Broadband Over Power Lines
A White Paper

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Table of Contents

1 INTRODUCTION 1

2 EXECUTIVE SUMMARY 2

3 BROADBAND ACCESS ALTERNATIVES 4

3.1 DIGITAL SUBSCRIBER LINE (DSL) - BROADBAND OVER FASTER COPPER 4
3.1.1 Advantages of DSL 4
3.1.2 Limitations of DSL 4
3.1.3 DSL Variations 5
3.2 FIBER TECHNOLOGIES 8
3.3 COAXIAL CABLE 8
3.3.1 Advantages and Disadvantages of Coaxial cable 9
3.4 WIRELESS 9
3.4.1 Unlicensed Wireless 9
Wi-Fi 10
WiMax 11
Wi-Fi vs. WiMax 13
3.4.2 Fixed Wireless Technologies 14
Multi-channel multipoint distribution service (MMDS) 14
Local multipoint distribution service (LMDS) 14
3.4.3 Satellite 15
3.5 COMPARATIVE ANALYSIS OF ACCESS ALTERNATIVES 16

4 WHAT IS BPL? 17

4.1 DEFINITIONS 17
4.2 AN OVERVIEW OF HOW BPL WORKS 20

5 INDUSTRY STRUCTURE – KEY ENABLING PARTNERS 23

6 IMPETUS FOR BPL AS AN ACCESS TECHNOLOGY 25

6.1 HOMELAND SECURITY AND NETWORK BENEFITS 25
6.2 CONSUMER BENEFITS 25
6.2.1 Is BPL Truly A Low Cost Alternative? 26
6.2.2 Geographical Coverage And Availability 27
6.2.3 A Better-Connected Appliance 28
6.3 COMMERCIAL OPPORTUNITIES 28
6.3.1 Overview Of Different Applications That Can Be Offered With BPL 28
6.3.2 Financial Impact Of Delivering Utility Applications Via BPL 29
6.3.3 BPL Business Models 31
The Landlord Model 31
The Developer Model 32
The Service Provider Model 32
6.4 SUPPORT FROM FEDERAL REGULATORS 34

7 FEASIBILITY ASSESSMENT 35

7.1 TECHNICAL 35
7.1.1 Vendor Systems And Architectures 36
Architecture #1 36
Architecture #2 37

Architecture #3....38
Potential Architectures And Their Financial Attractiveness....39
7.2 REGULATORY - ISSUES AND CHALLENGES....43
7.2.1 Interference and Radio Static....44
7.2.2 Universal Service and Pole Attachments....45
7.2.3 Open Access....46
7.2.4 Local/State Issues....47
7.2.5 Cross-subsidies....48

8 MARKET DYNAMICS....49

8.1 THE BROADBAND MARKET....49
8.2 COMPETITIVE POSITION OF BPL....50
8.3 CABLE AS A COMPETITOR....52
8.3.1 DSL as a Competitor....53
8.3.2 Wireless as a competitor....53

9 INDUSTRY INITIATIVES AND TRIALS....55

9.1 OVERVIEW OF NORTH AMERICAN BPL TRIALS....55
9.1.1 Commercial BPL Systems....55
9.1.2 Selected BPL Trials In North America....56
9.2 OVERVIEW OF EUROPEAN BPL ACTIVITIES....57
9.2.1 BPL Deployments at varying stages across the world....57
9.2.2 Utilities in Europe are very much involved in BPL....58
9.2.3 Operating Structure....59

10 INDUSTRY PERSPECTIVES....60

10.1 NATIONAL TELECOMMUNICATIONS & INFORMATION ADMINISTRATION (NTIA)....60
10.2 FEDERAL EMERGENCY MANAGEMENT AGENCY (FEMA)....60
10.3 AMERICAN RADIO RELAY LEAGUE (ARRL)....60
10.4 INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)....60
10.5 AMERICAN PUBLIC POWER ASSOCIATION (APPA)....61

11 INFORMATION SOURCES....61

11.2 CONSULTANTS' REPORTS....61

12 APPENDICES....61

12.1 APPENDIX A: BUSINESS CASE RESULTS FOR MULTIPLE ARCHITECTURES....61
12.1.1 Minneapolis/St.Paul Market....61
12.1.2 Syracuse Market....62
12.1.3 Lynchburg....62

13 LIST OF FIGURES....63

14 LIST OF TABLES....63

1 Introduction

The Ratepayer Advocate represents and protects the interests of all utility consumers - residential, small business, commercial and industrial - each time companies in New Jersey seek changes in how much they charge customers for natural gas, electric, water, wastewater or telephone service. The Ratepayer Advocate also represents consumers in setting energy and telecommunications policy that will affect the provision of services into the future.

The mission of the Ratepayer Advocate is to make sure that all classes of utility consumers receive safe, adequate and proper utility service at affordable rates that are just and nondiscriminatory. In addition, the Ratepayer Advocate works to insure that all consumers are knowledgeable about the choices they have in the emerging age of utility competition.

Consistent with its mission, the Division of Ratepayer Advocate presents an overview and assessment of technical feasibility of Broadband over Power Lines (BPL), prospects of BPL as a significant competitor in the industry, and associated regulatory control issues.

2 Executive Summary

Despite the spread of broadband technology in the last few years, there are significant areas of the world that don't have access to high-speed Internet. When weighed against the relatively small number of customers Internet providers would gain, the incremental expenditures of laying cable and building the necessary infrastructure to provide DSL or cable in many areas, especially rural, is too great. But if broadband could be served through power lines, there would be no need to build a new infrastructure. Anywhere there is electricity there could be broadband.

Technology to deliver high-speed data over the existing electric power delivery network is closer to reality in the marketplace. Broadband Over Powerline, is positioned to offer an alternative means of providing high-speed internet access, Voice over Internet Protocol (VoIP), and other broadband services, using medium – and low – voltage lines to reach customers' homes and businesses. By combining the technological principles of radio, wireless networking, and modems, developers have created a way to send data over power lines and into homes at speeds between 500 kilobits and 3 megabits per second (equivalent to DSL and cable). By modifying the current power grids with specialized equipment, the BPL developers could partner with power companies and Internet service providers to bring broadband to everyone with access to electricity.

The technology evolution in the next few years is important from a perspective of future competitive position of BPL as new networks are built and alternative technologies emerge. (See Table 3.5 for comparison of access technologies). Fiber and advanced wireless broadband are the new alternative broadband access systems that are most likely to emerge in the next few years. These could also become a part of an integrated BPL system.

Federal policy support is also strengthening the potential for BPL deployment. The FCC and others have hailed BPL as a potential "third wire" that may help increase the availability and affordability of broadband services in a market dominated by digital subscriber line (DSL) and cable modem service. As part of the federal effort to remove barriers to BPL implementation, the FCC issued a change to Part 15 rules for measures to mitigate radio interference caused by broadband over powerline. The FCC ruling on October 14, 2004 would essentially help to overcome BPL's potential to cause interference with radio and telecommunications signals.

However, a number of jurisdictional and classification issues remain open. For example, are the broadband services offered via BPL considered an information service or a telecommunications service? This has implications since telecommunications services are subject to regulations under the Telecommunications Act of 1996, most notably common carrier requirements. As of October 2004, the FCC has two proceedings that address the issue of broadband regulatory classification: one deals with cable modem services and another addressing all wireline broadband Internet access services generally. If classified as an information services, BPL service would be free from many if not all common carrier regulations except, contribution to the universal service fund (USF).

Reliability and safety of the power delivery system and provision of quality service are the main concerns for state commissions. In addition, affiliate transaction policies and cross subsidization issues are major concerns. State Commissions are obligated to prevent the unfair use of an asset developed with ratepayer funds for the benefit of shareholders. They are also obligated to ensure that electric utilities do not have an unfair advantage over competitors. Thus several solutions such as creation of unregulated BPL subsidiaries or implementation of accounting rules that guard against cross subsidization may be considered.

The state regulators will also need to address rights of way, and access to poles issues. For instance, some municipalities may seek to charge fees for BPL rights of way. Pole attachment rules may also need to be addressed because of potential interference problems.

The technical feasibility, the FCC rulemaking mitigating interference, and the announcements of the commercial-scale tests of BPL have stimulated considerable interest in BPL among electric utilities, with several now evaluating deployment of BPL. The market trials and commercial deployments will reveal business case attractiveness of BPL compared to established DSL and cable services. However, there is also interest in BPL's potential to serve as a communications system that can support the network management of the power delivery system. The electric utilities will determine if the combined benefits of a system allowing for consumer telecom services, other consumer services, and core utility network communications help make the business model attractive for BPL.

Utilities can consider applying three basic simplified business case models:

- The Landlord Model – leasing the conduit and assets to a third party, probably with a maintenance arrangement
- The Developer Model – a partnership or contract with an Internet service provider (ISP); the utility builds and owns the infrastructure, and the ISP handles all aspects of marketing, selling to and servicing the customer
- The Service Provider Model – utility manages the system, including serving as the Internet service provider

Each utility will assess BPL according to its own business objectives, risk tolerance, and procedures. The factors to evaluate are cost, market size and price, differentiating features of BPL, bundled services and average revenue per user, and the utility applications. While broadband Internet access may be the primary application that is the impetus for deployment of BPL networks, the range of potential applications using such a communications network is enormous and needs to be considered as the business model is developed.

3 Broadband Access Alternatives

Broadband access and services are delivered using a variety of technologies, network architectures and transmission methods. The most significant broadband technologies include:

- Digital Subscriber Line (DSL)
- Fiber Technologies
- Coaxial Cable
- Wireless
- BPL (Broadband Over Power Lines)

The following is a brief description of each of the above referenced access technology.

3.1 Digital Subscriber Line (DSL) - Broadband over faster copper

DSL is a very high-speed connection to Internet that uses the same wires as a regular telephone line. A standard telephone installation in the United States consists of a pair of copper wires. This pair of copper wires has sufficient bandwidth for carrying both data and voice. Voice signals use only a fraction of the available capacity on the wires. DSL exploits this remaining capacity to carry information on the wire without affecting the line's ability to carry voice conversations.

Standard phone service limits the frequencies that the switches, telephones and other equipment can carry. Human voices, speaking in normal conversational tones, can be carried in a frequency range of 400 to 3,400 Hertz (cycles per second). In most cases, the wires themselves have the potential to handle frequencies of up to several-million Hertz. Modern equipment that sends digital (rather than analog) data can safely use much more of the telephone line's capacity, and DSL does just that.

3.1.1 Advantages of DSL

- Simultaneous Use - Phone line can be used for voice calls and the Internet connection at the same time.
- A much higher speed when compared to regular modem (1.5 Mbps vs. 56 Kbps).
- Does not necessarily require new wiring, the existing phone line can be used.
- Providers generally include modem as part of the installation.

3.1.2 Limitations of DSL

- The quality of connection depends upon the proximity to the provider's central office, closer the better
- Receiving data is faster than sending data over the internet
- DSL is not available everywhere

3.1.3 DSL Variations

There are several variations of DSL technology. Often the term **xDSL**, where x is a variable, is used to discuss DSL in general.

1. Asymmetric DSL (ADSL) - It is called "asymmetric" because the download speed is greater than the upload speed. ADSL works this way because most Internet users look at, or download, much more information than they send, or upload.

2. High bit-rate DSL (HDSL) - Providing transfer rates comparable to a T1 line (about 1.5 Mbps), HDSL receives and sends data at the same speed, but it requires two lines that are separate from your normal phone line.

3. ISDN DSL (ISDL) - Geared primarily toward existing users of Integrated Services Digital Network (ISDN), ISDL is slower than most other forms of DSL, operating at fixed rate of 144 Kbps in both directions. The advantage for ISDL customers is that they can use their existing equipment, but the actual speed gain is typically only 16 Kbps (ISDN runs at 128 Kbps).

4. Multi-Rate Symmetric DSL (MSDSL) - This is Symmetric DSL that is capable of more than one transfer rate. The transfer rate is set by the service provider, typically based on the service (price) level.

5. Rate Adaptive DSL (RADSL) - This is a popular variation of ADSL that allows the modem to adjust the speed of the connection depending on the length and quality of the line.

6. Symmetric DSL (SDSL) - Like HDSL, this version receives and sends data at the same speed. While SDSL also requires a separate line from your phone, it uses only a single line instead of the two used by HDSL.

7. Very high bit-rate DSL (VDSL) - An extremely fast connection, VDSL is asymmetric, but only works over a short distance using standard copper phone wiring.

8. Voice-over DSL (VoDSL) - A type of IP Telephony, VoDSL allows multiple phone lines to be combined into a single phone line that also includes data-transmission capabilities.

Most homes and small business users are connected to an *asymmetric DSL* (ADSL) line. ADSL divides up the available frequencies in a line on the assumption that most Internet users look at, or download, much more information than they send, or upload. Under this assumption, if the connection speed from the Internet to the user is three to four times faster than the connection from the user back to the Internet, then the user will see the most benefit (most of the time).

Precisely how much benefit a user will see depends on how far the user is from the central office of the company providing the ADSL service. ADSL is a *distance-sensitive technology*: As the connection's length increases, the signal quality decreases and the connection speed goes down. The limit for ADSL service is 18,000 feet (5,460 meters), though for speed and quality of service many ADSL providers place a lower limit on the distances for the service. At the extremes of the distance limits, ADSL customers may see speeds far below the promised maximums, while customers nearer the central office have faster connections and may see extremely high speeds in the future. ADSL technology can provide maximum downstream (Internet to customer) speeds of up to 8 megabits per second (Mbps) at a distance of about 6,000 feet (1,820 meters), and upstream speeds of up to 640 kilobits per second (Kbps). In practice, the best speeds widely offered today are 1.5 Mbps downstream, with upstream speeds varying between 64 and 640 Kbps.

Distance is a limitation for DSL but not for voice telephone calls. This is because the voice signals are boosted (amplified) with small amplifiers called loading coils. These loading coils are incompatible with ADSL signals, so a voice coil in the loop between a telephone and the telephone company's central office will disqualify a user from receiving ADSL. Other factors that might disqualify a user from receiving ADSL include:

Bridge taps - These are extensions, between the user and the central office, that extend service to other customers. While the users would not notice these bridge taps in normal phone service, they may take the total length of the circuit beyond the distance limits of the service provider.

Fiber-optic cables - ADSL signals cannot pass through the conversion from analog to digital and back to analog that occurs if a portion of a telephone circuit comes through fiber-optic cables.

Distance - Even if you know where your central office is (don't be surprised if you don't—the telephone companies don't advertise their locations), looking at a map is no indication of the distance a signal must travel between your house and the office.

ADSL uses two pieces of equipment, one on the customer end and one at the provider end:

- At the customer's location, there is a DSL *transceiver*, which may also provide other services. Most residential customers call their DSL transceiver a DSL modem. The engineers at the telephone company or ISP call it an ATU-R, which stands for ADSL Transceiver Unit - Remote. Regardless of what it is called, the transceiver is the point where data from the user's computer or network is connected to the DSL line. The transceiver can connect to a customer's equipment in several ways, though most residential installations use Universal Serial Bus (USB) or 10BaseT Ethernet connections. Most of the ADSL transceivers sold by ISPs and telephone companies are simply transceivers, but the devices used by businesses may combine network routers, network switches or other networking equipment in the same box.
- The DSL service provider has a DSL *Access Multiplexer* (DSLAM) to receive customer connections. The DSLAM at the access provider is the equipment that makes DSL happen. A DSLAM takes connections from many customers and aggregates them onto a single, high-capacity connection to the Internet. DSLAMs are generally flexible and able to support multiple types of DSL, as well as provide additional functions such as routing and dynamic IP address assignment for customers.

VDSL (defined above) is seen by many as the next step in providing a complete home - communications/ entertainment package. There are already some companies, such as U.S. West (part of Qwest now), that offer VDSL service in selected areas.

VDSL operates over the copper wires in much the same way that ADSL does, but there are a couple of distinctions. VDSL can achieve incredible speeds, as high as 52 Mbps downstream and 16 Mbps upstream. That is much faster than ADSL, which provides up to 8 Mbps downstream and 800 Kbps (kilobits per second) upstream. However, VDSL's is distance sensitive. It can only operate over the copper line for a short distance, about 4,000 feet (1,200 m).

Compared to a maximum speed of 8 to 10 Mbps for ADSL or cable modem, it is clear that the move from current broadband technology to VDSL could be as significant as the migration from a 56K modem to broadband. However, the key to VDSL is that the telephone companies are replacing many of their main feeds with fiber-optic cable. In fact, many phone companies are planning Fiber to the Curb (FTTC), which means that they will replace all existing copper lines right up to the point where a phone line branches off to a house. At the least, most companies expect to implement Fiber to the Neighborhood (FTTN). Instead of installing fiber-optic cable along each street, FTTN has fiber going to the main junction box for a particular neighborhood.

By placing a VDSL transceiver in a home and a VDSL gateway in the junction box, the distance limitation is overcome. The gateway takes care of the analog-digital-analog conversion problem that disables ADSL over fiber-optic lines. It converts the data received from the transceiver into pulses of light that can be transmitted over the fiber-optic system to the central office, where the data is routed to the appropriate network to reach its final destination. When data is sent back to the computer, the VDSL gateway converts the signal from the fiber-optic cable and sends it to the transceiver.

There are two competing consortiums pushing to standardize VDSL. Their proposed standards use carrier technologies that are incompatible with one another. The VDSL Alliance, a partnership between Alcatel, Texas Instruments and others, supports VDSL using a carrier system called Discrete MultiTone (DMT). According to equipment manufacturers, most of the ADSL equipment installed today uses DMT.

The other VDSL group is called the VDSL Coalition. Led by Lucent and Broadcom, the Coalition proposes a carrier system that uses a pair of technologies called Quadrature Amplitude Modulation (QAM) and Carrierless Amplitude Phase (CAP).

While, VDSL provides a significant performance boost over any other version, for it to become widely available, it must first be standardized. The following Table 2 .1.3 lists the DSL variations and how they compare to each other.

Table 3.1.3: DSL Technologies Comparison

DSL Type	Max. Send Speed	Max Receive Speed	Max Distance	Lines Required
ADSL	800 Kbps	8 Mbps	18,000 ft	1
HDSL	1.54 Mbps	1.54 Mbps	12,000 ft.	2
IDSL	144 Kbps	144 Kbps	35,000 ft	1
MSDSL	2 Mbps	2 Mbps	29,000 ft	1
RADSL	1 Mbps	7 Mbps	18,000 ft	1
SDSL	2.3 Mbps	2.3 Mbps	22,000 ft	1
VDSL	16 Mbps	52 Mbps	4,000 ft	1

3.2 Fiber Technologies

In recent years, carriers have begun constructing entirely fiber optic cable transmission facilities that run from a distribution frame (or its equivalent) in an incumbent local exchange carrier's (ILEC's) central office to the loop demarcation point at an end-user customer premise. These loops are referred to as fiber-to-the-home (FTTH) loops. FTTH technology offers substantially more capacity than any copper-based technology. For example, Wav7 Optics provides a FTTH system today using commercially available equipment that delivers transmission speeds up to 500 Mbps shared over a maximum of 16 subscribers. This system can also provide up to 500 Mbps symmetrically to one subscriber if desired. The speed an actual user will experience depends upon the time of day and the number of users online. A typical FTTH system can deliver up to 870 MHz of cable television video services (for high definition television) or IP video services along with multiple telephone lines and current and next-generation data services at speeds in excess of 100 Mbps.

There are three basic types of architectures being used to provide FTTH. The most common architecture used is Passive Optical Network (PON) technology. This technology allows multiple homes to share a passive fiber network. In this type of network, the plant between the customer premises and the head-end at the central office consists entirely of passive components – no electronics are needed in the field. The other architectures being used are Home Run Fiber or Point-to-Point Fiber, in which subscribers have a dedicated fiber strand, and active or powered nodes are used to manage signal distribution, and hybrid PONs, which are a combination of home run and PON architecture.

Although FTTH technology is still in its infancy, the deployment of FTTH is growing significantly. Also, the equipment costs for FTTH have decreased significantly. As of May 2004, carriers have deployed FTTH technology to 128 communities in 32 states. Companies plan to deploy FTTH further in the future. Competitive carriers are also building FTTH facilities.

In addition to FTTH technologies, some carriers are constructing fiber-to-the-curb (FTTC) facilities that do not run all the way to the home, but run to a pedestal located within 500 feet of the subscriber premises. Copper lines are then used for the connection between the pedestal and the network interface device at the customer's premises. Because of the limited use of copper, FTTC technologies permit carriers to provide high-speed data in addition to high definition video services.

3.3 Coaxial Cable

For millions of people, television brings news, entertainment and educational programs into their homes. Many people get their TV signal from cable television (CATV) because cable TV provides better reception and more channels.

