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Energy Utilities in the Internet and NII: Users or Providers?

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Title (# 221): Energy Utilities in the Internet and NII: Users or Providers?

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Abstract

In its bid to respond to evolving business requirements, the energy utility industry is exploring new ways to provide cost effective quality energy to its constituency while concurrently reducing the need for additional generation plants, consumption of non-renewable fuel resources, and generation of emissions. Their options cover a full spectrum that includes the utilities providing the "last mile" access to its customers for both generic Internet access required for empowering the users as well as supporting the necessary utility applications. In one scenario the Energy utilities provide high speed NII access to both residences and industry over utility owned infrastructure in order to obtain the level of reliability they need as well as providing the infrastructure necessary to support real time energy supply and consumption management. In a second scenario, the energy utilities make use of a combination of their own infrastructure and that of existing service providers, such as cable and telecommunications companies to satisfy the same set of requirements. Either scenario can greatly increase the number of active nodes on the National Information Infrastructure (NII) and the Global Information Infrastructure (GII); and therefore have a large impact on the network.

As the utilities start making use of the Internet, NII, and GII for partial or total support of their own grid management and business activities, as well as utility to consumer transactions, they encounter certain obstacles that although are not unique are never the less forbidding due to the scale necessary for implementation. Imagine every house, industrial building, campus, office building, and the like having its own local area networks that include both information and energy appliances that need to communicate. Issues relevant to this application area include, but are not limited to: What protocols will be used? The use of multicast for broadcast of real time pricing information? What security and privacy issues will be introduced in this new model? What monetary/business/trade issues will be relevant when the distribution of energy and associated business transactions cross national boundaries? What communications and information models will be used for the utility to consumer interactions? What protocols are required to support re-aggregation of consumer responses to real time pricing updates or shortage notices? Will the building LAN be implemented over the existing power lines, telephone lines, cable, radio or other media? Will each building electrical outlet be addressable and will the smart appliances be nomadic (i.e. a Laptop, toaster, etc.).

This paper will outline the major areas and issues with respect to 1) the energy utilities use and possible provision of network services, 2) the current major business and regulatory issues, 3) the technical challenges facing an utility company wishing to use the Internet, NII, and GII to support both its internal and customer based communications needs; and 4) explore what models and technologies are required by both the utilities and their customers (e.g. premises LAN, the gateway to the premises, and the utility infrastructure) to support both energy demand management and possibly generic Internet/NII/GII access to the end user.

Introduction

In its bid to respond to evolving business requirements that will be more competitive in nature, and as a result of the Energy Policy Act of 1992, the energy utility industry must, and is, explore new ways to provide cost effective quality energy to its constituency while concurrently reducing the need for additional generation plants, consumption of non-renewable fuel resources, and generation of emissions; in addition to identifying customer-focused requirement and enabling strategies.^{1,2} Since 1970 the trend has been away from the use of large plants and increasing in-line service transmission lines towards the use of more dispersed smaller plants in the 500 megawatt range to address the increased load growth of the nation.³ The public attitude against the construction of new plants, coupled with a growing consumption and need for energy, requires innovative solutions for better utilization of available energy resources. Energy consumption varies by time of day as well as by the requirements of the consumer. The residential, commercial, and industrial sectors all require energy, but in varying amounts, at different times of the day, and for different durations of time. The Utilities can reduce their "spinning reserves," that is the energy required to satisfy burst peak demands during unusual conditions (i.e. continual sub-zero weather in the Washington D.C. area over a seven day period) or peak demands, and avoid blackouts or rolling brownouts (a rolling brownout is when the utility systematically reduces or cancels the delivery of electricity to one or more areas in order to stay within the bounds of their generation or delivery capacity) through several methods. The use of time of day (TOD) or real time pricing (RTP) adjusts the cost of the electricity delivered based on the demand for electricity, with the escalating costs acting as damper for non-critical energy consumption during high demand or severe situations. Load management, the ability for sharing or transferal of electricity from one power utility to another to satisfy a temporal requirement for additional electricity, usually at an increased cost, is another method that may work at least among neighboring utilities; however, the information and physical infrastructure for accomplishing this is only now being contemplated and deployed.

