Silver Spring NETWORKS

CASE STUDY:
UNITED ENERGY

Maximizing AMI Investment in Australia with Data Analytics

How much benefit can a utility derive from the analysis of AMI data? United Energy is finding out.

BUILDING ON A MANDATE

In 2010, Melbourne, Australia-based utility United Energy (UE) began installing AMI meters for all residential and small business electricity customers as mandated by the state government of Victoria. By 2015, the installation was complete with roughly 653,000 smart meters reporting basic billing and outage information to UE's back-office systems via a Silver Spring Networks (SSN) RF mesh network.

With the AMI implementation delivering on the initial targeted goals related to billing and outage, UE launched an advanced analytics initiative in 2012 to maximize the investment and fully utilize the data gathering capabilities of its smart meters to improve grid performance. By collecting and analyzing additional data, UE is proactively addressing service challenges, deferring network capital investment, driving operational efficiencies and realizing cost savings that are returned to UE's customers.

2010
- UE Begins AMI Meter Deployment

2012
- UE Begins Using Meter Communication Pings for Outage
- UE Begins Meter to Transformer Connectivity Mapping Exercise

2014
- UE Begins Deployment of Analytics Data Warehouse

2015
- UE Completes the Installation of 650,000 AMI Meters Across their Service Territory
- UE Fully Deploys SensorIQ™ with 5 Minute Intervals for all 650,000 Meters

2016
- UE Begins Trials for 1 Minute and 10 Second Interval Collection on Subsets of their Meter Population

High-level deployment timeline

To date UE's analytics team has developed more than 25 use cases for AMI meter data. In this whitepaper, we'll cover seven of them that have proven most beneficial to the utility thus far:

- » Neutral integrity monitoring
- » Service degradation monitoring
- » Backbone fault location
- » Transformer faults & neutral failures
- » Meter-to-transformer mapping
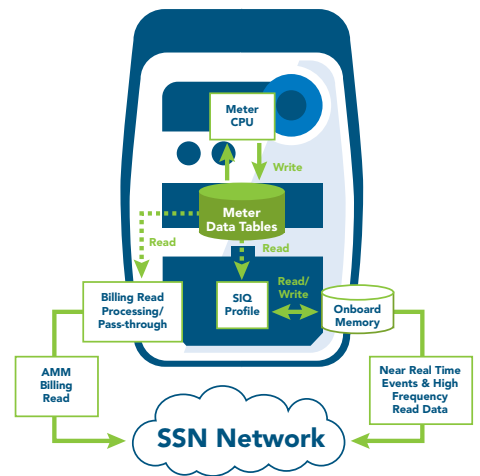- » Transformer loading & phase identification
- » Non-technical losses

UE'S ANALYTICS PLATFORM AND PERFORMANCE

The deployed SSN field area network consists of a RF mesh network that will aggregate many thousands of devices to a single cellular or Ethernet data backhaul. The network is managed, monitored, and integrated with UE's business systems via a back-office software suite (UIQ). For this system, UE is gathering 30-minute interval reads every hour (currently performing with a 99.83% read success rate) to support billing. Meter events and near-real-time power up/

down notifications also are gathered by the system to support meter operations and outage management. For the purposes of outage and billing, this system has met and exceeded expectations. However, UE desired to leverage their AMI meter and network investment further by gathering more fine-grain and real-time data to support grid operations.
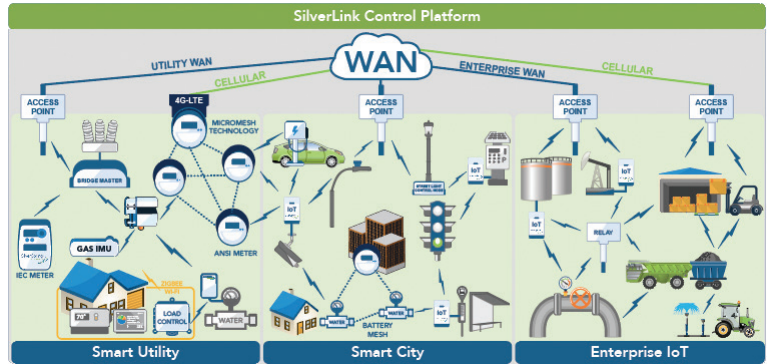
Outside of the defined outage and billing process, UE could initiate on demand "read jobs" from the back office software to collect point-in-time data elements from the smart meters in the field. However, their vision for a robust grid operations analytics program required more granular, time-stamped data from all endpoints on their network than this feature functionality could deliver. The challenge was to create an automated system for collecting, storing and analyzing massive amounts of data over the AMI network in a manner that didn't jeopardize established billing functions or bottleneck back-office systems.

