



# LTE for Smart Grid Communication

## The Canadian Outlook

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Communication infrastructure requirements for various smart grid applications are now well known and LTE cellular technology is being seriously considered by many utilities around the world due to its appealing cost, performance and sustainability benefits. While most utilities prefer to deploy their own communication infrastructure for security and performance guarantee reasons, Canadian utilities are currently investigating beneficial scenarios where LTE technology can be combined with the other already deployed broadband technologies. This article discusses the

feasibility of using LTE technology for smart grid applications in current Canadian settings as well as the extended vision of sharing spectrum with the public safety band.

The term smart grid has been coined for a long time. According to the CEA (Canadian Electricity Association) [1], a smart grid is nothing but a modern electricity system which uses monitoring, sensors, communications, automation and computerized processes to improve reliability, efficiency, and flexibility. In essence, a smart grid is a set of intelligent information based applications made possible by increased automation of the electricity grid encompassed by underlying automation techniques.

This article is an overview of how LTE (Long Term Evolution) technology can be used as the communication infrastructure needed to support common smart grid applications significant to Canadian

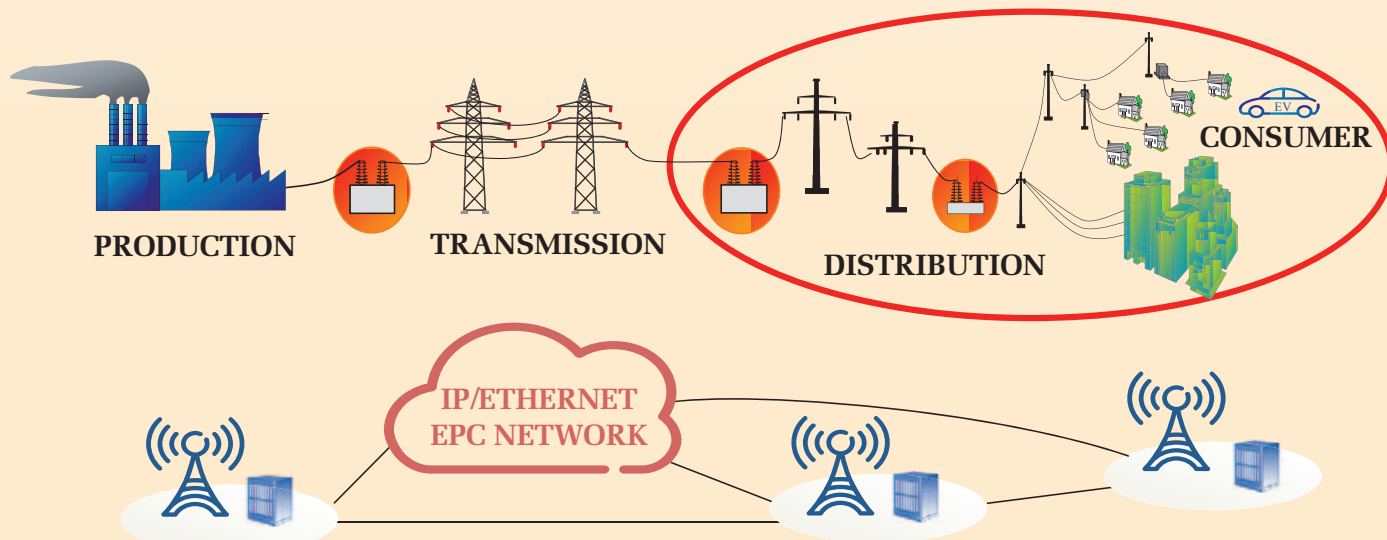
utilities. Moreover, it discusses the various networking scenarios that would involve LTE. The focus of this article will be on the grid's distribution network while most of the discussed facts will apply to the transport and generation scenarios (see Fig. 1).

