APEX Data Consulting
Maximizing your data performance

Sanitizing Your Data and Finding Theft

(And Convincing Management To Do It)

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Agenda

- The key is interval voltage data - many benefits
- Why isn’t it being used?
- A proven approach - why low-voltage outlier technique works so well
- How it works
- How we do it
- Overcoming hurdles to implementation

The Key is Interval Voltage Data
Delivers Multiple Benefits

- Enables transformer voltage and load management.
- Enhances other revenue protection tools already in place.
- Identifies faulty connections.
- Identifies utility's GIS mapping errors of meters to transformers.
- Improves grid visibility.
  - Looking for theft takes the focus, ideally, all the way down to the meter level.
  - Reveals valuable information that wasn't even available when meter readers inspected them.

With all These Benefits...Why Isn't it Being Used?

- Utilities don't know how to use it to augment other tools, including:
  - Software solutions: Brings back incrementally more diversions because it is based on electrical theory instead of usage patterns.
  - Transformer monitoring: Help with strategic placement of transformer load monitoring meters
- Utilities are implementing it manually...but it is very slow and difficult.
- Internal issues:
  - Management not aware of ROI, uncertain how to start -- can seem overwhelming.
  - IT concerned about possible impact on them

Benefits of Adding Low-voltage Outlier Analytics to Current Tools

- Transformer Operational Integrity/Efficiency
- Safety
- Immediate ROI
- Reduced Ratepayer Fees, Better Service
- Alignment with Sustainability Initiatives

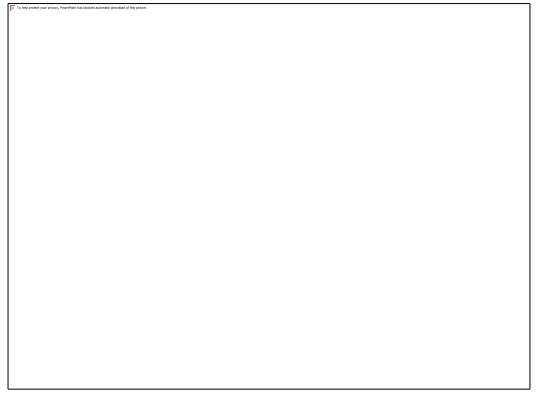
A Huge Problem: Energy Information Administration estimates $6 billion in annual theft

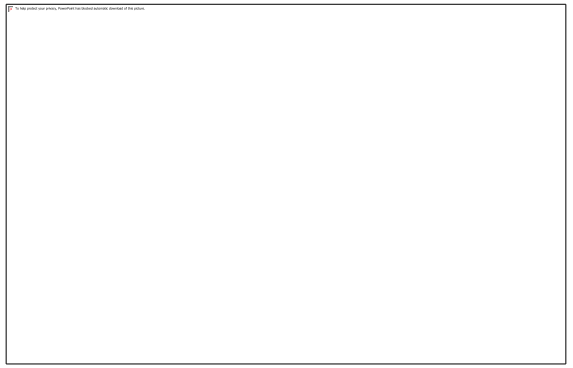
Transformer Operational Integrity/Efficiency

- Verifies that transformers aren’t exceeding their KVA limit.
- Duty cycle of transformers can be evaluated.
- Corrects mis-mapping of meters to transformers.

Safety

- Prevents fire or electrocution at the meter.
  - Diverted wires are very hazardous, directly connected to the utility grid with no secondary voltage protection.
  - Any type of short on this side of the meter has potential to act as an arc welder and continue to burn, as there are no breakers for auto shut off.
- Reduces risk involved with utility employees replacing overheated transformers.
  - Diversions mask the true amount of KVA a transformer is serving.
  - Can lead to overheating without distribution staff being aware.





Immediate ROI

- Costs to recover the energy loss and stop future losses are far less than the dollar amount that will be recovered.
  - A single diverted load can average between $12,000 to $15,000 in lost revenue, in some cases up to $60,000 or more.
  - If you have system with 100,000 meters and 1% of them are found to have diversions this would be equal to about $12,000,000 to $15,000,000.
- Stops the “bleeding” of revenue loss.
  - Recovers unpaid past usage while establishing new, higher revenue stream.
  - 2012 to 2015 MID captured over $2.6 million per year in revenue loss to diverted loads. Allowed them to create two new positions; Smart Grid Engineer, Smart Grid Technician.

