PN-ACE-284
100911

Task Order No 803
Contract No PCE-I-00-96-00002-00

Report

Lessons Learned and Remaining Needs for Expanded Application of DSM at Ahmedabad Electric Company

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December 1997

For
United States Agency for International Development/India
and the Government of India

Environmental Policy and Institutional Strengthening Indefinite Quantity Contract (EPIQ)
Partners International Resources Group, Winrock International
and Harvard Institute for International Development

Subcontractors PADCO Management Systems International, and Development Alternatives Inc

Collaborating Institutions Center for Naval Analysis Corporation, Conservation International KNB Engineering and Applied Sciences, Inc Keller Bliesner Engineering, Resource Management International Inc
Tellus Institute Urban Institute and World Resources Institute

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1 INTRODUCTION

1 1 Purpose of this Report

This report is specifically designed to assist USAID in maximizing the value of its DSM demonstration program at Ahmedabad Electricity Company (AEC), by extracting lessons from that program and by identifying remaining needs for ensuring its continued success This introduction explains the objectives of USAID and how this report addresses them

USAID Objectives in Funding of DSM at AEC This report examines the adequacy of current efforts to develop DSM at Ahmedabad Electric Company and the need for additional future efforts to refine those programs and transfer the technologies elsewhere The assessment must be viewed within the context of USAID's goals

USAID seeks to promote development demonstration and transfer of environmental and energy technologies throughout India and elsewhere in the world

USAID's EMCAT program seeks to improve management, expertise and capabilities for decreasing energy consumption (as well as developing energy supply and financing systems) throughout India

As a technology transfer program USAID has used the EMCAT program to work with AEC in developing its DSM programs as a demonstration model that can be replicated elsewhere AID has further supplemented that effort with assistance from its Sustainable Cities Initiative which also seeks to develop pilot demonstration programs to address energy issues

As AEC's programs move from initial pilot efforts to fuller implementation, it therefore becomes important that AID assist in *extracting maximum value from the AEC demonstration* by (1) supporting its transition to a fully-implemented, self-sufficient operation and (2) ensuring the development and documentation of program procedures, operational systems and organizational structures which can be readily applied elsewhere in India

Evaluation to Further AID Objectives There is a natural desire and appropriate need for implementation agencies funding agencies and supporting contractors to promote their program successes and AEC's DSM efforts have indeed been successful in demonstrating the feasibility and value of DSM However AID has a further need to maximize the value of that demonstration by understanding how it has evolved and changed extracting lessons learned for future applications and ensuring transfer of appropriate program designs and materials for adoption elsewhere

A number of prior reports have identified a wide variety of different elements of AEC's DSM efforts, spanning a range of activities (including metering, energy audits equipment installations equipment testing financing, promotion and workshops) for a range of technologies (lighting, motors, pumps pipes meters, capacitors filters and timing systems) applied to a range of customer types (four mills, apartment buildings, factories offices and municipal water supply) However it is difficult to extract from the various prior reports just how the AEC's DSM efforts have actually evolved and changed over time In fact AEC's

efforts have continued to change substantially over time, reflecting an important process of learning and program refinement Along the way, some initial program elements have been terminated or radically modified, while some new program elements have been added, planned for the near future or proposed for sometime later on The process that was used for program refinement at AEC can be of significant interest for program replication elsewhere

To maximize the value of its investment in DSM development, USAID asked its Phase II EMCAT contractor, IRG, to review the status of efforts at AEC identify lessons learned and help ensure transfer of developed processes and procedures to other utilities Accordingly this report has four goals

- to clarify the *evolution and current status* of DSM implementation at AEC for interested parties,
- to measure *program impacts* and *lessons learned from* the success of those pilot activities
- to further the process of *technology transfer* by providing useful details on program success in developing processes and procedures which can be replicated elsewhere
- to identify *remaining needs* for maximizing the success (and transferability) of the programs at AEC

1 2 Methodology and Content of the Report

To address the above goals the consultant and IRG staff collected information from three sources (1) meetings with AEC staff to discuss the evolution of program planning, implementation and needs, (2) review of forms documents and data bases relating to DSM planning and implementation, to assess program impacts and replicability, and (3) site visits and interviews with customers to examine installed measures, program impacts and satisfaction

The organization of this report reflects the findings from that information collection and analysis

Chapter 2 provides a background on the economic and organizational realities shaping the development and evolution of DSM at AEC

Chapter 3 examines the process of evolution of DSM measures at AEC over 1995-1997 and identifies lessons learned from it

Chapter 4 discusses the plans for full implementation (in 1998) and identifies remaining needs which must be addressed to ensure effective operation on a continuing basis

2 BACKGROUND ISSUES IN PRIORITIZATION AND IMPLEMENTING DSM

The initiation and development of DSM at Ahmedabad Electricity Company (AEC) has been strongly shaped by two realities (1) the available financial motivations and (2) the necessary evolutionary process This chapter describes these two realities and how they have shaped the DSM programs at AEC Subsequent chapters then provide details on the actual operation of those programs

2 1 Prioritization of DSM Activities Financial Motivations

Types of Activities Demand-Side Management (DSM) can encompass any programs or policies which seek to affect electricity demand in a systematic way The changes in demand may be in terms of

- energy conservation -- reducing energy use through increased equipment efficiency (achieved via installation of appropriate controls or substitution of equipment) or behavior changes (in equipment use patterns),
- peak load reduction – reducing peak period demand through shifting time-of-day usage patterns or reducing energy use only for specific types of energy demand at specific times,
- system efficiency – expansion of effective system capacity to meet peak power demand (achieved by reducing losses from reactive power load), or expansion of off-peak demand to better utilize base load capacity

