PROMOTION OF ENERGY EFFICIENCY THROUGH ENVIRONMENTAL COMPLIANCE - LESSONS LEARNED FROM A SOUTHERN CALIFORNIA CASE STUDY

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ABSTRACT

Industrial plants that are faced with regulated emissions constraints may be able to choose from a complex array of compliance options. Technology options may include a number of pollution control alternatives - retrofits with more efficient equipment, fuel-switching and/or process change to electrotechnologies, or advanced gas-fueled technologies. In some cases, a plant may be able to purchase emission allowances in lieu of changing equipment or adding controls, as would be the case in Southern California with the existing RECLAIM regulations. In such cases, emission allowances could also be sold by plants that achieve emission reductions, offsetting the costs of their technology investments.

This paper explores an extensive list of compliance options for the manufacturing sector (SICs 20-39). We describe how to collect data and compare options in terms of costs, commercial availability, impacts on energy use, emissions, plant throughput or productivity, product quality and other characteristics relevant to selecting an option to implement. We discuss an array of coping strategies to achieve environmental compliance.

This work is part of a recently completed project to develop a prototype system that includes a technology choice model and a competitive technology database, both of which document existing technologies and their corresponding emission discharges. The database also maps the technology applications by two-digit SIC code and the applicable environmental regulations that impact that industry segment. This paper outlines the overall results of the initial phase of the project, highlighting compliance strategies and technology options for a certain number of process end uses. Industry segments assessed in this phase totaled 73 four-digit SIC codes.

INTRODUCTION

Air pollution regulatory programs in Southern California place constraints on technology and process choice options otherwise available to the industrial and commercial sectors. The Southern California region is the most severely polluted area in the United States. State and federal Clean Air Acts as well as the guidelines set forth by the two local regulatory agencies - South Coast Air Quality Management District (SCAQMD) and the Ventura County Air Pollution Control District (VCAPCD) - require that regulations, policies and programs be established to reduce emissions from existing sources and to limit emissions growth from new or expanding facilities.

The SCAQMD has promulgated an array of command and control-source specific rules that cover most industrial and commercial operations. Under the command and control rules, an operator who chooses to retrofit their equipment is constrained by Best Available Retrofit Control Technology (BARCT). These rules are among the most stringent for existing sources in the world. In addition, the emissions or equipment size thresholds for applicability of these rules to individual facilities is at much lower levels than contemplated elsewhere in the United States. As costs for more advanced controls have risen with decreasing emissions reduction return, there has been a growing awareness that the classic command and control technique of regulating air pollution has reached its limits of effectiveness. Prompted also by the economic pressures of a recession and foreign competition, industry lobbied for the opportunity to have market forces determine the least cost method of meeting air pollution goals. Recognizing both the political need to be responsive to industry and that environmental improvements cannot be achieved at the expense of the underlying economy, the SCAQMD is developing a market-based air pollution control program.

Market-based systems are under consideration and development in a number of areas. Two recently-introduced systems include Regional Clean Air Emissions Market (RECLAIM) and New Source Review (NSR). Under RECLAIM, subject facilities are faced with an array of options which to decrease emissions, based upon cost and future business needs. Companies may change out equipment, add controls, curtail operations or change material formulations to achieve required emissions reductions. If excess emissions are generated, the facility may offer them for sale or retain them for future business expansion. If the cost of control options is prohibitive, the facility may opt to purchase emission reductions. NSR was developed as a means of coupling the economic necessity of expanding existing sources and building new facilities with the goal of reducing overall emissions. The four primary elements of NSR are: offsets, modeling, Best Available Control Technology (BACT), and public notice.

The most significant constraint on technology selection comes from the BACT requirements. This is defined as the most stringent control technique that has been achieved in practice for a class of source, contained in a state implementation plan, or determined to be technologically achievable and cost effective.

THE PROJECT

In response to these program efforts, the local electric utilities teamed together with the local air quality districts and the state energy commission to initiate a modeling and database project called the Competitive Environmental and Energy Technology (CEET) system. The CEET project assesses selected industrial processes and outlines the potential impact of new competitive technologies (electrotechnologies as well as gas) on these processes. The project sponsors included: Southern California Edison (SCE), Los Angeles Department of Water & Power (LADWP), and the California Energy Commission (CEC). The two local regulatory agencies - SCAQMD and VCAPCD - were also partners in the project.