In addition to TOD/RTP and load management, the current utility model is undergoing a paradigm shift from a self contained generation and distribu-

tion system to a more distributed and competitive model complete with separate energy generation corporations, backbone grid distribution providers (much like the Inter-exchange carriers in the telecommunications environment), and energy retailers and regional grid providers (much like the telecommunications local exchange carriers). Enhanced control by the consumer over how, how much, when, and at what cost energy is consumed is envisioned as not only helping the utilities achieve their goals with respect to more efficient energy generation and distribution but also giving the end user more control over their own energy practices and thereby saving them money, although the cost per kilowatt hour (kwh) may increase. All of these changes will require a more capable information and energy infrastructure that supports interactive energy services, automated and online infrastructure maintenance and operation, and business style interactions among all of the entities generating, providing, and consuming energy.⁴ There are currently many trials by utilities to provide the above enhanced services or combinations of energy and network information services. They include, but are not limited to: wireless meter reading, providing real time pricing to commercial customers,⁵ integrated provision of enhanced energy services as well as general Internet access and CATV services,⁶ and integrated municipal energy systems and telecommunications services.⁷ "Pacific Gas and Electric, the nation's largest investor-owned energy utility, is teaming with TCI, the country's largest cable firm, and Microsoft, the largest software company, to develop and market test energy management and information systems in 2,000 households in Walnut Creek, California."⁸ Many studies have recently been made that analyze the utilities' business requirements and regulatory stature, and consequently justify the utilities involvement in both using and providing network infrastructure.^{6,7,13}

Utility Regulation:

"Electric utilities are well-positioned to contribute to the National Information Infrastructure."⁹ Their legal powers, derived from their charters and operating authorities, are confirmed in their rights of way for carrying out the activities and functions necessary for the delivery and of electric services to their customers, including building required telecommuni-

cations facilities and undertaking information services that have become essential for managing electricity demand and supply.⁷ There are three main categories of utility, the Investor owned utility (IOU), Municipal Utility, and the Co-op. All function differently within various legal boundaries, yet all have some legal authority with respect to telecommunications that gives them certain leeway to build and/or deliver utility related telecommunications services. The utilities have a strong case, if they choose to pursue it, for justifying the need for high capacity and reliable telecommunications services to support their business requirements for interactive, real-time, energy demand and consumption management as well as to support their Supervisory Control and Data Acquisition (SCADA) systems. Leveraging these capabilities can further the goal of universal access for the NII, especially in rural areas where the cable industry and telecommunications providers are less likely to provide the necessary infrastructure due to the low density customer base.

The Energy Utilities currently provide their own telecommunications infrastructure for the provision, maintenance and operation of their generation and distribution systems in order to ensure, to the greatest degree possible, reliable operation and delivery of electricity to their customer base. There are some instances where they utilize services provided by the telecommunications carriers, but for the major part they provide and operate their own telecommunications infrastructure except for the "last mile" that provides connectivity to the consumer. Current Energy Information Systems (EIS) are mainly provided through wireless (e.g. radio frequency) technologies. The Energy Utilities' use of existing cable, telecommunications carrier and other providers for providing "last mile" access to the customer makes sense given today's regulatory environment; although it may make less sense with respect to the cable and telecommunications service providers' ability to support the utilities' technical requirements. However, many utilities, legislators, and the public have been wrestling with the notion of the Utility companies providing both "last mile" energy services capability as well as more general Internet and NII access to the consumer, either in a competitive or augmentary manner to the cable and telecommunications services sectors. The "electric utilities serve one percentage point more of the U.S. residential population than the telephone companies - 95% compared to 94% - and 30% more than cable television"⁸ and therefore are a logical choice for

providing "last mile" access to the end user and consumer. If the energy utilities were to provide last mile access via fiber to support their energy related services it is estimated that approximately 95% of the fiber optic network capacity will be in excess of the bandwidth required for energy services requirements. This excess capacity could be leased or sold to information service providers, including cable and telecommunications companies, with the profits from such sales distributed to the rate payers and the utility depending on what arrangements have been made with the Public Utilities Commissions (PUC).

