**A Practical and Cost Effective Demonstration
of Efficient Energy Usage and
Quality Management Using the NII**

(DOE Grant No. DE-FG05-95ER25275)

(ETK 5021)

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Preface

The Office of Scientific Computing of the Office of Energy Research (ER), U.S. Department of Energy (DOE) announced its interest in receiving research grant applications to support DOE's program in the President's National Information Infrastructure (NII) initiative.

"The NII program announced by Vice President Gore in 1993 encapsulates the promise of the Information Age to transform our society. Historically, communication and computing technology, i.e., leading edge information technology, has been a powerful instrument of change in our society. The National Information Infrastructure program seeks to enhance national competitiveness and improve the quality of life of the general populace. NII has established several principles and goals:

- Promote private sector investment;
- Extend the "universal service" concept to assure that information resources are available to all at affordable prices;
- Promote technological innovation and new applications;
- Promote seamless, interactive, user-driven operation of the NII;
- Ensure information security and network reliability;
- Improve management of the radio frequency spectrum;
- Protect intellectual property rights;
- Coordinate with other levels of government and with other nations; and
- Provide access to government information and improve government procurement."

Important criteria in the success of the program lie in use and integration of current Internet and NII services. The potential for impact on and advancement of NII applications, such as those called out by the Committee on Applications and Technology, especially Energy Demand and Supply Management are also important. Further, the potential for marketable and/or deployable technology and systems in conjunction with innovative partnerships will play a role in the future of information technology.

In a recent study released by Andersen Consulting titled "The Role of Broadband Communications and the Utility of the Future" they state, "customer focused services are likely to be the primary method of differentiating energy providers in the future, although radio and telephone technologies can handle some of the proposed services. Broadband communications methods – typically fiber optic or coaxial cable – offer the highest flexibility to meet the current and future needs of the utilities."

Within the next five years electric customers in Glasgow, Kentucky will be able to use their PC to monitor their electric power, water, and natural gas consumption. Daily feedback on the consumption levels, coupled with a new time differentiated rate structure, will allow everyone to alter their lifestyle and lower their monthly cost of energy. Since beginning to deliver Internet access to consumers using the HomeLAN product, connections to computers are beginning to outstrip connections to televisions. Since children in Glasgow schools begin using e-mail in elementary school, Glasgow is likely to become one of the first cities in the country to fully realize the increases in productivity in communications that a fully connected general public and business community can accomplish.

Utilities are being reinvented in the form of "technology utilities." Market forces allow the new technology utilities to find common ground (value added) among the utility, society, customers, and shareholders.

Project Description

Research projects funded beginning in FY1995 fell into two categories: *Wide Area and Distributed Network Based Technologies To Support Energy Demand and Supply Management*, and *Wide Area Network Based Collaboration Technology, Remote Facilities Usage, and Application Development*.

Under the first category, Electrotek Concepts, Inc., has developed and demonstrated a system for the remote acquisition, central analysis, and distribution of energy quality information to a level of detail that has not previously been available. The project addresses fundamental electric utility issues to improve the way the utilities interact with their customers. The project used "off-the-shelf" hardware and software integrated into a system that monitors power quality and energy usage devices placed at two industrial sites by an existing city-owned broadband network connected to Internet. The services demonstrated include power quality event summary and details along with on-line energy usage information.

A Practical and Cost Effective Demonstration Of Efficient Energy Usage and Quality Management Using the NII

Introduction

In order to be competitive in the changing electric power industry, and to promote energy efficiency and conservation, electric power providers need to have access to information on the power system to a level of detail that has not been available in the past. This level of detail extends beyond the usual voltage, current, power, and energy quantities obtained from traditional utility SCADA systems.

Information is now required about the quality of service at the customer's service entrance and maybe even directly at the point of use. This information is critical to customers who have processes that require a high level of power quality. Access to information on disturbances that do occur is required to evaluate the effectiveness of utility measures taken to improve power quality, determine the cause of the events, determine the effectiveness of methods used by the customer to minimize the impact of the events, and determine the sensitivity of end-use equipment to these disturbances. Historical information on the power quality performance of a utility is also of interest to new customers evaluating a move into a new utility service territory.

In addition to power quality related information, information about energy usage within a customer facility may be needed to facilitate real time, interruptible, and other innovative rate structures that promote energy conservation. This information is needed by utilities for billing, compliance monitoring, and evaluation of rate structure effectiveness. The information is needed by the customer to facilitate process scheduling, cost control, conservation, and process monitoring.

Electrotek has developed and demonstrated systems for the remote acquisition, central analysis, and wide distribution of information from power quality and energy monitoring devices at industrial and commercial facilities using the Internet. In addition, several services were demonstrated that take advantage of this information. These services include power quality event summary and on-line energy usage information. On-line bill evaluation is being developed and custom billing services are another area of future development to be investigated when the ability to provide those custom services is in the control of the host utility.

Electrotek used "off-the-shelf" hardware, software, and infrastructure to facilitate a quick and cost effective demonstration of implementing the higher level of monitoring and related services described above. The project was designed to concentrate on the utilization of an existing communications infrastructure and the resulting benefits associated with delivering information of this type to electric power providers and their customers. The results of this effort are transferable to any other utility or municipality.

Discussion

The NII is a platform to which facilities and services can be attached that will benefit all Americans. The far reaching implications of the NII will touch every aspect of our society, enabling the efficient creation and dissemination of useful information. This demonstration

project focused on the implications of the NII for the electric utility industry's operations and interrelationship with its industrial customers.

The explosive growth in Internet applications such as the World Wide Web demonstrates the tremendous increase in bandwidth that the coming world of multimedia interactive applications will require from future networks. This requires new manageable network architectures that are designed to evolve smoothly from today's networks. Transmission design for broadband communications networks with fiber, wireless, twisted-pair copper, and/or coaxial cable access ports is imperative in order for many new broadband services such as multimedia to reach business and residential users.

Current industry efforts in this area center around solving the broadband subscriber access problems, e.g., those associated with hybrid fiber/twisted-pair, hybrid fiber/coax, and hybrid fiber/wireless networks evolution. These networks are planned to be transparent, on the optical side, as far as advancement in the public communications networking is concerned, e.g., migration toward SONET (synchronous optical network) and ATM (asynchronous transfer mode) services.

Local access technologies (fiber, coax, and microwave) are becoming widely available at affordable costs to all potential service providers: LEC's, cable-television operators, alternate-access providers, electric utilities, and wireless-communications companies. All access products are relatively similar in cost, and offer comparable operations savings. Important differences are service and product reliability, service capabilities, speed of deployment, upgrading costs, evolution strategies, and new features that some may offer (e.g., wireless connectivity). The possible synergy between wired access platforms and wireless technologies are being examined.

A growing number of utilities are recognizing that customer satisfaction and productivity are dependent on an electric supply which is adequate to operate the new types of microprocessor-controlled equipment that are being installed. In order to support the customer, these utilities are initiating programs to help evaluate and solve power quality problems within customer facilities.

Developing a program for the remote acquisition, central analysis and distribution of energy quality information involves many important decisions regarding structure, funding, personnel, and customer interaction. Different alternatives must be evaluated and important questions related to program options, types of services, organizational structure, market needs, program costs, staffing, training needs, equipment requirements, and measuring performance must be answered. The answers to these questions must be developed through market analysis, customer surveys, analysis of technical and training requirements, analysis of existing organizational structure, and company preferences. Power quality problems encompass a wide range of disturbances and conditions on the system. They include everything from very fast voltage transients to long duration outages. Power quality problems also include steady state phenomena such as flicker. This wide variety of conditions makes the development of standard measurement procedures and equipment very difficult. Power quality surveys and monitoring efforts must be matched with the problem being experienced. Power quality investigations often require monitoring to identify the exact problem and to verify the solutions which are subsequently implemented.