PROJECT OBJECTIVES

The CEET project had four primary objectives:

- Develop a database of industrial processes and customer technologies to reduce environmental discharges, improve productivity, enhance product quality, reduce energy costs, and provide other valued benefits to the project sponsors;
- Develop an industrial customer technology choice model;
- Develop a database of "environmentally friendly" customer technologies for the commercial and residential sectors; and
- Produce scenarios and potentials of the penetration of electrotechnologies and other options.

In addition, it is anticipated that the study will help SCE and LADWP and various regulatory bodies understand how environmental and resource considerations are affecting and are likely to affect energy use and energy planning, particularly in the industrial sector.

PROJECT APPROACH AND METHODOLOGY

The CEET project took a systematic team approach to defining the overall project scope, the software requirements to develop the framework of the CEET system, and the specific elements of the technology choice model and the competitive technology database. Southern California Edison was the lead sponsor of the project and gained collaboration from each of the other sponsors prior to authorizing tasks to commence. Top priority was given to balancing the priorities and expectations of each project sponsor in determining a realistic scope-of-work.

Specific approaches undertaken to meet the key project objectives and supporting deliverables are outlined below:

Technology Choice Model

The technology choice model projects the selection of customer technology options to meet energy demands, emission limits or compliance requirements, competition and other criteria. Customer technology options comprise retrofit technologies, fossil fuel technologies and electrotechnologies. The technology choice model develops end use demand and assesses competing technologies within a least-cost scenario. Each specific end use is segmented to allow the development of the least-cost scenario as well as the selection of the optimum customer technology. This technology optimization process factors in all applicable technologies, capital and operating costs, energy use, and anticipated fuel prices to select the best customer technology.

The approach utilized for both technology segmentation and technology optimization centered around the development of process end use models across each of the targeted high-profile industries chosen within the CEET project. A total of fifteen end use models were assessed:

- Food Drying and Concentration
- Food Baking and Frying
- Food Heating
- Heat Treating
- Metal Paint/Coat Baking
- Non-Metal Paint./Coat Baking
- Plating
- Metal Melting
- Glass Melting
- Carpet Drying
- Process Steam
- Motive Power - Fossil
- Motive Power - Electric
- Plastics Forming
- Rubber Curing

Figure 1 profiles a food drying and concentration model that is applicable to SIC 20 (Food and Kindred Products) and outlines the approach for technology segmentation and the technology optimization process.

The technology choice model allows the selection of the optimum customer technology option that addresses a specific coping strategy. Customer coping strategies may include a more efficient technology, a process change, fuel-switching technology, pollution abatement technology, sale of emission credits or some combination of these.

The technology choice model utilizes the following fundamental equation to determine the annualized production cost:

Annualized Cost = (Total First Costs*) (Capital Recovery Factor)
+ (Annual Energy Use) (Expected Energy Price)
+ (Demand) (Expected Demand Charges)
+ (Annual O&M and Other Costs)

*For new and replacement equipment, total first costs include: (1) equipment costs, (2) installation costs, and (3) environmental technology costs. For surviving equipment in the early replacement analysis, there are no first costs.

The technology choice model evaluates the engineering and economic performance attributes of all the available coping strategies under a least-cost scenario with the assistance of a multinomial logit function. The CEET model goes far beyond typical least-cost optimization models, taking into account that industrial customers do not necessarily purchase the least-cost option. Most industrial customers look at a number of criteria - cost, quality, flexibility, reliability, and risk - before deciding to purchase equipment. Thus, some customers will choose the highest cost option and others will pick some of the intermediate cost options, while most customers will select the least cost option. To capture this real world perspective in the CEET system, we introduced the multinomial logit function.

The logit function attempts to predict the market share of competing equipment by placing values to cost sensitivity and other decision-making criteria. Values vary by industry. The preferred way to estimate it is through statistical regression analysis of primary market research. Such data does not exist for the equipment types contained in the CEET model, and collection of such information is expensive and time consuming. Subsequently, the approach of collecting secondary data was pursued. This involved two stages. In the first stage, the base year market shares were reviewed in order to determine what value of BETA corresponds to these market shares. In the second stage, this value of BETA was refined through interviews with trade associations and other trade professionals (equipment manufacturers and applications engineers). In addition, the BETA value was further enhanced through a survey of approximately 800 industrial customers in California which provided additional insight to the importance of first cost and the payback criteria issues.