A major applicable regulation, with respect to the Energy Utilities' legal ability to provide non-energy related information services and "last mile" Internet and NII access, is the Public Utility Holding Company Act (PUHCA) which was enacted as a centerpiece of the New Deal in 1935. To protect both investors and ratepayers, PUHCA requires that registered holding companies be confined to such other businesses as are reasonably relevant or economically justifiable for supporting the operations of the main business purpose(s) of integrated public utility systems or companies.⁹ Although the PUHCA does not stop utilities from providing energy related services to the end user, it does make it more difficult for the utilities to provide more general Internet, NII, and telecommunications services in its current form. Current telecommunications reform bill drafts will not only encourage competition among the cable, long distance providers, and local telecommunications providers but also loosen regulations on utilities thereby allowing them to also provide "last mile" services as well as NII and Internet access providers.¹⁰ This has the potential of truly engendering competition among the cable and telecommunications services providers since they will not be able to continue dragging their feet with respect to providing enhanced and cost efficient services to the consumer or they may lose customers to the energy utilities.

As the utilities enter the market of providing either energy related services or the more generic Internet and NII access, NII/Internet common carriage and privacy will become an issue. It is imperative that the utilities, as well as all NII/Internet and information service providers, be granted the same regulatory protection afforded to the telecommunications carriers, i.e. common carriage. In addition to the need for common carriage, privacy is another issue that may well require regulatory attention.

When the energy utility records information relating to a customer's use of electricity, i.e. billing information and appliance usage, who has the right to access this information and what safeguards are enlisted to prevent the non-authorized, either by retailers or the utility, dissemination or disclosure of information about a customer that was generated solely for the purposes of enabling more efficient energy management. In addition to the security and privacy issues associated with the utilities' providing "last mile" access, collocation, open access, and the interconnection/peering of the utilities with other information and telecommunications service providers must be enacted to ensure that the consumer sees a seamless information infrastructure.

Utility Business:

The monolithic utility model is quickly being replaced by a more distributed model that will see the occurrence of multiple generation companies (also known as GenCos), backbone style grid distribution providers (aka GridCos), delivery line carriers to the customer (aka DilCos), and retailers (aka RetailCos). This new model will require more advanced, adaptive, and flexible technical and business capabilities and models and technologies. In order to achieve the goals of reduced spinning reserves while not building new plants, the energy utilities expect to utilize both rapidly curtailable and selectively interruptable loads. An example of such loads in a residence include washing machines, dryers, hot water heaters, electric car battery chargers, air conditioners, and other appliances that can be turned off for certain time intervals without adversely affecting the customer. Industry and the business community also possess energy applications that can be time shifted or delayed. In addition to rapidly curtailable loads, both the utility and the consumer can benefit from the use of time of day (TOD) or real time pricing (RTP), whereby the cost of energy is driven by demand and the consumer is given the choice in quasi "real time," e.g. every 15 to 60 minutes the price is advertised, to reduce or sustain energy consumption based on their knowledge of the current price of electricity. An example is during the hot summer months when the demand for electricity to run the air conditioning units in office buildings outpaces the utilities ability to provide the required electricity, the utility could broadcast a higher price that encouraged residences to curtail their use of air conditioners and other appliances until the evening when they arrived home, at which time the air

conditioning/heating systems could be activated. This real time pricing and the subsequent action of a residence or business to turn off appliances in such times would be accomplished via command-response interactions over various telecommunications media. In order to save on energy related costs, industries could schedule their energy intensive operations at off peak time periods or curtail such operations during periods of high demand. The Electric Power Research Institute (EPRI),² Pacific Gas and Electric (PG&E), and Marriott Hotels are currently conducting trials in San Francisco and New York City on the use of real time pricing and control of the Hotels' heating, ventilation, and air conditioning (HVAC) systems.

