Exhibit No. -------------------

Commissioner: Michael Peevey

Adm. Law Judge: Michelle Cooke

Witnesses: Tom D. Tamarkin

California Public Utilities Commission

Testimony on Public Utilities Commission of the State of California Order Instituting Rulemaking on policies and practices for advanced metering, demand response, and dynamic pricing; Rulemaking 02-06-001 filed June 6, 2002

CPUC Rulemaking No. 02-06-001

Carmichael, California

August 20, 2005

Summary

Tom D. Tamarkin, hereinafter referred to as Tamarkin, a citizen of the State of California, County of Sacramento, presents this testimony on the functional requirements of Proposed Advanced Metering Infrastructure, hereinafter referred to as AMI, systems. Rulemaking 02-06-001 (hereinafter referred to as rulemaking order) provides guidance on AMI System functionality that may be lacking in specificity regarding benefits to ratepayers for the societal good. AMI may be deployed by the State of California's three Investor Owned Utilities pursuant to pending analysis and future Orders from the California Public Utilities Commission. It is incumbent upon the Commission to consider the benefits and advantages that can directly effect each and every ratepayer prior to approving a deployment of an AMI system. Not to do so could have the unfortunate effect of forfeiting opportunities to ratepayers to better manage their use of electricity, natural gas, and the like, thereby conserving fuel resources, reducing critical peak demand, and saving money through lower utility related expenditures. Tamarkin's recommendations are as follows:

- As a matter of fundamental public policy based on available technology at the beginning of the modern electric era and going back almost 100 years, ratepayers simply do not know how much electricity they are buying, how much it is costing to operate various combinations of loads in real time, and how much they have purchased to date from a beginning bill cycle, until they are billed at the end of the billing cycle. This relates to the fact that the power meter device provides only an accumulated energy use and in engineering units not easily understood. The situation is further exacerbated by the fact that the meters are typically located outdoors or other obscure locations. A primary goal of AMI should be the provision of tools to ratepayers that effectively transform the ratepayer into a decision-making customer.[1] Electricity, gas, water, and the like are the only remaining commodities that consumers purchase with absolutely no knowledge of the real time usage, accumulated cost and related pricing information. Analogies are abundant such as point of sale terminals at the retail store check out point that display quantity, and price. Today's gas stations provide electronic displays showing the price of

[1] Deputy Secretary of the Treasury, and Assistant to the President for Economic Policy, Dr. Lawrence B. Lindsey, letter of July 9, 2002 as attached as Exhibit "A."

the selected fuel, the amount pumped up to the second, and the total accumulated cost. Utility ratepayers do not have this information.

- The State's three Investor Owned Utilities have submitted various proposals to the CPUC for deployment which, in general, meet the minimum functionality as set forth in section 3 of the rulemaking order. However, since the Rulemaking Order is unclear with regard to best method (or at least minimal methods) to provide rate, cost, and usage information to customers, the possibility is strong that the utilities will inadvertently be allowed to deploy AMI systems which do not address this fundamental issue of providing commodity measuring information to allow the ratepayers to become decision making customers. Whereas, if a certain minimal interface is a part of the AMI system at the time of deployment, a customer may choose to "opt in" or "opt out" of a program that would allow the customer to acquire in-premise real time displays such as those typically used on modern gas pumps at filling stations at a marginally incremental increase of the total AMI system cost. However, if this interface is not included in the basic functionality of a deployed AMI system, the cost associated with acquiring and installing such devices in the future will be significantly higher and on the order of 5 to ten times higher due to labor and installation issues. Further, should this functional interface not be provided at the time of deployment the State will miss opportunities associated with the development of a myriad of new rate structures tailored to the needs of various types of customers.
- The State's principal interest in furthering AMI is to increase the level of demand response, in particular responsive demand, "as a resource to enhance electric system reliability, reduce power purchase and individual consumer costs, and protect the environment." California's energy agencies have already provided some guidance on the types of rates and technologies to be supported by the AMI system in the vision statement appended to Decision 03-06-032 and provided as Attachment "A" to the rulemaking order. In general, this guidance resulted from input from the three utilities and the California Energy Commission thorough a "Working Group" process and notably WG-2 and WG-3. To the credit of the agencies and the utilities, consideration of the customer user interface was explored. On July 28, 2004 a report entitled WG-3 Information Display Pilot Update was completed by Southern California Edison. The report is quoted

as stating: “To date, no significant compatible systems (are) available for IDP (Information Display Pilot) deployment.”[2] To put this another way, the report says as of that time products and technology to provide this information to the consumer were not available. Continued good faith due-diligence on the part of the WG-3 and lead by Southern California Edison lead to the engagement of the Electrical Power Research Institute’s (EPRI) Primen group (now known as EPRI Solutions) to conduct a detailed product search, investigation and analysis of this type of product. Primen released its findings in a report dated December 21, 2004 entitled "California Information Display Technology Assessment." This report did identify several such products and technologies; one that was 100% compatible with a commercially available revenue grade utility meter and AMI.[3] This report made several important determinations that will be further discussed in this testimony.

- Other third party testimony in related investor owned utilities AMI case testimony strongly raises this issue. Notably, testimony filed by the Silicon Valley Leadership Group (SVLG) dated June 13, 2005 under application No, 05-03-016 states, page 5, line 16: “Regarding the “flexibility” of customer access required by the February 19 ruling, SVLG further stresses that PG&E’s AMI system must provide energy users with cost data in addition to usage data. Specifically, the AMI system should provide pricing information and “pricing time usage” cost estimates. Just as they can request the current status of cell phone usage minutes via a website or automated telephone response, consumers and businesses (alike) should be able to request a “month-to-date energy bill via a website or IVR (like display.) The capability of providing cost data is added at the information system level and implemented in software, thus adding little to the total AMI cost while providing significant customer benefit.”[4] Again it is stressed that there are a variety ways to provide the information to the customer. The materially significant point is that the most useful methodology involves a dedicated information display and control unit. This is an option to AMI. However, the interface must be a basic functional requirement of any AMI system given the low cost of the interface versus the benefits to the customer and the State.

[2]WG-3 Information Display Pilot Update, Exhibit "B"
[3]California Information Display Pilot Technology Assessment, Exhibit "C"
[4]Silicon Valley Testimony under application No. 05-03-016, Exhibit "D"

- SB No. 1976 (Torlakson) approved by the Governor, September 24,2002, is in essence an act added to Section 454.5 of the Public Utilities Code noting that existing law requires the State Energy Resources Conservation and Development Commission (CEC) to conduct an ongoing assessment of the opportunities and constraints presented by all forms of energy. SB-1976 declared the urgency of the matter. Section 1 (A) states: "Californians can significantly increase the reliability of the electricity system and reduce the level of wholesale prices by reducing electricity usage at peak times through a variety of measures designed to reduce electricity consumption during those periods." Section 2 of SB-1976 states: (3) Options for facilitating customer response to real-time and critical peak prices and manage total customer costs, including but not limited to, interval metering and communication systems, consumer-side of the meter notification (display,) and automatic response equipment. (4) An Assessment of the options for a variety of customer classes, including but not limited to, industrial, commercial, residential, and tenants of a mobilehome park, apartment building, or similar residential complex, that receive electricity from a master-meter customer through a submetered system.[5] Section 5 of SB 1976 states: "This act is an urgency statute necessary for the immediate preservation of the public peace, health, or safety within the meaning of Article IV of the Constitution and shall go into immediate effect." This bill created state agencies and commissions to cooperate with the formation of the WG-2 and WG-3 working groups as noted above. A Statewide Pricing Project was put into effect which shows conclusively that consumers will conserve power when given the economic incentive to do so.[6] Further, on December 2, 2003 Senator Torlakson directed a letter to Commissioner Michael Peevey discussing a proposal by Los Angeles County and Southern California Edison to install electricity real time feedback display monitor devices in affordable housing projects to determine the degree to which such monitor and display devices effect the habits and methods of energy use by consumers when this direct real time information is provided. The CPUC subsequently voted to fund this project under an energy efficiencies grant. This project is in process now and should be fully operational

[5] Senate Bill 1976 Exhibit "E."
[6] SPP Summary Results, Charles River Associates, June 2004.

by the end of 2005.[7] It should be noted that the product being tested in these beta site pilot projects is the same revenue grade metering and AMI compatible technology noted in the Primen December 21, 2004 California Information Display Technology Assessment report described earlier herein.

- As part of Southern California Edison's commitment under the WG-3 proceedings and various directives of the CEC and CPUC, SCE engaged EPRI Solutions to coordinate the first known Real Time Energy Feedback forum held in Toronto, Canada, May 17 and 18, 2005. This forum was co-hosted by a leading Canadian utility, Hydro One and two industry providers of real time energy feedback monitors and displays. A major paper was presented by Dr. Sarah Darby, Professor, Oxford University, Oxford, England. The paper, entitled "Making it obvious: designing feedback into energy consumption," substantiates Senator Torlakson's comments in paragraph 2 and 3 in the above referenced letter to Commissioner Peevey regarding the impact of real time feedback if displayed on a dedicated display panel. Dr. Darby makes the intuitive point that the direct display of rate, cost, accumulated cost to date from beginning of the bill cycle, and real time consumption in dollars and cents per hour, on an always on and prominitely positioned dedicated display, will result in the largest percentage of conservation; up to 20%.[8]
- It should be noted that AMI is nothing more than an application specific wide area network, commonly referred to as a WAN, with application specific utility metrology node termination devices. Simply stated this means the WAN is connected to a power meter at the customer premise. Data can flow between the utility and the meter consistent with the utility's and consumer's needs. Utilities should be mindful of the lessons learned with the Internet in terms of bandwidth, connectivity, and the basic communications media; i. e., public access dial up telephone, broadband cable, Radio Frequency networks, WiFi, and the like. Undoubtedly, all of these basic communications media will have a place in an AMI system as can power line carrier technologies which allows the data to be carried directly over the power lines. Additional components of AMI may be interfaced at the utility "back office" in SCADA and Distribution Automation networks, service order dispatch, work order processing etc. The end point metrology node is in essence an electric power meter which communicates with the utility over the wide area network (WAN.) In order to insure a long AMI System life

[7]Tom Torlakson letter dated December 2, 2003 to Commissioner Michael Peevey, CPUC, Exhibit "F"

cycle, is critical that the wide area network as well as the data resultant from each power meter's real time measurement of a customer's power meter be capable of being interfaced to a local area network (LAN.) Such a LAN might be as simple as power meter communication with an in-premise display such as those advocated by Dr. Darby and being tested by Los Angeles County and Southern California Edison. The same interface, if properly specified and deployed, could communicate with a programmable communicating thermostat such as those proposed by the CEC under a change to CA Title 24 commencing in 2008. The same LAN could also comprise a multi point energy management and control system in which a plurality of appliances and large loads are 1) monitored, and 2) control the loads by either local manual control or utility control in the case of an emergency. The same LAN might comprise a total home-automation system.

- It should be noted that there is existing technology today that can be deployed. However, the inclusion of this customer premise communications interface will stimulate private industry to develop new, more powerful and less expensive products. The reason why more such product does not exist on the market today is that there has been no requirement for it by utilities. Thus the industry, with a few exceptions, has not taken the risk to design and commercialize such products. Just as in the era of radio introduction in the 1920s when many stations "went on the air," dozens of companies competed to design and commercialize better, more sensitivity, higher fidelity and cheaper radio sets. The same was true in the television industry and the cellular telephone industry. The California Public Utilities Commission has the power to empower all California electric customers to flex their power when it is in the best societal interest to do so such as during critical peak demand periods. Consumers may also manage their costs and reduce expenditures on energy when they see fit as a matter of personal management.
- Energy conversation is important in 2005. It will become increasingly more important over the upcoming years. As countries outside the U. S. begin to demand more energy the cost of fossil fuel resources can and will go up. It must be stressed that we have finite fossil fuel reserves and industry experts generally agree that we are decades away from a full-scale migration from fossil fuel to other alternative energy sources. The introduction of real time feedback to consumers through displays will not only provide practical management tools, it will provide a presence and awareness to begin the cultural shift to

[8] Making it obvious: designing feedback into energy consumption, Dr. Sarah Darby, Oxford University, Exhibit "G."

an environmentally friendly and conservation natural set of value systems. Whereas the public imperative to politicians is to take immediate short term steps to lower fuel and energy costs, the fact remains that we are depleting fossil fuels and at the same time, increasing demand daily with worldwide competition for the finite resources. This will have profound consequences to the citizens of California over the next decade. The life cycle of an AMI system is over twenty years, at a minimum. Therefore we must "get it right" at the beginning.

- To restate the important practical matter of this testimony, within the above context, any AMI system deployed should provide, at a minimum, for an interface to an in-premise <u>real time feedback</u> and control panel or system. In today's modern world, consumers are accustomed to immediate results and near instant gratification. Thus, a consumer should and will expect such a real time energy feedback system to show real time immediate results. As an example, with the air conditioner on and other high loads operating, the consumer should be able to turn on and off a 100-watt light bulb and see the results in seconds, not minutes, hours or days. Technology wise, this is a simple thing to do; the fact that there has not been wide spread use of this type of technology in the past, notwithstanding. The Commission need not be concerned with the specific technology(s) employed but only with the basic functionality of the provision of this interface. Generally speaking, this means a bi-directional or two-way data flow from each and every local power meter to a LAN device. From a cost consideration, this will have marginal impact on the overall AMI system price. The Commission must be mindful that the preponderance of the State's 11 million electric meters are located outdoors. Thus a low cost "plug and play" interface must be used which in all likelihood will involve Radio Frequency to insure low cost installation and near zero maintenance cost. A further objective should be the provision of an open set of data structures and communication protocols such as those being proposed by the OpenAMI task force in California. This will insure that the consumer has choice by being able to purchase displays and energy management products from the utility, or other means of distribution such as home improvement centers, consumer electronics stores, and the like.

Section I.

Introduction and Policy

Witness: Tom Tamarkin

Tamarkin presents this testimony on the rulemaking order as filed June 6, 2002.

There are several reasons why the Commission should consider the incorporation of an in-premise display and control interface. For the record, this testimony is not advocating the mandatory deployment of such in-premises devices. It is only advocating the AMI system be fully compatible with such devices through the incorporation of a suitable interface which will allow an external device from the meter to communicate with the meter in a bi-directional structure. The costs of including such an interface as a basic AMI system requirement are minimal and pale in comparison to the installation costs associated with the after market installation of such in-premise displays. The potential benefits to the consumer and to the State are enormous with little if any downside. The resulting benefits include but are not limited to a consumer's enhanced ability to manage their energy bills, more rate choices, improved customer service and better outage response and management. These benefits further include the ability for residential customers to participate meaningfully in the State's Critical Peak reduction efforts. As the previously cited Silicon Valley Leadership Group (SLVG) testimony points out, "Residential customers are critical because they not only are the greatest contributor to peak demands on the highest peak days, but also because they have the greatest ability to manage their peak demand. California's League of Women's Voters met with its members around the state and concluded that residential consumers have a duty to be part of the solution to California's peak demand problem. They are more price sensitive than businesses, as shown by extensive academic literature over the past decades and reaffirmed most recently in the California Statewide Pricing Pilot. In addition, residential customers face fewer constraints; businesses cannot close their doors or shut down processes to reduce peak loads, but residential consumers have many options.....California's energy users lag much of the world and country in receiving the benefits of AMI.

California faces peak energy shortages in the very near term. Further, fuel cost and energy costs will naturally increase over the upcoming years. AMI with the proper consumer tool sets and information and control displays has the greatest promise of voluntary peak demand reduction of any engineering solutions and at the same time allow the consumer to better manage their household expenses and make informed choices in power consumption.

California will almost certainly embark on some level of AMI shortly. Automation of the meter data collection process is a clear and growing national trend based on utility economics and consumer expectations. Automation costs are declining while manual reading and associated liability costs are rising. California has one of the lowest automation penetration rates in the nation. The previously cited SLVG testimony points out “Consumers and business in all areas of modern life get much more current, more accurate and more detailed information than ever before. The exceptions being in highly regulated industries such as electricity, gas, and water."

As stated in the summary section of this testimony, as a matter of fundamental policy, utility customers are as a matter of definition, ratepayers. AMI with optional real time in-premise information feedback, display and control systems can dramatically convert California’s ratepayers to decision making customers. At this same time this opens up tremendous opportunities for new rate structures tailored to the needs of specific customers. Rates based on class of service-as a function of peak demand-power factor-frequency and duration of service interruption, time of use, dynamic pricing, real time pricing, CPP, to name only the obvious.

Through a cost effective judicious set of engineering choices the enormous increase of data flow to and from a utility over the AMI WAN data telecommunication system can be significantly reduced by several orders of magnitude (10 power steps) when subscriber side processing and billing is implemented. This also reduces the utility back office complexities of dealing with the huge amounts of interval billing data and allows extremely advanced and flexible rate tariff designs.

It should also be a principal concern to the Commission that the California Energy Commission is considering changes to Title 24 beginning in the 2008 time frame that will require the mandatory use of programmable communicating thermostats. Based on by definition a LAN, these thermostats must be capable of receiving signals from the utility and exercising some appropriate set of local response or control actions as well as provide feedback to the utility that such action was in fact exercised. To the extent that AMI is deployed on a large scale basis, the AMI WAN and LAN interface becomes the logical, most cost effective communications media. Further, there will in all likelihood be a merging of the thermostat functionality and the real time feedback display and control technology that will be lead by industry, entrepreneurs, and system designers.

Woodstock Hydro in Canada deployed a pre payment plan and related system a few years ago. Part of the hardware includes a customer display that provides real time feedback information in terms of burn rate, cost, and descending balance (of prepaid credit.) The bottom line is that

Woodstock Hydro charges a flat $5.00 per month for the hardware and program. As of May 2005, over 25% of their customer base have signed up and pay the charge. The retention rate is virtually 100%. When customers were polled regarding their reasons to keep the equipment and plan, the results showed that the customers felt the display allowed them to manage their expenses and conserve power and that the savings was greater than the $5.00 per month charge. [9]

Section II.

Desired meter Functionality Criteria

Witness: Tom Tamarkin

Utilities in California must face the practical reality that there is an installed base of over 13 million electric single phase kWh power meters. Argument can be made to base an AMI deployment on two different strategies. The first involves the insertion of an AMI meter implant module in existing electro-mechanical meters. The second strategy involves the wholesale replacement of the existing electro-mechanical meter with more modern electronic solid state meters with WAN and LAN communications. An improved sub-set of the second approach is to create a new 21-century meter design.

Undoubtedly, each of the three California investor owned utilities has different strategies in mind. Although one can logically make a case that the first strategy is cost effective, the resulting metrology and AMI interface is extremely limited in what it can do in terms of long term accuracy, resolution (important to real time feedback) and just what can-or can not-be measured.

The Commission must recognize that the three utilities will have differing opinions and case model analysis during the Commission review and approval process. What is most important is that all utilities and the Commission agree from a feature-function-technological standpoint what can be done as opposed to simply what has to be done given the six points

9. Commodity Treatment of Electricity Pay as you Go / Consumption Awareness, presented by Woodstock Hydro, Real Time Energy Feedback Forum, Toronto, Canada, May 17 & 18, 2005 Exhibit "H."

articulated in the Section 3 of the rulemaking order and insure the implementation of open data structures and protocols so that the WAN termination metrology node (AMI meter) is universal and that any AMI system is capable of supporting any meter strategy.

Time will ultimately prove which strategy and technology is best. Technologies which support the greatest number of rate options, preformance measurement capabilities (over voltage, under voltage, power factor analysis, service outage and restoration notification, class of service, remote connect and disconnect, prepayment, etc., etc.) will ultimately become the defacto standard especially to the extent the consumers becomes aware of the benefits and begins to prove market demand which in turn, will stimulate industry response by offering new and lower cost products and services.

In the summary section of this testimony the December 21, 2004 Primen (EPRI Solutions) report was cited as a reference Exhibit "C." makes the point of stating "Most of the traditional metering and specialty meter device providers indicate that adding communications to show instantaneous energy use and cost under a CPP (or other) tariff was not an insurmountable technical challenge." Yet none of these firms are doing this now because there has not been a market demand from the industry. The industry has been driven by cost.

As the Commission and its distinguished colleagues and consultants surely understand, the trends are very, very clear in terms of functional integration and cost reduction. The main frame computer to simple PC in the seventies to today's PCs with massive amounts of memory and processing power to hand held PCs and PDA migration is clear. The same will be true in the metering and automation industry once demand is established. An advanced meter can be designed today which effectively integrates the metrology (Current & Voltage measurement and conversion to Watts or Kilowatts) time interval collation, local data storage for long term data archive, data telecommunications interface to WAN and LAN using ASIC (Application Specific Integrated Circuit) techniques such that a meter can be built today with a here to before un-thought-of set of functional capability at a cost no greater than that of much less feature rich commercially available meters.

One of the State's three Investor Owned Utilities, Southern California Edison (SCE) has taken this concept and brought it forward to the Commission in its landmark March 30, 2005 filing seeking approval to design its AMI system "from the ground up."

This is advanced thinking worthy of the Commission's fast track approval. In so doing, SCE will create the design of a commercially viable AMI system which will incorporate state-of-the-art design techniques and provide a super feature rich product. Much of the proposed capability was presented in Volume I and Volume II of SCE's filing. It should be noted that SCE has recently completed an extensive investigation and analysis of technology, trend forecasts, and current and future vendor ability.

SCE should be encouraged to move aggressively with its plan so as not to create an undesirably long latency window before deployment.

The following technical reference is provided to the Commission which helps create a better understanding of just what AMI is and what the possibilities are. This should be a useful body of work when evaluating the SCE proposal and others. This is based on a conference paper presented at an industry conference in April, 2005 in Las Vegas, Nevada. This paper was written in its entirety by this witness and prior to the filling of SCE's March 30, 2005 application to the Commission

Key to cost effective AMI is a real time two-way communication link between the utility and the customer. This implies a customer user interface or information display that communicates in real time with the customer's electric meter and the utility. This allows greater return on investment through multiple cost center savings, and the establishment of new non-core revenue streams.

The cost of the associated equipment must be very low. This requires a much higher level of integration between the various system components beyond the classical kWh meter interfaces, AMR modules, data collectors, and wide area network communications systems.

Cost of a system wide AMI can be reduced by a factor of 3 over traditional best case projections through effective integration and related ASIC chip development. The in-home Graphic User Interface that communicates with the utility, power meter, and controls loads such as HVAC, large appliances, etc., must be a part of such a system. Operational efficiencies will be gained, customer service greatly enhanced, and new revenue streams generated.

California has a problem. At brief but predictable times, we use more power than we can produce and deliver.

The solution is demand response enabled by Advanced Metering Infrastructure systems and related components.

A worthy societal vision is to turn California ratepayers into customers.

The problem is that as a fundamental matter of public policy, the ratepayers simply did not know how much they were buying, and how much they were paying for it, until they were billed.

Think about it. You wouldn't go to the gas station and fill up your tank without a meter on the pump providing you with the cost of the fuel per gallon, how much you have bought, and how many dollars you're going to have to shell out to pay for it.

Customers buying a commodity such as gasoline at the station, or electricity at the home, must know how much they are paying and how much they are buying. They could care less about rates. They want to know the bill….as they go.

At the public policy level, California is taking the lead. A recent CPUC administrative law ruling has required the State's three investor owned utilities to submit business case models and analysis leading to the large scale deployment of AMI or an Advanced Metering Infrastructure. AMI offers the ability to make the end customer central to the demand and purchase decision process.

AMI consists of three fundamental building blocks. These are:

1. Back-office computer, software, and data communications for the collection, processing, archival, report generation, and customer billing.
2. Wide Area Network (WAN) data telecommunications system to "back-haul" consumption and usage data from each and every customer to the utility's back-office processing center.
3. An Advanced Integrated Metrology unit that combines the necessary electronics and embedded firmware to:
   A. Serve as a Watt hour meter supporting complex real time variable rate tariffs.
   B. Communicate bi-directionally with a myriad of ancillary Graphic User Interface display, control, and remote monitoring devices including the integration of additional utility meters such as gas and water. In other words, the Advanced Integrated Metrology unit is a Local Area Network (LAN) to Wide Area Network gateway integrated with advanced, ANSI standard, metering functionality.

Key to the realization of the State's vision of effective demand response, and certainly critical peak demand response, is an indoor customer Graphic User Interface which enables customer behavior modification predicated on economic incentives, as well as utility accessible load control under emergency conditions. This customer display can, on the one hand, be considered as an option to an Advanced Integrated Metrology unit as it is physically separated from the Watt hour meter. On the other hand, it is a critical component if the Advanced Integrated Metrology unit is to achieve all of its promised paybacks and economic benefit to society, the customer, and the utility. The balance of this paper discusses the meter and display and treats them as one and the same. Functional and design requirements for the data telecommunications Wide Area Network and the back-office processing and software generally fall out of the meter functionality.

