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Internet-Based Energy Management Communication System,

The LiveWire Project Final Report

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ABSTRACT

Utilities across the United States have begun pilot testing a variety of hardware and software products to develop a two-way communications system between themselves and their customers. Their purpose is to reduce utility operating costs and to provide new and improved services for customers in light of pending changes in the electric industry being brought about by deregulation . A consortium including utilities, national labs, consultants, and contractors, with the support of the Department of Energy (DOE) and the Electric Power Research Institute (EPRI), initiated a project that utilized a hybrid fiber-coax (HFC) wide-area network integrated with a CEBus based local area network within the customers home . The system combined energy consumption data taken within the home, and home automation features to provided a suite of energy management services for residential customers. The information was transferred via the Internet through the HFC network, and presented to the customer on their personal computer.

This final project report discusses the design, prototype testing, and system deployment planning of the energy management system.

1 Executive Summary

Appendix

Background
The anticipation of increased competition arising from electric utility industry restructuring has causes a growing interest among utilities in two way communication with their customers as a means to provide additional customer services and to reduce operating costs. The rapid growth and ever expanding capabilities of the Internet make it a logical choice as the medium for implementing this two-way communication. It is against this background of exploring new content and connectivity for energy services that sponsors of this project came together. A grant from the Department of Energy to Enova Technologies Inc., an affiliate of San Diego Gas & Electric, and additional sponsorship from Pacific Bell, the Electric Power Research Institute, and Los Alamos National Laboratories set forth the foundations for a project to develop and demonstrate an advanced energy management system in the San Diego, California area.

Objectives
The project intended to develop and demonstrate energy management and home automation services that could be delivered through a high speed Internet connection. The demonstration would take advantage of an advanced broadband, hybrid fiber-coaxial (HFC) communications network being deployed in parts of San Diego by Pacific Bell. A fifty home demonstration was planned in areas of San Diego where the initial deployments of the HFC network were operational.

Design and Development
To build some of the services envisioned for the energy management system, the data which a utility normally collects from its customers could be used. However, because the project was anticipating the changes which would emerge from industry restructuring, it planned to collect more frequent and more detailed customer data than was the current utility practice. To accomplish this, the project needed to adapt existing technology to collect information in the home and transmit it through the HFC network to the Internet and back to a central location. The result was a multi-tiered system architecture which used the Internet both for data collection and presentation to the user.

Results and Conclusions
A prototype energy management system was designed, developed, and tested in a controlled environment. The project, however, was concluded just prior to the deployment phase into the fifty-homes. A decision in June 1997 by the recently merged Pacific Telesis Group, parent of Pacific Bell, and SBC Communications, Inc. to curtail all HFC initiatives forced the project sponsors to reevaluate system deployment. When a replacement broadband network sponsor could not immediately be found, the decision was made to conclude the project at the end of prototype testing and prior to system deployment.

The project offered a unique opportunity for energy and communications suppliers to test new products and services of mutual interest, and to measure consumer reactions to the offered product.

2 Introduction

Since 1992 regulators, public utilities, and other interested parties have been debating deregulation of the electric utility industry in California. In 1996, the California legislature passed Assembly Bill 1890 establishing the framework for industry deregulation which would promote completion among electricity generators, and would provide electricity consumers with choice in their electric service. As the deregulation debate took place, San Diego Gas & Electric Company (SDG&E), to position itself for increased competition, began investigating two-way communication with its residential customers as a means to provide its customers new energy products and services, and to reduce utility operating costs. The rapid growth in utilization and functionality of the Internet, and the recent deregulation of the telecommunications industry were also part of the external environment which influenced the development of this project.

Background

Discussions between SDG&E, Pacific Bell, and the U. S. Department of Energy (DOE), about the formation of a project which would entail energy management, the Internet and high speed communication began in early 1995. The project which emerged from these discussions would demonstrated energy management services over the Internet using a high-speed delivery network. Each of the participants had specific interests which encompassed by the overall project. SDG&E was interested in exploring the capabilities of the Internet to develop new energy service offerings for its customers and to collect the increased quantity of the energy consumption data that would be at the core of these services. Pacific Bell was interested in providing the communication network for this anticipated increase in communications traffic between utilities and their customers. The DOE was interested in promoting energy conservation by informing and empowering energy users, and stimulating new applications for the information superhighway, particularly those which took advantage of high speed communication

The final catalyst for the formation of the project was a grant solicitation from the Office of Energy Research division of DOE in Germantown, Maryland for demonstration of Internet-based energy management services. SDG&E and Pacific Bell agreed to form a project and solicit grant funding from the DOE in early 1996.

Early in the proposal preparation process, it was decided to make the proposal for the DOE grant as Enova Technologies, Inc. (ETI) rather than SDG&E, ETI is an unregulated affiliate company of SDG&E and wholly-owned subsidiary of SDG&E's parent, Enova Corporation (Enova). ETI would also contribute $250,000 in funding to the project, while SDG&E would contribute in-kind infrastructure support and that customer data necessary to support a 50 home demonstration.

The proposal to DOE was submitted in March 1996. It included $250,000 of direct funding from ETI and $200,000 of in-kind support from Pacific Bell. The proposal was accepted in April 1996, and a $500,000 grant was awarded to ETI. The project was formally known as the "Internet-Based Energy Management Communication System" project, but "LiveWire" was soon adopted as the internal project name. LiveWire is the name that is used throughout this report to refer to the project and its associated systems.

ETI was the LiveWire project manager. It entered into participation agreements with each project sponsor, and contracted for all the work performed for the project. Because the project involved a relationship between the regulated and unregulated subsidiaries of Enova, ETI entered into a contract with SDG&E to comply with Enova guidelines on affiliate relationships. The agreement defined the separation between to two subsidiaries, and established the roles and responsibilities of each party in the project.

Before the formal start of the project, the Electric Power Research Institute (EPRI) was solicited for participation in the project. EPRI, in its response to electric industry restructuring, had initiated its own project known as "Customer System 2000" which intended to develop a solution package for utilities that wanted to offer value-added services over the Internet. While the Customer System 2000 project was broader in scope than the project proposed to DOE, it embraced many of the elements encompassed by the Customer System 2000 program. As a result, EPRI elected to participate in the project through its T ¨ ,red Collaboration process.

An additional partner in the project was Los Alamos National Laboratories (LANL). Representatives from LANL had been involved in the earliest project formation discussions, and were instrumental in creating interest for a such a project among the two utility sponsors. In the proposal to the DOE, it was acknowledged that a key system component that could communicate both within the home and over the Internet did not really exist, although several hardware development efforts around the country were exploring that technology. The proposal to DOE included LANL as technical consultant to the project, and the project lead for key communications gateway equipment that was needed to support the planned energy management services.. In accepting the proposal from ETI, DOE also funded LANL separately to support the project.

The formal kick off meeting for the project was in June 1996 in San Diego. The initial tasks of the project were project planning, and kick off of the available technical review by LANL.

During the course of the project, two major organizational changes took place among the project's utility sponsors. In April 1996, just prior to the start of the project, Pacific Telesis Group, the parent of Pacific Bell, and SBC Communications Inc. announced a definitive agreement to merge into a single company under the name "SBC Communications Inc.". One year later, the merger was completed, creating the nation's second largest telecommunications company. Pacific Telesis Group was an SBC subsidiary, and still operated under the brand name of "Pacific Bell" for telephony services in California. In October 1996, Enova Corporation and Pacific Enterprises announced an agreement for the combination of the two companies. Following merger approval by the stock holders of both companies in March 1997, but before final regulatory approval, the formation of a joint venture named Energy Pacific, which would provide integrated energy products and services, was announced. Some of the assets of ETI, including those related to the LiveWire project, were transferred to Energy Pacific. The day to day management of the project, however, remained unchanged, and project agreements remained in the name of ETI.

Project Overview

The LiveWire project intended to develop and demonstrate energy management and home automation services delivered through the Internet. The project would take advantage of a broadband, hybrid fiber-coaxial (HFC) communications network being installed in parts of San Diego by Pacific Bell, and demonstrate its services in 50 HFC-connected homes. The objectives of the project were to:

- Create an interactive energy management interface for customers using the existing SDG&E Internet Web site
- Use Pacific Bell's newly deployed broadband communications network as a two-way information communication system for energy management and Internet connectivity
- Demonstrate the unique value of Pacific Bell's full service broadband network
- Develop and demonstrate a universal interface device that provides communication links between energy meters, customer appliances, energy providers, and the customer's PC
- Provide customers with information on their energy consumption, incentives for changing their energy consumption patterns, and the ability to control major energy consuming appliances
- Demonstrate the value to the customer of linking energy data and broadband connectivity to other value added information sets, such as household budgeting and telecommuting

The project was managed and cosponsored by ETI. The total project budget was $1.3M with $850K in actual direct funding consisting of a $500K grant from DOE, $250K from ETI, and $100K from EPRI . Los Alamos National Labs, through independent funding from DOE, and Pacific Bell provide in-kind contributions to the project for the remainder. SDG&E was also a project participant, providing infrastructure support. The installation of the LiveWire system was planned to begin in May 1997 and demonstration will run through November 1997.

Project Members

Implementation of the LiveWire energy management system required a skilled project team involving different companies, each assigned with specific tasks and roles. Table 2-1 shows the participating organizations and their key functions:

Organization	Contact Name	Address	Project Role
Department of Energy (DOE)	Mary Anne Scott	19901 Germantown Rd. Rm. ER-31 Germantown, MD 20874 (301) 903-6368	DOE Sponsorship & Project Support
Enova Technologies, Inc.	C. David Brown	9855 Scranton Rd San Diego, CA 92121 (619) 547-1445	Program Management
Echo Images	Norman Manes	4747 Morena Blvd. Suite 100 San Diego, CA 92117 (619) 270-4300	Web Page Development
Electric Power Research Institute (EPRI)	Sekhar Kondepudi	3412 Hillview Ave. Palo Alto, CA 94304 (415) 855-2131	EPRI Sponsorship & Project Advisory
Los A[illegible]s National Labs (LANL)	William Bostwick	P.O. Box 1663 Mail Stop B260 Los Alamos, NM 87545 (505) 665-7760	LANL Sponsorship & Project Support
Pacific Bell	Dana Crews	2410 Camino Ramon Rm. 240-H San Ramon, CA 94583 (510) 806-5881	Broadband Services Network Support
Paragon Consulting Services	Joseph Kelly	1925 McKinley Ave. Suite G La Verne, CA 91750 (909) 596-9626	System Integration and Project Management
San Diego Gas & Electric	Tiff Nelson	8330 Century Park Court San Diego, CA 92123 (619) 636-6822	Project Management, Contracts & SDG&E Coordination
Systems Integrated	Michael Jenkins	8080 Dagget St. San Diego, CA 92111 (619) 277-0700	System Installation & Operational Support
Unity Systems	Tom Riley	2606 Spring St. Redwood City, CA 94063 (415) 369-3233	Home Controller Development

Table 2-1: LiveWire Team

Project Conclusion

In June 1997, SBC Communication, Inc. announced several strategic decisions resulting from its merger integration process with Pacific Telesis Group. Included among those announcements was the decision to curtail all hybrid fiber-coaxial (HFC) initiatives, including the Pacific Bell deployments in San Jose and San Diego, California, to focus on other network architectures for communications services. The HFC network in San Diego was the communication link around which the LiveWire system was designed, and it appeared that the San Diego HFC network would be shut down before meaningful testing and customer deployment could take place. The project sponsors investigated a number of replacement options for a high speed communications network, including Asymmetric Digital Subscriber Line and local cable TV. However, the constraints of a completed system design and pending deployment made it difficult to find a replacement communications network partner for the project in a time frame that would not have significant adverse impact on the project's schedule and budget.

In late July, when it became apparent that a suitable replacement partner could not be found in a timely manner, the project sponsors elected to suspend the project at the completion of prototype testing prior to system deployment, and release unspent project funds back to their respective sponsors. Prototype system testing and web site development was completed in August, and project wrap up and documentation followed over the next two months.

While the LiveWire system was not deployed, the vision of the project sponsors from two years ago has been validated as details on electric industry restructuring emerge. The system architecture that evolved from LiveWire is serving as a model for current business systems at SDG&E that are being implemented to satisfy the some of the requirements of industry restructuring. The LiveWire web site, originally intended only to serve the 50 demonstration customers, has partial capability for all SDG&E customers, since it was designed around a new data base structure that is now operational, in part because of the requirements of the LiveWire project. The project has also surfaced the concern over the security of customer data and its vulnerability to attack from through the Internet connection which provides the connection to the customer. A follow on project sponsored by EPRI and DOE will look at the security implications of utilities offering energy related services, like those encompassed by LiveWire, over the Internet, with the LiveWire system serving as a model and test bed for the project.

3 Technical Description

System Overview

The system which was developed for the LiveWire project integrates broadband network technologies for high-speed Internet access, with an in-home data collection and control network and an interactive energy management user interface. The system would let customers review and manage their home energy consumption, providing customers with a tool that would help them understand energy costs and usage patterns while finding ways to save money. The system would also offer potential utility operating cost savings by providing a means to automate bill presentation and payment, and to collect the increased volume of electric consumption data needed to support the hourly pricing tariffs which are emerging from electric industry restructuring.

The LiveWire system architecture consists of three interconnected elements: an in-home, powerline carrier local area network (LAN) with a controller unit; a broadband wide area network (WAN), and a back-end data processing system. The customer's PC running a standard Internet browser servers as the user interface to the system. Figure 3-1 depicts the overall LiveWire system architecture.

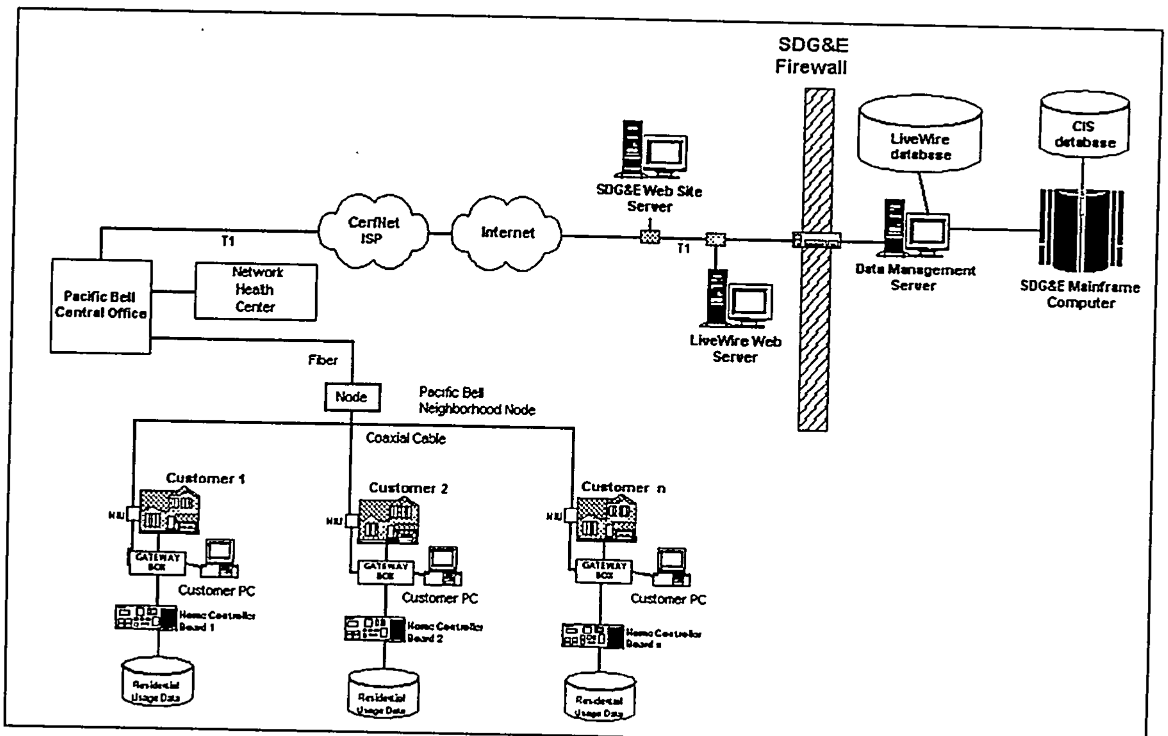


Figure 3-1: LiveWire Network Diagram

The WAN communications infrastructure provided by Pacific Bell's HFC Network and the World Wide Web served a dual functionality using two different communications protocols. The in-bound communication to the customer premise, which provided the Internet user interface to the LiveWire services via a high-speed connection, used the Internet standard TCP/IP communications protocol. Out-bound communication from the home, which consisted of data collection back to the utility server, used the UDP stack of the TCP/IP communications protocol.. The topology of the Pacific Bell network allowed the controller device located in the customer home to be a node on the network enabling the utility server to poll it directly and the institution of some security measures in the home controller by allowing it only to respond to certain node addresses.

CEBus[1] was selected as the powerline carrier communication protocol for the in-home LAN. An existing commercial CEBus controller was modified to incorporate a physical connection to the broadband network and TCP/IP communication with the back-end data processing system and associated Internet servers. The CEBus power line carrier (PLC) interface allowed the home controller to gather energy usage data gathering from CEBus appliance monitors and house meters. Time-stamped usage information was retrieved and processed by an application running on a web server via the Internet on a daily basis. In addition, energy usage data, customer account information and billing history was stored into a data manager server and available upon secure customer requests through the LiveWire web site.

The customer services envisioned by LiveWire are driven by the underlying data. The user interface is designed so that new features can be added as the supporting data becomes available. The three categories of LiveWire customer services are described below.

Basic LiveWire incorporates services built on standard utility customer billing and 30 day consumption data. The services are bill presentation and automated bill payment, graphic bill and consumption history, and bill segmentation through an on-line energy survey. The core element of these services is extraction and manipulation of existing data from the SDG&E legacy system.

AMR Enabled LiveWire incorporates services built around the hourly and daily energy consumption data normally available through implementation of an automated meter reading (AMR) system. While the LiveWire hardware installed at a customer's home will provide AMR-like data, these services are independent of the source of the data. These service features are hourly and daily load profiling, projected energy bills, and energy usage / bill to date.

Gateway Enabled LiveWire incorporates services built around equipment that must be installed in a customer's home. These services will allow the customer to monitor actual energy consumption by appliance, to receive information on projected energy prices, and to control lighting and appliances according to pre-defined criteria established by the customer. The gateway box can also become an avenue for providing other services to the customer such as home security.

[1] CEBus (Consumer Electronics Bus) is a communications standard for residential consumer products formulated by the Electronics Industry Association (EIA). The standard specifies rules for residential devices to interoperate and talk to each other using a common language over different media such as RF, power lines, infrared, and twisted pair

Residential Local Area Network

The residential LAN consisted of a gateway box, utility meters, appliance monitors, and a customer-provided PC (see Figure 3-2 below). To simplify the design a minimum specification of a '486 processor and 16 MB of RAM was placed on the PC. Refer to appendix section 9-5 for a detailed description of minimum PC hardware and software requirements. In addition, the project wired-in an Ethernet line that connected to a gateway box enclosure located on the side of the customers home. CEBus appliance modules collected specific appliance energy consumption data and transferred the data via CEBus power line carrier communications to a home controller board (HCB).

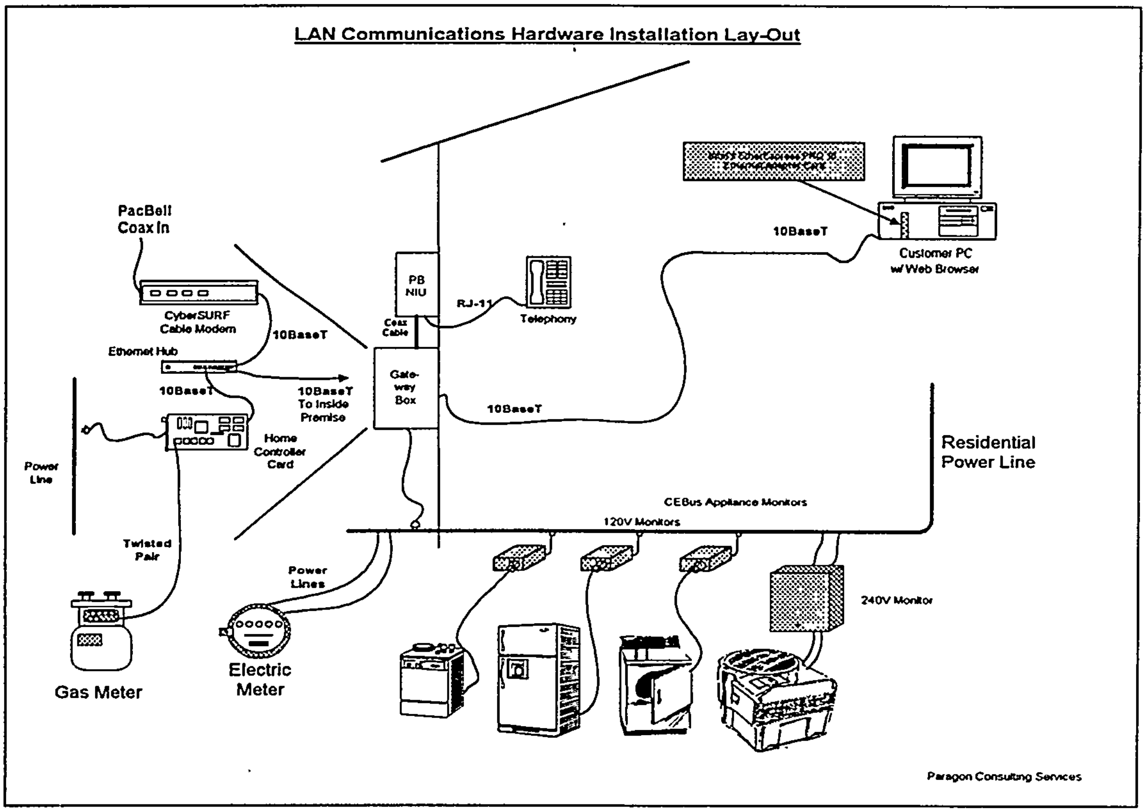


Figure 3-2: LiveWire Residential LAN

A gateway box was designed to house most of the electronic equipment required at each home. Although some of the equipment would normally reside within the home, like the cable modem, project members decided to minimize intrusion into the participating customer homes. Therefore, enclosing hardware equipment outside of the customer home would provide a convenient way to test and troubleshoot the system. Internally, the gateway box included a cable modem, a CEBus home controller board, an Ethernet hub and their respective power supplies. Electrical connections between the gateway box and the residential electric meter were also established to provide the 120VAC power source to the gateway box. Power was drawn from the utility side, thus avoiding electric consumption costs from the gateway box to project participants. The electric meter utilized in the project was a General Electric (GE) CEBus unit that communicated via PLC to the home controller board. The existing residential gas meter unit was replaced with an American gas meter retrofitted with a pulse initiator module that transferred its pulse data over a twisted pair connection to a home controller board.

At the time that the project was initiated, a controller which could perform all necessary functions to support the envisioned LiveWire services was not commercially available, although several companies had suitable hardware products in various stages of development. The first steps in getting the necessary controller for the project were taken by Los Alamos National Laboratories (LANL) which was providing technical support for the project. LANL reviewed the existing residential controller products and powerline carrier protocols that could provide some of the required functionality for the LiveWire project. As a result of the comparison analysis performed by LANL (see appendix section 9-3) CEBus was selected by the project as the power line carrier communications protocol to be used for the residential LAN.

Selection of suitable controller hardware for the project was a more difficult task. After review of the current state of available technology by LANL, it was decided by the project that development time would be the shortest by modifying an off-the shelf component to meet the projects requirements. Unity Systems, Inc. (Unity) of Redwood City, California, was found to have a commercially available CEBus controller which performed all the necessary LAN control and monitoring functions, and which could be modified to provide the necessary WAN communication functions. After an initial feasibility study was performed by Unity, a contract to was issued to them to make the necessary hardware and firmware modifications to their current CEBus Controller Card to fulfill the LiveWire home controller requirements. Unity's original CEBus card did not support Ethernet TCP/IP communications; therefore, some hardware and software development was needed to provide this functionality into a new home controller board.

In addition to the analysis of LAN communications protocols, LANL also performed an analysis (see appendix section 9-4) of WAN communications protocols for the home controller and recommended using the UDP (User Datagram Protocol) of the TCP/IP protocol suite. The UDP protocol is less complex than TCP/IP, and has a lower communication connectivity "overhead". In most cases, the home controller is polled, and does not initiate a transaction. The server sends a single datagram to the home controller, which then sends a single datagram back in response. Thus, it is a transaction process, with one request and one response. If the server does not get a response, or if the response is corrupted, it simply retries the transaction by sending the same packet again. The LANL analysis also included the message packets and packet format that would be required by the home controller. These message packets were also part of modifications implemented by Unity to their CEBus controller card.

The LiveWire system requirements included reading both gas and electric meters. While CEBus powerline carrier is a suitable means to read the electric meter, wireless technologies were initially investigated for the gas meter. Several options involving wireless, RF communication between a battery powered gas meter transmitter module and an RF receiver with CEBus output capability were analyzed, but in each case, the cost was high. In order to reduce equipment costs, a hard wired solution for gas meter reading was then reviewed, since an investigation of the proposed LiveWire deployment area revealed that gas and electric meters were typically located in close proximity. The gateway box, which contained the home controller, was planned to be located close to the electric meter as the source for electric power, so any wiring between the gas meter and gateway box would be minimal. A quick feasibility study performed by Unity concluded that they could modify an existing serial input capability on their controller card to perform a pulse counting function at a relatively small incremental cost to the production controller card. As a result, the output from a commercially available gas meter pulse initiator from Riotronics® was planned to be incorporated into the new home controller board to provide gas meter reads.

The home controller board was planned to be CEBus and Ethernet 10BaseT compliant. Its basic functionality intended for the LiveWire project included the following:

- Serve as a residential gateway to the utility (SDG&E) via the Internet
- Respond to queries for energy usage information
- Perform pre-defined load control functions
- Read and log total house and appliance electric energy usage consumption data
- Read and log gas meter module pulse counts
- Store and trigger homeowner-defined appliance load control events

Figure 3-3 describes a block diagram representation of the home controller board and its main circuit components.

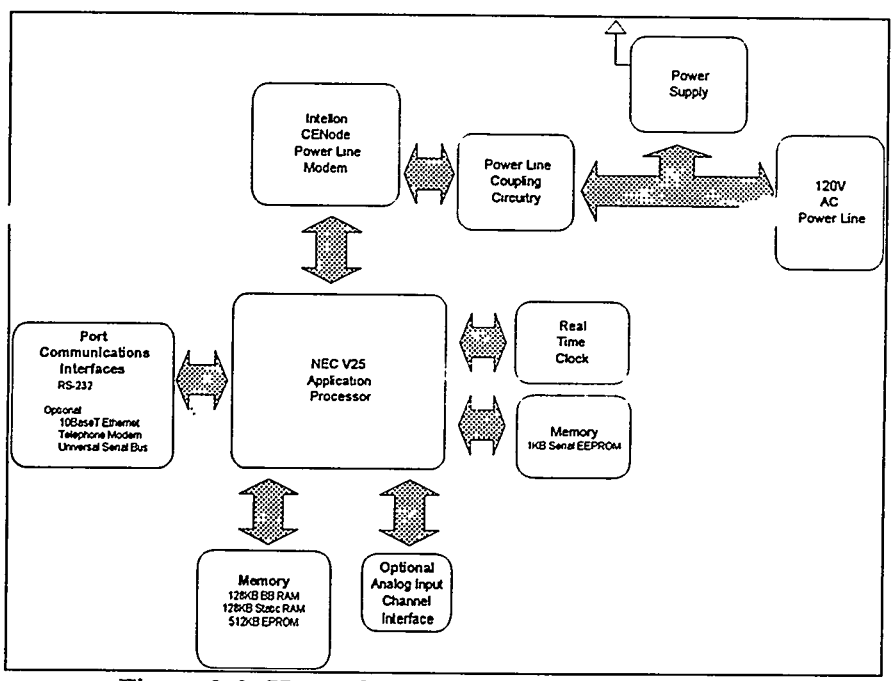


Figure 3-3: Home Controller Board Block Diagram

In order to identify particular CEBus nodes within each project premise, specific device addresses were assigned to each node. A CEBus device address is comprised of two parts: a "House" code and an "Unit" code. Together, they form the node's complete address on the global network. Both house and unit codes are 16-bit numbers in the range of 0H to FFFFH. The house code was used in the project to partition the address space of devices in one home from devices in another home.

Load control capabilities were planned to be supported within the CEBus LAN network. The home controller board would control appliances based on criteria set by the customer through the web page. Appliance control set points would be determined by the customer and relayed by the web server back to the home controller based on the proposed LANL data format specifications.

In summary, the cost for each LiveWire LAN component can be found in appendix section 9-2 and the functionality of those components is presented below. The specification sheets for LAN components can be found in appendix section 9-8.

Component	Function
120V CEBus Appliance Monitor and Load Controller	• Measures Appliance Electric Energy Consumption and Provides Load Control for 120V Appliances
240V CEBus Appliance Monitor and Load Controller	• Measures Appliance Electric Energy Consumption and Provides Load Control for 240V Appliances
CEBus Electric Meter	• Measures Total House Electric Energy Consumption
Gas Meter Encoder Module	• Counts Gas Meter ½ Pointer Shaft Cycles
Home Controller Board	• Collects and Stores Data from CEBus Electric Meter, CEBus Appliance Monitors, and Gas Meter Encoder • Sends Stored Information to Data Manager Server when Requested • Sends Control Commands to CEBus Appliance Monitors Based on Defined Scheduled Events
Cable Modem	• Provides High-Speed PacBell Internet Access Link and Return Path for Home Controller Board Data
Pacific Bell NIU Unit	• Provides High-Speed Data Connectivity to the Home and Telephony Services
Ethernet Hub	• Expands Ethernet Local Area Network
Customer PC	• High-Speed Internet Access • Provides Customer Interface for Energy Management System via Web Page

Table 3-1: LiveWire LAN Components

Wide Area Communications Network

The wide-area network consisted of Pacific Bell's advanced HFC network linked to the Point of Presence (POP) of an Internet access provider and the Internet itself. In order to provide cable modem communications over the HFC network, a cable modem router was installed at Pacific Bell's central office, and linked to CerfNet, the project Internet service provider (ISP), through a T1 connection[2]. At the start of the project, Pacific Bell Internet (PBI), an unregulated affiliate of Pacific Bell, had planned as the ISP for the project. In its advisory file to the California Public Utilities Commission (CPUC) for the ability to use its HFC network for limited data service to support the project, Pacific Bell was told by the CPUC that they could not use PBI as the project ISP since it had the appearance of a regulated affiliate soliciting customers for the unregulated affiliate. As a result, the project contract with CerfNet, SDG&E's ISP, for Internet access for the project.

From the central office, RF flow switches are activated for each customer enabling the data transport from a host digital terminal to Pacific Bell's network interface unit (NIU) located on the customer home. Signals received at the NIU (shown in Figure 3-4) are filtered and assigned for either telephony or data service spectrums. Non-telephony signals allocated for the data bandwidth are routed to the Motorola cable modem residing inside a LiveWire gateway box.

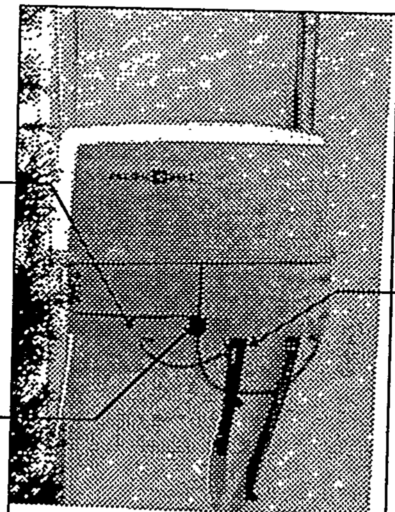


Figure 3-4: Pacific Bell Network Interface Unit (NIU)

Pacific Bell's Network Health Center (NHC) ensured that the RF flow to and from each project customer over the HFC network was configured properly, and that each cable modem was registered under the cable modem router configuration table. In addition, the NHC had the capability for pro-active network monitoring and management throughout the test trial, thus detecting network problems and notifying the central office for a prompt problem resolution. Figure 3-5 describes the Pacific Bell configuration network set-up for the LiveWire project.

The network operates up to 27 Mbps downstream (from cable router to the home) and 600 Kbps upstream (from home to the cable router) over a shared configuration. The data throughput perceived at the customer home varies according to data traffic congestion and the limitations of the customer hardware. The asymmetrical configuration is based on the

[2] Marks, Mike. "LiveWire Project: Conduct Project Activation/Deactivation". Pacific Bell Advanced Communications Network Group. April 23, 1997.

fact that normally customers download from a web server larger data files with rich graphical content, while the size of data streams uploaded from the customer home to a web server are typically small. The target cable modem data throughput for LiveWire customers was estimated at a maximum of 1.5 Mbps on the upstream direction and 384 Kbps on the downstream path.

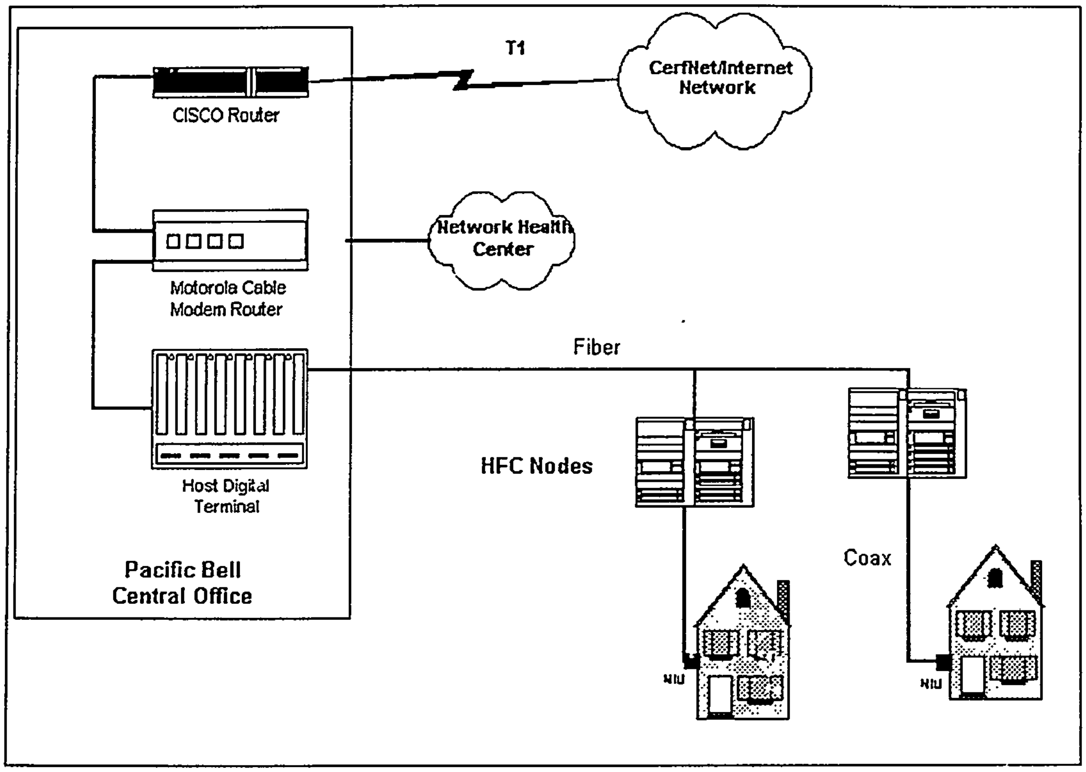


Figure 3-5: Pacific Bell LiveWire Communications Network

Although only limited to telephony services for regular customers in San Diego, the Pacific Bell advanced communications network is capable of supporting new services such as analog and digital broadcast video, inter-active video, and high-speed data transport.:

Back-End Processing System

The elements of the back-end processing system on the utility side included data collection and data validation components, a web server application, and a data warehousing mechanism residing inside the utility firewall, thus safeguarding the customers information (Figure 3-6). The following table summarizes functionality for the servers integrated into the LiveWire project:

LiveWire Servers:	Function:
Web Server	• Hosts LiveWire energy management web site • Hosts Energy Audit module • Provides link to Data Manager Server for customer data transfer/retrieval

Data Manager Server	• Stores LiveWire customer data from home controller • Stores SDG&E legacy system customer data

Table 3-2.- LiveWire Servers Functionality

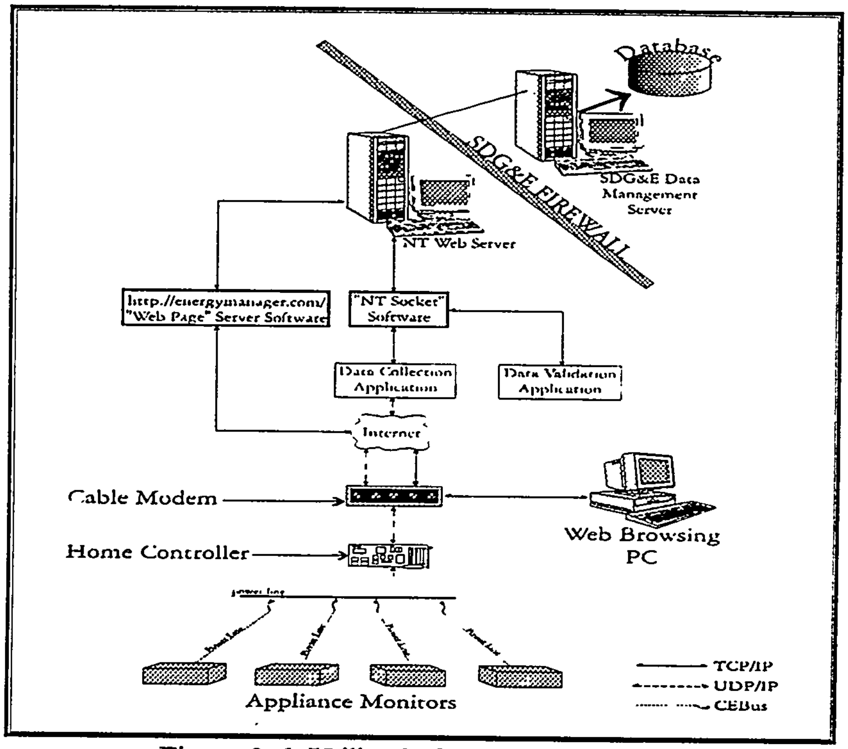


Figure 3-6: Utility Software Components

Servers Specifications and Requirements

To support value-added services provided to SDG&E customers through the LiveWire energy manager web page, both the web server and data manager server required to meet the following specifications:

- Web Server
  - ◊ Installed Software:
    - ◊ Windows NT v.4.0
    - ◊ Microsoft Internet Information Server v.3.0
    - ◊ PERL Compiler v.5.0
    - ◊ ColdFusion v.2.0
    - ◊ dbAnywhere v.1.0
  - ◊ Minimum Hardware Requirements:
    - ◊ (1) Compaq Proliant 1500R Server with 5/166 Processor
    - ◊ (1) Smart-2 Array Controller/PCI
    - ◊ (1) Remote Server Manager Board

- ◊ (3) 4.3 GB Pluggable Fats-Wide SCSI-2 Drives
- ◊ (2) 64 MB Memory Expansion Kits (2x32)
- ◊ (1) External 15/30 DLT Tape Drive
- ◊ (1) 15/30 DLT Cartridges (7-Pack)

- Data Manager Server
  - ◊ Installed Software
    - ◊ Windows NT v.4.0
    - ◊ SQL Server v.6.0
  - ◊ Minimum Hardware Requirements
  - ◊ (1) Compaq Dual Pentium 2-P5/166 Server
  - ◊ (1) 256MB RAM Memory
  - ◊ (1) 21GB SCSI Hard Drive
  - ◊ (1) External Back-Up Tape Drive

Database Manager and Web Servers

To support large quantities of data, primarily energy consumption data, that must be collected and processed, a data management system was required. Since most utility databases typically do not accommodate the quantity of residential energy consumption data that was anticipated for the energy management system, a separate database was developed. In addition to receiving, processing and storing energy consumption data, the database system also needed to interface with other mainframe computer systems, such as the utility legacy system for billing functions and the LiveWire web server for energy management functions. The client/server interaction between the web page application and the utility database manager server was based on a three-tier architecture. This type of architecture takes advantage of current advances in networking and high speed distributed environments, providing the additional benefit for implementing controls over user queries, without hindering the database performance.

The project web site developers applied advanced third party software development tools for web server applications such as Symantec's "dbANYWHERE.". In order to access the data from the database server, Java applet threads launched from the web server used JDBC classes provided by the middleware which converted the Java to the appropriate SQL calls to the database. Depending on the user requested web page feature, data was obtained from any of the following sources: home controller board, data management server, or the web server. See Figure 3-6 for a description of the LiveWire network system configuration and its associated utility server applications.