Power quality is an important issue for electric utilities. Electric utilities are recognizing that customer satisfaction and productivity are dependent on an electric supply which is free from disturbance. The increased complexity and computerization of commercial and industrial operations has resulted in more exposure to the consequences of poor power quality. Electric

utilities are dealing with power quality problems in a variety of ways. One of the most important ways is to educate customer service representatives and the customers themselves.

Energy Demand and Supply Management are important issues for electric utilities. Utilities have typically developed rates for various customer classes to reflect the cost of service of that customer class's generic loadshape. In general, the poorer the customer class's loadfactor, the more severe the demand charges for that customer class. The intent is to drive each customer class toward loadfactor improvements. The better the customer's loadfactor, the better the utility's capacity factor. The higher capacity factor translates into more efficient utility operations.

Innovative rates, made possible with technological advances, such as Real Time Pricing (RTP) can allow the utility and customer to take advantage of high speed data availability. High RTP prices offer opportunities to shed and/or shift loads to effect bill impacts. Prices provide system dispatchers with additional resources that can be dispatched incrementally to optimize overall performance and minimize supply costs. RTP can protect embedded revenues and provide subscribers with opportunities for benefits from load responses. Utility schedulers look at hourly demand forecast and unit availability for the following day to provide input into the RTP. Wholesale RTP prices are a function of marginal energy cost and marginal outage cost. They can be used to encourage a customer to use available capacity, cut back on usage when system stress is anticipated, reduce loads when the system is compromised, and curtail when the system is severely compromised.

In many areas of the country, such as in Glasgow Kentucky, RTP rates are not available. In this case it is because the Tennessee Valley Authority (TVA) supplies power to the municipality and does not offer RTP rates.

Purpose and Intent

The purpose and intent of this demonstration project was to use a municipally owned interactive communication and control system tied through the Internet to the National Information Infrastructure to address fundamental electric utility issues that will improve the way electric utilities and their customers relate. The scientific significance of this experiment is that it demonstrates the operation of a new class of electric utility service and customer interaction that has not been feasible in the past due to the lack of low cost, high speed data communications. Also significant is that the approach takes advantage of existing infrastructure, hardware and software in a real world environment that results in an economically viable project worthy of being immediately replicated at other utilities and municipalities throughout the United States. This will provide for immediate and significant use of the NII.

Some general issues have been addressed in the project.

- “What impact could a widely deployed NII have on utility operations and capital requirements?” [NIST Spec. Pub. 868]
- “How does possible use of the NII for utility operations impact the communication requirements of the NII?” [NIST Spec. Pub. 868]
- “What impact will a widely deployed NII (and attendant changes in utility pricing power policies) have on energy conservation?” [NIST Spec. Pub. 868]
- “What NII capabilities are needed to support real-time pricing and other energy conservation strategies?” [NIST Spec. Pub. 868]

- “Are the economic advantages to electric utilities sufficient to justify the construction of wideband communications to industrial sites?” [NIST Spec. Pub. 868]
- “How will a widely deployed NII facilitate market competition in the electric power industry?” [NIST Spec. Pub. 868]

Implementation

The infrastructure used included the existing Internet and the two-way broadband communication and control system owned and operated in the City of Glasgow, Kentucky. This communication system provided an ideal test-bed for implementing the concepts proposed. All of the city’s commercial and industrial electric power customers already have the communications cable at or near the electric service entrance. The city also owns and operates the electric power distribution system. The broadband communications system allows the utility to communicate to any device located on any utility pole in the city. The project was expanded to take advantage of other existing communications systems representative of many utility service areas throughout the world. The installation at Con Edison in New York City utilizes the local telephone network for system communications.

For monitoring power quality, the BMI 8010 was used. This is an existing instrument that has been used in a variety of power quality surveys including the EPRI Distribution Power Quality Project. Translation software needed to interface the PQNode with the communications system was written. This project is being demonstrated via a master station database gateway to a World Wide Web server (URL:<http://www.electrotek.com/>).

For energy monitoring and limited power quality data acquisition, the Square D circuit monitor was used. This instrument is also commercially available and inherently supports the use of networked communications to send data back to a master station. Gateways are available to connect the native SYLINK industrial network to standard Ethernet, RS-232, RS-485, and dial-up networks. Translation software needed to interface the circuit monitor master station to the communications system was written.

For the data gathering and analysis systems, the PC based software provided by the respective monitoring vendors was used. These vendors have open, non-proprietary interfaces to their software, which enables quick and efficient development of system integration software.

For end user data delivery, we utilized a World Wide Web server as the data server and client programs such as Netscape or Mosaic as the client software. These programs are readily available and have proven to be extremely popular recently, are easy to use, and available on a variety of computing platforms. The use of the WWW protocol, client, and server allowed the project team to eliminate the complexities and cost of developing custom client side software for the demonstration. It is very likely, given the popularity of WWW, that this method of data delivery will be viable in systems other than this demonstration project.

Glasgow

Glasgow elected to construct a municipally-owned broadband network because of competition. The people of Glasgow feared competition for their municipally owned electric utility in the coming deregulated environment, and they desired competition in the cable television marketplace, and the telephone marketplace. They also wished to establish a city-wide computer network, which was not available from either the telephone company nor the cable television company.

The City of Glasgow purchases all of its electricity from the Tennessee Valley Authority. Since the early 1980s TVA rates have been sending an increasingly strong signal through increases in wholesale electric power costs that cities should devise a system to shift the use of electricity off certain peak times of the month. Such a system would allow cities to save tens or possibly hundreds of thousands of dollars per month in their wholesale power cost. By mid-1985, staff at the Glasgow Electric Plant Board were involved in detailed studies of different methods that could be employed to accomplish this desired load management objective.

A system has been constructed with off-the-shelf technology that not only provides load management and remote meter reading capabilities combined with cable television entertainment signals on the same wire. This system also provides capacity for many new services that could be based on community-wide data communications. The following are major milestones in the development of the wideband network services:

- Electrotek Concepts was hired to study how cable television and the electric system distribution automation signals would coexist on same wire, May 1987;
- State approves trial of traffic signal synchronization through Glasgow's Broadband Information Highway Project, November 1993;
- Creation of a telephone service rate card to make the service developed by the EPB a real competitor to GTE. December 1993; and,
- Partnership with MCI, providing high speed access to the Internet, April, 1995.

By creating a constant flow of information among the utilities, businesses, schools, and homes within the City of Glasgow, the Glasgow Electric Plant Board will be able to completely change the way they provide energy to the people of Glasgow, offering abundant choices to consumers in the way they purchase that electric power. That same flow of information has allowed competition in the cable television marketplace and telephone marketplace. It has also allowed the creation of many new ways for the citizens of Glasgow to communicate with each other, with their customers, and with their government, which will ultimately improve their way of life. Glasgow's broadband network is expected to be the economic engine that will power Glasgow and hundreds of other communities into economic prosperity during the coming information age.

