Intra-Grid Sensors Stabilize the Clean Tech SuperGrid™

Why do we need intra-grid sensors to effectively manage our distribution grids?

Because times have changed IMMENSELY; with no end in sight.

By quickly retrofitting cost-effective intra-grid sensors onto existing transformers, we can quickly improve our understanding of perpetually changing distribution grid conditions. This is how we will proactively avert imminent increased power outages, imminent increased grid safety and stability concerns, and reduce growing liability risks. We are now stressing our grid assets with increased unplanned burden, and never previously conceived pressures caused by increased Distributed Energy Resource impacts. Yet, operators still are without comprehensive data that will accurately reveal the various intra-grid dynamics being caused by our 'advancements'. At present, we are indeed overlooking the significance of monitoring, evaluating, and caring for our distribution grids. Hoping the grid will somehow withstand all of the grid-edge changes we are introducing is not a sound plan.

The following is a sample list of real-life challenges requiring the adoption and use of intra-grid sensors.

1. Through solar and wind renewables (i.e., Distributed Energy Resources), we are introducing Reverse Energy onto the distribution grids. Although our grids and the millions of existing transformers were never even conceived, let alone designed to handle this impact. While renewables are beneficial, Reverse Energy can produce unstable, and unsafe grid conditions (Note: Two-way energy flow was never imagined when most grid assets were manufactured, and deployed). The pioneering class of emerging intra-grid sensors accurately measure and report Reverse Energy, and its impacts upon the grid. Utilities without Advanced Meter Infrastructure (i.e., AMI, or "smart meters") require intra-grid sensors to understand the Reverse Energy impacts inside their grid. And, utilities with AMI also require intra-grid sensors to understand Reverse Energy impacts on transformers; due to perpetually changing and therefore inaccurate GIS mapping for nearly every utility on the planet. The reality is that AMI generated Reverse Energy data does not accurately indicate impacts upon transformers, nor the resulting grid impacts. AMI data is typically not accurately aligned to the presumed upstream transformers due to pervasive GIS mapping errors, thus causing aggregated AMI data to be unreliable. Even though utilities are pre-notified of Distributed Energy Resources installations, operators still remain uncertain of potentially serious and/or dangerous impacts upon upstream assets since AMI intra-grid data is unreliable.

2. Reverse Energy also creates new instances of unknown and unplanned voltage fluctuations/conditions. This occurrence further contributes to potentially unstable and unsafe grid conditions. Safety for the public at-large is key, but so too is the safety of utility linemen who are increasingly at risk due to the unanticipated voltage levels being created by Distributed Energy Resources (DER). Safety and liability protections are top priorities now being elevated in importance due to Reverse Energy impacts. Intra-grid sensors accurately measure and report intra-grid voltages, providing critical grid insights. As noted above, while AMI-deployed utilities might think they know Reverse Energy impacts, the truth is they typically do not possess accurate AMI-to-transformer information. Thus, leaving linemen in a position of simply not knowing what to expect in the field when they approach DER-active transformers.

3. Electric Vehicle charging stations create a new, unplanned load on transformers. Each charging station has the capability of adding up to one additional home worth of power load on a transformer. This unplanned loading impacts transformers. Added unplanned load may actually exceed a transformer's designed capacity causing a series of negative, compounding impacts. Given that most transformers were deployed years, or decades ago, this type of added unplanned loading can drive serious concerns, including increased power outage risk, and additional grid safety and liability risks. By being swiftly retrofit directly onto existing transformers, intra-grid sensors report actual transformer loading information. This approach enables utility operators to properly size transformers, and ensure grid safety for ratepayers and linemen. And, it is important to note that utilities are not required to be informed of EV charging station installations, thus causing utilities to have no idea of this unplanned loading impact being introduced upon their grid. Intra-grid sensors remedy this real problem.

4. Illegal marijuana production is significant. Illegal marijuana grow houses commonly steal significant levels of power from the grid via thieves simply tapping power lines in front of their meters. No endpoint meter (including AMI smart meters) can effectively detect pre-meter power theft. This means thieves steal as much power as they want, and they steal it indefinitely without fear of detection. Not only does this result in stolen electricity that is commonly amortized across law-abiding ratepayers bills, but it also presents yet another unplanned, unknown, and significant load on transformers, and therefore the grid. Again, more grid safety and liability risk being created by unplanned/unknown load (Note: the US power theft estimates are $6 Billion PER YEAR, or higher. Power Theft is certainly not rare). Intra-grid sensors enable utility operators to identify and locate power theft within our grids.