In the case of Ahmedabad Electricity Company the DSM elements of primary interest were the achievement of peak load reduction and system efficiency enhancement both forms of load management intended to address the acute problem of insufficient peak period capacity

Roles of Interested Parties Depending on the sponsoring party and its motivations, DSM activities may be financed by

- utility customers – through direct payment or indirectly through the base electricity tariff)
- the utility company – through its own investment,
- government (taxpayers) – through subsidies to the utility or customers to promote DSM
- third parties – through investments by manufacturers or service providers who hope to recoup recover funds through expanded sales of their products or services

Each of these parties has a potentially different interest in DSM, in terms of one or more of the following potential benefits

- environmental benefit – through reduction of resources used and emissions of pollutants from power plants,
- customer benefit – through saving money on energy bills (from reduced consumption) and /or enhancing equipment performance and life (from improved power quality)
- utility benefit – through reduction of need for expensive actions to meet peak demand -- purchasing costly peak power, investing in new power plants or curtailing power

(achieved through net expansion of baseload capacity or reduction in peak demand), or through reduction in power theft

In the case of Ahmedabad Electricity Company, there are currently no mechanisms available for cost recovery via government subsidy or the base electricity tariff Therefore, DSM costs must be paid by utility investment, customer payment and/or third party investment In that context, the only financially viable and sustainable DSM activities will be those that make economic sense for such costs to be incurred by the utility, its customers or third parties The selection of DSM programs at AEC (discussed in the next chapter) reflects those realities

Development of DSM at AEC Ahmedabad Electricity Company is a privately-owned electric utility, which means it has a responsibility to its shareholders to engage in economically viable activities which provide a return on its investment From the viewpoint of AEC, DSM activities that improved the environment and improved customer well-being were attractive as long as they also improved the company's own electricity system performance and its economic performance With limited financial and technical capabilities available for initiating DSM the initial set of DSM programs were selected based on a set of eight criteria which basically can be grouped into three categories

peak impact (financial interest) – reducing peak demand and thus avoiding costly peak power importing by the utility,

readily implementable (modest cost) – can be implemented by utility staff, with a short lead time, using available equipment and data

market demand – applicable to a significant market of customers (and also third parties) who may be interested in covering some or all of the program costs

2 2 General Model for Development of a Successful DSM Program

The evolution of DSM at Ahmedabad Electric Company illustrates four phases in the development of an ongoing and viable DSM program in India

Research Investigations,

Limited-Scale Pilot Programs,

Initiation of Full-Scale Program and

Ongoing Program Refinement

The components of these four phases and the required implementation processes are illustrated in Figure 1 and are summarized on the pages which follow

Figure 1.
Phases & Requirements for Development of a Successful DSM Program

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Definition of Phase 1 -- Research Investigations The first phase involved collection of information necessary to ascertain utility goals and potential opportunities for use of DSM as a means for improving "system performance" – which may include technical performance of the transmission and distribution system, economic performance of the utility or other results towards socially desirable goals To accomplish this, it is necessary to collect information three types of information

- performance of the electricity supply system, in terms of factors such as (a) load profile (specifically the pattern of peak supply constraints) and (b) transmission and distribution system losses (specifically the extent of reactive power losses) This information can usually be assembled internally, from utility records
- characteristics of customer demand for electricity, in terms of factors such as (a) patterns of electricity demand and power factor, by time of day and customer size/type, and (b) customer ability to adopt or utilize various types of new technologies or equipment use changes in order to change those patterns This information requires the acquisition of appropriate metering equipment and effort to survey or visit a sample of customers to collect needed information about customer equipment and use
- appropriateness of alternative DSM measures, through information on (a) test results for existing equipment technologies and (b) specifications and availability of new technologies for equipment retrofit or replacement

AEC did successfully initiate all aspects of this phase Seasonal and time of day load profiles were assembled from available internal data Through the assistance of USAID 72 load research meters were obtained by AEC and were installed in various commercial and industrial customer premises These meters were useful in determining the load patterns of various types of customers and the extent of low power factor problems as well as a tool for detecting power theft AEC staff also initiated a set of special studies to conduct customer premises testing of motor equipment, flour mills and water pumps The results of those studies provided a basis for the company's subsequent decisions to focus the pilot programs on some specific technologies targeted to particular types of customers (Details on Phase 1 activities are provided in Section 3 1)

Definition of Phase 2 -- Pilot Programs The second phase involves the design and initiation of small-scale tests of possible DSM programs These "pilot programs" are experimental efforts in which some type of product service or pricing option is offered to a small set (e g 10-200) of customers They are intended to test whether there is customer interest in the offering and whether installation or adoption of it has the expected impact To accomplish this the following elements must be addressed

- specification and outreach for the offer to customers, in terms of factors such as (a) equipment or service technology to be offered to customers, (b) pricing or cost to be offered to customers and (c) method for targeting and conducting outreach efforts to make the offer to the desired type of customer
- delivery mechanism in terms of factors such as (a) how the equipment or service will be installed or provided to customers and (b) how quality assurance maintenance and/or other support services may need to be offered
- financing arrangement, in terms of (a) how costs will be collected and (b) how costs will be spread over time

AEC did successfully initiate all aspects of this phase Four programs were offered on a pilot basis, each to between 10 and 500 customers The utility's customer records were used to identify appropriate targets who were individually contacted with the program offer The installation and financing varied by program For the High Rise Water Pump program, initial outreach was done by AEC, the energy audit and new equipment installation was done by an energy services contractor, and customers were asked to provide payment in a lump sum one month after installation of new equipment under the program For the Lighting and Capacitor programs, the equipment and its installation was provided by manufacturer-owned ESCOs (Energy Services Companies), and customers were allowed to pay the costs through installments added to their electric bills Since the target for the Lighting program was residents of government-subsidized housing, these households were offered free installation and use of the lighting equipment for six months, after which time they would have lease payments assessed through their electricity bills

