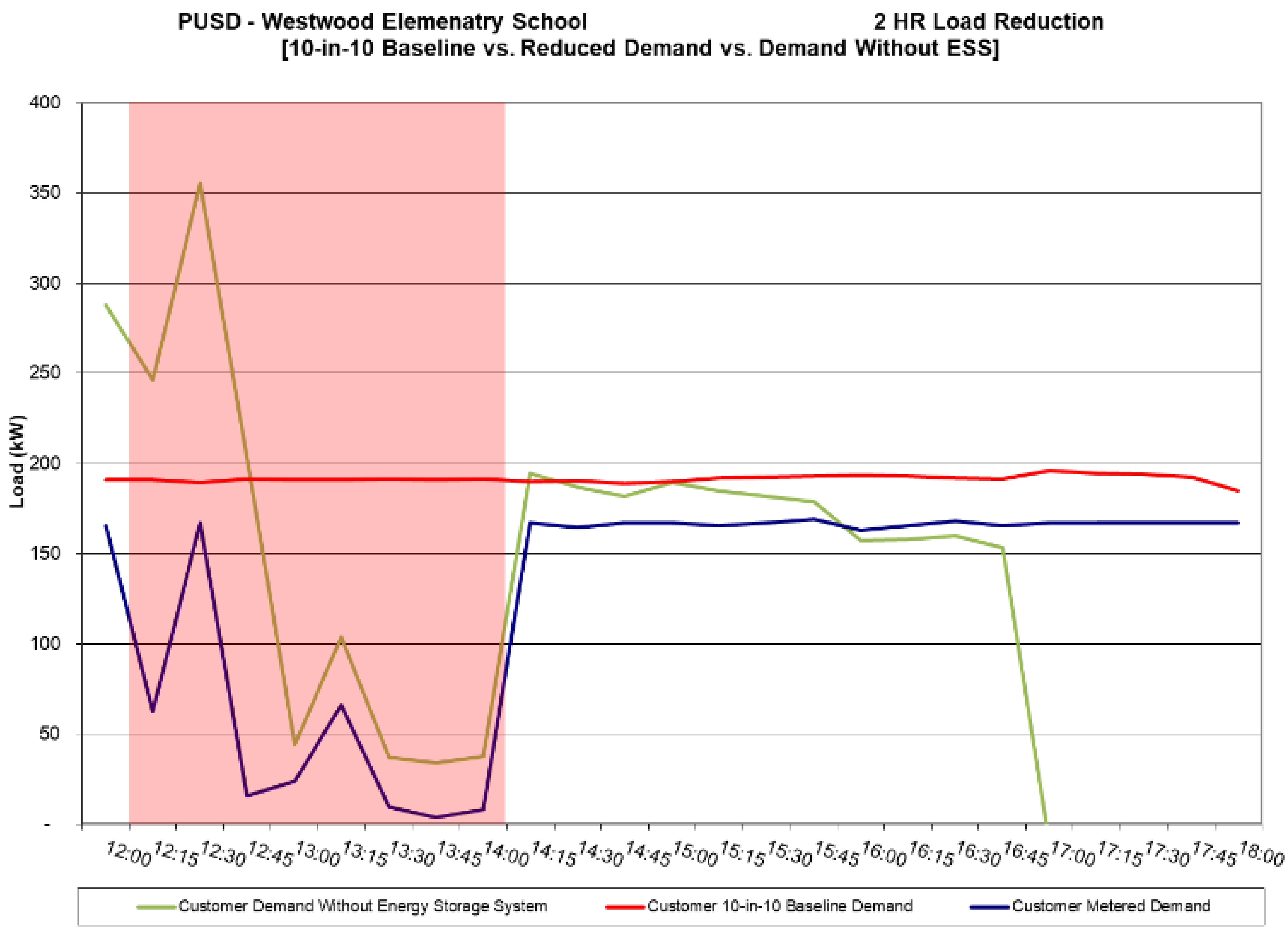
*Simulated DR Event #1*



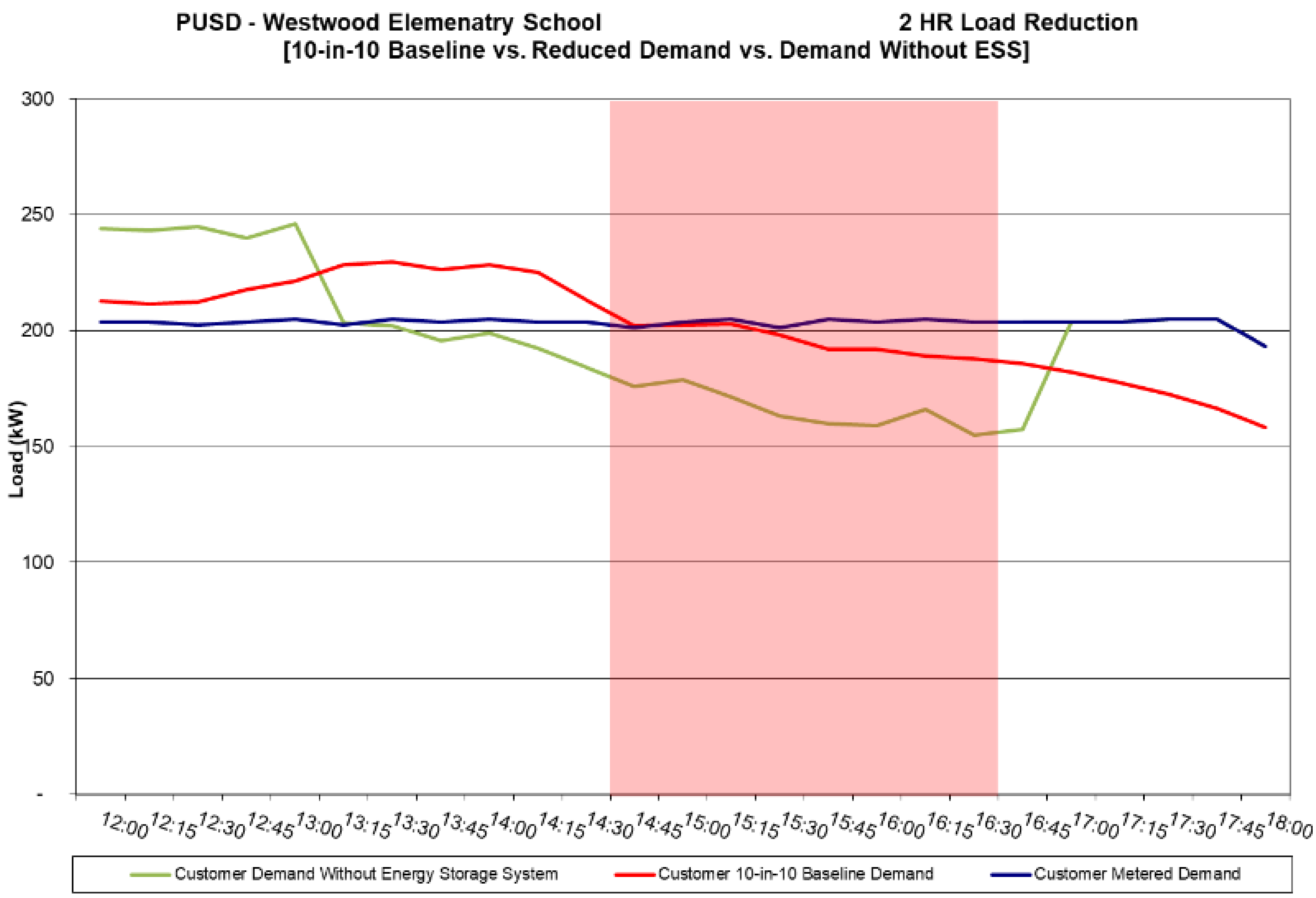
*Simulated DR Event #2*



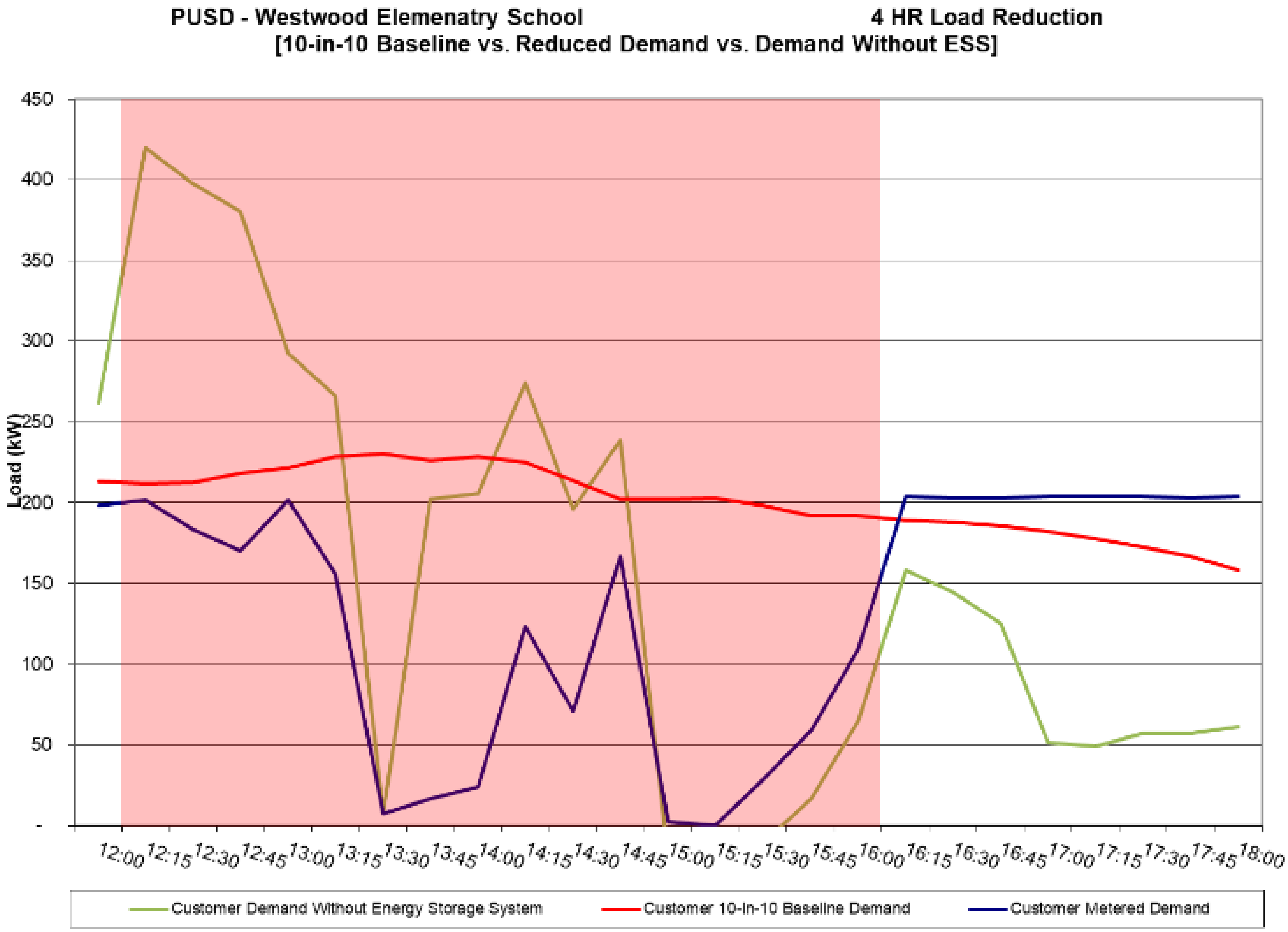
*Simulated DR Event #3*



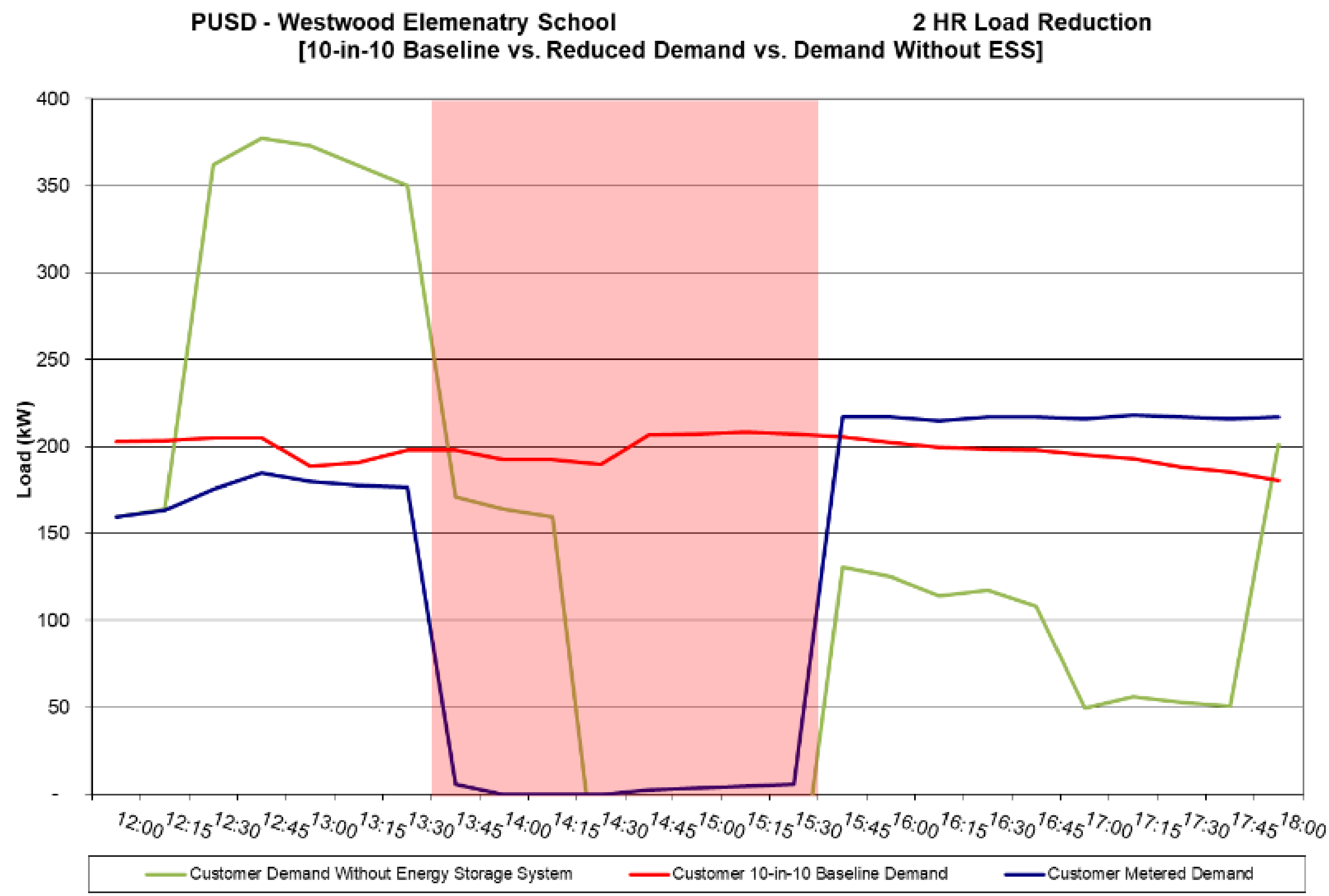
*Simulated DR Event #4*



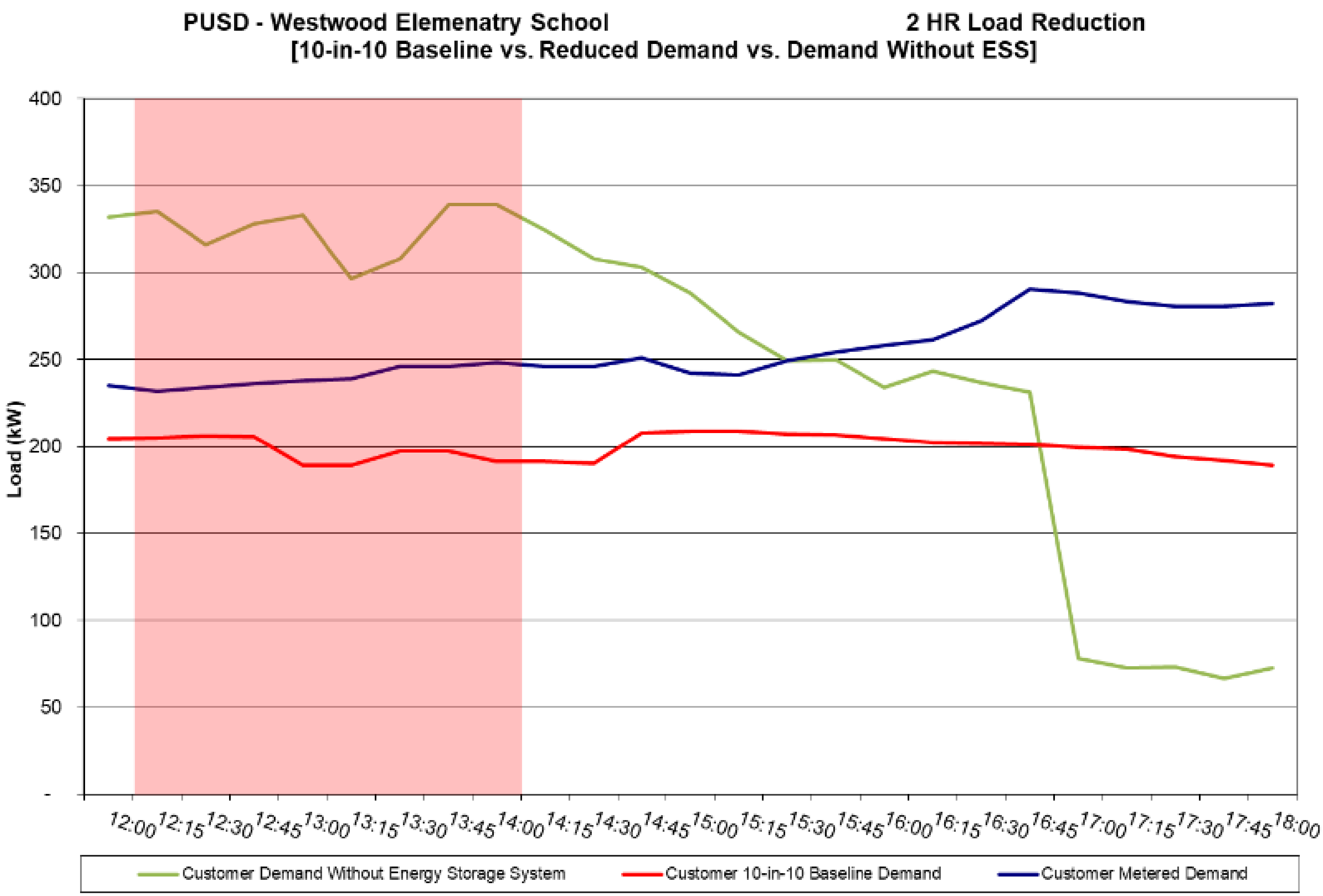
*Simulated DR Event #5*



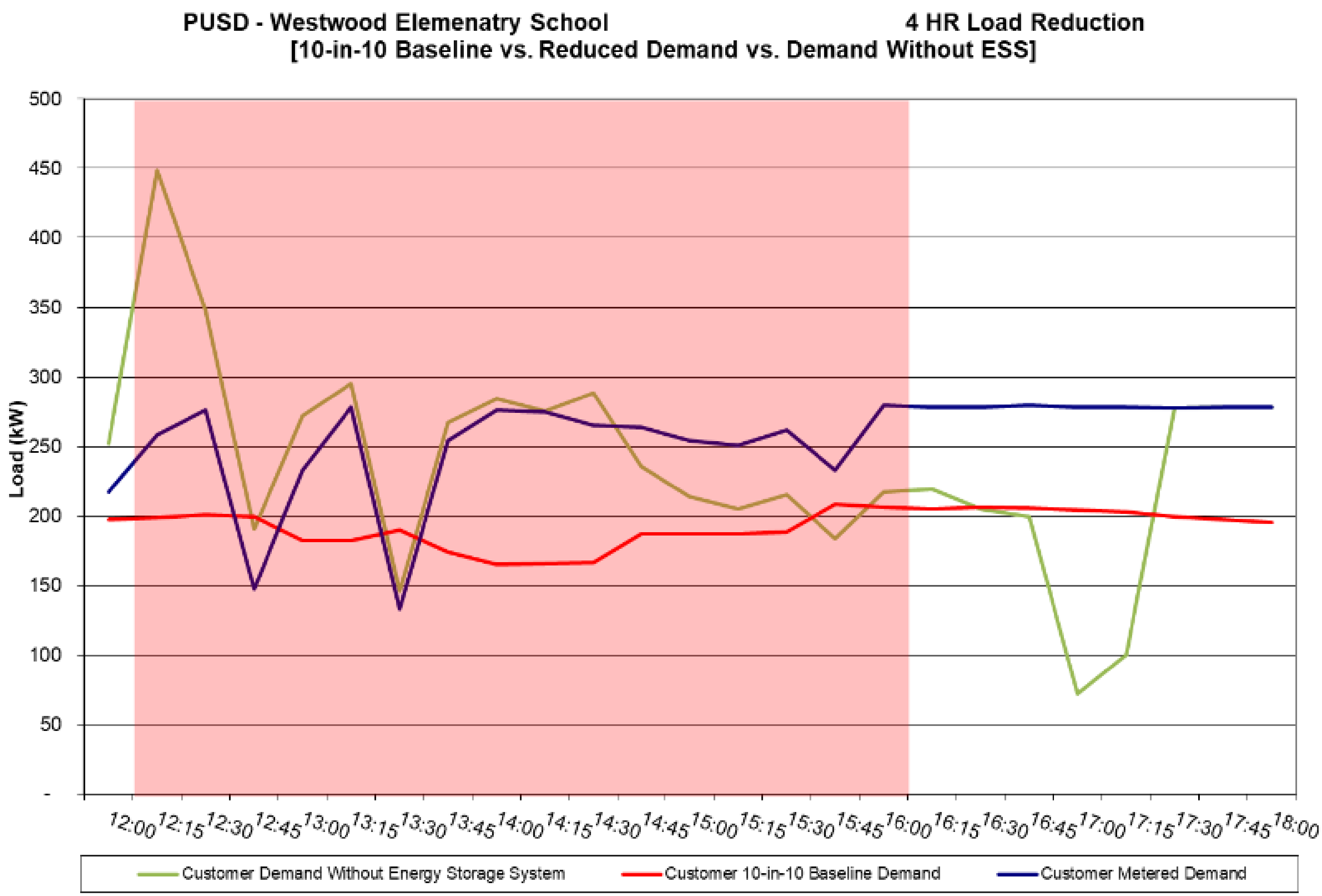
*Simulated DR Event #6*



*Simulated DR Event #7*

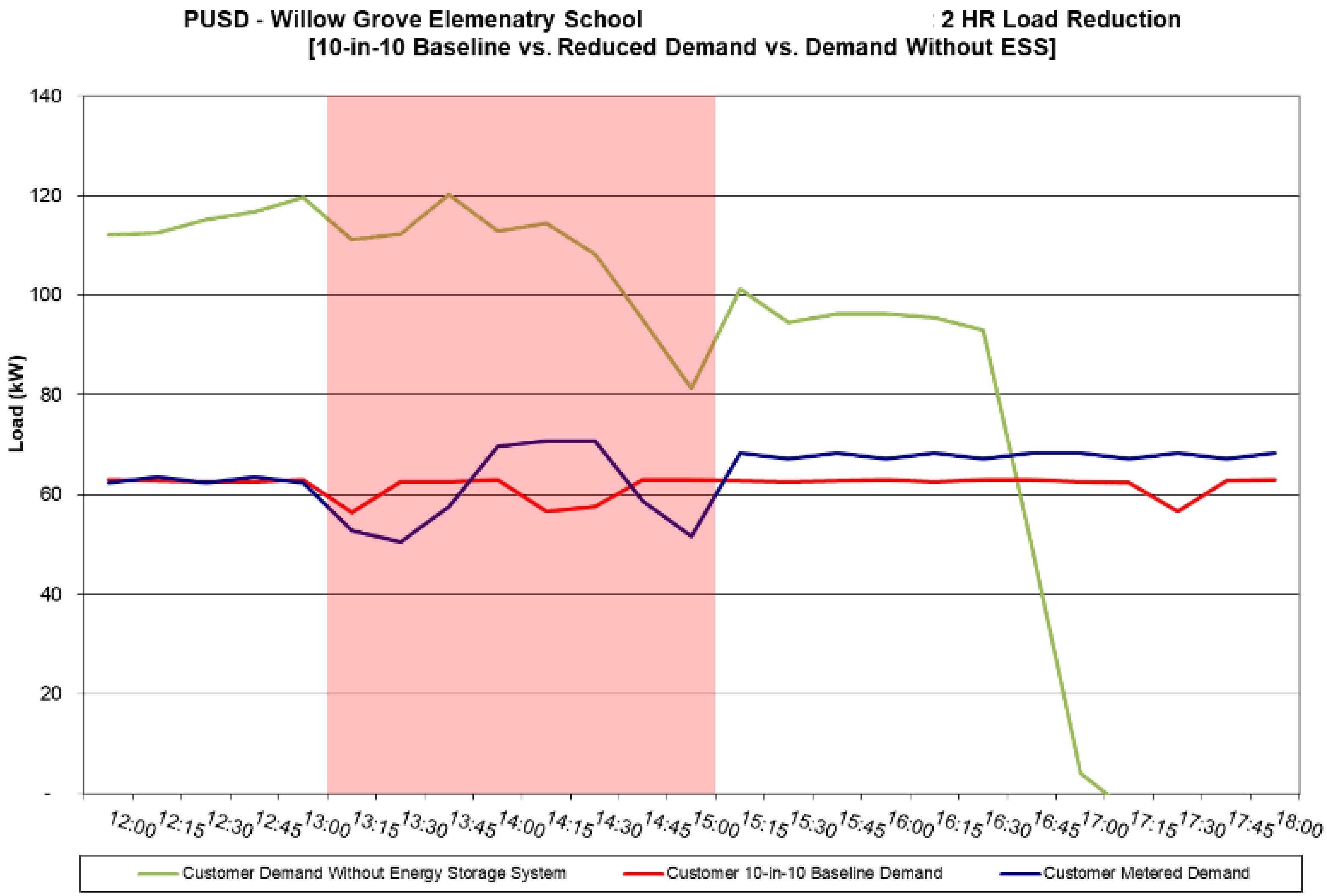


*Simulated DR Event #8*

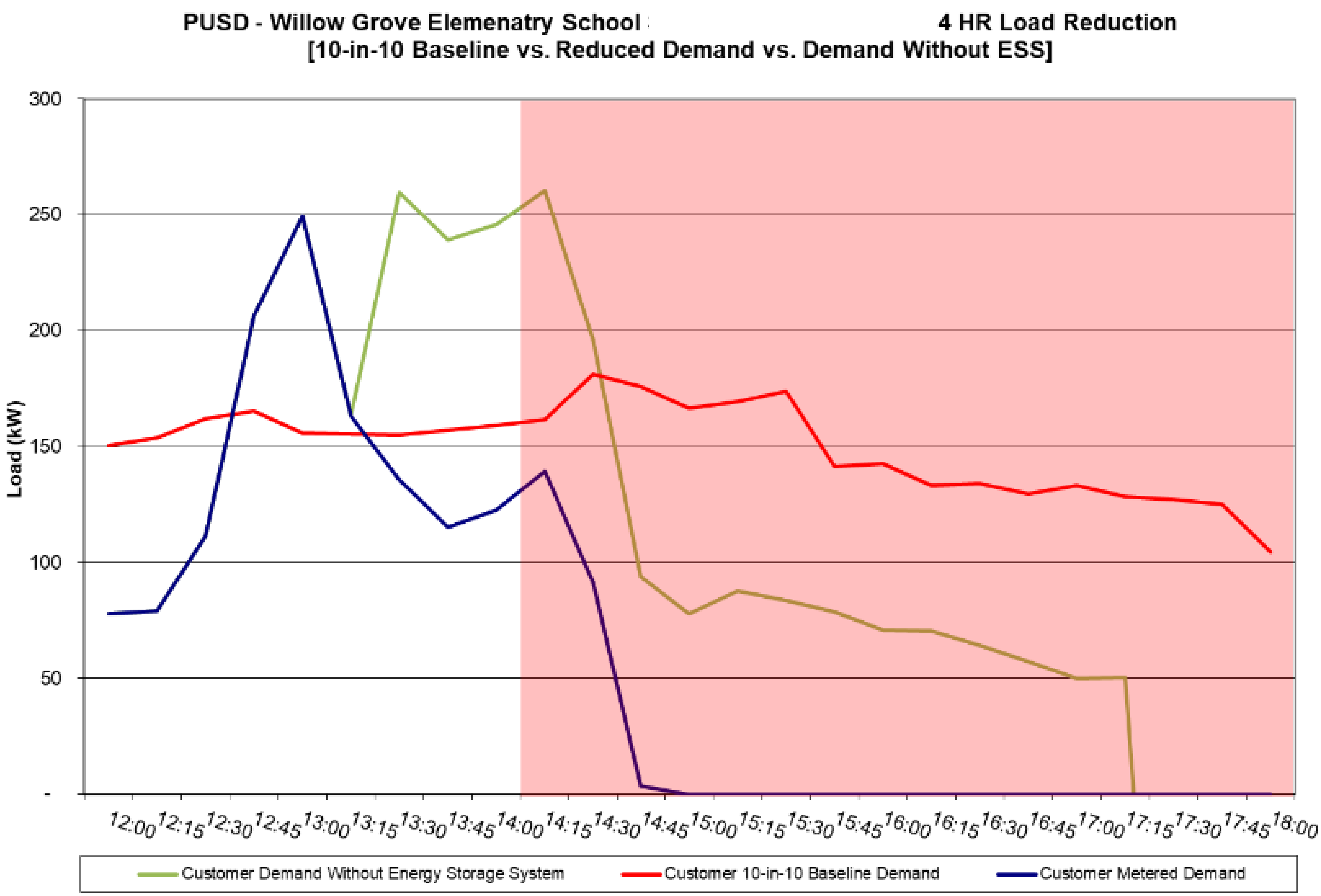


***PUSD – Willow Grove Elementary School***

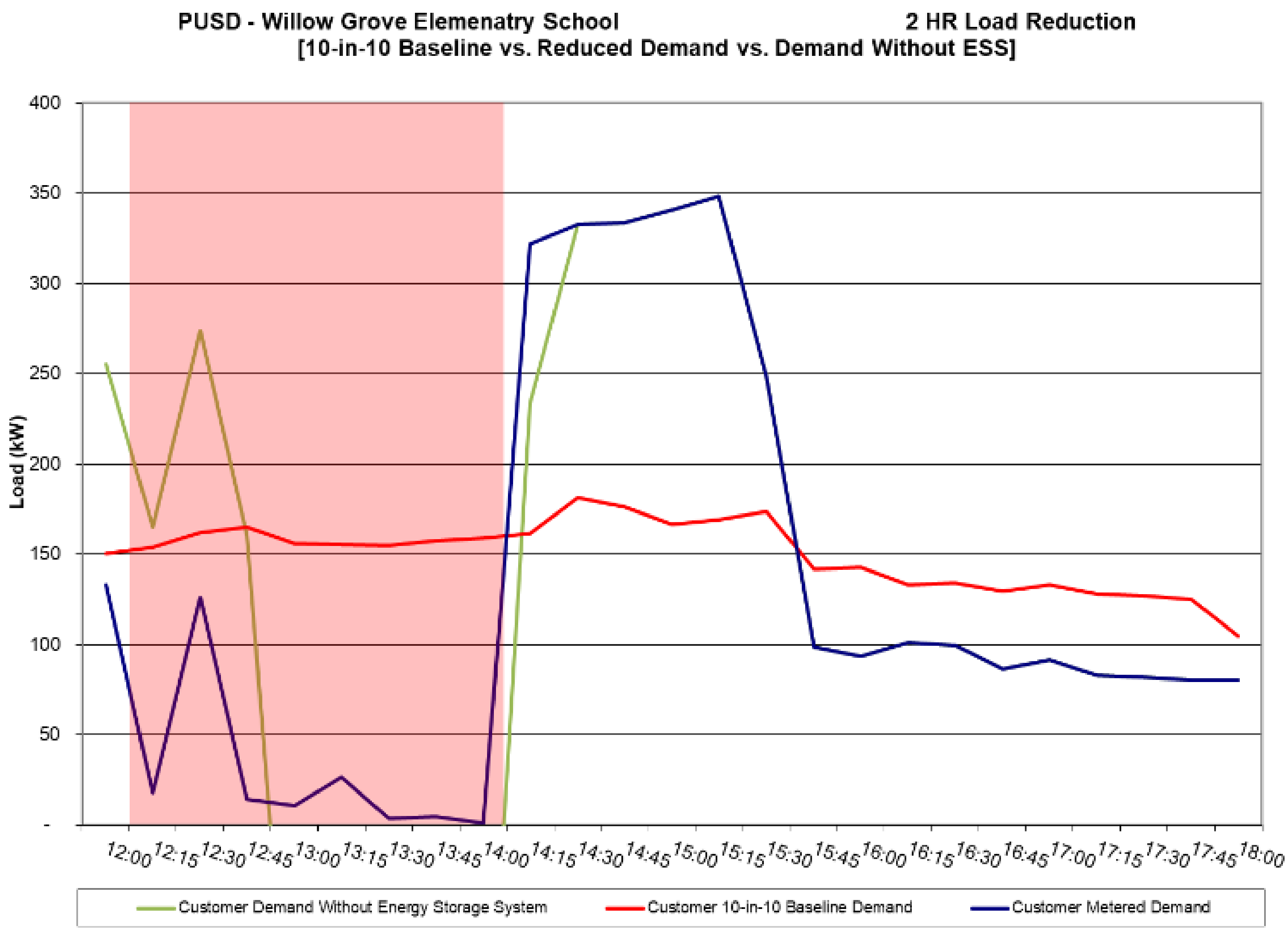
*Simulated DR Event #1*



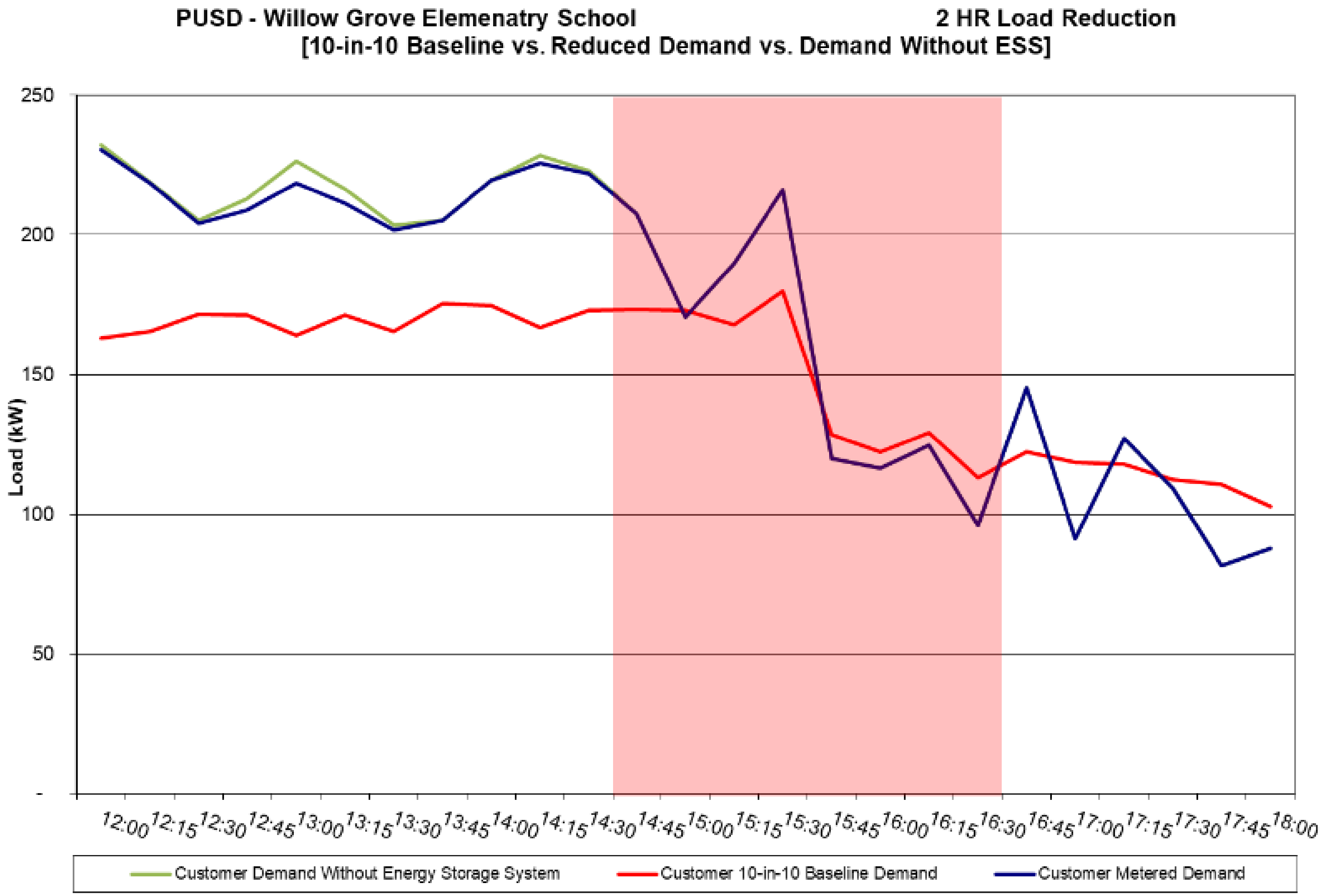
*Simulated DR Event #2*



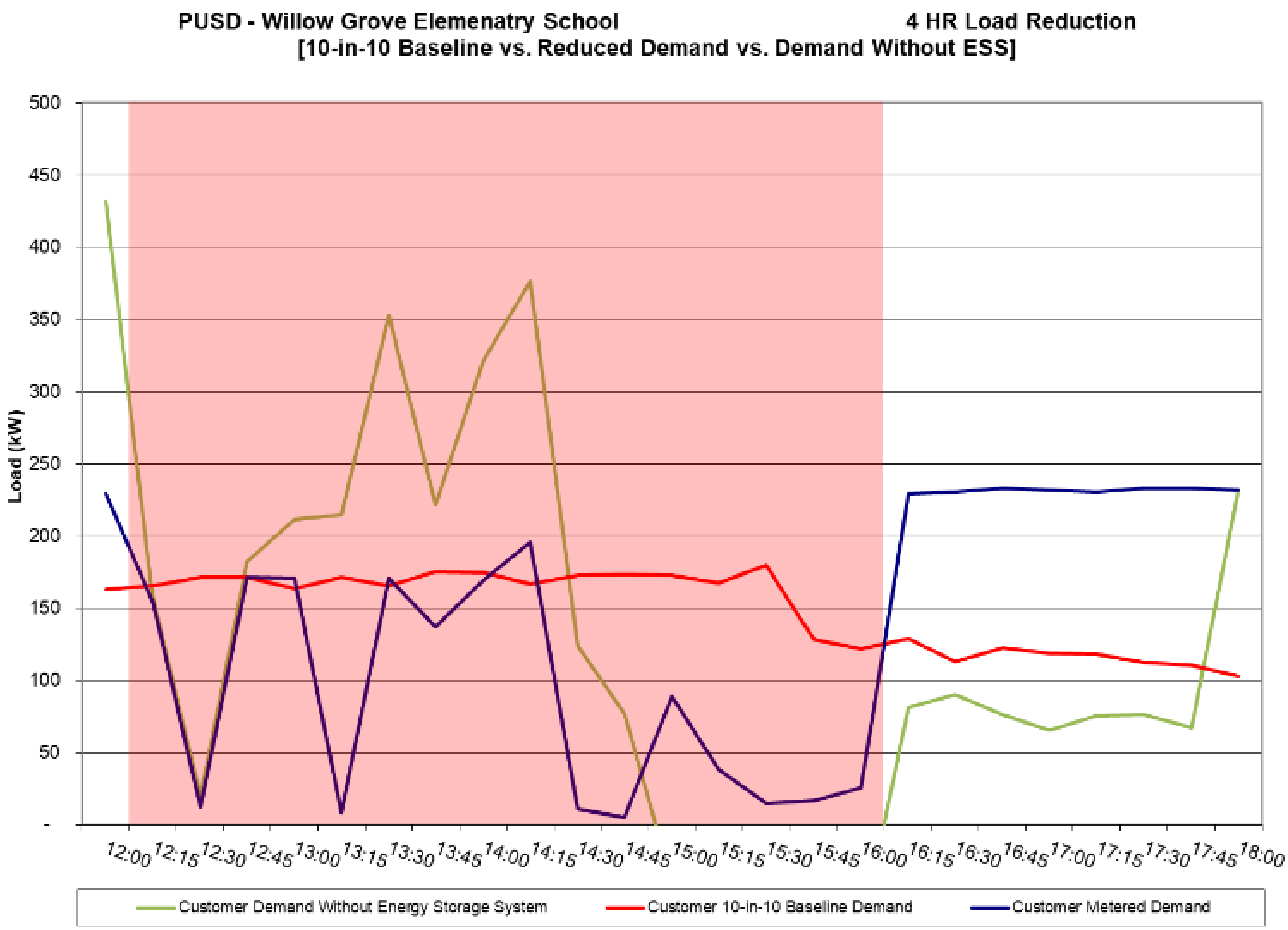
*Simulated DR Event #3*