SDG&E's Information Technology Services Department was responsible for the LiveWire database design and to oversee its development and system performance. The database contains specific utility customer information, energy usage and monitored devices data, and communications ID's such as fixed IP addresses assigned to each customer. While, relational databases provide easy access to the information, open access to this data brings on its own set of security issues. Therefore, plans were made for adding an additional firewall leg inside the utility, thus isolating the LiveWire data management server from SDG&E's local area network ring. Appendix section 9-6 provides a block diagram representing the final LiveWire database architecture.

Data Collection and Validation

Communications from the utility server to the home controller was done using the UDP (Unreliable Datagram Protocol) stack of the TCP/IP protocol. SDG&E contracted a software developer to build a "NT Socket" data collection application. The NT Socket application, which was written in Microsoft Visual C++, ver. 4, runs on a multi-tasking Windows NT operating system environment and resides in the web server PC. Internet communication from the home, either controller data or web site interaction, is routed from the web NT server to either the web page or the NT Socket applications based on a dedicated port number assignment. Figure 3-7 shows the screen window corresponding to the NT Socket data collection application.

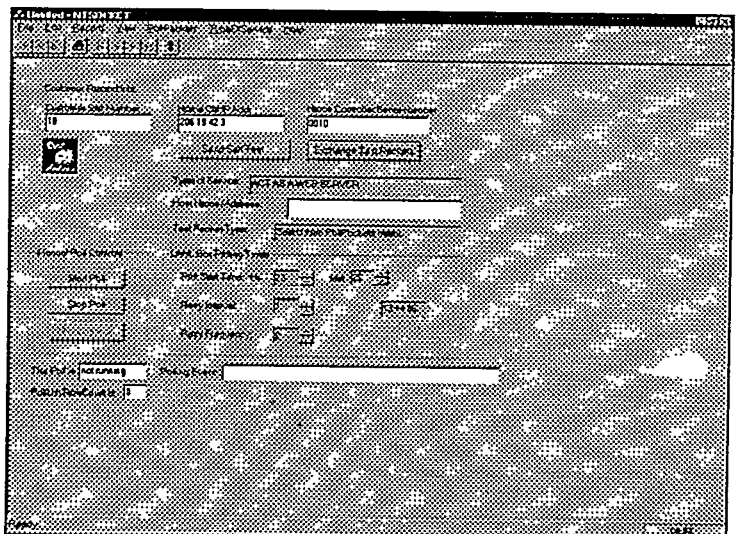


Figure 3-7: NT Socket Software Application Screen

For the majority of the home controller and utility server transactions, the home controller was polled by the NT Socket application, and did not initiate a transaction. In addition, the home controller was programmed to respond only to certain IP addresses as a security measure. The utility server sent a datagram to the home controller, which then sent a datagram back to the to the utility server in response. If the utility did not get a response after a time-out period, or if the response was corrupted, it simply retried the transaction by sending the same message packet again. The number of message retry attempts and time period between each retry were manually configurable parameters on the NT socket application. The only instance when the home controller initiated a message packet to the utility server was when the home controller had just rebooted or initialized in the network.

This table summarizes the data transfer messages supported between the home controller board and the NT Socket data collection application. (see appendix section 9-4)

Home Controller Message:	Function:
Read Appliance Request	Request the Home Controller to read the power usage associated with a specific appliance, including the house meter.
Read Appliance State Request	Request the Home Controller to report the 'On/Off' state of the specified appliance.
Write Appliance State Request	Request the Home Controller to change the 'On/Off' state of the specified appliance.
Read Scheduled Events Request	Request the Home Controller to report the number of events currently scheduled.
Read Schedule Request	Request the Home Controller to upload the control schedule associated with the specified appliance.
Write Schedule Request	Request the Home Controller to accept a new control schedule associated with a specific event number.
Write Rate Request	Request the Home Controller to accept a new set of electricity rates specified by the utility.
Write Time and Date Request	Request the Home Controller to update its real-time clock.
Read Controller Database Request	Request the Home Controller to report the database of all units it is monitoring or controlling. This is done so that the database for the appliances and meters that are being controlled or monitored is set up only in one place, preventing a mismatch of databases in the home controller and the Web Server.
Self Test Request	Request the Home Controller to perform a self test of its system. The Controller Type and Version fields specify which type and version of the controller is running at this address. The test results give a more detailed result of the self test, and would include detailed information about any failures.
Initialization Request	The Initialization Request is the only unsolicited request sent by the Home Controller to the Data Manager Server. This request informs the Data Manager Server that the Home Controller has lost all its information, and needs to be reloaded.

Table 3-3: Home Controller Messaging Support

Data packet formats for the home controller were structured as sets containing 32-bit data fields to facilitate processing. Each of the home controller packets started with a function type field, followed with a status field. Any other response than zero under the status filed indicated an error message and message data was flagged as invalid. For most of the home controller messages, a Customer ID file was included to identify specific customers communicating over the network, as only one home controller board was deployed for each customer.

Appliance and meter kWh counter data would be retrieved from the home controller according to a schedule set in the NT Socket application. Home controller information, electric meter, gas meter and appliance usage readings, would be polled by the utility server once a day. The home controller would poll the household appliances and meters on a much more frequent basis, and store that information for later response to the utility server poll. The typical polling interval for CEBus appliance modules was one-hour, where the values were processed and validated, before being written to consumption tables. Inaccurate data is modified where possible and flagged as such. Also, any data which is inaccurate and unable to be fixed is flagged as null. This will allow the inquires made by the Web server component to be aware of estimated and unusable data.

For data processing and validation purposes, a software application referenced as "Smooth.exe" was developed by the same software contractor as the NT socket application to automatically calculate interval energy usage data for each customer and validate processed data before populating the consumption database tables. The Smooth application, developed in Microsoft Visual Basic 5.0, compared reported energy usage values against calculated maximum threshold values for specific appliances. Moreover, missing data intervals or blanks (i.e. due to PLC interference) were filled-in by estimating end-use averages. In sum, the data processing and validation component consisted of the following:

- Processing of the home controller reported meter and appliance data into an ANSI SQL-Complaint database
- Validating the data for accuracy
- Correcting inaccurate data where possible

Figure 3-8 below shows the data flow path from the customer homes to the data collection and processing servers residing at the utility.

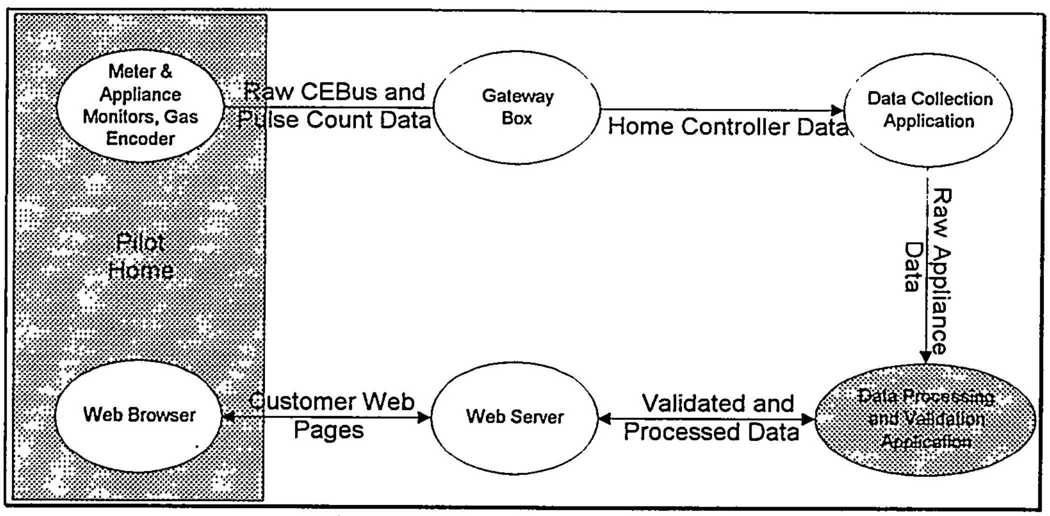


Figure 3-8: LiveWire Data Flow

In addition to storing finished data received from the home controller, the data management server also hosted a data warehouse populated with SDG&E customer consumption and billing information from the SDG&E legacy system. In addition to supporting certain features of the LiveWire web site, this data was used by other SDG&E applications such as the on-line energy audit.

Database Connectivity
The LiveWire web site design is based on a three-tiered architecture. The dbANYWHERE application, which runs the web server, adds a layer of security by acting as a middle ware server between the client and the msSQL data server.

The browser first requests an HTML page from the web server. As the proper HTML page downloads to the client, a Java applet is also downloaded. As the page loads, the header information, Javascript methods start the appropriate applet threads for that page. These threads obtain the data requested by the page, and store it in specific objects.

Depending on the page being loaded, the data is obtained from at least one of the following sources: the home controller card, the data management server, and/or the web server.

If the requested page requires data from the data management server, a connection to the database, all the information needed for that page is obtained, and the connection is dropped. In order to access the database, the Java threads use JDBC classes provided by dbANYWHERE. When the dbANYWHERE server receives the JDBC query from the client, the query is wrapped in the proper format, and sent to the data management server. The database returns file to the dbANYWHERE server, which then wraps it in the proper object and sends it back to the client.

Web Site Presentation

One of the goals of the LiveWire project was to explore new and emerging technologies as they apply to the delivery of high-bandwidth services to a group of pilot participants. The high bandwidth provided by the Pacific Bell HFC network provided an opportunity to create a web based client-server application that could dynamically process requests and user selections, and deliver that information to the server where it could then be stored, processed, and possibly returned to the user. The high-bandwidth access to the Internet would facilitate the use of a variety of Java applets (or mini-applications) that could, among other things: dynamically refresh screen data, provide motion-based or animated feedback to the user while the user selected or viewed various components, and would allow for rapid and reasonably secure transfer of data between the client and server.

For the user interface portion of the system, a web site developer, Echo Images, Inc., was hired. The LiveWire web site employs a three tier architecture and runs a set of graphical user interfaces involving HTML pages, CGI and Java scripts on the customer's web browsing PC. In addition, a middleware package is used for database accessibility to the SQL data manager server located inside SDG&E's firewall.. Consequently, data source information is requested by a client-side applet, and after a query statement is received by the data source, it replies with properly formatted return values again via a JDBC applet. The bandwidth afforded by the Pacific Bell network allowed the extensive use of Java applets to create a web based client-server application that could dynamically process requests and user selections and deliver that information to the user.

The LiveWire web site, which used the URL energymanager.com included the following modules:

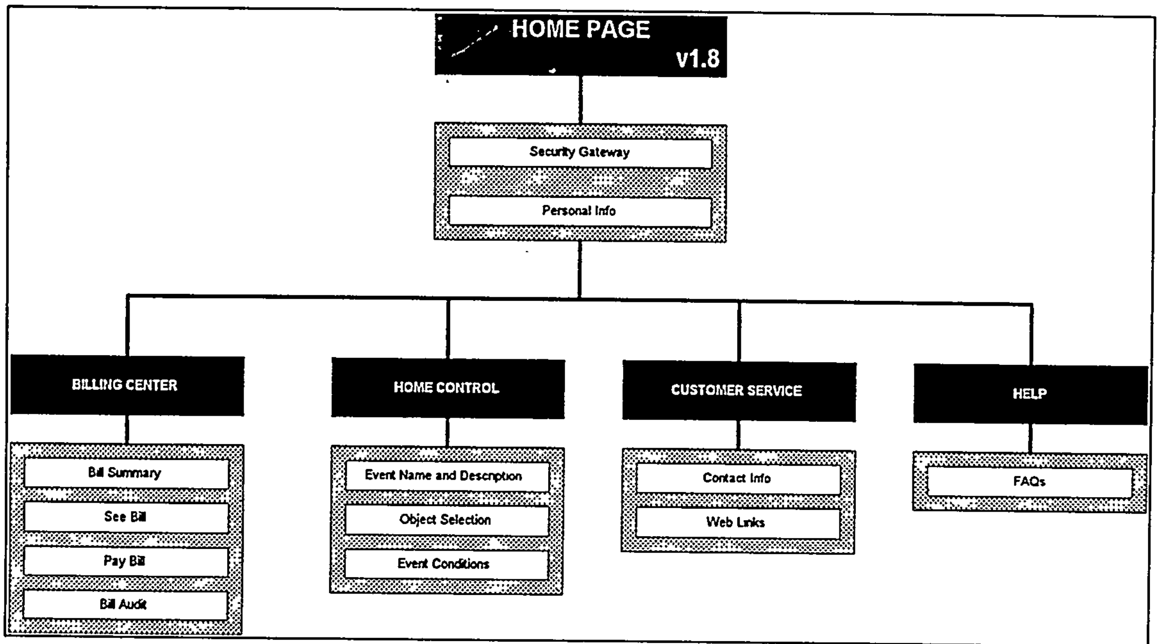


Figure 3-9: LiveWire Web Page Components

The corresponding functionality for each web page module can be summarized as follows:

- Energy Manager Main Home Page. The public home page provides generic information about LiveWire features and offers a system demo. Inside the security gateway, a second personal home page allows customers to personalized their main LiveWire screen with other information such as weather, news, sports, stock market, and favorite web links.

- Security Gateway. Provides :. login screen to the user that allows them to uniquely identify themselves to the web server for access to their energy information.

- Billing Center. This module presents to the LiveWire customer a summary of the customer SDG&E account, including bill hi^ctory, actual image of current bill, bill payment option, estimated bill projection for current billing period, and an energy audit application with residential energy efficiency information.

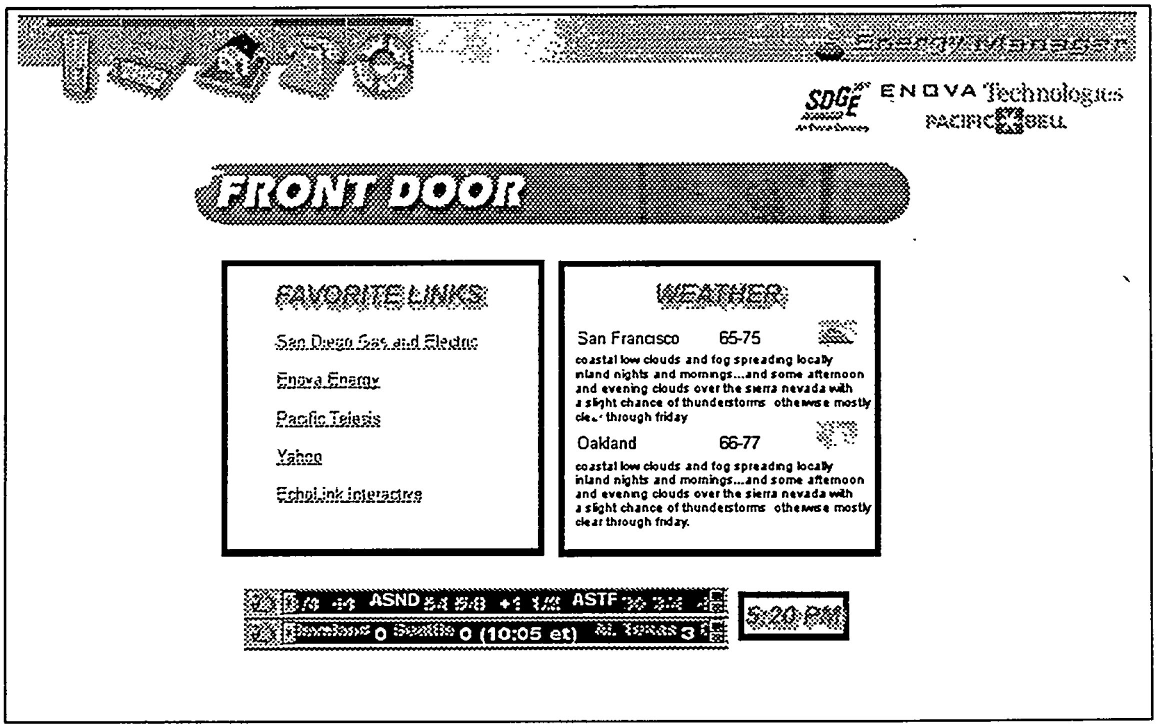
- Home Control. Presents to the customer data entry fields for setting up event scheduling profiles for load control via CEBus appliance monitors triggered by the home controller board residing inside the LiveWire gateway box.

- Customer Service. This section displays useful information to the customer such as toll free phone numbers for LiveWire customer technical support.

- Help. This component provides a list of frequently asked questions and answers. In addition, an on-line manual organized by topics allows the customer to quickly familiarize themselves with informative LiveWire topics and web page navigational details.

Energy Manager Home Page Module

Once a customer successfully logs into the energy manager web site, they reach the site home page, or "front door". The page is the center for navigation to the other web page modules, and provides useful information that is customizable by the customer. That information can be favorite web site links, or real time information such as news headlines, sports scores, stock quotes, or weather. A prototype of the home page is shown below.



Security Gateway Web Page Module

The security gateway is the first screen that a user sees when they log into the energy manager web site. It allows the utility to uniquely identify a customer with their data, and provides the customer with some assurance that only they can view their energy information. As part of the On-line Energy Audit project, SDG&E conducted an analysis of data elements that would link a customer to their utility account, and would not be susceptible tampering by unauthorized parties. That study selected three data elements, account number, electric meter number, and zip code, all of which are available from a customer's paper bill. The LiveWire project adopted these same data elements for its security gateway. In addition, a customer was asked to enter a four digit Personal ID number (PIN) on the first time that they enter the site. On subsequent visits to the energy manager site, a customer is only prompted for their PIN.

Summary Bill Web Page Module

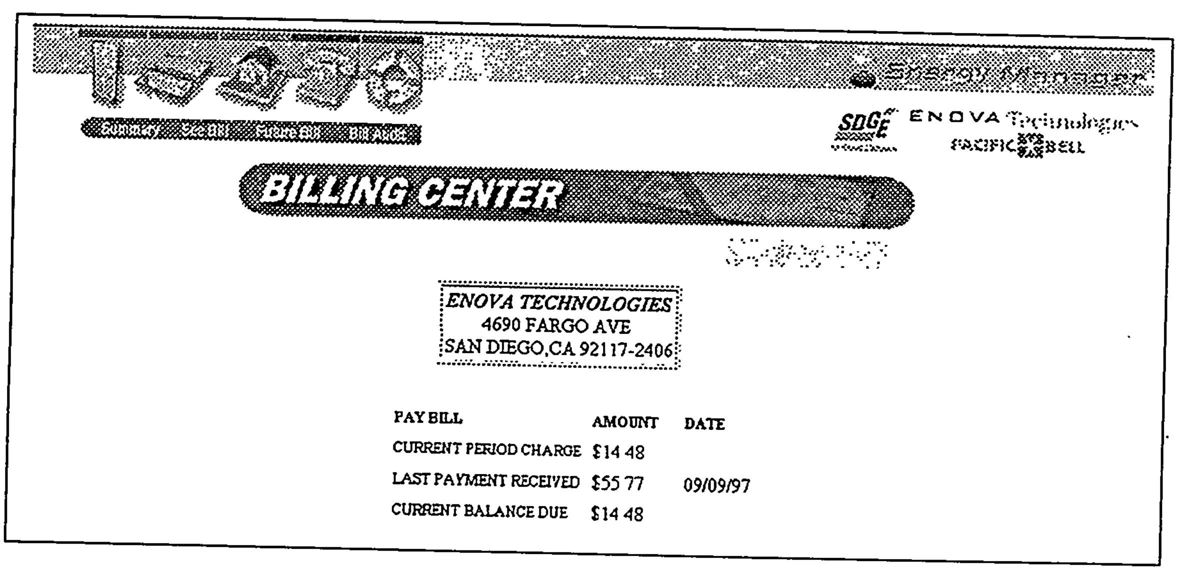
The Summary Bill page is the default page in the Billing Center module. It is intended to give customers basic information about their current energy bill. It would also show the status of their account as of the last business day and allow customers, through interactive graphs, to view past usage and billing history. With a few exceptions, all of the information presented on the SDG&E paper bill was available through the Summary Bill page, and the interactive graphs provided access to much more consumption history than was contained on the paper bill. The source data for the history graphs was from both the SDG&E legacy system and the LiveWire home controller. Both sets of data resided on the data management server.

The table below shows data frequency and data elements available to the customer through the interactive graphs. Most recent available information corresponded to energy usage up to the previous day.

Time Range:	Data Resolution:	Energy Usage Elements:	Measurement Units:
Last 13 Billing Periods	Monthly	• Total House Electric • Total House Gas	kWhrs, Therms, Dollars
Last 30 Days	Daily	• Total House Electric • Total House Gas	kWhrs, Therms
Previous Day	Hourly	• Total House Electric	kWhrs
Billing Period Aggregation	Monthly	• Total House Electric	kWhrs,

Table 3-4.- Summary Bill Energy Data Elements

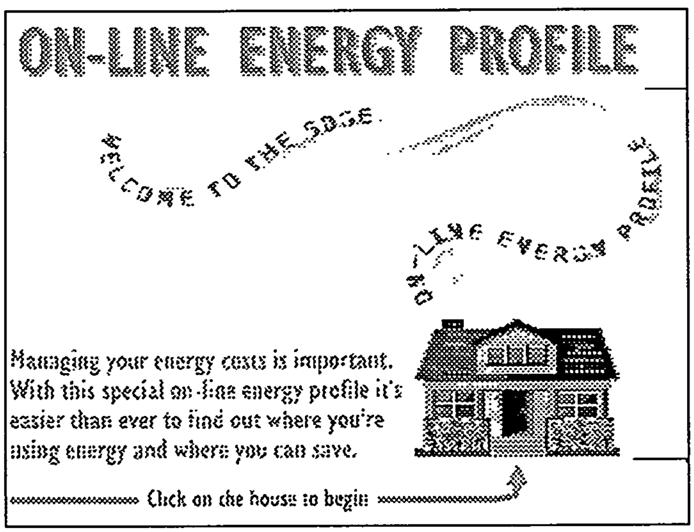
A view of the base Summary Bill page is shown below. Each of the interactive graphs used with the Summary Bill page are shown in appendix section 9-13.



On-line Energy Audit Web Page Module

About the time that the LiveWire project was being started, SDG&E was launching an on-line energy audit application that it intended to make available to all its residential customers. While the on-line audit was included as part of the overall functionality of the LiveWire user interface, it was developed outside of the LiveWire project. The LiveWire project, however, was able to share some of the hardware and data base infrastructure that supported the energy audit application. The LiveWire web site also adapted the security criteria used by the energy audit application to uniquely identify customers.

The on-line energy audit was intended to supplement a mail-in home energy audit program offered by SDG&E to help customers understand their energy costs. The input to the audit included a combination of customer responses to a questionnaire about their home and its appliances and billing history from the SDG&E legacy system. Using software from A&C Enercom, the customer receives a disaggregated total bill showing how energy costs are divided among: lighting, various appliances, heating, cooling. Shown below is the home screen for the on-line audit. (see appendix section 9-11 full module)



In order to provide a cost-effective and self-administered energy audit, work was performed to integrate A&C Enercom's software package into an Internet based service. Customers would use a web browser on their PC to fill-in user security requirements such as their own account information and meter number, then proceed with a residential profile questionnaire. Upon completion, the customer would also receive a detailed report of their energy usage in terms of both dollars and energy units, plus an analysis of the cost of using individual appliances over a year's time. In addition, the customer would receive individualized recommendations on ways to reduce energy usage along with the amount of potential savings that can result from implementing the suggestion.

The on-line software uses customers' billing histories based on downloaded input of twelve months of billing and energy consumption data for both gas and electric. The software then simulates the usage curves based on this information and other home data from the customer questionnaire. The base product was customized to interface with a central SQL database which includes the consumption history along with questionnaire data to analyze and disaggregate the customer's energy consumption for presentation of the energy audit on-line. The database management server stores the audit output record, and batch processes developed at SDG&E will be used for posting audit data back to the mainframe.

"See My Bill" Web Page Module

This module was planned to allow customers the display on their PC screen of a mirror image of their current energy bill, as they would see it on a regular SDG&E paper bill. It was intended to supplement the Summary Bill page for those customers that wanted to see an on-line energy bill that looked like their paper bill.

The SDG&E paper bill is generated by a billing application which runs on a mainframe computer. The monthly billing process calculates a bill and creates a bill print file formatted as an Advanced Function Presentation™ (AFP) print image. The approach taken with the See My Bill module was to use the print file to create the web site image of the bill rather than try to build a bill from data base values due to the large number of contingencies which the paper bill accommodates.

To view a bill image on the web site, a scheduled conversion process was planned which would access, read, and interpret the AFP file, creating a new Portable Document Format (PDF) file for each account. Inside SDG&E's firewall, a SQL server would store and index by customer account number the PDF files. Access to individual print images would be allowed only through a web server pipeline based on dynamic document retrieval methods. The PDF file format was selected because PDF files can preserve the format integrity of the original source document, while HTML is not able to do that, since the files have been optimized for faster downloading. Figure 3-10 summarizes the proposed "See my Bill" engine:

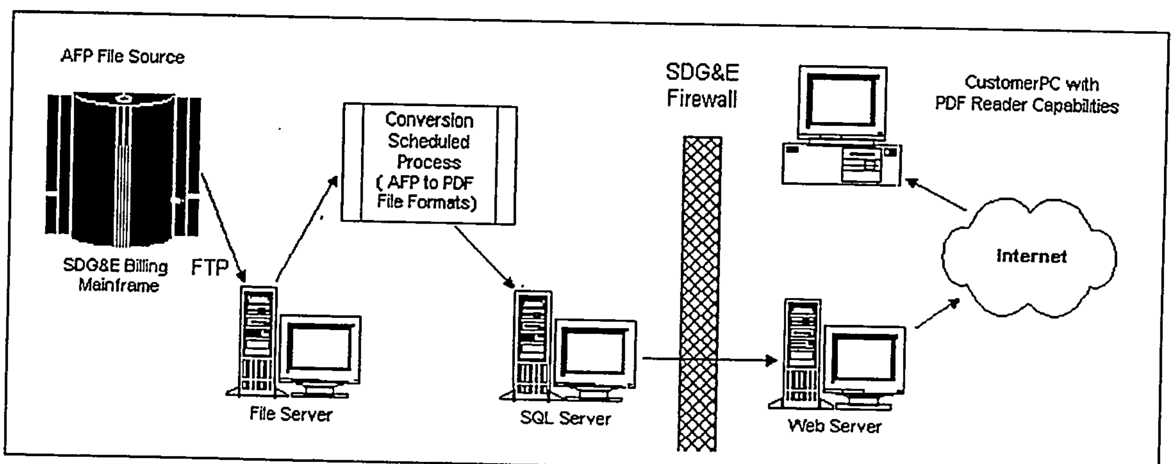


Figure 3-10: See My Bill Internet Based Process Flow

"Pay My Bill" Web Page Module

As customers would be able to see a mirror copy of their monthly energy bill on their PC screen, the "Pay My Bill" module which would allow customers to pay their bill after a "one-touch" button click was planned as well. The approach planned for the Pay My Bill module was to leverage off an existing interactive voice response (IVR) automatic payment systems. Customers would use the same subscription process as the IVR-based system. Once the subscription was complete, a customer could authorize payment of a specified amount which would generated an Automated Clearing House (ACH) transaction to electronically move that amount from the customer's checking account to SDG&E. Customers would have the option to pay the full or partial bill amount, and would able to see the results of their payment in the Billing Center section of the LiveWire web site the next business day.

To implement the Pay My Bill module, the subscription and ACH file generation processes for the IVR payment system were used as is, with the exception that the subscription process needed to be modified to recognize separate IVR and Internet automated payment subscriptions. When a customer authorized payment of a bill, a file with the proper account and payment information was sent from the web server to a server inside the SDG&E firewall for subsequent batch processing with similar IVR payment authorizations.

"Future Bill" Web Page Module

The Future Bill web page was intended to show the customer information which they could use take steps to influence upcoming energy bills. The components of the Future Bill page were a projection of the next bill, forecasted electricity prices for the next day, and an explanation of the changes from electric industry restructuring that effect them.

The projected bill would be accomplished by using the daily energy consumption data from the home controller. The projection would be based on average daily consumption for the completed portion of the billing period projected at the same rate over the remainder of the billing period. The projected bill would be generated by applying the appropriate billing formula to the projected electric and gas consumption. Since the accuracy of this estimating approach relies heavily on the number of days of consumption history, a projected bill would not be provided unless at least five days of history were available.

The other element of the Future Bill page was to a forecast of hourly electricity prices for the next day. This feature was in anticipation of changes from electric industry restructuring in California which will create an hourly time of use (TOU) rate for electricity. Since the home controller provides the necessary metering data to implement a TOU tariff, it would for a LiveWire customer to subscribe to this type of tariff. The LiveWire system would allow the customer to view forecasted electricity prices for the next day which the utility would receive from the Power Exchange, whose function in the restructured environment is to create a free market for electric power. The LiveWire customer could then take action to defer energy use to a less expensive time of day, or set criteria in the home controller to allow it to controller operation of certain appliances, based on threshold electricity prices. Since the system to generate forecast hourly electricity prices was not in place, four fixed pricing profiles, Summer, Winter, weekday and weekend, were developed from average system load data, and placed on the data management server to test the functionality of the system. The fixed electricity price profiles are shown in Figure 3-11 below. In addition to the hourly prices forecast, a text section of the page would explain the changes brought about by restructuring that effect the customer.

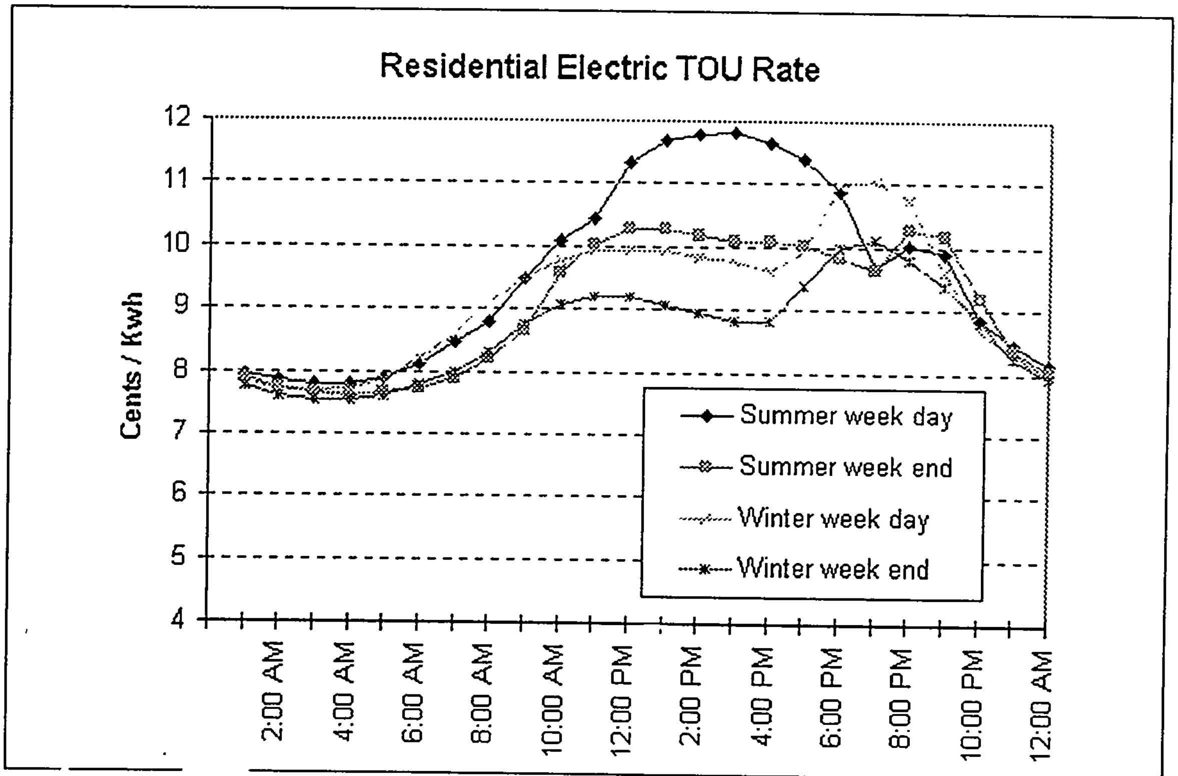
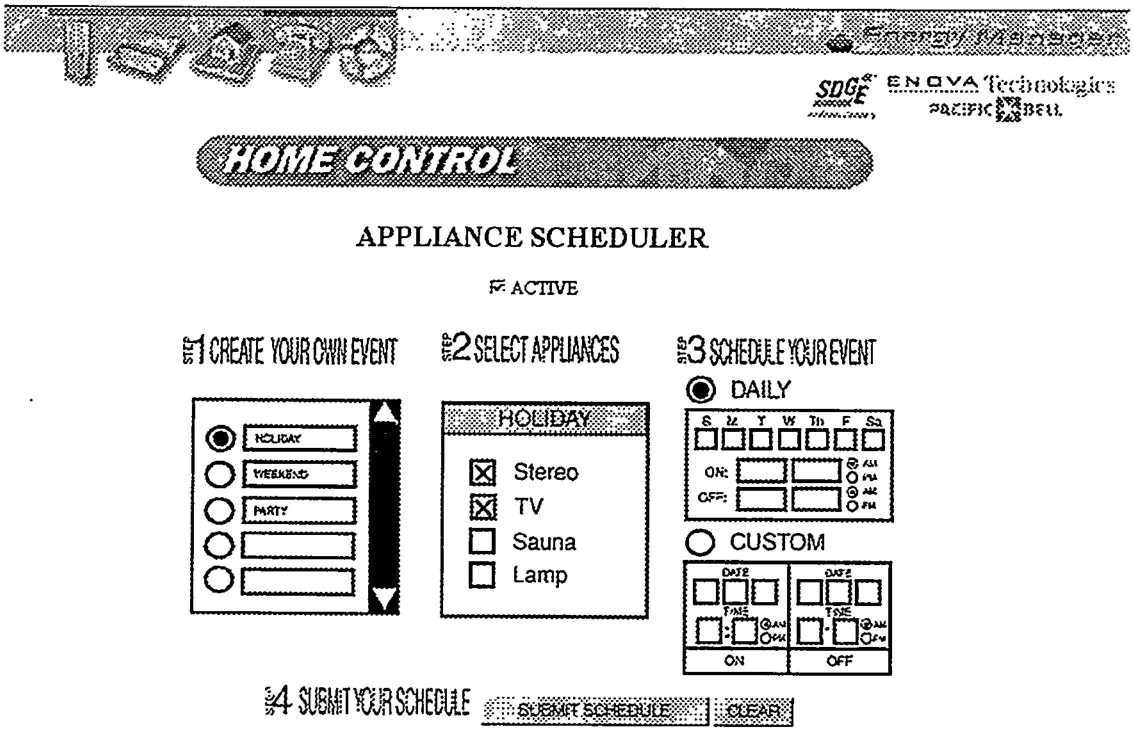


Fig 3-11 Forecasted TOU Electric Rates

Home Control Web Page Module

The home control web page was intended to be the user's interface to the home controller to implement the home automation features of the LiveWire system. Through this interface the user could build and groups of appliances, and establish criteria, typically days of week and time of day by which these appliance groups would turn on and off. The user could also specify a threshold electricity price above which an appliance would not operate.

To implement these features, the web server had to interact with the home controller to read which appliances were on the controller's LAN and to convey the user configured control parameters. The existing communication path between the web server and home controller used for daily data polling would be used for the home control functions. While data polling of the home controller was done a on scheduled basis, the home control functions required on demand communication with the home controller. Since the home controller's programming was already established, the user home control configuration parameters, which were entered via the web page, had to be converted to a command string the was recognized by the home controller. This conversion was to be accomplished by a Java applet which would be written by LANL. The prototype home control web page is shown below.



4 System Integration and Performance Testing

Prototype System Integration

As various team members and organizations contributed to the design, specifications and support for various LiveWire system components, it was necessary to employ a consultant company to provide system integration and testing functions. Paragon Consulting Services of La Verne, California was contracted by Enova Technologies to review the system design, integrate the overall system, and conduct prototype system testing.

Before system deployment into regular customer homes, a premise within one of the converted HFC areas that represented a typical home in the proposed deployment area was leased as a test facility. An SDG&E employee home was considered as a prototype test facility, but this was rejected due to the degree of access to the prototype system that was anticipated. The selected residence (Figure 4-4) was a one-story, three bedroom house, built in the late '70s. This home, situated within Pacific Bell's node 48, was set-up as a lab environment for prototyping, testing, and debugging overall LiveWire system components, in addition to documenting system installation processes and training personnel for the installations.

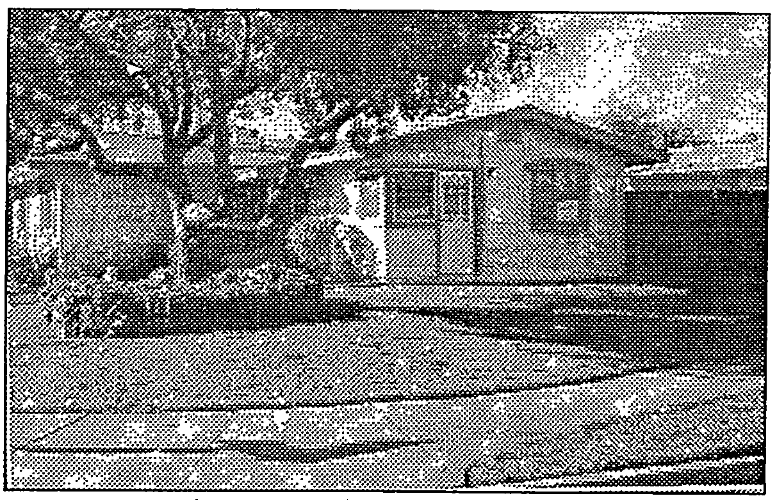


Figure 4-1: LiveWire Test-Home

Initial test-home activities included a thorough inspection and documentation of the electrical wiring configuration, and an evaluation of CEBus PLC communications reliability. The site presented a common electrical configuration corresponding to older constructions such as two-terminal outlets and multiple electric sub-panels. Additionally, the home had X-10 PLC devices for external lighting and sprinklers controls. Section 6-1 from this report presents quantified results from CEBus PLC communications reliability testing conducted at the test-home.

A gateway box containing a Motorola CyberSURF cable modem was installed at the test-home, and Pacific Bell deployed and fine-tuned their HFC high-speed communications link, and set-up Internet accessibility via SDG&E's own ISP (CerfNet). As a result, on-line connectivity via cable modem permitted the activation of the test-home web browsing

PC and the development of a detailed PC configuration procedure for Ethernet communications under a Windows'95 environment.

Residential LAN components were procured and tested at the test-home prior to the system integration. Following the home controller and database communications protocol definition, back-end processing software was developed and integrated with the test-home LAN. Since the home controller board (HCB) was in a development stage, and its delivery was expected no earlier than a four-month time frame, LiveWire team members opted for an alternate solution that would enable CEBus appliance data exchange and WAN communications testing before the delivery of the production version of the HCB. This approach sped-up back-end software development and refined database architecture and protocol definitions.

Figure 4-5 below describes the alternate prototype system configuration based on a Pentium single-board computer (SBC) and a Unity CEBus Serial Card. A DOS based software application running in the single board computer provided a translation mechanism for Unity's own CEBus Serial Card protocol messages (ACM) into the LiveWire defined home controller board (HCB) data messaging protocol. Additionally, the SBC software was integrated with a third-party software library (USNet™) for implementation of the TCP/IP communications protocol stack. The SBC was linked directly with a CEBus Serial Card, providing real CEBus PLC communications with appliance monitors and a GE house meter.

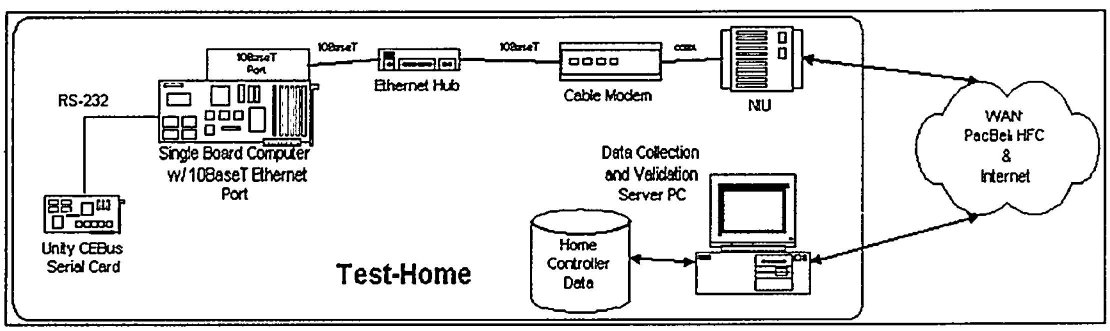


Figure 4-2: Prototype System Test Set-Up With Single Board Computer

Employing a configuration software application provided by Unity Systems (Figure 4-6), the Unity CEBus Serial Card was configured to poll, time stamp, and log load energy usage information from up to three residential appliances and total house using WeXL's Habitat appliance monitors and a GE Residential CEBus meter.