**Canadian utilities – today's reality**  
 Canadian electricity companies are mainly hydroelectric followed by nuclear and then fuel based. This distinction plays a role on the smart grid applications that are most significant in Canada.

### Smart grid applications– latency classification

The International Electrotechnical Commission (IEC) classifies smart grid application types based on their latency requirements. This classification is summarized in Table 1 [4]. This classification is used to select the viable communication media that are suitable for each type of application within and between substations. The applications requiring 10ms or less latency are better served with optical fiber media. The others can be served with broadband wireless technologies such as LTE.

Fig. 1 Electrical grid sub-division and focus area





Fallback scenarios from private to public or public to private could be considered. This type of redundancy could be extremely useful and again will be enabled by multi operator SIM technologies.

Type/Application	Performance class	Latency Requirements
<b>Type 1-Fast messages:</b>		
Type 1A “trip”:	P1 - P2/P3	10ms - 3ms
Type 1B “Others”:	P1 - P2/P3	100ms – 20 ms
<b>Type 2- Medium speed messages:</b>		
Type 3- Low speed messages:		100ms
Type 4- Raw data messages:	P1	500ms
Type 5- File transfer functions:		10ms
Type 6- Time synchronization messages		>=1000ms
		Accuracy ±1ms or ±0.1ms

Table 1 IEC61850-5 Latency requirement classification for substation applications [4]

Based on this table the various transmission applications of smart grid can be mapped to the different types. On the other end, distribution applications, such as demand-response, asset use efficiency, and electrical vehicle applications transactions require 0.5 to 5 seconds latency. Others like DA (Distribution Automation), VVC (Volt-Var Control), fault location and distributed generation applications have transactions latency in the range of 0.1 to 60 seconds.

**Characteristics of Canadian Utilities**

More than 60% of Canadian production is hydroelectric [5]. This is an important factor to consider because some of the popular smart grid applications are not as critical for hydroelectric generation plants. Hydroelectric production can be more rapidly adjusted to fill the demand. The main smart grid use cases for the distribution network in Canada are AMI (Advanced Metering Infrastructure), distribution power loss reduction through VVC and improvement on the installed grid control and monitoring equipment to reduce outages duration, i.e. DA. The latency requirements of these applications make broadband wireless technologies very suitable from a cost/performance view point.

On another note, interoperability is a key requirement for Canadian utilities. Canadian utilities value for example the Interoperability Framework by the GridWise Architecture Council [3]. Other guiding bodies include, EPRI, IEC, NIST/SGIP and IEEE. LTE technology’s interoperability and future proof properties are in line with Canadian utilities’ inclination towards standard and interoperable technologies.

**Current communication infrastructures**

Canadian utilities currently use a range of communication technologies for various applications. These include optical communication, BPL (Broadband over Power Line), Satellite, Microwave, 900MHz wireless mesh, cellular 3G, mobile broadband LTE and WiMAX (Worldwide Interoperability for Microwave Access). These technologies are often selected depending on the range of applications they can cover as well as characteristics such as performance, cost, open standards and availability of equipment, in particular LTE UEs (User Equipment).

**LTE Technology Possibilities and Promises**

LTE is the latest 3GPP standard in use for mobile communication technology. The LTE initial standard is officially called by the 3GPP document Release 8. LTE’s benefits include global standardization and future proofness, a secure ecosystem, rapid deployment with plug and play features, scalable bandwidth, simplified IP based architecture, multi-antenna support for a very low latency and QoS based (Quality of Service) and policy based traffic handling.

LTE supports peak data rates of 150Mbps downlink and 50Mbps uplink (in a 20MHz spectrum, although carriers of as low as 1.4MHz, 3MHz, 5MHz, 10MHz and 15MHz are possible with LTE). Enhancements are achieved when advanced antenna technologies (e.g MIMO) are used. An LTE cell can cover up to a 100 km area although best performance is achieved within a 30 km reach. LTE inherently supports interworking with existing 3GPP networks as well as non-3GPP networks (see Fig. 2).