To achieve this vision, United Energy uses Silver Spring Network's SensorIQ software to manage a parallel path (from billing) for the collection of new AMI analytics data. This programming package establishes a separate meter data gathering and alerting profile on

What's happening inside the meter?

the SSN network interface card (NIC) within each meter. UE analysts can program and reprogram the SensorIQ profiles on the interface card without ever touching the installed meter programming or the meter-to-cash data pipeline integrations. The software then pushes the gathered information to a separate, purpose-built, onsite analytics data store at UE for analysis and reporting (versus pushing this data into MDMS and CIS systems).

Currently SensorIQ reads five-minute interval data (instantaneous voltage, current, and power factor) on 650,000 meters, one-minute interval data on 5,000 meters, and ten-second interval data on 300 meters across their AMI network. All intervals are stored and time stamped on the NIC utilizing the built-in time synchronization mechanisms of the SSN network. This provides a (very) near-real-time and high-resolution snapshot of the entire distribution grid network and supports several important business use cases.
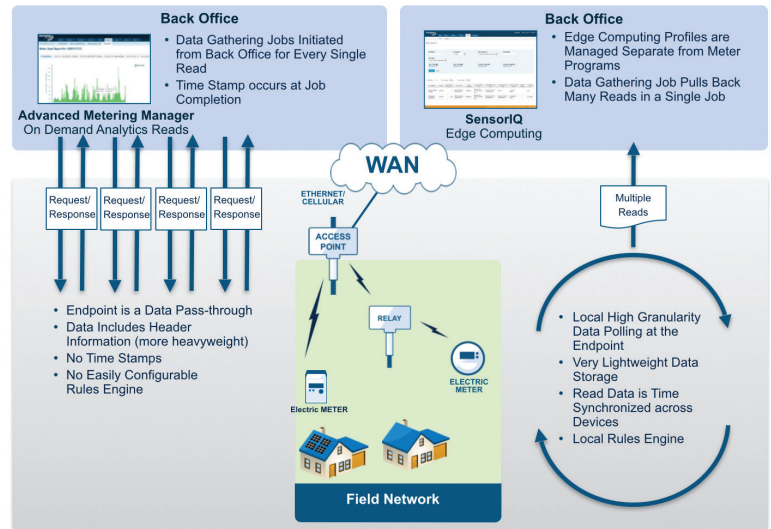
Benefits of an edge-computing approach to analytics data gathering

USE CASE #1: NEUTRAL INTEGRITY MONITORING

A loss-of-neutral condition at an electric service point consists of a degraded neutral line that can cause the surrounding equipment to become energized due to the lack of electric return path from the house. This is a very serious safety issue and over the last decade, three people have been killed by loss-of-neutral accidents in Australia. As a result, regulations now require Australian utilities to inspect customer meters once every ten years. United Energy sought to improve this monitoring practice by gathering and analyzing better data from their customer's service points.
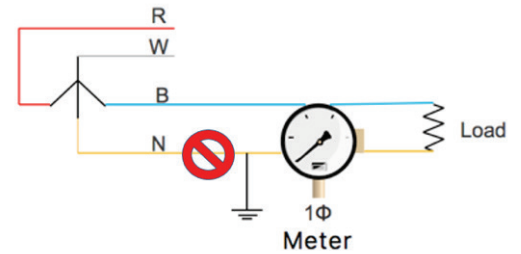
Loss of neutral on a single-phase meter

By collecting five-minute intervals once an hour, United Energy remotely inspects every customer meter 24 times a day for the danger of an open neutral and stray voltage—a vast improvement over once every 10 years. The algorithm estimates impedance of every customer's home to detect this condition. If the impedance surpasses 1 ohm, it's considered a "fail," and a truck is dispatched for service repair. This program also can be used for post repair validation to ensure that the work was completed appropriately and electrical patterns have returned to normal.

Meter Temperature Alerts
Monitoring for meter temperature is another common safety use case among SensorIQ customers. In the current version of SensorIQ, temperature threshold alerts can be set on the network card and analytics can run evaluations based on instantaneous demand, time of day, season, or other factors to identify problems before they happen.

Supply service-line failures and degradation

In 2016, UE performed 1,200 proactive repairs based on neutral integrity monitoring with a 98% success rate for identifying faults. Electric shocks were down more than 50% for the year (from 70 to 33) and UE expects to halve that number again in 2017 as they continue to improve the monitoring algorithms and applications. UE also is developing a risk analysis application to estimate the voltage on a neutral, which can help to quantify the severity of the problem.