The pilot programs were successfully conducted and studies of the participants' electric demand impacts proved the value of the installed measures to the company The pilot programs also confirmed to AEC that the concept of working with ESCOs was a viable one, worthy of larger scale implementation In addition, the experience with the high rise program illustrated some of the economic barriers and outreach efforts necessary to enroll apartment buildings in that program (Details on Phase 2 activities are provided in Section 3 2)

Definition of Phase 3 -- Full Scale Program The third phase involves the redesign of DSM programs (including the type of product or service offered and the financing offer) based on the pilot program experience, followed by initiation of large-scale implementation This step is intended to make substantive system-wide impact on energy consumption demand and/or system losses To accomplish this the following elements must be addressed

- refinement of the program offer financing arrangement and outreach targeting to maximize program effectiveness based customer acceptance and reaction to the pilot program
- adoption of an appropriate mechanism for large-scale program delivery including procedures for large-scale outreach/marketing, installation and payment based on both the pilot program experience and the necessities of adaptation for larger-scale operations
- adoption of administrative procedures for management and oversight of large-scale program delivery contractors (ESCOs) and staff

As of the end of 1997, AEC had initiated most aspects of this phase The programs have been revised based on lessons learned from the pilot efforts For instance, plans for the High Rise program offer have been revised to allow for installment payments (rather than lump sum up front payment) for future applicants Contracts have been signed with ESCOs to provide for large-scale capacitor and lighting installations, under arrangements whereby AEC provides customer lists a billing (revenue collection) mechanism and marketing assistance while the ESCO is responsible for the customer contact equipment installation, maintenance and lease/sale (Further details on Phase 3 status are provided in Section 3 3)

One additional aspect of the large scale implementation phase must still be put in place in order to provide for successful ongoing operation starting in 1998 That is the administration and oversight process necessary for large-scale operation Experience in the U S and elsewhere has

shown that quality control and cost-effectiveness can easily become problems when a program moves from a small-scale pilot effort to large-scale implementation The types of problems that often arise include (1) low participation due to ineffective outreach efforts or poorly trained marketing/outreach staff, (2) customer complaints of long time delays between program application and equipment installation (3) customer complaints of poor quality installation, or equipment failures due to inappropriate installation, (4) quality control findings of payments made for equipment never delivered or installed, due to poor record-keeping by the contractor, and (5) higher than expected program costs (incurred by either the utility or the contractor/ESCO) due to inefficient deployment of staff or ineffective management of their time

The administration and oversight process requires the designation of clear responsibilities for record-keeping and management of the utility and contractor/ESCO staff at each step in the program processes of outreach, installation, maintenance and financing/billing It also requires the setting of clear expectations for performance, with some periodic measurement and reporting of quality control measures for customer processing and follow-up Most importantly, it requires a process so that if the program fails to achieve expected results, the cause of that problem can be identified and addressed (Recommendations for oversight are given in Ch 4)

Definition of Phase 4 -- Ongoing Program Refinement The fourth and final phase involves the establishment of a comprehensive, ongoing monitoring and planning system so that DSM program design and operation can be changed over time As times change electricity costs, supply requirements, customer needs and/or available technologies may change Accordingly, there may be a need for program "refinements" including the elimination or radical restructuring of some programs or technologies while other new technologies may be added To accomplish this the following elements must be addressed

- <u>refinement of customer marketing targeting and program offering</u> to achieve greater energy awareness and program participation This requires a process of monitoring changes in customer acceptance rates, market penetration of equipment technologies, customer attitudes and behavior patterns and options to respond to those changes
- <u>refinement of contractor & utility roles and procedures</u> to achieve lower costs and more effective implementation as changes occur over time in the utility's needs and in the available set of external companies and organizations which can be of help to the program This requires a process of monitoring changes in effectiveness quality control and success in achieving desired supply, demand and financial results from the program and options to respond to those changes
- <u>refinement of program features</u> to maximize program impacts or avoid losses in program effectiveness This requires a process of monitoring changes in program costs and revenues, electricity supply costs and revenues, and program impacts of the program on electricity sales, as well as assessment of options to respond to those changes
- <u>changing technologies for DSM</u>, including the offering of new types of equipment and/or new pricing plans for equipment or electricity to reflect changes in the available options This requires a process of monitoring the available technologies and pricing policy options and assessing their applicability for the utility

To date AEC has focused on achievement of Phase 3 so all of the Phase 4 elements remain to be done in the future (Recommendations for addressing Phase 4 needs are provided in Ch 4)

3 HISTORY EVOLUTION OF DSM MEASURES AT AEC

The DSM program at Ahmedabad Electricity Company (AEC) has been evolving through the four phase process that were described in the preceding chapter although at the beginning it was not known that these phases existed This chapter provides details of how and why the DSM programs at AEC have evolved over time, as the lessons learned may be of interest for parties seeking to replicate the DSM development process at other utilities in India (Note that this discussion focuses only on the evolution of formal DSM programs at AEC Additional DSM-related efforts involving AEC-- including a variety of seminars, training workshops, conferences and general promotional materials – are not discussed here)

3 1 History -- Phase I Research Investigations (1994-1996)

Starting in 1994, USAID and its EMCAT Phase I contractor, Resource Management Associates of Madison Inc (RMA), worked with Ahmedabad Electricity Co to initiate DSM activities Initially AEC set up a DSM cell of professionals who were working within the context of broader commercial department responsibilities Their first activities were research investigations concerning (1) feasibility assessment and (2) load research summarized below

1) Feasibility Assessment (1994)

