Broadband Powerline/Smart Meter Integration Project:

Final Report

Submitted By: PUC Distribution Inc.
September 15, 2006

September 18, 2006

MR. JOHN WONG
MEARIE MANAGEMENT INC.
3700 STEELES AVENUE WEST, SU 1100
VAUGHAN, ON L4L 8K8

Dear John:

PUC Distribution Inc. is pleased to provide you with five copies of our final report for the Broadband Over Powerline Project that was financially supported by the Trustees of the *LDC Tomorrow Fund*. I trust that you will find that our report meets both the spirit and the specific objectives associated with the proposal that was approved by the Trustees.

As you will see in our report, our project was successful in demonstrating that smart metering networks can be successfully integrated with broadband powerline (BPL) technology. We have also determined that BPL technology is more cost-effective than optical fibre as a metering backhaul solution. Finally, a BPL backhaul solution would provide much greater network coverage, which could support both utility applications and the delivery of known telecommunications services such as Internet and Voice over Internet Protocol.

While our project successfully demonstrated "what can be done", it is also important to recognize that BPL technology is now in its second generation. The newer products are more stable, have greater bandwidth and have more attractive pricing than the equipment that we used during our trial. As a result, the business case using newer BPL technology would be markedly better than the case demonstrated in our project.

We would like to acknowledge the efforts of all of the partners that worked with us on this project. Without the direct assistance of our Metering and Stations Department, Amperion Inc., Olameter, Elster Metering, Lantronix and Nortel Networks, we would not have been able to successfully complete this project. We are pleased to have worked with such dedicated individuals and companies and would welcome the opportunity to work with them in the future.

It is important to note that our project would not have proceeded without the financial support that was provided to us by the *LDC Tomorrow Fund*. Given The lack of financial assistance available for LDCs who are interested in conducting research, combined with the ever-changing environment we find ourselves in as a result of evolving provincial policy, serves to underscore the importance of the *LDC Tomorrow Fund*. It is our hope that this fund will remain in place to support projects that can advance the interests of LDCs across the Province of Ontario.

Thank you again for your support. Should you have any questions regarding our project, please feel free to contact be at you convenience.

Best regards.

PUC DISTRIBUTION INC.

H.J. Brian Curran, P. Eng., MBA
President and CEO

cc Martin Wyant

Table of Contents

Appendices

1) Introduction

PUC Telecom began its initial research into powerline carrier technology, now known as broadband powerline technology or BPL, in 2003. Because BPL is installed on utility infrastructure, it was seen as a vehicle that would allow PUC Telecom to offer more services to residential and commercial customers within our community while creating an opportunity to host utility applications such as meter reading.

In October 2003, PUC Inc. granted approval to proceed with a two-phase BPL trial with Amperion Inc., an equipment manufacturer that had developed a unique BPL/wireless solution. A small trial network in Sault Ste. Marie was designed to bring the service from our Church Street substation to the PUC office on Queen Street. The equipment was installed and configured in January 2004 and a formal announcement about the project was released in February 2004.

Phase 1 of the trial was monitored for a two month period. During this time, we monitored the network, made periodic adjustments and as required and began the process of planning for an Internet pilot project which would be deployed in two areas in Sault Ste. Marie.

Having achieved the necessary network stability and bandwidth improvements, PUC Telecom moved to Phase 2, a commercial trial of the technology that would lead to the installation of small access networks on Great Northern Road and the Industrial Park. Our network technician received training during the spring of 2004 and worked with Amperion in the summer of 2004 to design, configure and eventually deploy the network with the assistance of our line department.

In September of 2004, volunteer businesses were recruited in the Industrial Park and Great Northern Road areas. The first ten volunteers in each area were given the opportunity to receive a free Internet service from PUC Telecom. Throughout October and November, our network technician installed services at customer locations in both areas, using a variety of customer access devices.

While we are able to achieve success in delivering Internet service to local business customers, we also determined that BPL technology required the inclusion of bundled utility services to help round out the business case. As a result, in the winter of 2005 we began to examine the possibilities related to the development of an IP-enabled distribution grid. Our research efforts led us to discuss this opportunity with Amperion, members of the Electric Power Research Institute, a variety of demand-side management hardware and software vendors and a number of meter manufacturing and meter network management companies.

It became clear that, while there was significant value seen in a product that could provide network oversight to distribution grids, there were no existing solutions that could simply be purchased and configured for a BPL network. As a result, we began the process of developing a proposal that would see PUC Distribution, PUC Telecom, Amperion, metering vendors and others work together to develop a project that provide us with the necessary "proof-of-concept" for an IP-enabled distribution grid.

Our proposal to the MEARIE's LDC Tomorrow Fund Committee was submitted in March 2005. This proposal described a project that would develop and test solutions related to meter reading, load control and other applications. After discussions with MEARIE, the focus of the project was tightened to a smart meter/BPL integration in an effort to make the project easier to complete within a reasonable time frame.

Martin Wyant and Allan Frederick from PUC Services traveled to Toronto in May 2005 to formally present our proposal to the LDC Tomorrow Fund Committee. Throughout the summer of 2005, representatives from MEARIE and PUC Services discussed the project and negotiated the necessary funding agreement, which was formalized on August 15, 2005. The LDC Tomorrow Fund Committee granted a total of $55,000 to the project.

