Practical Considerations for Smart Grid

How proven telecom industry solutions can accelerate Smart Grid benefits

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EXECUTIVE SUMMARY

Smart Grid means many things to many people. So much more than a delivery channel for Smart Meter data, Smart Grid promises a genuine revolution in the way the electrical power supply chain operates. The benefits are varied and far-reaching.

In early 2009, The Ontario Smart Grid Forum[1] released its report entitled, "*Enabling Tomorrow's Electricity System*". The report observed:

> "The institutional structure of the electricity industry makes it easy to look at how the smart grid will impact each piece of the system in isolation, but the most profound impact of a smart grid may be its ability to link these pieces more closely together."

Of the countless benefits offered by Smart Grid, energy conservation across the electrical energy supply chain is perhaps the most compelling. With the present grid and related distribution system, a significant percentage of generated power is lost before it reaches the point of consumption. Regardless of how committed, engaged and proactive the end consumer is in conserving electricity, the fact remains an enormous amount of energy is lost prior to reaching the consumer. There are two broad categories of electrical energy wastage upstream from the consumer: faults to ground, and resistive loading within the system.

In their 2007 yearbook, the Ontario Energy Board (OEB) calculated that on an annual basis 5,416,117,162 kWh of generated electrical power never reaches the electricity consumer. This is estimated to be approximately 4% of the total generated capacity in the province[2]. A Smart Grid preemptively addresses these inefficiencies. Containing these costs improves operational efficiency and perhaps equally significant, has the potential to delay or eliminate certain potentially sizable capital expenditures.

To take full advantage of opportunities afforded by Smart Grid, it is essential the real time data environment and related communication infrastructure use open network standards based on the Internet protocol (IP). These open standards power the Internet and with that, its infinite benefits to business and society at large. Smart Grid is well positioned to inherit the benefits derived from IP, regardless of whether the network is wired, wireless or a combination of both. As a result of the pervasiveness of the IP standard, Smart Grid operators will enjoy:

- Lower network equipment costs.
- Significantly increased flexibility in network design options.
- Simplified and repeatable design, installation, configuration and operational practices.
- Potentially seamless interoperability between system operators.

[1] The Smart Grid Forum is operated under the Independent Electricity System Operator (IESO). Report found at: http://www.ieso.ca/imoweb/pubs/smart_grid/Smart_Grid_Forum-Report.pdf

[2] Calculated by total kWh purchased by Ontario Local Distribution Companies verses what they sold.

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With this in mind, there are a number of wired and wireless IP technologies ideally suited for far-reaching, highly integrated Smart Grid solutions where thousands of 'touch points' are spread across a huge geographical area.

With ubiquitous IP-based networks as the primary delivery mechanism, Smart Grid data can then be aggregated and routed to a centralized Operational Support System where operational performance rules are set and enforced.

Operational Support Systems are found in all telecom networks and are mature, proven solutions for anticipating and responding to performance issues on the network. These mission critical systems are extremely flexible and highly scalable. Size and complexity, along with level of sophistication of the associated network performance rules, are fully supportable in today's modern Operation Support Systems.

Having addressed the ever-expanding operational needs of the telecom network operator for several decades, Operation Support Systems are ideally suited to address the data management and reporting needs of the Smart Grid operator. Business and operational rules are defined, implemented, monitored and ultimately responded to on a single, cohesive platform. The result is a flexible and robust environment where both pre-emptive and real time response to energy efficiency threats are addressed throughout the electricity supply chain. The Operation Support System is also a rich environment for the production of customized reports – from detailed system-wide performance analysis, to executive level operational summaries.

Through its extensive experience in network design and Operation Support Systems, WireIE will play a valuable role in designing, deploying and managing the next generation broadband wireless solutions essential to Smart Grid's success. Through these solutions, the electricity supply chain's efficiency will be optimized, resulting in immeasurable benefits to operators, consumers and society at large.

ABOUT THE AUTHORS

This paper was a collaborative effort spearheaded by WireIE's President and CEO, Rob Barlow and executed by Timothy Brown, WireIE's Chief Technology Officer / Chief Technology Strategist. Robert Cressatti and George Kaichis were invaluable contributors as were a number of important peer reviewers within the WireIE organization.

