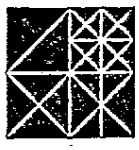
Industrial NOx Emissions Reduction

A report prepared for Southern California Edison
November 1991



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I EXECUTIVE SUMMARY

Chem Systems has been retained by Edison to develop a program for the demonstration of technologies (preferably electrotechnologies) with the potential to reduce fuel consumption so as to abate NOx emissions from stationary sources in Edison's territory. The program is to be similar to Edison's VOC abatement technology demonstration program. The overall program is proposed to take two approaches: reducing industrial (and commercial and institutional) needs for fuel burning, and helping to eliminate NOx formed in stationary fuel burners operated by Edison's customers. The program is ultimately to deal with both the demonstration and transfer needs of these technologies in Southern California.

NOx is a problem in Southern California because it contributes to forming the ozone component of the region's severe smog, as well as to acid rain and global warming. The present project is aimed at the first of the two approaches: identifying and screening technologies that can displace substantial amounts of fuel burning among Edison's customers and others in Southern California.

This project is the first step in an effort to:

- Identify and screen technologies to reduce fuel burning.
- Develop demonstrations at customer facilities.
- Implement the demonstrations.

The tasks of the project were to:

- Segment the stationary NOx emissions among Edison's industrial, commercial and institutional customers.

- Comprehensively search the literature for electrotechnologies, efficiency measures, or other approaches to reducing fuel burning.

- Contact vendors of promising technologies to increase understanding towards distinguishing candidates to select for demonstration.

- Develop more detailed understanding of a "short list" of candidates.

- Preliminarily match candidate technologies with generic industries and business hosts for demonstration.

It must be noted that because there is only a limited regulatory pressure on large, industrial and commercial NOx emitters, and little or none on small ones, in vivid contrast to the drastic regulations faced by large and small VOC emitters, it will be much more challenging to create incentives and find customers for demonstrations. It is therefore necessary to analyze candidates for their economic and operating benefits, besides for their NOx reduction potential.

The subject emissions of this study are stationary emissions, comprised of point sources and certain "area" sources of NOx. These together comprise just over 25 percent of the total estimated NOx emissions for 1987 on the South Coast, or about 250 to 280 tons per day. In contrast, the other three-quarters of the NOx emissions in the region are from mobile sources (autos, etc.), and about two-thirds of these emanate from Los Angeles County. Specifically, excluding electric utility and residential emissions, about 60 percent of the stationary emissions are in the scope of this study. If only manufacturing and industrial emissions were considered the scope, only 24 percent of the stationary sources would have been considered.

Excluding utilities and private residences, the largest categories of stationary emissions considered, in order of volume, are:

- Petroleum refineries and other petroleum-related operations.
- Airports, colleges, hospitals, prisons and other people-intensive facilities (primarily for dining and washing).
- Cement kilns.
- Glass melters.
- Metals processing.
- Municipal solid waste (MSW) incineration.
- Paper and paperboard products.
- Miscellaneous manufacturing.
- Chemicals.

- Municipal water and sewage.
- Concrete and building materials.
- Foods and beverages.
- Aerospace.
- Bricks and ceramics.
- Miscellaneous industrial and commercial facilities.

The "long list" of technologies emerging from the literature search was:

- Oxygen enrichment of combustion.
- High speed centrifuge dewatering of solids and liquids.
- Electroacoustical dewatering of solids.
- Heating systems based on electrically-conductive paint.
- Catalytic VOC destruction.
- Autothermostatic, electrically-conductive polymer heat tape.
- Continuous (electrolytic) membrane deionization of water.
- Electrical reactivation of carbon adsorbents.
- Electrochemical waste destruction.
- Ultrasonically-enhanced dishwashing.
- Supercritical fluid extraction and waste combustion.
- Sewage sludge dewatering by thin film evaporation with MVR.
- Air cleaning/aqueous electroincineration.

The "short list" emerging from a screening of these, and recommended for demonstration, is:

- Oxygen enrichment of combustion.
- Electrical reactivation of carbon adsorbents.
- Ultrasonically-enhanced dishwashing.
- Sewage sludge dewatering by thin film evaporation with MVR.

These "short-listed" technologies are briefly described below.

Electrical reactivation of carbon adsorbent beds for VOC control is being commercially demonstrated presently in California by Westates Carbon of Los Angeles.

Westates uses a highly retentive form of carbon derived from coconut shells, which is difficult to regenerate or uneconomical to use without pyroprocessing. An electrical furnace with a minimum air flow to provide oxygen is a logical approach to VOC destruction with minimum NOx generation. Westates also conducts the off-gas from the regeneration through the operating carbon bed of an alternately regenerated pair so there is no direct stack emission, and no regeneration (combustion) permit is required. They employ a specially-designed, staged, flowing solids furnace with several points of electrical resistance heating and air addition. The application is potentially very large, as established by the ROG emissions profile developed for this project as well as the previous work for Edison on VOC emissions technologies.