USE CASE #2: SERVICE DEGRADATION MONITORING

Measuring the impedance of a customer's home over time, allows United Energy to spot trends in service degradation and extend asset life. Previously, UE replaced a percentage of service connections every year based on end-of-life estimates for the age and type of equipment. Now the utility is able to defer much of that $15 million (AUS) in capital expenditures through just-in-time, predictive scheduling of service replacement.

The impedance of a home increases near the end of asset life, then returns to baseline after the degraded service equipment is replaced
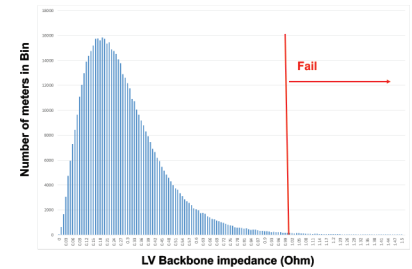
Predicting a failure causes a change in the typical customer interaction as, according to UE, customers often don't notice a change in their service and are surprised when repair crews arrive. However, surprise often turns to appreciation when crews explain the purpose of remote monitoring and point out obvious signs of degradation that were identified and remediated prior to any unpredicted loss of service.
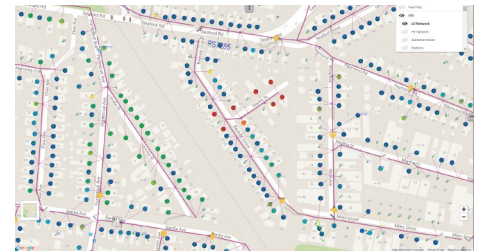
USE CASE #3: DISTRIBUTION FAULT LOCATION

Monitoring the quality of service to customers in close proximity to one another eliminates much of the guesswork in locating distribution grid infrastructure problems. Ultimately, this reduces trouble-order resolution times and operational expenditure.

Identifying low-voltage reticulation faults

Before implementing UE's AMI analytics program, when a customer complained about power quality issues, crews might have spent days trying to identify the root of the problem. It wasn't unusual to replace a service point only to discover the problem was in the distribution grid and affecting numerous homes. (In Australia up to 60 customers may be connected to a single transformer.) Now UE can determine remotely whether or not nearby homes are experiencing similar disruptions, use this information to identify the pole or underground connection where the problem originates, and direct crews straight to the problem. In fact, UE can sometimes even point to a specific cross-arm connection by using GIS tools and studying the pole from the back office before a crew arrives on site.

In addition to effectively reacting to problems, UE developed an application that regularly monitors for signs of faulty low-voltage distribution connections to predict failures. The application generates and compares backbone health "scores" for each segment and locates bad connections. In addition, it enables predictive maintenance scheduling and generates significant field-maintenance savings that result in better power quality and further savings passed back to customers.

USE CASE #4: TRANSFORMER FAULTS & NEUTRAL FAILURES

With AMI meter data alone, UE is able to monitor 12,000 substations each hour for fault detection and failing neutrals. If a fault is detected, the system automatically issues an order and fault location to the utility's DMS for truck dispatch. UE saidit is averaging seven fault detections per month and the operating response has become so efficient that repairs are often completed before customers even realize there's a problem.

Simple distribution transformer design

Identifying transformers with failing neutrals is another major benefit of this monitoring. When a substation loses neutral, it often results in enormous voltage spikes and dips that could damage thousands of dollars in customer equipment, including smart meters. Processing and repaying these claims is a significant cost to the utility, and one that largely can be avoided through proactive monitoring of the data.

Since implementing this monitoring algorithm, UE has been able to catch a handful of transformers trending quickly towards failure and reroute work crews to the site immediately. Often the crews were already enroute, or even reached the equipment, before catastrophic failure occurred.

USE CASE #5: METER-TO-TRANSFORMER MAPPING

Errors in the distribution connectivity model are a problem most utilities have encountered, mainly caused by human/system error and the rapid emergency work that often needs to be managed as part of an outage event. To improve this, United Energy has used the AMI data to gradually correct and refine the mapped model of the distribution network resulting in smoother operations and reduced regulatory fines.

UE's algorithms have uncovered a 4-6% error in the mapping of customer-to-substation relationships. The analytics team developed an application that regularly validates the connectivity model against the AMI data. The application automatically cross-references meters to the correct substation and identifies when customers have been assigned to the wrong side of low-voltage distribution open points. In addition, the application uses triangulation and GIS to locate meters that have been lost through the misfiling of serial numbers or other "paperwork" mistakes.

