Introduction

For electricity and gas utilities, the adoption of smart meters and advanced metering infrastructure (AMI) has been largely driven by regulatory efforts to enable a carbon-free energy system, to support renewable energy load growth, and to enable a smarter energy infrastructure, as well as utilities’ internal efforts to provide better customer service while at the same time increasing operational efficiency.

While the water utility industry has not faced the same kinds of regulatory pressures, the same motivation to provide better customer service and increase operational efficiency has been a leading driving force in leading water utilities’ deployment of smart meters and related technology. Through the deployment of smart meters, water utilities are extending their reach all the way from generation to the end customer. With smart water grids, we can now understand in detail how each piece of the network is stressed, connected and contributing to overall performance.

Smart Metering: extending the horizon of Network Monitoring

This end to end transparency is a unique opportunity for water utilities, as droughts and aging infrastructure issues put increased pressure on them around the globe. However, while this data provides many benefits, it is not a trivial technology exercise to deliver this new capability from an IT perspective, and certainly not one that water utilities are used to encountering. As a consequence of smart meter deployments, water utilities are faced with managing many times more information than before, and it is this volume of data that underscores the need for Big Data Advanced Analytical capabilities.
The Challenge

Smart metering has forced utilities to face the “Big Data Analytics” paradigm. Receiving hundreds of thousands of times more data on a daily basis makes the task of assimilating it and drawing reliable, actionable conclusions from it even more difficult. “Big Data” is characterized by the following four Vs:

» the Volume of data is very high;
» the Variety of data sources is extended (measurement data, weather, network topology, type of equipment, alarms recorded by the equipment, structured and sometimes unstructured data, etc.);
» the Velocity at which data is sampled, acquired and potentially may need to be processed is high; and
» the Veracity of the data is all relative (i.e., the information collected is not reliable), making interpretation difficult.

Big Data Analytics: 4 Vs characterizing Big Data environments

Big Data also represents a technology challenge. For a successful implementation, high-performance infrastructure and data management technology is needed. Powerful data integration, and analytical tools with native business visualizations, are also needed for a comprehensive solution. Implementing such architectures requires ownership of all integration pieces as well. Finally, qualified resources with experience in those technologies are still scarce, as pinpointed by a 2013 Oracle study[^1] noting that 62 percent of utilities surveyed in the energy sector in the United States believed their utility had a skills gap around smart grid data.

This is also a challenge for the business teams within the utilities. Much of the existing utility talent base does not have the technical understanding of what analytic methodologies should be used to most accurately understand the story the data is telling. In the sea of data provided by smart metering infrastructure, it is difficult to know what to look for and what analysis is needed to find it.

Given this context, “Big Data Analytics” capabilities should encompass:

» Business-relevant tools for exploration and visualization of data.
» Relevant tools for both deep and rapid ad hoc analysis of the data.
» Capabilities to operationalize advanced analytics to be run on a daily basis on the live data.
» Support of data scientists familiar with both smart grid data and analytical tools to help you develop and adapt the most reliable analytical algorithms.

The Opportunities

The value of the data—the Data Capital—that these smart metering systems make available is immense. Bundled together with the new investments in network sensing devices (such as leakage detection sensors, district flow

monitoring, pressure logging or network water quality measurement, etc), this represents a gold mine that is awaiting adequate mining.

Specific to water utilities, some of the key areas where value may be generated include business domains such as:

» Improved Advanced Metering Infrastructure Operations
» Optimized Meter Management and Revenue Management
» Improved Customer Service
» Improved Distribution Operation & Planning

Applying Big Data Analytics: Delivering Actionable Insights

Improve Advanced Metering Infrastructure Operations

Water utilities deploying smart water metering are confronted with the issues of ensuring the reliable operations of the overall system. Maintaining a healthy AMI infrastructure and understanding the root cause of malfunctions quickly is key to cost-controlled and sustainable performance. This includes:

» Pinpointing malfunctioning communication modules, or connectivity issues between modules and meters.
» Filtering and prioritizing all field devices events to find real problematic situations.
» Troubleshooting communication infrastructure issues, such as unreachable meters, low batteries impeding correct communication and incompatibility issues between devices of different manufacturers.
» Measuring and detecting data capture service level degradation and identifying root causes.

EXAMPLES

Distinguishing network vs meter issues:
By mining AMI Infrastructure performance and data collection success rates, different repeater profiles can be identified, which in turn allows the identification in detail of whether it is the meter or AMI infrastructure component that is underperforming.
Inventory demographic profiling:
Understanding performance of individual devices depends upon understanding devices’ manufacturers and their respective level of interoperability. An example of this is firmware compatibility levels. This, in turn, drives equipment selection and firmware deployment policies.

