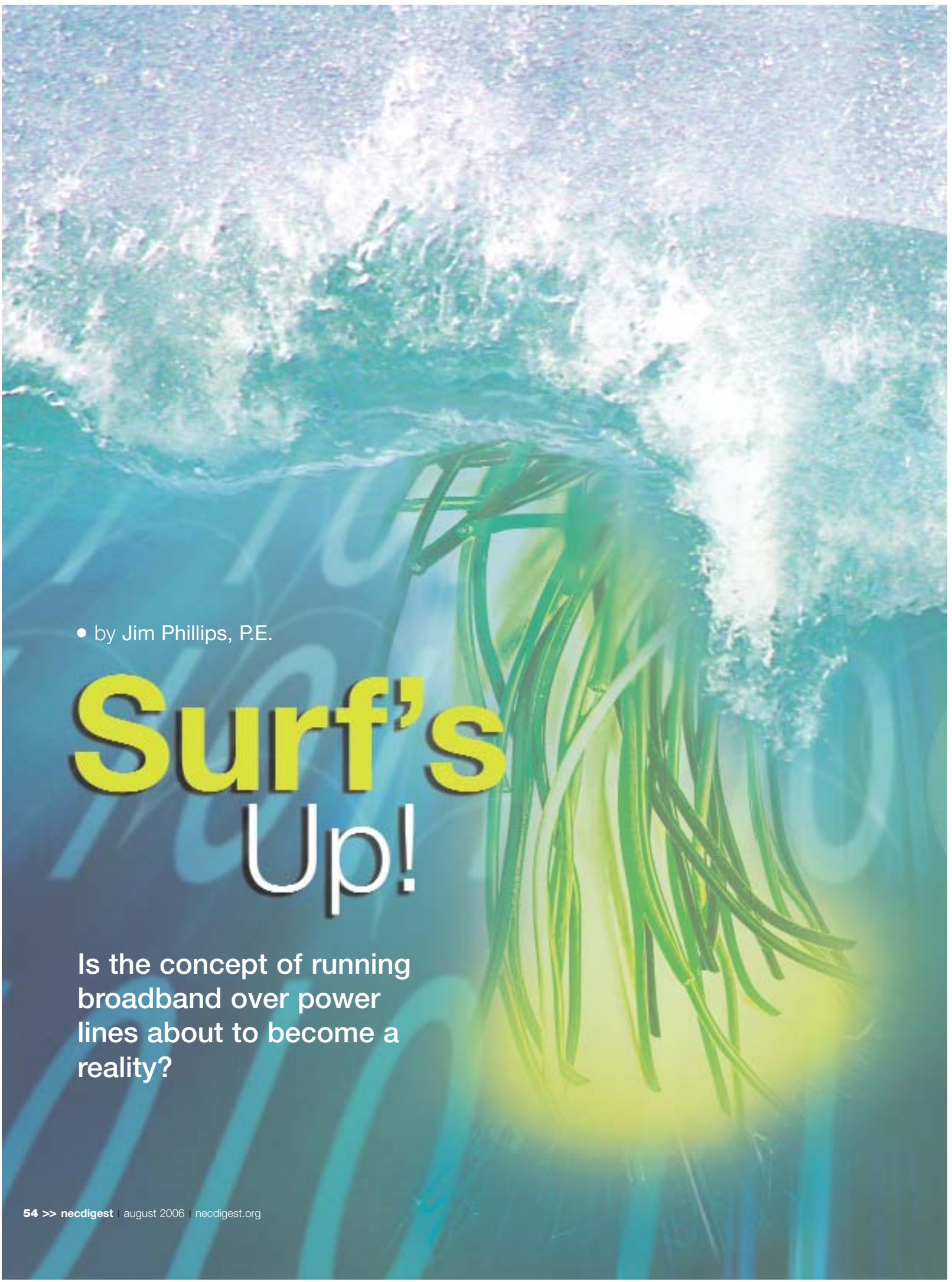


• by Jim Phillips, P.E.

Surf's Up!

Is the concept of running broadband over power lines about to become a reality?

