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**COORDINATION OF ENERGY
AND
AIR QUALITY MANAGEMENT**

**Urban Consortium
Energy Task Force**

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PREFACE

1991 URBAN CONSORTIUM ENERGY TASK FORCE RESEARCH

THE URBAN CONSORTIUM (UC) is a special network of the Nation's largest cities and urban counties brought together by PTI to find new solutions to their common concerns. The UC provides a creative forum where elected and appointed officials can identify, test, and validate practical ways to improve the provision of public services while generating new revenue opportunities. With staff, management, and business services provided by PTI, the UC addresses the critical needs of large local governments through its three task forces: Energy, Environment, and Telecommunications and Information.

The Urban Consortium Energy Task (UCETF) has 20 members and was established to improve urban energy management and decision-making through applied research and technology transfer. The UCETF focuses on developing and sharing new approaches and innovative solutions to energy management problems with local governments. Projects are organized in thematic units and co-managed by a member of the Task Force.

A description of the 1991 program Units and projects are:

ALTERNATIVE VEHICLE FUELS AND TECHNOLOGIES (AVF)

Alternative vehicle fuels offer a very strong potential to aid in the reduction of U.S. dependence on foreign oil supplies, with the resulting benefits of decreased air pollution in urban areas. Local governments can play an instrumental role in realizing this potential through practical applied research and highly visible demonstrations of alternative fuels and technologies. Issues addressed this year include identifying (a) intensive and credible market development efforts based on an applied research and demonstration program that combines reliable technology with experience-tested applications, (b) environmental and energy diversity benefits, and (c) institutional and infrastructure barriers. The 1991 AVF unit consists of:

Broward County, FL -- *Dual-Fuel Conversion Demonstration and Technology Transfer Project*

New York City, NY -- *Alternative Fuel Vehicle: Financing Issues*

Denver, CO -- *Technical and Market Comparison Between H₂/CNG (Hythane), Electric Hybrid, and CNG Fueled Vehicles*

Denver, CO -- *An Alternative Fuels Fleet Evaluation System -- A Transfer Project*

Detroit, MI -- *Analysis of Institutional and International Limitations for Alternative Fuel Vehicles*

Washington, DC -- *Comparison of Energy Consumption, Energy Savings, and Environmental Effects of EV/PV vs. Conventional Gasoline Vehicle*

ELECTRICITY MANAGEMENT

Urban interests for electricity management focus on means to maintain stable, secure and reasonably priced supplies of electric energy. Approaches include procedures for better demand management, application of "least cost" planning concepts, appropriate use of decentralized and/or small power production facilities, improved end-use efficiency, and developing sound structures for cooperative action among municipalities and energy utilities. Urban strategies include support for decentralized "small" power production, along with better demand management and improved end-use energy efficiency. The successful development and implementation of such strategies will require close cooperation with the utility industry and will address topics in areas of institutional relations, source flexibility, and demand-side management. The 1991 Electricity Management Unit consists of:

Albuquerque, NM -- *Alternatives to Traditional Rate Setting*

Chicago, IL -- *Integrating Innovative Supply and Efficiency Techniques*

Chicago, IL -- *The Chicago Energy Management Cooperative*

Dade County, FL -- *Energy Cost Reduction Through Resource Recovery*

Detroit, MI -- *Hydraulic Waste Energy Recovery (Phase II) City of Detroit Water Distribution System*

San Jose, CA -- *Utility/Local Government Partnership to Increase Energy Conservation in New Construction*

ENERGY EFFICIENT FACILITIES

Activities involving energy efficient facilities are at present, part of a national effort to achieve maximum cost-effective energy productivity in the building sector. There exists a need for collaboration between local government officials responsible for energy and environmental programs and other local government officials responsible for facilities, as well as the Federal officials and private sector groups, e.g. utilities. New technologies and management/administration practices to advance energy efficiency in facilities require major partnership efforts and transfer programs. Multi-family housing that has a large concentration of low-income families presents a unique challenge to lowering energy costs and maintaining energy efficient facilities. Projects in this unit are:

Boston, MA -- *Neighborhood Energy Efficiency Outreach Partnership*

Columbus, OH -- *Energy Efficiency and Indoor Air Quality: Solutions for Fire Stations*

Louisville, KY -- *Partnership Approach to Energy Efficiency in Non-Profit Facilities*

Montgomery County, MD -- *Technology Transfer of Building Energy Design Guidelines*

New Orleans, LA -- *Residential Utility Costs Comparative Study*

Phoenix, AZ -- *Variable Frequency Drive Applications Guide*

Portland, OR -- *Energy Savings Through Operation and Maintenance Training in the Low-Income Multi-Family Sector*

Washington, DC -- *Comparison of Two Techniques for Identifying Energy Conservation Measures in Low Income Homes*

ENERGY, ENVIRONMENT and ECONOMIC DEVELOPMENT

This an area that has both visionary and immediate practical emphases on the definition and evaluation of realistic strategies and actions to support energy-sustainable and

environmentally responsible communities. Emphases include uses for renewable energy, practical domestic supply and conservation alternatives, and the synthesis of energy concerns with wider local government interests in economic development, environmental quality, and internal cost control. Urban strategies to improve energy-sustainability require attention to both broad based institutional changes, as well as specific projects designed to encourage the application of appropriate technology and community development practices. The "Sustainable Communities" project has involved three municipalities with State agency, Lawrence Berkeley National Laboratory, and a formal advisory committee with broad national representation. Projects under this unit are:

Austin, TX -- *Energy Star Sustainable Rating Program*

Phoenix, AZ -- *Impact of Heat Island on Cooling and Environment: A Demonstration Project*

Pima County, AZ -- *Tucson Solar Village - Project Management*

Portland, OR -- *Sustainable City Transfer Project*

San Francisco, CA -- *Neighborhood Energy/Economic Development at South Bayshore*

San Francisco, CA -- *Sustainable City Transfer Project*

San Jose, CA -- *Sustainable City Transfer Project*

Seattle, WA -- *Coordination of Energy and Air Quality (CEAM)*

Seattle, WA -- *Bicycle Program -- Urban Trails System*

Tucson, AZ -- *Local Government Involvement in Long Term Resource Planning for Community Energy Services*

Reports from each of these research projects, including this report, are specifically designed to aid the transfer of proven experience to other local governments. Readers interested in obtaining any additional reports or further information about the Urban Consortium Energy Task Force and the Urban Consortium should contact:

*Energy R&D Program
Public Technology, Inc.
1301 Pennsylvania Avenue, NW
Washington, DC 20004
1-800-852-4934*

ABSTRACT:
FINAL REPORT
ON
COORDINATION OF ENERGY AND AIR QUALITY MANAGEMENT [CEAM]

Increasingly stringent air pollution control regulations have required that industry make substantial investments in new air pollution control equipment and systems. For many industrial firms, this imposes a severe financial burden, and these firms often resist the efforts of air pollution control authorities to implement and enforce new emission standards.

Meanwhile, many electric utilities have discovered that encouraging energy efficiency is often more cost effective than building new generating capacity. They offer their customers financial and technical assistance to help them become more energy efficient. Nonetheless, in spite of the large potential, utilities as a whole have had little success in achieving energy savings among their industrial customers.

In the Coordination of Energy and Air Quality Management (CEAM) Project, Seattle City Light, a municipally owned electric utility, and the Puget Sound Air Pollution Control Agency (PSAPCA), the primary air pollution control authority in the Puget Sound region, worked together to investigate how to address these two problems. The project had two goals: first, to demonstrate industrial firms can improve plant energy efficiency as air pollution emissions are reduced; second, to demonstrate that both Seattle City Light and PSAPCA could more effectively accomplish their individual objectives through mutual cooperation, even though the two agencies have very different missions.

The cooperative efforts promised benefits for all the parties involved. Seattle City Light hoped that PSAPCA's knowledge of the likely developments in air pollution controls would help the utility better target energy conservation opportunities among its industrial customers. PSAPCA hoped that the financial assistance offer by Seattle City Light through its conservation programs would make industry less resistant to PSAPCA enforcement of new air pollution control regulations. Finally, individual industrial firms could mitigate some of the cost of meeting the new air pollution control standards.

The results of the project were mixed. CEAM did demonstrate that industrial plants can improve energy efficiency as they reduce air pollution emissions, but the relationship between air pollution reduction and energy consumption is complicated; and the project was less successful in meeting its second goal. The project design did not include a measure by which results could be compared against what the two agencies would have accomplished had they not collaborated. Moreover, the project could have benefitted substantially from a more complete implementation plan and the production of data quantifying the energy conservation potential resulting from the development of more stringent air pollution control regulations for each of Seattle's major industries.