With the funding in place, a working group was struck to oversee the development and staging of the project. Members of the group included the following:

PUC Distribution BPL/Smart Meter Working Group

Martin Wyant PUC Services	Project Management
Kevin Orr PUC Services	Smart Meter Lead
Randy Johnson PUC Services	Marketing and Communications Lead
Ron Lusterio PUC Telecom	Network Integration Lead

The efforts of the working group were significantly aided by private sector participants in the project from the following companies:

- Amperion
- Olameter
- Elster
- Lantronix

Thanks to the support of the LDC Tomorrow Fund and the significant contributions of private sector supporter and many employees at PUC Services, we achieved excellent results. In addition to demonstrating that BPL technology can be successfully used to backhaul smart meter data, we also developed what we believe to be the world's first integrated BPL/smart meter network. Independent test scripts applied by the Ontario Utility Smart Meter (OUSM) group confirm that the solution that we engineered and tested met or exceeded the performance of other smart meter pilot projects that were conducted under the OUSM banner. We are pleased with the overall results that we have achieved and look forward developing and testing other solutions that can help LDCs continue to improve grid reliability and efficiency.

2) Overview of Broadband Powerline Technology

Broadband Powerline technology enables the transmission of high frequency data signals through the medium voltage (MV) wires that are used to bring power to neighbourhoods, commercial and industrial areas across North America. Amperion has developed proprietary equipment that uses MV wires as the BPL backbone while allowing customers to connect wirelessly to the network in order to receive voice, data and video services.

Amperion's solution is unique in the BPL industry, as other BPL developers have traditionally focused their efforts on developing solutions that provide access to customers by placing coupling devices that connect the medium voltage and low voltage networks, which enables customers to connect via a BPL modem that is placed in an electrical outlet in their home or business. While MV/LV solutions work, they have to deal an extra level of complexity with respect to dealing with line transformers.

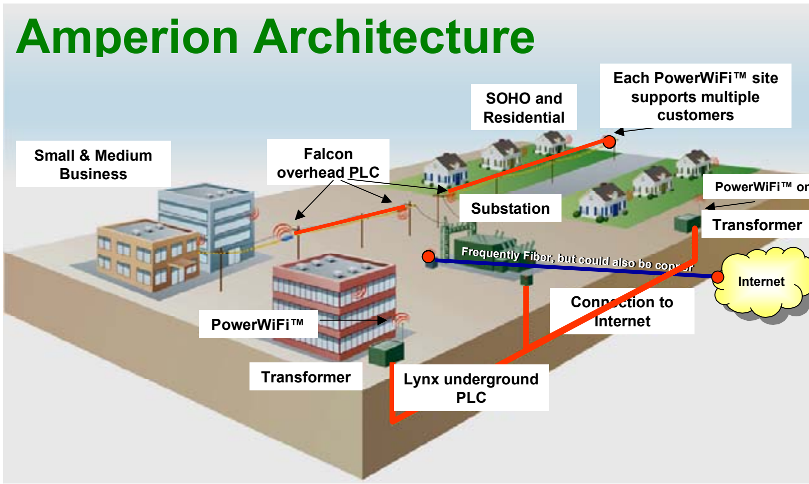
The BPL solution provided by Amperion combines new powerline technology with wireless technology that acts as the "last-mile" solution for broadband delivery. The process of transmitting and receiving signals between our existing network and customer locations is as follows:

- ≈ ***Injector*** — receives wireless signal from fibre node/WAP and launches BPL signal
- ≈ ***Repeater*** — receives BPL signal, decodes, reconstitutes, xmts BPL to next repeater, also xmt/rcv wireless signal to/from users
- ≈ ***Extractor*** — receives BPL signal; xmt/rcv wireless signal to/from users

Performance Characteristics in Trials

- ≈ Very-low latency (time loss)
- ≈ Repeatable over extended distances – single segments up to 2000 feet
- ≈ Up to 24 Mbps throughput

Please refer to the diagram on the next page for a pictorial representation of the BPL network and its associated processes.



Amperion has developed products that can be used to provide BPL on overhead lines (Falcon and Griffin) and underground lines (Lynx). These systems currently provide up to 24 Mbps of delivered throughput per injection point, depending on line quality and equipment spacing.

This is a standards-based solution that links the power line network to customers via an 802.11b connection on the public wireless spectrum. PowerWifi provides a broadband solution that is scalable, economical, safe and which conforms to globally accepted standards.

Because BPL technology shares the same wires and poles used to deliver power, and because BPL networks tend to be developed around the substations deployed by local distribution companies, there is a unique opportunity to examine how the introduction of the technology can serve to increase a utility's ability to apply greater predictive management to its grid.

The overwhelming interest in BPL technology stems from the unique nature of the technology and its applications and the ubiquity of the distribution grid. When the need to develop a more intelligent grid is added to the equation, it becomes clear that BPL technology provides a new and compelling opportunity to perform the research and development necessary to transform a single-purpose, data-poor grid into a multi-purpose, intelligent grid.