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INTRODUCTION: How Smart Grid Will Conserve Electricity

It is broadly recognized that a move to Smart Grid is a worthwhile, constructive pursuit. At this juncture, however, many are having difficulty defining with any precision the problems Smart Grid is expected to solve, along with the opportunities Smart Grid promises to deliver on. This challenge is not only faced by electrical energy professionals but also by those in Telecommunications and Information Technology (IT) – fields which are guaranteed to play an integral role in the successful development of Smart Grid solutions.

While Smart Grid promises to solve many operational problems in the electricity supply chain[3], it is the immediate detection and rapid remediation of lost energy within the system itself that holds the greatest promise. Smart Grid offers a system-wide "macro" view in aid of conserving electrical energy within the grid and related distribution systems. In contrast, initiatives such as Smart Metering incent consumers to conserve electricity through behavioural changes at the site where the electricity is actually used.

While this paper concentrates on the mitigation/elimination of energy wastage within the transmission and distribution portions of the electricity supply chain, it is also recognized that Smart Grid will facilitate other profound changes – not the least of which is the integration and management of new generation sources largely based on renewable energy.

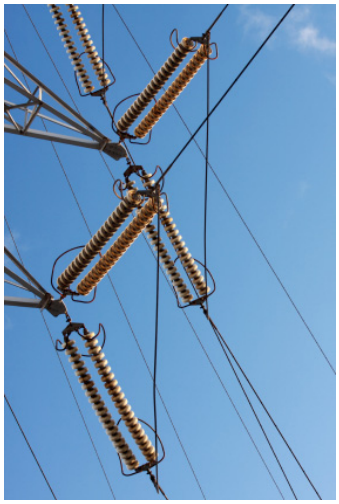
[3] At a high level, the electricity supply chain consists of generation, transmission, distribution and consumption.

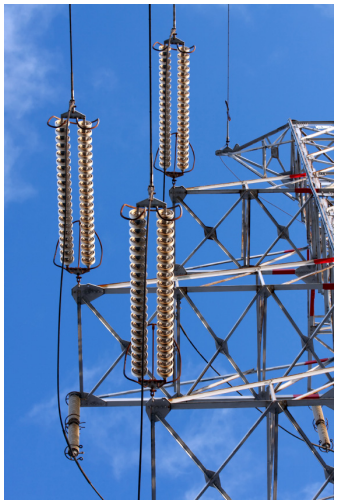
ELECTRICAL DRAIN & DISSIPATION AS HEAT: ENERGY WASTED

In their 2007 yearbook, the Ontario Energy Board (OEB) calculated that on an annual basis 5,416,117,162 kWh of generated electrical power never reaches the electricity consumer. This is estimated to be approximately 4% of the total generated capacity in the province[4].

Unintended Paths to Ground

Electric current has an unrelenting tendency to travel to ground – and it does so by using the path of least resistance. It is broadly recognized that within the electrical supply chain are points of vulnerability where precious electrical energy is travelling off the system by way of a path to ground. There is no way to recover the energy once it has travelled to ground. It is therefore essential to detect these leaks at the time they occur, or preferably, anticipate points of eventual failure and take preemptive action.





A typical example of a failure to ground would be where an insulator in the grid has been damaged (or lost its insulating properties with age and exposure to the elements) thus causing a path to ground. This is measured today using current transformers (measuring current flow) and potential transformers (measuring voltage).

Resistive Loading

The unintended production of heat anywhere between the site of electrical generation and the site of consumption is an indication of electrical resistance. Heat is the direct byproduct of resistance to the flow of electrical current. Unintended resistance in the distribution and consumption of electricity directly impacts system efficiency, resulting in wasted energy. It is essential that points of unintended electrical resistance be detected and repaired – preferably preemptively.

[4] Calculated by total kWh purchased by Ontario Local Distribution Companies verses what they sold.

The best way to detect such defects is to measure for unacceptable loading at appropriate connection points across the electrical supply chain. Resistive loading can also occur when an anomalous demand for electricity at the consuming point results in excessive loading on line feeders.