ACKNOWLEDGEMENTS

The Coordination of Energy and Air Quality Management [CEAM] project staff are indebted to many individuals who provided valuable advice and aid to the project. Five people, in particular, deserve special credit for their assistance.

Tim Newcomb
Puget Sound Power & Light Company
Bellevue, Washington

Formerly with the Seattle City Light Department, Tim originally conceived of the CEAM project and was the first project manager. Even after Tim left Seattle City Light, he continued to maintain an interest in the project and to provide valuable comments on its progress. Most of the project's accomplishments are due to his efforts.

Michelle A. Carter
Ebasco Services, Incorporated
Bellevue, Washington

Like Tim, formerly with the Seattle City Light Department, Michelle contributed superior technical assistance and performed much of the field work under CEAM.

David Lennington
Puget Sound Air Pollution Control Agency
Seattle, Washington

David served as the vital link between his agency and the Seattle City Light Department. He provided the necessary expertise on industrial air pollution control and helped City Light staff uncover several retrofit projects.

D. K. Das
Seattle City Light Department
Seattle, Washington

Deb offered timely and constructive advice on industrial conservation program planning.

Sidney Freeman
Seattle City Light Department
Seattle, Washington

Sidney made perhaps the most valuable contributions to the CEAM project. She assumed, on her own initiative, the responsibility for reviewing and proofing project documents. Her assistance with report style and content as well as her assistance in project administration were indispensable.

FINAL REPORT
for
THE URBAN CONSORTIUM ENERGY TASK FORCE
from the
Seattle City Light Department Project Entitled:
COORDINATION OF ENERGY AND AIR QUALITY MANAGEMENT
[CEAM]

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CHAPTER I, EXECUTIVE SUMMARY

This report describes the results of the Coordination of Energy and Air Quality Management Project [CEAM] which Seattle City Light and the Puget Sound Air Pollution Control Agency conducted during the calendar years 1991 and 1992.

The United States Department of Energy sponsored CEAM under the auspices of the Urban Consortium Energy Task Force. In CEAM, Seattle City Light and the Puget Sound Air Pollution Control Agency (PSAPCA) cooperated to accomplish two goals.

First, CEAM hoped to demonstrate that industries can conserve energy as they reduce air pollution emissions with positive economic effect. Increasingly stringent standards require investments by industry in new air pollution control equipment. These investments are often substantial and burdensome, especially in economically depressed times. However, industry can mitigate much of the cost of new air pollution control equipment by simultaneously improving energy efficiency in factories and plants. Since many utilities offer financial assistance to encourage customers to conserve energy, these incentives serve to further mitigate the costs of the more stringent air pollution control equipment.

Second, CEAM hoped to demonstrate that government agencies with different missions can effectively cooperate to achieve their separate objectives. Seattle City Light has a strong commitment to energy conservation and needs to raise the participation rate of industrial customers in its conservation programs. PSAPCA, with a regulatory mission, faces resistance from targeted industry to the installation of air pollution control equipment, primarily because of cost. Seattle City Light's incentives offered for energy efficiency should serve to reduce this resistance.

The report contains nine chapters, inclusive of this chapter, the Executive Summary; and an appendix.

- o Chapter II describes CEAM's goals.
- o Chapter III relates difficulties encountered pursuing industrial energy conservation and how these difficulties relate to new air pollution regulations.
- o Chapter IV discusses Seattle City Light, reviewing what City Light has accomplished in energy conservation among residential and commercial customers, and addresses what the utility wants to achieve with industrial customers as these goals are related to CEAM. Chapter IV also discusses PSAPCA, reviewing PSAPCA's major responsibilities, and the relevancy of these to CEAM.
- o Chapter V lists the strategies that Seattle City Light and PSAPCA adopted for CEAM.
- o Chapter VI examines the process by which PSAPCA and Seattle City Light established a working relationship. Chapter VI also examines the methods adopted by the two government agencies by which potential energy conservation retrofits were identified for CEAM.
- o Chapter VII presents the results of the project. Seattle City Light and PSAPCA identified six industrial plants as having energy conservation opportunities associated with air pollution control systems. Chapter VII describes the specific energy conservation opportunities which Seattle City Light staff uncovered in these plants; Chapter VII also discusses CEAM disappointments.
- o Chapter VIII assesses CEAM's success in meeting its goals. CEAM succeeded in demonstrating that industries can conserve energy as they reduce air pollution emissions. These electric savings belong to several categories. One category consists of measures which improve the energy efficiency of air pollution control systems; a second category consists of measures which

- reduce the air pollution generated by process but do not reduce the energy consumption occasioned by process; a third category consists of measures which reduce both the air pollution created by manufacturing process and the energy consumption attributable to manufacturing process.
- o Chapter IX contains some concluding remarks about problems encountered by CEAM. Chapter IX also explains in detail how the project could have been improved by more careful implementation planning.

The appendix is devoted to individual summaries of the energy conservation measures Seattle City Light observed at the six plants.

CHAPTER II, INTRODUCTION

The Coordination of Energy and Air Quality Management (CEAM) has been a cooperative project between Seattle City Light, a municipally owned electric utility committed to conservation, and the Puget Sound Air Pollution Control Agency (PSAPCA), the federal agency responsible for implementing and regulating air pollution control measures in the Puget Sound region. The Department of Energy sponsored CEAM through the Urban Consortium Energy Task Force. The project's goals were to demonstrate:

- (1) that industries can save energy as they take the necessary steps to control air pollution;
- and
- (2) that, through mutual cooperation, two government agencies from separate jurisdictions and with different missions can more effectively accomplish their separate objectives.

Seattle City Light has been notably successful, particularly over the last decade, in promoting electric energy conservation among residential and commercial customers; but the utility's efforts at promoting industrial conservation have been less impressive. Under CEAM and the concomitant cooperation with PSAPCA, Seattle City Light had anticipated Energy Management Services Division staff could better target electric conservation opportunities among industrial customers than had previously been possible.

PSAPCA is the major air pollution control agency in the Puget Sound region. Many industry representatives consider the federal standards enforced by PSAPCA overly burdensome and unreasonable. Accordingly, PSAPCA faces some resistance from industry to the implementation of these regulatory laws.

PSAPCA had anticipated that working with Seattle City Light on CEAM would improve relations with the industrial community, and make the regulation of air quality more palatable to Seattle industries.

CHAPTER III, BARRIERS TO PROMOTING ENERGY CONSERVATION WITHIN INDUSTRY AND THE RELATIONSHIP OF THESE BARRIERS TO NEW AIR POLLUTION CONTROL REGULATIONS

As a result of rising construction costs, increasing uncertainty in forecasting demand, environmental concerns, and escalating regulations, Seattle City Light and many other electric utilities now find it more cost effective to encourage customers to conserve electricity through demand side management (DSM) programs than to rely on utility generation of limitless electric power. Over the last few years Seattle City Light and other electric utilities have developed strong DSM programs for residential and commercial customer sectors, but, almost without exception, there has been little success in selling the industrial sector on conservation programs. In spite of potentially large electric savings available, a number of barriers stand in the way of successfully implementing industrial conservation programs.¹

1. Electric costs are only a small percentage of the overall production costs at an industrial site, generally between 2 % and 3 %, and plant management generally gives energy conservation low priority in decision making.

2. Plant management generally does not consider energy conservation strategic in the sense that a measure needs to be implemented within a specific time frame or production will suffer, for example. Consequently, energy conservation is postponed in favor of other, more pressing issues, over and over again, often indefinitely.

¹ Jordan, Jennifer; Nadel, Steve M., Industrial Demand-Side Management Programs: What Happened, What Worked, What's Needed?, Draft Report, The American Council for an Energy-Efficient Economy, June 1992

3. Industrial customers generally believe that energy conservation measures require large inputs of capital and time. During recessions capital is tight and difficult to obtain; during periods of economic expansion, management has little time.

4. Plant management frequently has serious reservations about the reliability of conservation measures, perceiving the measures as risky and asking for more field data to prove the measures perform as advocates assert. Consequently, utilities have difficulty in convincing plants to install the newest, most highly efficient technology.

5. Electric use patterns at industrial sites are much more complex and varied than those in the residential and commercial sectors. Even within a single plant, the patterns of electric use will vary tremendously from one time to another or from one manufacturing process to another. Consequently, many of the most effective conservation measures must be designed specifically for the particular plant adding to the costs.