Ultrasonic Dishwashing

Ultrasonic dishwashing is said to be approaching a commercial demonstration and presentation to the trade this fall. Ultrasonic Products, Inc., a small start-up firm in Los Angeles, has developed a concept of tuned control of a number of parameters, including surfactant, ultrasonic frequency and "ranging", water temperature, and residence time, to wash dishes, glasses and utensils without destructive frequency effects. Unlike others such as Raytheon, who are steeped in the dominant magnaresistor technology and have failed in developing ultrasonic dishwashing due to high frequency cracking problems, Ultrasonic Products uses piezoelectric transducers and other measures that avoid these problems.

The technology has the most potential of all the selected candidates to cut a significant swath through the stationary NOx emissions of the region, and ultimately of the nation. It is not widely understood that heating water for dishwashing has an enormous impact on domestic and commercial fuel use. Reasonable estimates are that typical commercial dishwashing uses for one step alone, 500,000 gallons per year of water heated to about 180°F, or 500 million Btu per year, or $2,000-$3,000 annually in fuel charges. There are over 39,000 restaurants in the South Coast, many of which have such size dishwashers or larger. The technology presents many ancillary benefits in water savings, lessened

environmental impact, reduced labor and insurance costs, superior dishwashing, reduced breakage, etc., to interest a customer.

Sewage Sludge Dewatering by Thin Film Evaporation with MVR

The well-established thin film evaporation technology, that is familiar to the process industries has been successfully and widely commercialized in Europe, by Buss AG of Switzerland, in applications to the dewatering or complete drying of municipal and industrial sewage sludges. Because of regulations precluding ocean dumping and incineration, options available to disposers of these materials will be increasingly limited and expensive. This approach, along with several similar but less efficient and less capable ones, will become attractive to such customers.

Buss has married the horizontal thin film evaporator to a second stage "Rovactor" (a bladed, heated thermal processor) with counterflow of evaporated water and use of mechanical vapor recompression (MVR) (heat pumping of the water vapor) to thermally drive the process. The MVR reduces or eliminates the NOx generation in providing the heating for dewatering. It can also reduce the NOx generation upon incineration, if that option is to be pursued. However, the feasibility of handling and sale of the dewatered sludge as a valuable product is increased many fold by complete drying.

Buss has an office in Charlotte, North Carolina and is teaming with YWC (Philadelphia, Pennsylvania) to present a complete, turnkey capability and finance options to customers. These large, established, and reputable firms can provide this service to the many municipalities and industries in the region that have a sludge disposal problem, and whose avoidance of direct thermal drying and/or incineration could avoid significant NOx generation in the region.

II INTRODUCTION

A. PROJECT OVERVIEW

1. Project Objective

Chem Systems has been retained by Edison to develop a program for the demonstration of technology with the potential for NOx reduction in Southern California. This program is patterned on and parallel to another program for which Chem Systems has been retained by Edison, for over two years, to reduce industrial VOC emissions. The VOC program has successfully resulted in the demonstration of a number of emerging technologies for VOC emission reduction at selected Edison customer facilities. It continues to identify VOC reduction options for demonstration, and has taken on other aspects of technology transfer, including an "expert system" approach.

The overall objective of this program, is to develop one or more demonstration projects in Southern California for promising NOx reduction electrotechnologies. This will result from a three phase effort, including to:

- Identify and screen technologies
- Develop site-specific demonstration projects for promising options
- Implement demonstration projects

This project is focused on the critical first phase, **the identification and screening of emerging technologies.**

2. NOx Emissions in the South Coast

Oxides of nitrogen or "NOx" is a collective term for various chemical compounds of nitrogen and oxygen only. The most common NOx compounds in the atmosphere are nitric oxide (NO) and nitrogen dioxide (NO_2). NOx compounds are involved in various reactions with reactive organics gases (ROG), oxygen, and ozone (O_3) in the atmosphere to produce net ozone in the presence of sunlight. The resulting mixture of compounds, plus other pollutants in the atmosphere, is called urban smog, which plagues the

California South Coast Basin more than any other area of the U.S. Ozone is perhaps the most harmful component of smog, and serves as the "criterion pollutant" indicative of smog severity. It is monitored and reduced by various means, in conformance with federal EPA requirements, and California state law and policy.

