Demand Response:
Get Paid for Not using Energy!

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Write Around the World Competition

Abstract

With the deregulation of energy markets and increasing competition amongst energy suppliers, end users now have ability to earn money by participating in various demand response programs offered by Independent System Operators (ISOs) as well as electric utilities. In past, end users had to be content with monthly energy billing data as sole basis for determining energy optimization strategies. Now with the advent of web enabled real time solutions, energy managers can modify the energy optimization strategies to respond to supply side cost reduction opportunities. The paper discusses the impacts of advanced meter reading and demand response technologies along with case studies.

Introduction

Due to an explosion of technology solutions in remote data transmission, storage and analysis, there has been a quantum leap in technology solutions for Energy Managers available to assist in operating cost control. Until recently energy managers had to use reactive energy optimization strategies as the only energy data available to them was the monthly billing data made available 2-6 weeks after the actual energy was consumed. This is changing rapidly with the explosion of web enabled IT solutions that provide real time energy information on demand as well as supply side. Now, with the deregulation of the energy industry in some states, the energy managers also have access to the supply side energy information that can open up new avenues for optimizing the energy costs for a facility. This energy information exchange is facilitated through new advanced meter reading (AMR) infrastructure. Today's energy customers need load usage profiles in real time, automated reporting, energy benchmarking tools, alarm functions, guidance on market developments, assistance in bidding and negotiating energy supply offers. Providing customers with this information presents great opportunity for energy companies and challenges energy managers to become informed consumers. With better information and the ability to communicate with their customers and influence energy usage patterns, utilities can optimize their energy supply / delivery planning, operations and provide new choices for their customers. One of these choices is price responsive load management (PRLM), under which, the end user is both informed of costs, and provided opportunities for controlling load through two-way communication (something not widely available cost effectively in past years). Empowering the management of these Demand Response (DR) resources is the Internet and online trading, both of which have brought "market transparency" to the forefront in the electric power industry. The Internet gives energy managers the ability to view real-time price signals and energy usage. This makes energy managers more sensitive to perceived differences in the mix of variables and allows them to make more informed operational decisions for managing their energy costs. It also intensifies competition between energy suppliers, making deregulation work as envisioned.

Understanding your energy usage

There are many means to utilize the wealth of energy data available through monitoring and control of energy usage. These include energy usage analysis, energy information monitoring of average usage, and peak demands, actual closed loop controls, benchmarking using energy data to ascertain short term and long term efficiencies and automatic diagnostic evaluation via software tools. These activities are discussed below.

- **Energy Usage Monitoring and Analysis:** Energy managers can use various IT tools for performing analysis of the energy billing history, long-term trend analysis of usage, regression analysis by kWh and kW for weather normalization and for uncovering other dependencies for whole facility. These tools can include simple spreadsheet based tools or sophisticated energy information systems. An example of this is shown in Fig. 1 which displays time, KW and KWH for a facility in a single graph. This graph was created using Excel based 3D load profiling tool developed by Energywize with funding from NYSERDA. This allows identification of patterns of the facility energy behavior and forecasting of future monthly costs. Various energy metering information service providers help energy managers track and analyze their electrical, gas and water consumption from a single circuit to an entire facility--using the convenience of the Internet. The information can be presented both in tabular as well as graphical format using load profiles and energy usage data to help users identify energy cost savings opportunities. Multi-site and aggregated load profiles enhance the energy manager's ability to proactively negotiate the best possible rates in the deregulated energy markets. Various online tools such as ABB's Online Energy Profiler allow the interval meter data to be presented in customized reports on a variety of bases, including 15-minute intervals, hourly, daily, month-to-date and year-to-date, to assist in a more detailed, comprehensive analysis. Remote energy monitoring and tracking via the internet has become one potential low cost method for rapidly gathering data With electronic systems, and internet data transfer, this aspect can be automated, and be more accurate. [1]