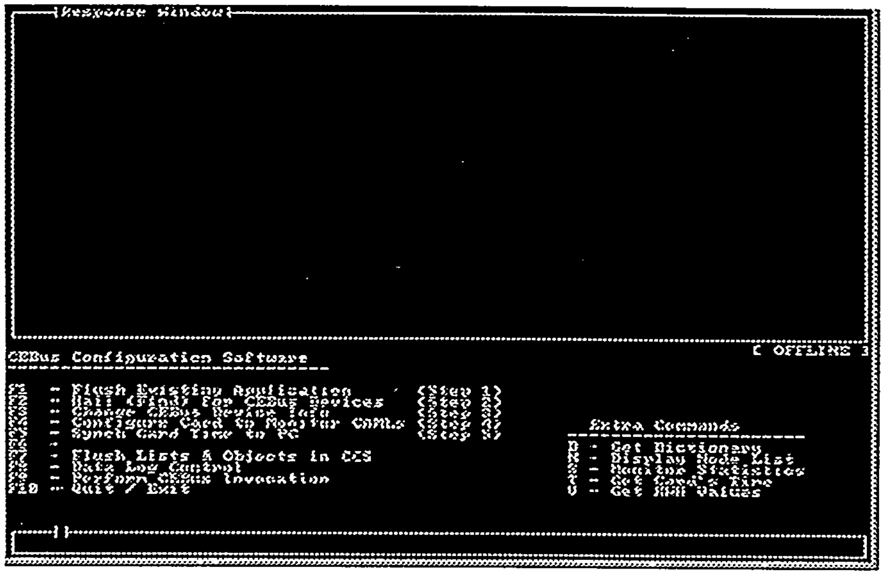


Figure 4-3: CEBus Serial Card Configuration Application Screen

Data collected and stored in the CEBus Serial card was queried, retrieved, and validated once a day by the data collection and validation server. During the initial system prototyping and testing phases, a data collection and validation server PC was installed at the test-home for convenience, thus facilitating software implementation and debugging without compromising SDG&E's network infrastructure inside their firewall. UDP/IP communications connectivity between the NT socket server application and the Unity home controller simulator via the Internet was successfully verified at the test-home. Evaluation of data packets exchange between the two devices, data content, and database population was also accomplished. Initial test results discovered LANL protocol messaging incompatibilities and word order swapping during data packets transmission. As a result, Unity Systems and SDG&E contractor for data collection and validation software development refined data formatting and verified protocol compliance before approving system installations into the employee homes.

At this stage on the project of prototype home controller and software applications testing and debugging, the LiveWire project was terminated due to Pacific Bell's corporate decision to curtail their advanced communications network programs, including the San Diego area. Consequently, no further home controller and utility server communications testing was conducted on employee home sites.

Gateway Box Assembly

In an effort to minimize intrusion caused by utility personnel entry into the homes of participating LiveWire demonstration customers, a gateway box was proposed to be mounted outside the customer's premise. The gateway box would house the cable modem, home controller, and hub. By taking the gateway box approach, field installation time could be minimized, components could be checked as a system before installation, and any troubleshooting or hardware replace could take place without disturbing the customer.

Two different versions of the gateway box were built and analyzed before the final prototype model. The first version consisted of a 16 gauge steel-body Hoffman enclosure. Its weather-tight build provided protection against heavy impacts, dust, dirt, oil, and water. This also provided adequate housing for all the individual components; but because its final heavy weight of 30 lb., additional modifications were required. The second version of the gateway box utilized a much lighter Hoffman Fiberglass enclosure. Its dimensions were the same as its predecessor (15.5"x12.0"x8.28"), but its final weight was reduced to a much more acceptable 19 lb. The fiberglass enclosure also contained a dust and watertight seal. The last version was accepted by team members, and three prototype units were built and installed at the test-home, and two SDG&E employee homes. Figure 4-1 shows a block diagram representation of the gateway box and internal components.

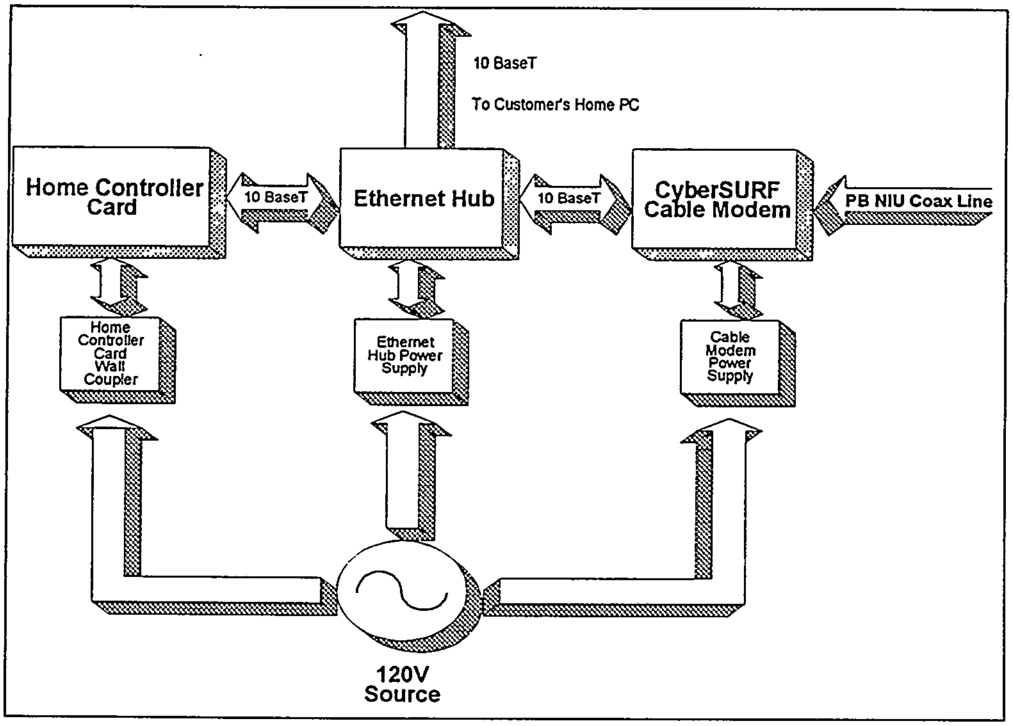


Figure 4-4: Gateway Box Block Diagram

Each gateway box housed three main hardware components: a cable modem, an Ethernet hub, and a CEBus home controller board. In addition, each box also contained a ventilation fan unit, and power supplies. The ventilation fan unit was necessary because components such as the cable modem and Ethernet hub are designed to operate under normal ambient conditions, and are not suitable for outdoor use. Therefore, the fan unit and ventilation vents provided adequate means for dissipating the heat generated by the internal components. The following picture shows the final lay-out of the gateway box.

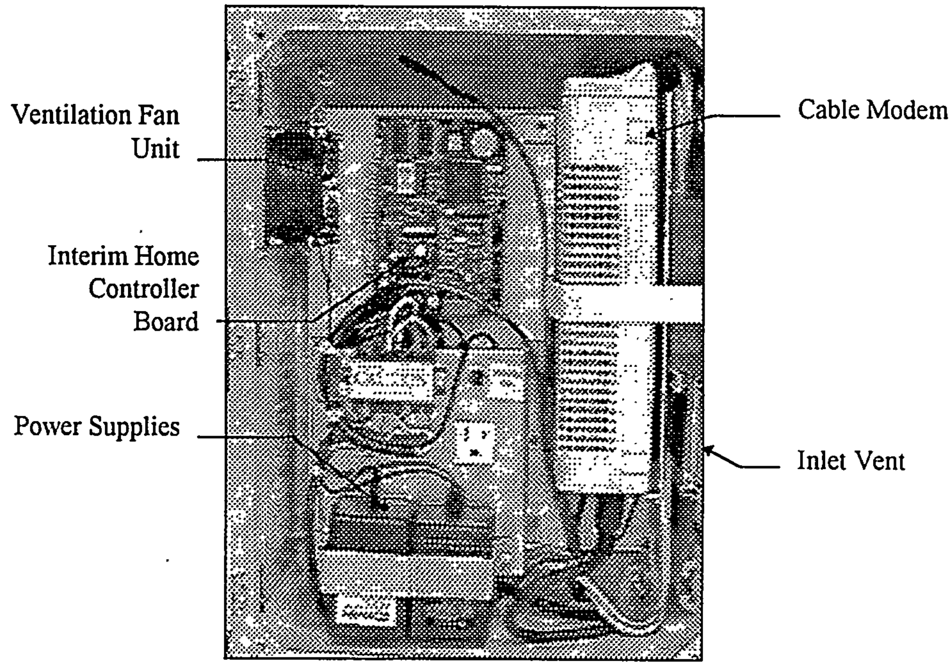


Figure 4-5: Gateway Box Final Lay-Out

A NetGear model EN 104 Ethernet Hub was used to expand and link the Ethernet LAN that included the home owner's PC, cable modem and the home controller. The selected hub had a small and efficient packaging with dimensions of 3"x2"x2". Each Ethernet Hub contained four 10Base-T ports. Port-1 was the cable modem input, port-2 was used by the home controller, and port-3 was used by the home PC. The last port-4 would only be used for a field laptop input for troubleshooting and diagnostics purposes.

To provide power to the gateway box, a means was devised to tapped into the electric meter socket. A small junction box was attached 4 inch plastic electric meter extender. Hot, neutral and ground wires from the meter panel were terminated in the junction box. Flexible conduit could then be run between the junction box at the electric meter to the from the gateway box for 120 VAC power.

Cable Modem Communications

A cable modem is a device that allows high-speed data access to the Internet via a coaxial cable network. A cable modem will typically have two connections, one to the coax cable and the other to a computer. Cable modems modulate and demodulate signals. But cable modems are more complicated than their telephone counterparts. Typically, a cable modem sends and receives data in two slightly different fashions. In the downstream direction, the digital data is modulated and then placed on a typical 6 MHz television carrier, somewhere between 42 MHz and 750 MHz. There are several modulation schemes, but the two most popular are QPSK (up to ~10-Mbps) and 64QAM (up to ~30-Mbps). This signal can be placed in a 6 MHz channel adjacent to TV signals on either side without disturbing the cable television video signals.

The cable modem communications path allowed LiveWire participants the ability to access energy usage data while utilizing added valued services such as fast Internet access. Cable modem communications required a 10BaseT compatible modem, as well as modifications to each of the participant's home PC Windows '95 network settings.
The selected Motorola CyberSURF cable modem provided high-speed data communications between the home and the Internet access provider. The Motorola modem was utilized in the project based on satisfactory performance results obtained by Pacific Bell during their 1996 "PC Connections" technology trial held in San Jose, CA.

In addition, other CyberSURF cable modem features such as front panel diagnostic LED indicators made the modem suitable for a trial deployment. Each cable modem had four LED indicators on their front panel. Each indicator was used to setup, monitor, and troubleshoot the modem. The following table gives a brief description of each LED indicator purpose.

Ref	LED Indicator	State	Description
1	POWER	Solid	Modem is powered ON
		OFF	Modem is powered OFF
2	CABLE	Blinking	Connecting to service provider
		Solid	Service provider connection established
3	PC	Solid	Connected to PC or Hub
4	TEST	Solid	A service provider error has occurred
		Blinking	Modem is off-line or power-up diagnostic in progress
		Off	Normal mode

Table 4-1: Cable Modem LED Indicator Descriptions

Other technical aspects planned to be investigated (Pacific Bell) under full project deployment included:

1) To quantify cable modem cable modem failure rate
2) To identify issues related with multiple IP devices under the cable modem network, including connectivity problems and IP management
3) To perform RF analysis such as ingress measurement at participating homes, and compare results with other telephony/video measurements
4) To evaluate issues associated with Internet access and potential for providing Internet access service via cable modems to regular Pacific Bell advanced communications network customers

Residential LAN-to-Utility Connectivity

Pacific Bell's advanced HFC communications network provided the data transport between the residential LAN and the utility servers. The topology of the network allowed the home controller and customer PC to exist as nodes on the network, each with their own IP address. This configuration eliminated the normal connection sequence experienced between modems in a standard telephony network. The gateway box provided a link to the local residential LAN established by CEBus home appliance monitors, a CEBus electric meter and the customer's web browsing PC. Each gateway box was connected to Pacific Bell's Network Interface Unit (NIU) via a coaxial cable connection. Before activation of cable modem communications, the San Diego Regional Operations Center (ROC) was responsible for placing a diplex filter in the NIU interdiction shroud. This filter separated up and down stream RF signals and provided upstream filtering for telephony service. Data routed through the NIU reached Pacific Bell's Central Office through a neighborhood fiber node like the one shown below:

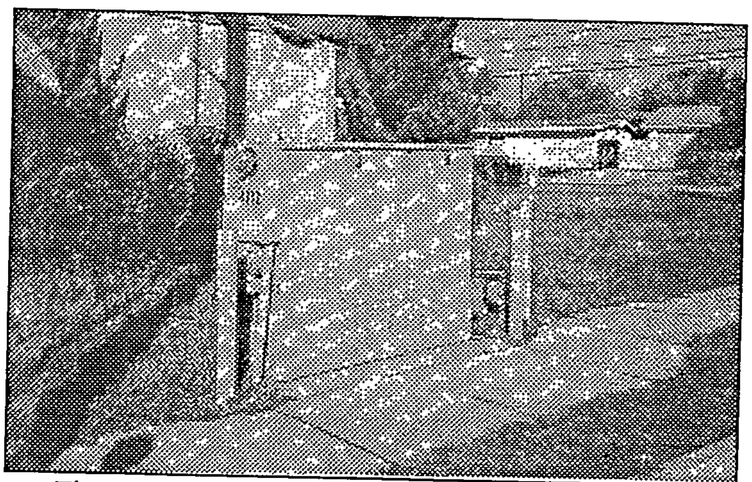


Figure 4-6: Pacific Bell Neighborhood HFC Node

At Pacific Bell's Central Office, data reached a host digital terminal. The host digital terminal then connected to a cable modem router. The selected Internet service provider (ISP) CerfNet, was linked to the Pacific Bell Central office via a T-1 connection. Finally, on the utility end, a LiveWire Web server reached the Internet network via its own ISP T1 connection. The web server interfaced with a data manager server located inside SDG&E's firewall every time that secured data was requested by a customer through the web page. Data traffic between the LiveWire web server and the data manager server was screened and authorized by a firewall, before accessing SDG&E's token ring LAN.

At the customer home, in order to activate cable modem communications, modifications to each of the participant's home PC Windows '95 network settings were required. The following is an outline of the customer's Web browsing PC settings procedures: (see appendix section 9-7 for full details)

1. Install TCP/IP protocols
2. Install Network PC adapter card
3. Setup TCP/IP properties
   a) Setup DNS configuration
   b) Setup IP settings
4. Setup the Network PC card properties

5 System Deployment Planning

Customer Recruitment

The recruitment of customers for participation in the trial was limited to those areas where Pacific Bell had converted its telephony customers to the HFC network. At the time when the planning for customer recruitment began, Pacific Bell had deployed their HFC network in 5 nodes from their Pacific Beach central office. Each node had between about 190 and 270 converted customers from which to select. Based on the demographics of the converted areas, two nodes, Node 7 in Crown Point and Node 71 in Bay Ho, were selected for solicitation of the demonstration customers.

Prior to deployment to demonstration customers, SDG&E employees from all 5 converted nodes were solicited for testing of the prototype systems to allow any "bugs" in the system to be worked out in a relatively friendly environment. Two SDG&E employees volunteered to take part in the prototype testing. Both employee homes were located outside of the planned deployment nodes.

SDG&E's Marketing Department was charged with the task of solicited fifty customers for participation in the demonstration. It was agreed among the project participants to only offer participation in the LiveWire demonstration to existing PC owners as a way on keeping down project costs. Because of the localized customer selection areas and the need to select only PC owners, a direct phone solicitation approach was planned rather than a mailer. Identification of prospective customers began with lists of converted addresses from Pacific Bell, and those lists were merged with other data bases to arrive at potential customer names and phone numbers. The telemarketing script which contained the customer offering was then reviewed by both SDG&E and Pacific Bell. Once selected, customers would be sent confirmation letters and asked to sign a demonstration participation agreement.

By participating in the LiveWire demonstration customers would receive:

a) High speed Internet access free of charge for the duration of the test
b) Necessary computer hardware and software for the high speed connection
c) Anti-virus software to protect the customer's PC
d) A home controller with up to five CEBus appliance modules
e) Access to the LiveWire energy management web site and associated services

The duration of the demonstration was planned for six to nine months. At the conclusion of the demonstration, the Internet access for the participating customers had to be terminated since Pacific Bell did not have the necessary franchise in San Diego to offer cable modem Internet access beyond what was planned for this demonstration.

The LiveWire project concluded before regular customer installations, thus no system deployments were completed other than the test home and two employee homes. The regular customer recruitment efforts were concluded at the planning levels described in this section. The remaining customer deployment and pre-deployment activities are described in the remaining sections of this chapter.

System Installation Process

For the purposes of system installation and operational support during the demonstration, a local engineering contractor, Systems Integrated, Inc., was hired. They had the capability to fabricate the gateway box, install the complete system, including computer components, and support the demonstration with troubleshoot technicians and a call center. Systems Integrated was brought on to the project during the conceptual design phase for the gateway box.

Project team members discussed and defined a detailed approach and responsibilities for installing, activating, monitoring, supporting, servicing trouble calls, and de-activating LiveWire customers. Upon questions or trouble with the LiveWire system after its deployment, customers were instructed to contact a SDG&E Customer Service Representative (CSR) via a toll-free number at anytime of the day. Only a very cursory troubleshooting attempt was planned for the SDG&E CSR. If the CSR did not answer or resolve the customer's problem, a service request would be forwarded to Systems Integrated's Help Desk for immediate attention between regular business hours (8:00am - 10:00pm) seven days a week. Any problems related to actual telephony or energy service would be directly handled by Pacific Bell's Advanced Communications Network Customer Care Center or SDG&E's Call Center, as appropriate.

The system installation process followed a sequence of specific events, each to be accomplished in order and in a timely fashion within a minimum four-day window. Each previous step was critical for the fulfillment of the next installation phase. In summary, the following table presents the individual installation phases for the LiveWire system deployment. Refer to appendix section 9-9 for specific system installation process details.

Phase	Description	Responsible
I. Gas and Electric Meters Installations	1) Replace Billing Meter with Electric CEBus GE Meter and Meter Power Box 2) Replace Gas Meter with Retrofitted American Gas Meter	SDG&E Metering Dept.
II. Gateway Box Installation	1) Mount and Power-Up Gateway Box on Premise Side 2) Set-Up 10BaseT Cables for Customer Web Browsing PC	Systems Integrated
III. Cable Modem Hook-Up	1) Add diplex filter to PacBell NIU unit 2) Link NIU coax cable to the cable modem in Gateway box	Pacific Bell ACN Dept.

IV. Customer PC Configuration and Internal Equipment Installation	1) Configure Customer's Web Browsing PC with Required Hardware and Software (see appendix section 9-5) 2) Install appliance monitors 3) Walk-Through and Educate Customer on System Usability	Systems Integrated

Table 5-1: LiveWire System Deployment Process Summary

Gateway Box Mounting

The gateway box packaging design considered the ease of enclosure mounting on the premise side and minimal wall drilling, reducing necessary patching work at the end of the project.

Physical location for gateway box mounting was investigated during the pre-installation site survey visit. Ideal conditions suggested a convenient mounting location near both the utility meter and the NIU box. Most of the homes from target node 71 presented the ideal configuration where both meter and NIU box were located next to each other (Figure 5-1). But, this was not the ideal case in some other selected sites, including the test-home and one employee home. For example, at one employee site, Pacific Bell had installed the NIU unit inside his garage area. According to Pacific Bell's NIU installation field crew, customer requests for NIU installations inside their premises were common, as customers considered "unaesthetic" to display a box mounted on their premise.

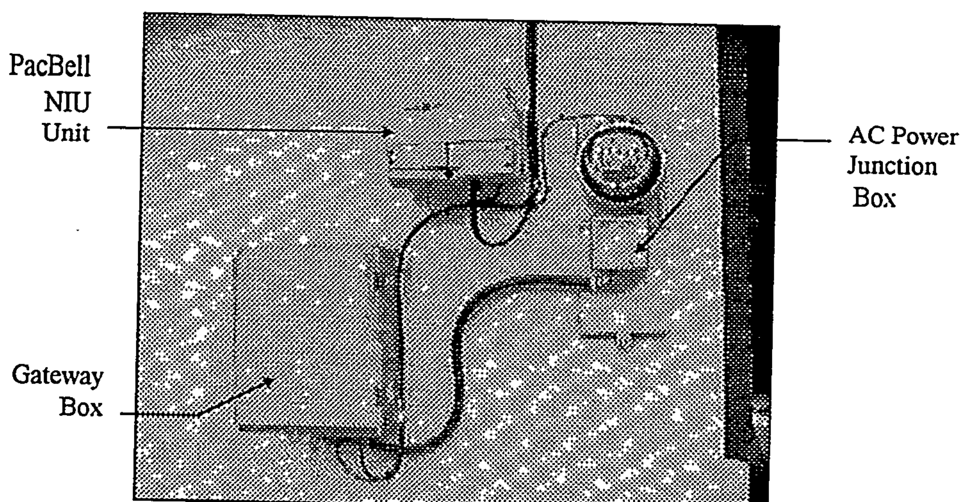


Figure 5-1: Typical Gateway Box Installation Lay-Out

In other utility field trials, participating customers have been concerned about increased utility electric bills due to the additional consumption of project equipment, and the apparent perception that their EMS energy savings are offset by the energy consumption of the utility provided equipment, particularly when hardware equipment operates 24 hrs. a day. With this customer sensitivity in mind, SDG&E decided to retrofit a terminal power box to each electric utility meter through an extension meter adapter (Figure 5-2). The terminal power box provided a 120Vac source from the utility side (non-billable energy) for all the gateway box components, in addition to fused circuit protection. A ½" waterproof conduit protected the electrical connections from the terminal power box to the gateway box.

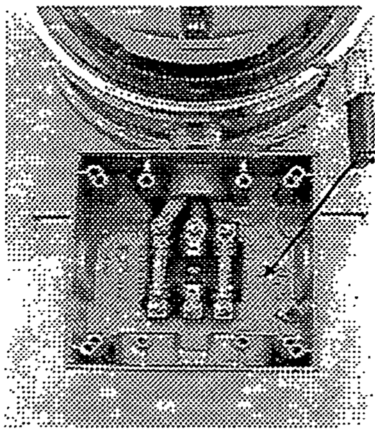


Figure 5-2: LiveWire Terminal Power Box

CEBus Appliance Monitors

Installation of the CEBus appliance monitors over specific appliances selected during the pre-installation site survey required the following basic steps:

1) Configure monitor with unique CEBus ID's and appliance data (Refer to appendix section 9-10 for configuration proceedure)
2) Plug monitor into the appliance
3) Verify appliance 'On/Off' functionality
4) Verify CEBus PLC communications from the home controller to the appliance monitor

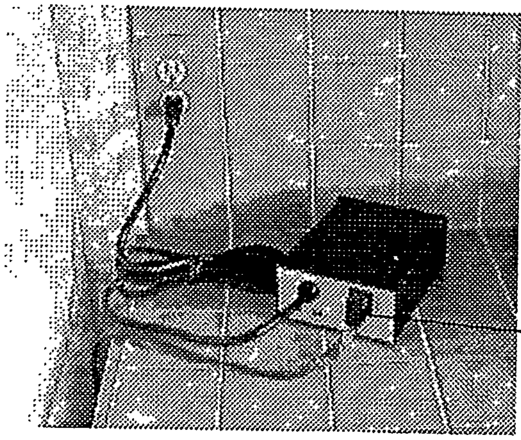


Figure 5-3a: 120V Appliance Monitor

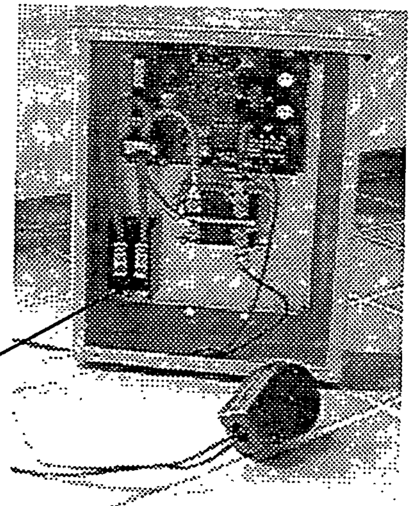


Figure 5-3b: 240V Appliance Monitor

In order to reduce customer home intrusion time, appliance monitors had to be set-up and configure in the lab before field deployment. Connecting the We.X.L. Habitat 120V appliance monitor (Figure 5-3a) to the appliance is quite easy and fast: just unplug the appliance power cord, plug it to the monitor receptacle, and extend the monitor power cord into the 120V wall outlet. On the other hand, some 240V appliances do not have plugs (i.e. spa pumps), rather they are hardwired to the power source. As a result, the installation of the 240V model required a hardwired connection from the appliance to the monitor load input (Figure 5-3b).

Employee Home Installations

Just weeks before project termination, home controller development delays suggested the deployment of an temporary alternate solution into both employee homes. This approach would allow LiveWire system (both hardware and software) testing and debugging capabilities while developing final home controller version. Implications to the new approach consisted of:

1) Addition on an alternate '486 PC into the customer home and consequent space requirements (Figure 5-4)
2) Need to wire-in a second 10BaseT Ethernet line into the home
3) Lack of analog input channel reading capability does not provide gas meter usage data into the system

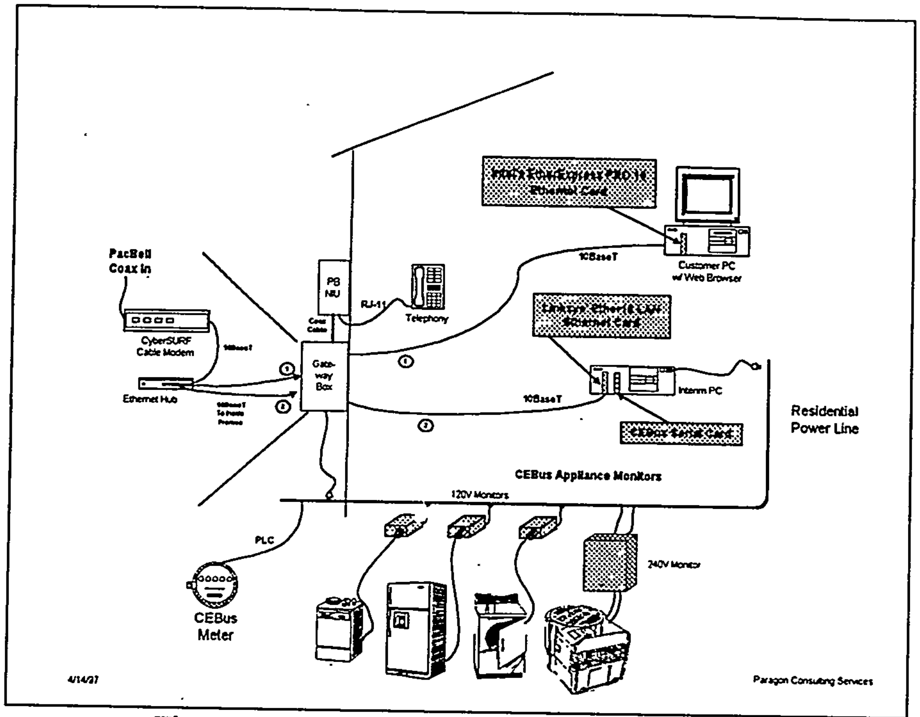


Figure 5-4: Home Controller Alternate Solution

In essence, the alternate home controller PC encapsulates the original Unity CEBus Serial Card and an Ethernet adapter card, hence emulating some of the proposed home controller functionality: CEBus PLC and UDP/IP Ethernet compliant communications.

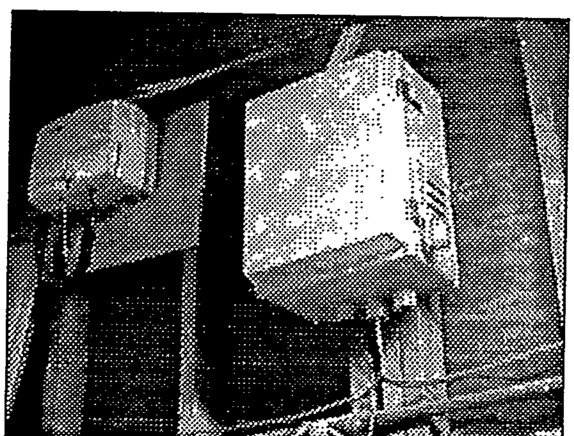


Figure 5-5: Gateway Box and NIU Unit Installed at Employee Home

A special situation was encountered at one of the employee home sites, as the homeowner was going through a full-house remodeling phase, but still was willing to participate on the trial. Therefore, project team members approved the site for installation as a test bed for the system installation and procedures under non-ideal scenarios. Since the NIU unit was originally installed inside the premise garage area, it was decided to also mount the gateway box next to the NIU in order to minimize cable runs and avoid through-wall drilling (Figure 5-5).

One advantage of the alternate employee home solution was that no additional software development would be required, since the DOS based application developed for the single board computer deployed at the test-home (see section 4-1) could be ported into the alternate PC. But, this implementation was not accomplished before project cancellation, and both employee sites were decommissioned before the end of August '97.

6 Results

Power Line Carrier Communications Reliability

The CEBus power line media communications protocol is based on spread spectrum technology with a frequency sweep range between 100kHz to 400kHz. Meanwhile, X-10 devices operates on fixed frequency bursts of 120kHz. Consequently, it is not unusual to observe irregular behavior when both CEBus and X-10 PLC devices coexist on the same premise as signaling transmission times might interfere with each other. Short term PLC reliability testing conducted and evaluated at the test-home reported no interference implications between CEBus and X-10 devices, but still an evaluation should be performed on each participating premise as to avoid any power line device related issues to the customers. As accorded before signing new participants, customers with any power line based devices such as X-10 or baby monitors should be avoided from the trial, unless problem devices are isolated or filtered-out.

Figure 6-1 describes a typical set-up for monitoring PLC CEBus communications employed in the initial testing at the test house. The CEBus card was configured to overwhelm the power lines with CEBus query messages destined to several appliance monitors installed throughout different locations inside the demo house. Statistical data for successful data packets sent by the card and replies received from each appliance monitor was retrieved through the laptop computer linked directly to the CEBus card.

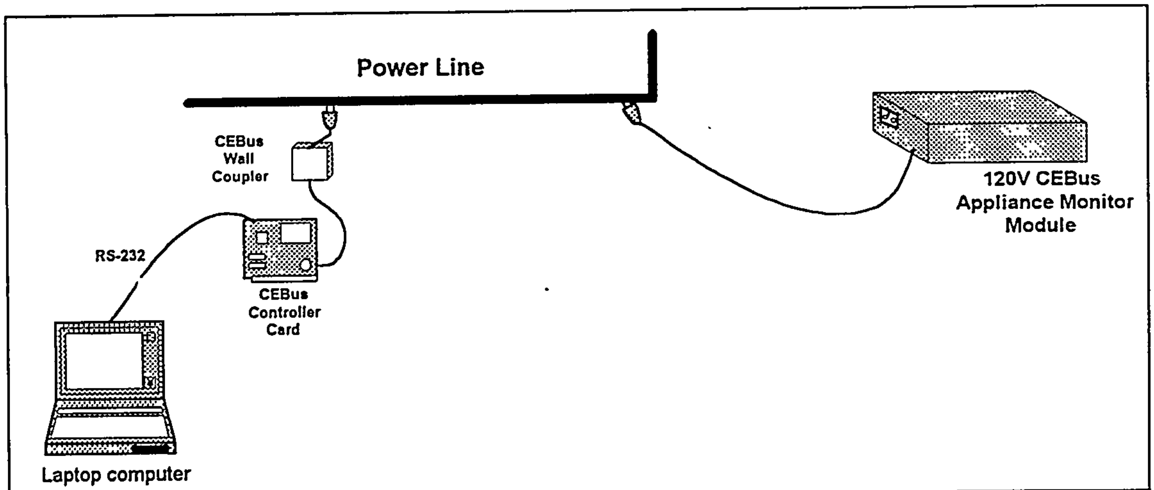


Figure 6-1: CEBus Power Line Carrier Communications Test Set-Up

Issues related to PLC interference at the test-home were also investigated during the PLC communications reliability testing, including:

1) Effects of the X-10 devices such as load control modules over CEBus communications
2) Power line interference due to harmonic line noise induced through old fluorescent light fixtures from kitchen and garage areas
3) Coupling of CEBus data packets from one residential electrical phase (A) to the other (B)

4) Attenuation of CEBus signals passing through dissimilar impedance media such as sub-meter panel breaker circuits

Results from test conducted at the demo home over a two week period of time are presented in table 6-1. As noted, despite the possible PLC interference sources mentioned above, a 100% communications efficiency was recorded.

CEBus Monitor Device	Location	Residential Phase	CEBus Packets Sent	CEBus Packets Received	% Comm. Efficiency
GE Electric Meter	Side of Premise	A,B	1374	1374	100%
120V WeXL Habitat	Bedroom 2	B	1374	1374	100%
120V WeXL Habitat	Kitchen	A	1374	1374	100%
240V WeXL Habitat	Kitchen	A,B	1374	1374	100%

Note: CEBus Serial Card was coupled to residential phase B in living room outlet

Table 6-1: Power Line Carrier Communications Results

Load control testing via Habitat CEBus appliance monitors was evaluated at the demo-home, employing a WeXL. supplied software utility (Figure 6-2). This Windows® based software also facilitated configuration of the appliance monitors at the lab prior to their field deployment. Appendix section 9-10 documents the monitors' configuration process.

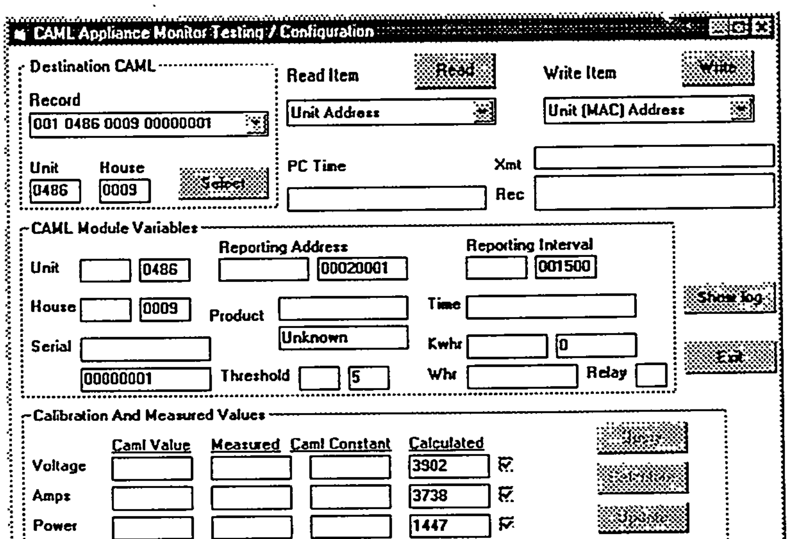


Figure 6-2: WeXL CEBus Communications Software Utility

Gateway Box Environmental Performance

One consideration during the performance testing of the gateway box hardware was the possible effect of the weather on the integrity of the gateway box, especially during the hot, summer months, in addition to the humid breeze near the beach areas.

Gateway box temperature monitoring was conducted prior to its field deployment. The cable modem performance under an enclosed and warmed environment was an initial concern. As determined by the manufacturer, the normal operating temperature range for the cable modem was between 32 °F to 122 °F. Results shown on figure 6-3 for a gateway box installed at the test-home, demonstrated the effectiveness of the implemented heat dissipation and ventilation mechanism, as the maximum differential temperature from the ambient temperature against the internal temperature was recorded at only 7 °F. Data was recorded during unseasonably hot San Diego weather from April 28 through May 7, 1997.

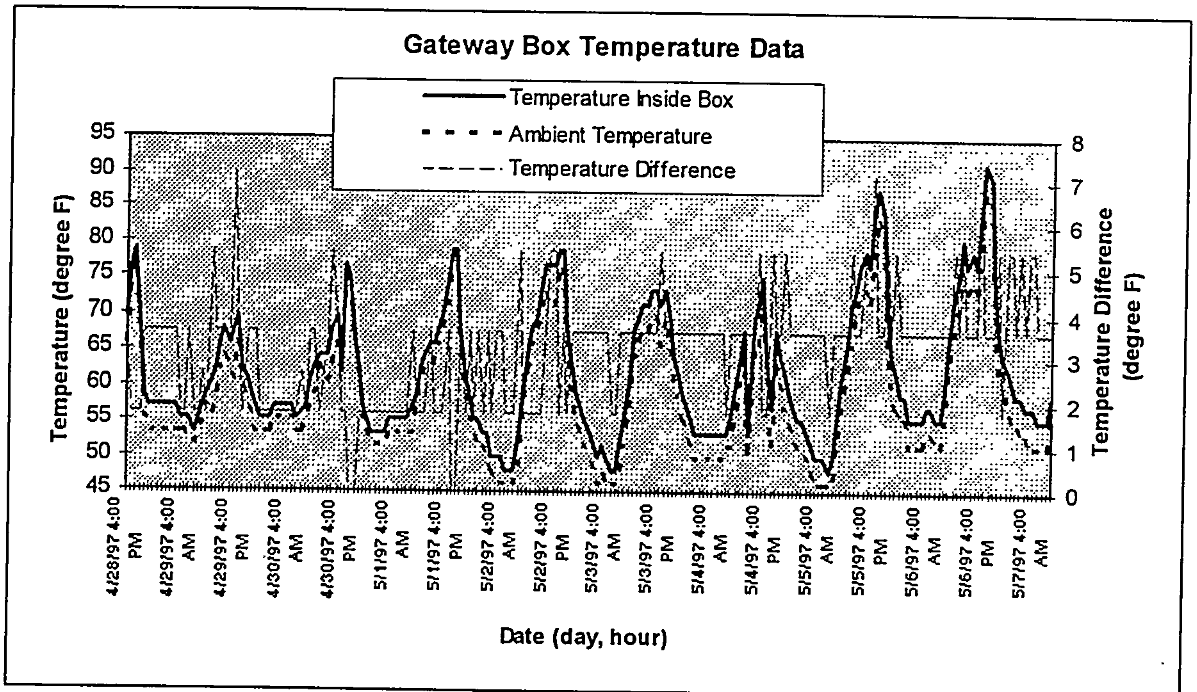


Figure 6-3: Gateway Box Temperature Profile

Home Controller Communications via UDP/IP

Unity Systems, Inc. completed software development work on the implementation of data exchange as specified by the LANL home controller messaging protocol for the LiveWire project over a UDP/IP data pipeline. Initial development efforts were concentrated on a Pentium single-board computer application with Ethernet communications capabilities. This temporary single-board computer solution was chosen in order to facilitate LiveWire data transport and concurrent testing of UDP/IP communications over the customer-utility data pipe link, while the final home controller production units are under the fabrication, testing and debugging phases.

Initial communications tests consisted of a single-board computer and CEBus Serial Card set-up at Unity Systems lab simulating the home controller functionality, and a data collection server application installed at the LiveWire test-home. (see Fig. below)

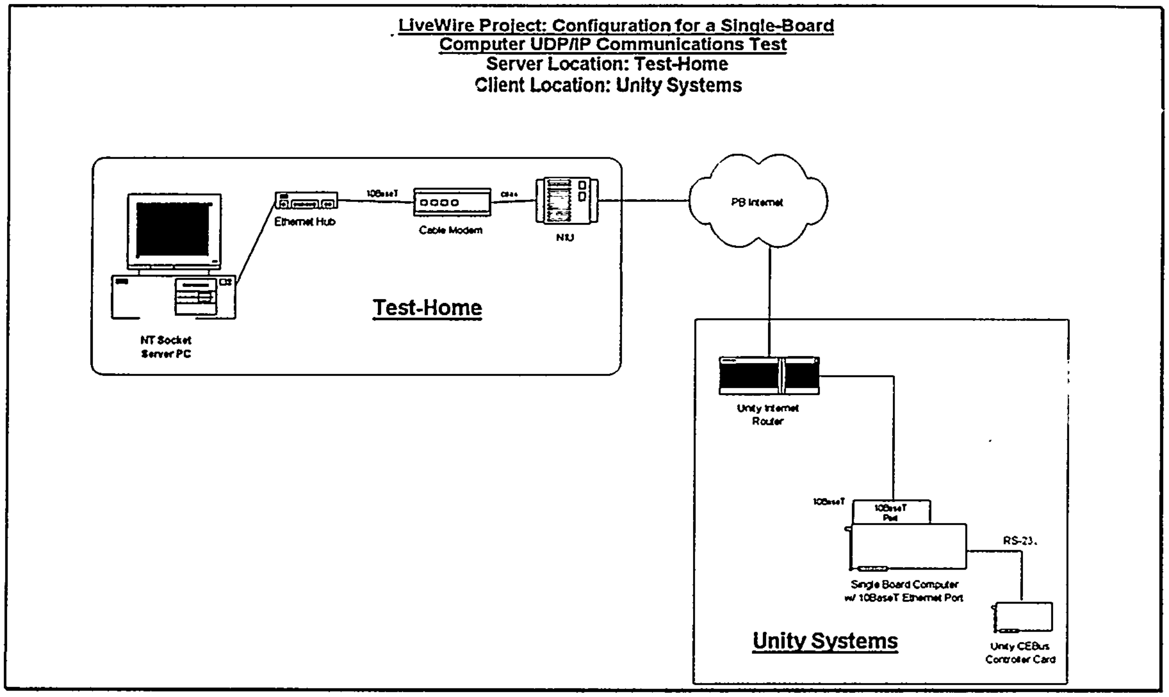


Figure 6-4: Initial Home Controller Communications Testing Set-Up

With the above configuration, UDP/IP connectivity between the NT socket server application and the Unity home controller simulator via the Internet was successfully tested and verified. Preliminary exchanged messages included basic home controller date/time reads and the identification of a self-generated home controller datagram intended to report itself to the NT Socket data collection application. This testing verified UDP/IP communications and integration work of a USNet™ software package to enable IP communications by the home controller over the Internet.

