EPRI

August 3, 2000

Loretta Lynch, President
State of California
Public Utilities Commission
505 Van Ness Avenue
San Francisco CA 94102

Re: A. 99-09-049 et al. CPUC Summer 2000 Energy Efficiency Initiative
Response Filing, Clarification and Amplification of EPRI filing of July 20, 2000

Dear President Lynch:

I am pleased to submit the enclosed response filing to the earlier EPRI filing of July 20, 2000 in response to CUPC Energy Efficiency Initiative. In order to avoid confusion, I have incorporated my clarification and amplification in the original filing and the four copies of the updated filing are enclosed. The clarification and amplification are highlighted in the beginning of the proposal.

We are working with the industry, including Silicon Valley Manufacturing Group (SVMG) and Major Energy Users Group in the Silicon Valley, to find urgent solutions to meet the immediate needs of the industry to prevent rolling blackouts. SVMG has 175 members with total economy of over $105 billions each year.

Please feel free to contact either myself at (650) 855-2699, Renee Guild at (650) 855-8987 or Roger Bedard at (650) 855-2131 for further information.

Thank you for your consideration on this proposal.

Sincerely,

Mukesh K. Khattar
Team Leader, HVAC&R Technologies
EPRI

BEFORE THE PUBLIC UTILITIES COMMISSION OF THE STATE OF CALIFORNIA

In The Matter Of:	)	
	)	
Application of SOUTHERN CALIFORNIA EDISION COMPANY	)	A. 99-09-049
For Approval of Program Year 2000 and 2001 Energy Efficiency	)	
Program Plans, Budgets, and Performance Award Mechanism.	)	
____	)	
	)	
And Related Matters	)	A. 99-09-050
	)	A. 99-09-057
	)	A. 99-09-058
____	)	

Response Filing to EPRI's Proposal

<u>Demand Responsive Electric Energy And Demand Reduction</u>

Clarification and Amplification

EPRI
3412 Hillview Ave.
Palo Alto, CA 94304

Mukesh K. Khattar, Ph.D., PE
Team Leader
(650) 855-2699; Mkhattar@epri.com

Roger Bedard
(650) 855-2131; Rbedard@epri.com

Renee H. Guild
(650) 855-8987; rhguild@epri.com

August 03, 2000

Updated with Clarification and Amplification
August 3, 2000

<u>Demand Responsive Electric Energy And Demand Reduction</u>

A Program Initiative

Submitted to:

California Public Utilities Commission
505 Van Ness Avenue
San Francisco, CA 94102
Attn: Loretta Lynch

In response to:
<u>Summer 2000 Energy Efficiency Initiative</u>
Docket No. A99-09-040 et al.
Decision No. D00-07-17

July 20, 2000

From:

EPRI
3412 Hillview Ave.
Palo Alto, CA 94304
Mukesh Khattar (650) 855-2699
Roger Bedard (650) 855-2131

Demand Responsive Electricity Demand Reduction

Update with clarification and expansion:

The program initiative originally filed on July 20 consists of the following elements. These elements have been clarified and expanded in this response filing. The updated program initiative is provided following this section:

1. Power Emergency ‘Fire’ Drills
   1.1 Communication network for impending rolling blackout
   1.2 Develop incentive structure for to reduce demand and energy use at peak hours
2. Develop a list of Demand and Energy savings Measures
3. Pilots to Demonstrate Demand Responsive Buildings Strategies
4. Building HVAC System Demand Control through Ventilation Control
5. Back up Generation Integration
6. Use of Personal Fans and Lights to Reduce Energy Use and Demand

In addition to the 6 specific tasks outlined above, EPRI would like to offer to perform the following technical activities, and requests feedback from the CPUC regarding its interest in receiving expanded proposals for any/all of these activities:

- Generalize each of the 6 tasks for statewide applicability.
- Conduct a Customer Potential Study statewide to determine the demand-responsiveness contributions that various sectors of the residential, commercial, industrial, and agricultural classes can provide (technical & market potential). Please see the attached service opportunity document in Appendix C1.
- Design pricing options for California electricity customers to choose from in dealing with deregulated electricity purchases, that will transmit appropriate pricing signals for inducing demand responsive behavior (this can include level payment plans accompanied by appropriate education).
- Design materials and administer educational programs to enlighten California electricity customers regarding which pricing options best suit them, and how they can maximize their energy bill savings.
- Design customer qualification criteria for various pricing options & demand-responsive programs. Establish ready-response SWAT Team capabilities for advising customers on how to maximize their demand reductions, including facility assessments and trial runs.
- Develop, screen, and prioritize technology (communications, control, metering, monitoring) options to enable demand-responsive programs and pricing options.

<u>Case study</u>: EPRI proposes to perform these functions for San Diego. These activities would augment the CEC-sponsored demonstration of the EPRI Energy Network Computer (Jefferson Project), and offer the opportunity for expanding this effort to other customer sectors. Please see the attached service opportunity document in Appendix C2.

The Jefferson Project has been receiving national attention. The August 3, 2000 edition of the Wall Street Journal reports on its front page that EPRI is doing a "neighborhood net" project with the California Energy Commission, whereby families in San Diego County can hook up with the net via set-top boxes on their TVs. Families "access the Net, email each other, see homework assigned at school, view the agenda for the town council and learn about energy conservation, among other things...It creates a virtual "town square" that isn't restricted to homes with PCs..." and is much cheaper. Further, although the program is aimed at homes without PCs, it is just as effective when used with PCs, in terms of giving a community access to energy information. In phase two, the additional step of supplanting the program with some type of meter telemetry and connection modules on each appliance would make even small users able to set a price beyond which they would not pay -- or pay for only those uses they deem essential. This, the "silver bullet" for small commercial, would allow users to program their systems to automatically shut down appliances in their home/businesses in response to those prices. Although all the necessary technology to do this is available today, it has never been put together in the way EPRI hereby proposes, linking local communities via demand-controlling and Internet technologies.

Complementary activities: EPRI would also appreciate CPUC feedback on interest in the activities contained in the attached proposal (appendix C3) previously submitted to the CEC entitled, “Using Demand Responsiveness Programs to Ensure Electrical System Adequacy in California.”

Qualifications: Please see the attached EPRI Load Management Resources listing in Appendix C4 that documents our unparalleled record of accomplishment. These resources complement our extensive staff expertise in all aspects of demand responsive programs.

Program Initiative:

In response to California Public Utilities Commissions' request for Initiative Programs to provide program options that will bring about the largest reductions in electrical demand and/or electrical usage reductions in the shortest period of time, EPRI is pleased to provide this Program Initiative.

The summary of the program is provided in the Table 1 below:

Table1:

Program Element	Summer 2000 Potential Peak Savings, kW	Summer 2000+2001 Potential Peak Savings, kW	Cost Effectiveness $/ kW Potential Demand Savings
7. Power Emergency 'Fire' Drills	20,000	45,000	20
8. Develop a list of Demand and Energy savings Measures		25,000	20
9. Pilots to Demonstrate Demand Responsive Buildings Strategies		25,000	50
10. Building HVAC System Demand Control through Ventilation Control		40,000	7.5
11. Back up Generation Integration		50,000	10
12. Use of Personal Fans and Lights to Reduce Energy Use and Demand		4,000	100-200

This program is primarily aimed at avoiding or minimizing rolling blackouts when power supplies are unable to keep up with demand and electricity production costs are very high. It will reduce peak demand as well as energy use during the Stage 2 Power Emergency Alert hours. In addition, the proposed solutions will also be effective in reducing electricity usage as well as demand during all hours of operation. This program will also achieve conservation at peak demand hours as well as all operating hours. Not only the demand reductions, but also the energy efficiency and conservation benefits of the proposed solutions are confirmed with data from in a pilot 'drill' that was held on July 28, 2000 in the Silicon Valley.

This program is conceptualized in coordination with the industry partners to address the industry's immediate need to reduce power demand during this summer (summer 2000) and prepare for summer 2001 so that power outages may be avoided are substantially reduced. The power outage costs to some of these users are enormous. In some cases it may take up to a week to bring back operations to normal after an outage, even if the outage is for a short time. The industry partners include Silicon Valley Manufacturing Group (SVMG), a group of over 175 companies in the Silicon Valley representing an economy of over $105 billions a year, as well as members of Major Energy Users Group (MEUG) in the Bay Area.

The proposed program encompasses some of the proven technologies, which are not in common use today. These technologies need to be demonstrated with verification of savings from the field and to dispel skepticism from potential customers, followed by education, training and communication for their adoption. Several members of the SVMG and MEUG, including Hewlett Packard, Lam Research, Cisco, AMD, Agilent, etc. are very actively involved in the design, planning, pilot demonstration and implementation of the proposed program. The SVGA has created an Energy Task Force (ETF) to address this issue of power shortages and to search for means to reduce demand, improve energy efficiency and increase power reliability. Some of the elements of the program are already being implemented by voluntary participation to mitigate the peak demand related problems this summer. These elements of the proposed initiative have been discussed and debated in the SVMG ETF as well as in a subcommittee of the ETF. In addition, the members have also solicited input from researchers at Lawrence Berkeley Laboratory, California Energy Commission and others active in energy efficiency. This Program Initiative is includes many of their suggestions in order to achieve the immediate goal of preventing rolling blackouts this and next summers.

The elements of the proposed Demand Responsive Electricity Reduction are outlined here.

1. Power Emergency ‘Fire’ Drills

The tasks under element have been clarified and expanded.

When this filing was filed on July 20, we had an emergency power reduction ‘drill’ in planning. The ‘drill’ took place on July 28. The participants in the drill were:

- Applied Materials
- AMD
- Cisco
- Hewlett Packard
- Intel
- Lam Research
- SDLI
- Solectron
- City of San Jose
- San Jose State University
- EPRI

Although final numbers are not in yet, preliminary data shows that about 10MW of power demand were reduced. This was from a combination of measures such as turning off non critical equipment, dimming lights (turning off one or more circuits), reducing HVAC system load by raising space temperature as well as bringing back up generation online. The back up generation was brought online to make sure all equipment and systems would work smoothly. My preliminary estimates are that about 70-75% of the demand reduction was from back up generation while the conservation and energy efficiency measures provided 25-30% demand reduction. How does energy efficiency figure in this? When supply air temperature is increased to raise the room temperature, the air conditioning system works more efficient. It is just the law of thermodynamics.

