

R E P O R T S U M M A R Y

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|----------|--|--|
| SUBJECT | EPRI R&D | |
| TOPICS | Research management Research funding Research planning | Technology utilization Benefits assessment Technology transfer |
| AUDIENCE | Utility R&D managers | |

The 1985 EPRI Benefits Assessment Program: A Report to the Electric Utility Industry

In internally conducted assessments, 24 representative member utilities found that, when quantified, their benefits from EPRI research products more than offset their support of the EPRI program. Moreover, all participants stressed the value of intangibles such as basic research and work in progress, which prepare new options for greater flexibility in utility planning.

| | |
|------------|---|
| BACKGROUND | Early in 1985, EPRI initiated a benefits assessment program as part of its long-term technology transfer strategy. Over the previous four years EPRI had responded to more than a dozen utility requests for help in justifying EPRI dues. That experience served as a starting point for development of the new program. |
| OBJECTIVES | <ul style="list-style-type: none">• To determine the extent to which EPRI members were benefiting from their support of the centralized, cooperative R&D program.• To develop a general approach utilities could use to identify and quantify their use of EPRI research results. |
| APPROACH | After an EPRI-wide committee had devised a general format for benefits assessments late in 1985, EPRI asked 24 utilities to participate in the initial study. The utilities represented a cross section of the 500 EPRI members in geographic location, generation mix, size, and ownership type. At each utility, personnel reviewed a list of the available products that had been developed in completed EPRI research. From that list, they identified products that were in use at their utilities, products that were potentially usable, and products that were inapplicable. Where possible, they quantified the dollar benefits from each product. Twenty participants delivered quantified results to EPRI for analysis by June 1986. |
| KEY POINTS | <ul style="list-style-type: none">• All participating utilities were using EPRI-developed products. Moreover, for every utility participating in the program, the current measurable benefits from using those products outweighed their EPRI dues. The reported benefit-cost ratios ranged from a low of 1.2:1 to a high of 13.6:1, with most falling between 1.5:1 and 5:1. The wide variation in the ratios was due |

in part to differences in assumptions and methodologies and in part to differences in the mix of EPRI products being used.

- The data underscored the diversity of the utility industry and the breadth of the EPRI research program: different utilities rarely used the same set of products. In fact, of the approximately 500 products reviewed, only 5 were in use at 14 or more of the 20 utilities reporting. A quarter of the products reviewed (119), however, were used by 5 or more utilities each, and 433 were used by at least 1 utility. An additional 66 were considered potentially useful by at least 1 utility each. Thus, although only a small portion of the products were in wide use, almost every product was in use at some utility in the sample.

- In addition to summarizing the results of the assessments, both graphically and in text, the report identifies and interprets trends in product use. It also includes the executive summaries of the individual utility reports, the data from the studies, a printout of the database for the 1985 benefits assessment program, and a discussion of benefit-cost methodologies.

EPRI
PERSPECTIVE

The 1985 results point out several ways to increase benefits for utilities from the cooperative research program in the future. More-widespread application of EPRI-developed products in the industry appears likely as utilities identify potentially useful products in similar assessments and as they become aware of the sizable benefits others have realized from certain products. The fact that only a small set of products dominates each utility's benefit total suggests that even a few more applications of the most successful products could increase benefits across the industry. The findings in these initial studies thus indicate that technology transfer remains a significant challenge for both EPRI and the utilities.

PROJECT

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The 1985 EPRI Benefits Assessment Program: A Report to the Electric Utility Industry

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ABSTRACT

This report describes a joint EPRI-utility program undertaken in 1985 to perform quantitative assessment of the benefits to the industry of EPRI R&D. Twenty-four utilities participated as a cross-section of the more-than-500 EPRI member utilities. Utility staff reviewed a selected set of 450 products, to identify which products were already in use and which could be used, and to make estimates where possible of the actual and potential dollar benefits of such applications. The results from 21 of the 24 participating utilities are presented in some detail in this report, along with an analysis of product trends. A major finding of the study is that all 24 selected utilities are realizing positive net benefits. Reported cost-benefit ratios range from 1.2 to 1 up to 13.6 to 1 as benefits are compared with dues paid to support the EPRI R&D program. The utilities also indicated that the intangible and unquantifiable benefits of the research are as important, if not more important. The study results indicate that benefits will increase over time through wider application of both existing and future products.

ACKNOWLEDGMENTS

This program was a cooperative effort on a truly massive scale, involving more than 100 EPRI staff at one time or another and comparable numbers of people at each of the 24 participating utilities. Clearly it isn't possible to mention everyone individually. Hopefully, each person who contributed to this program will recognize him- or herself in the following comments.

At each utility, one or two key people were principally responsible for directing the entire effort. These were the Benefits Assessment Program managers, whose job it was to establish a program management plan, to track the hundreds of products and people, to compile and revise the diverse product evaluations, and, importantly, to prepare a thorough and thoughtful final report that would gain the company's approval.

At most companies, these key individuals were supported by a committee or group of dedicated coordinators who would fan out across the company, carrying materials, instructions, and their own enthusiasm. In each case, the role of the utility's senior management was critical in establishing the commitment, priority, and resources--in many cases, their close continuing involvement helped ensure that the entire effort stayed well aligned with the utility's strategic goals.