Many people who have cable TV can now get a high-speed connection to the Internet from their cable provider. Cable modems allow subscribers to access high-speed data services over cable systems that are generally designed with hybrid fiber-coaxial (HFC) architecture. Cable modem service is primarily residential, but may also include some small business service.

Cable modems compete with technologies like Asymmetrical Digital Subscriber Lines (ADSL). Following is a look at how a cable modem works and how 100 cable television channels and web sites can flow over a single coaxial cable.

In a cable TV system, signals from the various channels are each given a 6-MHz slice of the cable's available bandwidth and then sent down the cable to your house. The coaxial cable used to carry cable television can carry hundreds of megahertz of signals and therefore, a large number of channels. In some systems, coaxial cable is the only medium used for distributing signals. In other systems, fiber-optic cable goes from the cable company to different neighborhoods or areas. Then the fiber is terminated and the signals move onto coaxial cable for distribution to individual houses.

When a cable company offers Internet access over the cable, Internet information can use the same cables because the cable modem system puts downstream data—data sent from the Internet to an individual computer—into a 6-MHz channel. On the cable, the data looks just like a TV channel. So Internet downstream data takes up the same amount of cable space as any single channel of programming. Upstream data—information sent from an individual back to the Internet—requires even less of the cable's bandwidth, just 2 MHz, since the assumption is that most people download far more information than they upload.

Putting both upstream and downstream data on the cable television system requires two types of equipment: a Cable Modem on the customer end and a Cable Modem Termination System (CMTS) at the cable provider's end. Between these two types of equipment, all the computer networking, security and management of Internet access over cable television is put into place.

3.3.1 Advantages and Disadvantages of Coaxial cable

If you are one of the first users to connect to the Internet through a particular cable channel, then you may have nearly the entire bandwidth of the channel available for your use. The disadvantage of coaxial cable however, is as new users, especially heavy-access users, are connected to the channel, you will have to share that bandwidth, and may see your performance degrade as a result. It is possible that, in times of heavy usage with many connected users, performance will be far below the theoretical maximums. The cable company can resolve this particular performance issue by adding a new channel and splitting the base of users.

Another benefit of the cable modem for Internet access is that, unlike ADSL, its performance does not depend on distance from the central cable office. A digital CATV system is designed to provide digital signals at a particular quality to customer households. On the upstream side, the burst modulator in cable modems is programmed with the distance from the head-end, and provides the proper signal strength for accurate transmission.

Cable industry has extended the broadband services offering to at least 90 percent of homes passed by cable systems. The cable industry expects that industry-wide facilities upgrades enabling the provision of broadband Internet access to residential customers will be completed in the near future.

3.4 Wireless

3.4.1 Unlicensed Wireless

Since the Commission first allocated spectrum in the 902-928 MHz band for use on an unlicensed basis under Part 15 of the rules, there has been an increasingly rapid expansion of products and markets in bands designated for unlicensed use. This Industrial, Scientific, and Medical (ISM) band was the first to experience the large-scale introduction of devices such as cordless phones, security alarms, wireless bar code readers, and data collection systems. A number of original equipment manufacturers continue to provide equipment for point-to-point and point-to-multipoint systems for such applications as Supervisory Control and Data Acquisition. In addition, there are several providers of wireless local area network equipment in this band.

Wi-Fi

Wi-Fi, short for *Wireless Fidelity*, is a term that is used generically to refer to any product or service using the 802.11 series standards developed by the Institute of Electrical and Electronics Engineers (IEEE) for wireless local area network connections. Wi-Fi networks operate on an unlicensed basis in the 2.4 and 5 GHz radio bands and provide multiple data rates up to a maximum of 54 Mbps. The bandwidth is shared among multiple users. Wi-Fi enabled wireless devices, such as laptop computers or personal digital assistants (PDAs), can send and receive data from any location within signal reach of a Wi-Fi equipped base station or access point (AP). Typically, mobile devices must be within approximately 300 feet of a base station.

The Wi-Fi technology features a creation of a “wireless cloud” that covers a *hot-spot* area. The specific dimensions of the coverage area vary based on environmental and power specifications of the equipment in use. Typically, coverage radius is in the range of 300-500 feet. Environmental conditions, like weather and line of site, can affect the ability to reach target customers.

With the expansion of Wi-Fi access to the Internet there has been a rapid growth of hot-spots. Networks of hot-spots consisting of many access points have been constructed to cover larger areas such as airports.

The IEEE 802.11 wireless LAN standards describe four radio link interfaces that operate in the 2.4 GHz or 5 GHz unlicensed radio bands. These are summarized in Table 3.4.1.

Table 3.4.1: IEEE 802.11 WLAN Radio Link Interfaces and Highlights

Standard	**Max. Bit Rate**	**Fallback Rate**	**Number of Channels**	**Frequency Band**	**Other Highlights**
802.11	2 Mbps	1 Mbps	3	2.4 GHz	
802.11a	54 Mbps	48 Mbps 36 Mbps 24 Mbps 18 Mbps 12 Mbps 9 Mbps 6 Mbps	12	5 GHz	•Signal delivery is very short range, limiting deployment potential •Not backwards compatible with the more widely used 802.11b •Very poor ability to penetrate walls or other obstructions
802.11b	11 Mbps	5.5 Mbps 2 Mbps 1 Mbps	3	2.4 GHz	•Most widely used WLAN platform •Widespread deployment activity has resulted in significantly lower prices for equipment
802.11g	54 Mbps	Same as 802.11a	3	2.4 GHz	•Signal delivery is significantly stronger than 802.11a •Backwards compatible with 802.11b •Products have begun to ship

Of all the different *Wireless LAN* interfaces, 802.11b has the most popular appeal due to the low number of technical problems and lower hardware costs. It is the only standard with widespread popularity and focused on residential users.

WiMax

Wireless Local Area Networks (LANs) based on the IEEE 802.11 or Wi-Fi standards have been quite successful, and therefore the focus in wireless is moving towards the wide area. While Wi-Fi dominates in the local area, the wide area market is still very much open.

The cellular carriers got into this market first with their 2.5G/3G data services, but they were positioned to offer essentially add-on to voice service. The real competition to cellular data services may come from emerging data-oriented technology, WiMax.

WiMax, short for *Worldwide Interoperability for Microwave Access*, refers to any broadband wireless access network based on the IEEE 802.16 standards. Internationally, a European Telecommunications Standards Institute (ETSI) initiative called HIPERMAN addresses the same area as WiMax/802.16 and shares some of the same technology.

WiMax includes fixed systems employing a point-to-multipoint architecture operating between 2 GHz and 66 GHz. WiMax based broadband wireless access (BWA) or, also known as wireless DSL, will offer data rates between 512 Kbps and 1 Mbps. The key will be to deliver low-cost, indoor, user installable premises devices that will not have to be aligned with the base station i.e., the antenna in the premises equipment would be integrated with the radio modem.

WiMax is designed to deliver a metro area broadband wireless access (BWA) service. The idea behind BWA is to provide a fixed location wireless Internet access service to compete with cable modems and DSL. WiMax systems could support users at ranges up to 30 miles and is intended as the basis of a carrier service.

The WiMax standards include a much wider range of potential implementation to address the requirements of carriers around the world. The original version of the 802.16 standard, when released addressed systems operating in the 10 GHz to 66 GHz frequency band. Such high frequency systems require line-of-sight (LOS) to the base station, which increases cost and limits the customer base. Also, in LOS systems, customer antennas must be realigned when a new cell is added to the network. Since the initial release, 802.16a standard released in 2003 has changed the playing field. The standard 802.16a describes systems operating between 2 GHz and 11 GHz. These lower frequency bands support non-line-of-sight (NLOS), thereby eliminating the need to align the customer unit with the base station. Table 3.4.2 presents a summary of WiMax (802.16) radio links.

*Table 3.4.2 Summary of WiMax (802.16) Radio Links (**Source needed**)*

Standard	Spectrum	Configuration	Bit Rate	Mobility	Channel Bandwidth	Typical Cell Radius
802.16	10-66 GHz	Line of Sight	32 to 134 Mbps (28 MHz Channel)	Fixed	20, 25, 28 MHz	1.3 miles
802.16a	2-11 GHz	Non – Line of Sight	</= 70 or 100 Mbps (20 MHz Channel)	Fixed	Selectable 1.25 to 20 MHz	3-5 miles
802.16e	< 6 GHz	Non – Line of Sight	Up to 15 Mbps	</= 75 MPH	5 MHz (planned)	1-3 miles

As mentioned earlier, Wi-Fi implementations use unlicensed frequency bands. WiMax, on the other hand can operate in either licensed or unlicensed spectrum. Within 802.16a's frequency range (2-11 GHz), there are four bands that are especially attractive:

- Licensed 2.5 GHz MMDS: The FCC has allocated 200 MHz of licensed radio spectrum between 2.5 – 2.7 GHz for Multichannel Multipoint Distribution Service (MMDS).
- Licensed 3.5 GHz Band: A band of licensed spectrum approximately equal to MMDS has been allocated in the 3.4 to 3.7 GHz range in most of the world.
- Unlicensed 3.5 GHz Band: The FCC has opened an additional 50 MHz of unlicensed spectrum in the 3.65 to 3.7 GHz range for fixed location wireless services.
- Unlicensed 5 GHz U-NII Band: In the U.S., 555 MHz of unlicensed frequency has been allocated in the 5.15 to 5.35 GHz and 5.47 to 5.825 GHz bands. This spectrum is called the Unlicensed National Information Infrastructure (U-NII) band, the same band used for 802.11a wireless LANs. The allocation was increased from 300 MHz to 555 MHz by an FCC order in November 2003.

Wi-Fi vs. WiMax

Wi-Fi and WiMax represent wireless applications from two completely different perspectives. Wi-Fi is a local network technology designed to add mobility to private wired LANs. WiMax, on the other hand, is designed to deliver a metro area broadband wireless access (BWA) service. The idea behind BWA is to provide a fixed location wireless Internet access service to compete with cable modems and DSL. While Wi-Fi supports transmission ranges up to a few hundred feet, WiMax systems could support users at ranges up to 30 miles. While Wi-Fi is targeted at the end-user, WiMax is intended as the basis of a carrier service. Besides the difference in transmission range, there are a number of improvements in the radio link technology that separate WiMax from Wi-Fi. Table 3.4.3 presents a comparison of Wi-Fi and WiMax Technologies:

Table 3.4.3: A comparison of WiMax and Wi-Fi

	Wi-Fi (802.11b)	**Wi-Fi (802.11a/g)**	**WiMax (802.16a)**
Primary Applications	Wireless LAN	Wireless LAN	Broadband Wireless Access
Frequency Band	2.4 GHz ISM	2.4 GHz ISM (g) 5 GHz U-NII (a)	Licensed/Unlicensed 2 GHz to 11 GHz
Channel Bandwidth	25 MHz	20 MHz	Adjustable 1.25 MHz to 20 MHz
Half/Full Duplex	Half	Half	Full
Radio Technology	Direct Sequence Spread Spectrum	OFDM* (64-channels)	OFDM* (256-channels)
Mobility	In Development	In Development	Mobile WiMax

* 256 – Sub-Carrier Orthogonal Frequency Division Multiplexing

3.4.2 Fixed Wireless Technologies

Point-to-point microwave connections have a long history in the backhaul networks of phone companies, cable TV companies, utilities and government agencies. In recent years, technology has advanced to enable higher frequencies and smaller antennas. This has resulted in lower cost systems that could be sold by carriers for the last mile of communications.

Multi-channel multipoint distribution service (MMDS)

This band, located at 2.5GHz, was initially used to distribute cable television service. Now MMDS is being developed for residential Internet service.

MMDS wireless technology can be deployed to offer "two-way" service at throughputs ranging from 64 kbps to 10Mbps. However, MMDS systems require line of sight between transmitter and receiver. The lower MMDS frequencies (2 GHz) do not attenuate very quickly and services can be provided at up to 30 miles from the hub, equivalent to coverage of approximately 2,800 square miles. This is one of the largest coverage areas of any point-to-multipoint communications system available today.

Local multipoint distribution service (LMDS)

This band (27.5GHz to 28.35 GHz, 29.1GHz to 29.25 GHz and 31GHz to 31.3 GHz) is being used for point-to-multipoint applications similar to the 39GHz band - Internet access and telephony. LMDS, though, only has a 3-mile coverage radius and uses TDMA (Time-Division Multiple Access) so that multiple customers can share the same radio channel.

The technology uses a cellular like network architecture of microwave radios placed at the client's location and at the company's base station to deliver fixed services, mainly telephony, video and Internet access. The use of time-division multiple access (TDMA) and frequency-division multiple access (FDMA) technologies allows multiple customers within a 3-5 mile coverage radius to share the same radio channel. Customers can receive data rates between 64kbps to 155Mbps.

An LMDS system consists of four parts:

- The network operations center (NOC) houses the network management system (NMS) equipment that manages large regions of the customer network.
- A fiber-based infrastructure connects separate NOCs.
- The base station, usually located on a cellular tower, is where the conversion from fibered infrastructure to wireless infrastructure occurs.
- The customer premises equipment (CPE) typically includes microwave equipment mounted on the outside of a consumer's home or business as well as equipment located within the building, providing modulation, demodulation, control, and interface functionality.
  - Advantages of LMDS: *Low entry and deployment costs* - Due to the fact that a large part of a wireless network's cost is not incurred until the CPE is installed, the operator is able to stage capital expenditures gradually with new customer acquisition.
  - *Speed of deployment* - A fiberless network requires no trenches, backhoes or construction, only a radio at the customer's location and another one on a tower in a central location. This enables a quicker deployment schedule than most broadband services.

- *Demand-based buildout* - LMDS uses a scalable architecture combined with industry standards to ensure service can be expanded as customer demand increases.
- *Variable component cost* - Most wireline systems require a large capital investment for the infrastructure component. LMDS systems shift the cost to the CPE, which means the operator only spends money when a revenue-paying customer signs on.

Limitations of LMDS:

- The system requires line-of-site (LOS) between the CPE and base station hub. This could require the use of repeaters to forward signals over obstacles.
- LMDS signals are affected by moisture, which could result in "rain fade," or the disruption of signals as a result of heavy rain. Increasing the power used to transmit the signals can usually alleviate problems associated with rain fade.

3.4.3 Satellite

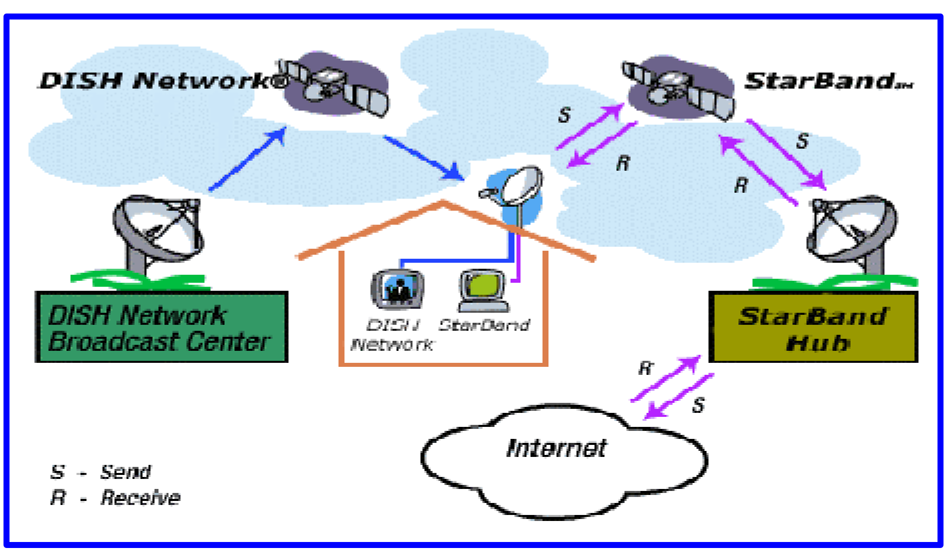
Satellite Internet access is ideal for rural Internet users who want broadband access. Satellite Internet does not use telephone lines or cable systems, but instead uses a satellite dish for two-way (upload and download) data communications. Upload speed is about one-tenth of the 500 kbps download speed. Cable and DSL have higher download speeds, but satellite systems are about 10 times faster than a normal modem.

Two-way satellite Internet consists of approximately a two-foot by three-foot dish, two modems (uplink and downlink), and coaxial cables between dish and modem. The key installation-planning requirement is a clear view to the south, since the orbiting satellites are over the equator area. And, like satellite TV, trees and heavy rains can affect reception of the Internet signals.

Two-way satellite Internet uses Internet Protocol (IP) multicasting technology, which means that a maximum of 5,000 channels of communication can simultaneously be served by a single satellite. IP multicasting sends data from one point to many points (at the same time) in a compressed format. Compression reduces the size of the data and the bandwidth. Usual dial-up land-based terrestrial systems have bandwidth limitations that prevent multicasting of this magnitude.

The satellite data downlink is just like the usual terrestrial link, except the satellite transmits the data to your computer via the same dish that would allow you to receive a Pay-Per-View television program.

Figure 3.4.3: Graphic Courtesy of StarBand. StarBand's System



3.5 Comparative Analysis of Access Alternatives

The use of fast Internet connections has grown rapidly over the last few years. As more people buy home computers and create home networks, the demand for broadband connections steadily increases. Currently, Coaxial Cable (Cable Modems) and Asymmetric Digital Subscriber Line (ADSL) dominate the industry. While both of these technologies provide Internet connections that are many times faster than a 56K modem, they still are not fast enough to support the integration of home services such as digital television and Video-On-Demand.

Table 3.5: Comparison of Access Technologies

Access Technology	Speed	Typical Prices per Month	Reach	Remarks
BPL	Commercial - up to 3 Mbps Residences - 5 Mbps or higher	$28 to $39 depending on speed and features	Ubiquitous electric distribution network	Speeds same for upload and download; Number of Users affects the speed
Cable	1 Mbps to 3 Mbps	$39 to $60	Available where cable has been installed so some rural and suburban locations may not have access	The speed of the signal varies by the number of users on the neighborhood network loop, it degrades with high numbers of users. Cable company may add another channel or split the users into small groups
DSL	1.5 Mbps	$27 to $49	In general, a residence must be within about 18,000 ft. of the DSL central equipment	Not capable of transmitting TV signals
Fiber	30 Mbps to 1 Gbps	$28 to $65 depending on locale, service features, and speed	Deployment has been limited by high costs	Cost reductions enabled by passive optical networks and advances in component technology are expected to bring costs down. Some telecom companies are already installing Fiber.
Satellite	500 Kbps	$50 to $100	Requires a clear view to the south	Trees and even heavy rain may affect reception on Internet data

4 What is BPL?

4.1 Definitions

Broadband over Power Line (BPL) is a technology that allows voice and Internet data to be transmitted over utility power lines. BPL is also sometimes called Power-line Communications or PLC. Many people use the terms PLC and BPL interchangeably. The FCC chose to use the term "broadband over power line" for consumer applications.

In order to make use of BPL, subscribers use neither a phone, cable nor a satellite connection. Instead, a subscriber installs a modem that plugs into an ordinary wall outlet and pays a subscription fee similar to those paid for other types of Internet service.

On April 23, 2003, the FCC adopted a Notice of Inquiry (*Inquiry*)[1], expressing enthusiasm about the potential of the BPL technology to enable electric power lines to function as a third wire into the home, and create competition with the copper telephone line and cable television coaxial cable line. The Commission subsequently issued a Notice of Proposed Rulemaking (*NPRM*)[2] in February 2004 based on the comments received in response to the *Inquiry*. Both the *Inquiry* and *NPRM* discusses two types of BPL: 1) Access BPL, and 2) In-house BPL.

Access BPL[3] is a technology that provides broadband access over medium voltage power lines. Medium voltage power lines are the electric lines that you see at the top of electric utility poles beside the roadways in areas that do not have underground electric service. Typically there are three electric lines (called phases A, B and C), each carrying several thousand volts. One phase is usually enough to power the houses on a residential street, two or even three phases can be joined together to power the big electric motors in an industrial or commercial area. (You also may see a fourth wire that is the ground wire.)

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[1]/ In April 2003, the Commission issued a *Notice of Inquiry (Inquiry)* on BPL technologies and systems. The *Inquiry* was issued to solicit comments to assist the Commission in reviewing its Part 15 rules to facilitate the deployment of Access BPL while ensuring that licensed services continue to be protected. In the *Inquiry*, the Commission encouraged continued deployment of Access BPL systems that comply with the existing rules. *See Inquiry Regarding Carrier Current Systems, Including Broadband over Power Line Systems, Notice of Inquiry*, ET Docket No. 03-104, 18 FCC Rcd 8498 (2003).