SMART GRID: ADDRESSING TODAY'S ELECTRICAL GRID CHALLENGES

In the absence of Smart Grid, the present way the quality of the electric supply chain is managed presents some fundamental challenges:

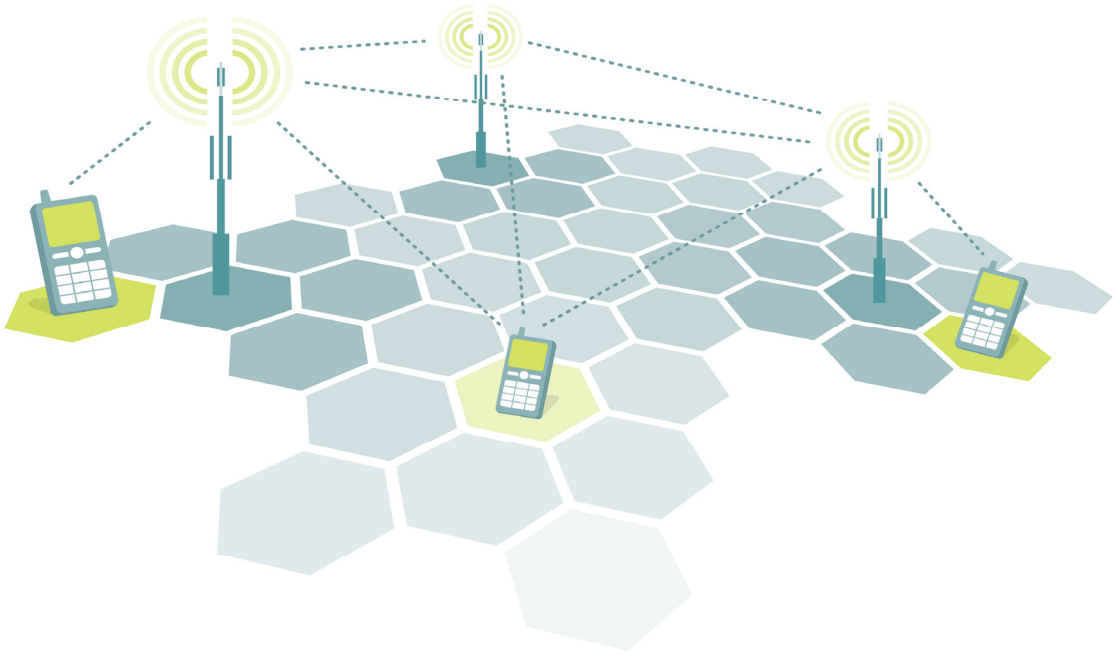
- As previously discussed, a sizable amount of generated electricity is being lost through faults and inefficiencies in an aging infrastructure.
- A large percentage of faults in the electricity supply chain are actually preventable but with limited or no visibility to all vulnerable elements, it is impossible to take preemptive action. As a result, a large amount of fault management in the electricity supply chain is reactive.
- Response to faults in the system is costly and can often take an unacceptable length of time to resolve. This is will only get worse as a result of workforce attrition in the coming years.
- As a result of the sheer vastness of the electricity supply chain, prioritization of preventive maintenance activities does not (cannot) necessarily coincide with where the greatest vulnerabilities are[5].
- Adherence to service level commitments (between supplier and distributor) is difficult to measure, manage and reconcile.
- Without Smart Grid, our society's transformation to a green-friendly approach to energy generation and consumption will not be realized.

[5] The sheer size of the grid in contrast to the scale of the workforce makes manual or semi-automatic measurement of each point of vulnerability unrealistic.

SMART GRID OBJECTIVES: LARGELY REALIZED IN TODAY'S TELECOM NETWORKS

There is much discussion about the critical role wireless networks will play in Smart Grid. While this is definitely true, a companion to wireless networks known as Operation Support Systems, are another essential component in realizing the objectives of Smart Grid.

With the advent of cellular telephony in the 1980s, a new generation of telecommunication facilities was born and with that a new set of practices governing network design, network maintenance and fault monitoring. Unlike the centralized network architectures that preceded them, certain key assets in the cellular world were 'pushed out' to the network edge. Hundreds (in many networks, thousands) of cellular base stations (cell sites) were deployed throughout a region. Cities were covered with high grades of service and highway corridors were built to link population centres.