5. Legalized marijuana production is increasing. When jurisdictions legalize weed, significant unplanned loading hits the respective transformers and the grid. Legalization permits (and possibly encourages) residents to grow weed using power-intense hydroponic resources. This never

anticipated reality then causes additional strain on the existing transformers, and the grid. While there are increased tax revenues being generated for jurisdictions via legalized marijuana, the grid assets are bearing the burden of this unplanned, significant loading impact. Intra-grid sensors report actual, not presumed or inaccurately estimated transformer loading information, thus enabling utility operators to properly size or resize transformers, and ensure grid safety for ratepayers and linemen.

6. By most measures, including the US Department of Energy, the average age of existing distribution grid transformers is presently in the range of 38-42 years. Yet, the average projected life span of transformers is typically 40 years. Simply, on average today's power grids are significantly aged… many transformers are nearing or have eclipsed their intended life span, yet we continue to demand even more performance, more reliability, and various unintended service capabilities from these same aged transformers. Intra-grid sensors proactively reveal over-burdened and failing transformer assets allowing operators to effectively enable preventive maintenance efforts. This new approach enables operators to transition away from costly and disruptive, reactive grid management practices.

7. Outages cause serious disruptions and problems to societies… from lifestyle inconveniences, to lost economic productivity, to serious health/medical/security impacts, to food spoilage, to sewage impacts, to water availability impacts, to communication interruptions, etc… Outages undeniably result in losses and impacts of various types. Due to increasing unplanned loading, and the effects of DER, increased outage occurrences will undoubtedly result in massive loss and serious disruptions if left unaddressed. Intra-grid sensors reveal burdened transformers which results in fewer power outages. And, intra-grid sensors accelerate outage location detection, and therefore accelerate power restoration which is superior to AMI smart meter capabilities. By now focusing on preventive maintenance, and transformer-level outages, crews can avoid, and/or locate the source of outages faster. Clearly, the use of intra-grid sensors will reduce outage occurrences (aka, improve reliability) by proactively revealing weak and failing transformers in advance of otherwise imminent costly, unplanned outages.

8. Excessive Voltages are pervasive throughout distribution grids. This means that utilities are delivering more power throughout the grid than is required to actually service ratepayers needs. But, most utility operators typically have no idea how much, and/or where the excessive voltages are occurring within the grid. This means that ratepayers simply bear the cost burden of excessive energy injection by operators resulting in energy inefficiency. Intra-grid sensors reveal excessively high voltage conditions thereby enabling operators to improve energy efficiency, lower operating costs, and provide meaningful energy conservation benefits.

9. Loss of electricity is pervasive throughout virtually all distribution grids on the planet. The US reports over $19.5 Billion of unknown, unmetered electricity loss having occurred in 2015 alone. Loss in this case is defined as the total amount of electricity that departed from distribution substations, but was never registered at the downstream endpoint meters. In essence, this electricity was injected into the grid at substations, but over $19.5Billion, or over 187 Billion kilowatt hours of electricity vanished inside the grid. This type of massive electricity loss inside the grid occurs annually, and ratepayers presently bear the financial burden even though they did not consume the vanished electricity. Loss is typically due to: a) power theft, b) improper transformer sizing, c) clerical billing errors, d) excessive voltages, and other factors. Until intra-grid sensors recently emerged, utilities had no reliable method to locate the ongoing massive electricity loss that unnecessarily wastes natural and financial resources. However, intra-grid sensors now provide operators with a cost-effective solution to locate the substantial ongoing electricity loss which otherwise will endlessly continue to occur inside the distribution grid.

10. Reactive versus Proactive grid management capability. Throughout the history of electricity grid management, operators have relied upon customer complaints, and reported outages to address ‘problems’ within the grid. In essence, operators have managed the grid “blindly”, by having no reliable access to the perpetually changing intra-grid information; nor did they have a way to interpret perpetually changing intra-grid conditions. Now, intra-grid sensors resolve the historic/present-day inefficient, costly, reactive grid management process. Intra-grid sensors create a cost effective, energy efficient, grid efficient, proactive grid management system, including automated alert notifications concerning unfavorable intra-grid conditions. This is a massive, positive paradigm shift for our grid management operators which will benefit ratepayers, operators and our global environment.

11. The distribution grid space occurring between substations and endpoint meters is undeniably the most volatile, most vulnerable, and most dynamic segment of the entire electricity delivery system. And it has always been the least monitored segment of the grid. Yet, operators have been required to manage this critical grid segment without the proper technology to assist them. Now, intra-grid sensors provide operators with clear vision into this extensive “black hole” segment of the grid. No longer do operators have to manage blindly and reactively; nor cause ratepayers to continue subsidizing utility operations inefficiencies, and ongoing energy inefficiencies within the distribution grid space.