[2]/ *In the Matter of Carrier Current Systems, including Broadband over Power Line Systems and Amendment of Part 15 regarding new requirements and measurement guidelines for Access Broadband over Power Line Systems, Notice of Proposed Rulemaking* (NPRM), ET Docket Nos. 03-104 and 04-37, 19 FCC Rcd 3335 (2004).

[3]/ The FCC's Report and Order on BPL defines Access BPL as:

> A carrier current system installed and operated on an electric utility service as an unintentional radiator that sends radio frequency energy on frequencies between 1.705 MHz and 80 MHz over medium voltage lines or low voltage lines to provide broadband communications and is located on the supply side of the utility service's points of interconnections with customer premises.

In The Matter of Amendment of Part 15 regarding new requirements and measurement guidelines for Access Broadband over Power Line Systems; Carrier Current Systems, including Broadband over Power Line Systems, Report and Order, ET Docket Nos. 03-104 and 04-37, para. 29 (rel. Oct. 28, 2004). ("BPL Report and Order").

In-house BPL[4] is a home networking technology that uses the transmission standards developed by the HomePlug Alliance[5]. In-house BPL products can comply relatively easily with the radiated emissions limits in Part 15[6] of the FCC's Rules, because the products connect directly with the low voltage electric lines inside your home or office.

In-home networking, while exciting and innovative, is not a major policy concern for the FCC. What the FCC is really wrestling with is how to get broadband Internet access over "the last mile" to the home.

The Last Mile is the portion of the network that connects end users, such as homes and business, to high-speed services and the Internet. For residential broadband service customers who get cable modem service, for example, the drop wire connecting the interface on a house to cable company's network and the wire from the interface connecting to the wall plates in the home would all be part of the last mile.

BPL modems use silicon chips designed to send signals over electric power lines, much like cable and DSL modems use silicon chips designed to send signals over cable and telephone lines. Advances in processing power have enabled new BPL modem chips to overcome difficulties in sending communications signals over the electric power lines.

Inductive couplers are used to connect BPL modems to the medium voltage power lines. An inductive coupler transfers the communications signal onto the power line by wrapping around the line, without directly connecting to the line. A major challenge is how to deliver the signal from the medium voltage line to the low voltage line that enters your house, because the transformer that lowers the electric power from several thousands volts down to 220/110 is a potential barrier to the broadband signal.

Router is a device that acts as an interface between two networks and provides network management functions.

Repeater is a physical-layer hardware device used on a network to extend the length, topology, or interconnectivity of the physical medium beyond that imposed by a single segment.

Concentrator/Injector is a device that aggregates the end-user CPE data onto the MV (medium voltage) grid. Injectors are tied to the Internet backbone via fiber of T1 lines and interface to the MV power lines feeding the BPL service area.

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[4]/ The FCC's Report and Order on BPL defines In-House BPL as:

> A carrier current system , operating as an unintentional radiator, that sends radio frequency energy to provide broadband communications on frequencies between 1.705 MHz and 80 Mhz over low-voltage electric power lines that are owned, operated or controlled by an electric service provider. The electric power lines may be aerial (overhead), underground, or inside walls, floors or ceilings of user premises.

See BPL Report and Order, para. 30.

[5]/ Home Plug Alliance is made up of industry-leading companies working to define how the items in your home connect to each other and to the Internet. The Alliance's mission is to enable and promote rapid availability, adoption and implementation of cost effective, interoperable and standards-based in-home powerline networks and products. *See* www.homeplug.org.

[6]/ Part 15 of the FCC's Rules governs interference issues between unlicensed devices, including BPL modems, and other electronic devices. All electronic devices sold in the U.S. have to meet FCC radio frequency (RF) emissions limits.

Extractors provide the interface between the MV power lines carrying BPL signals and the households within the service area. BPL extractors are usually located at each LV distribution transformer feeding a group of homes.

Carrier-Current System: There are a number of types of BPL systems, using different approaches and architecture. All are "Carrier-Current" systems, a term used to describe systems that intentionally conduct signals over electrical wiring or power lines.

Part 15 of the FCC's Rules governs interference issues between unlicensed devices, including BPL modems, and other electronic devices. All electronic devices sold in the U.S. have to meet FCC radio frequency (RF) emissions limits. When BPL modems are installed on underground electric lines, the communications signal is shielded by the conduit and the earth and as a result is unlikely to cause interference to other communications services. The FCC is more concerned about the interference potential of BPL signals transmitted on exposed, overhead medium voltage power lines.

Munis are municipally owned utilities that use the revenues from electricity sales toward operation of the system and the improvement of services to the community. They answer to the community and do not have to pay a dividend to shareholders.

Investor Owned Utilities (IOUs) are governed by a board of directors elected by stockholders. IOUs exist to make a profit for their stockholders while serving the public.

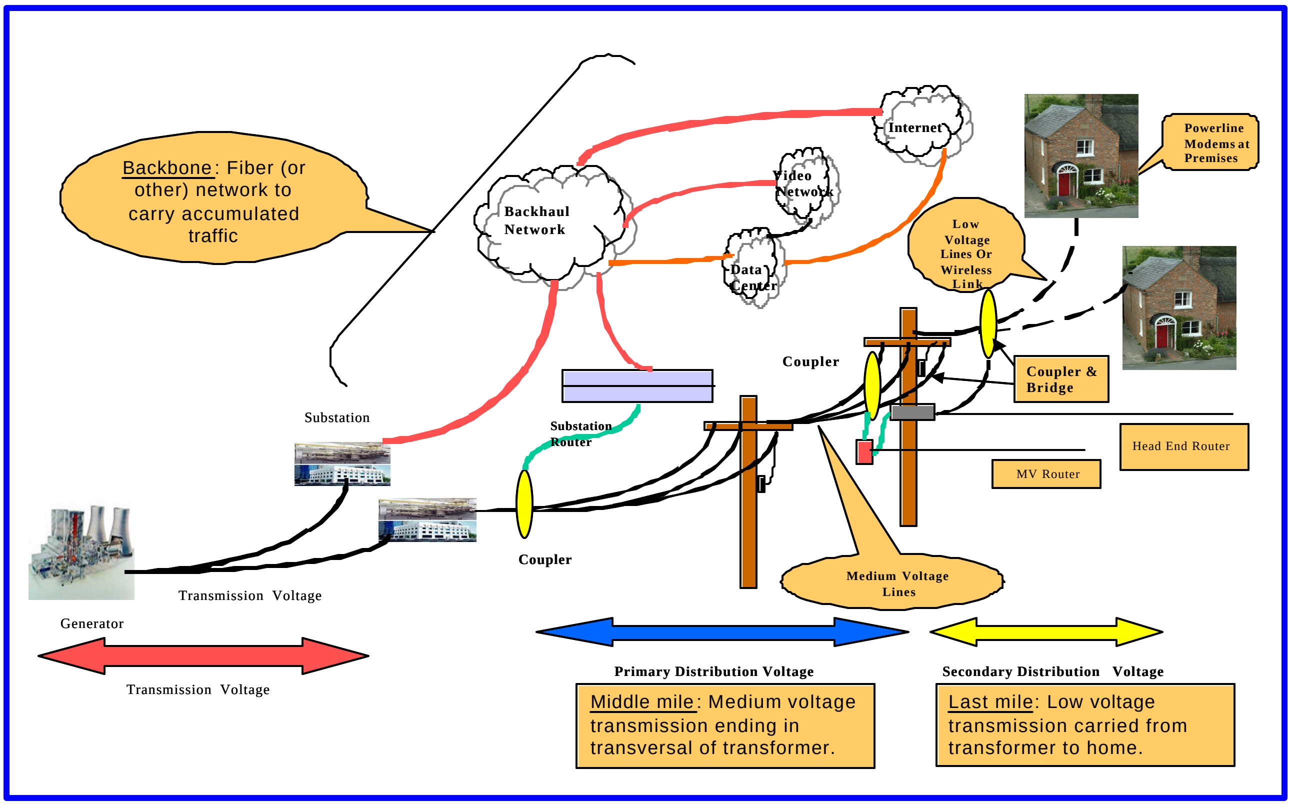
Co-Op is a third type of utility that is also known as electric membership corporations or cooperatives, which are consumer-owned electric systems with customers primarily in rural areas. An elected board of directors governs co-ops.

4.2 An Overview Of How BPL Works

At a high-level, a Powerline Telecom network consists of three key segments, the backbone, the middle mile, and the last mile as shown below in Figure 4.2.1. The BPL vendors are primarily seeking to address the "last mile" segment all the way into "the home" market.

From the end user's perspective, BPL technology works by sending high-speed data along medium or low voltage power lines into the customer's home. The signal traverses the network over medium and low voltage lines either through the transformers or by-passes the transformer using bridges or couplers. The technology transports data, voice and video at broadband speeds to the end-user's connection. The user only needs to plug an electrical cord from the "BPL modem" into any electrical outlet then plug an Ethernet or USB cable into the Ethernet card or USB interface on their PC. Any Internet Service Provider (ISP) can interface with the BPL network and provide high speed Internet access. The data signal can also interconnect with wireless, fiber or other media for backhaul and last mile completion. The actual hardware used for the deployment varies by manufacturer but typically feature some common characteristics.

Figure 4.2.1 An Overview of a BPL System- source: ITN, Inc.



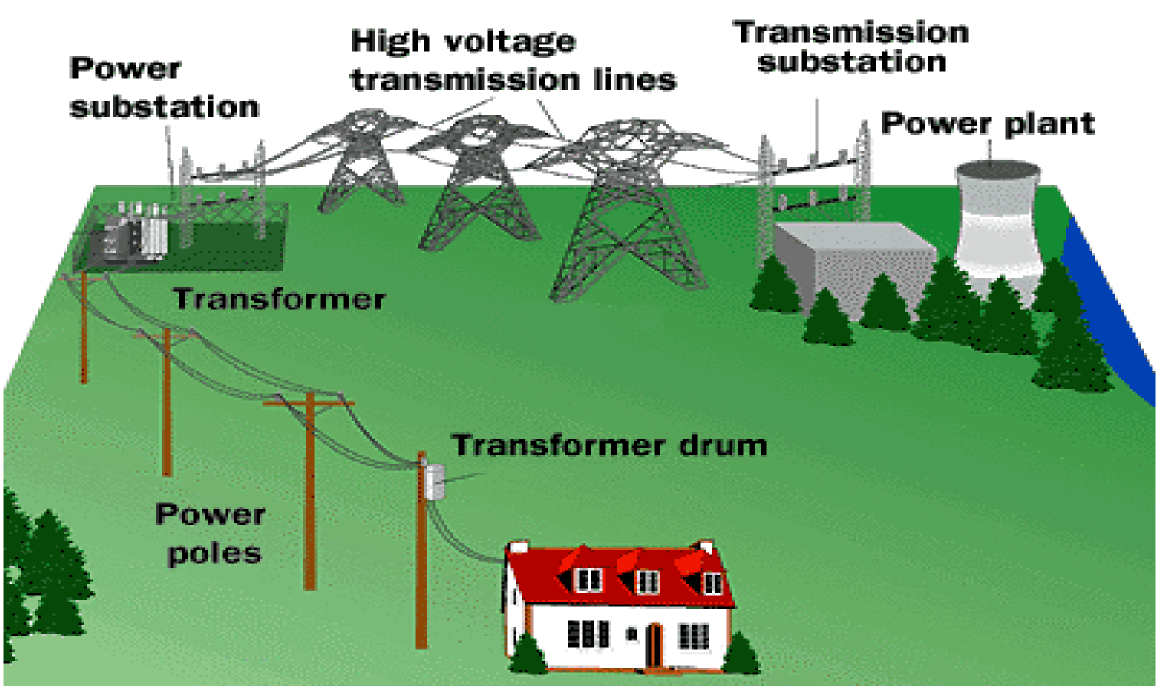
By combining the technological principles of radio, wireless networking, and modems, developers have created a way to send data over power lines and into homes at speeds equivalent to those of DSL and cable. By modifying the current power grids with specialized equipment, the BPL developers could partner with power companies and Internet service providers (ISPs) to bring broadband to everyone with access to electricity.

The Internet is a huge network of networks that are connected through cables, computers, and wired and wireless devices worldwide. Typically, large ISPs lease fiber-optic lines from the phone company to carry the data around the Internet and eventually to another medium (phone, DSL or cable line) and into the homes. Trillions of bytes of data a day are transferred on fiber-optic lines because they are a stable way to transmit data without interfering with other types of transmissions.

The idea of using AC (alternating current) power to transfer data is not new. By bundling radio-frequency (RF) energy on the same line with an electric current, data can be transmitted without the need for a separate data line. Because the electric current and RF vibrate at different frequencies, the two don't interfere with each other. Electric companies have used this technology for years to monitor the performance of power grids. There are even networking solutions available today that transfer data using the electrical wiring in a home or business. But this data is fairly simple and the transmission speed is relatively slow.

There are several different approaches to overcoming the hurdles presented when transmitting data through power lines. The power lines are just one component of electric companies' power grids. In addition to lines, power grids use generators, substations, transformers and other distributors that carry electricity from the power plant all the way to a plug in the wall. When power leaves the power plant, it hits a transmission substation and is then distributed to high-voltage transmission lines. When transmitting broadband, these high-voltage lines represent the first hurdle.

Figure 4.2.2: An Overview Of A Power Line System   Source: Howstuffworks.com



The power flowing down high-voltage lines is between 155,000 to 765,000 volts. That amount of power is unsuitable for data transmission. It's too "noisy." Both electricity and the RF used to transmit data vibrate at certain frequencies. In order for data to transmit cleanly from point to point, it must have a dedicated band of the radio spectrum at which to vibrate without interference from other sources.

Hundreds of thousands of volts of electricity don't vibrate at a consistent frequency. That amount of power jumps all over the spectrum. As it spikes and hums along, it creates all kinds of interference. If it spikes at a frequency that is the same as the RF used to transmit data, then it will cancel out that signal and the data transmission will be dropped or damaged en route.

BPL bypasses this problem by avoiding high-voltage power lines all together. The system drops the data off of traditional fiber-optic lines downstream, onto the much more manageable 7,200 volts of medium-voltage power lines.

Once dropped onto the medium-voltage lines, the data can only travel so far before it degrades. To counter this, special devices are installed on the lines to act as repeaters. The repeaters take in the data and repeat it in a new transmission, amplifying it for the next leg of the journey.

In one model of BPL, two other devices ride power poles to distribute Internet traffic. The **Coupler** allows the data on the line to bypass transformers, and the **Bridge**, a device that facilitates carrying the signal into the homes.

The transformer's job is to reduce the 7,200 volts down to the 240-volt standard that makes up normal household electrical service. There is no way for low-power data signals to pass through a transformer, so you need a coupler to provide a data path around the transformer. With the coupler, data can move easily from the 7,200-volt line to the 240-volt line and into the house without any degradation.

The last mile is the final step that carries Internet into the subscriber's home or office.

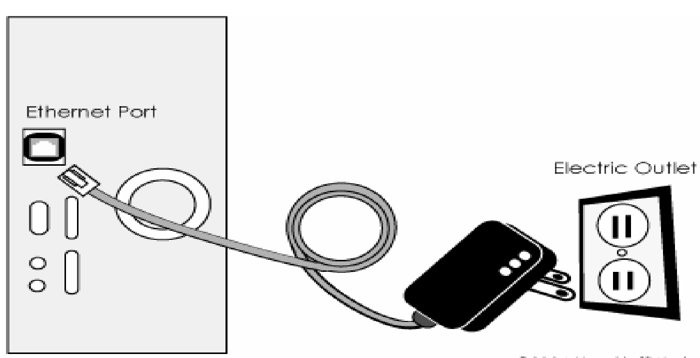
In the various approaches to last-mile solutions for BPL, some companies carry the signal in with the electricity on the power line, while others put wireless links on the poles and send the data wirelessly into homes. The Bridge facilitates both.

The signal is received by a powerline modem that plugs into the wall. The modem sends the signal to your computer.

BPL modems use silicon chipsets specially designed to handle the work load of pulling data out of an electric current. Using specially developed modulation techniques and adaptive algorithms, BPL modems are capable of handling powerline noise on a wide spectrum.

As shown in Figure 4.2.3, a BPL modem is plug and play and is roughly the size of a common power adapter. It plugs into a common wall socket, and an Ethernet cable running to your computer finishes the connection. Wireless versions are also available.

Figure 4.2.3: BPL Modem



5 Industry Structure – Key Enabling Partners

Electric utilities may not necessarily want to enter the communications business. In fact, they may want to leave that part of BPL to a partner, perhaps an ISP, a Competitive Local Exchange Carrier (CLEC), or a long distance company looking for an alternative last mile path to their customers. Current focus of most electric utilities is using BPL for an intelligent electric distribution grid. Power companies have often employed low-speed power line communication for their own internal use—to monitor and control equipment in the power grid. This could result in lower electric power costs, less pollution and greater reliability and security, essentially, **a more intelligent electric power grid**.

The Broadband services enabling partners may be in one or more of the delivery segments (Figure 5.1.1) or roles:

The last mile: This is the portion of the network that connects end users, such as homes and business, to high-speed services and the Internet. For residential broadband service customers who get cable modem service, for example, the drop wire connecting the interface on a house to cable company's network and the wire from the interface connecting to the wall plates in the home would all be part of the last mile.

The middle mile : This portion of the network consists of high-speed fiber backbones and other "middle-mile pipes" that connect computers to networks, connect those networks into the complex that constitutes the Internet, and deliver traffic among ISPs, content providers, online service companies, and other customers.

Internet service providers (ISPs): These are companies that receive and translate internet-bound data and help customers obtain online information from the Internet.

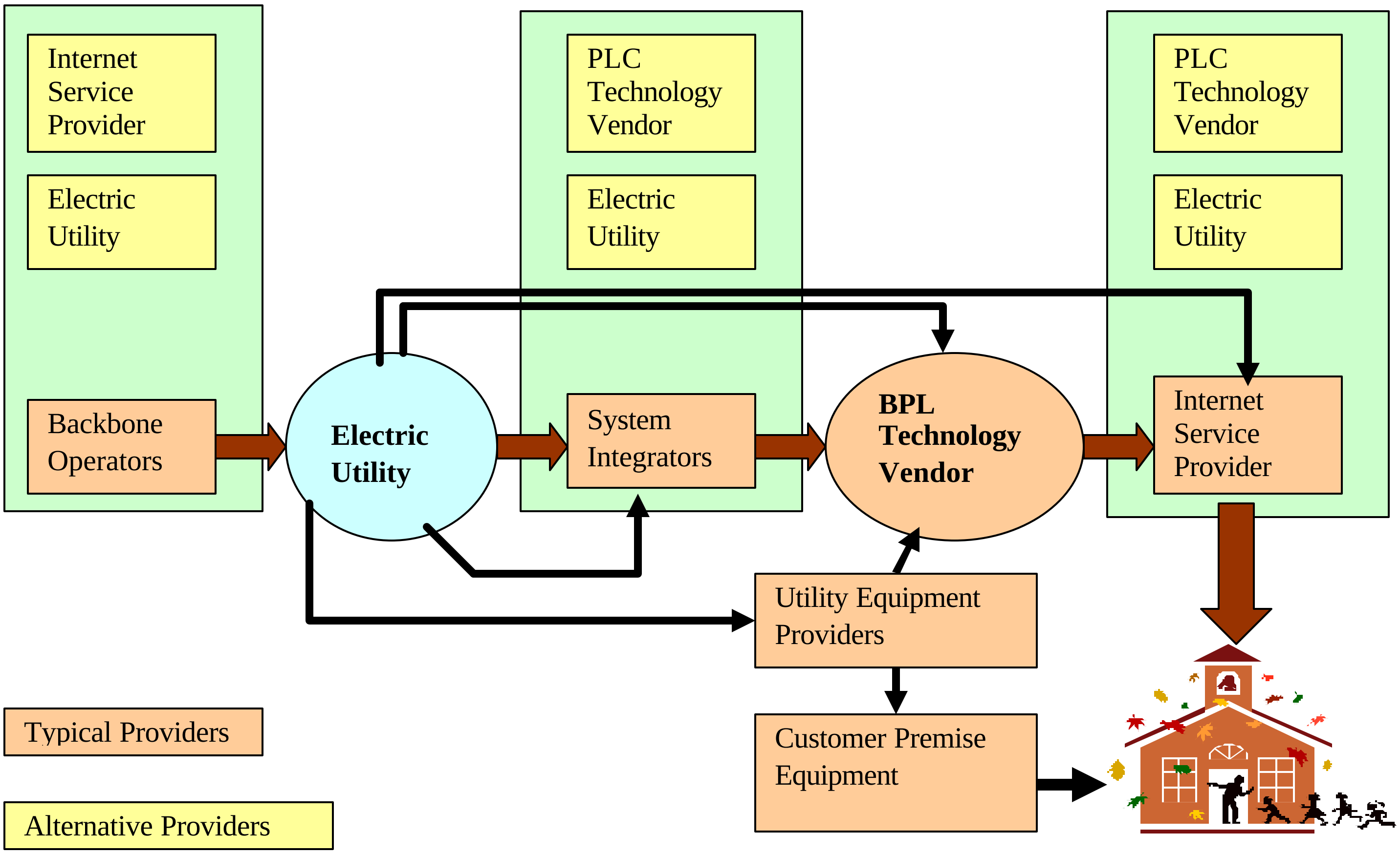
Content providers : This part of broadband consists of companies that provide information, goods, and services available to consumers through the Internet.

