US Power Grid Still Plagued by Energy Inefficiency

Over $20 Billion of Unmetered Loss Burdens Rate Payers

The Challenge: How does the US finally achieve a world-class energy efficient power grid that properly balances rates, maximizes conservation practices, and results in a genuinely modernized 'smart grid' that can serve our increasing demands and reliability expectations of the present, and future?

The (REAL) Problem: Over 199.1 Billion kWh of unmetered (i.e., unbilled) electricity loss 'leaked' from the US distribution grids in 2014 according to the US Energy Information Administration reports. This Loss represents in excess of $20.7 Billion that was unmetered, but was still amortized as electricity cost across US rate payer's bills. All of this while our government, utilities, and rate payers have appropriately been investing billions of dollars in 'smart meters', and a host of energy efficiency efforts.

Via US government incentives and/or local electric utility provider efforts, American's have been encouraged to install LED bulbs and 'smart' thermostats, and to embrace solar rooftop/wind renewables. The intention has been to help lower electricity costs for consumers, lessen generation demands, and reduce greenhouse gasses (GHG). Additionally, there are various periodic incentives to purchase electric vehicles (EV's) for similar pollution reduction reasons, but EV charging stations add more unplanned demand burden to the grid. However, simultaneous to these proactive efforts targeted at the grid edge which are intended to reduce costs, electricity consumption and pollution, over 199.1 Billion kWh was lost upstream from the rate payer's meters in 2014. And, it is worthy to note that while many benefits are attributed to America's 55+ percent AMI (i.e., 'smart meters') deployment, and nearly 80 percent total penetration of both AMI plus Automated Meter Reader (i.e., AMR) deployments, over 199.1 Billion kWh still went unmetered in 2014, even with this substantial 'smart meter' penetration. Clearly, the US grid still has serious problems.

The "Problem" is that electricity is invisible; but the "REAL Problem" is that electricity is "leaking" heavily from within the US distribution grid, in front of the 'smart' AMI/AMR meters, and at costly levels. Because electricity is invisible, electricity providers have been unable to accurately identify where these substantial power leaks have been occurring within the grid(s). To this end, while we have been actively engaging a series of beneficial maneuvers to improve conservation practices, and lower electricity rates in the US, the significance of losing over 199.1 Billion kWh, or over $20.7 Billion (annually) within America's distribution infrastructure in just one year is negatively offsetting our ongoing conservation and rate reduction investments. Intra-grid power loss is substantial, and it's quietly occurring every day.

This costly reality cannot continue to be overlooked, nor unattended any longer.

The Opportunity (Solution/Impacts): Through the use of emerging intra-grid sensors, the US now has the opportunity to create up to approximately $10.4 Billion of annual rate payer savings, up to 99.6 Terawatt Hours per year of reduced generation to serve its existing rate payers, up to $586 Million in

annual Carbon Emission Reduction Credits (CER) per year, and up to 53.2 Million metric tons of reduced CO_2 emissions per year.

Intra-grid sensors are rapidly retro-fit onto existing distribution transformers within the grid. The sensors' plug and play capability, and 5-10 minute average installation time, now empower utilities to immediately begin to locate the costly, invisible "leaks" occurring throughout all US grids. Additionally, intra-grid sensors provide "Automated Alert" capabilities which allow utilities to program desired grid tolerances and conditions, then operate "Hands-Free" until automated alerts are issued via SMS text, and/or email. Intra-grid sensors now provide game-changing distribution grid management capabilities.

While smart meters were touted to improve data acquisition and lessen power theft, the reality is that power theft is increasing; estimated by some industry experts to now be in excess of $6 Billion per year, and possibly up to $13 Billion per year (of the $20.7 Billion annual loss noted above). In essence, power thieves have discovered that with utility meter-reader personnel no longer coming onto their properties, they can now tap power lines in front of 'smart meters', and steal power indefinitely.

In addition to the increasing power theft impacts in spite of 80% smart meter penetration, it is now also clear that a series of items cause AMI/AMR data to be erroneous, and therefore incomplete. Smart meters are an important element in the quest for a 'smart grid', but it is now evident that intra-grid sensors are also required to help uncover power theft, correct erroneous AMI/AMR data instances, while also providing more accurate and timely intra-grid information for utility operators to better manage our grid(s).