Are we on the edge of another technological tidal wave or will this just be a small ripple in the pond? Surfing the internet is once again beginning to move in a whole new direction. For the past several years there has been slow and steady growth towards using existing electric power lines for broadband. Known as "Broadband Over Power Line" or BPL, the concept is simple. In fact, electric utilities have been transmitting data on transmission lines to control substations for decades. Traditional pipelines for broadband have included cable and DSL but this new technology is often referred to as the "third pipeline."

Twenty years ago, the internet seemed more like a research project for scientists. Today it is an integral part of our day-to-day communication, enabling us to send messages, conduct banking and other related business, view movies, download articles and music, and much more. Who could have imagined how dependent we'd become on the internet? When the public first began using it, the only available connections used very slow dial-up modems. As the internet evolved, DSL and cable were introduced as the first two major "pipelines" and speeds increased. For the cable companies, their lines were already installed in many homes. It was only a matter of getting the data onto the cable and then using a cable modem to extract it at the other end.

We are now at another turning point in the evolution of the internet, and electric utility companies are taking this cable concept one step further. Since almost every building in the United States and many parts of the world is directly wired to the electric utility system, the power companies have been exploring methods to place the signal on the power lines where it can be accessed anywhere an electrical outlet exists. What that means is broadband access could be in every part of the house, networking all computers, appliances and other components that are plugged in.

Imagine every receptacle in your house or office being a direct connection to the internet. The possibilities could be endless. Having voice, data, video and home automation could all be as easy as plugging your computer or wireless adapter into an outlet. Talk about the ultimate "plug and play"!

In theory, this seems like a simple idea but many obstacles had to be overcome and a few still remain. For example, how do you get broadband onto a power line operating at thousands of volts? How does data travel through transformers? Does the broadband's high frequency cause any interference when traveling on the utility lines?

Over the past several years many utilities, in conjunction with a few key BPL partners, have begun the implementation of pilot projects. The installations reach anywhere from a few hundred to tens of thousands of customers. Several utilities have plans in place to reach millions of customers within the next year or two.

BPL's Distant Cousin

The concept of a carrier signal on a power line is nothing new. Electric utility companies have used this concept for decades to transfer data between substations. Power Line Carrier, as it is called, is where the carrier signal is injected onto a transmission line at a substation. At the receiving substation this signal is used to communicate with various protection and control devices.

Power companies have even used fiber optic lines embedded in their overhead ground (static) wires on transmission lines. The middle strands of the overhead static wire would contain a core of fiber that could be used for internal communication as well as leased to other companies.

Access BPL—Broadband on the Power Lines

Traditionally, Internet Service Providers (ISPs) lease fiber optic lines from the telephone company to carry the internet. This giant network of lines forms the "web" in the worldwide web. The leased fiber optic lines connect to local cable, DSL and phone lines that deliver broadband access to the end user.

Access BPL is the term used to describe when broadband is carried over medium voltage power lines for distribution to local internet subscribers. This distribution method can bring broadband to a greater number of customers since the distribution lines serve hundreds or thousands of customers at one time. A big advantage of BPL is that remote locations that presently do not have access to high speed cable or DSL could have service provided via their existing electric company.

Similar to DSL and cable, the signal would be run on fiber optic lines. A fiber optic line would then be routed directly into a utility distribution substation where a coupler wraps around the electrical distribution line, inducing the broadband signal.

Access BPL has many technical challenges. As the signal travels on power lines it tends to weaken with distance and requires repeaters to be located every ½-mile to 1-mile apart. A repeater is a device that can take a weak signal and retransmit it at a higher power. The concept of the repeater dates back to the days of the telegraph. The same problem that existed in the 19th century when sending telegraph signals over long distances still exists in the 21st century with broadband.

Caution—Detour Ahead!

Most medium voltage distribution systems operate at voltages between 2,400 volts and 13,800 volts. This requires the use of transformers to step the voltage down to the utilization level such as 120V, 240V or 208V. A transformer actually acts like a roadblock for the broadband signal, requiring a detour around it. The transformer windings behave like a large inductor with an impedance that becomes extremely large at higher frequencies. The impedance of an inductor is jwL where w is 2pf and f is the frequency. This means that for a broadband signal that operates well into the megahertz range, the transformer will block the signal.