These characteristics and distinctions are based on network functionality and the fact that each of these categories has its own economic properties with distinct regulatory issues. Currently there is a dearth of competition in the provision of middle-mile services, which means existing providers can discriminate against their customers. Content providers, on the other hand, raise competitive issues in terms of their ability or willingness to engage in exclusive contracts for the carrying of their content, as well as posing challenges in the area of consumer protection and free speech.

The last mile and the middle mile are most relevant because they relate to the wires portion of the electricity network, the industry's easiest entry into the broadband industry.

The following Figure 5.1.1 shows key players interested in BPL, affording utilities the opportunity to structure partnerships to push the technology forward.

Figure 5.1.1 Industry Structure – Key Enabling Partners



A partnership between a utility and an external third party service provider offers strategic value as each player can focus on what it does best. Utilities have operated as monopolies and, while good at building infrastructure they lack experience in competitive environment. On the other hand, ISPs operate in a very competitive environment. The key success factors include effectively marketing to customers, cost effective customer acquisition and a high quality customer service.

Current broadband environment is expected to become very competitive with both cable modem providers and DSL providers aggressively marketing their services and other alternate providers looking at entering the market. Customer service appears to be a key differentiator with most of the consumers. A partnership with an ISP (or a local CLEC) might leverage key strengths: The utility could focus on network management while the ISP could focus on marketing. The opportunity to work together could also involve shared investment.

6 Impetus For BPL As An Access Technology

Most stakeholders in BPL industry suggest that BPL could offer a number of significant benefits in the delivery of broadband services to homes and businesses. A number of BPL proponents submit that this technology could increase the availability of broadband and improve the competitiveness of the broadband services market. Many players believe that Access BPL could facilitate the ubiquitous availability of broadband services and bring valuable new services to consumers, stimulate economic activity, improve national productivity, and advance economic opportunity for the American public. The ubiquitous nature of BPL is expected to create the opportunity for providing new and innovative services to virtually any location serviced with electric outlets. The National Telecommunications and Information Administration (NTIA) states that BPL holds great promise as a new source of innovation and competition in the broadband marketplace. It believes that BPL has the potential to open new avenues of Internet access, to enable new and expanded services for utility companies, and to create a new platform for further advances in communications technology.[7]

6.1 Homeland Security and Network Benefits

In the wake of the September 11 terrorist attacks, government officials and security experts have identified the need for the United States to possess communications network redundancy. By providing a third broadband technology, the nation would gain some of that needed redundancy. Also, with the development of voice-over-internet protocol (VoIP) there would be a network redundancy for voice communications as well.

The second benefit is the ability of BPL technology to improve the provision of electric power service and therefore advance homeland security. The BPL technology could also be used to assist the utility companies by adding intelligent capabilities to the electric grid, thereby improving efficiency in activities such as energy management, power outage notification and automated meter reading. As per United Power Line Council (UPLC), Access BPL would allow electric utilities to better monitor and control electric system operations and thereby improve the reliability of their service and reduce costs to consumers. Under the Mission Essential Voluntary Assets (MEVA) guidelines, utilities are responsible for ensuring secure infrastructure power for federal facilities, including military bases, and state, city and local government. BPL will also enhance security and enable other security applications such as video surveillance consistent with the MEVA guidelines.

6.2 Consumer Benefits

The supporters of BPL expect it to improve the competitiveness of the market for broadband services. It offers the long sought third wire (other two being telephone and cable) for last-mile delivery of broadband communication services to residences and small businesses. The United Power Line Council (UPLC) believes that BPL offers a unique opportunity in the broadband marketplace and that there is widespread interest in BPL among utilities. In the areas already served by other broadband providers, BPL will increase competition, which in turn will bring better service and lower prices for consumers.

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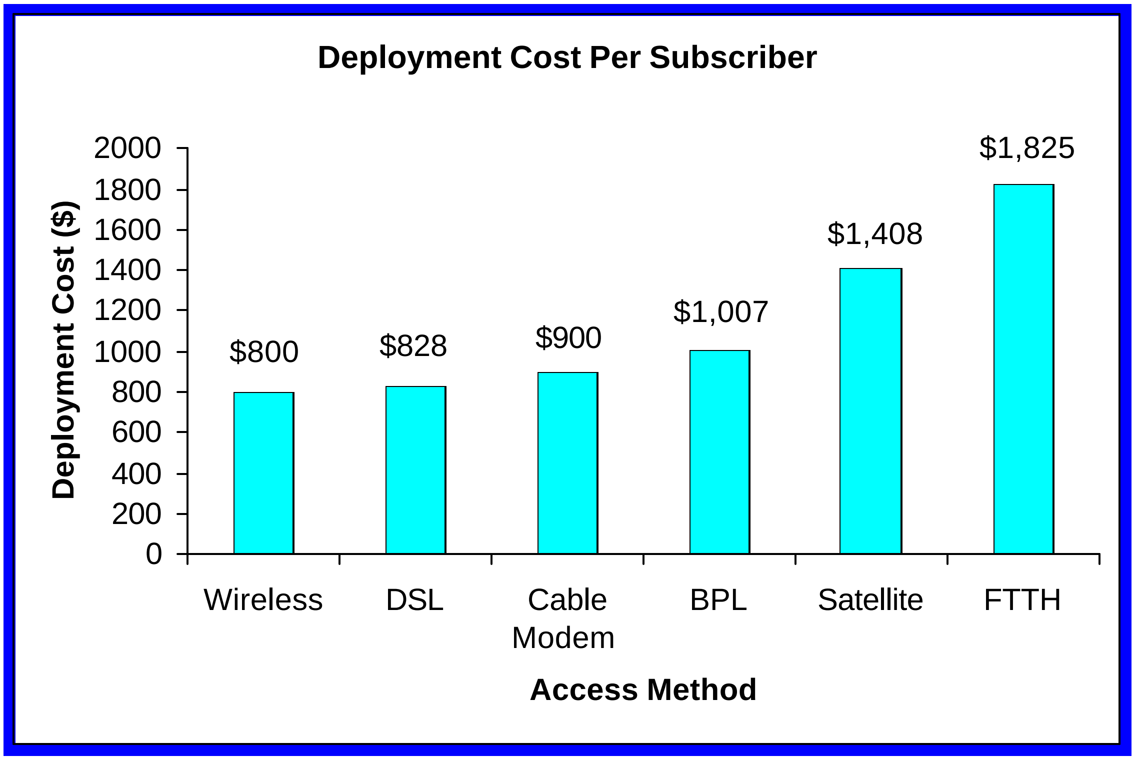
[7] Comments of NTIA at 2

6.2.1 Is BPL Truly A Low Cost Alternative?

According to a report conducted by the Shpigler Group, results suggest that BPL may be in the middle of the pack as far as deployment costs are concerned.[8]

Figure 6.2.1.1 Source: UTC Research; The Shpigler Group



[8]/ The Shpigler Group, United Telcom Council Research, *Opportunities in Broadband over Power Line, Final Report* at 189, (2004) ("*BPL Final Report*").

The Shpigler Report also suggests that in many market scenarios, BPL is expected to surpass other options as the low cost delivery option.[9] See Table 6.2.1.2.

Table 6.2.1.2: Deployment costs by market type and architecture/system type, Source UTC Research: The Shpigler Group

Area Type	Architecture/ System Type	Equipment Costs	Rollout Costs	Support Costs	Total Costs
	Classic	$125	$135	$144	$404
Urban	Cellular	$102	$135	$252	$489
	Wireless	$81	$135	$144	$350
	Classic	$251	$135	$144	$530
Suburban	Cellular	$193	$135	$252	$580
	Wireless	$362	$135	$144	$641
	Classic	$668	$135	$144	$947
Rural	Cellular	$490	$135	$252	$877
	Wireless	$803	$135	$144	$1,082

6.2.2 Geographical Coverage And Availability

It is forecasted that the ubiquitous nature of electric power grid will make it possible for Access BPL systems to bring broadband services to rural and other underserved locations. The American Public Power Association (APPA), for example, states that seventy five percent of its members serve communities with populations less than 10,000, many of which do not have access to broadband.[10] Current Technologies states that technical and economic considerations limit the deployment of cable and DSL. It submits that Access BPL is not constrained by these considerations and can deliver "broadband to many of those unserved by other broadband technologies" and " bring the advantages of the Internet to the people who need them most."[11] It is also expected that the availability of Access BPL will make it possible for those persons who currently do not have access to broadband to better participate and compete in the information age.[12] The Office of the People's Counsel, District of Columbia (OPC DC) supports the efforts to facilitate deployment of BPL because it has the potential to improve the District of Columbia's telecommunications landscape for consumers by providing a solution to the "digital divide" that currently exists in the District of Columbia and to increase the number of broadband service providers in the District.[13] The Alliance for Public Technology (APT) states that BPL may help

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9/ *BPL Final Report* at 190.

10/ *See* Reply comments of APPA at 2.

11/ *See* comments of Current Technologies at 8.

12/ *See* reply comments of APPA at 8-9.

13/ *See* comments of OPC DC at 1-2.

accelerate the deployment of advanced services and bring the new and enhanced applications to all Americans. APT urges that the FCC use its full authority under Section 706 to remove the barriers and create incentives for industry's rapid deployment of advanced services, such as BPL.

6.2.3 A Better-Connected Appliance

An interesting aspect of BPL is that every electric device is connected to the electric distribution network. Potentially, BPL could let chips in every electric device talk to each other. Of course, a Wi-Fi, Blue Tooth or other wireless chip could be placed in every appliance. But BPL may be a better solution. Those who had PC's before the Internet exploded remember the difference in functionality between a standalone PC and a networked PC. Networking every electric device together over the power lines might result in a similar growth in productivity and convenience for the home and office.

6.3 Commercial Opportunities

6.3.1 Overview Of Different Applications That Can Be Offered With BPL

Advances in BPL technology now allow for high-speed, broadband communications over medium and low voltage lines yielding potential market opportunities. Using BPL technology the utilities can now offer new facilities-based competition for broadband services and provide high-speed access to qualified urban, suburban, and rural areas of the country.

BPL can help utilities maximize the value of their existing assets by leveraging the transmission and distribution network infrastructures. The business development managers in utilities, at present, are focused on more traditional transition into the market via energy related applications such as Automatic Meter Reading (AMR), demand side management, outage notification, distribution transformer overload analysis, phase loss monitoring, fault characterization, and several others.

There are a number of applications BPL architecture can help deliver. These applications are shown below in Figure 6.3.1:

Figure 6.3.1: BPL Applications; Source: UTC Research – The Shpigler Group

Retail Applications	Utility Applications
▪ Applications Management ▪ Community Websites ▪ Data Storage ▪ Distance Learning ▪ Electronic Markets ▪ File Transfer ▪ High Speed data ▪ Home Energy Management ▪ Home Networking ▪ Home Security ▪ Intranet ▪ Smart Appliance Monitoring ▪ Tele-medicine ▪ Video Conferencing ▪ Voice-Over-IP (VOIP) ▪ VPN ▪ Web-based government services	▪ Automatic Meter Reading (AMR) ▪ Capacitor Control ▪ Copper Wire System Replacement ▪ Demand Prediction ▪ Detection and diagnosis of events at capacitors and regulators ▪ Distribution transformer overload analysis ▪ Line testing ▪ Microwave system replacement ▪ Outage localization and fault characterization ▪ Phase loss detection ▪ Power quality monitoring ▪ Safety Check for isolated circuits ▪ SCADA delivery ▪ Substation monitoring ▪ URD outage diagnosis

6.3.2 Financial Impact Of Delivering Utility Applications Via BPL

BPL as a communications platform for monitoring and diagnostic systems renders a utility's existing operations significantly more cost effective. It also improves profitability by making the operations more efficient. BPL can:

- Replace existing copper, microwave, fixed wireless, and satellite communications systems on the distribution network resulting in immediate cost savings
- Eliminate the cost barriers historically associated with the installation of Supervisory Control and Data Acquisition Systems ("SCADA"), AMR and Load Management Systems:
  - No payments to telephone utilities for installation fees and rights of way
  - No need for high-cost dedicated landlines or dial up lines
  - Fixed wireless networks can be very costly to install on an entire network
  - Eliminate charges associated with using cellular systems
- Data collection and analysis costs will be reduced with lower head count, vehicle fleet and other overhead.

Power monitoring and control applications have capabilities that can be fully automated to maximize efficiency and significantly reduce Operations and Maintenance (O&M) costs. The systems alone can collect and analyze data to diagnose and locate problems before they happen.

BPL could:

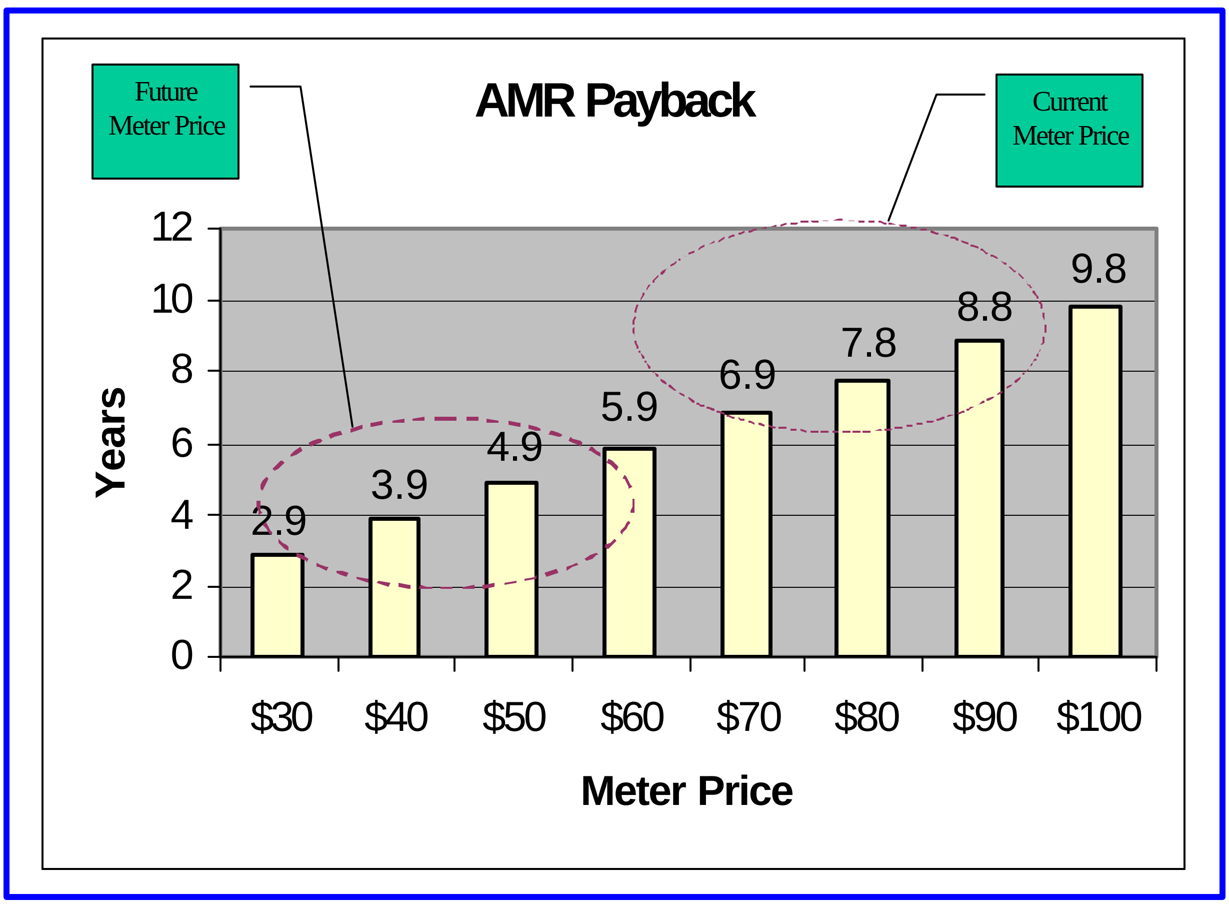
- Give control and ownership of the communications platforms to the utility
- Be ubiquitous and facilitate the provisioning of real-time information

- Improve efficiency by reducing the number of different architectures that need to be supported and managing all systems on one network.
- Reduce reliance upon another utility or provider:
  - The utility would own the meters and the communications system
  - No interruption of data transmission due to downed telephone or cellular systems
  - Maintenance and repairs scheduling is completely controlled by the utility

As per UTC Research:

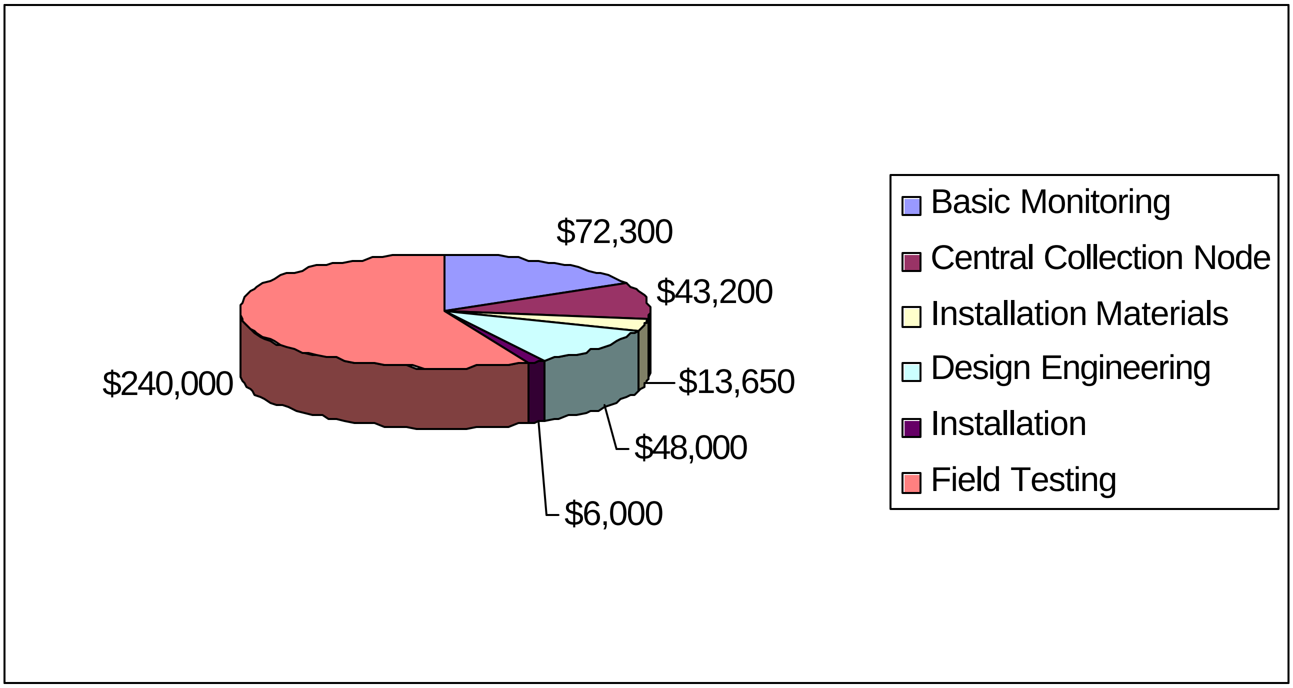
Over $30 million per year can be generated in utility savings through the implementation of a BPL system in an urban market. A modest savings could result by enabling 100% coverage for automatic meter reading (AMR), typically the most costly utility application due to the high cost of retrofitting the meter. (see Figure 6.3.2.1)

Figure 6.3.2.1: AMR Payback; Source: UTC Research – The Shpigler Group



A substation-monitoring program implemented by Kansas City Power and Light resulted in a payback of less than two years. An annual savings of $228,000 was realized against total Engineering and Installation (E&I) costs shown below in Figure 6.3.2.2.