Figure II.A.1 indicates the profile of NOx emissions within the South Coast region. Classification are by country and by type of source, among Mobile, (road vehicle), Area (localized but diffuse emitters, such as gasoline stations, residential water heaters, etc.), Other Mobile (non-road vehicle), and Major Point Sources. The South Coast region, excluding central Los Angeles (LADWP) and other minor municipal systems, contains most of Edison's significant customers. The Point Sources, which are the primary subject of this study, represent 17 percent of the total.

Figure II.A.2 shows the breakdown of stationary source NOx emissions by type of emitter, and superimposes an indication of the scope of this study among the emitters.

3. Scope and Approach

Introduction of electrotechnologies as considered herein is directed towards NOx abatement, rather than removal, by displacing a customer's on-site fuel combustion with electric energy or other approaches that are not fuel intensive. A key distinction between NOx removal processes and electrotechnologies is that the former are generic in their application, while the latter are largely process-specific and site-specific. In other words, NOx removal processes are potentially applicable at any fuel-burning site, for given types of combustors and fuels, while electrotechnologies must be selected and matched with appropriately corresponding targets. For this reason, a market segmentation was required.

The first task (market segmentation) was designed to profile direct fuel use within Edison's industrial sector and other sectors, where appropriate. Most major, and some minor (but widespread) fuel-consuming industries were ranked in terms of their on-site fuel use, as a proxy for NOx emissions. This task makes use of existing statistics published by the federal and state governmental agencies to accomplish this.

FIGURE II.A.1
PROFILE OF SOUTH COAST NOx EMISSIONS
(estimates for 1987; total emissions: 1,098 tons per day)