The individual savings varied among customers and the type of facilities. Some were able to achieve 20-22% demand savings (notably Hewlett Packard), while some achieved only 3% (they were not fully prepared.) EPRI was able to reduce demand by an impressive 32% in one of its 173,000 sft building while only about 6-13% in another 67,000 sft. building. These savings were achieved without use of any back up generator!

This 'drill' has brought many of the issues up front, and this experience has served to expand the scope of work to address these. The budget amount is also increased due to these changes.

The updated scope of work includes planning, coordination, communication, data collection and analysis, to be followed by program development and working with more companies to prepare and support them with expertise and knowhow and get them on board for participation during actual Stage2/3 emergency alerts.

Based on our experience with a limited number of participants, we can prepare and get about 20 MW peak reduction and prepare for an additional 25 MW peak reduction for summer 2001.

EPRI cost for providing this support will be $900,000. The earlier estimate of $150,000 was based on one time 'drill'. Our estimate was based on the fact that we will be able to get summary data from individual participants. We have, however, learnt that we would need a lot more resources to assemble and interpret data from individual accounts and providing them support to identify and select measures that will provide the most reduction with least inconvenience. The customers do not have in house resources to collect and reduce data in readily useable format, but are willing to provide raw data (with certain safeguards) if we could conduct our analysis.

We also learned of issues and concerns why some of the companies could not participate. We need analysis of the field data from participating sites to address any skepticism and develop sound practices to draw more customers into participation.

The cost effectiveness of this program is extremely good, i.e., $900,000 for 45MW demand reduction, or just $20 per kW demand reduction.

The reduction in demand and energy use does not have to be done only at stage 2/3. We are developing a procedures and processes to reduce demand when given a signal. The signal could be a price signal. This solution could help many customers to voluntarily reduce their energy use during high price periods and avoid exorbitant charges such as those faced by SDG&E customers this summer.

The purpose of this program element is to increase preparedness of member companies to respond to power emergencies such Stage 2/3 alert or price signals. Many companies have contingency plans to turn off loads that are not critical. Others have more elaborate plans that include control of air conditioning systems and lighting.

This task was rated very high at the SVMG ETF group meeting on July 17, 2000. John Wilson, Advisor to Commissioner Art Rosenfeld at California Energy Commission, also attended the meeting. The ETF voted EPRI to lead this ‘drill’. EPRI has proposed to conduct the first drill on Friday, July 28. Several high profile end users including Hewlett Packard, Intel, Cisco, AMD, City of San Jose, and San Jose State University have already signed up on a voluntary basis to participate in the drill. PG&E agreed to provide verification of demand and energy reductions. We are also enlisting support from Silicon Valley Energy and City of Palo Alto. Additional participants are being sought.

In follow up discussions with John Wilson and commissioner Rosenfeld about the proposed drill, they both suggested that we should continue this ‘drill’ on hot days or whenever the cost of electricity is high during this summer to reduce impact of peak demand.

This element of the proposed initiative can provide large amounts of electricity demand in shortest time.

This element could greatly benefit from some additional subelements or tasks that can be done as part of this task or independently. These subelements would additional funds and are not included in the above costs.

> 1.1 Real time communication with customers about the avoided cost of electricity so that consumers can make an informed decision to act on the information. Different versions of this are under consideration or development by CPUC, CEC, CAISO, etc. However, a major issue identified by the one of the SVMG member is the ability to track if there load is next on the rolling black out ‘block’ so that they can prepare to shut down safely rather than risk abrupt loss, especially when critical processes are involved.
>
> 1.2 Investigate if and what incentives could be provided to end users to reduce load during peak hours when energy procurement costs to utilities are very high. Some of the savings from not having to pay high prices at the exchange can be passed on the consumers who are willing to voluntarily reduce their load. EPRI has great experience in such program development. The projected cost for developing such program will be $600,000.

EPRI is seeking funding for coordinating with end users and managing the power emergency drills. The estimated cost is ~~$150,000~~.

2. Develop List of Demand and Energy Savings Measures:

The SVMG ETF recognized that some end users have quite elaborate plans to reduce demand in several stages where others may not have any plan. The committee voted that EPRI lead in development of a generic list of recommended measures with estimated demand and energy savings. The individual members can select and prioritize these measures based on their specific end use needs.

EPRI proposes to develop this list cooperatively with the end users by taking into considerations the types of lighting, mechanical air conditioning systems, and energy management systems. Field data from the task 1 will help us calibrate analytical tools that could provide verifiable savings.

For us to realize the most demand and/or energy reduction in the shortest time, we have to focus on energy management systems and control strategies. Some EMSs are capable of handling complex control strategies whereas others may be able to handle only simplistic ones. EPRI proposes to develop these strategies that will be able to adapt to the simplicity or the complexity of the EMS by working closely with the end users. Although the final report may take longer to produce, we hope to provide guidance to the end users through informal write-ups and personal contact quickly so that these could be adopted quickly.

The estimated cost for the project is $500,000.

Based on our experience with the field 'drill', the list of measures could lead to facility demand savings of as much as 10%. Assuming just 1% penetration by 2001, such measures could provide 25MW demand reduction, or $20 per kW.

3. Pilots to Demonstrate Demand Responsive Buildings Strategies

Two solutions that are often promoted for reducing peak demand and energy use: turning off or reducing light levels, and raising thermostat set point temperature. Lights can be turned off in perimeter zones, which have natural lighting. Switching off one or more circuits can reduce lighting (if the building is designed with multiple lighting circuits—it is my understanding that buildings built after 1984 must have at least two lighting circuits if the area covered is larger than 100 square foot.) Switching can be manual or through an EMS. More sophisticated dimming switches are now available that can gradually reduce light levels so that it will not strain eyes. However, for immediate demand savings, we will have to work around existing infrastructure.

Raising the set point temperature will cut down on the air conditioning demand, which will eventually translate to less electric demand for cooling. However, how soon the reduction is translated to electric demand savings depend upon many factors—type of air distribution system (constant volume, VAV, dual duct, etc.), type of air conditioning system (e.g., direct expansion, packaged, chilled water, etc.) and the control system.

There are two pilots under way, one with SMUD in Sacramento and the other with LADWP in Los Angeles, to implement these strategies and verify savings. A description of this pilot is enclosed as Appendix A.

EPRI proposes to expand on these concepts and conduct pilots in the Silicon Valley area with members of SVMG and MEUG so that we can identify and resolve any issues and expedite widespread use.

The estimated cost for this project will be $250,000 per pilot, and we recommend three pilots to encompass different types of systems for a total estimated cost of $750,000. Each pilot could save about 1000 kW. The cost effectiveness would be about $250 per kW demand reduction. This is, of course, the cost of demonstration and collection of data and knowledge base to develop a program. The program could be implemented with incentives as little as one-fifth the cost of demonstration or $50/kW. Assuming just a 1% penetration by 2001 from the pilot field test data, it could provide 25MW demand reduction potential.

4. Building HVAC System Demand Control through Ventilation Control

This element of the proposed initiative is to develop aggressive but practical solutions that can be implemented in a short time to reduce peak demand, particularly through control of outdoor ventilation air during power emergency stage 2 alert hours. A more detailed description is provided in the enclosed appendix B.

The ventilation air at peak demand hours, typically coincident with peak ambient temperatures, could account for as much as 30% of the air conditioning load, which in turn is about 40-45% of the total building load. Therefore, restricting ventilation during peak hours could reduce 5-8% of the facility peak demand. Overall, air conditioning accounts for about 30% of the power generation at peak hours. Therefore ventilation air could account for as much as 9% of the total load. Assuming that the ventilation load could be reduced to half, and a penetration of just 2% by 2001, a total demand saving of about .09%, or 40MW, on the state's grid is possible. However, we need to develop background knowledge to prepare for its design and implementation.

EPRI and Hewlett Packard have teamed up to propose and demonstrate this element in a pilot. We have conducted extensive research on its feasibility with leading experts in this field and determined that an application with monitoring and evaluation would best identify its energy and demand savings potential. The estimated cost for this element is $300,000. It is a very cost-effective measure. An investment of $300,000 could open up 40MW demand reduction, or $7.5 for each potential kW reduction.

Back up Generation Integration

Many of the major energy users in the Silicon Valley have back up generation. Its capacity ranges from 5–20% of their peak load. This program element will develop a plan, explore incentives and mechanisms of calling on the customers to turn on their generators to reduce demand at site during power emergency stage 2 alert hours. There may be enough back up power to avoid a rolling black out.

There are, of course, concerns about air quality and permitting requirement. This element will investigate it and work with concerned authorities and the industry to find out a mutually acceptable solution. The first task of the element will be to survey and develop an inventory the back up generation capacity with large energy users and any data on type of fuel used and its exhaust characteristics.

Initially for the first phase, this is a short-term measure, and will address demand in summer 2000 and 2001. The equipment is already in place. Only operational and control strategies are needed to be developed.

In the second phase for summer of 2001 and onwards, we will address the following limitations that we have come across: 1) the generators are stand-alone, i.e., they are not synchronized with the power grid. This limits the ability of many customers to switch to generator without disturbing operations. We will develop methodology/process to bring back up generation online; 2) some generators use fuels that have high emissions and others which have low. We will develop guidelines, criteria and methodology to convert to cleaner burning fuels.

The estimated cost of this project for the first phase is $150,000 and the second phase is $350,000 for a total of $500,000.

The potential demand reduction from back up and distributed generation could be as high as 50MW in the Bay Area. The cost effectiveness could be very high. An investment of $500,000 could untap $50MW potential, less than $10 per kW.