3) Project Report

A) Confirmation and Role of Project Participants

While the project was formally launched in September 2005, many discussions had already taken place during the Spring of 2005 with potential private sector participants who had expressed an interest in working with PUC Distribution. These participants and their roles in the project are summarized below:

i) PUC Distribution: As the operator of the local power distribution grid and having ultimate responsibility for the selection, deployment and management of a smart metering network in Sault Ste. Marie, PUC Distribution has a keen interest in the BPL/Smart meter project.

The Supervisor of Stations and Metering played a significant role in the working group and provided direct leadership in the following areas:

- smart meter hardware selection

- developing staging area maps

- selecting homes and businesses that would receive smart meters

- coordinating with PUC Engineering to ensure that hardware deployments on poles conformed to necessary safety regulations

- assigning metering staff to deploy smart meters and to work with PUC Telecom a PUC electrician on the design and build of the necessary "meet-me" device

- representing the project at a conference sponsored by Elster Canada

- ordering metering products from Elster

ii) PUC Telecom: PUC Telecom deployed Canada's only broadband powerline (BPL) access network in 2004. In assessing the performance of the network, it became clear that BPL technology could host a variety of utility applications and, as a result of its attachment to the grid, could provide LDCs with information regarding grid-related noise sources.

The General Manager of PUC Telecom acted as the project manager. PUC Telecom assisted in the following areas:

- coordinating of project meetings and teleconferences

- assembling and disseminating available research related to "smart grid" applications

- assist in the design and build of the necessary "meet-me" device

- providing access to our BPL network

- developing the integrated BPL/smart meter network design with Amperion

- designing the necessary communication gateway to allow metering data to be capture remotely by Olameter

- compiling project-related information and completing project reports

iii) Amperion: Amperion's BPL access technology was used to support the backhaul of smart metering data. As the vendor for PUC Telecom's BPL deployments in Sault Ste. Mare, Amperion staff were familiar with our network configuration and had established a remote network monitoring capability from their offices in Andover, Massachusetts.

In addition to their BPL telecommunications expertise, Amperion also had developed significant grid architecture and performance knowledge through the hiring of the former Chief Engineer for American Electric Power, Bruce Renz. Amperion made significant contributions to the project, including the following:

- working with Elster U.S. to develop and test the communication interfaces between Amperion equipment and Elster meter collectors

- working with PUC Telecom to develop and test the communication interfaces between Elster meter collectors and Lantronix WiFi/900 Mhz translators

- working with Elster, Lantronix, PUC Distribution and PUC Telecom in the field deployment of the collectors and the "meet-me" units.

- providing network troubleshooting support on an as-needed basis

iv) Olameter: Olameter acted as the project's meter data repository. In this role, Olameter collected the data and stored it using Elster's MAS software. In addition, Olameter staff provided our project team with information regarding a variety of metering vendor products and contacts.

v) Elster: Elster Canada was chosen as the smart meter vendor for our project. Elster representatives from Canada and the United States provided the necessary hardware (collectors and meters) and worked with both Amperion and PUC Telecom to ensure that all necessary interface configurations were designed and tested. Elster also installed the two collectors units used in the project.

vi) Lantronix: Lantronix was chosen to provide the project with a device that could be used to translate and send information between Elster's 900 Mhz radio and Amperion's WiFi antenna. Lantronix staff also assisted with the final deployment of the network and provided PUC Telecom staff with the assistance in developing the necessary interfaces between the networks.

This project developed a new, integrated solution that has given utilities a network option that can be deployed to support smart meters and other utility applications. It is important to note that a good deal of the work undertaken on the project occurred at far flung locations throughout Ontario and the United States. Key project participants were only available in Sault Ste. Marie for a one-day period, in order to support the physical deployment of the meter collectors and test the integration of the network.

The fact that this project ran extremely smoothly is a testament to the dedication and patience of all project participants.

B) Selection of Deployment Area

PUC Telecom deployed two BPL spurs in Sault Ste. Marie. The first spur is deployed in an industrial park that houses a variety of light manufacturing, industrial service and warehousing firms. The second spur is deployed on Great Northern Road, which is a commercial area of the city that has a mix of residential, restaurants, box stores, hotels and small shops.

The working group decided to deploy the smart meter network and "meet-me" devices in the Great Northern Road area due to the mix of building types in the area and the fact that we would be able to test more than one meter type. Maps of the deployment area are contained in Appendix 3, "Smart Meter Deployment Maps", at the end of this report.

With the area selected, the Stations and Metering Supervisor then recommended 13 commercial and 65 residential buildings that were to have their existing meters exchanged for new smart meters. The number of new meter installations was driven by the projected cost of purchasing meters and the estimated reach of the BPL spur. A complete list of all meter locations and types may be found in Appendix 4, "*List of Smart Meters by Type and Address*".

