PECAN STREET

Water Data Integration Toolkit

Conservation Program Measurement & Verification Guidelines for Variable Data Resolutions

The goal of water conservation measurement and verification (M&V) is to determine water and cost savings that result from implementation of specific water conservation measures and/or programs.

Water savings are determined by comparing the baseline water use to the use after the water conservation measure been implemented. Municipal water utilities are rapidly evolving their data game – embracing smart meters and other advanced technologies to bring greater insight to water management. Texas water utilities are some of the most advanced water utilities in the country and many are leading the charge in creatively and effectively leveraging new Information & Communications Technology (ICT) to help answer questions, such as "How are our conservation program marketing efforts working? Can we develop a better understanding of our customers and how they prefer we communicate with them to more strategically inform our community about water conservation rebates and incentives? Which programs should we plan to retire and which programs should we expand? What approach to conservation attracts the most people and what results in the most water savings?"

In Texas, many municipal water utilities have already deployed or are planning for roll-out of smart meters. Smart meters can provide critical insights into how water is used and, if data is available for at least a daily period, can help answer many of these questions while informing strategic planning processes. Access to data at an even higher resolution provides exponential insights into the impact of specific appliance changes, allowing for verifiable M&V of individual rebate and incentive programs at a household level.

Marrying these new datasets with customer information often held outside of the conservation department will enable critical insights into conservation program efficacy and cost-efficiency to be uncovered. Integration of these various datasets is discussed in the Data Schema Guide and Data Integration Manual provided as part of this toolkit.

Measurement and Verification with Variable Datasets

To assist water utilities that have access to more data than traditional monthly consumption billing data in optimizing access to this data for planning future conservation programs, program marketing, and best practices identification, Pecan Street has developed an overview of analytics that can be run on variable datasets to help answer these questions. Through survey of our University Municipal Water Consortium members, Pecan Street believes there are four general categories of data access that most water utilities should have available (listed from most to least common):

1. Monthly use and billing data
2. 15-minute interval smart meter data + conservation programs subscription and cost data
3. Monthly billing data + conservation programs subscription and cost data + one-minute interval, high resolution (sub–gallon interval) water use data, such as Pecan Street's BluBand data or other data logger products
4. M&V based on Conservation program data + billing data + real-time, high resolution (sub-gallon interval) water use data + disaggregated electric use data

This document is organized to address each of these four categories. It provides a description of each type of data and suggested approaches with calculations for utilizing this data to generate quantifiable M&V impacts analysis on conservation programs.

1. M&V using monthly billing data + water conservation programs (WCP) subscription and cost data

One of the easiest and most inexpensive methods to measure water savings is to use monthly billing data. Most water utilities have monthly billing data that can be used to measure the effectiveness of a water conservation program. Utility monthly bills also provide saving numbers in a format that can be easily understood by customers.

Water savings M&V using monthly water billing data are determined by comparing the water usage before and after the implementation of a water conservation program. The following calculation can be applied to monthly billing data if the date of adoption of a water conservation measure is known for the household(s) or building(s) under analysis.

$$\text{Water Savings} = \text{Baseline Water Use} - \text{Post-Retrofit or Post-audit Water Use} \pm \text{Adjustments}$$ [2]

where,

Baseline water use = water usage prior to program implementation

Post-retrofit or Post-audit water use = water usage after implementation of program

Adjustments = Factor applied to normalize water use where appropriate

Furthermore, utilities armed with monthly billing data can begin to perform basic M&V on almost all the current water-rebate programs, including toilet replacement programs, irrigation removal programs, and rain barrel programs, among others.

By combining monthly water consumption data with conservation program data within the database architecture recommended by Pecan Street, automated analysis of program impacts on a household-level and aggregated level to quickly analyze program effectiveness over variable time periods and within segmentation categories, such as neighborhood, program marketing type, and/or incentive type. Simply marrying together monthly billing data with conservation program data provides a powerful M&V platform for large water use programs – such as swimming pools, rain barrels and irrigation systems.

Though the calculations are simple, automating these within a relational database empowers conservation program managers to quickly analyze program results and make decisions about future resource allocations, program marketing, and management.

2. M&V based on 15-minute interval smart meter data + conservation program data

Smart meters can provide real-time or near real-time information on water consumption at the individually-metered building level. This level of insight enables utilities to undertake a suite of M&V useful for program evaluation, program enforcement and strategic planning that is not supported by monthly billing data.