Finally, individual product reviewers, sometimes numbering as many as 150 individual staff professionals, brought their experience, expertise, and judgment to the central task, which was to identify EPRI research results that were in use (or that could be used) to the benefit of their company and to quantify that benefit where possible. They performed this task with diligence and enthusiasm.

For EPRI's part, the program mobilized people from all across the Institute, as management made clear the importance it assigned to the activity by their continued active involvement and participation. In teams of 10-15, EPRI staff visited each of the 24 participating utilities to conduct the workshops (there was one exception, as Athens Utilities Board sent its people to EPRI). This came after 2-3 months of advance preparation, while EPRI's involvement with each

company was coordinated by the Member Services Regional Manager and the Benefits Assessment Team Leader. Each of the 80 or more members of technical staff who participated in one or more workshops approached the assignment with great interest, taking personal ownership of the program to see it through successfully.

An Institute-wide committee labored long on the program design and conduct, culminating in the work of the Editorial Board, which patiently reviewed a number of iterations in the preparation of this report. Kenneth Cox and Marilyn Elmer of the Graphics Department did their usual excellent work, under the extra pressure of very tight schedules. Needless to say, there would be no report if it weren't for the grace under pressure through countless drafts of Program Secretary Violet La Bang and the goodwill and excellent work of Word Processing Supervisor Sarah Brown.

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EXECUTIVE SUMMARY

During the latter part of 1985 and early 1986, the Electric Power Research Institute (EPRI) conducted an extensive program to assess the penetration of its research and development (R&D) products in the utility industry it serves and the benefits achieved by the utility members through use of those products. EPRI selected and asked 24 of its more-than-500 member utilities to undertake a Benefits Assessment Program; the utilities that participated represent a cross section of the industry in terms of geographic distribution, generation mix, size, and type (investor-owned, municipal, and cooperative).

Over 430 R&D products--hardware, software, manuals and guides, devices and entire systems--were reviewed and assessed by the staff at each utility to identify those products already in use, those potentially usable or not applicable. Wherever possible, the utility reviewers quantified the dollar benefits of each product.

The results of this program, which are detailed in this report, demonstrate that all 24 utilities are realizing positive net benefits from their use of EPRI R&D products. The ratios of benefits to EPRI dues they report range from 1.2 to 13.6 with most falling in the range of 1.5 to 5, the wide range of variation due in part to different underlying methodologies and assumptions.

The 24 utilities are unanimous in finding that the intangible and unquantifiable benefits of EPRI resources and products are as important, if not more important, than the quantifiable benefits.

Several distinct patterns emerge from the data on product use across the 24 utilities. Nearly all EPRI products are in use by 1 or more utilities, with a smaller number of products in use at a majority of the utilities. Some utilities identified as many as 200 products as being in use on their system. All of the utilities found that as few as 5-15 products contributed the bulk of their quantified benefits totals.

The Executive Summaries from the reports prepared by each of the utilities participating in the Program are reproduced in appendix A and reflect both the uniqueness of each utility's approach and the commonality in the overall findings. If it is indeed possible to "prove" the genuine value of collective R&D by the U.S. electric utility industry, this program has taken a major step forward by measuring the payback being achieved by a representative subset of the industry.

I. INTRODUCTION

A. Objectives and Background

As the cooperative R&D arm of the U.S electric utility industry, EPRI conducts technical R&D and development on the major aspects of electric power production and use, including fuels, generation, delivery, energy management and conservation, environmental effects, and energy analysis. Founded in 1972, it now has an annual budget exceeding \$300 million, supported exclusively by the dues payments of the more-than-500 member utilities, which represent two-thirds of the nation's generating capacity.

For this support to be justified, the results of the R&D must be applied by (or on behalf of) member utilities and bring benefits to the utility and its ratepayers. In its 1984 "Effectiveness Review," the EPRI Board of Directors recommended that EPRI devote more effort to technology transfer, "encouraging utilities to increase their utilization and application of EPRI research results."* The Benefits Assessment Program was conceived within EPRI early in 1985 as part of a long-term strategy to enhance technology transfer. The immediate goal, however, was to determine if current EPRI members are benefitting from their support of the Institute's R&D program.

EPRI first responded to a utility's request for help in justifying its EPRI dues to regulators in 1981. Through early 1985, EPRI had participated in over 20 such exercises with utility members. Although their scope was more limited and their objectives different, these assessments provided the experience on which to build a comprehensive approach to assessing the value of the entire range of EPRI's R&D results.

The immediate objective of the Program was to provide the means for utilities to identify and quantify applications of EPRI R&D results, documenting what benefits

* Effectiveness Review of the Electric Power Research Institute, December 11, 1984, page 7.

can be realized when utilities avail themselves of EPRI's resources. At the same time, the Program offered a unique opportunity for EPRI and participating utilities to explore new approaches to technology transfer and to assess the effectiveness of existing mechanisms.

B. The 1985 Benefits Assessment Campaign

The campaign in 1985 was a major undertaking by EPRI and 24 of its member utilities in which each utility reviewed about 430 existing EPRI products (see the discussion of the products and the product list below) to identify those already in use, potentially usable, or not applicable to its system. Utility staffs quantified, wherever possible, the dollar benefits of each product.

The result in each case was the completion by the utility, using its own methodology and approach, of a report detailing its past, present, and future (potential) applications of EPRI R&D products, together with estimates of the resulting benefits and, in many cases, a thorough discussion of the utility's overall perspective on R&D.