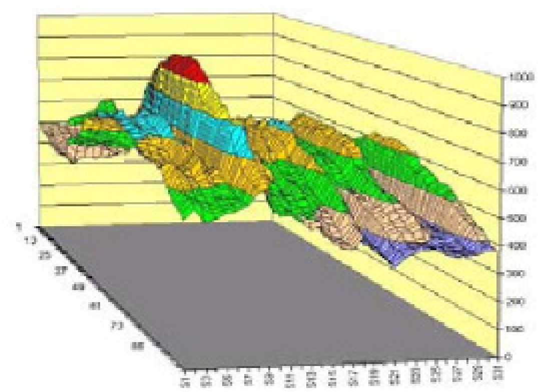

Fig 1. Sample 3D Load Profile Using 15 Min Demand Interval Data. [2-3]

- **Energy Controls:** With deregulation of energy markets, it is possible for real time control of the cumulative total electric peak of all facility instantaneous peaks for all facilities owned by a client, regardless of their location within a given electrical transmission system. This real time ability for load control could be incorporated with limited two way communications to reduce coincident demand charges either from the power grid or the local utility. Energy management controls not only includes the actual modulation of systems to maintain the set points desired, but also includes trending of multiple control points shown in convenient "month-at-a-glance" format so that the end user can ascertain that the units are operating properly. Fig 2. shows a simple online energy calculator that allows end users to select appliances from a list and view the expected consumption as well as energy cost [6-8]. Energy managers can monitor daily comparison of current load profiles with expected load shapes based on historical data. Energy managers can utilize the load profiles to anticipate seasonal / daily usage patterns and select appropriate control algorithms in the EMS/SCADA systems to optimize the energy usage.

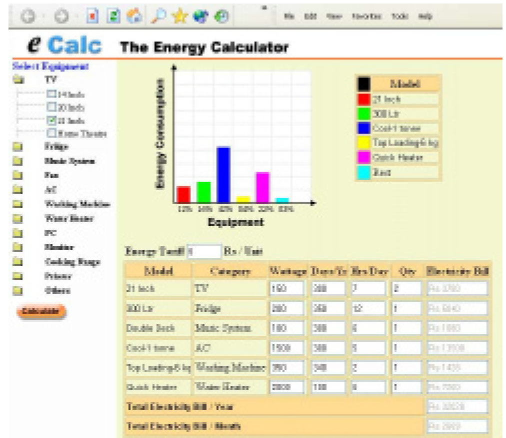

Fig 2 eCalc Online Energy Calculation Too

One successful case study on web-based energy monitoring and controls is the retail corporation Staples Inc. After the year 2000 California Energy Crisis, Staples implemented an energy management plan to protect over 100 California stores from steep demand charges and rolling blackouts. Staples utilized the installation of wireless control technology which allowed energy managers to automatically reduce lighting and HVAC loads at selected stores communicating through the internet. They even have web-enabled utility meters. This not only lead to significant savings in demand charges during peak periods, but also improved the regional power reliability. The ability to curtail and verify load reductions using interval meter data also enabled Staples to participate in demand response programs offered by California ISO [4].

Opportunities from Electric Utility Deregulation

The Internet and electricity deregulation were made for each other. Without the Internet to collect and disseminate information in near real time and to make it easier to compare rates and procure energy, the idea of electrical deregulation would be far less persuasive and effective. At the same time, without deregulation to open power markets, the Internet's ability to collect information and enable transactions would be of little use to the energy supply side markets. The deregulated energy marketplace is providing the energy industry as well as energy managers with new opportunities, challenges and risks. As the market continues to develop in various US states, the key to maintaining a competitive edge is the development and implementation of technologies with real time capabilities. This applies to electricity or natural gas purchases, although the majority of the work has been focused in the electrical field. Now more than ever, advanced technologies related to metering, energy management and billing are allowing energy managers to leverage future opportunities and minimize financial risks. [5] Under FERC's Standard Market Design (SMD), ISOs and RTOs are setting up Day-Ahead and Real Time Energy Markets that consist of voluntary, bid-based, security-constrained markets in which generators, energy suppliers and DR resources are free to engage in bilateral transactions. Market participants can follow market fluctuations as they happen and make informed decisions either in day ahead markets or in real time. Participants can respond to high prices and bring generation or DR resources to the region in times of high demand.