Figure 6.3.2.2: E&I Costs- An Illustration: Source: UTC Research – The Shpigler Group



6.3.3 BPL Business Models

In addition to resolving regulatory issues, each utility has to figure out the right BPL business model to pursue, which varies according to an electric utility's business and economic objectives. The business model selection is experimental and fluid right now. Some utilities may make their lines available to a third party that would then install BPL equipment. Others may decide to offer broadband directly. It depends on their risk/reward appetite. There are a number of variations to the following three fundamental business models available to electric utilities.

The Landlord Model

This model emphasizes partnering with an existing communications company who would give an electric company immediate access to operations and marketing expertise and personnel without having to invest in either the expenses or the personnel. The value brought to the table by the electric company, of course, would be its broadband network.

Cautious utilities that want to avoid capital or operating exposure will look to enter into such partnership arrangements as part of a landlord strategy. The landlord business model is a very stable structure and can be risk-free if positioned correctly. This model allows for small returns for small investment and effort.

Impetus for the Landlord Model[14]

- There is no desire to invest funds in building out the network
- There is no desire to run a BPL operation
- Regulations can be managed to allow for value creation to be maintained by the utility without requiring that all proceeds are returned to the ratepayer base

The Developer Model

This model involves building the infrastructure and offering wholesale access. Utilities seeking to leverage their core competencies in building and maintaining networks will look to this model.

Those electric companies that are reluctant to incur the marketing costs associated with selling retail broadband services may want to consider marketing to a smaller group of customers—traditional broadband companies. Traditional broadband companies are those that primarily or exclusively sell communications services, such as broadband. There are many companies that already have personnel experienced in the marketing and selling of broadband services but that have failed to thrive due to the high costs of building networks. In fact, many of these companies must rely on ILECs to provide broadband service to their customers.

BPL presents electric companies with the opportunity to sell broadband services to these companies. By upgrading their electricity networks to include broadband capabilities, electric companies could make ready-made last-mile broadband networks for competitive broadband companies that seek to eliminate their dependency on ILECs, which are their direct competitors for customers.

According to the report drafted by the Shpigler Group and UTC Research, "the developer will be equally involved in network construction as a service provider but will trade in lower operational burdens for diminished financial returns."[15]

Impetus for the Developer Model[16]

- Regulations do not prevent opportunities to leverage the utility's position in the market
- Internal skills are present to construct a BPL network that is economically able to compete with other players
- Viable candidates to serve as the BPL service provider are available in the market.
- Interest or capability does not exist in running the network and the operations
- Attractive segments of the market exist, enabling select build opportunities

The Service Provider Model

This model is one in which the utility interfaces with the customer. Aggressive utilities seeking to offer retail broadband services may consider the service provider model. The service provider business model involves the highest risk, but can feature tremendous upside.

Electric utilities are certainly poised to provide this service because they already own the poles and lines that access virtually every residential and business customer in the United States. Providing broadband service to these customers would simply require adding equipment to their wires. The feature of BPL that would make it more attractive than DSL or cable modem is that

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14/ *BPL Final Report* at 197.

15/ BPL Final Report at 195.

16/ *Id*.

BPL customers would immediately have in-house networks without having to purchase and install additional wiring in their homes.

The challenge with providing retail service, however, is that there are marketing costs that some companies may be unwilling or unable to absorb. The cost of advertising to create market share where none exists can be overwhelming. An electric company deciding to enter this retail market would also have to hire or retrain staff with expertise in marketing broadband services. Any utility interested in pursuing the service provider model will need to address market, operational, and network build issues

Impetus for the Service Provider Model[17]

- Regulations allow for joint marketing, thus enabling a superior projected market penetration performance
- Internal skills are present to construct a BPL network and maintain it during operations
- Skills needed to support marketing, operations, and network management are in house
- The market is an attractive one that offers solid promise for financial returns

Table 6.3.3 summarizes the functional activities associated with each of the business model described above.

Table 5.3.3: Functional Activities By Business Model, Source: UTC Research, The Shpigler Group

Function / Business Model	**Landlord**	**Developer**	**Service Provider**
Allow Access to Network	Yes	Yes	No
Network Construction	No	Yes	Yes
Network Maintenance	No	Yes	Yes
Network and Customer Operations	No	No	Yes

17/ *Id*. at 193.

6.4 Support from Federal Regulators

High-speed Internet access is still unavailable in a significant number of areas. This is especially applicable to rural areas. When weighed against the relatively small number of customers Internet providers would gain, the cost of laying cable and building the necessary infrastructure to provide DSL or cable in rural areas is too great. But if broadband could be served through power lines, there would be no need to build a new infrastructure. Anywhere there is electricity there could be broadband.

The FCC believes that BPL has the potential to offer a number of significant benefits, such as 1) increasing the availability of the broadband services to homes and businesses; 2) improving the competitiveness of the broadband services market; 3) improving the quality and reliability of electric power delivery; and 4) advancing homeland security..

The October 14, 2004 rulemaking by the Federal Communications Commission (FCC) provides regulatory guidelines for the provisioning of BPL. In this ruling, the FCC has clearly established the rules and eliminated the guesswork and doubt as to what the regulatory climate will be for BPL. This rulemaking illustrates an endorsement of BPL by the FCC.

In this ruling, FCC recognized the legitimate concerns of licensed radio services, and therefore, established new technical requirements for BPL devices that require, among other things, that BPL avoid specific frequency bands and frequency exclusion zones to protect aeronautical and aircraft communications.

The FCC explained that the rules would require the equipment to mitigate interference by either notching (reducing power) or shifting frequencies of operation, or by shutting down remotely. Many of the BPL technologies already have that capability. At the same time, the FCC will also exclude BPL from operating on certain frequencies on a local or nationwide basis in order to protect certain licensed operations that are life and safety related. The FCC also will only require limited disclosure of BPL operations for a publicly accessible database to provide notice and BPL operator contact information to licensees that experience interference. Finally, there will be new measurement guidelines that are "consistent and repeatable" and that BPL equipment authorization will be subject to the Certification process rather than simple Verification by the manufacturer. According to the FCC, these rules remove uncertainty and ensure licensed services are protected.

The FCC believes that the revised Part 15 rules will help promote and foster the development of the BPL technology with its associated benefits while at the same time ensure that existing licensed operations are protected from harmful interference.

7 Feasibility Assessment

Several utilities, particularly municipally owned ones, have been running pilots of broadband services over **fiber to the home** (FTTH), and some have moved to full deployment. While BPL has come a long way in the past two years, some issues, especially the lack of standards for "Access BPL", remain unresolved. However, the technologies appear to work well enough to provide commercial service. In fact, the state of BPL today strikes in many ways resemblances to what cable modem service was like in 1997. There are several proprietary technologies that work, standards are not yet there, and a pretty significant culture change will have to occur in utility personnel, just as it did for cable.

Willingness of utilities to invest in new technologies and take risks, is to some extent, determined by what constituencies they serve. Historically, it appears that "**Munis**" have been quicker to embrace new technology, since they do not have to produce results for shareholders.

7.1 Technical

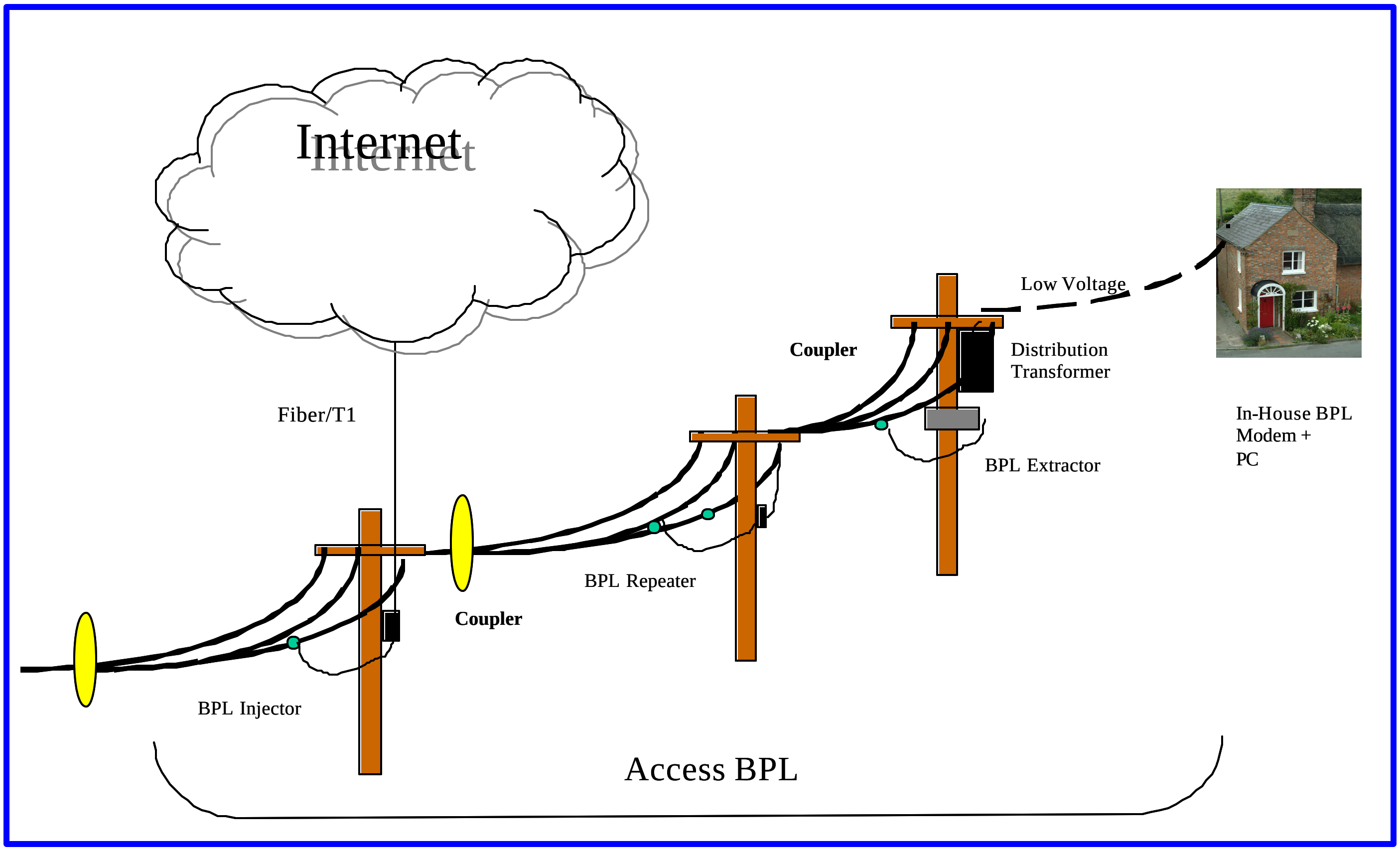
Access BPL equipment consists of injectors (also known as concentrators), repeaters, and extractors. BPL injectors are tied to the Internet backbone via fiber of T1 lines and interface to the Medium Voltage (MV) power lines feeding the BPL service area. MV lines, typically carrying 1,000 to 40,000 volts, bring power from an electrical substation to a residential neighborhood. Low Voltage distribution transformers step down the line voltage to 220/110 volts for residential use.

MV power lines may be overhead on utility poles that are typically 10 meters above the ground. Three-phase wiring generally comprises an MV distribution circuit running from a substation, and these wires may be physically oriented on the utility pole in a number of configurations (e.g. horizontal, vertical, or triangular). This physical orientation may change from one pole to the next. One or more phase lines may branch out from the three phase lines to serve a number of customers. A grounded neutral conductor is generally located below the phase conductors and runs between distribution transformers that provide Low Voltage (LV) electric power for customer use. In theory, BPL signals may be injected onto MV power lines between two-phase conductors, between a phase conductor and the neutral conductor, or onto a single phase or neutral conductor.

Extractors provide the interface between the MV power lines carrying BPL signals and the households within the service area. BPL extractors are usually located at each LV distribution transformer feeding a group of homes. Some extractors boost BPL signal strength sufficiently to allow transmission through LV transformers and others relay the BPL signal around the transformers via couplers on the proximate MV and LV power lines. Other kinds of extractors interface with non-BPL devices (e.g. WiFi, WiMax) that extend the BPL network to the customers' premises.

For long runs of MV power lines, signal attenuation or distortion through the power line may lead BPL service providers to employ repeaters to maintain the required BPL signal strength and fidelity. Figure 6.1 illustrates the basic BPL system, which can be deployed in cell-like fashion over a large area served by existing MV power lines.

Figure 7.1: Basic BPL System Source: ITN, Inc.



7.1.1 Vendor Systems And Architectures

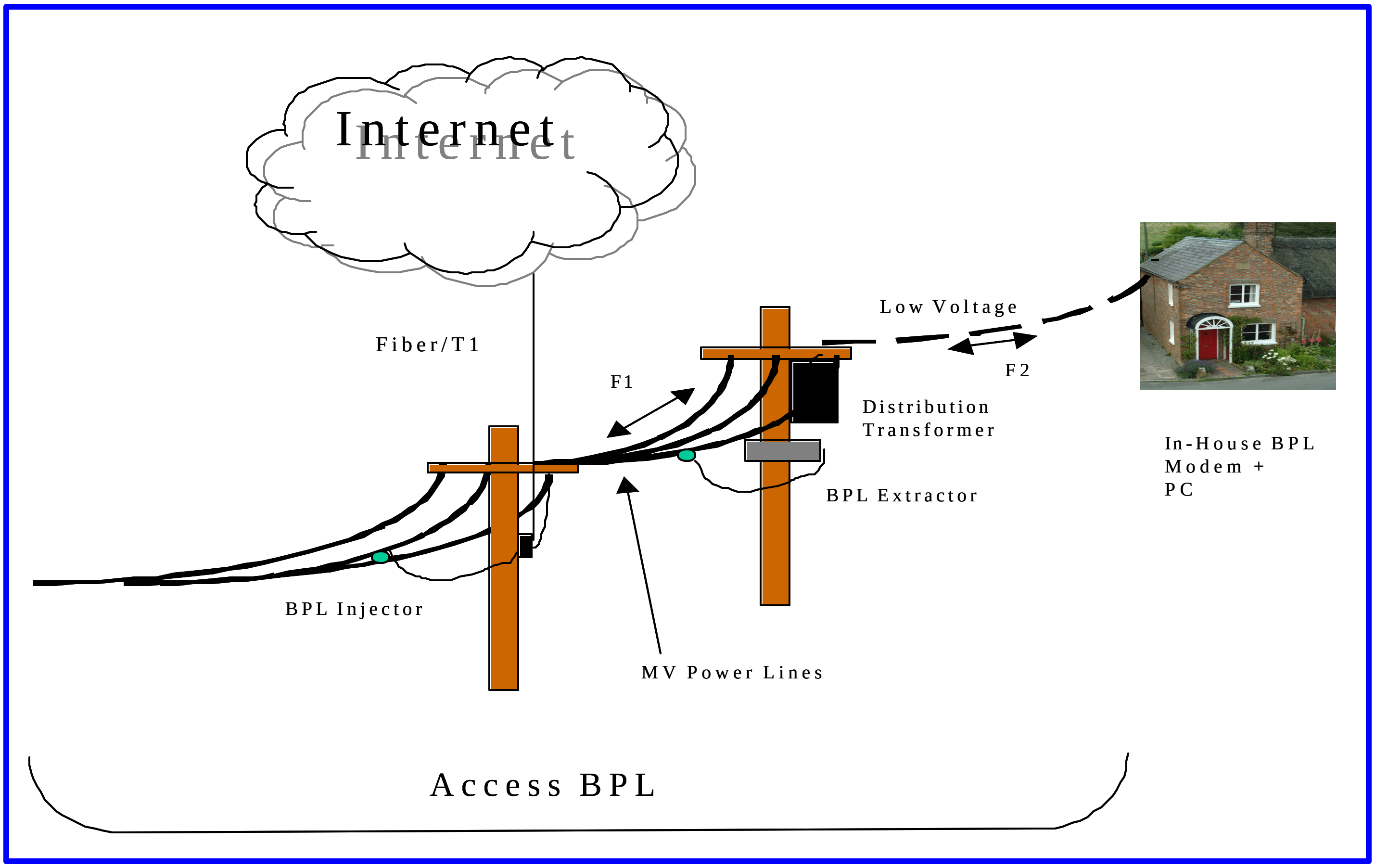
Developments by BPL vendors have moved the BPL industry close to being commercially available. Several trials in North America have proven some technical approaches and either eliminated or cast doubt on others. Multiple choices in possible architectures offer electric utilities and their partners flexibility in selection of BPL business model and deployment plans by market type.

This section provides a brief description of three different network architectures used by BPL equipment vendors.

Architecture #1

Architecture #1 (see Figure 7.1.1.1) employs Orthogonal Frequency Division Multiplexing (OFDM) to distribute the BPL signal over a wide bandwidth using many narrow-band sub-carriers. At the BPL injector, data from the Internet backbone is converted into the OFDM signal format and is then coupled onto one phase of the MV power line. An injector also converts BPL signals on the MV power lines to the format used at the Internet backbone connection. The two-way data are transferred to and from the LV lines, each feeding a cluster of homes, using BPL extractors to bypass the LV distribution transformers. The extractor routes data and converts between access and in-house BPL signal formats. The subscribers access this BPL signal using in-house BPL devices. To span large distances between a BPL injector and the extractors it serves, repeaters may be employed.

*Figure 7.1.1.1: Architecture # 1(**Source: ITN, Inc.**)*



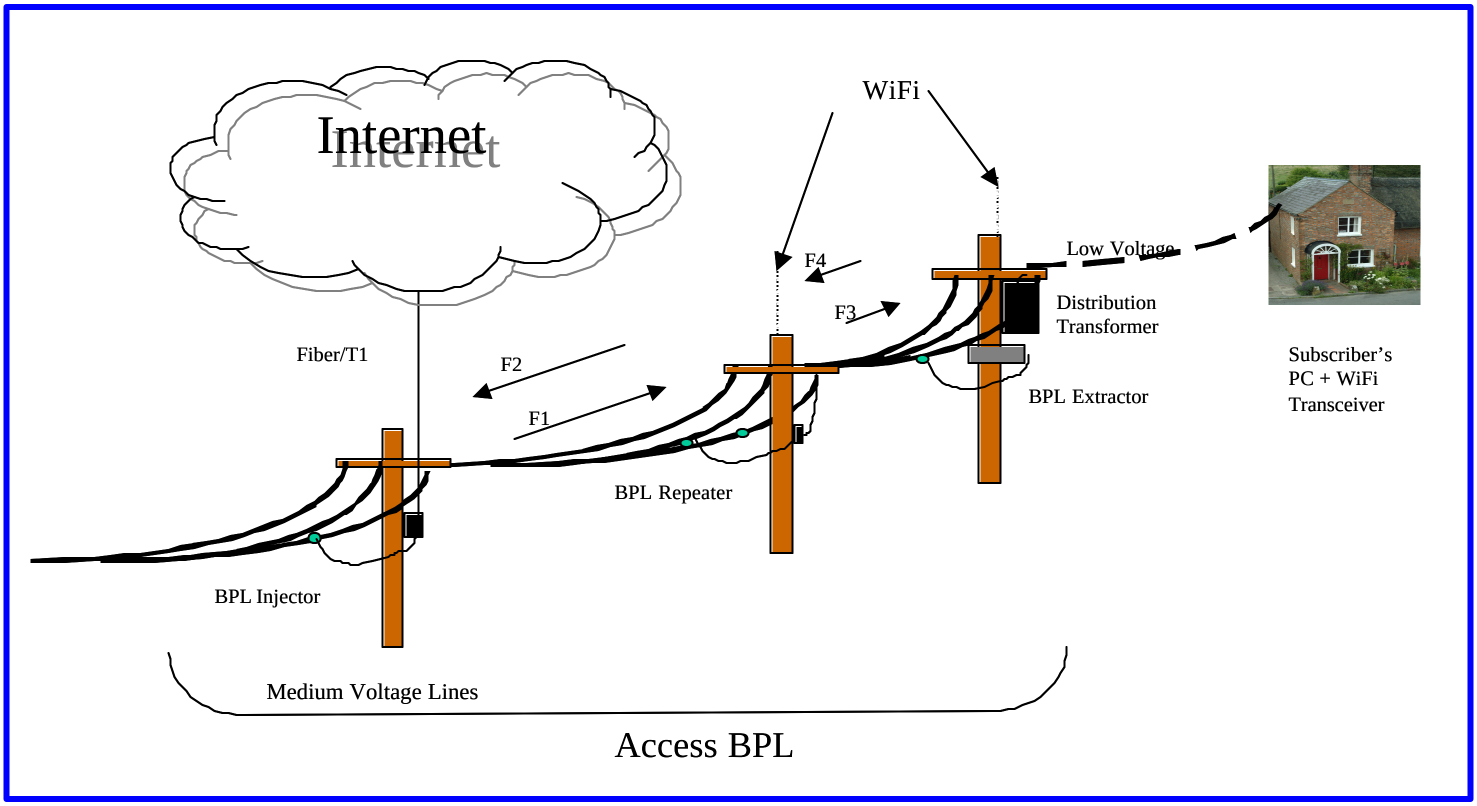
In this architecture, injector and extractors share a common frequency band (F1) on the MV power lines, different than the frequency band (F2) used on the LV lines by the subscriber's in-house BPL devices. In order to minimize contention for the channel, Carrier Sense Multiple Access (CSMA) is used with Collision Avoidance (CA) extensions. This type of system is designed to accept some amount of co-channel interference between quasi-independent BPL cells without the use of isolation filters on the power lines, as all devices on the MV lines operate over the same frequency band. The BPL signal may be sufficiently tolerant of co-channel BPL interference to enable implementation of two or three of these systems independently on adjacent MV power lines. This architecture couples BPL signals into one phase line.