The initial construction of the Broadband network cost approximately \$1.5 million. One hundred twenty miles of Broadband plant were constructed at a cost of approximately \$12,000 per mile. Adding the cable television service to the project required an additional expenditure of approximately \$1.3 million. This expenditure was used to build a cable TV headend, the antenna towers and earth stations and to purchase cable television computers, converters, and other hardware and software related solely to the provision of cable television. The telephone initiative required an expenditure of approximately \$500 per telephone line served. The telephone business uses equipment manufactured by First Pacific Networks, Inc., in San Jose, California. The community-wide computer network requires the purchase of a card (Ethernet) to go in an expansion slot on either a home PC or a file server which is to be interfaced to the network. In turn, this card connects to a "cable modem," which is rented to the customer for \$9.95 per month. There are approximately 5,000 potential households with a population of approximately 15,000 within the City of Glasgow Electric Power Board service area.

The two elements that provided the economic justification for the Broadband Network project were electric energy management and competitive cable television. Today the project allows energy management through this city of approximately 15,000 people in the same fashion that energy management activities are carried out in an individual office complex or industrial facility. The other

core activity is the provision of a competitive cable television service. Through the same wire that load management signals flow, everyone in Glasgow can elect to receive an alternative cable television service to that which is provided from a private cable operator. The cable television service also enhances the effectiveness of the energy management function, since commercial availability on major networks can be utilized to pass load management information to consumers. In an emergency, the programming can be interrupted to appeal for power usage reductions in order for the entire community to save money on its power bill.

Since the early provision of those two functions, many other capabilities of the broadband network have been discovered. The same system is used to offer a municipally operated telephone service in direct competition with GTE.

A significant service available over the Broadband network is a 4-megabit per second city-wide computer network, which ties together all homes, schools, businesses and government agencies. This network connects stand-alone PCs and file servers with their associated workstations to Novell® and Microsoft Network servers. The network is also connected to a T-1 circuit, provided by MCI, which allows anyone on the Glasgow network to have T-1 shared speed access to the Internet simply by clicking on their browser icon to establish the connection, without any connection to a telephone or a telephone modem. The system is even utilized to synchronize all traffic signals in town, so the streets can carry the optimum amount of traffic thus, achieving much higher efficiency in the investments the city has made in streets, roads and highways.

Figure 1 shows the City of Glasgow's growth in their various information services markets.

Figure 1 - Glasgow Electric Power Board Information Services Growth

Con Edison

This project was expanded to include Con Edison in order to demonstrate the flexibility of the communications system configurations that could be accommodated. Con Edison does not currently have a broadband network connecting the system components but instead uses its intranet and local telephone services for all data collection and transfer functions. Con Edison has many more sites being monitored than the Glasgow case previously described. Con Edison uses a combination of BMI's PQNode and PQPager products for energy quality data collection as well as energy quantity data collection. The use of the PQNodes for energy quantity data collection is stretching the functionality of the devices which saves additional equipment installation and monitoring cost. This is achieved under the premise that periodic "snapshots" of energy demand will provide a reasonable approximation of actual energy consumption, as would be obtained from using equipment that measures actual kilo-watt-hour consumption. The reliability of this method is within +/- 2 percent. This is well within the tolerance limits practiced by many utilities that reconcile electronic pulse data against the totalized electromechanical "billing" meter.

Con Edison has installed over 60 PQNode devices. Approximately 20 percent of these devices are using additional channels to monitor current as well as voltage. Eighty percent of the Con Edison system consist of a Network Power Grid with the remaining 20 percent of the system covered by radial feeders. The PQNodes monitor the Con Edison system in the same respective percentages. Con Edison chose to put PQNodes at the majority of their Network substations, to provide themselves with complete data that could be used to analyze system interactions, not just substation specific power quality data. The type of system interactions that could be analyzed include system fault recovery characteristics, sag analysis, and transient susceptibility. The ability to provide accurate power disturbance profiles also exist.

In addition to the PQNode equipment, Con Edison also used the PQPager. This equipment and service provides timely notification to the customer of event occurrences. Because power quality events can have severe economic impacts on industrial and commercial customers, the use of the PQPager can greatly improve the customer relationships in the event of a quality disturbance. A customer with potentially high economic impacts will be willing to pay for the value added service.

United Illuminating

United Illuminating has installed 34 PQNode 8010 and 8020 units. Most units are installed at the utility's substations with the exception of a single unit installed at a customer site. United Illuminating has been building their power quality monitoring system for several reasons. First, they wished to collect data on their substations to allow a comparison of substation performance. Second, they wanted to make their system maintenance more efficient. The data collected on the substations would be used to optimize the maintenance dollars spent based on system performance. Third, they would be able to establish a baseline of information about the power quality both they and their customers could expect to be provided. And last, they would have data available to compare with the average power quality provided by other utilities.

United Illuminating chose a customer site to install the monitoring unit based upon the customers desire to find out more about their power quality. Several customer and utility concerns were satisfied by using Web-based data access to the power quality information. The utility's concerns included the desire not to have customer access to the utilities internal network. With the web-based access the data is stored and accessed completely separate from the utilities internal network. In addition to this security for their network, they were able to provide their customer

with non-censored information. This removed any perception that the data may have been filtered or manipulated prior to the customer having access to it.

Tennessee Valley Authority (TVA)

TVA is the nation's largest power company, producing more than 130 billion kilowatt-hours of electricity a year. In a partnership with 160 locally owned power distributors, TVA provides electricity to 7.3 million people. TVA power travels across 17,000 miles of transmission lines. These lines carry power to customers in parts of seven states. TVA owns and maintains an extensive telecommunications network to enable automated process control of its transmission and generating facilities and to provide for voice and data flow. TVA is setting up telecommunications networks among rural communities to help schools share teachers and to give business partners access to the information highway.

TVA plans to use PQNode monitoring equipment in conjunction with the T-1 communications links to their customers to monitor flicker at a low cost as opposed to the typical monitoring methods in current practice among utilities.

Description of Work Performed

The project was performed in four phases:

Phase 1.	Project Plan and Experimental Design:
Developed a detailed project plan to implement the experiments.
Phase 2.	Infrastructure Deployment:
Installed energy and quality monitoring devices at two industrial sites. Set up monitor device, vendor supplied, master station software.
Phase 3.	Perform Experiments:
Performed two primary experiments - On-Line Quality of Service, Information Service and On-Line Allocation of Energy Usage and Costs Monitoring Service.
Phase 4.	Final Analysis and Report:
Analysis of results from experiments and preparation of the final report.

The following sections provide detailed descriptions of each task in each phase of the project.

Phase 1 - Project Plan and Experimental Design

Quality of service and allocation of energy usage and cost are discussed in this section. Quality of service accounts for 90 percent of the performance results. The energy data was collected and stored but was not utilized due to market preferences and lack of rate alternatives in the location the study was performed. The primary interest, both of the utility and the customer was in quality of service. The off-the-shelf tools for demonstrating quality of service aspects were also better and easier to implement. A summary of the energy data is provided in Phase 4 of this draft report.

In this phase, we developed a comprehensive list of technology products that could support potential service products. For example, the service of "real time pricing" for a direct serve customer required data links to the TVA dispatch center (marginal price information), a link to the TVA distributor, price-posting software at TVA (sending) and at the customer (receiving), information display at the customer (industrial customer workstation—hardware and software), monitoring/metering equipment that is remotely accessible, and access to the customer's load profile/billing data base. Physical communication links were needed, cable and other communication media modems were needed, network (LAN/WAN) manager software and protocols were required, and data base interface and interchange software and protocols were needed.

We considered as candidates for this project, the technology products with the following attributes:

- Extension of existing GEPB systems, or compatible with existing systems.
- Able to support user-friendly interface.
- Reasonable cost and exceptional reliability.
- Strong vendor support and evolutionary/upgrade potential for software products, including data bases, servers, and arbitrators.