5. Use of Personal Fans and Lights to Reduce Energy Use and Demand

The human comfort is a function of six parameters—four of them environmental, i.e., temperature, humidity, radiant heat or temperature, air speed and two of them non environmental, i.e., metabolic activity level and personal clothing level. We give a lot of attention to temperature, and some times humidity, for comfort. However, air motion is mostly considered in context with avoiding cold drafts only.

Moving air through central air handling units is quite expensive—about 1-2 watt per square foot. On the other hand moving air through personal fans can be very energy efficient, .02-.04 Watts per square foot. But using a personal may allow raising of the space temperatures by as much as 6 F, which could provide additional air conditioning or chiller energy savings that may be as high as 3-4 kWh per square foot per year. It could also reduce peak demand by as much as 2-4 Watts per square foot. Typical peak demand savings are estimated to be about 0.1kW per fan (after subtracting fan power). With cost of a personal fan at $10-20 apiece, the cost of demand reduction will be $100-200 per kW, a very cost-effective measure. With just 1/10th of 1% of penetration by 2001, the potential peak demand savings could be as high as 4000 kW for California. Besides, the biggest benefit would be derived from productivity increase, greater occupant physiological and psychological comfort levels and avoidance of occupant complaints.

This element of the proposed initiative would provide personal fans to occupants and raise the thermostat set point temperatures in steps and verify energy savings. EPRI and Hewlett Packard have teamed up to conduct a pilot and expand it to the all facilities. Through SVMG and MEUG, other facilities will also be teamed up.

This is a very short-term measure. The personal fans can be easily procured and brought to the site literally in a day.

The estimated project cost will depend upon number of facilities and number of workers in each facility. But for a peak demand savings of 100-300 Watts per worker, and 30 to 50 kWh per year per worker in the building, a cost of $10-20 per worker is still very cost effective.

The estimated cost of this element is $500,000.

Appendix A

Demand Responsive Building Strategy

From:

Arthur H. Rosenfeld
Commissioner
California Energy Commission

Appendix A:
Arthur H. Rosenfeld, Commissioner, California Energy Commission
(916) 654 4930; Cell phone (916)719 7829; Arosenfe@energy.state.ca.us
07/20/00

DEMAND-RESPONSIVE BUILDINGS STRATEGY, Version of 7-18-00

Short Term: *A few commercial building pilots to demonstrate 800-1200 MW potential by 2001 by dimming lights and letting indoor temperatures float up by 2 deg. F (pilots underway).*

This Year – 2000: *Avoid outages by turning on emergency generators, 10% of 20 GW of commercial buildings, so 2 GW.*

Medium Term: *Initiate a "cool communities" program (cool roofs, etc), good for 100 MW/year, which will become about 1,500 MW after the program is complete in 15 years.*

Long Term: *Revise Title-24 (efficiency standards for new building) to take effect 2002, taking into account real-time electricity prices. Should save 300 MW/year, or about 3,000 MW after 10 years of new construction, 6,000 MW after 20 years, etc.*

ESTIMATE OF POTENTIAL AVOIDED PEAK POWER

On a very hot afternoon the California ISO sees a peak demand approaching 45,000 MW. Of this, about 35,000 MW (70%) goes to buildings, and of this 35,000, 13,000 MW goes to air conditioning (AC) which can quickly be transformed into a more "flexible" (price responsive) load. With today's communications (internet, cellular phone) it is now cost effective to have indoor temperatures float up 1-2 deg. F on a voluntary, consumer-controlled preset ramp, in response to a rising real time price.

A 2 deg. F ("no-sweat") rise, statewide, should reduce AC demand by about 5 %, i.e., shave 650 MW off the peak. Of this avoided power, about half comes from commercial buildings, which can be lucratively controlled within 1-2 years. The other half is residential, controlled about 10 million thermostats, which unfortunately have a service life of perhaps 10 years. If we assume that smarter thermostats, responsive to real time price, replace present thermostats at 10%/year, then we can avoid another 30 MW each year after we get the residential price incentives right.

We return to the half of commercial building AC, about 325 MW that can be avoided quickly. This number is uncertain because we do not know quite yet what fraction of commercial chillers are undersized, right-sized, or oversized. If they are undersized, or even rightsize, then they can maintain a temperature difference of only about 20-25 deg. F between indoors and ambient temperature. Thus on hottest days, the indoor temperature will float up on its own, and we cannot save power by lettering it float up from its normal 74-75 deg. F. Our Pilot has called for utility data on 4 pm demand vs. 4 pm temperature, to clarify this question. So far we have assumed that half of all buildings are ineligable.

Arthur H. Rosenfeld, Commissioner, California Energy Commission
(916) 654 4930; Cell phone (916)719 7829; Arosenfe@energy.state.ca.us
07/20/00

Another 5 GW goes to lighting commercial buildings, and some of this is discretionary (particularly because peak demand occurs on sunny afternoons). Some buildings are already wired so that exterior and parking-lot lights, and lighting in the peripheral (daylit) zones of buildings, can be dimmed or partly switched off, saving 1/3 of the lighting demand. With installation of some controls it should be cost-effective to quickly cut commercial building lighting demand by 10%-20% during peak demand hours, for saving another 500 to 1000 MW.

BARRIERS AND ECONOMICS

In California, an **average** retail price is about 10 cents per kWh ($100/MWh), but the real-time cost to the distribution companies varies greatly and during peak hours hits 75 cents/kWh ($750/MWh), and during the week of June 12 cost one utility (SCE) $1 billion. But, absurdly, these prices are rarely passed on to customers. The big exceptions are in San Diego, and to direct access customers (~15% of peak load). The most interesting but small exceptions are the pilot real-time rates already offered to a few customers by both PG&E and SCE. But all residences and small buildings see a price stuck at the 10 cent average, and almost all of the large customers with interval meters see only summer-average peak period prices. **This is an almost total barrier to responsiveness – as I understand it, the customers see no more incentive to manage load during a heat wave than during a cool period.**

Communications and switching hardware/software exist that can avoid peak power for about 1 cent/kWh ($10/MWh), but installation is lagging because of this lack of price incentives and of metering. The distribution utilities and the ISO are still thinking in terms of accurate (“revenue quality”) real-time (“interval”) meters, and only in pilot projects have two utilities announced that they will pay for each avoided kWh at its true value, which for PG&E on the afternoon of June 28 was over $1/kWh for four hours. Restated, that’s over $1000/MWh, and is roughly 100 x larger than the load management solutions. Of course in some transmission- or distribution-constrained areas, the true avoided costs are even larger. .

The benefits to all ratepayers is much greater than the savings to the individual participating customers for several reasons.

1. Electric supply is very price inelastic on hot days, so a few % reduction in demand can drastically cut not only **bills** for those that reduce load, but also energy market **prices** for all customers, reducing electric bills for the non-participants as well as participants in peak-reducing programs.
2. The risk of outages such as occurred in the Bay Area in June would be reduced.
3. While we need new generation, transmission, and distribution capacity, but we don’t want to **over invest** when load management is a cheaper and greener way to meet peak demands.

Appendix A:

Arthur H. Rosenfeld, Commissioner, California Energy Commission
(916) 654 4930; Cell phone (916)719 7829; Arosenfe@energy.state.ca.us
07/20/00

While real time pricing and metering is ideal, much could be done immediately if utilities offered to pay consumers for participating in programs that rewarded demand responsive load reductions without waiting for meters.   This leads us to our Pilot Project.

SHORT TERM: PILOT PROJECT FOR COMMERCIAL BUILDINGS

Power plants already in the pipeline will not come on line until 2002-03.   Before then, the most practical measures are on the customer side of the meter.

We are planning a demonstration project for this summer (in 2-5 buildings owned by SMUD and DGS in Sacramento, 2-3 DWP buildings in LA) for buildings that already run under the control of an "EMCS" (Energy Management Control System) that already controls lights and thermostats and can listen to real time prices on the internet, but do note have real-time meters. The pilot is to install relatively simple hardware/software, which will dim lights, and let the temperature float up slowly about 2 deg. F along a consumer-selected price-dependent ramp.   We will also look at the 24-hour predicted price and temperature and pre-cool the buildings early in the day of a predicted "scorcher."

A qualified engineer will test the system on a hot afternoon and certify how many kW are saved (and for how long) at a few specified test prices and ambient temperatures.   This certification will be the basis for payments for peak load reductions.

An occupant comfort survey will be taken on normal days and during hot afternoons when the temperature is drifting up.

After the pilot we propose a workshop for building operators, utilities and vendors, to be sponsored by the CPUC and the CEC at which we will present results (costs of avoided power and any discomfort) and recommend whether the process should "go commercial" for the summer of 2001.

This assumes participation by the major electric distribution companies who must announce that:

1. They will post a real-time price on the web. It may vary by location. This is because only some parts of utility service territories may be transmission- or distribution-constrained.
2. They will give a bill credit to customers (avoided kWh x real time price). Large customers may have interval meters.   If not, the rebate will be based on engineering estimates based on reading traditional meters.   We repeat that at least

PG&E and SCE presently offer real-time prices, but only to a handful of large customers.

3. They will test the system every hot afternoon, to inspire their own confidence and those of the building operators (i.e., a "notch test" to observe the load reduction by customer and systemwide).

This summer's pilot addressed commercial buildings with EMCS, and not homes, which will go slower because it will be necessary to install "smart" thermostats and controllers. This will occur naturally in new homes, or as the thermostats in existing buildings reach the end of their service life. For the summer of 2001 we should start a Pilot for residential buildings. We should also monitor how fast State and Public buildings (e.g. school) respond – we might need a pilot for schools.

MEDIUM TERM: ACCELERATE "COOL COMMUNITIES"

This will not only save peak power, but it will cool smoggy cities, and is the only way to help them comply with ozone standards while saving money. For new schools it will actually reduce first costs because the white roof is a no-cost or low-cost specification, but one can then downsize the expensive AC by 10-20%.