Reduced Ratepayer Fees, Better Service

- Protects ratepayers from costs of energy theft and loss.
  - 100,000-meter example: average bill is $120/year per ratepayer higher to cover theft.
- Prevents damage to ratepayers' connected electrical equipment from:
  - Large diverted loads that significantly reduce neighbors' voltage
  - Faulty secondary connections
- Improves service quality.
  - Preempts transformer overuse, overheating and unplanned outages during peak loading periods -- enables planned maintenance during regular business hours.
- Mitigates utility's liability risk from theft-related problems.

Alignment with Sustainability Initiatives

- Enables utilities to support such state/local initiatives as:
  - Boulder County's usage offset program for marijuana cultivators
  - Arcata, Calif., 45% tax assessment on residences above 600% of baseline usage
- Prepares utilities for possible rise in theft as these initiatives make diversion more attractive:
  - Marijuana growers may not be able to make the investments these initiatives require, from carbon offsets to $500,000 transformer upgrades.

A Proven Approach
Why “Low-Voltage Outlier” Technique Works So Well

- Outliers are voltage anomalies that identify:
  - Loads connected on line side of secondary
  - Meters mapped to the incorrect transformer
  - Faulty utility-side electrical connections
  - Voltage drops caused by heavy metered loads
- Isolating and analyzing outliers can stop fraud within days after diversion.
  - This technique was used to identify 700+ cases of energy diversion or meter integrity problems between 2012 and 2017.
  - Technique has been limited to what forensic analysts can review manually.

A Proven Approach, continued
Improve With Data Mining and Analytics

- Hands-on forensics experience is augmented with custom data mining tools.
  - Filtering/correlation algorithms are based on top dozen voltage interrelationships among and between meters and transformers that signal safety or theft issues
  - These complex correlations/exceptions and iterative queries are continuously changing as meter/transformer interrelationships and diversion techniques evolve
- Gather meter data, run analytics and identify meters to physically investigate.
- Review site investigation feedback, adapt algorithms.
- Apply this process to the entire grid, section by section, with goal of virtually “touching” each meter.