C) Selection of Metering Technology

Members of the project working group attended many meetings, teleconferences, web conferences and trade shows to investigate metering solutions. Information (reports, presentations, brochures, data sheets) was received from a variety of vendors, including:

- Tantalus
- Cannon
- Itron
- Elster
- SmartSync
- Audlogic
- Sensus

A number of important criteria were used to arrive at the selection of the metering solution:

- the vendor needed to demonstrate Measurement Canada approval of their meters

- the metering solution needed to meet the presumed basic specifications outlined by the Ontario Energy Board

- the vendor needed to have a mature product offering

- Olameter needed to have the software and equipment necessary to support the data gathering aspect of the project

- the vendor needed to be willing to work on a small project (80 to 100 meters)

- the vendor needed to be willing to dedicate staff to work with PUC Telecom and Amperion to design and build "meet-me" unit that would house a collector, a translating device and an antenna

Our initial discussions focused on an Itron solution. In our introductory calls with Itron representatives, it was determined that they would be unable to support a pilot unless 500 meters were ordered. The working group was unwilling to satisfy Itron's condition and our discussions turned to Elster.

Elster's "Energy Axis" metering solution was found to be an excellent fit for our project. Their solution met the key, presumed performance specifications that were being discussed by the Ontario Energy Board. In addition, their 900 Mhz radio system provided us with an opportunity to develop a simpler interface between the BPL network and the meter collector unit.

Olameter was familiar with Elster's meter data management system and had, in fact, arranged to purchased the newest commercially-available version of their Energy Axis Metering Automation (MAS) software. Please refer to Appendix 7, "*Elster Equipment Information*", for an overview of how their solution configures itself.

Finally, Elster officials in Canada expressed significant interest in our project and assigned a technical and sales resource to assist in the development and staging of the network. Similarly, Elster officials in the United States provided equipment and staff resources to Amperion in order to test integration solutions in Amperion's testing lab in Andover. This level of commitment and engagement was maintained throughout the duration of our project.

Once deployed, Elster's REX meters themselves (attached to homes and businesses) form their own two-way data network, intelligently communicating with each other while building a MESH network on the 900MHz frequency. This MESH design allows for redundant paths for the data to travel so if one link is compromised, the data can choose an alternate path back to the collector. A3 units acting as a collector are placed in a location where they can "see" the maximum number of REX meters that are deployed in homes and businesses.

The REX meter by is an electronic meter with a built-in two way 900Mhz radio that operates on a Wireless LAN. Designed for residential metering this meter self-registers to an Elster A3 Collector Unit.

With two-way communications, the REX Meter offers demand, time-of-use (TOU), load profile recording, bi-directional metering and critical tier pricing (CTP) capabilities in addition to kWh consumption measurement.

The A3 Collector also has a 900 Mhz radio and is a data collector with both a LAN interface for communication with the REX meters and a WAN interface for communication with the MAS (Metering Automation Server).

Not only does the A3 ALPHA function as a data collector, it also is a full functioning meter that could be installed at a customer's home or business. Up to 1,024 REX meters can be managed by the A3 on a local area network (LAN). For a more detailed description of the Elster A3 and Rex meters and an overview of their system architecture, please refer to Appendix 7, "Elster Equipment Information".

Having reviewed and understood the basic functioning of the Elster network we were now ready to begin the process of researching technology options that would help us connect the BPL and smart metering networks.

D) Network Integration Design and Build

PUC Telecom runs an existing BPL network that successfully sends and receives traffic on both our MV electrical grid and a wireless (802.11) network. The smart meter network deployed in Sault Ste. Marie also uses the wireless network communication medium but on a different (900Mhz) frequency. The differing nature of 802.11 wireless and 900Mhz wireless meant that we would need to design and build a solution that would facilitate the sharing of data between the two networks.

Although Amperion had achieved some success at creating an interface between their WiFi technology and Elster's 900 Mhz radio technology, it was determined that the hardware that was being used to bridge the two networks together was not approved for use in Canada.

PUC Telecom then began its own research into Canadian-approved WiFi/900Mhz bridges and found an American company, Lantronix, that had manufactured the type of bridge we required. Lantronix had also registered the product, called a "WiBox", with Industry Canada, which allowed us to deploy the equipment without needing to obtain an experimental license. Finally, the Lantronix device had a serial port, which would allow us to connect directly to the serial interface on the Elster A3 collector unit.

The following diagram provides a basic overview of the integration:

Smart Meter Network	Integration Point	BPL Network

REX Meters ←-----→ **A3 Collector---bridging device** ←-----→ BPL Repeater

After the initial design was conceived, the actual integration between the existing BPL network and the smart metering network involved 4 distinct steps:

i) Hardware Assembly
ii) Software Configuration
iii) Field Installation
iv) Testing

i) Hardware Assembly

Two weatherized enclosures were sourced to house our integration equipment. Once fully constructed and tested, the enclosures were installed in two pole-mounted locations between the smart meter networks and the BPL network.

Discussions with Amperion, PUC Engineering and Elster led us to select a fiberglass enclosure was instead of metal due to the radio interference that can sometimes occur with metal objects.

Internal enclosure design work was conducted by the Field Technician from PUC Telecom, a member of PUC Distribution's metering department, a PUC Distribution electrician, Elster and Amperion. Inside the enclosures were plug-in bases for the A3 Collectors, plug receptacles, the A3 Collectors and Lantronix WiBox units. The Lantronix WiBox is the device which 'bridges' the data between the A3 Collector and the Amperion BPL Extractor.

The enclosures were drilled, and fitted with the Bridging Device/A3 ALPHA Collector. Finally, Square D service entrances were installed on the outside walls of the enclosures in order to allow for quick power disconnects. The Electrical Safety Authority (ESA) was then called in to inspect and approve all internal wiring.