This vision has been shared by this witness for over fifteen years. In 1992 he wrote an article published by Public Power Magazine that highlighted the importance of bringing the customer into the process by means of an in-home customer information display.[10] Now, this vision is materializing. These products are being developed. They bring the electric, gas, water, and other energy fuel meter displays inside the house, and convert the engineering units (kWh, cubic feet or gallons per minute) into dollars and cents. A graphic display provides the real time burn rate in cents per hour or minute, and provides the accumulated use since the start of the bill cycle . . . in dollars and cents. At the end of the month the bill may be "trued up" with rebates, offsets, credits, and taxes. One hundred percent accurate. . . one hundred percent of the time. Think about what that does to a utility's customer service call center. And yes, the system does service outage and restoration reporting as well as theft of service reporting.

These products can be the hub of a wireless, radio based, in-home LAN or Local Area Network. The LAN connects electric, gas, oil, propane, and water meters along with appliance sensors, heating and air conditioning thermostats, the in-home display, and the WAN or Wide Area Network, real time, AMI. This allows information and data to be exchanged to and from the customer and utilities and eliminates the need for personnel to be wasted on tasks like meter reading, service disconnects, etc.

California has recently wrapped up its SPP or Statewide Pricing Project and has seen conservation figures as high as 20% when customers (not ratepayers) are given the economic incentive to do so.

[10] Automatic Meter Reading Systems, Tom D. Tamarkin, Public Power Magazine, October 1992, Exhibit "I."

This type of in-home display and control device is the fundamental missing ingredient to the effective implementation of TOU (time of use) and peak demand rates, dynamic or real time pricing, for residential and small business accounts.

AMI starts with the meter.

The heart of an effective AMI system is the Watt hour meter. In retail business there is an old saying: "Location, location, location." With respect to AMI the adage becomes: "Cost, cost, cost." First and foremost, the meter must be low cost. That being said, the meter must be an Advanced Integrated Metrology unit. AMI has the promise of providing multiple paybacks.

The paybacks become manifest in several ways. These include reduction of operating expenses, improved efficiencies, lower acquisition cost of wholesale power, improved cashflow, and additional revenues resulting from new none-core products and services. A review of the various paybacks and the meter attributes necessary to support them follows.

Firstly, in California, the policy drivers for AMI have up to the present been the reduction of peak demand. In order to maximize this reduction there must be a combination of immediate customer feedback in terms of the up to the minute cost of power, the present "burn rate" or load, in dollars and cents, and rate structures designed to alter customer behavior, thereby shifting unnecessary usage to lower peak times.

A well designed AMI Advanced Integrated Metrology unit meter hardware and embedded firmware requirements should support:

- Time of Use rate structures. A minimum of 15-minute time interval data must be processed and stored in the meter with 45 day archival within the meter.
- Peak Demand or Class of Service rate structures. The meter must determine and record the maximum peak demand of its load in each of the interval "bin" periods, and store these values with 45 day archival within the meter.
- Dynamic or Real Time Pricing. The meter must be capable of receiving real time cost of power information through the Wide Area Network data telecommunications network and transferring this information to the customer via an in-home information display device. Further, the meter should be capable of performing the billing calculations internally based on the current billing determinants which include the real time cost as well as TOU and Peak Demand load information. This reduces network congestion, back

office processing and software complexity, and allows the implementation of Subscriber Side Billing.

- Critical Peak Pricing. Critical Peak Pricing and the various schemes associated with advanced customer notification become a sub-set of the real time pricing methodologies described above.
- Wide Area Network Data Telecommunications. The meter must contain internal electronic circuitry to interface with a data Wide Area Network to allow for the bi-directional transfer of data to and from the meter and utility back-office. Although an effective AMI system may well employ multiple means of data back-haul including, but not limited to, radio frequency, power line carrier, telephone, wide band cable, and cellular telephonics, the practical limitations imposed by the United States distribution system involving limited numbers of customers per transformer and lack of a neutral or Earth ground connection to the meter, dictate that the principal data interface to the meter must be RF. This becomes increasingly important as the amount of information transferred between the meter and utility increases as a result of incorporating new revenue producing value added products and services.

The AMI data Wide Area Network should be structured to allow for the transfer of customer service messaging, emergency notification and homeland security messaging, emergency disconnect of electric, gas, and water services in the event of natural or man made disasters, and service personnel data base and report transmittal.

- Service Outage Reporting. Each meter should have sufficient non-interruptible power to allow for the transmittal of service outage conditions including time stamping and meter ID number to the utility.
- Service Restoration Reporting. Upon service restoration each meter should transmit a time stamped notification of the service restoration event along with the meter ID number to the utility.
- Theft of Power Reporting. Revenue diversion events and activities such as the shunting, bypassing, or tampering of the meter should be time stamped and transmitted to the utility.
- Remote Service Connect & Disconnect. Each meter should support the optional internal mounting and connection of a 2-pole 100-ampere relay or contactor. The meter should

include an integrated electronic interface to the relay and embedded firmware to allow the relay to be switched from state to state by the utility through communications over the data Wide Area Network. The associated electronics and control firmware should be designed to support various prepayment options including on site Smart Card and over-the-network activation, as well as class of service or maximum load thresholds before automatic shutoff of service. Additionally, an external control button must be provided for final account activation by the customer prior to power restoration by the relay as a safety precaution. This control may be mounted on the meter with external access, or it may be incorporated in the in-home display unit.

- <u>Over Voltage and Under Voltage Reporting.</u> Each meter should automatically record and archive for 45 days the maximum and minimum voltage over a 500-millisecond period in each interval time "bin." Further, the embedded firmware should trigger the transmittal of a time stamped notification to the utility in the event of a sustained over voltage or under voltage in excess of a programmable threshold for a programmable period. Ideally, the meter should monitor each leg of the incoming circuit with respect to neutral as a function of the sinusoidal waveform phase relationship and distortion monitoring.
- <u>Power Factor Monitoring and Reporting.</u> Each meter should be capable of monitoring the power factor or quality of each of the circuit lines with respect to the zero cross point and recording statistically relevant deviations for each interval time bin and generate a time stamped transmittal of power factor data in the event programmable thresholds of uncorrected power factor conditions occur. Through digital signature analysis, the meter should be capable of differentiating between distribution system related load factors creating power factor changes and customer load conditions creating power factor changes. The first set of information is of use to the utility for distribution system preformance monitoring and optimization, and the second set of data is of relevance to the customer for preventative maintenance. The data may further be used as billing determinates in Class of Service rate structures in which power factor is included.
- <u>Local Area Network Gateway.</u> The meter must be designed as the principal node or gateway in a wireless customer Local Area Network that can receive data from and transmit data to other utility meters such as water, and natural or propane gas. Sufficient data logging and processing hardware and embedded firmware should be included to

allow for the implementation of the same type of variable rate structures defined above for electrical service with gas and water service. Whereas this need may not be obvious at first glance, this is only because the technology has not been available in the past to support variable rate implementation such as TOU, peak demand, day of use, etc., for gas and water service except in the case of large commercial and industrial users.

Implementation of such variable rate structures for water and gas service offers manifold benefits to consumers, the respective utilities and most of all, the electrical utility, as both gas and water require enormous amounts of electricity to pump the commodity through their distribution systems and this use of electricity typically runs parallel to the critical peak demand. Further, the cost of both water and gas is escalating and many areas face peak demand limitations of both commodities.

Additionally, the customers' Local Area Network gateway is the interface to an in-home information display panel as well as an in-home appliance and load monitoring and control network.

- Remote Programmability. The meter must be capable of being remotely programmed and future updates of the embedded firmware comprising the real-time run system must be capable of being down loaded over the Wide Area Network to insure that future enhancements and upgrades may be cost effectively implemented.
- Product Life Cycle, MTBF, and Environmental Considerations. The meter should be designed to ensure a 20-year life cycle, a MTBF consistent with traditional electro-mechanical meters, and continuous operation at -40/+85 degree C temperatures. The electronic and mechanical design must allow for long term operation in sea cost areas with high concentrations of sodium chloride and other salts in the air and generally be immune from transient power events consistent with ANSI C-12.11 and other relevant specifications.
- In-home Information Display. A wireless in-home Graphic User Interface or information display and control device must be provided with each Advanced Integrated Metrology unit in order to enable the use of most of the above features. Communications between the display and the Watt hour meter must be wireless as opposed to power line carrier in order to allow for the portability of the display and hence its use as an audit and conservation management tool. The display must be

reasonably large and full color in order to capture the full attention of the customer. The screen displays must be nested in complexity to allow for the device's use by a broad spectrum of customers with different social economic backgrounds, interests, and levels of patience. Screens could, for an example, be a simple as a blank screen that varies in color indicating either cost information or usage information. They can also be quite complex providing enormous amounts of information to those interested. Screens can be entertaining or educational as well.

The Advanced Integrated Metrology unit's Graphic User Interface provides an in-home hardware platform to support features including but not limited to the following:

- User interface to "Smart Home" appliances through the use of the wireless LAN and remote appliance modules which both monitor the specific load of the appliance as well as modulate that load under the command of the consumer or the utility in an emergency or under the terms of a preferred rate structure allowing remote access to loads by the utility.
- Network node connection to a customer's PC through a "plug-and-play" RF to USB interface.
- Prepayment of service request and enablement over the Wide Area Network.
- Prepayment of service through the use of a customer inserted Smart Card programmed at an authorized utility charging location or payment station. In both prepayment instances, the customer and utility can enjoy all the benefits of all the advanced AMI and Advanced Integrated Metrology unit features, including remote data access and complex rate structures, while the utility enjoys the benefit of enhanced cashflow, reduced collection activities, and an overall reduction of liabilities relating to customer site visits.
- The utility can use the Graphic User Interface device to display messages created by the customer service department or other departments as well as emergency notification messages.
- The utility can partner with local business to offer the messaging service as a distinctive, customer addressable, advertising and messaging service to those customers who choose to enable this function.

- The utility can partner with local businesses and use the AMI and display system to deliver electronic coupons to the same Smart Card which, in some instances, may be used for those customers who prefer to take advantage of a prepayment program.

Conclusion:

AMI can provide a significant Return on Investment if:

- The cost is low.
- The system provides many functions & multiple pay back cost centers
- Allows the generation of new revenue streams through non-core opportunities

The "Right Economics" will require:

- Support bi-directional communications between the customer and utility
- Include an in-home customer interface to:
  - a Automatic real-time transfer of current rate information from utility to customer
  - b Provide real-time consumption feedback
  - c Provide accumulated cost from start of bill cycle
  - d Customer presentation of end of month bill
  - e Provide means for consumer to set and monitor a budget

The in-home customer interface will also need to:

- Allow load reduction through communications with thermostats and appliance modules
- Support prepayment option in conjunction with all advanced tariffs over network or customer inserted Smart Card
- Allow delivery of messaging and media content from utility to customer
- Allow downloading of data to customer inserted Smart Card

Advanced Integrated Metrology functionality should at a minimum support:

- Peak demand rates
- Time interval rates
- CPP rates
- Real time pricing
- Prepayment of service with all complex tariffs
- Subscriber side billing capability to support all complex tariffs for reduction of network communications traffic and congestion

- Theft of service remote reporting
- Low cost optional remote service connect/disconnect
- Local power factor monitoring
- Service outage and service restoration reporting
- Forty-five day archival of billing determinants for complex tariffs
- Serve as a communications hub between utility, gas, water, and other meters & devices for monitoring and control
- End point termination of Wide Area Network data telemetry communications

Technology wise, the functional and cost goals are very realistic:

- A single vendor "off the shelf" solution offering the above does not exist as of Q2 2005.
- The meter company's have not invested in this solution because of a lack of market demand
- Application wise, technology must be refined and integrated to reduce cost
- Production wise, Enel Electric in Italy has shown the feasibility of producing and installing over 500,000 meters per month on a sustainable basis

A Beta site deployment:

- SCE is working with Los Angeles County and a Sacramento based firm for a beta site deployment of leading age real time feedback energy usage feedback devices which will be operational by the end of 2005 in several public housing authority projects in Los Angeles County.
- In-premise display and control units and associated ANSI compliant revenue kWh meters offer:
  1. Download of current rate information from utility to customer
  2. Provide real-time consumption feedback
  3. Provide accumulated cost from start of bill cycle
  4. Customer presentation of end of month bill
  5. Provide means for consumer to set and monitor a budget

Planned continued development and incremental improvements to these products will allow for:

- Allow load reduction through communications with thermostats and appliance modules under automatic, user manual and utility remote control.
- Support prepayment option in conjunction with all advanced tariffs over network or customer inserted Smart Card
- Allow delivery of messaging and media content from utility to customer
- Allow downloading of data to customer inserted Smart Card

Additional Benefits that should be modeled on a case by case basis:

- Cost savings associated with wholesale power acquisition at peak demand times
- Lower costs in maintaining Transmission and Distribution system at peak demand times
- Cost reduction in service connection and disconnection in selected accounts
- Cost reduction associated with reduction of customer service inquiries
- Reassignment of traditional meter reading resources
- Cost reduction associated with accurate service outage and restoration reporting

New none-core revenue stream examples that should be modeled on a case by case basis:

- Sales of product upgrade (in-premise information displays, etc.) to customers
- Retail messaging transaction fees
- Retail electronic in-service coupon fees
- In-home wiring insurance and preventive maintenance service based on local power factor monitoring & signature analysis
- Increase in sales velocities of utility retail product offerings
- Contract meter data collection services for gas & water utilities; emergency remote gas shut-off (earthquake event as an example)

Witness Qualifications

Qualifications of Tom Tamarkin

Q1. Please state your name and address.

A1. My name is Tom D. Tamarkin. I reside at 5545 El Camino Avenue, Carmichael, California 95608

Q 2. By whom are you employed and in what capacity?

A2. I am employed by USCL Corporation, Sacramento, California 95821 as President & CEO.

Q3. What experience do you have testifying before state utility commissions?

A3. I have provided in person testimony to the Connecticut, and Idaho Public Utility Commissions as well as combined California CEC and CPUC public hearings.

Q4. What is your professional experience?

A4. My resume follows as inserted text herein:

Tom D. Tamarkin
5545 El Camino Avenue
Carmichael, California 95608
Office (916) 482-2000
Home 916-974-1800
CA Cellular 916-628-8100

5/95 to Present **<u>Chief Executive Officer, Chairman USCL Corporation</u>:**

- Responsible for the general management of the firm on a daily basis.
- Responsible for capital formation and equity sales to fund ongoing business activities
- Responsible for the development of the EMS-2020 product and management of hardware and software engineering.
- Developed EnergyCite product concepts in February 2001.
- Managed EMS-2020 development from conception in February 2001 to prototype state in May 2001.
- Negotiated the acquisition of U.S. Patent 5,994,892 and all IWP, technology, and related assets developed by the Sacramento Municipal Utility District (SMUD) in conjunction with the U.S. Department of Defense related to the Smart Utilities Meter.
- Negotiated and closed development contract for a light directed pick system, a distributed intelligence RS485 networked system for use in warehouse automation for ASAP Automation, Inc. in Louisville, Kentucky. Conducted U.S. and foreign competitive intelligence program; wrote competitive features/function cost matrix; wrote system and component hardware, software and user interface specification. Received contract for product design including hardware, firmware and software of host, mater controllers, slave controllers and six remote user interface date entry and display panels.
- Manufactured over 15,000 devices from 1996 to December 2000.
- Consultant to Tsinghau University in Beijing, China; prepared detailed product development design specification for embedded PLC controllers.
- Consultant to Shanghai Ship and Shipping Research Institute Ministry of Communications

to Shanghai, China. Prepared detailed design engineering specification for embedded controllers and systems; assisted with applications related marketing tools.

05/94 to 5/95 **General Manager, COO, Industrial Control Links, Inc., Auburn, CA:**

Industrial Control Links, Inc. is engaged in the PLC controller and custom OEM engineering business with FY94 sales approximating $5 million.

- Managed smart overtop shut down board project for Thermco Systems Division of Silicon Valley Group (SVG) and Intel Fab 7. Implemented plan to meet Thermco's subcontractor certification requirements as an ISO 9002 certified company who manufactures wafer furnaces for the semiconductor industry.
- Negotiated and signed a $700,000 contract with Thermco Systems/SVG 90 days after joining firm.
- Commercialized Microprocessor controlled Si wafer furnace flange cooling system for CVD tubes; worked with Intel fabs in Oregon, New Mexico, Arizona and Israel.
- Commercialized redundant thermocouple monitoring system for AMD Si wafer Fab furnaces in Austin, Texas; wrote spec, defined product, negotiated contract and managed first article installation, test and device certification.
- Defined market place for embedded PLC controllers, conducted competitive intelligence analysis, prepared feature/function cost matrix of all competitive product, wrote spec for V.25 and 386ex board embedded controller utilizing advanced features such as PMCCIA memory and onboard DTMF auto dialer which became the ICL 4000 series of controllers; negotiated software license contracts with Paradyne and Borland for resale of C compilers for use as development tools.
- Identified Raychem Corporation as prospect, made sales presentations, and closed contract for the development of a new generation of liquid leak detection systems. Managed an ongoing development program and served as technical interface between Raychem technical staff and Industrial Control Links.

02/93 to 04/94 **Assistant to the President, Mactronix Corporation, Dallas, Texas:**

Mactronix is an established leader in the field of Semiconductor Wafer Transfer and Sorting systems used by the Semiconductor device manufacturing industry. The company has an installed base of over 12,500 unites at 245 facilities worldwide with FY93 revenues of approximately $10 million.

- Responsible for all direct sales to the firm's largest single account (Intel).
- Responsible for the management of sales, marketing, and customer support staff of 24 members, worldwide.
- Responsible for all application engineering, documentation, collateral materials, trade shows, and marketing communications.
- Established a new department for technical and user documentation development, significantly raising the company's standards for reference materials.
- Implemented in-house marketing communication function using state of the art computer, color printer and optical scanner technology.

- Created and implemented an online Customer Equipment and Information System for the entire installed base, account by account; this system is accessible by the in house sales force and worldwide service organization via CD ROM and hand-held dos based terminal for use inside class 10 cleanrooms.
- Instituted company wide TQM (Total Quality Management) program modeled on the Crosby method.
- Instituted ISO 9002 training and organization program.
- Responsible for the direction and management of the firm's Quality Assurance and Control functions.

09/89 to 01/93 **<u>President – TAMAR Corporation, Richardson, Texas</u>:**

TAMAR Corporation is the successor corporation to Omnidata Corp organized in October 1989 having purchased Omnidata in November 1991. TAMAR Corporation designed and manufactured 902-928 MHz spread spectrum RF data acquisition and communication devices used by electric, gas and water utility companies to remotely read utility meters and, consumer oriented energy management devices meant to reduce residential utility bills through energy conservation.

- Conceived and incorporated TAMAR Corporation
- Wrote and implemented company business plan.
- Recruited and installed firm's Board of Directors.
- Developed TAMAR's initial product consisting of 902-928 MHz spread spectrum RF remote data telemetry devices used by utility companies to remotely read electric, gas and water utility meters.
- Hired management team including Chief Financial Officer, V.P. Engineering, Director of Operations, VP Sales & Marketing, Etc.
- Designed initial sales and marketing strategies and program; managed production of company newsletter, trade show displays, booth, and all collateral materials; i.e., spec sheets, brochures, etc.
- Sold the firm's first major system three months after introduction to a major U.S. investor owned electrical utility, Texas Utilities, Dallas, Texas.
- Authored several articles and conference papers for various industry magazine publications and conferences.
- Presented numerous seminars and multi-media presentations for key industry conferences and trade shows.

<u>Omnidata</u>: Omnidata Corp. was the predecessor company to Tamar Corporation and specialized in utility industry information publications and engineering consulting services. The firm was capitalized through $45,000.00 in loans from Datamatic, Inc. (former employer) and personal savings.

- Company exceeded $110,000 in first year revenues from sales of its' technical publications, consulting, and software product.
- Designed, developed and managed the firm's SAMREIM PC product. SAMREIM is an economic impact modeling CASE tool used by electrical, gas and water utilities to cost

justify automation systems. The product became an industry standard and benchmark and was funded by Ameritech Service Inc., the Midwest Regional Bell Telephone Operating Company.

- Conceived, wrote and published a definitive market research report entitled *"The Electrical Utility AMR Industry Outlook Survey"*. The report sold for $975 and customers included Motorola Inc., General Electric, Panasonic, Osaki, and Ameritech Services.
- Conceived, published, and co-author of "The Complete Handbook of AMR", a 600+ page technical handbook on the operation and applications of remote data telemetry for utility company meter reading. Over 150 copies sold; the publication sold for $795. Customers included AT&T, Motorola, G.E., Westinghouse (now AB&B), and major electric, gas and water utilities, worldwide.
- Responsible for marketing and sales of all Omnidata products.
- Provided business, marketing and technical engineering consulting services to several high technology companies. Services ranged from software product engineering, design and development to total company business plans and financial documents including an industry consortium prospectus resulting in the infusion of several million dollars of R&D capital, to company situational analysis (detailed analysis of company's condition, culture, employee morale and competitive posture) and turn-around plan. Clients included Ameritech, American Innovations, and Hexagram, Inc.

10/86 to 08/89 **V.P., General Manager & COO, Datamatic Inc., Richardson, Texas:**

Datamatic Inc. was a $10 million per year (FY89) supplier of remote data telemetry systems used by the utility industry. The company was highly profitable, over ten years old, supported a maximum staff of approximately 100 and was privately held. The General Manager held full P&L responsibilities and was responsible for all functional departments including CFO, V.P. Marketing, V.P. Sales, V.P. Engineering, and Customer Support. Reported to firm's CEO and Board Chairman.

- Joined firm as consultant and assistant to firm's CEO. Promoted to V.P. Marketing and Business Development
- Promoted to V.P. Advanced Technology Division
- Promoted to Chief Operating Officer and General Manager
- Responsible for firm's acquisition of the Databeam Co., Hartford, CT.
- Designed, implemented, and managed the Datamatic turn-around plan and wrote company business plan resulting in an internal LBO and a $5 million cash recapitalization.
- Recruited key personnel including V.P. of Sales/marketing, V.P. Operations and Director of Customer Support. Personally interviewed and hired over 50 employees including engineers, marketing specialists, secretaries, customer services reps, controller, etc.
- Successfully managed the completion and timely installation of over $6 million in software development and system integration contracts during period of high stress and employee turnover resulting from the CEO's purchase of Datamatic's co-founder's position and holdings.

01/85 to 08/86 **V.P., General Manager, White River Technologies/ETEC, Dallas, Texas:**

Manufacturer and distributor of process control equipment for use by utilities in pollution control; i.e., electrostatic precipitators, scrubbers. The company also operated a consumer electronics division.

- Recruited by bank holding company to turn around White River Technologies.
- Responsible for the product development, design, production, and introduction of several micro-processor based process control and data telemetry products.
- Responsible for the firm's acquisition of the pollution control division of Allen Bradley/Rockwell International. Relocated engineering and manufacturing of product line to Dallas facility from Milwaukee, Wisconsin.
- Organized, staffed and managed marketing and sales department.
- Guided company through negative cash flow product R&D phase to positive cash flow, revenue-producing phase.
- Organized company's consumer products division and served as its President.

A ruling by the United States Federal Regulatory Agency overseeing Savings and Loan institutions forced the S&L to divest itself of the business in 1986.

05/81 to 12/84 **President, Texcon Corporation, Phoenix, Arizona:**

- Company founder.
- Conceived of, invented and developed the Allegro Mentor piano teaching system.
- Managed staff of four professional hardware and software engineers.
- Guided company from conception through product engineering and into production.
- Hired and managed staff of professional educators and pedagogists in the preparation of course material.
- Sold interest in firm due to strategic disagreements involving the integrity of the teaching methods and marketing strategies. Company ultimately acquired by Baldwin International, Piano Division, Cincinnati, Ohio.
- CBS and NBC local television news coverage VHS videotape available upon request.

09/80 to 04/81 **Codex Division, Motorola, Inc., Phoenix, Arizona:**

- Developed various automated test and engineering strategies to support volume production of Motorola micro-controller based terminals obtained from the Motorola Microsystems business and reposition product as a commercially viable office computing product line.

The operation was discontinued and liquidated by Motorola due to heavy competition from emerging first generation PC companies and Apple.

03/75 to 08/80 **Founder and President, Mizar Inc., Phoenix, Arizona:**

- Developed firm's line of Compu-Serve discotheque and entertainment computer controlled lighting systems.
- Manufactured, distributed and supported nationwide sales and service of the firm's products.

- Negotiated $450,000 OEM contract for the production of light controllers sold by the entertainment products division of National Auto Sound (NAS), Kansas City, Missouri.

Sold company to Omnicomp, Phoenix, Arizona after a downturn in NAS business.

08/76 to 02/77 **<u>Honeywell Commercial Building Control Systems, San Francisco, California</u>:**

- Joined the branch division to develop sales of CCTV, sound and communications systems in the San Francisco Bay area.