Network Performance:
Understanding connectivity over time from meters to repeaters by tracking badly covered areas and identifying issues such as poor communication due to surrounding construction which may in turn alter AMI deployment plans.

Optimize Meter Management and Revenues
Meters are at the very heart of utilities’ cash flow. Non-technical losses (also called commercial losses) can significantly impact the utility’s bottom line. Water that is delivered but not billed directly impacts the company’s profitability. The ability to mine the smart meter data in this process can aid in the following:

- Quickly identifying slowing meters using not only usage data, but also meter events, possible start/stop statistics, or even other data logged (such as the percentage of consumption consumed at different flows). This is related to well-known issues with decreasing accuracy due to meter aging; consumption benchmarking and peer-to-peer comparisons can bring additional qualification criteria.
- Identifying problematic zero consumption meters corresponding to broken or blocked meters.
- Identifying inadequate meter sizing that may significantly affect the usage metering accuracy.
- Quickly identifying and prioritizing meter-to-cash exceptions, including high/low bills, possible customer leakages, or drastic consumption changes to proactively engage customers and reduce re-bills.
- Detect any data inconsistencies (wrong locations, lost customers, etc.).

EXAMPLES
Meter malfunction root cause:
By mining AMI data for both lack of consumption data and meter/communication events, one can proactively identify battery module failure and understand root causes of these failures (including location, temperature history of premises, manufacturers, year of make, and distance to repeaters).
Commodity monitoring:
By understanding slowing meter patterns, and influencing factors (such as manufacturer, diameter, historical load, installation location), one can identify both slow slowing meters and fast slowing meters by analyzing the percentage of volume at different flows.

![Graph showing slowing meter patterns and influencing factors.]

Anomaly detection:
Mine flow histograms (% of volume metered / flow) to detect meters working outside of their normal range leading to wear or commercial losses (Qmin-Qmax).
» Mine zero consumption meters to detect and distinguish meter failures from vacancies to increase hit rates, and correlate based on temperature
» Mine hourly data to determine communication issues, find leaks, and identify time of use for irrigation customers.

![Graph showing anomaly detection with flow histograms.]

Improve Customer Service
Customer service is all about trust and value. Insights gained from data can help support informed conversations, improve service, and deliver more value to end customers of water utilities. Ensuring reliable meter-to-cash processes are also at the heart of the relationship with customers; sometimes extended manual review is required to confirm no issues appear that could potentially generate inaccurate billing and cause customer discontent. Beyond billing, new services may also be delivered, thanks to better qualified insights around customers. Adequate data mining around usage information along with extended customer insight can allow utilities to:
» Proactively engage with and support informed conversation with customers based on detailed usage insight, as well as consumption benchmarking with each customer’s peers; engage in water saving and/or budget control behaviors with customers.
» Better and extended engagements with pre-empted notification of abnormal consumption, consumption during expected vacancies during holidays, leakage detection, security monitoring, etc.
» Implement creative conservation programs mining customer base usage patterns to encourage water savings or social tariff programs, such as block tariffs or time-based price discrimination models.
» Better understand / monitor service outage events and their impact on customers.
### EXAMPLES

#### Informed Customer Service:
Detailed usage insight including previous history and peer-to-peer comparison can help drive informed discussions with customers and diagnose misuse, troubleshoot billing issues or drive rational use campaigns.

#### Supplemental Services:
Provide value-added services such as vacancy consumption detection and major leakages situations automatically and reliably taking advantage of detailed customer insight.

#### Customer Targeting:
Target customers for conservation and rebate programs using segmentation by various attributes (lot size, household size, etc.).

#### Program Design:
Implement water-saving programs and monitor compliance over time for overall water consumption reduction, drought periods and watering prevention by analyzing water use and peer to peer benchmarking.

#### Improve Distribution Operation & Planning
By extending the monitoring down to customer end points, smart metering is enabling an end-to-end understanding of flows and service quality from the water production plant down to virtually a customer’s water tap. What used to be performed as ad-hoc flow studies requiring extensive investments, field crews can now run continuously. The usage of smart meter data, in conjunction with newly installed network sensors, allows utilities to:

- Identify and prioritize **areas with high losses** and poor service conditions.
- Drive **better localization and prioritization** of field operations for leakage detection and remediation.
- Detect **abnormal equipment states** like valves and network district separation.
» Confirm / measure extension of service outages and water pollutants.
» Run root cause analysis for all events to better understand the evolution of conditions and causes.
» Optimize / improve pressure plans based on better insight on customer perceived service levels.
» Quickly identify safety hazards from backwards flowing meters; perform root cause analysis of backwards flow issues.
» Optimize pumping plans against energy sourcing cost, based on detailed water demand insight.