The section of the US grid which connects substations to AMI/AMR/mechanical meters is predominantly comprised of power poles, approximately 6.3 Million line miles of wire, and approximately 40 Million distribution transformers. This same grid area is by far the most vulnerable, most volatile, and most dynamic segment of any distribution grid (US, and worldwide). Yet, until the recent emergence of intra-grid sensors, utilities were unable to gain timely, accurate access to enough critical data from within this vital 'heart of the grid' segment. Costly loss, unnecessary pollution, and wasteful inefficiencies have been unavoidable by-products due to our lack of technology. However, intra-grid sensors now provide utilities with a cost-effective solution to stop unnecessary, costly, and wasteful loss conditions from continuing to plague US grids, and continuing to drain rate payer's wallets.

In addition to creating the series of powerful benefits noted above, intra-grid sensors also provide utilities with a growing list of meaningful value propositions --- all from the same, one investment required to deploy intra-grid sensors. Some utility operators already suggest that Intra-grid sensors represent the "Swiss Army Knife" tool needed to address a myriad of grid management issues occurring within the heart of the grid; thus substantially enhancing the grid edge focus that has dominated our recent efforts and investments (e.g., smart meters, smart thermostats, LED bulbs, solar and wind renewables).

The American Recovery and Reinvestment Act of 2009 initiated the necessary grid modernization efforts in the US by providing $4.5 Billion in grant funding. This was the first significant step whereby efforts were targeted at the grid edge as noted above. Yet, with well over $8 Billion now having been committed to grid edge efforts (e.g., grant funding, incentives, utility financial contributions, etc..), the US still experiences massive annual loss within its grid architecture, creating a series of unnecessary negative impacts upon utilities, rate payers, business owners, and the environment.

Now, intra-grid sensors uncover this pervasive, costly, 'invisible loss', while simultaneously yielding a series of financial gains, service delivery improvements, and necessary grid management upsides to be realized. It is the unique deployment location of the intra-grid sensors within the distribution space that distinguishes this asset class. By capturing and reporting actionable information from within the heart of the grid, intra-grid sensors represent a valuable, necessary tool that is required for us to finally achieve a comprehensive smart grid. Until we combine substation information, endpoint meter information, and accurate/timely/multi-purpose intra-grid sensor data, energy efficiency will not be realized. As industry leaders realize that AMI/AMR data is prone to inaccuracy for intra-grid data reporting purposes, and that algorithms using this flawed smart meter data cannot accurately predict volatile, costly intra-grid conditions, intra-grid sensors will then be embraced and leveraged for maximum value.

The following is a sample list of features and benefits derived through the use of intra-grid sensors:

- Line Loss Identification – revealing invisible loss; permitting visible loss to then be remediated
- Increased Metered Revenues – converting unmetered loss into metered revenue
- Conservation Voltage Reduction – providing accurate/timely intra-grid voltage information
- DER/DG Readiness & Monitoring – safely integrating reverse energy, and monitoring voltages
- Unplanned Outages Reduction – proactively identifying failing transformer assets
- Technical Loss Identification–revealing over/under-sized transformers and incorrect tap settings
- Power Theft Identification – revealing the sources of $6+ Billion per year of unconscionable loss
- Electric Vehicle Readiness & Monitoring – identifying unplanned loading due to charging stations
- GIS Mapping & Accuracy Improvements – revealing improper meter-to-transformer association
- AMI Data Errors Reconciliation – identifying bad multipliers, pre-meter tap impacts, GIS errors
- Voltage Imbalance Identification – preventing downstream equipment damage and related costs
- Automated "Hands-Free" Alerts – reporting problematic intra-grid conditions/ stressed assets
- Premature Transformer Failures Avoided – proactive information enabling proactive measures
- Pole Fires & Hazardous Material Spills Avoided – lessening operating and capital expenditures
- Rate Payer Cost Reductions – achieved via reduced OpEx/CapEx, and improved energy efficiency
- CO_2 Reductions – remediating line loss lessens generation demand; improves energy efficiency
- CO_2 Emissions Reduction Credits (CER) – creating revenue to improve utilities' financial strength
- Improve SAIDI & SAIFI Ratings – lessening outages and duration via unique/timely intra-grid data