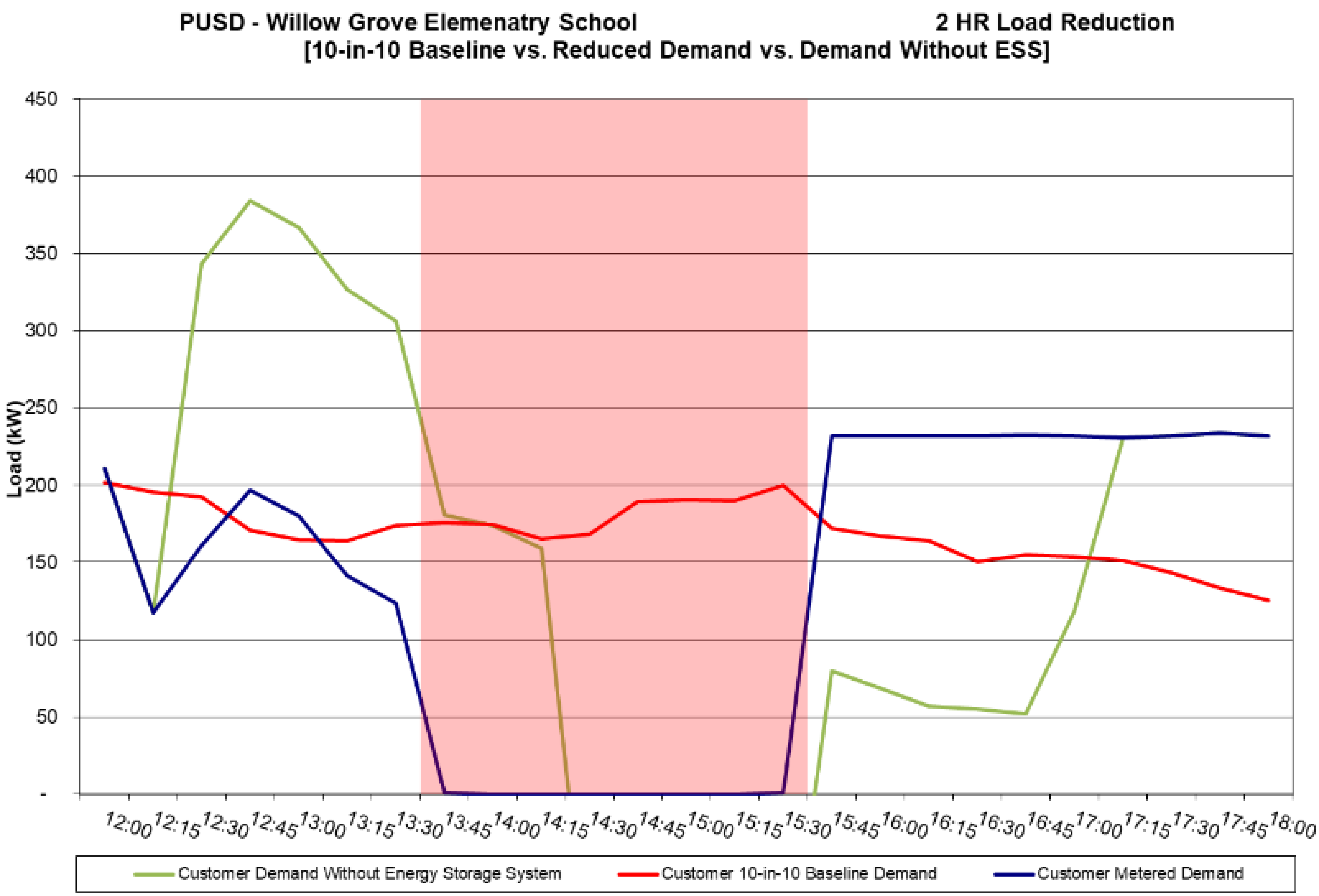
*Simulated DR Event #4*



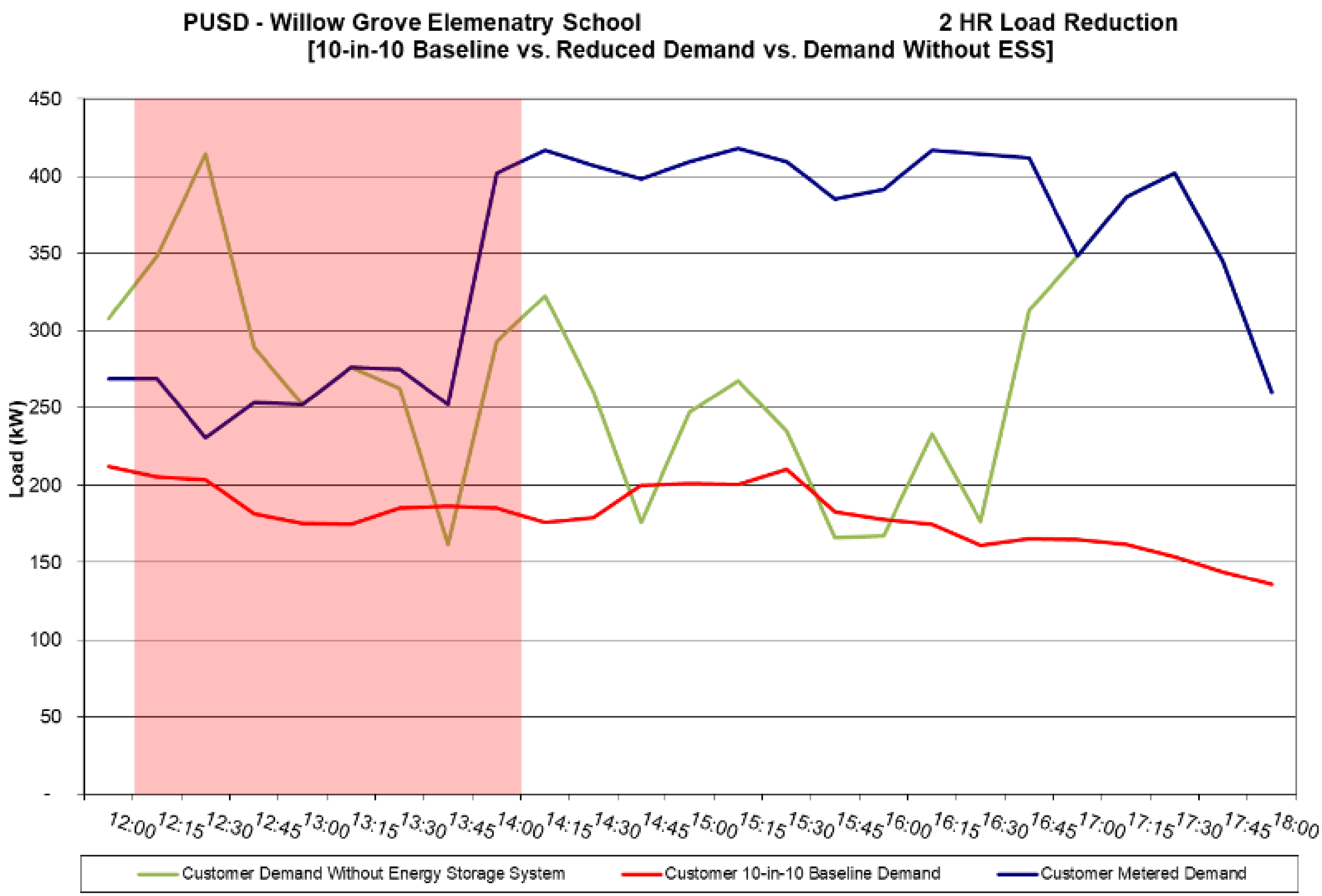
*Simulated DR Event #5*



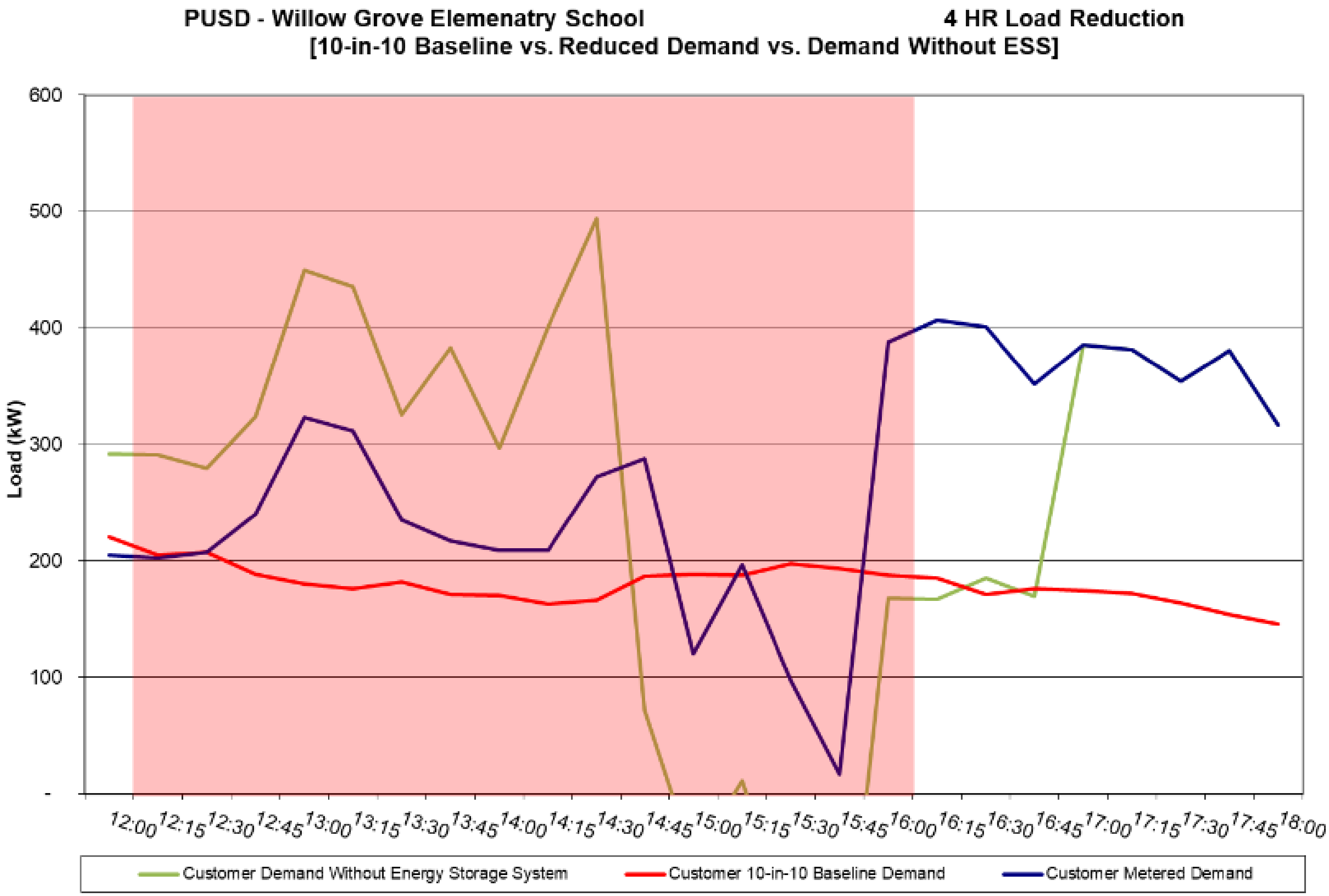
*Simulated DR Event #6*



*Simulated DR Event #7*

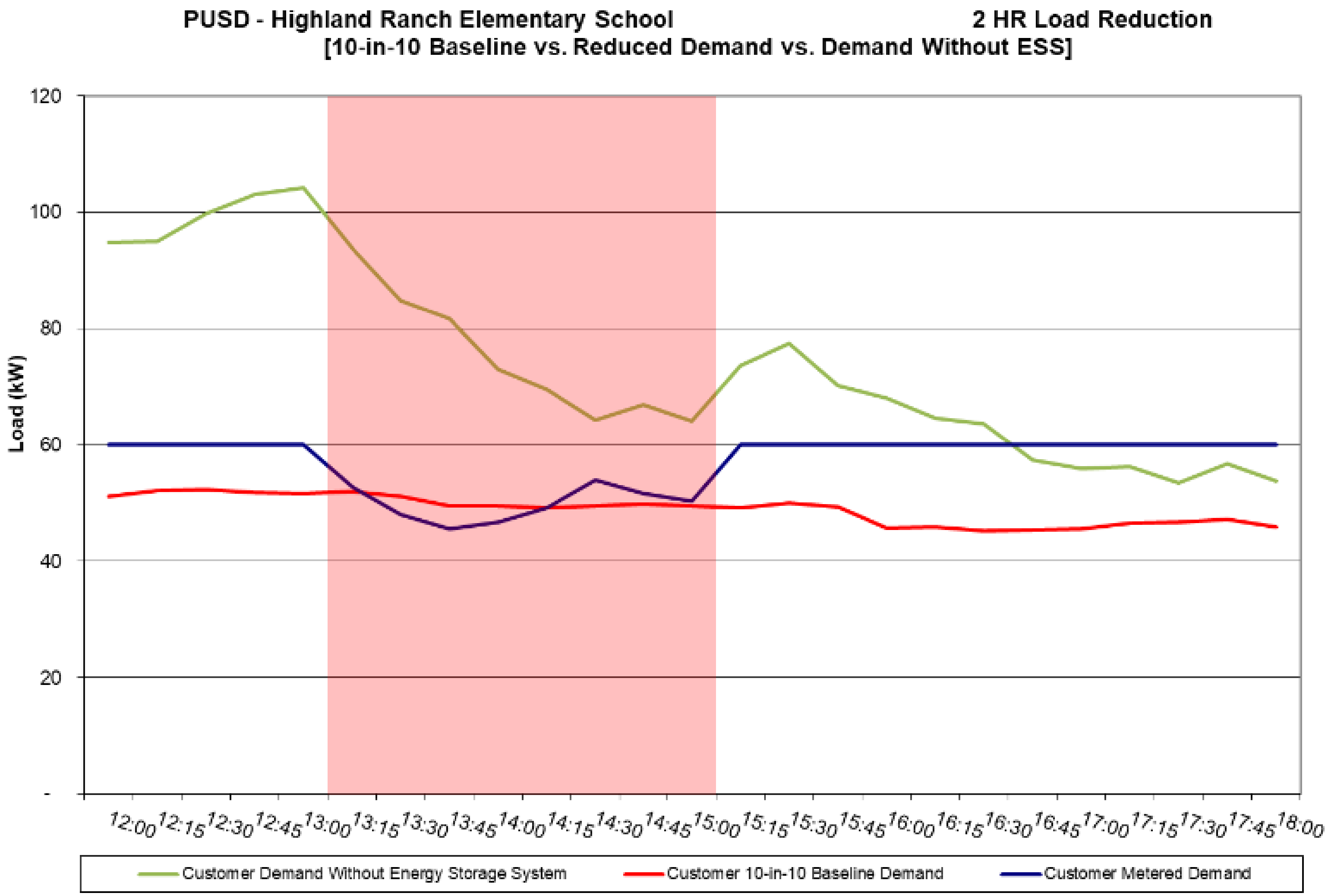


*Simulated DR Event #8*

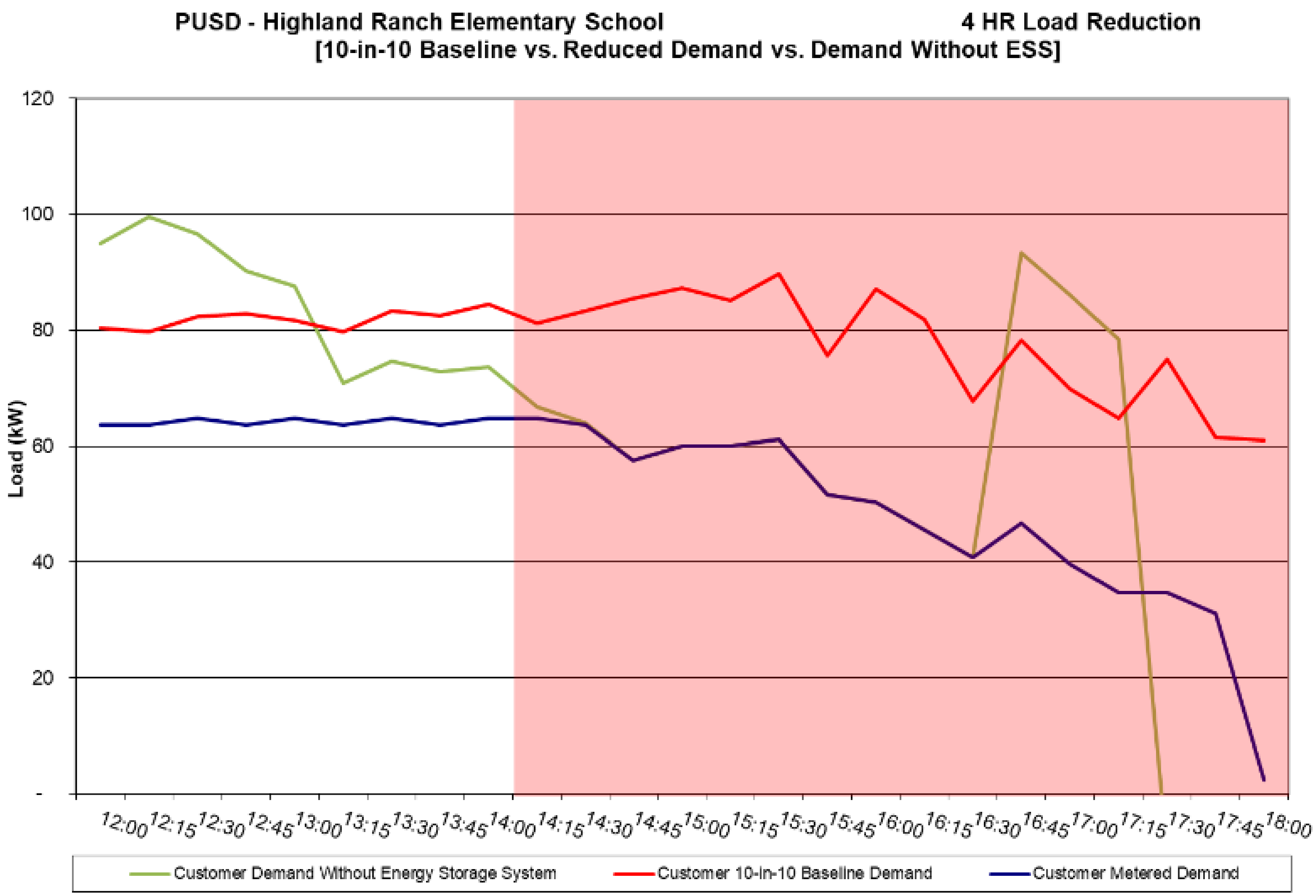


***PUSD – Highland Ranch Elementary School***

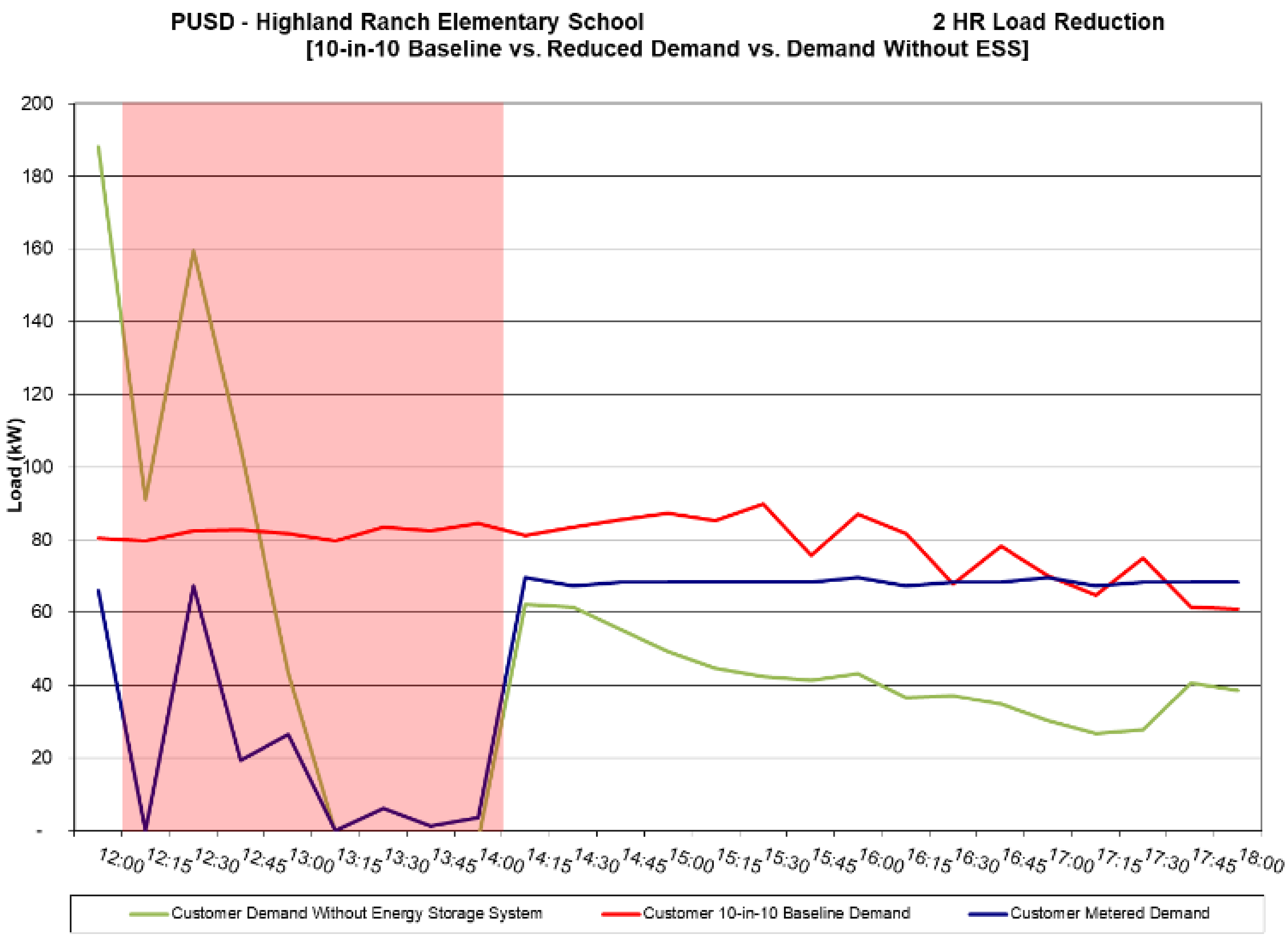
*Simulated DR Event #1*



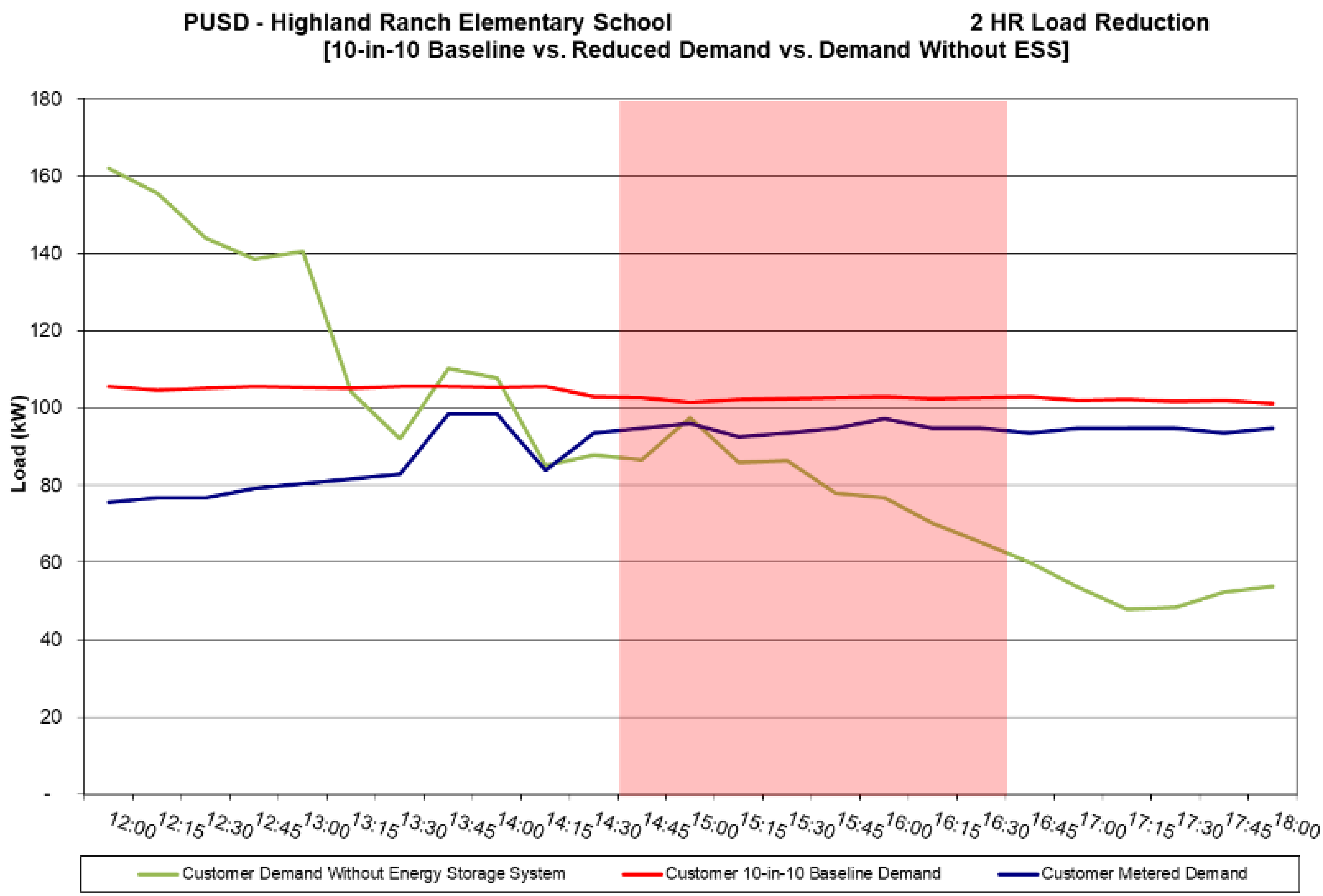
*Simulated DR Event #2*



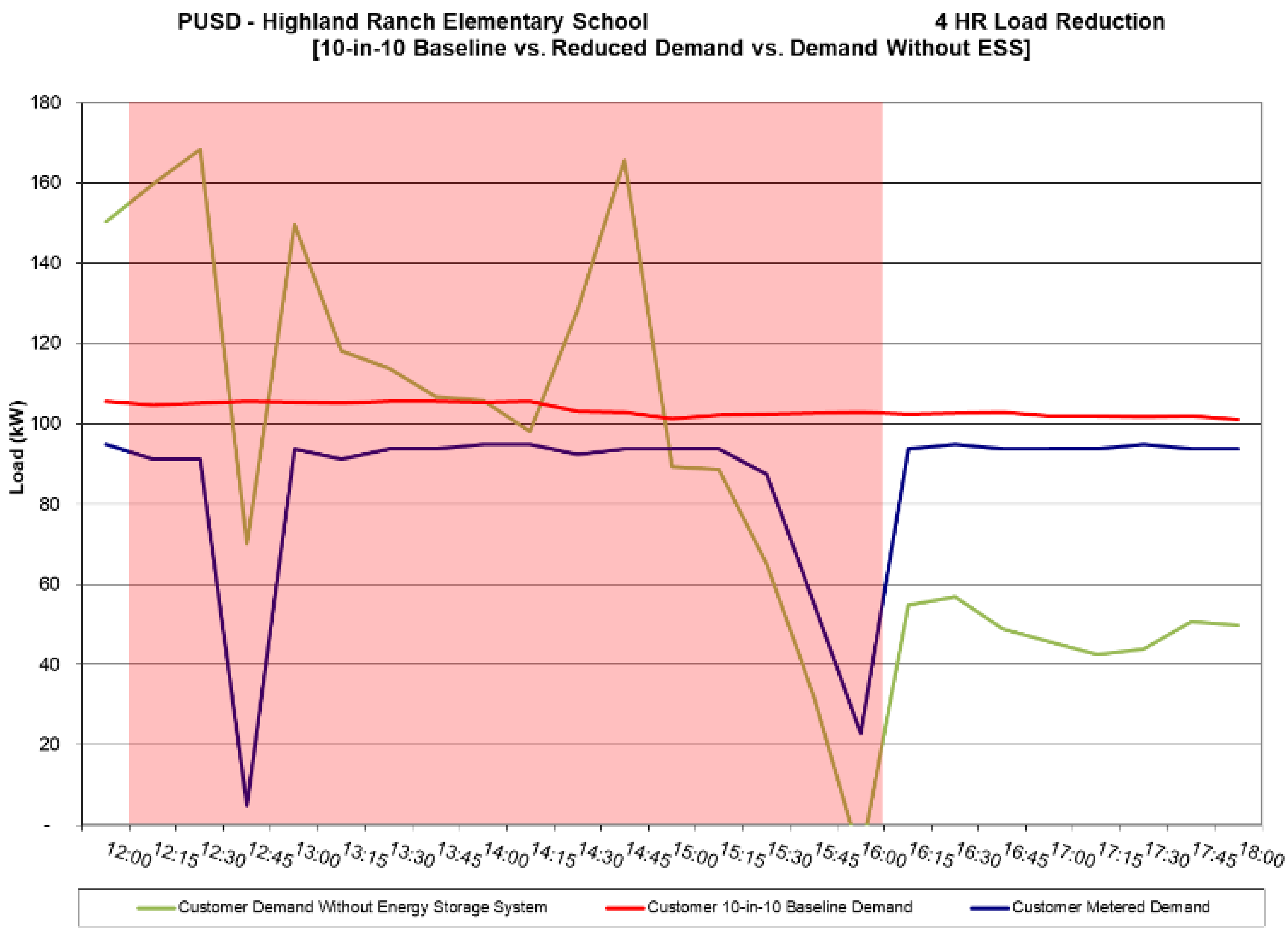
*Simulated DR Event #3*



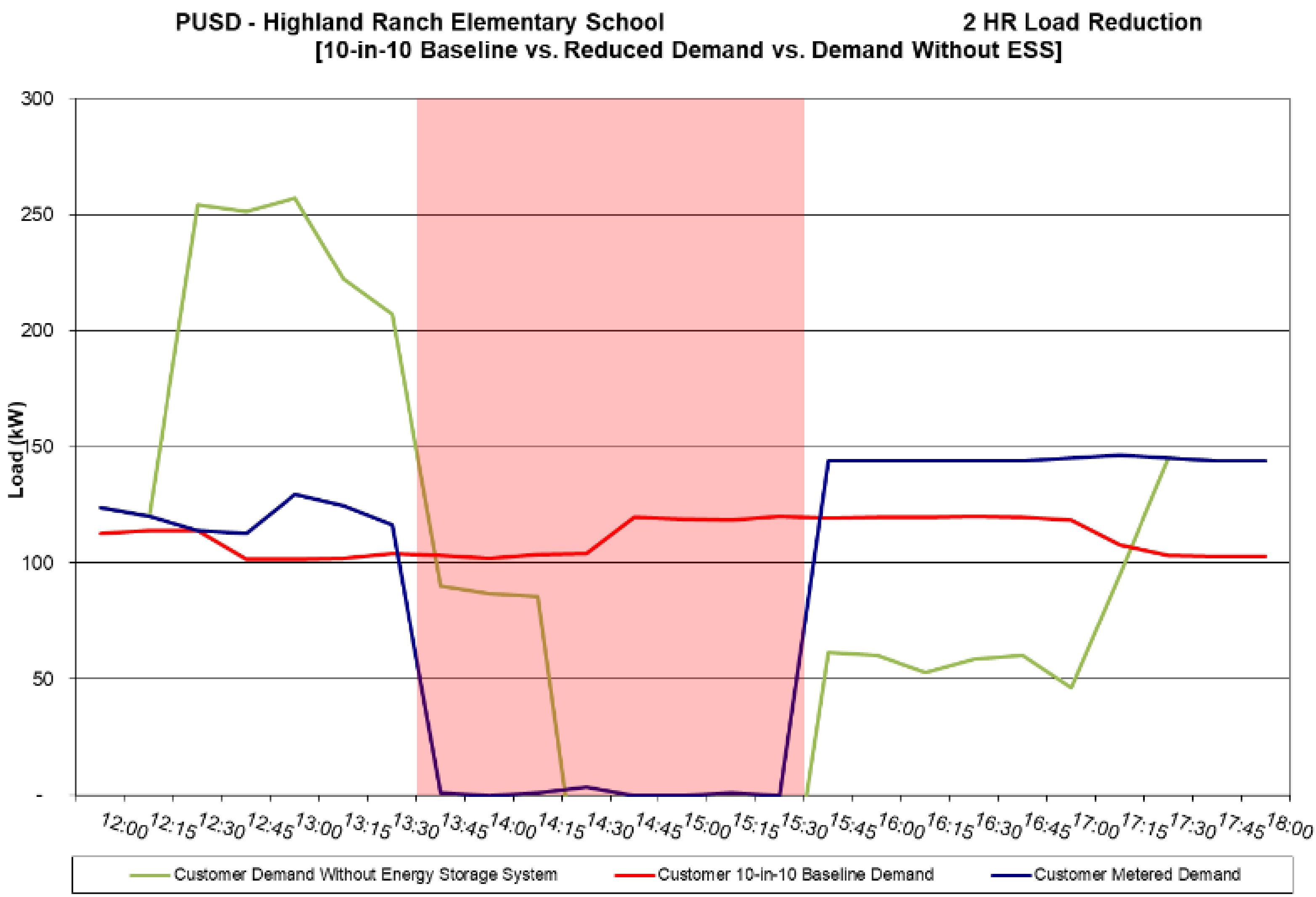
*Simulated DR Event #4*



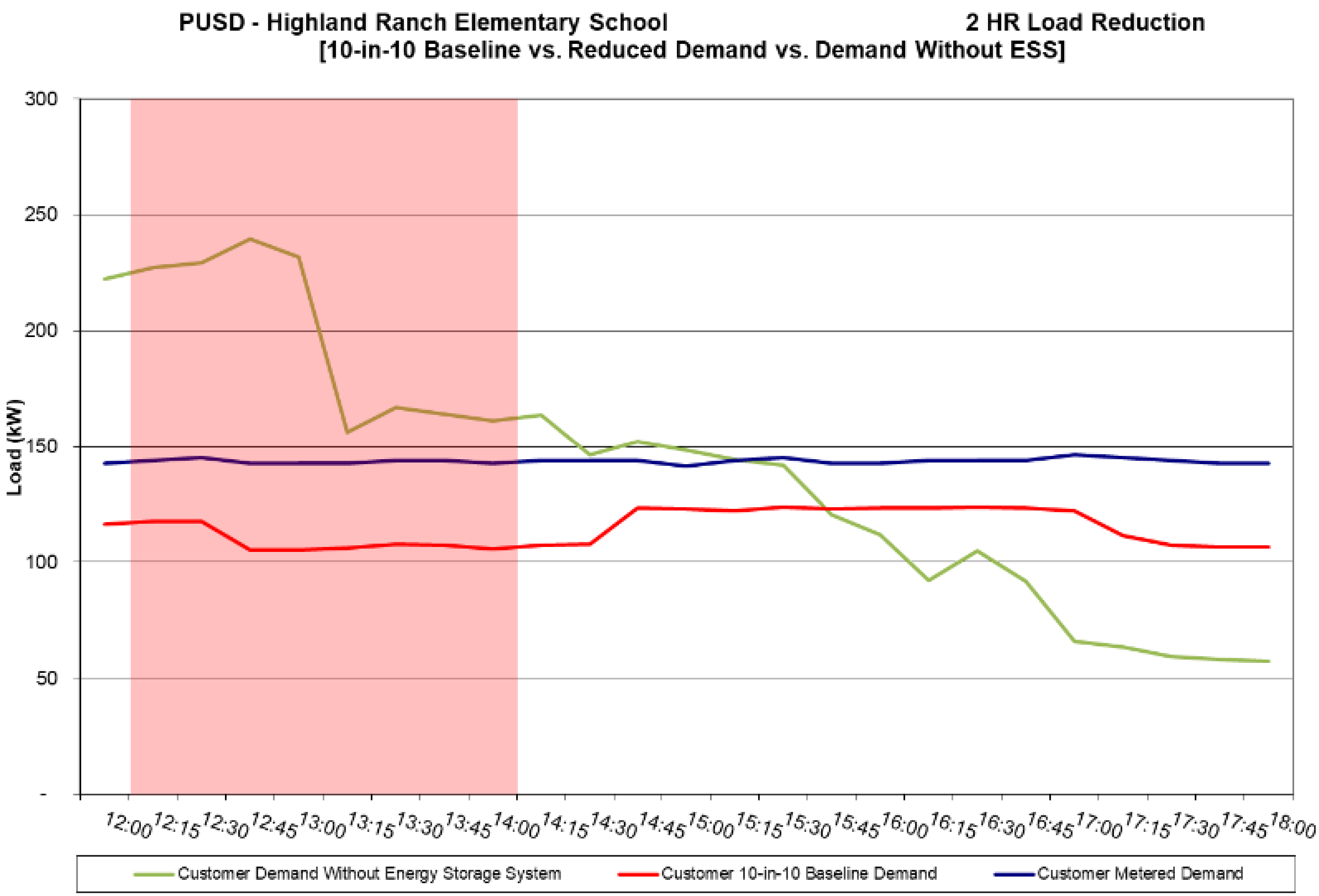
*Simulated DR Event #5*



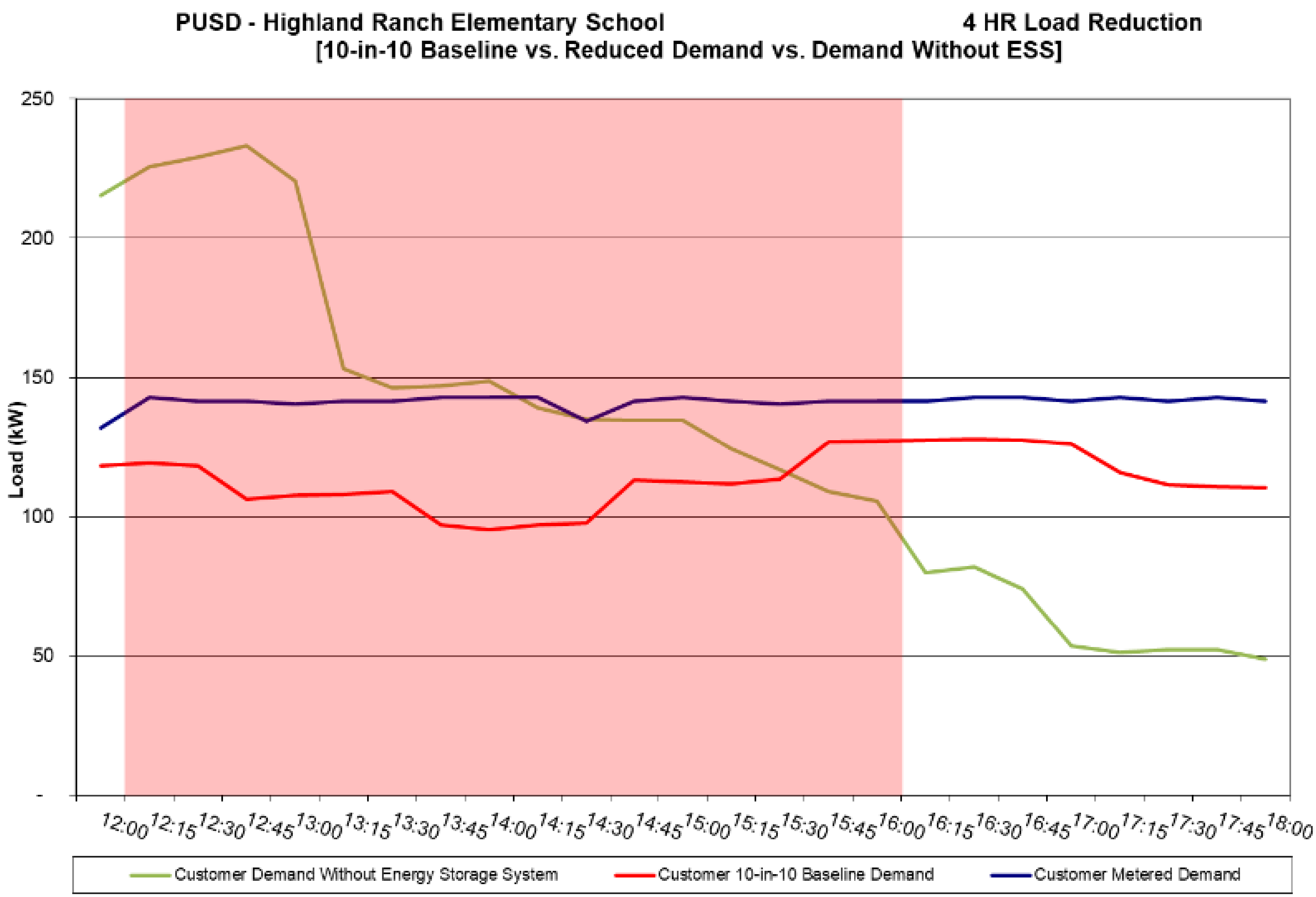
