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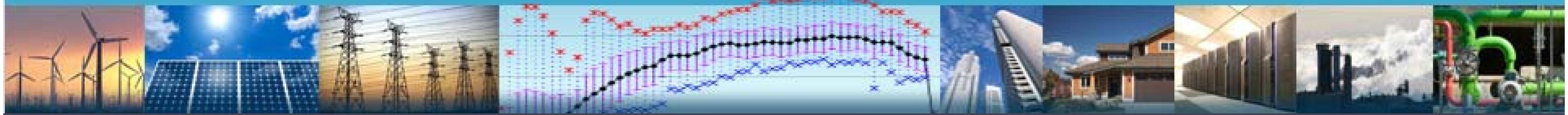
DEMAND RESPONSE RESEARCH CENTER



Automated Demand Response Demonstration for large customers in New York using OpenADR

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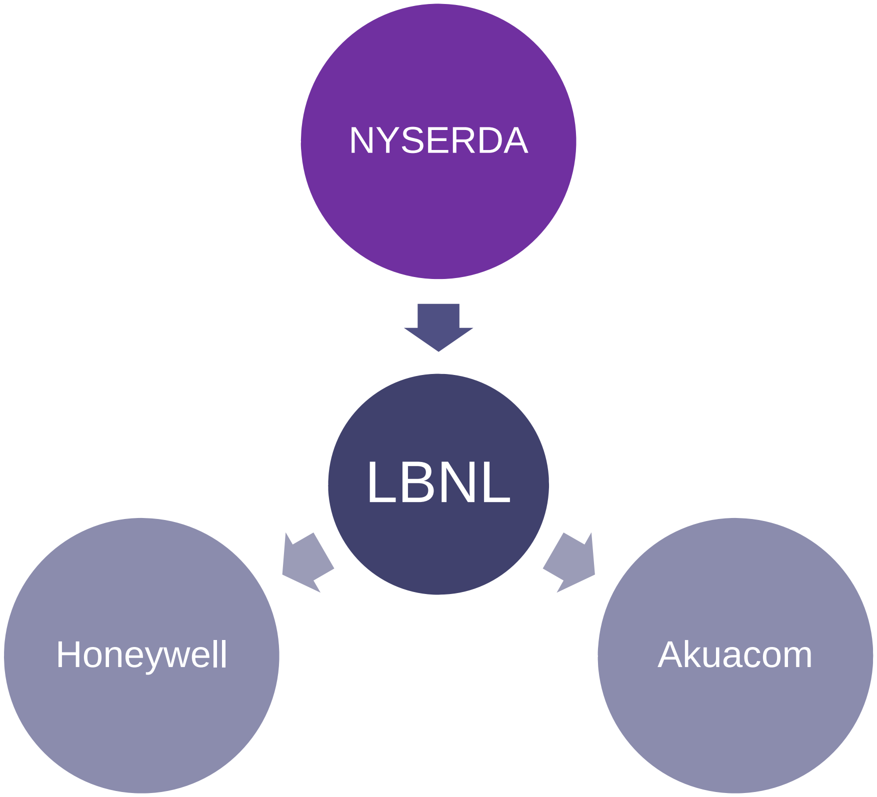
Outline

- Project Description
- Dynamic Pricing in New York
- Enabling Automated Demand Response (Auto-DR)
  - Communication Architecture
  - DR Signal Prioritization
  - System Configuration
- Case Studies
  - Load Analysis
  - Field Test Results
- Conclusions
- Next Steps

Project Description

- Objective
  - Demonstrate automated response to price and reliability signals for large commercial buildings in New York City using OpenADR communication protocols
- Significance
  - Provide a practical solution to facility managers for continuous energy management under day-ahead hourly pricing
  - Provide a framework to develop and test control algorithms that optimize energy use and cost in large commercial buildings

Project Partners

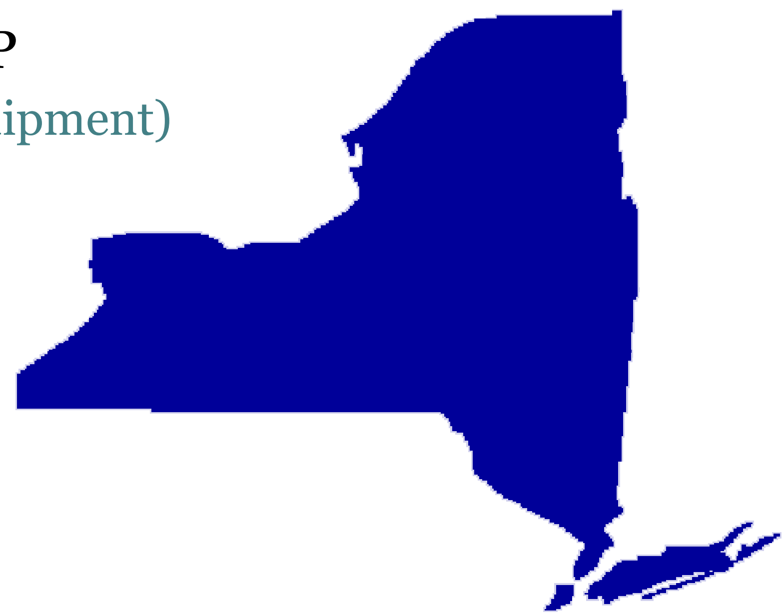


- Project Sponsor
  - New York State Research Energy Research & Development Authority (NYSERDA)
- Project Manager
  - Lawrence Berkeley National Lab (LBNL)
- Sub Consultants
  - Honeywell
  - Akuacom

Dynamic Pricing in New York

- Mandatory Hourly Pricing (MHP)
  - Since 2005, MHP has been the default tariff in New York State to non-residential customers with demand over 500 kW
  - Customers' energy cost is calculated based on NYISO's day-ahead zonal *locational based marginal price* (LBMP)

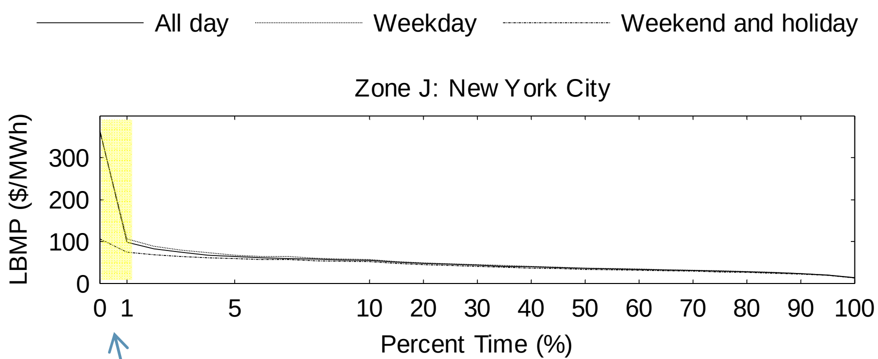
- Primary barriers to the adoption of MHP
  - insufficient resources (both labor and equipment) to monitor hourly prices
  - Inflexible labor schedule (KEMA, 2012)

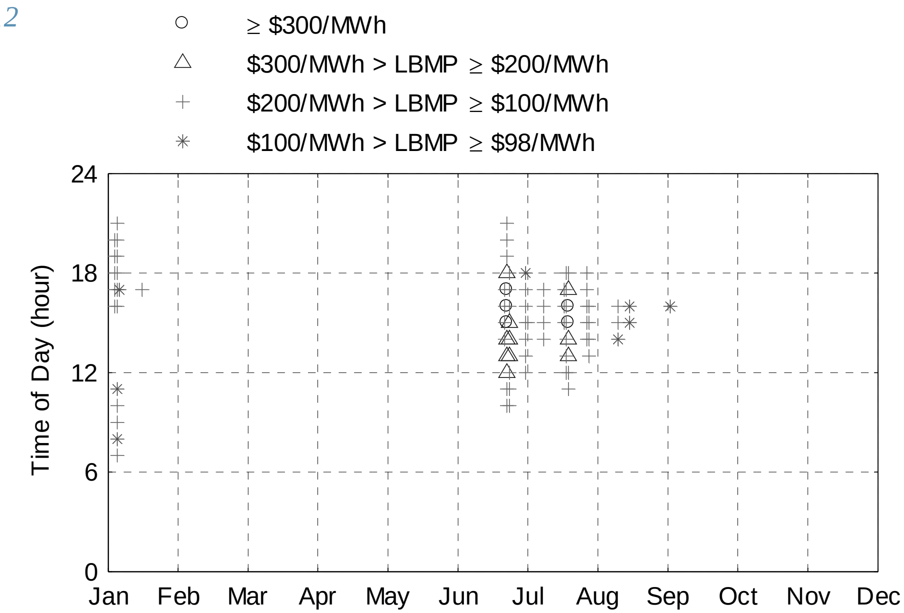


Day-Ahead Locational Based Marginal Price (LBMP)