In addition to providing more real time driven costing and control of energy consumption via telecommunications based services, the utilities will need to provide for a more efficient and quality energy services infrastructure. This will require enhanced monitoring and management of the energy generation and distribution components through the use of telecommunications. Better management and accountability of its infrastructure is expected to at least partially recoup some of the monies lost to energy piracy, which is estimated to be .5 to 1.0% of the power distributed and in terms of the 1990 figures of 177 billion dollars worth of energy distributed in 1990 could well save .8 to 1.7 billion dollars per year.³ Manual meter reading has been estimated to cost \$6 per household with a possible savings from automated (infers need for some sort of telecommunications) of 55 billion dollars based on the figure of 92 million occupied households in 1990. Telecommunications based monitoring, data gathering, and predictive analysis can help anticipate the need for parts or component replacement before a failure occurs that causes the loss of service to its customers, as well as to identify failures in real time and pinpoint both the location and cause of the problem. Scalable online and both computing and communications based network and energy grid management is crucial for supporting these goals. A future use of computing and communications capabilities for enhancing energy services could include the use of real time weather analysis of variables such as pollution and heat/cold extremes to control the real time pricing values for the purposes of reducing emissions and avoiding brownouts on a per geographic or metropolitan area.

One result of the information age is that the

utilities will need to not only provide quality energy to its customers, but will also need to give the consumer, both residential and others, more enhanced and easy to use online billing and accounting. In addition, a trend towards more customer control over their own information and energy appliances will require the utilities and third party energy providers, to provide enhanced interactive capabilities for curtailing the use of electricity. This switch to user driven selection will require more information technology to be built into energy appliances to enable energy customers to manage their energy use.

The immediate future will probably see retail competition for large customers, with the possibility of concurrent multiple suppliers, much as today many large facilities have more than one major telecommunication service provider in order to obtain the best possible price as well as to enhance reliability. The timeline for extension of retail choices, to residences and the remainder of the industrial and commercial sectors is less certain. In either case, the future business and technical models must account for and plan for the eventual real time choice of energy suppliers by the customers. In addition to the complexities introduced by a multi-provider energy infrastructure, the utilities will require support for new information/data flows, peering/gateway technologies and models for supporting inter-utility and intra-utility component energy and information services and retailing providers.

Users or Providers of Infrastructure:

As noted earlier, the energy utilities have the choice of either creating and running their own telecommunications infrastructure or utilizing the connectivity provided by other telecommunications service providers. The Glasgow Electric Plant Board offers competitive CATV services in addition to EIS. This has caused the local CATV provider to reduce their rates by as much as 50%. Glasgow is now planning on also providing 2 megabit per second Internet access. On the other hand, Entergy and others are using existing CATV providers and infrastructure for providing EIS. A recent study by Anderson Consulting found that "In Most cases, the benefits and risks of using a third party provider's network outweigh the benefits and risks of a utility owning and operating its own network."⁸ This is

especially true with respect to the utilities Supervisory Control and data Acquisition (SCADA) that have real time and high reliability requirements. Although the majority of the electric grid management is accomplished through the use of the utilities' own telecommunications infrastructure, there are some experimental projects that utilize cable, wireless and other services for providing "last mile" access for the purposes of energy services management. Possible synergies between the utility companies and the cable and telecommunications providers could be exploited such that the utilities could take advantage of the "last mile" infrastructure already in place to address the energy applications currently deployed. However, the future will require more enhanced capabilities for the "last mile," as noted by the Anderson Consulting study, "For the present, narrowband alternatives such as radio-based infrastructures are adequate to deliver many of the communications-enabled services being considered. Nevertheless, trends in other industries are moving toward customer interfaces through televisions and personal computers; these interfaces will require broadband."⁹ Broadband is required and necessary, not as much for the bandwidth, but more for the speed and real-time capabilities it provides. In order to use existing cable infrastructure for two way communications, the cable providers will be required to retrofit their infrastructure to handle high bandwidth two way interactive traffic. In addition, since the majority of the cable companies' current infrastructure is residential they will have to partner with alternate providers or extend their reach to the business and industrial sectors as well as to expand in residential areas that they currently do not support. The cable companies currently reach approximately 60% of residences. The local telecommunications service providers, aka known as the local exchange carriers or regional Bell Operating Companies (RBOCs), have a much larger footprint with respect to customer base. They are only one percentage point behind the energy utilities, 94% and 95% respectively. However, even though the telecommunications industry has made strides in the amount of information, they can provide over conventional twisted pair lines, it may make more economical sense for the utilities to provide fiber directly to their customers, which could be funded by increased revenues from the sale of excess capacity, by overall energy savings to the customer, by the savings from defered plant construction, and also by the provision (at less cost) of the other services to the customer, such as the cable and other Information Services (e.g. Internet) exemplified in the Glasgow

