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AMI & TRANSFORMERS

Using AMI Data to Appropriately Size Instrument Transformers and Improve Billing Accuracy

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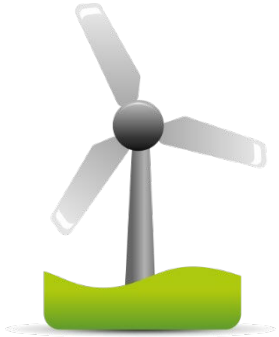
What is an Intra- Grid Sensor?

A sensor used to provide detailed information about conditions that exist between the distribution transformer and the meter.

Why do we need Intra- Grid Sensors?

We are now stressing grid assets with increased unplanned burden and never previously conceived pressures.

Many utilities are still without the comprehensive data that will accurately reveal the intra-grid dynamics created by these changes.



DISTRIBUTED ENERGY RESOURCES (DER)

Through solar and wind renewables, we are introducing Reverse Energy onto the distribution grids.

The millions of existing transformers were not designed to handle this impact.

While renewables are beneficial, Reverse Energy can produce unstable, and unsafe grid conditions.

DISTRIBUTED ENERGY RESOURCES (DER)

Intra-grid sensors accurately measure and report Reverse Energy, and its impacts on the grid.

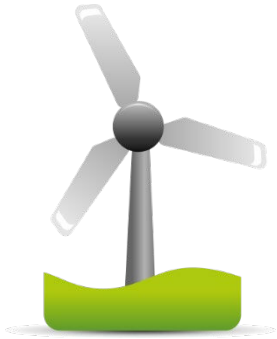
Utilities without AMI, or “smart meters” need intra-grid sensors to understand the Reverse Energy impacts inside their grid.

Utilities with AMI need intra-grid sensors to understand Reverse Energy impacts on transformers.

DISTRIBUTED ENERGY RESOURCES (DER)

The reality is that AMI generated Reverse Energy data does not accurately indicate impacts on transformers or the resulting grid impacts.

AMI data is typically not accurately aligned to the upstream transformers due to pervasive GIS mapping errors, thus causing aggregated AMI data to be unreliable.



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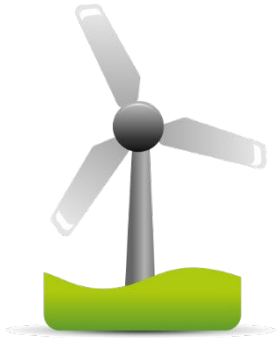
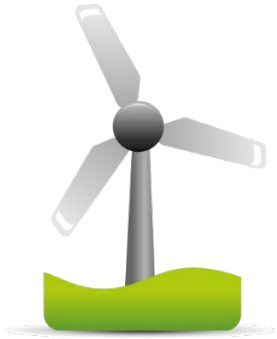


REVERSE ENERGY

AMI-deployed utilities might think they know Reverse Energy impacts, the truth is they typically do not possess accurate AMI-to-transformer information.

This can leave linemen in a position of not knowing what to expect when they approach DER-active transformers.



Aging Assets

According to the US Department of Energy, the average age of existing distribution grid transformer is presently in the range of around 38 years.

The average projected life span of transformers is typically 25 years so many transformers have already eclipsed their intended life span, yet we demand more performance, reliability, and various unintended service capabilities.

Aging Assets

Intra-grid sensors proactively reveal over-burdened and failing transformer assets allowing operators to effectively enable preventive maintenance efforts.

This approach enables operators to transition away from costly and disruptive, reactive grid management practices.

Meter Programming Issues

An incorrectly programmed meter can result in significant errors.

For example: a meter programmed for a 200:5 transformer but has a 400:5 transformer will significantly misreport usage.

What are System Losses?

Energy generated by Power Station does not match energy distributed to the consumers.

The difference between generated and distributed energy is known as Transmission and Distribution loss; aka system loss.

System loss is the energy that is generated but not paid for by users.

Line Loss

According to US Energy Information Administration reports, nearly 200 Billion unmetered kWh's are 'leaked' from US distribution grids annually.

This loss represents nearly $21 Billion that was unmetered but was amortized as electricity cost across rate payer's bills.