6. Electric utility staff, unfamiliar with industrial systems and failing to recognize that industrial and commercial customers are fundamentally different, often make the mistake of offering joint commercial and industrial conservation programs. An industrial plant generally employs a variety of industrial processes in production. These processes may be highly integrated and an energy conservation measure which changes one can have unintended effects on others. In short, installing the most effective conservation measures in a specific plant often requires specialized knowledge and experience not ordinarily found among electric utility staff.

Energy conservation remains an option to industry; air quality control, on the other hand, is now a legal obligation. Under increasingly stringent regulations, industries are being required to make substantial investments in air pollution control equipment, in order to meet the tougher regulations. Nationally, the Clean Air Act Amendment could cost industry as much as \$ 25 billion annually. The steel industry alone may need to invest over \$ 5 billion per year to comply with the Act.

Clearly, required investments of this size will impose severe financial burdens on many industrial firms. However, these regulatory developments and industry's response do continue to present a recognized opportunity for utilities to better target their industrial customers for energy conservation, in the general CEAM manner. By cooperating with the local environmental agency in its service area, a utility can anticipate which of its industrial customers will need to invest in new air pollution control technology, can contact these customers, and can use incentives to motivate the purchase of equipment with greater energy efficiency. In other words, by linking air pollution control with energy efficiency, a utility can solve many of the problems faced in promoting energy efficiency among industrial customers.

1. Linking energy conservation with strategic investments reduces the net cost of energy conservation. If the industrial firm is making a major investment, significant electric savings can usually be leveraged with a relatively small addition to total cost.

2. Energy conservation measures installed in conjunction with other equipment upgrades and plant expansion are less likely to disrupt plant operations.

3. Conservation measures would, in these instances, become more strategic; installation would have to occur within a specific time frame for benefits to be fully realized.

CHAPTER IV, THE RELEVANCY OF CEAM TO THE PROGRAM PARTNERS

Seattle City Light

Seattle City Light through its Energy Management Services Division has pursued conservation aggressively as an alternative to new generation since 1977. The utility has developed and implemented a number of programs to stimulate electric efficiency among customers, providing financial incentives and technical assistance. Residential programs have included rebates for installing energy efficient water heaters, no-interest loans for weatherizing homes, incentives to install efficient lighting in the common areas of multifamily residential buildings, and, more recently, the distribution of free energy and water-efficient showerheads to all households in the Seattle City Light service area. The combined impact of the residential programs between 1977 and 1990 reduced the utility's average electric load by more than 13.5 average megawatts.

Seattle City Light began offering its commercial customers financial incentives in 1986 with the Commercial Incentives Pilot Program (CIPP), sponsored by the Bonneville Power Administration. Under CIPP the utility paid rebates to customers who installed energy efficient lighting, heating, ventilation, and air conditioning (HVAC) equipment. CIPP ended in September 1990 but in January 1991, the utility resumed paying rebates under the Energy Smart Design program (ESD), again with Bonneville sponsorship. CIPP reduced the utility's load by 0.75 AMWs. The impact of ESD on load has not yet been determined although it is expected to be substantial. These commercial programs, while implemented later than the residential programs, are now the main focus of the utility's conservation activities.

Seattle City Light also offers financial incentives to industrial customers to encourage the installation of electrically efficient equipment. From 1987 through the end of 1991, Seattle City Light funded and operated the Industrial Research and Demonstration Project (IRD). Under IRD, Seattle City Light paid the participating industrial customer an incentive proportional to the estimated total electric savings over the life of the measure.² Since 1991 Bonneville has sponsored the Energy Savings Plan (ESP) at Seattle City Light. Under ESP, Bonneville pays an incentive proportional to the estimated first year savings of the measure, conditioned on verification of these savings. Both IRD and ESP emphasize improvement in process energy efficiency.

Industrial electric consumption comprises almost 20 % of Seattle City Light's load compared to 40 % for the commercial sector. Yet spending levels for industrial conservation at the utility presently equal only one tenth that for commercial conservation.

In addition to those barriers against successful industrial conservation programs as first set forth above, Seattle City Light has another problem: some of the lowest industrial rates in the nation. Seattle City Light's average industrial rate is about 3 ¢ per kilowatt hour which seriously discourages industrial investment in electric efficiency. Moreover, the Seattle industrial mix is broad but very shallow. There is no one industry with a concentration of large firms. In the electrically intensive industries, one

² A complete description of the IRD project and results will be published by Seattle City Light in early 1993 in an internal report entitled I.R.D., The Industrial Research and Demonstration Project, 1987 to 1992 as reported by D. K. Das, Jim Healy, Jeremy Battis, and Cynthia Blazina.

plant dominates the rest. Seattle City Light has 297 industrial customers. The top ten plants' electric consumption comprises 67 % of the entire industrial load; yet each of the top ten is in a separate industrial subcategory. This makes it impractical for Seattle City Light staff to develop in-house expertise for specific industries, since there is little scope for application beyond one or two plants.

The consequences of all these obstructions to Seattle City Light's industrial conservation efforts are more critical than ever. The entire Pacific Northwest region has recently gone from power surplus to power deficit and has plans to dramatically increase its electric energy savings through conservation over the next decade. Seattle City Light's share of the regional plan equals savings of 100 aMW by the year 2003, and if the utility is to meet this goal, Seattle City Light will need to quadruple its present conservation efforts. Industrial conservation goals are even more ambitious, and the utility expects to increase its efforts in this area tenfold. Seattle City Light may need to rely heavily on outside expertise to meet these goals for industrial conservation.

Puget Sound Air Pollution Control Agency

Funded by the State of Washington and accountable to the State and various affected local jurisdictions, PSAPCA's mandate extends over the four western counties of King, Pierce, Kitsap, and Snohomish. Under the Washington State Clean Air Act, PSAPCA has responsibility for monitoring and controlling stationary air pollution sources located in the area served. PSAPCA meets this responsibility by implementing and enforcing Regulations I, II, and III of the Act.

Regulation I covers the registration of air contaminant sources, notices of construction permits requiring plants to install the "best available control technology" or BACT, outdoor fire regulations, and the establishment of ambient air quality standards and control measures. Regulation I also covers setting emissions standards for opacity, sulphur dioxide (SO₂), odors, and fugitive dust.

Regulation II covers volatile organic compounds (VOCs) and emission standards to reduce ozone concentration. Regulation II applies primarily to gasoline stations, petroleum refineries and terminals/bulk plants, graphic arts businesses, surface finishing shops, and aerospace firms.

Regulation III covers asbestos renovation and removal, and other air contaminants from sources specifically listed under this regulation which exceed the allowable source impact levels.

PSAPCA is an active agency with field engineers frequently responsible for more than 100 sites at any one time. Although the agency can impose penalties and fines on recalcitrant firms, necessary due process conditions place enormous demands on field staff time. Any strategy which effectively promotes compliance with the Washington Clean Air Act is therefore of benefit to PSAPCA in meeting its charge.

By working with Seattle City Light on CEAM, PSAPCA expected to improve its relations with the industrial community, at least within the utility's service area. When encountering resistance from plant management to PSAPCA directives for additional air pollution control, PSAPCA staff hoped to temper this resistance with information about possible financial assistance available through Seattle City

Light's conservation programs and about the conservation measures to be installed in conjunction with the pollution control measures. In conveying the conservation information, PSAPCA intended to show sensitivity to the financial burdens imposed on industry by the new State regulations.

CHAPTER VI, ESTABLISHING A WORKING RELATIONSHIP BETWEEN PSAPCA AND SEATTLE CITY LIGHT AND IDENTIFYING INDUSTRIAL CUSTOMERS FOR ENERGY SAVINGS RETROFITS

PSAPCA and Seattle City Light adopted an approach consisting of four action strategies:

1. Establish a working group between Seattle City Light and PSAPCA which allows the agencies to coordinate their activities to further the project's aims.

2. Study Seattle City Light's industrial customers to identify which firms will be most affected by more stringent air pollution control regulations; assess the energy conservation potential in these firms.