LONG TERM: REVISE TITLE 24 IN 2002 TO INCORPORATE THE REAL-TIME VALUE OF ELECTRICITY

The California Title 24 building efficiency standards specify efficiency levels that minimize life cycle costs based on average retail rates. Restructuring of the electric industry brought about by AB 1890 will necessitate introduction of real time prices and metering at some point in the near future. Therefore it is essential that buildings be designed to incorporate measures that not only reduce peak demand, but can respond to varying real time prices.

The CEC proposes to update T-24, re-running all the calculations under the modern assumption that new buildings will see real-time prices. This will change existing requirement (for example the optimum efficiency for air conditioning systems), but also at least double the list of emerging technologies which must be evaluated for potential incorporation in the standards. Some examples are:

- Cool roofs
- Selective window glazings
- Variable speed motor and drive systems for pumps and fans
- Controls for lighting, air conditioning, elevators, escalators, etc,
- Increasing the wiring size inside buildings (where 2-5% of peak power is lost),
- Efficient transformers in commercial buildings,
- Thermal storage in large buildings (cost effective, but somewhat forgotten),
- HVAC systems optimized for peak power, with non-leaky ducts.

- Cooling without electric chillers (multi-stage evaporative, “thermally” driven, …). The thermal energy can come from “CHP” (combined heat and power), from gas, or from the sun.

The list of emerging technologies that have not been evaluated for use in T-24 is long, and growing with R&D efforts around the country, including the CEC's PIER program.

A Title-24 “recommended” list of measures could be used by both new building designers and retrofitters to beat Title 24 and thus be eligible for proposed federal tax credits (S. 2718). We could formally call it “Tier 2” and consider California tax credits for these measures. The federal treasury now figures that tax credits for commercial buildings stimulate investments with such large benefit/cost ratios (typically 7:1) that they significantly increase profits (and hence business taxes) and actually make money for the treasury.

Annual Savings. California peak power is now growing about 1 GW/year, of which 700 MW is attributed to buildings. Excluding cool roofs (which alone should save 100 MW each year) a revised T-24 could reduce demand by another 300 MW for each year of new construction (for example 3 GW by 2012), all at lucrative payback times, since T-24 calls only for cost-effective investments.

RESOURCES NEEDED

Steve Larson and Scott Matthews will complete this section.

Appendix B

Prevention of Industry Rolling Blackout and Economic Loss From Stage 2 Emergency Power Alert

Building HVAC System Demand Control

Mukesh K. Khattar
EPRI

Paul Stephen
Hewlett Packard

Appendix B

A Proposal For
Prevention of Industry Rolling Blackout and Economic Loss
From Stage 2 Emergency Power Alert

Building HVAC System Demand Control

Contacts: *Paul Stephens, Hewlett Packard, (408) 718-4105, paul_stephens@hp.com*
Mukesh Khattar, EPRI, (650) 855-2699, mkhattar@epri.com

Project Objectives:

The primary objective of this proposed project is to find aggressive but practical solutions that can be implemented in a short time to reduce peak demand, and particularly, investigate the control of ventilation during power emergency stage 2 alert hours. A secondary objective is to develop long term control strategies that maximize the amount of energy demand reduction during stage 2 power alerts for California high energy use industry.

Background and Discussion:

Rolling blackouts cause severe economic losses to industry from lost productivity, devastating impact on the State's economy, and disastrous effects from expensive equipment failure during such power interruptions. The disruption in business may take several hours to a few days to bring it back to normal, even though the actual power outage may last for a brief time.

Large energy users such as Hewlett Packard take several measures to curtail demand when they are notified of Emergency Stage 2 Power alerts (i.e., when Electricity Operating reserves fall below 5%). These measures include turning off lights and idling office equipment, as well as other measures to reduce air conditioning needs. However, more aggressive measures must be found to assure power reliability and avoid rolling blackouts.

Paul Stephens, Energy Manager at Hewlett Packard, approached EPRI to investigate one innovative new measure: controlling ventilation during Stage 2 Power emergency alert hours. This measure could be adopted after all other measures such as raising thermostat set point have been exhausted. Ventilation air may account for 10 to 20+% of the total air conditioning load during the emergency stage 2 alert hours, since the ambient air temperatures are quite high at these hours. In addition, generally the ambient air quality is also poor at the same time and restricting ventilation may even be helpful.

The first reaction to the proposed approach is that 'it can not be done! Or, the codes would not allow it.' But a closer look at the codes and potential loss from disruption due to rolling blackout if power demand is not curtailed argues that this approach may have some merit. The California Title 24 code allows air conditioning system shut down for up to 90 hours a year for maintenance or when utility power supply is constrained. The ASHRAE standard permits closing of outdoor air damper if out door air quality is worse than inside. Moreover, although the current standards call for some 15 to 20cfm per person in office environment, yet only 5cfm per person were accepted in non-smoking buildings between mid 70's to late 80's. This would suggest that the ventilation could be reduced for very short periods of time (a couple of hours at a time) during Stage 2 power emergency alerts, which may last for only a few hours and for just a few days a year. And to compensate it, the ventilation can be made up increasing outdoor air during off peak hours.

There are several issues, however, that must be addressed before such a measure could be adopted in practice. These issues primarily revolve around consequences of resultant indoor air quality from reducing ventilation during the alert hours on building occupant's health and productivity. These temporary reductions are not likely to increase indoor air pollutants in normal office buildings to any appreciable levels. But, if a suitable solution could be found for the few hours of the emergency stage 2 alert, it could provide much needed relief for the state's electricity operating reserve as well as mitigate economic loss. On the other hand, increasing ventilation during off peak hours can boost productivity. Preliminary data suggests that doubling ventilation can cut down absenteeism by 30%!

Approach:

Our approach is to address the project on two fronts: On the first front, we will explore practical solutions that can be implemented in the next couple of weeks, prior to the onset of summer. This short-term objective is the most important driver for Hewlett Packard and other major energy users. On the second front we will conduct research, and collect and analyze information and data to develop and support practical solutions for the long term. We have discussed this approach with Dr. W. Fisk at LBL and plan to team up with LBL in the design of the field demonstration/experiment and data collection protocol so that the data can be analyzed scientifically.

The following approach is proposed on the first front.

1. Controlled Facility Tests:

   We will conduct testing of ventilation control strategies in controlled settings so that we can document resultant air quality different control schemes. Ventilation (out side air, not necessarily the airflow) will be cut back in a stepwise fashion and the resultant power savings will be determined. The effect on health and productivity from short time reductions could not be practically measured. Instead, we will record incidence of complaints. We plan to conduct tests in two wings of the same office building, and rotate control of ventilation between the two wings. Prior to actual tests, analysis will be performed to roughly predict what will happen to the IAQ and study different scenarios of control strategies in order to guide the tests. These activities will be supported with information gatherings, data collection and analysis, which will also be useful for the second front.

2. System Wide Implementation:

   The primary interest and the most benefit can be achieved by implementing the strategies on system wide basis where they could be activated on the emergency stage 2 alert hours. The system could be installed and activated only when it is necessary to curtail peak. The strategies learned from the controlled tests can be implemented at the larger number of facilities. This will provide the most benefit to the facility owners and the state. We propose to select Pilot Buildings to test system wide applicability and potential of the technology.

The following activities are proposed on the second front. These will provide rigorous scientific support for the experimental work on the first front. Our approach here is designed to meet the following five objectives.

1. To determine when increasing ventilation rates in the morning of an expected peak-demand day, can enable reduced ventilation during the afternoon peak-demand period without increasing indoor pollutant concentrations.
2. To determine if temporary reductions in ventilation rates in particular buildings are likely to result in unacceptable indoor pollutant concentrations or an unusual level of occupant health complaints;
3. To determine the reasonable minimum ventilation rate during periods of peak demand.
4. To identify the procedures for temporarily reducing ventilation rates; and
5. To estimate the reductions in electrical power demand that result from reducing ventilation rates.

<u>Time Frame:</u>

The project must start immediately in order to provide meaningful curtailment of power during this summer. The first task on the first front must start immediately, with the second task for a pilot batch of buildings to be completed this summer. The tasks on the second front can begin now, but will be accomplished over longer period spanning next summer.

<u>Budget:</u>

The estimated budget for Task 1 is about $100,000 to $300,000 for planning, management, instrumentation, testing, data collection, strategy implementation, analysis, etc. The budget for other tasks will be estimated later. What is learned from this study will be applicable to other facility owners in the state. This falls under the public interest energy research, and we are seeking funds from the state of California and public utilities. The project scope of work can be broken up into several phases to accommodate funding limitations.

Key Players:

Hewlett Packard has pledged the availability of their facilities for testing and energy managers' time required for coordinating and implementing the strategies.

EPRI would provide rapid overall design of the project, experimental design and project management. EPRI and EPRI's subcontractors will collect and assemble the information described above, provide this information to the client, and discuss the implications with the client. Decisions to temporarily reduce ventilation rates will be made by HP. EPRI and EPRI's subcontractors will provide information enabling HP to make informed decisions.

The project will be coordinated with LBL either as an advisor or as a sub-contractor to ensure that our test and monitoring plans are sound and that we will get scientifically valid data. Bill Fisk at LBL has already provided valuable advice in strategic approach to addressing the issues and particular tasks that should be undertaken.

service opportunity

Customer Potential Studies: Key Strategies for Market-Driven Load Management

Maximize Profitability by Turning Your Customers into Valuable Assets

INCREASE PROFITABILITY, REDUCE COST, MANAGE RISK, AND IMPROVE CUSTOMER SATISFACTION.
Electricity customers can play an active role in helping you reach these critical business objectives. Under deregulation, your customers can help you respond effectively to challenges and opportunities such as spiking spot prices, rotating outages due to generation unavailability, T&D congestion, economic asset utilization, and interregional arbitrage. All players in the electric business environment— generator, power exchange, ISO, power marketer, distribution company, and energy services provider—can design improved customer load management programs with EPRI's unique expertise in evaluating customer characteristics and performance.

EPRI's *Customer Potential Studies* help you to engage the most promising customers for program participation, and provide the basis for screening customers for the future.