Program Screening Multi-Attribute Decision Analysis – The USAID contractor (RMA) and AEC staff together identified key criteria and used them to rate the feasibility of potential programs The final results was the identification of 31 potential DSM programs, including various education, audit rebate, dealer incentive and pricing programs focusing on promoting energy efficiency and load control

Market Self-Assessment – AEC staff assessed the extent to which various types of customers contribute to their peak load problems the number of such customers and feasibility of reaching those customers They concluded that

High-rise building water pumping during the morning and commercial/industrial motors during the midday create a significant share of daytime power demand

There are many hundreds of high rise apartment buildings and flour mills which could be good targets for equipment improvements,

The municipal water system of Ahmedabad Municipal Corporation (AMC) is characterized by hundreds of well pumps and distribution pumps which also create high demand in the early morning, while generating lower than average revenues

The pump motors in the high-rise buildings and AMC water system and the mill motors in the flour mills are also generally characterized by a low power factor (i e high reactive power requirement), which causes AEC to experience higher transmission and distribution system losses This can also cause customers to suffer more from voltage drops hotter-running machinery with greater motor wear

Direct installation of appropriate equipment is more realistic in the Indian context than the rebate and dealer incentive types of programs prevalent in the U S Pricing changes may be possible, but will take time to be implemented

2) Small-Scale Testing (1995-1996)

Targets for initial testing were identified based on outcomes of the above-discussed feasibility assessment The small-scale data collection efforts were referred to as "pilot programs" in early RMA reports, but were different from the true pilot programs which later emerged in Phase II

Time-of-Use Meters -- installation of time-of-use load research meters (purchased with USAID covering most of the total cost) and an accompanying customer survey at 72 High Tension (over 100 kW) industrial business sites

Energy Audits -- including

(1) comprehensive audits for 27 High Tension industrial customers,

(2) water pump systems audits for 75 High Rise Apartment Buildings (candidates for the residential water pump installations noted below)

Technical Studies of Motor/Pump System Replacements – covering overhaul and replacement installations of

(1) Residential Water Pump Systems at 4 High Rise Buildings

Mill Motors Systems at 4 Flour Mills

Municipal Water Pumps & Capacitors at 2 sites of Ahmedabad Municipal Corporation (1 bore well and 1 French well)

Motor Testing -- study overhaul and lab testing of rewound 5 HP and 7 5 HP motors in a testing lab

Results of these initial investigations revealed that

The installation of 72 load research meters was most useful for detection of power theft in addition to load forecasting (where they also showed the value of capacitors for reactive power savings)

The 27 industrial energy audits revealed potential savings of 8% - 12% from a range of energy efficiency measures, but also a common need to address poor load factor

The 4 water pump installations (replacing pumps pipes and foot valves and installing capacitors) showed substantial energy savings (30% - 45%) and demand savings (35% - 63%) with payback of less than one year

The 4 flour mill installations (replacing motors and belts installing capacitors and adjusting mill speeds) showed only modest energy savings (2% - 5% from maintenance 1% - 12% from drive belts and 10% from motor replacement)

The 2 municipal pump installations (replacing pumps and pipes, renovating bowls and installing capacitors) showed promising results (30% improvement for the bore well pump and 20% for the "French well" pump), with payback of less than one year

The motor studies showed that improved rewinding techniques could enhance the efficiency of rewound motors by a modest 2% - 4%

3 2 History -- Phase II Larger Pilot Programs (1996-1997)

Decisions Regarding Program Redesign for Pilot Experiments Results of the research investigations led to the decision to focus on four program efforts, each to be implemented at a couple of hundred sites The key decisions were as follows

The High Rise Residential Water Pump investigation (including pump system audits and retrofit installations) was expanded into a pilot program

The Flour Mills, Motors and Industrial Audit investigations, which revealed lesser efficiency benefits (or greater complexity), were put on hold However, those investigations did lead to a decision to focus on offering a Capacitor installation pilot program (to reduce reactive power requirements) at industrial sites This was designed to reduce AEC's transmission and distribution losses and thus increase net effective system capacity during the peak period as well as improve voltage at the customer end

The Time-of-Use Metering investigation led AEC to purchase 600 and later 2000 additional meters, justified largely by their value for theft detection That continuing effort was found to have substantial value for enhancing company revenue and resource utilitization, although it was no longer referred to as a DSM program

The Ahmedabad Municipal Corporation water pumping investigation was expanded into a broader program to install capacitors and other system improvements at additional pump sites

Discussions with a manufacturer led AEC staff to add a new experimental pilot program for installation of energy-saving fluorescent tube lamps

Conduct and Refinement of Pilot Experiments The outcome of the above decisions was the following efforts, which were initiated during 1997

Pilot DSM Programs (testing for consideration as full-scale programs)

Multi-Story (High Rise) Residential Water Pumps – Of the 75 residential building sites originally audited 14 building associations (resident cooperatives) agreed to pay for equipment retrofits -- 8 had work completed in 1997 and 2 more were in progress at the end of 1997 in addition to the original 4 completed as part of the initial research investigation in 1996 This work was initiated by AEC, using a small revolving loan fund AEC arranged for energy service firms to develop the specifications acquire and install the equipment

Capacitor (Reactive Power Management) Program – AEC decided to actively request that capacitors be installed for reactive power compensation at all sites of industrial customers who otherwise fail its conditions of service which call for a minimum power factor of 85 Customers finance the equipment via a 3 or 5 year lease (paid through AEC's billing system) with ownership reverting to the lessee at the end of the period AEC arranged for the capacitor lease and installation to be provided by the energy service arms of two manufacturers – Asean Electronics Ltd (AEL) and Saha Sprague Ltd (SSL) As of the end of 1997 AEC had identified 760 industrial customers received "consent letters" from 500 of them and had capacitor installations completed at 460 sites – comprised of 160 LTMD (Low Tension Maximum Demand, 15-50 HP) industrial customers and 300 LTP (Low Tension Power, under 15 HP) industrial and commercial customers Reactive power management was already required at the 500 HT