These cell sites are mission-critical assets and are often hundreds of kilometers from the nearest switching centre. The necessity to monitor these vastly dispersed facilities is an absolute business imperative. Disruption of service in one link of the network chain can have a domino effect. Customer tolerance to service disruptions is profoundly low – be it disruption of coverage in a single city block, or the failure of an entire corridor. Depending on circumstances, subscriber inconvenience is trumped by issues of public safety.

With this in mind, all key operational parameters from the cell network edge, back to the switching centre are automatically sensed and reported on. Based on business rules, network performance thresholds are established to trigger the appropriate operational response. In addition, trending within the envelope of acceptable operational performance parameters is tracked to anticipate eventual breach from the performance envelope. This affords the network operator the opportunity to take preemptive action at a known site of vulnerability. Finally, these comprehensive Operation Support Systems have powerful reporting capabilities – playing an essential role in routine activities such as network capacity planning.

Operation Support Systems are a mature, proven, integral component found in any telecom network. These systems often reach out to tens of thousands of network elements and return data on countless operational and performance parameters on a per element basis.

Operation Support Systems are essential in ensuring optimal performance of every network element on a second-by-second basis while also providing immediate notification of network element failures, or predisposition to failure. Operation Support Systems are scalable, both in terms of the number of network elements to be monitored, as well as the number of parameters within each element to be measured and reported on.

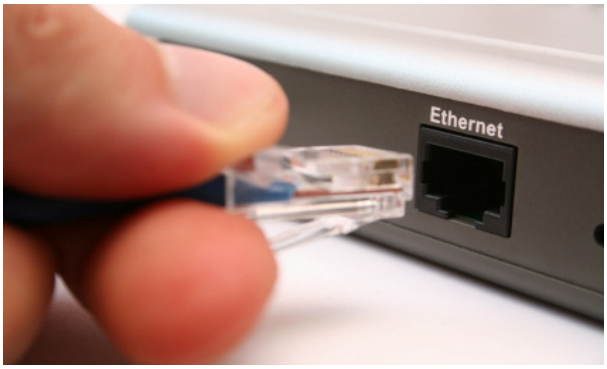
The operational goals of Smart Grid and the capabilities of today's telecom network Operation Support Systems align exceptionally well. In addition, the scalability of today's Operation Support Systems ensure that even the largest, most complex of Smart Grids, will be well within the capacity of the system. Operation Support Systems are a practical solution for performance data management on Smart Grid and hold the promise of hastening Smart Grid's broad adoption.

OPEN NETWORKS ESSENTIAL TO THE SUCCESS OF SMART GRID

Through WireIE's extensive experience in countless wireless network platforms, one thing is clear: Smart Grid must be based on open standards and in the world of modern networking, the Internet Protocol (IP) is the only logical choice.

It is the standardization based on IP that has led to the global pervasion of the Internet in both business, and society at large. The limitless evolution of Internet applications is directly facilitated by the openness inherent in IP.

Correspondingly, everything from computer hardware, network equipment, Internet usage fees, right through to the Internet applications themselves, carry a relatively low cost because of the standards associated with the IP ecosystem.



Smart Grid is ideally positioned to ride the momentous IP wave. By adopting an all-IP philosophy, Smart Grid benefits by having an open network which:

- Has the greatest degree of network design flexibility while also retaining relative simplicity.
- Offers the most options for network redundancy and diversity (reliability).
- Enjoys the widest selection of network equipment choices at comparatively low prices.
- Facilitates simplified sensor device connectivity and configuration in a deployment process that is repeatable.
- Offers the greatest amount of visibility to all assets in the electricity supply chain (to the degree business and operational rules deem necessary).
- Reduces deployment costs.
- Offers access to vast array of standards-based, easily administered network security options.
- Is essentially future-proof – allowing growth to be a relatively seamless, non-disruptive exercise.
- Permits virtually effortless interconnection with neighbouring networks (including those of other operators).
- Optimizes network operation costs.

WireIE's VALUE-ADD IN SMART GRID

WireIE specializes in next generation networks in support of Smart Grid. The company's unique in-depth expertise in broadband wireless technologies extends from the network edge, across the backhaul, to the IP core. Through strategic partnerships with leaders in data aggregation and Operation Support Systems, WireIE offers a complete Smart Grid solution.