"Valuable" Intra-grid Sensors - Who Says So? Through its Smart Grid Fund initiative, the Ontario Ministry of Energy partially funded a Demonstration Project in 2014/2015 to help determine if intra-grid sensor technology could deliver value within its Province, and beyond. By the conclusion of the Demonstration Project, the Ministry of Energy featured the project as a success story (see attached pamphlet produced by the Ontario Ministry of Energy.) The prominent utility participant in the project concluded project success and grid management value via intra-grid sensors experience.

Hawaiian Electric Company has publicly released information on its successful use of intra-grid sensors. These devices permit safe and efficient management of previously unknown voltage and reverse energy impacts associated with solar rooftop distributed energy resource (DER/DG) deployments.

Sacramento Municipal Utility Department (SMUD) has publicly announced its use of intra-grid sensors to identify over $376k (and counting) of power theft discovery and remediation.

CenterPoint Energy has indicated its use of intra-grid sensors to identify various grid anomalies for the improvement of power service to its valued customers.

Maui Electric Company has publicly released information declaring its use of intra-grid sensors to locate intra-grid anomalies, technical loss issues, and monitor solar rooftop-related impacts.

The above stories can be accessed via http://grid2020.com/news. Additionally a host of utilities are similarly beginning to leverage intra-grid sensors to create energy efficiency. As each utility recognizes the multiple value impacts provided by intra-grid sensors, and the accelerated return on investment (ROI) capability yielded by this pioneering technology, energy efficiency will then become a reality.

Net Benefits to the US: Leveraging intra-grid sensors to identify and remedy the significant power leaks occurring within the US grid(s) has the ability to yield the following estimated Net Benefits:

a) Reduce Rate Payer's bills by up to $10.4 Billion per year by removing unnecessary loss/leaks,

b) Conserve up to 99.6 Terawatt Hours/Year--- in addition to other ongoing efficiency efforts,

c) Reduce Greenhouse Gas Emissions (CO_2) by up to 53.2 Metric Tons per year,

d) Create US Manufacturing Jobs (i.e., up to or over $31 Billion manufacturing opportunity- estimated),

e) Generate up to $8.1 Billion (or more) in US Tax Revenues (i.e., factored at 25% taxation),

f) Safely Posture the Grid for emerging/unplanned Solar and Wind Renewables (i.e., DER/DG),

g) Embrace emerging/unplanned electric vehicle (EV) impacts upon the grid,

h) Decrease power outages and durations which impact US commercial productivity and residents,

i) Shrink operating expenses of US utilities (e.g., fewer unplanned outages, fewer trouble calls, etc),

j) Facilitate conservation voltage reduction (CVR) to lessen excessive power costs,

k) Produce US Carbon Emission Reduction Credits (CER) value up to/over $586 Million per year,

l) Reduce US trade deficit by manufacturing and supplying intra-grid sensors for the global market,

m) Increase metered revenues for utilities (i.e., converting unmetered loss into metered revenue),

n) Lower capital expense by reducing premature replacement of transformers due to overloading, and

o) Deliver a deployment ROI of approximately 5.1 years driven by line loss reduction benefits,

The Extensive Value Propositions Created Via Intra-Grid Sensors: By installing intra-grid sensors onto distribution transformers, a myriad of unique, powerful opportunities become unveiled to utility operators. While substations and AMI/AMR meters place a reasonable grasp on the grid at the beginning and endpoints, neither asset class can reliably reach into the 'heart of the grid' in a timely,

accurate, and consistent manner; algorithms are unable to displace the need or value of accurate/timely information being extracted by reliable sensors from within the grid.

The area/assets of the grid which connect all substations to AMI/AMR meters represents the undisputed most volatile, most dynamic, and most vulnerable section of any grid in the world. It is this 'heart of the grid' space that when monitored via cost-effective intra-grid sensors, can produce an unrivaled (growing) list of value propositions for utility operators.