12. AMI smart meters have been unable to provide accurate intra-grid information. Because of perpetually inaccurate meter to transformer association (i.e., inaccurate GIS mapping), and because of pervasive pre-meter tapping which may have escalated since AMI deployments, AMI intra-grid data is typically unreliable. Intra-grid sensors remedy this problem in conjunction with

AMI smart meters by creating a critical data reconciliation point inside the grid, upstream from the AMI smart meters, at the transformer level. By combining intra-grid sensors with AMI smart meters, operators achieve maximum data value, and maximum grid management capability. With AMI smart meters alone, operators remain unaware of actual intra-grid conditions which results in documented energy inefficiency, documented electricity loss, and elevated operating costs; all of which land on ratepayers' wallets.

13. Fiscal stewardship by operators can now be enhanced by decreasing electricity provider's Operating Expenses, and increasing Capital Expense Return on Investment. Intra-grid sensors provide proactive, unique, timely, accurate, granular intra-grid data which allows operators to reduce unplanned power outages, to reduce costly truck rolls, to reduce premature transformer replacement costs, to remediate extensive electricity loss within the grid, and to lessen transformer oil spills/fires/hazardous material cleanup costs resulting from premature transformer failures. Operators can also reduce excessive voltages which lessens energy purchasing costs that are otherwise being paid by operators and passed along to ratepayers.

14. Greenhouse Gasses (GHG) Reduction is yet another upside that can be leveraged. Intra-grid sensors allow operators to proactively identify annual electricity loss (e.g., > $19.5 Billion in the US alone during 2015), to identify excessive voltages which equates to wasted power, to identify improperly sized transformers which are inefficient, and to reduce unplanned truck rolls. Collectively the energy efficiency and operating efficiency gains created by intra-grid sensors allows distribution operators to reduce their purchases of power and fuel for their trucks, which transcends upstream to reduced generation costs, along with fewer unplanned truck rolls. This compounding effect results in reduced GHG. This GHG reduction can then be converted to Carbon Emission Reduction credits, thus creating added revenues.

15. Increased Metered Revenues for utility operators also result when using intra-grid sensors. By identifying the significant unmetered electricity loss within the grid, identifying meter clerical/billing errors, and reducing power outages which results in more consistent power delivery to endpoint meters, operators actually increase their metered revenues while simultaneously reducing their Operating Expenses and increasing their Capital Expense ROI as noted above. Intra-grid sensors create and facilitate improved financial stewardship of our grids.

16. Monitoring, maintaining, and supporting the health and continued growth of the emerging Clean Tech SuperGrid™ is yet another important value proposition created by intra-grid sensors. Approximately 65-100 years ago, the distribution grid was conceived and designed to be a one-way delivery system of electricity; and operators were primarily tasked with simply "keeping everyone's lights on". Those days are swiftly vanishing. Our grids have already become a

bi-directional network of power flow, and a valuable source of critical information which will drive substantial monetary savings and efficiency gains for operators, and ratepayers alike.

In summary, today and increasingly as the future unfolds, the one-way simple electricity grid of the past is rapidly evolving into a complex bi-directional, multi-purpose network requiring a new identity for the grid. The Clean Tech SuperGrid™ will be the backbone for genuine energy efficiency, increasing energy conservation, along with supporting commercial transactions such as block chain and Conservation Emission Reduction (CER) credits, and facilitating increased tax revenues through the legalization of marijuana. In addition, the Clean Tech SuperGrid™ will facilitate the ongoing adoption of Distributed Energy Resources (DER), and Electric Vehicle sales.

This is the dawn of the Clean Tech SuperGrid™. Where improved reliability, genuine energy efficiency, bi-directional energy flow, commercial transactions, increased renewables, battery storage, electric vehicle charging stations, and reduced GHG will all simultaneously originate, reside, and travel.

Intra-grid sensors are required to ensure that a stable, reliable Clean Tech SuperGrid™ is operating at maximum capability and capacity. And societies will demand and expect leadership to provide and maintain a healthy Clean Tech SuperGrid™ to support our future. We can no longer focus solely on creating burdensome demands upon the grid and grid-edge without caring for the grid itself. Without proper monitoring and reliability enhancements, we are setting the stage for serious, and potentially harmful grid pressures. This will undoubtedly result in excessive outages, decreased reliability, heightened cost burdens on societies, and increased grid safety concerns. Such a myopic behavior will prove to be counter-productive to our ongoing efforts and needs. But now we can avoid such outcomes.

Intra-grid sensors will facilitate progress, and properly stabilize our emerging Clean Tech SuperGrid™.