The process itself was a dynamic partnership, involving numerous intense and varied interactions between the utility and EPRI staff over a period of months, and it provided many direct and indirect benefits to each participating utility and to EPRI, though not without the participants devoting considerable effort and resources. On the order of 40-150 utility staff were involved briefly (one to several days) at each company. The total effort within each utility was on the order of a man-year. Nearly 100 EPRI staff were involved to varying degrees, devoting approximately seven man-years, with over 300 person-visits to utilities.

EPRI's role was to launch the process, set the schedule, and act as facilitator, providing technical information, resource materials, and a suggested set of procedures. The process, consisting of a structured series of meetings and workshops, was designed as a standard approach. In practice, however, each utility required an individually tailored approach to match its own organizational character and needs. On the average, each utility's principal coordinator spent as much as half-time on the Program over a six-month period, drawing intermittently on a network of departmental coordinators. From the EPRI side, each utility's program was supported by a counterpart coordinator, the Member Services Regional Manager, and by 8 to 10 representatives of the technical programs.

C. Participating Utilities

Participating utilities were selected to represent a cross section of the EPRI membership in terms of geographic distribution, generation mix, and size. As shown in table 1 and the map in figure 1, all regions of the country are represented by the 24 utilities that agreed to participate. Participants ranged from some of the largest investor-owned utilities (such as Texas Utilities and Pacific Gas & Electric) to small municipals (Lincoln Electric System and Athens Utility Board) and include one generation and transmission (G&T) cooperative (United Power Association).

One criterion in choosing candidates for participation was that the utility be among the more active companies in the industry in terms of its EPRI involvement. The goal of the Program, therefore, was to demonstrate what benefits can accrue when utilities actively manage their investment in EPRI, rather than to measure R&D utilization across the industry as a whole.

D. The Products of EPRI Research

For the 1985 campaign, EPRI deliberately adopted a rather open-ended definition of product that embraced a wide variety of R&D results from hardware that is commercially produced and widely available to demonstration of new technologies at commercial scale, to computer software, and to environmental research results published in peer-reviewed scientific journals. The 432 items on the original product list were identified by EPRI's six technical divisions, with the primary purpose of providing utilities with a structure on which to base their review process.

Utilities frequently identified products not on the list. Sometimes they chose to consider an individual item included in a more broadly defined product in which several related products had been clustered under one heading. Conversely, utilities sometimes chose to treat a group of EPRI-defined products as a single, more generic item. Thus, there is nothing intrinsic about the actual total number of products. The list of 432 was expanded to 507 during the course of the program, as additional products were distinguished to accommodate the utilities' findings.

The product list has undergone major revision as a consequence of the 1985 benefits assessment campaign. Some items have been broken out into several

separate products; some have been deleted; and many more have been added--the 1986 list numbers more than 750 products. As many as 100 new products of one kind or another might be added to the list each year.

Table 1

CHARACTERISTICS OF PARTICIPATING UTILITIES

| UTILITY | OWNERSHIP | 1984* PEAK (MW) | 1984** RETAIL SALES (GWH) | PRINCIPAL SOURCES OF GENERATION |
|------------------|-----------|--------------------|------------------------------------|------------------------------------|
| Athens Util | MUNI | 88(W) | 422* | TVA Distributor |
| Boston Edison | IOU | 2,515 | 10,646 | oil, nuclear |
| Carolina P&L | IOU | 7,799(W) | 25,456 | coal, nuclear, hydro, gas |
| Cleveland Elec | IOU | 3,371 | 17,263 | coal, nuclear |
| Commonwealth Ed | IOU | 14,572 | 62,282 | nuclear, coal, oil |
| Con Edison | IOU | 7,435 | 29,390 | oil, nuclear |
| Delmarva | IOU | 1,682(W) | 6,942 | coal, nuclear |
| Florida P&L | IOU | 11,198(W) | 46,612 | oil, gas, nuclear |
| Houston L&P | IOU | 10,851 | 56,161 | gas, coal |
| Kentucky Util | IOU | 2,193(W) | 9,632 | coal |
| Lincoln Elec | MUNI | 435 | 1,548* | purchase, coal, nuclear |
| Nevada Power | IOU | 1,537 | 6,091 | coal, gas |
| NYSEG | IOU | 2,253(W) | 11,266 | coal |
| NSP | IOU | 5,544 | 24,712 | coal, nuclear, hydro |
| Pacific G&E | IOU | 14,224 | 60,817 | oil, hydro, nuclear, gas |
| Penn P&L | IOU | 5,519(W) | 23,221 | coal, oil, nuclear |
| PSE&G | IOU | 7,422(W) | 31,429 | gas, oil, coal, nuclear |
| Pugst Power | IOU | 3,481(W) | 14,347 | coal, hydro, gas |
| Salt River | MUNI | 2,260(W) | 12,612* | nuclear, coal, oil |
| SWEPCO | IOU | 2,948 | 10,972 | coal |
| Texas Util | IOU | 15,265 | 63,984 | coal, nuclear, gas |
| United Pwr Assoc | COOP | 471(W) | 5,484* | coal |
| Virginia Power | IOU | 8,895 | 38,487 | coal, nuclear |
| Wisconsin Elec | IOU | 3,684 | 16,770 | coal, nuclear |

MUNI = Municipal utility

IOU = Investor-owned-utility

COOP = Rural electric cooperative

(W) = Winter peaking (others are summer peaking)

* Electrical World Directory, 1985-1986.

