California Public Utilities Commission Extends M&V 2.0 Analyses to Gas Data

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

What is M&V 2.0?

M&V 2.0 (sometimes called advanced M&V or automated M&V), is characterized by: [1] Increased data availability, 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.

With a high penetration of smart meters, California regulators and utilities have been exploring advanced M&V methods for several years. Emerging technology R&D programs have explored analytics tools and methods, and a commercial whole-building pilot was conducted to assess how holistic efficiency approaches could enable deeper energy savings. California legislation passed in 2015 (Assembly Bill 802 and Senate Bill 350) has paved the way for scaled adoption of advanced M&V.

Moving Beyond Electricity

Smart meter installations typically target electricity and advanced M&V efforts to date have been similarly focused. However, many efficiency measures can affect electricity and natural gas use, and some market sectors can achieve higher savings by targeting gas-saving measures. As utilities start installing meters capable of reporting hourly or daily gas data there is a desire to explore advanced M&V for gas. Advanced M&V allows for quantification of a lower percent savings compared to monthly data analysis, and can also be used to better understand buildings' gas consumption profiles.

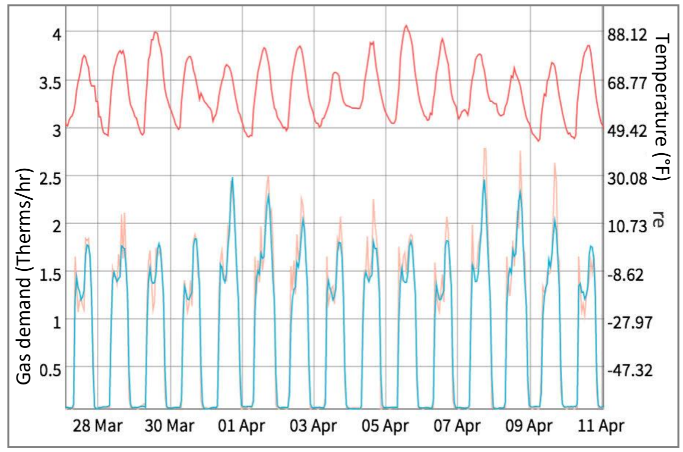

Figure: Time-series plot of a building's hourly gas demand (orange), model-predicted consumption (blue) and outdoor air temperature (red)

California's Move Toward Meter-Based Energy Efficiency

With a long and successful history implementing energy efficiency programs California is always looking to innovate. Building on this historical success the state legislature laid down a challenge in 2015, to double energy efficiency in the state by 2030 (Senate Bill 350). In tandem the legislature also called for new approaches that count savings at the meter (Assembly Bill 802), referring to this as measuring Normalized Metered Energy Consumption or "NMEC." This has paved the way for new program approaches that employ advanced M&V and utilize the state's significant investment in advanced metering infrastructure.

As of 2018 the California Public Utilities Commission (CPUC) has overseen the launch of pilot meter-based programs for residential and commercial sectors, and is in the advanced stage of developing rulings and guidance to support long term scaling of meter-based approaches alongside traditional program portfolios.