Kentucky experiment. Any one of the above scenarios has been proven feasible, yet a heterogeneous environment, comprised of some combination of all of the above will most likely be the case. It should also be expected that many customers, especially the residential customer, will probably already have Internet access; therefore the energy services paradigm must provide and take advantage of this capability and others.

Some of the variables affecting the decision as to what subset(s) of solution space defined above will be employed for delivering energy services to the consumer or for supporting the utility's management and operation of its generation and distribution system will depend on the actual services deployed. The utilities are investigating the use of automatic processing of acoustical signals and optical spectra for assessing the state of generating equipment and switching gear for the purposes of detecting or predicting faulty equipment. This application will require that data be collected from the monitoring processes and dispatched to processing centers which will run the analyses required to detect possible faults and trigger appropriate actions, whether manual or automated. Real time pricing will require wide broadcasts of real time prices, anywhere from a 15 minute to one hour basis, and will require the capability for aggregating responses from all customers within a very short time period. Some managers in the utility business do not believe that the current Internet or public telecommunications infrastructure (POTS oriented) is capable of handling the broadcasts, necessary for real time pricing, rapidly curtailable load requests and other such time critical interactions. "Electric utility communications network reliability must meet a higher standard than that for telephone service." This is because the communication network must fulfill two unique requirement "... First the communications network must handle an increasing volume of mission critical functions (i.e. real-time billing information)... requiring complete communications redundancy" and "Power Grid repair considerations also require that repair crew communications be reliable..."¹² Load balancing between utility providers will require highly reliable and secure communications to ensure that smooth operation of the energy grid(s) is achieved. Remote connection and disconnection of electric service, especially with respect to high density units that see a high rate of occupant turnover, is another goal of the utilities in their efforts to reduce unnecessary overhead and provide more

responsive services. This application will require accelerated deployment of secured information, albeit on a less frequent basis than other energy applications. Another tool for providing reliable and adaptive energy systems, that the utilities will utilize is video based monitoring and recording of events at power plants and substations, which will require fairly persistent high bandwidth capacity. All of these, including the business aspects of real time pricing or time of day pricing, as well as remote control of energy and information appliances, will require business level security and reliability, including authentication and digital signatures, as well as reliable and predictable telecommunications services. The telecommunications requirements for interacting with the customer, i.e. real time pricing, remote control of user of energy appliances (hot water heaters, air conditioners, etc.) are not quite as severe, yet also demand a lot of the same level of capabilities and surety. Many of these applications can be met through either existing service providers of the "last mile" or through new fiber optics and radio frequency services.

Infrastructure Models for Utilities:

Energy Services can be roughly divided into two categories. Those services focused on the operation and management of energy services include, but are not limited to: automated meter reading; data collection and management; document handling (electronic archival) and distribution of utility documents; field data transfer; automated network control of distribution networks including SCADA, dynamic load control, and other such uses; outage handling (fault detection, fault isolation, predictive maintenance, etc.); and video conferencing for internal communications. Customer focused services include, but are not limited to: aggregated customer billing (for customers with multiple locations); customer usage management (RTP, TOD, direct load control); providing information on general energy use and management through television and online services such as the Internet; specific energy usage information to the consumer on per appliance basis; interactive utility-to-customers service communications; competitive energy market options and pricing; non-traditional services such as security and other non-energy services; monitoring of customer power quality; energy and non-energy service bundling, such as telephone and cable; and other business activities that support the utilities as both a consumer and producer. In addition non-energy customer focused services

would include cable, Internet access and more.