** Edison Electric Institute, Uniform Statistical Reports, for the year ending December 31, 1984.

UTILITIES PARTICIPATING IN THE 1985 BENEFITS ASSESSMENT PROGRAM

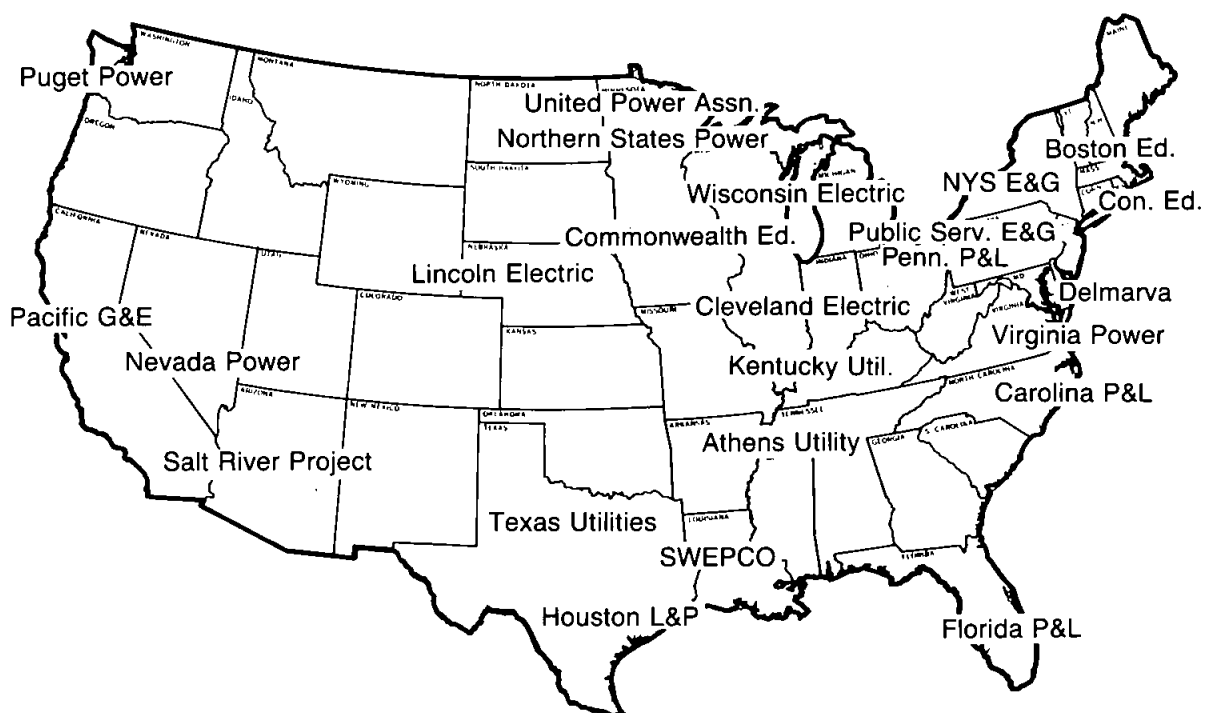


Figure 1

II. RESULTS OF BENEFITS ASSESSMENTS

By June 1986, quantitative results were delivered to EPRI from almost all participating utilities. The overriding conclusion that emerges from these 24 separate studies is that each utility is using EPRI R&D and receiving currently measurable benefits greater than its dues. Benefit-cost ratios reported by the utilities range from 1.2 to 1 to 13.6 to 1; even higher ratios might be inferred from some of the other benefits totals that are indicated.

The participating utilities used different approaches to quantification of benefits and to the calculation of total "benefit" and total "cost." As the results do not easily lend themselves to meaningful cross-comparison, they have not been placed side by side in a single table. Instead, to preserve the uniqueness of the individual approaches, the charts and tables on the following several pages present the quantitative benefit-cost results from each of the participating utilities,* along with a brief description of the quantification method employed.

The program provided a unique opportunity to begin to study patterns of the industry's use of EPRI results, as discussed in part B of this section. The market penetration achieved by EPRI products is highly variable, with relatively few products reaching most utilities. However, nearly all products are in use by at least one or two utilities.

"Profiles" of product applications at utilities of different size and generation mix are presented in part D of this section. These summaries and highlights, along with the databases and utility report summaries provided in the appendixes, are a strong reminder that product use by different utilities is conditioned almost entirely by their individual operating needs and strategic situations.

*At time of publication, a few final utility reports were not ready for release, although the results have been informally relayed to EPRI.

All the 24 participating utilities demonstrated to themselves that they were receiving solid dollar returns on their investment in collective R&D. Beyond that, they also testified to the intrinsic value of R&D that is difficult to quantify or that is truly unquantifiable. As discussed in part C of this section, many of the participating utilities strongly emphasized the importance of unquantifiable benefits, such as the value of strategic options for the future and the indirect benefits of R&D in areas of industrywide concern.

In view of the different approaches to quantification, the fact that all arrived at positive results reinforces EPRI's conviction that utility members can gain immediate measurable benefits from R&D and that, given aggressive implementation of technological innovations, such benefits can only increase with time.