Once successful communication testing of the home controller in a development environment was completed, testing shifted to the prototype environment of the test house. With the test house PC configured as a server and running the NT Socket and smooth programs, software testing was conducted to verify the functionality of the data polling and data verification programs. As a result of this testing, modifications were made in both the home controller and NT socket software. When these modifications were successfully tested, some limited stress testing of the home controller and server was conducted understand the robustness of the system.

Following prototype testing at the test house, testing shifted to the proposed production version of the system with the NT Socket program loaded on the web server outside the firewall and the Smooth program running on the data management server. Only limited testing was conducted in this environment due to the decision by the project sponsors to conclude the project prior to the deployment phase.

Appliance Usage Data

Data collection and processing from the test-home CEBus LAN produced energy usage profiles for specific monitored appliances. Data from the home controller could be directly downloaded to a floppy disk drive on attached to the single board controller using a utility program supplied by Unity Systems. This data could then by imported into a spreadsheet program to verify the data being populated on the data management server by the NT Socket application polling process. Data was collected on all home controller-monitored meters/appliances on an hourly basis, but not all of that data was used by the LiveWire web site to avoid overwhelming the user with too much information. The hourly data for all monitored equipment also facilitated the replacement algorithm for any missing raw data. Only hourly electric meter data was retained. Raw electric appliance data and gas meter data was reduced to daily values, and stored in the LiveWire data base. Typical data for a two week period from the home controller during prototype testing is shown in figure 6-5 below.

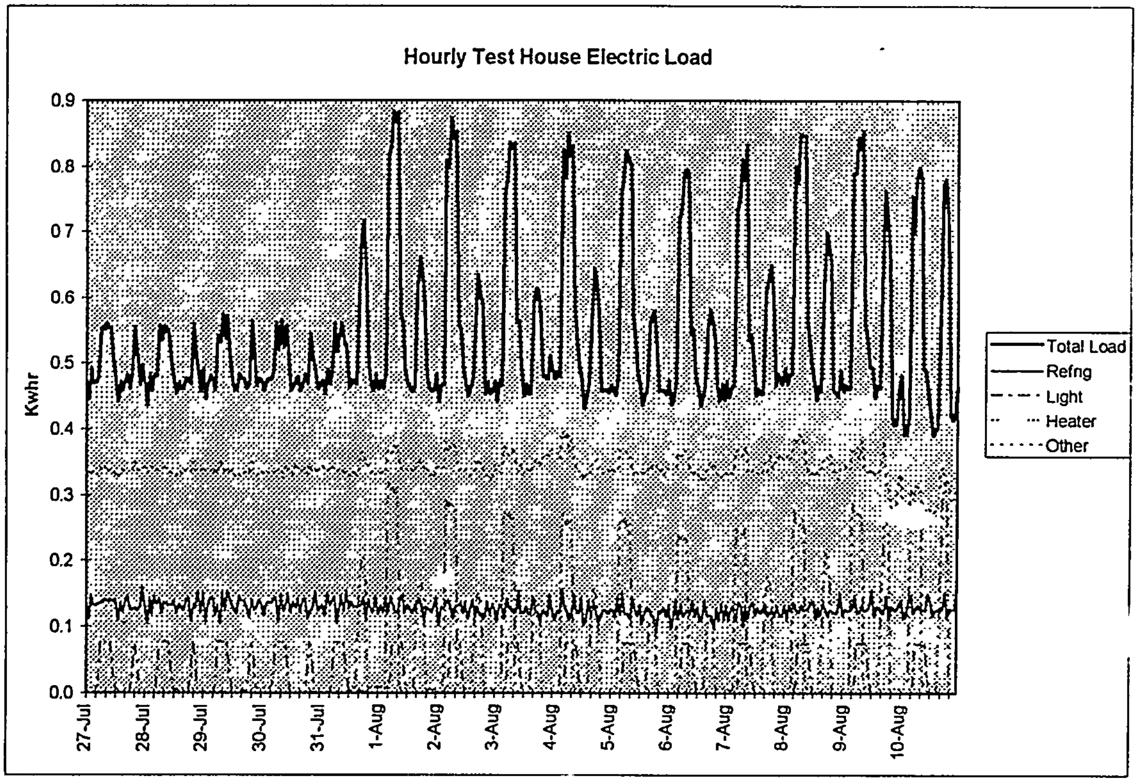


Figure 6-5: Disaggregated Appliance Load Profile

The "Other" category on the graph represents the electric consumption by all unmonitored appliance, and is calculated by subtracting all monitored loads from the electric meter load. Since the test house was unoccupied, timers were placed on a lamp and heater to provide a simulated occupied home load profile. A typical hourly electric load profile on a single day is shown in Figure 6-6

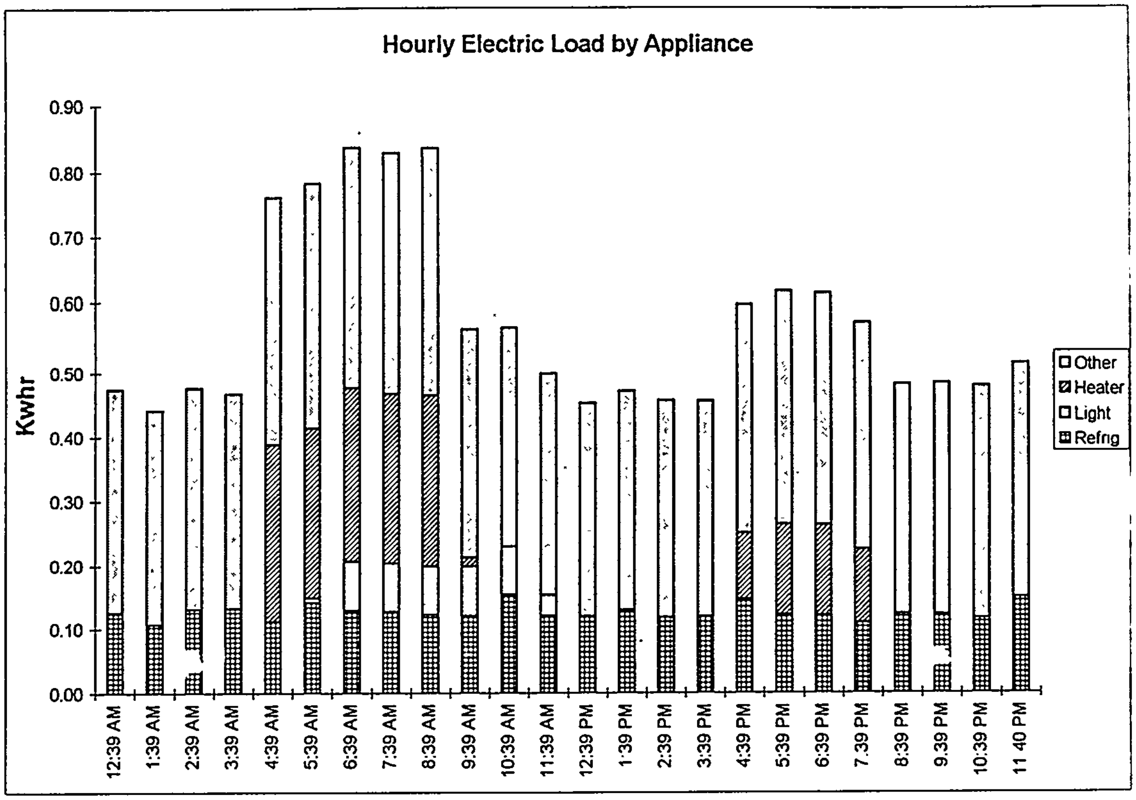


Figure 6-6: Typical Daily Appliance Load Profile

These graphical representations of a simulated customer's energy usage pattern offer a way to quickly identify peak times and major energy consumption loads, assuming several appliance monitors have been deployed on typical appliances. Even further, customers familiar with uniform appliance consumption patterns could identify faulty appliances once they noticed an inconsistent usage pattern. For example, from the load profile charts below we can observe a very steady shape for the refrigerator use throughout each day of the week. Other typical graphical representations for appliance usage profiles might include pie charts showing a percentage usage for specific appliances over the total house usage, monthly bar charts, and daily line charts broken up by 1 hour time intervals suitable for customers under TOU rate implementations, among others.

Web Page Usability Test Results

During the design phase of the LiveWire web site, usability testing of prototype web pages was conducted among average computer users. (see appendix section 9-1) Test users were familiar using specific software applications to perform their respective jobs. The usability tests targeted a prototype "Pay My Bill" web page, since it was considered to include most of the design characteristics and fundamental features for the intended LiveWire web page.

The users had very little difficulty logging in and using the "Pay My Bill" web page feature. Navigation through the interface seemed straight-forward and predictable, according to user comments. Their performance and comments suggested that the current design paradigm is easy to understand and use. User actions suggest that some subtle behaviors need to be included in the design, but overall, the current design was acceptable.

The following table describes users observations and recommendations to improve the web page product:

Observations	Recommendations
a) Users performed well with and commented on the organization of the screens. Specifically that things seemed to flow smoothly. This suggests that the progressive disclosure paradigm, on which this design is based, fits these users and tasks.	Maintain and reuse the logical sequence and screen hierarchy structure and organization throughout the product.
b) Users commented that their success was due in part to the numerous instruction on the various screens that briefly identified the purpose of the screen they were on.	Ensure that each screen provides some introductory information regarding the purpose of and what is done on the screen.
c) Users incorrectly identified the required information, specifically the account number and meter number, in the Login Screen. They also had some difficulty getting back to the beginning screen after completing their tasks.	The control buttons need to be more explicit and could include rollover pop-ups to indicate to the user what each one does. For that matter, the use of rollover pop-ups throughout the product is recommended. Additionally, the screen could include a graphic of an SDG&E bill with the location of the information circled.
d) Users seemed concerned that the entry box for the Account # on the login screen was too short to display the entire account number.	Each entry box must be large enough to accommodate the data requested. Entry boxes that limit the users input should be small enough to suggest that only a limited number of characters can be entered. For example: provide room for only 2 characters in a State field of an address screen.
e) Users didn't always select the "OK" button to submit their entries when filling in information on some screens. Instead they used the control bar buttons to move to another screen.	This suggests that the program should prompt the users if they leave a screen without submitting the information. Additionally, the word OK could be changed to reflect that the user must submit the information before it can take effect.
f) Users used the "Enter" key to accept an entry and move the cursor to the next control.	This suggests that the program should accept the entry and move the cursor or focus to the next logical control when the user uses the enter key.

g) Users asked how the system know their account information. They correctly guessed that they would have to submit their account information to establish electronic payments.	A graphic of a check on the Bill Pay screen might reinforce the electronic check concept.

Table 6-2 : Usability Test Results Summary

Web Site Development

The web site design approach described in Chapter 3 intended to make maximum use of the bandwidth afforded by the HFC network. This included extensive use of Java and Java applets. The programming of the web site was being finalized when the announcement the curtailment of HFC activities came. In order to have a web site which would not suffer performance degradation without the HFC network speed, an alternative approach for the operation web site that was placed on the SDG&E web server was taken. Instead of the dbANYWHERE middleware which converted Java client programming script into SQL database calls, another web site development tool, Allaire's "Cold Fusion", was used. "Cold Fusion" can be used to create dynamic HTML pages which can access data from the data management server SQL data base. It was also the tool which was used by the on-line energy audit program to access much of the same data, so it was already running on the web server. In addition, it came with a Java graphing applet for presentation of the data extracted from the LiveWire database. All of the interactive graphs shown in appendix section 9-13 were produced by a "Cold Fusion" web page using the graph applet.

The decision to suspend the project prior to its deployment also put a halt to the final implementation of the home control, "see my bill", and "pay my bill" features of the LiveWire web site. The design approach for these features, however, is contained in Chapter 3.

The use of "Cold Fusion" as the last minute development platform for some of the LiveWire web pages and the sharing of the on-line energy audit data base did have a beneficial effect of creating web pages that could be deployed to all of SDG&E customers. The Billing Center web page and the interactive graph of monthly billing data is supported by data from the SDG&E legacy system. As a result, the summary bill information and graphs of the last 13 billing period consumption and bill will work for all residential customers, provided they have the necessary log in information. Beta testing of that function is currently underway with SDG&E employees.

Project Costs

The project began using the SDG&E accounting system to track project expenses and later a combination of SDG&E and ETI systems was used with the SDG&E system providing input into the ETI system. A single ETI work order was issued for the project to capture all costs. Borrowed SDG&E labor was used throughout the project for both project management and back-end data processing (IT) system development. It was billed to the ETI work order using the prescribed billing schedule for regulated affiliate providing labor services to the unregulated affiliate. All purchase orders with contractors were issued in the name of ETI, and invoices against those purchase orders were paid initially from the SDG&E system and later from the ETI system. Total project costs, which are shown in Table 6-3 below, consists of only of those costs charged against the project work order. No attempt was made to track costs associated with in kind support from project sponsors.

Cost Description	Subtotals	Amount
Total Labor		$ 241,456
Project management	$ 150,929	
IT	$ 90,528	
Materials		$ 36,687
Subcontractors		$ 460,943
Web site development	$ 221,499	
System design integration	$ 96,011	
Communication software development	$ 20,528	
Home controller modification	$ 64,251	
System fabrication & installation	$ 37,797	
Internet access	$ 8,057	
Marker research	$ 12,802	
Travel & Other		$ 45,912
Total Project		$ 784,998

Table 6-3, Total Project Costs

Note: The "Travel & Other" category includes travel and meeting costs, computer system charges. Test House rental costs and, other miscellaneous charges.

The monthly and cumulative total project costs by major cost description are shown below in Figures 6-7 and 6-8.

Appendix

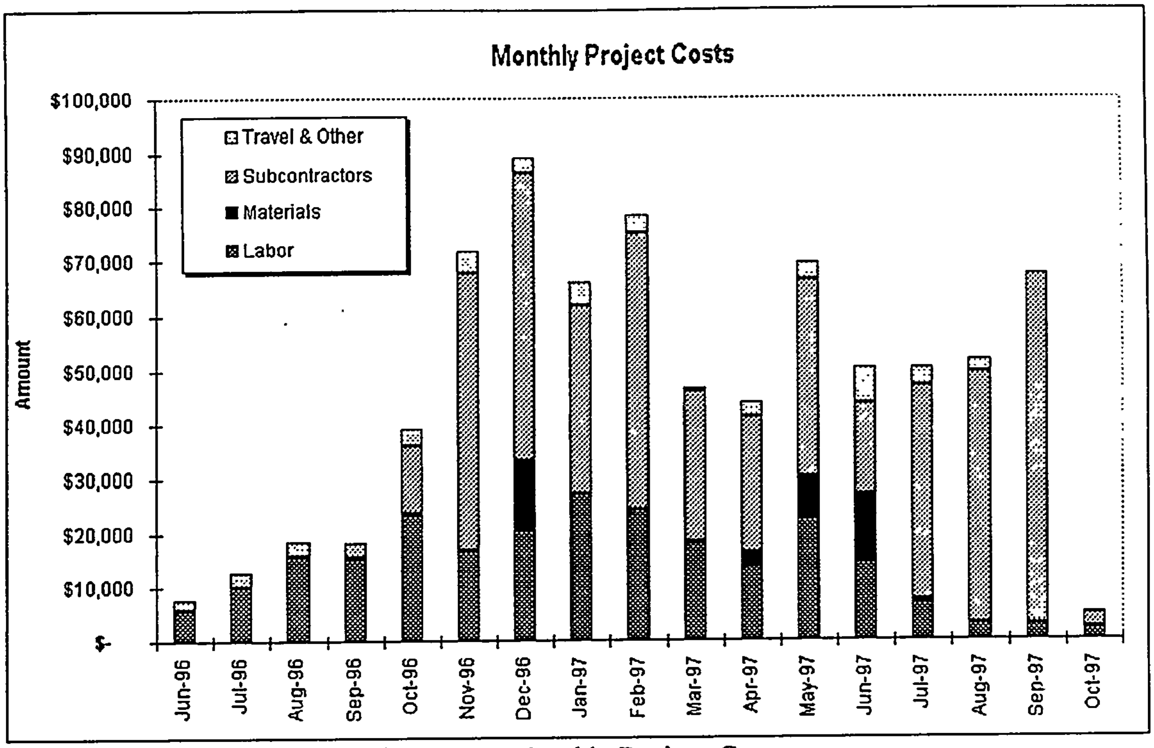


Figure 6-7 Monthly Project Costs

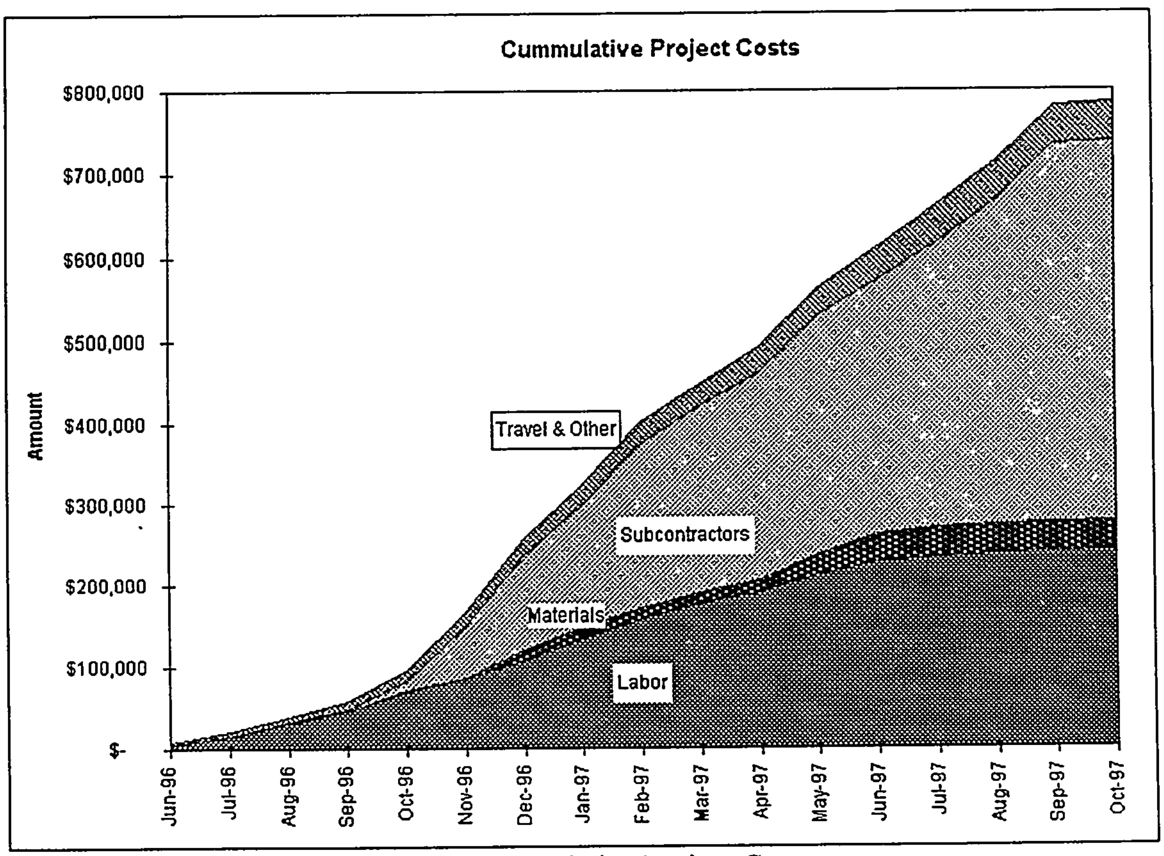


Figure 6-8 Cumulative Project Costs

7 Market Research

Concept Development

Very early in the project, brain storming sessions and focus groups were conducted to identify potential features and to obtain preliminary customer input and suggestions for the proposed LiveWire Internet-based energy management system and value-added service offerings. In the concept development brain storming sessions, project team members envisioned service offerings which might be presented to customers through the LiveWire web site. This initial phase was conducted without consideration for technical feasibility or cost. The features which were considered for LiveWire would allow customers to:

- Uniquely identify themselves as a means to access their energy data
- View their latest gas and electric consumption and energy cost
- View their total amount due on their energy bill and due date
- Authorize payment of their energy bill
- View historical (last 12 months) gas and electric consumption
- Compare current energy consumption with past consumption
- Compare current energy consumption with that of your neighbors
- Answer a questionnaire about home and appliances for estimated energy consumption
- View projected energy consumption by home and individual appliances
- Compare actual energy consumption with estimated consumption for similar home
- Offer suggestions on ways to conserve energy
- Provide "what if" scenarios for cost savings with different appliances
- Offer purchase of energy saving products
- E-mail communications with utility for energy or service questions
- Provide consumption to date within new billing cycle and projected bill amount
- View load profiles of total home consumption (1 hr data for 24 hr, and 24 hr data resolution for monthly time periods)
- View total energy cost by appliance contribution
- View status of monitored appliances (off/on, rate of energy use)
- View cost of energy by time of day

- Conduct rate analysis to find best rate to lower energy cost
- Show cost benefit of life style changes which shift load with TOU rate
- Show environmental benefit of energy savings
- View water consumption for current billing period
- Compare current water consumption with historic consumption (last 12 months)
- Provide for control of major appliances and home lighting
- Set criteria for control of electric appliances based on energy price and lifestyle
- Monitor status of home security system
- Set up various modes for home security (day, night, vacation, at home, away, etc.)

Based on this comprehensive list of proposed features for the LiveWire product, further technology and market research was conducted to define the final LiveWire energy management system service offerings. The subsequent sections discuss the market research activities employed by the project to solicit customer expectations of the proposed services.

Market Research Methodology

Three sets of focus groups were conducted the during the week of September 2, 1996. The focus groups were segmented into regular computer users and general SDG&E residential customers. One set focus groups was conducted with customers in the same area as the planned LiveWire deployment, and the remaining focus groups were solicited from around San Diego County.

The questions posed to the focus groups were designed to get their reactions to a "core" product which contained basic energy information services as well as other enhancements to the core product which included enhanced energy and other related services.

Evaluated "Core" Product Services

The following listing of services was presented to the focus groups as the "core" services of the proposed energy management product:

- High-speed access to the Internet (up to 5 times faster than typical telephone modems)
- Direct access to billing information and the ability to compare household billing and consumption with a typical household in the area

- Energy saving tips, an on-line energy audit, and individualized recommendations for saving energy
- Control and energy measurements of household appliances through a personal computer
- The ability to read household consumption (electric, gas and water) directly through the computer
- A facility to ask "what if" questions, such as the impact of a new appliance or a change in energy use on household consumption
- Rate or pricing options provided by SDG&E to allow customers to curtail or change energy-related behaviors in order to save energy and money

Customer Expectations of an Energy Management System

In the general focus group discussions about what should be in an energy management system prior to being shown the "core" services, the most commonly articulated expectations of such a system were:

- Tips on how to conserve energy and save money
- Energy audits
- Review and possible electronic payment of monthly SDG&E billing
- Historical perspective of energy usage, billing and rate increases
- Meter readings and energy consumption
- Service requests by e-mail (ability to avoid annoying SDG&E telephone voice menu)
- Brownout/power outage notifications, locations and information (planned outages)
- "How to" information/answers to most frequently asked questions (FAQs)
- Seasonal tips
- Information generally available in Energy Notes and SDG&E brochures
- A "smart house" (fully automated appliances); how to build a "smart house"
- Interactive technical support information
- List of energy providers (deregulation)

Respondents felt that most of the expectations they would have for an energy management system already existed. Some assumed that if they were to access the SDG&E Home Page they would find much of the information currently available (with the exception of their personal billing history and an electronic payment option).

Customer "Wants" of an Energy Management System

Following the "expectations" discussions, the focus groups were asked what they really "wanted" in an energy management system. The groups were encouraged not to confine themselves to just energy related products. The most common responses form the groups were:

- Free Internet Access
- Smart house--ability to control appliances and lighting throughout the home
- A system that would automatically page the owner in event of problems in the home and a remote control to re-set or turn off appliances
- Room-by-room breakdown of energy costs
- On-going consumption and cost figures for gas and electricity, water and telephone
- Guide to best buys in energy-saving appliances--what and where to buy
- List of reliable and proficient suppliers for appliance repair and other services
- Information on where SDG&E is getting power (costs); alternate sources of power information
- Fire monitor
- Shareholder information (Electronic Annual Report)
- Planned services interruptions--when and where (customer is automatically informed)
- SDG&E Bulletin Board of latest technical information, products and services
- Schematic of underground cables, lines etc. to assist in landscaping and construction plans
- Analysis of peak-time versus off-time rates and usage
- Start up and stop services for all utilities
- Information/education data addressed specifically to children
- Video/Picture phones capabilities

During the discussions of an on-line energy management system, privacy and security issues were raised in relationship to electronic bill paying, the notion of "big brother" monitoring and/or controlling personal energy consumption, and lifestyle information. Such concerns were not targeted at the energy management system alone, the groups appeared to recognize them as a fact of life on the Internet. Computer "hackers" were well known and an unwelcomed aspect of computer usage.

Market Research Conclusions

- With the exceptions of high-speed Internet access and the automated or "smart house" capabilities, the "Core" product contained no surprises and elicited little enthusiasm.

- Services in the "Core" product are generally what customers anticipated. Most felt them to be currently available either through SDG&E's Home Page or through a telephone call to an SDG&E customer representative. Further, they believed that if SDG&E entered this competitive environment, they too would be offering many of the basic services detailed in the "core" product for "free" to their customers.
- The high speed Internet access and the "smart house," in particular, were the services which elicited the greatest enthusiasm. The concept of an automated house which provides convenience and promotes a sense of personal security (short of positioning itself as a substitute for a "Security System") was integral to the appeal of an Energy Management System.
- Questions and concerns were voiced about who controls and who has access to their personalized Energy Management System. Fear of computer hackers was also a critical concern.

In summary, respondents felt that the "core" product services would be "nice to have", but something they would use rarely. With the few exceptions most felt the "Core" product should or would probably be free, especially if deregulation forces SDG&E to become more competitive. The high speed Internet access and home automation features were recognized as separate items from the "core" services which would probably involve additional fees to acquire. The avid computer buffs most enthusiastic about the high speed Internet access.

Appendix

8 Conclusions

Lessons Learned

Based on the knowledge gained during the LiveWire project, the following statements can be determined:

• Two-way field communication pilot tests offer utilities a unique opportunity for testing new products and services. In today's de-regulated environment, knowing what your customer wants and delivering it efficiently and cost effectively, is essential to success. Gathering market data in this manner takes a great deal of planning and coordination to do it effectively, in addition to the initial capital investment.

• Utility pilot tests can present some frustrating problems which can be greatly reduced through advanced planning. Most of the problems occur in system integration, packaging and installation. Detailed planning, periodic meetings and the use of subject matter experts can help surface details which might lead to future problems.

• System integration must include hardware and software teams working closely together. Each must understand the addressing requirements, messaging formats at interface points, and protocols used. Team members must clearly describe what will be delivered at each interface point, in sufficient detail for the next group to design their segment based on that information.

• Packaging most of the LAN equipment in the gateway box outside of the home made sense for the project, since allowed pre-installation configuration testing, minimized customer intrusions, and permitted easy equipment upgrade, troubleshooting and repair. Once system reliability and deployment procedures can be determined through pilot testing, the "gateway box" approach to LAN component packaging used by the project should be reevaluated in light of the requirements for larger deployments.

• Implementation of embedded systems (such as the home controller) with flash memory circuitry, can reduce labor costs and speed-up system evaluation and debugging time. New firmware upgrades can be downloaded into the controller through a serial communications interface or remotely through the wide area network.

• Deployment of an energy management and disaggregated end-use monitoring program can generate an immense amount of data from a residential premise. To accommodate this quantity of data, an efficient data warehousing mechanism and integrated IT design with the existing customer information systems is required. Additional business opportunities should be investigated which take advantage of the new end-use data or data repository systems. For example, specific appliance end-use information could be very valuable to appliance manufacturers and product marketing organizations.

• Value-added services offered by energy service providers to their customers are not restricted to the energy management system offerings. Since residential customers are not lured to pay an additional fee for just energy related services. Other opportunities which leverage the energy service infrastructure can be paired with more appealing non-energy related propositions such as home security and high-speed Internet access.

• Use of the Energy Manager web site as the primary user interface to the home controller limited functionality to basic scheduling of configured appliance groups, since user-entered configuration parameters had to be translated from HTML form into the controller command string and then transmitted to the controller. This approach resulted in a round about path to the home controller and required configuring the Web server for on-demand communication with the home controller. Use may also have the perception of a security problem since home control parameters are passed through a web server and the Internet. Configuring the home controller locally, outside of the web site using its normal configuration software is a better approach. Use of the Internet, on the other hand, not as the primary interface, but to remotely activate pre-configured controller actions is a desirable feature of a home automation system.

• The topology of the Pacific Bell HFC network substantially reduced the complexity of the software associated with polling the home controller for its data. By being a node on the HFC network with its own IP address, the home controller could be polled using the relatively simple UDP protocol. None of "handshaking" and "negotiating" which is typical of modem based communication systems needed to take place between the Web server and home controller network nodes.

• The size of the daily data file from the home controller, even with hourly recording of four devices, was small; under 2000 characters. The speed afforded by the HFC network for transporting the home controller data files back to the LiveWire data base was far greater than needed for the task. On a transport speed alone basis, even a modest telephone modem system would have been satisfactory. The real value of the HFC network on the inbound to the data base path is described section above On the outbound path to the customer, the HFC speed was a valuable asset in creating of high performance presentation for the customer,

• With the 3-tier system architecture, the "dbANYWHERE" middleware can provide additional data access security for the web server to database manager server communications. The client applet running on the customer web browsing PC must originate from the same server as the "dbANYWHERE" server, so it can only talk to other Java applets or applications if they come from the same server.

• The World Wide Web is a valuable resource to locate and establish business relationships with advanced technology vendors. In the case of the "See My Bill" LiveWire module, a software company offering a key application in the "See My Bill" process was located using the Internet and sample print files were exchanged using the Internet to test the suitability of their software.

9 Appendix

Table of Contents

INTUITIVE DESIGN ENGINEERING

USABILITY TEST RESULTS

The following report describes the second round of usability testing of the LiveWire product. This test was conducted with 3 users and a working prototype of the product. We specifically tested the Bill Pay feature since it embodies many of the design characteristics of the rest of the design and is a fundamental feature of the product.

EXECUTIVE SUMMARY

This test was conducted to evaluate the usability of the Bill Pay feature with the average consumer. The test users all seemed somewhat familiar with computers, but were not "power users." Specifically, they all used computers were familiar using specific programs to do their jobs, but were initially unsure if they could use the new LiveWire product. They seemed representative of the average consumer likely to use this product. Overall the design was successful, but still requires some refinement.

BEAUTY...

The users had very little difficulty logging in and using the Bill Pay feature. Navigation through the interface seemed straight-forward and predictable, according to user comments. Their performance and comments suggest that the current design paradigm is easy to understand and use. User actions suggest that some subtle behaviors need to be included in the design, but overall, the current design is close to the mark.

The following table describes user successes and recommendations to leverage them:

observations	recommendations
Users performed well with and commented on the organization of the screens. Specifically that things seemed to flow smoothly. This suggests that the progressive disclosure paradigm1, on which this design is based, fits these users and tasks.	Maintain and reuse the progressive disclosure structure and organization throughout the product.
Users commented that their success was due in part to the numerous instruction on the various screens that briefly identified the purpose of the screen they were on.	Ensure that each screen provides some introductory information regarding the purpose of and what is done on the screen.

[1] **Progressive disclosure** - the logical sequence and hierarchy of related screens for a particular task, as opposed to having everything on one screen. This is similar to a tree structure, such as files and folders.

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AND THE BEAST...

Although, the users completed their tasks successfully, we observed some notable errors due to the interface design.

The following table describes user errors and recommendations to correct them:

observations	recommendations
Users incorrectly identified the required information, specifically the account number and meter number, in the Login Screen. They also had some difficulty getting back to the beginning screen after completing their tasks.	The control buttons need to be more explicit and could include rollover pop-ups[2] to indicate to the user what each one does. For that matter, the use of rollover pop-ups throughout the product is recommended. Additionally, the screen could include a graphic of an SDG&E bill with the location of the information circled.
Users seemed concerned that the entry box for the Account # on the login screen was too short to display the entire account number.	Each entry box must be large e gh to accommodate the data requested. Additionally, Entry boxes that limit the users input should be small enough to suggest that only a limited number of characters can be entered. For example: provide room for only 2 characters in a State field of an address screen.
Users didn't always select the OK button to submit their entries when filling in information on some screens. Instead they used the control bar buttons to move to another screen.	This suggests that the program should prompt the users if they leave a screen without submitting the information. Additionally, the word OK could be changed to reflect that the user must submit the i nformation before it can take effect. Investigate the correct word or phrase for this.
Users used the Enter key to accept an entry and move the cursor to the next control.	This suggests that the program should accept the entry and move the cursor or focus to the next logical control when the user uses the enter key.
Users asked how the system know their account information. They correctly guessed that they would have to submit their account information to establish electronic payments.	A graphic of a check on the Bill Pay screen might reinforce the electronic check concept.

[2] **Rollover pop-up** - a brief message that appears above a control pointed to by the cursor, that provides additional information about the control or its actions.

AND THEY LIVED HAPPILY...

The test users successfully performed the tasks without instructions concerning the screens or navigation of the program. The interaction design and the task and screen organization seems reasonable to the users.

Observations and user comments suggest that users recognize, understand, and are comfortable with the electronic payment paradigm. This is reassuring given that the success of the product hinges on the acceptance of electronic financial activity.

THE SEQUEL

The next step is to test other features of the product with the working prototype. The next rounds of testing should include more users and a more rigorous test plan in order to fully test the remaining features or design corrections, such as Home Automation, My Page, etc.

ENOVA LIVEWIRE PROJECT: LAN Equipment List

Assumptions:

a) Each participating homeowner has required PC with one available ISA slot for Ethernet card

b) Up to four electric residential appliances are monitored/controlled (three 120V and one 240V)

c) The NIU device is already in place

No.	Item / Model	Quantity per Home	Unit Cost	Total Cost	Source	Hardware Status: Off-the-Shelf	Hardware Status: Prototype	Hardware Status: Under Development & Delivery Date
1	**Cable Modem w/ External Power Supply** CyberSURFR	1	$500	$0 *	PacBell	X		
2	**Ethernet 10BaseT 4-Port Hub** NetGear EN104 by Bay Networks	1	$72	$72	Datel	X		
3	**CEBus Home Controller Board** CC2 -Ethernet	1	$750	$750	Unity			X - End of July '97
4	**Appliance Monitors & Controllers -120V 15 amp** Habitat Series H1300C	3	$325	$975	We.X.L.	X		
5	**Appliance Monitor & Controller -240V 60 amp** Habitat Series H2600C	1	$475	$475	We.X.L.	X		
6	**CEBus Electric Meter Module** CM21P Residential CEBus PLC	1	$200	$200	GE	X		
7	**Gas Meter Encoder Module** RD-AMRC-2P	1	$50	$50	RioTronics	X		
8	**Ethernet 10BaseT Adapter Card for PC** Intel EtherExpress PRO TP/Coax	1	$78	$78	Datel	X		
9	**Electric Meter Adapter** EZ 1000-0-R	1	$35	$35	Marwell Inc.	X		
10	**Gateway Box (Enclosure)** A16128JFGQRR	1	$100	$100 **	Hoffman	X		
11	**Miscellaneous Items** cables, connectors, flex conduit	1	$30	$30	Systems Integrated	X		
			TOTAL:	**$2,735**				

Notes:

*** Cable modems were loaned by PacBell**

**** Gateway box cost does not include packaging labor**

Power Line Protocol Comparison

By
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Items included in document:

1. Introduction
2. Protocols Considered
3. Hardware Availability
4. Power Line Transceivers
5. Legacy Electrical Wiring
6. Regulatory Issues
7. Operational Issues
8. Installation Issues
9. Protocol Similarities
10. Conclusion

1. INTRODUCTION

The goal of the Internet Energy Management Project is to demonstrate the viability of providing customer driven residential energy management capabilities with interactive data links to the utility via the Internet. The selected protocol and associated hardware is merely a tool to assist in proving or disproving the projects intended goals. The project does not intend as one of it's objectives to develop or to select any particular protocol and associated hardware over another. With that in mind, th e reader should understand, comparisons made in this document are not intended to define one protocol or manufacturer as being better than another. Rather the intent is only to select a protocol to use for this project; a protocol which meets the requir ements for this project and currently has the largest availability of off-the-shelf products. Utilizing all available products to the extent possible will greatly reduce hardware development time. Reduction in hardware development time is essential to b ring the first demonstration house on line within the scheduled time frame. Any of the examined protocols, with the right amount of hardware development, could be used for this project.

2. PROTOCOLS CONSIDERED

Three protocols were examined as possible candidates for this project. X10 was ruled out initially because at this time X10 does not have the functionality required for the project. X10 essentially provides only one-way capability and does not provid e acknowledged service with retransmission. Acknowledged service with retransmission was a defined requirement for this project. It was defined as such to ensure a robust reliable environment. The remaining two protocols are LONWORKS and CEBus.

LONWORKS is a proprietary protocol owned by Echelon Corporation. The protocol is referred to as LonTalk. Echelon initially developed the Neuron chip which is the heart of the LONWORKS technology. Echelon sold the exclusive manufacturing rights for the Neuron chip to Motorola and Toshiba several years ago. The Neuron is the control and communications processor engine that supports LonTalk.

CEBus (the Consumer Electronics Bus, pronounced 'see-bus') is a communications standard for residential consumer products. CEBus is an open standard and was conceived beginning in April 1984 by 12 member companies of the Electronics Industries Associa tion (EIA). The standard provides a standardized physical interface between devices in the home so information can be easily and reliably exchanged. Additionally, it provides a standardized way for devices to interoperate and 'communicate' to each other using a common language. The standard also includes a cabling standard to handle all data communications requirements for the home such as audio, video, CEBus product communications and even computer data. Whether the cabling standard portion of CEBus is ever put into use inside the home remains to be seen.

3. HARDWARE AVAILABILITY

The two major players who have taken the CEBus standard and developed products are Intellon Corporation and an Canadian company called Domosys Labs. Intellon markets numerous CEBus products. These include a data link layer (DLL) controller, power lin e transceivers, radio frequency transceivers, single board computer with power line transceiver, and development tools. Noticeably absent are twisted pair transceivers. However, given the intend of CEBus to target residential consumer products, the abse nce of twisted pair wiring devices is understandable. In that same light, there is also an absence of devices such as routers/brouters to interconnect different communications mediums.

Intellon has several patented radio frequency (RF) devices for CEBus. The use of RF to communicate within the home has advantages over power line. It allows for portable devices and is not subject to the interference encountered on the power line. Ga s and water meters are generally located in areas where it is impractical to provide wireline connectivity. RF communications in this situation provides an excellent method to connect these meters. It is possible to install a single base station unit i. . neighborhood and with the single base station read gas and water meters for as many as 50-75 homes.

Domosys Labs markets a development tool for CEBus. They are also poised to introduce a new power line carrier transceiver. Their new transceiver will incorporate the physical layer, which is to say it has the circuitry necessary to connect to the pow er line, including the power plug. The data link layer will also be part of the transceiver.

Echelon currently markets transceivers, routers (for use between different communications mediums such as twisted pair and power line), network interfaces, network services products and development tools. At this time LONWORKS has a much greater penet ration within the industrial market segment as compared to the residential and consumer products market.

4. POWER LINE TRANSCEIVERS

Power line transceivers will play a major role in our project. Therefor further discussion regarding the various products is warranted. The issue with the data link layer being part of the transceiver is unique to CEBus as LONWORKS implements the dat a link layer within the Neuron chip. The role of the DLL is to provide for reliable transmission and reception of packets over the power line. Intellon's new power line transceiver incorporates both the physical layer and the DLL into the transceiver. Having the DLL as part of the transceiver means less software work for developers when implementing products using CEBus.