The Ontario Energy Board (OEB) has recently established high level requirements for the province's Smart Grid. The following table highlights those requirements along with WireIE's corresponding value-add.

OEB Requirements	WireIE's Open Network Value-Add
Integrated communications, connecting components to open architecture for real-time information and control, allowing every part of the grid to both 'talk' and 'listen'.	IP-based wireless network solutions ensure complete integration of delivery systems and decision support systems. IP is conducive to a fully open architecture where communication flows bi-directionally from end-to-end.
Sensing and measurement technologies, to support faster and more accurate response such as remote monitoring, time-of-use pricing and demand-side management.	WireIE offers vendor and technology agnostic consulting services on the application of OEM sensors and related devices. Once defined, engineering, integration and support services are provided. These apply to both new installations as well as upgrades to existing facilities.
Advanced control methods, to monitor essential components, enabling rapid diagnosis and precise solutions appropriate to any event.	Extensive expertise in defining real-time Operation Support System solutions ensuring complete flexibility in meeting both the business and operational rules as set out by any operator. Today's Operation Support Systems, backed up by WireIE's expertise in IP-based wireless networks, ensure complete flexibility in the development of highly customizable decision support environments for Smart Grid.
Improved interfaces and decision support, to amplify human decision-making, transforming grid operators and managers quite literally into visionaries when it come to seeing into their systems.	

The robustness and capacity inherent in WireIE's Smart Grid solutions also enable a reliable delivery path for secondary services such as Smart Metering data. Backhauling Advanced Meter Regional Collector (AMRC) data is an obvious application. Moreover, the Smart Grid Operation Support Systems are sufficiently flexible to accept, collate and process data from assets along the electricity supply chain, yet outside of the grid and distribution infrastructure (e.g.: smart meters, smart transformers).

WireIE's LEADERSHIP IN NEXT GENERATION WIRELESS TECHNOLOGIES

In realizing the objectives of Smart Grid, a hybrid of wireless technologies (along with fiber optics) will likely be deployed. Transparent integration and interoperability are essential characteristics to ensure operational flexibility and reliability. Again, an open networking approach using IP as a routing mechanism ensures seamless interoperability – even when disparate radio technologies are employed across the system.

WireIE enjoys both depth and breadth in the design, deployment and management of wireless networks. With unique expertise in network transformations to 4G/IP, WireIE offers solutions in support of many wireless technologies including WiMAX and soon, LTE. Our expertise in 3G technologies such as UMTS and EV-DO augment our background in PCS technologies such as GSM & CDMA (including 1xRTT, GPRS and EDGE). In addition, WireIE has in-depth knowledge and experience in the design and deployment of IP-based point-to-point and point-to-multipoint microwave networks.

WireIE is unique in that its Radio Frequency (RF) engineering expertise includes extensive design work in the 1.9 GHz PCS (Personal Communications System) band – virtually identical in propagation characteristics to the 30 MHz sub-band[6] proposed by Industry Canada for management and operation of the electricity system. Moreover, WireIE enjoys significant expertise in broadband wireless network design and engineering with particular emphasis on WiMAX[7].

WireIE best-in-class professional services include:

- Wireless network planning, design, deployment and management.
- Integration of Operational Support Systems within a network – be it a telecommunications network, or a Smart Grid network.
- Knowledge, experience and expertise in the operational challenges and requirements of an electrical utility.

[6] 1800 – 1830 MHz
[7] This expertise includes pre-WiMAX technologies

CONCLUSION

While Smart Grid promises many improvements over the status quo, the single most significant opportunity lies in Smart Grid's ability to conserve energy through the reduction in wasted electrical power within the electricity supply chain itself.

The inherent openness in Internet Protocol (IP)-based wireless network solutions will ensure lowest cost, along with the highest flexibility and greatest capability in the delivery of data from remote sensors in the field back to the aggregation point. Mature Operation Support Systems based on open standards are available today and integrate seamlessly with IP-based networks. These systems are powerful and flexible – permitting a high degree of customization, along with a wealth of reporting capabilities.

WireIE enjoys a unique combination of comprehensive capabilities in next generation wireless networking, in addition to an in-depth knowledge of the operational challenges of hydro electric generation, transmission and distribution.