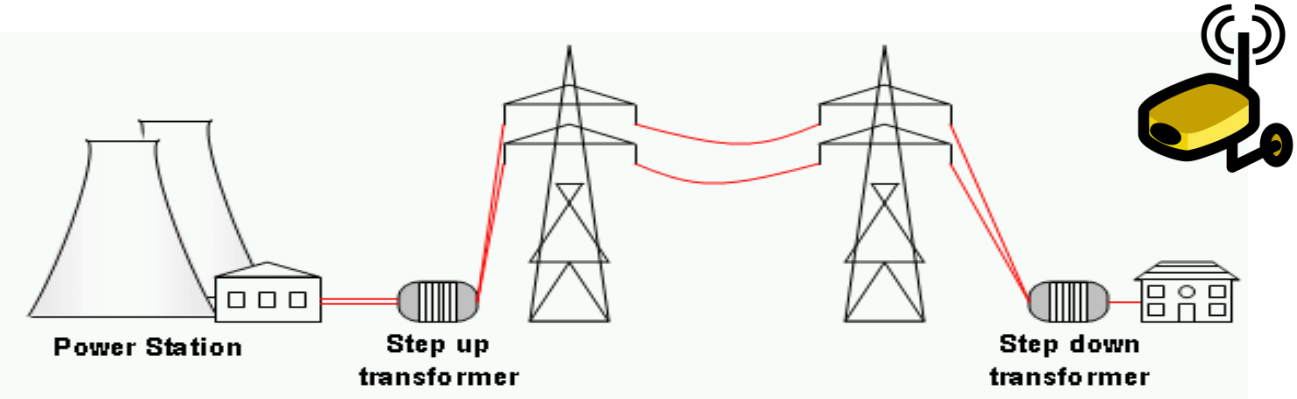
All of this while our government, utilities, and rate payers have been investing billions of dollars in 'smart meters', and other energy efficiency efforts.

LINE LOSS

Electric distribution grids do not have adequate sensor technology and analytic capabilities to allow utilities to directly reduce system losses.

As a result, a blind spot exists between the substation SCADA and the AMI meter.

Intra-Grid Sensors can provide visibility into this critical area.



The Promise of AMI

The introduction ten years ago and the continued development of an Advanced Meter Infrastructure (AMI) system promised more effective and more efficient Meter Service Operations.

This was to be accomplished in a variety of ways starting with:

- No need to read meters (if AMR had not previously been deployed)
- No need to roll a truck to perform a disconnect or a reconnect
- Better ability to detect and respond to outages
- Better ability to detect theft
- Better ability to detect (and eventually capture) unbilled energy
- Better understand customer usage and make better energy buying decisions

And with all of this came a promise of “Additional Capabilities and additional Operating data.”

Moving Into The Future

Utilities now collect hundreds of millions of events and readings every day from sources such as the following:

- Meters (status, manufacturer, purchase date, events such as reprogramming notifications and tamper alerts)
- Transformers (ID, circuit section, circuit ID)
- Service points
- Customer accounts (type, status, billing cycle)

What Data Are We Getting & How Are We Using It?

- **Meter quality assurance:** Focusing on meter reading performance enables utilities to ensure AMI reliability. For instance, when meter readings are expected but not delivered, the system takes note, and calculates overall performance statistics for the AMI system. Utilities are made privy to problems they never would have been able to identify in the past.

Good Start

The Basics

- **Outage event analysis and prevention:** Integration enables real-time, accurate, and complete outage event analysis that helps identify nested outages and optimize field crew dispatch – all to support efficient response and restoration.
  - We can often determine the exact piece of equipment causing a problem, along with the customers directly impacted by it.
  - We can use outage information that is delivered along with meter readings to identify and track outages.
  - These outage event reports help us to understand the overall impact of outages, then drill down to find the problem areas in the distribution network.
  - We can then isolate areas of high impact and work to understand how to address them.

And of Course…Report!

- We can filter planned outages and momentary from this data for reporting purposes and provide meaningful customer satisfaction and performance measures and trends

  - Average interruption durations
  - Number of interruptions
  - Number of customers impacted
  - These system performance indexes and information can be shared with management, regulators, customers, media, and other stakeholders.

What Else?

- Gain a better understanding of events, as well as what they mean. For instance, we can correlate power outage events or voltage alarms with the transformers involved to identify faulty or aging infrastructure. And we can roll trucks between 8 AM and 4 PM, Monday to Friday on non-storm days.
- Generate new customer insights
- Size distribution assets
- Implement preventive maintenance techniques
- Forecast and build predictive models for demand program planning
- Develop new rate plans and services for customers
- Address Line Loss in a meaningful and impactful way

What Else?