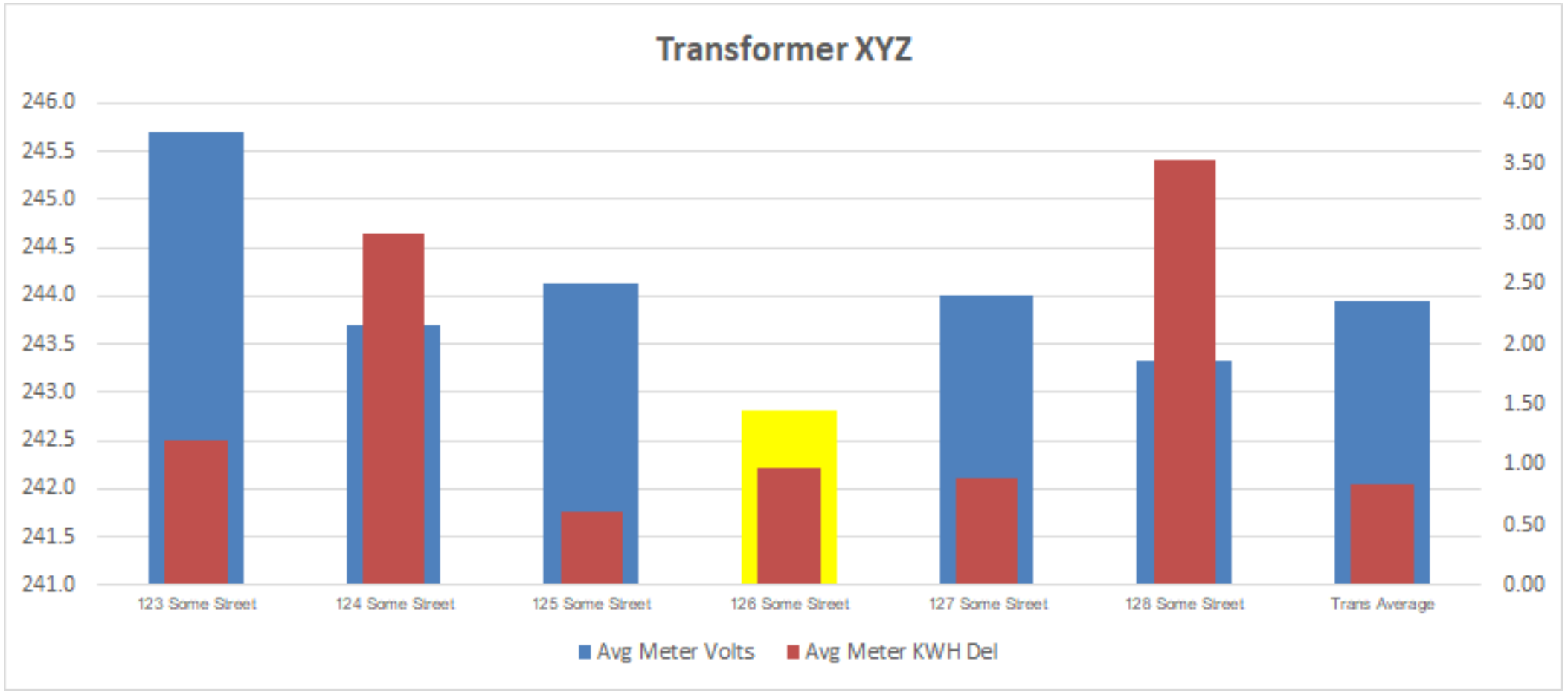
How it Works

- Basic Elements
  - **Data:** AMI software must be capable of returning voltage and kilowatt hours in a minimum of one-hour increments, higher frequency is better.
  - **Analytics:** Keeping algorithms current requires close collaboration and a feedback loop with technicians who visit suspected theft sites and report findings.
  - **Reporting:** Identifies those meters that require further investigation and where, with near certainty, utility will confirm problem and can initiate next steps.
- First Step: Clean the system of irregularities that hide fraud.
  - Review how meters are mapped to transformers and correct where needed to unmask energy diversion.
  - Find and correct faulty connections (can also mask energy diversions).
  - “Clean” systems enable analytics to find theft and other problems based on much smaller anomalies.