In April, a mutual decision was made by the branch manager not to deviate from Honeywell's core competency of Heating Ventilation and Air Conditioning control systems and commercial security and fire alarm systems.

06/73 to 07-77 **<u>Nelson Hershfield Electronics, Phoenix, Arizona</u>:**

- Managed field service and customer support of the firm's sound, communications, and closed circuit television product line.
- Project manager for the U.S. Postal Service bulk mail center installations of process control related CCTV and advanced switching systems at twenty-one bulk mail centers around the country. Served as liaison between the U. S. Corps of Army Engineers, U. S. Postal Service, Bentley Engineers, and SOM, the principal architectural and engineering firms for the bulk mail centers.
- Managed the firm's acquisition of the space and technology division of the Packard Bell Corporation, New Berry Park, California. Integrated the production of Packard Bell's line of closed circuit and studio television cameras and switching equipment acquired in the acquisition into Nelson Hershfield's internal production facility.
- Managed various government contracts and projects including Scott Air Force Base Mac Headquarters, Tinker Air Force Base, Luke Air Force Base, Litchfield Park Air Force Base, Fort Riley, Federal Aviation Administration, Secret Service, Washington D. C., Federal Bureau of Investigation, Washington D. C., and the CIA, Washington, D. C. Held Federal "Secret" clearance 1974-1977.
- Conceived of, developed, and sold a new generation of pilot briefing information systems to various FAA Flight Service Stations across the country to replace the old teletype terminals used to provide civil and commercial aviation pilots with weather condition information.

Education: Northern Arizona University, Flagstaff, Arizona. September 1971 to May 1973. Bachelor of Science program. Physics major, chemistry and applied math minor. Did not complete the program due to full time pursuit of employment opportunity initially taken as a summer job at Nelson Hershfield Electronics.

Family Status: Married, April, 1981. Twenty year old son at home.

Articles & Publications:

Tamarkin (Thorpe), Tom, *Corporate Growth Through an Employee Entrepreneurship Development Program*, KTRON, 1982, Scottsdale Arizona, 90 pages.

Tamarkin, Tom & Starkey, Gene, *The Complete Handbook of Automatic Meter Reading*, 1999, Techno-Pub Ltd., Boulder, Co., Five Volumes, 650 pages.

Tamarkin, Tom, *Electrical Utility AMR Industry Outlook Survey*, 1999, Techno-Pub Ltd., Boulder, Co., Four volumes, 350 pages. First AMR industry outlook report preceding *The Scott Report*, *Chartwell*, et al.

Tamarkin, Tom, *Understanding Utility Automatic Meter Reading*, Proceedings of the Automatic Meter Reading Association, 1992, Hackensack, New Jersey, 22 pages.

Tamarkin, Tom, *Automatic Meter Reading*, Public Power Magazine, American Public Power Authority, October-November, 1992, Washington D. C.

Tamarkin, Tom, *Software for Automatic Meter Reading Economic Impact Modeling*, SAMREIM Partners, Ltd., 1991, Dallas Texas. DOS based AMR Return On Investment analysis computer program for Electric, Gas and Water Utilities. Underwritten by AMERITECH (Bell Tel Company), Chicago, IL.

Tamarkin, Tom, The Convergence of Technology and Market Needs; *The Benefits of Combining AMR, Energy Management, Utility Remote Account Access and Information Distribution*, Energy Pulse Magazine, Aurora, Co., July 12, 2005.

Tamarkin, Tom, *Thorpe to Tamarkin; a Commitment to Judaism*, The Jewish Voice, Jewish Federation of the Sacramento Region, October 2000, full-page article, page 17.

Arizona Republic Newspaper, Phoenix, Arizona, December, 1984, Allegro Mentor Invention

Arizona Republic Newspaper, Phoenix Arizona, April 1994, interview and photo with Clark Suttle, associate conductor, Phoenix Symphony Orchestra reference dinner party at Tamarkin's home.

Sacramento Business Journal, Sacramento, California, March 15, 2002, Measuring Vision: Company battles the giants of high-tech metering.

Television Interviews:

KOOL, Channel 10, CBS, Phoenix Arizona, Sunday Evening News, January 1, 1984, Interview, Allegro Mentor Invention.

KTAR, Channel 12, NBC, Phoenix Arizona, Tuesday Nightly News, May 8, 1984, Interview, Allegro Mentor Invention.

KCRA, Channel 3, NBC, Sacramento, California, "Power Watch", June 14, 2001, Tom Sullivan Moderator, Q&As by Tom Tamarkin and panel.

Q5. What industry associations do you have a leadership position in if any?

A5. I am the Chairman of the Advanced Metering Committee of the National Energy Marketers Association (NEM) and Co-Chairman of the Demand Response Committee of NEM.

Q6. What is the purpose of your testimony and have you been paid by any third party or otherwise compensated for the preparation of your testimony?

A6. The purpose of my testimony is to provide the California Public Utilities Commission and other relevant state agencies and parties who will review this testimony with information which I believe is in the best interest of the citizens of the State of California. This testimony, although more detailed, generally tracks that of written and oral testimony I provided the State of Idaho Public Utility Commission on the same subject matter hereof two years ago. I have not been paid, compensated or otherwise encouraged by any third party to take the time and expense associated with the preparation and filling of this testimony and do so simply as an obligation to the State in view of my background and knowledge in this field.

The foregoing was written and prepared in its entirety by Tom D. Tamarkin and I hereby attest that this document represents the professional judgements of the undersigned and is true and correct to the best of the my knowledge and belief as of the date indicated below.

____

Tom D. Tamarkin August 22, 2005

CA State Notary of Public ____________________________________

Exhibit "A"
Tamarkin Testimony
CPUC Rulemaking No. 02-06-001

Deputy Secretary of the Treasury, and
Assistant to the President for Economic Policy
Dr. Lawrence B. Lindsey
Letter dated July 9, 2002

THE WHITE HOUSE

WASHINGTON

July 9, 2002

Mr. Hugh Roy Marshall
Director, USCL Corporation
146 South D Street
Virginia City, Nevada 89440-0890

Dear Mr. Marshall:

The president asked me to respond to your letter to him providing information about technologies to promote energy conservation. As you know, the president believes energy conservation and efficiency are essential components of a balanced and comprehensive energy plan.

Metering technologies like those you sent with your letter to the President will enable consumers to see their energy costs more directly and will thereby encourage energy and budgetary savings by promoting demand responses.

Again, thank you for taking the time to write and to send the President the information on (USCL) metering technologies. These technologies will contribute to our Nation's crucial need to conserve energy and consumer's need to economize on energy expenses.

Sincerely,

Larry Lindsey

Lawrence B. Lindsey
Assistant to the President for Economic Policy

Exhibit "B"
Tamarkin Testimony
CPUC Rulemaking No. 02-06-001

WG-3 Information Display Pilot Update

SPP Information Display Pilot Update

Working Group 3

July 28, 2004

SOUTHERN CALIFORNIA EDISON

An *EDISON INTERNATIONAL* Company

Project Overview

- Scope of work was finalized in mid-July and conformed scope submitted
- Purchase order finalized last week
- Extra scope items included additional cross-utility focus groups on enabling technology. More quantitative research
- Weekly conf. calls, all teams engaged

SOUTHERN CALIFORNIA EDISON
An *EDISON INTERNATIONAL* Company

Recent Activities

- Load and customer data are being collected from IOUs
- Most action items have been dealt with
- Significant decision to synchronize treatment periods with customer billing cycle in August (accelerated)
- Numerous events in July have established significant SPP baseline
- Planning on "going live" on August 2

SOUTHERN CALIFORNIA EDISON
An *EDISON INTERNATIONAL* Company

Project Tasks

- Conduct Project Initiation Meeting
- Develop Research Plan to Produce Research Deliverables
- Perform Technology Assessment
- Develop survey design approach about what forms of info treatment customers want/ will use/ will pay for
- Deploy the information treatments and install the technologies on existing SPP participant homes/ meters

SOUTHERN CALIFORNIA EDISON
An *EDISON INTERNATIONAL* Company

Project tasks

- Review data collected from consumption of participants and estimate load impact changes in any versus a control group after 3 to 4 months
- Prepare Draft and Final Study Reports
- Project Documentation and Databases
- Project Management
- Deliver presentation(s) to SPP stakeholder meetings

SOUTHERN CALIFORNIA EDISON
An EDISON INTERNATIONAL Company

Task Schedule

Task	June	July	August	September	October	November	December
Task 1							
Task 2							
Task 3							
Task 4							
Task 5							
Task 6							
Task 7							
Task 8							
Task 9							
Task 10							

Information Treatments

- Nexus has significantly developed interactive tool for customer information
- Push technology includes e-mail and on-line analysis of SPP usage performance
- Bill analysis tool in progress, with interactive recommendations
- Enhanced information (humanizing the bill) approach with subscriber approach

SOUTHERN CALIFORNIA
EDISON
An *EDISON INTERNATIONAL* Company

Enhanced Information Approaches

- Value-added communications via web, e-mail and contract describe benefits, encourage enrollments
- Support tools to explain past, suggest future strategies for CPP-V customers
- Customer-controlled software to read rates on Internet, with future potential to possible control loads via Internet

SOUTHERN CALIFORNIA EDISON
An EDISON INTERNATIONAL Company

Subscriber-Based Info

- Integrated electronic newsletters for critical peak pricing will:
  - Provide estimated cost of super peak by appliance for the last month
  - Benchmark on last months bill in relation to the norms provided by customer
  - Provide strategies for controlling next months energy costs and bill

SOUTHERN CALIFORNIA EDISON

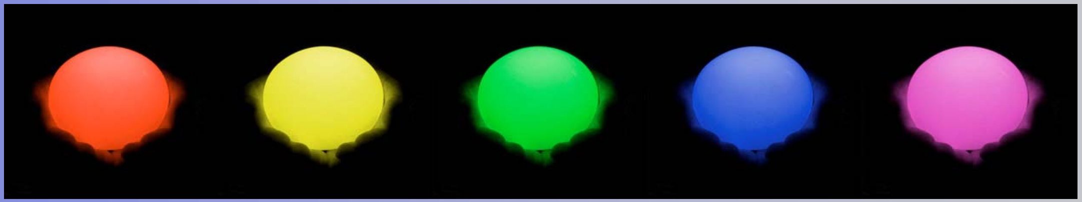
An *EDISON INTERNATIONAL* Company

Technology Assessment

- Primen is reviewing technology treatments in preparation of customer assessment of technology and overall white paper
- To date, no significant compatible systems available for IDP deployment
- Expanded quantitative assessment will focus on customer preferences for technology
- Deployment of price signaling devices in progress with SCE

Price signaling device

- Using “orb” from Ambient Devices
- Provides an alternative and non-intrusive information display system for price
- Displays all prices for CPP-V schedule
  - Off –peak (blue)
  - On-peak (green)
  - Warning for super peak (flashing red)
  - Super peak (solid red)



SOUTHERN CALIFORNIA EDISON
An *EDISON INTERNATIONAL* Company

Friendly and Unobtrusive

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Customer Assessment

- Opinion Dynamics is deploying telephone survey to assess customer awareness and understanding of feedback technology, their usefulness, willingness to pay, and likelihood of adoption
- Pretreatment assessment of IDP sample, as well as comparison to control groups
- 18 surveys completed out of 65 as of 7/26

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Orb Testing at SCE

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Weeding out the “bad orbs”

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Orb Programming

Exhibit "C"

Tamarkin Testimony

CPUC Rulemaking No. 02-06-001

California Information Display Pilot Technology Assessment primen

Final Report

California Information Display Pilot Technology Assessment

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Executive Summary

Mass-market electricity customers' behavior accounts for one-quarter to one-third of home energy use. Research over the past two decades has documented that useful feedback can result in reductions in energy use of 4 to 15 percent. Moreover, feedback is more useful when it is immediate and easily accessible rather than antecedent; e.g., provided with the monthly bill). Even monthly information, though, is useful, especially if the customers previously hadn't received any feedback other than the amount owed for the utility bill. But for dynamic electricity pricing, timely feedback is essential.

As part of the Information Display Pilot (IDP), Primen investigated devices for displaying dynamic pricing signals and immediate energy use and cost information. We assumed that the residential and small commercial customers participating in the IDP were, like most customers, not particularly focused on energy use or inclined to actively seek out feedback on energy use and costs. We researched energy use display devices but did not find any that were compatible with existing IDP customers' meters, could also display the energy cost information with the CPP-V rate, and were commercially available for deployment in July 2004.

As a result of this initial assessment, we decided to use a non traditional but commercial viable approach to meet the research goals of the project. To convey the CPP pricing signals and critical peak periods, we deployed an "Energy Orb," a small, grapefruit-sized glass globe that glows different colors. We programmed the orb to change colors when prices changed. The color would depend on whether the current electricity price was low (off-peak), medium (on-peak) or high (critical peak). The orb also flashed to give notice that a critical peak was imminent. Customers—especially those who felt they could take actions in response to price signals—liked the orb and found it useful.

Primen also completed a detailed examination of energy and pricing display devices as part of the IDP research objectives. We found numerous meter display devices that work independently of the existing IOU meter. Depending on the model, the units display some combination of instantaneous and cumulative energy use and cost. Some can also estimate monthly bills. Many models include alarms that emit sound or light when energy use or cost exceeds pre-set limits. Some of the displays are hard-wired to the CT (current transducer) and therefore are located near the circuit panel. Others use wireless or powerline communication, allowing the display device to be located anywhere in the home or business.

Many of these devices available today can show instantaneous electricity use, but none accurately reflect electricity costs under a critical peak pricing- variable period (CPP-V) tariff. This is because they don't have built-in network communications and therefore cannot indicate when the critical peak price is in effect. Most of them are designed to work with a flat rate, and there are some models that can be programmed for fixed time-of-use or demand rates.

Another category of metering display devices requires changing out the meter or installing a submeter. Some of these electronic meters can communicate data wirelessly or over the powerline to display devices. Prepayment meters already provide in-home information on current spend rate and number of hours/days left. Meters currently in development can provide instantaneous, daily, and month-to-date use and cost. Many existing electrical meters can be programmed for time-of-use (TOU) or demand rates. Unless the metering system has some kind of communications with the utility, though, the display device will not be able to accurately reflect energy costs during critical peak times. These systems would need to be compatible with an Automated Meter Reading (AMR) system to receive daily price signals, or without AMR could incorporate a paging receiver.

Most of the traditional metering and specialty meter device providers we interviewed indicated that adding communications to show instantaneous energy use and cost under a CPP tariff was not a technical challenge. The devices do not include communications because vendors have been trying to keep the costs down for traditional applications. Although the providers haven't looked into the issue extensively, one-way paging or utilizing existing IOU network communications was often mentioned as a relatively inexpensive way to receive a signal of critical peak in the absence of AMR. If needed, vendors think that the communications functionality necessary to support a CPP rate could be incorporated fairly easily into the existing metering designs, with devices available within 6 to 9 months of an order.

Background

The California Statewide Pricing Pilot (SPP) is a demand response scientific experiment designed to test the effectiveness of three experimental dynamic pricing tariffs – time of use (TOU), critical peak pricing, fixed period (CPP-F), and critical peak pricing, variable period (CPP-V). The tariffs have fixed prices that vary according to the time of day for the TOU customers, and during special peak pricing events for the CPP customers. CPP customers receive a telephone notification either a day ahead or four hours prior to a critical peak pricing event, during which the price of electricity is significantly higher than their normal TOU daytime rate.

In this report, “customers” refers to residential and small commercial (<200 kW peak demand) customers.

Information available to the participants in the SPP is provided by the utilities sponsoring the project, and includes:

- A customer “welcome package” that explains the program
- Monthly billing statements that are delivered by mail
- A bi-annual bill comparison, which compares the customer’s energy costs on their current dynamic rate to a “what if” scenario based on their original rate
- Next-day access to their daily usage via the Internet

Customer responsiveness to the tariffs in the SPP is being measured through participant surveys and electrical usage, and an index of their “elasticity” to the pricing schedules is being calculated using econometric models. After preliminary results were analyzed in 2003, the SPP advisory committee believed that additional direct feedback and dynamic tools could possibly enhance the customer benefits and improve the effectiveness of the tariffs.

As a result, a special additional experiment called the Information Display Pilot (IDP) was designed and implemented with a subset of customers on the CPP-V rates to test whether giving these customers better information about energy prices and enhanced feedback about their energy use would result in greater reduction during critical peak periods.

Specifically, the IDP was set up to investigate five sets of research questions. This report addresses two of them.

- What is the potential for real-time feedback and/or detailed consumption analysis beyond what the Joint Utilities are offering in the SPP and within the schedule for the SPP timeline for significant analysis?

- What types of enhanced feedback information technologies are currently available for dynamic pricing? What types of information feedback tools are available to customers and what are their costs?

To answer these questions, Primen identified and reviewed relevant information technology and information treatments that could be used in the IDP program. We also reviewed the literature and conducted interviews with vendors and consultants to assess technology design trends, and find previous studies about information treatments and their effectiveness in modifying customer behavior and electrical usage.

What is the Potential for Real-Time Energy Feedback?

The concept and application of giving customers real-time feedback on how much energy they're using in order to get them to modify their behavior is not new. By real-time, we mean instantaneous feedback that customers can see and understand. It might be displayed on a meter or other device in the home or business. It is not defined as logging on to a website to see interval data updated daily. Researchers have studied the effects of both direct and indirect feedback for energy conservation for years, and have asked the vendors of electrical metering devices to provide feedback displays in some manner for almost as long.

This section of the report details the technical potential for reduction in energy use resulting from real-time feedback devices. It is important to note that most of the studies relate to reductions in energy use for customers of flat rates. The effect of feedback on residential and small-commercial customers who are on dynamic rates does not appear in the literature.

Feedback serves two purposes: 1) it fills a knowledge gap; and/or 2) it can be used to motivate behavior, guiding goal attainment. Based on the research studies noted below, feedback to customers on energy use can result in reductions in consumption from 4 to 15 percent.

Feedback appears to be most useful when accompanied by a specific goal, such as reducing energy use by 10 percent:

- An experiment in the Netherlands involved giving 50 households in-home displays of gas use (called the Indicator). The Indicator corrected for degree-days so residents could tell weather-related effects apart from behavior-related effects. Residents had a goal of 10 percent energy use reduction. With the Indicator, they reduced natural gas use by over 12 percent. (Van Houwelingen and Van Raaij, 1989).

The habits of home residents greatly affect overall energy use:

- 33% of home energy use in US is attributable to residents' behavior (Sonderegger, 1978)
- 26% of home energy use in Netherlands is attributable to residents' behavior (Verhallen et at, 1981)

Even providing monthly feedback results in reduced energy use:

- In a study of 105 district-heated homes in Finland, energy consumption for space heating decreased 3 – 9 %after customers received monthly feedback. Electricity consumption decreased 17 – 21%. (Haakana et al, 1997).
- In a survey for Energy Star Billing, Delaware residents were asked what they would do if they received an Energy Star Billing graph showing high usage. 44% of respondents indicated they would make some changes, such as turning off lights or using the dryer less (Bengtson, 1997).

The time between the behavior and the feedback on the resulting energy use and cost (action and consequence) is very important.

- The sooner the feedback is delivered, the more effective it is (Seligman et al, 1977).
- Daily feedback has an impact on heating and cooling. Continuous feedback affects other energy uses (McClelland and Cook, 1979).

It is worth noting that in the late 1970s, when energy conservation research was just developing, electronic meters, programmable thermostats, and other tools for providing or responding to feedback weren't widely available. Customers relied more on educational tips and estimates of savings related to specific actions to guide them for the right actions to take. Their belief in that they had taken the "right" action was an immediate self-reinforcement, even in situations when the electric bill did not change a month later.

In-home displays can give customers access to energy use and cost information in real-time. This is important because the customers can actually see the costs of using various equipment or appliances in the home. They can see high costs (or projected high costs) and make changes in their behavior, rather than seeing an end-of-month high bill, making some changes, and then waiting for the next bill. This ability to do something different as soon as possible to avoid a high bill is especially important with dynamic pricing.

- A study of in-home displays in Canada found savings of 4-5% (Hutton et al, 1986)
- Customers refer to in-home displays less frequently after the first few months (Hutton et al., 1986)
- Nonetheless, savings do not necessarily persist after the devices are removed (Hutton et al., 1986)
- A study of 44 UK households found that giving customers in-home displays for cooking energy only resulted in average reductions of 15%. Giving them only antecedent information reduced consumption by 3%. (Wood et al., 2003)
- In Norway, customers with feedback reduced energy use by about 9% (Notes from Ofgem seminar, 2004).

- Northern Ireland Electricity has keypad meters (prepayment) installed for about 20% (125,000) of their customers. With training, customers reduced consumption by 11 percent. Customers who received keypad meters without instruction still reduced consumption by 4 percent (Graeme Hunter, NIE presentation, undated and personal communication 10/26/04).

When applying these results to present-day California and the SPP, it is important to make note of circumstances that may have changed since the research was performed. First, most of these studies were conducted with customers on flat, or non-dynamic, rates. There is little experience of providing customers with feedback on their consumption on dynamic pricing. The potential lack of motivations for quick feedback and response, as well as the lack of a dynamic price signal, can affect the transferability of these studies to the current research.

Second, expectations about the availability and frequency of information are vastly different now that in the 1970s and 80s, when much of this research was conducted. Information flows have changed dramatically since that time. The Internet, widespread wireless communications, cell phones, and paging are all commonplace now, but were not available then. Thus, we hypothesize that customers would both want and expect better information about energy use. Likewise, technologies that can automatically reduce or shift energy use are much more common now than they were 25 years ago.

We cannot say definitively how these two changes have affected customer desire for and ability to respond to energy use feedback, but speculate they would make the effects of feedback for an “information hungry” customer even more pronounced.

Kinds of Energy Information Feedback Tools

Primen focused on communication of two types of energy information: energy prices and energy use. For the SPP program (and specifically the CPP-V rate), the time-of-use prices are known in advance, although when the highest price will occur (the Super Peak Period) is not. The prices are fixed for customers on the CPP-V rate. Energy use, of course, varies depending on the behavior of the occupants and the appliances and end uses. The actual resulting cost of the energy being used depends on both usage and the price. We consider energy cost in the same category as energy use, since it is unique to each customer.

In our research, we looked for technologies that:

- Met minimum criteria for IDP deployment and were not redundant with existing utility information treatments or programs
- Were affordable to deploy and had the potential for wide-scale deployment

- Were compatible with existing metering and communications systems at SPP customer sites.

Specifically, information feedback devices needed to be able to show energy cost throughout the day, including critical peak periods, which are dispatched with as little as four hours' notice. The existing billing meters collected 15-minute interval data and sent it to the utility once a day. They were not designed to allow the customer access to the data throughout the day.

Energy Prices

We first looked at ways to communicate the price signal to the IDP participants throughout the day. The basic off-peak and on-peak structure is simple (on-peak Monday-Friday from 12-6 pm for commercial customers and 2-7 pm for residential customers and off-peak at all other times). Critical peak periods can occur 15 times a year during the on-peak period and last either 2 or 5 hours. The customer is notified four hours before the critical peak time is to start. Current SPP participants receive a "welcome package" that lists the pricings and time periods, and gives examples of what could be done to reduce costs. There is also a refrigerator magnet with the on-peak time period indicated that is distributed for general awareness.

Although the price structure is not terribly complex, paying attention to prices is new, so we looked for a technology that would remind customers of prices. Since there are only three prices (off-peak, peak, and super-peak) in the CPP-V structure, we felt it was not necessary to convey exact prices to raise customer awareness. Instead, we looked for technologies that could convey the notification of the timing of these three different prices levels relatively simply and easily.

Energy Orbs

We found an existing technology that had the potential to notify energy prices in a clear, appealing, and unusual way. Originally designed as an entertainment device to indicate the status of the stock market, that technology is the Energy Orb, a glass globe that glows different colors in response to a wireless paging signal. (See **Figure 1**.) We purchased the original stock orbs, reprogrammed the paging system that communicates with the orbs to indicate the prices of the CPP-V rate, and installed them in customers' homes and businesses. Many customers liked the Energy Orbs, and found them interesting and engaging. The IDP customer and non-participant reaction to Energy Orbs is included in the IDP Evaluation Report.[1]

[1] "Information Display Pilot: California Statewide Pilot," submitted by Nexus Energy Software, Opinion Dynamics Corporation, and Primen to the California Energy Commission. Draft final report dated December 18, 2004.

Figure 1: Energy Orb

This Energy Orb is installed at Beanscene Espresso in Los Angeles.

Source: Geltz Communications

How Energy Orbs Work

The Energy Orb is actually an off-the-shelf consumer electronics technology from Ambient Devices. They sell the orb (called the Stock Orb) to indicate the Stock Market status by communicating to the orb to change colors. Inside the globe is a wireless paging receiver and colored LEDs (light emitting diodes). The orb is programmed to "listen" to this specific set of radio signals and the only installation required is plugging the orb into a wall outlet for power.