Echelon's new PLT-21 power line transceiver has increased power output, +6db (4 times the original power) more than the earlier PLT-20 version. It does not include the physical layer so the OEM must build the coupling circuitry to the power line. B oth the PLT-20 and PLT-21 must be used with a neuron chip. The PLT-20 and PLT-21 are narrow band devices (125kHZ-140kHZ). Data rate is 5kbps. Echelon's new higher power PLT-21 unit does not require installation of any special coupling device between the split phase wiring as found in the majority of homes. Echelon advertises that the 7vp-p output of the new PLT-21 provides enough signal to allow inductive coupling between the split phases to allow transceivers located on each of the split phases to com municate without installing any type of coupling device between the split phases. Echelon owns all rights to their power line transceivers. Echelon is unwilling for business reasons to license the manufacture of these devices to others. OEMs wishing to manufacturer devices using LONWORKS protocols which utilize power line communications must purchase the transceiver units exclusively from Echelon or develop a new transceiver of their own.

Intellon's new power line transceiver is a spread spectrum device (100kHZ-300kHZ). It's data rate is 10,000 'one-bits' per second. Zero bits require twice the 'one-bits' transmission time. Intellon's transceiver does require the installation of a cou pling device between split phases. These coupling devices are available for about $20.00. Installation requires a knowledgeable homeowner or an electrician. Intellon will sell the rights to manufacture their power line transceiver for a one time charge of $2,500.00. Domosys Labs purchased the rights from Intellon to manufacturer the transceiver they are about to introduce to the market. My understanding per Domosys Labs is they have made a number of refinements to the original Intellon transceiver.

Which implementation, spread sprectum or narrow band is best? The debate rages on! The answer of course depends upon which vendor you ask. Echelon claims that the spread sprectum devices should never be used in residential environments. Echelon mark ets a spread spectrum transceiver, the PLT-10. This unit operates in the 100kHZ-450kHZ range with a data rate of 10kbps. Echelon recommends their spread sprectum PLT-10 device be used only in environments where you are confident you have a very clean (devoid of interfering signals) environment. One such application is braking control in the railroad industry. Indeed the PLT-10 spread spectrum device Echelon sells has been endorsed by the National Railroad Association for this application. Echelon's position is far too many devices emitting signals within the operating frequency range of the spread sprectum transceiver are found in the home to expect the spread spectrum transceivers to work reliably in a broadly deployed environment. Echelon indicat ed they have very carefully selected the operating frequency (125Khz-140Khz) range for the PLT-20 and PLT-21 based upon their experience with power line environments. I am not sure what residential experience base they used if any. If it's true today tha t this is a quiet zone, what guarantees are there that this frequency range will continue to be interference free? The 125Khz to 140Khz frequency range is not protected by the FCC with respect to limiting it's use exclusively for LONWORKS products. When you speak with vendors manufacturing CEBus hardware they state that a narrow band transceiver is a poor choice because should an interfering signal exist within that bandwidth, transceiver operation could be impaired or completely blocked. Echelon sell s a power line communications analyzer which you can plug into the wall outlet and check if their narrow band transceiver will function. This only guarantees it will work today. Tomorrow it's anyone's guess as other consumer electronics devices are plug ged into the home wiring. The analyzer allows you to test different transceiver power output levels, check phase relationship, and check signal margins between 0db and 24db. The output of the analyzer provides number of packets lost and percent of lost packets. This device is appropriate for laboratory use and large industrial companies, but probably impractical for homeowners due to cost of the analyzer and it's technical complexity of use.

The intercoms and baby monitors marketed today which utilize the home's power wiring for communications definitely cause significant interference problems for Intellon's spread spectrum power line transceiver. Echelon's narrow band transceiver is outs ide the operating frequency range of today's intercoms and monitors. Additionally, Echelon's design provides sufficiently steep bandwidth skirts and high out of band attenuation as to preclude interference in most cases from these types of devices. The intercoms don't present as significant of an issue to the CEBus transceiver as baby monitors because intercoms are not continuous transmit devices. The baby monitors on the other hand are continuous transmit devices and will cause interference problems on a continuous basis. The interference in many cases will disrupt all communications.

This writers opinion with respect to power line transceivers is there exists no clear choice today which guarantees successful communications in all types of residential environments. With the narrow band unit you could easily have an interfering sig nal within the operating bandwidth that either interferes with the signal or is strong enough to completely overload the receiver and stop all communications. With the spread spectrum unit you have a larger bandwidth window which the receiver can see. O ne could conclude under these conditions you might expect to increase your probability of seeing a strong interfering signal that could either interfere or overload the receiver and stop all communications. As more of these devices are installed in resid ential environments affording increased operational experience. a clearer picture should emerge regarding the best protocol to use.

All of these transceiver devices are in their infancy at this point of development and we should expect to see significant improvements in the operational characteristics over the next few years. The challenge for developers is to produce an improved device operationally and at the same time reduce the cost of the unit.

5. LEGACY ELECTRICAL WIRING

Another issue to consider is with lighting circuits in older homes. Many older homes have light switches with 'switched leg' wiring. The neutral is not taken to the switch, but only the hot side of the circuit is available at the switch. Today CEBus products are not available for use in 'switched leg' wiring environments. Echelon states they have a transceiver that can be connected in series with the switched leg wiring and will communicate though the light filament allowing control of the light. One can assume that if a market for such a device exists, that eventually CEBus products will become available as well.

6. REGULATORY ISSUES

The use of power line communications devices in North America, Canada and Europe is governed by the Federal Communications Commission, Industry Canada, and European Committee for Electrotechnical Standardization (CENELEC EN50065-1) respectively. Sprea d spectrum technology used with CEBus is not approved for use in Europe or Canada due to perceived potential interference that the spread sprectum transmitter might impose upon other devices. Today spread spectrum power line transceiver technology is lim ited to use within the United States. The narrow band unit which Echelon markets is approved in Europe, Canada and the US.

7. OPERATIONAL ISSUES

Another issue to be aware of is the problems experienced with surge protection devices found on the market today targeted at protecting consumer electronic devices from power surges. Many of these devices will completely attenuate both the LONWORKS an d the CEBus signals, stopping all communications.

8. INSTALLATION ISSUES

A significant issue to consider with respect to residential use of power line devices is the mechanics of how you install an initial system and add new devices into an existing home electrical system. This is of special concern where several homes sha re a single power distribution transformer. In an environment where all homes or apartments share the transformer, they also share all the communications signals transmitted on the power lines. There are filters which may be installed at the power line service entrances to isolate each home or apartment's communications signals from one another. These devices when you include both the device cost and the electricians labor to install can cost upwards of $200 to install.

LONWORKS has the ability to automatically install the initial network and add new devices into an existing network. To use automatic installation the network must be autonomous. This is not the case with the shared distribution transformer unless you install the filters to segregate each home. Automatic installation devices operating concurrently in several homes and all being able to see one another because they are all on 'one network' is unworkable. You may not use automatic installation under th ese conditions. The recourse for the homeowner would be to use Echelon's field install process, which today is most likely beyond the technical capabilities of the average homeowner.

CEBus protocol developers addressed the shared transformer issue in the protocol. An algorithm is in place to easily allow the homeowner to install a new device into his or her home without interfering with other home's devices. It virtually eliminat es the possibility of inadvertently installing a neighbor's device or controlling it from your home. This is not to say a clever and knowledgeable neighbor couldn't figure out how to control your devices. Unless you install a filter at your power servi ce entrance to block all signals, unwanted control by your neighbor is within the realm of possibility.

9. PROTOCOL SIMILARITIES

Both protocols have many similarities. They are both designed around the Open System Interface (OSI) seven layer communications protocol. LONWORKS and CEBus both use modified versions of the C and C++ programming languages. LONWORKS uses what they c all Neuron C and CEBus uses CEBus Common Application Language (CAL). LONWORKS uses standard network variables to define attributes and interoperability between devices. CEBus uses standard contexts (such as 'tuner' for a television), objects (channel), and instance variables (channel = 15). They both use similar processes to 'bind' devices together. Binding is a process of logically defining which devices communicate with each other and what information they share. There are so many similarities tha t you wonder how both could have been developed independently and in parallel?

10. CONCLUSIONS

The comparison as a basis for deciding which protocol to select will focus on the following project requirements. The focus is on hardware, as the software aspects of each protocol are not viewed as having a bearing on the decision process.

The devices required for this project are:

1.on/off control and kwh usage for appliances.
2.on/off control and kwh usage for pool pumps.
3.single board computer or generic 486 machine with power line transceiver.
4.Software and hardware necessary to bind (logically connect) all node devices together.
5.10baseT hub.
6.Device to read the KWH meter.
7.Optionally, an RF device to read the gas and water meter.

The following matrix compares LONWORKS and CEBus available hardware required specifically for this project. The recommendation regarding which protocol should be used is based upon this matrix. For this project we don't feel that the cost of the hard ware for either protocol is a major issue. Besides, both LONWORKS and CEBus hardware costs appear reasonably close. Today's cost for hardware items are high for both protocols. The high costs are most likely not representative of what the actual costs w ill be when these products gain greater acceptance and market penetration. We would expect mass production of these devices to bring today's per-unit hardware costs down substantially for both LONWORKS and CEBus. Because we are demonstrating a concept, not a protocol or specific hardware technology, any development completed for this project will be done on a one time basis with production limited to a very few devices. As such, we are not deciding on a protocol with long term product development in m ind. Because of this, the comparison of the two protocols and their associated hardware for this project should be viewed differently from that of a manufacturing company about to undertake significant product development. The major issue for us is to br ing the demonstration house on line within the scheduled time. As can be seen from the matrix, utilizing CEBus will require the least hardware development. The comparison matrix's reference to 'development required' refers to hardware design and developm ent Los Alamos would need to accomplish and not to further development of either protocol. Based upon our analysis and the matrix results, we recommend CEBus as the selected protocol for this project.

Protocol Interface to Home Controller

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Overview

The communication to the Home Controller is done using UDP (User Datagram Protocol) of the TCP/IP protocol suite. In most cases, the Home Controller is polled, and thus does not initiate a transaction. The Web Server sends a datagram to the Home Controller, which then sends a datagram back in response. Thus, it is a transaction process, with one request and one response. If the Web Server does not get a response, or if the response is corrupted, it simply retries the transaction by sending the same packet again.

The only packet that is initiated by the Home Controller is one that is sent when the Home Controller has just rebooted and/or initialized. It then may send an initialization request to the Web Server to find out what its configuration is, and uses this to initialize itself.

Security

The communication to and from the Home Controller may need to be secured from eavesdropping or from another system masquerading as the Web Server. There is a group at LANL, CIC-3, that is looking into this problem under a separate contract to EPRI.

To help prevent masquerading, the Home Controller might have configured into it what the addresses are of the authorized Web Servers. Any messages that do not come from this list of authorized addresses would be ignored. This adds complexity in configuration, however, and problems if the address of the Web Servers are changed.

To protect from eavesdropping, the data in the packets could be encrypted with a public key encryption system. All messages from the Home Controller to the Web Server could be encrypted using the public key of the Web Server, and all messages to the Home Controller could be encrypted using the public key of the Home Controller.

However, no security will be incorporated at this time, until the report and suggestions from the security research team can be considered. Also at this time, there is only one Web Server authorized to send messages to the home controller, which does not support dynamically changing IP addresses. The home controller will check packets to insure that they are coming from the Web server, and do no other security checking.

Packet Formats

Packet formats will be described in this section. For each type of packet, the request is described first, followed by the response. The packets are shown as a set of fields that are 32 bits wide. As far as possible, all fields are 32 bits wide for ease of processing.

For each packet, there is a fixed part that identifies the packet and gives general information. For most requests, this is the only part of the packet. For each packet that contains data, there is a field in the fixed part that tells the length, in bytes, of the data contained.

Each packet starts off with a field that indicates the function type for this packet. This tells the receiving system what packet has been received.

The next field is the status field. For a request packet, this field is ignored by the receiver, and must be set to zero by the sender. For the response packet, a zero indicates a successful transaction, and that the data in the packet is valid. Any other response indicates a processing error, and the data is not valid.

Most packets have a Customer ID. This identifies the customer for which the home controller is working. It is assumed that there is only one customer per home controller, and that the customer ID will be set to the CEBus House Code for the home.

Read Appliance Request

The Read Appliance Request is sent by the Web Server to request the Home Controller to read the power usage associated with this appliance.

The appliance number is an ID code to identify which appliance is to be read. This is not the same as the CEBus Device Code, but an index used by the system to identify which appliance in the house is to be read. The first appliance number is number 1, and that will be reserved for the electric meter. Number 2 will be reserved for the gas meter.

The date is used to tell the home controller the date for which the power usage is requested. The home controller will then reply with all the energy usage for that specified date.

Packet Format

```
+------------------------------------------------------------+
|      Function Code READ_APPLIANCE_REQUEST                  |
+------------------------------------------------------------+
|             Zero                                           |
+------------------------------------------------------------+
|             Customer ID                                    |
+------------------------------------------------------------+
|             Appliance Number                               |
+------------------------------------------------------------+
|             Date of Energy Usage Data                      |
+------------------------------------------------------------+
```

Read Appliance Response

The Read Appliance Response is sent by the Home Controller as an answer to the Read Appliance Request.

For the appliance, the amount of energy used is given for the day requested. The date specifies the date of the data. The data consists energy measurements for the appliance. If this is an electric appliance, the number is a count of 1/10 watt-hours of electricity used. If it is a gas appliance, the number is the number of cubic feet used. It is a cumulative count, not a count of energy used during the interval. There is a reading for every 15 minutes throughout the day, so the total number of entries is 96. If data is unavailable for the day, the status code indicates an error. If data is unavailable for any entries within the day, those entries are set to a value of all 1's.

Packet Format

```
+-------------------------------------------------------+
|     Function Code READ_APPLIANCE_RESPONSE             |
+-------------------------------------------------------+
|            Status                                     |
+-------------------------------------------------------+
|            Customer ID                                |
+-------------------------------------------------------+
|            Appliance Number                           |
+-------------------------------------------------------+
|            Number of entries                          |
+-------------------------------------------------------+
|            Date of Data                               |
+-------------------------------------------------------+
|                                                       |
|            Energy Usage Data                          |
|                                                       |
+-------------------------------------------------------+
```

Possible status codes:

STATUS_SUCCESS
STATUS_UNKNOWN_CUSTOMER_ID
STATUS_UNRECOGNIZED_APPLIANCE
STATUS_UNAVAILABLE_APPLIANCE
STATUS_UNAVAILABLE_DATA

Read Scheduled Events Request

The Read Scheduled Events Request is sent by the Web Server to request the Home Controller to report the number of events currently scheduled.

The Customer ID identifies the customer whose schedule is to be read.

Packet Format

```
+-------------------------------------------------------------+
|      Function Code READ_SCHEDULED_EVENTS_REQUEST            |
+-------------------------------------------------------------+
|            Zero                                             |
+-------------------------------------------------------------+
|            Customer ID                                      |
+-------------------------------------------------------------+
```

Read Scheduled Events Response

The Read Scheduled Event Response is sent by the Home Controller as an answer to the Read Scheduled Events Request.

The response contains the total number of events currently scheduled, and the scheduled events contains the event number for each of those events.

Packet Format

```
+-----------------------------------------------------------+
|     Function Code READ_SCHEDULE_RESPONSE                  |
+-----------------------------------------------------------+
|           Status                                          |
+-----------------------------------------------------------+
|           Customer ID                                     |
+-----------------------------------------------------------+
|           Total Events Scheduled                          |
+-----------------------------------------------------------+
|                                                           |
|           Scheduled Events                                |
|                                                           |
+-----------------------------------------------------------+
```

Possible status codes:

STATUS_SUCCESS
STATUS_UNKNOWN_CUSTOMER_ID
STATUS_UNAVAILABLE_SCHEDULE

Read Schedule Request

The Read Schedule Request is sent by the Web Server to request the Home Controller to upload the control schedule associated with the specified appliance.

The Customer ID identifies the customer whose schedule is to be read. The Event Number specifies which event is to be read.

Packet Format

```
+-----------------------------------------------------+
|      Function Code READ_SCHEDULE_REQUEST            |
+-----------------------------------------------------+
|             Zero                                    |
+-----------------------------------------------------+
|             Customer ID                             |
+-----------------------------------------------------+
|             Event Number                            |
+-----------------------------------------------------+
```

Read Schedule Response

The Read Schedule Response is sent by the Home Controller as an answer to the Read Schedule Request.

The schedule data contains, for the event specified, what appliances are to be controller, when they are to be turned on or off, or the thermostat setting for the specific time, or whatever other information is needed by that appliance. This format is specified in a document by Unity Systems.

Packet Format

```
+------------------------------------------------------------+
|      Function Code READ_SCHEDULE_RESPONSE                  |
+------------------------------------------------------------+
|            Status                                          |
+------------------------------------------------------------+
|            Customer ID                                     |
+------------------------------------------------------------+
|            Event Number                                    |
+------------------------------------------------------------+
|            Size of Schedule Data (bytes)                   |
+------------------------------------------------------------+
|                                                            |
|            Schedule Data                                   |
|                                                            |
+------------------------------------------------------------+
```

Possible status codes:

STATUS_SUCCESS
STATUS_UNKNOWN_CUSTOMER_ID
STATUS_UNAVAILABLE_SCHEDULE

Write Schedule Request

The Write Schedule Request is sent by the Web Server to request the Home Controller to accept a new control schedule associated with the event number.

The Customer ID identifies the customer whose schedule is to be written. If the size of the scheduled data is zero, then that event, if it is already scheduled on the home controller, is deleted.

Packet Format

```
+------------------------------------------------------------+
|     Function Code WRITE_SCHEDULE_REQUEST                   |
+------------------------------------------------------------+
|           Zero                                             |
+------------------------------------------------------------+
|           Customer ID                                      |
+------------------------------------------------------------+
|           Event Number                                     |
+------------------------------------------------------------+
|           Size of Schedule Data (bytes)                    |
+------------------------------------------------------------+
|                                                            |
|           Schedule Data                                    |
|                                                            |
+------------------------------------------------------------+
```

Write Schedule Response

The Write Schedule Response is sent by the Home Controller as an answer to the Write Schedule Request.

Packet Format

```
+-----------------------------------------------------------+
|     Function Code WRITE_SCHEDULE_RESPONSE                 |
+-----------------------------------------------------------+
|           Status                                          |
+-----------------------------------------------------------+
|           Customer ID                                     |
+-----------------------------------------------------------+
|           Event Number                                    |
+-----------------------------------------------------------+
```

Possible status codes:

STATUS_SUCCESS
STATUS_UNKNOWN_CUSTOMER_ID
STATUS_UNRECOGNIZED_SCHEDULE

Write Rate Request

The Write Rate Request is sent by the Web Server to request the Home Controller to accept a new set of electricity rates.

The Customer ID identifies the customer whose rate table is to be written. The rate table format is two lists of 24 numbers, each a 32-bit integer, giving the cost of energy for a specific hour of the day. One list is for weekdays, and the other is for weekends. The effective date states when this rate table goes into effect. The entries are in 1/10,000 of a dollar for that hour.

The Meter Type field specifies the rate for the type of meter, and is currently either METER_TYPE_ELECTRIC, METER_TYPE_GAS, or METER_TYPE_WATER.

The holiday data consists of the dates for holidays, in date format. For each holiday, the rates will be set to weekend rates.

Packet Format

```
+-------------------------------------------------------+
|      Function Code WRITE_RATE_REQUEST                 |
+-------------------------------------------------------+
|            Zero                                       |
+-------------------------------------------------------+
|            Customer ID                                |
+-------------------------------------------------------+
|            Meter Type                                 |
+-------------------------------------------------------+
|            Effective Date                             |
+-------------------------------------------------------+
|                                                       |
|            Rate Data                                  |
|                                                       |
+-------------------------------------------------------+
|            Number of holidays                         |
+-------------------------------------------------------+
|                                                       |
|            Holiday Data                               |
|                                                       |
+-------------------------------------------------------+
```

Write Rate Response

The Write Rate Response is sent by the Home Controller as an answer to the Write Rate Request.

Packet Format

```
+-----------------------------------------------------------+
|     Function Code WRITE_RATE_RESPONSE                     |
+-----------------------------------------------------------+
|           Status                                          |
+-----------------------------------------------------------+
|           Customer ID                                     |
+-----------------------------------------------------------+
|           Meter Type                                      |
+-----------------------------------------------------------+
|           Effective Date                                  |
+-----------------------------------------------------------+
```

Possible status codes:

STATUS_SUCCESS
STATUS_UNKNOWN_CUSTOMER_ID
STATUS_UNRECOGNIZED_RATE

Read Appliance State Request

The Read Appliance State Request is sent by the Web Server to request the Home Controller to report the state of the specified appliance.

The Customer ID identifies the customer whose appliance is to be returned. The Appliance Number field specifies the specific appliance number.

Packet Format

```
+---------------------------------------------------------+
|     Function Code READ_APPLIANCE_STATE_REQUEST          |
+---------------------------------------------------------+
|           Zero                                          |
+---------------------------------------------------------+
|           Customer ID                                   |
+---------------------------------------------------------+
|           Appliance Number                              |
+---------------------------------------------------------+
```

Read Appliance State Response

The Read Appliance State Response is sent by the Home Controller as an answer to the Read Appliance State Request.

Packet Format

```
+-----------------------------------------------------------+
|      Function Code READ_APPLIANCE_STATE_RESPONSE          |
+-----------------------------------------------------------+
|            Status                                         |
+-----------------------------------------------------------+
|            Customer ID                                    |
+-----------------------------------------------------------+
|            Appliance Number                               |
+-----------------------------------------------------------+
|            Current State                                  |
+-----------------------------------------------------------+
```

Possible status codes:

STATUS_SUCCESS
STATUS_UNKNOWN_CUSTOMER_ID
STATUS_UNRECOGNIZED_APPLIANCE
STATUS_UNAVAILABLE_APPLIANCE

Write Appliance State Request

The Write Appliance State Request is sent by the Web Server to request the Home Controller to change the state of the specified appliance.

The Customer ID identifies the customer whose appliance is to be changed. The Appliance Number field specifies the specific appliance number.

Packet Format

```
+------------------------------------------------------------+
|      Function Code WRITE_APPLIANCE_STATE_REQUEST           |
+------------------------------------------------------------+
|            Zero                                            |
+------------------------------------------------------------+
|            Customer ID                                     |
+------------------------------------------------------------+
|            Appliance Number                                |
+------------------------------------------------------------+
|            New State                                       |
+------------------------------------------------------------+
```

Write Appliance State Response

The Write Appliance State Response is sent by the Home Controller as an answer to the Write Appliance State Request.

Packet Format

```
+----------------------------------------------------------+
|      Function Code WRITE_APPLIANCE_STATE_RESPONSE         |
+----------------------------------------------------------+
|            Status                                         |
+----------------------------------------------------------+
|            Customer ID                                    |
+----------------------------------------------------------+
|            Appliance Number                               |
+----------------------------------------------------------+
```

Possible status codes:

STATUS_SUCCESS
STATUS_UNKNOWN_CUSTOMER_ID
STATUS_UNRECOGNIZED_APPLIANCE
STATUS_UNAVAILABLE_APPLIANCE

Write Time and Date Request

The Write Time and Date Request is sent by the Web Server to request the Home Controller to update its clock.

The Customer ID identifies the customer. The date is stored in a 32-bit number, with the upper 16 bits being the year (1996), the next 8 bits is the month, and the lowest 8 bits is the day. The time is the number of seconds since midnight.

Packet Format

```
+--------------------------------------------------------+
|     Function Code WRITE_TIME_AND_DATE_REQUEST          |
+--------------------------------------------------------+
|            Zero                                        |
+--------------------------------------------------------+
|            Customer ID                                 |
+--------------------------------------------------------+
|            New Date                                    |
+--------------------------------------------------------+
|            New Time                                    |
+--------------------------------------------------------+
```

Write Time and Date Response

The Write Time and Date Response is sent by the Home Controller as an answer to the Write Time and Date Request.

Packet Format

```
+-----------------------------------------------------------+
|      Function Code WRITE_TIME_AND_DATE_RESPONSE           |
+-----------------------------------------------------------+
|            Status                                         |
+-----------------------------------------------------------+
|            Customer ID                                    |
+-----------------------------------------------------------+
```

Possible status codes:

STATUS_SUCCESS
STATUS_UNKNOWN_CUSTOMER_ID

Read Controller Database Request

The Read Controller Database Request is sent by the Web Server to request the Home Controller to report the database of all units it is monitoring or controlling. This is used by the Web Server to initialize or update its records of what units are available at that location. This is done so that the database for the appliances and meters that are being controlled or monitored is set up only in one place, preventing a mismatch of databases in the home controller and the Web Server.

Packet Format

```
+----------------------------------------------------------+
|     Function Code READ_CONTROLLER_DATABASE_REQUEST        |
+----------------------------------------------------------+
|            Zero                                           |
+----------------------------------------------------------+
|            Customer ID                                    |
+----------------------------------------------------------+
```

Read Controller Database Response

The Read Controller Database Response is sent by the Home Controller as an answer to the Read Controller Database Request.

The response data consists of the customer ID, followed by a block of appliance data for each appliance monitored or controlled by this home controller for this customer ID.

Packet Format

```
+------------------------------------------------------------+
|     Function Code READ_CONTROLLER_DATABASE_RESPONSE        |
+------------------------------------------------------------+
|           Status                                           |
+------------------------------------------------------------+
|           Customer ID                                      |
+------------------------------------------------------------+
|           Request Type                                     |
+------------------------------------------------------------+
|           Size of Response Data (32-bit numbers)           |
+------------------------------------------------------------+
|                                                            |
|           Response Data                                    |
|                                                            |
+------------------------------------------------------------+
```

Possible status codes:

STATUS_SUCCESS
STATUS_UNKNOWN_CUSTOMER_ID
STATUS_UNRECOGNIZED_APPLIANCE
STATUS_UNAVAILABLE_APPLIANCE

Self Test Request

The Self Test Request is sent by the Web Server to request the Home Controller to perform a self test of its system.

Packet Format

```
+--------------------------------------------------------------+
|     Function Code SELF_TEST_REQUEST                           |
+--------------------------------------------------------------+
|           Zero                                                |
+--------------------------------------------------------------+
|           Customer ID                                         |
+--------------------------------------------------------------+
```

Self Test Response

The Self Test Response is sent by the Home Controller as an answer to the Self Test Request.

The Controller Type and Version fields specify which type and version of the controller is running at this address. The test results give a more detailed result of the self test, and would include detailed information about any failures. These test results consist of one 32-bit vector, with individual bits set to indicate failures of specific parts of the home controller. Following that is a word consisting of number of times a CEBus message was sent to a specific appliance in the upper 16 bits of the word, and the number of replies received from that appliance in the lower 16 bits of the word. There is one of these entries for each appliance controlled in the house.

Packet Format

```
+-----------------------------------------------------------+
|      Function Code SELF_TEST_RESPONSE                      |
+-----------------------------------------------------------+
|            Status                                          |
+-----------------------------------------------------------+
|            Customer ID                                     |
+-----------------------------------------------------------+
|            Controller Type                                 |
+-----------------------------------------------------------+
|            Controller Version                              |
+-----------------------------------------------------------+
|            Size of Test Results (bytes)                    |
+-----------------------------------------------------------+
|                                                            |
|            Test Results                                    |
|                                                            |
+-----------------------------------------------------------+
```

Possible status codes:

STATUS_SUCCESS
STATUS_SELF_TEST_FAILURE

Initialization Request

The Initialization Request is the only unsolicited request sent by the Home Controller to the Data Manager Server.

This request informs the Data Manager Server that the Home Controller has lost all its information, and needs to be reloaded. The Home Controller should periodically send out this Initialization Request until the Data Manager Server sends any write request.

The Test Results are the results of the power-up tests run by the controller, and would be the same as in the self test response.

Packet Format

```
+-----------------------------------------------------+
|   Function Code INITIALIZATION_REQUEST              |
+-----------------------------------------------------+
|          Status                                     |
+-----------------------------------------------------+
|          Customer ID                                |
+-----------------------------------------------------+
|          Controller Type                            |
+-----------------------------------------------------+
|          Controller Version                         |
+-----------------------------------------------------+
|          Size of Test Results (bytes)               |
+-----------------------------------------------------+
|                                                     |
|          Test Results                               |
|                                                     |
+-----------------------------------------------------+
```

Possible status codes:

STATUS_SUCCESS
STATUS_SELF_TEST_FAILURE

Appliance Data

The Appliance Number is an index value (starting at one) that identifies this particular appliance from a list of appliances being monitored/controlled in a particular premise. The Appliance Name field indicates what type of appliance is connected to the monitor/control unit, e.g., electric meter, gas meter, refrigerator, pool pump, etc. The Appliance Location is a 16-byte string, blank filled, field indicating physical location of the appliance, e.g. kitchen, garage, living room, etc. The Appliance Type field identifies the appliance voltage rating or encoder type. The Vendor field identifies the vendor of the monitor/control/encoder unit (not the appliance). The monitor/control capability field when applicable indicates whether the appliance energy usage can be monitored and/or controlled. The control type, if applicable, indicates what control the controller has over this appliance, such as on/off, temperature, dim, volume, etc.

Format

```
+------------------------------------------------------------+
|            Appliance Number                                |
+------------------------------------------------------------+
|            Appliance Name                                  |
+------------------------------------------------------------+
|                                                            |
|            Appliance Location                              |
|                                                            |
+------------------------------------------------------------+
|            Appliance Type                                  |
+------------------------------------------------------------+
|            Monitor/Control/Encoder Vendor                  |
+------------------------------------------------------------+
|            Monitor/Control Capability                      |
+------------------------------------------------------------+
|            Measuring Units                                 |
+------------------------------------------------------------+
|            Control Type                                    |
+------------------------------------------------------------+
```

Other Formats

Date and Time

The date is stored in a 32-bit number, with the upper 16 bits specifying the year (full year format, e.g., 1996), the next 8 bits specifying the month, and the lowest 8 bits specifying the day of the month. The time is stored in a 32-bit number as the number of seconds since midnight.

Customer ID

The customer ID is stored as a 32-bit number in the home controller, but not interpreted by the home controller. It is specified and interpreted by the Web Server, and only used as a reference by the home controller.

Values for Constants

Status Codes

The status codes and their values and meanings are as follows:

STATUS_SUCCESS	= 0	Operation was successful, and data is valid
STATUS_DATAGRAM_NOT_READ	= 1	The request was not read successfully
STATUS_DATAGRAM_INVALID	= 2	The request contained an invalid request ID
STATUS_UNKNOWN_CUSTOMER_ID	= 3	Customer ID not recognized
STATUS_UNRECOGNIZED_METER	= 4	Meter type not recognized
STATUS_UNAVAILABLE_METER	= 5	Meter data not available on this controller
STATUS_UNAVAILABLE_DATE	= 6	Meter found but data not available
STATUS_UNRECOGNIZED_APPLIANCE	= 7	Appliance number not recognized
STATUS_UNAVAILABLE_APPLIANCE	= 8	Appliance number not on this controller
STATUS_UNAVAILABLE_DATA	= 9	Appliance found but data not available
STATUS_UNAVAILABLE_SCHEDULE	= 10	Schedule not available on this controller
STATUS_UNRECOGNIZED_SCHEDULE	= 11	Schedule data not understood
STATUS_UNRECOGNIZED_RATE	= 12	Rate data not understood
STATUS_SELF_TEST_FAILURE	= 13	Controller failed self test

Request and Response Values

The values to be used with the request and response packets are as follows:

READ_SCHEDULED_EVENTS_REQUEST	1
READ_SCHEDULED_EVENTS _RESPONSE	2
READ_APPLIANCE_REQUEST	3
READ_APPLIANCE_RESPONSE	4
READ_SCHEDULE_REQUEST	5
READ_SCHEDULE_RESPONSE	6
WRITE_SCHEDULE_REQUEST	7
WRITE_SCHEDULE_RESPONSE	8
WRITE_RATE_REQUEST	9
WRITE_RATE_RESPONSE	10
READ_APPLIANCE_STATE_REQUEST	11
READ_APPLIANCE_STATE_RESPONSE	12
WRITE_APPLIANCE_STATE_REQUEST	13
WRITE_APPLIANCE_STATE_RESPONSE	14
WRITE_TIME_AND_DATE_REQUEST	15
WRITE_TIME_AND_DATE_RESPONSE	16
READ_CONTROLLER_DATABASE_REQUEST	17
READ_CONTROLLER_DATABASE_RESPONSE	18
SELF_TEST_REQUEST	19
SELF_TEST_RESPONSE	20
INITIALIZATION_REQUEST	21

Read Controller Database Request Types

READ_CTLR_DB_TYPE_CUSTOMERS_SERVED	1
READ_CTLR_DB_TYPE_APPLIANCES	2

Meter Type Values

The values to be used to specify which meter to be read are as follows:

METER_TYPE_ELECTRIC	1
METER_TYPE_GAS	2
METER_TYPE_WATER	3

Appliance Name

1	Electric Meter
2	Gas Meter Encoder
3	Water Meter Encoder
4	Clothes Dryer Electric
5	Clothes Dryer Gas
6	Clothes Washer
7	Coffee Maker
8	Computer
9	Dishwasher
10	Electric Oven
11	Electric Range
12	Electric Vehicle Charger
13	Evaporative Cooler
14	Force Air Unit
15	Freezer
16	Home Audio System
17	HVAC Air Conditioner Unit
18	HVAC Heating Unit
19	Lamp
20	Light Dimmer Switch
21	Light Switch
22	Microwave Oven
23	Pool Pump
24	Portable Fan Unit
25	Refrigerator
26	Room A/C
27	Spa Pump
28	Space Heater
29	Television
30	Toaster
31	Water Heater
32	Waterbed Heater
40	Unknown Appliance Name

Appliance Type

APPLIANCE_TYPE_120V	1
APPLIANCE_TYPE_240V	2
APPLIANCE_TYPE_GAS_ENCODER	3
APPLIANCE_TYPE_WATER_ENCODER	4

Appliance Monitor/Control/Encoder Vendor

APPLIANCE_VENDOR_DEG	1
APPLIANCE_VENDOR_DIABLO	2
APPLIANCE_VENDOR_GE	3
APPLIANCE_VENDOR_LEVITON	4
APPLIANCE_VENDOR_RIOTRONICS	5
APPLIANCE_VENDOR_SENSUS	6
APPLIANCE_VENDOR_WEXL	7
APPLIANCE_VENDOR_AMP	8

Appliance Monitor/Control Capability

The values to be used to specify the monitor/control capability for the appliance are as follows (these can be added together for combinations):

APPLIANCE_CAPABILITY_MONITOR	1	- Monitor the appliance
APPLIANCE_CAPABILITY_CONTROL	2	- Control the appliance
APPLIANCE_CAPABILITY_MONITOR_AND_CONTROL	3	- Monitor and Control appliance

Appliance measuring units

The units of data returned when measuring energy usage of the appliance are defined as follows:

APPLIANCE_MEASURING_KWHRS	1	- Kilowatt-hours
APPLIANCE_MEASURING_WHRS	2	- Watt-hours
APPLIANCE_MEASURING_dWHRS	3	- deciWatt-hours
APPLIANCE_MEASURING_ENCODER_PULSES	4	- Pulse count
APPLIANCE_MEASURING_CUBIC_FEET_PER_MINUTE	5	- Cubic feet per minute
APPLIANCE_MEASURING_CUBIC_INCHES_PER_MINUTE	6	- Cubic inches per minute
APPLIANCE_MEASURING_GALLONS_PER_MINUTE	7	- Gallons per minute

Appliance control types

The types of control that can be performed on this appliance are defined as follows (these can be added together for multiple types of control):

APPLIANCE_CONTROL_ON_OFF	1	- Can turn appliance on or off
APPLIANCE_CONTROL_TEMP	2	- Can set temperature of appliance
APPLIANCE_TYPE_DIM	4	- Can brighten or dim appliance

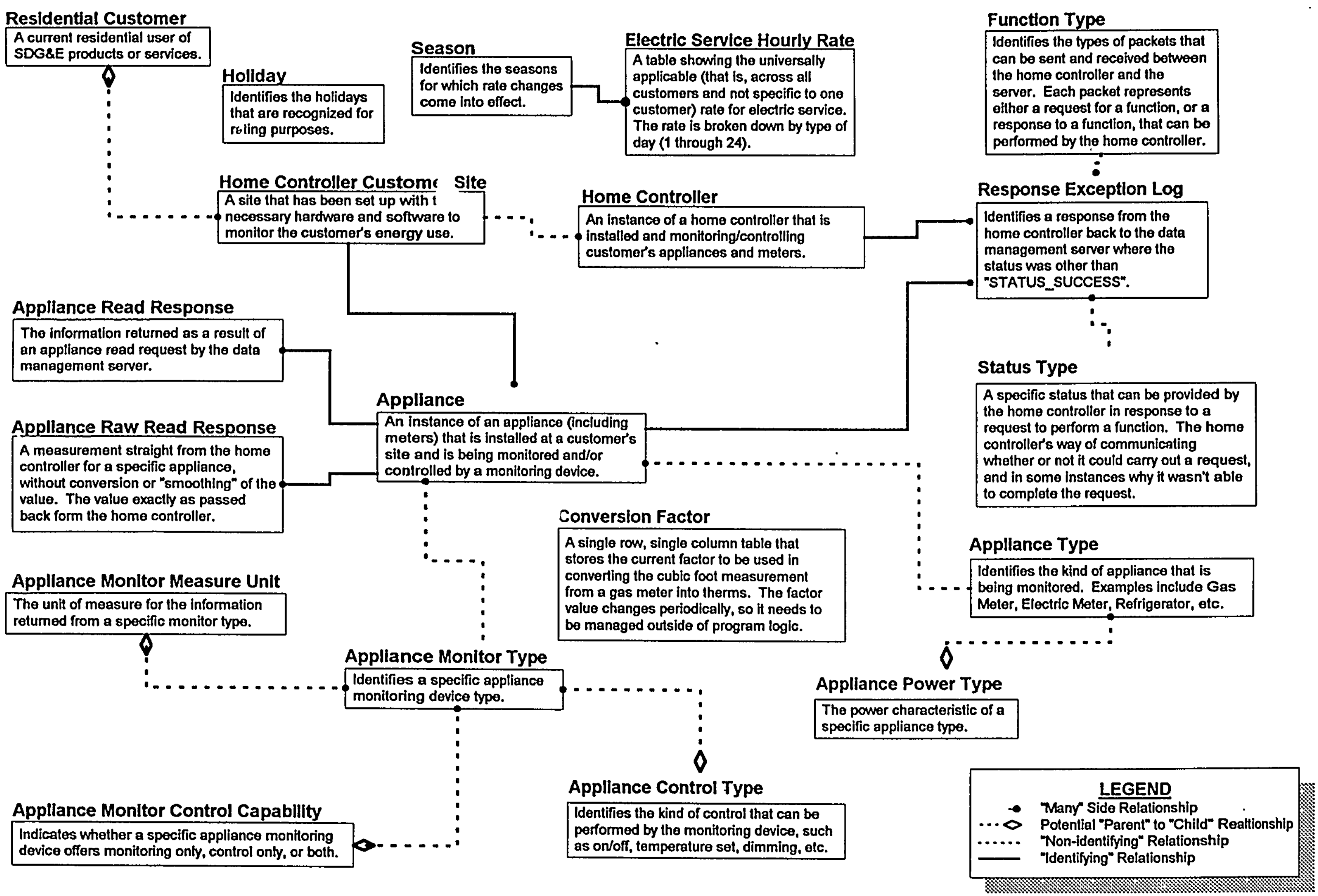
LiveWire Project: Customer PC Requirements

	MINIMUM	PREFERRED
Software		
Operating System:	Window 3.1 (will upgrade Win 3.1 to Win 95 if Win 3.1 installed	Windows '95
Web Browser:	Netscape 3.0, Internet Explorer 3.0	Netscape 3.0, Internet Explorer 3.0 or later
Anti Virus Utility:	None, will upgrade customer system to latest McAfee release	Latest McAfee release
Hardware		
Architecture:	IBM Compatible	IBM Compatible
Processor:	486 -DX 33 MHz	Pentium - 75 MHz
Available Disk Space: (assuming Windows '95 installed)	18 MB	28 MB
RAM Memory:	8 MB	16 MB
Drives:	one 3.5" - 1.44 MB floppy drive	2X CD ROM drive or faster
Mouse	2 button mouse	2 button mouse
Monitor:	14" SGVA - 256 colors, 640 x480 minimum resolution	15" SGVA - 256 colors, 640 x480 minimum resolution

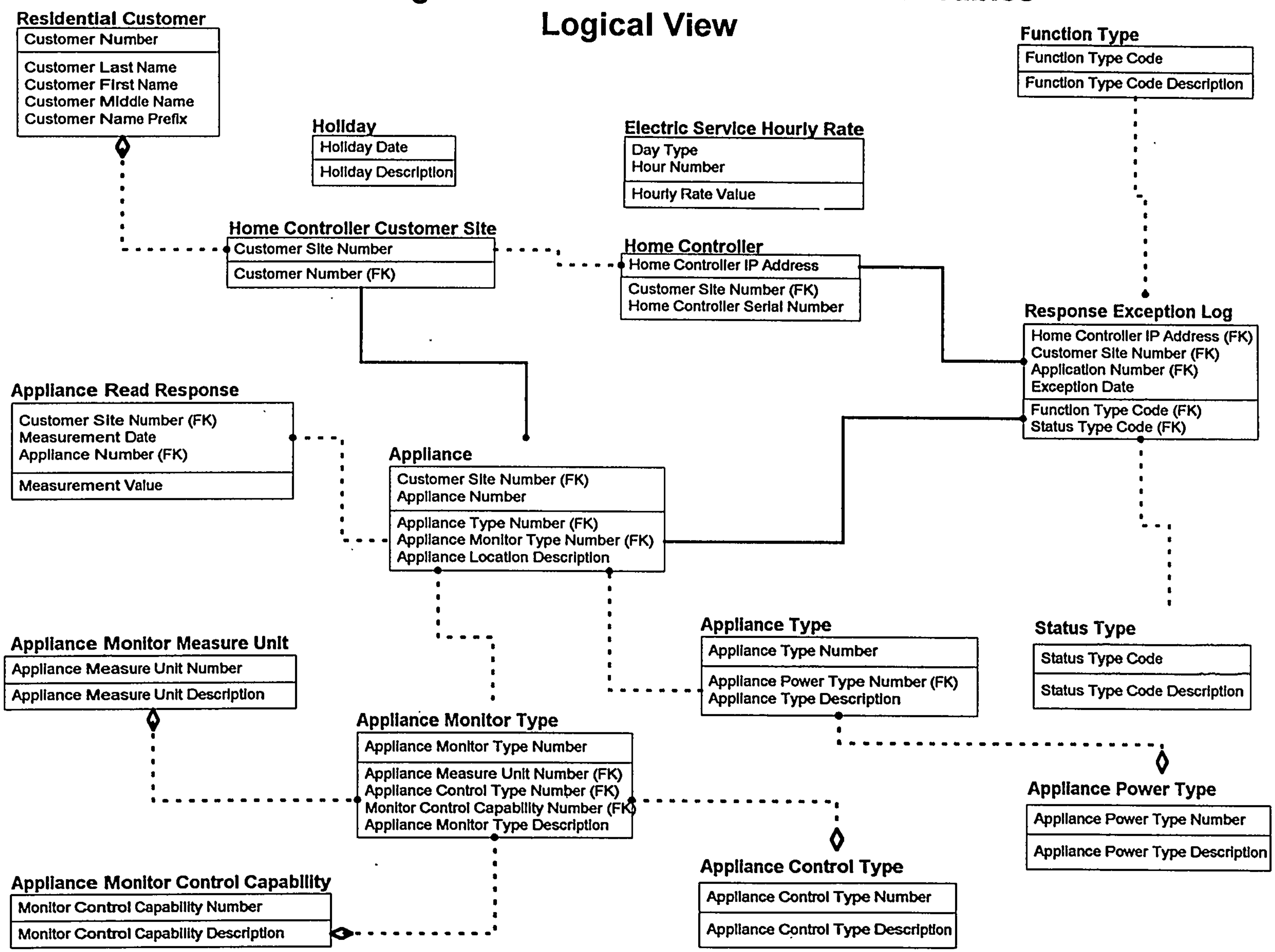
NOTES:

1) IBM PS/2 PC's (microchannel architecture) should be excluded from the test
2) Customer PC must have an open ISA slot for ne'work adapter card.