The LTE’s EPC (Evolved Packet Core) is a flat IP-based multi-access core network which makes it very suitable for interworking with, and migration from, existing technologies. The PDN-GW (Packet Data Network Gateway) can serve as such an interconnection point for 3GPP and non-3GPP access networks.

A list of further improvements of LTE is summarized in reference [2]. LTE-A or LTE-Advanced relates to Releases 10 and 11. LTE-A release 10 enhances the radio access technologies of LTE with the improved spectrum flexibility of carrier aggregation, enhanced multiple antenna transmission and relaying functionality allowing use of LTE as wireless backhaul media (as opposed to only network to UE media). LTE release 11 will include functionality for CoMP (Coordinated Multi Point) Tx/Rx for the deployment of low power network nodes under macro node coverage.

LTE release 12 and beyond is referred to as LTE-B and will address new use cases such as MTC (Machine-Type Communication) and NSPS (National Security and Public Safety) services. LTE-B will include further enhancements to multiple-antenna and CoMP technologies as well as advanced terminal receivers with always-on signals. The benefits are expected not only for macro deployments, but also for deployments with low power nodes. LTE-B will address device to device (D2D) discovery and communication, a feature highly anticipated for national safety as well as smart grid applications.

**LTE for Canadian Utilities**

In Canada, like many other countries, smart grid deployments included other broadband technologies (i.e. pre-LTE era technologies). To face this reality, LTE technology can be introduced in three deployment scenarios, one being a private LTE network, another using operator owned public LTE networks and a third one, and the most desirable one, being a shared network scenario with public safety LTE deployments.

**Private LTE network**

In this scenario, the utility company will be in charge of deploying and operating its own LTE network. This has the advantage of full network control and access to configuration parameters. Private deployments are favored for reasons of robustness and availability,

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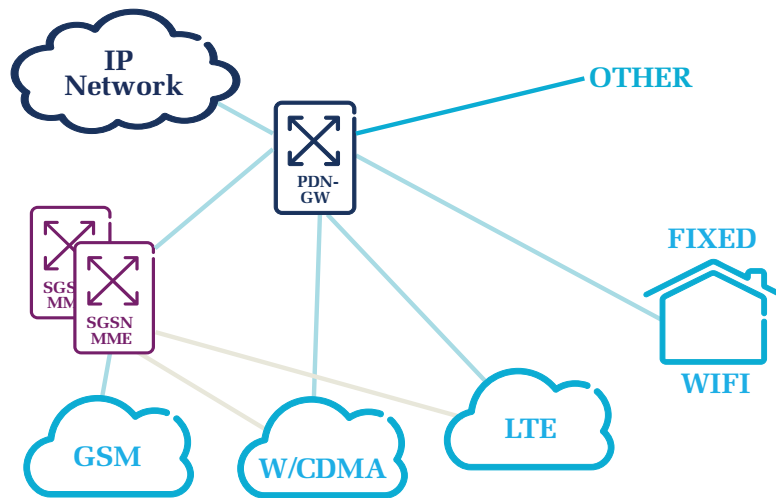



Fig. 2 EPC inter-working with various access networks.

which are not yet explicitly available in current public SLAs. This comes at the greatest cost of green field deployment and spectrum acquisition as well as considerable network under-utilization. The former is less of a problem when it comes to base station site acquisition as utilities have thorough infrastructure that can be leveraged for this mean. This type of deployment can inter-operate with existing infrastructures (e.g. WiMAX). In such an example, the WiMAX's ASN-GW (Access Service Network Gateway) can be interconnected to the EPC's PDN-GW, with possible interconnection to the EPC's PCRF as well.

even more common in the near future by allowing for multi operator SIM support. Currently the biggest concern of utilities with public network operators is the service availability, as well as lack of differentiated SLA for M2M type applications and corresponding QoS configuration, although the technology is available.