- Potentially bad metering
- Non metering of certain usage
- Failing equipment and bad connections
- Bad GIS integration and information. To make any of this work we need an up to date and integrated geographic information system (GIS) geodatabase. We need to be able to link our meters accurately to the rest of the system along with every other piece of equipment between the sub station and the meter. The initial investigative work will uncover not system errors but GIS errors and holes. Once corrected this work will begin to uncover correctible losses.

Longer Term Planning

- Load profiling – You have accurate and highly granular transformer load profiles, especially significant for effective distribution planning when electric vehicle (EV) charging and distributed generation are involved. What will the impact on your system be as isolated pockets of users influence each other and purchase electric vehicles; adopt home level energy storage and renewable energy solutions.
- Pricing analysis – Perform ‘what if’ rate and load shift analysis. Compare current tariffs with alternative pricing scenarios. Estimate energy costs for a new rate at different load levels.

What are Some of the Challenges in Analyzing this "Flood of Data?"

The first issue is that currently data required for complete meter data analytics solution does not reside in the same database. While there is tremendous real time data being collected the information required to complete many types of analysis may reside in other data bases (e.g. system mapping data).

Another challenge is that while the MDM is configured as a "Fast Write" data base, since it needs to quickly record large volumes of real-time meter information, a useful analytics tool needs to be normalized for "Fast Reads," since it needs to provide fast access to data for users looking for real-time insights.

Additional Challenges?

- **No impact on billing:** Making sure that you can analyze the data in the MDM system (the “system of truth”) without impacting basic billing operations in any way. As important as meter data analytics is, this capability cannot interrupt billing and other operational systems in terms of performance, data corruption or functionality. Bottom line: The analytics capability cannot threaten the utility’s ability to collect revenues.

Additional Challenges?

- **Near real-time:** Lastly, in order to retain its value to executives, engineers and operational staff, data analytics need to be performed in as near real-time as possible.
- **The ultimate goal:** To establish a repeatable data analytics discipline and infrastructure to reduce the time, cost and complexity of each incremental capability, and with the lowest risk possible to the existing MDM functionality.

How Should an "Analytics" Database Be Set-Up?

The analytics database should use a different design that classifies the attributes of an event into "facts," which would include the data itself, and "dimensions" that can give the facts context such as meters, transformers, service points, customer accounts, register reads, billing values, interval readings, register readings, missed reads, data quality information and meter events.

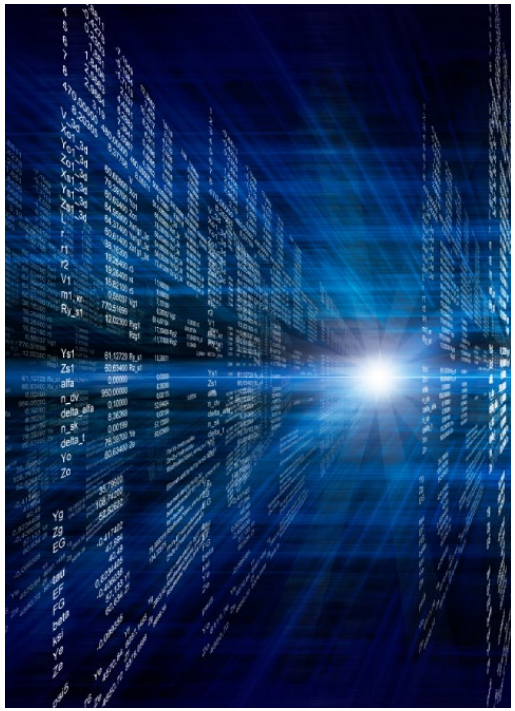
Using a "Fast Read" design, the analytics database correlates measured data ("facts") along many "dimensions" (e.g., location, by transformer, etc.) and stages them so that the data can be analyzed in many ways.

This enables users to gain more understanding of events, as well as what they mean. For instance, analysts can correlate power outage events or voltage alarms ("fact") with the transformers ("dimension") to identify faulty or aging infrastructure with a single simple calculation.