To overcome this roadblock, a coupler is used that takes the signal from the high voltage side, bypasses around the transformer and injects it into the low voltage side. Two types of couplers are available: passive and active. A passive coupler only takes the signal from one side of the transformer and injects it to the other. However the active coupler not only takes the signal from one side of the transformer to the other, it also acts as a repeater.

In-House BPL—Coming to a Receptacle Near You!

In-House BPL allows the networking of components within a building, using the existing electrical distribution system. This allows access to broadband from any receptacle on the premises that is part of the same wiring system. Where there is a receptacle, there is an internet connection.

The physical connection of devices to the in-house network requires nothing more than the traditional USB or Ethernet cord connecting the computer to a wall adapter plugged into the receptacle. In the future, a separate data connection will not be required and equipment will only need to be plugged in with a standard AC power cord. The electrical system can also serve as backhaul for 802.11 wireless access and access points can be plugged directly into the BPL network. *[Editor's translation: Wireless access points can also be plugged directly into the electrical system, providing a direct connection to BPL.]*

Initially there were concerns that power line disturbances could interfere with or disrupt the signal. This problem was solved by splitting the signal into many different carrier frequencies on the electrical system. If there is a surge, noise or some other disturbance that disrupts one of the frequencies, it will be sensed and the data routed to another frequency.

BPL Types

In-House BPL—Uses electric outlets and the building's electrical wiring for networking computers and associated peripherals.

Access BPL—Broadband internet carried over electric utility distribution to homes and other end users.

Adapters like this one from Belkin allow USB and Ethernet equipped computers to link together over existing 120V electrical wiring.

French company LEA S.A.S. builds power line networking adapters based on Intellon Corporation's HomePlug technology.

The Next Chapter in BP— Intelligent Utility Systems

Electric utilities companies are already thinking ahead about the next chapter of BPL. Having the capability for broadband on the power lines will enable the development of an intelligent electrical grid. This can provide utility systems with the means to continuously monitor themselves and make automatic "self healing" decisions critical to maintaining reliability. Longer term plans might provide utility customers with the ability to monitor their home energy use in real time and integrate the data with load control programs that can manage energy consumption.

Development is already underway to explore real-time simulation and modeling capabilities that would enable the grid to solve its own real-time loading and outage

PHOTOGRAPHS: BELKIN (TOP) — INTELLON (BOTTOM)

problems. As utility system capacities are pushed to their limits during summer heat waves and storms, monitoring real-time weather data from strategically located sensors on the grid will make it easier to predict peak load problems. The intelligent grid could automatically dispatch additional generation during peak load periods. Many utilities have "interruptible rates" for large industrial and commercial users of electricity. The interruptible customers receive special rate incentives in exchange for the utility being allowed to take them off-line during peak and emergency conditions. The intelligent grid could be used to send signals to the interruptible customers to shed load automatically. Even residential customers could have load control equipment tied into the electric utility's control system, enabling automatic load reduction such as dimming of lights and resetting thermostats.

Another BPL application is for the power lines to monitor themselves for outages. When a storm rolls through an area, outages can occur such as when a downed tree takes out a power line. Rather than waiting for a customer to call about the outage, the line could immediately sense the problem and send a signal to dispatch the utility crew or initiate circuit switching for system restoration.