Architecture #2

This architecture also uses OFDM as its modulation scheme, but differs from Architecture #1 in the way it delivers the BPL signal to the subscribers' homes. Instead of using a device that uses LV power lines, this architecture extracts the BPL signal from the MV power line and converts it into an IEEE 802.11b WiFi signal for a wireless interface to subscribers' home computers as well as local portable computers (see Figure7.1.1.2). **Technologies other than WiFi might also be**

used to interface to subscribers' devices with the BPL network, the important point being that BPL is not used on LV power lines in this system.

*Figure 7.1.1.2: Architecture # 2 (**Source: ITN, Inc.**)*

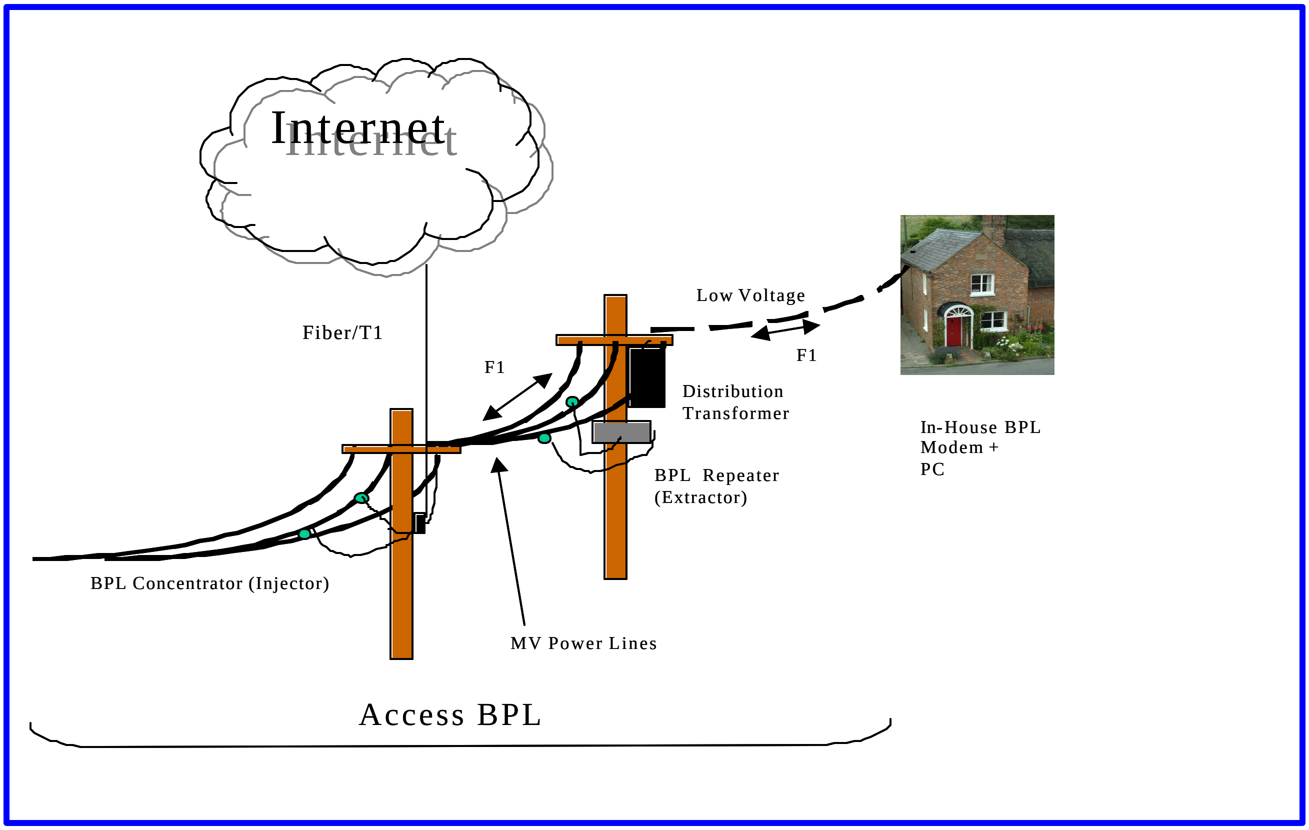


This architecture uses different radio frequency bands to separate upstream (from the user) and downstream (to the user) BPL signals, and to minimize co-channel interference with other nearby access BPL devices. To span large distances between a BPL injector and the extractors it serves, repeaters may be employed. Like the injectors, BPL repeaters transmit and receive on different frequencies, and they use different frequencies from those used by the injector and other nearby repeaters. In this architecture repeaters may also provide the capabilities of an extractor when outfitted with a WiFi transceiver. This system/architecture couples BPL signals onto one phase of the MV power line.

Architecture #3

Architecture #3 uses Direct Sequence Spread Spectrum (DSSS) to transmit the BPL data over the MV power lines. All users within a BPL cell share a common frequency band. In order to minimize contention for the channel, Carrier Sense Multiple Access (CSMA) is used. Like Architecture #1, this system is designed to accept some amount of co-channel interference between cells, as all devices operate over the same frequency bands. At one trial deployment of this architecture, the BPL service provider independently implements two phases of the same run of three phase power lines.

Figure 7.1.1.3: Architecture # 3(Source: ITN, Inc.)



Each cell in this architecture (see Figure 7.1.1.3) is comprised of a concentrator (injector) that provides an interface to a T1 or fiber link to the Internet backbone, a number of repeaters (extractors) to make up for signal losses in the electric power line and through the distribution transformers feeding clusters of dwellings, and customer premises BPL equipment, used to bridge between the user's computer and the electrical wiring carrying the BPL signal. Adjacent cells typically overlap and the customers' BPL terminals and repeaters are able to communicate with the concentrator that affords the best communication path at any time. This architecture couples the BPL signal onto the power line using a pair of couplers on a phase and neutral line.

Potential Architectures And Their Financial Attractiveness

BPL providers anticipate a wider range of applications that may be offered to their subscribers. High quality, multi-channel video, audio, voice over Internet Protocol (VoIP), and on-line gaming applications are expected to rapidly increase the demand for additional bandwidth. To support the typical subscriber at 1 Mbps, BPL systems are expected to operate at speeds of 100 Mbps or more on the MV power lines in the near future. A number of comments filed in response to the NOI indicate that the BPL industry is already preparing for this growth.

A number of BPL vendors have suggested use of frequencies up to 50 MHz. At least one vendor is considering use of 4 MHz to 130 MHz, while excluding frequencies that are actively in use by certain licensed services. One solution put forward in an attempt to mitigate interference with licensed services is to attenuate or "notch" BPL signals in frequency bands where licensed services are in nearby use. Future BPL systems may be able to accomplish this automatically without system operator intervention. To implement this solution while simultaneously maximizing the useable bandwidth, BPL systems are expected to use new modulations that can support more sub-carriers that are more finely spaced.

As data rates and bandwidths requirements grow, the BPL systems may require operation at greater transmitted power levels but not necessarily with higher power density than is used today. BPL vendors may employ techniques to dynamically adjust the power level to maintain a minimum signal-to-noise ratio (SNR) over the entire BPL spectrum, while limiting emissions to levels compliant with Part 15. One vendor has proposed such a solution for adjusting transmitted power to maintain a constant SNR across the BPL spectrum, with a hard limit based on Part 15 rules. The challenge will be to develop the control mechanism that can maximize transmitted power while simultaneously limiting the radiated emissions, perhaps in conjunction with frequency agility.

Nortel has developed and patented a filter that blocks BPL signals while concurrently passing medium-voltage AC power. The judicious use of such blocking filters will enable optimal segmentation of BPL networks into cells of various sizes having low conducted co-channel interference from neighboring cells. This will enable a greater level of frequency reuse than what is currently available.

Another BPL technology utilizes the 2.4 GHz and 5.8 GHz unlicensed bands. An implementation using multiple IEEE 802.11b/g WiFi chips sets has been used to demonstrate the concept of carrying data over medium-voltage power lines at rates exceeding 200 Mbps.

Consistent with the three Architecture types, the following are three distinct BPL systems. (See Figure 7.1.1.4) Each BPL system offers a separate set of characteristics that distinguish it from the others. These three systems (Table 7.1.1) are further tested in different market types (Table 7.1.2) to assess their financial feasibility.

Figure 7.1.1.4: Three Distinct BPL Systems; *Source UTC Research: The Shpigler Group*

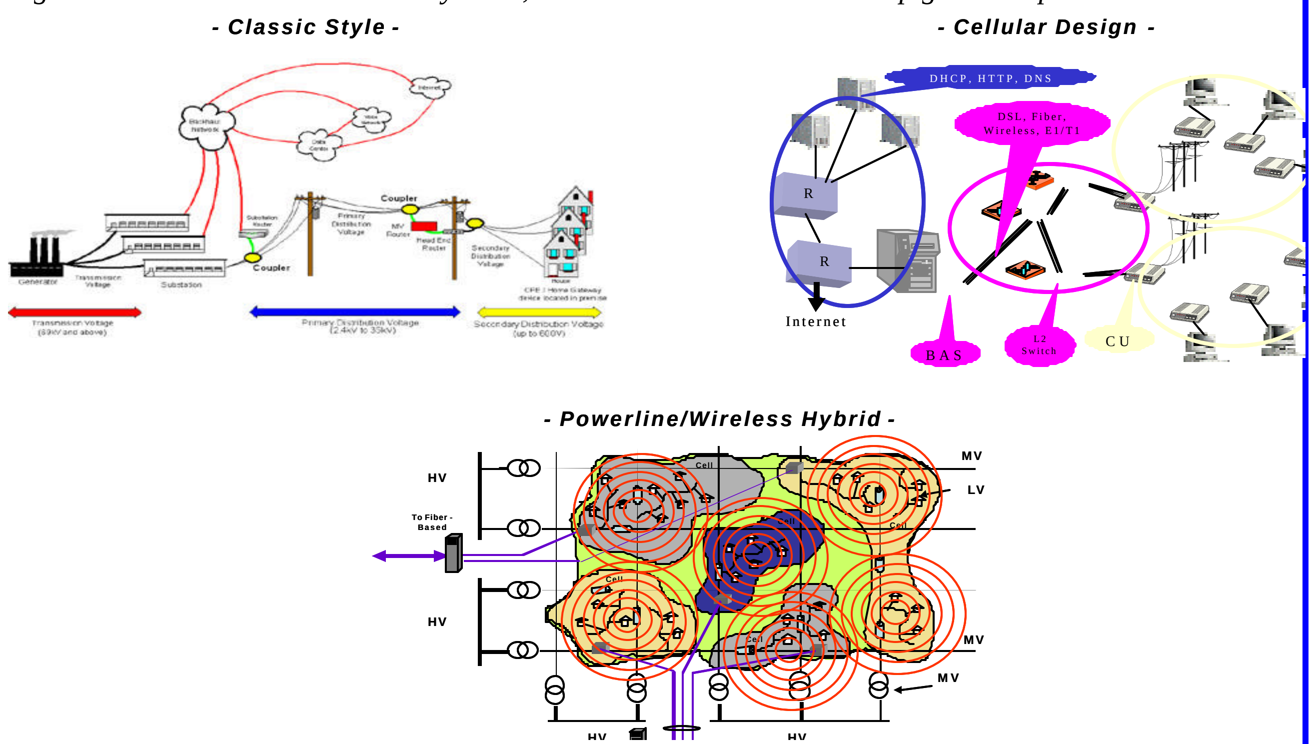


Table 7.1.1:Three Distinct Systems - Characteristics; Source: UTC Research

	Classic	**Cellular**	**Powerline /Wireless**
Injection Point	Substation	Close to Customer Area	Substation
Signal Across Transformer	Yes	Yes	No
Last Mile	Powerline	Powerline	Wi-Fi (possibly WiMax in near future)
Advantage	Full use of power grid	Low Capital Cost in low density areas	High potential reach
Limitation	Extensive Repetition	High backhaul cost	Wireless Interference

Each system was tested and analyzed in three distinct market areas with the following characteristics:

Table 7.1.2: The Three Test Markets

	Urban (Tier 1)	Suburban (Tier 3)	Rural (Tier 5)
Population	3,179,099	783,614	168,856
Households	1,208,658	292,627	66,232
Business Locations	118,188	27,601	5,955

The results of these tests are summarized in Table 7.1.3 below.
Source: UTC Research; The Shpigler Group

	Urban – Tier 1			***Suburban – Tier 3***			***Rural – Tier 5***		
	Classic	*Cellular*	*Wireless*	*Classic*	*Cellular*	*Wireless*	*Classic*	*Cellular*	*Wireless*
NPV ($M)	*137*	*(33)*	*178*	*57*	*(18)*	*38*	*12*	*7*	*(13)*
IRR %	*39*	*6*	*74*	*36*	*5*	*27*	*27*	*25*	*8*
Peak Funding ($M)	*59*	*124*	*18*	*30*	*56*	*47*	*15*	*10*	*40*
Year 10 Revenue ($M)	*85*	*85*	*85*	*39*	*39*	*39*	*10*	*10*	*10*
Year 10 EBITDA ($M)	*52*	*23*	*53*	*24*	*10*	*24*	*6*	*5*	*6*

At a high-level it can be concluded that in general:

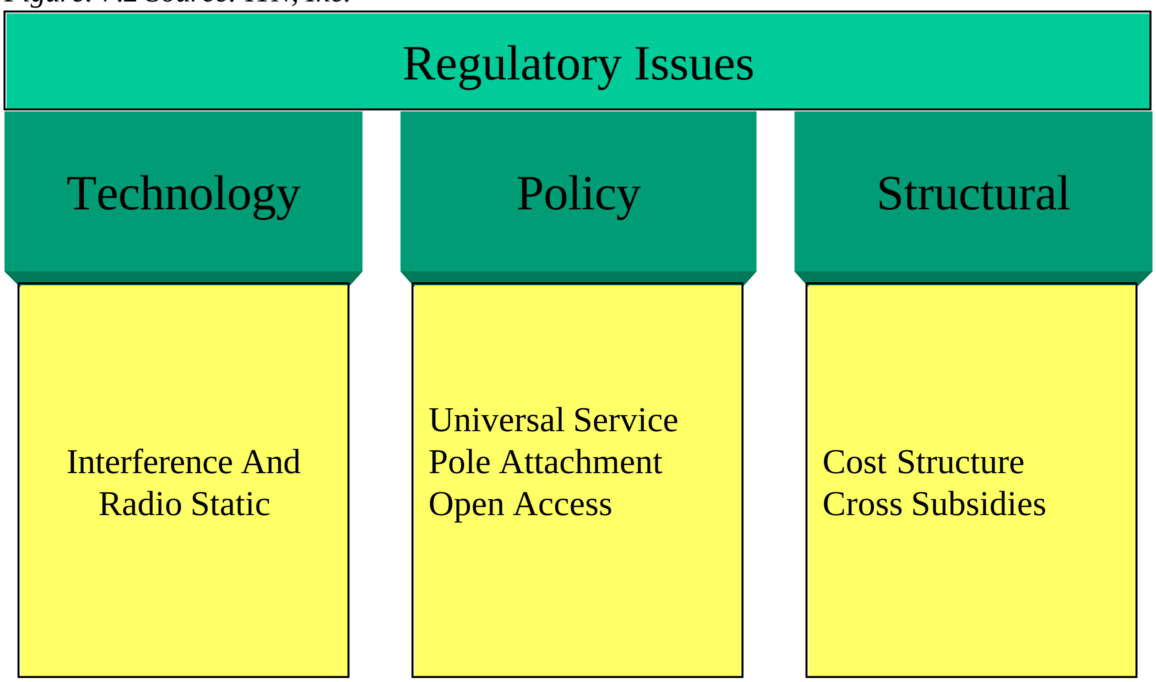
- Hybrid wireless-BPL systems can be very attractive in dense metro environments.
- As the market gets smaller, classic systems will often dominate.
- Deploying a cellular system can often minimize the capital cost for entry in a rural market.

7.2 Regulatory - Issues and Challenges

The FCC has implemented new rules after obtaining comments from proponents of the new BPL service, i.e., electric utilities and BPL vendors, as well as those who might be impacted by the BPL signals. On most electric utility poles below the four electric utility lines there is a lower segment of the pole where telephone and cable television wires are attached (referred to as the communications space). One of the questions the FCC has addressed is whether radiated signals from access BPL systems on the electric power lines would interfere with signals on the cable and telephone lines, and vice versa.

Regulations in the BPL arena can broadly be grouped into three categories of issues as shown in Figure 7.2:

Figure: 7.2 Source: ITN, Inc.



Even though the Telecommunications Act of 1996 mandated that broadband service be widely available in the United States, the actual market for that service today is a duopoly—with customers in most jurisdictions connecting to the internet through either their incumbent local exchange carrier (ILEC), which provides broadband service through digital subscriber lines (DSL), or their local cable operator, which provides the service through cable modem. Duopoly does not necessarily provide consumers the opportunity to get the best combination of rates and services, and many now are looking to electric companies as a third competitive provider of broadband.

BPL technology provides the opportunity to have true competition for broadband service. Given the applications and services it can offer, it is incumbent upon regulators to adopt a uniform set of rules and regulations that will facilitate the provision of BPL service in the United States while ensuring that public interest concerns are protected . In order to provide broadband access to all Americans, the FCC and the states are defining and adopting a regulatory scheme that removes unnecessary barriers to market entry and permits electric companies to be competitive in the marketplace.

7.2.1 Interference and Radio Static

Powerline system is a type of carrier current system that electric utility companies have traditionally used for protective relaying and telemetry. They operate between 10 kilohertz (KHZ) and 490 KHZ, although today many utilities rely on the 1-30 megahertz (MHZ) bandwidth for BPL transmission. A carrier current system transmits radio frequency energy to a receiver by conduction over the electric power line.

Under Part 15 of the FCC's current rules, which regulate carrier current systems and powerline carrier systems, each is subject to different emission limits. The FCC also limits the amount of conducted radio frequency (RF) energy that may be injected into a building's wiring by an RF device that receives power from the commercial power source, including carrier current systems that couple RF energy onto the AC wiring for communications purposes.

This conducted energy can cause interference to radio communications by two possible paths. First, the RF energy may be carried through electrical wiring to other devices also connected to the electrical wiring. Second, at frequencies below 30 MHZ, where wavelengths exceed 10 meters, long stretches of electrical wiring can act as an antenna, permitting the RF energy to be radiated over the airwaves. Due to low propagation loss at these frequencies, such radiated energy can cause interference to other services at considerable distances.

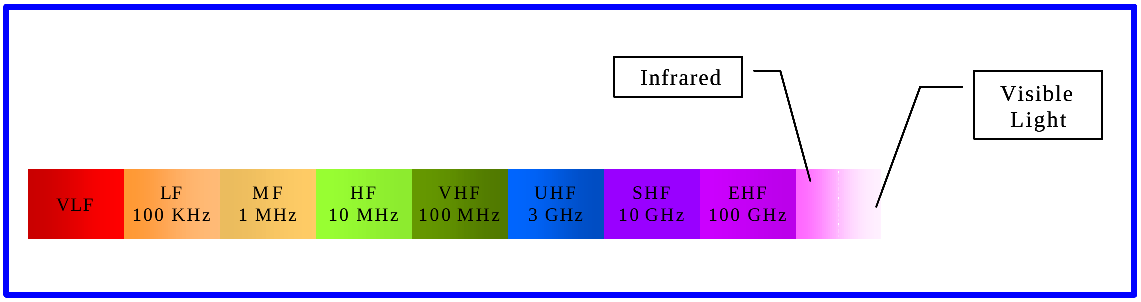
A BPL modem is considered an unlicensed device, like a cordless phone or garage door opener. All unlicensed devices are governed by the FCC's Part 15 rules. Part 15 mandates that all electronic devices sold in the United States must meet FCC radio-frequency emissions limits. These limits are in place to secure against interference with important transmissions like CB communications, air-traffic control and government channels. ARRL and FEMA are concerned about the interference caused by BPL signals transmitted on exposed medium-voltage power lines.