THE RIGHT PROGRAMS FOR THE RIGHT CUSTOMER . . .
EPRI *Customer Potential Studies* provides you with a customized report tailored to your business, giving you the information you need to maximize profitable revenues. You will have the ability to encourage customers to modify their electric demand patterns to your advantage by targeting key customer segments (micromarkets) with the appropriate load management programs, such as

- Responding to real-time requests
  – load curtailment
  – real time pricing
  – mass market comfort modification
  – demand trading (negawatts)

- Employing technologies that result in ongoing benefits to the electricity value chain
  – customer energy management systems
  – thermal energy storage
  – electrotechnology adoption to promote economic development or reduce demand
  – distributed resources
  – fuel switching

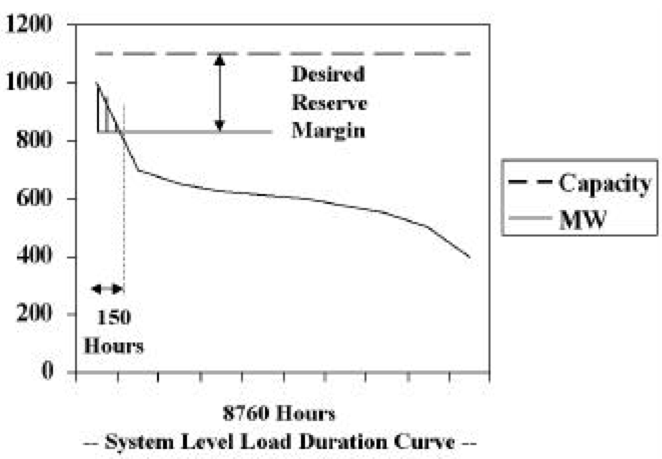
THE CAPABILITIES YOU NEED TO SUCCEED
EPRI's *Customer Potential Studies* help you achieve your business objectives by providing a complete determination of *customer performance* with respect to:

- customer class (residential, commercial, industrial, agricultural, municipal)
- customer segment discriminators (SIC code, building type, appliance mix)
- risk profile (factors influencing the likelihood of customers responding effectively to requests, and technology performance)
- geographic location and proximity to areas of concern
- climate zone

- load shapes and energy use
- technical potential (what would be achieved if all customers eligible for a program participated)
- market potential (degree of customer participation likely to be realized)
- sensitivity to program parameter changes (singly or severally), especially price elasticity

The studies analyze the impacts of these factors on customer program performance to help you specify the likely individual/aggregate demand modifications, market penetration, customer acceptance, and sustainability of customer participation. These factors are a function of program attributes, such as

- frequency of requests
- duration of demand modification required
- annual customer exposure to requests
- price (levels and time variability)
- customer discomfort, inconvenience, or out-of-the-ordinary effort
- participation/performance incentives



Load Duration Curves define program objectives

YOUR RETURN ON INVESTMENT

EPRI's *Customer Potential Studies* can help your company prosper financially during and after the transition to deregulation, and avoid adverse public reaction to uncontrolled operational situations. These Studies can also hedge your competitive risks, by offering the right programs to only the right electricity customers. EPRI's expertise and experience can save companies up to three years of effort in learning how to perform and use the results of Customer Potential Studies, and can help you avoid pitfalls in customer program development. Your return will be leveraged by a broad portfolio of EPRI-developed tools in areas like

- customer preference and behavior
- customer response to pricing options
- DSM technologies and programs
- end-use load shapes
- data transferability
- program evaluation

DEMONSTRATED VALUE

Through utility industry support, EPRI has evolved into the world's leading integrated electricity science, technology, and market knowledge resource, from generation through end use. Our clients have consistently utilized EPRI information, tools, and staff expertise to address deregulation head-on, thus reducing or avoiding the costs to develop or obtain these resources themselves.

PROGRAM STATUS AND SCHEDULE

This program is available immediately. Participants will play an active role in determining final deliverables, priorities, and schedule of the project.

CONTACT INFORMATION For more information, please contact the EPRI Customer Assistance Center (EPRI CAC) at 800-313-3774 or askepri@epri.com.

SO-XXXXXX

The Energy NC – Information Services for the Networked Neighborhood

An Offering of EPRICSG, Inc.

The Energy NC is an information systems management business that opens up non-PC households -- 50% of the population, and 80% of households with income less than $30,000 – to Internet services and one-on-one market connection. It can be used to create a real community of shared interests between local service providers and their consumers. It brings a cheap, easy-to-use, personally tailored two-way consumer service to every home with a phone and a TV set.

Using a set-top box that connects to a phone, cable or DSL line, the Energy NC facilitates the following:

- E-mail access from television screen
- Personal interest & activities
- Personal shopping connection with preferred neighborhood merchants
- Strengthening of school-centered communities -- communications between teachers, parents and students
- Personally programmable television access and control through personally configured data chips (allowing parents to control length of time of children's viewing)
- Energy consumption awareness
- On-line bill presentment and paying
- Home security and safety control
- Home media operations
- Comfort controls
- Operation, scheduling and maintenance of "smart" appliances
- Neighborhood news
- Local restaurant guide
- Local news/weather
- Local road repair & city information
- Home banking
- Online shopping
- Classified ads
- World portal to Internet

With a click of the remote control, users can switch from regular TV programming to the custom information portal, (keeping the TV picture in view), where they find their choices from their customized menu of applications and services. They can check e-mail, pay bills, confirm a restaurant reservation, see what school is serving for their kid's lunch, and surf the Internet – all without the need for special computer skills that have proven a barrier to wider market penetration of PCs. Most importantly, the Energy NC serves as a familiarizing agent for all forms of communication technologies, both opening doors for these technologies to the vast untapped residential and small commercial markets and helping these markets become less intimidated by them.

Several demonstration projects are currently running, in ???? short description

In addition, the San Francisco Bay Area Urban League is proposing a project that would center on one school in the 800,000 student Oakland City School District. This project would link parents, teachers and students using the EnergyNC, providing information on homework assignments, special issues that occur during a student's day, parent's comments on student's special needs, via an icon that appears on the television screen. In addition, the project will provide participating households with energy management information that will help them lower their energy costs and become more active participants in the deregulating energy marketplace. Information gathered during the demonstration project will be used to roll out the program in 2000 to the school district at-large.

The Energy NC seeks partners to inject financial capital that will help it more fully utilize its utility-sponsored customer base to expand the reach of this technology. We aggregate upstream technology providers for our utilities, with their huge captive customer base, and school district customers. The cost of customer acquisition for these upstream providers is therefore reduced, while non-early adopter customers themselves begin to see the value of new technologies as they are introduced to them on the Energy NC.

Using Demand Responsiveness Programs to Ensure Electrical System Adequacy in California

A Proposal to the California Energy Commission

April 7, 2000

UNDERSTANDING OF THE PROBLEM

The State of California is facing a significant problem balancing the demand and supply of electricity, and ensuring the adequacy of its electrical system. This problem has arisen from rising load growth that has not been matched by commensurate growth in installed capacity. About 75% of California's demand requirements are met by in-state capacity. The balance is imported from out of state, with 14% coming from the Southwest and 11% coming from the Pacific Northwest.[1] During periods of peak demand in the summer, the ability to import power from the Southwest goes down, as that region's peak tends to be contemporaneous with California's peak.

The California Energy Commission (CEC) has estimated that non-coincident peak demand reserve margins were under 4% in 1998, compared to 10% in 1995 and 13% in 1993.[2] There were four Stage Two emergency alerts in California during the summer of 1998. The California Independent System Operator (ISO) estimates that in the summer of 2000, the state will have a nominal surplus of 100 MW under normal weather conditions and a significant deficit of 1100 MW under hot weather conditions.[3]

An often overlooked-- but potentially highly cost-effective-- resource for meeting this shortage is the natural response of customer demand to changing electricity prices. We call this behavior demand responsiveness, and we refer to initiatives designed to promote demand responsiveness as programs.

BENEFITS OF DEMAND RESPONSIVENESS

It has been shown elsewhere that using prices to ration demand is superior to random quantity rationing which ignores customer diversity, and creates a loss in economic efficiency.[4] Some load is typically more willing to be rescheduled and curtailed than other load.

Incorporating demand response in the state's arsenal of energy policy measures can provide several benefits. These include a reduction in the market power of energy suppliers. It has been shown that during the first year of operation, California's energy prices were approximately 22% above competitive benchmark. This represents a significant exercise of market power that cost the state's citizens roughly $800 million dollars in the first 18 months of deregulation.[5]

Additional benefits include enhanced reliability, lower price volatility, greater product diversity, and a faster rate of customer switching. Demand responsiveness programs (DRPs) will help increase the market efficiency of the California Power Exchange (CA

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[1] William J. Keese, "Electricity Supply Adequacy in the West," February 23-25, 2000.
[2] Michael R. Jaske, "Electrical System Adequacy and Demand Responsiveness Programs," March 24, 2000.
[3] Donald L. Fuller, "Summer 2000 Trial Load Participation Programs," March 24, 2000.
[4] Douglas Cave, Kelly Eakin and Ahmad Faruqui, "Mitigating Price Spikes in Wholesale Markets through Market-Based Pricing in Retail Markets," **Electricity Journal**, April 2000, forthcoming.
[5] Borenstein, Bushnell and Frank Wolak, "Measuring Market Power in California's Restructured Electricity Market," 1999.

PX) because the market clearing price (MCP) is effectively set by supply bidders that face vertically-inelastic demand curves. DRPs may eliminate the need for price caps, and would also provide the state with an option to balance demand and supply in critical reliability periods when the current set of interruptible tariffs expire in 2002.

Statement of Work

EPRI is pleased to submit this proposal to the California Energy Commission. Our proposal rests on two strategic premises:

1. Optimal resource allocation occurs when private participants in energy markets, including energy providers and end users, are given incentives to act in their self-interest, rather than through the imposition of “command-and-control” systems that seek to promote the public interest.