Price duration curves and LBMP distribution

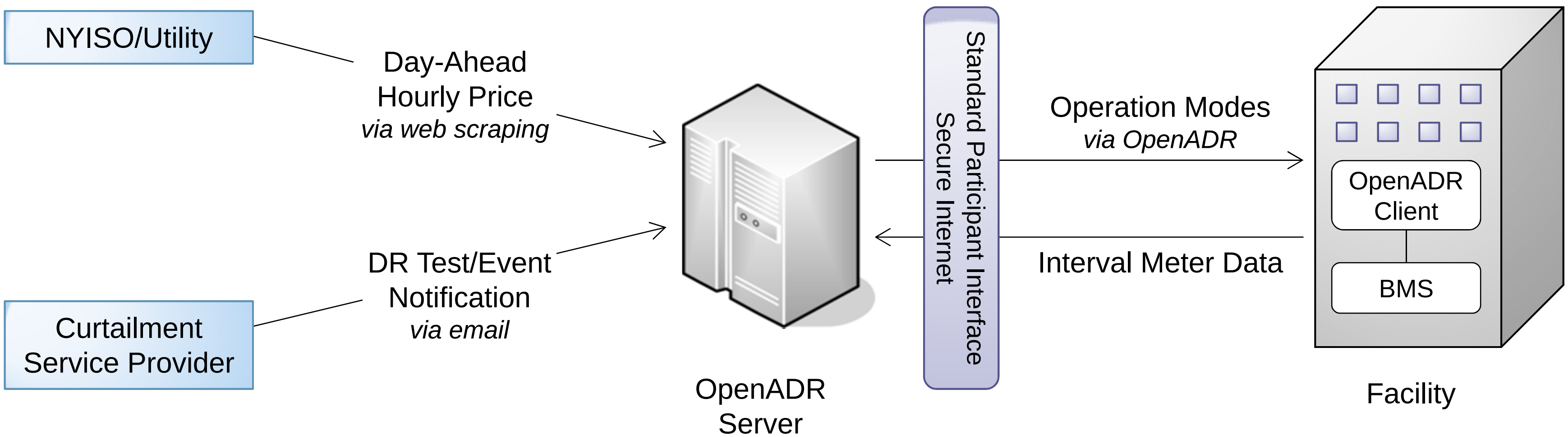
Data shown are from Sep 2011 to Aug 2012





Only the top 1 % accounts for the price > $100/MWh

Communication Architecture



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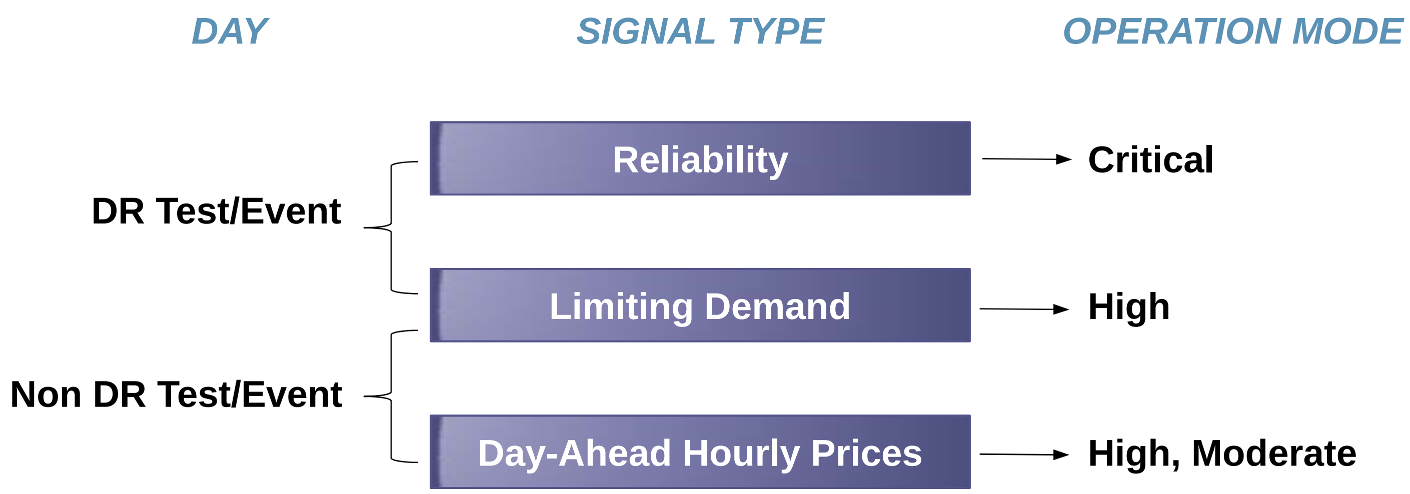
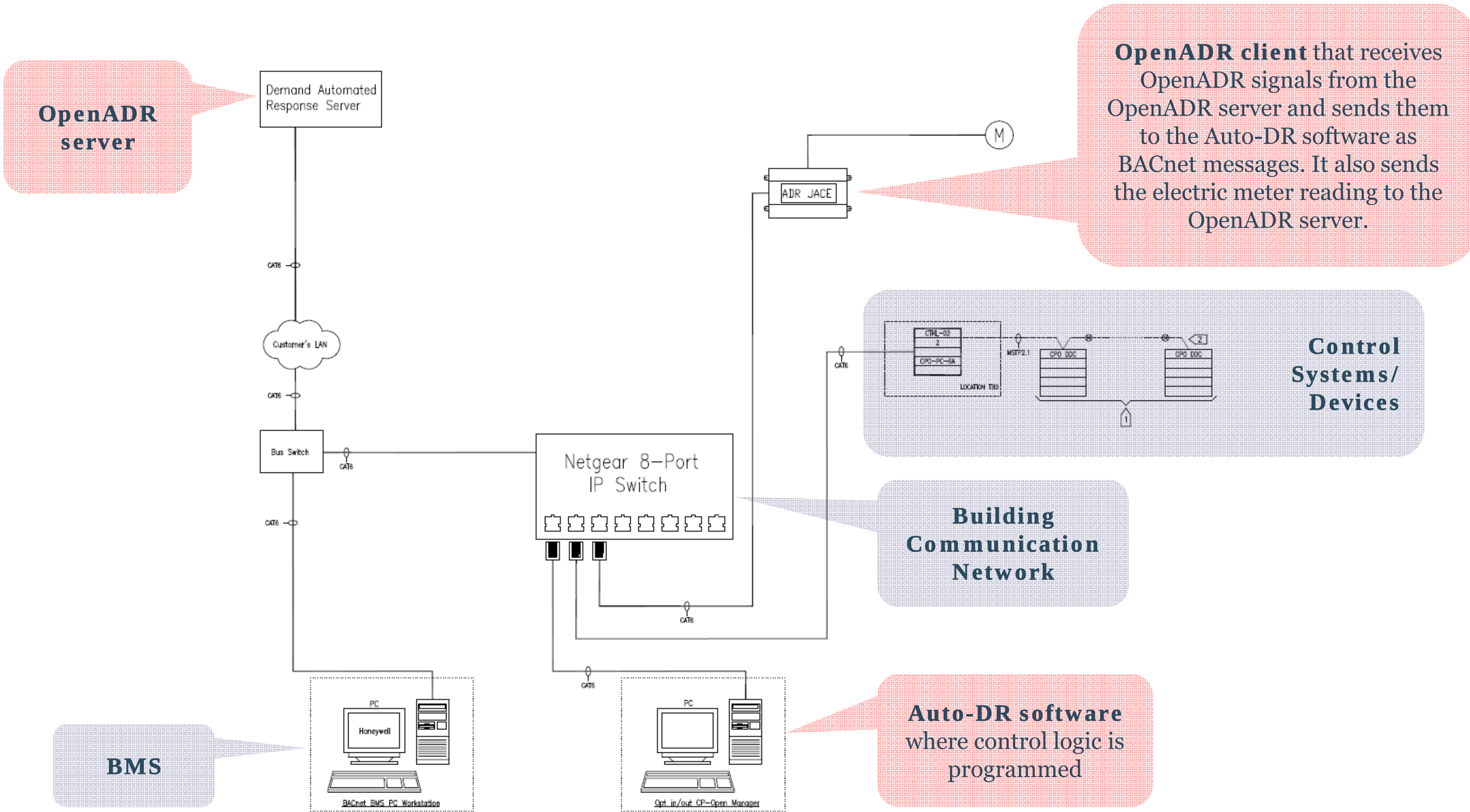
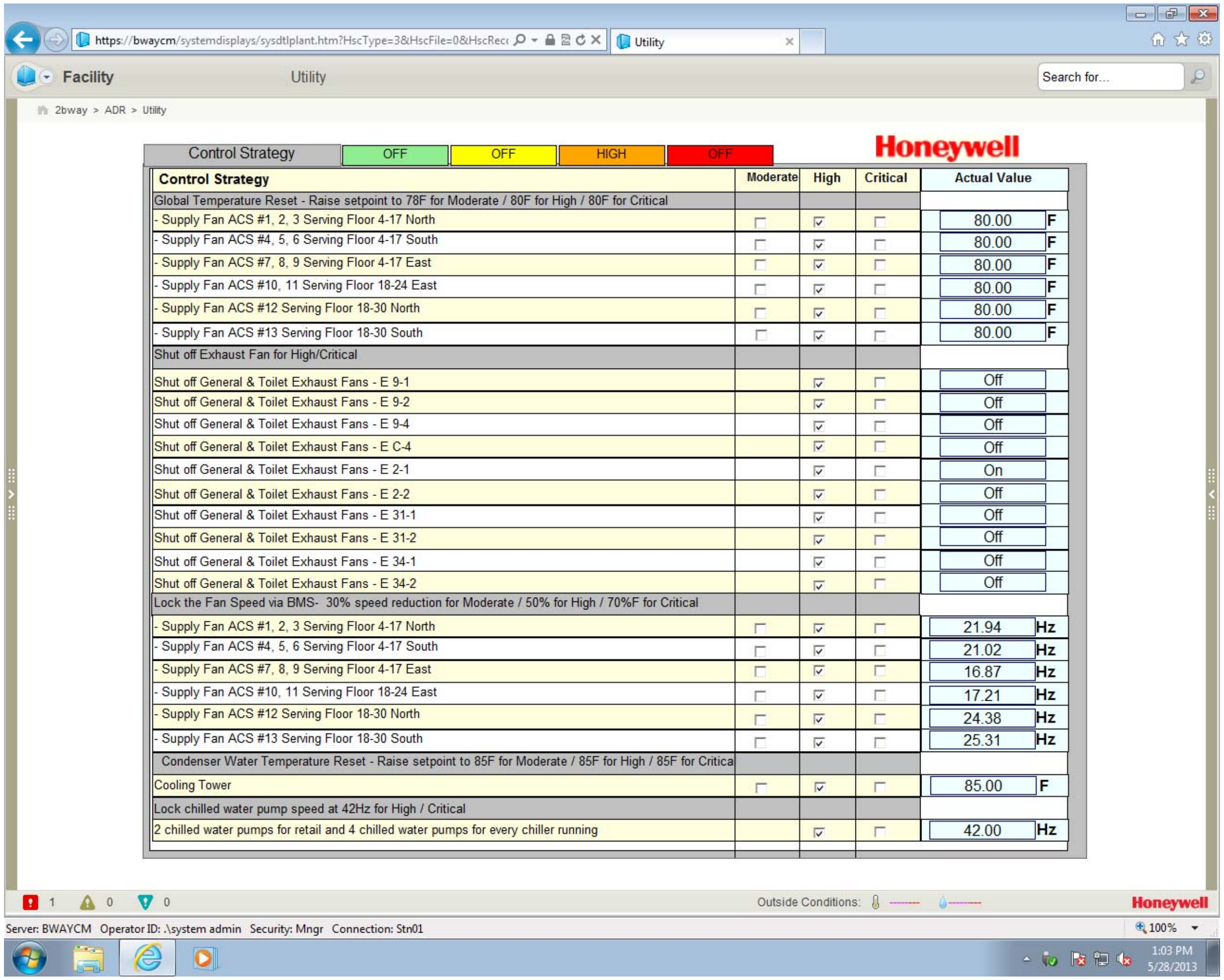
DR Signal Prioritization