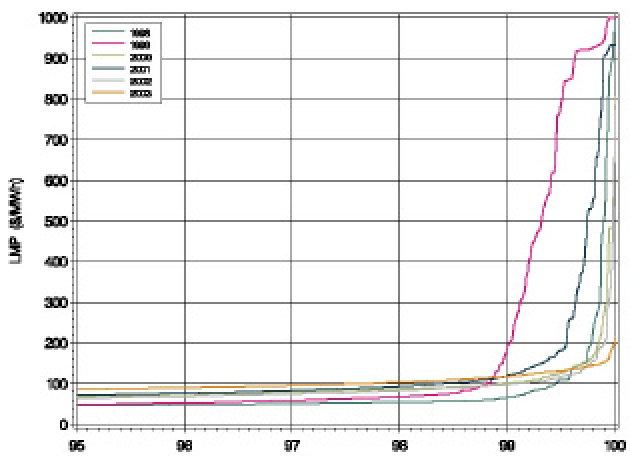

Fig 3: PJM Hourly Load Duration vs LMP Curve [17]

As an example, consider the PJM Interconnection - a regional transmission organization (RTO) that coordinates the movement of wholesale electricity in all or parts of Delaware, Maryland, New Jersey, Ohio, Pennsylvania, Virginia, West Virginia and the District of Columbia., serving more than 25 million people. The company dispatches more than 76,000 megawatts of generation capacity through 245 market participants and has administered more than $17 billion in energy and energy-service trades since the regional markets opened in 1997. Fig. 3 shows the PJM hourly load duration against the Locational Marginal Prices (LMP) from 1998 to 2003. During this period the highest 15% of load on that system is used only 2% of the time, or less than 200 hours per year. The PJM price curve shows that this 2% of time also corresponds to time when LMPs have maximum volatility with price fluctuating between 100$/MWh ($0.10/KWh) to 1000$/MWh ($1/KWh).

Price Responsive Demand Response Techniques

Prior to electric deregulation, timely information on detailed pricing breakdowns and consumption patterns was generally not readily accessible to end users. Customers were typically not able to determine accurately how much they were paying for energy until they received the bill the following month after the usage had been set. With electric market transparency, the customer with demand response capabilities now has the opportunity to get paid as much as an energy generator would get paid for selling electrical generation into the market, helping make it a more level playing field. DR programs provide incentives to end users to reduce the electric load in response to system reliability or market conditions. DR is favored by many utilities because it addresses their primary problem of bridging the gap between wholesale prices and retail prices and ensuring reliability of supply during these periods. Utilities would rather give a customer an incentive to reduce its load during such events rather than pay the customer to permanently reduce its overall load, which can result in lost revenue for the utility. By using direct load control or pre-programmed optimization strategies in an EMCS system, Curtailment Service Providers (CSPs) can respond to load reduction request by the ISOs and then distribute the incentives to program participants. The programs offer incentives which are directly linked to the real time LMP. In 2002 it was estimated the market potential for price responsive demand response programs will be $10 billion by 2005, opening up a market for DR infrastructure of $1.1 billion [16]. The potential benefit from demand response was estimated at $15 billion in benefits in 2001 according to McKinsey Company. A finding by the Edison Electric Institute suggests that a 5 % of demand reduction can reduce market prices by 50 %and thus provide a significant check against exercise of market power during those times. Fig 4 shows the $10 million savings achieved by PJM Interconnection during a 9 hour DR event that resulted in 3.5% load relief.

