Building-Wide, Adaptive Energy Management Systems for High-Performance Buildings

Final CRADA Report

Mathematics and Computer Science

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prepared by
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Mathematics and Computer Science, Argonne National Laboratory

Participants: Building IQ

October 27, 2016

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**Non Proprietary
Final CRADA Report**

Date: October 27, 2016

CRADA Number: C1100401

CRADA Title: Building-wide, Adaptive Energy Management Systems for High-Performance Buildings

CRADA Start/End Date: 10/25/11 to 05/14/13

Argonne Dollars: \$300,000

Participant Dollars: \$0

Argonne PI: Victor M. Zavala (PI)

Participant(s):

BuildingIQ

Name

\$0

Participant Dollars

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Complete Address

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\$

Participant Dollars

Complete Address

Name

\$

Participant Dollars

Complete Address

DOE Program Alan Schroeder
Manager:

Summary of Major Accomplishments:

Development and field demonstration of the minimum ratio policy for occupancy-driven, predictive control of outdoor air ventilation. Technology transfer of Argonne's methods for occupancy estimation and forecasting and for M&V to BuildingIQ for their deployment. Selection of CO2 sensing as the currently best-available technology for occupancy-driven controls. Accelerated restart capability for the commercial BuildingIQ system using horizon shifting strategies applied to receding horizon optimal control problems. Empirical-based evidence of 30% chilled water energy savings and 22% total HVAC energy savings achievable with the BuildingIQ system operating in the APS Office Building on-site at

Summary of Major Accomplishments:
Argonne.

Summary of Technology Transfer Benefits to Industry:

Technology transfer of Argonne's methods for occupancy estimation and forecasting and for M&V to BuildingIQ for their deployment. Empirical evidence of 30% chilled water energy savings and 22% total HVAC energy savings achievable with the BuildingIQ system operating in the APS Office Building on-site at Argonne

Other Information/Results: (Papers, Inventions, Software, etc.)

Heo, Y. and Zavala, V. M. 2012. Gaussian process modeling for measurement and verification of building energy savings. *Energy and Buildings* 53:7-18.

Burkhart, Michael C., Yeonsook Heo, and Victor M. Zavala. "Measurement and verification of building systems under uncertain data: A Gaussian process modeling approach." *Energy and Buildings* 75 (2014): 189-198.

Heo, Yeonsook, et al. "Cost-effective measurement and verification method for determining energy savings under uncertainty." *ASHRAE Transactions* 119 (2013): EE1.

Zavala, Victor M. "Inference of building occupancy signals using moving horizon estimation and Fourier regularization." *Journal of Process Control* 24.6 (2014): 714-722.

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