System Configuration



Customer User Interface



Control Strategy	Moderate	High	Critical	Actual Value
Global Temperature Reset - Raise setpoint to 78F for Moderate / 80F for High / 80F for Critical				
- Supply Fan ACS #1, 2, 3 Serving Floor 4-17 North	☐	☑	☐	80.00 F
- Supply Fan ACS #4, 5, 6 Serving Floor 4-17 South	☐	☑	☐	80.00 F
- Supply Fan ACS #7, 8, 9 Serving Floor 4-17 East	☐	☑	☐	80.00 F
- Supply Fan ACS #10, 11 Serving Floor 18-24 East	☐	☑	☐	80.00 F
- Supply Fan ACS #12 Serving Floor 18-30 North	☐	☑	☐	80.00 F
- Supply Fan ACS #13 Serving Floor 18-30 South	☐	☑	☐	80.00 F
Shut off Exhaust Fan for High/Critical				
Shut off General & Toilet Exhaust Fans - E 9-1		☑	☐	Off
Shut off General & Toilet Exhaust Fans - E 9-2		☑	☐	Off
Shut off General & Toilet Exhaust Fans - E 9-4		☑	☐	Off
Shut off General & Toilet Exhaust Fans - E C-4		☑	☐	Off
Shut off General & Toilet Exhaust Fans - E 2-1		☑	☐	On
Shut off General & Toilet Exhaust Fans - E 2-2		☑	☐	Off
Shut off General & Toilet Exhaust Fans - E 31-1		☑	☐	Off
Shut off General & Toilet Exhaust Fans - E 31-2		☑	☐	Off
Shut off General & Toilet Exhaust Fans - E 34-1		☑	☐	Off
Shut off General & Toilet Exhaust Fans - E 34-2		☑	☐	Off
Lock the Fan Speed via BMS- 30% speed reduction for Moderate / 50% for High / 70%F for Critical				
- Supply Fan ACS #1, 2, 3 Serving Floor 4-17 North	☐	☑	☐	21.94 Hz
- Supply Fan ACS #4, 5, 6 Serving Floor 4-17 South	☐	☑	☐	21.02 Hz
- Supply Fan ACS #7, 8, 9 Serving Floor 4-17 East	☐	☑	☐	16.87 Hz
- Supply Fan ACS #10, 11 Serving Floor 18-24 East	☐	☑	☐	17.21 Hz
- Supply Fan ACS #12 Serving Floor 18-30 North	☐	☑	☐	24.38 Hz
- Supply Fan ACS #13 Serving Floor 18-30 South	☐	☑	☐	25.31 Hz
Condenser Water Temperature Reset - Raise setpoint to 85F for Moderate / 85F for High / 85F for Critica				
Cooling Tower	☐	☑	☐	85.00 F
Lock chilled water pump speed at 42Hz for High / Critical				
2 chilled water pumps for retail and 4 chilled water pumps for every chiller running		☑	☐	42.00 Hz

Case Studies

Enabling Auto-DR in Large Commercial Buildings in New York City

Building #1 - Office Building

- Building characteristics
  - 32-storey office building in NYC
  - 130,000 m² (1.4 Million ft²)
  - HVAC systems
    - Multiple-zone reheat systems with constant air volume
    - AHUs controlled by VFD
    - 3 x 1,350-ton centrifugal chillers with constant speed
    - 1 x 900-ton centrifugal chiller with variable speed
  - Operation schedule: weekdays, 6am – 6pm

- Opportunities
  - Centralized BMS for HVAC controls
    - Honeywell's Enterprise Buildings Integrator™
  - Open communication protocol: BACnet
  - A good track record of DR performance
  - Night flushing during weekends and precooling throughout summer