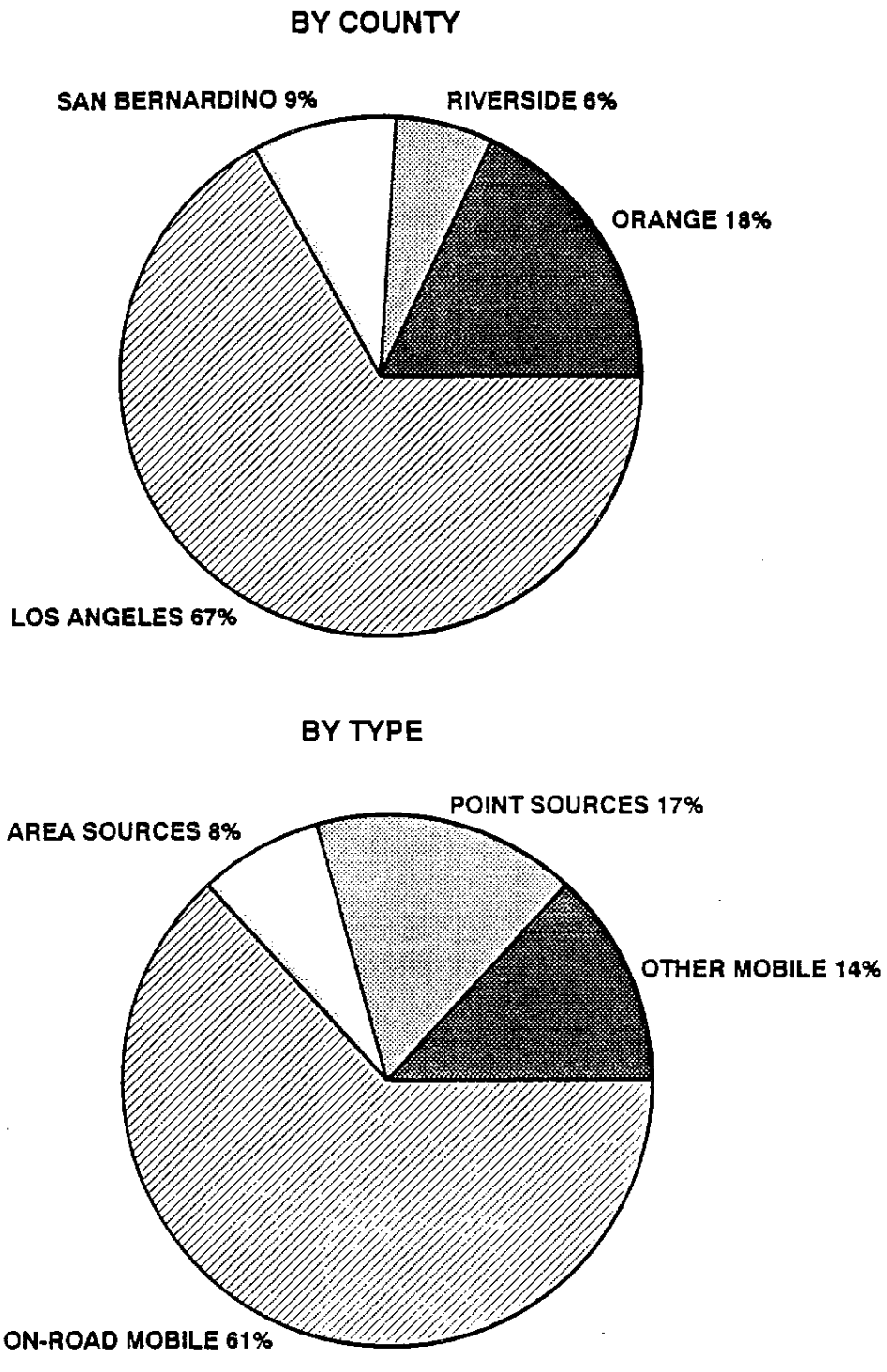
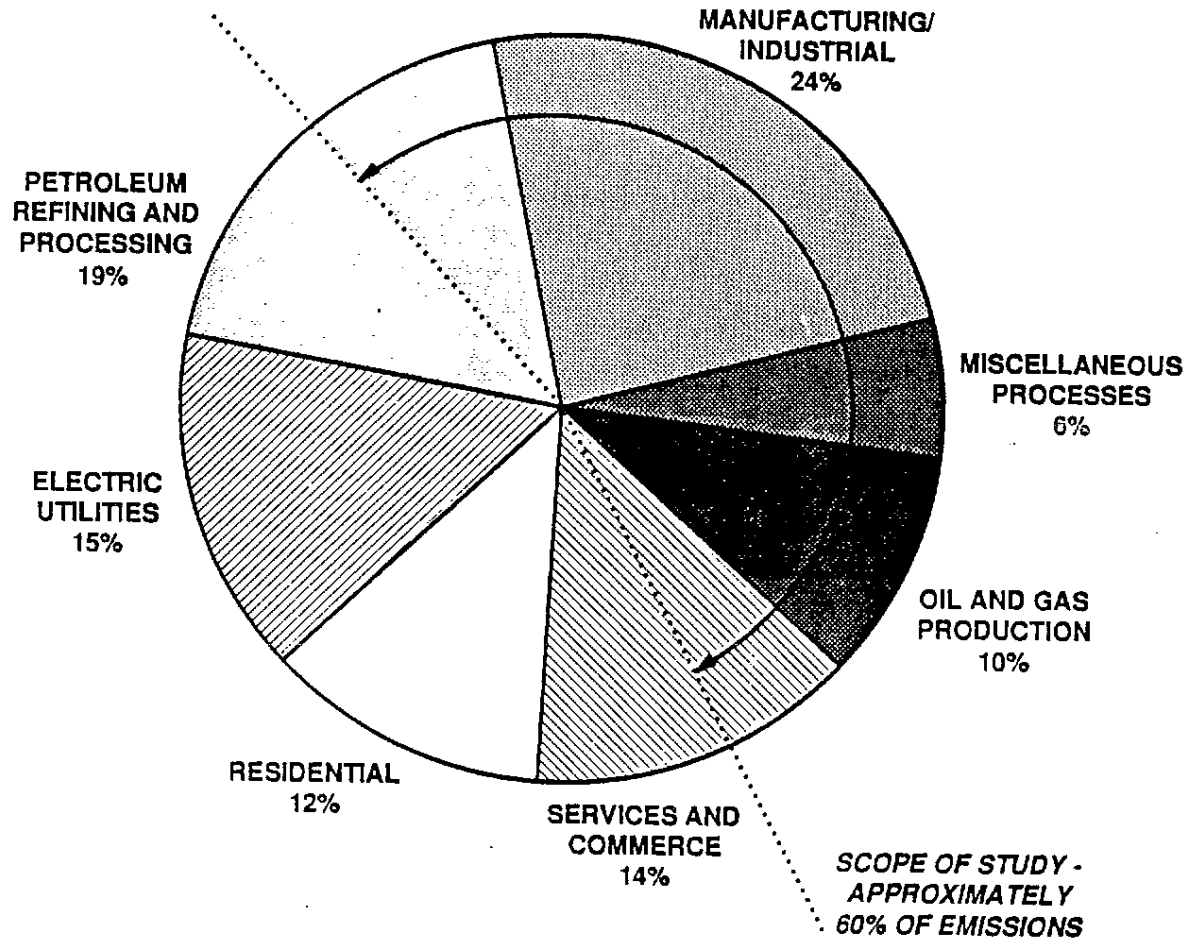


FIGURE II.A.2
CONTRIBUTION BY STATIONARY SOURCES TO SOUTH COAST NOx EMISSIONS

(estimates for 1987; total stationary emissions: 280 tons per day)



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The second task was a comprehensive computerized literature search, focusing on electrotechnologies that can reduce NOx emissions by reducing fuel use among a wide base of Edison's customers. The identified technologies were those that were reviewed or at least briefed in the technical literature in a meaningful way, along with the companies that have been active in developing the various alternatives. The literature search focused on citations from the U.S., Western Europe, and Japan. The search was also for technologies that could benefit most from demonstration in Southern California, and that offered other benefits to attract customers to their use. It must be understood that, unlike VOC control technologies, most small and medium-size customers are not under current regulatory pressure to reduce NOx from fuel burning, so the project must identify and develop other benefits and incentives.