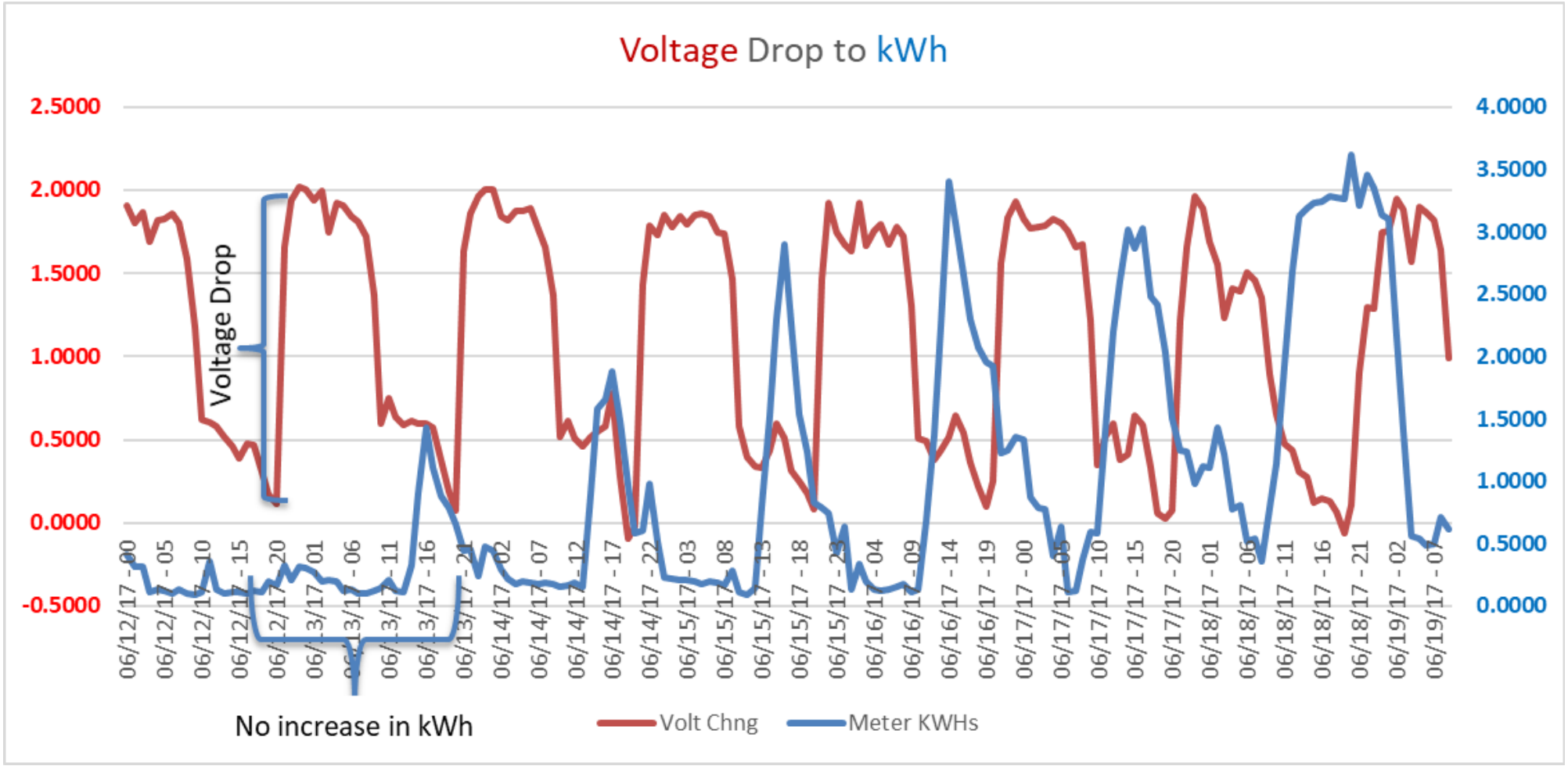
How We Do It

- Perform low-voltage outlier analytics as a monthly service
  - Eliminates capex requirements and headcount additions.
  - Enables collaboration on algorithm improvement as dynamics change.
- Deliver ROI within the 30-day setup period.
  - Set up database tables and automate data loading.
  - Clean up system-wide mis-mapping problems.
  - Start reviewing meters and report high-probability theft locations.
- Continue to grow utility ROI while improving grid safety and integrity.
  - Finalize scheduling for loading metering data, analyzing it and reporting highest-probability diversions for investigation.
  - Identify “low hanging fruit” during first step to start getting an immediate ROI.
  - Scalable to any size utility and frequency of meter review.