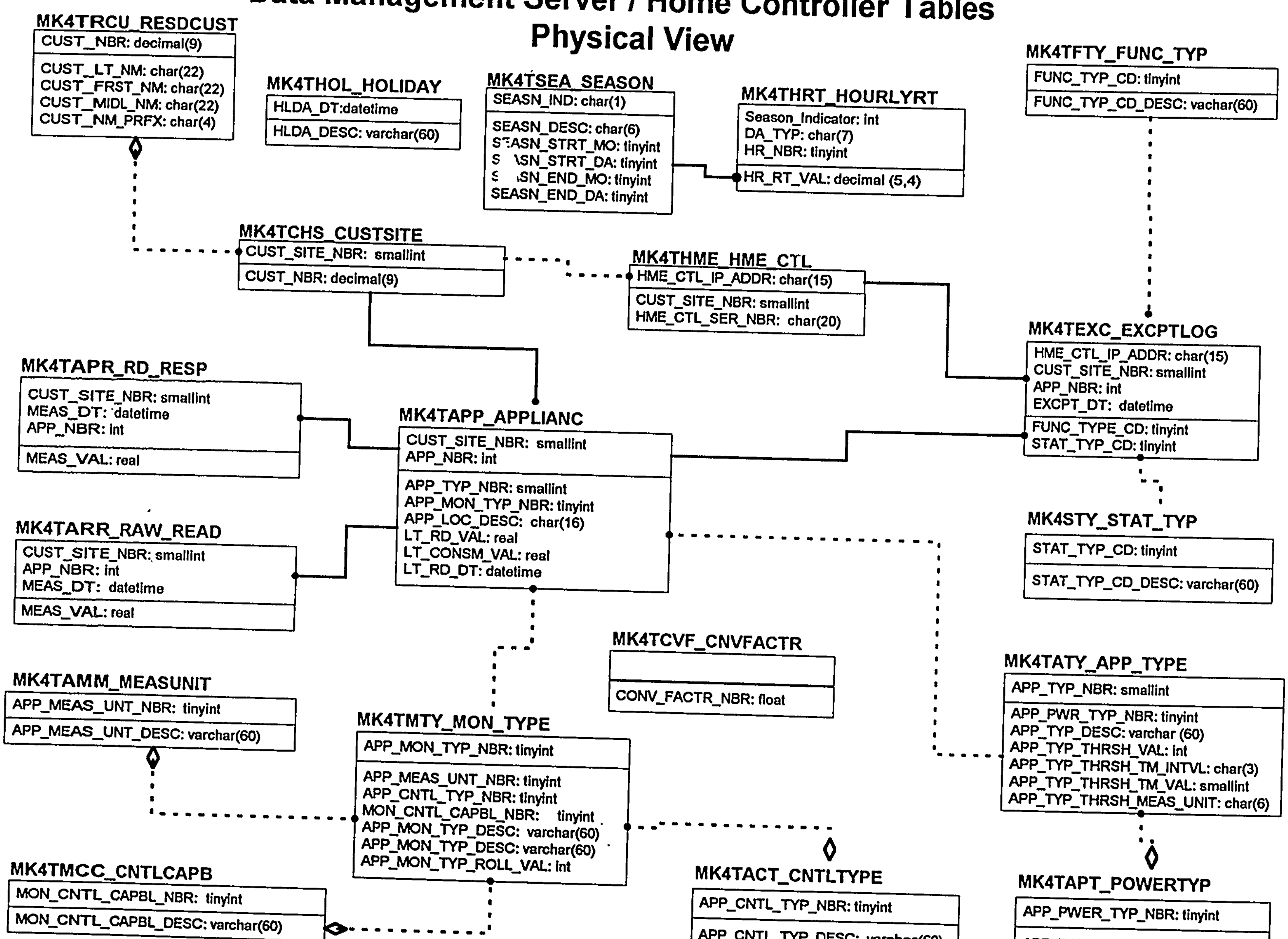
Data Management Server / Home Controller Tables: Definition View



Data Management Server / Home Controller Tables
Logical View



Data Management Server / Home Controller Tables
Physical View



Customer PC Settings for LiveWire Participation

Introduction

San Diego Gas and Electric (SDG&E) initiated a project in which residential customers would retrieve appliance usage data via Internet. Participating customers were required to use their home PCs attached to a SDG&E's cable modem. The cable modem was then connected to Pacific Bell's Coax/Fiber hybrid cable for fast Internet access. Each PC was upgraded with the required software: Netscape Navigator version 3.0, Windows 95, and McAfee Anti-virus.

The minimum PC requirements included a 486MHz or faster, 8 Megabytes RAM, and one empty ISA expansion slot. An Intel EtherExpress PRO/10+ Network card was also installed into each computer.

Windows 95 was configured to identify the ISA Network card installed into the home PC, and setup with TCP/IP communication protocols. The following settings were successfully used to gain Internet access from a participant's home PC. Netscape Navigator mail settings are also documented.

1.0 Test-Home PC: Installed Win'95 Network Components

Follow the next set of steps to add the required adapters and protocols

1.1 Double-click the My Computer icon on the desktop.
1.2 Double-click the Control Panel icon.
1.3 Double-click the Network icon.
1.4 Add the all the adapters and protocols shown in the Figure 1.

NOTE: If a set of protocols already exist in a computer, Win'95 will use arrows to point new protocol to adapter. Figure 1, shows how Win'95 displays multiple protocols.

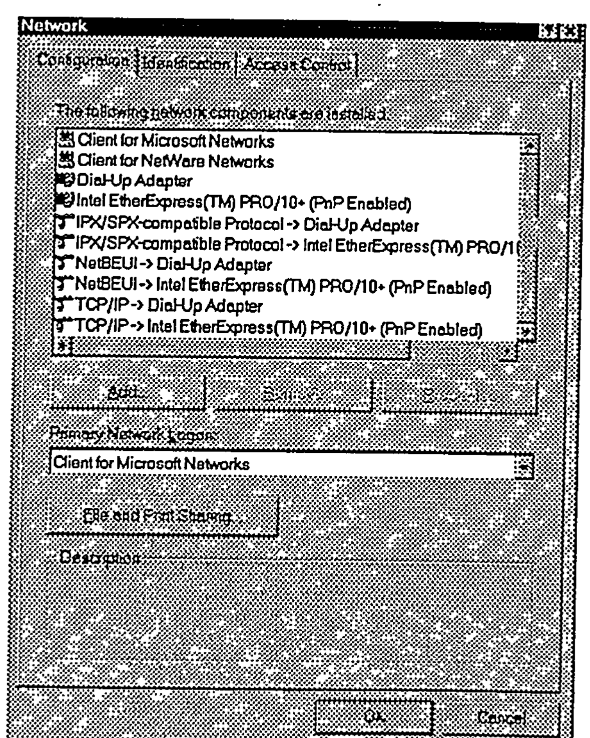


Figure 1. Network settings window.

2.0 Test-Home PC: Network Identification Settings:

The Network Identification settings may be accessed by clicking the Identification tab from Network settings.

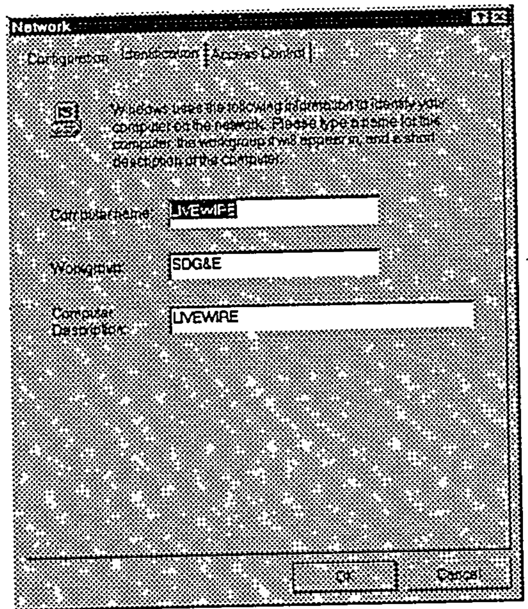


Figure 2. Network Identification

3.0 Test-Home PC: Network Access Control Settings:

The Network Access Control settings may be accessed by clicking the Access Control tab from the Network settings window.

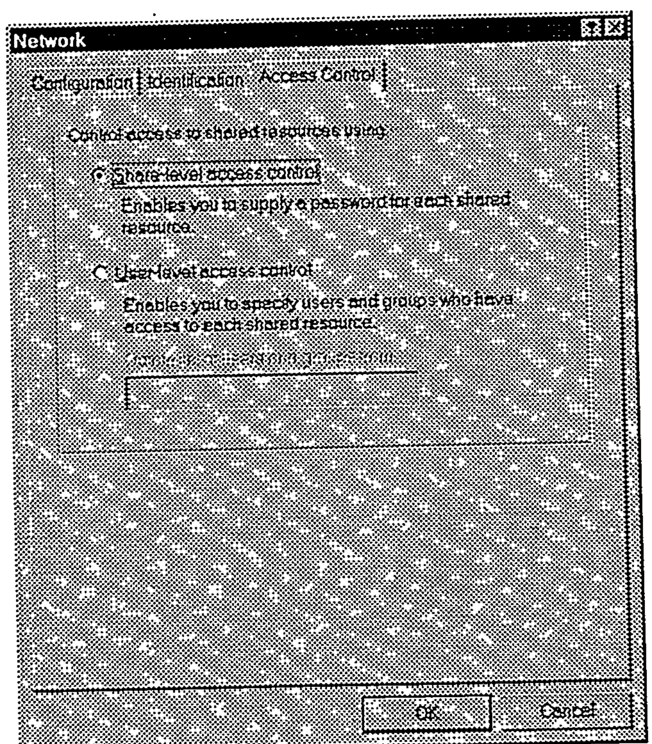


Figure 3. Network Access Control window

4.0 Test-Home PC: Client for Microsoft Networks Properties:

To access the Client for Microsoft Networks Properties window

1. Highlight Client for Microsoft Networks from the Network window (Figure 1).
2. Click the Properties button.
3. Copy all the settings from Figure 4.

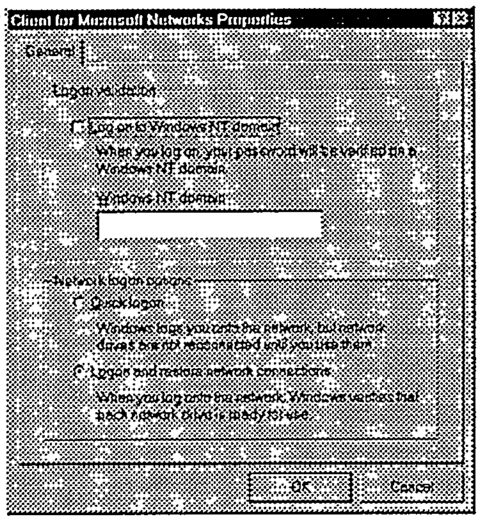


Figure 4. Client for Microsoft Networks Properties

5.0 Test-Home PC: EtherExpress Network Adapter Card Properties:

To access the Intel EtherExpress (TM) PRO/10+ (PnP Enabled) Properties window

1. Highlight Intel EtherExpress (TM) PRO/10+ (PnP Enabled) from the Network window (Figure 1).
2. Click the Properties button.
3. Click the Driver Type tab.
4. Copy all the settings from Figure 5.

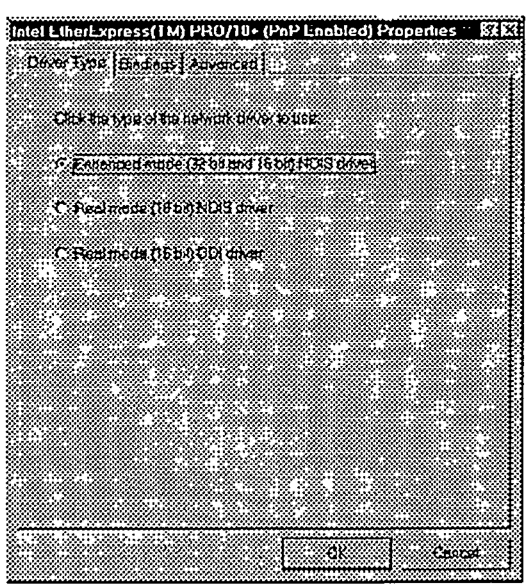


Figure 5. Intel EtherExpress Network Adapter Card Properties Driver Type tab

5.0 Test-Home PC: EtherExpress Network Adapter Card Properties (cont.):

To access the Intel EtherExpress(TM) PRO/10+ (PnP Enabled) Properties window

1. Highlight Intel EtherExpress (TM) PRO/10+ (PnP Enabled) from the Network window (Figure 1).
2. Click the Properties button.
3. Click the Bindings tab.
4. Copy all the settings from Figure 6.
5. Click the Advanced tab.
6. Copy all the settings from Figure 7a and Figure 7b.

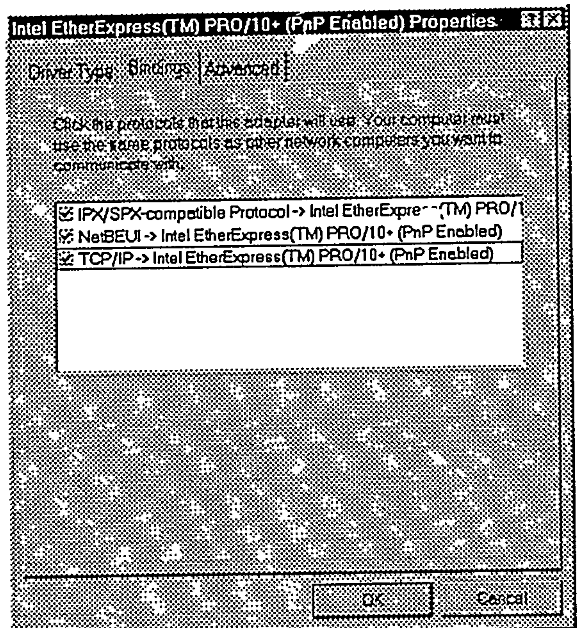


Figure 6. Intel EtherExpress Network Adapter Card Properties Bindings tab

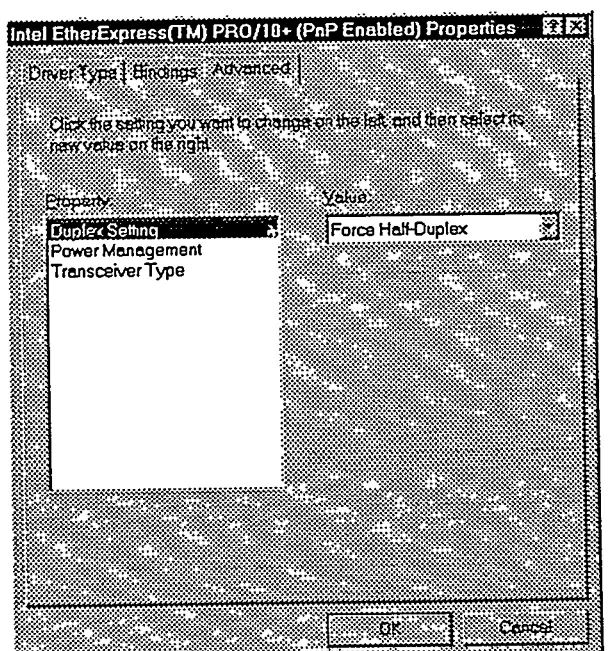


Figure 7a. Intel EtherExpress Network Adapter Card Properties Advanced tab, Duplex Setting values.

5.0 Test-Home PC: EtherExpress Network Adapter Card Properties (cont.):

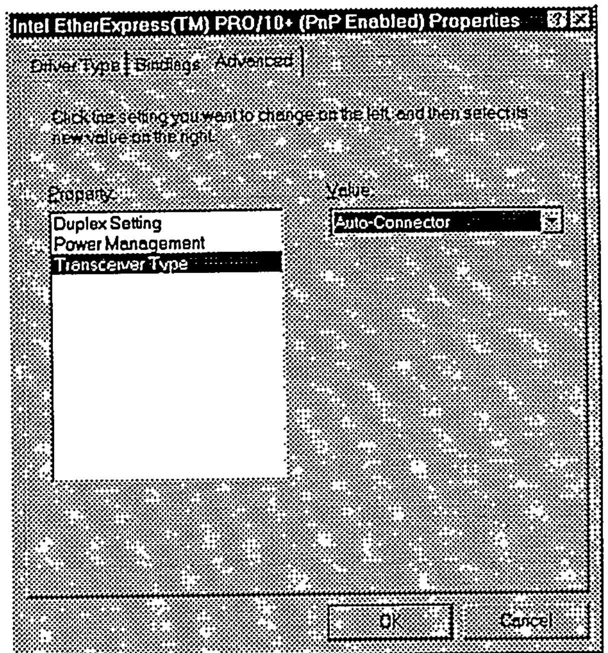


Figure 7b. Intel EtherExpress Network Adapter Card Properties Advanced tab, Transceiver Type values.

6.0 Test-Home PC: TCP/IP Settings:

To access the TCP/IP Properties window

1. Highlight TCP/IP from the Network window (Figure 1).
2. Click the Properties button.
3. Click the Bindings tab.
4. Copy all the settings from Figure 8.
5. Repeat Steps 4 for each tab in the TCP/IP properties window using Figure 9 - Figure 13.

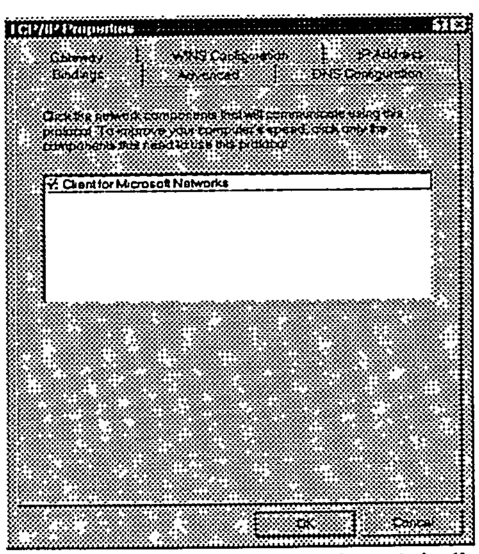


Figure 8. TCP/IP Properties window, Bindings tab.

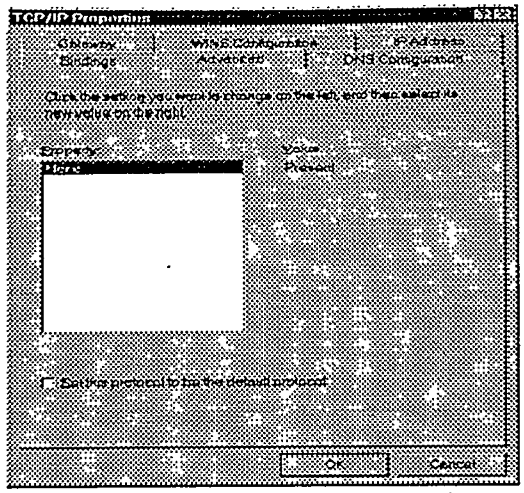


Figure 9. TCP/IP Properties window, Advanced tab.

6.0 Test-Home PC: TCP/IP Settings (cont.):

To add IP addresses

1. Type IP's in the DNS Server Search Order field.
2. Click the Add button.

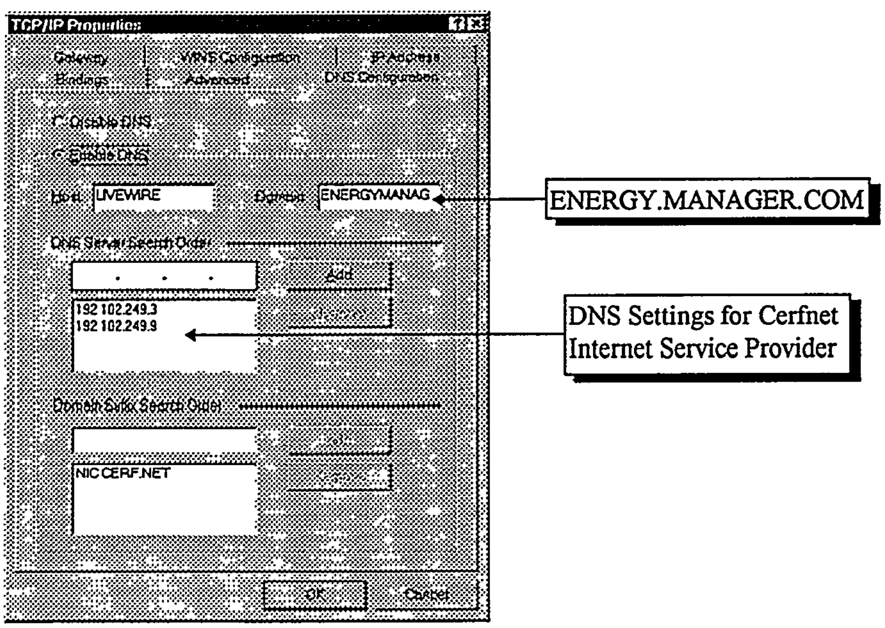


Figure 10. TCP/IP Properties window, DNS Configuration tab.

To add IP addresses:

1. Type IP's in the New gatway: field.
2. Click the Add button.

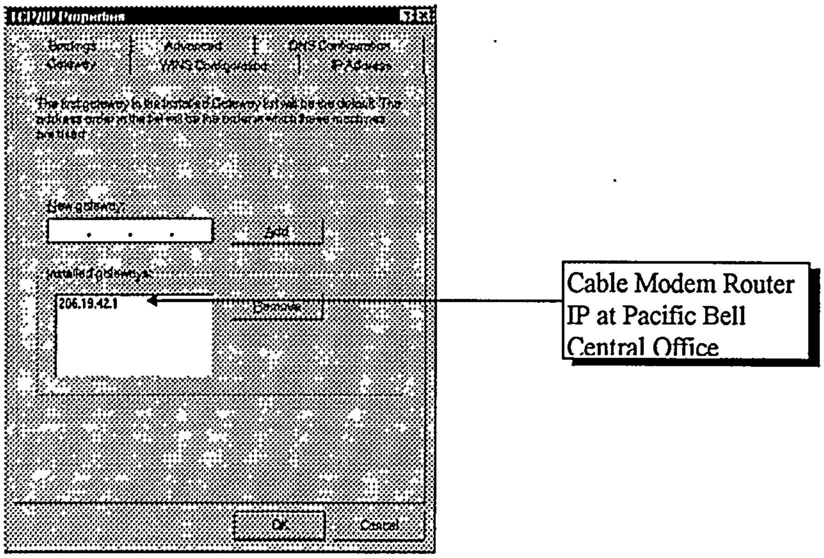


Figure 11. TCP/IP Properties window, Gateway tab.

6.0 Test-Home PC: TCP/IP Settings (cont.):

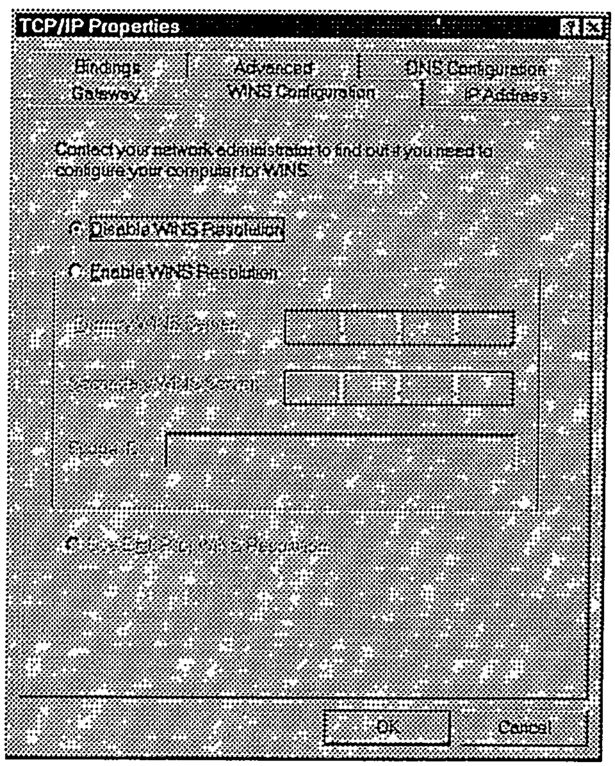


Figure 12. TCP/IP Properties window, WINS Configuration tab.

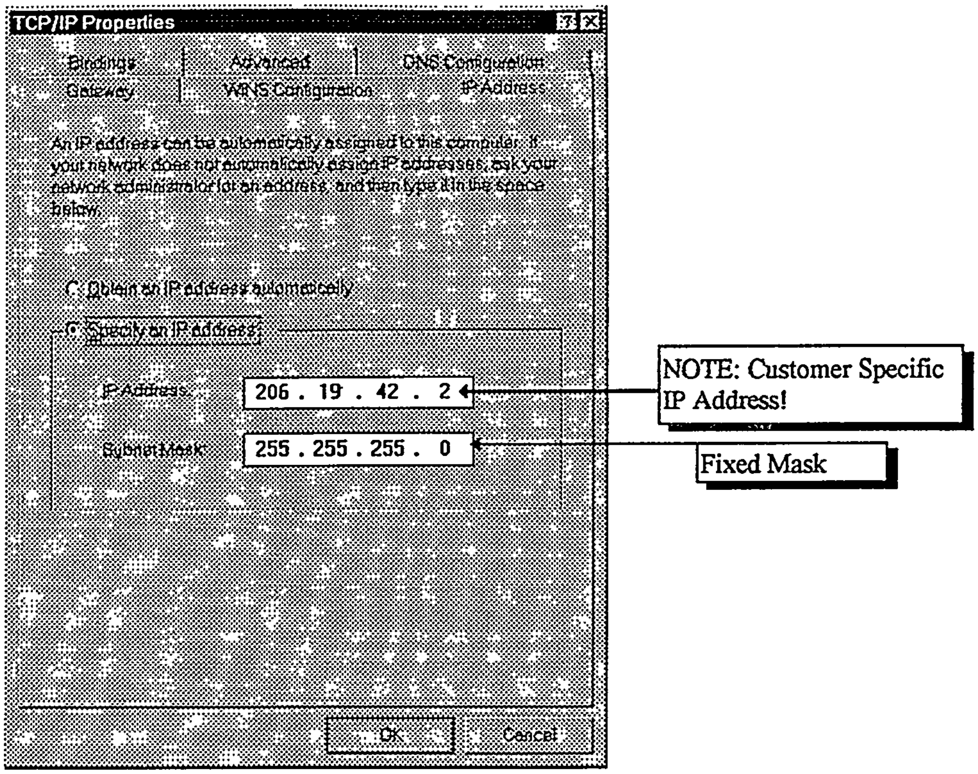


Figure 13. TCP/IP Properties window, WINS Configuration tab.

NOTE: The IP Address shown in Figure 13 is specific to each customer.

7.0 IntelEtherExpress PRO/10 Adapter Card Properties

To access the Intel EtherExpress PRO/10 Adapter Card Properties window

1. Highlight Intel EtherExpress PRO/10 Adapter Card from the Network window (Figure 1).
2. Click the Properties button.
3. Click the General tab.
4. Copy all the settings from Figure 14.
5. Click The Resource tab.
6. Copy all the settings from Figure 15.

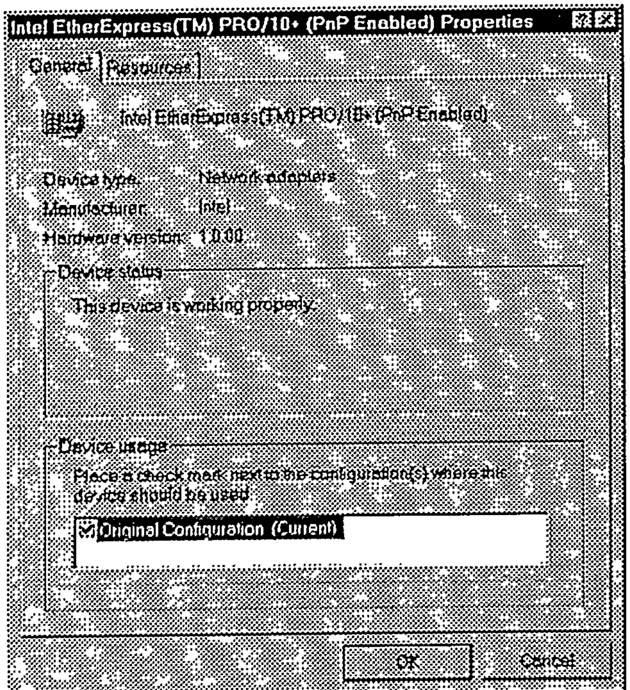


Figure 14. Intel EtherExpress PRO/10 Adapter Card Properties window, General tab.

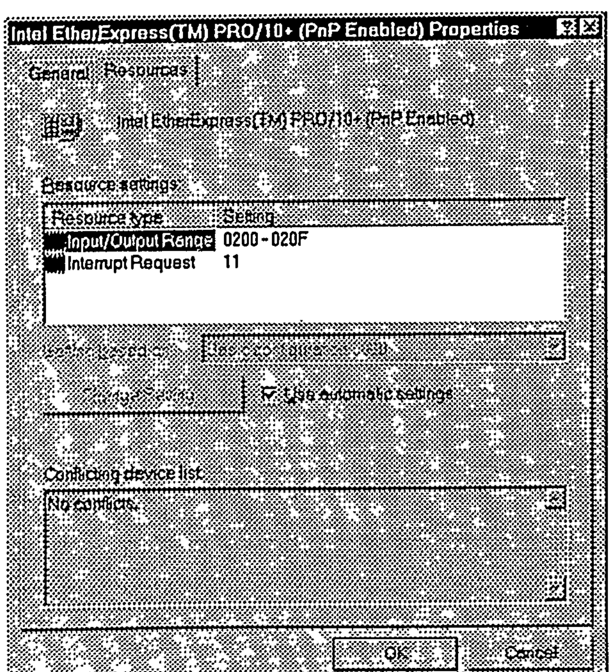


Figure 15. Intel EtherExpress PRO/10 Adapter Card Properties window, Resource tab.

7.0 Test-Home PC: NETSCAPE NAVIGATOR 3.0 E-mail Settings:

To access Netscape Navigator 3.0 e-mail settings

1. Start the Netscape Navigator program by double clicking its icon.
2. Pick Mail and News Preferences… from the Options menu.
3. Click the Servers tab.
4. Copy all the settings from Figure 16.
5. Click the Identify tab.
6. Copy all the settings from Figure 17.

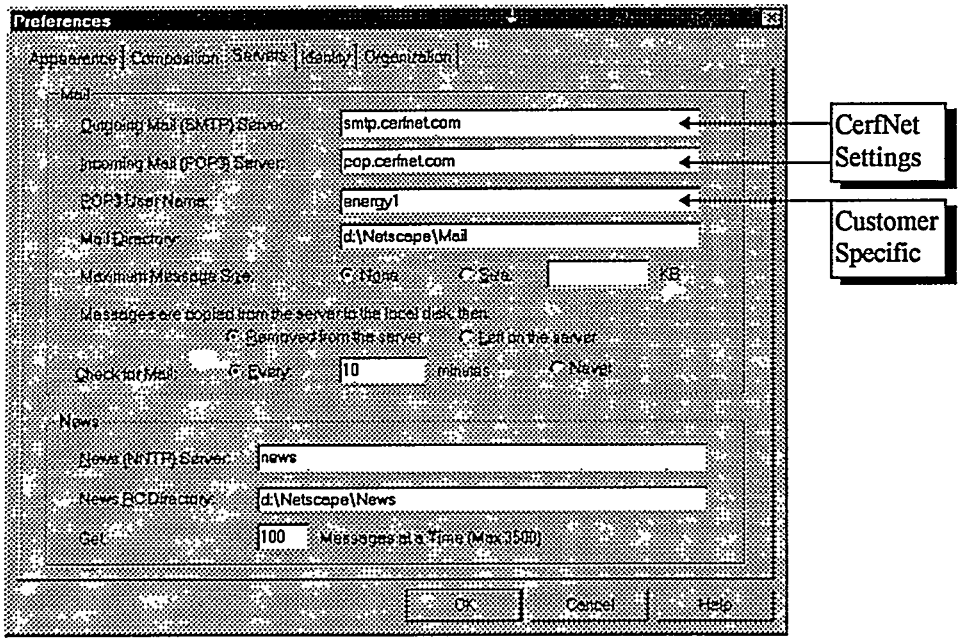


Figure 16. Netscape Navigator 3.0 e-mail settings, Servers tab.

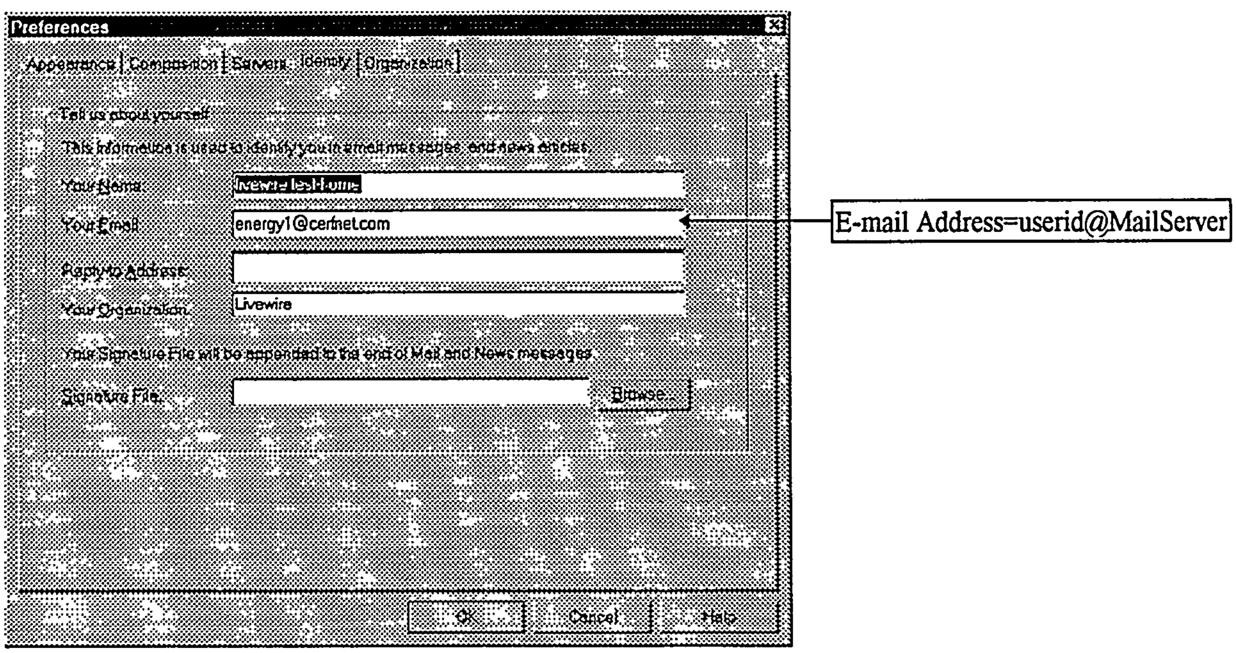
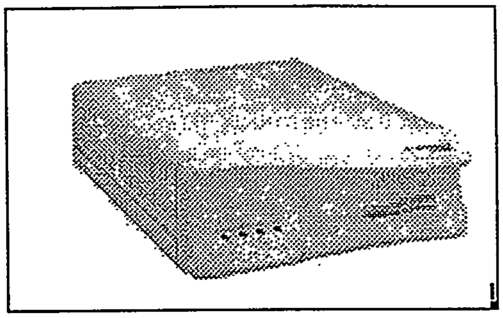


Figure 17. Netscape Navigator 3.0 e-mail settings, Identify tab.

Motorola CyberSURFRTM Cable Modem
Manufacturer Specifications



SOURCE: http://www.mot.com/MIMS/Multimedia/prod/specs/modemSpec.html

Features:

High-speed upstream and downstream ethernet network communications for subscriber's personal computer, workstation, Macintosh computer or other network device running TCP/IP protocol
Modem configuration file automatically provisioned within Cable Router database
Supports communications for multiple network devices
Standard 10BaseT Ethernet connectivity
TCP/IP protocol transport system
Upstream noise robustness in hostile noise environments
DES based encryption in both upstream and downstream communications
Easy to install and operate
Low cost per subscriber

Description:

The CyberSURFRTM Cable Modem is a component of the Motorola Cable Data System which connects a subscriber's personal computer or other TCP/IP addressable device to a hybrid fiber / coaxial (HFC) system. The Cable Data System is specifically designed for high-speed communications for online services, Internet access, telecommuting and other emerging services for home and business PC users.

The CyberSURFR connects to the subscriber PC using standard 10BaseT ethernet. A single CyberSURFR supports communications for multiple personal computers with IP addresses. An ethernet wiring hub interface provides the connections for more than one PC.

The CyberSURFR Cable Modem supports IP communications from the subscriber's PC to host computers and servers. The CyberSURFR Cable Modem is not assigned an IP address and does not require an IP subnet, conserving operator IP addresses.

Motorola CyberSURFRTM Cable Modem
Manufacturer Specifications

The modem performs the function of filtering and forwarding packets both to and from the PC attached to it, giving the appearance that the PC is directly connected to a LAN in the cable headend.

RF transmitters and receivers in the CyberSURFR Cable Modem provide the physical layer communications over the HFC system. The data from a subscriber PC is transmitted upstream on a 768 kbps shared packet data channel which uses a 600 kHz carrier. Downstream the subscriber shares a 30 Mbps channel which uses a 6 MHz carrier and provides a maximum of 10 Mbps throughput to each subscriber. Throughput varies depending on internet access, channel load, PC processor and configuration, and headend equipment load. The CyberSURFR Cable Modem operates in the upstream spectrum of 6 MHz - 42 MHz and downstream between 65 MHz - 750 MHz.

High performance communications across HFC systems is ensured by the CyberSURFR Cable Modem's ability to identify and correct errors caused by transient ingress noise through sophisticated forward error correction (FEC) techniques. In addition, the frequency agility feature embedded in the Cable Router enables the CyberSURFR to switch automatically to an alternate frequency if a sustained high noise level is experienced on the existing frequency.

