Project 2.7

Measurement & Verification in Controlled Complex Systems

Jim Follum, Yannan Sun, Tao Fu, and Jian Yin

Objective

Traditionally, Measurement and Verification (M&V) involves quantifying the performance of an energy conservation measure. This project's objective is to extend M&V principles and approaches to:

- Evaluate impact of control on systems too complex to be baselined with traditional methods
- Calculate performance-based payments for applications where baselining is impractical
- Verify payments utilized in transactive controls

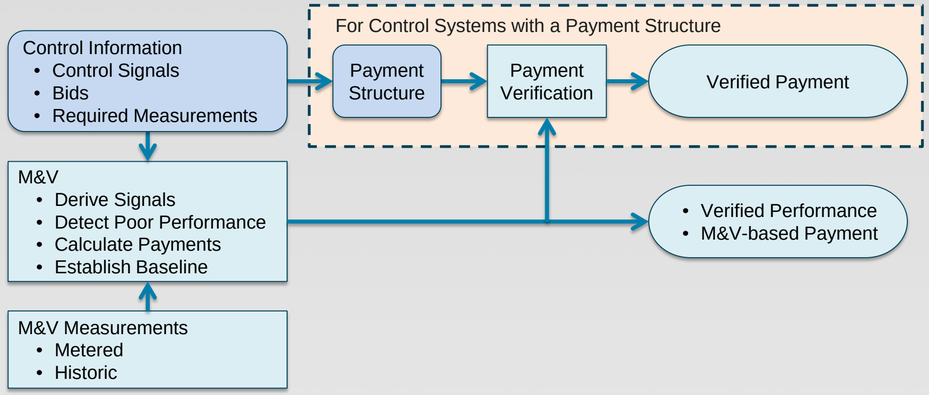
Methodology

Distributed M&V

- Utilize the intelligence of distributed control devices
- Alleviate communication, privacy, and computational barriers through distributed online processing

Data Mining

- Establish baseline behavior using techniques well-suited to large, complex datasets
- Compare baseline to controlled operation to quantify performance



General structure for M&V applied to controlled complex systems

Experimental Results

Purpose

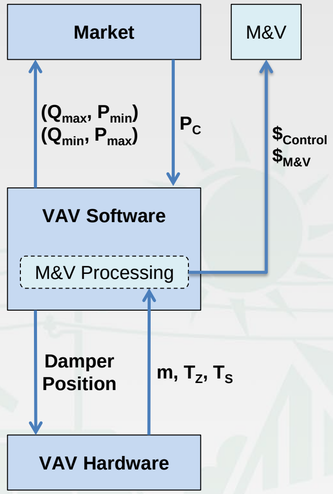
- Demonstrate the viability of a distributed M&V method through deployment in the SEB building

Control

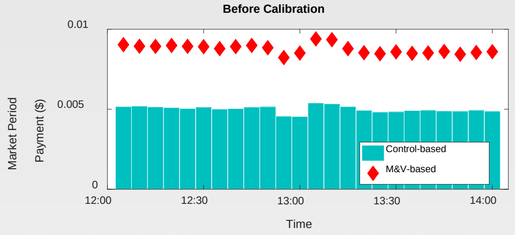
- Designed to reduce overall energy consumption
- Transactive between an air market (AHU) and 17 AC zones (VAV boxes)
- Payments based on bids for power **before** each market period

M&V

- Verifies control-based payments through comparison with a performance-based alternative
- Payment calculation
  - Distributed to each zone
  - Performed **after** market periods using measurements

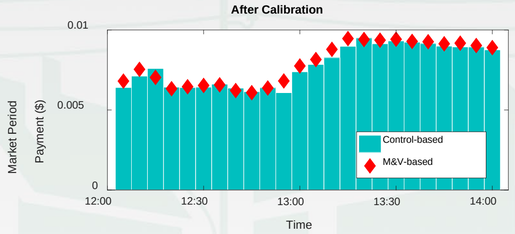


Block diagram of the distributed M&V approach



Comparison of control- and M&V-based payments for SEB zone 129 before the control's model was calibrated

M&V pinpointed controller's poorly tuned zone models



Comparison of control- and M&V-based payments for SEB zone 129 after the control's model was calibrated

M&V verified model improvement

Future Work

- Continue experimentation with real-time M&V
- Develop a prototype tool to streamline the design and implementation of M&V methods
- Extend distributed M&V methods to controls that are fully-distributed and non-transactive

CCSI Control of Complex Systems Initiative

Pacific Northwest NATIONAL LABORATORY

Proudly Operated by Battelle Since 1965

U.S. DEPARTMENT OF ENERGY