*Simulated DR Event #6*



*Simulated DR Event #7*

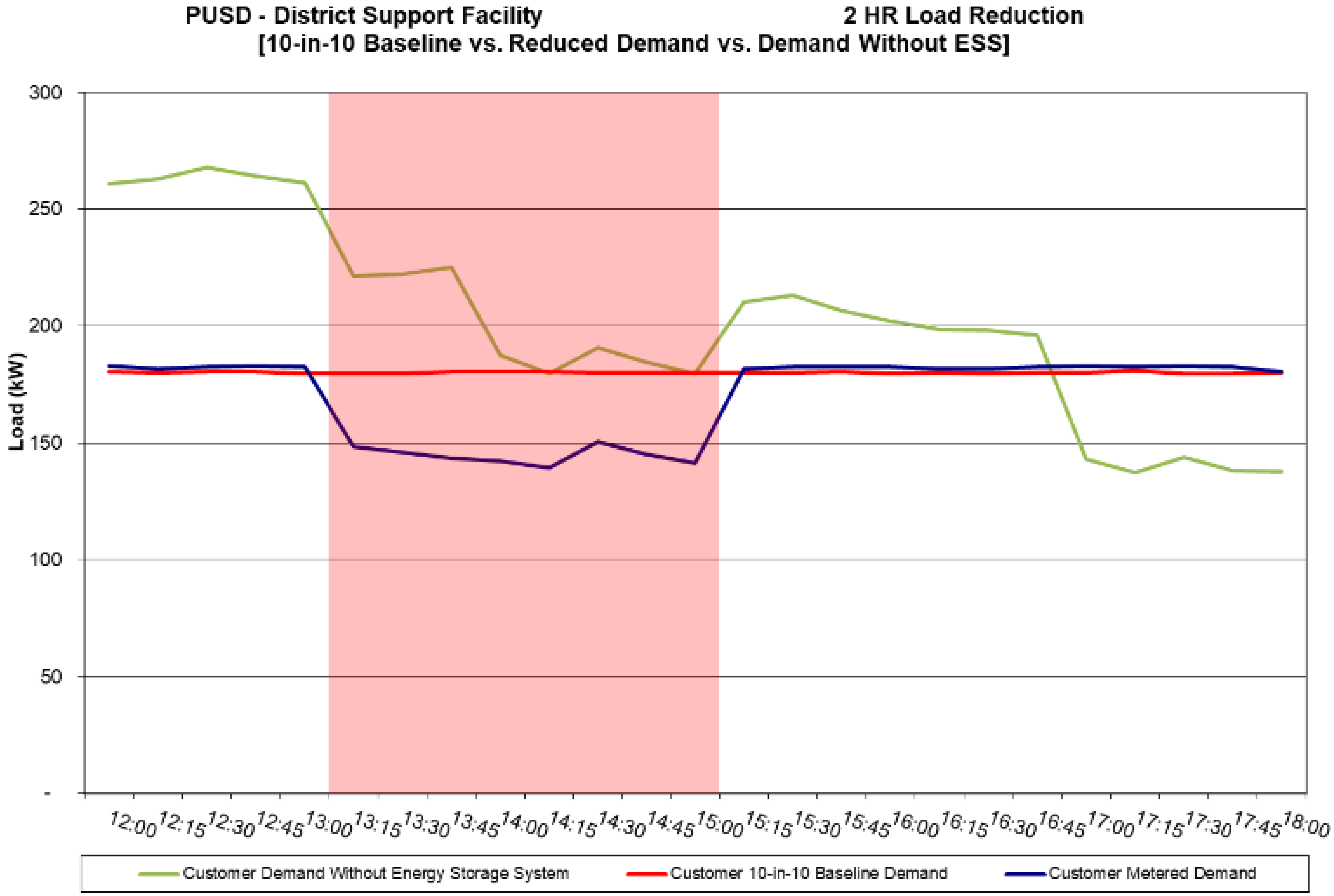


*Simulated DR Event #8*

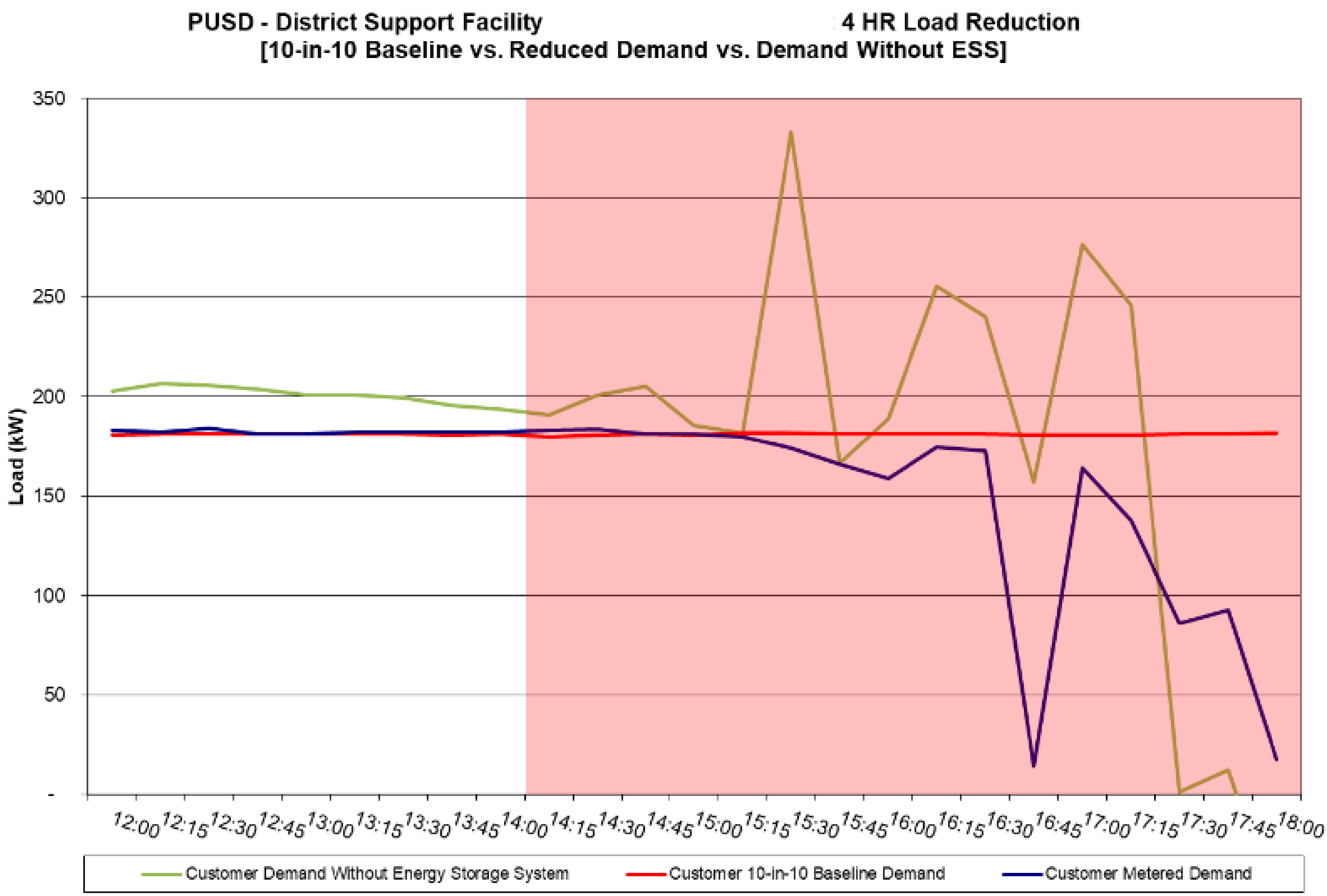


***PUSD – District Office***

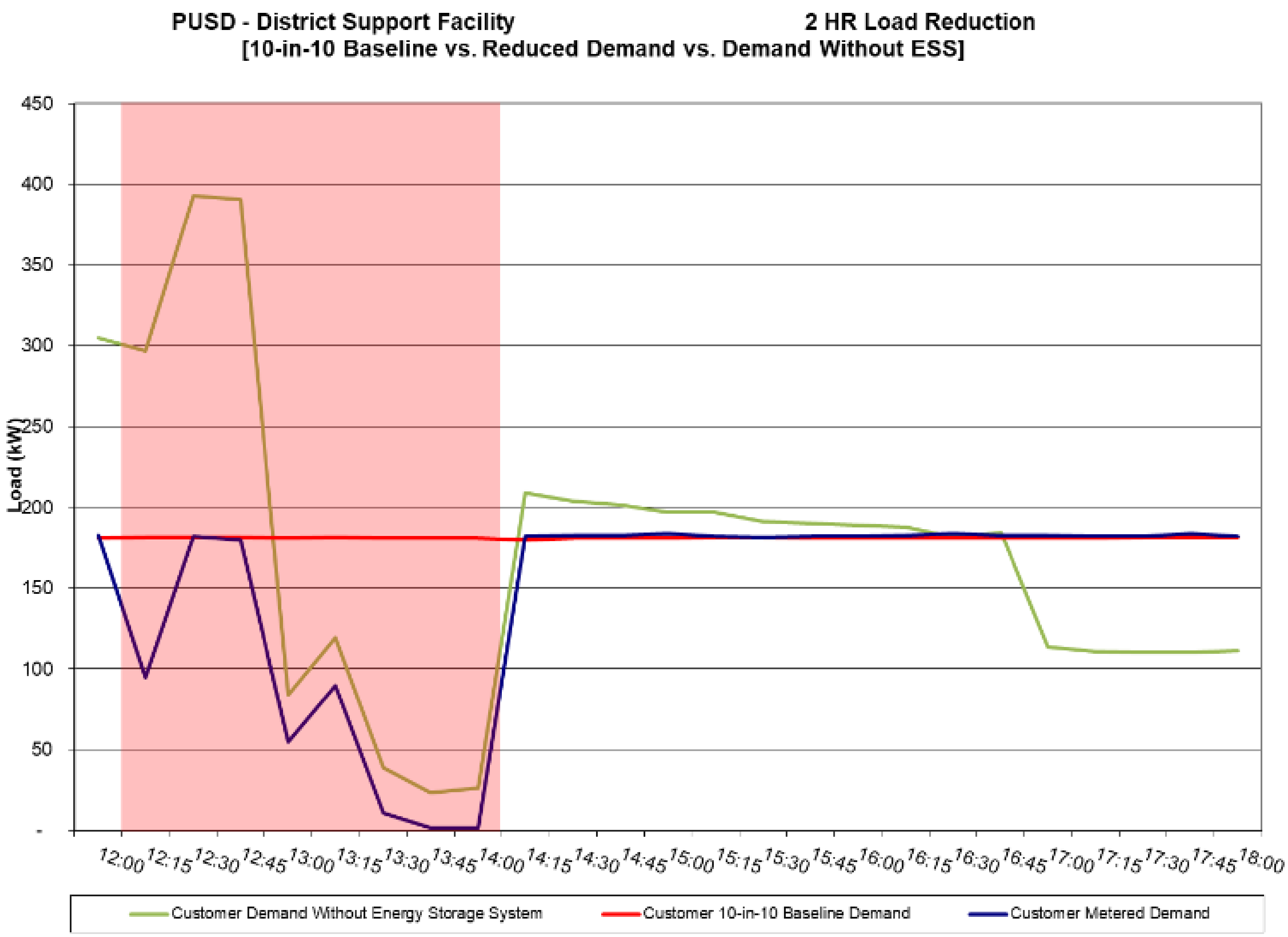
*Simulated DR Event #1*



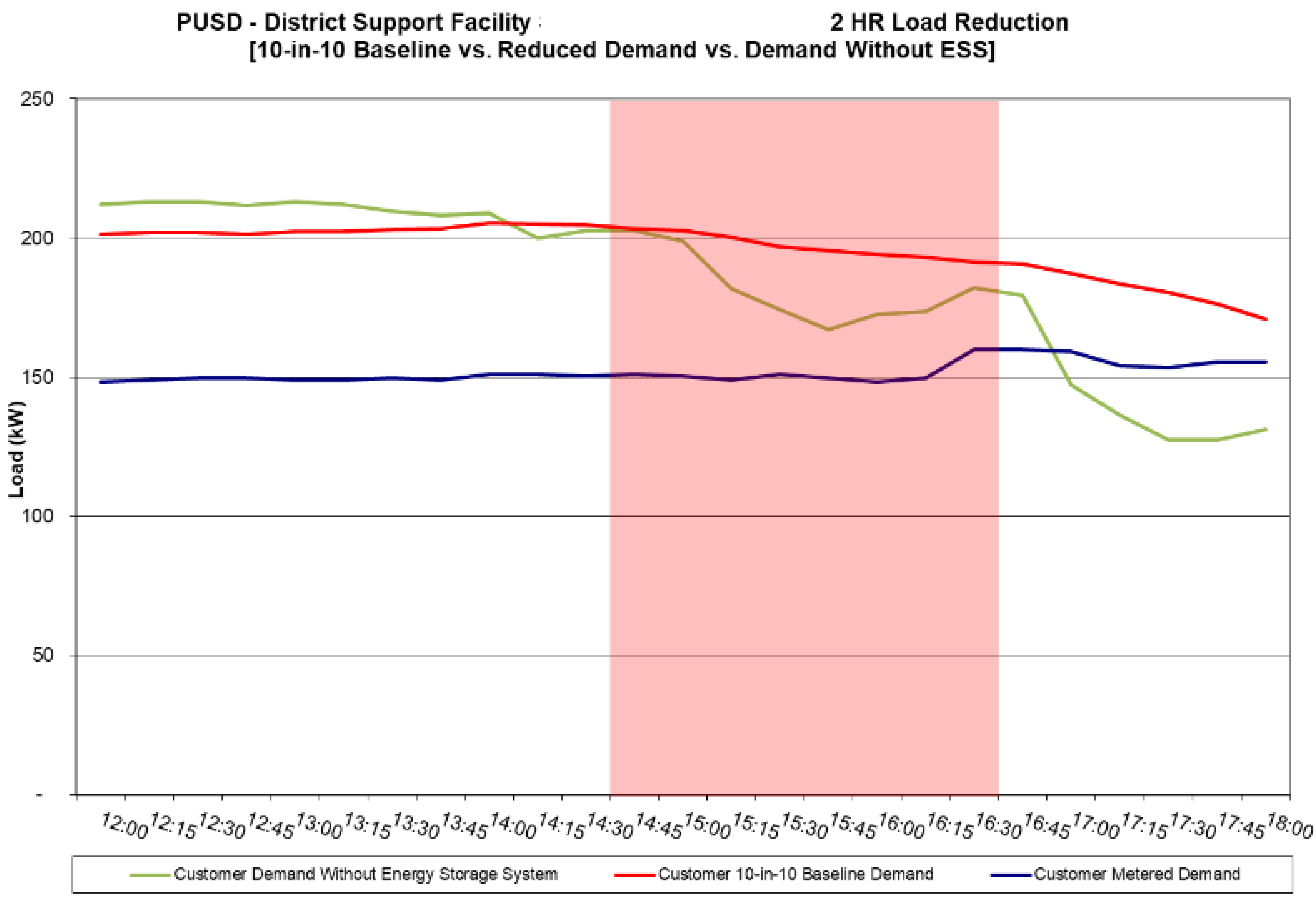
*Simulated DR Event #2*



*Simulated DR Event #3*



*Simulated DR Event #4*



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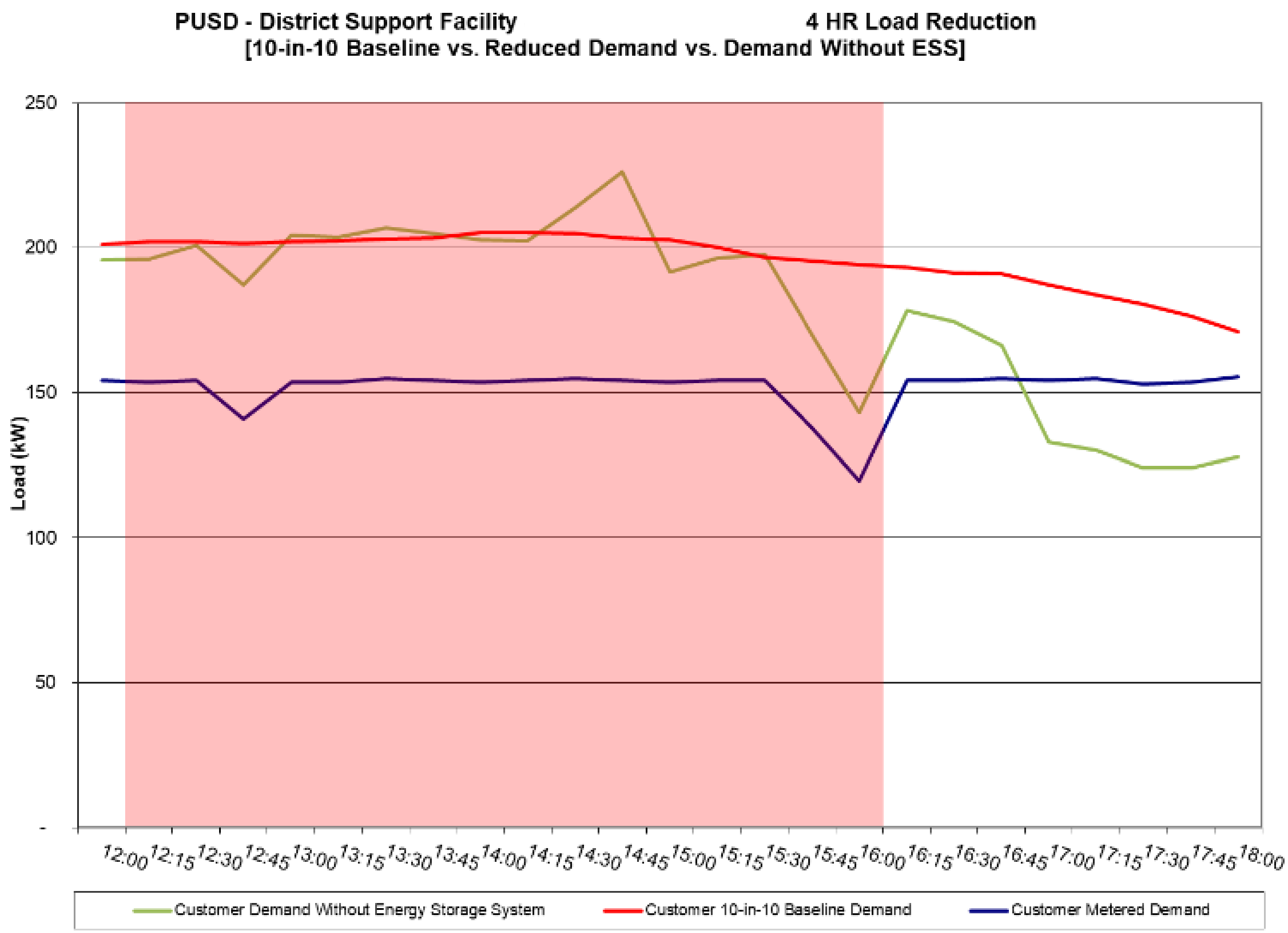
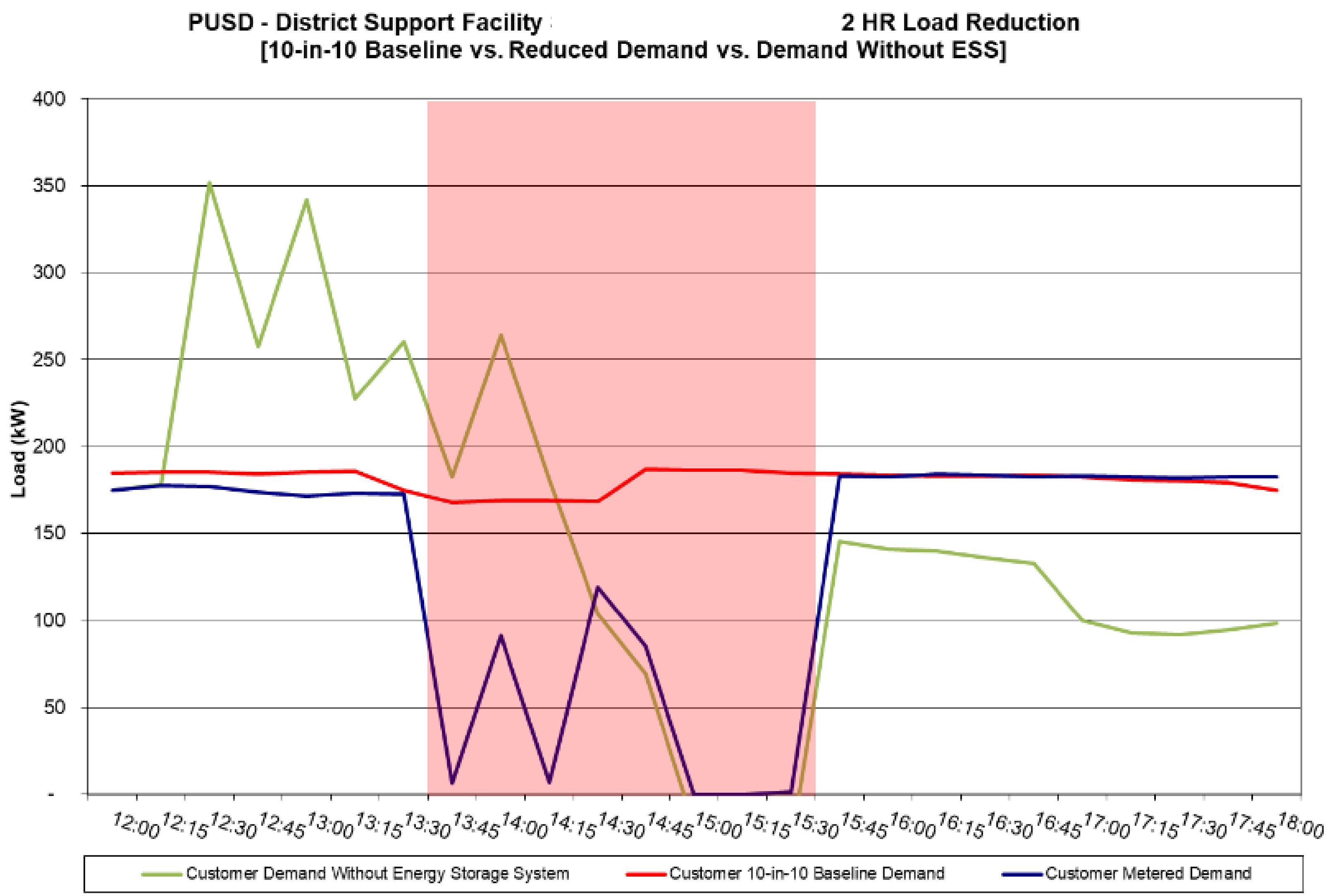
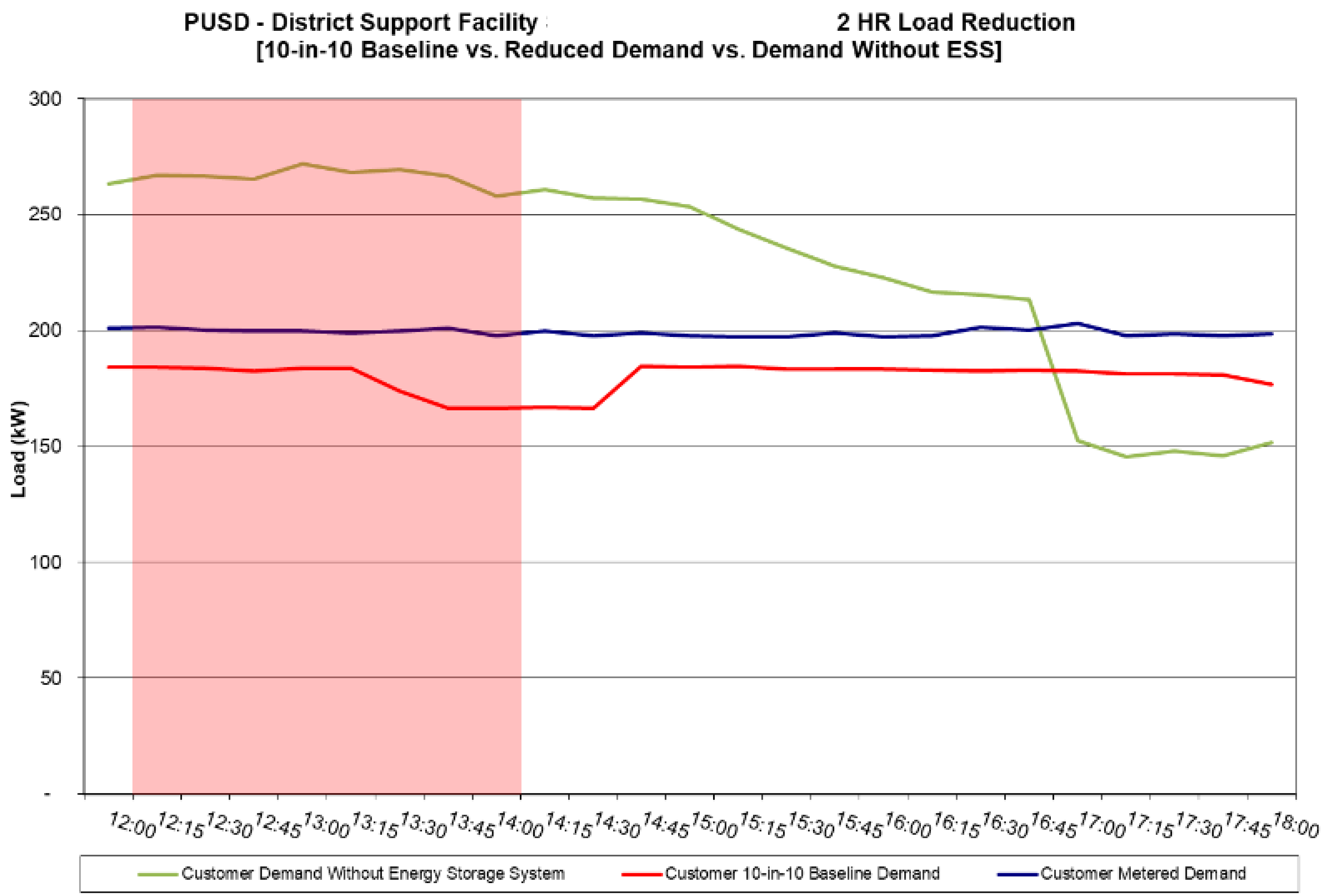


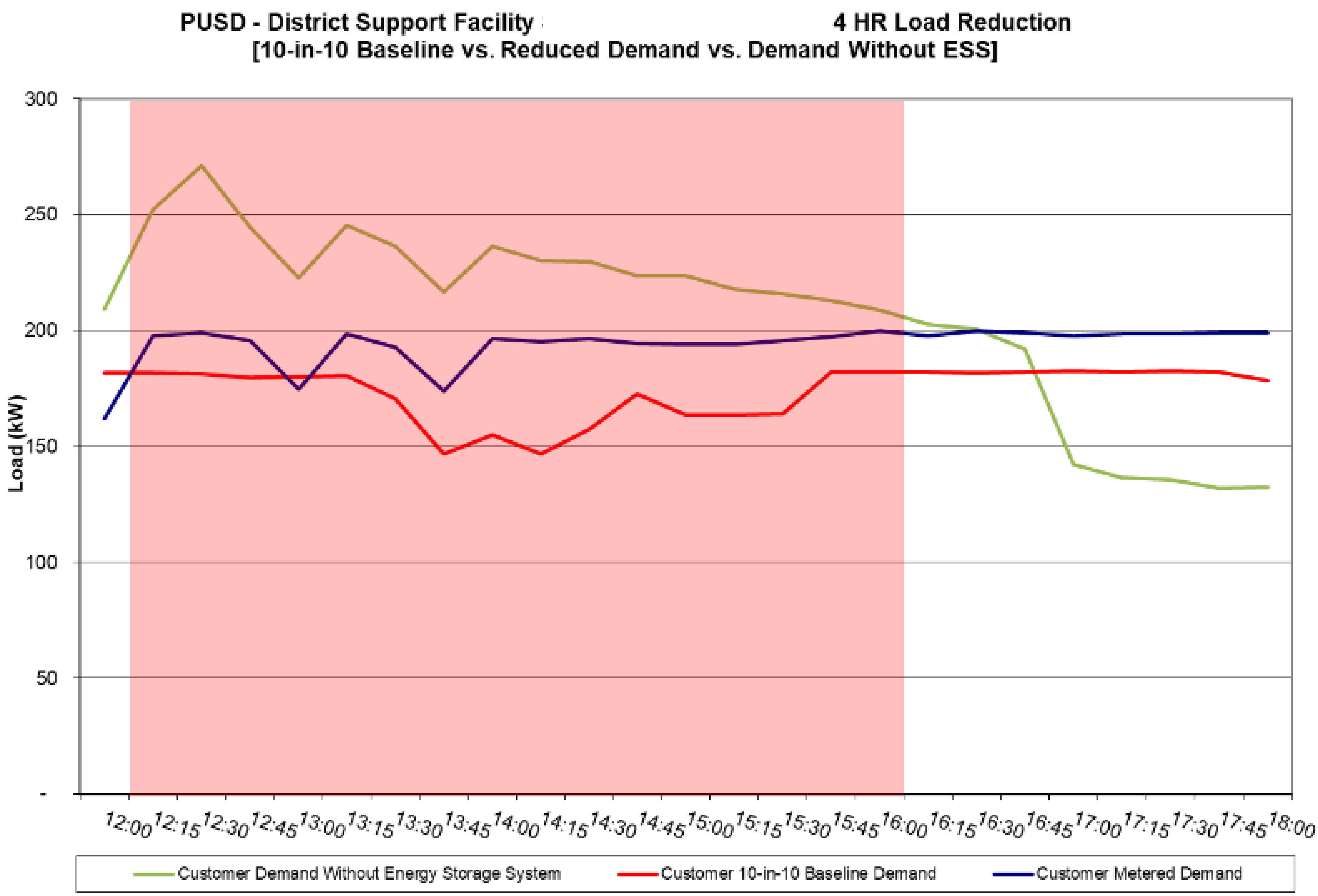
*Simulated DR Event #6*



*Simulated DR Event #7*



*Simulated DR Event #8*



## Appendix F

*IES Sub-Metering System - Equipment Cut-Sheets*

*Installation Guide*