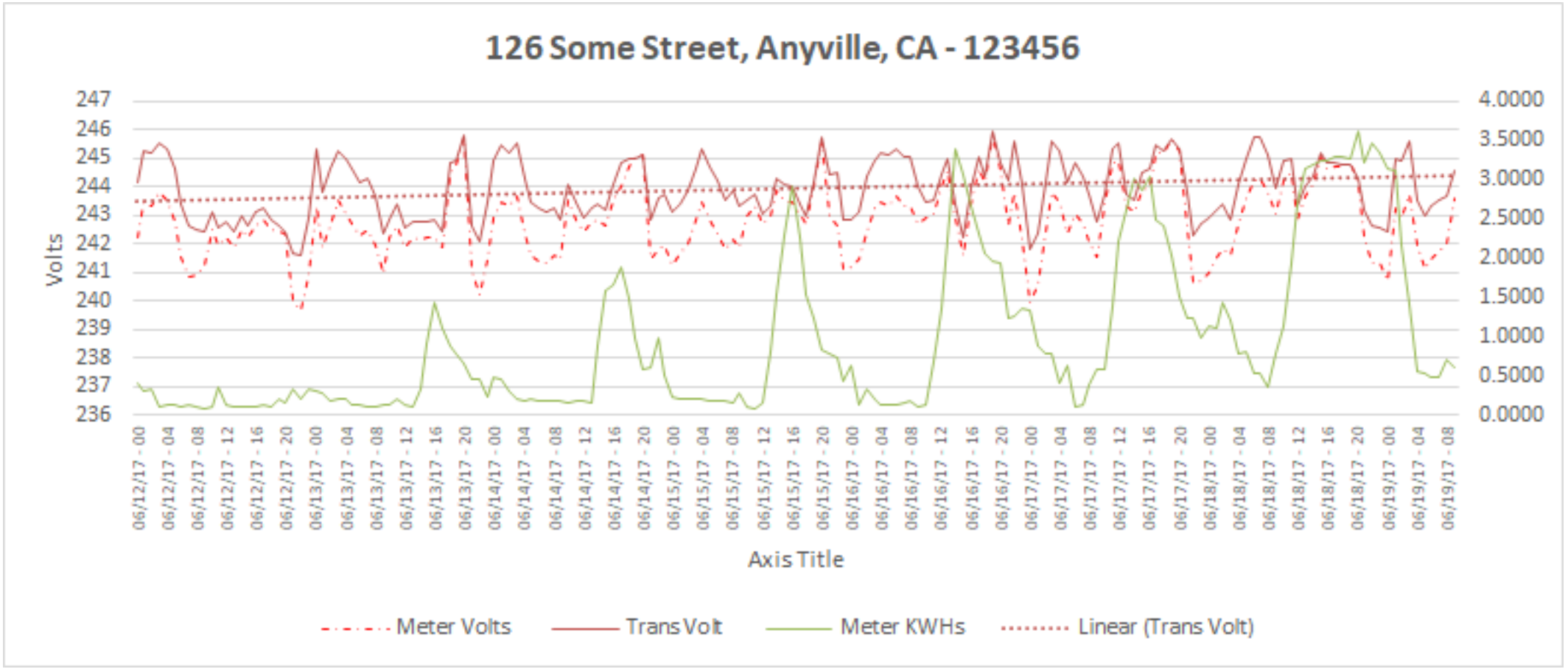
Voltage to kWh comparison



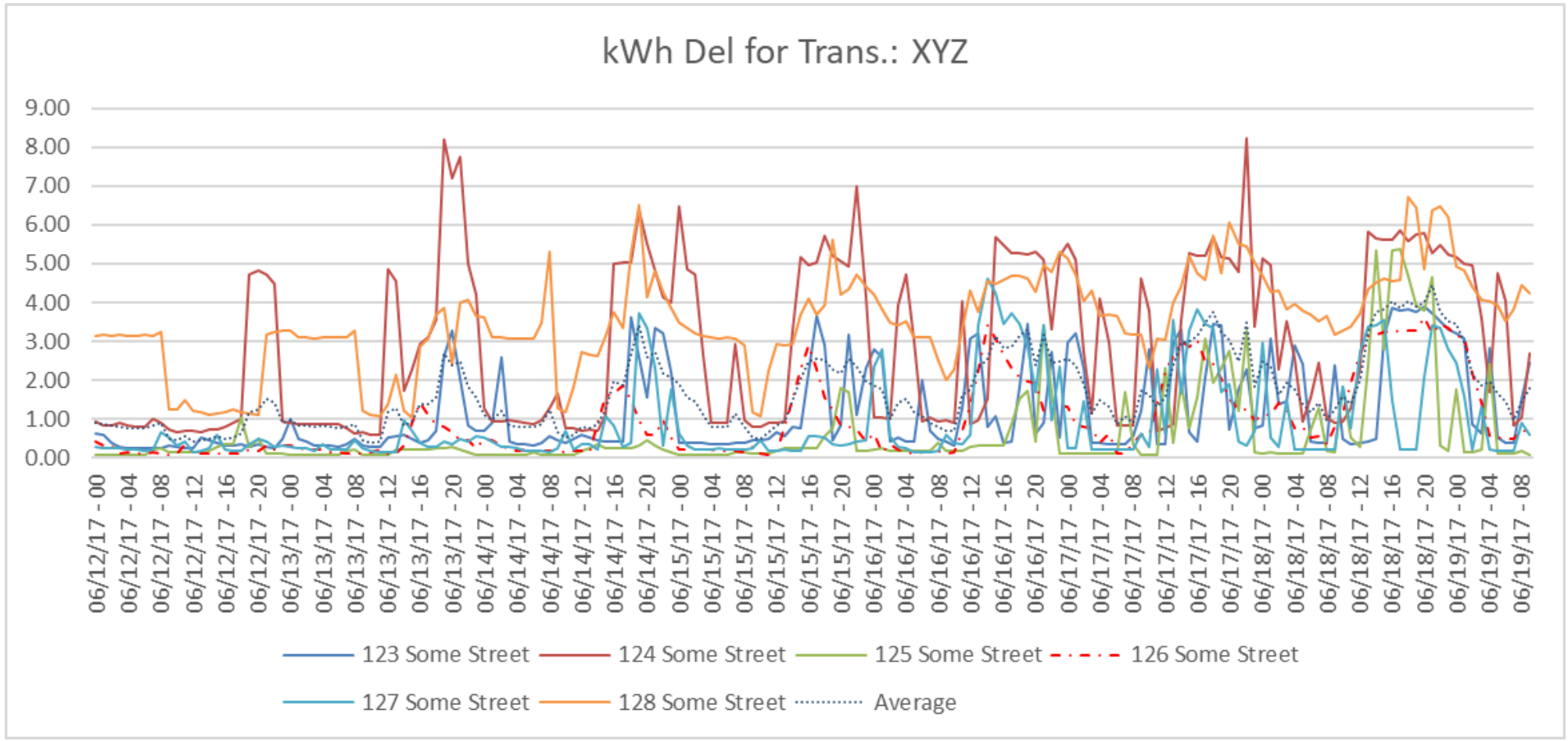