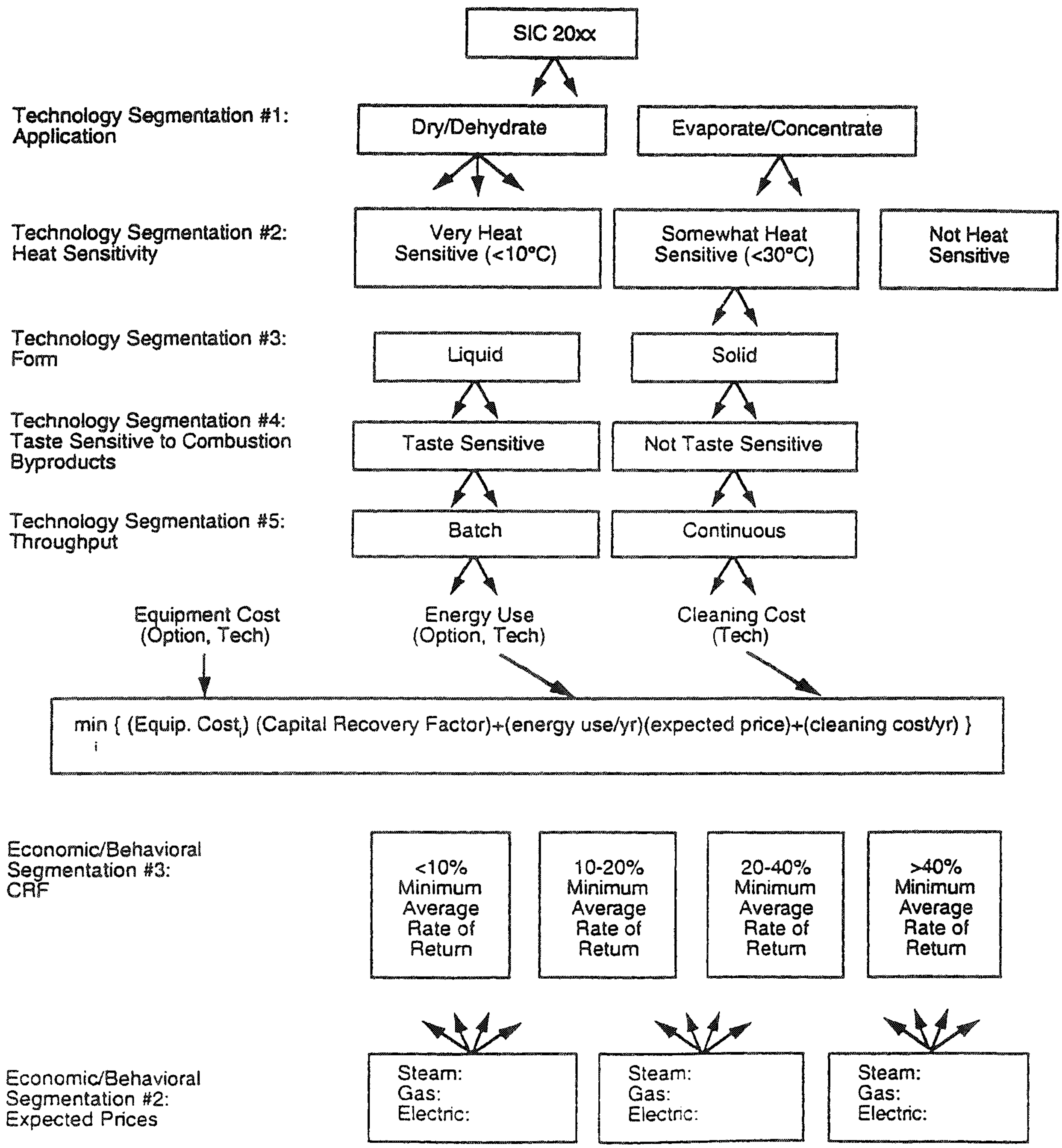
The technology choice model also provides estimates of customer technology potential by analyzing technical and economic criteria. Potential estimates that can be performed by the CEET system include:

- Technical potential, measuring the total electrotechnology market regardless of cost.
- Economic potential, measuring cost-effective potential of electrotechnologies.
- Source-fuel potential, measuring technology potential based on source-fuel efficiency.
- Emissions potential, determining the least-emissions scenario of technology options.

Figure 1
Food Drying and Concentration Model

Options: **Concentration:** **3-effects steam evaporator, mechanical vapor recompression, freeze concentration**

Drying/Dehydration: microwave, drum, spray, tray; indirect/direct, batch/continuous, vacuum/no vacuum



The CEET system including its data inputs and outputs as well as its overall framework is outlined in Figure 2. Figure 3 illustrates the different technology potential concepts and the relative magnitude of their energy savings in primary energy consumption.