# Power Monitoring

VERIS INDUSTRIES™

c UL us LISTED  CE  RoHS Compliant  SunSpec™ alliance

### ⚠ ⚠ DANGER

**HAZARD OF ELECTRIC SHOCK, EXPLOSION, OR ARC FLASH**

- Follow safe electrical work practices. See NFPA 70E in the USA, or applicable local codes.
- This equipment must only be installed and serviced by qualified electrical personnel.
- Read, understand and follow the instructions before installing this product.
- Turn off all power supplying equipment before working on or inside the equipment.
- Any covers that may be displaced during the installation must be reinstalled before powering the unit.
- Use a properly rated voltage sensing device to confirm power is off.
  DO NOT DEPEND ON THIS PRODUCT FOR VOLTAGE INDICATION

**Failure to follow these instructions will result in death or serious injury.**

A qualified person is one who has skills and knowledge related to the construction and operation of this electrical equipment and the installation, and has received safety training to recognize and avoid the hazards involved. NEC2009 Article 100

No responsibility is assumed by Veris Industries for any consequences arising out of the use of this material.

Control system design must consider the potential failure modes of control paths and, for certain critical control functions, provide a means to achieve a safe state during and after a path failure. Examples of critical control functions are emergency stop and over-travel stop.

### ⚠ WARNING

**LOSS OF CONTROL**

- Assure that the system will reach a safe state during and after a control path failure.
- Separate or redundant control paths must be provided for critical control functions.
- Test the effect of transmission delays or failures of communication links.[1]
- Each implementation of equipment using communication links must be individually and thoroughly tested for proper operation before placing it in service.

**Failure to follow these instructions may cause injury, death or equipment damage.**

[1] For additional information about anticipated transmission delays or failures of the link, refer to NEMA ICS 1.1 (latest edition). *Safety Guidelines for the Application, Installation, and Maintenance of Solid-State Control* or its equivalent in your specific country, language, and/or location.

### NOTICE

- This product is not intended for life or safety applications.
- Do not install this product in hazardous or classified locations.
- The installer is responsible for conformance to all applicable codes.
- Mount this product inside a suitable fire and electrical enclosure.

**FCC PART 15 INFORMATION**

NOTE: This equipment has been tested by the manufacturer and found to comply with the limits for a class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a residential environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions:

(1) This device may not cause harmful interference, and
(2) this device must accept any interference received, including interference that may cause undesired operation.

Modifications to this product without the express authorization of the manufacturer nullify this statement.