2. One of the goals of the state of California is to offer end users a menu of choices regarding products and suppliers. I.e., an approach that relies on "one size fits all" will not work. End users should be given the option of self-selecting themselves into the product and service option that best meets their need.

Technical Approach

Our approach is comprised of a series of tasks that are listed below, and discussed in detail in the next several pages. Some of these tasks include optional sub-tasks. We recognize that the Commission may not choose to fund all of these tasks or sub-tasks, and would be prepared to rescope the approach in response to the Commission's comments.

The tasks are structured as follows:

1. Create Policy Framework
2. Establish Market Potential of Demand Responsiveness Programs
3. Identify Barriers to Achieving Market Potential
4. Develop a State-wide Action Plan
5. Design Demand Responsiveness Programs
6. Optional: Field-test Demand Responsiveness Programs

Task 1 Create Policy Framework

In this task, we will work with Commission staff to define the state's policy objectives. These might include (a) meeting California's energy needs at least cost, (b) enabling the benefits of deregulation to flow to all end users, (c) mitigating price volatility, (d) ensuring price transparency, and (e) encouraging end users to switch to non-incumbent energy service providers.

In this task, we will also identify market participants whose cooperation would be essential to the successful implementation of demand response. These are likely to include energy end users, utility distribution companies (UDCs), energy service providers (ESPs), regulatory agencies (CPUC and CEC), the CA ISO, the CA PX, and the legislature. Likely roles for these organizations have already been identified by the CEC. We will work with the CEC to update the characterizations of these roles based on this summer's likely activities.

Cost: $10K

Optional Sub-Task. We will develop analytical tests for assessing the cost-effectiveness of various demand responsiveness measures. These new tests will build off the existing Standard Practice tests for assessing the cost-effectiveness of demand-side resources. These tests will be modified to work in a market-driven environment. The cost of this optional sub-task is estimated at $50K.

Task 2 Establish Market Potential of Demand Responsiveness Measures

In this task, we will identify a wide range of demand-responsiveness measures that can be used to introduce demand responsiveness in California's competitive energy markets. We will draw upon our extensive knowledge of such measures in other markets in the United States and abroad to develop this list.

The list is likely to include items such as the following: providing price signals that reflect the time-varying cost of electricity, rescheduling operations by rearranging production schedules and business hours, installing energy management control systems (EMS), installing distributed generation options such as co-generation and self-generation, and switching end use equipment to more-time flexible options such as thermal energy storage (TES).

Estimates will be developed of the unit demand impact of these measures, drawing upon a wide range of data sources. These include EPRI's *StatsBank* that contains demand responsiveness information derived from econometric analysis of 1,000 customers located in Britain and the United States. Other sources include California utility studies of demand responsiveness exhibited by customers on pilot real-time pricing programs and full-scale curtailable and interruptible tariffs, studies by other utilities in the US not included in the *StatsBank* library, and a literature survey.

We will then quantify the market potential of these products by combining the unit demand impacts with information on customer equipment, buildings, and process inventories. Much of the latter information is contained in the CEC's system of end-use forecasting models.

The market potential estimates represent the maximum amount of demand reduction that can be expected from the various demand responsiveness measures. The potential will be developed at a variety of different levels. The different levels will be developed in conjunction with the CEC, and are likely to include:

- time frames (short term versus medium term versus long term)
- geographic regions within California
- market segments
- vintage (e.g., existing buildings versus new construction)

Cost: $75K
Insert description of *StatsBank*

Task 3 Identify Barriers to Achieving Market Potential

This task will assess the feasibility of achieving the market potential identified in the previous task. It will begin by reviewing California's limited but valuable prior experience with innovative pricing and load management programs. Evaluations of these programs will be reveal insights about market barriers. It is expected that such a review will bring out the problems posed by lack of information, lack of financing, long pay-back periods, lack of appropriate technologies, and lack of technical support.

It is also expected that this task will highlight the key role of advanced metering equipment in implementing demand responsiveness. Some type of interval metering is a necessary condition for implementing DRPs, and the temptation to rely on load profiling will need to be resisted. Load profiling is essentially an oxymoron in the context of implementing DRPs, because it assumes static--and thereby price unresponsive--load shapes. This task will also explore the role of the Internet as a medium of communication with end users.

It will also review the barriers posed by the existing regulatory environment in which retail rates are frozen, wholesale costs are determined in the competitive power exchange market, and a competitive transition charge (CTC) to pay for stranded costs is derived as a residual. In his work with EPRI, Frank Wolak of Stanford University has argued that this barrier is the most stringent barrier to the successful introduction of DRPs.

Core Cost: $25K

Optional Sub-Task: EPRI's *Product Mix* model can be used to simulate market response, and develop quantitative impacts of likely demand impacts. Unlike other tools that use a deterministic approach, *ProductMix* provides expected values and standard deviations of impacts. Insert model description. The cost of implementing this optional sub-task is estimated at $100K.

Task 4 Develop a State-Wide Action Plan

In the short term, several efforts are underway for implementing DRPs to deal with the looming crisis this summer. As directed by Senate Bill 735, the two commissions are required by May 1 to submit reports to the legislature. The CA ISO has developed several types of ancillary service and demand relief programs for this summer. And the UDCs have submitted designs for various interruptible tariff modifications and demand responsiveness pilots to the PUC. This project will of course focus on issues of relevance to the summer of 2001. But in so doing, it will seek to learn from the experiences of this summer.

This task will develop an action plan for achieving the benefits of DRPs at least cost. It will involve identifying and prioritizing market opportunities. Short and long-term goals of likely program impacts will be developed by market segment. In addition, it will identify ways for attacking the market and regulatory barriers identified in Task 3.

The plan will have to engender flexibility in energy planning, and rely extensively on "learning by doing" given the considerable uncertainty that exists with DRPs. E.g., there is considerable uncertainty about how many end users will actually sign up for a particular DRP, and how the end users will respond to the program's incentives.

However, once the programs are offered in the field, some of this uncertainty will be eliminated. This iterative process is exactly what the airlines went through when they introduced revenue management several years ago.[6]

Cost: $50K
Optional Sub-Task: Update estimates of end user outage costs, by market segment. These estimates serve as a foundation for all types of DRPs. However, the best available estimates are more than a decade old. This optional sub-task is estimated to cost between $50K-$500K, depending on how much new primary data collection occurs.

[6] Robert Cross, **Revenue Management**.

Task 5 Design Demand-Responsiveness Programs

This task will take the measures identified in the previous tasks and turn them into market-ready program designs. A program design converts measures into actionable items in the market place. As such, it encompasses a variety of elements:

- a statement of what is the "product"
- value proposition by target market
- end-use technology
- metering and communication
- control technology
- pricing (both of electricity and of the associated technologies)
- channels (trade associations, Web sites)
- promotion and incentives (direct mail, phone calls and visits; seminars, workshops and technical training; financing)

We will begin by reviewing the existing menu of products that is being offered this summer in California, and enhance the list based on brainstorming discussions with the CEC staff. We will review the products being offered by the CA ISO [ancillary services and demand relief], the products that have been proposed by the CA PX [pay for performance, call options, demand ancillary service bids], the products that are being offered by the UDCs, and the products that are being offered by the ESPS [e.g., CTC loans, PX arbitrage discounts, post transition period, and load curtailment].[7]

These program concepts will then be further developed through a series of focus groups involving each of the major stakeholders in the demand responsiveness business. It is evident that a variety of products should be offered, to meet the diverse needs of various customer segments. One utility, Central & Southwest, has found that the best approach is to offer a menu of pricing options to its customers, ranging from single-part real-time pricing to time-of-use pricing to standard fixed rates, and to let customers self-select themselves into the various products based on their needs and interests.

Cost: $50K, for a total of five focus groups

[7] William Washburn and Brian Kick, "Energy Service Provider Load Curtailment Product Offerings," presentation at EPRI, January 14, 2000.

Optional Task 6 Field-Test Demand Responsiveness Programs

We understand that this is a task that does not fall under the purview of the CEC's activities. However, the CEC may act as a catalyst in getting others to implement it.

The task is likely to involve the following activities:

1. Choose segments and regions for field-testing, and obtain participation from appropriate stakeholders such as ESPs, UDCs, and third parties
2. Narrow the list of DRPs to a small manageable number such as three to five
3. Conduct field testing to identify likely magnitudes of demand response, and barriers to full-scale launch
4. Identify end user recruitment strategies

If there is interest in this task at a later stage, we can provide an expanded work scope.

This optional task is likely to cost between $300K-$1,000K

APPENDIX C4: CONTENTS

Appendix C4: EPRI Load Management Resources

With the recent summer spikes in market-based prices for wholesale electric energy, EPRI has seen increased interest in Load Management (LM) strategies and options, particularly for the Commercial and Industrial market segments. While some of this can be addressed through the application of Demand-Side Management programs and services, additional efforts through alternative rate and energy pricing strategies can also be pursued.

The purpose of the following discussion is to provide a brief, high-level summary of some of EPRI's past, current, and developing products and services in Load Management. This information should not be construed as a thorough representation of the capabilities that EPRI has developed in this area. Upon request, EPRI is pleased to offer a more detailed description of these activities, as well as a more comprehensive response to customer-specific Load Management needs.