Products in the following areas were evaluated and considered:

- Communication media and systems.
- Modems/gateways.
- LAN.
- Applications software (e-mail, data base, engineering software).
- Customer interface hardware and software.
- Monitoring, metering, sensor and control equipment.

In preparing this project plan, preliminary investigation had shown that many capable, affordable technology products in all these areas are commercially available to support the anticipated service products and functions to be implemented. We were able to identify existing products and protocols, that were compatible with the GEPB systems.

The network software and “almost” network ready instrumentation that could be hooked together in a system included Square D and PQ Node equipment, because the software for these products was usable on PCs. The Square D equipment was readily networkable and the PQ Node had dial-up capability. Other software evaluated included PML (Power Measurements Limited.)

A list of commercially available technology products to support anticipated utility/customer service products can be found in Appendix A. The candidate technology products were reviewed for completeness, appropriateness, and compatibility with other open systems initiatives. The Square D POWERLOGIC® power meter is designed for use in basic power metering applications. It can replace conventional metering devices such as ammeters, voltmeters, and watt-hour meters, while providing powerful capabilities not offered by analog metering. The power meter's true RMS readings (31st harmonic response) reflect non-linear circuit loading more accurately than conventional analog metering devices. The power meter calculates the neutral current, which can assist in identifying overloaded neutrals due to either unbalanced single-phase loads or triplen harmonics. Circuits can be closely monitored for available capacity by keeping track of the peak average demand current. Accurate circuit loading information is essential to get the most out of existing power equipment, while maintaining power system reliability.

Disturbance analyzers and disturbance monitors form a category of instruments which have been developed specifically for power quality measurements. They typically can measure a wide variety of system disturbances from very short duration transient voltages to long duration outages or under-voltages. Thresholds can be set and the instruments left unattended to record disturbances over a period of time. The information is most commonly recorded on a paper tape but many devices have attachments so that it can be recorded on disk as well.

There are basically two categories of these devices:

- Conventional analyzers that summarize events with specific information such as over and under voltage magnitudes, sag and surge magnitudes and duration, and transient magnitude and duration.
- Graphics-Based analyzers that save and print the actual waveform along with the descriptive information which would be generated by one of the conventional analyzers.

It is often difficult to determine the characteristics of a disturbance or a transient from the summary information available from conventional disturbance analyzers. For instance, an oscillatory transient cannot be effectively described by a peak and a duration. Therefore, it is almost imperative to have

the waveform capture capability in a disturbance analyzer for detailed analysis of a power quality problem.

This project had a product emphasis to define feasible and economic applications for integrated communication technology and requirements for utility-customer interface systems. This involves using the communication networks to augment the utility's capabilities so that it could offer more than just commodity service to customers; it could offer services more closely associated with value or utility.

The utilities and their customers were apprehensive about the project. The utilities were not sure how much of the data the customer would be able to understand without assistance and clarification from the utility. The utilities thought it would make additional work for the customer service representatives. The customers were unsure of what data the utilities would actually provide to them, and were concerned about the utilities having detailed system operation data on their facility. The quality of service issue was the common ground of interest for both the utilities and their customers. The utilities and their customers needed to be presented with thoughts and examples that would increase interest to make them participate more freely in the project. The apprehension from the utilities and the customers gave the appearance to each other that neither party was interested in participating in the project.

Systems configured for testing included Square D Circuit Monitors, BMI PQNodes, First Pacific Networks telephone device for connectivity, Microsoft Networking for access to the PCs to download the Square D Circuit Monitor data over TCP/IP using Microsoft's file sharing protocol over netbios. Refer to the next section for diagrams of system connections.

Phase 2 - Deploy Infrastructure

The use of the City of Glasgow's existing communications infrastructure and off-the-shelf monitoring hardware made this task relatively straightforward and economical. Precise installation instructions and caveats were provided with the instrument vendors' respective documentation and are not included in this documentation. The linemen not only installed the monitoring devices, potential and current transformers, but they also had to work with RS485 and RS232 connections, coaxial cable connections, debug RF modem connections, make sure the meters themselves were operating correctly, and verify the equipment could be contacted over the broadband network by the phone system.

Data Acquisition System Description

Each location where data was to be gathered is configured as shown in the following diagram. A BMI PQNode is placed at the building service entrance (or in the case of a utility substation, on a primary bus) to gather detailed power quality disturbance and harmonic information. Also at the service entrance is a Square D circuit monitor. The Square D device was used to gather energy and demand information as well as simple power quality information.

Figure 2 - Typical Customer Site Equipment Configuration

Inside the facility at key locations defined by the facility manager, two additional circuit monitors were placed. These devices again were used for energy usage and basic power quality data, including harmonics.

The circuit monitors are connected together by a multi-drop RS-485 serial link that terminates at a RS 485 to RS 232 protocol converter. The RS 232 side of the converter is then connected to a standard PC running the Square D SMS software. This software provides all of the instrument setup and data logging capability of the system. It also provides the facility manager with a local display of the raw data from the Square D monitors.

The PC is also running a custom software program that converts the data being placed in the Square D history file into the Power Quality Data Interchange Format (PQDIF) and forwards it to the Electrotek site via the Internet using the Power Quality Internet Transport Protocol (PQITP), which runs on top of TCP/IP. This software utilizes the WINSOCK interface to communicate using TCP/IP through a standard 10Base-T Ethernet network interface card. The Ethernet bus is connected to the Broadband cable system through a broadband to Ethernet converter/router. To further demonstrate configuration flexibility, the PQITP (proprietary protocol) was replaced by MMS protocol near the end of the project.

The BMI PQNode is connected to a broadband modem by its RS-232 ports. This modem allows full control of the PQNode by its serial port from the Glasgow Electric Plant Board (GEPB) head end facility. A custom version of BMI's PASS software allows each PQNode in the system to be individually addressed and downloaded on a polling schedule.

Glasgow Electric Plant Board Location

The following figure illustrates the components at the GEPB headend facility. The primary purpose of the components at the headend is to provide connectivity between the broadband system and the Internet. This location is also responsible for polling the BMI PQNodes.

Figure 3 - Glasgow Electric Power Board Equipment Configuration

A broadband cable to Ethernet converter/router is used to route TCP/IP traffic from the remote sites to the GEPB head end 10Base-T Ethernet network. Also connected to this network is a CISCO router that forwards data packets to or from MCI's network (MCI is GEPB's Internet provider) via a T1 (1.544 mbps) connection. Once in MCI's network, packets destined for the Internet are forwarded to the appropriate next router in the chain that forms the Internet.

Electrotek Location

The Electrotek side of the system is where all of the data being gathered is accumulated, analyzed, and eventually distributed.

The following figure illustrates the system components.

Figure 4 - Electrotek Site Equipment Configuration

Packets from the Internet destined for the Electrotek site are forwarded to a router acting as a gateway to Sprint's frame relay network (Sprint is Electrotek's Internet provider). From this router, the traffic is carried by frame relay to the Electrotek site, which is connected a T1 line. Since Electrotek uses the T1 for both voice and data, a channel bank is used to separate the voice from the data traffic. The data is then connected a 256 kbps V.35 connection to a Nile router which connects to Electrotek's internal 10Base-T Ethernet distribution system.

Once on the LAN, the incoming traffic generated by the PQITP gateway is routed to a server, running the same protocol. This server extracts the PQDIF data sent and sends it on to the PQView power quality database management system for characterization, analysis, and storage in the database.