- Challenges
  - Limited lighting control
  - No Global Temperature Adjustment (GTA)

Building #2 - Campus Building

- Building characteristics
  - 14-storey university building in NYC
  - 11,300 m2 (122,000 ft^2)
  - Operation hours: 7am – 11pm, 7 days a week
- Opportunities
  - Centralized BMS for HVAC controls
    - Automated Logic Corporation's WebCTRL®
  - Communication protocol: BACnet
- Challenges
  - Lighting control not tied to the BMS
  - Stringent network security requirements
  - No designated facility manager
  - Energy usage is less predictable during school semesters

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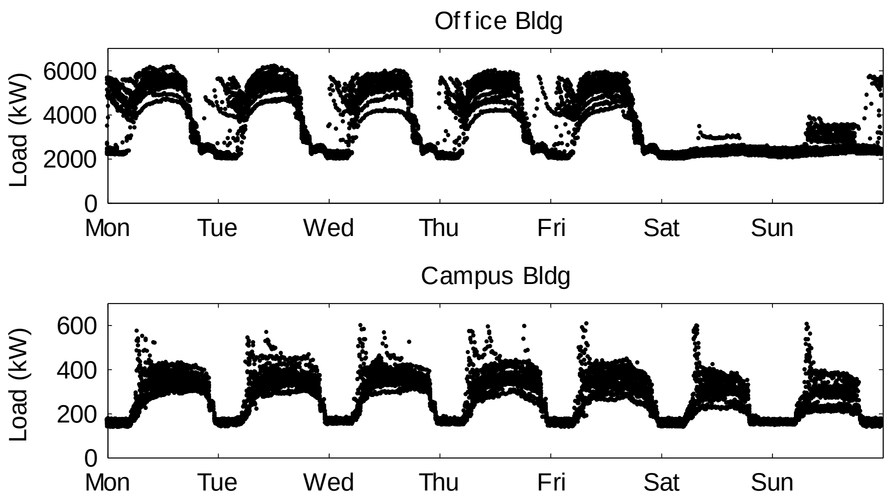
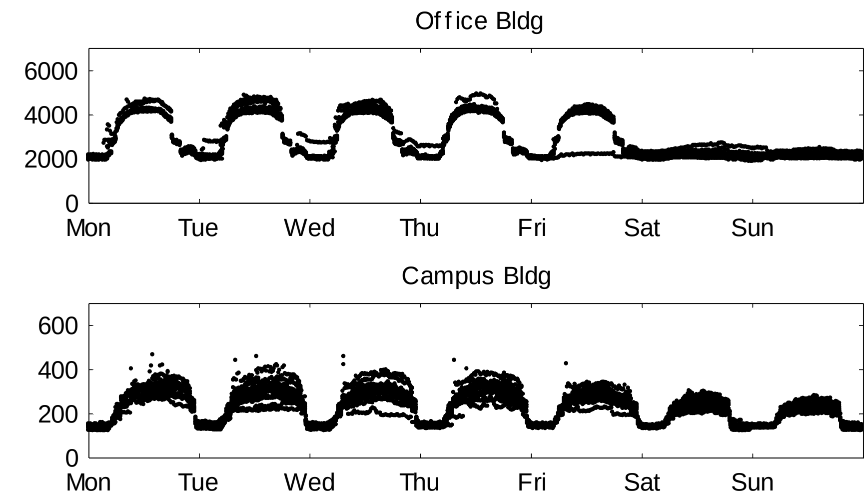
Building Load Characteristics

Facility	Peak Load (kW)	Peak Load Intensity (W/m^2)	Load Factor	Annual Consumption (kWh)
Office Bldg	6,200	48.0	0.51	27,612,000
Campus Bldg	600	53.0	0.40	2,150,000

Summer 2012

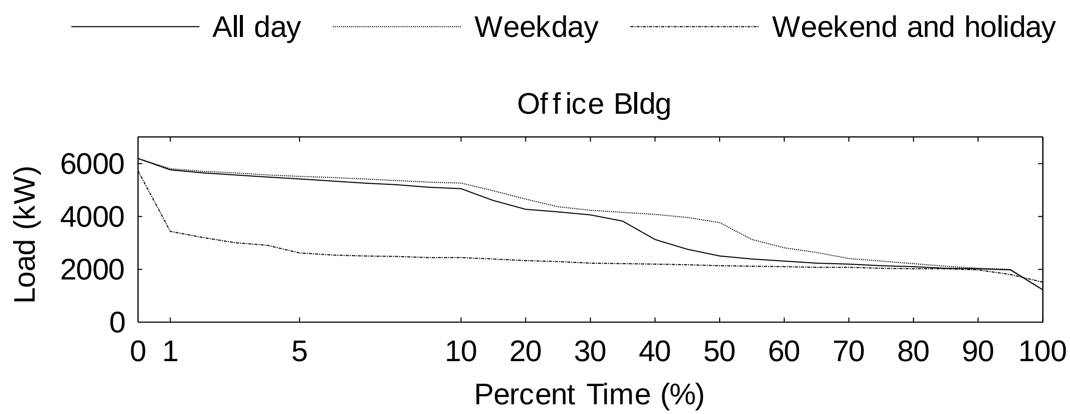


Winter 2012

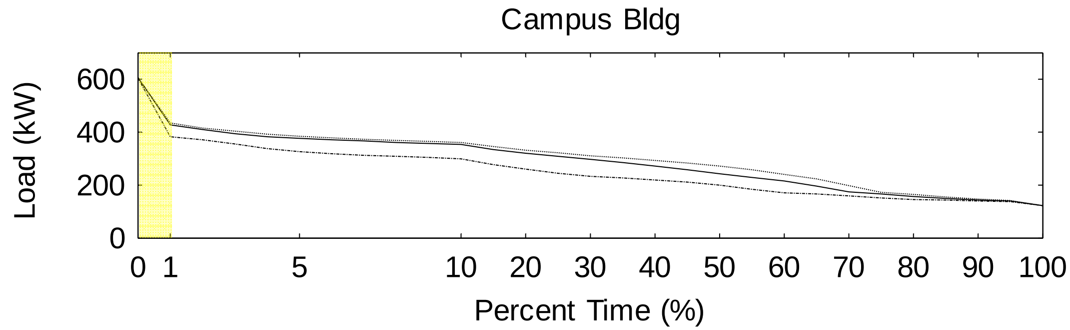


Load Duration Curves

Office Building



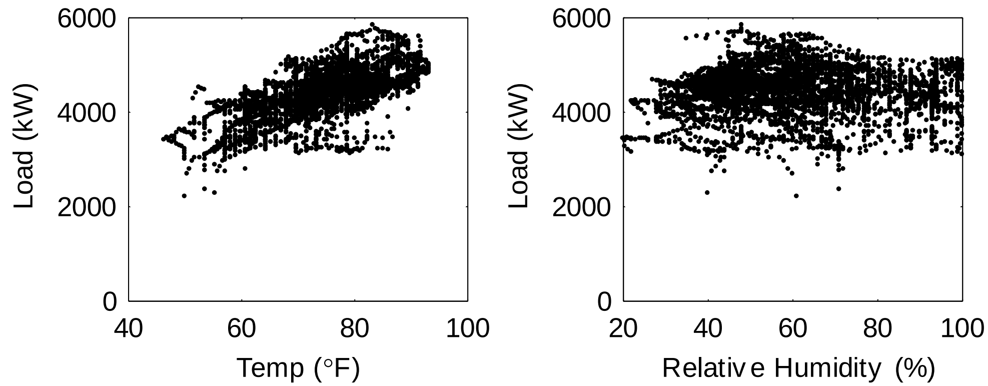
Campus Building



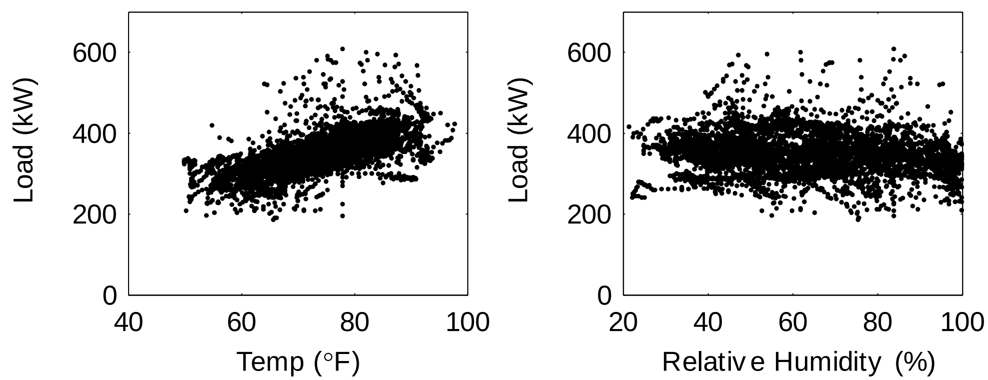
Data shown are from Sep 2011 to Aug 2012.