Regulatory Choices in the Model

The permitting history of a given facility and existing emissions can also effect the New Source Review requirements and toxic review requirements for given facilities. Likewise, individual facilities with existing equipment are complying through the following options: (1) in various stages of compliance with rules and regulations, (2) coming into compliance with rules and regulations, and (3) replacing equipment to come into compliance rather than upgrading existing equipment. CEET has simplified this seemingly impossible modeling situation by assuming that all equipment to be installed is new and that BACT would be required. Because the level of compliance and age of existing equipment are dynamic within industry and are really facility-specific, *existing* equipment and processes are *not* considered as choices in the models.

The CEET system has been programmed with the costs of emission fees as well as RECLAIM and New Source Review emission trading cost projections. The user has the option of running the technology decision models with the default values for RECLAIM and ERC credits or using zero to simulate the full presence or absence of emissions trading requirements. By running the model with the default values and again with zero, the user will be able to fully bracket the range of scenarios and decisions that might be made.

There is considerable flexibility in the models through which a user can assess a number of potential decision scenarios at *specific* facilities. For example, the user could assess whether a facility would choose to maintain present equipment rather than replace or upgrade the equipment. This would be done by entering another choice into the model that is unique to the specific facility. For the existing situation, there would be no capital cost, but there would be an existing emissions rate, unique to that facility, that would trigger annual emissions fees. Since there would be no change in emissions requiring mitigating offsets, the emission trading defaults would be turned off for this choice.

The CEET modeling protocols for regulatory choices in the short and long term can be summarized as follows:

- **Short Term.** Without RECLAIM, the CEET decision process would be considerably less complex. The difficulty with RECLAIM is that it is inconsistent. Some pollutants are covered while others are not. Some facilities within the industry category will be included, while others are exempted, at least until potential future phases that will expand the scope of RECLAIM are implemented.

- **Long Term.** The model assumes that the study period is beyond the service life of all existing equipment and processes. As a result, owners and operators will face a new equipment decision regardless of whether they are considering a completely new installation as a result of market forces (competition) or a replacement of worn-out equipment. Their decision will be constrained by BACT.

Competitive Technology Database

The competitive technology database documents existing technologies and their corresponding emission discharges. The approach utilized was to collect this data and establish the connection between energy use and emission characteristics, linking specific emissions with the technologies and processes which cause them, for which energy consumption and cost characteristics are known. Within the targeted industrial four-digit SIC codes, the larger emissions sources were identified individually using SCAQMD and VCAPCD databases while a number of other sources helped account for the remaining energy use and discharges for that specific four-digit SIC code. The technology database provides an output of the delivered energy requirements (MMBtu) of existing market shares of equipment for subsequent input into the technology choice model.

Specific data inputted into the database includes: energy and demand impacts, discharge impacts, technology lifetimes, capital, O&M, and process costs, environmental compliance costs, and economic and labor impacts. Table 1 outlines the specific elements of data population for each of the commercially available competitive technologies profiled in the database.