Voltage Drop Caused by Diverted Load



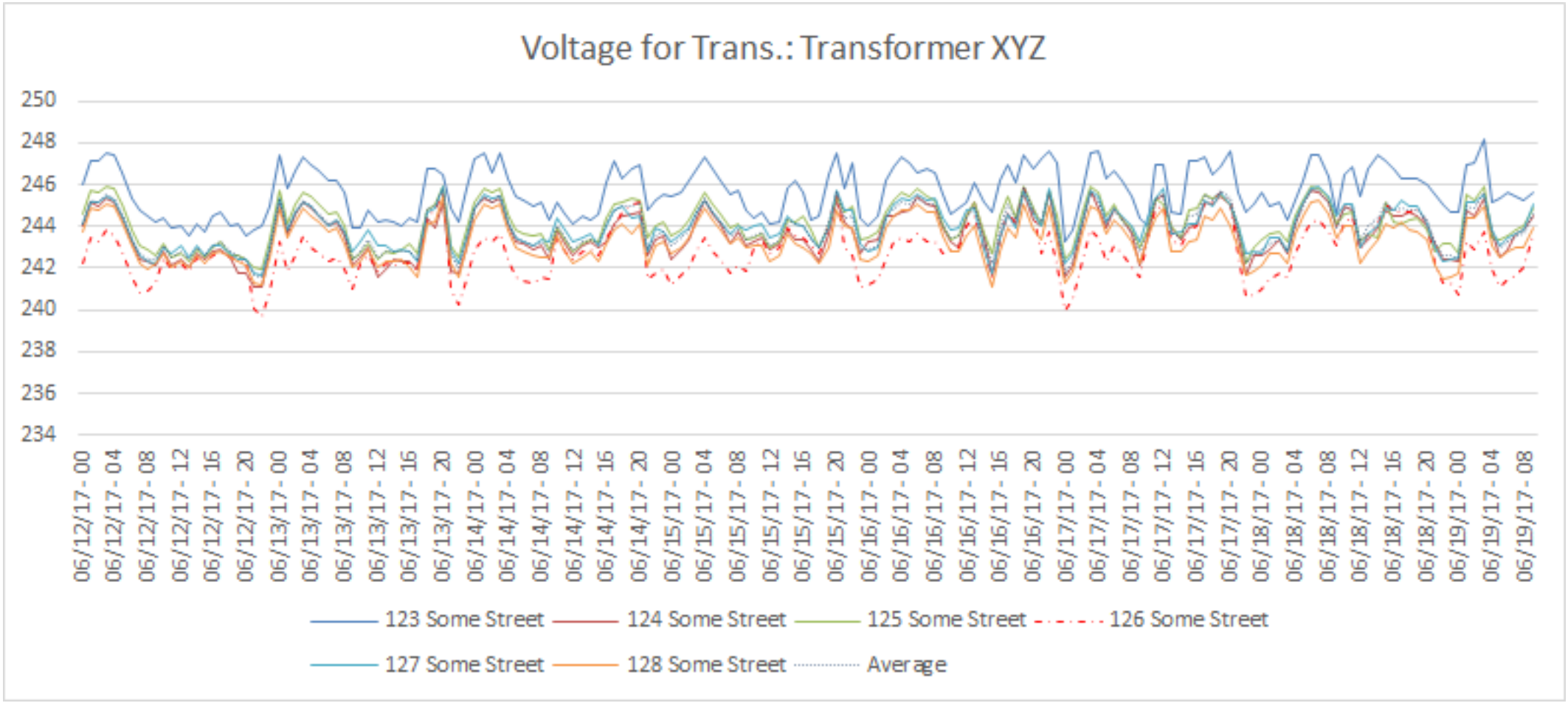
Meter Volts, Meter kWh to Transformer Volts