Weather Sensitivity

Office Building



Campus Building

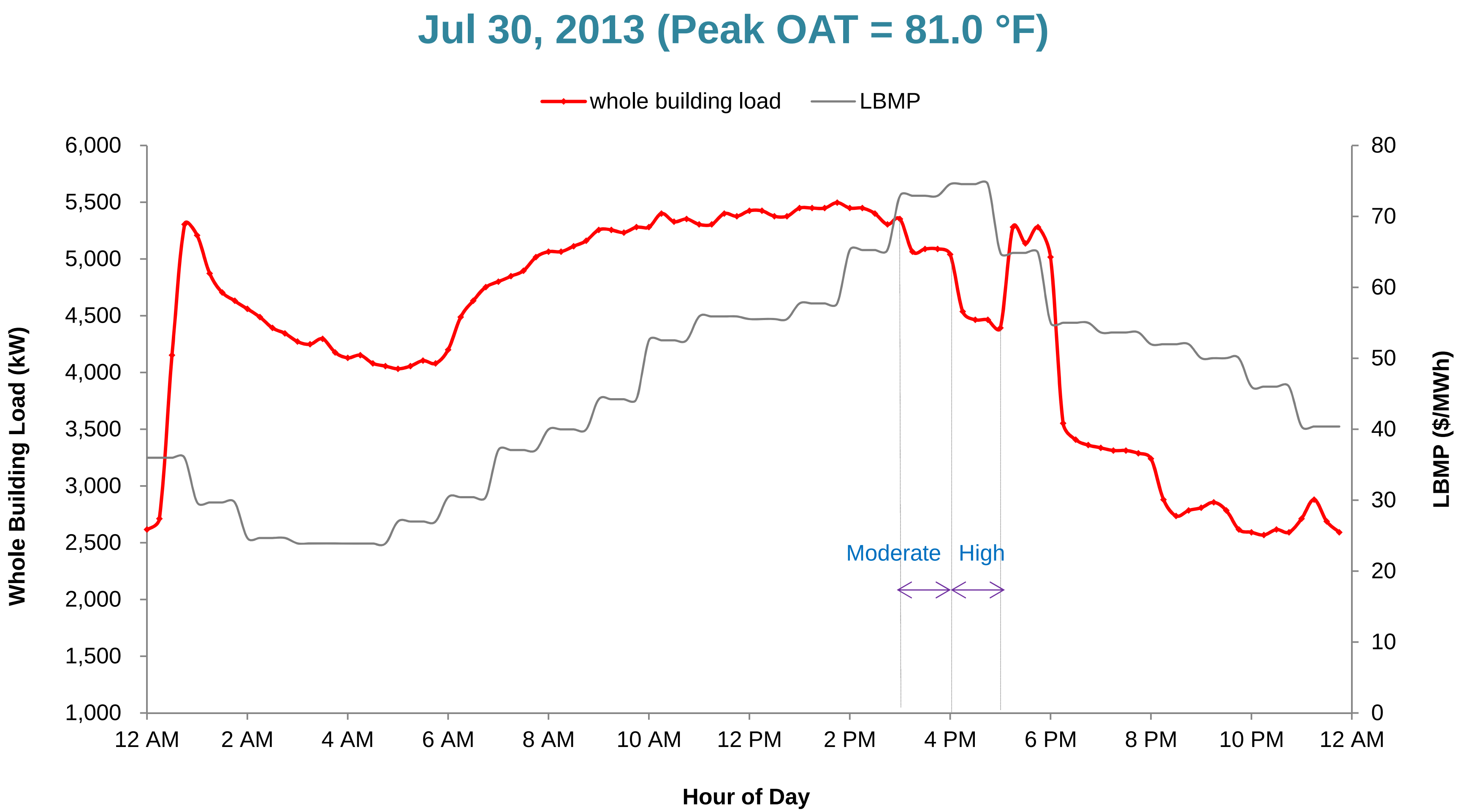


Data shown are from May to Aug 2012.

DR Control Strategies

Facility	Operation Mode	Global temperature adjustment	Supply fan speed reduction	Exhaust fan quantity reduction	Chilled water temperature increase	Chilled water pump speed reduction	Shutting off chilled water pumps	Chiller quantity reduction	Condenser water temperature increase	Shutting off condenser water pumps	Slow and sequential recovery	Sequential equipment recovery	Extended DR control Period
Office Bldg	Critical	x	x	x	x	x	x	x	x	x	x	x	x
	High	x	x	x	x	x			x	x	x	x	x
	Moderate	x	x		x				x	x	x	x	x
Campus Bldg	Critical	x	x	x						x	x	x	x
	High	x	x	x						x	x	x	x
	Moderate	x	x							x	x	x	x