Cable TV operators get around the interference problem by shielding all of their cables. "Coaxial cable" used by cable TV operators has a braided metal shield that surrounds the signal wire. Telephone cables are also shielded. Power lines, on the other hand, have no shielding. In many cases, a power line is a bare wire, or a wire coated in plastic. The lack of shielding is where the interference concern comes from.

While FEMA is willing to allow the FCC to seek a compromise, the ARRL claims that compromise is not possible because the bandwidth needed for BPL will directly interfere with ham radio and short-wave radio transmissions. Developers of BPL say that these interference issues have been solved. Meanwhile, advancement of BPL moves forward slowly as it waits for standards and logistics to be decided by regulating bodies.

Currently, the frequency band breaks down as follows:

Figure 7.2.1: Frequency Spectrum Allocation



- AM radio - 535 kilohertz to 1.7 megahertz
- Short-wave radio - 5.9 megahertz to 26.1 megahertz - The "short waves" - the only part of the radio spectrum that supports long-distance, intercontinental radio communication. The short waves are used for international broadcasting, aeronautical, maritime, disaster relief, and other services including the military
- Citizens-band (CB) radio - 26.96 megahertz to 27.41 megahertz
- Television stations - 54 to 88 megahertz for channels 2 through 6
- VHF - The "low-band VHF" frequency range is heavily used by volunteer fire departments, police, and other first responders
- FM radio - 88 megahertz to 108 megahertz
- Television stations - 174 to 220 megahertz for channels 7 through 13

In nutshell:

- Limits are stricter for Class B settings (residential) than for Class A (commercial, industrial, business environment)
- Emissions above 30 MHz are under stricter control than those below 30 MHz
- Internal use of BPL for activities like AMR and load balancing are likely to involve the low end of the 1-30 MHz range, thus reducing stress on Federal emissions limits
- The FCC Notice of Proposed Rulemaking seeks to promote BPL deployment while preventing harmful interference to authorized radio operators
- FCC is taking a cautious approach that would permit deployment under existing emission limits, but which proposes additional safeguards to mitigate interference that might occur from BPL operations

7.2.2 Universal Service and Pole Attachments

Currently, all interstate telecommunications, wireless phone, and paging service providers must contribute 6.8 percent of their long distance and international calling revenue to a universal service fund. The fund is designed to provide rural, low income, and other consumers access to advanced and inter-exchange telecommunications services at reasonably comparable rates charged for similar services in urban areas. The obligation to contribute to the universal fund, if applied to BPL providers, would add to the costs of providing such service.

BPL presents unique issues for pole attachment regulation, including access, rates, modifications, and surveys, all of which can impact BPL operational expenses.[18] FCC has jurisdiction over investor-owned utilities, unless states reverse preemption Some states that are exempt include AK, CA, CT, DE, DC, ID, IL, KY, LA, ME, MA, MI, NJ, NY, OH, OR, UT, VT, WA.[19]

Pole attachments have been an issue since before BPL technology arrived on the scene. Pursuant to the adoption of the Telecom Act, an electric utility had to provide access to its poles—if the utility used its poles for any type of communications, including its own—to any company requesting access. Under the FCC's rules, where access is mandated, the rates, terms, and conditions of access must be uniformly applied to all telecommunications carriers and cable operators that have or seek access. Utilities may deny access for reasons related to insufficient capacity, safety, reliability and other engineering purposes

Many electric companies have avoided the administrative costs of implementing a system for managing the access and use of its poles by avoiding any kind of communications assets on its poles. They would not be able to avoid it any longer, however, if they wanted to provide BPL service. Hence, these administrative costs would have to be factored into the costs of providing broadband services, unless the FCC could be convinced to create a BPL exemption as an incentive for electric companies to develop and deploy BPL networks.

Issues outstanding as they relate to BPL are:

- Does BPL equipment represent a pole attachment?
- Open access, safety, capacity, interoperability issues
- Occupied space and imputation issues
- Cost sharing and notice issues
- Cost sharing and competitive issues
- Local zoning restrictions, franchise fees, and right of way
- Private easements – state jurisdiction

Pole attachment obligations also need to be addressed in light of interference concerns. The FCC acknowledged that this is a potential problem: "The close proximity of BPL equipment on utility poles may affect (and be affected by) the operation of cable television service and high-speed digital transmission service, such as DSL."

7.2.3 Open Access

Interestingly, the regulatory paradigm for ILEC and the local cable provider has differed despite the fact that the FCC has jurisdiction over both modes of providing service.

Telephone companies that provide DSL service are regulated under Title II of the Communications Act of 1934, which includes common carrier provisions and obligations that are not shared by cable operators. These provisions, adopted based on the ILECs' historical possession of monopoly power over their respective service areas, require them to provide network access to competitors on nondiscriminatory, cost-based terms (also known as open access). Federal and state regulators currently face the challenge of determining how much market share an ILEC must lose before those obligations are eliminated. Many ILECs believe the requirements are no longer necessary given the number of competitors that have taken away their potential customers.

Cable modem broadband service, in contrast, is not subject to open access obligations because the FCC deemed cable to be an information service only. This classification has been challenged in

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18/ *BPL Final Report* at 208.

19/ *Id.*

court and, if overturned, could open cable companies to the same requirements now imposed on ILECs. Many believe that cable's exemption from open access obligations has been unjust because of the lack of competition in the provision of cable services - after all, many U.S. cities and towns have only one cable company - and because it has given cable companies an unfair competitive edge over ILECs.

7.2.4 Local/State Issues

The Telecom Act directs state utility commissions to share in the responsibility of making broadband service available to all Americans. At the same time, state laws give regulators sole jurisdiction over electric companies providing service in their state. The most basic question is whether state commissions will permit their electric companies to use their current power networks to provide broadband service.

State utility commissions also will be able to decide the cost structure for how electric companies will recover any investment for a BPL network upgrade and how to treat the earnings from BPL. Will state commissions require electric companies to offset their electricity earnings with their BPL earnings so as to stay within a defined rate of return? If so, is this a sufficient financial incentive for electric companies to invest in BPL network upgrades?

Yet another issue pertains to those states that have restructured their electricity markets. Under rate-of-return regulation, electricity rates for residential customers are subsidized by the rates paid by business customers. Under a restructured market, that subsidy disappears. This presents a difficult challenge for restructured states: *Low and fixed-income customers struggle to pay market-based rates.* Will state commissions be tempted to ask utilities to subsidize electricity rates with BPL service earnings?

Further, investor-owned utilities and municipal utilities may face unique regulatory issues before they can offer broadband services.

Section 103 of the Telecommunications Act established a simple self-certification process for investor owned utilities, that are registered holding companies under the Public Utility Holding Company Act (PUHCA) to become "Exempt Telecommunications Companies" (ETC). The process involves filing an Application which requires a brief description of the ETC and a sworn statement that the ETC will be engaged exclusively in the business of providing telecommunications services, information services, other services subject to FCC jurisdiction, or products or services that are related or incidental to any of these services. This is effective upon filing and deemed granted if the FCC does not act within 60 days.[20]

As far as Municipal Utilities are concerned, twelve states have restrictions on telecom offerings by municipal entities (AR, FL, MO, MN, NE, NV, SC, TN, TX, UT, VA, and WA). Furthermore the Supreme Court held that Section 253 of the Communications Act does not protect public entities from state laws that prohibit or have the effect of prohibiting them from offering telecommunications services. This affects BPL to the extent that state laws broadly restrict the type of communications equipment and services that municipal entities may offer.[21]

Utilities that leverage BPL as a purely internal vehicle to optimize delivery of existing utility applications may have the easiest regulatory experience. Even without a "telecom business",

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[20]/ *BPL Final Report* at 210.

[21]/ *Id*.

utilities may seek to apply BPL technology to support operations, including such activities as automatic meter reading (AMR) and energy management systems like load balancing.[22]

7.2.5 Cross-subsidies

Cross-subsidization is a particularly significant concern when a company provides one service in a competitive market, but is a monopoly provider of another service, as is the case with many electric companies. As for BPL technology, the concern is whether electric companies will use earnings or resources from the provision of electric service to subsidize their BPL businesses. Regulators will focus on this issue for two reasons—first, such subsidies could provide electric companies with an unfair advantage in the broadband market and, second, needed resources that are diverted away from the provision of electric service could hurt quality of service. The latter one is acutely important in light of the recent challenges with the restoration of electric service in many states.

Both federal and state regulators have struggled with this issue in various contexts. The FCC has, at times, required companies to establish separate subsidiaries. An approach to this issue is the adoption of accounting rules that would permit federal and state regulators to guard against cross-subsidization without requiring companies to incur the cost of creating separate subsidiaries.

State commissions are routinely charged to mandate fair dealing regarding the operations of a regulated electric utility and its affiliates. Rules are put in place to ensure fairness to the competitive marketplace while enabling ratepayers to be compensated for use of ratepayer-based assets.[23] These rules can be roughly categorized into three areas:

1. Asset Transfers: These rules deal with the way in which assets can be allocated from the books of the regulated utility to the books of the unregulated telecom affiliate

2. Employee Sharing: These rules determine the extent to which employees can be utilized across multiple business lines

3. Joint Marketing: These rules deal with how a utility can market a new service to existing ratepayers.[24]

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[22]/ *Id*. at 211.

[23]/ *Id*. at 217.

[24]/ *Id*.

8 Market Dynamics

8.1 The Broadband Market

Three trends are likely to shape the future of broadband. First, broadband adoption will continue. Second, broadband connections will become "faster," and will be able to carry greater volume of data during a given interval. Third, a wide array of technologies will be able to deliver broadband to consumers and businesses.

The continuing deployment of broadband and the development of more market driven services that rely upon broadband will thus have a synergistic impact. The deployment will likely spur the development of more market driven services that, in turn, will spur further deployment.

A report from Strategy Analytics predicts that an additional 8.5 million homes will add broadband in 2004, totaling approximately 33.5 million users by the end of 2004, compared to 25 million users in April 2004. Of course, the rate of growth of broadband will slow as it becomes more widespread. However, the growth of market driven services using broadband will continue for a much longer period of time.

Providers of broadband access consistently assert that they will continue to increase the speed of the connections they offer their customers. They expect that within the next several years, users can expect connections providing symmetrical service at 10 to 20 Mbps. Within five to ten years, these connection speeds should increase to 100 Mbps. It is possible that some premium services may provide consumers with 1 Gbps access within next ten years.

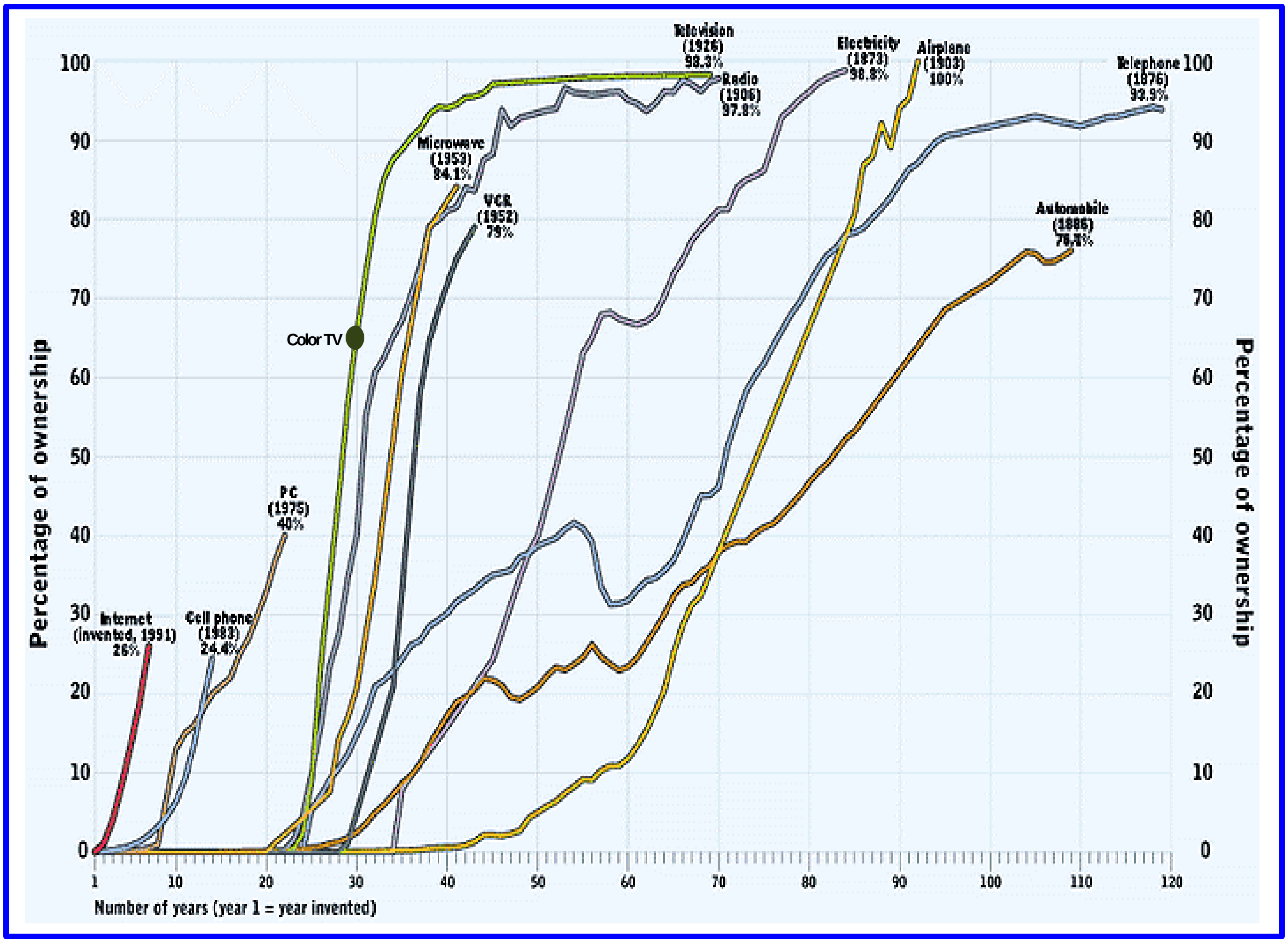
One of the most encouraging aspects of the growing market for broadband appears to be the diverse range of technologies and facilities-based platforms capable of providing broadband access. This presents two critical advantages.

First, potentially competing access technologies can promote both price and quality-of-service competition among broadband-access providers. This competition may be critical to overall adoption of broadband: as consumers discover new uses for broadband access, competition can ensure that service providers have incentives to shape their offerings to reflect fast evolving consumer preferences as well as competitive pricing.

Second, access technologies may also have complementary roles that, taken together, may hasten the overall speed at which broadband access becomes universally available. For example, wireless broadband networks may provide coverage for mobile and portable devices and "fill in the gaps" where wireline broadband coverage is unavailable. Additionally, wireless broadband services, along with satellite services, may bring high-speed broadband to remote areas where wireline broadband services are currently infeasible or uneconomical. Additional access technologies, such as BPL, may play important roles in the not too distant future.

As illustrated in Figure 8.1, new technology releases have typically generated high rate of acceptance and therefore impressive growth over short time periods. Broadband is exhibiting a similar growth pattern. BPL, if introduced in reasonable time, would share in the overall rise in broadband access services.

Figure 8.1: New Technology Releases - Lifecycle; Source: UTC Research: The Shpigler Group



8.2 Competitive Position of BPL

Several market factors support the potential for an additional broadband provider. A few of these factors are highlighted here.

- Growth Phase: Broadband penetration is in its growth phase of lifecycle. Nationwide, broadband penetration within the residential sector stood at 23% at the end of 2003, approximately one-third of what is expected in ten years' time.
- Enterprise Segment: A very significant growth is expected in enterprise usage of broadband services. The percentage of business enterprises with active broadband accounts is expected to more than double over the next ten years
- In-home Networking: While a majority of the customers may be dial-up upgrades, non-Internet users, and new move-ins to the service territory, BPL providers may be able to leverage reliable and immediate in-home networking offer to shift significant subscribers from DSL and Cable to BPL.
- The BPL is well positioned to enter the market with data-led product (Internet access), followed with Voice-over-IP and other "smart home" services.

Just as other players in the broadband market, utilities will need to be strategy savvy. Each utility will need to design a composite competitive strategy customized to its territory and market. While pricing will be one of the key components, other components of strategy such as product packages, Quality of Service, Incentive Programs, availability (Uptime) will be as important for retaining the customers. None of the players may want to stimulate customer churn seen in telecom industry, as no provider will profit from it.

As a fiscally prudent practice, utilities may elect to build least risky markets first. These markets will be based on a mix of potential penetration, density, cost, and other key factors.

Broadband providers seek opportunities to build in areas with low cost and high customer acceptance. For utilities, keeping costs low will be based on two factors

- Customer density
- Location of utility assets

While customer density is the same for all providers, the location of usable utility assets, by the host utility, may differentiate one market from another for BPL providers.

Area demographics and the level of competitive intensity will be the drivers of customer penetration. While the deployment costs can be kept lower by building in urban and suburban areas where network density is high, often, higher market penetration rates can be achieved in underserved rural areas.

Industry research suggests price to be the greatest change agent in the Broadband industry. The research indicates a greater likelihood to purchase high-speed Internet access at lower prices, supporting industry conclusions that price elasticity among prospective customers may spur industry with lower prices for service. Overall, price factors are viewed as more important than speed for Internet connectivity as shown in Figure 8.2.

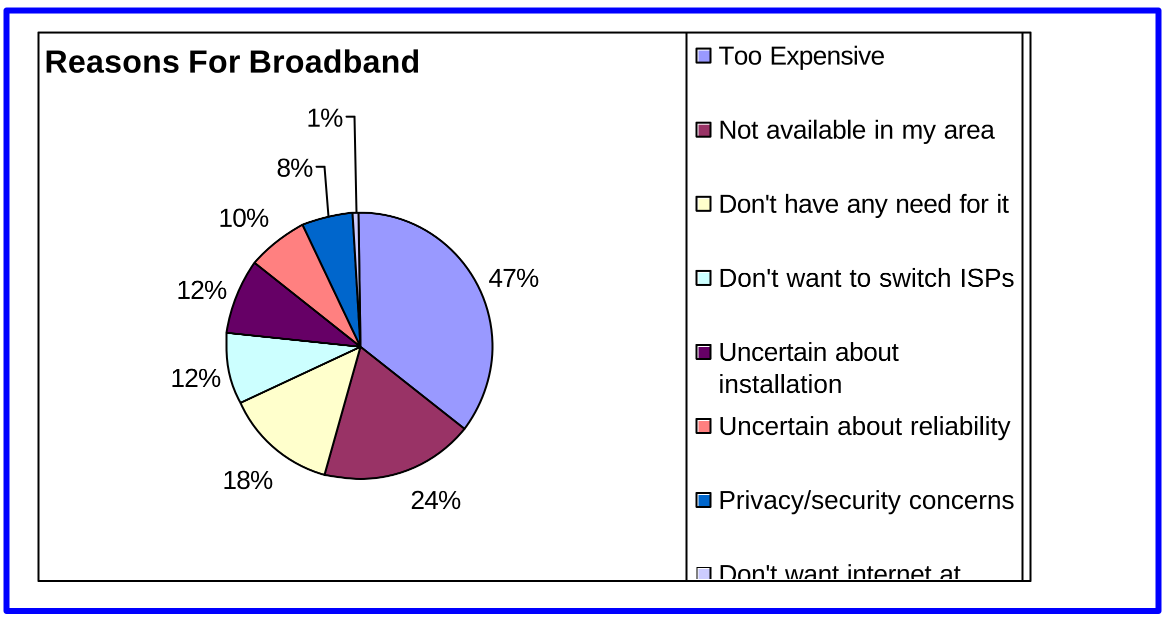


Figure 8.2: Reasons for Broadband; Source: UTC Research; The Shpigler Group

Price is an even more important factor for dial-up customers, suggesting that a marketing effort might have to stress value to entice Internet users to "graduate" to broadband. Industry research suggests that low speed (dial-up) users are the most likely to switch service providers.