As an option, owners of the orb can log into a website and subscribe to other indexes (weather, Homeland Security) or can reprogram their orb to receive customized commands. Primen utilized this customized channel programming to convert the Stock Orb into an Energy Orb for the purposes of the IDP.

Energy Orb Colors

We programmed the radio-paging server to send a signal to operate the Orbs to show the status of the CPP-V energy prices, and to notify the customers when critical peak was imminent:

Blue: off-peak (mornings, evenings and weekends/holidays)

Green: peak (weekday afternoons only)

Red: super peak (during test events and system emergencies)

Flashing red: warning of imminent super peak, beginning four hours before super peak events.

We had originally planned to use the intuitive green/yellow/red color scheme (traffic signal protocol) for the off-peak/peak/super peak prices. However, we found the yellow color from the LEDs in the Energy Orb to be pale and difficult to distinguish from green (yellow is made by lighting both green and red LEDs), so we used the blue/green/red combination.

Calm Technology

Why was initial customer response to the Energy Orbs so positive? Customers didn't have to stop what they're doing and go to a website or peruse a list of numbers to understand electricity prices. The intuitive, unobtrusive, easily accessible display of information is known as "calm technology." Calm technology, which would both encalm and inform, was the vision of Mark Weiser and John Seely Brown of Xerox PARC.[2]

The premise of Calm Technology is that people can take in information at the periphery, as effectively as maintaining direct focus. For example, when driving, the car engine makes noise, but we scarcely hear it. Instead, we are tuned in to the conversation, our thoughts, or music from the radio. As soon as that engine noise changes, though, we're instantly aware, and shift our attention to focus on it. This shifting of attention back and forth between periphery and central focus is the hallmark of calm technology.

This concept appeals today to many people who feel "on" all the time. Although people can be connected to direct stimuli (radio, TV, cell phone, pager, etc.), they can also receive and process information on the periphery. The current "overload of information" provides new appreciation for the utilization of peripheral notification.

Interestingly, Calm Technology is similar to the information displays of 50 years ago or more, when there was little connectivity and people relied on easily viewed visual symbols. A childhood icon comes to mind: the Weather Ball. The Weather Ball perched on top of the Northwestern Bank Building in Minneapolis. It was installed in 1949, and remained there until 1982 when the building burned. Want to know the weather in Minneapolis?[3] No need to find a radio and wait for the top of the hour. Just look. Residents all knew the jingle:

> *When the Weatherball is red, warmer weather is ahead.*
>
> *When the Weatherball is green, no change in weather is foreseen.*
>
> *When the Weatherball is white, colder weather is in sight.*
>
> *If colors blink by night or day, precipitation's on the way.*

Fifty-five years later, the Energy Orb technology communicates price information in a very similar display. Indeed, one of the available commercial channels for the Orb shows current temperature and the Ambient Beacon (a cube version of the Orb) shows forecasts by color. Everything old is new again.

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[2] See Weiser, Mark and John Seely Brown, "Designing Calm Technology," Xerox PARC (December 21, 1995) http://www.ubiq.com/weiser/calmtech.calmtech.htm and Weiser, Mark and John Seely Brown "The Coming Age of Calm Technology," Xerox PARC (October 5, 1996) http://www.ubiq.com/hypertext/weiser/acmfuture2endnote.htm.

[3] See Weiser, Mark and John Seely Brown, "Designing Calm Technology," Xerox PARC (December 21, 1995) http://www.ubiq.com/weiser/calmtech.calmtech.htm and Weiser, Mark and John Seely Brown "The Coming Age of Calm Technology," Xerox PARC (October 5, 1996) http://www.ubiq.com/hypertext/weiser/acmfuture2endnote.htm.

Other Ways to Display Price Signals

Several other devices can be used to display price signals, ranging from stoplights to plug-in LED indicators. We did not install any other price display devices other than the Energy Orb. We did test one other, the Comverge Customer Alert Device (CAD), in focus groups. The CAD is a four-inch square radio-paging receiver that plugs into a wall outlet and has three small LEDs in three colors (red, green, and yellow) on the faceplate. It looks much like a plug-in smoke detector, and even has an audible tone that can be programmed to beep or chirp in conjunction with the lights.

There are numerous other price notification displays, but they tend to be incorporated in either a unique pilot program technology, beta prototype designs, or as part of energy pre-payment or pay-as-you-go metering system. We did not find others that were available in summer 2004 and that could display energy costs incurred through time-varying rates. Although some in-home metering displays exist in Europe (as part of the utility's TOU tariff) these were not available for use in California. Over the years of electricity pricing and behavior research, displays have ranged from the simplicity of a small light on an appliance to the more complex home automation systems that displayed daily prices in residences.

We present a few intriguing examples here of ways to display price signals, for information and possible future adaptation:

- Stoplight. PG&E put together a signal for pricing in the late 1980s. PG&E ran a dispatchable rate pilot for small commercial and industrial customers (SCIP-- Small Commercial and Industrial Program). Customers were on a flat rate. During certain times, PG&E would dispatch a critical rate, with a minimum of one hours' notice. Program Manager Bill LeBlanc used a stoplight to convey prices. The light was green most of the time for the standard flat rate. Yellow meant a critical peak was coming and red meant critical. LeBlanc used a novelty stoplight from a retail outlet (smaller and lighter than the real thing). It was triggered by a signal sent over the existing 154 MHz load control network.[4] Customers liked the stoplight and found it easy to respond to.

- Electricite de France (EDP) offers the Tempo rate. Days are designated blue (lowest price, 300 days), white (medium price, 43 days) or red (highest price, 22 days). Each day has fixed peak and off-peak hours. The day type is determined at the end of the day for the next day. EDF uses a simple notification box that plugs into any power socket to indicate the day's color and the current hourly cost.[5] In a pilot program with 800 customers, the average daily consumption was reduced by 15% on white days and 45% on red days. Participants shifted 30% more energy use from peak to off-peak times on white days as compared to blue days, and shifted even more on red days.

[4] Bill LeBlanc, personal communication (December 7, 2004), President, Boulder Energy Group, 907 Brooklawn Drive, Boulder, CO 80303. Tel: 303-668-2977. email billleblanc@comcast.net.
[5] "Results from the EFFLOCOM Pilots," EU/SAVE 132/2001, June 30, 2004. Available from http://www.efflocom.com (Report No. 7).

- Data fountains, developed by Netherlands artist Koerte, vary the height of water to convey information. (Think of the fountains at the Bellagio in Las Vegas, but set to data instead of music. See **Figure 2**.) One data fountain already built compares the exchange rates of the dollar, euro, and yen. (www.datafountain.com)

Figure 2: Data Fountain

Source: datafountain

- Laughing Lily is designed to facilitate meetings to run more smoothly. Frequently, either too many people talk at once, interrupting each other, or there is silence. The Laughing Lily is a flower that wilts when there is too much or too little noise. (Antifakos, 2003)
- Colored computer monitor. Apple has a patent for a computer monitor frame surrounded by LEDs embedded in clear plastic. The frame can change color depending, for example, on whether you have email from your boss or your spouse.

In-Home Displays of Energy Use/Cost

The second type of information to display is current energy use and cost. An in-home display of energy use or cost provides immediate and intuitive feedback. Turning on a light or an electric stove increases energy usage and causes the display to change significantly. The display system collects data from the meter or circuit panel, so it can register all energy use in the home or business. It is virtually impossible to get the displays to read zero. Indeed, with everything off, it is easy to see the amount of electricity consumed by electronics that are in the “off” position.

We did not install any of these types of displays during the IDP because:

1) There were no devices in the commercial market that were both suitable for installation within the IDP customer base and compatible with existing metering infrastructure.

2) The technologies that were available off-the-shelf in summer 2004 that worked with existing metering infrastructure could not display energy costs for the CPP-V rate structure. They all worked with a flat rate.

3) The expedited timeline required devices that were available and ready to install off-the-shelf.

The only device that claimed to be capable of showing energy costs associated with the CPP-V rate structure was the USCL EMS-2020. A demonstration was available by July 2004, but working models had not yet been installed. In addition, the EMS-2020 requires replacement of the electric meter, and installations were limited to those that could work with existing CPP customer metering.

Of the clip-on type devices, none could accommodate the CPP-V rate structure. Several of the manufacturers said they could add a clock and show costs for a TOU rate. Making that change would require an order of several thousand units and take 4-8 months, and even so would not be able to show costs during critical peak events. A few makers of the clip-on type devices were planning product launch for late 2004 or early 2005.

While there are several manufacturers of in-home displays, or products that could be modified to provide in-home displays, the expedited timeline for IDP deployment necessitated technologies that could be quickly and effectively deployed. It did not allow for modifications and the extra care that technologies new to market require. Given more time and with proper development, there are some potentially good energy display systems, but our schedule did not allow for standard testing. (See **Table 1**.)

Table 1: In-home Display Technologies

Technology	Company	Contact Info	Description	Typical Use	Status	Purchase Cost	Installation Cost
Cent-a-Meter	Island Power Pty Ltd. (Cenergies in US)	Colin Kelly Director/Business Development Island Power Pty Ltd (Whitesands Limited - Distribution Vehicle for USA operations) Email: colinkelly@smartchat.net.au Tel: 61 2 4963 1241 Kent E. Nelson President Cenergies Unlimited 9501 Cargo Avenue, Suite 100 Austin, Texas 78719 Tel: 512-215-4332 kentnelson@cenergies.com www.cenergies.com	▪ Clip-on technology ▪ Movable in-home display (wireless) ▪ Instantaneous $, kWh, temperature, humidity, greenhouse gas emissions	▪ Learn baseline and monitor ▪ Check unit before leaving house to make sure everything off ▪ See cost of running appliances	~ 9000 sold in Australia and New Zealand. US launch planned for early 2005.	~ $100-150	~ $75-200 (electrician or contractor)
EUM-2000	Energy Monitoring Technologies	Juan Gonzales President Energy Monitoring Technologies 7516 NW 55 Street Miami, FL 33166 Tel: (305) 470-9716 Email: jgonzalez@energymonitor.com http://www.energymonitor.com	▪ Clip-on technology ▪ Display hard-wired to panel ▪ Instantaneous $, kW; bill projected energy bill, alarm	▪ Learn baseline and monitor ▪ Monitor projected bill	~10,000 devices installed.	$225 (whole house) or $175 (apartment)	~ $75-200 (electrician or contractor)
The Energy Detective	Energy, Inc.	Dolph Rodenberg President P.O. Box 415 Mt. Pleasant, SC 29465 Tel 843-849-7008 info@theenergydetective.com www.theenergydetective.com	▪ Clip-on technology ▪ Movable display (powerline carrier) ▪ Instantaneous $, kW; day, month-to-date and projected monthly $ and kWh ▪ Voltage ▪ Alarms ▪ LEDs ▪ Programmable for various rate structures (TOU, fixed bill component, taxes, etc.)	▪ Learn baseline and monitor ▪ Check voltage ▪ Estimate bill ▪ Store data and download for additional analysis	Product launch planned for early 2005	~ $100-150	~ $75-200 (electrician or contractor)

Technology	Company	Contact Info	Description	Typical Use	Status	Purchase Cost	Installation Cost
			▪ Stores 2 months worth of hourly data, can be transferred to computer				
Greenwire Energy Monitor	Greenwire LLC	Mark Palasz President Greenwire LLC 907 Sweetwater River Drive Austin, TX 78748 Tel: 512-914-4931 Email: mark.palasz@greenwirellc.com	▪ Energy-use sensor installs outside of existing electric meter ▪ Display device communicates via wireless RF ▪ Displays last 24 hours' cost and use ▪ Displays instantaneous use (kW) in graphical form (bar chart or pace of blinking lights).	▪ Learn baseline and monitor ▪ Check unit before leaving house to make sure everything off ▪ See cost of running appliances	Product launch planned for 1Q 2005	~$50 target price	$0 (done by customer)
Power Cost Display Monitor	Energy Control Systems	Bill Littlehales CTO and Inventor Energy Control Systems P.O. Box 3360 Incline Village, NV 89450-3360 Tel: (775) 831-0727 Mob: (775) 771-3649 Email: wmlit@aol.com energycontrolsysinc.com	▪ Transmitter collar installs behind meter ▪ Display device communicates via powerline, can be located anywhere ▪ Displays cost only ▪ "Cost" shown is monthly cost if all loads currently on ran for entire month	▪ See cost of running appliances	A few devices installed	$380 in small quantities	Few minutes of utility electrician's time to pull meter, set transmitter, replace meter
kWh Meter	E-Mon (MeterSmart)	Frank Russell MeterSmart 2212 Arlington Downs Road, Suite 204 Arlington, TX 76011 Tel: (831) 801-7758 Email: frussell@huntpower.com www.metersmart.com www.emon.com	▪ Highly accurate submetering ▪ One-line display shows instantaneous energy use ▪ Does not display cost ▪ Also measures waveforms and other power quality variables	▪ Designed for submetering, not display ▪ View instantaneous use ▪ Can download data to computer for additional analysis	Proven technology, thousands of devices installed	~$300	$75-200
Customer Interface Display	Dent Instruments	Chris Dent President Dent Instruments 64 NW Franklin Avenue Bend, OR 97701-2906	▪ Display communicates with meter via powerline, can be located anywhere ▪ Install with meter replacement (Dent's PowerPal, based on	▪ Learn baseline and monitor ▪ See cost of running appliances	Piloting with Tacoma Power	~$300 for meter plus ~$250-280 for Customer Interface	Few minutes of utility electrician's time to replace meter

Technology	Company	Contact Info	Description	Typical Use	Status	Purchase Cost	Installation Cost
		Tel: (541) 388-4774 Email: cdent@DentInstruments.com www.DentInstruments.com	Sensus iCon) ▪ Display queries meter for energy use			Display	
PowerStat	DCSI	Mark Day DCSI 945 Hornet Drive Hazelwood, MO 63042 tel 314-895-6510 mday@twacs.com www.dcsi.com http://www.twacs.com/Support/2004%20Spec%20Sheets/PowerStat.pdf	▪ Prepayment meter and display ▪ In mid 1990s, field trial of in-home display with existing meter ▪ System not currently available ▪ DCSI has AMR, load control, prepayment and display capabilities	▪ Learn baseline and monitor ▪ See cost of running appliances ▪ Monthly bill projection ▪ Alarm if exceed budget or during peak times	Display without prepayment not currently available, though did pilot with PacifiCorp in mid 1990s	NA	NA
EMS-2020	UCSL	Tom Tamarkin President 2737 Eastern Avenue Sacramento, CA 95821 Tel: 916-482-2000 Email: tdtamarkin@usclcorp.com http://www.usclcorp.com	▪ Collects data from revenue meter ▪ Two-way communications, between utility and EMS-2020 provide ability to handle complex, dynamic rates ▪ Moveable in-home display (wireless) ▪ Displays instantaneous use (kW, kWh and $), day, month-to-day ▪ Calculates monthly budget ▪ Alarm when use exceeds preset use or budget ▪ Displays data for electric, gas and water ▪ Part of full AMR system with associated features (remote read, connect/disconnect) ▪ Matches utility bill exactly	▪ Learn baseline and monitor use ▪ See cost (burn rate) of running appliances ▪ Monthly bill projection ▪ Alarm if exceed budget or during peak times	360 currently being installed in Los Angeles County	Cost is dependent on scale. $250/home (for 400 units) includes meter and EMS-2020 Projected ~$175/home for 10,000 units RF network $10-30/meter	Few minutes of utility electrician's time to replace meter

In addition, there were technical challenges with incorporating display technologies with the existing systems used by the IDP customers. Some metering display systems, such as those used with prepayment, are packaged together with the meter. To install such a system would have meant replacing the CPP meter, which was necessary for the CPP billing and existing IOU web presentation of usage.

Technically, it is possible to install separate meters for the purpose of providing feedback to customers. Institutionally, though, that raises a few problems. First, there is the added expense of duplicate meters. Second, if the customer has two different sources of data, it is at some point likely that they won't agree exactly, and the utility may need to explain the discrepancy. For this very reason, one of the in-home display devices does not show a month-to-date energy cost, even though customers are very interested in that feature. The utility that helped develop the display intentionally omitted that function because they didn't want to have to explain why the display didn't match the bill.

By far the majority of in-home displays are made to show energy use and energy cost *if the customer is on a flat rate*. They can be somewhat easily adapted to account for a time-of-use rate. That would require adding a clock chip and programming in two different rates. However, showing accurate costs on a critical peak rate is more complex and requires that the display device be capable of two-way communications so it can receive either notification of critical peak or an actual price signal from the utility.

We group the various display technologies by means of data collection.

In-Home Displays that Work with Existing Metering

There are several meter and electronics manufacturers working on relatively simple in-home displays that collect consumption data by a clip-on current transformer (CT) at the electrical panel. Others work with the existing meter, either collecting data from an attachment to the outside of the meter, or via transmitter installed between the existing electric meter and the utility meter socket. The displays are fairly small and look reassuringly familiar to customers—much like a temperature display. They display a variety of use and cost metrics (typically current, daily, and month-to-date). They have only a few buttons and can be "easily" programmed by the customer, providing s/he knows the right combinations and sequences of buttons to press. (Similar to the programming complexity to the functions of a digital watch, including alarm and stopwatch functions.)

An in-home display is a quick and easy way for consumers to see what it's costing to actually run their appliances. If the devices offer cumulative readouts, the consumer can see what the electric bill to date is and even project the bill for the end of the month. These devices are relatively inexpensive and easy to install. Costs to purchase range from $100-250 (although some devices not yet to market are aiming for costs as low as $50). Because installation of clip-on CTs requires removal of the front of circuit breaker housing, an electrician is recommended, though perhaps not strictly necessary. One vendor recommends an electrician, another posts installation directions on their website. Estimated installation costs for clip-on technologies are $75-200.

Devices include: Cent-a-Meter, EUM-2000, The Energy Detective, Greenwire Energy Monitor, Power Cost Display Monitor, Customer Interface Display, PowerStat, EMS-2020 These companies are relatively small. None has experience delivering units in large volumes. Chief differences among these devices are location and communication mode between display unit and panel and the format for displaying cost information.

The main drawback of these devices is that they are set up to show energy costs for a single rate (average electricity cost), so cannot show the cost of running an appliance at a super-peak time as compared to an off-peak time. The manufacturers say they could relatively easily add a clock chip and accommodate a two-part TOU rate. However, they do not have communications, so cannot indicate costs during a critical peak period.

Some of the manufacturers (Energy Monitoring Technologies, The Energy Detective) measure voltage and current and correct for power factor. Others (Cent-a-Meter) measure current but have customer input voltage. Such devices do not measure reactive power accurately and also cannot account for voltage fluctuations. As long as the inaccuracy is consistent, it shouldn't present a problem to residential customers, who will be gauging relative energy use and reductions resulting from turning off appliances.

The following section describes specific brands of clip-on devices:

Cent-a-Meter (Island Power and Cenergies)

Description

The Cent-a-Meter is an in-home display device. It looks similar to a digital clock (see Figure 3). The user inputs an average electricity rate and the Cent-a-Meter shows current use (kWh) and cost ($). It does not totalize usage, so a cost-to-date for the month is not available. This feature was deliberatively omitted, as the utilities that use the Cent-a-Meter in Australia did not want the customer to be able to check and question the utility bill.

Programming is minimal and, if one reads the instruction manual, fairly straightforward. Viewing the various displays is accomplished by pushing just a few buttons. It displays: cost ($), use (kWh), temperature, humidity, and greenhouse gas emissions.

Figure 3: Cent-a-Meter

Source: Cent-a-Meter

Company and Experience

The Cent-a-Meter is made by Island Power Pty Ltd (an Australian company). The product has been actively promoted for less than a year (January 2004 launch in Australia and May 2004 launch in New Zealand) but has garnered a lot of local publicity. It has been featured on TV news spots, was a finalist for the Australian Museum Eureka Prize,[6] and is reportedly popular with customers. Many customers use it to make sure everything is turned off. They learn what their regular use is. Before leaving home, they check to make sure the use is about that; if it's more, they go back to see if they've left something on. As of October 2004, over 9,000 have been installed in Australia and New Zealand, though retail outlets, distributors, and utilities. Australian utility AGL offers Cent-a-Meters from its webpage.[7] A US launch is planned for early 2005. In the US, the Cent-a-Meter will be distributed through a newly formed Austin, Texas-based company, Cenergies.

[6] The Australian Museum Eureka Prizes are "awarded to a business, company or corporation which, through innovation or outstanding commitment to research, development or training, has sought to elevate corporate responsibility for scientific endeavour to a level consistent with our national capacity and needs." http://www.amonline.net.au/eureka/industry/2003_finalists.htm.

[7] See http://www.agl.com.au/AGLNew/Your+home/Energy+efficiency/Cent-a-Meter.htm.

Installation

Installation requires a licensed electrician. CTs are attached at the circuit panel. The wires go to a transmitter mounted on the wall near the panel. The battery-powered display unit can be placed anywhere in the home and moved as desired.

Differentiating Features

The Cent-a-Meter display is large and easy to read. It is wireless and battery-powered, so can be moved around the house. There is a transmitter mounted neared the circuit panel.

The Cent-a-Meter displays temperature and humidity. It also displays a conversion of energy to greenhouse gas emissions (not a big selling point for the US market, but of interest in New Zealand and Australia).

Unlike the other in-home displays that use CTs, the Cent-a-Meter does not measure voltage. The CT measures amps and is accurate to +/- 5 percent. The user inputs the voltage. The measured use (actually calculated by multiplying measured amps by stipulated voltage) accounts for neither voltage fluctuations nor power factor correction. It is therefore less accurate for reactive loads or locations with under, over, or variable voltage. As noted above, this inaccuracy is not likely to be very noticeable to the customer.

Cost

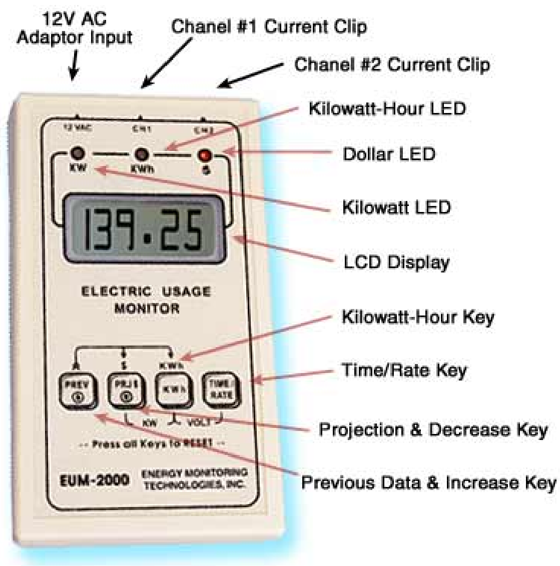
The Cent-a-Meter will be priced at $100-150 US. Installation costs would vary with location and the contract negotiated between utility and installers, likely in the $75-200 range.

EUM-2000 (Energy Monitoring Technologies)

Description

Energy Monitoring Technologies' display device, the EUM-2000, is also fairly simple, though a bit more complex than Cent-a-Meter's, and it is rated with more accuracy. It displays both instantaneous energy use (kW) and cumulative energy use (kWh) and cost ($). It also calculates a projected energy bill and can show an alarm if projected monthly bill or peak demand exceed preset levels. Like all the other CT-based displays, it uses only one electricity rate, so cannot show cost for TOU or CPP rates. The display is wired to the CT, so must be located near the circuit panel.

Figure 4: EUM-2000



Source: Energy Monitoring Technologies

Company and Experience

Two former utility employees founded energy Monitoring Technologies in 2000. Based in Florida, it currently has 12 employees and about 10,000 devices installed. EMT sells to distributors and directly to end-users. EMT is talking to several utilities, but has not yet sold to them.

Installation

Installation requires an electrician. CTs are attached at the circuit panel.

Differentiating Features

The EUM-2000 uses a split-core CT that measures both volts and amps, so it can measure and account for power factor accurately. The split-core CT has 7500 turns and is accurate to +/- 1%.

The EUM-2000 is most often used in the monthly bill projection mode. It calculates average use/minute month-to-date and calculates the projected monthly bill. Use and cost for each of the past 60 days is stored and accessible.

Versions of the EUM-2000 are also available for individual appliances, apartments, as well as the whole-house monitor.

Cost

The EUM-2000 costs $225 retail for a whole house monitor. An apartment version (one current clip instead of two) costs $175. Installation costs would be similar to other CT-based devices, dependent on local electrician costs but about $75-200.

The Energy Detective (Energy, Inc.)

Description

The Energy Detective (TED) by Energy, Inc. shows instantaneous kW and month-to-date kWh. It also projects what the use at end of month will be. It is somewhat programmable for complex rates (time-of-use and demand, but not CPP-V). TED communicates the data via powerline to the display unit, which can be moved and plugged into any outlet. Data displayed include: instantaneous use (kW and $), use today (kWh and $), use month-to-date (kWh and $), projected monthly bill, peak demand (kW and $), voltage (current, highest and lowest today), and current electricity rate. It also has an alarm that can be programmed in various ways: if cost/hour or kW/hour exceed limit, if $ or kWh per day or month-to-date or monthly projection exceed limit, and for low or high voltage.