Intra-Grid Sensor Value Proposition capabilities include, but are not limited to:

Conservation Voltage Reduction (CVR) – timely/accurate intra-grid voltages to enhance CVR

Renewables – safe and effective embracement of Distributed Energy Resources (e.g., wind, solar)

Asset Loading – ensures proper sizing, avoids premature asset failure, improves SAIFI ratings

Outage Restoration – accelerated to reduce customer impact, improves SAIDI ratings

Aging Infrastructure – preventive maintenance avoids unplanned outages, and lost meter revenue

Voltage Imbalances – reduce downstream equipment damage/costs, and maximizes asset longevity

Unmetered Loss Identification – reveals technical loss, and power theft loss for remediation

Improper Multipliers/Billing Errors – helps to uncover clerical billing errors that cause lost revenue

Improved GIS Mapping Accuracy – ensures proper meter-to-transformer association/data accuracy

Enhanced AMI Data Value – uncover GIS errors and pre-meter taps to ensure AMI data accuracy

AMI Range Extender – can function as a repeater inside AMI networks for hard-to-reach meters

Micro-grids – permits detailed data leveraging to maximize distribution management efficiencies

Carbon Footprint Reduction – reduces generation demand by identifying leaks for remediation

CO_2 Emission Reduction Credits – lessens generation to lower CO_2 emissions and create revenue

Future Proof – "Over The Air" technology affords ongoing upgrades/advancements to the sensors

Automated Alerts – creates a "Hands-Free" grid management solution for utilities

Tap Settings Errors – detects improperly set taps which cause inefficient power delivery

Outages Reduction – detects failing assets, permits preventive maintenance, increases revenues

It is important to note that utility personnel are commonly discovering new methods and applications for maximizing the use of intra-grid sensors. This growing list of valuable uses stems from the intra-grid sensor's unique deployment location within the heart of the grid, and the expanding list of features that can continually be added via Over The Air technology which serves to future proof the devices.

Additionally, as utility operators become acquainted with the "Hands Free" automated alert capability of intra-grid sensors, new applications and benefits will subsequently emerge.

It is this growing list of value propositions presented to utility operators that delivers actionable information driven by accurate sensors. In turn, ongoing data errors associated with AMI/AMR, and the associated algorithms driven by these erroneous smart meter inputs can now be remedied with accurate, timely information. Intra-grid sensors provide utility operators with the data granularity and accuracy needed to properly manage distribution grids, and achieve improved energy efficiency.

The US Business Case:

The following business case overview contains factual, and estimated data which serves to illustrate the accelerated Return On Investment (ROI) capability of intra-grid sensors. Unmetered power loss occurring within the US grids is substantial as reported by the US Energy Information Administration (2014). It is this significant level of ongoing 'invisible loss' that justifies the critical need for intra-grid sensor deployment. However, as noted herein, a series of additional financial, grid performance, and grid management upsides further solidify the need for leveraging this emerging sensor technology.

State	United States
Total Customers (Meters) Year 2014	147,373,702
Average Cost per kWh in Cents Year 2014	10.44
Proprietary Information within this section	
Total Distribution Losses per Meter (kWh)	1,351
Total Losses in Dollars	$20,786,371,052.40
Losses in Dollars per Meter	$141.05
Losses Expressed as a Percent	4.84%
Total Distribution Transformer Monitors (Qty)	40,047,202
Proprietary Information within this section	
Total H/W Cost $ (Equals DTM plus PDTM cost)	$31,013,994,641.87
Proprietary Information within this section	$1,681,982,468.48
	$530,545,327.20
	$20,023,600,815.22
Estimated Return on Investment (ROI) in Years	5.12
1 kWh (unit) reduction is calculated to reduce CO2 emissions by 0.535 Kg	
Total Losses Yearly in kWh	199,103,171,000
Amount of CO2 Generated in Tonne (Metric Ton) per Year	106,520,196
CER Credit USD equals CO2 Tonne x USD $11.00	$1,171,722,161.34
USD Dollar Value of 50% Reduction of Total Losses per Year	$585,861,080.67

Note – The US grid(s) collectively sustained 4.84% loss in 2014 per the Energy Information Administration report. This seemingly harmless loss percentage equates to more than $20.7 Billion that rate payers financially subsidized, beyond their personal consumption. Loss is an annual occurrence in the US, and occurs throughout electricity grids worldwide.