In the third task, Chem Systems conducted a program of telephone contacts to enhance the information developed in the literature search. Technology developers and vendors were contacted utilizing staff in Chem Systems' offices in New York, London and Tokyo. The phone contacts developed sufficient information and perspective, through discussions and project literature received, to distinguish technologies for further consideration.

In the fourth task, based on the largely qualitative previous work, Chem Systems developed a "short list" of processes recommended for further analysis. Criteria used for this selection were developed jointly with Edison, including:

- Expected fuel savings, leading to NOx emissions reductions, based on published and vendor-provided data. The hurdle criterion is that the technology must have the theoretical potential, if widely adopted, to reduce area NOx emissions by at least two tons per day.

- Process economics, based on data supplied by developers

- Current developmental status of the technology

- Anticipated applicability to Southern California industries

- Breadth of technological coverage. The emphasis is on technologies applicable across several industries

- Opportunity to transfer technology from overseas to California

In the fifth task, Chem Systems developed a more careful characterization of the selected processes. This includes a simplified process flow diagram, process description, and associated capital and operating cost parameters. This task also required making generic "matches" between the electrotechnologies selected and candidate industries. Comparisons were also made with displaced technologies. These results can by shared, in subsequent phases of this program, with vendors and possible demonstration candidate targets in Edison's service territory.

Data Availability

Various data bases were used in this study to analyze the segmentation of markets for candidate technologies, and to estimate the potential aggregate benefits to be realized by adopting technologies. Most of the data bases used are from federal, or California state and regional authorities. These differ significantly among each other in their structures and definitions of industrial and other sectors.

California authorities do not use the U.S. federal SIC system, but use classification systems of their own. Definitions of larger categories also vary. In many cases, energy or emissions data are not explicitly broken down as to government facilities (military and NASA bases, VA hospitals, prisons, agency offices and laboratories, etc.) or institutional facilities (hospitals, universities, private laboratories, office cafeterias, etc.). For the purposes of this study, Chem Systems has assumed that military and institutional categories are included with the appropriately similar commercial, residential, and industrial categories.

It should be realized that all data on NOx emissions is based on estimates, not direct measurements. The understanding and characterization of equipment and processes that emit NOx, used by the agencies in making the estimates, may be out-of-date and otherwise inaccurate especially for industrial processes.

No source presents all the data in the form required to perform a meaningful segmentation of industrial, commercial, and institutional NOx emitters. It has been

necessary to piece together a picture based on information from diverse sources, and by exercising professional judgement.

III CANDIDATE NOx-EMITTING CUSTOMER GROUPS

A. INTRODUCTION

Published estimates of California South Coast emissions of NOx and other air pollutants were analyzed to help identify customer groups that might benefit from development and/or transfer of technologies to reduce fuel burning. The primary source used was the "Draft Air Quality Management Plan, 1991 Revision - Appendix III-A, 1987 Emissions Inventory for the South Coast Air Basin: Average Annual Day - SCAQMD, December, 1990."

Salient SCAQMD point-source (non-mobile) NOx emitters were identified. Among these are utility and independent power generators and co-generators, oil refineries, public MSW incinerators, and fuel-intensive major process operations, such as cement kilns, glass melters, and large fabrication and chemical facilities. Such facilities generally have fuel efficiency and NOx reduction as key considerations of their operations, and their staffs usually remain current on the technical options available. This program is not primarily focused on these facilities, and so they are not emphasized. They may, however, also benefit from some of the technologies to be demonstrated.

Industrial, commercial, and institutional NOx emitters that do fit the objectives of this study are:

- Medical centers, prisons, military bases, universities, and other institutions with food services and/or laundries
- Restaurants
- Brick, tile and ceramics manufacturers
- Metals processors
- Smaller fabrication facilities

technology is in current commercial demonstration, and seems at a most appropriate stage for Edison's involvement.

9. Electrochemical Process (AEA)

Chem Systems obtained information on this process from its inventors, AEA Technology, the UK Atomic Energy Authority. The details given in the Appendix are only those in the public domain, and it is not possible to present quantitative economics as they are dependent on information given in confidence. The conclusion of the analysis is that Chem Systems does not recommend this process for Edison's program at this time, since an economic attraction is not shown, and the process is in only an early stage of development.