At this point, the newly arrived data is available for query. Another server running the WWW HTTP protocol provides the interface between the end user and the PQ database. By using the familiar WWW interface by a WWW browser like Netscape, the user is presented with a series of screens that guide him or her through the process of generating a report on power quality, quantity, or pricing. The WWW server receives the request and through the use of several back end server applications, formulates a query for the SQL Server base PQView database, formats the response into a suitable HTML page with graphics as appropriate, and returns it to the user.

In addition to being able to query the database for existing data, mechanisms are provided to forward a request for instantaneous values by the PQITP to a particular instrument. The response to this request is processed and displayed in a similar manner as the database.

Figure 5 - Example System Configurations - from basis direct access to multi-point Web access.

Phase 3 - Implement Experiments

This phase was the actual implementation of a World Wide Web based system for delivering data from the power quality monitors to utility and customer personnel. Software was developed for a WWW server back end to acquire data and prepare reports based on form type input from the end user running a WWW browser. Differentiated data products were provided based on user login ID and password. The data products included:

- Searchable database of all disturbances measured to date.
- Most recent disturbance summary report.

The following figure illustrates a WWW based user interface for acquiring PQNode event summary data as was found at the beginning of the demonstration project.

Figure 6 - Original PQNode Device List for Query Submission Dialog Box

Address <http://www.electrotek.com/scripts/webpqv/webpqv.dll/pqweb/db2/webpqv.ini?rmsform>

PQ Network_{tm}**Electrotek Concepts, Inc.**

RMS Variation Query Parameters

[Set Display Preferences](#)

Create RMS Variation Report

From Date: 05/16/1996
To Date: 11/12/1996

Report Elements to Display

Event List: ☐ Mag Dur Plot: ☒
Histogram Table: ☐ 3D Histogram: ☒

Site List:

Service Entrance 1
Service Entrance 2
Utility Substation

Create RMS Variation Report

Figure 7 - PQNode Device List for Query Submission Dialog Box. Now includes Event List, Duration Curves and Histograms

Figure 8 - Original PQNode Event Summary Table

This phase was the actual implementation of a World Wide Web based system for delivering data from the energy monitors to utility and customer personnel. Software was developed for a WWW server back end to acquire data and prepare reports based on form type input from the end

user, running a WWW browser. Differentiated data products were provided based on user login ID and password. The data products included

- Historical energy usage summaries for plant and sub-metered points.
- On-line access to current usage.

On-line bill calculation and review and on-line rate option evaluation for historic load profiles were also originally intended to be customer evaluation options. These functions were not provided, as the customer preferences for quality information were of higher consideration in light of the lack of rate options.

Even though the bill calculation information was not implemented, some energy and other traditional power monitoring was desired. After several iterations, the decision was made to implement an interface familiar to many power engineers. This interface mimicked a traditional SCADA like display as shown in Figure 9.

Figure 9 - SCADA Like Display for Power Quality and Quantity

This display provides the user with a familiar, not too intimidating view of the power system of interest. In addition to the traditional power quantities, some quality related variables are shown. These include total harmonic distortion, unbalance, and an indicator if a power quality event has occurred recently. The latter item is implemented as a colored PQ symbol on the display. The color of this icon indicates the severity of a recent event. Clicking on the circles results in more detailed information on the power quantity data while clicking on the PQ symbol results in a summary of recent events as shown in Figure 10.

PQNODE DISTURBANCE SUMMARY TABLE - MICROSOFT INTERNET EXPLORER

File Edit View Go Favorites Help

Back Forward Stop Refresh Home Search Favorites Print Font Mail Edit

ADDRESS <http://www.electrotek.com/scripts/webpass/webpass.dll/pqweb/db1/pqnode/doe/webpass.ini?queryd> LINKS

Event Summary Table for events from 05/01/1997 00:00:00 to 05/08/1997 23:59:59
Click on the time stamp for details on any event

Event Time	Node	Event Type	Mag (%)	Mag (V)	Duration	Category
Wed, 05/07 14:37:51	GEPB Substation	RMS Variation	90.1	6650.2	53 Cyc	1
Wed, 05/07 12:55:56	GEPB Substation	RMS Variation	92.9	6852.5	32 Cyc	1
Wed, 05/07 12:03:04	GEPB Substation	RMS Variation	87.8	6481.7	22 Cyc	2
Mon, 05/05 19:30:04	GEPB Substation	RMS Variation	88.0	6497.4	19 Cyc	2
Mon, 05/05 19:28:13	GEPB Substation	RMS Variation	90.1	6648.8	21 Cyc	1
Mon, 05/05 19:18:45	GEPB Substation	RMS Variation	91.8	6773.9	24 Cyc	1
Mon, 05/05 19:08:19	GEPB Substation	RMS Variation	92.5	6826.0	27 Cyc	1
Mon, 05/05 18:59:08	GEPB Substation	RMS Variation	90.3	6665.1	21 Cyc	1
Mon, 05/05 18:39:23	GEPB Substation	RMS Variation	85.3	6298.6	19 Cyc	2
Mon, 05/05 18:19:53	GEPB Substation	RMS Variation	88.8	6550.9	20 Cyc	2
Mon, 05/05 18:15:47	GEPB Substation	RMS Variation	94.5	6975.0	15 Cyc	1
Mon, 05/05 18:12:13	GEPB Substation	RMS Variation	92.6	6830.7	24 Cyc	1
Mon, 05/05 14:50:30	GEPB Substation	RMS Variation	92.4	6816.5	2 Cyc	1
Mon, 05/05 14:50:23	GEPB Substation	RMS Variation	63.7	4702.6	6 Cyc	3

Done

Figure 10 - Event Summary Display

The event summary display provides a relatively simple view of the power quality events that have occurred on the system recently. This table has evolved over the course of the project and the host utilities were instrumental in defining the final format shown here. The end result was a display that indicated when the events occurred, at what location, of what type, how high or low the voltage went in units of system volts or percent or nominal. In addition, a color-coded severity factor was defined to facilitate quickly identifying the most important events.

The event summary table of Figure 10 was produced by an automated query created as the result of clicking on the PQ symbol in the SCADA interface. The power quality system can also be accessed directly through an initial WWW page identifying the power quality database of interest (Figure 11) and then the query page (Figure 12).

Figure 11 - PQWeb Entry Screen

Figure 12 - Query Page

The query page is designed to allow the user to enter very basic information to formulate a query. The user selects one or more monitoring locations, a date/time range of interest, disturbance types of interest, and if desired, severity levels of interest. The design of this page also evolved over time during the project. A key concept implemented was intelligent initialization of the query selections such that modification was seldom necessary. The page defaulted to the last week of data for the most common disturbance types (RMS variations and outages) and all severity factors. When the desired query parameters are entered on this page, pressing the *Get Event Summary Table* button results in the Event Summary Table shown before (Figure 10).

The severity factors have been mentioned a few times in this report. After considerable iterations, a set of severity factors based on the characterization of RMS variations and transients into magnitude/duration space was arrived at. Figure 13 shows the mapping between magnitude and duration areas to color severity levels.

Figure 13 - Severity Mapping

A principal concept developed early on in the design of this user interface was the idea of a successive revelation of detail. By presenting simple, familiar information upon entering the system (the SCADA interface), unskilled or infrequent users of the system can use the system without being intimidated by its ultimate capabilities. Within these simple initial screens can be found one or more clickable elements that result in a new display with more information about the clicked object. This capability allows skilled users to access all features of the system in a systematic and logical fashion to the level of detail required. For example, Figure 14 shows the display that results when the hyperlink in the event summary table (Figure 10) is activated.