Field Test Results – Office Building



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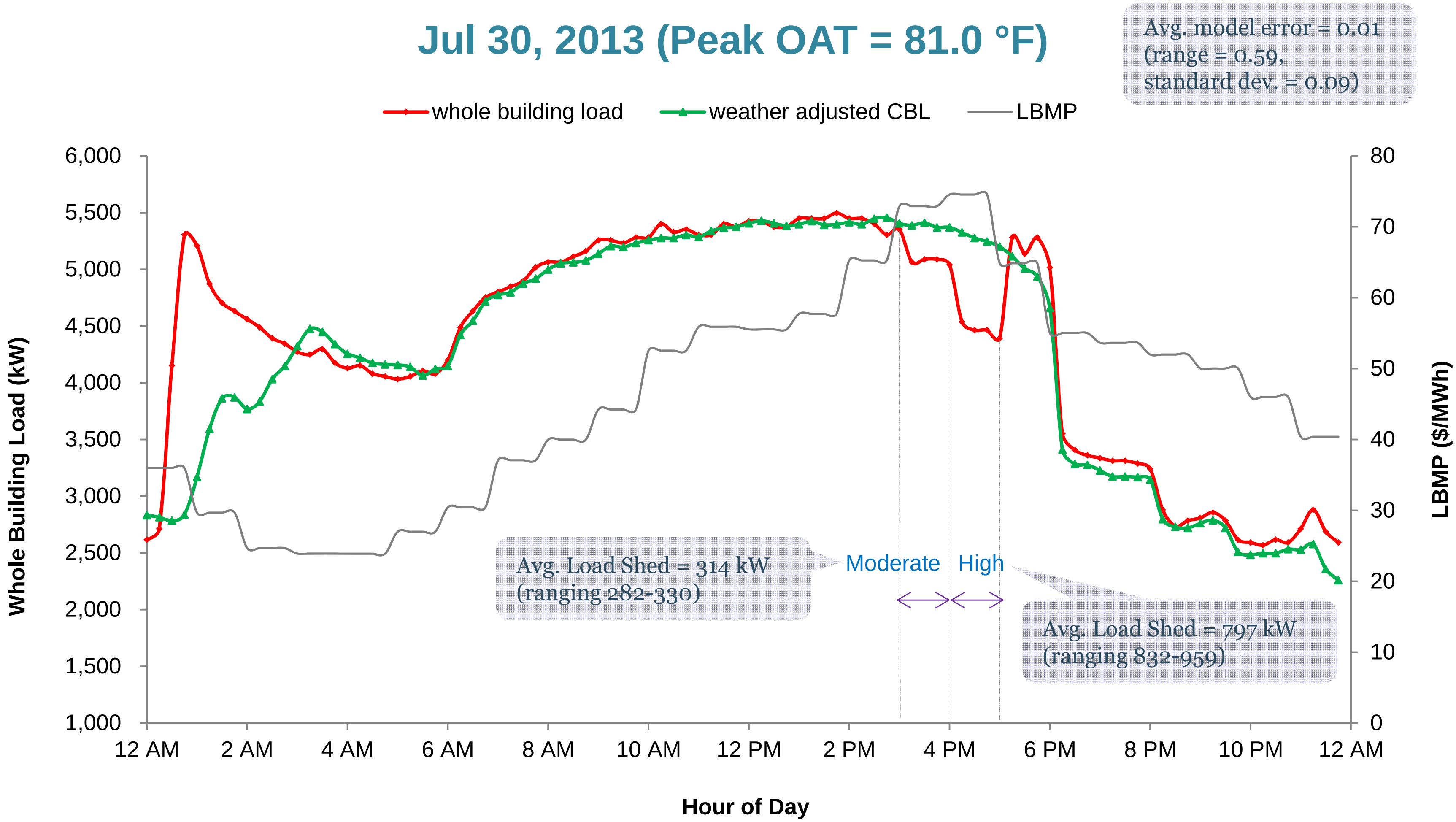
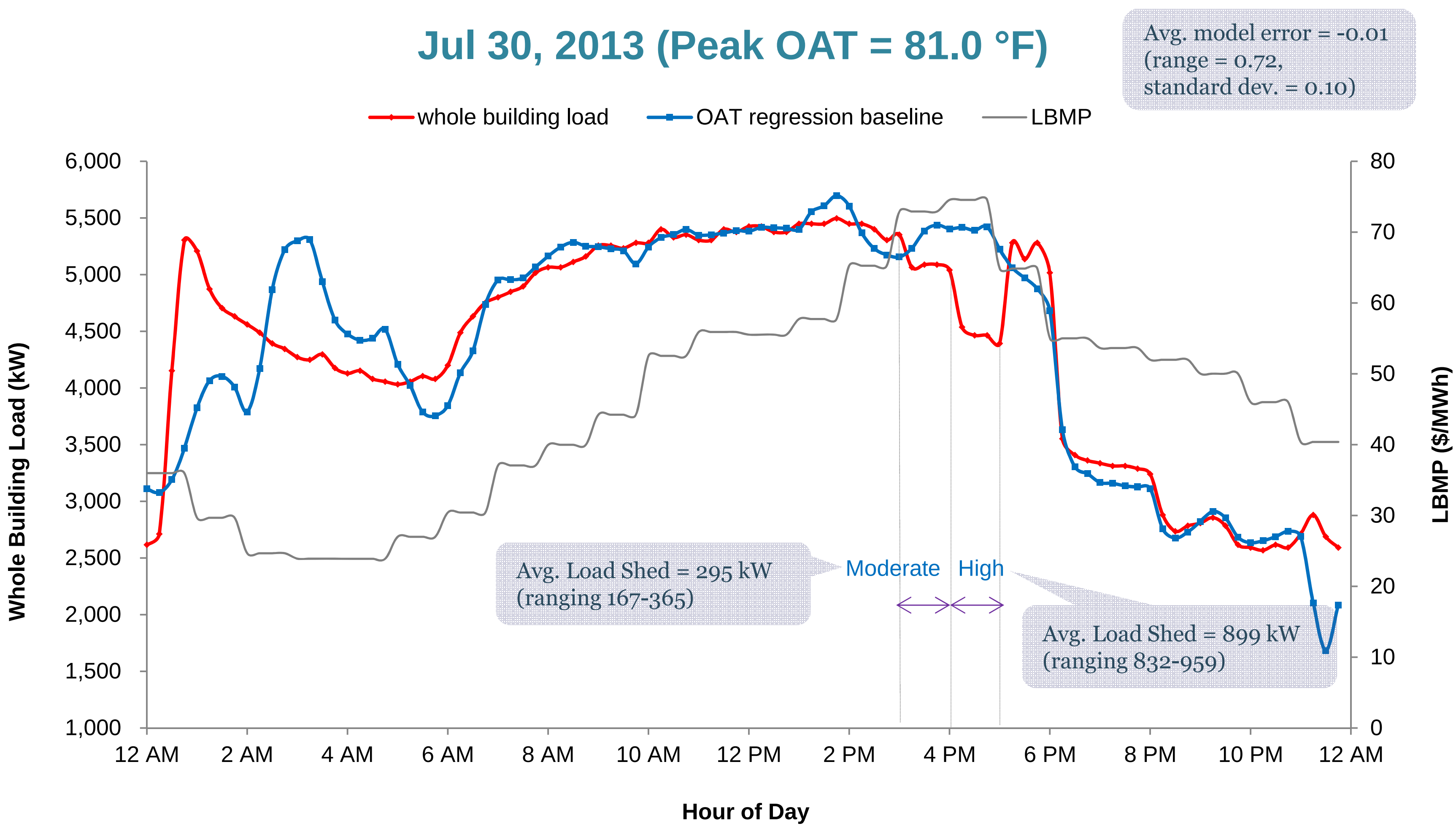
Field Test Results - Office Building



Field Test Results - Office Building



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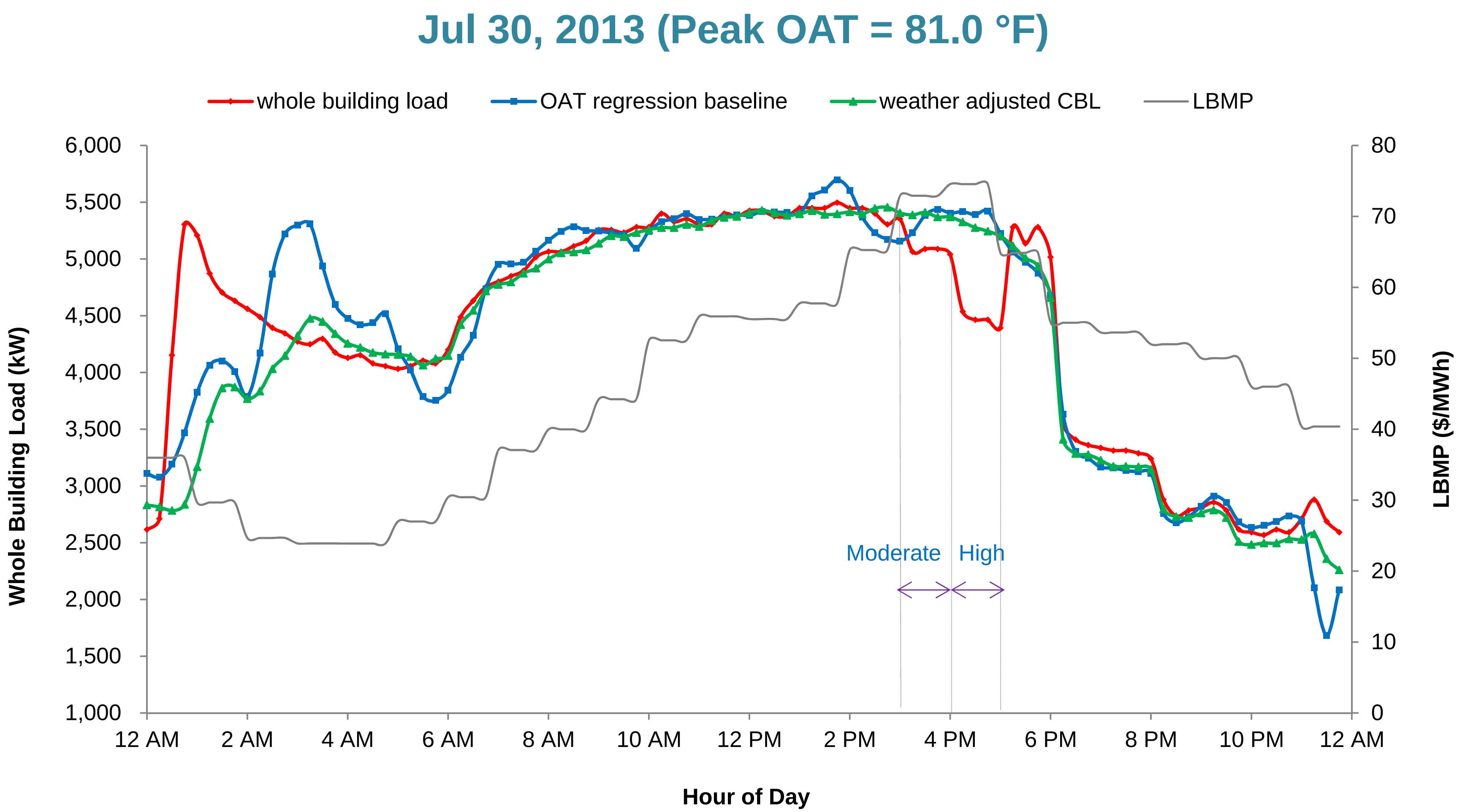
Field Test Results - Office Building