A variant of this scenario is a mix of private and public deployment. Fallback scenarios from private to public or public to private could be considered. This type of redundancy could be extremely useful and again will be enabled by multi operator SIM technologies.

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### Public LTE network

This scenario seems like the most reasonable one for Canadian utilities in the short run. Certainly less critical smart grid applications could be supported by public operator LTE networks. An example would be the AMI infrastructures where the primary requirement is the periodic relay of meter readings from collectors to the back office. New, more time critical, applications could be developed as operators offer new SLA's for specific M2M use cases and/or as the utilities migrate towards their own private LTE network. Soft SIM (Subscriber Identity Module) technology will make such transitions

### Private Virtual Network Operator (PVNO)

This scenario is one of the most promising ones as a follow through with scenario B. A PVNO is nothing but an adaptation of an MVNO (Mobile Virtual Network Operator) for private use. Like MVNOs, a PVNO does not have a mobile license or mobile infrastructure, but has its own HSS (Home Subscriber Server), SIM/IMSI (International Mobile Subscriber Identity) range, billing system and core network which gives a large degree of control and management of resources. A PVNO deployment often avoids SIM lock-in by making use of embedded SIM concepts. A PVNO eliminates security and authenti-

cation issues as both SIM and HSS belong to the PVNO. Moreover, using multiple networks will provide redundancy and a more reliable PVNO. Utilities can deploy and manage their own PVNO or request the services of a PVNO service provider.

### Semi-private LTE network shared with Public Safety

This last scenario is being touted in general in the United States where the public safety departments have been granted a block of 20MHz within the 700MHz band but there are currently issues with deployment costs of an LTE based Public Safety Network. One very beneficial scenario would be the split of the cost and network between utilities and first order public safeties. This is a logical strategy that could leverage on utilities' widespread grid infrastructure where substations, high voltage line towers and poles can be strategically used as base station sites. The other gain for utilities would be the avoidance of bidding on LTE spectrum or waiting for future government allocations.

### LTE – Desired Enhancements

As discussed in Section II.A, current LTE performance is suitable for most smart grid applications not related to grid protection. To reach the next class of latency would be improbable by any mobile broadband technology. Despite this, improving LTE latency could provide a margin and anticipate future applications in a new latency class not yet determined.

### Causes of latency in LTE networks include

- The idle to connected stated delay.
- Random access delay
- Scheduling and HARQ (Hybrid Automatic Repeat Request) retransmissions
- Latency introduced by the UE
- Non-differentiation of traffic

Delay improvement can be achieved either by configuration (e.g. use of proprietary QoS class profiles), or may require changes to the 3GPP standards. This usually comes with cost, such as increased power consumption at the UE, underutilization of resources and increased complexity.

There are other architectural changes that could improve latency and be more suitable for smart grid deployment, like colocalizing the P-GW and S-GW.



The true concern in Canada is the deployment scenario of choice which varies between using a public infrastructure and PVNO concepts, or the potential of network sharing with the public safety's upcoming infrastructure in the 700 MHz band.

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2. Ericsson Whitepaper, "LTE Release 12-Taking another step toward the networked society", January 2013, Accessed



Finally end user equipment for smart grid applications needs to focus on latency criteria and ruggedness. While the market for such UEs was initially slow there are a number of UEs being currently advertised. Many smart grid applications rely on Ethernet connectivity creating the need for LTE UEs to offer Ethernet connectivity on the client side. LTE UEs can also be enhanced to noticeably improve latency.

This paper sheds light on the Canadian perspective of using LTE technology for smart grid applications. Overall LTE technology is sufficient for most of the current applications. With upcoming enhancements LTE will be even more suitable for MTC and future smart grid applications. The true concern in Canada is the deployment scenario of choice which varies between using a public infrastructure and PVNO concepts, or the potential of network sharing with the public safety's upcoming infrastructure in the 700 MHz band.

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