kWh Delivered for Transformer

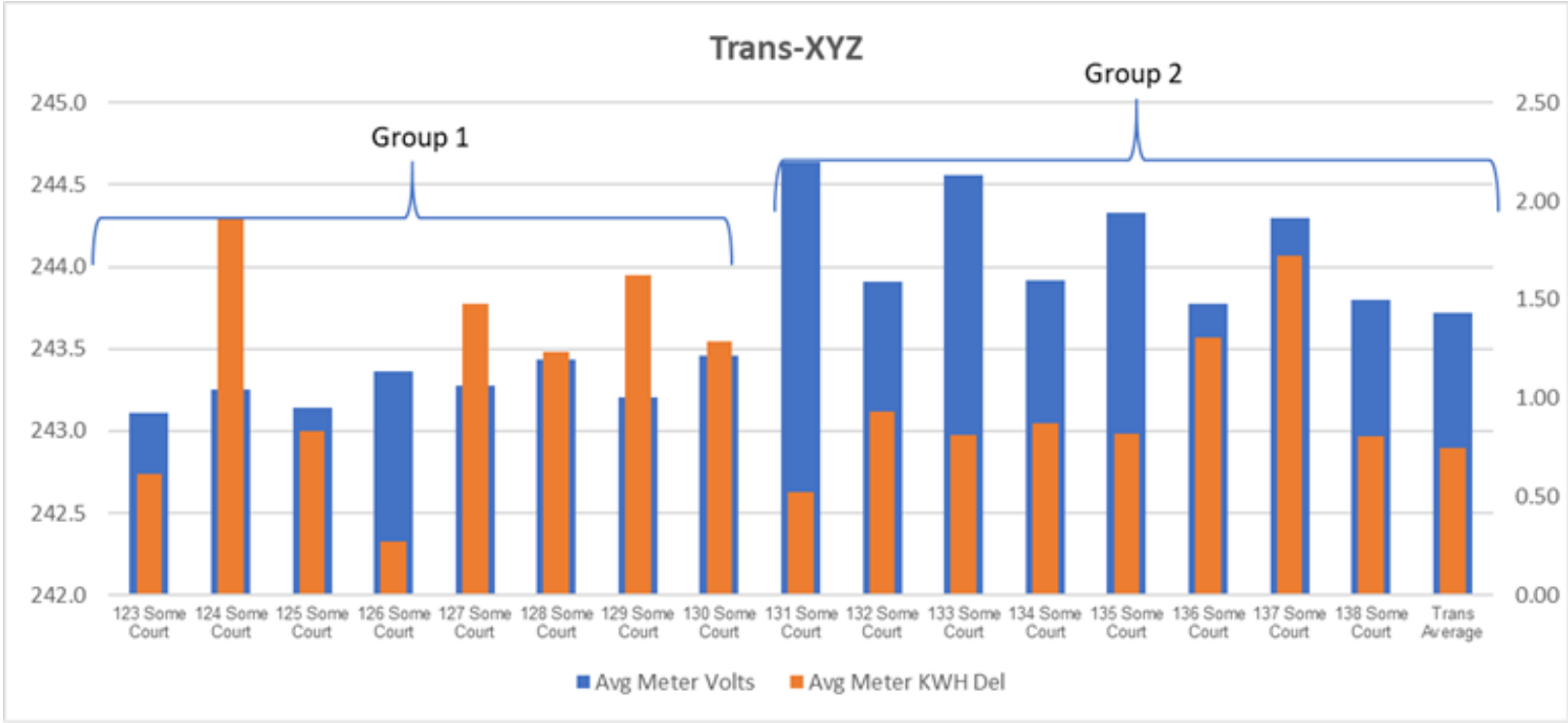


Voltage for Meters on Transformer



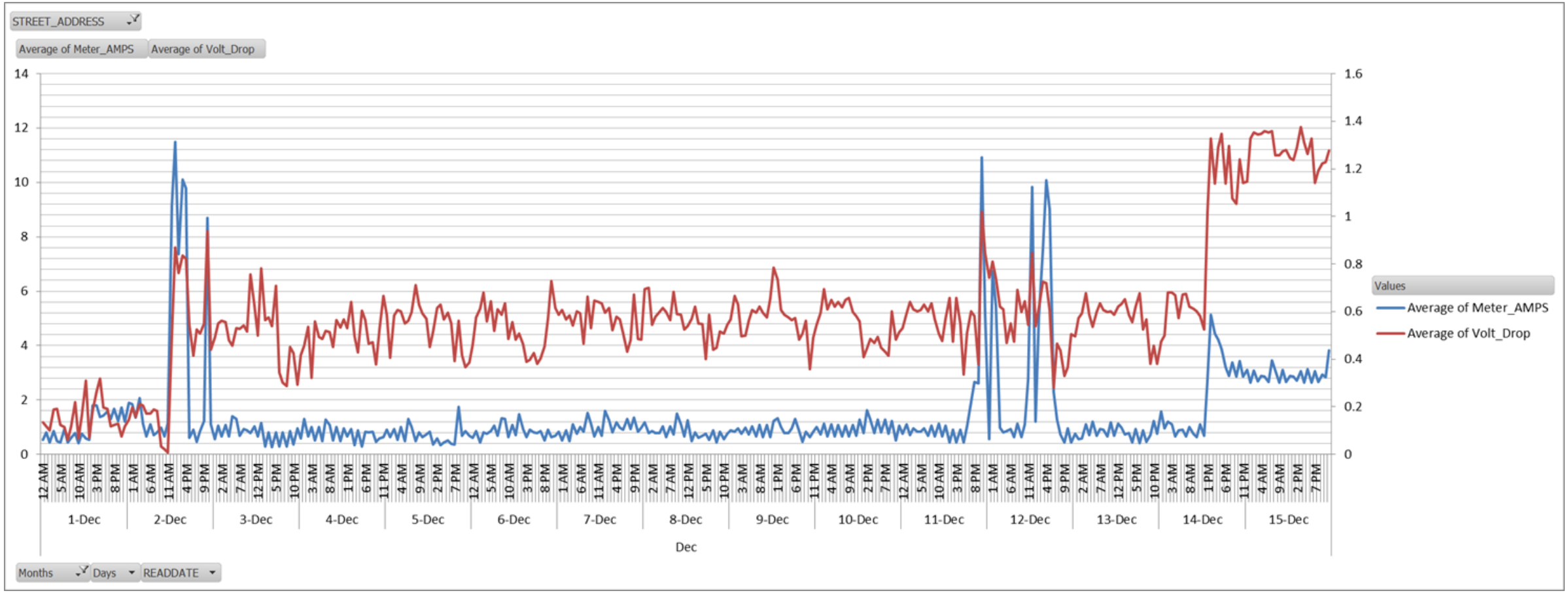
Sample of Mapping Error

The chart to the right shows the voltage and kWh for one transformer. It appears there may be a mapping issue as we see two distinct groups when looking at voltage. Mapping issues will mask voltage drops.



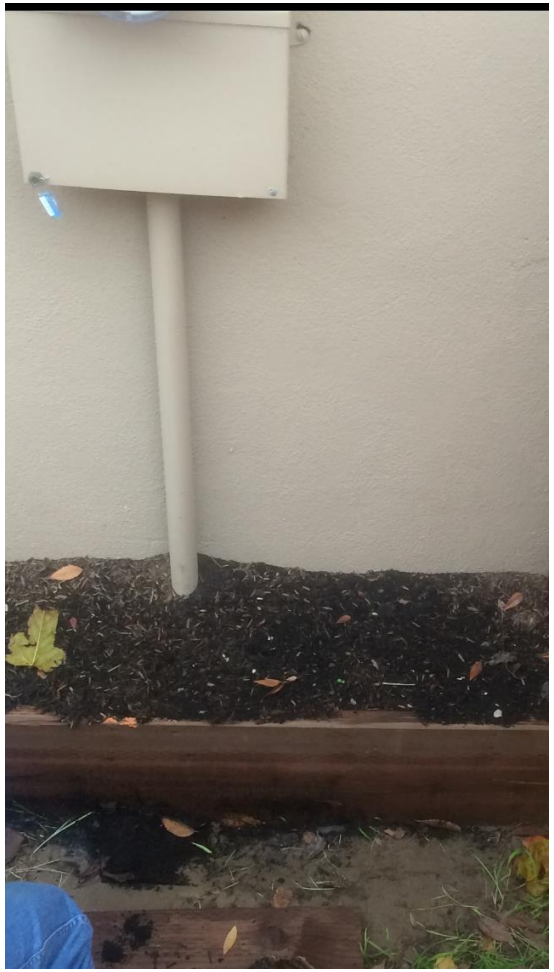
Voltage from group 1 significantly different that voltage from group 2

Voltage Drop Identified Within 2 Days of Diverted Load Installed



Types of Diversions Found

This diversion was found two days after it was set up.



Types of Diversions Found

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Hole was dug to expose conduit coming from street.

Types of Diversions Found

Caught in the act!!

Questions/Comments?