For a block diagram of the enclosures and pictures of the finished units, please refer to Appendix 5, "*Enclosure Design*".

The final piece of hardware requiring installation was the 802.11 omni-directional antenna, which is connected to the Lantronix bridging device, fed through a drilled hole in the enclosure, and mounted on the designated utility pole within reasonable range on the nearest Amperion BPL repeater unit.

ii) <u>Software Configuration</u>

With the integration hardware assembled, the next step was to properly configure the software and assign the necessary IP and SSID addresses to ensure that the BPL network and the A3 collector units could see each other and send and receive information as required.

In the PUC Distribution metering shop, the bridging devices (Lantronix WiBox) were configured to be used on a private wireless network, (a local network that is accessed only by those who know it exists) using a wireless access point (a wireless device that allows wireless clients to connect and become part of the private network). This was done to simulate what would happen in the field using the BPL repeater. The devices were powered up in the metering shop and tested to ensure that there was connectivity between the bridging device and the access point.

After this connectivity was confirmed for both bridging devices, each assembled unit was brought to its respective deployment sites, re-configured and tested to determine whether they would work with the BPL repeaters and the existing GNR

subnet (the private BPL network on GNR Great Northern Road) that was already in active operation.

The following SSIDs and static IP addresses were assigned to the A3 Collectors:

Collector 1 Detail:		**Collector 2 Detail:**	
SSID:	GR10RSSM-PT	SSID:	GR7RSSM-PT
Static IP Address:	10.0.2.151	Static IP Address:	10.0.2.152

While still in the vehicle, connectivity was tested and confirmed to the BPL Repeaters and the integration enclosures were deemed to be ready for physical installation on the poles that had been selected and approved for use by PUC Engineering staff.

iii) <u>Field Installation</u>

PUC Distribution line crews, working with PUC Distribution metering staff, were deployed to mount the fiberglass enclosures on their respective deployment poles. After the enclosures were mounted, the Electrical Safety Authority (ESA) was again contacted to inspect and approve the installations.

Upon receiving ESA approval for the installations, a PUC Distribution line crew was deployed to power up the enclosures. PUC Telecom arranged to be onsite with staff from the metering department during the powering of the enclosures to ensure that the bridging devices and collectors received power and could communicate with each other and with the BPL network. These tests were successful.

The PUC Telecom BPL network receives its Internet service from the PUC Telecom fibre network, which is powered by telecommunications equipment that is housed at our point-of-presence (POP) site in Sault Ste. Marie. The PUC Telecom POP site not only manages all fibre customer services within the city, it also serves as our customers' gateway to the Internet. While we had demonstrated that we could send and receive data between our BPL and the A3 collectors, we now needed to focus on the task of connecting this new network to our POP site.

The next step was to access the Collector units privately from within the BPL network by testing for connectivity from the Sault Ste. Marie POP site. This testing was also successful. Further testing was confirmed when the GUI interface on each bridging device was accessed and a configuration screen was able to be viewed on both devices. This allowed us the ability to remotely configure devices from our POP site location.

With the enclosures installed, the network configured and the connectivity proven, PUC Telecom arranged for representatives from Elster, Amperion, Lantronix and PUC Distribution metering to meet in Sault Ste. Marie in November 2005 to fully commission the network. The commissioning was primarily focused on Elster reconfiguring their A3 units so that they could see the previously deployed smart meters. This work was successfully completed in one day.

Testing of the units began and it was discovered that both Collector units were accessible both from outside of the private BPL network using a Virtual Private Network (VPN) tunnel from Burlington, Ontario. The integration between the two networks was testing successfully and "dummy" meter data from the Sault Ste. Marie collectors was being read by Elster VPN tunnel.

Within a few days, once Elster solved an internal time stamp issue with their collector units, they were able to begin polling all deployed meters on-demand and receiving all necessary metering data. In December, this back office function was switched to Olameter, who had successfully installed Elster's most recent MAS software upgrade. Although we experienced some difficulties established a consistent VPN tunnel between PUC Telecom and Olameter, these difficulties were overcome when Olameter purchased and installed a new router in their Toronto offices.

For a graphical representation of the network, please refer to Appendix 6, "Network Map and Communications Path".

<u>E) BPL Network Performance</u>

The use of network monitoring software allows PUC Telecom to monitor the performance of the BPL network. One of the best ways to determine network uptime is to run a Summary Performance Report showing network availability as determined by Round Trip Time (RTT) in milliseconds.

The BPL network performance for the testing period of November 1 to December 31, 2005 averaged 91% uptime. Please see Appendix 10, "*BPL Network Performance, November 1 – December 31, 2005*" for a detailed summary report.

The majority of network down time was due to an unplanned network outage which required troubleshooting, and eventual replacement of BPL hardware in the Great Northern Road network. Limited network downtime also occurred for regular network maintenance and software upgrades, rebooting of network devices and further testing.

F) Testing of Network (OUSM)

The most important test of our BPL/smart meter network was conducted by the Ontario Utility Smart Meter (OUSM) working group, facilitated by Util-Assist. The OUSM working group is composed of local distribution company members who wish to gain an in-depth understanding of Ontario's "Smart Metering" initiative.