(High Tension Power, over 100 kW) industrial sites

AEC also conducted a pilot installation of capacitors at 200 residential sites in Gandhinagar The equipment and installations were paid for by AEC and provided at no cost to the residential customer

Lighting Program - Under the pilot test program, AEC is offering high efficiency fluorescent tube lamps to residents of government-subsidized housing This includes a 36W tube with a 2W capacitive /electronic choke (ballast) having a leading power factor (reactive power compensation), to replace the standard 40W tube with 15W magnetic (poor power factor) choke The equipment has been offered and installed in 200 homes, with the resident getting to use it for six months at no cost At the end of that test period (in 1998), the resident may keep the equipment if he agrees to pay for it through a monthly lease payment (The old tube light is not being taken out during the trial period) The lamp and its installation (as well as its planned leasing after 1997) are being provided by AEL As of the end of 1997, consumer response was being evaluated based on a door-to-door survey of installed sites

Other Programs (expanded efforts, but not as pilot testing for further expansion)

Advanced Metering - AEC purchased an additional 2000 advanced meters to provide time-of-use and reactive power measurement As of the end of 1997 it had installed the meters at all 500 of its HT customers and 1 000 LTMD customers This is part of a continuing effort to expand metering of time of use and reactive power eventually reaching all 6 000 LTMD customers for both power theft detection and capacitor installation requirement at all applicable sites (where power factor is below 85)

Ahmedabad Municipal Corporation (AMC) - AEC continued to work with AMC which initiated its own internal DSM efforts with additional funding assistance from USAID's Sustainable Cities Initiative As of the end of 1997 this included reported installation of 200 capacitors (153 confirmed to date) in station pumps and bore well pumps as well as initiation of staggered use of intake and supply pumps at 19 pumping stations

These pilot programs provided AEC with much useful experience

Advanced Metering – development of *meter installation and monitoring procedures*

Multistory (High Rise) Residential Water Pumps – development of *customer application forms* and *audit procedures* also experience demonstrating the benefits in terms of customer bill reduction and the need to add multi-year financing for the future

Capacitor (Reactive Power Management) Program – development of *customer targeting consent letters* for program participation and lease *billing procedures* plus *installation protocols*, also experience demonstrating the value of improving power factor

Lighting Program – development of lease *billing procedures* and ESCO *installation procedures*

Organizational Arrangements – Assignment of one staff member of the utility's DSM cell to coordinate each program plus *demonstration of the utility's ability to work with ESCOs* for installation and leasing on a limited scale

3 4 Status -- Plans for Phase III Full Program Implementation

Design of Programs for Full Implementation in 1998 Based on its initial experience with the pilot program efforts in 1997, AEC has decided to proceed with full-scale implementation of three DSM programs starting in 1998 They all focus on achieving (1) net capacity and revenue expansion for AEC, (2) customer power improvement and (3) customer bill reduction They are

Multistory Residential Building Water Pump Retrofit Program

Reactive Power Management (Capacitor) Program

Residential Lighting Retrofit Program

AEC's plan for delivery of all three programs follows a similar three step process

AEC to provide general program marketing and identification of customers,

An ESCO (Energy Service Company) to conduct the customer outreach, installation and lease financing to customers (with ownership reverting to the customer at the end of the lease period), and maintenance of equipment during the 3-5 year lease period,

AEC to collect the lease payments through its monthly (business) or bi-monthly (residential) billing process

As of the end of 1997, the status of planning for each of these programs is as follows

Multistory Residential Water Pump Retrofit Program – AEC is still seeking one or more ESCOs to implement this program No ESCO has yet signed on, due to the limited market for this energy efficiency measure and the more customized nature of the audit and installation process (compared to the other two programs) The backup plan is for AEC to continue to market the program and arrange for contractors to install the equipment as it has under the pilot phase The initial 1998 goal is to expand the program from 14 to 50 sites, the eventual goal is to expand the program to 1000 of the total 4000 residential high-rise buildings in AEC's customer base

Status Multistory Residential Water Pump Program	Buildings
Total Market Base	4,000
Program Target	1 000
Current Plan for AEC implementation	50*
Pilot Effort to Date	14

* MOU for ESCO implementation of this program is being sought

Reactive Power Management (Capacitor) Program – As of the end of 1997, AEC had signed Memos of Understanding (MOUs) with the two ESCOs (AEL and SSL) already involved in the pilot program of capacitor installation at industrial sites Under those agreements the ESCOs will sign up customers for leasing of the designated equipment, install that equipment, maintain it over the 3 - 5 year lease period, and turn over ownership to the customer at the end of that period AEC will continue to support the program effort by providing customer lists to the ESCO and collecting the lease payments (on behalf of the ESCO) through its billing process The target is to install capacitors at 20 000 industrial sites the current MOUs cover 8 000 sites

AEC also seeks to achieve a full-scale installation of capacitors (at its own cost) at 800,000 residential and small commercial customer sites As of the end of 1997 it is still seeking an ESCO agreement for that program component

Status Reactive Power Management Program	LTMD Customers	LTP Customers	Residential Customers
Total Market Base	6,000	30,000	800,000
Program Target	5,000	15,000	800 000
Current MOU (2-year period)	3,000	5,000	*
Pilot Effort to Date	160 (plan 200)	300	200