Figure 2
CEET System

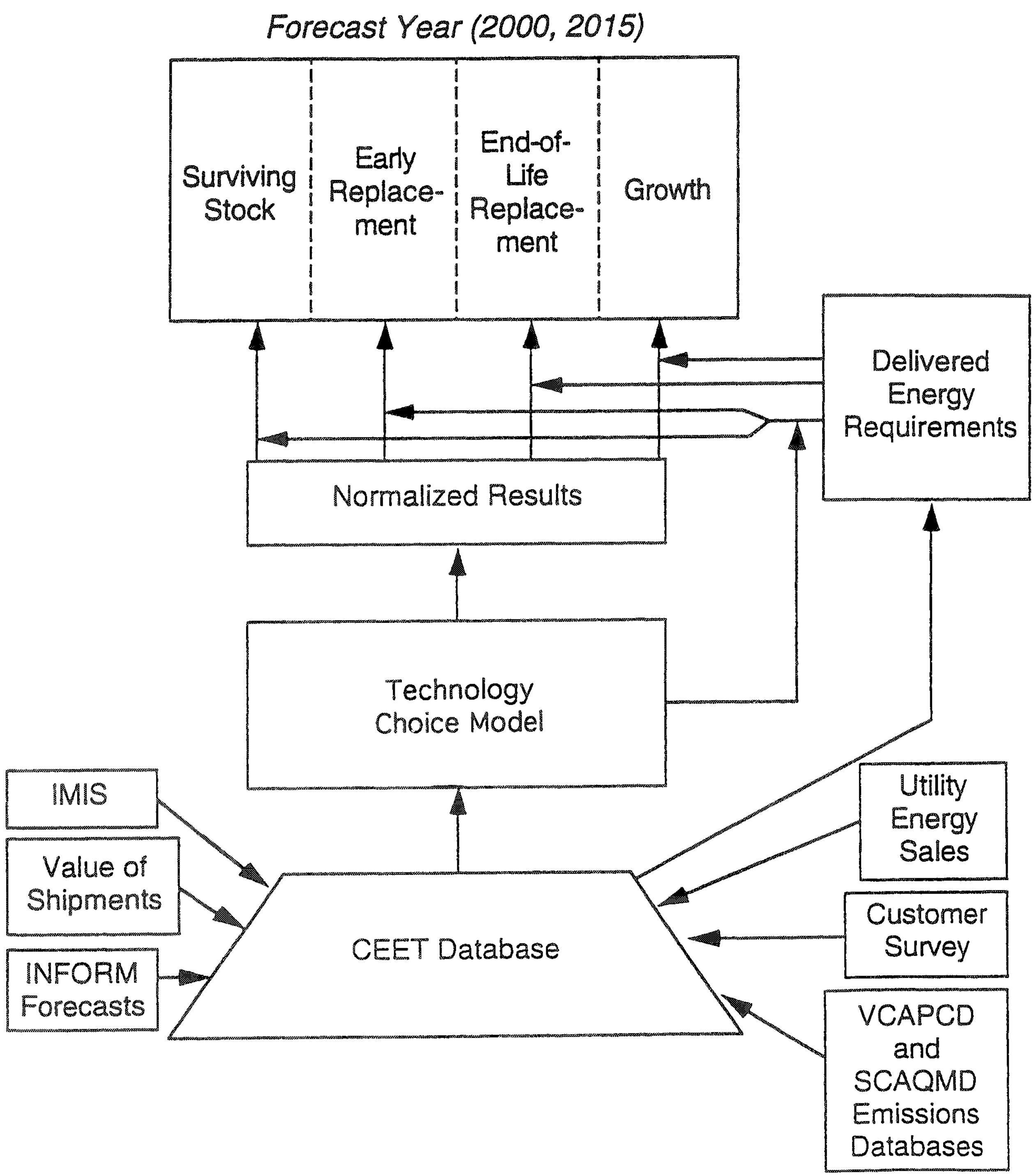
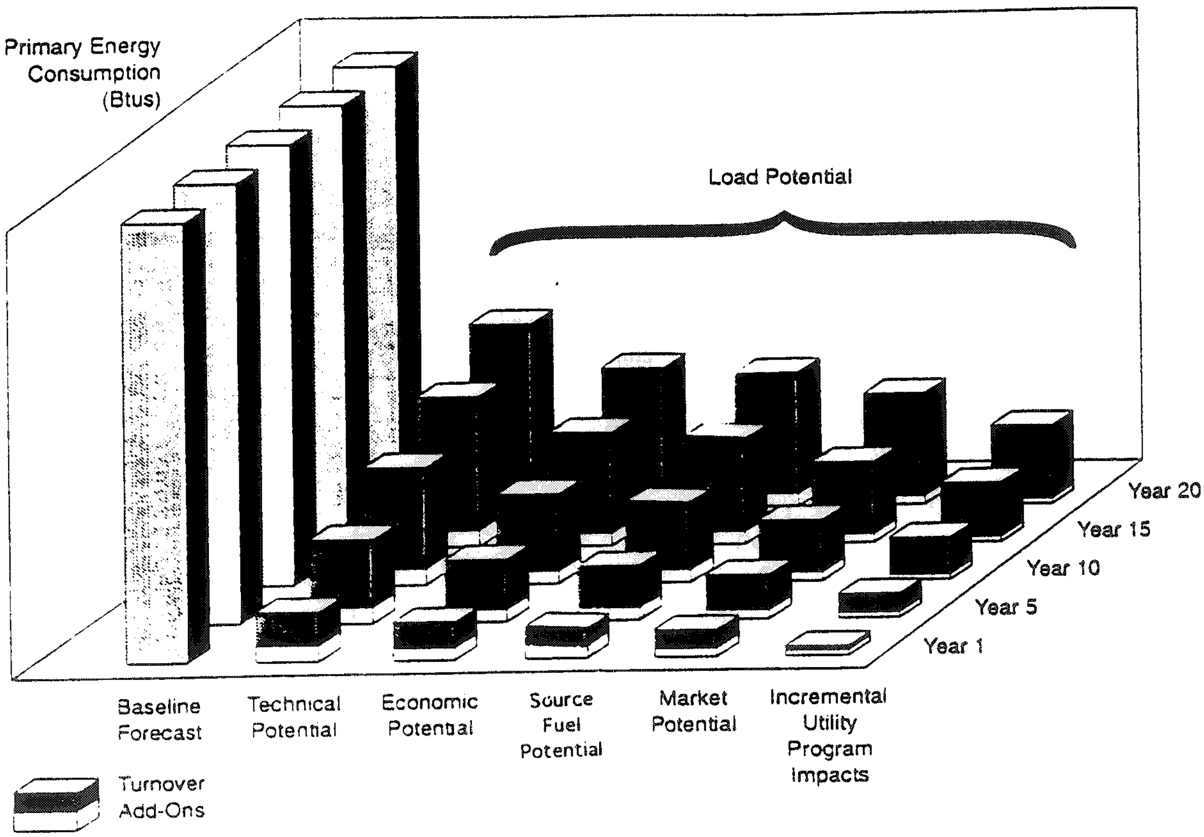