3. Target the most promising firms for possible conservation retrofits and audit six to seven plants.

4. Install two or three electric energy conservation measures which affect industrial air pollution control equipment.

CHAPTER VI, ESTABLISHING A WORKING RELATIONSHIP
BETWEEN PSAPCA AND SEATTLE CITY LIGHT AND IDENTIFYING
INDUSTRIAL CUSTOMERS FOR ENERGY SAVINGS RETROFITS

Staff from PSAPCA and Seattle City Light met on a monthly basis from January 1991 through February 1992. During the early meetings they discussed the formation of teams consisting of one or two staff from each agency to visit and inspect selected plants by appointment with plant management present. Unfortunately, the idea of these joint, scheduled visits was abandoned. PSAPCA field engineers did not want a third party present during their inspections, believing this would obscure the purpose of the inspections. Seattle City Light was reluctant to have utility customers associate the utility's conservation programs with PSAPCA's enforcement procedures, fearing a negative backlash to participation in conservation programs as a result. In place of joint visits CEAM staff decided PSAPCA inspections for compliance with the Washington State Clean Air Act would continue as they had in the past; and that information on plants of interest to the CEAM project would be shared with Seattle City Light at the monthly CEAM meetings.

In retrospect, it appears the advantages of having representatives from both agencies inspect plants together with plant management might have outweighed the disadvantages. The exchange of information between Seattle City Light and PSAPCA would have been aided; questions could have been answered on the spot; plant management would have been present, adding a critical perspective to the agency discussion.

To identify potential CEAM retrofit projects, PSAPCA and Seattle City Light used several methods in lieu of joint inspections. PSAPCA engineers working on CEAM referred

Seattle City Light to specific plants and in this connection, the PSAPCA director signed a memorandum of agreement holding PSAPCA engineers responsible for providing the utility with two referrals each month. If a PSAPCA engineer believed an inspected plant presented opportunities for energy conservation, the engineer could advise plant management to contact Seattle City Light's Energy Management Services Division about industrial conservation programs. At CEAM meetings, these particular PSAPCA inspections and the particular alternatives available for air pollution control were discussed.

For each PSAPCA referral, Seattle City Light staff arranged for a follow-on site visit to look for potential energy conservation opportunities and to recommend specific energy conservation measures. This PSAPCA referral follow-on gave Seattle City Light staff a chance to promote the most energy efficient alternatives to plant management during the critical period when new air pollution control options were under consideration and decisions needed to be made. Results of the PSAPCA referrals and Seattle City Light follow-on contacts were shared at routine CEAM meetings.

There were a few cases in which Seattle City Light was already working with a firm on energy efficiency when the issue of improved plant or factory air pollution control arose. In these cases, Seattle City Light staff sought advice from PSAPCA on how electric energy conservation measures might help solve emission control problems.

CEAM also used an outreach method in an effort to build up interest in the CEAM project. PSAPCA distributed leaflets describing Seattle City Light's conservation programs and incentives for industry among suppliers of industrial ventilation and air pollution control equipment. Here it was

assumed that vendors with the most energy efficient products would have a natural interest in promoting energy efficiency and that the incentives offered by Seattle City Light would give these vendors a competitive advantage; in other words, these vendors would serve as a sort of sales force for Seattle City Light's industrial conservation programs.

Seattle City Light worked hard to solicit interest in the CEAM project. The Urban Consortium Energy Task Force suggested local professional groups might be of assistance in this regard. The project manager described CEAM over the telephone to several such organizations and the project manager and project director, accompanied by a PSAPCA engineer, gave a brief presentation on CEAM to Seattle's Greater Chamber of Commerce. Unfortunately, little came of these outreach efforts.

CHAPTER VII, RESULTS OF THE CEAM PROJECT

From PSAPCA referrals, Seattle City Light identified six industrial plants for the CEAM project: a large cement manufacturing facility, two small steel foundries, two small metal finishing shops, and a galvanizing plant. Seattle City Light uncovered eight electric energy conservation opportunities in the plants and recommended specific measures to explore the opportunities. In three cases, plant management installed the recommended measures; in two cases, recommendations are still under consideration. The appendix to this report contains detailed summaries of these energy conservation opportunities and recommended measures.

The measures are in three different categories. In the first category are measures which improve the electric efficiency of existing air pollution control systems. The cement plant accepted two energy conservation measures which belong to this category. The plant installed a variable speed drive on the baghouse fan motor. The baghouse's efficiency in removing aerosols from contaminated air remained the same but the annual electric consumption dropped from 1,124,000 kilowatt hours to 850,000 kilowatt hours, a 25 % reduction. The plant also replaced a magnetically controlled rectifier/transformer on the plant's electrostatic precipitator with an electronically controlled device. This allowed the electrostatic precipitator to cut emissions in half with an additional electric consumption of 23,616 kilowatt hours/year. If the capacity of the magnetically controlled precipitator had been increased to achieve this higher air pollution control, the additional electric

consumption would have been over 228,000 kilowatt hours annually.³

A second category consists of measures which reduce the air pollution generated by processes but do not increase the energy efficiency of these processes. These measures indirectly conserve energy, however, by reducing the energy expended on emissions control. For example, one of the small foundries may replace an electric arc furnace with an electric induction furnace. Although the energy efficiency of melting steel by electric induction and by electric arc furnace is about the same, this measure would reduce the air pollution generated by the melting process by over 80 %. This, in turn, would reduce the electric consumption of the plant's air pollution control system by 110,000 kilowatts annually, approximately 7 % of the total furnace load.

A third category consists of measures which reduce both air pollution and the energy consumption associated with the manufacturing process. In the second small foundry, Seattle City Light located two measures which belong to this category and foundry management has agreed to install the first, a replacement of the plant's ladle preheating system. Ladles are used to transport the molten metal from furnace to molds for casting; good foundry practice dictates that ladles be

³ Baghouses and electrostatic precipitators are the most common industrial removal systems for aerosols (particulates). A baghouse relies on filtration to separate the aerosols from the contaminated air and the energy consumption depends primarily on a fan which forces the air through a series of filters. An electrostatic precipitator relies on electrostatic attraction to separate the aerosols from the air. This system imparts electric charges to the aerosols, blows the air across plates of opposite charges, and the plates attract the aerosols and remove them from the air stream. It is the charging process which accounts for most of the precipitator's electric energy consumption.

preheated before they are filled with metal. Preheating removes moisture from the ladle, as a safety precaution, and prevents premature solidification of the metal.

The foundry presently preheats the ladles by blowing a natural gas flame jet into them. The replacement system offers snugly fitted covers for the ladles with integrated air blowers and gas burners; valves will automatically adjust the gas flow to ensure complete combustion, and the covers will reduce heat loss. The new system will reduce natural gas consumption by half (by 25,000 therms), saving the foundry \$11,000 annually on its gas bill. The reduction in gas consumption will, in turn, reduce the system's compressed air consumption, leading to a modest annual electric savings of 22,500 kilowatt hours. The reduced gas consumption will also lead to a reduction in the generation of nitrous oxide compounds [NO_x] by the process; the more complete combustion will reduce the generation of carbon monoxide and hydrocarbons.

The second measure uncovered at the foundry involved the installation of covers on the induction furnaces. Although induction melting is relatively "clean", it still emits (at a lower level) dust similar in composition to the dust emitted by arc melting. Seattle City Light estimated that by covering the furnace, the foundry could reduce its electric consumption by over 200,000 kilowatts annually. A PSAPCA engineer working on the CEAM project estimated (very roughly) that the covers would reduce furnaces emissions by 60 %.

While this foundry's management agreed to install the ladle preheater and had planned to do so by April 1992, installation was postponed because of the economic recession.

The foundry's management decided not to install the furnaces covers.

The three other measures recommended but not installed also involved covering the pollution source as a means of decontaminating air and reducing energy consumption, but they proved to be less practical. As with the induction furnace covers, these covers would contain the air pollution within a limited space, either reducing emissions or allowing pollution removal with less energy; and since the pollution source is heated, the covers would save energy by reducing heat loss.

The galvanizing plant management replaced the galvanizing kettle's old insulating covers with a new set for use when the plant is closed. The new covers reduced the plant's annual electric consumption by 393,000 kilowatts. On the other hand, Seattle City Light commissioned some air quality tests and discovered the new covers had no effect on the plant's air pollution emissions. Although the galvanizing kettle is the plant's major pollution source, emissions almost exclusively occur during production and the covers cannot be used then because they would interfere with plant operations.

The main sources of air pollution in electroplating shops are electroplating tanks containing acidic solutions of chromium. These solutions are maintained at elevated temperatures, leading to high energy losses from evaporation, and emit chromic acid mist which the shops control by applying mist suppressants and through ventilation, with ducts located just above the tanks.

Seattle City Light suggested 1) covering the tanks with blankets made of plastic balls which would float on top of the solutions or 2) installing rigid covers over the tanks. When

in use, either covering would block evaporative losses and suppress emissions.

In one electroplating shop, management decided against the recommendations for covers, reasoning that covering would slow down the electroplating operations. In the other shop, Seattle City Light's contact with management came too late. A decision had already been made on how to meet PSAPCA requirements; investments in equipment had already begun.