The current utility infrastructure is a centralized and monolith based model, where one utility is responsible for the distribution and management of electricity from generation to end user delivery. Any communications enabled services, such as the adjustment of energy appliances to an advertised real time price or request for cessation in order to stave off a brownout, are currently activated by the utility issuing a control sequence from an utility central office or substation directly into the consumers premises to turn on/off or adjust the consumer's energy appliances. This paradigm, now recognized by many in the energy utility sector, drastically affects the techniques, protocols, information, concepts and models for providing an enhanced, secure, efficient, and component based energy services. The old monolithic model is now undergoing a transformation to one based on competition at all levels and the de-aggregation of the utilities functions into multiple independent providers. As such, it is expected that the energy utilities will undergo a lot of the same evolutions and changes that the telecommunications businesses as a result of divestiture. Expect the creation and competition of both backbone and local energy service providers as well as the use and provision of the required information infrastructure. The anticipated end state will include the residence, industrial, or business customer having a separate local area information and energy appliance network infrastructure (equivalent of a local area network) that interfaces and connects to the energy utilities and information service providers, analogous to the current telephony model of today. From the consumers' perspective the missing link is the cheap (say, \$100 or less) gateway, router, or equivalent, the equivalent to the "holy grail" desk top box sought by cable companies and others, that will provide multiple residence/building/campus local area network capabilities, which allow new choices (interfaces such as COAX, twisted pair, X10, CEBus, etc.) on one side and a similar set of choices (interfaces such as radio frequency, ISDN, twisted pair, fiber optics, cable, etc.) on the other side. This building block will spawn new businesses and services providers who will provide software and hardware systems, as well as services agreements for managing the consumers (homeowners, industry, and businesses) information and energy appliances. The end user will now determine what information regarding their energy consumption they allow the utilities or energy appliance producers have access

to, as well as maintaining control over when/how their own energy (as well as information) appliances are turned off or on. This deaggregation of utility components and functions, as well as ensuring proper business and technical demarcation/ interconnection/peering/open access points between the various energy utility components and the consumers premises, will enable the incremental evolution of both components and capabilities in an inherently heterogeneous environment, as well as engender new services and solutions due to the competitive energy and telecommunications (NII and Internet) environment.

Technologies:

The current technology basis for energy services is quite diverse. They range from proprietary SCADA and energy services protocols to systems based on open protocols, such as Open Systems Interconnect (OSI) and the Transmission Control Protocol/Internet Protocol (TCP/IP) protocols. SCADA is "a system of remote units which monitor the power network (e.g. substation voltage, current, breaker status), report network status to a master control unit, and allows operators to remotely control network performance."¹²

The majority of residence based solutions to date use the X10 protocol, which is implemented with simple command controls using frequency modulated power line carrier communications. CEBus, a protocol proposed by the Electrical Industry Association, and the LONWORKS protocols developed by a joint effort of the Echelon Corporation, Motorola and Toshiba are two newer entries in the residence energy management arena.² In addition, CEBus has been used in conjunction with proprietary power line monitoring systems. BACnet (Building Automation and Control Network) is yet another new protocol that is being developed by NIST and the American Society of Heating, Refrigeration, and Air conditioning Engineers (ASHRAE). The latter three of these solutions can be implemented over a variety of media, such as twisted pair lines, infrared, fiber optics, coax, and radio frequency; yet the majority of these solutions have significant drawbacks for addressing the requirements of a general LAN that supports advanced information and energy appliances. For example, CEBUS lacks an integrated implementation in integrated circuits, X10 can only communicate with energy appliances using the power carrier as a communications media, and BACnet is primarily designed to interface with heating and

cooling appliances.