Previous EPRI Work

While a number of past EPRI research projects have focused on Load Management program design and implementation, some of the more notable ones have outlined ideas that are still valid and can be examined in today's market situation. A few of the key EPRI publications that describe LM in general program terms includes:

- *Lessons Learned in Commercial Sector DSM (TR-102551),*
- *Principles and Practice of Demand-Side Management (TR-102556),*
- *Drivers of Electricity Growth and the Role of DSM (TR-102639).*

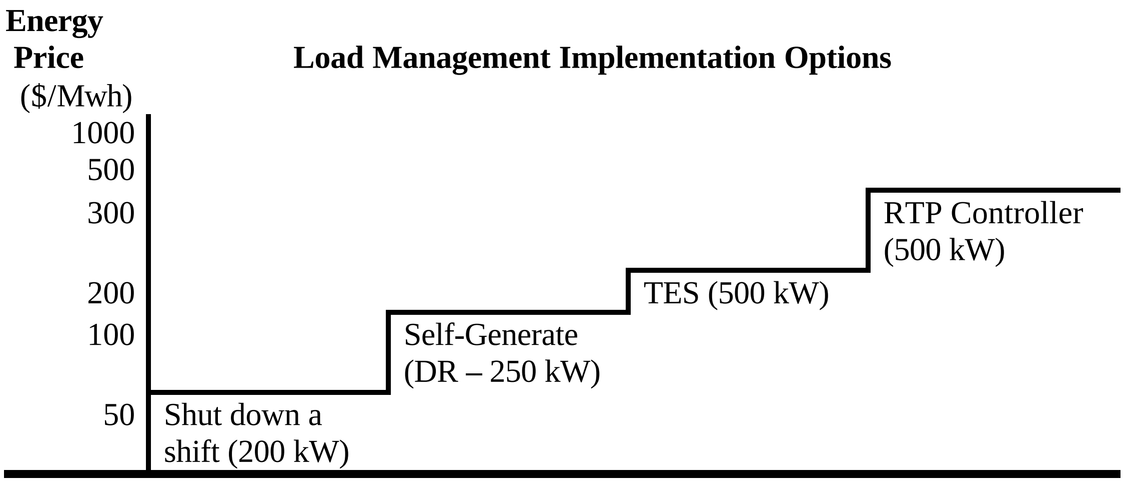
These studies suggest a general framework for developing successful programs in LM, as briefly described in three steps:

(1) Perform a market assessment to determine how much capacity exists for load management in the region of interest. This is usually done at the market segment level.

(2) Review the effectiveness of current programs & rate designs (DSM, load curtailment, Real Time Pricing).

(3) Evaluate the potential of the market penetration of specific, new opportunities, technologies and Coping strategies for specific customer segments. Some of the new opportunities may come through Distributed Generation, RTP Controllers, and management of Load Curtailment Co-operatives. These strategies can also be coupled with the use of proven technologies, such as Thermal Energy Storage (TES).

To illustrate, a Load Management Coping Strategy developed for a particular customer may look like:



The various options that a customer may pursue are dependent on many factors, such as cost to operate, time of day, level of load, and energy purchase prices. The various end-use systems that are capable of being controlled may include Lighting, HVAC, Water Heating and others. While EPRI has developed many useful resources in these areas, and is in fact considered a world leader for most of them, a summary of the most relevant and recent products is provided in resource listings attached to this document. These provide a variety of publications, briefs, and software products on end-use technologies that are appropriate for energy efficiency and load management options.

As implementation options for LM, additional EPRI resources in the areas of Thermal Energy Storage (TES) and Distributed Resources (DR) are also available. These are summarized in the following sections.

Thermal Energy Storage

EPRI has a long history in TES development and promotional activities. Some of the more recent examples are documented in case studies and conferences, which have disseminated successful strategies and information addressing implementation issues. These can be found in:

- *Proceedings: 1992 Electric Thermal Storage (ETS) and Thermal Energy Storage (TES) Conference (TR-103729),*
- *Proceedings: Load Management Conference: Dynamic DSM Options for the Future (TR-105422),*
- *Proceedings: International Sustainable Thermal Energy Storage Conference (TR-108927),*
- *Case Study of an Ice Storage System with Cold Air Distribution and Heat Recovery (TR-105858),*
- *Guide to Successful Implementation of Cool Storage Projects (TR-107338),*
- *Market Assessment of Thermal Energy Storage (TR-109478),*

- *OG&E Electric Services Uses EPRI Publications In Leading Thermal Energy Storage Program (IN-104364),*
- *EPRI/HECO Partnership Helps Thermal Energy Storage Break into Hawai`s Private-Sector Market (IN-105898),*
- *Thermal Energy Storage for Healthcare Facilities: TechCommentary (TC-106603),*
- *Thermal Energy Storage for a Hospital: TechApplication (TA-106628),*
- *Thermal Energy Storage with Cold Air Distribution in a Healthcare Facility: TechApplication (TA-106683),*
- *Spring-Ford Area School District and PECO Energy Case Study: Middle School Chooses Between Conventional Chillers and Thermal Energy Storage (MI-107871),*
- *Planning Surgical Suite Construction: TechCommentary (TC-107932),*
- *Data, Demonstrations, and Development to Put More Buildings on Ice: Commercial Building Thermal Storage (TS-110562).*

EPRI science & technology development has recently focused on the optimization of TES control strategies. This is for implementing TES systems with more capability of adapting to varied rate options, as well as predicting daily cooling requirements and adapting to seasonal variations and daily fluctuations in demand. Two reports & a white paper have been published summarizing some of the results to date:

- *Near-Optimal Cool Storage Controller Development (TR-109756),*
- *Near-Optimal Cool Storage Controller Development: Field Testing During the 1997 Cooling Season (TR-109767),*
- *Real Time Pricing and Thermal Energy Storage: Dealing with Rate Uncertainty (TE-114678).*

For the later subject on Real Time Pricing, EPRI is launching a collaborative project in 2000 to develop design, application and control strategies for thermal energy storage systems under emerging flexible and real time pricing scenarios.

For the small commercial market, EPRI has worked with manufacturers to develop and demonstrate packaged, unitary TES systems. This effort is summarized in the following documents:

- *Unitary Thermal Energy Storage System Performance (TR-106729),*
- *Market Assessment of Thermal Energy Storage (TR-109924).*

Distributed Resources

Evaluation & development of DR technologies represents an active area at EPRI. Because of the high interest, an annual conference has been held to focus on providing timely updates on evolving regulatory policy & report on market development activities and trends in technology. EPRI's *Fifth Annual DR Conference,* took place on Oct. 20-22, 1999 in Phoenix, Arizona. Proceedings from this event have been captured on CD-ROM. The Sixth Annual conference is being planned for October 4-6, 2000 in Tucson, Arizona.

Proceedings from previous conferences are also available:
1. Planning for a Competitive Market: EPRI's First Annual Distributed Resources Conference Proceedings (TR-105791),
2. Proceedings: Second Annual Distributed Resources Conference (TR-107585),
3. Distributed Resources Week 1997: EPRI's Third Annual Distributed Resources Conference (TR-109722),
4. Proceedings: Distributed Resources Week 1998 Strategies for Successful Implementation (TR-112300).

In order to evaluate the economic feasibility of DR technologies for retail customers, EPRI has developed a software tool, DRWorkstation (AP-111900-CD). The DRWS consists primarily of a technology information base and an economics evaluation engine. The economics engine is used to model the customer's cost of energy services with and without the DR equipment selected from the technology database. The technology database contains vendor-specific DR equipment information, including performance, cost, O&M requirements, and physical characteristics.

Additional EPRI publications summarizing recent advancements in the Distributed Resources technical area include:

- *Technical Assessment Guide (TAG (TM)) Volume 5: Distributed Resources (TR-105124-R1),*
- *Application Experiences with Distributed Generation in the Data Processing Center Market Segment (TR-109151),*
- *Application Experiences with Distributed Generation in the Power Critical Manufacturing Market Segment (TR-109152),*
- *Understanding Customer Needs and Markets for Distributed Resources (TR-109234-V1),*
- *Markets for Distributed Resources: Business Cases for DR Applications (TR-109234-V2),*
- *Distributed Resources Strategic Review: Market Drivers Impacting Future Business Prospects (TR-110245),*
- *The Knowledge You Need To Create Seamless DR Solutions: Distributed Resources Information and Tools for Business Strategy Development (TS-110636-R1),*
- *Emerging Distributed Resources Technologies: Position Your Company to Take Full Advantage of DR Opportunities (TS-110635-R1),*
- *Office Complexes Update: Distributed Resources -- Technology and Application: Issue 1, August 1998 (MI-111184),*
- *Integration of Distributed Resources in Electric Utility Systems: Functional Definition for Communication and Control Requirements (TR-111489).*

Transmission & Distribution Impacts

EPRI has also explored the T&D benefits that can be derived from DSM efforts:

- *DSM Transmission & Distribution Impacts: Volumes 1 and 2 (CU-6924-V! & V2),*
- *Prototype Expert System for Load Management (TR-100732-V! & V2),*

- *Targeting DSM for Transmission and Distribution Benefits: A Case Study of PG&E's Delta District (TR-100487).*

Load Curtailment

As a particular rate strategy for LM, Load Curtailment has received considerable attention from EPRI members in the past and is beginning to garner renewed interest.

Based on past experience in the areas of technology development, market research, and program design, EPRI is prepared to offer turnkey Load Curtailment program development, implementation, and management services. While specific details and program requirements can be tailored for individual client needs, a full program would entail the following steps.

ESTABLISH AND MANAGE A SUSTAINING LOAD CURTAILMENT PROGRAM

- Review current load management programs provided by the Energy Company to customers. Evaluate complementary and/or competing existing or planned load management programs (and price structures) with load curtailment.
- Identify the load curtailment potential of the Energy Company's customer base, based on energy use patterns and knowledge of customer energy use practices. Determine the curtailment compliance timescale (once notified), the maximum duration of a curtailment, and the number of days per year the customers would be subject to curtailment notification.
- Determine the relative value of approaching specific customers regarding participation in individually based or group (co-op) load curtailment programs. Pay special attention to proximity issues (so customers in a co-op can get to meetings easily). Co-ops should involve meetings of executives (strategic) and technical customer personnel (operations-oriented). Careful attention should be paid to the relative size of customer load curtailment potential (avoid mixing a 5 MW demand reduction customer with several 200kW demand reduction customers).
- Identify specific customers to approach.
- Develop pricing structure(s); decide the relative weight to give to participation (standby) incentives like reduced demand charges and to performance incentives (per kW or kWh of reduction). Avoid penalties – build in sufficient safety margins to the load reduction requirements for each customer that participates.
- Establish billing requirements and systems.
- Identify the technology to be used for curtailment notification, monitoring, and verification. It should be as real-time as possible, within the financial constraints of the program.
- Establish criteria for initiating a curtailment (e.g., temperature, spot price of electricity, system peak demand, reserve margin, and others).