Business Use Cases for this Big Data

Now what can we do with this information? Well….To start;

- Isolate and determine where we have voltage issues, correct them and bring an entire line to the same level. This not only works better for our customers but also allows the utility to pursue voltage reduction in a meaningful and controlled way.
- Determine what transformers should be used in any location
- Determine which transformers to store in which inventory yards
- Determine when new loads are present and which transformers are in jeopardy
- Locate Bad connections
- Locate Undersized lines
- For Transformer Rated Services determine which ones are operating for a substantial amount of time below 10% of the rated current
- Find and remediate theft
- Find and remediate remote outages before the user knows they exist
- Find and address Power factor issues



New Skill Sets

- Utilities also need new skill sets to be able to perform this analysis. To use this data we need
  - Data base experts
  - Metering and operations experts
  - Business analysts

- In a perfect world all of these characteristics are rolled up into one. In a less perfect world into two. And is an even less perfect world – three individual groups or people. But too many utilities are missing one or more of these groups or people even after completing their AMI deployment.

New Tools for the Meter Shop and the Field

- Advanced functional test boards
- Automated firmware and setting comparison tools
- Site Verification equipment, procedures and data
- …….and data
- …….and data
- …….and data

AND NOW WE WANT MORE……

More data

Greater frequency

Whatever bandwidth you thought you needed, now you need more.

AMI 2.0

Can we use our existing infrastructure?

Do we have to rip out and replace with a new infrastructure?

What about LTL back haul or a Private Network?

What about Power Line Carrier? Is there life there for my most remote service areas?

New Tools

- Advanced visualization tools – Built-in tools provide an alternative to cumbersome data tables and provide enhanced visibility of your smart meters, AMI network, and distribution network
- AMI system health dashboards – A custom definable user interface enabling a visualization of real-time events and trending

2024 AND BEYOND (CONT.)

On the distribution side customers will be encouraged to put in more and more renewable energy and they will also add more and more energy storage

Residential loads will move further and further away from power factors of one and put increasing pressure to move to either a Blondel solution for them, a VA/VAR solution for them, or a correction factor for them as AMI systems begin to report back customer power factor for all metering solutions

- 12S or 2S?
- kVA/kVAR or kWh w/ PF correction?
- DC metering?

2024 AND BEYOND (CONT.)

On the distribution side customers will be encouraged to put in more and more renewable energy and they will also add more and more energy storage

- Larger customer based energy production and solutions will lead to expanded micro grids.
- Second Generation AMI and potentially new communication paradigms as LTL data becomes less and less expensive and reaches larger and larger areas.

Generation vs Storage

Utility grade energy storage will replace new generation at an increasing pace as some of the largest capital investment projects for utilities.

- The great tunnel under Niagara Falls, Ontario $1.6 Billion; 150 megawatts – part of an Ontario plan to shut all of their Coal generation Plants

New generation projects are increasingly becoming renewables coupled with energy storage

- Island communities are already showing us this on larger and larger scales – Ta'u American Samoa; 1.5 megawatts with battery storage for three days

AMI 2.0 Infrastructure

- Second Generation AMI and potentially new communication paradigms as LTL data becomes less and less expensive and reaches larger and larger areas – without new infrastructure

- Research in Power Line Carrier Technology may provide expanded bandwidth to allow for greater data transfer more frequently without as much new infrastructure

- Mesh networks continue to improve and AMI 2.0 is anticipating leveraging the infrastructure installed in AMI 1.0

How Dangerous is Metering?

Electricity is Organized Lightning – George Carlin

Any Voltage without current will not kill you, but any voltage with current can kill you.

How Dangerous is Metering?

What is Arc Flash?

While an arc flash is sometimes used interchangeably with “arc fault”, an arc flash is more accurately defined as the light produced during an arc fault. An arc fault is a type of electrical fault that results from the breakdown of an insulating medium between two conductors where the energy is sufficient to sustain an arc across the insulator (often air) and can cause extreme amounts of light (arc flash), immense heat upwards of 19,000 degrees C, and a resulting explosive pressure wave (arc blast). These forces combine to create a hazardous condition that can vaporize metal, destroy equipment, and pose a significant hazard to anyone in the vicinity.

Field Audits, Trouble Shooting and Testing

- Always approach an electrical service with caution and while wearing your full PPE. Why?
- Never stand directly in front of the meter when removing the meter
- Before you even open the box or get the cover off….
    - Live box
    - Bees
    - Other live animals
- Broken Seal
- Cover dropping off

REMEMBER...

- Be Careful
- Assume the box is live
- Assume there is something live in the box
- Treat electricity with respect
- Treat all meter boxes with respect

Questions and Discussion

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