Currently, very few households use PCs to control their appliances or energy consumption, most are controlled by timer based or remote controls using X10. The industrial premises control systems are a little more advanced, using PCs to control their systems, especially for HVAC, since the benefits to be gained (cost savings) are much higher, and therefore justify the investment. These PCs usually communicate with the energy supplier using dial up lines, or for industrial organizations the communications is achieved via the use of PCs or workstations over dedicated lines.

The technologies deployed for support of energy generation and distribution, e.g. SCADA systems, have been based on both proprietary and open systems protocols (e.g. X.25). EPRI⁹ has identified the OSI protocol suite as the basis for their Utility Communications Architecture (UCA),¹⁴ which many of its members have adopted. They have developed a two way, utility-to-customer communications gateway using manufacturing message specification (MMS) over a reduced OSI stack. In addition, the utilities are making more use of radio frequency based wireless communications for utility to customer, especially residential, communications.

Current trials with advanced energy distribution and management systems are deployed by utilities utilizing either their own coax systems that provide energy services and cable or internet services,¹⁵ as well as attempts to combine existing energy utility, telecommunications, and cable providers.¹⁶ There are some instances of more advanced systems. PG&E is using the TCP/IP protocol suite for managing their energy distribution system. In addition, to base transport network services, EIS are becoming more important. EPRI provides an energy information services network, that is multiprotocol, using both OSI and TCP/IP based services such as WAIS and Mosaic.

Future technical requirements will include the ability to make use of existing and future technologies such as Asynchronous Transfer Mode (ATM), multimedia, field data transfer, security, wireless, quality of services/resource management, TCP/IP, and more. As noted earlier, broadband capabilities will be required for the Quality of services and real-time capabilities they provide. Trials are already underway for enhanced monitoring and predictive

maintenance of energy distribution and generation systems. This application requires a large number of addressable nodes with the capability for gathering and the transmission of observation data to the center(s) who will then perform the analyses. Users will want to access energy related information, including energy related accounting and billing information over both the Internet and any alternate route provided as part of the utility-user infrastructure for real time energy demand management and control. This requires the utilities to operate a multiprotocol system. The end user premises will require a cheap multiprotocol gateway/interface/desktop-box. TOD and RTP both require real time protocol support (such as the IETF's Real Time Protocol- RTP) and both multicast protocols and the infrastructure to handle the reverse aggregation of responses in real time. The residential real-time pricing service POWERVIEW provides for simultaneous bidirectional communications in under 12 seconds. Scalable network management tools, that handle the plethora of devices employed to support both the energy related and information related infrastructure, sometimes on the same infrastructure, and allow for the end-to-end maintenance and operation of the energy system over various media and between different competing and cooperating business units. Finally, secure mechanisms and protocols are necessary before any real energy related business will be conducted over an open packet switched network such as the Internet or allow for the remote control of end-user premises appliances; however, we are starting to see such capabilities and as they are deployed the growth in this area will be large. There exists a real need for a general purpose gateway and control model implementation for the residence that allows the consumer to control both their energy and information appliances from a PC or a unit attached to their TVs, in addition to permitting the user to control what data and information passes beyond the walls of their premises (both residences and businesses). As this occurs the Utilities will need to define the data and information exchange paradigm, e.g. Electronic Data Interchange (EDI), between Utilities and between Utility and consumer. Easy to use application software for PCs, that will allow the consumer to address and control all of their energy and information appliances, down to the electrical outlets and autoconfiguration and identification of appliances, will start providing users with real control over their energy usage.

The decision of utilities to adopt a narrow set of technical standards for the purposes of attaining interoperability or scale of economies may at first seem like a sound choice, but over the long term this will definitely put them at a technological disadvantage.¹¹ The NII and the Internet, as well as any energy system infrastructure will continue to be composed of a heterogeneous mix of media and protocols, networks, and paradigms; therefore interoperability will be achieved more through affinity group coordination, the use of open access and standards for gateways and interfaces, not through end to end homogeneity based on a small set of protocols.

