Sacramento Municipal Utility District Explores Advanced M&V Capabilities

With the support of DOE's Building Technologies Office (BTO), LBNL has worked to develop and test promising "M&V 2.0" approaches that rely on the analysis of time-series meter data. The LBNL team has shown through statistical test procedures that these streamlined techniques are accurate and robust in characterizing and predicting building energy use.

What is M&V 2.0?

M&V 2.0 (sometimes called automated M&V or advanced M&V), is characterized by: [1] Increased data availability, primarily in terms of finer time scales or higher volume, and [2] enabling the processing of large volumes of data at high speed via automated analytics, to give more timely savings estimates. These approaches are intended to be conducted more quickly, more accurately, and potentially at lower cost than non-automated methods

SMUD's Interest in Advanced M&V

Sacramento Municipal Utility District (SMUD) approached LBNL in 2018 to collaborate in exploring advanced M&V modeling methods. While the core focus of advanced M&V has typically been to quantify energy savings, SMUD's interests extend more broadly (although quantifying savings *does* feature in future plans). Their initial questions concern electricity consumption load shapes, particularly: [a] the ability to reliably model them, and [b] how they can use that knowledge as a tool to better manage feeder and transformer level infrastructure investment.

Within this context, LBNL and SMUD partnered to gain an understanding of energy efficiency savings estimates using advanced meter data analytics, and to use the insights to inform program monitoring and design. The goals of the partnership are to develop a deeper understanding of how advanced M&V could support SMUD's energy efficiency programs.

Key research questions to be addressed by SMUD and LBNL include:

- Which customers are best suited for a pay-for-performance program design[1]?
- How does screening with baseline model fitness metrics improve savings confidence vs. randomly choosing sites, when using meter-based M&V?
- How much has energy efficiency reduced load for a given feeder or transformer, and how persistent is this reduction?

The initial work highlighted in this case study was focused on addressing the first key research question.

SMUD's goal to leverage M&V 2.0

SMUD is in a unique position to leverage M&V 2.0 in its efficiency programs because it has territory-wide smart meters and the internal resources to utilize these rich data sources to perform advanced M&V. Advanced M&V can help better understand customer load profiles and identify those better suited to pay for performance programs, improve savings estimation and analyze the impacts of energy efficiency for deferment of transformer infrastructure upgrades

Exploratory Findings

SMUD ran LBNL's Time-of-Week-and-Temperature baseline model ("TOWT") on data from over 48,000 commercial building meters. TOWT is a statistical model that can be used to generate energy use baselines. It includes time-of-week and temperature as independent variables to account for load dependence on weather, time of day, and day of week. TOWT has been used in prior work and found to be accurate in predicting future energy use[2].

Assessing model quality ('fitness') for buildings can help in targeting candidates for a pay-for-performance (P4P) program, since fitness is one contributor the overall robustness of meter-based savings results.

[1] Pay for Performance (P4P) programs reward energy savings on an ongoing basis as the savings occur, often by examining data from a building's energy meters, rather than providing up-front payments based on estimated future savings.