- Approach a subset of customers with the proposed program; obtain feedback regarding their perspectives on program elements and their likelihood of participation. Modify program design as appropriate.
- Approach customers regarding participation; obtain signups.
- Perform curtailment audits of customer facilities to determine which loads are discretionary, and discuss with customer on-site. Devise both primary and secondary curtailable load lists for each customer (especially for co-ops). Perform trial curtailments of individual loads that the customer shows concern about.
- Establish a baseline load shape for each customer using historical or proxy load data, against which to evaluate later curtailment performance. Generally, this should be developed as a function of temperature.
- Provide customers with methods to estimate the value of their participation.
- Install the notification and verification technology at customer sites. Assure that the notification technology is placed in a manned space. Establish notification and compliance protocols.
- Perform customer training regarding how to comply with curtailment requests, how to respond to request for faster or greater demand reductions using their secondary lists, and how to monitor their curtailment compliance, in real time.
- Perform several test curtailments to assure the systems and customers are able to comply effectively. Do these for a variety of daily temperatures.
- Operate the program.
- Conduct analysis of curtailment compliance at the end of each curtailment day, and at the end of the operating season. Pay special attention to temperature dependence, customer motivation (especially regarding successive days), and customer dropout rates/reasons.
- Based on the experiences of the previous operating season(s), plan the next year's program.

An EPRI Technical Team Leader would be assigned to manage these services, as product and knowledge resource contributions would come from many EPRI technical areas. As a supplement to this information, the following provides a list of some of the key resources that EPRI has developed in pursuing the above strategies.

Commercial/Industrial Pricing Strategies and Controls

As Real-Time Pricing (RTP) has gained popularity as a load management option in recent years, EPRI has developed products to incorporate customer energy management systems and their response to RTP requirements. One of the more successful applications has been through the RTP Controller, which has seen success in several installations, most notably in two, high profile, and large commercial buildings in New York City.

The first RTP Controller was applied in the Marriott Marquis Hotel in 1993. Approximately 1.4 MW of the building's 6 MW electric demand was controlled by the RTP Controller strategy, which automatically regulates building energy consumption as a function of variable energy prices transmitted from the energy supplier to the hotel. Economic evaluations indicated a simple payback of under one-year for this installation.

Detailed information on this product is in the following EPRI publications:

- *EPRI Demonstrates Real-Time Pricing and Energy Management System at New York City Hotel (IN-101200),*
- *Development and Demonstration of Energy Management Control Strategies for Automated Real-Time Pricing (TR-111365).*

A follow-on test of an improved version of the RTP Controller added sensors to measure Indoor Air Quality. It also included new control strategies to optimize performance of an integrated Thermal Energy Storage system with automated response to real-time prices. This modification and the resulting demonstrations are detailed in:

- *EPRI Technologies Make Real-Time Pricing A Winner at Con Edison Customer (IN-107182),*
- *Automated CO2 and VOC-Based Control of Ventilation Systems Under Real-Time Pricing (TR-109117).*

Other activities pursued by EPRI in response to Energy Management and RTP strategies can be found in the following additional publications and case studies:

- *Honeywell Real-Time Pricing (RTP) Controller: Automated Controller Manages Energy Use of Commercial and Industrial Buildings on RTP Prices (BR-105227),*
- *Quick Starting a Retail Market Management Initiative — Real-Time Pricing: A Georgia Power Company/EPRI Collaborative Project (TB-101798),*
- *EPRI/GPC Retail Market Management Collaboration Uses Real-Time Pricing to Improve Utility Efficiency and Enhance Customer Satisfaction (IN-102200),*
- *Reaping the Benefits of RTP: Georgia Power's RTP Evaluation Case Study (TR-105044),*
- *Fielding a Real-Time Pricing Program: Pennsylvania Power and Light Case Study (TR-105042),*
- *Real-Time Pricing Quick Start Guide: Fielding Real-Time Pricing (TR-105045),*
- *Development of Energy Management Strategies for Automated Real-Time Pricing: Control System Enhancements for Thermal Energy Storage (TES) and Modulating Building Loads (TR-105501),*
- *Customer Load Response to Spot Prices in England: Implications for Retail Service Design (TR-109143),*
- *Increasing the Yield of Real-Time Pricing: Kansas City Power & Light's Real-Time Pricing Innovations (TR-110747),*
- *Small Commercial Customer Energy Management System Demonstration Project (TR-110183).*

Finally, an article in the EPRI Journal, ("Taking Advantage of Real-Time Pricing", March/April 1997) does a good job of summarizing the RTP Controller activities and is available in reprints, JR-108197.

Pricing & Load Shapes

Using curtailable, RTP, or other interruptible pricing options in a Load Management portfolio requires an understanding of the *profitability* of these strategic choices. EPRI's *Product Mix* model estimates customer response to a variety of pricing strategies, including those of potential competitors, and computes the resulting changes in profitability and risk for individual customers to groups of customers. It also forecasts potential market size for these pricing options, as well as the risk exposure to a pricing portfolio. Product Mix is available as a software tool from EPRI's Producing Successful Retail Products and Services Target in the Market Analysis and Resource Management (MA/RM) Product Line.

Also available from the MA/RM area is a new product called *PowerShape* (CD-111998), which contains a series of market profiles for customer segments in the commercial and residential sectors. Each profile is a stand-alone document that provides information about a sector, segment region, or technology. *PowerShape* market profiles provide key insights into the market, demographic, business, and energy characteristics of segments within the commercial and residential sectors. It provides vital information for contacting customers equipped with an understanding of their business, lifestyle, and energy needs. Commercial segments covered include: small offices (less than 50,000 square feet), large offices, restaurants, retail, grocery stores, warehouses, schools (excluding post-secondary), health facilities, lodging, services, and public assembly. This product also comes with remote technical support and optional on-site assistance.

A few other EPRI resources that offer further background or direct support for Load Curtailment, includes the following:

- *EPRI Pulp and Paper Office Helps BG&E Identify Energy and Cost-Saving Options for Industrial Customer (IN-102650),*
- *Application of Interruptible and Curtailable Electric Service in Foundries (CR-105046),*
- *Customer Response to Interruptible and Curtailable Rates, Volumes 1-3 (EM-5630),*
- *Costing and Pricing Electric Power Reserve Services (TR-108916),*
- *EPRI Load Curtailment training course for energy companies (SO-112756).*

Emerging Products from the EPRI Portfolio

Load Management controls

EPRI is developing and preparing to field test an enhanced version of the RTP Controller called the Automated Energy Control System (AECS). AECS will interface with any building management system, metering, and pricing signals, as well as include a feature to download weather information to develop its own short-term load forecasts.

Development plans for AECS include the following product features:

- Multiple rate and transaction types
  - Firm retail purchases
  - Spot retail purchases (of PX or Bulk Market)
  - Curtailable Rates
- Building load forecasts with different prediction horizons
- Interface with existing building management systems
- Central control of multiple facilities
- Handle multiple accounts
- Customizable logic
- Load Control algorithms:
  - Normal operating calendars
  - Load shedding under RTP
  - Load shedding under peak demand control
  - Overrides for environmental, equipment and occupancy concerns or limits
- Electricity cost calculations
- Charts, reports, and output to spreadsheets.

Load Profiling

One of the first steps in defining load management capabilities for a C/I customer is in knowing the electrical load profile for their facility. As an alternative to expensive monitoring of individual loads with custom instrumentation, EPRI has been developing a Commercial Non-Intrusive Load Monitoring System (CNILMS). With a single attachment to the meter, CNILMS can determine the actual energy usage and load shapes for all end-use loads on a circuit.

Currently being tested by three energy companies in a supermarket, convenience store, office building and a mall retail store, C-NILMS is being fine-tuned with field experience. Customer feedback and installation experiences are being used to enhance the product and debug the prototypes. The beta test program was documented in an EPRI report, *Commercial Nonintrusive Load Monitoring System Beta Test Results (TR-114236)*. Development programs are still needed to bring this product to a state of commercial readiness.

Billing Requirements

In order to be most successful, Load Management program options in open energy markets require new combinations of flexibility in business systems being used by energy companies. EPRI has developed, and continues to improve, a new billing solution that is designed to handle any program or service offering, to any markets for any kind of pricing or billing structure. This product, called Custom-ER™ Special Billing Engine, is being applied as a “bolt-on” solution to existing, legacy CIS systems, or as part of new front-office system installations. It is more fully described in its original generic name, Customer Operations Support System (COSS), and under the trade name Custom-ER in recent EPRI reports:

- *COSS Service Bureau (TR-111924),*
- *Methods for CIS and Billing Evaluation (TR-112067)*
- *Custom-ER Billing Engine (CBE) TR-114254.*

Site-specific installation of the Custom-ER™ Special Billing Engine is available from EPRI, as described in document BR-113647.

Battery Load Management

As part of an effort to expand battery markets through EPRI’s Transportation area, research is being conducted on using high-energy batteries for potential load management applications. In conjunction with the United States Advanced Battery Consortium (USABC) and selected EPRI-members, batteries that no longer provide enough capacity to meet the power needs of an electric vehicle are being tested in stationary applications. Specifically, this project is testing nickel-metal hydride and lithium-polymer batteries in laboratory and field settings in load management strategies such as load leveling and peak shaving.

Furthermore, EPRI has been testing battery energy storage systems through rectification of electrical energy directly from the utility grid. The stored energy is inverted to AC for use by customers when needed. This also includes the operation of high voltage FACTS devices with energy storage media such as superconducting magnetic energy storage and conventional capacitors. These projects are documented in recent EPRI reports:

- *Multi-Mode Transportable Battery Energy Storage System (TBESS) for Salt River Project (TR-110859-V2),*
- FACTS With Energy Storage: Conceptual Design Study (TR-111093).