A. Benefit-Cost Results and Quantification Methods

The following charts and tables attempt to summarize the overall quantitative results obtained by the participating utilities; captions highlight some of the differences in the approaches taken to quantification. (A fuller examination of the different approaches appears in appendix C.)

These brief accounts are necessarily very much simplified to give a sense of the results and various approaches and do not report the extensive analyses that underlies each study. The Executive Summaries from the utilities, which are reproduced in appendix A, provide a more complete account of each utility's findings as expressed in its own report.

Utilities had several issues to resolve for themselves before their results could be fully developed and reported, such as what timeframe to consider, whether to include estimates for potential applications and some of the other difficult-to-quantify items, how (or whether) to combine one-time and continuing annual benefits, whether to use discounted present-value techniques, and how to treat the "cost" part of the benefit-cost ratio (i.e., the utility's EPRI dues payments).

Several chose not to derive ratios and instead simply reported total benefits in one or more categories. Others established various ranges and scenarios of benefits before dividing by cost. These decisions were strictly in the hands of each individual utility, as EPRI made no attempt to impose a uniform methodology or structure.

AUB

The Athens Utilities Board considered only those products directly used in distribution and end use and did not include benefits accruing indirectly from Tennessee Valley Authority's (TVA) use of EPRI's G&T research. To account for this distinction, dues are prorated according to the fraction (13%) of AUB's revenues that relates to AUB's own activities (the balance of 87% represents the cost of power paid to TVA).

ATHENS UTILITIES BOARD

Benefits (total '85-'89)

| | |
|-----------|-----------|
| Actual | \$ 58,000 |
| Potential | \$477,000 |
| Total | \$535,000 |

EPRI Dues (total '85-'89)

| | |
|--|----------|
| 13% of AUB equivalent dues* | \$67,000 |
| (13% is portion of AUB revenues retained by AUB) | |

Benefit/cost ratio = 8.0

*Dues are paid by TVA, and attributed to its 160 distributors

Boston Edison

BECO identified total benefits in each of the four categories with individual products contributing anywhere from less than \$1000 to greater than \$50 million. A formal benefit-cost ratio was obtained by comparing only the actual benefits obtained through 1985 with total payments (converted to 1985 dollars) through 1985.

BOSTON EDISON

| <i>Total Benefits*</i> | 1985 (\$ million) |
|--------------------------|----------------------|
| Products actually in use | 166.4 |
| Firm plans | 31.5 |
| Probable use | 11.2 |
| Possible future use | 23.0 |

*One-time benefits plus one-year of multiyear benefits. Includes only 50% of individual product benefits exceeding \$5 million.

| <i>Total Dues Payments to EPRI</i> | 1985 (\$ million) |
|------------------------------------|----------------------|
| (1972-1985) | 21.7 |

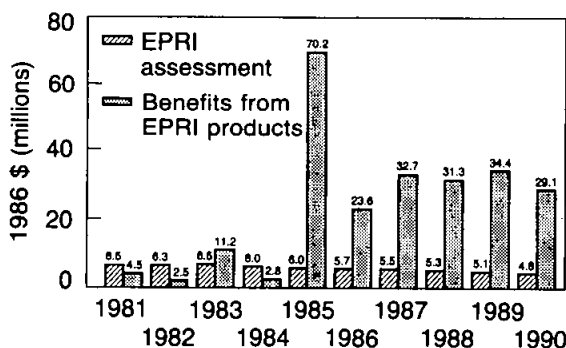
Benefit/cost ratio = 7.65
(actual benefits only)

Carolina P&L

CP&L relied on the professional judgments of actual users of the research to do the analysis for each product. Noting that their quantification methods varied from "back of the envelope" to sophisticated discounted present-worth studies, any inaccuracies were overshadowed by the uncertainties of identifying all the benefits of research and thus would not affect the overall conclusion.

The cumulative net benefit for the 1980-1985 period was \$91.2 million; the cumulative net benefit for the 1986-1990 period was estimated to be \$151 million. (The large benefits in 1985 included a one-time \$55 million savings on boiling water reactor (BWR) stress corrosion pipe cracking.)