Secure communications is supported through the use of Data Encryption Standard (DES) in both upstream and downstream transmissions. User data is encrypted providing complete privacy to subscriber transmissions over the shared HFC system. When the CyberSURFR is powered up, a registration authorization is performed to ensure that a subscriber is using a valid system CyberSURFR Cable Modem.

The CyberSURFR Cable Modem is easily installed by connecting it to the subscriber PC using a standard 10BaseT Ethernet connection. The installation is completed by simply plugging the CyberSURFR Cable Modem into the cable in the home. The CyberSURFR Cable Modem will then automatically go through the registration and authentication process. Four LEDs indicate connectivity status and also act as a diagnostic aid. The TCP/IP address for the subscriber's network device is either configured statically in the IP communications software or the address can be configured dynamically by using a DHCP server.

Management of the CyberSURFR Cable Modem is provided through an SNMP proxy agent in the Cable Router and the Enterprise MIB variables. MIB II variables are also supported. Software in the CyberSURFR Cable Modem can be updated to the

Motorola CyberSURFRTM Cable Modem
Manufacturer Specifications

latest version through a down-line load process executed by the Cable Router to allow an operator to maintain consistent software throughout the subscriber base.

A customized label can be affixed on the inset on the crest of the wave of the front panel for brand labeling of the CyberSURFR Cable Modem.

Interfaces:
- 10BaseT Ethernet Connector
- HFC Drop Connector: Female "F" Type

RF Specifications:

Transmitter
- Bandwidth: 600 kHz
- Data Signaling Rate: 768 kbps
- Symbol Rate: 384 ksym/sec
- Modulation: pi/4-DQPSK
- Transmit Frequency Range: 6 MHz - 42 MHz w/dynamic frequency agility
- Input Impedance: 75 Ohms (nominally)
- Dynamic Range: 24 - 55 dBmV

Receiver
- Bandwidth: 6 MHz
- Data Signaling Rate: 30 Mbps
- Symbol Rate: 5 Msym/sec
- Modulation: 64 QAM
- Receive Frequency Range: 65 - 750 MHz w/frequency selectable
- Channel Plans: Standard, IRC, HRC
- Input Impedance: 75 Ohms (nominally)
- Minimum CNR (at receiver): 30 dB
- Sensitivity: +5 to -15 dBmV
- Group Delay Tolerance: 130 nS

Physical and Environmental

- Dimensions: 2 1/2" x 6 5/8" x 9.6"
- Weight: 2.8 lbs (1.3 kgs)
- Front Panel LEDs: Power, Test, Cable, PC
- Rear Panel Connectors/Controls:
  - Cable Type F connector
  - Reset Button
  - EIA 232 25-pin port - reserved
  - RJ45 PC/hub connector
  - Power connection (DIN connector)

Motorola CyberSURFRTM Cable Modem
Manufacturer Specifications

Universal Power Supply 100 to 250 VAC, 47 to 63 Hz

Operating Temperature: 0o C to +40o C (+32o F to +104o F)

Safety Specifications: UL 1950; CSA C22.2 No.950; IEC 950; EN 60950; AS/NZS 3260

Emissions: FCC Part 15, Class B; CISPR 22, Class B; EN 55022, Class B; AS/NZ 3548, Class B.

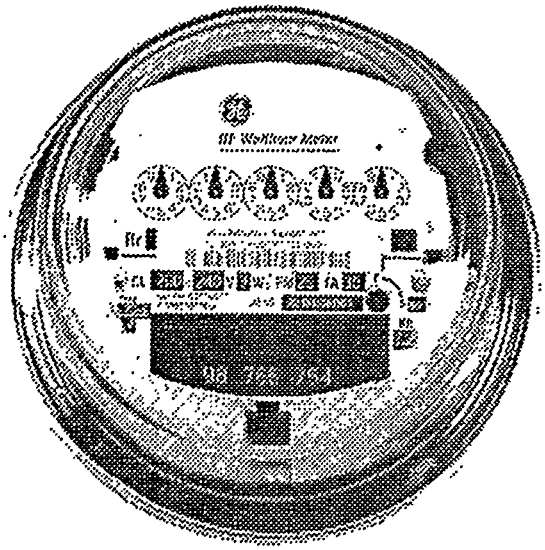
Immunity: EN 50082-1.

To contact Motorola Multimedia Group call 1-800-2-WAY-HFC or e-mail: multimedia@mot.com

GE Meter

CM21P

CEBus® Communicating Register



CM21P on GE I-70
(Cat # 721X008001)

CM21P CEBus® Power Line Module

Overview

The CM21P is a communicating electronic register designed to fit GE's electro-mechanical meters. The CM21P measures and communicates advanced metering data via power lines in residential and light commercial applications using Consumer Electronic Bus (CEBus®) protocol.

The CM21P is more than just a communications module it's functionalty includes consumption, demand, load profile data recording, and full two-way communications including meter initiated warnings of theft or tampering. The CM21P does all this without a battery, reducing maintenance costs and environmental impact.

In fact, the CM21P is a gateway to your customer. An AMR system using power line communications allows you to expand beyond the meter to your customers. Your system will be able to communicate with any CEBus® products including thermostats, appliances, controllers, and interface devices plugged into your customers power line.

In addition, the CM21P has provisions for an option board which can be used for remote connect/disconnect, load control, customer alert services and other services, all controlled directly from the meter.

The CM21P is designed to be Wide Area Network (WAN) independent allowing you maximum flexibility in your system. You can choose the optimal solution for your needs, whether it's fiber, phone, radio, satellite or a combination of media.

CM21P Features

<u>Energy Measurements</u>
- Consumption
- Demand
  - Programmable Intervals/ Block or Rolling
  - Maximum Demand
  - Cumulative Demand
- Load Profile
  - 672 Buckets - Programmable Intervals
  - Time of Use and Real-time Pricing capability

<u>Tamper Detection/Prevention</u>
- CEBus® Authentication/Encryption algorithm ensures system security
- Report-by-exception capabilities:
  - Reverse disk rotation
  - Demand threshold exceeded
  - Zero pulses in LP interval
  - New Maximum demand
- History Log:
  - Time and date of last programming
  - Time and date of last demand reset
  - Number of demand resets
  - Time and date of last power outage
  - Number of power outages

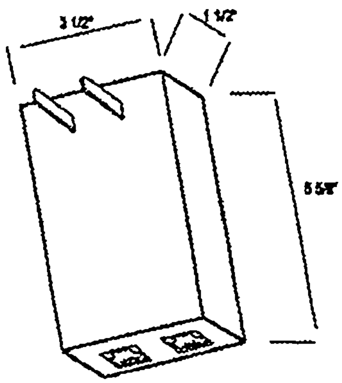
<u>Communications</u>
- Full two-way communication
- 10 Kbps

<u>Industry Standards</u>
- Consumer Electronic Bus (CEBus®) communication protocol
- The 1st meter to utilize the Automated Meter Reading Association (AMRA) Standard Tables

<u>Advanced Functions</u>
- Three minute load profile "snapshot" to analyze effects of DSM actions
- Lock out timers
  - Prevent multiple demand resets and false peaks after outages
- Provisions for an Option Board
  - Remote Connect/Disconnect, Load Control, External Demand Threshold Alert etc...

®Unity Systems Inc.®

CEBus Controller 2

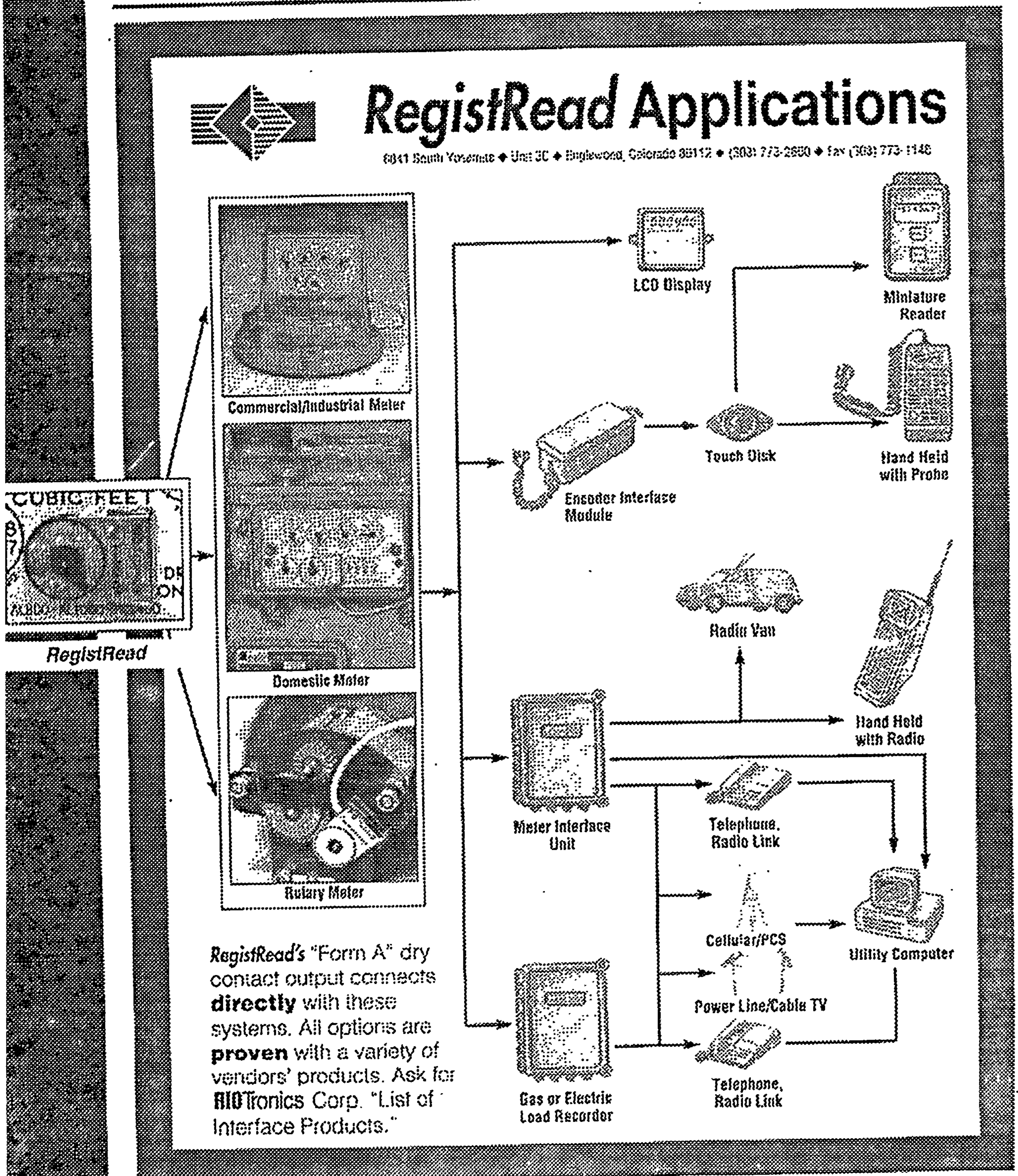


Product Specifications

- CEBus Power Line Carrier (PLC) or Radio Frequency (RF) Communications.
- Complete PC Windows-based programs for Setup, Monitoring and Control of Energy Management, Home Automation, or Utility DSM application programs.
- Operates as standalone controller with monitor and routing capabilities.
- CPU: V25 16 MHz
- 128K byte EPROM Program Memory space (upgradable to 512K) to hold CEBus support code, gateway protocol support code, and application programs.
- 128K byte battery-backed RAM (upgradable to 256K bytes) for settings, downloaded software components, and application programs.
- 128 byte EEPROM
- Real Time Clock/Calendar
- RS232 Serial port (for PC setup and control or for communication with modem and other devices)
- Directly plugs into 110V wall outlet for power and CEBus signals.
- Optional Attachments - small internal daughter-board for one of the following:
  1. 10BaseT Ethernet
  2. Modem
  3. USB (Universal Serial Bus)
  4. Extra RS232 Port

"There's a lot of skilled engineering behind RegistRead. The product has the same integrity as its high-end competitors, but the difference in cost is night and day."

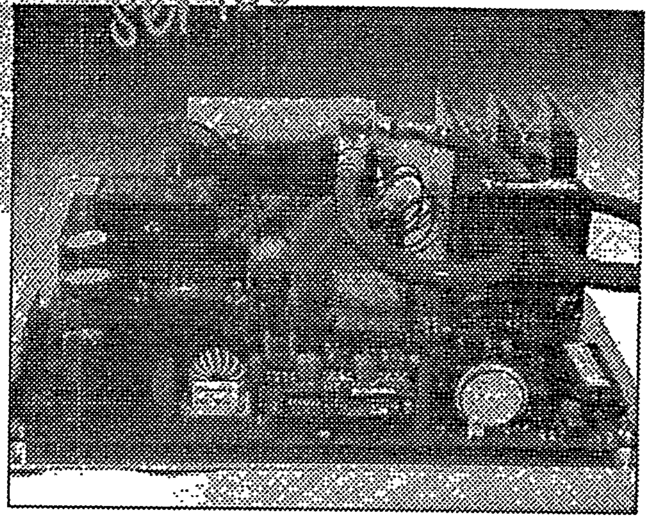
Randy Bishop
Technician/Gas Engineering
Public Service Company of Colorado



SPECIFICATIONS

Temperature: Operational from -40° to +240°F
Moisture: Operational to 100% humidity: case is plated to protect from corrosion; all electronics are potted.
Length: 1.12" Width: .75" Height: .30" Weight: .6oz
Maximum switching voltage D.C.: ± 30 volts
Maximum switching current D.C.: ± 0.01 amps
Maximum switching watts D.C.: 0.30 watts
Minimum voltage breakdown D.C.: ± 150 volts
Contact resistance: 0.5 ohms
Open circuit resistance: > 10^8 ohms
Maximum rate contact closure: 1000 pulses/sec
Maximum bounce time: 0.2 ms max.
Resistance: 100Ω standard electric throughput resistance for interference suppression. Custom series and parallel values available.
Canadian approvals: #AG0343 for gas meters
Custom switch circuits and resistor values available; 90 volt model available.
Patent# 4008458. Additional patents pending.
RioTronics Corp. reserves the right to modify features and specifications without notice.

Electric Appliance Monitoring and Control



Application

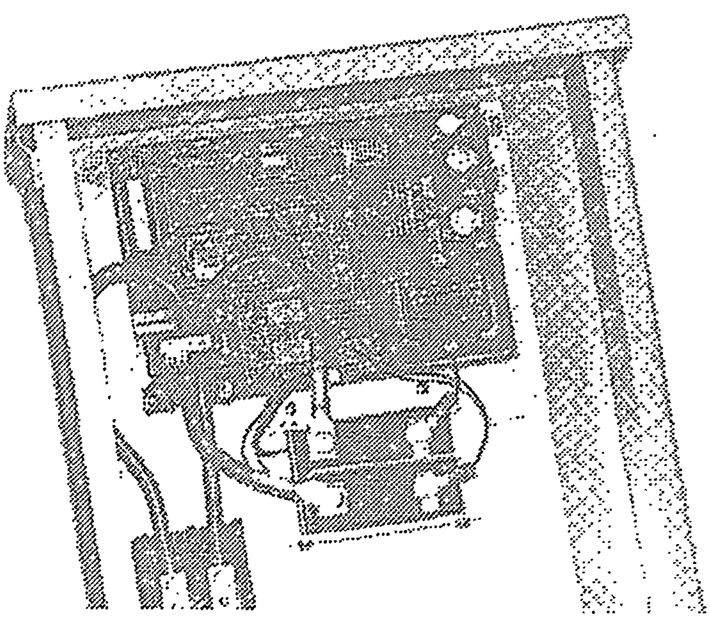
The We X.L. Habitat Series is a family of non-proprietary, CEBus Appliance Monitor and Load Control devices designed to provide accurate energy consumption information and control for existing household appliances. With an on-board microprocessor, memory, communications controller and measurement circuitry the Habitat Series are capable of relaying consumption information ranging from simple kWhrs to demand. Utilities implementing load control schemes can either implement this option or request that the device be enabled for control only. As with all We X.L. products, the Habitat Series will allow communications with any CEBus compatible device on the home's existing power network.

The We X.L. Habitat has been designed to retrofit any home appliance operating at up to 240 VAC and drawing current of up to 60 amps.

Communications

Using proven electronic and electro-mechanical technology the We X.L. Habitat Series applies the industry standard CEBus communications protocol to power-line carrier to relay stored i[illegible]ion. This facilitates data collection from all devices on a single distribution transformer at any point in the network. We X.L.'s implementation of the CEBus protocol utilizes Intellon's Spread Spectrum Carrier™ technology, enabling the creation of an Ethernet-like carrier sense, multiple access (CSMA) network over existing power lines. This Local Area Network (LAN) offers an attractive solution to customers concerned about future application growth.

Various gateway technologies that allow access to this Local Area Network include radio, CATV and telephone, available from a host of different vendors, including We X.L.



Functionality

The Habitat Series

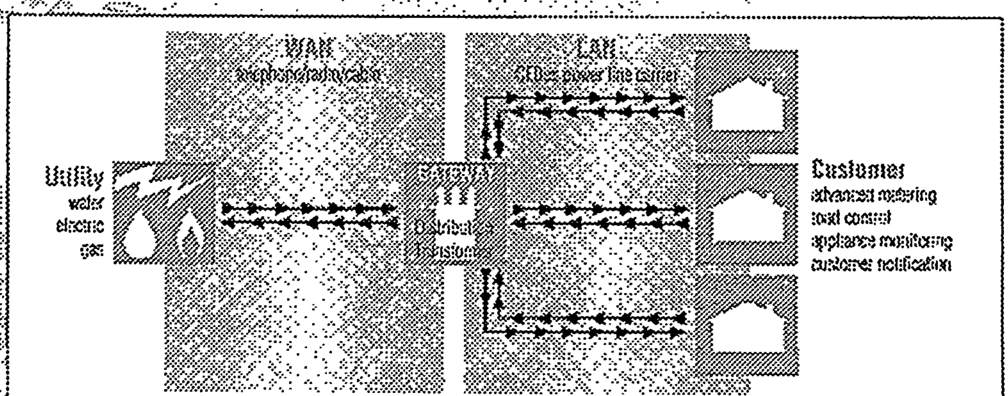
Monitoring	Control	Monitoring & Control
H1300	**H1300L**	**H1300C**
120 VAC; 30 amps kWh kW	120 VAC; 30 amps Control up to 30 amps	120 VAC; 30 amps kWh kW Control up to 30 amps
H2300	**H2300L**	**H2300C**
240 VAC; 30 amps kWh kW	240 VAC; 30 amps Control up to 30 amps	240 VAC; 30 amps kWh kW Control up to 30 amps
H2600		**H2600C**
240 VAC; 60 amps kWh kW		240 VAC; 60 amps kWh kW Control up to 60 amps

Features and Benefits Summary

Feature	Benefit
retrofits existing appliances	addresses DSM and research
measurement accuracy <2%	useful for submetering
on-board load control	integrated energy management tool
no on-site modifications	low-cost installation by utility personnel
power-line carrier within the home	no-cost network installation
recognized standard protocol (CEBus)	vendor compatibility
lithium battery back-up	maintain critical information in the event of an outage

Specifications

Environmental:	Operating Temperature 0°C - +70°C
EMC:	FCC Part 15 Class B
Surge Withstand Capacity:	As per ANSI C37.90a, C62.41, IEC 801-4.
Typical Relay Specifications:	Contact Configuration: DPST-N Material: Silver Cadmium Oxide Maximum Load Rating: 30 A @ 120/277 VAC, resistive Expected Mechanical Life: 5,000,000 operations Expected Electrical Life: 100,000 operations at rated load



We X.L. Inc., *901, 1333 - 8th Street S.W. Calgary Alberta, Canada T3R 1M6*
Phone (403) 571-5700 Fax (403) 571-8704 email: sales@wexl.com

LiveWire Project: LiveWire Customer Home
Installation Process and Checklist

Customer Name: ____________________ **Address:** ____________________________
____

Phase	Details	Responsible (Initial & Date)

Gas and Electric Meters Installations	• Review Work Order before departure and verify the following:
	  • Installation date and time
	  • Customer name and address
	  • Customer house code
		SDG&E
		______________

	• Select the following equipment from warehouse:
	  • GE CEBus meter labeled with pre-designated house code for the scheduled customer
	  • Electric meter extender adapter with terminal box
	  • American gas meter with retrofitted Riotronics pulse initiator module
		______________

	• Arrive to premise and:
	
	Electric GE meter installation
	  • Interrupt electric power
	  • Remove existing electric meter and install meter extender adapter with terminal box
	  • Install GE CEBus meter
	  • Restore electric power
		______________

	[illegible] meter installation
	  • Interrupt main gas inlet
	  • Remove existing gas meter
	  • Install American gas meter with retrofitted Riotronics pulse initiator module
	  • Restore main gas line supply
		______________

LiveWire Project: LiveWire Customer Home Installation Process and Checklist

Customer Name: ____________________ **Address:** ______________________________

____

Phase	Details	Responsible (Initial & Date)
Gateway Box Installation	• Review Work Order before departure and verify the following: • Installation date and time • Customer name and address • Customer house code • Pre-Installation data survey results: utility meters location and proposed gateway box mounting • Identify the pre-assigned gateway box for scheduled customer and verify that cable modem serial number has been registered into the LiveWire customer activation table • Select the following equipment from warehouse: • Assigned gateway box and padlock • Enclosure mounting kit • Roll of UTP L5 - 10BaseT cable and RJ-45 conn. • ½" flexible conduit and power cable roll • Misc. tools, screws, power drill and bits, etc. for mounting enclosure and terminate 10Baset cables • Arrive to premise and: <u>Gateway Box Installation</u> • Identify best-fit location for gateway box mounting • Mount and secure gateway box • Turn-off gateway box master switch • Run flexible conduit and power cable extension from meter terminal box into the gateway box power input • Turn-on gateway box master switch <u>10BaseT Cable Runs</u> • Identify location of customer's web browsing PC • Run 10BaseT cable from gateway box to web browsing PC • Identify location for Interim home controller PC • Run 10BaseT cable from gateway box to the selected location for the home controller PC • Connect both 10BaseT lines to gateway box Ethernet hub	Systems Integrated __________ __________ __________ __________ __________

LiveWire Project: LiveWire Customer Home
Installation Process and Checklist

Customer Name: ________________ **Address:** ________________________

____

Phase	Details (Please Review Pacific Bell's Established Procedures)	Responsible (Initial & Date)
Cable Modem Hook-Up	• Review Work Order before departure and verify the following: • Installation date and time • Customer name and address • Ensure that a cable modem is registered into the CMR table for that premise • Arrive to premise and: • Power-up cable modem while inside Gateway box • Install diplex filter into the NIU Interdiction Shroud • Connect the NIU coax cable to the cable modem in Gateway box • Connect a 10-BaseT line from the Ethernet Hub in the Gateway Box to PC input on the cable modem • Depress the "Reset" button on the rear panel of the cable modem • Ensure that the modem "Power" and "Cable" LEDs are ON (blinking LEDs indicate an error states) • Verify telephony service is functional	Pacific Bell ACN Cutover Technician

LiveWire Project: LiveWire Customer Home Installation Process and Checklist

Customer Name: ________________ **Address:** ________________________

____

Phase	Details	Responsible (Initial & Date)
Customer PC Configuration and Internal Equipment Installation	• Review Work Order before departure and verify the following: • Installation date and time • Customer name and address • Customer house code • Pre-Installation data survey results: customer PC configuration and monitoring appliance information • Select the following equipment from warehouse: Required for PC configuration • PC screw driver kit • Power strip • Intel EtherExpress Ethernet ISA adapter card and set-up diskette • Anti-virus software bootable diskette • Win '95 Upgrade installation CD • McAffee virus scanner installation software • Netscape 3.0 CD installation software • Parallel port CD drive and installation diskette Required for internal equipment deployment • Pre-configured appliance monitors for the scheduled LiveWire customer • Right-angle appliance plugs (if needed) • Leviton noise block filters • Leviton phase coupler • Miscellaneous AWG wiring (if needed for 240V appliance monitor hard-wired installation) • Arrive to premise and: PC Configuration • Boot-up anti-virus diskette on drive A:\ and inform customer of any viruses present in their system • Run scandisk on customer hard drives and inform customer of any hard drive problems • Install/Upgrade Win '95 (if needed) • Install/Upgrade latest McAfee anti-virus software	Systems Integrated ________ ________ ________

LiveWire Project: LiveWire Customer Home Installation Process and Checklist

Customer Name: ________________ **Address:**________________________

____

	• Install Intel's EtherExpress 10BaseT Ethernet adapter card into customer PC • Set-up Win '95 Network configuration for cable modem communications • Set-up Netscape 3.0 and Internet access/E-mail settings for CerfNet Network • Run Win'95's Disk Defragmenter utility <u>Internal Equipment Installation</u> • Install appliance monitors into the pre-selected appliances <u>Customer Education</u> • Start-up and walk-through customer over the energy manager homepage • Notify customer that the UserID and Password are the only means for accessing their energy manager system though the "www.energymanager.com" web page • Review with homeowner the customer and technical service hours of support and phone numbers	________ ________

WeXL Habitat Series Modules: Configuration Procedure

Required Hardware:

- (1) Intellon CEMonitor CEBus Power Line Monitor
- (1) '486 Laptop/PC, Loaded with Windows '95

Required for 240V modules only:
- (2) Terminal Slugs (Part #SLU-70)
- (1) Male 240V Plug
- (3) AWG 10 Size Wire

Required Software:

- (1) We.X.L. CAMLTEST.EXE Windows Based Application (Version 2.1 3/12/97) Installed in Laptop/PC

☞ Habitat Module Configuration Hardware Set-Up:

Figures 1 and 2 describe the hardware configuration for 120V and 240V CEBus appliance monitors:

Note: On 240V modules and for safety precautions, terminal slugs (Part # SLU-70) were added to the V_{in} terminal for each solid state latching relay of the 240V Habitat Series module. AWG 10 stranded wire was fastened to the terminal slug, providing a solid and reliable connection.

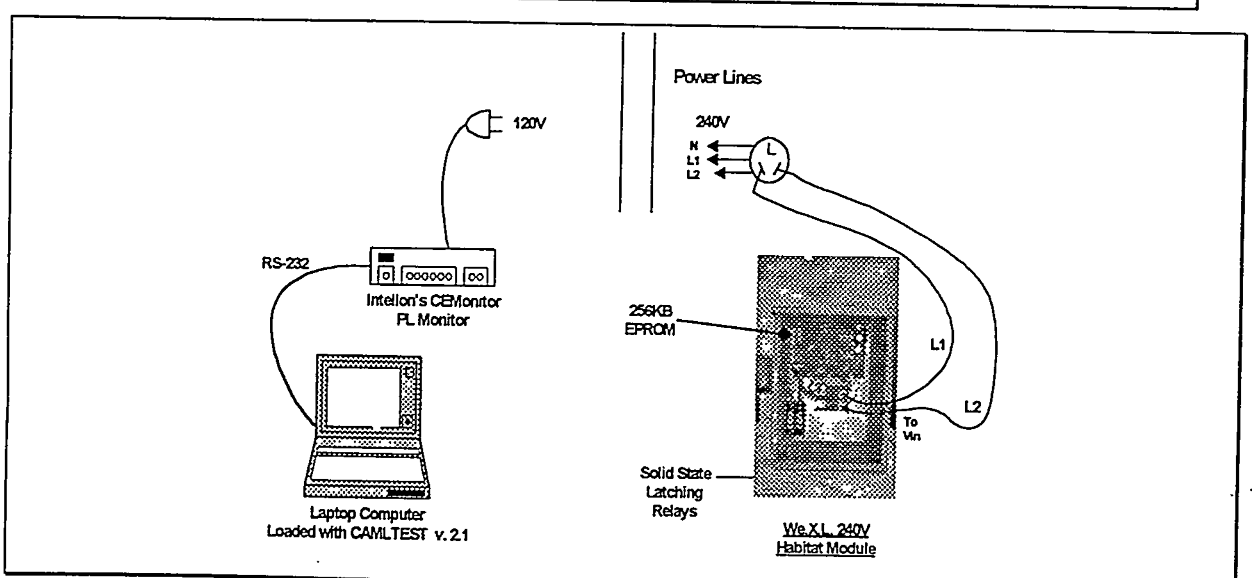


Figure 1.- 240V Appliance Monitor Hardware Set-Up

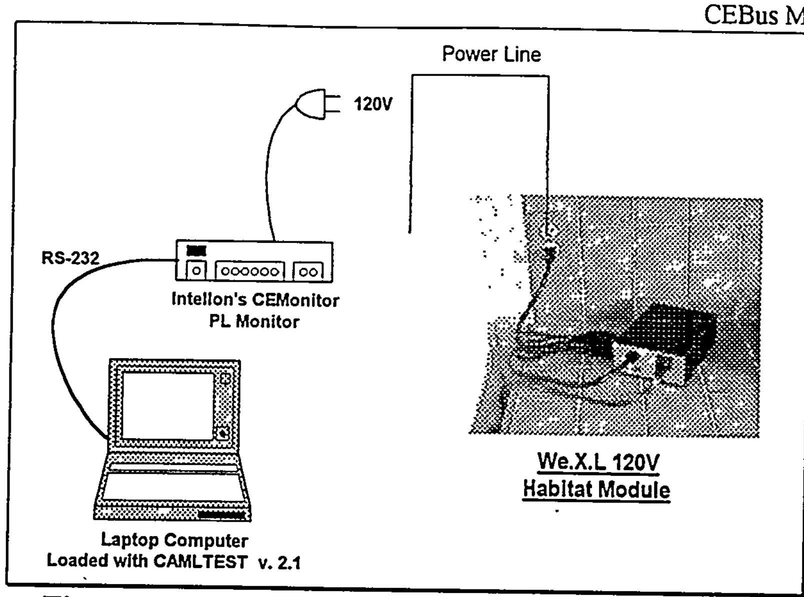


Figure 2.- 120V Appliance Monitor Hardware Set-Up

☞ <u>Habitat Module Configuration: Software Set-Up:</u>

1) The CAMLTEST.EXE application is invoked via double clicking on the CAMLTEST icon from the program manager, which brings up the main menu form with the following options: *Setup*, *Testing*, *Commands*, and *Configure*. Before the application can be used on-line the database and CEBus setup options must be selected. Selecting the ***database*** option will bring up another form with the following option:

<u>File</u>

Under the File menu select ***Open Database***. A file entry listbox will appear and display a list of filenames with a .MDB extension (MDB is the default access database extent). A pre-configured database is supplied with the distribution. Select database named ***caml.mdb***, and press ***OK***. See figure 3 for a database management form screen:

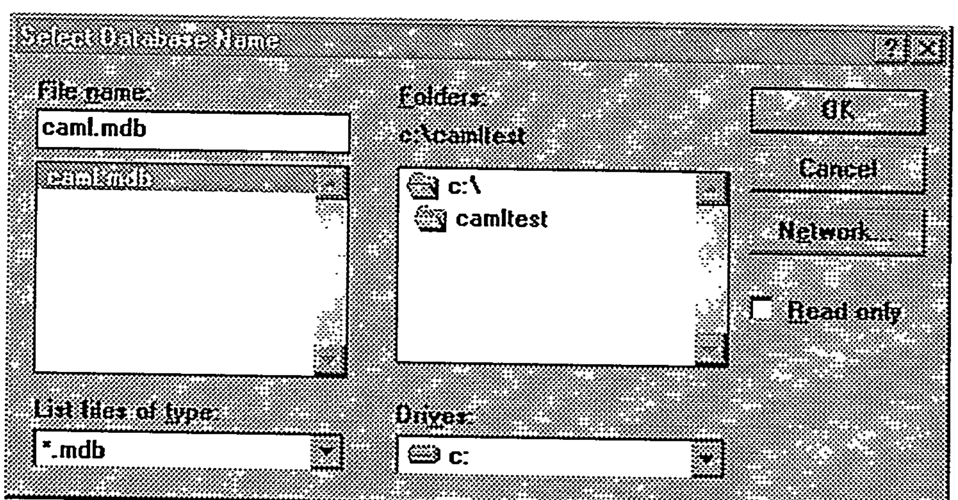


Figure 3.- Database Management Form

Return to the main application menu selecting the *exit* option from the database management form.

2) Under the Setup menu select the *CEBus* item. A display form will appear containing CEBus configuration. The following picture describes the CEBus Communications Set-up form:

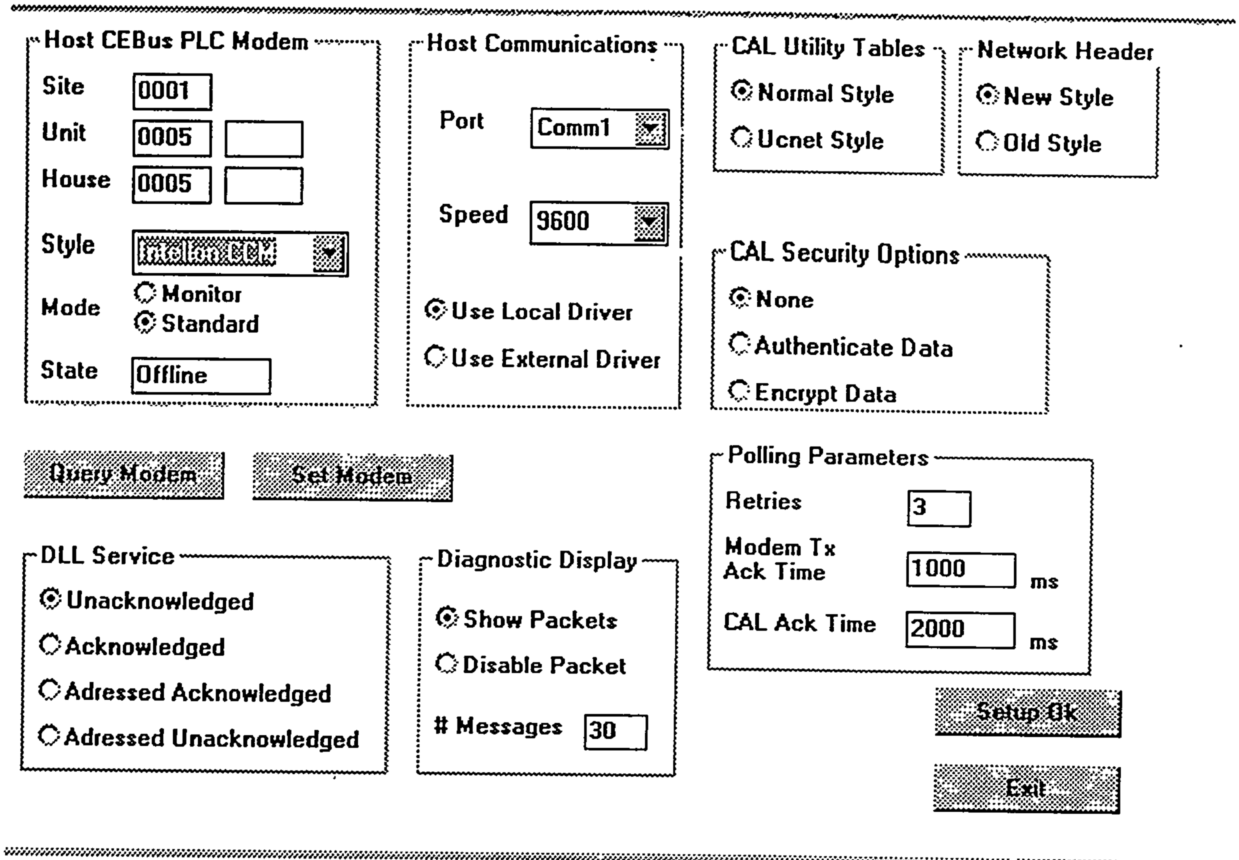


Figure 4.- CEBus Communications Set-Up Screen

The only item that needs to be changed from default settings is the "***Host CEBus PLC Modem Style***". From the listbox, select *Intellon CCM*. Select ***query modem*** command key to confirm the cable connection to the PLC modem. If an error occurs check comm port and modem style settings. Once the settings are correct select ***Setup Ok*** command key and then *Exit*. Control is returned to the main application menu.

Habitat Series Module Configuration via CAMLTEST.EXE Application

a) After the hardware and CAMLTEST software have been properly set-up accordingly to the above section guidelines, highlight the *Configure* option from the CAMLTEST main menu, and select *Appliance Monitors.* The *Configure* option allows the user configuration of Habitat Series device parameters.

Figure 5 below shows the actual CAML Configuration screen.

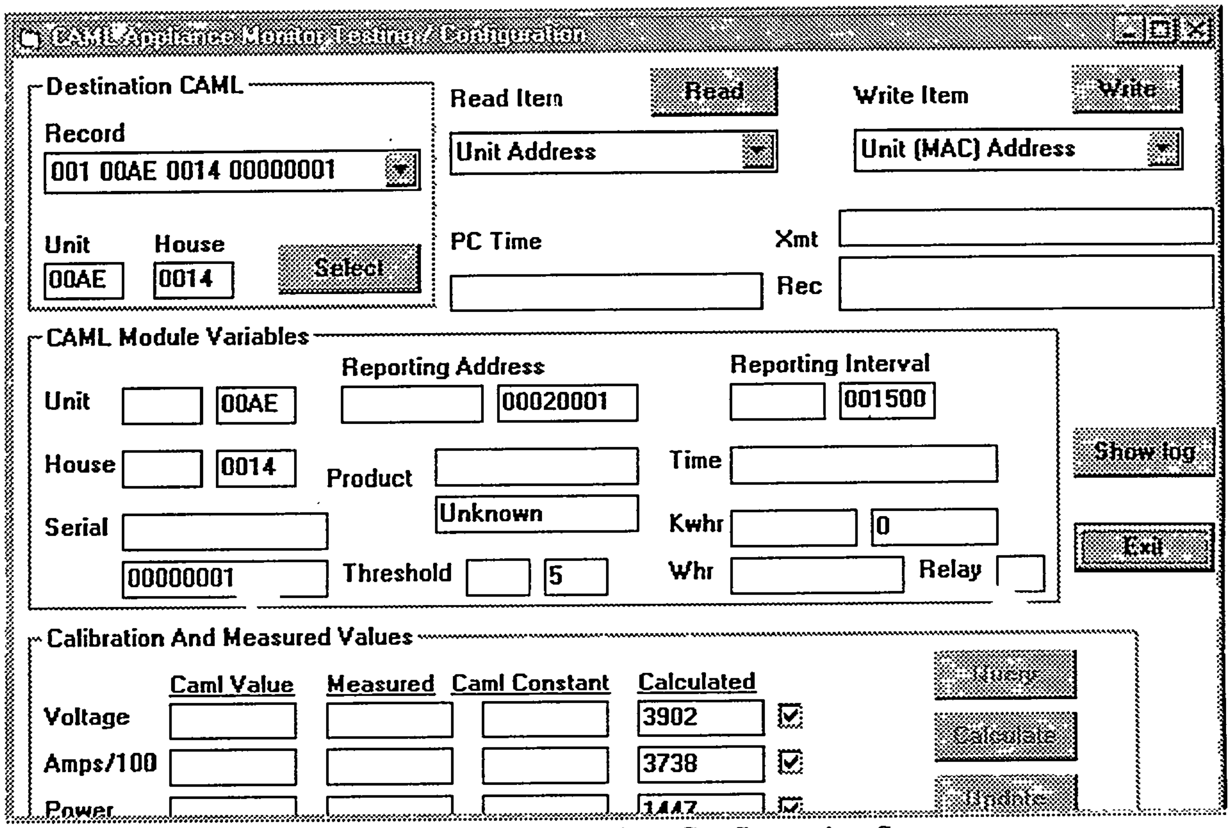


Figure 5.- Appliance Monitor Configuration Screen

b) Next, from the CAML Configuration screen (Fig. 5), click on the ***Show Log*** button. A new window will appear at the bottom of the screen. This new screen displays the power line CEBus data traffic intercepted through the Intellon CCM Power Line Modem.

c) Plug the Habitat Series module to be upgraded into the power source outlet, and after the second "relay click" from the module, observe the new CEBus data packet displayed on the Log screen. The displayed data packet should follow the format:

rx OA <0000 0000> <UhUl HhHl>

where:

Uh = CEBus Unit High Byte Address
Ul = CEBus Unit Low Byte Address
Hh = CEBus House High Byte Address
Hl = CEBus House Low Byte Address

Use the previous information to determine the House and Unit addresses for the Habitat Series module. Type-in current House and Unit CEBus Addresses for the appliance monitor under the ***Destination CAML Unit*** and ***House*** boxes (See Fig. 5) of the CAML Configuration screen .

d) Select ***Read All Parameters*** from the ***Read Item*** List Box, and click on the ***Read*** button. This command will query the assigned Habitat module for the current configuration parameters. New parameters read from the module will be displayed under the ***CAML Module Variables*** and ***Calibration and Measured Values*** groups of items.