8.3 Cable as a competitor

As mentioned earlier, cable is a shared medium and all subscribers from the Head-End share the available bandwidth. Additionally, old cable networks have been upgraded to HFC (Hybrid Fiber Co-axial networks) and therefore many products and services can be bundled through cable such as video, data and voice. This could result in a discount of approximately 10 % to 15%.

Table 8.3: Prices of Cable Bundles

Product/Bundle	Incumbent Price ($)	HFCO Price ($)
Cable Only	36.12	32,51
Cable + Internet	76.07	65.21
Cable + Telephony	66.71	56.79
Cable + Telephony +Internet	106.66	92.75
Internet Only	39.95	39.95
Internet + Telephony	63.49	70.54

As the dominant providers of broadband access, cable companies are seeking ways to solidify their position rather than pushing prices down. One trend is the continued emergence of tiered service levels as a way of enticing lower potential customers while retaining margins on higher value customers. Among the offerings by cable companies are VoIP and digital cable.

Cable has extended the broadband services offering to at least 90 percent of homes passed by cable systems. The cable industry expects that industry-wide facilities upgrades enabling the provision of broadband Internet access to residential customers will be completed soon.

In addition to expanding the reach of upgraded broadband facilities, cable operators have increased download transmission speeds from 200 kbps to as much as 6 Mbps. Cable companies have also continued to upgrade equipment used to deliver broadband services. The CableLabs Certified Cable Modem Project, also known as Data Over Cable Service Interface Specification or DOCSIS, has continued to develop the critical interface requirements for cable modems and cable modem termination systems used for high-speed data distribution and connection to the Internet. PacketCable, another CableLabs project, develops specifications for delivering advanced, real-time multimedia services over two-way cable plant. The PacketCable specifications enable a wide range of services, including IP telephony, multimedia conferencing, interactive gaming, and general multi-media applications.

The cable industry also is reported to be pursuing "next Generation Network Architecture" (NGNA), which is in part a competitive response to wireline broadband providers and in part a response to Direct Broadcast satellite's (DBS) Digital Video Recorder (DVR) technology. The NGNA project seeks to define the features of a next-generation all-digital cable network, which could have broad implications for functionality and cost. The effort involves rethinking cable's basic technologies, including everything from encryption strategies to set-top boxes that can be dramatically upgraded via software uploads, to create more carriage capacity by completely migrating cable service from analog-to-digital transmission so that all services could be provided utilizing IP.

A number of cost factors effectively form the pricing floor for cable companies. These factors include:

- Programming and labor costs have been rising steadily, and in excess of inflation rates
- Cable companies have collectively invested over $75 billion, or over $1,000 per customer in network upgrades. Of this amount, $200 per customer has been spent in 2002 alone
- Cable companies view satellite providers and not DSL providers as key competitors for pricing.

8.3.1 DSL as a Competitor

DSL technology can be provisioned on most of the existing phone networks and comes in many different flavors. As mentioned earlier in the report, ADSL is the most common DSL-type currently deployed by service providers.

DSL deployments have lagged behind that of cable modem. Once projected to exceed the penetration of cable modem, DSL's market penetration today is barely one-half of its broadband counterpart. Financial failure of the entire DLEC community and the lack of strong push on the part of the ILECs have resulted in lower-than-expected DSL penetration in the market. However, today we see significantly higher growth rates than in the past, as market consolidation has returned the market to the ILECs. Key Issues are:

- DSL is primarily a low-margin product; providers view DSL as a mechanism to sell Value Added Service ("VAS").
- ILECs effectively controlled the provisioning process and prevented data local exchange carriers (DLECs) from being able to effectively serve customers.
- ILECs have been relatively slow to aggressively deploy DSL for fear of cannibalizing their T1 business.

8.3.2 Wireless as a competitor

Hot spot coverage is projected to grow to nearly 60,000 points within the U.S. within the next four years. This continued growth affords the industry opportunities to benefit from economies of scale, as already low equipment costs will continue to push downward. While Wi-Fi application is moving forward, there are several concerns that are also being addressed:

- Convenience and simplicity vs. Network security - Radio signals typically extend beyond the physical boundaries that are part of planned signal propagation. In many instances network security breaches have occurred when users failed to implement Wireless Encryption Protocol (WEP). The development 802.11i standard, which can serve as an adjunct to either 802.11b or 802.11g, may support increased security through the implementation of 128-bit encryption.
- Limited market reach due to short range - A concern for developers is that customer reach may be limited to extend the business beyond a pure hot spot. However, new

technologies are expected to increase reach and offer a greater chance to develop a broadcast access market play.

- A format to establish IP roaming has not yet been established – This is essential for a viable long-term growth strategy. A pure hot spot market approach does not necessarily depend on roaming agreements to be in place, however a growth strategy necessitate roaming agreements.
- Interference issues - High degrees of deployment can cause interference in the Industrial, Scientific, and Medical ("ISM") spectrum band.

There are a number of industry experts predicting strong market potential for WiMax (802.16) However, it carries some challenges that must be overcome before stated potential can be realized.

- CPE is very expensive - Industry estimates indicate a $500 price point for CPE by 3Q05 and reductions to $200 by 2007 resulting in current market prices for service around $500 per month for 1 Mbps service

- Slow market release of products - Original forecasts called for 802.16 to be market ready by early 2004 and 802.20 with mobility to be available by early 2005. Now, it appears those time estimates may be early by a year or more.

9 Industry Initiatives and Trials

9.1 Overview of North American BPL trials

Many North American electric utility companies have run BPL trials and several are now moving toward deployment. In the absence of BPL standards, utilities are deploying several different technologies, with different ways of carrying data over the electrical grid and different ways of delivering data to the home. The municipal electric utility of Manassas, VA—already offers the service to all its customers. PPL has a 60-customer pilot project in Allentown, PA, that is successful, and the utility is looking at ways to make it available to all customers.

Another utility, Progress Energy has taken a two-pronged approach to testing the viability of BPL. The technological phase was successfully completed in mid-2003, and the company is currently undergoing a BPL market test for approximately 500 homes. Ameren is pursuing a pilot that makes them the provider of not only the technology but also customer service. Other utilities conducting pilots include Cinergy, Southern Company, PEPCO, Idaho Power, and Consolidated Edison. Of these, five BPL deployments could be categorized as being “commercial” in that they are charging for the service.

9.1.1 Commercial BPL Systems

Table 9.1.1: Commercial BPL Systems

Utility	Vendor	Estimated Homes Passed	Monthly Base Price
PPL	Amperion Main.net	10,000	$39.95
City of Manassas	Main.net	3,000	$26.95
Cinergy	Current	15,000	$29.95
Central Virginia Electric Coop	IBEC	500	$29.95
Progress Energy	Amperion	500	$29.95

9.1.2 Selected BPL Trials in North America

Table 9.1.2: Selected BPL Trials

Utility	Vendor(s)	Estimated Trial Customers
PEPCO	Current	95
Ameron	Main.net	50
Southern Company	Ambient, Amperion, Grid Stream, Main.net	30
Idaho Power	Ambient, Amperion	25
Duke Energy	Main.net	20
Dominion	Main.net	15
Bowling Green	Amperion	15
Cullman Coop	Grid Stream, IBEC	15
PG&E	Corridor, Main.net	15
Arizona Public Service	Mitsubishi	12
OPPD	Main.net	10
Hawaiian Electric	Amperion, Current, Main.net, PowerWan	10
Rochester Public Utilities	Main.net	10
City of Salem	Amperion, Designed Telecommunications	10
Con Edison	Ambient	6
Indianola Municipal	PowerWan	5
Sierra Pacific	PowerWan	1

9.2 Overview of European BPL activities

The United States is not the only country experimenting with BPL. Spanish electricity company Iberdrola SA, for example, offers BPL service to customers in two Madrid suburbs. Last-mile broadband service (essentially from the distribution pole to the other side of the outlet) is also being used in Finland, Iceland, and Russia. The European Union is seeking to develop a common regulatory framework for the development and deployment of BPL technology throughout its member nations, according to Business Europe.

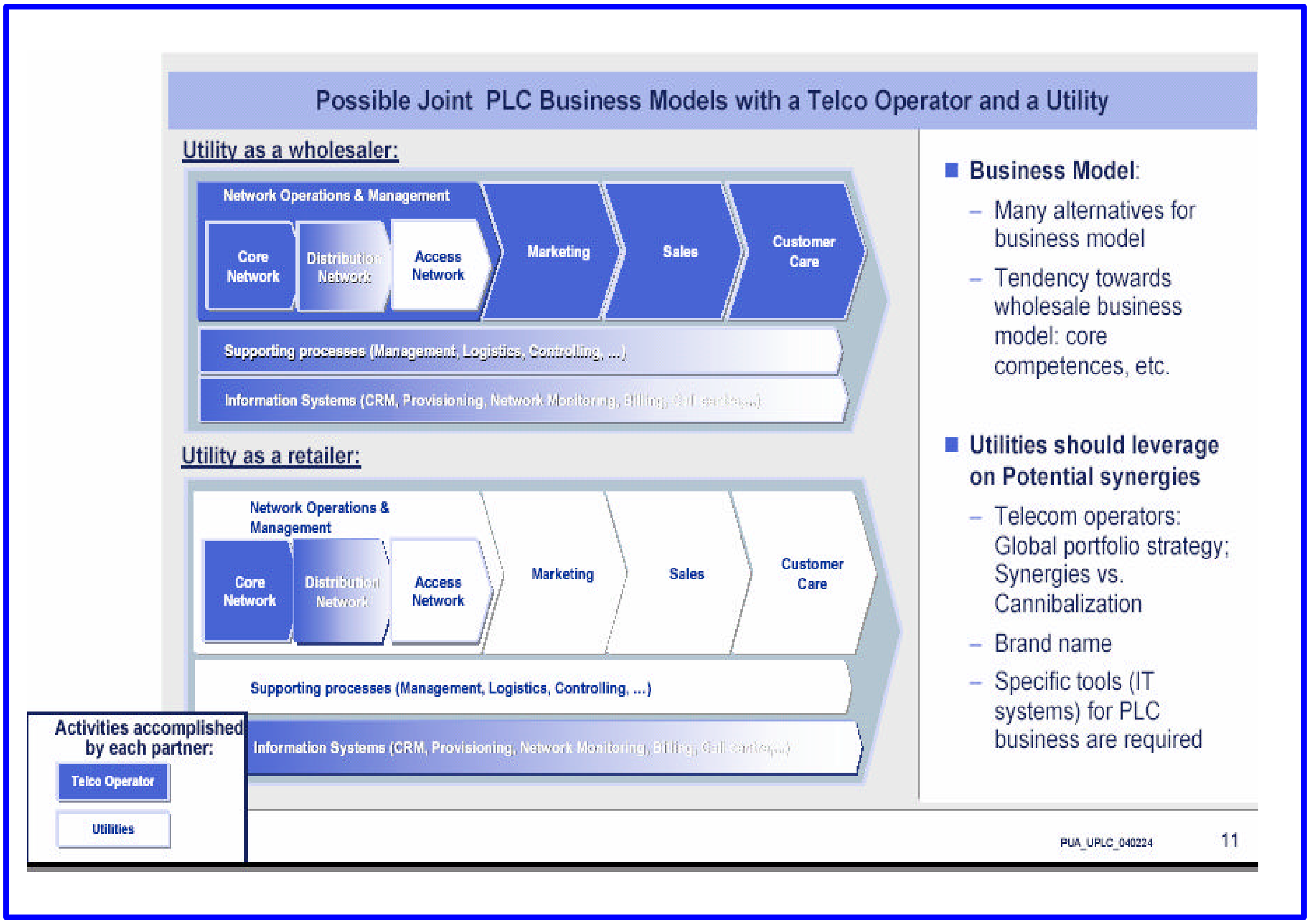
Higher density of homes per transformer in overseas countries makes their power grids more efficient for BPL deployment. In the U.S. there are 5-6 houses per transformer, requiring more hardware to provision large communities. In Europe and Asia there are 200-300 houses per transformer, requiring much less hardware to service large communities. Europe has had commercial deployments for over two years. The prevailing trend in Europe is for utilitie s to deploy BPL as a “developer” with open access. The big differences are that utilities abroad tend to be less sensitive to capital investments in the telecom market and lower broadband penetration rates to date in Europe present a greater upside.

9.2.1 BPL Deployments at varying stages across the world

Figure 9.2.1: BPL Abroad; Source: Arthur D. Little

9.2.2 Utilities in Europe are very much involved in BPL

Figure 9.2.2: BPL Abroad; Source: UTC Research; Shpigler Group



9.2.3 Operating Structure

The prevailing trend in Europe is for utilities to deploy BPL as a "developer" with open access

–Utilities abroad tend to be less sensitive to capital investments in the telecom market
–In addition, lower broadband penetration rates to date in Europe present a greater upside

Table 9.2.3: Operating Structure in Europe; Source: UTC Research: The Shpigler Group

	Landlord	Developer	Service Provider
Allow Access to Network	Yes	Yes	No
Network Construction	No	Yes	Yes
Network Maintenance	No	Yes	Yes
Network and Customer Operations	No	No	Yes

10 Industry Perspectives

10.1 National Telecommunications & Information Administration (NTIA)

While NTIA recognizes the potential benefits of Access BPL, it also states that FCC must ensure that other communications services, especially Federal Government operations, are adequately protected from unacceptable interference. It states that the Federal Government has extensive operations that potentially could be affected by BPL systems. It notes that there are over 18,000 Federal Government frequency assignments in the 1.7 – 80 MHz spectrum range. NTIA also indicates that it has initiated modeling, analysis and measurement efforts in order to develop means for accommodating BPL technologies while precluding unacceptable interference to Federal Government systems.

10.2 Federal Emergency Management Agency (FEMA)

FEMA is supportive of extensively deployed broadband facilities and of a more robust electrical utility infrastructure and states that it appreciates that BPL could be a major factor in achieving these objectives. FEMA indicates, however, that it has become aware that certain distinct approaches to BPL may have the potential to cause interference to its high frequency radio emergency communications system although it has not concluded at this time that there is a material interference problem or that all of the distinct technological approaches to BPL pose a risk of interference. FEMA states that it expects that there may be ways to provide the public with the benefits of BPL without compromising emergency communications.

10.3 American Radio Relay League (ARRL)

ARRL expresses concern that Access BPL, if not appropriately restricted, will cause interference to amateur operations. ARRL states that amateurs use very sensitive receivers and high gain outdoor antennas that could be located in close proximity to electric power lines.

ARRL contends that entire communities will be affected by radiated BPL emissions. ARRL contends that in an Access BPL system, the power lines would act as an efficient antenna covering an entire city, causing widespread interference to amateur operations. ARRL believes that the potential interference from Access BPL would be so severe as to warrant its exclusion from all bands allocated for amateur use.

10.4 Institute of Electrical and Electronics Engineers (IEEE)

In seeking to help realize BPL its potential, the IEEE has begun to develop IEEE P1675™, "Standard for Broadband over Power Line Hardware." The IEEE Power Engineering Society, Power System Communications Committee, has sponsored IEEE 1675. When finished, IEEE P1675 will give electric utilities a comprehensive standard for installing the required hardware on distribution lines, both underground and overhead, which provide the infrastructure for broadband-over-power-line (BPL) systems. It also will include installation requirements for the protection of those who work on BPL equipment and to ensure such systems do not place the public at risk. The standard is targeted for completion in mid 2006.

"By turning the local power grid into a broadband conduit, we create another option for universal access to the Internet," says Terrence Burns, Chair of the IEEE BPL Standards Working Group. "This technology offers a neat solution to the 'last-mile' quandary of how to bring information from long-distance fiber optic cables to individual computers without investing in costly infrastructure." [25]

10.5 American Public Power Association (APPA)

APPA supports the FCC's general approach to promoting BPL technology and strongly urges the agency to adopt flexible rules that accommodate the various types of BPL technologies being developed. The APPA stated that the FCC should adopt rules that make widespread deployment of BPL a reality.

11 Information Sources

11.1 Consultants' Reports

Opportunities in Broadband over Power Line – Industry Overview – The Shpigler Group; UTC Research

12 Appendices

12.1 Appendix A: Business case results for multiple architectures [26]

12.1.1 Minneapolis/St. Paul Market

- Hybrid wireless-BPL systems can be very attractive in dense metro environments
- Net Income for the classic design is projected to go positive in the fourth year of operation
- Earnings margins in excess of 60% can be achieved
- The classic design calls for capital funding in excess of nearly $35 million in the first year of operation
- Cash flow is projected to go positive at the same time as net income
- The higher operating expenses associated with the cellular architecture results in a prolonged wait until net income break even
- The high cost of backhaul pushes earnings margins to very low levels in the market
- "Cell splitting" results in continuing capital needs
- Cash flow is not attractive in this design due to the lower marginal revenues
- The net income profile for the wireless design is very robust in a dense urban environment
- Earnings rates once again exceed 60%
- Capital requirements are reduced significantly due to limited number of devices needed driven by market density
- The lower capital needs results in rapid network payback

[25] IEEE Starts Standard for Broadband Power Lines; *Enterprise Networks & Servers. August 2004*

[26] Source: UTC Research – Opportunities in Broadband over Power Line July 23, 2004; Shpigler Group

12.1.2 Syracuse Market

- As the market gets smaller, classic systems often dominate
- Net Income for the classic design is projected to go positive in the fourth year of operation
- Earnings margins in excess of 60% can be achieved
- The classic design calls for capital funding in excess of $20 million in the first year of operation
- Cash flow is projected to go positive at the same time as net income
- The higher operating expenses associated with the cellular architecture results in a prolonged wait until net income break even
- The high cost of backhaul pushes earnings margins to very low levels in the Syracuse market
- Immediate capital expense is reduced with the cellular design, but “cell splitting” results in continued capital needs
- Cash flow is not attractive in this design due to the lower marginal revenues
- The net income profile for the wireless design is somewhat similar to the classic network
- Earnings rates once again exceed 60%
- Capital requirements are quite a bit higher in the lower density portions of the market
- The higher capital needs results in annual cash flow breakeven being delayed by two years

12.1.3 Lynchburg

- The capital cost for market entry for a rural system can often be minimized by deploying a cellular system
- Net Income for the classic design is projected to go positive in the fourth year of operation
- Earnings margins may approach 60% in Lynchburg
- The classic design calls for capital funding in excess of $12 million in the first year of operation
- Cash flow is projected to go positive one year prior to net income
- The cellular architecture trades capital savings for higher operating costs
- Earnings margins are slightly reduced…while capital is shrunk relative to the classic design
- Cash flow is roughly comparable to the classic model
- High capital expense for rural wireless can be problematic
- Earnings rates are strong overall
- However, high capital needs create a challenge
- Overall, the business case is not attractive

13 List of Figures

Figure 3.4.3	Starband System	17
Figure 4.2.1	An Overview Of BPL System	22
Figure 4.2.2	An Overview Of PowerLine System	23
Figure 4.2.3	BPL Modem	24
Figure 5.1.1	Industry Structure – Key Enabling Partners	26
Figure 6.2.1.1	Deployment Costs per Subscriber	28
Figure 6.3.1	BPL Applications	30
Figure 6.3.2.1	AMR Payback	32
Figure 6.3.2.2	E&I Costs – An Illustration	33
Figure 7.1	Basic BPL System	38
Figure 7.1.1.1	Architecture # 1	39
Figure 7.1.1.2	Architecture # 2	40
Figure 7.1.1.3	Architecture # 3	41
Figure 7.1.1.4	Three Distinct BPL Systems	42
Figure 7.2	Three Categories Of Regulatory Issues	45
Figure 7.2.1	Frequency Spectrum Allocation	46
Figure 8.1	New Technology Release – Lifecycle	51
Figure 9.2	Reasons For Broadband	53
Figure 9.2.1	BPL Deployment Stages – World	59
Figure 9.2.2	BPL Abroad	60

14 List of Tables

Table 2.1.3	DSL Technologies Comparison	9
Table 2.4.1	IEEE 802.11 WLAN Radio Link Interfaces And Highlights	13
Table 2.4.2	Summary Of WiMax (802.16) Radio Links	14
Table 2.4.3	A Comparison Of WiMax and WiFi	15
Table 2.5.1	A Comparison Of Access Alternatives	18
Table 5.2.1.1	Deployment Costs By Market and Architecture Types	29
Table 5.3.3	Functional Activities By Business Model	36
Table 6.1.1	Three Distinct Systems – Characteristics	44
Table 6.1.2	Three Test Markets	44
Table 6.1.3	Summary Of Test Results	45
Table 7.3	Cable Bundles and Prices	55
Table 8.1.1	Commercial BPL Systems	58
Table 8.1.2	Selected BPL Trials – North America	59
Table 8.2.3	Operating Structure In Europe	62