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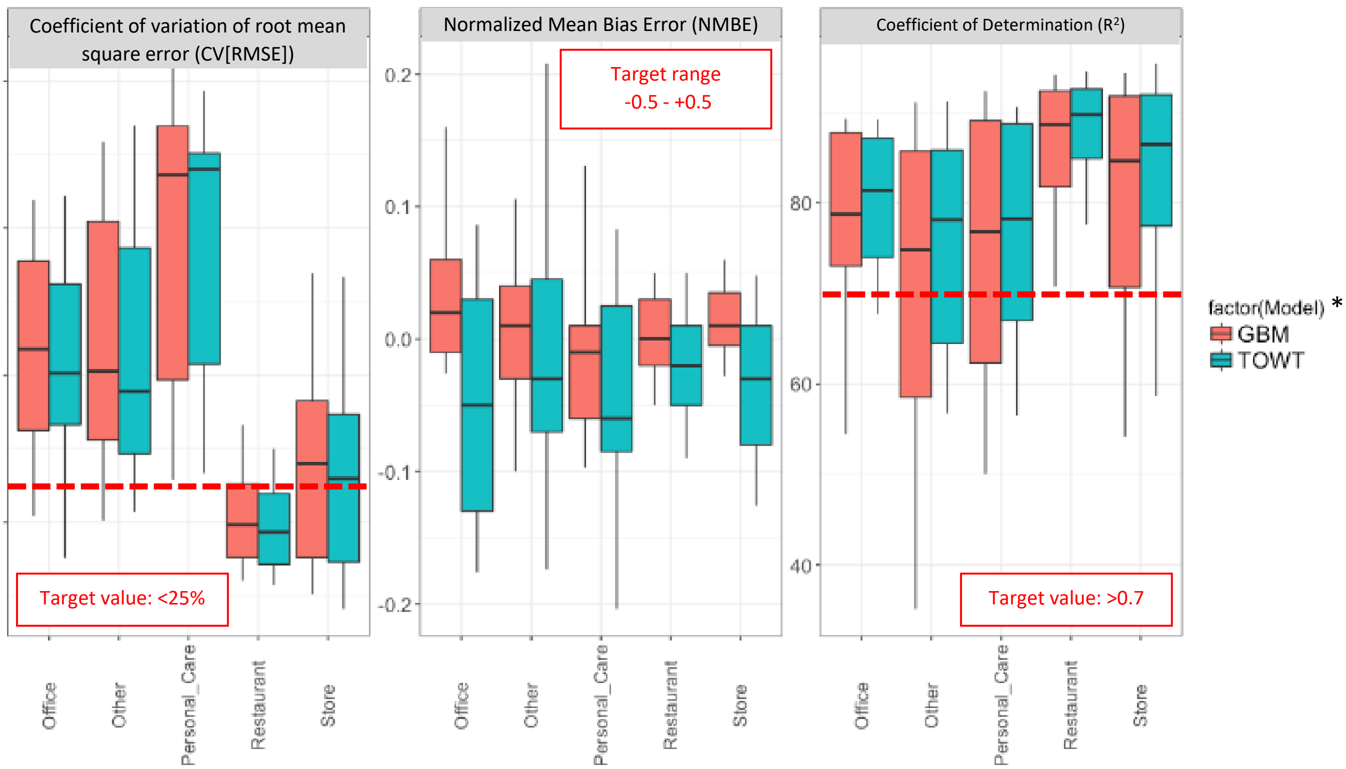

Figure: Boxplots of model fitness metrics for hourly gas data, indicating median, 25th/75th percentile, and 10th/90th percentile values for each building type modeled. A total of 406 models were created, of which 305 were for standalone restaurants.

With utilities planning to implement restaurant efficiency programs utilizing advanced M&V the California Public Utilities Commission (CPUC) saw a need to address some of the key technical questions pertaining to gas energy modeling:

- How well can gas data be modeled with existing advanced M&V methods?
- How well can restaurants in particular be modeled?
- What is the impact of daily versus hourly modeling resolution on model fitness?

In 2018 the CPUC collaborated with LBNL and California's investor-owned gas utilities (PG&E, SoCal Gas, and SDG&E) to address these initial questions.

Using a full year of hourly gas data provided by PG&E and SoCal Gas, and daily data from SDG&E, LBNL created energy models for over 600 buildings. The majority of data provided was from standalone restaurants, with smaller sample sets for several other building types. Since this was the first effort modeling hourly gas use two energy modeling methods were applied to allow for comparison: a piecewise linear model (known as time-of-week and temperature, or "TOWT"), and a machine learning method (Gradient Boosting Machine, or "GBM"). Daily data modeling utilized a daily linear model and a Bayesian additive regression trees ("BART") method. The models use outside air temperature and either time of week or time of day as independent variables. Model accuracy was assessed using three model fitness metrics:

- R^2, target >0.7
- CV(RMSE), target <25%
- NMBE, target between -0.5 and 0.5

Initial modeling results are summarized below.

Exploratory Findings

Hourly models were created for 406 sites, of which 305 were standalone restaurants. As illustrated in the figure above, model fitness results varied depending on building type and the model used. Findings relating to the key technical questions are summarized below.

How well can gas data be modeled with existing advanced M&V methods (Restaurants in particular)? Across the whole dataset the TOWT and GBM models produced similar model fitness metrics, with approximately 60% of sites meeting target values (see figure above). For standalone restaurants approximately 70% met model fitness thresholds, which is comparable with electric hourly models where similar analyses have shown between 70% and 85% of commercial sites in general (not exclusively restaurants) meet these fitness targets. Other facility types assessed in addition to the

* Hourly model types used: GBM (Gradient Boosting Machine) and TOWT (LBNL Time of Week and Temperature)