CAROLINA POWER & LIGHT

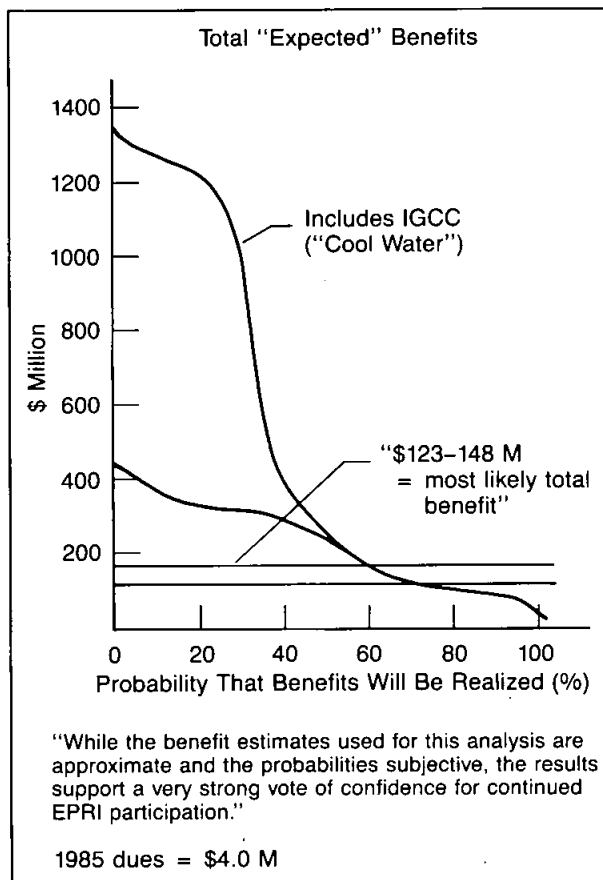


Benefit/cost ratio
1981-1985 = 2.9
1986-1990 = 5.7

Cleveland

In this innovative approach, reviewers estimated both benefits and the probability that the estimated benefits would be (or had been) realized. The estimate of total "expected" benefits thus ranges from a minimum of about \$25 million (at 100% probability) to \$75 million (at 95% probability) and to considerably larger figures at lower probabilities. If the integrated-gasification-combined-cycle (IGCC) technology is pursued, total benefits exceed \$1 billion (at 25% probability).

CLEVELAND ELECTRIC



Con Ed

Con Ed focused its efforts on matching EPRI research explicitly to its own corporate goals. The benefits total reported does not include benefits from over 80 additional products that were also identified as important to the company. Con Ed recognized that its recent dues payments went towards research still in progress, so it estimated the portion that could be attributed to completed research.

CONSOLIDATED EDISON

| | |
|--|--------------|
| Total Estimated Savings | \$69,226,000 |
| Total dues* (completed research only) | \$44,000,000 |

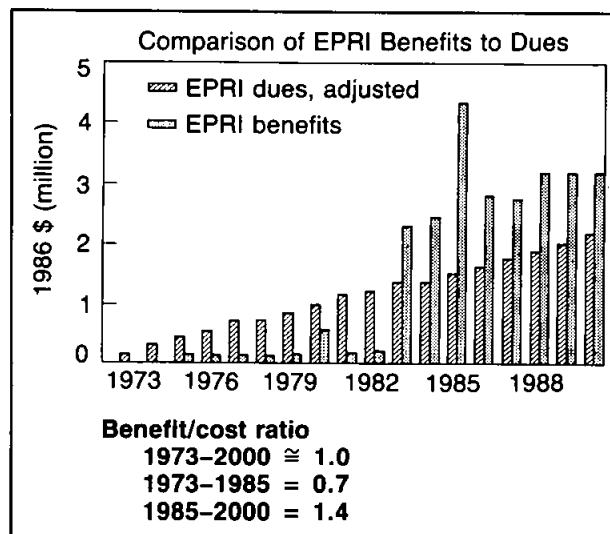
Benefit/cost ratio = 1.6

*Total dues (1972-1984) = \$61,384,000. Estimate was made of portion that went to completed research, as distinct from research still in progress.

Delmarva

Delmarva found the benefit-cost ratio increasing over time and suggested that it may be due to the lead time of R&D, EPRI's shift to the near term in the early eighties, and the recent emphasis on technology transfer. The graph includes only actual benefits, though nearly twice again as many products were identified as having potential application to the company.

DELMARVA POWER & LIGHT



Florida Power & Light

At Florida Power & Light, the study methodology involved development of benefits estimates using a simple one-page assessment process. Discounted cash flow analyses were performed where possible. Over 80% of the products were found to have already produced benefits or were projected to produce benefits.

FLORIDA POWER & LIGHT

| | Benefits (\$ million) | |
|--|-----------------------|---------------------|
| | Past | Total Present Value |
| Now in use | 132 | 758 |
| Probable immediate use | — | 15 |
| Probable future use | — | 216 |
| | 132 | 989 |
| Benefit/cost ratio | 1.8 | 13.6 |
| Total EPRI dues = \$72.9 million 1975-85 | | |

Houston L&P

Houston Light & Power's original study preceded the formal EPRI program, although the utility reviewed results in 1985 with some EPRI staff involvement. In what is termed the microscopic view, only a small sampling of products was selected for review, and total benefits numbers were not reported. A macroscopic view was also provided, placing the "subject of Research Benefits in broad perspective," a historical perspective on the long-range nature of R&D and its effect on society and the world.

HOUSTON LIGHTING & POWER

- "Macro" View
- "Micro" View

Lincoln Electric

Lincoln used two techniques to calculate benefits: actual cash-flow savings and annual equivalent (present-worth) value of extending the life of newly installed equipment. Different carrying charges were used depending on the type of equipment. Not included in these figures were benefits from future potential applications totalling \$901,500 per year continuing and potential one-time savings of \$865,000. Also, products in use at co-owned generation facilities (Laramie River and Cooper nuclear station) were not identified, although it was estimated that benefits there were probably in the "millions of dollars."

LINCOLN ELECTRIC SYSTEM

*Benefits**

| | |
|---|-----------------|
| Total annual cash flow savings | \$314,803 |
| Annual present worth—extended life of new equipment | \$ 75,495 |
| | <hr/> \$390,298 |

Total 1985 EPRI Dues

\$330,402

Benefit/cost ratio = 1.18

*Excludes future potential benefits.

Nevada Power

Like all the utilities participating, Nevada recognized the difficulties in quantifying benefits and organized the effort around redefined categories that were more manageable in its system. The products in the "Past and Continuing" category were identified as providing either one-time benefits or continuing annual benefits. Estimates of savings were based on reduction of engineering staff labor, consultant's costs, or capital and operation and maintenance (O&M) costs.