UNITED ENERGY AMI INSTALLATION (2010)
 » 653,000 Secure™ AMI Meters
 » Integrated SSN network card (Multi-generation NIC)
 » 300 RF mesh network access points; 800 relays
 » 99.88% of reads daily

Initial Applications
 » Automated billing
 » Outage reporting

AMI ANALYTICS IMPLEMENTATION (2012)
 » SSN Sensor IQ
 » Standard licensed enterprise data platform
 » United Energy custom analytics

Advanced Applications
25+ use cases in development, including:

Neutral integrity monitoring
 » Exempted from 65,000 yearly manual inspections

Service degradation monitoring
 » $15M in annual batch replacements deferred

Backbone fault location
 » $ Thousands in annual field maintenance savings

Transformer faults & neutral failures
 » $ Thousands in avoided customer damage claims

Phase identification
 » $100s of thousands in avoided AUGEX

Meter-to-transformer mapping
 » $ Millions in avoided regulatory fines

Non-technical losses
 » $100s of thousands in theft mitigation

Accurate model-mapping helps UE correctly notify customers of upcoming planned outages and prevent regulatory fines associated with incorrect customer notifications. It also ensures customers are assigned to the appropriate transformers (and subsequently phase and circuit) for accurate load aggregations to the transformer, relevant phase, and circuit level.

USE CASE #6: TRANSFORMER LOADING & PHASE IDENTIFICATION

Managing load for distribution transformers is typically a large asset-management expense for utilities. But by monitoring the voltage and current profiles of all the customers on a single transformer, UE is generating tens of thousands of dollars in avoided costs. UE uses these profiles to determine the phase connectivity of every customer on a transformer. The aggregated current profiles indicate phase unbalances that could cause the overloading of a single phase. At UE, most substation outages, especially on hot days, are due to overloading a single phase and causing the LV fuses to trip. In some cases, this also could lead to damage to the transformers.
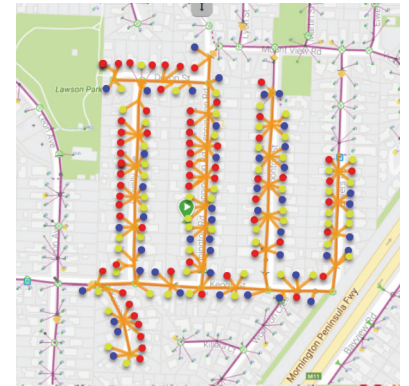
Pattern matching results in improved phase mapping for the distribution system

Measuring distribution phasing in the field through traditional methods is prohibitively expensive to perform on a large population. Now, UE can perform the measurement from the back office by leveraging the AMI data in their GIS toolset. UE can remediate overloading scenarios by identifying peak users that should be moved to a different line, or they can choose to upgrade LV fuses.

This application improves overall reliability, helps meet regulated voltage requirements and reduces LV fuse operation. According to UE, accurate information about load balancing transformers also results in hundreds of thousands of dollars in avoided capital expenditure for unnecessary system augmentations.

USE CASE #7: NON-TECHNICAL LOSSES

Marijuana grow houses, which use large amounts of electricity to power grow lamps, regularly bypass electric meters so consumption levels look normal in billing cycles. The extent to which United Energy had a problem with this type of electricity theft was unclear until the analytics team began analyzing voltage and current data for revenue protection. With the fine grain AMI data, UE can determine when supply is being taken out unlawfully for marijuana production. The analytics team also developed investigation tools to determine exactly how much electricity has been stolen, and over how long of a period.

In the first year alone, they were able to uncover 150 cases in need of further investigation by authorities. Initially, UE would support local law enforcement who would come to the utility to help analyze a suspected grow house. However, the process has matured to the point authorities are issuing search warrants based on UE's analytical methods.

Data-Driven Conservation Voltage Regulation (CVR)
For years, grid operators have tried with varying levels of success to estimate voltage requirements and mathematically model conservation voltage regulation (CVR) programs. Now several SensorIQ customers have eliminated the guesswork. By constantly monitoring voltage at the meter, they can feed near-real-time data into their CVR calculations to reduce peak demand and improve grid efficiency.

Beyond theft, UE also found another 150 instances of incorrectly wired or failed meters that would not have been discovered through conventional methods.

ANALYTICAL INNOVATIONS UNDER DEVELOPMENT

In 2017, UE's analytics team plans to continue fine-tuning their system to collect more granular and real-time data through SensorIQ. Currently, the team is gathering data over the network every five minutes for 20% of their meters to move closer to real-time data and looking to deploy that collection schedule to the remainder of their population. Alternatively, it could mean installing another profile on each meter that would utilize the onboard rules engine at the endpoint—a method that would offer a more targeted approach and reduce network bandwidth utilization by processing data in the field.