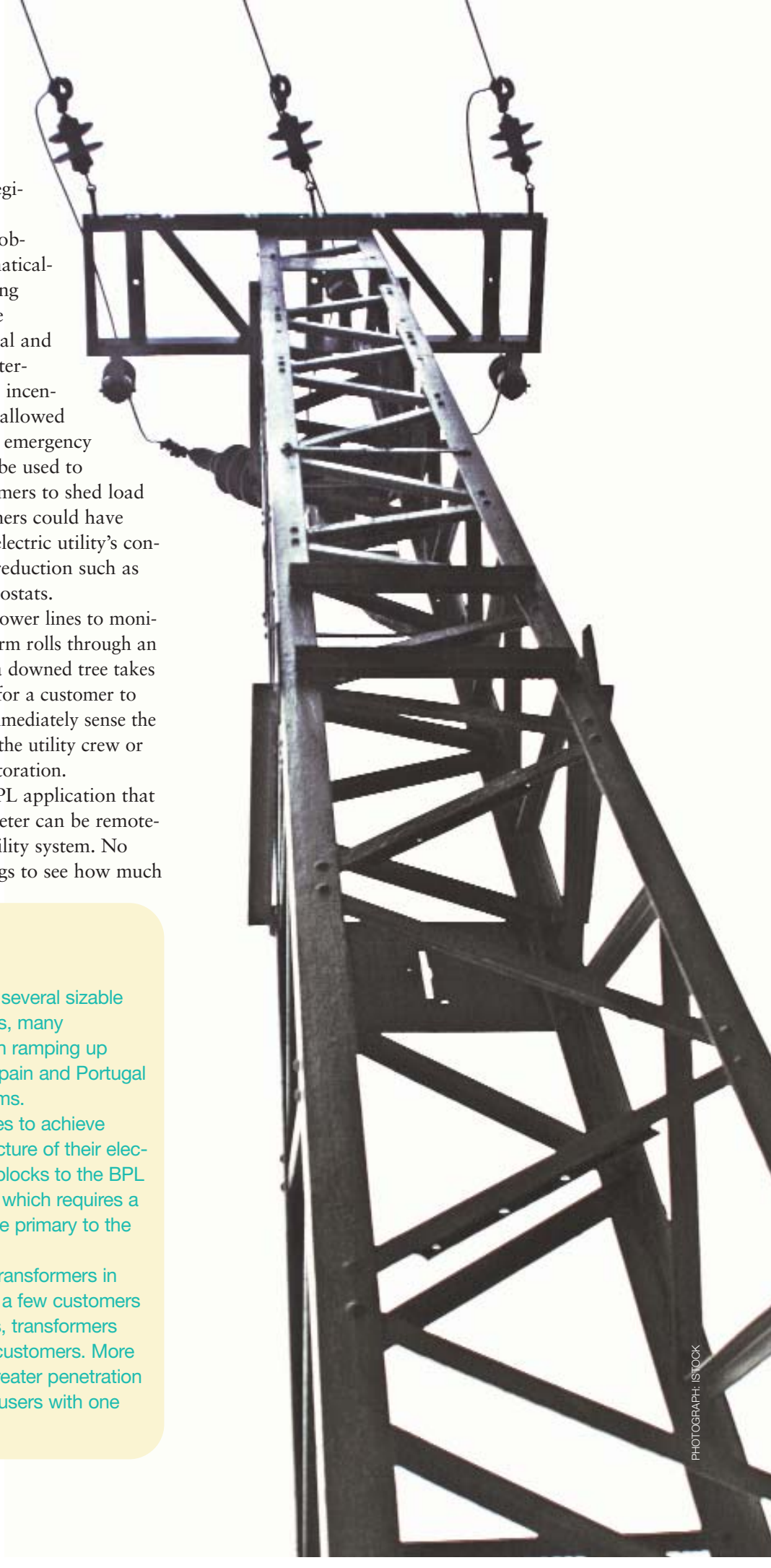
Remote meter reading is another BPL application that is underway. Data from the electric meter can be remotely read from a central point on the utility system. No more fighting with rain, snow and dogs to see how much

World View

Although the United States has had several sizable deployments over the past few years, many European and Asian countries began ramping up their BPL efforts as early as 1999. Spain and Portugal have some of the largest BPL systems.

Part of the ability of these countries to achieve early deployment resides in the structure of their electric utility systems. One of the road blocks to the BPL signal is the distribution transformer which requires a coupler to bypass the signal from the primary to the secondary side.

In the United States, distribution transformers in residential areas typically serve only a few customers but in European and Asian countries, transformers often serve as many as 100 to 200 customers. More customers per transformer allows greater penetration of broadband to a larger number of users with one coupler. *—Jim Phillips, P.E.*



PHOTOGRAPH: ISTOCK

electricity is being used each month.