NEVADA POWER

Benefits

| | |
|-----------------------------|-------------------|
| Past and continuing | |
| • One-time ('85) | \$3,458,000 |
| • Annual (per year) | 259,000 |
| | <hr/> \$3,717,000 |
| Future potential (per year) | \$1,082,000 |

Benefit/cost ratio = 3.0

(not including future potential benefits)

NYSEG

NYSEG has had a program in place called Electric Research Value Assessment (ERVA), a method of continually documenting the value to the company of its application of finished research, both internally and externally developed.

The criteria for pricing applications are strict--only "hard dollar" evaluations are made, though possible future applications and unquantifiable research appear as separate categories.

NEW YORK STATE ELECTRIC & GAS

Benefits = approx. \$5 million/yr

Dues = approx. \$2.5 million/yr

Benefit/cost ratio = 2

(not including future potential benefits)

NSP

At Northern States Power, there was a particular emphasis on making the program broad-based, relying "heavily on the judgment and perceptions of our personnel who are the actual users." These totalled benefits estimates do not include benefits coming to the company by way of improved products from vendors but do include a generic evaluation of the value of information products.

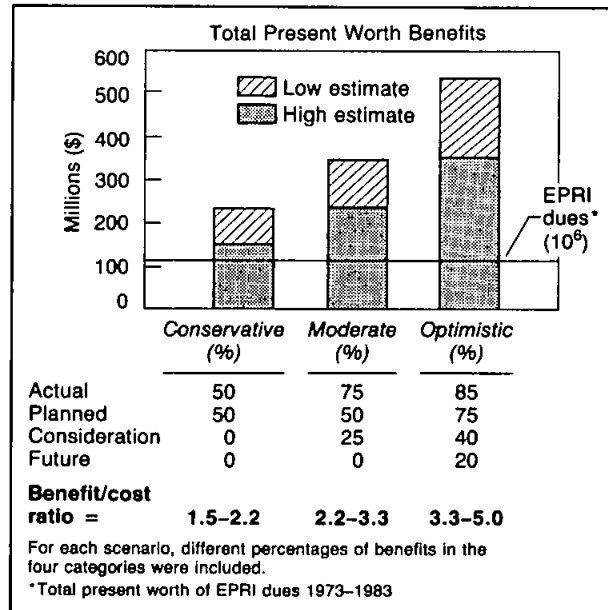
NORTHERN STATES POWER

| | (\$ million) | |
|----------------------------------|--------------|------------|
| | One-Time | Continuing |
| Past and present | 27.9 | 5.8 |
| Firm plans | 4.1 | 14.2 |
| Potential future | 6.5 | 17.0 |
| | 38.5 | 37.0 |
| EPRI dues (1985) = \$5.1 million | | |

PG&E

PG&E carefully kept benefit estimates both by benefit category and by the time period of the anticipated benefits. By making these sets of assumptions about the percentage of benefits in each category that will be realized, these benefit/cost ratios--conservative, moderate, optimistic--were produced. The weighting factors account for differences in the inherent quality of estimates in each of the four categories.

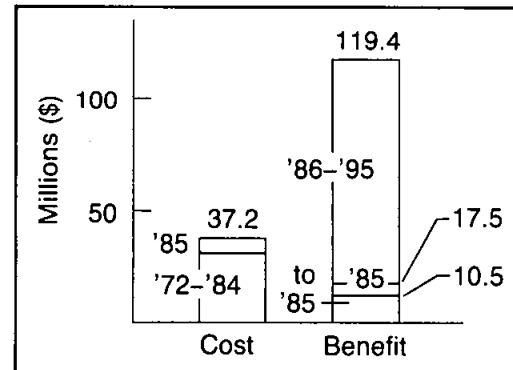
PACIFIC GAS & ELECTRIC



Penn P&L

PP&L had done its own internal benefits assessment of major EPRI projects for several years, finding in 1985 that these benefits almost equaled their support of EPRI. The present analysis was much more thorough, raising the 1985 ratio to 1-1/2 to 1 and projecting 2 to 1 in 1986. Benefits were distinguished by their timing: prior to 1985, during 1985, and 1986 to 1995. The results show that net benefits to the company will turn sharply positive over the next 10 years, even without inclusion of projects completed by EPRI after 1985.