For the most part, efforts to interest outside parties in CEAM proved disappointing. Members of Seattle's Greater Chamber of Commerce listened politely to Seattle City Light's presentation, but demonstrated little real interest in the project, one member commenting that the presentation did not reveal how CEAM could provide specific benefits to members. Similar complaints about the too general nature of CEAM's objectives were heard from other professional organizations.

The leaflets did elicit a response from suppliers of industrial ventilation and air pollution control equipment and a number of these suppliers called Seattle City Light requesting additional conservation literature; but these contacts failed to generate any new energy conservation opportunities. Most of the suppliers serve individual customers who are very small energy users, offering no significant potential for energy savings, and lack of follow-on interest suggests the utility's conservation incentives for small industry are too low to generate interest.

One specific example illustrates this problem clearly. PSAPCA had directed a paint shop to improve the ventilation conditions of spray painting operations. At the same time, the shop owners were considering expansion, anticipating business would grow by as much as three times the present

level over the next three to four years. Ultimately, the owners decided to move the shop to a larger site, estimating annual electric consumption would increase from 40,000 kilowatt hours in 1991 to somewhere between 250,000 and 300,000 kilowatts once they reached expected production levels.

The supplier, or vendor, in question was a design engineer who wanted to sell the owners an energy efficient painting system, costing approximately \$ 100,000. The supplier believed the owners would select another less efficient system costing approximately \$ 75,000 unless Seattle City Light's incentives worked to offset the \$ 25,000 difference. The engineer met with CEAM's project manager several times in an effort to work out such an incentive. Unfortunately, under the most optimistic assumptions, maximum incentives from the utility to the paint shop would equal only about \$ 1,000; the shop would save only 2,500 kilowatt hours annually. In other words, it would have taken the owners ten years to recoup their investment, if they had invested in energy savings.

Seattle City Light's Energy Savings Program [ESP] is simply not organized to handle very small industrial customers in a cost-effective way. ESP is based on the assumption that industrial customers are unique and that the most effective energy conservation measures for industry are customized design. From a utility perspective, however, custom designs have high administrative costs which, for small jobs, become prohibitive. From a customer's perspective, participation in Seattle City Light's ESP program requires too much paperwork and effort to make the low incentive offering worthwhile.

As it turned out, PSAPCA was unable to meet the terms of the memorandum of agreement by providing Seattle City Light with two CEAM referrals each month. According to the PSAPCA engineer assigned to the project, most plant managers were not interested and/or did not believe the energy efficient alternatives proposed would be cost effective. In the second year, the number of referrals declined seriously; the last referral was in June 1992.

Seattle City Light and PSAPCA had hoped a cooperative relationship could continue beyond the completion of the CEAM project. However, in the second year, commitment declined. Regular monthly meetings ended in February; staff from the two agencies met briefly in March and in May, but achieved little.

CHAPTER VIII, CEAM SUCCESS IN GOAL ACHIEVEMENT

The CEAM project had two goals.

1. The first was to demonstrate that industries can achieve energy savings as they improve their pollution control; for the most part, CEAM succeeded in achieving this goal.

Industries can save energy as they reduce air pollution emissions but not necessarily in the ways one might expect. Escalated air pollution control regulations will cause many industries to increase their consumption of electric energy, as the retrofits in the cement plant exemplify. However, utilities can motivate industrial customers to minimize these increases through conservation programs.

A retrofit which reduces air pollution derived from an industrial process can lead to energy savings, even if the retrofit does not improve the energy efficiency of the process itself. In many cases such a retrofit will allow the plant to reduce the energy consumption of air pollution control system(s). The proposed replacement of the electric arc furnace with an electric induction furnace at the small foundry would have accomplished this.

On the other hand, reducing air pollution will not necessarily lead to reduced energy consumption. The proposed ladle preheater replacement and installation of covers on the induction furnaces at the second foundry probably would not reduce load on the plant's air pollution control system. The difference between these two measures is that the arc furnace would require a dedicated air pollution control system in addition to the existing ventilation system, releasing the furnace exhaust directly to the baghouse. The ladle preheater

and the uncovered induction furnaces do not require dedicated systems.

Isolating the pollution source can lead to energy savings. Covering the galvanizing kettle, the electroplating tanks, and the induction furnaces are simplistic but clear applications of this approach. While the approach proved inadequate for the galvanizing plant and electroplating shops, the concept of isolating the pollution source is still valid. A more sophisticated approach leading to energy savings might involve designing the plant's material handling in such a way as to bring the product to the pollution source, and process and remove the product while keeping the pollution source isolated. Pollution confined to a limited space becomes easier to treat. Moreover, for processes like galvanizing or electroplating, isolating the source would also save energy by reducing heat loss.

2. The second goal was to demonstrate that two agencies with different missions can effectively cooperate to achieve separate objectives. CEAM was not successful in meeting this goal.

In spite of the work done at the six plants, it is not clear what benefit either PSAPCA or Seattle City Light obtained from a collaborative relationship.

Seattle City Light was interested in obtaining greater energy conservation from industrial customers. The three retrofits are real benefits. However, and noting the CEAM project design provided no means of determining this with certainty, the utility might well have achieved equivalent results without PSAPCA assistance.

From PSAPCA's perspective, CEAM was supposed to improve PSAPCA's relations with Seattle's industrial community, making the agency's task of enforcing the Washington Clean Air Act regulations a little easier. Again, the CEAM project design provided no means of testing this assumption; but, in fact, the difficulty PSAPCA experienced in generating referrals to Seattle City Light indicates the assumption was invalid.

Nevertheless, the cooperative effort cost the agencies little. Aside from its commitments to the Urban Consortium Energy Task Force, Seattle City Light's responsibilities consisted of duties performed routinely as part of energy management services activities.

The referral work and monthly meeting attendance constituted all the extra CEAM work required of PSAPCA. According to the engineer assigned, little extra work was required of PSAPCA staff in support of the CEAM project.

For other jurisdictions contemplating similar cooperative projects, CEAM results may be of little value. However, the results suggest jurisdictional risk in such projects is minimal or non-existent.

CHAPTER IX, CONCLUDING REMARKS; SUGGESTIONS FOR OTHER JURISDICTIONS

Problems Encountered

A number of problems hindered CEAM's progress, some coincidental; some the sort that could happen to any project. The most disruptive occurred as a result of changes within Seattle City Light briefly described below.

1) Midway through the CEAM project, the utility began a reorganization which resulted in the original project manager leaving Seattle City Light employment, and while he continued to provide assistance to his replacement for several months, his departure caused a serious break in the project's continuity.

2) At the same time the head of Seattle City Light's Energy Management Services Division moved to another division within the utility and the CEAM project director assumed these duties until a permanent replacement was hired for the position. Consequently, the project director could dedicate only a fraction of her time to CEAM in the project's second year.

3) In CEAM's second year Seattle City Light began a substantial ramp-up of conservation efforts whereby the utility expects to quadruple conservation levels in 10 years. The utility's short-staffed Energy Management Services Division was responsible for planning how Seattle City Light would meet these ambitious conservation goals.

4) Seattle City Light's 5-year Industrial Research and Demonstration (IRD) Project began to close down at the end of 1991, and the utility stopped contracting for new industrial

projects at that time. Ongoing projects continued until June 1992, and much of the CEAM project manager's time in the second half of 1992 was devoted to writing the completion report for the IRD Project.

These problems illustrate difficulties encountered in running a small project over more than one year. Initially, management in Seattle City Light's Energy Management Services Division viewed CEAM as a potentially valuable source of information for industrial conservation planning. Nonetheless, throughout its second year, CEAM was, by necessity, of secondary priority and when matters of greater priority arose, CEAM work was postponed. Consequently, CEAM progress occurred in fits and starts.

Suggestions for Other Jurisdictions

CEAM would have benefitted if, in the very early stages of the project, Seattle City Light and PSAPCA staff had developed a project-specific implementation plan. The purpose here would have been to identify which of Seattle's industrial subgroups were likely to make timely investments in improved air pollution control and to quantify the conservation potential for each of these subgroups. This approach would have produced information useful to the utility's industrial conservation efforts and of great value to the CEAM project.

1) Seattle City Light could have explicitly compared the conservation potential of the individual industrial subgroups and divided them into classes accordingly. Seattle City Light and PSAPCA could have concentrated on those classes showing the best potential for electric savings. PSAPCA could have limited referrals to firms in the most promising classes. Seattle City Light would not have wasted time following up referrals to industry with little potential for conservation.