Figure 5: The Energy Detective

Source: Energy, Inc.

Company and Experience

TED is a relatively new company, founded in 2002. ORNL was involved in the development of TED. At the end of 2004, the first units were in production. TED plans to begin marketing to utilities and home stores in 2005. TED is also working with homebuilders to get the devices installed in new construction.

Installation

Like others clip-on devices, requires electrician to install the CTs. Data is communicated to display device over powerline. Display can be plugged into any standard electrical outlet.

Differentiating Features

The design is very simple and easy to read. TED displays instantaneous and month-to-date energy use and cost. It also has an audible alarm and red and yellow LEDs. TED stores 2 months worth of hourly readings. The user can download the data to a computer for further analysis.

TED is very accurate and programmable. The user can input rate details, including flat fees, time-of-use or demand pricing, and taxes. Based on these data, TED can estimate the electric bill accurately. There will always be some discrepancy because the exact time of the utility read will vary.

According to President Dolph Rodenberg, future plans include being able to control loads directly from TED and adding communications capability so TED could display costs for dynamic pricing. TED also has a connection directly from the display to USB so data can be downloaded to computer for analysis.

Cost

Target cost $150. Installation costs similar to others at $75-200.

Greenwire Energy Monitor (Greenwire)

Description

The Greenwire Energy Monitor is an in-home energy display designed to provide a simple readout with very low installation costs. Rather than using a clip-on CT, which requires an electrician, the Energy Monitor collects energy consumption data via an attachment to the outside of the meter and communicates to an in-home display device. According to the inventor, the homeowner can install it. The display shows past 24 hours' energy use (kWh) and cost ($, based on a fixed average cost). Instantaneous energy use is displayed in non-numeric ways: bar graph, and a light that flashes faster when electricity use is higher. The light mimics the meter spinning faster during high usage. The display is battery operated and communicates via wireless RF, so it can be placed anywhere in the home or business and moved at any time.

The Energy Monitor is not yet commercially available. A few prototype units have been built. A product launch is planned for 1st Quarter 2005.

Figure 6: Greenwire Energy Monitor

Source: Greenwire LLC

Company and Experience

Greenwire LLC is a start-up company located in Austin, Texas. Greenwire is a joint venture between inventor Mark Palasz and Good Company Associates, a business development, advocacy and consulting company.

Installation

The Greenwire Energy Monitor was designed to be installed by the user. There is an energy use-sensing device that attaches to the outside of the existing electric meter. Greenwire chose not to disclose the technology they use for competitive reasons. They report that users can install the device themselves, so installation cost is zero.

Differentiating Features

According to Greenwire, their Energy Monitor will be very simple to use. The homeowner will simply take it out of the box, turn it on, and attach the sensing device to the meter. The display runs on batteries and can be moved around the home or business. Energy use will be shown graphically as well as numerically.

Cost

The Greenwire Energy Monitor is not yet commercially available. Target cost is $50.

Power Cost Display Monitor (Energy Control Systems)

Description

The Power Cost Display Monitor by Energy Control Systems has two components: the transmitter and the display monitor. It does not use a clip-on CT, but we include it in this section because it works with the existing utility meter. It does not require an additional or replacement meter, as it acts as a “add on” to the existing analog residential utility meter. The advantage of this approach is that it can function as a customer display device in parallel with the utility meter, without disturbing the utility meter reading or billing processes.

The transmitter is installed between the existing electric meter and the utility meter socket. Meter data are communicated over the powerline to the display monitor located in the home. The monitor is very simple. It looks a bit like a digital clock, with no function keys, and plugs into a standard electrical outlet. It displays a conversion of the current energy usage into what the energy cost would be for the whole month. That is, the cost displayed is the instantaneous energy use (kW) times the cost (cents/hour) times 24 hours/day times 30 days/month.

The PCDM received National Safety Testing Lab (NSTL) approval in December, 2004. Like the other in-home displays previously discussed, the PCDM bases cost calculations on a flat rate. The designers state they could program fixed TOU prices into the conversion upon request. But since it has no external communications interface, the device could not respond to critical peal or cannot calculate costs for real time rates.

Figure 7: Power Cost Display Monitor

Source: Energy Control Systems

Company and Experience

Energy Control Systems is a start-up company located in Incline Village, Nevada, with fewer than ten employees. They report to have provided demonstration units to several utilities, and that the City of Palo Alto has purchased ten units as a trial and will be starting a program in

January, 2005 to install PCDMs in low-income housing. Southern California Edison has tested two units in their meter shop and found them to be accurate within ANSI guidelines, and has also conducted some in home tests.

Installation

A utility electrician must install the PCDM, since it requires removing the meter in order to install. It is a meter extension socket fits between the meter and the meter panel, and measures the electrical usage of the entire residence. The display monitor is located in the residence, and can be moved around and plugged into any outlet. It communicates via power line carrier with the PCDM at the meter.

Differentiating Features

PCDM was designed for use as a means to provide direct feedback to residents, from high-end luxury homes to low-income housing. Its display is the simplest of all the monitors we studied. It shows only the " estimated monthly cost," though, as noted above, and the cost displayed is not a cost a customer would actually pay, but rather a cost if the house ran at current state for a month.

Cost

The PCDM costs about $380 in small quantities. The transmitter is installed behind the meter, so requires a utility electrician. Energy Control Systems says the entire installation should take only a few minutes. Installation costs will vary depending on locations of meters and utility labor rates.

Submetering Systems

Submetering is a much more established metering application than in-home energy displays. Manufacturers of non-utility residential submetering, such as Dent Instruments and MeterSmart (acquired E-Mon) are established companies with a wide selection of products, for whole-premise or sub loads. Their systems are highly accurate, in some cases even revenue grade. Typically, submetering systems are designed to be read using software and do not have displays. Like meters, they gather consumption data only, not energy prices.

Submeters are generally designed for either tenant billing or collecting data for further analysis. While they could be used for in-home displays, they are not that well suited to the task. They are over-designed for this use: they measure waveforms, power quality and other variables not needed for simple in-home displays. They measure power very accurately, but they do not store energy price or provide any energy cost information. They are hard-wired to the circuit panels and thus not easily accessible to users. E-Mon's kWh E-CON Meter has a simple display showing instantaneous use. It does not show use month-to-date or cost. Dent Instruments' ElitePro is similar. It currently has no display at all. Dent says they will be adding a display, but even so, cautions that the submeter is not the right vehicle for in-home display for dynamic pricing.

Meter-Based Systems

Displays that receive data flows directly from the meter by definition see the same consumption as the meter does. Questions about whether the display is accurate are minimized. At first blush, it seems that in-home display devices would be a natural product for the meter industry to offer.

The major meter manufacturers in the United States are not pursuing in-home display devices as a feature of their meters. We talked to marketing representatives from Elster Electricity, Landis+Gyr, Itron, and GE. They have no current plans to develop in-home displays, but say that if utilities are seriously interested (i.e.: interest accompanied by a request for proposals and subsequent purchase order) they would be able to develop prototypes. New meters can be purchased with under-the-glass additions from manufacturers of in-home displays. For example, the Landis+Gyr Focus meter works with the USCL EMS-2020. The Itron Centron meter works with the TWACS (formerly CIC) PowerStat in-home display for prepayment.

MTC, a start-up metering company no longer in business, tried to market a meter with an in-home display unit. A few utilities were very interested in the technology. MTC was acquired by Echelon and is no longer working on this product.

Since these technologies rely on installation of new meters to deploy the display technologies, they do not appear to be a good fit for a utility seeking to provide in-home displays to some of its customers without replacing the existing metering infrastructure. However, some of the vendors make the point that replacing a meter can be done more simply at lower cost than having an electrical contractor come to a house and install a parallel or CT-based display device.

Replacing a meter is work on the utility “right of way”. In the United States, it is often done outside the home or business and does not require the customer to be present, so it is easier to schedule. There is usually no problem gaining access to the meter panel, for replacement or meter reading. In comparison, circuit breaker panels that carry the customer energy load can be located in basements or garages. In theory, installing the clip-on CT takes only 20 minutes, but the real-life details of access to the panel can add to that time considerably. In addition, if utilities are installing devices at the panel, they must be prepared to deal with customer owned panels that are not to code or otherwise unsafe.[8]

[8] Chris Dent, President of Dent Instruments, tells datalogger installation difficulties. For example, they have opened a panel box to find water pouring down the back wall. Chris Dent, personal communication (December 13, 2004), Dent Instruments, 64 NW Franklin Avenue, Bend, OR 977041-2906, tel: 541-388-4774, email: cdent@dentinstruments.com..

EMS-2020 (USCL)

Description

The EMS-2020 is a portable display monitor that works with a Landis+Gyr Focus meter with a communications chip. It is necessary to replace the existing utility meter with the new meter. The EMS-2020 display monitor looks a bit like a TV remote control, with the addition of a full-color screen. The monitor communicates wirelessly with the metering system. In the optimal configuration, according to USCL, the meter and display unit are part of an integrated utility communications infrastructure, or AMR network.

The display gets data directly from the meter and is programmed with all components of the utility tariff. Because the meter has two-way communication with the utility, it can accurately show energy costs on a CPP tariff. It is the only display studied that reportedly presents cost information that matches the utility bill exactly. The EMS-2020's budget feature allows the customer to set a monthly dollar budget. An alarm sounds when use is predicted to exceed budget.

For geographically dense areas, the AMR network can be a fixed radio frequency. For less dense areas, USCL uses a powerline carrier technology. In either case, many additional AMR functions such as remote disconnect, tamper/theft detection, outage reporting, and meter reading, are also available. Alternatively, the EMS-2020 can be used as an in-home display, with the Landis+Gyr Focus meter.

The EMS-2020 and Focus meter combination can be used without the full AMI network. In this configuration, however, it won't have two-way communications between meter and utility, so won't be able to show costs for dynamic rates.

Figure 8: EMS-2020

Source

Company and Experience

USCL is a metering and communications company located in Sacramento, California. President Tom Tamarkin has long been involved in the areas of AMR and information display and in 1990 formed TAMAR Corporation, one of the early AMR vendors. In 1992, Tamarkin wrote an article in Public Power that posited customer display as one of many benefits of AMR: "Utilities can enhance customer relations by selling internal display units to customers that provide up-to-the-minute monitoring of power consumption, in dollars and cents. This can be used as an energy management tool and allows customers to verify and reconcile bills."[9]

USCL has a partnership with AMR company Arad Technologies of Israel for collecting data from electric, gas, and water meters. This partnership gives USCL the ability to integrate a wide-area or fixed AMR network into their product offering. USCL reports that the County of Los Angeles is deploying 360 EMS-2020s in 5 housing developments in the near future.

Installation

The EMS-2020 is part of a system that includes a new meter and RF wireless communications between the meter and the display unit. Once the advanced metering is in place, the EMS-2020 communicates wirelessly and requires no installation. However, the underlying meter with a chip that communicates with the EMS-2020, requires utility purchase and installation.

Differentiating Features

The EMS-2020 is by far the most complex of the displays studied. Its full color screen shows bar graphs of energy use. The user can choose from dozens of screens. The most unique feature is that the calculation of the energy cost will match the utility bill exactly, since all tariff components are programmed into the EMS-2020. In fact, USCL says the utility could actually implement "subscriber-side billing"--calculate the bill at the home or business, even for advanced variable rate structures, and send the bill, rather than just billing determinants, back to the head office.

The USCL system has features beyond the in-home display, such as meter reading, outage reporting, and tamper detection in real-time. It can support remote disconnect of service with an additional contactor module. It can also collect data from gas and water meters, all of which can be displayed on the EMS-2020.'

If the utility chooses not to implement a full AMR deployment, it can still leverage of the EMS-2020, but it will require installing a new meter, since the meter is the data collector for the display. As noted above, without a communication path between utility and meter, the meter/display will not be able to accurately reflect energy costs during critical peak times.

[9] Tom Taramkin, "Automatic Meter Reading," *Public Power,* September-October, 1992.

Cost

The cost of the EMS-2020 and whole USCL system is very much dependent on scale. In small quantities (~400) the cost is about $250 per home (includes meter and EMS-2020). Installation costs are the utility electrician's time for a few minutes to replace the meter. In quantities of 10,000 USCL projects costs at about $175 per home. Costs for an RF network range from $10-30 per meter, depending on geography and density.

PowerPal Meter with Customer Interface Display (Dent Instruments)

Description

The PowerPal Meter with Customer Interface (CI) Display is a combination of a Sensus iCon meter with powerline communications to the display unit. Dent Instruments is currently developing this product and expects it to be ready 3rd quarter, 2005. (They note that with a specific order, units could be ready 2nd quarter.) The CI Display can show instantaneous and cumulative use and cost. The CID is also used in the City of Tacoma's PAYGo project (see below). The meter can be programmed for TOU or demand rates. Although not currently planned, it would be possible to add a paging receiver to the meter so that it could also collect and display data for a critical peak tariff. The CI Display also has two LEDs that Tacoma can be turned on or flash to indicate price signals.

Company and Experience

Dent Instruments, formerly Pacific Science & Technology, is a well-established and respected manufacturer of equipment for electronic data acquisition, storage, analysis and presentation. Dent is headquartered in Bend, Oregon.

Installation

The replacement meter requires a few minutes of a utility electrician's time to set. The CI Display plugs directly into the wall. This type of installation may well be simpler than going into the customer's premises and attaching to the circuit panel.

Differentiating Features

To see how much energy is being used or what it costs, the users pushes a button on the CI Display. The CI Display then queries the meter and displays the requested information.

Cost

The PowerPal meter will cost about $300 in pilot quantities, less at higher volumes. The CI Display device costs $250-280. Installation will be a few minutes of a utility electrician's time to reset the meter.

Prepayment Meters

Prepayment systems have long included in-home displays, for the obvious reason that customers needed some indication of when they were about to run out of credit and power. The prepayment manufacturers have not been moving into the in-home display market for the purposes of dynamic tariffs.

Customer Interface Display (Dent Instruments)

Description

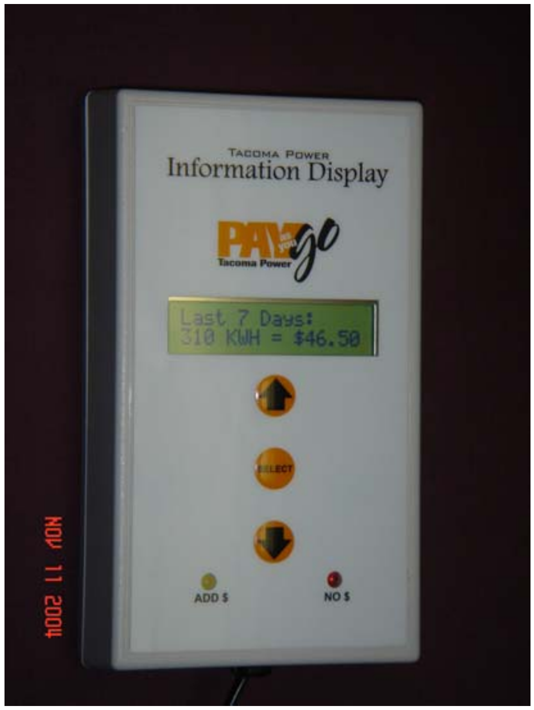
Dent Instruments is working with the City of Tacoma's Pre-Pay Metering (PAYGo) project. Tacoma has a citywide fiber network and has replaced all meters with network-interface meters. Tacoma can remotely read the meters, connect/disconnect power, etc. over the fiber network. For the PAYGo program, Tacoma needed a way to let customers see how much power/money they have left. Dent Instruments developed the Customer Interface Display for this purpose.

The Customer Interface Display is a simple unit that communicates with the utility via powerline. The user scrolls through a list of questions, finds the one he wants, and presses the button. The CI device itself has little intelligence. The text lives not on the CI device, but on the Tacoma server, so can be changed easily. Once the query is sent, the response is relayed from the Tacoma server and displayed on the device. Typical displays are: amount remaining ($ and time remaining), current use (kW and $/hr), yesterday's use (kWh and $), last 7 days' and last 30 days' use.

The CI display relies on the fiber network to be able to read the meter at any time. It is not directly applicable to the IDP. Dent Instruments has said it could incorporate a wireless receiver into the CI display to replace the powerline communication. However, it would still require some kind of always-on network to read the meter. It wouldn't work with interval meters read daily because customers couldn't see instantaneous use.

The CI Display also has two LEDs that Tacoma can turn on or flash to indicate a new message or other account information, for example that the account is running low. For a CPP tariff, the LEDs could also indicate price signals.

Figure 9: Customer Interface Display



Source: Dent Instruments

Company and Experience

Dent Instruments, formerly Pacific Science & Technology, is a well-established and respected manufacturer of equipment for electronic data acquisition, storage, analysis and presentation. Dent is headquartered in Bend, Oregon.

Installation

The CI Display plugs directly into a standard electrical outlet and requires no special setup.

Differentiating Features

The CI Display is very versatile in that in can display any message from the utility. Since the device itself communicates but queries are stored/generated at the utility server, it is extremely flexible. When the utility wants to make more information available to the customer, the query is added to the scroll list. The CI Display requires internet-connected meters, since it collects data as it is requested.

Cost

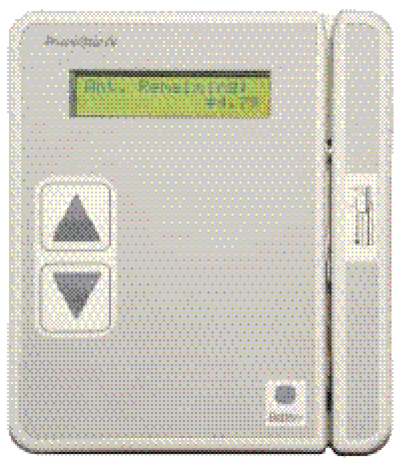
The CI Display device costs $250-280. There is no installation cost for the CI Display, since it just plugs in. It is, however, part of a prepayment metering system.

PowerStat (DCSI)

Description

PowerStat is part of a prepayment metering system. The meter is replaced with a prepayment meter, which communicates with the PowerStat display device via powerline. The display shows the current cost of electricity, the current rate of use, cost of electricity for previous day, week, and month, and amount of credit remaining. These are typical of values displayed with prepayment metering systems.

Figure 10: PowerStat



Source: DCSI

In 1995, CIC Global (now part of DCSI) worked on a pilot project with PacifiCorp to provide in-home display of electricity use and cost to about 50 customers. The display device, called the EM-1, was similar to the prepayment display except that it worked with the standard utility meter. It also had LED indicators that would light during peak rate, when the customer was under load control, or projected to exceed monthly budget. The system used Metricom communications.

According to Ken Anderson, who managed the in-home monitoring program for PacifiCorp, the system worked well. Only 50 were deployed because it was part of a larger AMR project that ultimately did not go forward. The key was to get customers to position them for easy viewing. That meant making them useful—and useful to the customer meant more than electricity use. Had the program continued, Anderson would have had the displays show time (they always had the right time because they synched daily and had batteries) and temperature. He also found that making the displays fit into the existing décor was important and was working on customized faceplates, including a few colors and a clear option that could hold a photo.[10]

Figure 11: EM-1

Source: DCSI

DCSI does not currently have an active in-home display without prepayment offering, but they are working on it. Indeed, CIC's experience with in-home display and knowledge of customer preferences for information display was a key factor in DCSI's acquisition of CIC.[11]

Company and Experience

DCSI, a provider of AMR and load control using powerline carrier technology, acquired CIC Global in July 2004. DCSI is currently working on ways to incorporate prepayment and in-home display technology with their AMR system. CIC's PowerStat is the in-home display for their prepayment system and could be modified for in-home display. In addition, CIC had an in-home display they piloted with PacifiCorp ten years ago that had many of the features of interest.

Installation

The PowerStat plugs directly into the wall. It communicates with the meter via powerline.

[10] Ken Anderson, Project Planning Engineer, Northwest Efficiency Alliance, 529 SW Third Avenue, Suite 600, Portland, OR 97204, tel 503-827-8416 ext. 249, email kanderson@nwalliance.org.
[11] Kevin Cornish, personal communication (December 14, 2004), Director, Utility Solutions, TWACS by DCSI, 66 Maryland Avenue, Berkeley, CA 94704, tel 510-528-3038, email kcornish@twacs.com.

Differentiating Features

In-home display works with existing utility meter.

Cost

The PowerStat unit works only with replacement meter. The EM-1 is not currently commercially available.

Research Technologies

Research into new ways to display information is ongoing at universities.

Energy Cube

Ken Camarata of Carnegie Mellon University works on combining tangible interfaces with calm technology, or “peripheral representation of ambient displays.” (Camerata et al 2004). His team has created two prototype energy displays. He envisions them as part of an energy kit that the utility would loan to customers. Customers would take the kit home for a month, configure a non-invasive sensor network, and see energy use information on the included displays. The occupants would see how their behaviors affect energy use. After a month, they would return the kit to the utility.

The first prototype is the Energy Cube. Each side of the cube corresponds to a zone in the house (egg: kitchen, bedroom, etc.). Inside the cube are red and blue LEDs embedded in a ping-pong ball. The ball acts as a diffuser and the color changes from blue to purple to red as energy use increases. To find out how much energy the kitchen is using, pick up the cube and rotate it so the kitchen side is up.

The prototype did not actually gather real energy use data. Instead it used a network of photocells. The varying amount of light falling on the photocells was used as a proxy for energy consumption. This demonstrated that the cube was able to change colors for the different zones. Actually gathering energy use data on a room-by-room basis is a challenge yet to be overcome.

Energy Magnets

Camarata’s second prototype is modeled after refrigerator magnets. Various household appliances have magnetic icons. The user places icons on a board and a bar graph showing energy use appears. A bar chart for whole house energy use is also shown.

Like the Energy Cube, the Energy Magnets are in the early prototype phase. Camarata notes the “represent an interesting and engaging first step.”

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Effects of Energy Information and Feedback

Abrahamse, Wokje, Linda Steg and Charles Vlek. "Energy Conservation Through. Behavioural Changes: The Effect of Tailor Information and Feedback on Residential Energy Use."

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Bengtson, Kevin. "Can Better Utility Bills Save Energy?" *Home Energy*, (May/June, 1997).

Identified customers preferences for on-bill information display.

Camarata, Ken, Drew Bregel, Ellen Ti-Luen Do, and Mark D. Gross. "Artifacts for Displaying Home Energy Use," presented at Generative CAD Symposium, Carnegie Mellon, July 12-14, 2004. Downloaded from http://depts.washington.edu/dmgftp/publications/pdfs/GCAD04-Energy.pdf.

Explains Energy Magnets and Energy Cube concepts.

Centre for Sustainable Energy. "Energy Matters: Home Energy Resource, Its Effects on Energy Efficiency in the Home" (April 2003).

Centre for Sustainable Energy. "Energy Education Hitting Home: A Summary of the Evaluation Report into the Impact of the Energy Matters Programme," (2004). Available at http://www.cse.org.uk/pdf/pub1025.pdf.

Over half (54%) of parents have installed energy-savings measures, including energy efficient light bulbs, appliances, and upgrading insulation. That investment rate is similar to what is seen after visits from professional energy advisors.

Parents are likely (three-quarters) to take actions to save energy after their school-age children have been educated about energy efficiency.

Darby, Sarah. "Making it Obvious: Designing Feedback into Energy Consumption," Proceedings 2nd International Conference on Energy Efficiency in Household Appliances and Lighting. Italian Association of Energy Economists. (2000)

Reviews previous literature and finds that in 21 studies (various sample size, housing type, additional interventions, feedback frequency and duration), savings after participants given direct feedback was 5 percent or greater in most cases. "Metering displays should be provided for each individual household in a form that is accessible, attractive and clear."

Darby, Sarah. "Making Sense of Energy Advice," Proceedings, European Council for an Energy-Efficient Economy, 6.167 (2003)

Darby, Sarah. "Energy Advice—What Is It Worth?" Proceedings, European Council for an Energy-Efficient Economy, III.05 (1999)

Reviews effects of energy advice, including more frequent meter readings. In Europe, where meters were often read semi-annually, increasing frequency of meter reads to bi-monthly, or giving customer ability to read own meter, resulted in savings of 10 percent.

Dobson, John K., and J.D. Anthony Griffin. "Conservation Effect of Immediate Electricity Cost Feedback on Residential Consumption Behavior," Proceedings, ACEEE (1992).

Garafalo, Andrew, and Carol Mulholland. "Knowledge is Power: How Information Alone Can Convince Commercial Customers to Install Energy-Efficient Measures. Proceedings, Energy Program Evaluation: Uses, Methods, and Results, Chicago, IL (1993).