10. Ultrasonic Dishwashing (Ultrasonic Products, Inc.)

This appears to be an excellent candidate for Edison's program, although it is still in the "just pre-commercial" or emerging stage at present. There appear to be enough pieces put in place by this financed, experienced, but small 3-man company to lead to a commercial success. The market and potential benefit in NOx reduction is very significant. Details are provided in the Appendix.

11. Supercritical Fluids (Glitsch, Lummus)

Both of these technologies (supercritical CO_2 and water) are presented by large companies. However, supercritical fluid extraction (SFE) appears to have too small of a market to compete in Edison's program. Supercritical water oxidation (SCWO) is the Modar technology, which has been under development for various applications for over 10 years. The latter may be a reasonable candidate for further evaluation in a program expansion, but its market (hazardous waste combustion) appears to be relatively small and specialized in competition with the candidates selected. It was not selected for immediate attention.

C. ULTRASONIC DISHWASHING (ULTRASONIC PRODUCTS, INC.)

1. Introduction

Ultrasonic Products, Inc., has applied the known technique of ultrasonic cleaning in a water bath to the task of washing dishes (including glassware, flatware, and kitchen utensils) in commercial facilities and various institutions. This development can be applied in restaurants, and in private and institutional cafeterias, including schools, hospitals, prisons, camps, hotels, spas, and the like. The 30 million people residing in the Southern California region are said to eat at least 10 million meals per day in such facilities.

Ultrasonic Products Inc. is currently exploring the possibility of aligning themselves with established manufacturers of conventional commercial dishwashers. This would enable UPI to utilize an established infrastructure serving the commercial/institutional market. This would provide an expeditious and immediate vehicle to "go to market." Companies under consideration include Jackson Products Co., Tampa, Florida (813/985-8144). UPI would provide the proprietory, patented technical input and equipment to the existing manufacturer. The manufacturer selected would in turn provide sales, service, and on-going support.

An Ultrasonics, Inc. test unit was installed at Edison's CTAC facility during late 1990 and early 1991. It was demonstrated to a number of prospective end users while cleaning and sanitizing dining and kitchenware items from CTAC's in-house dining facility. Several Edison personnel witnessed these demonstrations.

The company currently has a kitchen utensil washing machine in fabrication in Los Angeles that they expect to demonstrate at the International Hotel Restaurant Show, in New York City, during November 9-12, 1991. It is anticipated that this machine should be ready for demonstration by mid-October 1991, if Edison wishes to inspect it.

The technology has the promise to save a typical 500,000 gallons of water per year (typically heated, by code, to approximately 170°F) per dishwasher. This heated water is flushed to drain and accounts for approximately 500 million Btu per year per dishwasher, for water heating. In many cases, the primary heating of water from a typical

supply temperature of 55°F to approximately 140°F is in a fired water heater, with trim heat (160-180°F) achieved with electrical resistance heaters. The cost savings to a customer could be $2-$3 thousand per year in fuel alone. Considering electricity costs also, the overall energy savings could be $5-$6 thousand per year. There are many additional benefits to owners and operators, which are discussed below.

Gross Savings Potentially Achievable

It is extremely difficult to generalize total water use (and savings) for all commercial dishwashers, because restaurants and institutions differ widely in hours per day and per week of operation, use of disposables along with (or instead of) washable dishware and utensils, dishwasher labor productivity, kitchen practices, and in styles of table settings and serving. Use of glassware, dishes, and kitchen utensils per meal served can be much greater in fine restaurants than in fast-food establishments or cafeterias. Nonetheless, it can be assumed that the more than ten million meals per day that are estimated to be served outside of homes in the region, are served in approximately 20,000 establishments of significant enough size to use large scale automatic commercial dishwashing (500 meals per facility average). The actual profile of the restaurant and cafeteria population in the South Coast Basin is given in Table C.1. It is assumed that about half of these facilities are too small to have a full-scale automatic dishwashing line, but these others, plus bars, may also eventually be potential candidates for some version of ultrasonic dishwashing leading to fuel savings.

TABLE C.1
RESTAURANTS[1] IN CALIFORNIA SOUTH COAST REGION
(1990)

Los Angeles & Long Beach	11,139
Anaheim & Santa Ana	3,519
Oxnard & Ventura	779
San Bernardino & Riverside	2,520
Santa Barbara, Santa Maria & Lompoc	578
Total for ~~South Coast~~ California	**39,401**

[1] Including fast food restaurants and cafeterias
(Source: Sept. 1991, Restaurant Business Magazine)

If each dishwasher uses the assumed average of 500,000 gallons per year of hot water, then 10 x 10^6 million Btu per year can ultimately be saved with this technology. This corresponds to a saving in fuel of approximately $50 million per year for the region. This can be estimated to be equivalent to 3,600 tons per year of NOx emissions, or about one-third of the "People and Traffic-Intensive" heating requirement for residences and commercial establishments given in Section III.