One of the key activities undertaken through the OUSM group was the staging of pilot projects that were focused on demonstrating the technology, costs and overall performance of a variety of automatic meter reading (AMR) networks that were deemed to meet the basic functional specifications developed by the Ontario Energy Board. The BPL/Smart Meter project supported by the Tomorrow Fund was one of nine AMR pilots undertaken by members of the OUSM working group.

Staff from Util-Assist, working with representatives from Elster, applied a series of test scripts to our project. The first batch of test scripts was run on November 17, 2005 and the second batch was run on November 24, 2005. All test scripts led to "pass" results with the exception of two load control and load limiting functions. While Elster meters support load limiting, the MAS software does not support the function. Similarly, load control functionality can be performed on an Elster metering network, but only through the use of a third-party vendor.

The full OUSM report may be found in Appendix 9, "*OUSM Test Scripts Report*".

G) Cost Comparison: Fibre versus BPL

One of the key objectives associated with our project was to compare the overall network costs associated with collecting and backhauling metering data using optical fibre and BPL technology. While the footprint from our project was small, we can extrapolate from the data that we have compiled and arrive at cost comparisons that could be applied on a community-wide basis.

In 2000, the PUC Telecom fibre network was commissioned. The original network was comprised of two fibre rings that encircled the majority of the populated areas of Sault Ste. Marie. These two rings are powered by municipal area network electronic equipment that is housed at two substations within the city.

When comparing BPL and fibre backhaul services to collect metering data, we decided to create a model that would review the estimated costs associated with deploying a network that would cover 50 square kilometers within Sault Ste. Marie. This network footprint was selected for the following reasons:

- ⇨ The actual BPL/smart metering network that was developed covered a small area, approximately one square kilometer in size. The size of the network was kept small in order to minimize the costs associated with staging the project.
- ⇨ The financial information gathered from a small network deployment could not be reliably used to draw conclusions about the cost-effectiveness of deploying BPL versus fibre for backhauling metering data.
- ⇨ The 50 square kilometer network that was selected contains a total of 24,047 meters, which represents approximately 80% of the total number of meters that PUC Distribution will need to deploy in its smart meter implementation project.
- ⇨ There is a good range of commercial, industrial and residential meters that will be deployed within this footprint.

The spreadsheet on the following page of this report, "*Cost Comparison: Fibre Network versus BPL in a 50 Square Kilometre Footprint*", summarizes the key comparative information that was gathered and analyzed for this report. In order to assist in the interpretation of the information, we have developed a description of some of the items included in the spreadsheet. This description may be found on the page immediately following the spreadsheet.

While we are aware that a variety of financial analysis tools could be deployed to analyze data, we have decided to take a straightforward approach that is based on known or closely estimated costs for the equipment, material and labour required to provide the BPL or fibre backhaul solutions that we are comparing.

The information contained in the spreadsheet is based on known costs that have been experienced through:

- ⇨ the development and implementation of an optical fibre network
- ⇨ the quoting of 100 separate fibre spurs
- ⇨ the building of 83 individual fibre spurs
- ⇨ the development and implementation of three BPL network spurs
- ⇨ the implementation of the BPL/smart meter network

Cost Comparison: Fibre Network Versus BPL in a 50 Sq. Km. Footprint

Fibre Network with 83 Existing Spurs

POP* Site MAN* Electronics	$537,490
Gateway Equipment	$546,860
Network Build/Installation/Material	$1,713,837
Specialty Vehicles/Transportation	$36,151
PUC Telecom Labour	$223,755
ON Telcom Labour	$40,752
Travel and Related Expenses	$30,082
Number of Metering Collectors Required	50
Cost to Build 50 Fibre Spurs**	$478,650
Cost to Build 50 Fibre/AMR Meet-Me Nodes***	$64,500
Total:	**$3,672,077**
Approximate number of customers able to be served	83
Cost per potential customer served	**$44,242**

BPL Network

POP Site Equipment	$100,000
Cost to Build Fibre/BPL/Wireless Meet-Me-Nodes	$161,000
BPL Equipment/Installation	$1,935,000
Specialty Vehicles/Transportation	$75,000
PUC Telecom Labour	$59,425
BPL Vendor Labour	$25,000
Travel and Related Expenses	$25,000
Number of Metering Collectors Required	50
Cost to Build 50 Fibre Spurs**	$478,650
Cost to Build 50 BPL/AMR Meet-Me Nodes****	$33,500
Total:	**$2,892,575**
Approximate number of customers able to be served	23,948
Cost per potential customer served	**$121**

* POP = point of presence

* MAN = Municipal Area Network

** see Appendix 13, "Fibre Spur Cost Analysis"

*** media converter, enclosure, cabling, connectors

**** wireless access point, media converter, enclosure, antenna, cabling, connectors

***** WiBox device, antenna, cabling, connectors

The following details are provided to help interpret the data included in the preceding spreadsheet.

i) Fibre Network with 83 Existing Spurs

a) POP Site MAN Electronics/Gateway Equipment:

PUC Telecom has a Point-of-Presence, or "POP" site located in a PUC Distribution Substation. The POP site is a major meeting point for the transport fibre from the two fibre rings that comprise our fibre network in Sault Ste. Marie.