* MOU for ESCO implementation of residential capacitors is being sought

Residential Lighting Retrofit Program -- As of the end of 1997 AEC had signed a Memo of Understanding (MOU) with one ESCO (AEL) to expand the lighting program into a large-scale effort for tube lamps, and was hopeful of eventually also signing on a second ESCO As with the industrial capacitor program the ESCOs will sign up customers for leasing of the designated equipment install that equipment, maintain it for the lease period and turn over ownership to the customer at the end of that period AEC will continue to support the program effort by providing customer lists to the ESCO and collecting the lease payments through its billing process

AEC also seeks to achieve a full-scale leasing of CFLs at residential customer sites (up to 4 per household) As of the end of 1997, it is still seeking an ESCO agreement for that program component

Status Residential Lighting Retrofit Program	Customers	Tube Lamps	CFLs
Total Market Base	800,000		
Program Target		800,000	250 000
Current MOU (2-year period)		50 000	*
Pilot Effort to Date		200	--

* MOU for ESCO installation of 5 000 CFLs is being sought

3 4 Lessons Learned from DSM Evolution at AEC

The experience of DSM development at AEC has several lessons which are important for technology transfer and program replication at other utilities

Program Focus Since there is no mechanism for recovery of DSM program costs in the electric rate base, the American concept of integrated resource planning (considering tradeoffs in customer and/or societal costs of demand reduction vs supply expansion) could not be implemented Instead the set of DSM measures that could realistically be implemented by the utility had to have economic value to the utility (as well as value to society) Those were measures focusing on (1) increasing system efficiency and (2) accommodating or modifying peak demand

Phased Strategy There is significant value in the phased approach adopted by AEC in

which there was a progression from (1) research investigation to (2) pilot program to (3) full-scale implementation This incremental approach helped to prove the value of DSM to the company, in terms of direct benefits (e g , expanding effective system capacity) and spillover benefits (e g , using load research meters to reduce theft of power) It also allowed AEC to make significant refinements in the program mix and design (as evident by the evolution of program measures over time)

Initial Testing A process of initial testing can be important in refining the set of appropriate DSM programs for a local area, before moving to pilot program testing (e g , findings that the flour mills were not a high priority for program development despite initial expectations that they would be a good target)

Pilot Program Refinement The step of pilot program testing is also important in working out issues concerning program design and delivery, before moving on to large scale implementation (e g , refinement of the financing arrangement for residential water pumps as well as negotiation and testing of working relationships with ESCOs)

Special Purpose Programs There may be cases where it makes sense to have some limited-term, highly targeted programs that are not further expanded by the utility (e g AMC Municipal Pump Program, in which AMC pursued further efficiency improvements on its own)

Externality Benefits Some efforts that start out as DSM may end up being most valuable for providing other "external benefits" (e g finding that the load research meters were helpful for power theft detection, leading to additional revenue collection)

Use of ESCOs The ESCO implementation model adopted by AEC was attractive to the utility because it minimizes the extent of utility staff and capital resources needed for program delivery The selected ESCOs (and others being considered) are associated with manufacturing of energy efficiency equipment, which makes them willing to incur some of the costs of program marketing and operation in return for potential revenue from equipment sales and financing AEC has succeeded in demonstrating that ESCO / utility partnerships can be made to implement some types of DSM programs on a limited basis although customer acceptance and resulting economic viability of such programs remain to be seen during 1998

- It is also important to note that the experience to date indicates that ESCOs agreements take time and may only be possible for a subset of possible DSM programs in which there is a sufficiently large volume of potential sales to provide economies of scale

3 5 Findings on Energy and Power Demand Savings

Types of Impacts on Electricity-Related Costs Consumers and businesses in Ahmedabad effectively pay "excess costs" to compensate for the inadequate infrastructure for supply and distribution of electricity and water This occurs both *directly* in the form of extra expenditures to compensate for supply shortcomings (e g , voltage regulators backup power generators and water pumps for supplementary private wells and storage tanks) and *indirectly* in the form of extra expenditures for prematurely failed equipment (including motor rewinding)

The DSM programs of AEC, by improving load management are one step towards reducing the

excess costs associated with inadequate peak electricity supply The capacitor, lighting and water pump programs all include additional expenditures for end user equipment to reduce reactive power demand thus reducing line losses and voltage reductions and effectively increasing the electric system capacity to meet peak power demand The lighting and water pump programs also include expenditures for more efficient equipment retrofits, which can also reduce overall energy demand during peak periods In all of these cases the utility can benefit as it can sell more peak period electricity (due to effectively increased transmission and distribution system capacity) and/or reduce its needs for importing expensive power during those periods The utility can also lose some revenue insofar as more efficient lighting and water pump systems slightly reduce off-peak energy sales

While the customer pays costs of the installed measures (except for residential capacitors), the customer also benefits from money savings associated with reduced energy consumption better equipment performance and longer motor life In the case of the lighting and high rise residential water pump programs it is possible to directly calculate the customer cost savings associated with reduced electricity consumption (resulting from substitution of more efficient equipment) However, the additional customer benefits associated with capacitors (installed under the capacitor program as well as the lighting and water pump programs) occurs in the form of enhanced equipment performance and life – benefits which have not been quantified at this time

<u>Case Studies</u> Site visits and interviews were conducted by IRG staff accompanied by AEC and USAID staff, to observe examples of the program measures and how customers have responded to them Of course, it is not possible to extrapolate any overall conclusions from a limited number of site visits Nevertheless these visits did serve a useful purpose in providing insight into how customer behavior can affect program impacts – both perceived and actual Some of these observations are listed below