Green, J, S Darby, C Maby and B Boardman. "Advice into Action: An Evaluation of the Effectiveness of Energy Advice to Low-Income Households," EAGA Charitable Trust (1998).

Haakana, Maarit, Liisa Sillanpää, and Marjatta Talsi. "The Effect of Feedback and Focused Advice on Household Energy Consumption," Proceedings, ECEEE Summer Study (1997).

Households receiving feedback on energy consumption reduced electricity consumption by 17-21 percent.

Heijne, Caroline. "Energy Education Hitting Home: Monitoring the Impact of Energy Matters," A Report to Ofgem by the Centre for Sustainable Energy (April 2003). Available at http://www.cse.org.uk/pdf/pub1022.pdf.

Energy Matters is an energy education program for children ages 7-14 in the UK. Three-quarters of parents changed their behavior to save energy after their children participated in Energy Matters. Almost half of them were more interested in saving energy after their children participated, and overall 90% were interested in saving energy in the home.

Hutton, R. Bruce, Gary A. Mauser, Pierre Filiatrault, and Olli T. Ahtola. "Effects of Cost-Related Feedback on Consumer Knowledge and Consumption Behavior: a Field Experimental Approach," *Journal of Consumer Research*, v. 13: 327-336 (1986).

Field experiments with in-home displays in US and Canada. The displays showed cumulative total cost of energy for a 24-hour period and also cost for the next hour. Customers liked and indicated willingness to pay for the devices, although their use of the devices declined after a few months. Savings in Canada were 4 to 5 percent. Savings were not found in California. Paper concludes that authors cannot prove hypothesis that any feedback to any customer will result in savings.

Kempton, Willett, and Linda L. Layne. "The Consumer's Energy Analysis Environment," *Energy Policy* 22 (10):857-866 (1994).

Concludes that energy data collection and analysis tasks "are currently assigned to the less efficient parties, degrading decision quality and creating a market barrier to energy conservation. We suggest a more efficient allocation of data collection and analysis between the consumer and energy utility."

Machrone, Bill. "The Electron Leak: Why Doesn't the 'Off' Button Really Turn Things Off?" PC Magazine, (October 5, 2004). Downloaded from http://www.pcmag.com/article2/0%2C1759%2C1645410%2C00.asp.

Reporter finds that his cable box, sound system, computer equipment and home theatre equipment all consumes energy, even when it's turned off—to the tune of about 100W. He calculates that as 9 percent of his total electric bill, or $100 for the convenience of having equipment turn on right away.

Roberts, Simon and William Baker, "Towards Effective Energy Information: Improving Consumer Feedback on Energy Consumption," A Report to Ofgem by the Centre for Sustainable Energy (July 2003). Available at http://www.cse.org.uk/pdf/pub1014.pdf.

Finds feedback on energy use to customers is "most effective when it is immediate, prominent, accessible and specific [to the customer]" and that customers can respond to historical comparison information and in-the-home meter displays.

Further, finds that in addition to relevant, engaging feedback, customers also need a "motivating justification" to act.

Concludes that Ofgen should "consider whether it can and should act to ensure new meter installations also offer the clear additional benefit of integrating quality consumption feedback to the consumer through in-the-home displays."

Roberts, Simon, Helen Humphries and Verity Hyldon, "Consumer Preferences for Improving Energy Consumption Feedback," A Report to Ofgem by the Centre for Sustainable Energy (May 2004). Available at http://www.cse.org.uk/pdf/pub1033.pdf.

Based on 7 focus groups of residential customers in the UK, the preference for on-bill feedback is for bar charts on bills to compare current energy use with previous. The focus groups expressed strong dislike for feedback comparing their home to an average or to other homes in their neighborhood. In addition, participants were interested in better messages about energy savings.

Siero, Frans W., Arnold B. Bakker, Gerda B. Dekker, and Marcel T.C. van den Burg. "Changing Organizational Energy Consumption Behaviour through Comparative Feedback," *Journal of Environmental Psychology* 16 (3):235-246. (1996).

Employees in one unit of a metallurgical company received information about energy conservation, set goals, and received feedback on their behaviour. Employees of a second unit received the same information, and also information on the performance of the first unit (comparative feedback). The comparative feedback group saved more energy, even "with hardly any changes in attitudes or intentions".

Van Houwellinger, Jeannet H. and W. Fred Van Raaij. "The Effect of Goal-Setting and Daily Electronic Feedback on In-Home Energy Use," *Journal of Consumer Research*, v. 16: 98-105 (1989).

In-home display devices were installed in 50 households in the Netherlands in 1984-85. Note these devices monitored gas use only. Households were given a goal of 10 percent gas reduction. With the in-home displays, they reduced their consumption by 12 percent.

Wilhite, Harold and Asbjørn Høivik and Johan-Gjemre Olsen. "Advances in the Use of Consumption Feedback Information in Energy Billing: The Experiences of a Norwegian Energy Utility," Proceedings, ECEEE Summer Study (1999) Panel III.02.

Tested Norwegian customer response to historical, normative, and end-use disaggregation feedback on the bill. Each of these types of feedback was highly valued and showed potential for energy savings.

Wood, G. and M. Newborough. "Dynamic Energy-Consumption Indicators for Domestic Appliances: Environment, Behaviour and Design," *Energy and Buildings*, v. 35:8 (September 2003).

Field study of 44 UK households monitoring electric cooking. With in-home displays, energy use was reduced 15 percent. Households receiving antecedent information (monthly, on bill) only reduced electricity consumption 3 percent.

Metering and In-Home Display Technologies

Tamarkin, Tom D., "Automatic Meter Reading," Public Power v. 50, No. 5 (September-October, 1992).

An overview of AMR systems and technologies. Identifies new revenue-producing services, including "Customer display—utilities can enhance customer relations by selling internal display units to customers that provide up-to-the-minute monitoring of power consumptions, in dollars and cents."

Calm Technology

Antifakos, Stavros and Bernt Schiele, “LaughingLily: Using a Flower as a Real World Information Display,” Poster Submission, *The Fifth International Conference on Ubiquitous Computing* (Ubicomp), Seattle, USA, October 2003.

Blaze, William, “Calm Technology,” (September 19, 2004) posted at http://www.abstractdynamics.org/archives/2004/09/19/calm technology.html.

Matthews, Tara, Anink Dey, Jennifer Mankoff, Scott Carter and Tye Rattenbury, “A Toolkit for Managing User Attention in Peripheral Displays,” TK.

Prante, Thorsten, Carsten Rocker, Norbert Streitz, Richard Stenzel, Carsten Magerkurth, Daniel van Alphen, and Daniela Plewe, “Hello.Wall—Beyond Ambient Displays,” *5th International Conference on Ubiquitous Computing (*Ubicomp ’03), October 12-15, 2003, Seattle, WA (2003).

Rheingold, Howard, “Tangible Bits,” The Feature (October 24, 2003). Downloaded from http://www.thefeature.com/article?articleid=100163.

Santifakos, Stavros and Bernt Schiele, “LaughingLily: Using a Flower as a Real World Information Display,” TK.

Walker, Kevin, “Interactive and Informative Art,” IEEE Computer Society (2003).

Weiser,Mark and John Seely Brown, “Designing Calm Technology,” Xerox PARC (December 21, 1995) published *PowerGrid Journal*, v 1.01. Available at http://sandbox.parc.com/hypertext/weiser/calmtech/calmtech.htm.

Weiser,Mark and John Seely Brown, “The Coming Age of Calm Technology,” Xerox PARC (October 5, 1996). Available at http://www.ubiq.com/hypertext/weiser/acmfuture2endnote.htm.

These are the papers that first posit technologies that will both encalm and inform by placing things in the periphery.

Wenham, Chris, “Ah, the ambience,” (September 4, 2004), posted at http://www.disenchanted.com/technology/ambience.html.

Musings on Ambient Devices and other calm technologies.

Exhibit "D"
Tamarkin Testimony
CPUC Rulemaking No. 02-06-001

Silicon Valley Testimony
under
Application No. 05-03-016

Exhibit Number:___________________
Commissioner: Dian M. Grueneich
Adm. Law Judge: Michelle Cooke
Witnesses: Chris King

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CALIFORNIA PUBLIC UTILITIES COMMISSION

TESTIMONY ON PACIFIC GAS & ELECTRIC COMPANY'S APPLICATION FOR RECOVERY OF PRE-DEPLOYMENT COSTS OF THE ADVANCED METERING INFRASTRUCTURE (AMI) PROJECT

Application No. 05-03-016

San Jose, California
June 13, 2005

SUMMARY

The Silicon Valley Leadership Group (SVLG) presents this testimony on functionality, pre-deployment tasks, and pre-deployment costs in response to Pacific Gas & Electric Company's (PG&E) request for authority to spend $49 million for pre-deployment activities for its Advanced Metering Infrastructure (AMI) program.[1] SVLG's recommendations are as follows:

- PG&E's request for recovery of pre-deployment costs of $49 million for 2005 and 2006 should be approved, since PG&E has indicated that the business case for AMI is very positive. Provided PG&E achieves its targets, PG&E will cover over 90 percent of the cost of AMI via utility operating savings.[2] The precise level of demand response benefits is subject to discussion, but SVLG is confident that these benefits are very large and very positive. SVLG's support is based in part on the threshold approach, which will be effective in minimizing incremental AMI costs.

- Based on PG&E's supplemental testimony, PG&E's proposed AMI infrastructure will meet the minimum functionality criteria as set forth in Appendix A of the ACR. This functionality will provide the critical customer and utility benefits associated with an AMI infrastructure.

- Importantly, while an AMI would be new in the sense that it has not been deployed in California, there are many technologies already available in the marketplace. These technologies, including many provided by California-based companies, ensure that the AMI can be deployed successfully and that the capabilities of the AMI can be utilized for the benefit of California's energy customers.

- SVLG's members are particularly interested in having the AMI system be capable of providing real-time controls and/or data so that the demand response function can be automated. Automated response is easier for customers and increases the level of peak demand reductions. SVLG's understanding is that PG&E's proposed AMI solution is capable of providing this functionality for those customers who desire it and for whom a small added investment – such as a smart thermostat, load control switch, or interface to a building energy management system – is cost-effective.

- Businesses are also interested in obtaining running energy cost information by linking usage with pricing data and provision of the results more frequently than monthly. Our preference is at least daily, with the possibility of more frequent updates.

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[1] PG&E filed its application on March 15, 2005 and filed a supplemental testimony on May 31, 2005. The Commission issued an Assigned Commissioner's Ruling (ACR) on PG&E's application on May 18, 2005 and set forth the scope for this testimony.

[2] PG&E Supplemental Testimony, May 31, 2005 at 12.

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CHAPTER 1
INTRODUCTION AND OVERALL POLICY
Witness: C. King

SVLG presents this testimony on PG&E's pre-deployment tasks as outlined in its March 15, 2005 application and in its Supplemental Testimony on May 31, 2005.

In its March 15, 2005 application, PG&E requested $49 million for its AMI pre-deployment activities. These activities would enable PG&E to proceed on a rapid, but measured, schedule to prepare for rollout of its AMI following a final Commission decision in 2006.

There are several reasons such preparatory activities are in the public interest. First, these activities will enable PG&E to deliver the AMI will provide the many benefits of AMI to customers significantly sooner. These benefits include better ability to manage their energy bills, more rate choices, improved customer service, and better outage management. These benefits will include the ability for residential customers to participate meaningfully in meeting the State's peak energy needs. Residential customers are critical because they not only are the greatest contributor to peak demands on the highest peak days, but also because they have the greatest ability to manage their peak demand. California's League of Women's Voters met with its members around the state and concluded that residential consumers have a duty to be part of the solution to California's peak energy problem. They are more price sensitive than businesses, as shown by extensive academic literature over the past decades and reaffirmed most recently in the California Statewide Pricing Pilot. In addition, residential customers face fewer constraints; businesses cannot close their doors or shut down processes to reduce peak loads, but residential consumers have many options. These can be as simple as rescheduling laundry and other household chores temporarily or reprogramming timers on appliances. California's energy users lag much of the country in receiving the benefits of AMI. PG&E's proposal is an appropriate way to deliver these benefits without unnecessary further delay.

The second reason PG&E's proposed activities are in the public interest is because California faces peak energy shortages in the very near term, certainly within the next five years, depending on which of the many authoritative sources (these include the utilities, the California Energy Commission, and the California Independent System Operator) is relied upon. Deploying AMI will take five years, and capturing the full potential of demand response will take even longer. This is because the infrastructure must be in place, then demand response programs approved and implemented, then customer and utility experience gained with program operations. AMI helps solve California's problem not just by enabling demand response, but also by providing consumers with the combination of greater awareness of energy usage and more tools to manage that usage. Public appeals, such as the Flex Your Power campaign, are important and valuable. Yet, as Commissioner Kennedy reported regarding the highly successful 2001 20/20 Program, such appeals need to be reinforced through bill savings.[3]

The third reason the Commission should approve PG&E's application is that the pre-deployment activities will be useful regardless of the specific outcome of the Commission's decision on PG&E's final AMI application. This is because it is almost certain that some level of AMI deployment will be ultimately authorized, and the pre-deployment activities will support any type of deployment. PG&E has already reported that operating savings exceed over 90 percent of the costs of AMI, and demand response and non-quantified customer benefits (improved outage response, better customer service) offer significant additional benefits. Moreover, automation of metering is a clear, growing, and national trend, based partly on economics and partly on customer expectations. Automation costs continue to decline, albeit slowly, while manual meter reading and utility operations costs continue to rise. Over half of the electric meters in the U.S. are read remotely – California has one of the lowest automation penetration rates in the nation – and the rate of installation is accelerating. In an age where consumers and businesses can access their latest bank or cell phone call records in seconds via an automated phone call or the Internet, energy users must wait over a month to find out their bill amount. Consumers and businesses in all areas of modern life get much more current, much more accurate, and much more detailed information than ever before. The exceptions are in highly regulated industries – electricity, gas, and water – which also happen to be three of the most critical natural resource issues faced by Californians.

[3] Presentation at American Council for an Energy Efficient Economy, Berkeley, California, June 10, 2003.

Finally, SVLG strongly endorses the Commission's threshold approach to evaluating PG&E's AMI investment. The threshold approach virtually guarantees that AMI will be successful for energy customers (ratepayers). Because the benefits of AMI to consumers and businesses are so well documented, and because AMI and AMI-related technologies are so well proved, the major risk of AMI is related to the overall cost. In the threshold approach outlined in the ACR, PG&E's shareholders would be required not only to assume any cost risks of AMI but also to guarantee achieving all of the operating benefits of AMI. Under the threshold approach, incremental cost recovery is limited to a very small percentage of the total cost, putting ratepayers at virtually no risk (again, even this risk is far more than offset by major known demand response and customer service benefits). The threshold approach provides PG&E with tremendous incentives to do the right thing, namely minimize AMI deployment costs and maximize utility operating savings. These are two of the same efficiency-maximizing incentives that make competitive markets work so well, and which put so much pressure on SVLG member companies every day – pressure that lower energy costs can help relieve. A third market incentive, that of forcing continual improvement in product quality and functionality, is not covered by the threshold approach and is the critical area where the Commission must represent the needs and interests of consumers and businesses with respect to AMI.

CHAPTER 2

METER FUNCTIONALITY CRITERIA

Witness: Chris King

In his May 18, 2005 Ruling, Commissioner Peevey directed PG&E to provide supplemental testimony "that specifically addresses how its proposed technology/ deployment plan meets the functionality criteria set forth in the February 19 Ruling" in R.02-06-001. As noted in Chapter 1 of SVLG's testimony, the Commission's threshold approach provides PG&E with very powerful incentives to minimize AMI incremental costs and shifts the vast majority of cost risks to PG&E's shareholders and away from ratepayers. However, the threshold approach does not ensure that PG&E's proposed solution will provide the functionality needed to meet consumer and business needs, in addition to meeting its own operating needs.

SVLG begins by commenting on the functionality set forth in the February 19 ruling. SVLG agrees that all six of the requirements listed in this functionality are essential elements of the AMI. It supports rate options already known to be of interest to businesses and consumers, such as critical peak pricing and two-part real-time pricing. The collection of hourly usage data ensures that the Commission will have the flexibility to design any other rates consistent with market and customer needs in the future. The hourly interval corresponds with existing electricity spot markets and the California ISO's planned day-ahead and real-time spot markets. On the customer side, the hourly data can be aggregated into a variety of rate designs – time-of-use, critical peak pricing, inverted tier rates – that best balance customer needs for simplicity with appropriate accuracy of price signals. Hourly data also enables new and innovative designs, such as the critical peak rebate program being piloted at Anaheim Public Utilities.

The February 19 ruling requirement for flexible data delivery and access ensures that the AMI will include a communications network that is always on and always connected to the meter. Such a network is essential for delivery of data to energy users on a timely basis, as well as utility functions such as outage management and restoration verification. SVLG believes the minimum requirement for data updates is daily. This is consistent with most business practice (for example, banking and cell phone companies update customer data on their websites daily). It is consistent with wholesale energy markets, where day-ahead market prices are set daily. It allows energy users to review the results of their energy conservation actions on a next-day basis, enabling changes in the next days operations, if appropriate, prior to the beginning of the next peak period. Daily data delivery, as proposed by PG&E, also balances customer needs with costs. More frequent access to data requires a more expensive link to the meter, but is important for some customers, particularly business customers who want to link the meter to an energy management system. It is important that PG&E's AMI include a low-cost capability for providing such a link to those business customers desiring it. PG&E's AMI should also keep the door open – i.e., "ensure that changes in customer preference of access frequency do not result in additional AMI system hardware costs"[4] – for in-premise near real-time energy usage displays. Such displays would be a customer option and could be either a purpose-built device or built into another device, such as a thermostat or software on a personal computer. SVLG believes PG&E's proposed solution supports these options, but the Commission should ensure this prior to approving PG&E's application.

Regarding the "flexibility" of customer access required by the February 19 ruling, SVLG further stresses that PG&E's AMI system must provide energy users with cost data in addition to usage data. Specifically, the AMI system should provide pricing information and "price times usage" cost estimates. Just as they can request the current status of cell phone usage minutes via a website or automated telephone response (IVR), consumers and businesses should be able to request a "month-to-date" energy bill via a website or IVR. The capability of providing cost data is added at the information system level and implemented in software, thus adding little to the total AMI cost while providing significant customer benefit.

The February 19 ruling requirement that AMI support utility functions imposes numerous software-related requirements. One requirement is that PG&E appropriately integrate the AMI with its other information systems, such as outage management and asset management. SVLG has seen several instances where AMI has been deployed at other utilities, but many of the customer service capabilities have not been utilized because such integration was not performed or the AMI system software was incapable

[4] - May 18, 2005 ACR, Appendix A

of supporting the functionality. Another requirement regards the data handling and processing capabilities of PG&E's AMI software. Obtaining the full benefits of AMI requires real-time access for up to millions of meter data points reporting, for example, outage alarms, as well as real-time software applications to process the data. The data and processing requirements for such data quantities far exceed traditional utility requirements. These data include power flow and hourly energy consumption for millions of residential and business customers, as well as measurements on the transmission and distribution systems. The data processing rates required for these applications are far higher than traditional monthly billing transactions and far exceed the capabilities of traditional transactional databases. However, real-time database products and applications, on the other hand, can readily handle this load. For example, the California ISO is routinely storing over 250,000 measurements from the grid updated [every four seconds] and SDG&E is routinely storing about the same number for their transmission control system. Based on real time data and analysis, control instructions are issued to load control or other systems. Demand response actions are monitored to ensure the desired effect is achieved. An additional load on the database servers is from direct customer access. Energy usage data must be available in an Internet format for use on standard client browsers. Finally, the data warehouse must be secure from intrusion. This requires special expertise in both hardware and software design and implementation.

The February 19 requirement for interfacing to load control systems is also critical to SVLG members. Dynamic pricing encourages demand response, but automated controls are essential to enabling energy users to maximize response and making it as easy as possible for customers to participate in programs. The literature shows that customer response to dynamic pricing is approximately doubled when pricing is combined with load control.[5] We interpret "load control" to include control of smart thermostats and interfaces to building energy management systems. Also, such control need not use the same communications network as AMI; the interface may be equally (or perhaps more) effective at the system level.

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[5] - King, C. "Integrating Residential Dynamic Pricing and Load Control: The Literature," EnergyPulse, December 14, 2004.

Finally, SVLG applauds the Commission in taking an appropriate, high-level approach to AMI, specifying critical functionality but not intruding into technical and design decisions best left to the technical implementers. SVLG's concern is that the AMI be implemented at the lowest possible cost, with sufficient performance reliability, and with all of the functionality required not only by our members, but Californians generally. With the solution proposed by PG&E in its testimony, and subject to the various caveats and clarifications described in our testimony above, SVLG believes PG&E's AMI meets the necessary functional requirements for AMI.

APPENDIX A

WITNESS QUALIFICATIONS

QUALIFICATIONS OF CHRIS KING

Q.1. Please state your name and business address.

A.1. My name is Chris King. My business address is One Twin Dolphin Drive, Redwood City, CA 94065.

Q.2. By whom are you employed and in what capacity?

A.2. I am employed by eMeter Corporation as Chief Strategy Officer.

Q.3. Please state your educational background and experience.

A.3. I received a B.S. and M.S. in Biological Sciences from Stanford University in 1980 and an M.S. in Management Science from the Stanford Graduate School of Business in 1991. I have been employed primarily in the energy and metering industry since 1980, including positions as Supervisor-Rate Design for Pacific Gas & Electric Company, Vice President-Regulatory Affairs for CellNet Data Systems, and Chief Executive Officer for Utility.com, an ESP that had 50,000 customers in California, Pennsylvania, and Massachusetts. I have testified in numerous proceedings before the CPUC, the State Legislature, the California Energy Commission, other state commissions and legislatures, and the Commerce Committee of the U.S. House of Representatives. A few of the issues I have addressed include:

- Energy efficiency programs;
- Demand response programs;
- Advanced metering and communications hardware and software technologies;
- Advanced metering business case development;
- Cost-effectiveness of energy efficiency, demand response, and optional rate programs;
- Dynamic pricing rate design, including TOU, CPP, and real-time pricing;
- Competitive market design, including competitive metering;
- Calculation of transition costs.

Q.4. What is the purpose of your testimony?

A.4. I am responsible for Chapters 1 and 2 of SVLG’s testimony.

Exhibit "E"
Tamarkin Testimony
CPUC Rulemaking No. 02-06-001

California Senate Bill 1976

Senate Bill No. 1976

CHAPTER 850

An act to add Section 454.5 to the Public Utilities Code, relating to electricity, and declaring the urgency thereof, to take effect immediately.

[Approved by Governor September 24, 2002. Filed with Secretary of State September 24, 2002.]

LEGISLATIVE COUNSEL'S DIGEST

SB 1976, Torlakson. State Energy Resources Conservation and Development Commission: report: real-time pricing: electrical corporation: procurement plans.

(1) Existing law requires the State Energy Resources Conservation and Development Commission (Energy Commission) to conduct an ongoing assessment of the opportunities and constraints presented by all forms of energy.

Under existing law, the Public Utilities Commission is required to conduct a pilot study of real-time metering for nonresidential customers, to determine the effectiveness of real-time metering in reducing energy demand and overall energy consumption, to examine customer response, to determine how real time metering should be implemented, and to determine whether more widespread use of real-time metering is in the public interest. Real-time metering is a system for measuring a customer's usage of electricity on at least an hourly basis, variably pricing that electricity based on the cost of acquisition or production, and regularly providing and updating that usage and pricing information to the customer.

This bill would require the commission, in consultation with the Public Utilities Energy Commission, to report to the Legislature and the Governor, by March 31, 2003, regarding the feasibility of implementing real-time, critical peak, and other dynamic pricing tariffs for electricity in California, as strategies which can either reduce peak demand or shift peak demand load to off-peak periods.

(2) The Public Utilities Act imposes various duties and responsibilities on the Public Utilities Commission with respect to the purchase of electricity.

The bill would amend the act to require the commission to review and adopt a procurement plan for each electrical corporation in accordance with elements, incentive mechanisms, and objectives set forth in the bill.

The bill would authorize the commission to engage an independent consultant or advisory service to evaluate risk management and strategy.

The bill would require the commission to adopt appropriate procedures to ensure the confidentiality of any market sensitive information submitted in an electrical corporation's proposed procurement plan or resulting from or related to its approved procurement plan, and to determine the impact of a proposed divestiture on an electrical corporation's procurement plan.

The bill would allow an electrical corporation that serves less than 500,000 retail customers within the state to file with the commission a request for exemption from the provisions of the bill. The bill would require the commission to grant the exemption upon a showing of good cause.

(3) Existing law makes a violation of the provisions of the act a crime.

This bill, by imposing new requirements on electrical corporations, would expand the scope of that crime, and thus impose a state-mandated local program.

(4) The California Constitution requires the state to reimburse local agencies and school districts for certain costs mandated by the state. Statutory provisions establish procedures for making that reimbursement.

This bill would provide that no reimbursement is required by this act for a specified reason.