In addition to acting as a termination point for fibre, the POP site also houses the majority of the municipal area network equipment that is required to manage data traffic on our fibre network. It is this equipment that "lights" and then routes data to ensure that Internet services, voice services and transparent LAN services work correctly for our customers. Finally, we receive our Internet gateway services from Ontera, which houses a significant amount of gateway equipment at our POP site. This equipment is connected by fibre that is terminated in Sudbury, Ontario.

b) Network Build/Installation/Material:

An optical fibre network is comprised of fibre, splice enclosures, patch panels and a variety of telecommunications equipment, which are contained in this line item. In addition, we have included the costs of designing and installing the network. The majority of the design and installation work was performed by contractors with expertise in fibre network planning and implementation.

c) Number of Metering Collectors Required:

It is estimated that 50 collectors would be required to cover the 50 square kilometer network. While terrain, foliage and other environmental factors might influence the actual number of collectors in a final design, 50 is a reasonable estimate.

d) Cost to Build 50 Fibre Spurs

Since formally beginning our business in 2001, PUC Telecom has completed 100 quotations for customers who were interested in receiving service from us. The costs associated with these quotations were added together and then divided by 100, to give us an estimated cost of $9,573 for a typical fibre spur installation. Please refer to Appendix 13, "*Fibre Spur Cost Analysis*" for additional details.

e) Cost to Build 50 Fibre/AMR "Meet-Me" Nodes:

In order to backhaul metering data, each meter collector would need to have a direct fibre connection, which would require us to build 50 fibre spurs. Each meet-me node would require a fibre media converter, a weatherized enclosure and a variety of cables and connectors. The total cost for equipment and materials for a single fibre/AMR meet-me-node is estimated to be $1,290.

ii) <u>BPL Network</u>

a) POP Site Equipment:

Our BPL network uses a Nortel "Contivity" router as the interface between the BPL network and the municipal area network equipment housed at the PUC Telecom POP site. It is estimated that 50 Contivity outers, at a cost of $2,000 each, would be required to support a 50 square kilometer network.

b) Cost to Build Fibre/BPL/Wireless Meet-Me-Nodes:

Each fibre/BPL meet-me node would require a wireless access point, a media converter, a weatherized enclosure, an antenna and a variety of cables and connectors. It is estimated that each meet-me node would cost approximately $3,220.

c) BPL Equipment/Installation:

It is estimated that we would require 450 BPL devices, at $4,000 each, to cover the 50 square kilometer footprint. It is also estimated that each device would require one hour to install and configure, at a cost of $300 per hour.

d) Cost to Build 50 Fibre Spurs:

Since formally beginning our business in 2001, PUC Telecom has completed 100 quotations for customers who were interested in receiving service from us. The costs associated with these quotations were added together and then divided by 100, to give us an estimated cost of $9,573 for a typical fibre spur installation. Please refer to Appendix 13, "*Fibre Spur Cost Analysis*" for additional details.

e) Cost to Build 50 BPL/AMR Meet-Me Nodes:

Each meet-me node would require a WiBox 900 Mhz/WiFi translator, an antenna, a weatherized enclosure and a variety of cables and connectors. The total cost for equipment and materials for a single fibre/AMR meet-me-node is estimated to be $670.

In reviewing the cost comparison, a number of key items stand out:

- ➪ A BPL network to support AMR would cost $779,502 less to deploy than a fibre network to support AMR.

- ➪ A fibre network is, by definition, a point-to-point network. As a result, a fibre network does not lend itself to easily supporting other utility applications, Internet, or voice services. Although fibre would be deployed to the meter collectors, it would cost a significant amount of funds to allow other, non-utility users to access services from the network.

  Because the BPL network is accessed wirelessly by customers, using the ubiquitous 802.11 standard, a broad range of additional services could be made available to LDCs, residential and commercial customers. These services, such as VoIP, Internet and new utility applications, would improve the business case associated with the deployment of smart meter networks.

- ➪ The cost-per-potential-customer-served is $121 for the BPL network, compared to $44,242 for the fibre network. While fibre is an excellent product, it is simply not cost-effective to deploy it to all homes and businesses. In fact, most “fibre-to-the-home” or “fibre-to-the-curb” projects have stalled because average customers are simply unable or unwilling to pay the rates required for telecommunications firms to break even.

H) Project Expenditures

For a detailed accounting of project-related expenditures, please refer to Appendix 14, “*BPL/Smart Metering Project Expenditures*”.

I) Conclusion

The BPL/Smart Metering project has successfully demonstrated that utilities can, and perhaps should, consider building a multi-purpose telecommunications network that can support their AMR requirements in a cost-effective manner. While it needs to be acknowledged that fibre has proven to have greater stability than BPL, it is also true that BPL vendors have recently released second generation versions of their products to add significant bandwidth and stability to their networks. In addition, the cost of BPL equipment continues to decrease due to the development of less expensive coupling technologies, market forces and the increasing number of BPL products that are being sold in Europe and Asia.

Our BPL/Smart Metering project has helped us develop new relationships with a variety of hardware vendors, software developers, GIS developers and electric power organizations such as EPRI. These relationships have continued past the conclusion of the project and have allowed us to begin working on a second proposal that is related to the development of an IP-enabled distribution grid.