[2] http://eis.lbl.gov/pubs/applied-energy-173-2016.pdf

Factsheet date: 12/5/2018

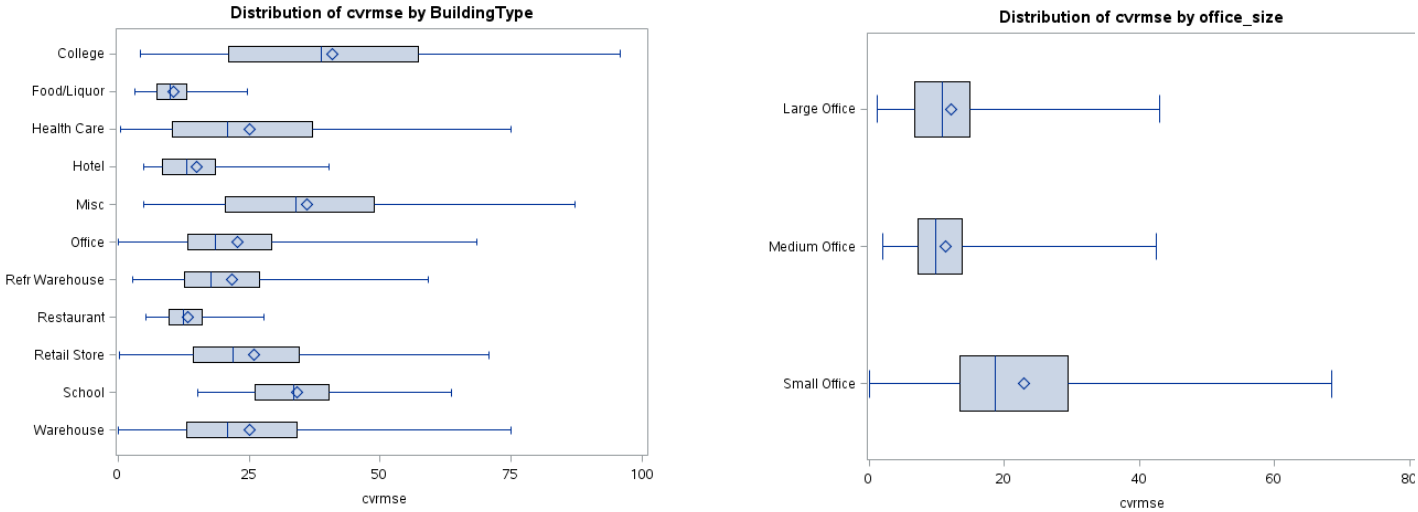

Chart above illustrates the difference in model fitness between different building types (left), and an example (right) showing small/medium/large office illustrating building size also affects model fitness. Box and whisker plots shown indicate the median, 25th percentile, 75th percentile, max & min values.

Using fitness metric thresholds[3] of R^2 > 0.7, CVRMSE <25%, and NMBE <0.5%, almost 15,000 commercial sites met all three criteria (31%). The model fitting was fully automated for the entire portfolio of buildings and not custom fit for individual buildings. A summary table showing model results by business type is shown below.

Business Type	No. of Sites Screened	Sites meeting screening criteria	Percent passed
College	430	76	17%
Food/Liquor	1,351	960	71%
Health Care	610	180	29%
Hotel	210	61	29%
Miscellaneous	7,612	1282	16%
Office	25,697	7519	29%
Refrigerated Warehouse	201	79	39%
Restaurant	2,554	1885	73%
Retail Store	3,564	1168	32%
School	814	136	16%
Warehouse	5,135	1596	31%

The results from the screening show that model fitness is much better for certain types/sizes of buildings. Restaurants were the best performing type with 73% meeting all screening thresholds, followed by food/liquor establishments at 71%. Colleges and schools had low pass percentages, which is expected since energy consumption can vary significantly based on whether classes are in session or not (not an input to the TOWT model, but other models do account for this).

When business types were further split up into small medium and large based on floor area, further insights were gained. For example, 29% of office buildings met fitness criteria overall, but for *medium and large* office, 59% and 69% of sites met fitness criteria respectively. Across building types, smaller buildings were less likely to pass all fitness criteria; the high number of small buildings in the sample decreased the overall pass percentage. It is also possible that meter data quality was an issue at some sites with poor fitness. These results have implications for P4P design illustrating how automated screening can assist in targeting buildings to increase the likelihood of accurate savings results.

Ongoing Development

SMUD and LBNL will continue to work together to assess how screening using model fitness could improve savings confidence vs randomly choosing sides. Additional next steps are to further investigate how energy efficiency reduces load for a given feeder or transformer, and how hourly data can help in targeting efficiency programs to specific market sectors and address time-varying generation and distribution needs. Findings from the next phase of investigation are expected late 2019.

Lawrence Berkeley National Laboratory's M&V 2.0 Research

The recent phase of LBNL's automated M&V research started in 2014 and has encompassed development of test methods for M&V tools, technical evaluations of advanced M&V tools and methods, guidance on accuracy and documentation requirements, and application of M&V 2.0 techniques to historical project data. More information on these efforts can be found at http://eis.lbl.gov/auto-mv.html

[3] R^2 is the coefficient of determination, CVRMSE is the root mean squared error divided by the mean of the measured values. NMBE is the mean of the error in the predictions divided by the mean of the actual energy use.