Summary:

The success of future energy services is dependent upon the creation and deployment of a deaggregated electricity and energy information infrastructure, complete with open access between energy, information, and telecommunications service providers as well as the end user premises. The deployment of an open non-proprietary residential premises network "black box" may well be the most important advancement for both the energy services and NII information services since it will enable new and innovative supporting hardware, software, system, and services that will drive not only the energy supply and consumption applications arena but will also spur on the deployment of NII and Internet access. The model must support a heterogeneous collection of telecommunications media and services, advanced energy and information applications and access strategies, and a variety of consumer premises solutions. It is also crucial that a general LAN for businesses and residences be developed that supports integrated energy and information services. The utilities will most likely deploy telecommunications infrastructure to mainly support energy services applications, but also to provide generic NII and Internet access where it makes sense. However, it is expected that in either case the utilities will need to work with, interoperate with, and utilize the services and "last mile" access provided by cable companies, telecommunications, Internet, and other service providers.

The delivery of adaptive energy services and the business requirements of both inter-utility and utility-to-consumer business activities will require the deployment of appropriate security mechanisms. Another issue that will quickly come to the fore-

front, and should be addressed, is the need for consumer privacy. Industry and companies, as well as homeowners, will demand control over who collects and has access to the information collected on their use of electricity. The inferences that can be deduced from energy consumption, and what devices are active at any given time, can easily disclose information to an industrial competitor, "big brother,"¹⁰ or other organizations.

Whether the utilities use the Internet and NII or just use the Internet technologies and protocols, the adoption of such technologies will require a large number of addresses, reliable and adaptive interconnection and peering technologies and protocols; imagine every outlet in a home, office building, or industry having its own address. The delivery of energy services will require multicast, aggregation/rendezvous of responses, authentication and access control, quality of service and network resource management support for real time and interactive multimedia communications, and enhanced real time network management. Similar activities are currently under examination and deployment worldwide, including the United Kingdom, the Netherlands, Japan, Germany, and many other countries.

In closing we leave you with an ironic issue. If real time and time of day energy pricing causes the shifting of industrial or business activities and processes to off peak hours, will this eventually cause the leveling off of demand such that the utilities will then have no incentive for offering lower cost energy for off peak hour usage? How will the higher cost of energy, during peak times of the day affect those persons and organizations that are just beginning to telecommute? The majority of people participating in a telecommuting plan are responsible for assuming the energy costs for heating/cooling their residences as well as running their computing and communications equipment.

References:

1. "Transmission and Distribution Technologies : A Multi-Year Program Plan FY 1995-1996," U.S. Department of Energy, September 1994, Draft.
2. "Supply and Demand of Electric Power and the NII," The Information Infrastructure: Reaching Society's Goals, Report of the Information Infrastructure Task Force Committee on Applications and Technology, NIST Special Publication 868, Septem-

ber 1994.

3. John Flood, UCS, Oak Ridge, NJ., Private Communication.
4. Glasglow document - need reference.
5. "San Diego: City of the Future, The Role of Telecommunications," International Center for Communications, San Diego State University, March 1994
6. Business Opportunities and Risks for Electric Utilities in The National Information Infrastructure", EPRI TR-104539, October 1994.
7. "Positioning the Electric Utility to Build Information Infrastructure." S.R. Rivkin, U.S. Department of Energy, DOE/ER-0638, November 1994.
8. "The Role of Broadband Communications in The Utility of the Future," Anderson Consulting, 1994
9. URL:<http://www.epri.com/>
10. "Nineteen Eightyfour; a Novel," George Orwell, Harcourt, Brace 1949.
11. "Standards: Too much of a good thing?", R. J. Aiken, J. S. Cavallini, *Connections: The Interoperability Report*, August 1994, Vol. 8, No. 8, and *ACM StandardView*, June 1994, Vol. 2, No. 2.
12. "The Role of Electric Companies in the Information Economy," Mesa Research, August 1994.
13. "The Economics Impact of Electric Utility Provision of Energy Information System," ORI/McGraw Hill, July 1994.
14. "Utility Communications Architecture (UCA)," EPRI, EPRI EL-7547, December 1991.

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