We would like to thank the Tomorrow Fund committee for their support and patience. In addition, we would like to acknowledge the efforts of our Stations and Metering department, PUC Telecom, Elster, Olameter, Amperion and Lantronix. Our focus on delivering an effective but inexpensive project required all parties to donate their time and their expertise, often from many different parts of North America. The success of this project is a testament to their commitment and good will.

Appendix 1:

Definitions

MESH Network:

A self healing data/communications network that automatically routes traffic using redundant paths.

BPL/Broadband over Powerline:

A technology that allows broadband services to be delivered via medium voltage distribution grids.

VPN/Virtual Private Network:

A secure communication "tunnel" between network devices. It is virtual because there is no physical connection and it is private because any data sent back and forth inside this "virtual connection" cannot be intercepted.

LAN/Local Area Network:

A private computer network that spans a relatively small area. Most LANs are confined to a single building or group of buildings that are located near each other in a community.

WAN/Wide Area Network:

A computer network that spans a relatively large geographical area. Typically, a WAN consists of two or more local-area networks (LANs). Network devices connected to a wide-area network are often connected through public networks, such as the telephone system.

MAS/Metering Automation Server:

The technology used by Elster Metering to acquire, store and manage metering data that is pulled from Elster meters.

Serial:

Of or relating to the sequential transmission of all the bits of a byte over one wire.

Interface - The point of interaction or communication between a computer and any other entity, such as a printer or human operator.

SSID/Service Set Identifier:

A sequence of characters that uniquely names a wireless local area network (WLAN).

Static IP Address:

The unique Internet Protocol (IP) Address permanently assigned to a network device.

POP Site/Point of Presence:

A major communications junction where all the core network devices are physically installed.

Appendix 2:

Tomorrow Fund Project Description

PUC Distribution: Final Tomorrow Fund Project Description

1) Project Objectives

The key project objectives are:

A) Demonstrate how smart metering networks can be integrated with broadband powerline (BPL) technology.

B) Assess and compare the costs of integrating smart meter networks with BPL versus smart meter networks and other access technologies (fibre and wireless).

C) Assess the performance of the BPL/smart metering solution in terms of:

- network uptime
- accuracy of meter reads
- ability to poll meters in 15 minute increments
- ability to present metering data in a useable format

2) Scope of Work

A) Smart Metering

i) Identify smart meter specifications
ii) Identify smart meter vendors
iii) Assess vendor "fit" with specifications
iv) Select vendor
v) Develop BPL/smart metering integration plan
vi) Order necessary BPL equipment
vii) Develop deployment plan
viii) Order equipment
ix) Install smart metering network
x) Configure and enable data backhaul for data presentment
xi) Gather and anlayze metering data
xii) Troubleshoot and adjust network as required
xiii) Complete final report

3) Deliverables

A) A network design will be completed, highlighting the hardware, software and basic configurations required to incorporate smart-metering and load control with BPL technology. The design will document:

- the telecommunications network core used in the project
- the meet-me-gear design used in the project
- the placement of BPL units on overhead and underground grid spurs
- the placement of metering aggregators and meet-me devices on overhead and underground grid spurs
- a listing of all equipment required to complete the network installation

B) A customer premises design will be completed, highlighting the hardware, software, installation procedures and basic configurations required at the customer premises to enable basic load control functionality.

C) The performance of the BPL network will be documented.

D) The cost of the solution will be presented and broken out in the following areas and compared with other communications options:

- BPL hardware costs
- AMR hardware and software costs
- Installation costs
- Staffing costs

E) The functioning of the smart-metering component of the project will be documented and analyzed in the following areas:

- number of reads able to be completed per hour
- number of unsuccessful read attempts per week
- identification of known interoperability issues, with a description of successful fixes

F) An overall report will be completed at the conclusion of the project. The report will focus on the key elements of the project, including:

- project costs, by area
- performance of the integrated BPL and AMR network
- lessons learned and recommendations for future integrated deployments
- an overview of the business case implications for future BPL/AMR deployments
- a description of opportunities for using BPL to deliver demand-side management services

4) Schedule

The project will begin, formally, once we have received the signed contracts and funds from Tomorrow Fund representatives. Once this has occurred, we anticipate an eighteen week project, with six weeks dedicated to the development and implementation of the integrated solutions and twelve weeks of monitoring. Assuming we receive the necessary funds and approvals by the end of August 2005, we believe that the project can begin by September 6th, 2005 and end by January 6, 2006.

Appendix 3:

Smart Meter Deployment Maps

Appendix 4:

List of Smart Meter by Type and Address

Appendix 5:

Enclosure Design

Appendix 6:

Network Map and Communications Path

Appendix 7:

Elster Equipment Information

Appendix 8:

Amperion and Lantronix Equipment Information

Appendix 9:

OUSM Test Scripts Report

Appendix 10:

BPL Network Performance, November 1/December 3, 2006

Appendix 11:

EDIST Presentation

Appendix 12:

Elster Canada Conference Presentation

Appendix 13:

Fibre Spur Cost Analysis

Appendix 14:

BPL/Smart Metering Project Expenditures