<u>Typical Installation Multistory (High Rise) Residential Water Pump</u> – At a typical high rise residential building, the water pump system served to move water from the municipal system and a supplementary bore well to the rooftop tank The Water Pump DSM pilot program *replaced* water pipes and foot valves to provide for greater flow with less resistance It also *installed* a new, more efficient pump motor but did not take out the old one which remained to serve as a backup system The new system achieved an impressive 30-35% reduction in electricity use and provided a very attractive 2-3 year payback The customer was very satisfied with that result However this was less than the originally-calculated theoretical potential for a 65% reduction in electricity use at the site While theoretical potentials are seldom achieved anywhere, part of the reason can be customer behavior In this case it was noted that the new pump saves electricity by improving basic motor efficiency and also downsizing the motor so the result is a smaller pump motor which runs for a longer period of time to move the required amount of water While that makes more efficient use of electricity it also requires additional labor time on the part of the pump operator Thus there can be a practical incentive for the pump operator to continue running the larger old pump (with the new pipes and valve) to get the job done faster (even though that saves less electricity than using the new pump)

<u>Typical Installation Capacitor (Reactive Power Management) Program</u> – At a typical manufacturing site the presence of many motors and an adjustable speed drive system together led to a power factor of 0 64 indicating that 36% of the power demand was due to

non-useful reactive power load To address the situation, AEC installed an advanced meter (measuring time of use, demand and power factor) and as part of the Capacitor DSM pilot program, an ESCO *installed* a heavy duty capacitor to reduce reactive power demand and thus improve the power factor The new equipment was observed to successfully increase the power factor from 0 64 to 0 90, thus bringing the customer into compliance with AEC's power factor requirement The factory manager was satisfied with that result The capacitor can be bypassed by the customer, but there is no apparent advantage to it The factory manager was not aware of any dramatic changes in equipment performance and/or energy costs after installation of the capacitor, but reported that there were many month-to-month changes in plant operations and he was not the party ultimately monitoring the books on plant costs and output

Typical Installation Lighting Program – At a typical home in a subsidized housing development, there was a single fluorescent tube lamp in the living room, with the standard specifications of 40W tube and 12W ballast (choke) As part of the Lighting DSM pilot program, an ESCO *installed* a new more efficient tube lamp (36W tube and 2W ballast) in the living room but left the old tube lamp in place and in operable condition This was done because under the pilot test the customer was offered six months free trial of the new lamp after which the customer could either agree to lease/purchase of the new lamp or have it taken out at no cost The customer perceived that his electricity bills had generally fallen since installation of the new lamp, but could not actually distinguish the effect of the more efficient lamp from the effect of diminishing electric heat requirements over the same period With the availability of two instead of one lamp in the living room the customer did have the option of getting more lighting in the room (although that would use more rather than less total energy) It is unclear whether the customer actually made frequent use of both lamps at the same time although AEC staff noted a desire to have the old lamp taken out once the decision has been made to pay for the new lamp Under an ongoing program there would be no such free trial period, but the issue of whether or not the ESCO would automatically take out the old fixture remains uncertain at this time

Ahmedabad Municipal Corporation (AMC) Program – The water supply system of AMC has experienced rising electric bills, due to increasing pumping needs as water table levels drop in the region motors age and system leaks develop AMC has been developing a range of activities to address these problems It has established its own DSM Cell, with support from USAID's Sustainable Cities Program and instituted energy savings improvements ranging from staggered timing of intake and supply pumps to replacement of incandescent lights with CFLs Under AEC's DSM program capacitors have been installed on submersible bore pumps as well as some drainage pumps Motor operation improvements and internal distribution line losses were improved by these capacitors However more expensive replacements or overhauls of existing large pump motors and impeller systems are not being instituted at this time pending the outcome of AMC plans to acquire water from a new dam and canal within the next decade

Aggregate Impacts Overall impacts of AEC's DSM programs are currently limited to those associated with the small scale pilot efforts completed to date Projected impacts associated with the planned full-scale ESCO implementation in 1998 are substantially higher, although the success of the ESCOs in achieving these numbers remains to be seen The table which follows summarizes estimates of the magnitude of actual and proposed installations and the associated savings in energy and demand Due to a lack of systematic monitoring and documentation of

program accomplishments and impacts to date, there have been a variety of differing estimates of program impact produced over time The numbers shown here reflect a composite of measured and estimated values, derived from our review of many documents produced over the last two years Clearly, more systematic monitoring is desirable for the future

Table 1 Summary of DSM Program Impacts

Program Component	Units Installed	Reactive Comp (kVAR)	Demand Reduction (kW)	Energy Saving [1] (mWh/Yr)	Equipment Cost [1] ($)	Cost Saving [1] ($/Yr)
Pilot Program 1996-1997 (actual)						
Capacitors - Industrial	500 capacitors	3,000	300	925	$ 25 000	$ 85 000 [2]
Capacitors - Residential	200 capacitors (in Gandhinagar)	20	2 0	NA	NA	NA
Residential Lighting	200 fl Tubes	22 5	3 4	10 5	$ 2,000	$ 500
Res High-Rise Water Pump	14 systems [3]	36 0	24 0	65 0	$ 12,000	$ 5 400
AMC Municipal Pump System	200 capacitors + staggered use	5,000 [4] + 1,500	800 [4] −1,500	4,500 [4]	$120,000	$270 000
Goals for Signed Memo of Understanding Between AEC and ESCOs planned for 1998						
Industrial Capacitors	8,000 capacitors	32,000	3,200	14,800	$ 0 4 m	$ 1 4 m
Residential Lighting	50 000 fl Tubes 5,000 CFLs [5]	6 200	940	2 900	$330,000	$140 000
Additional Goals for AEC by end of 1999 (still seeking ESCOs for these commitments)						
Industrial Capacitors	12,000 capacitors	48,000	4,800	22 200	$ 0 6 m	$ 2 1 m
Residential Lighting	745,000 lamps	83 800	12,660	39 100	$ 4 5 m	$ 2 0 m
Res High-Rise Water Pump	1 000 systems	3 000	2 000	10 000	$ 1 0 m	$ 0 8 m