(5) This bill would declare that it is to take effect immediately as an urgency statute.

The people of the State of California do enact as follows:

SECTION 1. The Legislature finds and declares all of the following:

(a) Californians can significantly increase the reliability of the electricity system and reduce the level of wholesale electricity prices by reducing electricity usage at peak times through a variety of measures designed to reduce electricity consumption during those periods.

(b) Dynamic pricing, including real-time pricing, provides incentives to reduce electricity consumption in precisely those hours when supplies are tight and provides lower prices when wholesale prices are low.

(c) The State of California, through Assembly Bill 29 of the 2001–02 First Extraordinary Session, has already invested thirty-five million dollars ($35,000,000) in real-time metering systems for customers who consume greater than 200 kilowatts.

(d) Real-time pricing integrates information technology into the energy business, and creates new markets for communications, microelectronic controls, and information.

(e) Electricity consumption for air conditioning purposes during peak demand periods significantly contributes to California's electricity shortage vulnerability during summer periods.

(f) It is the intent of the Legislature to promote energy conservation and demand reduction in the State of California.

SEC. 2. (a) On or before March 31, 2003, the State Energy Resources Conservation and Development Commission, in consultation with the Public Utilities Commission, shall report to the Legislature and the Governor regarding the feasibility of implementing real-time pricing, critical peak pricing, and other dynamic pricing tariffs for electricity in California, as strategies which can either reduce peak demand or shift peak demand load to off-peak periods.

(b) The report shall consider all of the following:

(1) How wholesale real-time prices would be calculated and made available to customers.

(2) Options for day-ahead and hour-ahead retail prices.

(3) Options for facilitating customer response to real-time and critical peak prices and managing total customer costs, including, but not limited to, interval metering and communication systems, consumer-side of the meter notification, and automatic response equipment.

(4) An assessment of the options for a variety of customer classes, including, but not limited to, industrial, commercial, residential, and tenants of a mobilehome park, apartment building, or similar residential complex, that receive electricity from a master-meter customer through a submetered system.

(5) Estimates of potential peak load reductions, including the shifting of peak load demand to off-peak periods.

(6) Options for incorporating demand responsiveness into the wholesale competitive market and operations of the California Independent System Operator.

(7) Options for ensuring customer protection under a real-time, critical peak, and other dynamic pricing scenarios, including identifying potentially disadvantaged groups who may be disproportionately vulnerable to the impact of volatile prices and suggestions for effective safeguards for those customers.

SEC. 3. Section 454.5 is added to the Public Utilities Code, to read:

454.5. (a) The commission shall specify the allocation of electricity, including quantity, characteristics, and duration of electricity delivery, that the Department of Water Resources shall provide under its power purchase agreements to the customers of each electrical corporation, which shall be reflected in the electrical corporation's proposed procurement plan. Each electrical corporation shall file a proposed procurement plan with the commission not later than 60 days after the commission specifies the allocation of electricity. The proposed procurement plan shall specify the date that the electrical corporation intends to resume procurement of electricity for its retail customers, consistent with its obligation to serve. After the commission's adoption of a procurement plan, the commission shall allow not less than 60 days before the electrical corporation resumes procurement pursuant to this section.

(b) An electrical corporation's proposed procurement plan shall include, but not be limited to, all of the following:

(1) An assessment of the price risk associated with the electrical corporation's portfolio, including any utility-retained generation, existing power purchase and exchange contracts, and proposed contracts or purchases under which an electrical corporation will procure electricity, electricity demand reductions, and electricity-related products and the remaining open position to be served by spot market transactions.

(2) A definition of each electricity product, electricity-related product, and procurement related financial product, including support and justification for the product type and amount to be procured under the plan.

(3) The duration of the plan.

(4) The duration, timing, and range of quantities of each product to be procured.

(5) A competitive procurement process under which the electrical corporation may request bids for procurement-related services, including the format and criteria of that procurement process.

(6) An incentive mechanism, if any incentive mechanism is proposed, including the type of transactions to be covered by that mechanism, their respective procurement benchmarks, and other parameters needed to determine the sharing of risks and benefits.

(7) The upfront standards and criteria by which the acceptability and eligibility for rate recovery of a proposed procurement transaction will be known by the electrical corporation prior to execution of the transaction. This shall include an expedited approval process for the commission's review of proposed contracts and subsequent approval or rejection thereof. The electrical corporation shall propose alternative procurement choices in the event a contract is rejected.

(8) Procedures for updating the procurement plan.

(9) A showing that the procurement plan will achieve the following:

(A) The electrical corporation will, in order to fulfill its unmet resource needs and in furtherance of Section 701.3, until a 20 percent renewable resources portfolio is achieved, procure renewable energy resources with the goal of ensuring that at least an additional 1 percent per year of the electricity sold by the electrical corporation is generated from renewable energy resources, provided sufficient funds are made available pursuant to Section 399.6, to cover the above-market costs for new renewable energy resources.

(B) The electrical corporation will create or maintain a diversified procurement portfolio consisting of both short-term and long-term electricity and electricity-related and demand reductions products.

(10) The electrical corporation's risk management policy, strategy, and practices, including specific measures of price stability.

(11) A plan to achieve appropriate increases in diversity of ownership and diversity of fuel supply of nonutility electrical generation.

(12) A mechanism for recovery of reasonable administrative costs related to procurement in the generation component of rates.

(c) The commission shall review and accept, modify, or reject each electrical corporation's procurement plan. The commission's review shall consider each electrical corporation's individual procurement situation, and shall give strong consideration to that situation in determining which one or more of the features set forth in this subdivision shall apply to that electrical corporation. A procurement plan approved by the commission shall contain one or more of the following features, provided that the commission may not approve a feature or mechanism for an electrical corporation if it finds that the feature or mechanism would impair the restoration of an electrical corporation's creditworthiness or would lead to a deterioration of an electrical corporation's creditworthiness:

(1) A competitive procurement process under which the electrical corporation may request bids for procurement-related services. The commission shall specify the format of that procurement process, as well as criteria to ensure that the auction process is open and adequately subscribed. Any purchases made in compliance with the commission-authorized process shall be recovered in the generation component of rates.

(2) An incentive mechanism that establishes a procurement benchmark or benchmarks and authorizes the electrical corporation to procure from the market, subject to comparing the electrical corporation's performance to the commission-authorized benchmark or benchmarks. The incentive mechanism shall be clear, achievable, and contain quantifiable objectives and standards. The incentive mechanism shall contain balanced risk and reward incentives that limit the risk and reward of an electrical corporation.

(3) Upfront achievable standards and criteria by which the acceptability and eligibility for rate recovery of a proposed procurement

transaction will be known by the electrical corporation prior to the execution of the bilateral contract for the transaction. The commission shall provide for expedited review and either approve or reject the individual contracts submitted by the electrical corporation to ensure compliance with its procurement plan. To the extent the commission rejects a proposed contract pursuant to this criteria, the commission shall designate alternative procurement choices obtained in the procurement plan that will be recoverable for ratemaking purposes.

(d) A procurement plan approved by the commission shall accomplish each of the following objectives:

(1) Enable the electrical corporation to fulfill its obligation to serve its customers at just and reasonable rates.

(2) Eliminate the need for after-the-fact reasonableness reviews of an electrical corporation's actions in compliance with an approved procurement plan, including resulting electricity procurement contracts, practices, and related expenses. However, the commission may establish a regulatory process to verify and assure that each contract was administered in accordance with the terms of the contract, and contract disputes which may arise are reasonably resolved.

(3) Ensure timely recovery of prospective procurement costs incurred pursuant to an approved procurement plan. The commission shall establish rates based on forecasts of procurement costs adopted by the commission, actual procurement costs incurred, or combination thereof, as determined by the commission. The commission shall establish power procurement balancing accounts to track the differences between recorded revenues and costs incurred pursuant to an approved procurement plan. The commission shall review the power procurement balancing accounts, not less than semiannually, and shall adjust rates or order refunds, as necessary, to promptly amortize a balancing account, according to a schedule determined by the commission. Until January 1, 2006, the commission shall ensure that any overcollection or undercollection in the power procurement balancing account does not exceed 5 percent of the electrical corporation's actual recorded generation revenues for the prior calendar year excluding revenues collected for the Department of Water Resources. The commission shall determine the schedule for amortizing the overcollection or undercollection in the balancing account to ensure that the 5 percent threshold is not exceeded. After January 1, 2006, this adjustment shall occur when deemed appropriate by the commission consistent with the objectives of this section.

(4) Moderate the price risk associated with serving its retail customers, including the price risk embedded in its long-term supply

contracts, by authorizing an electrical corporation to enter into financial and other electricity-related product contracts.

(5) Provide for just and reasonable rates, with an appropriate balancing of price stability and price level in the electrical corporation's procurement plan.

(e) The commission shall provide for the periodic review and prospective modification of an electrical corporation's procurement plan.

(f) The commission may engage an independent consultant or advisory service to evaluate risk management and strategy. The reasonable costs of any consultant or advisory service is a reimbursable expense and eligible for funding pursuant to Section 631.

(g) The commission shall adopt appropriate procedures to ensure the confidentiality of any market sensitive information submitted in an electrical corporation's proposed procurement plan or resulting from or related to its approved procurement plan, including, but not limited to, proposed or executed power purchase agreements, data request responses, or consultant reports, or any combination, provided that the Office of Ratepayer Advocates and other consumer groups that are nonmarket participants shall be provided access to this information under confidentiality procedures authorized by the commission.

(h) Nothing in this section alters, modifies, or amends the commission's oversight of affiliate transactions under its rules and decisions or the commission's existing authority to investigate and penalize an electrical corporation's alleged fraudulent activities, or to disallow costs incurred as a result of gross incompetence, fraud, abuse, or similar grounds. Nothing in this section expands, modifies, or limits the State Energy Resources Conservation and Development Commission's existing authority and responsibilities as set forth in Sections 25216, 25216.5, and 25323 of the Public Resources Code.

(i) An electrical corporation that serves less than 500,000 electric retail customers within the state may file with the commission a request for exemption from this section, which the commission shall grant upon a showing of good cause.

(j) (1) Prior to its approval pursuant to Section 851 of any divestiture of generation assets owned by an electrical corporation on or after the date of enactment of the act adding this section, the commission shall determine the impact of the proposed divestiture on the electrical corporation's procurement rates and shall approve a divestiture only to the extent it finds, taking into account the effect of the divestiture on procurement rates, that the divestiture is in the public interest and will result in net ratepayer benefits.

(2) Any electrical corporation's procurement necessitated as a result of the divestiture of generation assets on or after the effective date of the act adding this subdivision shall be subject to the mechanisms and procedures set forth in this section only if its actual cost is less than the recent historical cost of the divested generation assets.

(3) Notwithstanding paragraph (2), the commission may deem proposed procurement eligible to use the procedures in this section upon its approval of asset divestiture pursuant to Section 851.

SEC. 4. No reimbursement is required by this act pursuant to Section 6 of Article XIII B of the California Constitution because the only costs that may be incurred by a local agency or school district will be incurred because this act creates a new crime or infraction, eliminates a crime or infraction, or changes the penalty for a crime or infraction, within the meaning of Section 17556 of the Government Code, or changes the definition of a crime within the meaning of Section 6 of Article XIII B of the California Constitution.

SEC. 5. This act is an urgency statute necessary for the immediate preservation of the public peace, health, or safety within the meaning of Article IV of the Constitution and shall go into immediate effect. The facts constituting the necessity are:

In order to determine the feasibility of dynamic pricing as soon as possible, and in order that the Public Utilities Commission may undertake the review and approval of each electric corporation's procurement plan at the earliest possible time in a manner consistent with this act, it is necessary that this act take effect immediately.

O

Exhibit "F"
Tamarkin Testimony
CPUC Rulemaking No. 02-06-001

Senator Tom Torlakson
Letter to Commissioner Michael Peevey, CPUC
dated December 2, 2003

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December 2, 2003

Commissioner Michael Peevey, President
California Public Utilities Commission
505 Van Ness Avenue
San Francisco, California 94102

Dear ~~Mr. Peevey~~: Michael

Thank you for taking time the other day to return my call about the Public Utility Commission's draft grant response on the Los Angeles County pilot project to install electricity usage display panels in an affordable housing project.

I am a great believer in the positive effects real-time information will have on customer behavior and its tremendous potential to promote conservation for residential consumers.

USCL Corporation's display panel, the EMS-2020, allows consumers to observe their energy usage as it occurs, rather than on a monthly basis as is now the case. This enables consumers to take control of their energy usage and their electricity bills. I have seen the product demonstrated and believe in the benefits California could reap with the large scale use of this and similar products.

The pilot project in Los Angeles will test whether the information provided via an in-home usage display panel will reduce peak demand for energy, thus reducing the need for utilities to fire up their oldest dirtiest plants. I believe that the pilot program USCL plans on running in Los Angeles County will provide evidence that people, who can see what they are spending, will conserve.

Thank you again for your consideration of the grant proposal to install USCL's display panels in these Los Angeles homes.

Sincerely,

Tom

Tom Torlakson

TT:cc

Exhibit "G"
Tamarkin Testimony
CPUC Rulemaking No. 02-06-001

"Making it obvious: designing feedback into energy consumption"
by Dr. Sarah Darby, Oxford University

Making it obvious: designing feedback into energy consumption

Sarah Darby
Environmental Change Institute, University of Oxford

ABSTRACT

The process of giving feedback on consumption motivates consumers to save energy through reduced waste, yet the body of evidence testifying to this is rarely acted upon in any systematic way. The paper reviews the literature on the effectiveness of three types of feedback to domestic consumers: direct feedback in the home, indirect feedback via billing and 'inadvertent' feedback (a by-product of technical, household or social changes). The lessons learned on the importance of clear, immediate and user-specific information are then applied in a survey of the opportunities for better feedback to consumers in terms of technology, design and location of meters and display panels, energy billing and services such as audits and advice programmes.

The paper concludes that feedback has a significant role to play in raising energy awareness and in bringing about reduced consumption of the order of 10%; and that opportunities exist for designing it into energy-related systems which have yet to be realised.

INTRODUCTION

While some aspects of energy usage may be highly visible, domestic energy consumption as such is largely hidden from view. This 'invisibility' hampers our ability to learn about how to use energy more intelligently and less wastefully. Evidence from the survey of implementation of the EU directive on labelling of cold appliances in the EU indicates that 'the message about energy saving and the environment has been noted by consumers in every country', but that few actually link the importance of energy saving to their own personal behaviour (Winward et al, 1998). 'Noting' a message is clearly not enough to spur people to action: much work remains to be done to build on a low level of awareness of a need to save energy, by developing peoples' ability to identify what can be done in *specific* terms to improve the situation.

This paper begins an investigation into *the extent to which householders can teach themselves* about energy usage in the way in which they teach themselves about so many other things: by using feedback signals from their own actions and their own consumption.

CONCEPTUALISING ENERGY

How do we think of energy? At the level of the individual consumer, in three main ways: as a commodity, a social necessity and an ecological resource (though see Sheldrick and Macgill, 1988, for a fuller account). All of these suggest ways of making consumption more visible, while pointing to shortcomings in policy and practice aimed at carbon reductions.

1. Energy is a *commodity*: much policy is based on this conception. With the liberalisation of utilities, customers have become more aware of fuel price, but most only have fleeting contact with the financial cost of their energy services, when they receive a bill or bank statement or if they change their fuel supplier. Those who are constantly reminded of their usage because they rely on solid or 'packaged' fuel, or because they pay in advance for energy, are in a minority. For the rest, individual metering and prepayment send stronger signals about usage than group metering and payment in arrears (Birka Teknik og Miljo, 1999). For the majority who pay in arrears for their energy, billing can be developed in ways which send more frequent and clearer messages to customers (Kempton, 1995; Wilhite and Ling, 1992).

2. Energy is a *basic human need*: in that sense, it is most noticeable when in short supply. Users of modern energy systems, and especially those living in poverty, need to be able to understand how to control their energy to best effect and to have access to help when it is needed. Feedback and information systems must be as accessible, clear and simple as possible in order to allow for this.

3. Energy is an *ecological resource* – that is, energy use never occurs without side-effects. Production of energy for human use requires mining, tree felling, the growing of fuel crops, gas and oil extraction, the construction of dams, pipelines, power lines and power stations. Some of this production may be highly visible in a localised way, so that there is a vague awareness of the ecological dimension of energy; but electricity and gas, along with carbon dioxide and other waste gases, are largely invisible in consumption. This invisibility comes about in a number of ways: through connection to huge hidden distribution networks; through lack of thought about energy unless it becomes expensive or suddenly scarce; through design for convenience or utility rather than for visibility and learning; and through obscure metering and billing systems.

These conceptions of energy show consumption to have extensive financial, social, ecological and cultural aspects that are inadequately recognised, not least because they are often obscured. It is becoming more and more clear that existing policies aimed at increased efficiency, fuel switching and development of renewables cannot bring about savings in carbon in the timescale necessary to stave off significant climate change. The recent UK study of *Lower Carbon Futures*, for example, concludes that a scenario which does not involve any change to lifestyle, behaviour or standards of service 'will not achieve, by 2020, the reductions in carbon emissions needed to achieve sustainability by 2100. To do so requires behavioural change. Some of this can be encouraged through policy changes, particularly provision of information and feedback to consumers' (Fawcett et al, 2000).

HOW FEEDBACK WORKS

Feedback is defined as *The modification, adjustment or control of a process or system … by a result/effect of the process, especially by a difference between a desired and an actual result; information about the result of a process, experiment etc; a response.*

Oxford English Dictionary, 2000

This definition is here applied to the process of learning. Observation of a young child quickly shows how fundamental feedback is as an element in early learning, but we tend to forget that it remains crucial throughout life:

> *We are obliged to act…as intelligently as possible in a world in which…we know very little, in which, even if the experts know more than we do, we have no way of knowing which expert knows the most. In other words, we are obliged to live out our lives thinking, acting, judging on the basis of the most fragmentary and uncertain and temporary information. The point of all this is that this is what very young children are good at doing…The young child is continually building what I like to call a mental model of the world, the universe, and then checking it against reality as it presents itself to him, and then tearing it down and rebuilding it as necessary…We have got to learn…this business of continually comparing our mental model against reality and being willing to check it, modify it, change it, in order to take account of circumstances.* - Holt, 1970

Such an approach to learning helps to explain why environmental information and education do not necessarily lead to behavioural change. Learning is an active process and learning about practical issues is related to 'reality as it presents itself'. Environmental policy aimed at reducing energy use has failed so far to recognise adequately the crucial link between our (generalised) sense of our environment and our (specific) daily needs and actions: there is a need to extend expertise much more widely and to do so by focusing on how people *connect* their lives to the environment (Eden, 1996)

Policymakers have a major contribution to make in providing a 'toolkit' for householders that enables them to learn how to do this. Such a toolkit can be immediate and tangible – as with better direct displays of energy use – but the concept can also be extended to the cultural context (see, for example, Bruner, 1996). Opportunities for learning about energy from the daily usage in homes could connect with learning in the local community, or from interactions with utilities, government and government agencies.

Two general approaches to cutting carbon can be observed. The first begins with identification of carbon reduction targets and aims to meet them in the most efficient way by identifying promising areas for reduction in the hope of persuading or ordering people to implement the necessary actions. The second begins from existing patterns of energy use in their cultural context and looks at needs and aspirations, aiming to identify processes by which people might come to use energy in more environmentally-friendly ways. This paper is concerned more with the second approach: with the processes by which people may learn, by trial and error, to use energy in an ecological fashion.

FORMS OF FEEDBACK

The literature on feedback on domestic energy use is limited, but it does supply some pointers as to the approaches most likely to be successful in bringing about energy conservation. A typology, with some examples, provides an outline of what is possible:

A. Direct feedback: available on demand. Learning by looking or paying.

(a) *Direct displays*, such as those tested in Canada and Japan (Dobson and Griffin, 1992; Tanabe, 2000). Customers who have their supply metered in the standard way are unlikely to consult their meter: it will probably be hidden away and difficult to understand. Some more attractive and user-friendly displays of energy usage have now been tested, and the indications are that these do lead to energy savings as well as to increased awareness (eg Tanabe, 2000; Mansouri and Newborough, 1999). An additional benefit is likely to be that better-designed meters will have an appeal because of they will be seen as high quality products: this appears to be the case with high-efficiency cold appliances (Winward et al, ibid).

(b) *Interactive feedback* via a PC has shown promise and is an obvious candidate for further development (Brandon and Lewis, 1999). Some utilities (eg Scottish and Southern Energy) already offer this service to large business customers.

(c) *Smart meters*. Possibilities include meters operated by smart cards (Birka Teknik & Miljo, 1999) and two-way (automatic) metering (Sidler and Waide, 1999; Kennedy, 1999).

(d) *Trigger devices/consumption limiters*. These are contentious because they can cut the supply of low-income consumers. However, there are possible solutions to this, such as that in use by EdF for providing such customers with help from social services (Ranninger, pers comm.)

(e) *Prepayment meters.* The continued usage of these meters by consumers on low incomes in the UK - in spite of the extra cost - is an indication of the high importance attached to debt avoidance and the value of direct feedback to people with limited resources (Doble, 1999).

(f) *Self-meter-reading*. The review below shows the value of this as part of an effective feedback programme.

(g) *Meter reading with an adviser*, as a tool in energy advice programmes (see LEEP, 1996; Harrigan, 1992).

(h) *Cost plugs* or similar devices on appliances (though they tend to be complicated to operate and can be unreliable).

B. Indirect feedback – raw data processed by the utility and sent out to customers. Learning by reading and reflecting.

(a) *More frequent bills*, based on meter readings rather than estimates (Wilhite and Ling, 1992; Arvola et al, 1994).

(b) *Frequent bills based on readings plus historical feedback* - comparison with the same period of the previous year, weather-adjusted. (Wilhite and Ling, 1995).
(c) *Frequent bills based on readings plus normative feedback* - comparison with similar households. (Kempton and Layne, 1994; Wilhite et al, 1999).
(d) *Frequent bills plus disaggregated feedback.* This is relatively expensive, though popular when tested (Wilhite et al, 1999). The NIALMS and DIACE systems allow for automatic end-use breakdown by pattern recognition (Sidler and Waide, 1999).
(e) *Frequent bills plus offers of audits or discounts on efficiency measures.* Frequent, informative bills can stimulate a demand for audits by raising awareness (see Lord et al, 1996).
(f) *Frequent bills plus detailed annual or quarterly energy reports.* See Wilhite et al (1999) and Kempton (1995).

C. Inadvertent feedback – learning by association

There is little in the way of literature on this, but there are pointers to the potential for such feedback.

(a) *New energy-using equipment* in the home, when a person moves house or when there are changes in the physical fabric of the dwelling, provides an opening for effective 'opportunistic' advice (Green et al, 1998).
(b) With the advent of solar water heaters and photovoltaic arrays, the home can become a site for *generation* as well as consumption of power and it is highly likely that this causes increased observation of energy use and a shift in thinking.
(c) A further possibility for inadvertent feedback is the development of community energy conservation projects, with their potential for *social learning* (see, for example, Sharpe and Watts, 1992).

Two further types are worth noting in passing. They are:

D. Utility-controlled feedback – learning about the customer

Utility-controlled feedback is not designed with householders' learning in mind, but it is rapidly being developed and debated with a view to better load management.

E. Energy audits

Audits are included here because they provide vital baseline information on the 'energy capital' of a dwelling as well as giving guidance on how to improve it. Audits may be

(a) undertaken by a surveyor on the client's initiative
(b) undertaken as part of a mortgage or other mandatory survey
(c) *carried out on an informal basis by the consumer* using freely available software such as HESTIA or the UK 'EcoCal'. A series of audits can give a stream of feedback, guiding a motivated consumer towards a target consumption. More formal audits are likely to be infrequent, but can still indicate degrees of progress.