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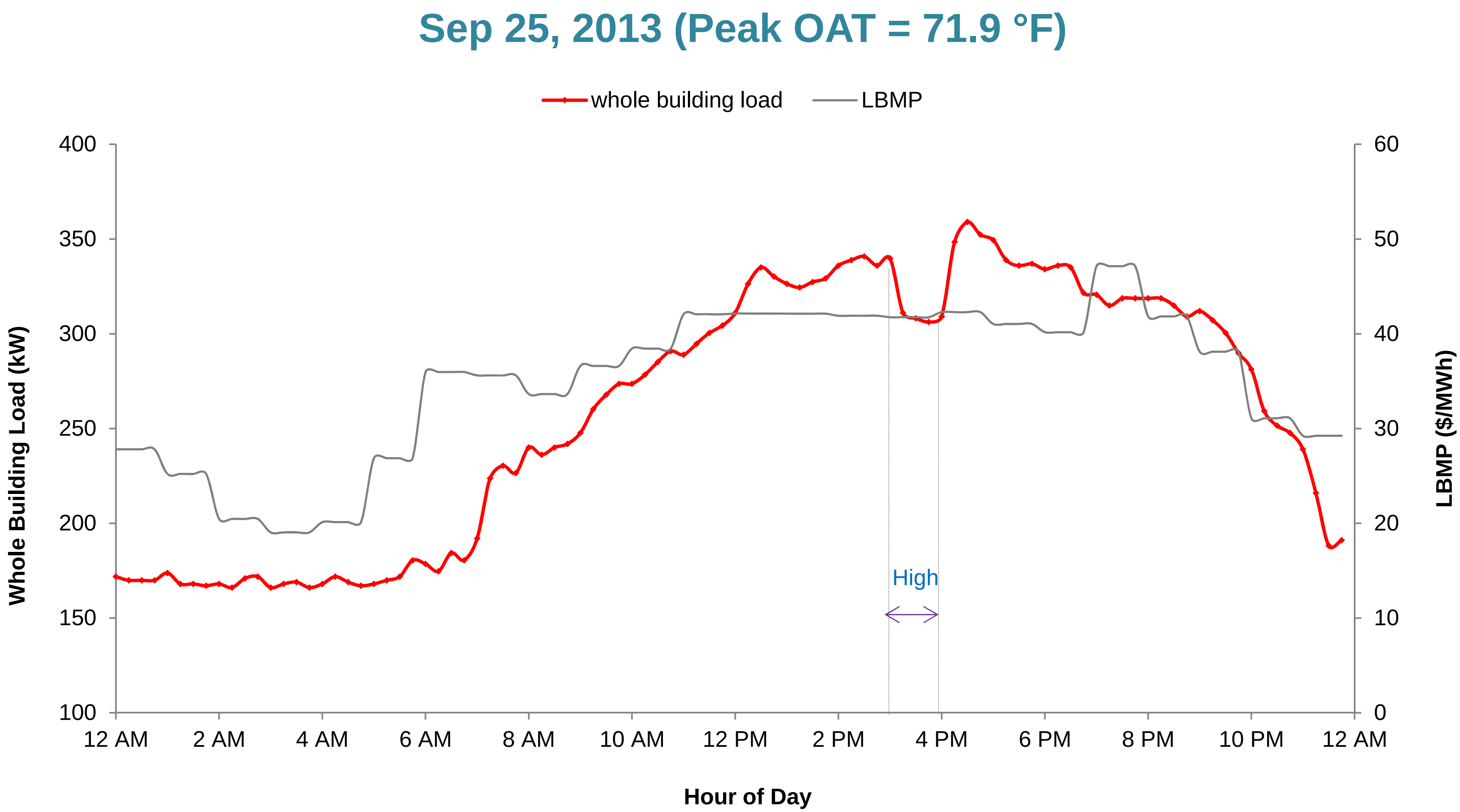
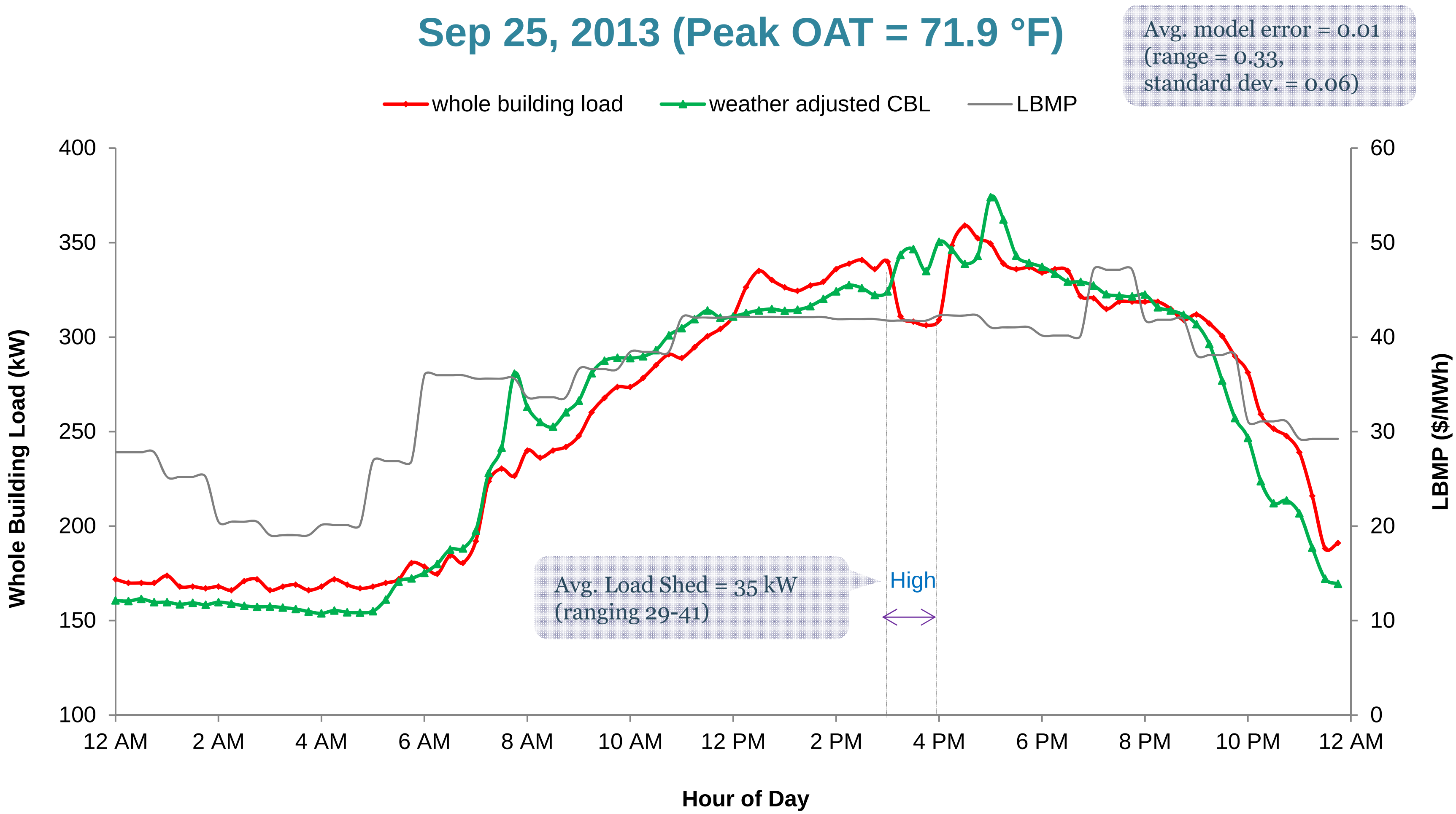
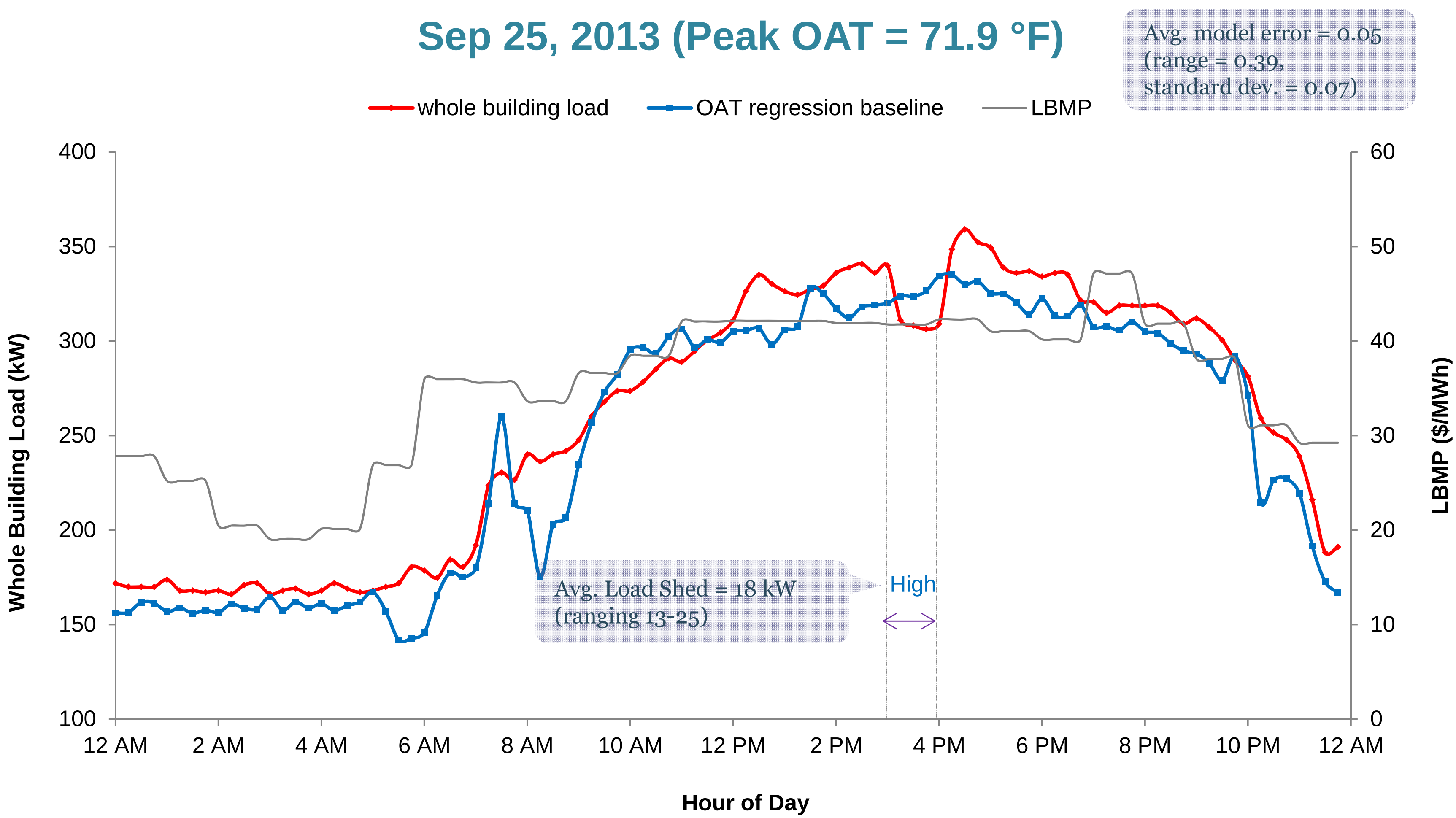
Field Results – Campus Building