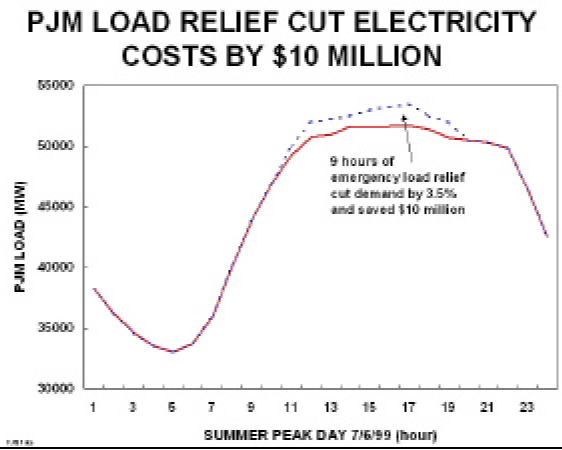

Fig 4: Reliability Benefits of DR by Eric Hirst

The recent growth in AMR installations for cost-saving reasons unrelated to retail pricing has reduced some of the existing barriers to more efficient pricing, and offers the potential for utilities to offer new services to their mass market customers. For example, Gulf Power Company in Florida is expanding its critical peak TOU pricing program, known as GoodCents Select, finding that customers like both the opportunity to save money and the flexibility provided by the program's communication and pre-programmed control technology. During 85% of the hours of the year, Gulf Power customers see prices that are lower than under their standard tariff. Only in peak periods and the infrequent (1% of hours) critical periods do they face higher prices. Gulf Power has seen substantial load reductions during peak and critical peak periods, producing bill savings to customers and cost savings to the utility.

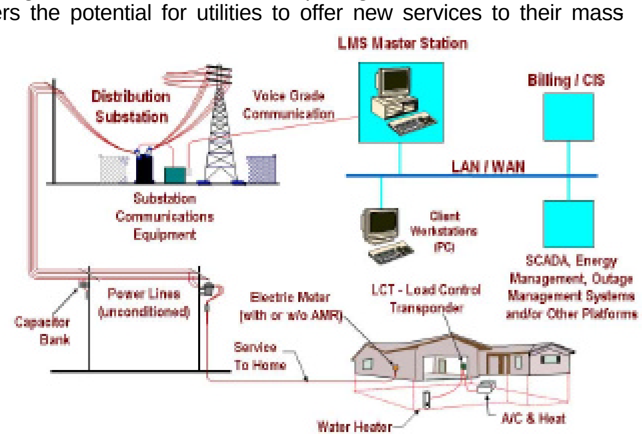

Fig 5. FPL's Residential and Business On Call System [13]

Florida Power & Light Co. (FPL) operates a simple and voluntary direct load control program that has proven to be highly successful. FPL uses a Two-Way Automatic Control System (TWACS) power-line frequency system as shown in Fig. 5. Using a portfolio of Demand Side Management programs, including interruptible rates for large power customers and a predominantly residential load-control program, FPL and its customers have successfully reduced demand by over 3000 MW. This reduction has allowed FPL to avoid building approximately 10 new 400-MW power plants. Of that total, 1000 MW of peak demand savings can be directly attributed to FPL's Load Management System (LMS). To achieve this, FPL generally avoids using load management to curtail air-conditioning loads and instead controls water heaters and pool pumps, unless capacity needs are critical. However, on a monthly basis, the LMS performs a 15-minute control on water heaters and pool pumps year-round.

The 3 ISOs controlling wholesale energy markets in northeastern US offer variety of incentive programs to market participants. The programs are typically divided into Emergency DR programs and Economic DR programs. Most of these programs are voluntary and provide financial incentives to DR service providers. Fig. 6 shows a comparison of 12 such programs offered by PJM, ISO New England (ISO NE) and New York ISO (NY ISO).