Lastly, future iterations of SensorIQ will enable additional and complex logic operations to be programmed onto the endpoint. As this edge-computing capability matures, UE will begin running more algorithms on the SSN network card, as opposed to in the back office. This has the potential for drastically improving response times on critical events like neutral failures, and it can reduce back-office and network-data overhead. Instead of doing evaluations on the back-office analytics platform every hour, certain evaluations can be performed at the meter on a minute-by-minute basis and report back only actionable data.
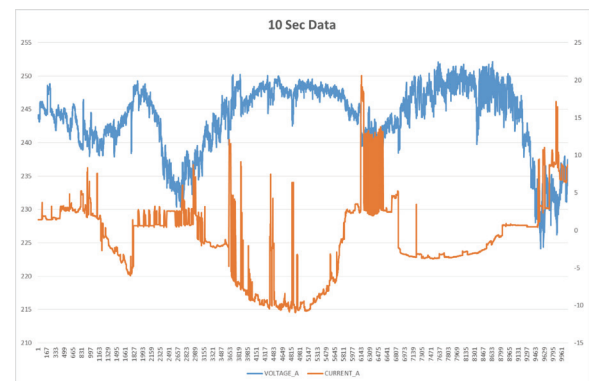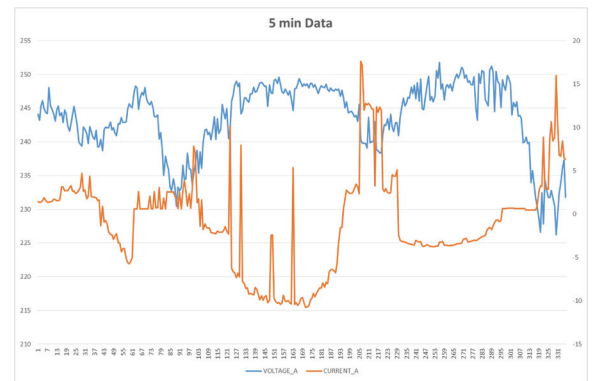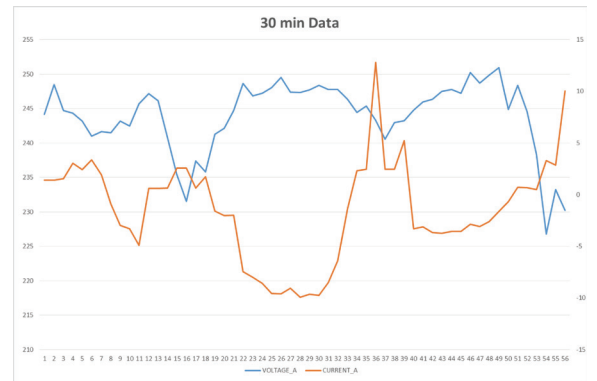
Improvements in data gathering result in far better resolution for grid analytics

Thinking Generations Ahead

United Energy's AMI analytics are enabled by Silver Spring's multi-generation network communications card. Currently, our 24+ smart meter manufacturing partners and dozens of applications partners are integrating our newest Gen5 communications module, which has exponentially more memory and higher data-transfer speeds.

However, as a dedicated network platform provider, our hardware engineers have always thought years ahead of the data-analytics field. That's why UE's 2010 network communications card, performs admirably in 2017 and will continue to provide tremendous value for years to come. Furthermore, we're adamant at SSN about maintaining backward compatibility to protect all of our customers' hardware investments.

THE TAKEAWAY ON AMI ANALYTICS

"The use of SensorIQ to provide high frequency voltage, current and power factor data from United Energy's smart meter population on the Silver Spring mesh network has changed the way we manage and operate our electricity network," said Tobie de Villiers, United Energy's network intelligence manager. "This high granularity, time-synced across all meters, and near-real-time data has been hugely beneficial as an input to our network and compliance management, customer claim management, and revenue protection. It has also provided valuable insights to help us increase low-voltage network reliability and reduce some safety risks to our employees and the community."

Analytics In a Box
United Energy has the expertise and capacity to build its own data-analytics platform and develop its own algorithms and applications for using Sensor IQ data. However, Silver Springs Operations Optimizer™ offers out-of-the-box hardware, software and analytics support for:

» AMI Operations
» Grid Operations
» Revenue Assurance
» Customer Programs

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