Figure 3
Alternative Estimates of Technology Potential



Legend of Key Definitions

Baseline Forecast: Forecast of customer Btu demands based on existing equipment stock and output forecasts.

Technical Potential: The savings forecast assuming the most efficient electrotechnologies are brought in to meet new Btu demands and when existing equipment needs to be replaced, regardless of cost.

Economic Potential: The technical potential forecast, but including only electrotechnologies with superior net lifecycle benefits to other options.

Source Fuel Potential: The potential of electrotechnologies when source (primary) fuel efficiency is the technology selection criterion (may be greater or less than economic potential).

Market Potential: Forecast of customer Btu demands based on existing equipment stock and output forecasts.

Incremental Program Impact: Incremental penetration of electrotechnologies over market potential due to utility economic incentives and technical assistance programs.

Table 1: CEET Database Fields

Technology-Specific Characteristics

1. Energy consumption
   - Electric or gas
   - MMBBtu/hr or kW
   - Annual hours of operation (depends on market segmentation)

2. Capital costs
   - Equipment trade price (year of cost)
   - Installation cost (year of cost)
   - Decepreciation lifetime
   - Physical lifetime

3. Environmental/emissions and associated costs
   - Environmental technology cost (year of cost)
   - Emissions lb/MMBtu
     - NOx
     - PMIO
     - COP
     - ROG
     - SOx

4. Other costs
   - Fixed O&M
   - Variable

Applicability for Modeling

1. Four-digit SIC applicability
2. MArket segmentation applicability
3. Current share of market segment delivered energy

In addition, environmental regulations that apply to each discharge by each source will be identified in separate data fields that are linked to each industry segment (four-digit SIC code). The regulatory requirements in the CEET project focus on new or replacement equipment (BACT).

The scope of commercially available electrotechnologies and gas technologies has been well defined, and their respective attributes and applications are documented. Existing scenarios are assumed to be covered under BARCT and are not assessed within the CEET environmental review.

Emerging technology options for five high-priority industries have been identified and are incorporated within the CEET technology database. Quantification of the impacts of each emerging technology is limited, because many of these technologies are still under development or are in the demonstration stage. Two scenarios of emerging technologies are explored within the project. The first scenario provides a short-term outlook of technologies that basically represent higher efficiency upgrades of technologies currently in the marketplace. The second scenario provides a longer-term outlook of emerging technologies that represent significant enhancements in addressing those customer intangibles - product quality, precision, controllability, and flexibility - that are somewhat unquantifiable at the present time.

While the primary emphasis of the CEET database is in the industrial sector, the database does include a select group of "environmentally-friendly" technologies that have direct applicability in the commercial and residential sectors.

Priority Industry and Process Selection

Within the industrial sector, priority industries were determined based on a number of factors such as energy consumption, industry growth, economic vitality, level of environmental compliance required, level of risk from the customer retention perspective, and technology opportunity. Thus, a number of high-priority industries were identified initially at the two-digit SIC code (major industry group) level and then at the four-digit SIC code (industry segment) level.