From a planning standpoint, detailed usage insight allows utilities to understand and predict future consumption and usage accurately, and identify possible network upgrade requirements as new consumers get connected or their usage evolves. Detailed understanding of overall asset conditions during the operations allows for stress monitoring and better overall investment planning.

EXAMPLES

Aggregated Data Views:
Ability to aggregate bottom-up consumption data along network infrastructure thanks to connectivity data; mismatch per districts, per pipes may allow to identify areas with issues (technical losses or data quality issues).

Correlation Analysis:
Temperature correlations, as well as other analysis, allow the utility to quality leakages on the network or in premises and their possible locations.

Outlier Detection:
Connectivity and network asset information can also allow the utility to track network asset stress and outlier operation situations to predict early failures or abnormal condition operation (low/high pressure events, bottlenecks) in conjunction with operation events (valves switches, pumping, etc.) may help predict failures.

Real Results
Big data analytics solutions are best justified through real results. Here are some specific examples highlighting how utilities have been using Oracle DataRaker analytics to deliver better service at lower cost:

» Meter-to-Bill operations: Quickly and more accurately identified defective meters or metering conditions. By eliminating false positives, a utility in the U.S. Midwest was able to reduce one of its manual review work queues
by 80 percent and its largest back office billing exception work queue by 38 percent. Another utility in the southeast United States leveraged analytics to create an automated process to prioritize billing exception queues from its legacy Customer Information System (CIS). This increased the hit rate effectiveness of its High/Low billing process from 2 percent to over 90 percent, allowing for a time reduction equivalent to 2.2 full-time employee hours per year. Another Midwest utility using water leak detection tests reported a 90 percent hit rate on Oracle DataRaker generated leads.

» **Meter maintenance**: Reduced break-to-fix time from 90 days to 30 days, cut re-bills by as much as 50 percent, and recovered in billing months of consumption which would otherwise not have been billed. Another utility achieved a four-fold improvement in identifying zero-consumption meters, resulting in 75 percent fewer truck rolls to fix the same number of broken meters, saving hundreds of thousands of dollars on a yearly basis.

» **Rational use and conservation**: Identified with 99 percent confidence consumers complying with water saving recommendations and forbidden watering instructions; determined overall effectiveness of a water conservation program for a utility by looking at total water savings, demand response from customers participating and comparisons to historical years; and segmented irrigation and domestic water use populations for a Midwest utility to find outliers to target for conservation programs.

» **Grid operations**: Reduced premature asset failure and outages by identifying overloaded assets, improving planned network investments strategy.

» **Revenue protection**: Detected thousands of theft situations, leading to the recovery of millions of dollars in lost revenue, achieving up to 80 percent-plus hit rates on specific detection algorithms; detected and prioritized thousands of non-technical losses from unbilled usage for a Midwest utility.

» **Safety**: Identified hundreds of backwards-flowing meters and mitigated risk of water contamination from these issues.

How to Get Started: Quick-Win approach with Advanced Analytics Cloud Services

Is your utility using analytics to drive similar business value? What areas should you focus on? Where are the biggest opportunities? Oracle understands the importance of Big Data Advanced Analytics for the digital utility of the future. We work with utilities around the world to drive business efficiency utilizing the data they already own from smart meters and smart grid devices to improve business processes. We understand how important it is for utilities to be able to deliver quick results.

Practical Approach. Real Results.
Oracle DataRaker delivers a turnkey Cloud service solution to deliver real value to your business operations, quickly and easily. In a matter of weeks, Oracle DataRaker will take your data and integrate it with additional available and relevant data sources. Our utilities data scientists will deliver results from our existing library of algorithms, and will also work with you to develop new algorithms targeted and tailored to your needs. The results? Practical outputs. In a matter of weeks, utilities start improving operations with actionable insights.

As each utility progresses in its analytic adoption journey, the Oracle DataRaker teams will work to further expand your analytic footprint to new domains across the enterprise and to deliver more value across all utilities operations.

End-to-End Service from Exploration, Profiling, Advanced Algorithmic and Data Scientists

To us, analytics is not just a theoretical exercise; it is a pragmatic approach to getting the most out of the enterprise’s operations by providing top-quality, best-of-class, personalized solutions for our customers.
Mastering Water Smart Meter Advanced Analytics
April 2015
Author: Oracle Utilities