Figure 14 - Event Detail Display

In this case, the detail exposed by the hyperlink includes a view of the RMS envelope and waveform of the voltage that represents the event summarized in the table. Power quality engineers can use this information to determine the likely impact of the event on end use equipment as well as the likely cause of the event.

During the course of the project, it was determined that another view that provided an overview of the system quality performance like the event summary table, only graphical, was needed. Since most power engineers are familiar with long term RMS voltage chart recorders often found in substations, this kind of model was used. Figure 15 shows the result.

Figure 15 - Long Term RMS Trending

These displays can display the RMS voltage or current over periods of time from minutes to years. The major innovation in this display is that the data shown includes the minimum and maximum values that occur over each sampling interval (typically 5 or 15 minutes) and are computed on a cycle by cycle basis. Every power quality related event of one cycle duration or more is therefore represented on the display, while still allowing a very long term view of the system. The end result is a single display that illustrates long term voltage regulation, load levels, daily, weekly, and monthly trends, as well as the power quality events (for example, you can count the voltage sags by inspection).

This display is being enhanced to permit clicking on a portion of interest with the result being an event summary table covering the time frame near the clicked point. This further implements the successive revelation of detail concept.

In addition to specific event viewing, which has been the primary concentration, displays were developed to help visualize the overall performance of the system. Two display types include a magnitude versus duration plot and a three dimensional histogram. Figures 16 and 17 illustrate these plots respectively.

Figure 16 - Magnitude versus Duration Plot with Susceptibility Curve Overlay

Figure 16 is often used to compare recorded power quality events with equipment susceptibility curves. Most devices begin to misoperate when the voltage gets too low or too high but can tolerate more extreme values for short periods of time.

Figure 17 - Three Dimensional Magnitude versus Duration Display

Figure 17 presents a similar view of the same information but provides more information on the specific regions of magnitude versus duration space that the disturbances fall in and how often.

At the request of Con Edison, steady state energy data was added to supplement the PQWeb quality information. The existing monitoring devices that could easily be networked into the system could not handle energy all that well, but could handle snapshots of voltage, current, and power. Figure 18 shows the display developed to provide this information. With this display, the instantaneous steady state parameters of the system were made available to authorized personnel through the WWW interface.

The screenshot shows a Microsoft Internet Explorer window titled 'PQNode Disturbance Detail'. The address bar shows a URL from electrotek.com. The main content is a table with 5 columns: Parameter, Phase A, Phase B, Phase C, and 3 Phase. The table lists various electrical parameters such as RMS Voltage, Peak Voltage, VI, Harmonic RMS Voltage, Voltage Crest Factor, Voltage THD, Voltage TIF, Real Power, Reactive Power, Apparent Power, True Power Factor, P1, Q1, S1, Displacement PF, and Ph (Watts).

	Phase A	Phase B	Phase C	3 Phase
RMS Voltage (Volts)	7428.610	7441.310	7403.195	7424.372
Peak Voltage (Volts)	10638.428	10550.537	10603.638	10597.534
VI (Volts)	7427.406	7440.197	7401.714	7423.106
Harmonic RMS Voltage (Volts)	133.721	128.683	148.051	136.818
Voltage Crest Factor	1.432	1.418	1.432	1.427
Voltage THD (%)	1.800	1.730	2.000	1.843
Voltage TIF	31.590	17.123	36.957	28.556
Real Power (kW)	2127.376	2071.501	2063.741	6262.618
Reactive Power (kvar)	1269.782	951.527	1225.835	3447.144
Apparent Power (kva)	2477.514	2279.587	2400.354	7157.455
True Power Factor	0.859	0.909	0.860	0.875
P1 (kW)	2126.369	2070.284	2062.483	6259.136
Q1 (kW)	1270.380	952.588	1227.207	3450.175
S1 (kW)	2476.956	2278.925	2399.973	7155.854
Displacement PF	0.858	0.908	0.859	0.875
Ph (Watts)	65456.733	70978.611	72057.875	208807.912

Figure 18 - Steady State Summary Information

It must be noted that a major design point for this system was to ensure that the system performed well. To this end, all of the graphic images and databases were designed to make sure the WWW server was never a bottleneck. In addition, care was taken in the design of the graphic image to ensure that they were small (<5k for a typical event detail graphic) so that someone with a 14.4 kbps modem could use the system with very good performance. This goal was achieved to a level much better than expected, making this project more than an academic exercise and allowing commercialization to occur (described in the next section).

Phase 4 - Final Analysis and Report

The performance of the system includes the reliability of the data transfer infrastructure, overall throughput, user interface response time, data integrity, data storage characteristics and limitations, round robin customer polling time, and data compression effectiveness. Industry standard web server logs were used as the measurement method for collecting data on the use of the system by the utility and customers. The logs were able to track and allow quantification of Web access, Web server performance and communications reliability. The performance of the system was enhanced through the use of small graphics. The small graphics improved the speed of transfer of the information to the utility and customer. The usage statistics and logs that indicate how often the system was up, and how often the system was collecting data. Logs are available for the Glasgow server as well as for the power quality data stored on the Electrotek server. Although the concentration of the project is on technical performance, the *people nature* of things does come into play. Support and equipment availability logs from the Felker site were found to be poor because the computer was turned off for an extended period of time by personnel who didn't realize the computer was routinely collecting data.

It is likely that the utility will have to take full responsibility for the service of equipment within a plant. The utility generally has the expertise available or can get themselves up to speed with the installation issues, more readily than the host site. This was clearly the case at Glasgow, and consistent with results at Con Edison. The technical performance of the system has clearly been the responsibility of the utility. Consolidated Edison chose to use a completely conventional dial-up system to gain access to the power quality data.

We found that the cost and ease of communications significantly affects the decision on how often to obtain data. Traditionally power quality data is downloaded daily during the night to take advantage of the cheapest communications rates. This applies especially to utilities with large service areas, encompassing several area codes, where the communications are subject to long distance charges. Consolidated Edison is a large utility, whose load is very concentrated. They chose to download hourly, because all of their communications were by local phone service. So, where communications cost are not an issue (or bandwidth is not a restriction) the data is downloaded hourly. The utility knows within the hour if there was any quality disturbance on their system. The data was immediately available on-line, and the customers could be notified of the event by e-mail. Con Edison has had a great deal of experience in this area.

There are many benefits associated with downloading more often than once a day. Data is available for more near real time analysis. The ability to link system operations to system performance can significantly improve the modeling of the system in relation to contingency operations. The system quality control can be improved by learning more the way the system reacts under various operating conditions. If there is a data collection problem, the amount of lost data until the problem is resolved is minimized. The customer can learn the significance and value of power quality to their operation. This is a major step in placing a value on service quality and can be directly used for cost benefit analysis of addressing the response to power quality issues. The utility and customer can work together to arrive at least cost solutions to quality issues. As bandwidth becomes wider and cheaper, more ways to take advantage of the system will be found. People do change the way they do things to adapt to the available information, especially when there is a catalyst to the change. The catalyst is evident today in the certainty of deregulation and open competition.

Equipment performance and reliability is always a concern when designing or integrating a system. Equipment used in this demonstration project included systems to gather data, e.g. transformers and transducers and the communications equipment to get data from the instrument to the control point (Electrotek or Con Edison). For Glasgow, the communications equipment was a First Pacific Network phone switching system over the broadband cable system. Many pieces of equipment are in the chain from data collection to data arriving at Electrotek. Con Edison's data collection was direct, utilizing a dial-up phone system. In both cases the information could be downloaded more rapidly. Consolidated Edison had sixty data collection units in operation at a wide range of utility system and customer sites, so the data obtained is better statistically than that at Glasgow.