The diagram in Figure 1 shows some of the types on two axes, approximately related to the level of immediacy and the extent to which the energy user is in control of finding and using the information:

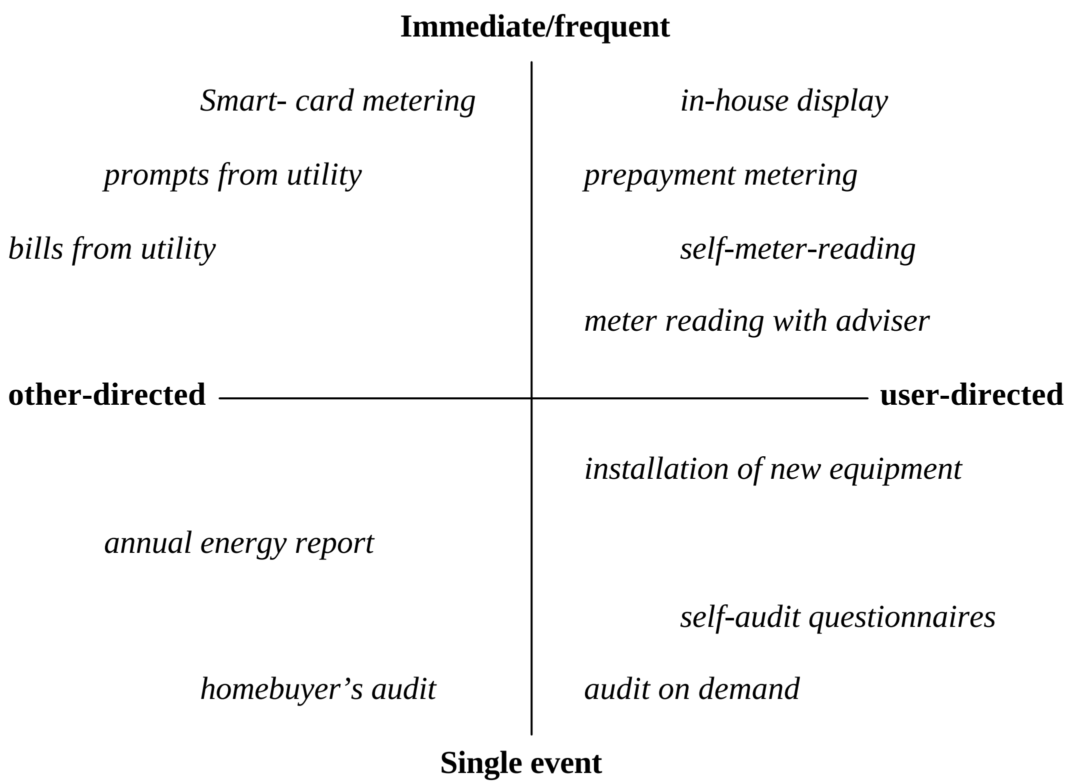

Figure 1: feedback in terms of immediacy and control

If feedback is to promote learning, the discussion above would suggest that immediacy and control of the process by the user would tend to lead to the most effective feedback. What does the literature show?

FEEDBACK EFFECTIVENESS – A REVIEW

A review of 38 feedback studies carried out over a period of 25 years demonstrated the possibilities of some types of feedback and also some of the issues which affect interpretation of the results. A number of difficulties arise in comparing, and even categorising, these studies: all contain a different mix of elements such as sample size (from three to 2,000), housing type, additional interventions such as insulation or the provision of financial incentives to save, and feedback frequency and duration. The timing of the study itself may also be significant in relation to the energy politics and research paradigms of the period. In spite of these areas of uncertainty, though, some lessons can be learned from the review.

First, feedback has a significant part to play in bringing about energy awareness and conservation. Savings achieved by the 38 projects were as follows:

Table 1: savings demonstrated by the feedback studies

Savings	**Direct feedback studies** (n=21)	**Indirect feedback studies** (n=13)	**Studies 1987-2000** (n=21)	**Studies 1975-2000** (n=38)
20%	3		3	3
20% of peak			1	1
15-19%	1	1	1	3
10-14%	7	6	5	13
5-9%	8		6	9
0-4%	2	3	4	6
unknown		3	1	3

Awareness is more difficult to assess, but an increase in awareness was noted in half of the studies and some continuing or additional effect in 11.

While it is not possible here to go into the detail of each study, it appears that *direct feedback*, alone or in combination with other factors, is the most promising single type, with almost all of the projects involving direct feedback producing savings of 5% or more. The highest savings – in the region of 20% - were achieved by using a table-top interactive cost- and power- display unit; a smart-card meter for prepayment of electricity (coinciding with a change from group to individual metering); and an indicator showing the cumulative cost of operating an electric cooker. In the absence of a special display or a PC display, the feedback was supplied by the reading of standard household meters, sometimes accompanied by the keeping of a chart or diary of energy use. The implication that this meter-reading was a factor in reducing consumption demonstrates how seldom people normally consult their meters (probably hidden away) and/or convert their readings into useful information.

Direct feedback in conjunction with some form of advice or information gave savings in the region of 10% in four programmes aimed at low-income households (with constant or improved levels of comfort), indicating the potential for feedback to be incorporated into advice programmes on a regular basis.

Providing direct financial incentives for consumers to save energy (a method tested during the late 1970s) made little lasting impact: consumption reverted to what it had been once the incentive was removed. Cost signals need to be long-term to have a durable effect.

Where *indirect feedback* is concerned, the range of savings achieved does not go so high, although significant levels are still achievable at relatively low cost (eg Wilhite and Ling, 1995). There was also agreement between most of the studies that interest and awareness levels of consumers were raised as a result of supplying informative bills. One study (Garay and Lindholm, 1995) found no savings at all (but increased customer satisfaction) after providing bills for electricity and water with historical and normative feedback over a period of 18 months. This was an unusual outcome but interesting in that it pointed to at least one possible reason for the lack of change: many of the customers were users of district heating and it could be that they feel less incentive to save than others because of a perception that the heat would be available whether or not they made use of it.

Only three of the studies might be thought of as *inadvertent feedback,* as defined above, but they give an idea of the possibilities for learning using novel technology or situations. The first involved a cable service to over 600 electricity customers which combined energy information to the householder with automatic meter reading, load control by the utility and time-of-use pricing This produced average bill savings (not necessarily energy savings) of 7-10% along with a 2kW peak demand reduction per household (Goldman et al, 1998). The second and third, both unpublished small-scale projects reviewed by Ellis and Gaskell (1978) contained 'trigger' signals which went on when the outside temperature dropped below 68F or when the electricity load went above a specified amount. They achieved a 16% reduction in air-conditioning consumption and a 'moderate' reduction in peak load respectively.

Finally, one community programme involved energy audits for 1,600 households followed by subsidised retrofitting according to customer choice (Sharpe and Watts, ibid). The whole programme was estimated to have achieved a reduction of 20% in peak demand: it could be argued that this was solely due to physical measures, but the strong emphasis on participation and learning suggests a contribution from inadvertent feedback.

In general, there does not seem to be any correlation between the scale of a project and the outcome in terms of reported savings and awareness: the spread of results for the 12 larger-scale projects, with experimental samples of 200-2000, mirrors that for the whole range of studies. Similarly, the best-documented studies show a spread of outcomes which parallels that of the whole range. When the more recent studies are compared with those carried out over the whole 25-year period, the ratio of 'successful' ones (5%+ or 10%+ savings) to the whole is almost exactly the same (although the four most effective projects in terms of savings were all carried out from 1992 onwards).

The implication is that all those studies which demonstrated some effectiveness had enough of a common element (or elements) to succeed; or that they compensated for lack of one element with another. It could be, as a minimal explanation, that *any* intervention helps if it triggers householders into examining their consumption. It could also be that the personal attention of the experimenters motivated the householders into action. However, the documentation of these feedback projects points strongly to other factors at work, of which immediacy or accessibility of feedback data - allowing the householder to be in control - are highly important, accompanied by clear information that is specific to the household in question. Provision of such data is coming well within reach in terms of the technical possibilities for metering, appliance and heating system design. It also requires political determination if it is to be implemented soon.

Feedback is a necessary but not always a sufficient condition for savings and awareness. It should not be treated in isolation: this is also a clear lesson from this review. The range of savings, as well as the accompanying detail, shows the importance of factors such as the condition of housing, personal contact with a trustworthy advisor when needed, and the support from utilities and government which can provide the technical, training and social infrastructure to make learning and change possible.

CONCLUSION

Feedback is an essential element in effective learning: this is as true of domestic energy use as of anything else. A variety of feedback types can be identified and the literature on three – direct, indirect and inadvertent – indicates that they have a significant role to play in raising energy awareness and in bringing about reduced consumption of the order of 10%.

A number of lessons emerge from the literature. Metering displays should be provided for each individual household in a form that is accessible, attractive and clear. Signals which are activated when a given load is exceeded may have potential – though not in isolation, without the means to learn from them - but need testing with great caution, especially where low-income households are concerned. Informative billing, designed and tested on customers before becoming widely available, shows promise as a means of raising awareness. Audits can provide baseline information on each dwelling and are increasingly used to assess the quality of the housing stock. The language of the audit should fit with that of the utility and the householder: there should be a common language for maximum clarity.

Feedback implies monitoring, which can be used at an individual or at a collective level: design for feedback should take this into account, as debate on whether energy-saving initiatives are reaching their goals is often ill-informed. Finally, new technologies are making possible generation of power at a household level, automatic and highly sophisticated metering and more detailed communication between utilities and customers. All these developments hold out the possibility for improved learning and control of energy use, if handled with attention to the principles of immediacy, clarity and specificity.

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Exhibit "H"
Tamarkin Testimony
CPUC Rulemaking No. 02-06-001

"Commodity Treatment of Electricity Pay as you Go/
Consumption Awareness"

Presented by Woodstock Hydro
Real Time Energy Feedback Forum
Toronto, Canada
May 17 and 18, 2005

Commodity Treatment of Electricity

Pay as you Go / Consumption Awareness

Overview

- The Woodstock Hydro Experience
- Customer Reaction/Behavior
- Customer Benefits
- The Empowered Consumer

Woodstock Hydro Experience

- “Pay as you Go” program initiated in 1989
- Utility was seeking to lower customer care costs
- 25% of residential customers on the “Pay as you Go” program
- High bill complaints virtually eliminated

Customer Reaction/Behavior

- High level of acceptance
- Purchasing pattern mimics that of auto fuel purchases
- Electricity is now on the shopping list

Customer Benefits

- Gains awareness of the commodity and their consumption
- Ability to monitor and therefore manage
- No Surprises
- Real time priority setting

In Home Display

- Cost per hour $.....
- Cost today $......
- Cost yesterday $.....
- Cost this Month $......
- Cost last month $......
- Remaining credit $......
- Current Rate $...../per hour (vary due to TOU rates)

The Empowered Consumer

- “Pay as you go” establishes a different relationship with energy provider
- The Consumer adopts a new concept of what the roles and responsibilities are of themselves and the energy provider
- Consumption awareness of energy places it in same group as most other commodities

What is the most significant benefit of consumption awareness?

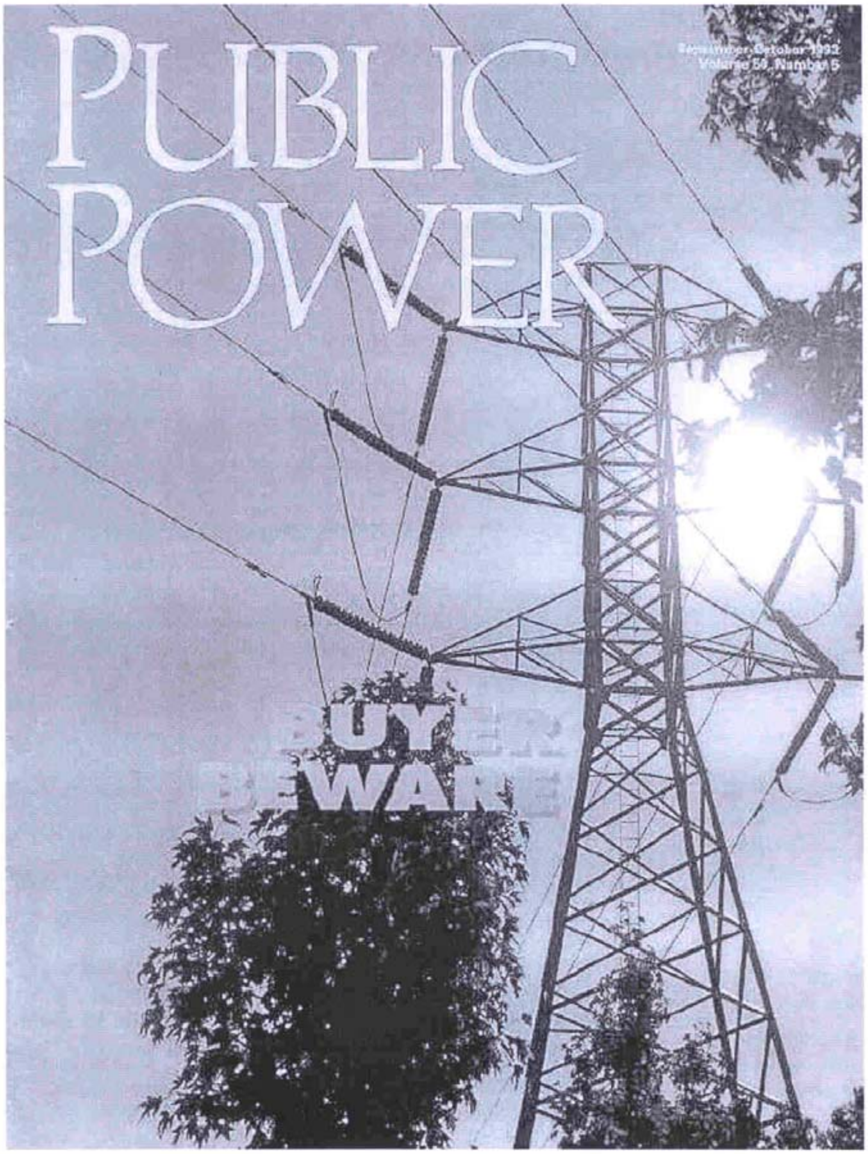
- The true Commodity Treatment of Electricity

Exhibit "I"
Tamarkin Testimony
CPUC Rulemaking No. 02-06-001

"Automatic Meter Reading Systems"
Public Power Magazine, October 1992
by, Tom D. Tamarkin

Automatic Meter Reading

by Tom D. Tamarkin



as published in *Public Power* magazine

Volume 50, Number 5
September-October 1992

Automatic meter reading (AMR) was first tested 30 years ago when trials were conducted by AT&T in cooperation with a group of utilities and Westinghouse. After those successful experiments, AT&T offered to provide phone system-based AMR services at $2 per meter. The price was four times more than the monthly cost of a person to read the mcter-50 cents. Thus the program was considered economically unfeasible.

The modern era of AMR began in 1985, when several major full-scale projects were implemented. Hackensack Water Co. and Equitable Gas Go. were the first to commit to full-scale implementation of AMR on water and gas meters, respectively. In 1986, Minnegasco initiated a 450,000-point radio-based AMR system. In 1987, Philadelphia Electric Co., faced with a large number of inaccessible meters, installed thousands of distribution line carrier AMR units to solve this problem. Thus, AMR is becoming more viable each day. Advances in solid-state electronics, microprocessor components and low-cost surface-mount technology assembly techniques have been the catalyst to produce reliable cost-effective products capable of providing the economic and human benefits that justify use of AMR systems on a large, if not full-scale, basis.

Automatic meter reading systems consist of three primary components:

1. **Meter interface module** with power supply, meter sensors, controlling electronics and a communication interface that allows data to be transmitted from this remote device to a central location. In many instances, this communication interface is bi-directional and allows central office signals to be received by the remote unit as well. Every electric, gas or water meter must have such an interface unit to be remotely read. Some key components of the remote device may be shared by more than one meter without regard for the type of meter; i.e.., electric, gas or water.

2. **Communications systems** used for the transmission, or telemetry, of data and control send signals between the meter interface units and the central office. Typically, such communications take the form of telephone, powerline carrier (plc), radio frequency (RF), or cable television. The system components in the communications system depend on the communication media used.

"The AMR system starts at the meter. Some means of translating readings from rotating meter

3. **Central office systems equipment** including modems, receivers, data concentrators, controllers, host upload links, and host computer. Many utilities have for some time been taking advantage of electronic meter reading systems using hand-held data terminals that communicate with a central controller via phone lines. There is great similarity between the host side electronic meter reading and automatic meter reading system function.

dials, or cyclometer style meter dials, into digital form is necessary in order to send digital metering data from the customer site to a central point.

There are three major building block functions that the meter interface and related electronics must perform. These are common to electric, gas and water implementations. First, an electromechanical or electro-optical interface must be incorporated into or attached to the meter. This converts information conveyed by the meter's mechanical register indexes, or dial readings, into electronic signals which may be processed, manipulated, stored and transmitted.

The second functional building block is a controller unit consisting of a low-voltage power supply, signal processing electronics, microcomputer, random access memory and program memory used to store the real-time run or operating system program. The controller unit is used to process the signals originating from the meter's electromechanical or electro-optical interface device. In effect, the controller unit converts the meter's electromechanical interface device signals into computer type electronic digital representations of the meter's exact index or dial readings-much as a calculator converts keypad entries into numbers appearing on the display. The controller's RAM memory maintains an up-to-the-minute mirror image of the meter's dials and as the dials increment, so do the numerical representations stored in RAM.

The third functional building block is the communication scheme and its associated transmit/receive electronics. Generally, meter-to-utility host communications use one or more transmission techniques: telephone, powerline carrier, radio frequency through the airwaves, or television cable. There are many sub-categories of each of these communication forms having to do with data flow, modulation techniques, distance from remote site to central station and data transmission rates.

The AMR system starts at the meter. Some means of translating readings from rotating meter dials, or cyclometer style meter dials, into digital form is necessary in order to send digital metering data from the customer site to a central point. In most cases, the meter that is used in an AMR system is the same ordinary meter used for manual reading. The internal mechanism used for metering consumption is identical in both cases. The one difference is the addition of some device to generate pulses relating to the amount of consumption monitored, or generate an electronic, digital code that translates to the actual reading on the meter dials.

The four communication methods used for meter reading have various strengths and weaknesses.

Telephone lines -Telephone lines are desirable from an economic point of view since most electricity users in the country have telephone service. The telephone system provides an ideal communication infrastructure for AMR systems due to simplicity of operation, quality of data, high noise immunity, reliability and low cost, both at the remote site and the central station.

Telephone communications AMR systems are categorized by the method of call initiation and initial data flow. The two most common forms are inbound communications and outbound communications.

With inbound communications, a unit at the customer site (usually the controller or a modem connected to the controller) dials in to the central station system at the utility without first receiving an interrogation message. The remote site unit initiates the communication at a date and time programmed into the controller's memory. In the case of tampering or system malfunctions, a call can be initiated to the utility's central station, where the alarm condition will be received and processed. This approach takes advantage of the fixed monthly charge for local calls that the customer is already paying. No additional telephone access equipment is required.

The disadvantages of inbound communications are that the utility cannot obtain real-time data upon request, nor can the utility reprogram the controller unit or issue control commands as in the case of connect-disconnect or energy management, should these capabilities be incorporated into the system.

Outbound communications arc those where data communications are initiated by a central unit located at the utility or at a local telephone company switching station. These systems respond to a query and require central telephone switching equipment and test trunk lines. Telephone company involvement is required to enable the utility's central station computer to dial out to a customer's remote unit without ringing the customer's telephone. The advantage of this approach is that these systems function in real time, as needed, which simplifies the implementation of demand load recording surveys, status monitoring, etc. The primary disadvantages to an outbound communications approach are the capital costs associated with the telephone company's involvement and the recurring tariffs that telephone companies charge. An additional complication arises in geographical areas served by one electric utility and two or more telephone companies.

A third approach is termed bidirectional communications. In this case, communications are initiated from the remote site or the utility's central station. The advantages of both inbound and outbound communications are incorporated in this system design. In the majority of cases, the inbound function is used, thereby reducing telephone charges. Also, due to the decreased density of outbound traffic, telephone company switchgear and test trunk lines are minimized.

Powerline carrier -Powerline carrier communications take place over the same lines that deliver electricity. This technique involves injecting a high frequency AC carrier onto the powerline and modulating this carrier with data originating from the remote meter or central station. Years of research, however, have not overcome the technical problems that preclude this medium from being a cost-effective solution over primary transmission lines. Powerline carrier techniques may be used successfully and cost effectively for short distances; i.e., from a customer's meter to a pole or surface-mounted transformer. It is very expensive to pass this data through a distribution transformer and onto the primary distribution lines and the resulting communications is slow due to the narrow bandwidth and mono-directional meaning data is transmitted from the meter to the utility but the utility can not send data or control signals back to the meter or associated devices at the subscriber side.

Radio frequency -Radio frequency, or RF, systems make use of small low power RF transmitters or transceivers located at the controller. These may take advantage of licensed or unlicensed portions of the RF spectrum and the effective radiated power of the transmitter and the distances capable of being traversed will vary as a function of the frequency and power of the remote transmitters and the receiving strategies employed. A variety of system configurations have been field tested thus far. The most successful employs a mobile unit operated in a van that sends a wakeup and transmit command to the remote meter units in its range. The remote meter units pick up the signal and respond by sending back requested data to the van's computer for later uploading and billing. This system is commercially available for use with gas meters. A variation of this approach employs remote meter units that regularly transmit every few seconds and a small portable receiver connected to a hand-held data terminal. Two of the more exotic approaches (in 1992) involves use of a cellular telephone network system and satellite communications.

The mobile receiver approach suffers the significant disadvantage of being effectively mono-directional; thus, communication cannot be initiated from the utility's central office. Therefore, systems of this type have limited function and relatively low feature/function cost ratios and are not well suited for use by electric utilities.

Cable television communication -This communication approach uses existing cable television lines to transmit data. Some tests have shown that this may be a cumbersome and expensive approach but some municipal utilities that own cable systems are undertaking this type of communication. Additionally, many installed cable systems are not configured to pass signals from the subscriber's site to a central facility. It is expensive to upgrade these systems with wide-band bidirectional amplifiers and subscriber interactive taps. Cable television should not be discounted, however, as a viable communications medium. Several municipal electric utilities have purchased their local cable companies and upgraded systems consistent with the needs of AMR. If these utilities sell AMR services to local gas and water utilities, this approach can prove very viable. Future advances in cable will include bi-directional digital signal transmission and much wider band width ultimately using fiber optics at which point cable will be an ideal communications medium.

The full-scale implementation of AMR requires that a data communication network be established that effectively links every utility customer with the utility's central office. The actual amount of AMR-related data and its frequency of transmission is very low. These factors contribute to the difficulties encountered in the economic justification of AMR systems. There are, however, a myriad of services and functions that can be accomplished through this communication system, some of which significantly reduce a utility's operating costs and some of which can actually generate additional revenues. The incremental costs associated with incorporating these functions in the AMR system controllers is marginal. Payback can vary enormously. In theory, it is almost possible to finance a full-scale AMR system installation through the resulting costs savings and new revenue-producing services. **Ten examples follow**:

- **Remote service connect and disconnect**-A recent survey indicated that the average annual turn-on and turn-off rate for electric utilities nationwide is 18 percent of total utility customers. Costs are incurred by sending a qualified service technician to a site to connect or disconnect a meter or power drop. With remote operation, these procedures are eliminated.
- **Energy management**-Indirect load control and direct load control offer a financially attractive alternative to increased production and delivery capacity.
- **Prepayment**-A number of utilities are investigating various prepayment systems. Such systems effectively eliminate collection problems and enhance cash flow.
- **Combining utility services**-The incremental cost associated with manufacturing a controller capable of receiving input from three or more meters is marginal. By the same token, data can be retrieved at the host end and segregated and partitioned with relative case and total security. By combining electric, gas and water AMR data on one system, the most expensive components-the communications infrastructure and the multitude of controllers-are shared by the utilities. Hence, the cost to each utility to go AMR systemwide is reduced to less than 40 percent of what it would otherwise be.

- **Submetering**-Multi-tenant properties can provide individual user data to the utility on a remote basis. The reduction of associated costs coupled with the magnitude of the transmitted information can, in many cases, allow the utility to offer its commercial customers new report-oriented services.
- **Customer display,**-Utilities can enhance customer relations by selling internal display units to customers that provide up-to-the-minute monitoring of power consumption, in dollars and cents. This can be used as an energy management tool and allows customers to verify and reconcile bills.
- **Security system and services**-A utility so inclined could have a central office security system data communication infrastructure in place. The controller could serve as the communications gateway and the utility could operate a security business directly and use its monthly mailing of bills for marketing, or it could simply provide the data, on a contract basis, to an outside security company.
- **Medical alert services**-As with security services, a utility could enter the rapidly expanding business of medical alert monitoring. The principles are the same as those for security services.
- **Intelligent building applications**-An area of overlap between intelligent buildings and the AMR system is customer information coupled with the variable rate structures. The AMR system can act as a specialized interface between the building and the outside world. Information regarding operations, prevailing rates, customer usage, etc., would be instrumental to intelligent building owners and operators. This information would be made available to the building's computer an-d could be displayed on wall-mounted units as well. Such displays of rate information have been tested by utilities for years.
- **Distribution automation and AM/FM**-Most utilities have begun computer-based mapping programs. By combining distribution automation and automated mapping systems and operating over the AMR network, any operational change occurring within the utility's equipment in the field can immediately be pinpointed on the computer based mapping system-a feature that greatly facilitates troubleshooting operations. When an outage occurs, data from the AMR and DA systems can be sent to the mapping system for immediate display as part of a geographical information map used for dispatching service personnel.

Article written and published in September, 1992 *by Tom Tamarkin, now President & CEO of USCL Corporation, Sacramento, California.*

Independent AMR Resource Sites:

themeterguy.com

USMeterReading/amr.html

History of Walk by & Drive by AMR

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