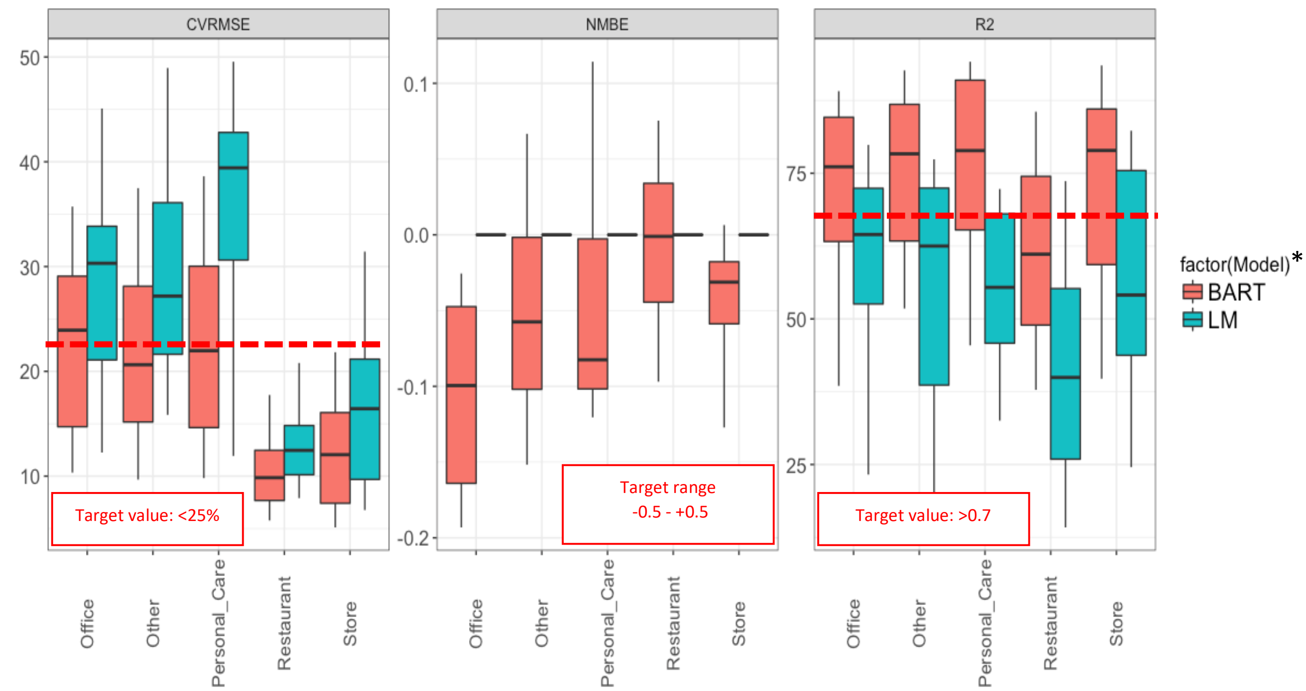

Figure: Boxplots of model fitness metrics for daily gas data, indicating median, 25th/75th percentile, and 10th/90th percentile values for each building type modeled. A total of 654 models were created, of which 553 were standalone restaurants.

restaurants included office, retail, and personal care facilities (see table below). Of these, retail had the highest percentage meeting model fitness criteria (56%), and personal care had the lowest percentage (8%).

TOWT Hourly Models: Percent Meeting Fitness Criteria		
Business Type	**Sample Size**	**Met Fitness Criteria**
Restaurant	305	74%
Office	25	9%
Store	23	56%
Personal Care	10	8%
Other	43	16%
BART Daily Models: Percent Meeting Fitness Criteria		
Business Type	**Sample Size**	**Met Fitness Criteria**
Restaurant	553	33%
Office	25	41%
Store	23	67%
Personal Care	10	62%
Other	43	48%

What is the impact of daily versus hourly modeling resolution on model fitness? Moving from hourly to daily modeling was found to significantly degrade model performance. Across the whole dataset only 14% of sites met all model fitness target values using the linear model, and only 35% using the BART model (see table left and figure above).

Ongoing Development

Initial results for hourly modeling of restaurants were promising, with weaker performance for other facility types and for daily models. It is possible that restaurants' gas consumption is strongly influenced by operating schedules, leading to better model fitness compared to other building types that have a less consistent relationship with both schedule and weather. Ongoing work will move beyond model fitness to look at predictive capability of hourly gas models (i.e., 'out of sample' testing), and savings analysis for facilities in which measures were installed. Analysis of larger data sets for building types other than restaurants is also a potential area of ongoing work. This technical research is complemented by ongoing collaboration to develop technical guidance for programs using advanced M&V.

Lawrence Berkeley National Laboratory's M&V 2.0 Research

LBNL's advanced M&V research encompasses 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

* Daily model types used: LM (linear Model) and BART (Bayesian Additive Regression Tree)