United Illuminating

The system at United Illuminating has experienced communications system problems. The problems have been related to the coordination of the communications system and some of the system components. With a communication system failure, the PQNodes would lockup, requiring a technician to make a site visit to reset the equipment. No data would be collected from the time of the lockup to when the equipment was reset. United Illuminating downloads the data hourly. Coordinating the polling rate of the download machine may reduce or eliminate the lockup problem.

Since the project has neared its end, the interest in the energy data has skyrocketed, which may be attributed to the reality of the coming of deregulation. Originally, it was the quality aspect that got everyone to jump on board because it was (is) unique and different. Utilities felt they already had a good idea of what was going on energy-wise on their system, and were not interested in the customer side so much. The utilities were able to learn things from the voltage and current profiles and, with the changing utility climate are now very interested in the energy piece, and will want to go forward to try to do something with that.

Obstacles

Significant obstacles the project has encountered.

*There have been, and continue to be, several small problems with the project, including the cross-training required for GEPB staff in implementing new services after a 30 year history of providing only one service. Inventing ways to do data communications across the cable was a challenge; most data communication manufacturer representatives were of little or no help with combining cable television and data communication on one medium. The largest obstacle faced was the "turf battle" with the cable television operators. The cable television operators used litigation and an excessive capital to make the Glasgow project unsuccessful and to prevent replication of the project. When nationwide cable rates for basic service averaged around \$20, the incumbent operator lowered the rates in Glasgow to \$5.95 in order to thwart the new competition from the municipal project. The cable television operators also rebuilt their system, offering 48 channels of basic service, instead of the 21 channels previously offered. Wherever possible, the cable television operators entered into exclusive contracts with programmers such as TNT and ESPN to make this programming unavailable to the Glasgow project. **William J. Ray, Superintendent, Glasgow Electric Plant Board, Glasgow, Kentucky.***

First, there is a need for a more cost effective solution to allow an electric meter to report its readings back by the broadband interface to construct a database that the customer can query and make decisions on future purchases based upon that information. The second problem exists because the electric industry is still not open

and deregulated. Glasgow still has an all-requirements contract with the Tennessee Valley Authority. In other words, we are not yet allowed to purchase our electric energy from whomever we please. The Tennessee Valley Authority is a very large federally owned and operated electric utility. As a result, adapting and implementing innovative ideas like ours is difficult and slow to say the least. We are only now beginning to interest TVA in the possibilities of utilizing communications technology to operate existing electric systems more efficiently and mitigate the need for construction of new generating plants. **William J. Ray, Superintendent, Glasgow Electric Plant board, Glasgow, Kentucky.**

Benefits at Glasgow

Since the project's inception, the immediate competitive environment in cable television has saved, by conservative estimates, nearly \$6 million for the people of Glasgow. In other cities without the benefits of competition, this money would go to the stockholders of the private cable operator. In Glasgow, this money has remained in the local retail economy and has turned over many times before leaving the community. This amount of money injected into the retail economy of a community of 14,000 people has had a significant impact. Retail development in Glasgow has outpaced the balance of the country.

Major industries such as R. R. Donnelley & Sons, Johnson Controls, Akebomo Brake, International Paper, SKF Tapered Bearings, and others have made recent decisions to expand their operations or construct new facilities in Glasgow, even though Glasgow is lacking in many of the classic infrastructure features that tend to attract industrial development. For example, a manufacturer of stainless steel piping announced plans to relocate to Glasgow because, as an electric energy intensive operation, they were convinced the electric rates in Glasgow should be more competitive over a long term than anywhere else they could relocate to, as a result of the broadband highway project. **William J. Ray, Superintendent, Glasgow Electric Plant Board, Glasgow, Kentucky.**

Innovations

“Municipally owned electric utilities across the country have struggled to implement effective load management programs. Generally, the programs in place reward consumers for allowing the municipal utility to control loads such as electric water heaters, air conditioners, heat pumps, swimming pool pumps, etc., with a \$3-\$5 per month credit on the customer's electric bill. A lack of consumer understanding of the need for the program and the lack of interest in a \$3 or \$5 per month savings have rendered these programs less than overwhelmingly successful. This program's initiative provides the foundation for a real-time exchange of data between municipal utility and electric consumer that will facilitate real changes in power consumption. The medium of cable television will allow continuous information to flow to the consumers, explaining how this program can help them lower their energy bills. It also gives the utility new incentive tools. Instead of offering that \$3-\$5 per month credit on the electric bill, our project allows us to offer a premium cable television service such as HBO or Showtime, which has a similar cost to the utility, but a much higher perceived value to the consumer. In short, a consumer may not be interested in allowing his water heater to be controlled for \$3-\$5 a month, but he may very well be interested in allowing the same control in return for the reception of HBO.” **William J. Ray, Superintendent, Glasgow Electric Power Board, Glasgow, Kentucky.**

HomeLAN

HomeLAN is a service provided by the Glasgow Electric Plant Board that attaches our customers to a Local Area Network (LAN). This network allows our customers to have access to local schools, businesses, and the Internet, all at high speeds. The system uses special data channels to transmit data to and from customers' homes by broadband cable; the same broadband cable used to provide cable television programming. The customer receives this data through a Zenith product which is hooked up to their home computer.

Types of Access

There are two methods to access HomeLAN:

- Windows for Workgroups (3.11) or Windows 95.
- The Macintosh Operating System.

In order to access the HomeLAN system, the customer's home PC must use one of the above methods of access.

General Requirements

In order to receive the HomeLAN service, you must receive electric service and cable television programming from the Glasgow EPB. If you are an electric customer and do not receive GEPB cable television programming, you must be scheduled for a cable installation before signing up for the HomeLAN service.

Computer Requirements

Customers must have at least a 386 PC with Windows Version 3.11 or higher, and 4MB of RAM. Although HomeLAN will work on a 386 with 4MB, a 486 or greater with 8MB of RAM is encouraged. Customers will also be required to either lease or purchase a Zenith Elite/Universal. Customers will also need to purchase a 10baseT Ethernet card (see Costs).

Installation

The installation of HomeLAN consists of installing the Zenith equipment and the necessary software. To install the Zenith equipment, the technician will remove the case of the PC and install a network card. The GEPB will supply the customer with a copy of Netscape and Eudora Light. Installation usually takes one and a half to two hours.

Costs

One-time installation fee - \$39.00

Additional cable outlet (if needed) - \$9.95

Unlimited Internet access - \$11.45 per month

Rental of Zenith Universal** - \$9.95 per month

Basic cable - \$13.50 per month

**The Zenith Universal can be purchased for \$425.00. However, a 10baseT Ethernet Card must be purchased when using the Universal. The price of the card varies, but is very reasonably priced. The consumer demand for the service in Glasgow is high.

Evolution and Commercialization of the Monitoring System

As noted earlier in this report, the publication of papers at the DA/DSM, IEEE T&D, PQA, and other conferences as well as a prominent WWW page, lead to significant interest by other utilities in the WWW based power monitoring system. Con Edison was the first to deploy the system

significantly and contributed heavily to this project. Since that time, Con Edison has continued to expand their use of the system and has contracted with Electrotek to enhance it to their specifications.