NOTE: Some of the listed items under the CAML Module Variables group include two fields. The field on the left side presents gray colored fonts, and corresponds to the current Habitat module parameters. The field on the right side shows bold black fonts, and corresponds to the default parameters.

e) Overwrite default parameters with the new appliance monitor information for the following items:

- ***Unit Address***

iv) Type-in new Unit address under the "Unit" module variable box.

v) Select *Unit (MAC) Address* from the ***Write Item*** List Box, and click on the ***Write*** button. This command will transfer the new assigned Unit address into the Habitat module.

vi) Type-in the new Unit Address for the appliance monitor under the ***Destination CAML Unit*** box (See Fig. 5) of the CAML Configuration menu screen .

- ***House Address***

iv) Type-in new House address under the "House" module variable box.

v) Select *House Code Address* from the ***Write Item*** List Box, and click on the ***Write*** button. This command will transfer the new assigned House address into the Habitat module.

vi) Type-in the new House Address for the appliance monitor under the ***Destination CAML House*** box of the CAML Configuration menu screen .

- ***Product Name***

vii) Type-in the **assigned product name ID** (NOT the actual appliance name) under the "Product" module variable box.

viii) Select *Product Name* from the ***Write Item*** List Box, and click on the ***Write*** button.

- ***Current Time/Date***

ix) Select *Set Current Time* from the ***Write Item*** List Box, and click on the ***Write*** button. This command will automatically set the PC time/date into the Habitat module.

NOTE: Affix a label onto the Habitat module's metal back plate (240V model or the bottom face of a 120V module, and include the CEBus House and Unit address information. This will allow the easy identification of the module's CEBus address for future applications and installations.

☞ **Configuration Verification:**

a) Unplug the Habitat module from the power source.

b) Plug the Habitat module back to the power source outlet.

c) Observe under the View Log window the reported CEBus House and Unit address. Verify that the new addresses have been properly configured into the Habitat module.

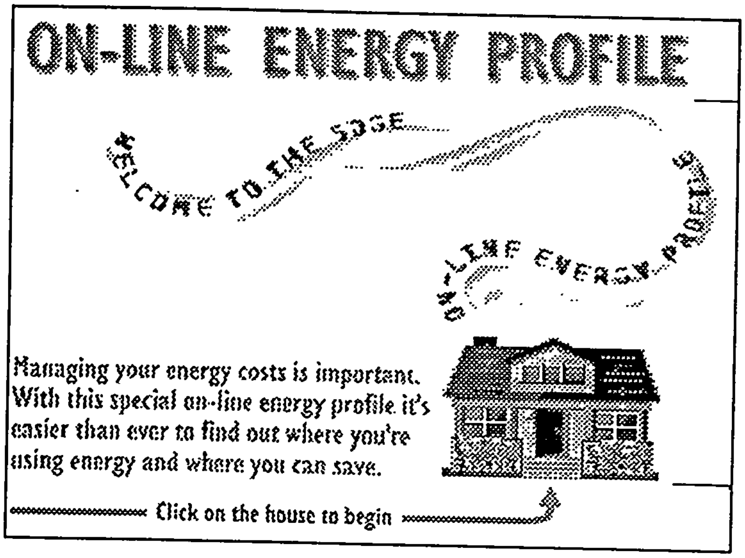
d) Highlight the ***Configure*** option from the CAMLTEST main menu, and select ***Appliance Monitors.***

e) Type-in current House and Unit CEBus Addresses for the appliance monitor under the ***Destination CAML Unit*** and ***House*** boxes (See Fig. 5) of the CAML Configuration screen .

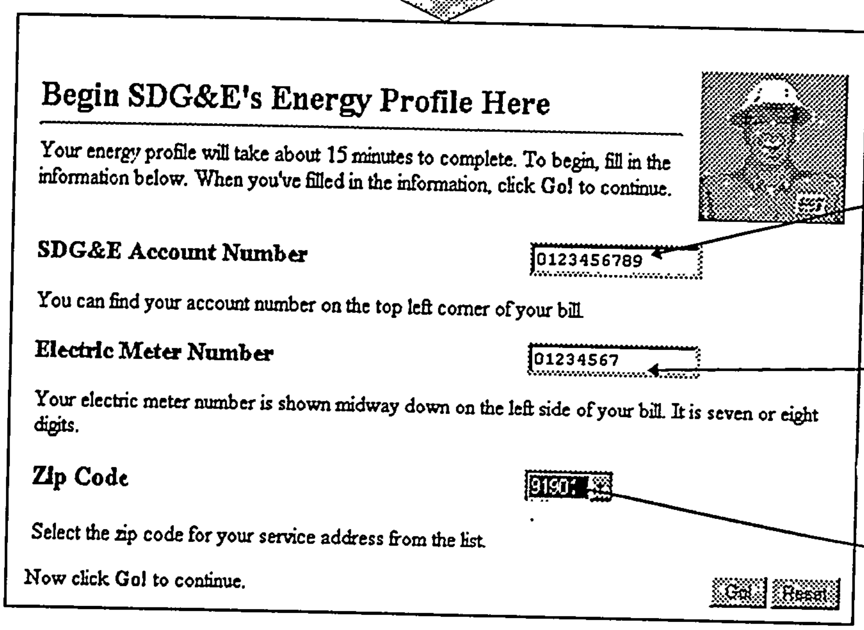
f) Select ***Read All Parameters*** from the ***Read Item*** List Box, and click on the ***Read*** button. This command will query the assigned Habitat module for the current configuration parameters. Verify that the product name ID and current date/time has been successfully configured.

ON-LINE ENERGY PROFILE SAMPLE

Window Capture | **Description**



- ON-LINE ENERGY PROFILE MAIN WINDOW



- CUSTOMER SPECIFIC SDG&E ACCOUNT NUMBER
- CUSTOMER SPECIFIC ELECTRIC METER NUMBER
- CUSTOMER ZIP CODE

Window Capture **Description**

Please Verify the Service Address

Is the service address below correct? Click on "Correct" to access the energy profile.

Account Number: 9375623200

Meter Number: 00358330

Service Address: 78607 POWER RD
City, State Zip: POWAY , CA 92064

[Correct] [Re-enter]

- CUSTOMER INFORMATION VERIFICATION WINDOW

What Is the On-line Energy Profile?

The On-line Energy Profile provides a breakdown of your home's energy use. It factors in your actual or estimated usage, weather conditions for your region, and billing information. At the end you'll get recommendations that can help you adjust your energy consumption.

Instructions

To receive your analysis and recommendations, answer the questions in each category below and press the **Submit Profile** button at the bottom of this form when you are finished.

General Information

1. What type of home do you have? [Single Family Detached]
2. What is the conditioned square footage of your home? [Less than 1000]
3. What year was your home built? [1970 - 1979]
4. Including yourself, how many people live in your home? [3]

- ENERGY PROFILE QUESTIONNAIRE SAMPLE WINDOW

Thank You!

We have received your information and are ready to analyze your energy use. Click on the **Run Analysis** button below and in approximately 20-25 seconds your profile will be completed.

[Run Analysis]

- RUN ANALYSIS WINDOW

ON-LINE ENERGY PROFILE SAMPLE

Window Capture | **Description**

Results

Dear Mr./Ms. Smith

Thank you for using SDG&E's *On-line Energy Profile!* We hope that you find this service to be of value.

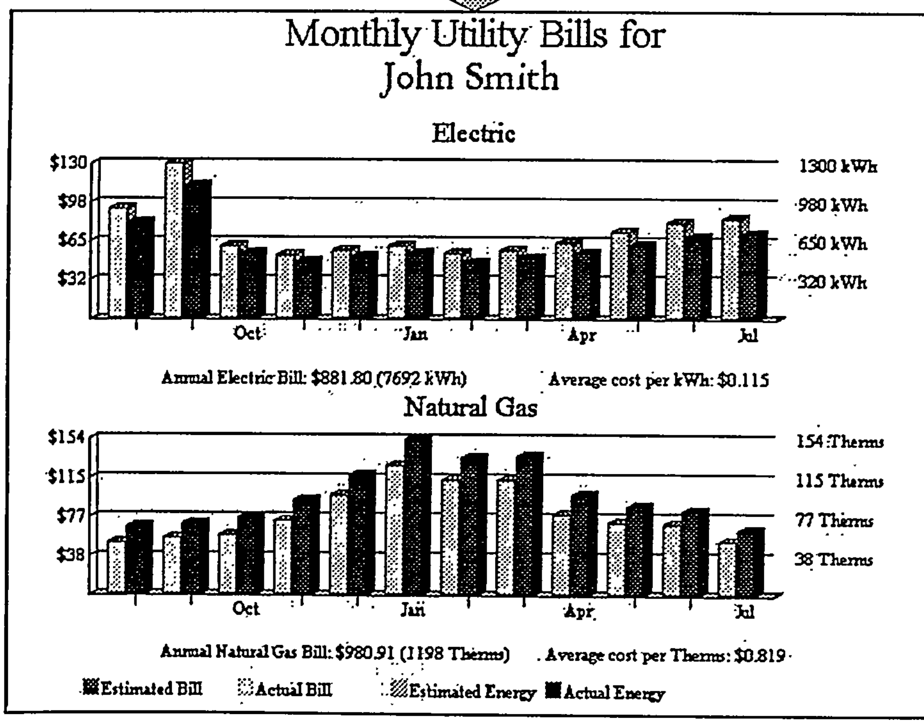
Your **Monthly Utility Bill** graph shows your household's monthly electricity use for the past year. With this graph you can determine in which months you use the most energy, and can see the effect that weather can have on your utility bill.

Your **Annual Energy Costs** graph will help you spot the biggest users of energy in your home. The annual and monthly energy cost graphs show where your energy dollar is going and the greatest opportunities for saving throughout the year.

The **Recommendations** describe simple valuable steps that you can take today to manage your energy costs. This "Smarter Energy Advice" is tailored to your home's energy use.

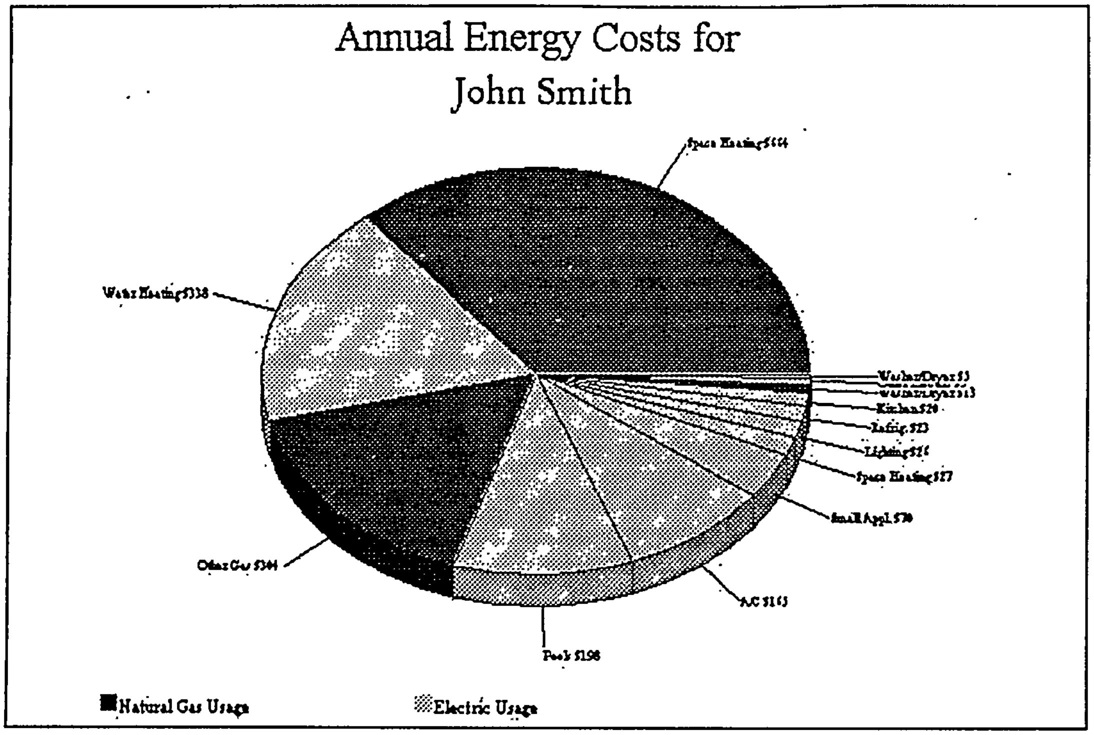
If you have any questions about this profile or would like to learn how to save energy and money, please call us at 1-800-411-SDGE (7343).

- ENERGY PROFILE RESULTS INTRODUCTION

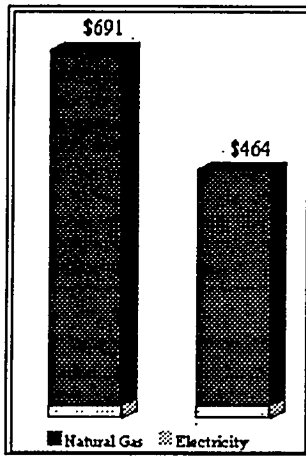


- GRAPH OF MONTHLY ELECTRIC USE FOR PAST YEAR

Window Capture **Description**



- ANNUAL ELECTRIC USE PER APPLIANCE PIE CHART



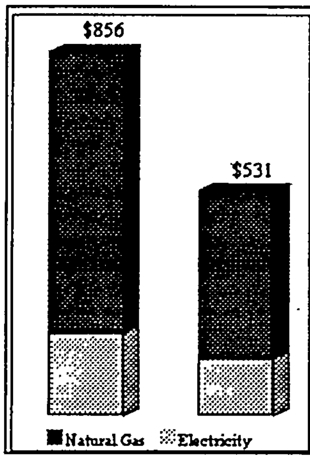
Space Heating

Your space heating costs are $691 per year. This is about 37% of your total electric and natural gas bill. By implementing the recommendations below, you can save up to $227.

Do not make expensive repairs to your existing gas furnace. When it is time to replace your furnace, a new furnace can use 20% to 30% less energy.

Use a clock thermostat to decrease the temperature when you are at work or asleep. Every degree of setback can reduce heating bills by 1-3% for an eight hour period.

- RECOMENDATIONS SAMPLE WINDOW



Insulation

Your heating & air conditioning costs are $856 per year. This is about 45% of your total electric and natural gas bill. By implementing the recommendations below, you can save up to $325.

Attic insulation can save up to 15% in heating and air conditioning costs. You should have an insulation value of R19 in your attic. Insulation helps keep your home warm in winter and cool during the summer, reducing both heating and cooling cost.

Make sure your walls are well insulated. You should have an insulation value of between R-11 in your walls.

- RECOMENDATIONS SAMPLE WINDOW

Address: ______

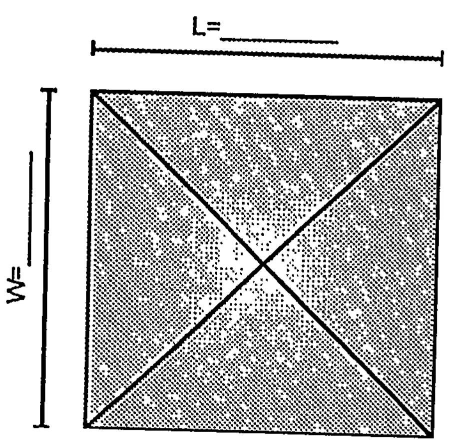
Home Phone Number: ______
Work Phone Number: ______

1.- Utility Meters Information

	Gas Meter	Electric Meter
Manufacturer:		
Model Number:		
Optional Electric Meter Adapter Type? (Vertical or Horizontal):		

2.- Utility Meters and NIU Box Location Information

Premise Over-Head View

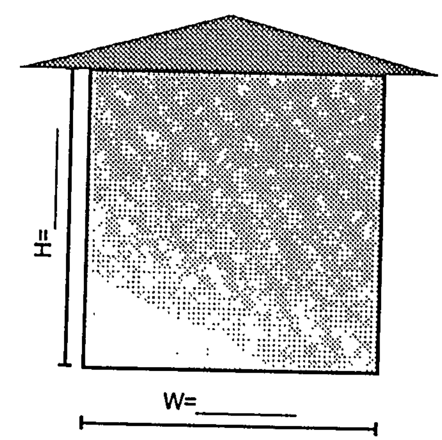


Legend:

Indicate locations of: Electric Meter, Gas Meter, Sprinklers, and proposed location of Gateway Box using the following convention.

X = Electric Meter
O = Gas Meter
# = PacBell NIU Box
Y =Sprinkler

Premise Side View



Outside Wall Material: ______

Gateway Box - Special Installation Instructions: ______

Customer Name:______________ **NODE:**________

3.- Personal Computer Information

Computer Location:		3.5" Floppy Drive:	
Manufacturer:		CD ROM Drive Type:	
Model Number:		Printer Type:	
Serial Number:		Multimedia Options Installed:	
Processor Type and Speed:		Other Peripheral Equipment:	
RAM Memory:		Operating System Installed:	
Video Monitor Type:		Anti-Virus Software Installed:	
Internal Modem Type:		Web Browser Software Installed:	
Available Hard Disk Space:		e-mail Software Installed:	
Available ISA Slots:		Internet Access Service Provider:	

4.- Miscellaneous Information

a) Is the house single story or double story with attic access ?
❒ single story **OR** ❒ double story **AND** ❒ flat roof **OR** ❒ raised roof, with attic access

b) Is there air conditioning at the home? ❒ yes ❒ no
c) Is there a pool pump at this home? ❒ yes ❒ no
d) Is there a spa pump at this home? ❒ yes ❒ no

e) Is there an all electric clothes dryer or all electric stove at this home?
❒ all electric clothes dryer (240V) ❒ all electric stove (240V)

f) Are there any X-10 devices or other power line carrier based system in this home?
❒ yes ❒ no If yes, specify:______________________

5.- Proposed Monitoring Appliances Information

Item	Appliance 1	Appliance 2	Appliance 3	Appliance 4
Name				
Ma ıufacturer				
Model				
Approximate Age				
Voltage Rating				
Current Rating				
Appliance Location				
Proposed Appliance Monitor Location				
Appliance Monitor Installation Requirements (plug type, wire size, etc.)				
Other				

6.- Special Instructions for Accessing Premise (locks, gates, pets, etc.)

____

____

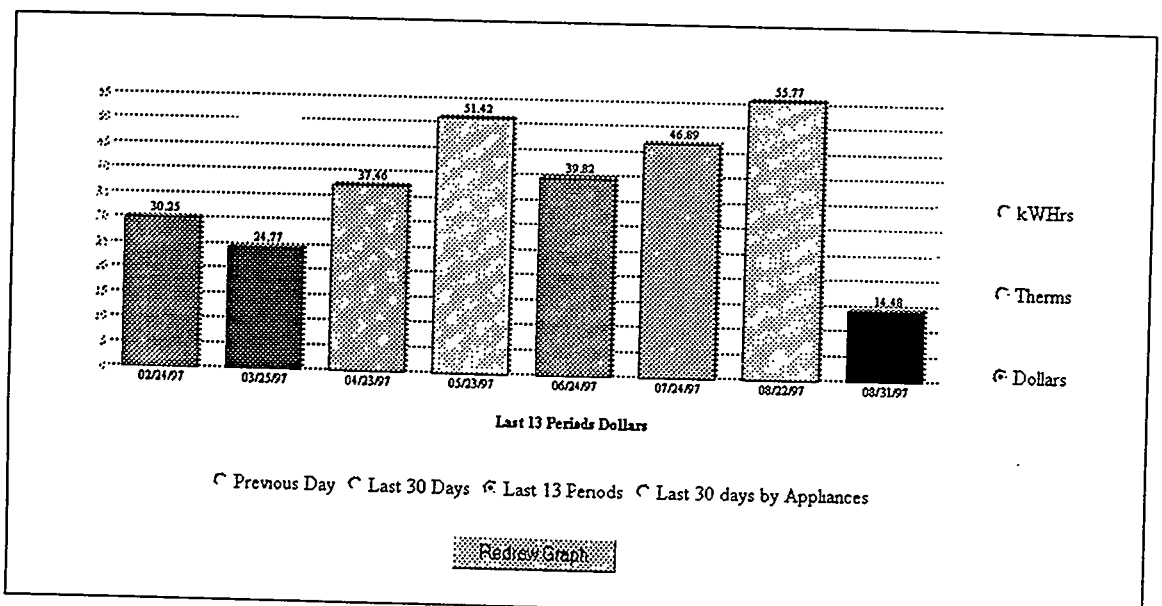
Surveyor Name: ____________________ **Date Completed:** ________________

Summary Bill Web Page Interactive Graphs

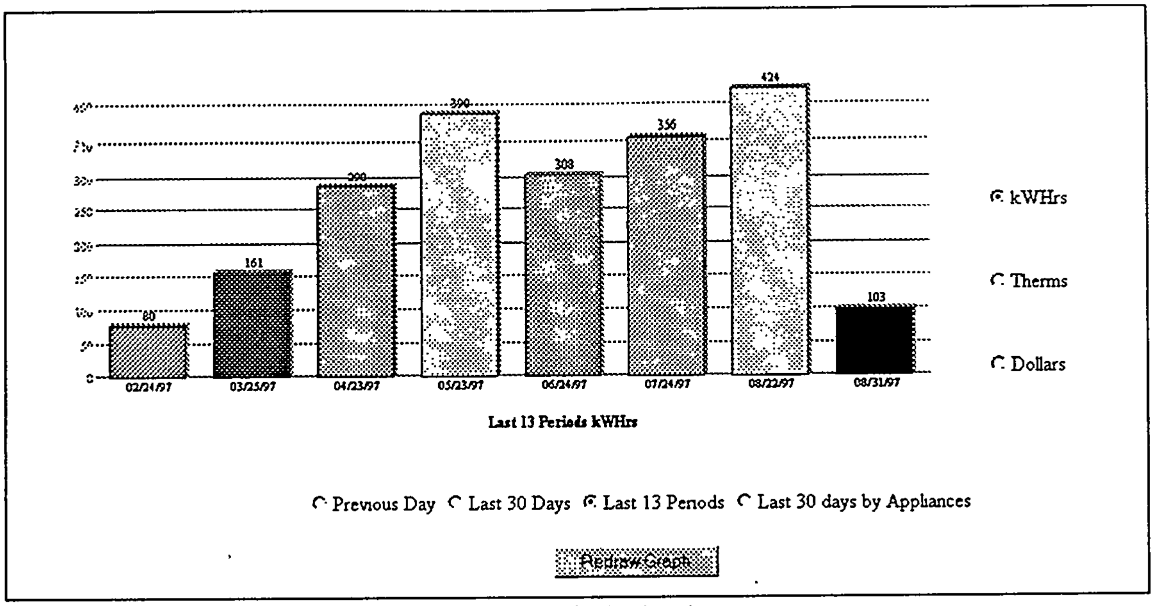
The following graphs are selectable from the Summary Bill web page described on page 3-13 and will appear below the billing information screen shown on the same page. Each of the graphs in this appendix are from data collected at the LiveWire test house either by the home controller or the normal SDG&E meter read. Each graph is selected by choosing one of the buttons along bottom of the graph which control the frequency of the data, and one of buttons along the right side of graph which control the type of data. A new graph is drawn when the "redraw graph" button at the bottom of the screen is selected.

Last 13 Periods

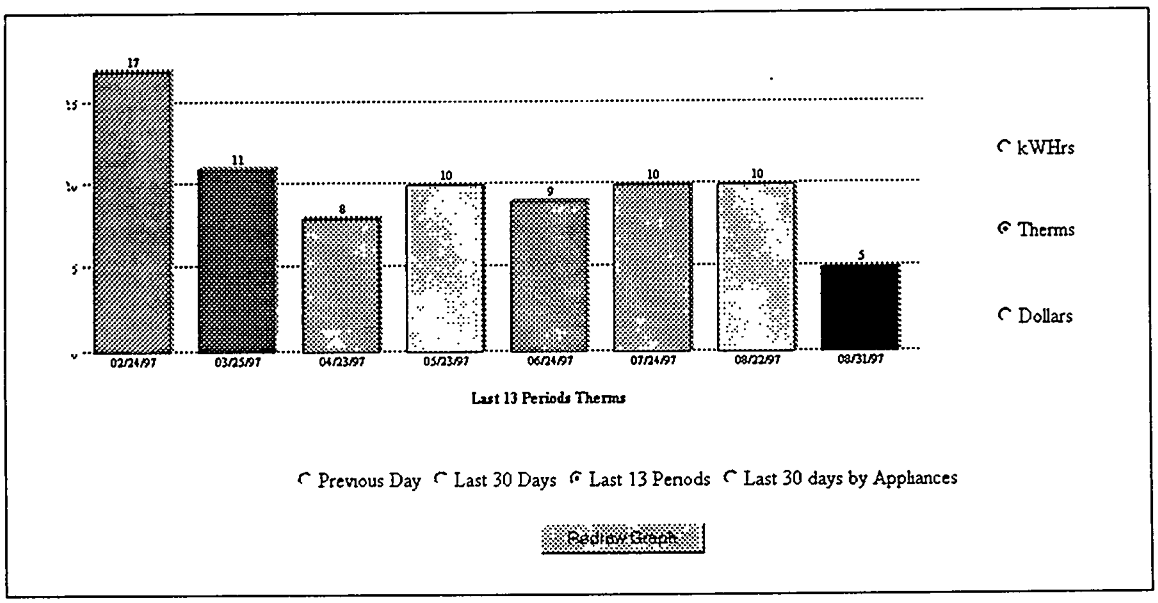
The Last 13 Periods graphs are generated from normal billing and consumption history data which is contained on the SDG&E legacy system, and extracted to the LiveWire data base each billing cycle. The dollar graph is the default graph which appears on the Summary Bill page when the Billing Center module is selected from the Energy Manager home page. These graphs only show 7 and a fraction months of data which corresponds to the period that the project rented the test house. The data for this premise from the previous tenant is not available from the LiveWire system since that tenant would have had a different account number.



Last 13 Periods, Dollars



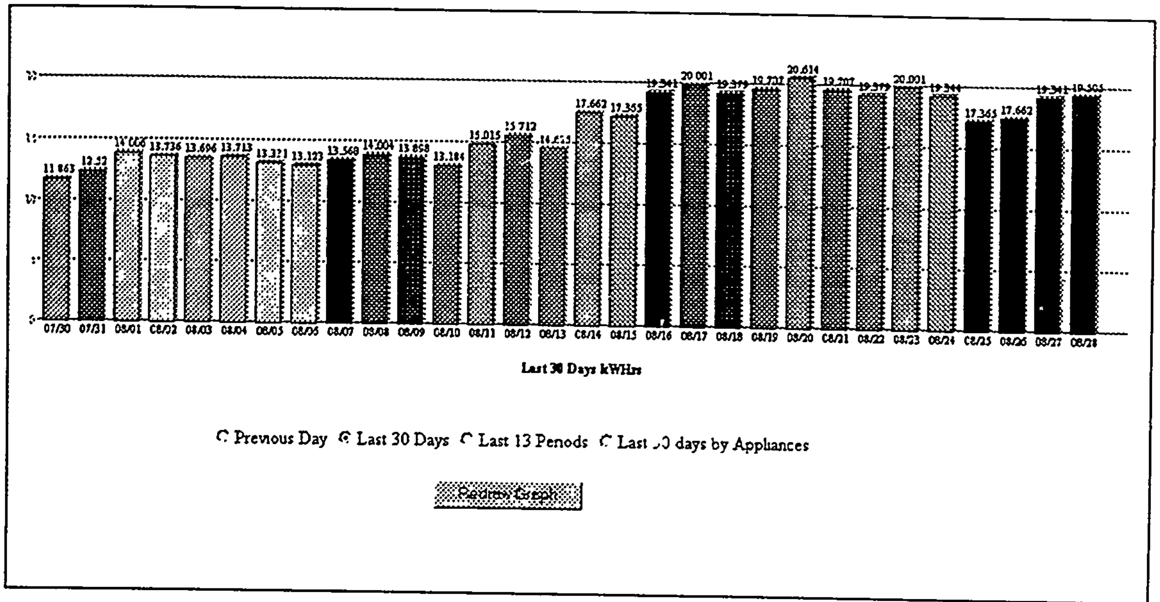
Last 13 Periods, kWhrs



Last 13 Periods, Therms

Last 30 Days

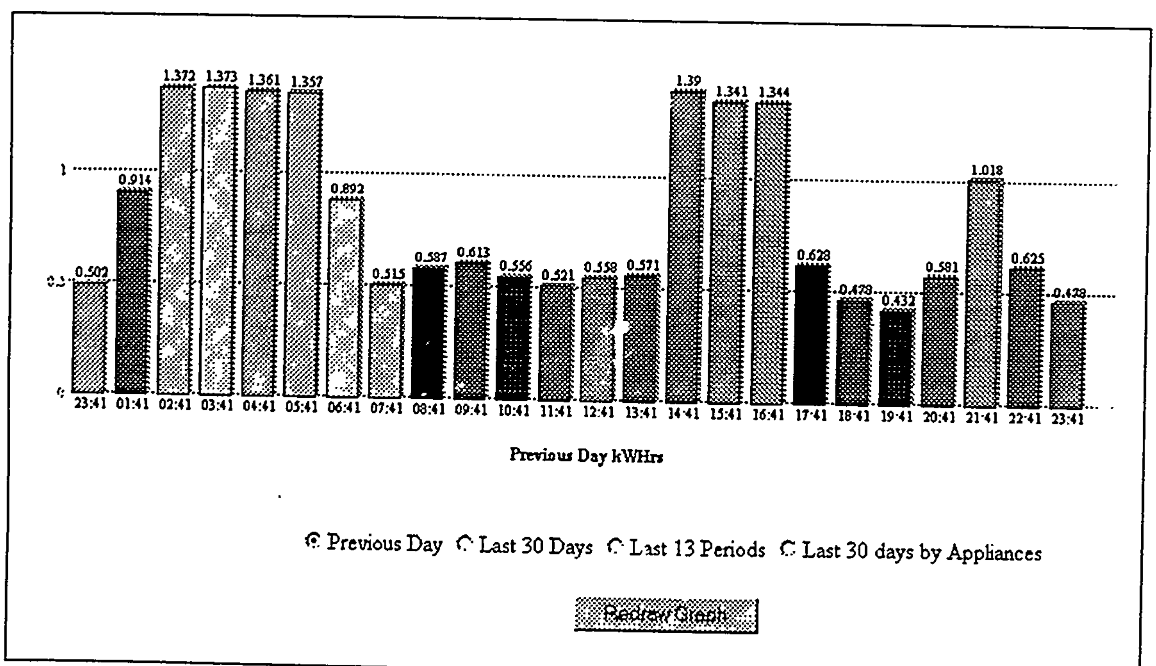
The Last 30 Days graphs are generated from data collected from the home controller and stored in the LiveWire data base. It plots daily gas or electric consumption data for the past 30 day period. While the production version of the home controller would collect both gas and electric consumption data, the single board controller version of the home controller used at the Test House did not have a gas meter reading capability. As a result, only electric data is shown for this category.



Last 30 Days, kWhrs

Previous Day

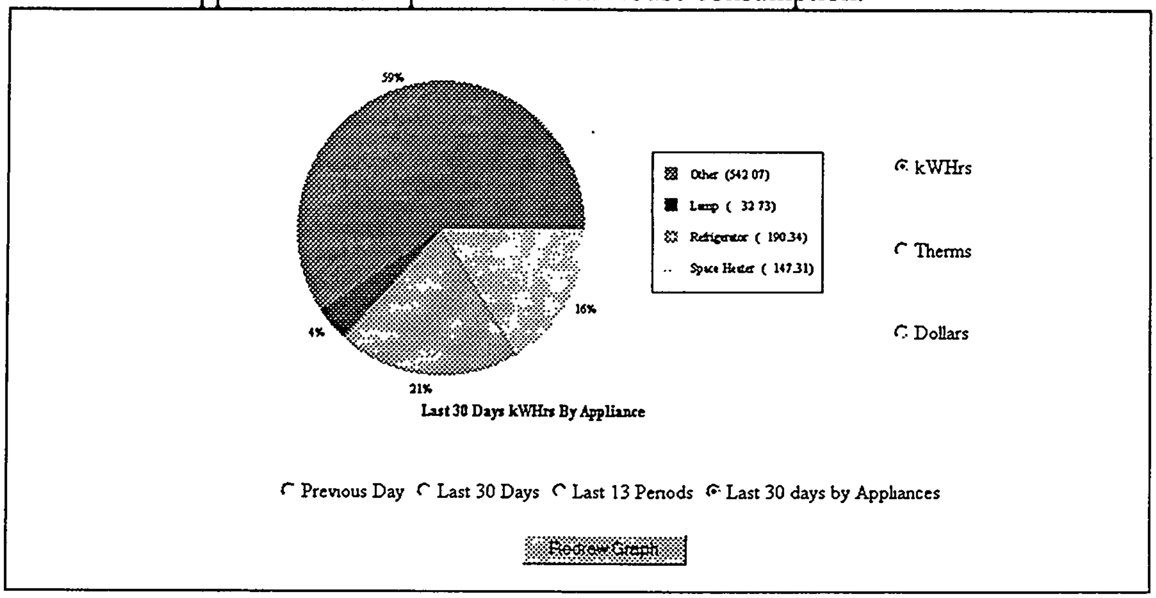
The Previous Day graph is generated from data collected from the home controller and stored in the LiveWire data base. It plots hourly electric consumption data for the past 24 hour period. Hourly gas data, while collected by the home controller, is not part of the web site, since there is no proposed hourly gas tariff which would allow a customer to reduce their bill by shifting gas load.



Previous Day, kWhrs

Last 30 Days By Appliance

The Last 30 Days By Appliance graph is generated from data collected from the home controller and stored in the LiveWire data base. It plots total house and appliance electric consumption data for the past 30 day period. This is the only of the interactive graphs which uses a pie chart format. Since no gas appliances are monitored, there is a graph for gas consumption. The "Other" category shown in the graph is calculated by subtracting all monitored appliance consumption from total house consumption.



Last 30 Days By Appliance, Kwhrs

Energy Manager

Design Document

Version 1.5

Prepared for:

Enova Technologies, Inc.
101 Ash Street
San Diego, CA 92101

Prepared by:

Norman M[illegible]nes
Echo Images, Inc.
4747 Morena Blvd., Suite 100
San Diego, CA 92117

April 17, 1997

General Project Outline

The role of Echo Images in this project is the creation of a home energy management pilot program on-line system, which will be known as "Energy Manager". Echo Images seeks to achieve three main goals: to integrate the needs of the customer into the form and function of the graphical user interface by applying focused user analysis and testing, to build highly functional and aesthetically active multimedia design into the foundation of the interface, and to create coding structures and programming that add cohesiveness and functionality to the fundamental goals set forth by the project.

Echo Images will develop a functional software based graphical user interface (GUI) based upon the HMTL 2.0 standard which will be accessed via compliant Web browsers: Netscape Navigator 3.0 or Microsoft Internet Explorer 3.0. This Web based system will be designed as a prototype for integration into the on-line home pilot product, and will utilize HTML, Java applications, and Javascript Symantec's dbANYWHERE application server will be the means to access the database. Elements of the form and function of the GUI will be tested by usability experts for functionality and quality of user adaptation, and the content will be structured according to market research information and user needs. Echo Images seeks to take advantage of the bandwidth afforded by the Pacific Bell network to utilize emerging technologies such as audio, animation, and video as well as highly refined user interface design combined into a cohesive product to create a design that is practical, intuitive, and rewarding.

Project Development Outline

The outline of the work for the web site development project is shown below:

A. **Content Development**
B. **Site Architecture and Flow Diagram**
C. **User Testing & Usability Analysis**
D. **Pre-Production**

E. **Production**
1. Create design assets
2. Create final artwork
3. Approval

F. **Engineering**
1. Convert the design and design assets to Web formats
2. Create HTML page templates
3. Create CGI scripts, Java code, and SQL integration
4. Complete programming
5. Conduct final usability testing
6. Approval

G. **Site Review & Testing**
1. Review and proofread the content
2. Review the design
3. Test all links and navigational elements
4. Approval

H. **Uploading Finished Content**
1. Create a file structure
2. Upload files to the server
3. Test the entire site on-line "live"
4. Approval

I. **Product Support & Training**
1. Assist in the deployment of the pilot
2. Provide assistance to project participants
3. Train customer service personnel
4. Maintenance and upgrades
5. Create printed manuals or help guides
6. Content suggestions and proposals
7. Provide technology recommendations

Feature Descriptions

1.0 Energy Manager Central

System Demo
This section provides a slide show of screen images from the system with a voice narrative describing key features of the product. The demo will utilize Shockwave technology from Macromedia and will have a duration of less than one minute. In addition to being a part of Energy Manager, it can be made available to individuals outside of the pilot program for promotional or instructional purposes.

Personal Info
This section provides the user with a few options that they can customize in order to see a personalized screen when they enter the system. The available features may include, but are not limited to, the user's name, a personal greeting (audible), the current time, and the current weather conditions. This area could also include stock quotes, sports scores, and links to favorite sites.

Security Gateway
This feature provides a measure of security for the user so that a guest or maintenance person at their home cannot log in to their system and make changes to its configuration or possibly access account information. This security access code will take the form of a four digit personal ID number (PIN) that must be chosen by the user. After choosing a PIN,.the user will need to enter their SDG&E account number, electric meter number, and zip code when they first log

in to the system. These three pieces of data will be stored locally, and subsequent use will require only the PIN. If users forget their PIN, they will be required to reenter their account, meter, and zip code along with the customer name for the account. Additional security measures such as those related to encrypted data transmission, remote access, and server administration are not part of the scope of this project.

2.0 Billing Center

Bill Summary
This section will provide an account summary to the user by displaying the following information: name, billing address, current period charge, last payment received (amount and date), current balance due (amount and date), and a multi-function chart displaying consumption (dollars, kWhrs, or therms) for a variety of time intervals. Appliance load will also be featured on the multi-function chart as an aggregate over a 30 day period. The last payment received and current balance due data will be updated on a next business day basis to reflect actual payments made by the customer during billing cycle.

Energy Audit
This energy audit section will exist as an on-line connection to the residential on-line energy audit which is being developed separately by SDG&E using a product form A&C Enercom. Energy Manager users will access that system through this web page. The audit will run in a client window within the Energy Manager interface. If possible, the Energy Manager user will not have to re-enter their security information, since it is the same security information as required to enter Energy Manager

See My Bill
In this section, users will be able to see a representation of the actual billing statement that is sent to their home. SDG&E will be responsible for providing the bill image file in a .PDF format which is accessible from the database.

Future Bill
This section gives the user a quick glimpse of the estimated amount of their next bill. The area also includes a brief description of the potential impact that electric restructuring may have on how their energy bill is calculated and things that they might be able to do to keep it low. The user may will be able to see graph depicting forecast hourly energy prices.

Pay My Bill
This section provides a method by which users, who have subscribed to this service, can pay their bill automatically. They will be given an option of paying a portion of their bill or the full amount. Users who return to this section before the next billing period begins will see an indication of having authorized the payment

of a bill recently and the amount authorized. Once they elect to pay their bill, they will be given an opportunity to change the selection that they have made. When they have completed the payment process, users can receive notification that their payment has been made and that it will be credited to their account within a given period of time.

3.0 Home Control

The Energy Manager user will be able to set control parameter for the home controller via this web page. The parameters will then be converted to a command string recognizable by the home controller using a Java applet. The home controller command string will then be upload from the web server to the home controller on a near real time basis. The Java applet will be provided to Echo by SDG&E. The home controller features which will be enabled for the user are shown below:

Event Name and Description

This section allows the user create a new scheduled event, assign a name to it, and create a description for it.

Object Selection

This section provides the capability to select appliances that they want activated via a scheduling routine.

Event Conditions

This section gives the user the capability to create and or modify specific schedules for turning appliance groups on or off. These schedules provide for setting regular or discrete events based upon hourly, daily, weekly, or monthly parameters.

4.0 Customer Service

Contact Info

This section offers valuable contact information to the users such as toll free phone numbers, customer service addresses, and technical support contacts. This section could also contain any additional contact information that might be beneficial to the user.

Web Links

This area should contain a listing of approved external Web resources that enhance the overall home energy management experience. These resources can reinforce the principles and ideas that this system embodies. They could direct users to environmental, energy conservation, technology, mechanical efficiency, news, or Energy Pacific, San Diego Gas & Electric, or Pacific Bell corporate Web resources.

5.0 Help

FAQ's

This region provides a helpful list of Frequently Asked Questions for the user. This section is incredibly beneficial to both the user and the provider (Energy Pacific and San Diego Gas & Electric) because as questions come into the customer service representatives, they can record them and have them quickly uploaded onto the site. This keeps the information fresh, and if used by the customers on a regular basis, can reduce the amount of redundant requests form information.

On-line Manual

This area provided a more informative and organized resource than the FAQ's, however, unless the information is updated regularly with supplements, the information can be somewhat static. Nevertheless, the on-line manual is organized by topics and has a table of contents for quick queries. The on-line manual can have its own search engine and can either compliment or repla printed manual.

List of Deliverables

Development & Production

Design Document
Visual Design Sample

Engineering

Initial Prototype

Site Review & Testing

Reviewed and Tested On-line System

Uploading Finished Content

Final Approved On-line System

Product Support & Training

Energy Manager Training Proposal
Quick-Start Guide
On-line Manual

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