Summary: Heretofore, utilities and the related government entities that oversee regulatory interests, conservation, and power delivery standards/requirements did not have awareness of, nor access to the recently developed, cost-effective intra-grid sensors. However, it was the Ontario Ministry of Energy that had the foresight in 2014 to strategically invest Smart Grid Fund (SGF) resources to vet the value of intra-grid sensors within the Ontario grid. The SGF focus was to assess the grid management capability of this new technology, determine its conservation value, and to permit real-world testing for Ontario utility vetting to occur. Resulting from the intra-grid sensor testing in Ontario, the US utilities (and global utilities) are now postured to embrace this emerging, cost-effective intra-grid sensor technology. These rapidly-installed sensors will assist efforts to improve energy efficiency, increase conservation, and reduce power bills for American rate payers over time. The unique value of intra-grid sensors is vast; due to the deployment location of the sensors within the "heart of the grid", a myriad of features/benefits and unparalleled value is now available to US, and global utilities. It is important to note that the estimated Business Case Overview presented herein is focused solely on the effort of identifying/remediating approximately 50% of the 199.1Billion kWh (over $20.7 Billion) of loss presently escaping, in unmetered/unbilled fashion, from within the US distribution grid(s) – even while an estimated 80% smart meter deployment is already in place. When the additional value propositions presented by intra-grid sensors are similarly factored into the ROI equation, and leveraged over time to the benefit of utilities and Americans, a powerful justification for this cost-effective technology is visible to those who actively pursue energy efficiency, conservation efforts, improved operating efficiencies, reduced electricity bills, and future grid preparedness. The aforementioned value propositions can be harnessed by utilities, lowering operating costs, improving power delivery performance to rate payers, improving capital expenditure value for shareholders, and converting unmetered loss and meter multiplier errors into properly metered revenues for utilities.

It is important to note that within all distribution grids, approximately 1.0% - 1.5% technical loss (of the US 4.84% Loss) is 'expected' due to the shear physics of electricity delivery (e.g., line dissipation loss, resistance loss). This suggests that approximately 69%-80% of both technical and non-technical (i.e., unauthorized unmetered consumption) loss occurring within the US may be outside of the 'expected' technical loss range of 1.0% - 1.5%. In turn, the intra-grid sensors bring 'vision' into the heart of the grid, allowing utilities to now identify the otherwise "invisible", costly loss that has been, and is still perpetually leaking from the distribution grid(s) throughout the US, and similarly throughout grids around the world.

Intra-grid sensors present a unique, unparalleled value enabling the US to vastly improve energy efficiency, increase conservation efforts, shrink utility operating costs, improve reliability of power, increase metered revenues, improve capital expense investment value, and simultaneously lower electricity rates over time for Americans.

No other emerging technology solution presents this depth and breadth of ability to create such a vast series of value and benefits, supported by such a rapid return on investment. The intra-grid sensors convert 'invisible power loss', into 'visible loss" that can be cost-effectively remediated. Utilities can now be empowered to proactively manage the grid(s). Costly, reactive behavior is now a process of the past, due to the emergence of cost-effective intra-grid sensors.

NOTE: The views expressed in this White Paper are the views of GRID20/20, Inc. and do not necessarily reflect those of the Province of Ontario, nor any party mentioned within this document.

Ontario Ministry of Energy's Authored and Produced Intra-grid Sensor Success Story- (page1 of 2)

GRID20/20®
Optimize Energy Efficiency

ONTARIO'S SMART GRID

SUCCESS STORY

AT A GLANCE

Technology
OptaNODE™ intra-grid sensor and software solution

Collaborators
- Aequus Global Solutions Inc.
- Kinectrics Inc.
- Vexos

Project Partners
- EnWin Utilities
- Cambridge North Dumfries Hydro

Recognition
2015 Smart Grid Product of the Year Award
- SmartGridTMCnet.com

2015 Fierce Innovation Awards: Energy Edition Winner

Project Duration
21 month pilot

Fastest installation time in industry
typically 3-9 minutes

Key Outcome
$170,000 of power theft identified from only two transformers

Instant intra-grid data availability once installed. Scalable sensor solution.