2. Conventional Commercial Dishwashing

The technology of commercial dishwashing has not advanced much in over 100 years. It was specified originally in 1880 and updated in 1932, by the National Sanitation Foundation of Ann Arbor, Michigan. The conventional procedure for a high volume institutional kitchen consists of four distinct steps. The first two are manual steps; the last two are performed in an "automatic commercial dishwasher" machine. This line requires at least three people for a high-volume, continuous operation.

- **Hand scrapping** - physical removal of gross food debris (scraps) by manual scraping of plates and utensils into garbage receptacles. Formerly, these scraps were fed to hogs in most urban areas. Today, they are primarily sent to landfills, though proposals are being made to compost this waste in the future. This step is not changed by the new technology.

- **Water scrapping** - a worker at a sink, using a shower head on a flexible gantry or arm, blasts each dish, glass, or utensil, so as remove caked-on grease, proteins, other food debris (scraps), lipstick, etc. The water must be at 160°F-180°F. The exact temperature required varies according to each state code. The worker loads the water-scrapped items into a racked basket for transfer to the next and final steps. This is the step that would be eliminated on all cases of ultrasonic application (retro-fit or new system) to save typically, 500,000 gallons per machine per year (estimated, based on analysis of worker behavior). Water scrapping is typically the efficiency "choke point" for all the steps, and the primary source of quality control problems.

- **Automatic dishwashing - hot water cycle** - The racked items are placed in the sealed chamber of the commercial automatic dishwashing machine. The first step

is to blast the rack with an agitated, pressurized stream of hot (180°F) solution of several percent caustic (lye), which is intended to remove lipstick and other adhering, typically hydrophobic (oily or waxy) materials missed by hand and wet scrapping.

- **Automatic dishwashing - finish rinse** - This step requires spraying the items in the machine with dilute NaOCl (bleach) solution to rinse away the caustic, and assure destruction of pathogens.

3. Ultrasonic Products Alternative

Ultrasonic Products, Inc. is offering two approaches: the Series 3000 machines would replace water scrapping only, leaving the washing machine in place, so as to retrofit existing kitchen equipment and achieve the greatest savings with minimum investment; Series 4000 machines would be placed in new facilities and offer comprehensive substitution for all the conventional dishwashing steps outlined above.

Ultrasonic Products uses a non-foaming, non-ionic surfactant or "wetting agent" (typically, a 2.0 percent solution) to enhance cleaning by ultrasonic bubble cavitation in hot water (110°F-130°F preferred) that lifts oils, proteins and adhering material from surfaces and even from small cavities and crevices. The items must be submerged in the ultrasonic bath. In Series 4000 machines, the surfactant, rather than caustic, is the only chemical required to clean the items. A pre-rinse removes gross debris, followed by about 40 seconds residence in the bath. The post-rinse sanitizing wash with 0.5-1 percent, (rather than 1-2 percent) NaOCl, which is required by code, supplies make-up water to the ultrasonic bath. Greases and proteins that are atomized into the bath water by the ultrasonic activity are removed on a media (felt, paper, etc.) filter from a stream circulated from/to the bath. Gross debris floats to the surface and is taken over a weir at the side of the chamber, to be periodically manually removed to garbage bins. A screen ahead of the filter, which is also periodically manually dumped to garbage bins, picks up gross debris that does not go over the weir. Typically, bath chamber dimensions are 30 inches square at the base, by 24 inches high. Construction is typically 316ss. Automatic clean-in-place (CID) systems are being designed into the dishwashing systems in the event blockage occurs due to operator negligence.

Items to be washed are carried into and out of the bath on a conveyor rack. The conveyor systems allows a heat seal to be created in the fully automatic machine (new installation) that allows the conversion of a batch operation to a continuous conveying system.

Figure C.1 gives a sketch of this equipment.

Electronic and Control Features

Features that Ultrasonic Products, Inc. claims distinguishes their approach and makes their technology work where others may have failed in applying ultrasonics to dishwashing are:

- Can exert finite control over frequency and 10 other electronic/acoustical parameters to allow high efficiency cleaning on a selective basis. Ultrasonic Products uses piezoelectric transducers (analogous to home humidifiers) not magnarestrictive (analogous to stereo speakers).

- Can set a nominal frequency, and from that reference band width, frequency is swept 1-2 kilohertz above and below (over 1/10 of a second) to avoid standing waves leading to pitting and structural disintegration (cracking, shattering, etc.)

- Integration of ultrasonics with other, non-electronic parameters to optimize operations: chemical regime (welting agent), temperature control, immersion time.