Smart meters also provide the capability to automatically detect customer-side leaks, which are responsible for an estimated loss of one trillion (1,000,000,000,000) gallons of water per year by the EPA (https://www.epa.gov/watersense/fix-leak-week). A leak is identified when there has been a continuous flow of water for 24 hours (i.e., the meter does not report at least one zero during at least one 15-minute interval for a 24-hour period). This leak alert can instantly be seen by the utility and can be notified to the customer.

Identification of leaks in early stage can save thousands of gallons of water per year and hundreds of dollars in customer's water bills.

The following calculation can be used to measure the amount of water wasted in a leak.

Let,

$w_{baseline}$ = baseline water usage in gallons. This is the average amount of water used per day over the previous 30 day period preceding a leak detected

w_{leak} = water usage in gallons when leak is active

$$savings = (n \times w_{leak}) - (n \times w_{baseline}) \pm \text{Adjustments}$$

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If below variables are known then equation 2 can be used to verify the savings calculated in equation 1.

$$\text{Wasted water } (\%) = \frac{\sum_{i=1}^{n} t_i - \sum_{i=1}^{n} w_i \times h_i}{\sum_{i=1}^{n} t_i} \times 100 \qquad \text{--2}$$

where,

Adjustments = Factor applied to normalize water use where appropriate

w = average gallons wasted as a result of leak per hour

h = number of hours

t = total gallons used in a day

n = total number of days

i = n^{th} day

Providing customers with access to more frequent water use information, such as daily information, over a mobile app or online portal, can also help the customer in identification of water waste. Additionally, this level of insight can be analyzed and provided through a few useful visualizations as part of the monthly customer bill to provide more information – and therefore more opportunity for customer's to better manage their water use – to households or building owners that are not likely to use an online interface.

For instance, a difficult to detect rebate can be that of an Irrigation System Removal Rebate program. On face, it seems trivial to determine if an irrigation system has been removed, but if a homeowner switches their use from automated irrigation to manual irrigation during the peak months, it will be more difficult to discover with monthly data. By having access to 15-minutes data, and targeting program evaluation to times where outdoor automated irrigation would be running at night, versus manual irrigation which would still exist after an Irrigation System Removal Rebate, better program evaluation is possible. Here is such a calculation:

$$\Delta w = \frac{\sum_{i=1}^{m} w\_irr_i - \sum_{i=1}^{m} w_i}{n}$$

Δw = water saved in gallons per season per nighttime watering window.

m = number of days in the calculation window.

w_irr = water in gallons with irrigation system on i^{th} day within the hours of 10p to 6a.

w_i = water used in gallons after implementation of conservation program within the hours of 10p to 6a.

n = number of months for the season.

3. M&V based on conservation program data + billing data + real-time, high resolution (sub – gallon interval) water use-data

More granular real-time water use data can help in identification of volume of water being used by each water technology in a home. This level of insight can help drive efficient allocation of limited conservation program resources and inform industry in development of new products.

High-resolution (sub-gallon interval) data also enables remote diagnostics of water-using appliances and fixtures. The water use patterns can be analyzed to identify customer-specific inefficiencies. Utilities then can help customers in identifying where they are using more water and recommend conservation or rebate programs to reduce the water usage.

One of the very common rebate programs offered by many water utilities is High Efficiency Toilet (HET) program. As per EPA, toilets account for about 30% of an average home's indoor water usage and by replacing inefficient toilets water used from toilets can be reduced by 20-60%.

Utilities can analyze this high-resolution data for each of their customers and identify homes using less efficient toilets. This can be done by identifying patterns where same amount of water is being used on multiple occasions daily and is likely from a single source of water consumption.

Generally older toilets use 3gpf to 5gpf while HET uses 1.6gpf or less. Once identified, utilities can reach out to the identified customers and offer rebates as per their budget.

Utilities can calculate average savings from HET conservation program using below formula:

$$\text{Overall Savings} = \frac{\sum_{i=1}^{n} w\_old_i - \sum_{i=1}^{n} w\_new_i}{n}$$

Where,

n = number of homes identified to offer HET rebates.

w_old_i = average toilet water usage before installing HET for i^{th} home.

w_new_i = average toilet water usage after installing HET for i^{th} home.

Customers can also verify overall savings using their monthly billing data.

4. M&V based on conservation program data + billing data + real-time, high resolution (sub-gallon interval) water use data + disaggregated electric use data.