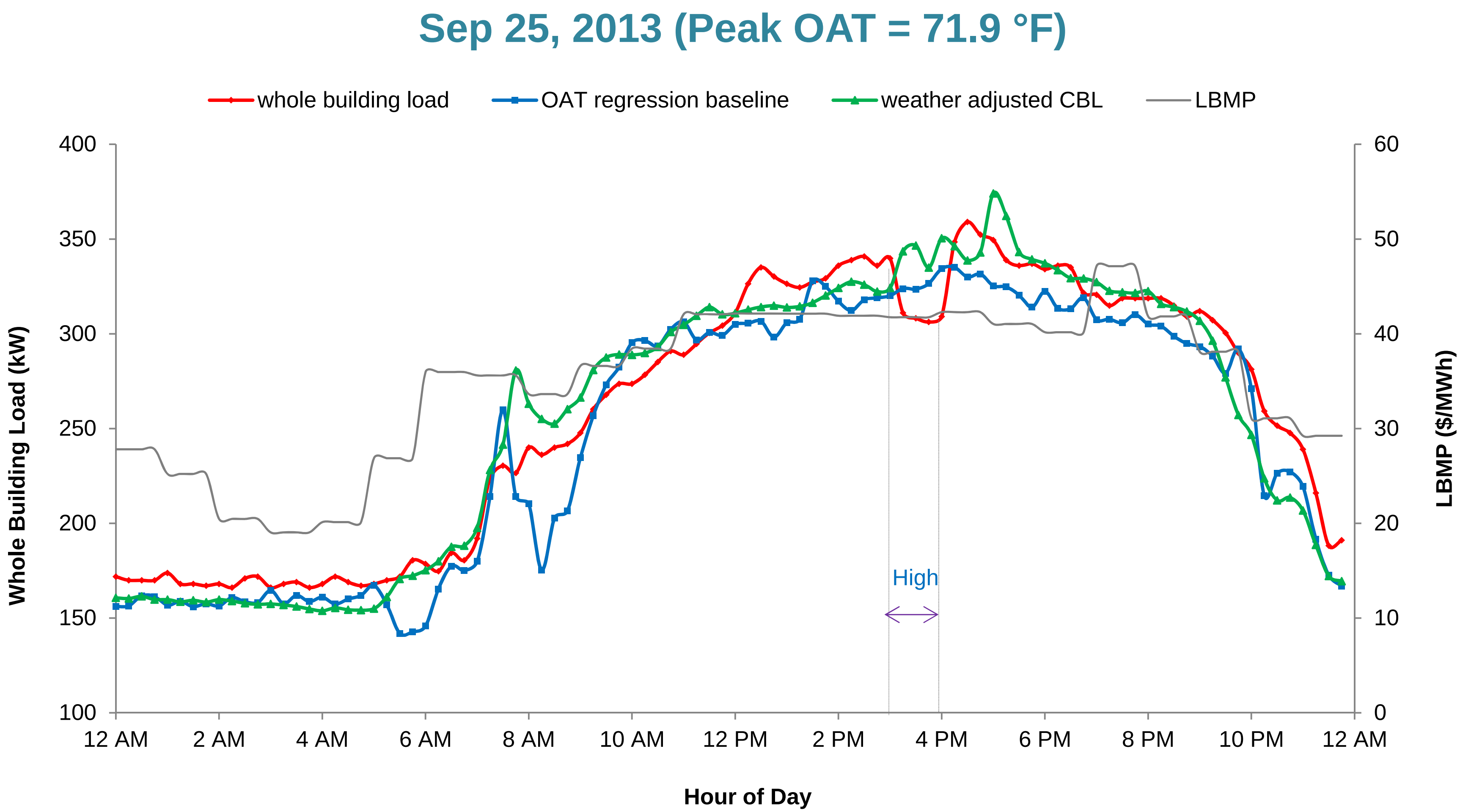
Field Results – Campus Building



Field Results – Campus Building



Field Results – Campus Building



Conclusions

- Centralized BMS and open communication protocols have a central role in Auto-DR enablement.
- Understanding customer's financial and operational goals is key to successful adoption of Auto-DR.
- Allowing opt-out capabilities and modifications over individual DR control strategies can reduce the customer's feeling of "loss of control" and increase the participation in Auto-DR.

Next Steps

- Complete field tests
- Conduct follow-up interview with facility managers
- Develop short-term load prediction model to quantify energy savings under dynamic pricing
- Examine the cost of implementation and predicted energy savings for Auto-DR