Region		PJM	PJM	PJM	PJM	ISO NE	ISO NE	ISO NE	NY ISO	NY ISO	NY ISO
Program Name		Emergency	Real-Time Economic	Real-Time Economic - Dispatch Option	Day-Ahead Economic	Real-Time Price Response	Real-Time Demand Response	Real-Time Profile Response	Emergency Demand Response	Day-Ahead Demand Response	ICAP Special Case Resource
Frequency	I can respond frequently. Notify me when prices are high		✔	✔		✔					
	I can respond infrequently. Only notify me when the lights are in danger of going out	✔					✔	✔	✔		✔
Risk	I want a 100% voluntary program with no risk and no penalities	✔	✔	✔		✔	✔	✔	✔		
	I'm willing take on some risk if the reward is worth it.				✔					✔	✔
Payment and Notification	I want to set my own price. I will tell you the price at which I am willing to reduce load.		✔	✔	✔					✔	✔
	You tell me when prices are expected to be high and I'll decide if its worth interrupting					✔					
	I am willing to be dispatched for a specified price. You tell me when and for how long.	✔		✔			✔	✔	✔	✔	✔
	When I reduce load I want a guaranteed minimum payment.	✔		✔		✔	✔	✔	✔	✔	✔
	I will only reduce load if I'm paid a minimum of $0.50/kWh	✔		(Request to be dispatched at $0.50/kWh)			✔		✔		
Implementation	I want to use my emergency generators and I have the proper permits.	✔	✔	✔	✔	✔	✔	✔	✔		✔
	I want to aggregate several facilities together to achieve the minimum kW requirements		✔	✔		✔	✔	✔	✔	✔	✔
Metering	I already have an interval (hourly) meter on my building	✔	✔	✔	✔	✔			✔	✔	✔
	I want more advanced metering along with Internet access.						✔		(Available via NYSERDA PON-733-02 see www.nyserda.org)		
	I want to use a method other than interval metering every building to determine by response (e.g., statistical sampling, smart thremostats)	(Available via pilot progilable via pilot program)						✔	✔	✔	✔

Fig 6. Which DR Incentive Program is Right for me? Source NYISO

Advanced Meter Reading (AMR) Technology For Energy Cost Control in the 21st Century

Until recently the metering and billing methods employed by most of the utilities in North America and Western Europe had not changed appreciably in about 80 years. With the regulatory changes happening in energy markets, it is inevitable that new metering and control strategies had to come into play. In recent years utilities looking to capitalize on AMR technology are committed to replacing, upgrading or retrofitting existing meters along withthe billing system upgrades. With new AMR and electronic systems provide the capabilities even at the individual meter level the ability to collect and present metering information to the end user in a timely manner, and influence the energy use patterns. As discussed in previous section, such technology can be used at large scale by utilities to effect changes by end use customers, in a manner which can both benefit them and the local utility. The downside to these opportunities is that the end user could end up with higher utility costs than before, if the user is not agile, trained, and cognizant of the circumstances. So, along with cost savings opportunities is the risk of price increases.

As upgrades to existing metering infrastructure are being considered, the opportunity exists to look 'beyond the billing' and address other meter data requirements. Measuring billing data needs information on real energy, kWh, reactive energy, kVAR, and maximum demand data. The next step is to obtain data that can tell both the supplier and the consumer about the quality and reliability of the supply. With the technology available today, metering infrastructure can be easily transformed into a virtual energy information network used by both the energy consumer and the utility. To make a customer communication network work, utilities are deploying metering solutions with two-way communications capabilities. Key features of the modern metering systems include active and reactive energy measurement, AMR functions, TOU contract management functions, remote connect/disconnect for load control, fraud detection/anti-tampering functions, prepayment, demand management and potential development of value added services. This data allow companies to analyze, diagnose and mitigate a variety of power quality issues. Power quality problems are costly to both energy supplier and consumer, and direct equipment damage is only a small portion of the overall disturbance-related costs. Unplanned outages and abnormal line losses can add significantly to the costs. Historically, power quality problems have been identified, analyzed and corrected with off line means, but now the technology exists to measure harmonics in real time, and to adjust for it with active harmonic filters for example.