OptaNODE™ devices successfully tested in 10 countries

PROJECT OVERVIEW

The most vulnerable segment of Ontario's power grid is between substations and endpoint meters. This section of the larger grid translates to around 123,500 km of power lines and over 330,000 transformers.

Lightning strikes, pole damage, power theft, renewable energy sources, and overloaded transformers all place stress on the grid, leading to outages and inefficiencies. Local Distribution Companies (LDCs) are particularly susceptible to fluctuating grid conditions.

North American distribution transformer monitoring (DTM) company, GRID20/20, partnered with two Ontario LDCs to install and test an intelligent sensor system that offers an unparalleled window into the heart of the power grid.

With additional help from manufacturing and design experts, GRID20/20 has evolved its OptaNODE™ sensor and software platform into a world-class solution with plans for future deployment across Ontario and international markets.

Sponsored by Ontario's Ministry of Energy, the 21-month pilot is an important demonstration in grid reliability and a shining example of the innovative projects being funded through Ontario's Smart Grid Fund.

Ontario

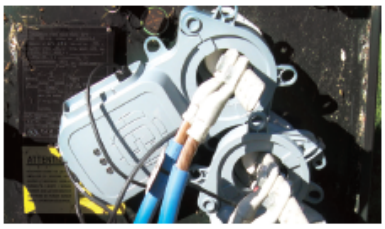
THE TECHNOLOGY

GRID20/20's OptaNODE™ intra-grid sensor solution is a reliable, versatile, and intelligent power grid monitoring system that captures highly accurate energy, voltage, current, and external temperature readings and sends them (via a network of cellular carriers or radio frequency mesh) to a secure location for interpretation by LDCs.

The information generated helps LDCs reduce operating costs by:

- Pinpointing losses (both technical & theft)
- Accelerating outage detection
- Foreseeing maintenance needs
- Embracing renewable energy
- Monitoring EV charging station impacts
- Improving reliability of power delivery to customers

GRID20/20 is the only Distribution Transformer Monitor (DTM) provider in the world that can be deployed into both Landis+Gyr's Gridstream and Itron's OpenWay Advanced Metering Infrastructure (AMI) systems. The OptaNODE™ DTM sensor also boasts the fastest installation rate in the marketplace with no need to de-energize or pierce assets.



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HOW IT WORKS

Substations and endpoint meters across Ontario have been substantially upgraded to strengthen grid monitoring capabilities. However, the entire grid segment that connects substations to endpoint meters is lacking in sufficient data awareness by LDCs. The GRID20/20 OptaNODE™ solution offers unprecedented visibility into this grid segment, changing the grid management dynamic from reactive to proactive, while embracing energy conservation practices and lowering costs for rate payers.

PROJECT OUTCOMES

The GRID20/20 pilot, which involved the installation of 128 sensors at partner LDCs in Ontario, proved that intra-grid data can be extracted in a fast and accurate manner and used proactively to identify unfavorable distribution grid conditions for remediation by LDC operators.

Following is a summary of project outcomes:

- Significant power losses identified and remediated
- Voltage levels and imbalances identified and corrected
- Electric vehicle charging stations monitored for loading impacts
- Reverse energy monitored to properly manage renewables/conservation practices
- Automatic alerts to notify LDCs of undesirable intra-grid conditions
- Under/oversized transformers identified

NEXT STEPS

LDCs across Ontario are beginning to take notice and understand the intra-grid data value provided by GRID20/20's breakthrough technology. Sensors will be incorporated via targeted niche applications in some instances, and comprehensively deployed on transformers within other LDCs. GRID20/20 has established collaborative activity with industry providers and plans to expand commercial operations into international markets such as the United States, Latin America, the Caribbean Islands, Asia Pacific, and Africa.

Powered by ONTARIO'S SMART GRID through a $1,607,450 investment.

For more information about Ontario's Smart Grid Fund, visit **ontario.ca/smartgrid**

Full Story available at: ***http://grid2020.com/news_images/MOE-GRID2020-SGF-Success-Story.pdf***