These concepts will take time to develop and implement but many utilities have programs well underway, such as TXU of Dallas, Texas. They are planning one of the more aggressive deployments of intelligent systems by implementing an automated meter reading program that will include three million meters. This program will require the widespread installation of intelligent digital meters that automatically communicate with the utility data center.

There are many players in the BPL arena. One of the larger players to date is Current Communications Group of Gaithersburg, MD. They have formed partnerships with many utility companies to develop BPL pilot projects. One such partnership is only a few hours from me. Cinergy, which has recently merged with Duke Energy, serves the Cincinnati, Oho area. They began serving a few hundred internet customers from their BPL distribution network and the number has now grown to 50,000. There are many similar stories of BPL projects, with each project being larger than the last. TXU has plans to serve 2 million customers and develop an intelligent electrical system in the near future.

Many utility companies are presently re-evaluating their business models. With BPL, they are studying whether they will be leasing their infrastructure to other internet providers or entering the market as the next Internet Service Provider (ISP).

Progress Has Its Challenges

One of the more significant issues that BPL has faced is RF interference. Unlike cable and phone lines, power lines are not shielded and can act as a large antenna. These systems operate in the high frequency (HF) and Very High Frequency (VHF) bands, which includes a number of radio services including military, international air traffic control, amateur radio, and public safety services. Amateur radio operators and the U.S. Navy have reported interference from BPL systems. The Federal Communications Commission (FCC) has been involved in investigating complaints and has ordered some corrective action.

Early in the deployment of the BPL pilot projects, the FCC issued a "Notice of Inquiry" on April 23, 2003 to obtain information on a variety of BPL issues. One key issue was to determine whether changes were necessary to Part 15 of the FCC's rules as they existed. Part 15 rules do not specifically provide measurement procedures that apply to systems using power lines for signal transmission. The FCC notice is aimed at prompting and encouraging deployment of BPL technology while adhering to existing FCC rules.

On October 14, 2004, the FCC adopted changes to Part 15. This was in an effort to provide continued support of the development of BPL while safeguarding existing licensed service against harmful interference. Some of these changes include the requirement that BPL devices have the capability to avoid using any specific frequency and to remotely adjust or shut down any unit. Excluded frequency bands where BPL must avoid operation were established to protect aeronautical receivers. In addition, exclusion zones close to sensitive operations such as coast guard or radio astronomy stations have been established. The changes also include improvements in measurement procedures for all equipment that use RF energy to communicate over power lines.

The interference issue has also been taken up by Congress with a recent amendment to the House telecom bill HR 5252 that will require the FCC to study BPL interference.

The Need for Standardization - IEEE P1901

Like any other emerging technology, standardization will be a critical issue for successful implementation. Without standardization, BPL devices and systems could conflict with each other, leading to unacceptable operation.

There are many groups and organizations addressing BPL but so far one of the main standards that's emerging is IEEE P1901, *Standard for Broadband over Power Line Networks: Medium Access Control and Physical Layer Specifications*. When completed in 2007, this standard will apply to BPL devices for the first/last mile connections to broadband services as well as devices used in buildings for LANs and other data distribution.

The goal is to define the necessary requirements for coexistence and interoperability between different BPL devices and ensure that desired bandwidth and quality of service can be delivered. Security issues regarding privacy of communications between users are also an integral part of this standard.

To address standardization of BPL hardware, IEEE P1675 *Standard for Broadband over Power Line Hardware* is being developed, which will address testing and verification standards for commonly used hardware, primarily couplers and enclosures for BPL installations. This document will also define installation methods to ensure compliance with applicable codes and standards.

Catch the Wave

The wave is just beginning to form. Will it be just a ripple or a tidal wave? Many utilities have already deployed successful BPL pilot projects with larger scale projects slated for the near future. The FCC, as well as many other standards and regulatory bodies all seem to be on board to develop viable codes and standards to move the "third pipeline" forward. However, the FCC recognizes that interference problems must be dealt with to prevent disruption of existing spectrum users.

Will BPL be the next big technological wave? Just look back at the internet 20 years ago and see where we are today. The BPL tidal wave will not form overnight but when it does come, it will be very, very big. Surf's up!