4. Additional Benefits

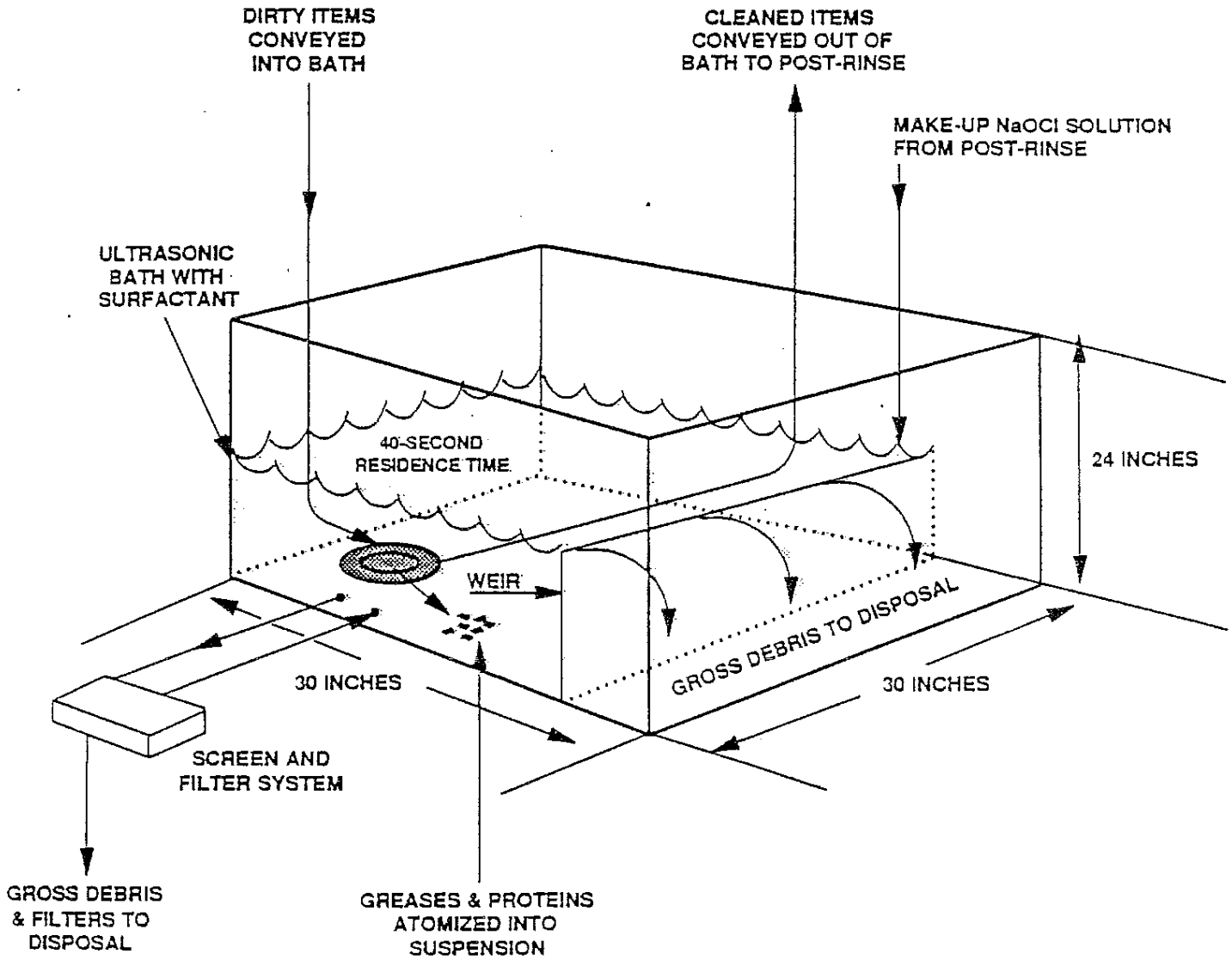
Besides energy savings, there are a number of additional benefits to customers and others in using the Ultrasonic Products approach to commercial dishwashing:

- Superior quality of cleaning dishes, glassware, and utensils

- Labor savings (through automating and mechanizing the operation)

- Water savings

FIGURE C.1
ULTRASONIC PRODUCTS, INC.
DISHWASHER



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- Reduced sewage loading of chemicals and BOD
- Increased operator safety, especially around water scrapping (prevents bodily injury from slipping on wet greasy floors, hand and ligament injury from handling of broken glass, scalding, etc.)
- Reduced wear and breakage of dishes, glassware, and utensils
- Elimination or reduction of the capacity bottlenecks of manual operations
- Reduced inventory requirements for place settings and utensils because of faster turnover of washing, and less breakage