Enel Distribuzione, the Italian power electricity utility with more than 30 million customers, launched a project in 2001 to replace all 30 million electromechanical meters with a new system. The Telegestore project is expected to be completed by 2005 at a cost of 2 billion Euros and will cover approximately 30 million customers. The Telegestore includes a remote meter reading system, a customer management system, and a potential 'value added services' delivery system. The project started in June 2000 with the development of a remote metering management system which used the low-voltage distribution grid as a data carrier, in combination with the public telecommunication network. It includes a completely electronic and integrated meter, instead of a traditional electromechanical meter integrated with an external electronic communication device [11]. Similarly in California, a joint initiative by California Energy Commission (CEC), Public Utilities Commission (CPUC) and California Power Authority (CPA) is trying to establish a technology and pricing policy foundation that links customer rates with the market price for energy [12]. Preliminary results from a $10 million statistically designed statewide pricing pilot implemented in 2003 by utilities demonstrated customer demand and energy impacts that substantially exceeded most expectations in terms of demand reduction. The project involved notifying customers using telephone / fax systems, as well as allowing customers to monitor their real time energy consumption data online. Such an approach could have helped California avoid power blackouts such as the Year 2000 problems. Interestingly, preliminary results show that residential users will respond to price controls if given the opportunity and real time data; this contradicts the prevailing attitude that residential customers are not good DSM candidates. Now, many utilities, either internally or with outside assistance, have developed procedures for end users to secure either real time information, or summarized electronic historical data along with basic computer diagnostic tools for analyzing the energy usage and patterns [1]. This data empowerment then allows the end user to adapt the use of utilities through virtual on-line feedback. Fig 7 shows an online Energy Speedometer™, currently being developed by eMeter. Using real time data, the Energy Speedometer™ allows the end users and energy managers to see how fast they are consuming electricity in real time.

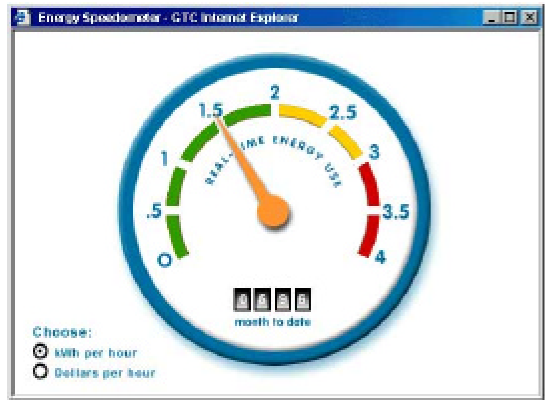

Fig 7 eMeter's Energy Speedometer™

GHG Emissions Credits

With the growing focus on environmental impact of development and efforts to build sustainable facilities, energy managers of future will need to implement green design techniques, that help direct / indirect Green House gas (GHG) emissions from the facility. Various proposed mechanisms such as the (Global) Kyoto Protocol or the (US) Climate Stewardship Act are trying to develop incentives for early action by allowing emission trading. Implementing GHG emissions trading is complicated. In an effectively designed market, emitters with low cost options for reducing emissions receive revenue from emitters with higher cost emission reduction options. DR resources utilizing renewable energy sources can benefit by participating in emission trading to maximize revenues.

There are industry based initiatives such as 'Chicago Climate Exchange' (CCX®) to help establish mechanisms for facilitating emission trading. The CCX is a GHG emission reduction and trading pilot program for emission sources and offset projects in the United States, Canada, Mexico and Brazil. CCX is a self-regulatory, rules based exchange designed and governed by CCX® Members. These members have made a voluntary, legally binding commitment to reduce their emissions of greenhouse gases by four percent below the average of their 1998-2001 baseline by the year 2006, the last year of the pilot program. The CCX Trading Platform is an internet-accessible marketplace that is used to execute trades among CCX Registry Account Holders. The system utilizes SUN java technology to bring live and active content to your screen. The Platform features a price transparent marketplace that displays order size, market depth and a market ticker. The system supports both exchange-cleared which preserve anonymity, and bilateral trades that are established through private negotiations off-system.

Conclusion

With deregulation, end users and energy managers have lot more opportunities to intelligently use the energy information and get paid by utilizing demand response capabilities. As more and more participants start developing demand response capabilities, these programs will evolve into standard feature for deregulated energy markets. This would lead to installation of more two way communications for metering and load control not only for the larger commercial and industrial users but also for the residential users. Interaction capabilities with state level / national database for GHG emission reporting as well as benchmarking and exchange of emission reduction credits can further enhance the commercial benefits from these demand response technologies. Thus allowing end users to get paid more and more for not using energy.

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