While disaggregated electricity use is not widely available now, thousands of researchers within academic and the private sector are working to develop algorithms that accurately disaggregate one-hour interval smart meter data down to the individual uses. Pecan Street is supporting these efforts through our electricity research programs and data collection efforts. Currently, Pecan Street's research instrumentation for our energy programs directly measures circuit-level use in near real-time for approximately 1,000 homes. This data can be used as a proxy for future algorithmically-disaggregated data (data use at the appliance level inferred from meter data through software as-a-service applications rather than direct measurement as Pecan Street does). Pairing Pecan Street's existing appliance-level data to whole home water data has been shown to enable disaggregation of water end uses and critical measurement & verification of individual conservation interventions – including messaging and technology-based interventions.

Looking to the day when high-resolution electric data is available, Pecan Street believes it could be low-cost approach for water utilities to develop greater insights about water use. High-resolution water and electricity disaggregated data can be used to calculate total water and energy costs and use at an appliance level. Appliances such as dishwashers, clothes-washer, etc. use both electricity and water to operate.

Total energy and water cost calculation for a given-appliance level event requires four values.

For a given event,

Total energy and water cost = total direct energy use + total direct water use +total energy embedded in direct water use + total water embedded in direct water use

This can only be done after we have identified a specific event for a given appliance in the database and then calculated the total directly consumed energy and water over time for that event. After those values have been determined using the appropriate energy and water intensity value for the given home we can compute the energy and water embedded in the use.

Let the following functions represent identification and calculation of water and energy for a given appliance performing a given end-use.

$\omega(\mathrm{i})$ - this function returns the total water used for a given activity.

$\varepsilon(\mathrm{i})$ – this function returns total energy used for a given activity.

$\omega\rightarrow\varepsilon(\mathrm{i})$ – this function returns total water embedded in the energy used for a given activity.

$\varepsilon\rightarrow\omega(\mathrm{i})$ – this function returns total energy embedded in the water used for a given activity.

Using these functions our total energy and water cost equation becomes,

$$Total\ energy\ and\ water\ cost = \varepsilon(\mathrm{i}) + \omega(\mathrm{i}) + \varepsilon\rightarrow\omega(\mathrm{i}) + \omega\rightarrow\varepsilon(\mathrm{i}) \quad [1]$$

Some residential activities are the combination of several appliance-level activities. For example, "doing laundry" typically involves two activities, washing clothes and drying clothes. To understand the total energy and water cost of "doing laundry" we need to combine the total energy and water cost for washing clothes and for drying clothes. We can represent "doing laundry" mathematically by first representing the appliances needed to complete the task in a set.

Let *clothes washer* be represented as *CW* and *electric clothes dryer* be represented as *CDe*.
Let A = $\{CW|CDe\}$, here A represents the set of appliances used in the activity of "doing laundry".

Given A= $\{CW|CDe\}$
Total water cost = $\Sigma_{i\epsilon A}\ \omega(\mathrm{i}) + \omega \rightarrow \varepsilon(i)$

Total energy cost= $\Sigma_{i\epsilon A}\ \varepsilon(i) + \varepsilon \rightarrow \omega(i)$

Where,

$Total\ Water\ Cost\ of\ doing\ laundry = \Sigma_{i\epsilon A}\ \omega(i) + \omega \rightarrow \varepsilon(i) \Rightarrow \omega(CW) + \omega \rightarrow \varepsilon(CW) + \omega(CDe) + \omega \rightarrow \varepsilon(CDe)$

and,

$Total\ Energy\ Cost\ of\ "doing\ laundry" = \Sigma_{i\epsilon A}\ \epsilon(i) + \varepsilon \rightarrow \omega(i) \Rightarrow \varepsilon(CW) + \varepsilon \rightarrow \omega(CW) + \varepsilon(CDe) + \varepsilon \rightarrow \omega(CDe)$

Since no water is used when drying the clothes, the following functions evaluate to zero.

$\omega(CDe) = \epsilon \rightarrow \omega(CDe) = 0$, and

$Total\ Water\ Cost\ of\ doing\ laundry = \omega(CW) + \omega \rightarrow \varepsilon(CW) + \omega \rightarrow \varepsilon(CDe)$

$Total\ Energy\ Cost\ of\ "doing\ laundry" = \varepsilon(CW) + \varepsilon \rightarrow \omega(CW) + \varepsilon(CDe)$

References:

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