The determination of the major industry groups included a screening of each industry group against an extensive list of evaluation criteria and industry rankings. Table 2 profiles the evaluation criteria and the respective industry group rankings.

The screening analysis yielded five priority industries, including:

- SIC 20 (Food and Kindred Products)
- SIC 25 (Furniture)
- SIC 30 (Plastics)
- SIC 33 (Primary Metals)
- SIC 34 (Fabricated Metals)

These five priority industries were assessed at the four-digit SIC code level based on the factors outlined above to determine which industry segments would be selected for initial analysis within the CEET system. Three prototype industry segments were chosen from two key Southern California industry groups: Food and Kindred Products and Fabricated Metals. Specific prototype industries were: SIC 2033 (Canned Fruits), SIC 3462 (Ferrous Forgings), and SIC 3463 (Non-Ferrous Forgings).

Subsequent analysis yielded an initial total of 25 industry segments within the five major industry groups. These 25 four-digit SICs were representative of those key energy-intensive manufacturing processes that offered the opportunity for detailed assessment of competitive technologies. Further analysis of high-priority industries expanded this initial list of industry segments to the final project scope: a total of 73 four-digit SIC codes across eighteen major industry groups. These four-digit SIC codes have varying levels of coverage within this initial phase of the CEET project.

Industry and Process Customization

The customization of the technology database involved taking largely national data on competing technologies and their specific process applications and modifying it to reflect the Southern California marketplace. The Southern California market is comprised of a diverse mix of industry groups that can be generally characterized as primarily small-to-medium size operations. For the most part, Southern California industry consists of a large secondary supplier network that feeds the primary manufacturers such as Aerospace. The majority of these industrial customers are smaller operations that have specific processes and equipment applications that are unique to this region.

Thus, it was essential to perform the customization of each specific end use model and its process segments so as to ensure that the deliverable reflected the present Southern California marketplace and would typify customer operations. Customization included a series of steps that were performed by the project team including:

- Selective customer interviews
- Trade association interviews
- Trade ally (equipment manufacturers, distributors, sales engineers) discussions
- Interviews with the technology research network
- Interviews with industry experts
- Insights shared by the collective project team

Table 2. Analysis of Prototype Industry Candidates

Evaluation Criteria	Primary				Other					
	Food SIC 20	Furniture SIC 25	Primary Metals SIC 33	Fabricated Metals SIC 34	Chemicals SIC 28	Petroleum Refineries SIC 29	Rubber and Plastics SIC 30	Electronic Equipment SIC 36	Transportation (Aerospace) SIC 37	Instruments and Controls SIC 38
SCE Energy (GWh)*	1,059	195	1,025	809	1,094	1,261	1,183	1,046	2,307	1,189
SCE Demand (MW)	238	63	297	255	212	191	251	212	484	227
SCE Energy Ranking*	7	15	9	10	6	2	5	8	1	4
LADWP Energy (GWh)**	354	32	91	184	340	1,182	72	206	317	62
LADWP Energy Ranking**	2	17	10	7	3	1	13	5	4	14
Gas Consumption (Therms)**	2	14	6	5	3	1	11	12	9	16
Industry Type (A), (B) (Process vs. Assembly)	Process	Assembly	Process	Assembly	Process	Process	Assembly	Assembly	Assembly	Assembly
Industry Growth Trend	Growing	Growing	Declining	Growing	Growing	Declining	Growing	Growing	Declining	Growing
Data Availability (C)	2	1	1	1	3	3	2	3	1	3
Import Competition (C)	2	1	1	1	2	1	2	1	2	2
Customer Retention/Risk (C)	3	1	1	2	3	3	3	3	1	1
Environmental Compliance Issues (C)	3	1	2	1	1-2	1	1-2	2	3	3
Potential Electrotechnology Opportunity (C)	2	1	1	2	3	3	1	2	3	2
Ease of Segmentation (C)	2	2	1	3	3	1	2	3	3	3

Notes
(A) Process industries convert raw materials into higher-value products used by other industries.
(B) Assembly industries fabricate and manufacture consumer products.
*Based on SCE's Basic SIC Code Report (1/9/93)
**Based on LADWP's INFORM forecasts.
***Based on LA County 2-Digit So. Cal. Gas Data Report (1992)
(C) Qualitative ranking scale of impact/risk/opportunity: 1 = high; 2 = medium; 3 = low

PROTOTYPE INDUSTRIES RESULTS

Three prototype industries were reviewed within the technology choice model to determine the delivered energy forecast (MMBtu) by process and end use share. These industries included: SIC 2033 (Canned Fruits), SIC 3462 (Ferrous Forgings), and 3463 (Non-ferrous Forgings).