2) Seattle City Light could have devoted more staff time to study of the relationship between air pollution control and energy consumption specific to those industries offering the greatest potential for energy conservation in air pollution control. This would have given utility staff more opportunity to explore the specific energy conservation measures which serve to help reduce air pollution emissions. Seattle City Light would have gained greater credibility with its industrial customers by demonstrating a better understanding of the specific processes affecting air pollution emissions.

3) By concentrating efforts on the most promising industrial subgroups, Seattle City Light would have gained greater understanding in the CEAM project. This might have increased CEAM plausibility to outside groups such as the Chamber of Commerce.

To produce such an implementation plan for CEAM would have required two or three months of consistent effort from the project manager; the general methodology is described below. Although some of the steps rely on data sources not necessarily available to other organizations, any jurisdiction should be able to follow the same basic approach.

Initially, the project manager would work closely with PSAPCA staff to catalog the industrial subgroups required to improve air pollution control. At this stage PSAPCA would also identify major sources of air pollution for each industry and what types of equipment are required to treat the air pollution.

The project manager would use the utility's electric billing data to determine total electric consumption for each

of the industrial subgroups catalogued. By drawing upon a number of additional data sources, this consumption data could have been disaggregated to estimates of how much electric energy each industry subgroup expends on processes that emit pollution and how much each expends on air pollution control.

Seattle City Light has data which disaggregate the industrial customer's electric consumption by subgroup and major industrial end-uses.⁴ The data determine, for instance, how much electric energy primary metal manufacturers in Seattle consume in running motors. Since baghouses comprise the majority of air pollution control systems used by this particular industrial subgroup and baghouse electric power is used to drive a fan motor, the data reveal the maximum energy expended on air pollution control. The project manager could have obtained additional data from a number of disparate sources, including the IRD Project Report, information reports from Seattle City Light's Major Accounts Section, and Electric Power Research Institute [EPRI] publications.

In addition, for example, the project manager could have made use of the EPRI software package, "Industrial Market Information System" [IMIS]. IMIS has information on how what types of processes are found in different industrial subgroups and a breakdown of the energy consumption in each of the industrial subgroups by fuel type and by major end use.

The project manager could have set up a series of equations to determine the energy consumption of polluting processes and the energy consumption of treating polluted air

⁴ End-uses are equipment types driven by electricity. In Seattle City Light's service area, major end-uses are industrial lighting, HVAC/other, motors, air compressor, furnaces, refrigeration, and welding.

by industry. He or she would have needed to make a number of estimates in order to solve the equations by specific firm and the accuracy of these results might have varied widely; but for each industrial subgroup, the project manager would have the information from which to derive tolerable estimates.

The project manager then would have worked with PSAPCA to identify opportunities for reducing the air pollution generated by the industrial subgroups and for increasing the energy efficiency of air pollution control systems. The Department of Energy has published a database, "Directory of Industrial Energy Conservation Opportunities", or DIECO, which could have provided the project manager with a list of successful energy conservation opportunities for different processes in the various industrial subgroups.

The final step would have been to assess the conservation potential offered Seattle City Light by each of these energy conservation opportunities and to tabulate energy conservation potential for each industrial subgroup. This tabulation could have served as a dynamic tool for use in amending assessments as additional information during the course of the CEAM project.

APPENDIX

CASE STUDIES OF INDUSTRIAL ENERGY AUDITS PERFORMED UNDER THE CEAM PROJECT

Seattle City Light staff performed energy audits at six industrial sites under the CEAM Project, identified eight energy conservation opportunities, and recommended specific measures for installation. Results of the individual audits are summarized below.

The basic format of the summaries consists of:

1. Site description,
 2. Description of measures recommended by Seattle City Light,
- and, when relevant to the CEAM Project,
3. Information on either impact of measures (if installed) or on estimated energy and economic impacts.

In Plant B, one of the small foundries, Seattle City Light did not have the data necessary for an economic analysis. In Plants E and F, the electroplating shops, Seattle City Light lacked the data required to make either the energy savings estimate or the economic analysis.

PLANT A: TWO ENERGY CONSERVATION MEASURES IN A SMALL STEEL FOUNDRY

Plant A is a small steel foundry which supplies railroad companies with couplings and chains to hold train cars together. In 1990 the foundry firm consumed 3,638,160 kilowatt hours of electricity and paid \$108,126 in electric bills. Three induction melting furnaces accounted for 58 % and 60 % of the plant's energy consumption and electric bill, respectively. Motors, air compressors, and lighting comprised the remaining electric consumption and costs. Seattle City Light suggested two measures to improve the plant's energy efficiency and reduce air pollution control.

MEASURE ONE - PLANT A:

The first measure consisted of installing covers on the plant's induction furnaces. With furnace openings uncovered

during the melting process, approximately 15 % of input energy is wasted as a result of radiation and convection heat loss through the openings. This translated into a total of 316,520 kilowatt hours in 1990, costing the firm an additional \$7,309 in electric bills.

Additionally, while induction furnaces are relatively "clean" and generally do not require special air pollution controls, they still emit fumes which can contain lead, cadmium and chromium, depending on the metal being melted. These fumes are generated as a result of the reaction of the molten metal with air. From an air quality control perspective and according to the PSAPCA engineer assigned to CEAM, leaving induction furnaces uncovered is one of the worst practices encountered.

The foundry's management had tried to improvise furnace covers by tacking insulating blankets to a wire mesh to which they welded handles, but the intense heat of the molten metal quickly burned through the insulation. Ceramic covers, which can withstand the heat, may weigh up to 250 pounds apiece - unacceptable as workers need periodic access to the furnaces during the melting process to add more metal or skim off slag that builds on top of the molten metal.

Seattle City Light arranged for an engineer who specializes in furnace design to visit the foundry. The engineer estimated that ceramic covers, when in use, would reduce heat loss by more than 95 % and suggested two possible designs permitting the use of ceramic covers without interference with the plant's operations. The first such design consisted of hydraulically operated covers where a pedal switch would activate the hydraulic lift to raise the covers away from the furnace and allow operator access or pouring. The second design required constructing covers with a counter balance permitting the operator to move covers away easily from the furnace when needed.

Seattle City Light observed foundry operations over several days and determined the furnaces could be covered for 65 % to 75 % of melting time without impeding process or production. Seattle City Light estimated that by covering the furnaces during these times, foundry workers could cut furnace electric consumption per ton of product by 10 % (210,000 kilowatt hours a year at 1990 production levels); could reduce furnace generation of air pollutants by 60 %; and could increase efficiency of the melting process by 5 %.

The table below presents the results of the pre-retrofit economic analysis for the recommended measure.

Electric costs = 3 ¢/kWh

Expected life = 15 years

Real discount rate for Seattle City Light = 3 % per year

TABLE 1 - PLANT A - MEASURE ONE
ESTIMATED ECONOMIC IMPACT

Total Cost for the Measure	\$38,300
Seattle City Light's Cost	\$26,810
Net Cost to the Firm	\$11,490
Electric Savings	210,000 kWh/yr
Cost per kWh to the Utility	1.07¢
Electric Bill Savings for the Firm	\$6,300/yr
Simple Pay Back for the Firm	1.82 years

The firm would also realize labor and capital savings from increased melting rates, and potential capital savings from reduced pollution generation likely to require additional control equipment. Seattle City Light did not have the means to quantify these potential benefits.

Foundry management expressed interest in this recommendation. However, because of the recession, management determined the firm was not in a position to make the necessary investment.

MEASURE TWO - PLANT A:

The second measure consisted of replacing the plant's ladle preheaters with a more efficient system. Ladles are used in foundries to transport the molten metal from the furnace to molds for casting. Good foundry practice dictates preheating the ladles prior to filling them with the molten metal, and this practice provides several benefits. Preheating removes residual moisture in the ladle which, on contact with the molten metal, can cause dangerous explosions. Preheating prevents the molten metal from solidifying prematurely thereby reducing scrap. Finally, preheating allows the foundry to tap the metal at a lower superheated temperature (superheating is raising the temperature above the

melting temperature), which saves energy and decreases melting time.

The foundry's present practice is to preheat the ladles by means of a long tube with a natural gas burner mouth and placed on top of the ladle without protective covering. This system has the following disadvantages:

1. Lack of a ladle cover during the heating leads to excessive heat loss;

2. Lack of adequate control leads to poor heat distribution and incomplete combustion of the natural gas;

3. The system generates excessive noise and contaminated air in the ladle's immediate environment;

Finally,

4. The system inefficiently utilizes the foundry's compressed air.

Seattle City Light was interested in reducing the consumption of compressed air during the ladle preheating process for electricity savings and suggested a ladle preheating system consisting of a separate blower and ladle cover with an integrated burner, known as a HVTA system. This system would regulate the natural gas flow, mixing the gas with the optimal amount of air prior to burning, ensuring more complete combustion and thereby improving energy efficiency and reducing the level of carbon monoxide, nitrous oxide compounds, and hydrocarbons released into the work environment.