For use in a Pollution Degree 2 or better environment only. A Pollution Degree 2 environment must control conductive pollution and the possibility of condensation or high humidity. Consider the enclosure, the correct use of ventilation, thermal properties of the equipment, and the relationship with the environment. Installation category: CAT II or CAT III. Provide a disconnect device to disconnect the meter from the supply source. Place this device in close proximity to the equipment and within easy reach of the operator, and mark it as the disconnecting device. The disconnecting device shall meet the relevant requirements of IEC 60947-1 and IEC 60947-3 and shall be suitable for the application. In the US and Canada, disconnecting fuse holders can be used. Provide overcurrent protection and disconnecting device for supply conductors with approved current limiting devices suitable for protecting the wiring. If the equipment is used in a manner not specified by the manufacturer, the protection provided by the device may be impaired.

# E51C2, E51C3

*Compact Bi-Directional Power and Energy Meter*

## Product Overview

The E51 DIN Rail Power Meter provides a solution for measuring energy data with a single device. Inputs include Control Power, CTs, and 3-phase voltage. The E51 supports multiple output options, including solid state relay contacts, Modbus (with or without data logging), and pulse. The LCD screen on the faceplate allows instant output viewing.

The E51 Meter is capable of bidirectional metering. Power is monitored in both directions (upstream and downstream from the meter). The meter is housed in a plastic enclosure suitable for installation on T35 DIN rail according to EN50022. The E51 can be mounted either on a DIN rail or in a panel. **Observe correct CT orientation when installing the device.**

## Product Identification

| Model | Description | Output | | | Data Logging |
|---|---|---|---|---|---|
| | | Pulse | RS-485 | Alarm | |
| E51C2 | Modbus output, full data set | • | • | • | |
| E51C3 | Modbus output, data logging | • | • | • | • |

## Specifications

| | |
|---|---|
| ***MEASUREMENT ACCURACY*** | |
| Real Power and Energy | IEC 62053-22 Class 0.2S, ANSI C12.20 0.2% |
| Reactive Power and Energy | IEC 62053-23 Class 2, 2% |
| Current | 0.2% (+0.005% per °C deviation from 25°C) from 1% to 5% of range;<br>0.1% (+0.005% per °C deviation from 25°C) from 5% to 100% of range |
| Voltage | 0.1% (+0.005% per °C deviation from 25°C) from 90 $VAC_{L-N}$ to 600 $VAC_{L-L}$ |
| Sample Rate | 2520 samples per second; no blind time |
| Data Update Rate | 1 sec. |
| Type of Measurement | True RMS; one to three phase AC system |
| ***INPUT VOLTAGE CHARACTERISTICS*** | |
| Measured AC Voltage | Minimum 90 $V_{L-N}$ (156 $V_{L-L}$) for stated accuracy;<br>UL Maximums: 600 $V_{L-L}$ (347 $V_{L-N}$); CE Maximum: 300 $V_{L-N}$ |
| Metering Over-Range | +20% |
| Impedance | 2.5 $M\Omega_{L-N}$ /5 $M\Omega_{L-L}$ |
| Frequency Range | 45 to 65 Hz |
| ***INPUT CURRENT CHARACTERISTICS*** | |
| CT Scaling | Primary: Adjustable from 5 A to 32,000 A |
| Measurement Input Range | 0 to 0.333 VAC or 0 to 1.0 VAC (+20% over-range), rated for use with Class 1 voltage inputs |
| Impedance | 10.6 kΩ (1/3 V mode) or 32.1 kΩ (1 V mode) |

## Specifications (cont.)

| | |
|---|---|
| ***CONTROL POWER*** | |
| **AC** | 5 VA max.; 90V min.; UL Maximums: 600 $V_{L-L}$ (347 $V_{L-N}$); CE Maximum: 300 $V_{L-N}$ |
| **DC*** | 3 W max.; UL and CE: 125 to 300 VDC |
| **Ride Through Time** | 100 msec at 120 VAC |
| ***OUTPUT*** | |
| **Alarm Contacts** | N.C., static output (30VAC/DC, 100mA max. @ 25°C, derate 0.56mA per °C above 25°C) |
| **Real Energy Pulse Contacts** | N.O., static output (30 VAC/DC, 100 mA max. @ 25°C, derate 0.56 mA per °C above 25°C) |
| **RS-485 Port** | 2-wire, 1200 to 38400 baud, Modbus RTU |
| ***MECHANICAL CHARACTERISTICS*** | |
| **Weight** | 0.62 lb (0.28 kg) |
| **IP Degree of Protection (IEC 60529)** | IP40 front display; IP20 Meter |
| **Display Characteristics** | Back-lit blue LCD |
| **Terminal Block Screw Torque** | 0.37 to 0.44 ft-lb (0.5 to 0.6 N·m) |
| **Terminal Block Wire Size** | 24 to 14 AWG (0.2 to 2.1 mm²) |
| **Rail** | T35 (35mm) DIN Rail per EN50022 |
| ***OPERATING CONDITIONS*** | |
| **Operating Temperature Range** | -30° to 70°C (-22° to 158°F) |
| **Storage Temperature Range** | -40° to 85°C (-40° to 185°F) |
| **Humidity Range** | <95% RH noncondensing |
| **Altitude of Operation** | 3000 m |
| ***COMPLIANCE INFORMATION*** | |
| **US and Canada** | CAT III, Pollution degree 2; for distribution systems up to 347$V_{L-N}$ /600$VAC_{L-L}$ |
| **CE** | CAT III, Pollution degree 2; for distribution systems up to 300$V_{L-N}$ |
| **Dielectric Withstand** | Per UL 508, EN61010 |
| **Conducted and Radiated Emissions** | FCC part 15 Class B, EN55011/EN61000 Class B (residential and light industrial) |
| **Conducted and Radiated Immunity** | EN61000 Class A (heavy industrial) |
| **US and Canada (cULus)** | UL508 (open type device)/CSA 22.2 No. 14-05 |
| **Europe (CE)** | EN61010-1 |

** External DC current limiting is required, see fuse recommendations.*

## SunSpec Alliance Interoperability Specification Compliance

This meter implements the draft SunSpec 1.0 common elements starting at base 1 address 40001, and the proposed SunSpec 1.1 meter model at 40070 (these addresses are not in Modicon notation). See www.veris.com or www.sunspec.org for copies of these specifications.

The SunSpec Alliance logo is a trademark or registered trademark of the SunSpec Alliance.

obvius

*Energy Information Made Obvius*

PRODUCT DATASHEET


# AcquiSuite – EMB

## Data Acquisition Server

### ACQUISUITE – EMB A8810

Obvius' AcquiSuite is an intelligent, flexible data acquisition server allowing users to collect energy data from meters and environmental sensors. Designed to connect to IP-based applications such as enterprise energy management, demand response and smart grid programs, the AcquiSuite server lets you connect thousands of energy points, benchmark energy usage and reduce energy costs.

### EMBEDDED (OEM) SOLUTION

The compact EMB footprint and industrial temperature range (-30 to 70C) makes this a perfect solution for embedded applications. Reduce development time and speed up integration by collecting and distributing energy information directly from your equipment.

### DATA COLLECTION

The AcquiSuite collects and logs data from connected (wired or wireless) devices based on user selected intervals. Data from downstream devices is time stamped and stored locally in non-volatile memory until the next scheduled upload or manual download. Using an Ethernet (LAN) connection you can push or pull data via HTTP, XML, FTP or any custom protocol utilizing our AcquiSuite Module to build your own application, including integrated cellular communication options.

### INSTALLATION & FEATURES

No software is required. Easily access information through ANY web browser. There are several additional features including alarming, SNMP Traps, network configuration, wireless diagnostics, USB, security provisions and backlit LCD. Our integrated meter driver library is designed to speed up installation and lower integration costs through "plug-and-play" connectivity.

### COMPATIBILITY

The AcquiSuite is compatible with nearly any front-end software platform allowing customers to use a variety of reporting tools; whether it's a local server or an enterprise wide reporting suite. Obvius offers a free utility for automated .CSV file downloads or an affordable hosted solution for $195.00 annually (unlimited data storage).

### PARTNERS

Obvius' outstanding integration and software partners supplement our products and services to ensure you receive the very best energy monitoring solution.

### APPLICATIONS

- Measurement and verification (M&V)
- Reduce energy costs
- Access energy information from local or remote sites
- Benchmark building energy usage
- View "real time" performance data
- Track energy use and peak demand for Demand Response programs
- Monitor performance of critical systems (lighting, HVAC, PDUs, inverters, etc.)
- Alarm notification for data points above or below target levels (including SNMP Traps)
- Monitor renewable energy performance and production
- Push or pull meter data to energy dashboards, kiosks and software applications
- LEED / Energy Star certification

### ABOUT OBVIUS

Obvius manufactures data acquisition and wireless connectivity products specifically for energy management. We deliver cost-effective, reliable hardware designed to speed up installation. Our products are based on an open architecture allowing our customers to collect and log energy information from virtually any meter or sensor. The ability to support multiple communication options provides remote access to all your energy information. Founded in 2003, Obvius is located in Tualatin, Oregon. We serve a global clientele and continue to drive innovation by simplifying data collection.

### SOLUTIONS

- Data Acquisition
- Wireless Communication
- Meters & Sensors
- Custom Packaged Solutions
- Integration & Software Partners

### HEADQUARTERS

Tualatin, Oregon

### CONTACT US

sales@obvius.com

## AcquiSuite A8810

Obvius helps customers collect and distribute energy information. Users can begin with one best-of-breed product that satisfies a requirement, or incorporate several products and services for a complete energy management solution.

| Specifications | |
|---|---|
| Processor | ARM9 embedded CPU |
| Operating System | Linux 2.6 |
| Memory | 32 MB RAM |
| Flash ROM | 16 MB NOR Flash (expandable with USB memory device) |
| Interval Recording | 1 to 60 minutes, user selectable (default 15 minutes) |
| LEDs | Ethernet, Modbus TX/RX, power, alarm |
| Console | 2 x 16 LCD character, two push buttons |
| **Power** | |
| Power Supply | 24VDC, 500mA<br>*This unit is to be sourced by a Class 2 power supply with the following output: 24VDC, 500mA min not to exceed 8A |
| Isolation | RJ45 Ethernet and RS-485 port are isolated to 1500VDC from the main board. (Power and USB non-isolated) |
| **Communication** | |
| Protocols | Modbus/RTU, Modbus/TCP, TCP/IP, PPP, HTTP/HTML, FTP, NTP, XML, SNMP-Trap |
| LAN | RJ45 10/100 Ethernet, full half duplex, auto polarity |
| USB | USB expansion port |
| **Inputs** | |
| Serial Port | RS-485 Modbus, supports up to 32 external devices (expandable) |
| **Physical** | |
| Weight | 0.42lbs (0.19kg) |
| Size | 4" x 4.25" x 2" (102mm x 108mm x 51mm) |
| **Environment** | |
| North America | -30 to 70C, 95% RH, non-condensing |
| **Codes and Standards** | |
| FCC CFR 47 Part 15, Class A, EN 61000, EN 61326, CE, UL61010 Recognized | |
| **Additional Notes** | |
| NEMA enclosures available upon request | |
| Cellular modems available upon request | |
| Manufactured in the USA | |

c UL us CE

obvius

Obvius
20497 SW Teton Avenue
Tualatin, OR 97062

503 601 2099
866 204 8134 (USA only)
sales@obvius.com

# Appendix G

*Vendor ESS - Equipment Cut-Sheets*

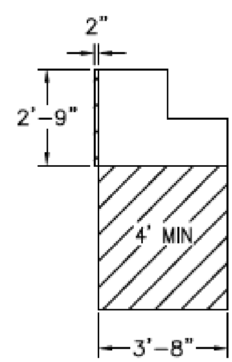
**30 KW/60 KWH ENERGY STORAGE SYSTEM**
Data Sheet

## GS 30-60 P2

A scalable and space efficient energy storage system for small to medium sized installations. 30 kW inverter with 60 kWh of storage.

## GENERAL SPECIFICATIONS

| | |
|---|---|
| System | 30 kW inverter with 60 kWh storage |
| Battery Chemistry | Li-ion NCM |
| Battery Certification | UL 1973 (Rack & Tray), UL 1642 (Cell) |
| Inverter Certification | UL 1741/IEEE 1547 |
| Round-trip Efficiency at Full Load | 90% |
| AC Voltage | 480 VAC +10%, -12%, 3-phase 3/4 wire<br>208 VAC (w/transformer) |
| AC Frequency | 60 Hz nominal, 59.3-60.5 Hz (per UL) |
| Max Continuous AC Current | 40 A RMS |
| Max Continuous AC Power | 30 kVA |
| SGIP Discharge Capacity 2 Hour Min | 30 kW; Capable of discharge at least once per day |
| Energy Storage Capacity measured at AC Terminals | 65 kWh |
| Battery Capacity Nominal | 68 kWh |
| Cooling for Battery Cabinet (Internal) | HVAC 0.4 Ton |
| Cooling for Inverter Cabinet | Forced Air |
| Cooling for Transformer (Transformer Model Only) | Convection |




## FOOTPRINT & SYSTEM CHARACTERISTICS

| | |
|---|---|
| Enclosure | NEMA 3R |
| Dimensions | 3'8" (W) x 2'9" (D) x 7' 6" (H) |
| Footprint (Including Clearances) | 3' 10" x 6' 9" |
| Weight (480VAC Transformerless) | 2,150 lbs (with batteries)<br>1,100 lbs (without batteries) |
| Weight (208VAC) | 2,350 lbs (with batteries)<br>1,300 lbs (without batteries) |

## ENVIRONMENTAL SPECIFICATIONS

| | |
|---|---|
| Humidity | 5-95% (non-condensing) |
| Rated Max Elevation | 3,300 Feet |
| Operating Temperature | -20 to 50°C |

## SUPPORTED APPLICATIONS

| | |
|---|---|
| Peak Shaving | Demand Response |
| VAR Support | Area Frequency Regulation (AFR) |
| Grid-Tied Mode | Island Mode / Backup Power |
| Microgrid Mode | |

## COMMUNICATIONS

Ethernet connectivity standard/Cellular connectivity optional

Revision Date: 10.30.17

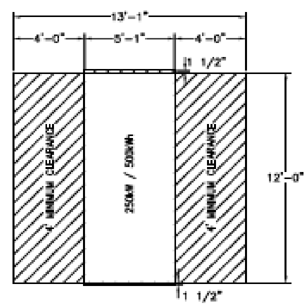
**250 KW/500 KWH ENERGY STORAGE SYSTEM**
Data Sheet


# GS 250-500 P2

A scalable, efficient, and cost-effective energy storage system for larger installations. 250 kW inverter with 500 kWh of storage.

## GENERAL SPECIFICATIONS

| | |
|---|---|
| System | 250 kW inverter with 500 kWh storage |
| Battery Chemistry | Li-ion NCM |
| Battery Certification | UL 1973 (Rack & Tray), UL 1642 (Cell) |
| Inverter Certification | UL 1741/IEEE 1547 |
| Round-trip Efficiency at Full Load | 92% |
| AC Voltage | 480 VAC +10%, -12%, 3-phase |
| AC Frequency | 60 Hz nominal, 59.3-60.5 Hz (UL) |
| Max Continuous AC Current | 320 A Per Phase at 480V |
| Max Continuous AC Power | 250 kVA/250 kW |
| SGIP Discharge Capacity 2 Hour Min | 250 kW; Capable of discharge at least once per day |
| Energy Storage Capacity measured at AC Terminals | 503 kWh |
| Battery Capacity Nominal | 548 kWh |
| Cooling for Battery Cabinet (Internal) | HVAC 2.2 Ton |
| Cooling for Inverter Cabinet | Forced Air |
| Cooling for Transformer (Transformer Model Only) | Convection |




## FOOTPRINT & SYSTEM CHARACTERISTICS

| | |
|---|---|
| Enclosure | NEMA 3R |
| Dimensions | 12' (W) x 5' 1" (D) x 8' (H) |
| Footprint (Including Clearances) | 13' x 12' 3" |
| Weight (480VAC Transformerless) | 15,100 lbs (with batteries)<br>6,600 lbs (without batteries) |

## ENVIRONMENTAL SPECIFICATIONS

| | |
|---|---|
| Humidity | 5-95% (non-condensing) |
| Rated Max Elevation | 3,300 Feet |
| Operating Temperature | -20 to 50°C |

## SUPPORTED APPLICATIONS

| | |
|---|---|
| Peak Shaving | Demand Response |
| VAR Support | Area Frequency Regulation (AFR) |
| Grid-Tied Mode | Island Mode / Backup Power |
| Microgrid Mode | |

## COMMUNICATIONS

Ethernet connectivity standard/Cellular connectivity optional

Revision Date: 10.30.17