1 Values for energy savings and equipment costs include both those accruing to the electric company and those accruing to the consumer

2 Cost savings includes value of avoided transmission and distribution system losses incurred by AEC, additional value of consumer savings due to longer equipment life and more efficient operation is not quantified Other potential customer savings associated with avoidance of power factor penalties are not applicable since such penalties are currently rarely applied

3 includes 4 High Rise water pump systems installed during research investigation stage 8 installed under pilot program and 2 more in process of installation at this time

4 Estimated savings shown here for AMC water pumps reflects actual measured savings for confirmed capacitor installations at 89 bore wells pumps and 32 drainage pumps factored up to represent the 200 total installations claimed

5 MOU for Compact Fluorescent Lamps is not yet signed as of the end of 1997

4 FUTURE NEEDS AND PLANS FOR FULL IMPLEMENTATION

4 1 Overall Needs Vision and Systematic Operation

The planned implementation of full DSM programs at AEC is in fact the first experiment in India involving utility and ESCO relationships to implement DSM programs on a large scale As such neither the efficacy of that program delivery structure for large-scale implementation nor customer response to program offers at that level are yet known Therefore, it can be important for AID to ensure that there are systems in place to maximize the value of full scale program operation by

carefully *monitoring the results* of AEC's experiments with full-scale program implementation using ESCOs (for each program this includes monitoring its market penetration operational effectiveness and net impact),

providing a mechanism to *refine the programs* in response to the initial results (in terms of modifying program design, targeting and delivery as needed), and

providing a mechanism for the utility's program planning staff to *obtain ongoing information* about additional types of new technologies and program delivery concepts which may be appropriate complements to (or improvements on) these programs

At present AEC needs to enhance its formal plans, staff resources and staff training to fully accomplish these three types of "system needs" for ongoing program operation AEC staff have acknowledged such needs and indicated interest in obtaining USAID assistance in building their capabilities to meet them By demonstrating the value of appropriate monitoring and program refinement systems the transfer of lessons learned from these programs can be enhanced

Recommended EMCAT Strategy for Completion of Activities at AEC The recommended activities for completion of USAID's EMCAT program at AEC focus on completion of the necessary steps & requirements for establishing a systematic overall process of ongoing DSM planning and operations The elements of a comprehensive database and analysis system to support that overall process for planning and operations are illustrated in Figure 2 The development and implementation of such a process will help ensure that (1) AEC can continue DSM programs on its own and (2) AEC can effectively function as a model program for replication by other utilities Neither of these goals is likely to be achievable without development of the necessary systems and procedures for monitoring market segmentation costing and decision-making support These include the following five elements

Program Monitoring – assessment of participation rates and follow-up to assess participation decisions, with tracking and estimation of energy and business impacts

Market Segmentation – assessment of customer profiles, attitudes and equipment use which provide a basis for segmenting and targeting specific groups

System Economics – assessment of load shape marginal costs and revenues associated with various classes of customers and times of day,

Available Options – assessment of available options for equipment services and policies to maximize efficiency in energy distribution and use

Decision-making – methods for optimizing current and future products/services/pricing and

customer targeting through appropriate reporting and evaluation procedures

Figure 2
Overall Structure of a Comprehensive Database and Analysis System

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4 2 Specific Recommendations for EMCAT Assistance to AEC

Recommended activities are to provide assistance in five areas of need for systematic operation and planning which together provide AEC with the necessary capabilities to fully implement the a systematic planning and operations process, including implementation of the database and analysis systems previously outlined in Figure 2 These areas of need are listed below

Marketing Campaign -- Develop a systematic campaign for overall *marketing* including (a) awareness/ education campaign for general energy efficiency and (b) outreach effort for specific equipment technologies

(Note Alliance to Save Energy through its Global Agreement with USAID has provided AEC with a start in the design of brochures and advertising for increasing public awareness of energy efficiency, but the development of more targeted materials and promotion plans for AEC are still needed)

Program Monitoring System -- Develop monitoring protocols and tracking systems for immediate administration oversight and performance evaluation of large-scale program operation (including effectiveness of marketing installation billing and maintenance)

Market Segmentation Planning System -- Develop information collection and analysis systems which can be used to maintain an ongoing process of continued market assessment program planning and customer targeting for the future

Decision Support System -- Develop systematic methods for ongoing business evaluation and reporting, which can be used to (a) refine the program mix and features to optimize business results and (b) to help attract additional (external and internal) investment and risk-sharing in expanded full-scale operations

Technology Evaluation Process – Develop methods and procedures to (a) ensure continuing access to information about new end-use technologies, distribution improvement technologies, tariffs and program delivery options, and (b) evaluate those options in terms of potential feasibility and value

(Note Hagler Bailly, under contract to USAID, has developed some benefit/cost models and associated information collection instruments which can provide the core of a model for technology assessment and evaluation, but the broader framework for AEC to acquire technology information and assess tariff and revenue impacts remains to be developed)

The necessary methods, procedures and systems can be developed to address each of these areas However, they will only be successful if there is commitment by the staff and management (including directors) of Ahmedabad Electricity Company to support the full implementation of them If that commitment is provided, then the EMCAT program could provide technical assistance covering design of the necessary procedures and systems, as well as training (building internal staff capacity) to implement them Additional financial assistance in these areas could also be justified based on needs that cannot be otherwise met as long as they are consistent with the EMCAT goal of developing programs which are ultimately self-sustaining (i e which can survive without continued dependence on USAID support)

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