The resulting reduction in compressed air consumption would yield modest electric energy savings, an estimated 22,500 kilowatt hours yearly. The natural gas savings, however, would be quite substantial, an estimated 25,000 therms (equivalent to 732,350 kilowatt hours).

The table below presents the results of the pre-retrofit economic analysis for the recommended measure.

Electric costs = 3 ¢/kWh

Expected life = 15 years

Real discount rate for Seattle City Light = 3 % per year

Natural gas cost to the firm = 44.7 ¢/therm [one therm = 100,000 British thermal units (Btu's) = 29.3 kilowatt hours.

**TABLE 2 - PLANT A - MEASURE TWO
ESTIMATED ECONOMIC IMPACT**

Total Cost for the Measure	\$26,950
Seattle City Light's Cost	\$9,500
Net Cost to the Firm	\$17,450
Electric Savings	22,500 kWh/yr
Cost per kWh to the Utility	5.00¢
Electric Bill Savings for the Firm	675/yr
Simple Pay Back for the Firm (electric savings only)	25.85 years
Natural Gas Savings	25,000 therms
Natural Gas Bills Savings for the Firm	\$11,175
Total Energy Bill Savings for the Firm	\$11,850
Simple Pay Back for the Firm (both electric and natural gas savings)	1.47 years

Foundry management agreed to install the measure by April 1992 and then postponed installation. The terms of the contract between Seattle City Light and this industrial customer allow the customer to postpone measure installation until the end of 1993.

**PLANT B: ENERGY SAVINGS FROM REDUCING
POLLUTION GENERATION IN A SMALL FOUNDRY**

Plant B is a small foundry which produces replacement parts for ocean going ships. In 1991 the foundry consumed 3,267,160 kilowatt hours of electricity with an electric arc furnace accounting for 46 % of this consumption; motors, lighting, air compressors, and air pollution control system accounting for the balance.

In the spring of 1991, PSAPCA directed Plant B management to increase the capacity of the baghouse fan so as to adequately control the arc furnace fumes. Arc furnaces release dust which can contain lead, cadmium and chromium,

depending on the type of scrap metal melted. PSAPCA suggested Plant B management contact Seattle City Light about conservation incentives as a possible means of mitigating the cost of meeting the PSAPCA directive.

Seattle City Light, following visits to Plant B, recommended installation of a variable speed drive on the new baghouse fan motor. With a standard drive, the new fan would have increased Plant B electricity consumption by approximately 110,000 kilowatt hours yearly. Seattle City Light estimated a variable speed drive on the new fan motor would reduce this increased consumption by 30,000 to 60,000 annual kilowatt hours. At the time, however, Plant B management was confronted with the likelihood of an operational relocation; and PSAPCA allowed delay of the new fan installation until Plant B's future was settled.

Approximately a year later Plant B management contacted Seattle City Light and explained that instead of replacing the fan, the plan now was to replace the arc furnace with an electric induction furnace. Induction melting has about the same energy efficiency as does arc melting but causes 20 % less dust and with properly fitted covers, the existing system would sufficiently control air pollution. Plant B could therefore completely avoid the increased electric consumption to meet PSAPCA standards.

The table below presents the results of the pre-retrofit energy savings analysis for the recommended measure. Plant B suffered a major fire in July 1992 and will not reopen until 1993 at the earliest. Seattle City Light has not received the information needed to complete the pre-retrofit economic analysis.

TABLE 3 - PLANT B
ESTIMATED ENERGY SAVINGS

OPTION	EFFECTIVE ENERGY SAVINGS
ARC FURNACE WITH STANDARD MOTOR DRIVE ON THE NEW BAGHOUSE FAN	0 kWh/yr
ARC FURNACE WITH VARIABLE SPEED DRIVE ON THE NEW BAGHOUSE FAN	45,000 kWh/yr
INDUCTION FURNACE WITH EXISTING BAGHOUSE FAN	110,000 kWh/yr

PLANT C: TWO ENERGY CONSERVATION MEASURES IN A LARGE CEMENT MANUFACTURING FACILITY

Plant C is a large manufacturer of Portland cement in Seattle. In response to competition from a recently modernized competitor, as well as PSAPCA's directive that any incident in which the opacity of emission⁵ exceeds 5 % must be reported, new management sought to increase both the plant's electric energy efficiency and the effectiveness of the plant's air pollution control.

Plant C installed two energy conservation measures sponsored by Seattle City Light under two separate conservation programs. The combined energy savings for these measures exceeded 500,000 kilowatt hours annually, saving the firm \$ 15,900 annually in electric bills.

In addition to the energy savings, one of the measures also reduced opacity of emissions to 2.5 %. The production of cement creates a large volume of dust which must be removed from the contaminated air before the plant can exhaust air to the outside. Plant C has two major air pollution control systems. The first is a baghouse which removes the aerosols by forcing the air through a series of filters; the second is an electrostatic precipitator which removes the aerosol by electrostatic attraction.

MEASURE ONE - PLANT C:

Seattle City Light sponsored this first retrofit in 1991 through the IRD Project, installing a variable speed drive (VSD) on Plant C's 300 horsepower baghouse fan motor. A baghouse removes aerosols from contaminated air by forcing the air through a series of filters with the fan's load varied so as to maintain a positive static upstream pressure. Before the retrofit, the load was controlled by adjusting the degree to which the inlet vanes leading to the baghouse were opened. After the retrofit, the VSD controlled the load by varying the fan speed.

⁵ Opacity is a measure of the numeric density of particles in a volume of air. The particles refract light as they pass through the air volume. Measuring the level of refraction, the opacity, determines the number of particles contained in the air volume.

Affinity laws state that for a constant motor efficiency the power requirement of the fan varies proportionally with the static pressure to the one and one half power:

$$W_2/W_1 = (P_{s2}/P_{s1})^{1.5}$$

in which W_1 and W_2 are the fan's power requirements for states 1 and 2, respectively, and P_{s1} and P_{s2} are the fan's static pressures for states 1 and 2, respectively. Theoretically, when the fan maintains static pressures equaling only 75 %, 50 %, or 25 % of its maximum capacity, the fan power requirement should then equal only 65 %, 35 %, or 12.5 %, respectively, of its maximum capacity.

A standard motor responds to a reduction in load by reducing the torque on its shaft, while speed remains nearly constant. As the torque decreases, the efficiency of the motor in converting electric input to mechanical output declines, and much of the energy savings obtained from reducing the fan load is lost as a result of this lower efficiency.

A motor with a VSD, on the other hand, responds to a reduction in load by varying speed while maintaining constant torque. Consequently, the motor's electric efficiency remains relatively constant as fan load is reduced, and most of the energy savings obtained from reducing static pressure is realized.

The fan operates 7,872 hours per year. An analysis of the data collected prior to the retrofit indicated the fan operated at an average of 48 +/- 2 % of its maximum capacity with an average electric consumption of 143 +/- 4 kW (1,124,000 +/- 32,000 kWh/year). Post-retrofit data indicated the fan required an average of 108 +/- 2 kW (850,000 +/- 16 kWh/year). The following table presents results of the retrofit.

Electric costs = 3 ¢/kWh

Expected life = 15 years

Real discount rate for Seattle City Light = 3 % per year

TABLE 4 - PLANT C - MEASURE ONE
FAN OPERATION BEFORE AND AFTER
INSTALLATION OF THE VARIABLE SPEED DRIVE

	PRE-RETROFIT	POST-RETROFIT	CHANGE
AVERAGE POWER	143 kW	108 kW	- 35 kW
ANNUAL HOURS OF OPERATION	7,872	7,872	0
ANNUAL ELECTRIC CONSUMPTION	1,124,000 kWh	850,000 kWh	- 274,000 kWh
AVERAGE OPACITY	5 %	5 %	5 %
TOTAL COST OF RETROFIT	-----	-----	\$ 30,254
UTILITY COST	-----	-----	\$ 21,178
COST PER kWh	-----	-----	0.89 ¢
PLANT C COST	-----	-----	\$ 9,076
ANNUAL ELECTRIC COST	\$ 33,720	\$ 25,500	\$ 8,220
SIMPLE PAYBACK	-----	-----	1.10 years

MEASURE TWO - PLANT C:

Seattle City Light sponsored the second energy conservation measure for Plant C through the Energy Savings Program. This measure consisted of a silicon control rectifier installed on a electrostatic precipitator, replacing the previous control device, a saturable core reactor. An electrostatic precipitator, like a baghouse, cleans the air of aerosols but employs electrostatic attraction instead of filtration as the separating mechanism. The particle-laden

air is electrically charged and forced to pass by oppositely charged plates, the charge in the air ionizing the particles which are then attracted to the plates.