Con Edison now utilizes the system to make data downloaded hourly from over 100 sites available to engineering, account management, and executive staff within Con Edison. This information is helping Con Edison operate their system in a more efficient manner, support their key customers, and in general, improve their overall system operations.

The power quality component of the system developed for Con Edison evolved into a commercial product called WebPASS. This product provides WWW based access to the power quality event database used for the BMI 8010/8020 PQNode. This product is now a standard offering as an entry level (low cost) WWW based data visualization system for new installations of 8010/8020 based power monitoring systems. This concept is authorized to be applied to other power monitoring instruments at BMI and Dranetz.

The success of the Con Edison use of the system and other publicity resulted in the Electric Power Research Institute (EPRI) becoming interested in employing these techniques in several ongoing power quality related projects. These projects include the Distribution Power Quality (DPQ) monitoring project, the Power Quality Diagnostic System (PQDS) and the PQView power quality database commercialization. The end result was a component of the PQView and PQDS systems called PQWeb that provides a comprehensive WWW based interface to the PQView database for power quality events gathered from several new power monitors in addition to the ones developed during the project.

Since the involvement of EPRI and the availability of PQWeb to EPRI member utilities, several EPRI and non-EPRI member utilities and institutions have implemented the system:

- Con Edison - New York City
- United Illuminating - New Haven, Connecticut
- Tennessee Valley Authority - Chattanooga
- City of Austin Texas
- Entergy - New Orleans
- Southern California Edison
- Westar - Western Resources - Kansas
- PECO - Philadelphia
- Intel - Santa Clara Mission Campus

Figures 19 through 22 illustrates how Western Resources has implemented the system on their Intranet.

Westar Energy

Welcome to the PQWeb at Westar

Power Technology Center

Telephone -
(316) 261-6773

Fax -
(316) 261-6622

Internet -
ptc@wstnres.com

Select one of the following options :

- [Aggregation Preferences](#)
- [Event Viewer](#)
- [RMS Report Setup](#)
- [Display Preferences](#)

Figure 19 - Main PQWeb Page at Westar Energy

RMS Variation Report

Query results for location(s) **3100, Arnold Sub, Boeing Lithograph, Dillons 33 and Sealright** from 02/28/1997 00:00:00 to 05/07/1997 23:59:59 with no aggregation.

Event List

Type	Event Description	Mag (Per Unit)	Duration
RMS Variation	Dillons 33 - Phase B Voltage Momt. Nominal 05/07/97 09:18:31 PM	0.483	5 Cyc
RMS Variation	Boeing Lithograph - Phase BC Voltage Momt. Nominal 05/07/97 09:18:30 PM	0.831	4 Cyc
RMS Variation	Dillons 33 - Phase A Voltage Momt. Nominal 05/07/97 07:42:17 PM	0.889	1 Cyc
RMS Variation	Sealright - Phase B Voltage Inst. Interruption 05/07/97 07:39:30 PM	0.000	20 Cyc

Figure 20 - Event Summary Report for RMS Variations

Figure 21 - Event Details

APPENDICES

Appendix A

Monitoring Equipment Listing

BMI Equipment: Power Visa, BMI 3030A, BMI 4800

Fluke Equipment: Fluke 97, Fluke 41, Fluke 87

Square D Equipment: Square D Circuit Monitor 2350

Communications Equipment Listing

Home Computer Requirements (for HomeLAN)

Customers must have at least a 386 PC with Windows Version 3.11 or higher, and 4MB of RAM.

Although HomeLAN will work on a 386 with 4MB, a 486 or greater with 8MB of RAM is encouraged. Customers will also be required to either lease or purchase a Zenith Elite/Universal.

Customers will also need to purchase a 10baseT Ethernet card.

Software Products

UPLINK - 804 Totalizer

V-LINK - VDR-1200

DEMAND-LINK - APD2430 & APD24357

FMT-100 - APTECH Recorders

MV90 & MVL T - Recorders

PCRP - LPR-2000 Recorders

WinMeter - Criterion

Considerations

Monitoring Fundamentals

Overview of Equipment

Transducer Selection

Safety Concerns

Connection / Disconnection

Monitoring Live Circuits

Intrusive and Non-Intrusive Transducers

Ground Loops

Site Survey Procedures

Basic Site Survey Procedures

Where to Monitor

What to Monitor

Equipment Selection

Analyzing Results

What is Valid Data?

Setting Thresholds on Monitors

Vendor Supplied Equipment

Third Party Statistical Software

Appendix B

Glossary

ATM - Asynchronous Transfer Mode. A high bandwidth network that ranges from T1 to OC12.

B-ISDN - Broadband ISDN, is for high bandwidth services up to 100Mbps.

Bandwidth - A network's capability to transmit data (the amount of bandwidth a particular network has affects the speed of transmission. The greater the bandwidth, the faster the transmission).

Broadband Network - A high-bandwidth network.

Cable Modem - A modem that connects your computer to a cable network. Enables a much faster connection to the Internet.

Compression - A way to reduce the number of bits needed to store and transmit digital media. For example, JPEG is a compression scheme.

Ethernet - a 10Mbps network connection.

Firewall - The virtual barrier between an internal network and the Internet.

FTP - File Transfer Protocol - A simple file storage and transfer mechanism that allows the user to easily gain access to files on the Internet.

Gopher - A distributed database of text documents.

Hypermedia - Audio, video, image or text files that are "linked," or connected, with other such files.

HTML - Hypertext Markup Language. The language that authors use to create pages for the World Wide Web.

HTTP - Hypertext Transfer Protocol. The protocol that allows users to gain access to World Wide Web pages.

Internet - The Information Superhighway. The virtual place in the universe where people all over the world are connected through their computers.

Intranet - A series of HTML or VRML files that can only be accessed within the confines of a LAN (for example, within a university or workplace).

ISDN - Integrated Services Digital Network. A high-speed network that delivers data to and from the Internet over phone lines.

JPEG - Joint Photography Experts Group. An image compression standard.

LAN - Local Area Network. A network that allows computers to connect with each other over a short distance, such as the workplace.

Modem - A device that connects a computer with a phone line, and thus to the Internet or directly to other computers.

MPEG - Motion Picture Experts Group. A compression scheme for digital video.

MPEG2 - Video compression at broadcast quality (30 frames per second).

Multimedia - The mixing of various forms of digital media, including video, audio, image and text, intended for computer playback.

MIME - Multipurpose Internet Mail Extension. Extensions that allow the user, and computer authoring and playback software, to know the kind of format a particular file is in (for example, image.jpeg).

ODBC - Open Data Base Connectivity, is an open, vendor-neutral interface, based on SQL, for accessing heterogeneous relational and non-relational databases.

OLE - Object Linking and Embedding, enables interoperability among distributed objects.

Online Service - A service such as America Online or CompuServe, that acts as a user's "gateway" to the Internet.

PPP - Point-to-Point Protocol, is a standard for data transmission over WAN's, for both synchronous and asynchronous modes.

Proxy Servers - A server that acts as a firewall between an internal network and the Internet.

SCSI - Small Computer System Interconnection. Ports on the computer that allow a user to connect peripheral devices, such as CD-ROM drives or CD-ROM recorders.

T1 - A network connection that operates at 1.54Mbps.

TCP - Transmission Control Protocol, is a connection-oriented transport service for the Internet protocol suite.

Video-On-Demand - A method by which a user could access a video server through their television and play the video of their choice at any time.

WWW - World Wide Web. The more graphical arm of the Internet.

Web Browser - A software-based interface, such as Netscape or Microsoft Internet Explorer, that allows the user to view material on the World Wide Web.

Appendix C

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