The initial results of the three industry segments indicated that certain electrotechnologies such as motors and induction heating would gain significant market share against traditional fossil fuel technologies, such as in the ferrous forging heat treating process segment. Consequently, cost-effective fossil fuel technologies gained additional market share in the ferrous forging preheat process segment. Additional trends profiled within the prototype results included:

- Increased equipment efficiency across all market segments;
- Capital costs actually decreasing because of the intensively competitive regional and global marketplace;
- SCAQMD and VCAPCD rules and regulations are making somewhat of an impact to customer technology choice (environmental compliance is not a primary driver in equipment selection)
- The concern for long-term environmental compliance is increasingly being factored into the customer decision-making process.

Table 3 provides specific gas and electric market shares by specific process segment within SIC code 3462 for additional results.

Table 3: SIC 3462: Ferrous Forging (Iron & Steel Forgings)

Gas and Electric Market Shares, 1995-2015

End Use and Market Segmentation	Share of Delivered Energy	1995 Fuel Shares		2000 Fuel Shares		2015 Fuel Shares	
		Electric	Gas	Electric	Gas	Electric	Gas
PreHeating							
Segment #1: Short product run, low volume	7%	59%	41%	47%	53%	28%	72%
Segment #2: Long product run, low volume	6%	34%	66%	32%	68%	30%	70%
Segment #3: Long Product run, billets <6"	1%	36%	64%	28%	72%	15%	85%
Segment #4: Long product run, billets >6"	0%	0%	10%	0%	100%	0%	100%
Heat Treating							
Segment #1: Batch heat treatment	78%	9%	91%	26%	74%	55%	45%
Segment #2: Continuous heat treatment	6%	12%	88%	14%	86%	17%	83%
TOTAL	100%						

ADDITIONAL INDUSTRY RESULTS

Additional opportunities were found in many of the industrial process end use models assessed and across the total 73 industry segments assessed within the CEET project. Table 4 provides a listing of additional priority industries. Specific electrotechnology opportunities for these industries exist in the following areas:

- Induction Heat Treating for Ferrous and Non-Ferrous Forging Operations
- Resistance and Induction Heat Treating in Non-Metal Applications
- Induction Metal Melting in Non-Ferrous Foundries
- Electric Arc Metal Melting in Ferrous Foundries
- Infrared and Ultraviolet Drying for Non-Metal Paint Coat/Baking
- Radio Frequency Drying for Carpet Drying

Table 4: Additional Priority Industries

Two-Digit SIC	Four-Digit SIC
SIC 20	2022, 2026, 2033, 2034, 2037, 2041, 2051, 2082, 2096
SIC 22	2273
SIC 23	2331, 2335, 2339
SIC 24	2434, 2499
SIC 25	2511, 2512, 2514, 2522, 2531, 2542
SIC 26	2673, 2676, 2677
SIC 27	2711, 2741, 2752, 2754, 2759
SIC 28	2813, 2819, 2833, 2834, 2844 2851, 2865
SIC 30	3069, 3081, 3084, 3085, 3089
SIC 32	3221
SIC 33	3312, 3341, 3354, 3357, 3363, 3369, 3398
SIC 34	3411, 3462, 3463, 3471, 3479, 3494
SIC 35	3544, 3562, 3571, 3599
SIC 36	3651, 3652, 3672, 3674, 3679
SIC 37	3721, 3724, 3728, 3761
SIC 38	3812, 3823, 3841, 3845
SIC 39	3999

CONCLUSION

The CEET project has yielded the development of a state-of-the-art prototype system that includes a technology choice forecasting model and a competitive technology database for 73 high-priority industry segments. The CEET system offers sponsoring utilities and agencies the ability to determine the optimum customer technology choice based on all criteria outlined within this paper.

The customization of all industrial process end use models , all supporting manufacturing processes, and all applicable competing technologies replicates the existing marketplace and allows the utility Marketing staff to develop potential customer solutions on a specific case-by-case basis. This customization effort further allows the both utility staff and regulatory agency staff to better understand the dynamics of the marketplace and the status of technology adoption throughout the region or service territory.

Subsequent phases of the project will allow expansion and population of industrial process end use models (including applicable processes and technologies) across the entire manufacturing sector. The CEET system is flexible and can be readily expanded to provide coverage across any sector - industrial, agricultural, commercial, or residential.

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