Prior to the retrofit, the saturated core reactor controlled the power input to the transformer/rectifier set, which, in turn, converted the AC power into DC power for the precipitator. Installing the silicon controlled rectifier improved the precipitator's electric efficiency by avoiding three problems that commonly occur with saturable core reactors:

1) Slowness in quenching sparks. Sparking in the precipitator leads to the loss of useful energy. The magnitude of this loss increases as the frequency and the duration of the sparks increase. Because it is a magnetic device, the saturable core reactor is slow to react and takes a relatively long time to quench sparking. Typically, the saturable core reactor takes 300 milliseconds to quench sparking.

In contrast, the silicon control rectifier with a solid state switching device, reacts much more quickly. The silicon control rectifier generally quenches sparking within 8 milliseconds.

2) Power efficiency. The saturable core reactor has a high leakage rate requiring an AC power supply to the transformer/rectifier set at all times, even when the precipitator is not in operation; resistors must be in place and parallel to the transformer/rectifier set. The resistors are sized to 10 % to 15 % of the power rating leading to an additional 10 % to 15 % of the precipitator power consumption.

3) Collection efficiency. The sinusoidal shapes of the incoming AC current and voltages are deformed by the saturable core reactor into a narrow and highly peaked wave shape. Poor wave shapes degrade efficiency by lowering the fraction of power delivered to the precipitator before sparking occurs (fractional conduction). A saturable core reactor has a fractional conduction ranging between 40 % and 70 %.

A silicon control reactor distorts the wave shapes to a much lower degree. It typically has a fractional conduction ranging between 80 % and 90 %.

Pre-retrofit and post-retrofit measurements were conducted on the precipitator's electric efficiency through monitoring and logging input (average power supplied to the saturable core reactor or the silicon controlled rectifier) and output (average power measured on the precipitator). The electric efficiency was defined as the ratio of the output divided by the input.

$$\text{Eff} = \text{power}_{\text{out}} / \text{power}_{\text{in}},$$

in which Eff, $\text{power}_{\text{out}}$, and power_{in} equal efficiency, output power, and input power, respectively.

The tables below present the results of the retrofit on the precipitator's electric consumption.

TABLE 5.1 - PLANT C - MEASURE TWO
ELECTROSTATIC PRECIPITATOR'S ELECTRIC EFFICIENCIES
BEFORE AND AFTER RETROFIT

	PRE-RETROFIT SATURABLE CORE REACTOR	POST-RETROFIT SILICON CONTROLLED RECTIFIER
POWER INPUT	109 kW	111 kW
POWER OUTPUT	84 kW	108 kW
EFFICIENCY	77 %	97 %
OPACITY	5 %	2.5 %

Plant C management had increased the precipitator's power output from 84 kW to 108 kW so as to decrease the average opacity from 5 % to 2.5 %. Had they decided to increase the size of the saturable core reactor, the required input power would have had to have been 140 kW (108 kW/77 %).

The table below presents the results of the pre-retrofit economic analysis for this recommended measure.

Electric costs = 3 ¢/kWh

Expected life = 15 years

Real discount rate for Seattle City Light = 3 % per year

TABLE 5.2 - PLANT C - MEASURE TWO
ESTIMATED ENERGY AND COSTS SAVINGS RESULTING FROM RETROFIT

	PRE-RETROFIT	POST-RETROFIT	CHANGE
POWER OUTPUT	108 kW	108 kW	0
ESTIMATED EFFICIENCY	77 %	97 %	20 %
POWER INPUT	140 kW	111 kW	- 29 kW
ANNUAL HOURS OF OPERATION	7,872	7,872	0
ANNUAL CONSUMPTION	1,102,080 kWh	873,892 kWh	- 228,288 kWh
TOTAL COST OF RETROFIT	-----	-----	\$ 33,452
UTILITY COST	-----	-----	\$ 20,676
COST per kWh	-----	-----	0.76 ¢
PLANT COST	-----	-----	\$ 12,776
ANNUAL COST OF ELECTRICITY	\$ 33,062	\$ 26,217	- \$ 6,846
SIMPLE PAYBACK	-----	-----	1.87 years

**PLANT D: INSTALLATION OF INSULATING COVERS
ON A GALVANIZING KETTLE**

Plant D is a galvanizing facility. Galvanizing lays a zinc coating on steel products to protect them from rusting. Plant D's operations are simple; after initial machining, all Plant D products go through the same series of steps:

1. The product is immersed in a highly concentrated solution of sulfuric acid which removes the remaining rust by chemical reduction;
2. The product is immersed in a fresh water bath to rinse off byproducts;

3. The product is immersed in a highly concentrated basic solution of zinc ammonium chloride which arrests further chemical reduction;

4. After reduction has been stopped, the product is immersed in another fresh water bath to remove the basic solution;

5. The product is immersed in a solution known as flux which coats the product and protects it from air;

6. Finally, the product is galvanized by immersion in a molten zinc bath.

Steps 1 through 5 are commonly known as pickling the product; the acidic and basic solutions are known as pickling liquors.

In 1991 Plant D consumed 6,307,000 kilowatt hours of electric energy, costing the firm over \$190,000. The galvanizing kettle holding the molten zinc accounted for 4,000,000 kilowatt hours, and the pickling tanks holding the sulfuric acid solution, the flux, and the rinse water accounted for 2,000,000 kilowatt hours.

The retrofit consisted of replacing the galvanizing kettle's old insulating covers with a new set for use when Plant D operations are suspended. The new covers fit the kettle more tightly, providing better insulation. The old covers reduced heat loss from the top of the kettle by 19 kilowatts; the new covers reduce the heat loss by 103 kilowatts.

More importantly, the new covers are much easier to use as it takes only one-quarter the time to install and remove them from the kettle; as a result, the new covers are used 4 times more often. Through better insulation and greater frequency of use, the new covers reduced Plant D's annual electric consumption by 393,000 kilowatt hours.

This retrofit, on the other hand, had no effect in reducing Plant D's air pollution emissions. According to the PSAPCA engineer, the galvanizing kettle was the plant's major source of air pollution. Seattle City Light assumed covering the kettle would reduce the aggregate emissions but to test this concept, commissioned an industrial chemist to measure for zinc released into the air from the galvanizing kettle. Because the covers are only in use when the plant is closed, the tests were done at night after operations ceased. In one test, the covers were left off the kettle. In another, they

were installed on the kettle for several minutes before starting measurements.

The results of the chemist's tests showed no trace of zinc in the air with or without the covers. It appears zinc emissions occur during the galvanizing process due to the reaction of hot zinc and cold flux; and moisture in the flux rapidly evaporates on contact with the zinc causing small explosions. These explosions form the zinc aerosols.

The table below presents results of the retrofit.

Electric costs = 3 ¢/kWh

Expected life = 15 years

Real discount rate for Seattle City Light = 3 % per year

TABLE 6 - PLANT D
ENERGY AND ECONOMIC IMPACT OF NEW KETTLE COVERS
AT A GALVANIZING PLANT

	PRE-RETROFIT	POST-RETROFIT
TOP HEAT LOSS RATE REDUCTION	19 kW	103kW
ANNUAL USE	1,000 HOURS	4,000 HOURS
ANNUAL ELECTRIC SAVINGS	19,000 kWh	412,000 kWh
DIFFERENCE	-----	- 393,000 kWh
TOTAL COSTS	-----	
UTILITY COSTS	-----	\$ 6,500
LIFE	-----	15 years
COST PER KILOWATT HOUR	-----	0.14 ¢

REPORT AND INFORMATION SOURCES

Additional copies of this report, "Coordination of Energy and Air Quality Management, Seattle City Light Department," are available from:

Publications and Distribution
Public Technology, Inc.
1301 Pennsylvania Avenue, NW
Washington, DC 20004

For additional information on the process and the results of the work described in this report or for information on the overall energy management programs in the Seattle City Light service area, Seattle, Washington, please contact:

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Energy Management Services Division
1015 Third Avenue, Room 818
Seattle, WA 98104-1198

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