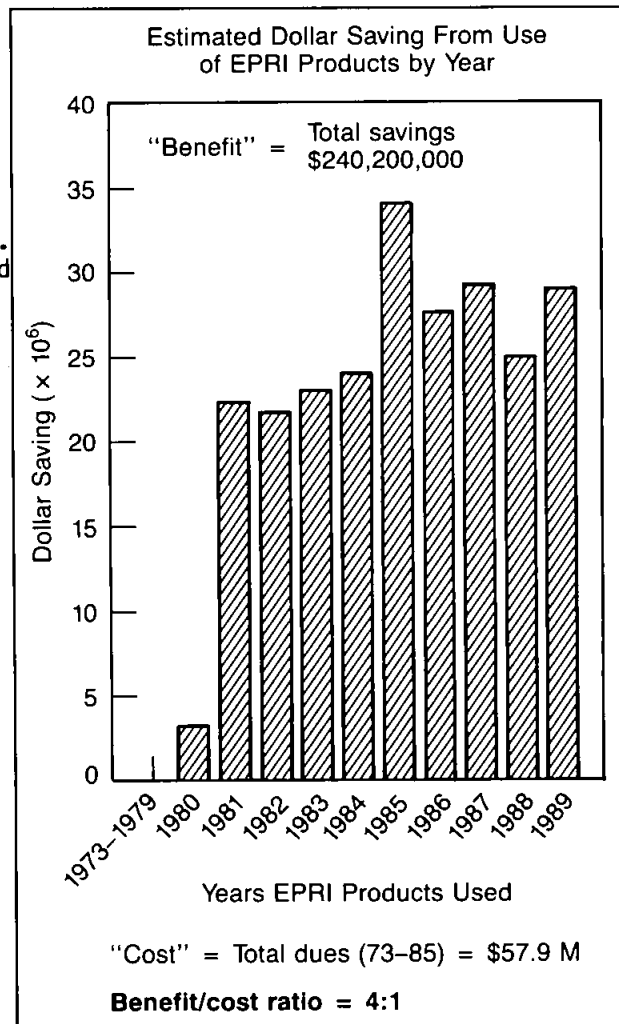
PENNSYLVANIA POWER & LIGHT



Public Service E&G

The time series developed by PSE&G summarizes the results for those products actually in use or for which there were firm plans for application during 1986. Another \$6 million was identified from potential applications currently under consideration, and an additional \$5 million in the future consideration category. In all categories, benefits were projected only through 1989.

PUBLIC SERVICE ELECTRIC & GAS



Puget Power

Early in its Benefits Assessment Program, Puget Power realized that much of the research on coal-fired power plants would not be applicable unless the company decides to build a new plant. As this decision is still in the future, the utility solved the assessment problem by making a generalized assumption, for the sake of analysis, that a plant would be built in 1996.

PUGET SOUND POWER & LIGHT

| | \$ Million |
|---|------------|
| Quantifiable benefits through 1999 | 138-152 |
| Added benefits if coal plant is built starting 1996 | 25 |
| Estimated support to EPRI through 1999 | 76 |
| Benefit/cost ratio = 1.8-2 | |

Salt River Project

One of the first utilities to go through the benefits assessment process, Salt River carefully distinguished among categories of products, recognizing the various degrees of difficulty in quantification. One unusual aspect here was the circumstance of a major ongoing joint project with EPRI at its Coronado unit, which is under construction.

SALT RIVER PROJECT

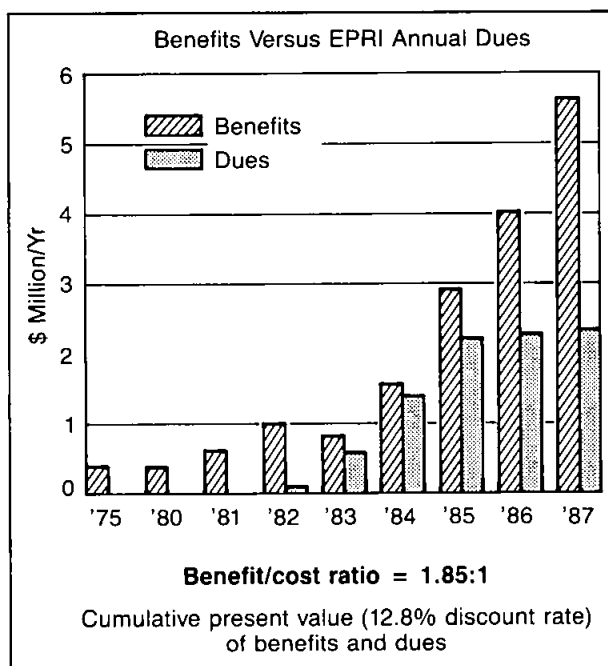
| | <i>Continuing Benefits (\$ million/yr)</i> | <i>One-Time Benefits (\$ million)</i> |
|--|--|---|
| Products actually in use | 2.5-3.1 | 51 |
| Products potentially applicable | 2.2-11.0 | 1.6 |
| Products used at jointly owned plants | 11.5 | 5.2 |
| SRP annual EPRI payments (1985) | 2.4 | |
| Total dues paid 1972-1985 = \$12 million | | |

SWEPCo

SWEPCo compiled benefits results in a time series, combining one-time benefits with continuing annual benefits, with each product contributing to the totals in the appropriate year or years. Only actual benefits of products in use or previously used were included. Potential future applications were identified but not quantified. The benefits and costs in each year from 1975 to 1987 were combined in a cumulative present value in 1985 dollars:

Benefits = \$18.2 million
Costs = \$9.8 million

SOUTHWESTERN ELECTRIC POWER



Texas Utilities

The formalized approach taken by Texas Utilities used a detailed worksheet to identify various types of costs and savings for input to a present-worth analysis computer program. The program and its internal data were designed to be consistent with other studies within the company. Many substantial economic benefits of research were recognized, especially the broad strategic value of R&D, but these were specifically excluded from the quantification. Only actual applications were included, where the basis for an economic analysis could be determined.

TEXAS UTILITIES

| <i>Benefits</i> | <i>Cumulative Present Value (1985 \$)</i> | <i>B/C Ratio</i> |
|-----------------|---|------------------|
| Direct | 266,171,000 | 2.0 |
| SGOG* | 425,302,000 | 3.2 |
| Indirect | 169,917,000 | 1.3 |
| EPRI dues | 134,179,000 | |

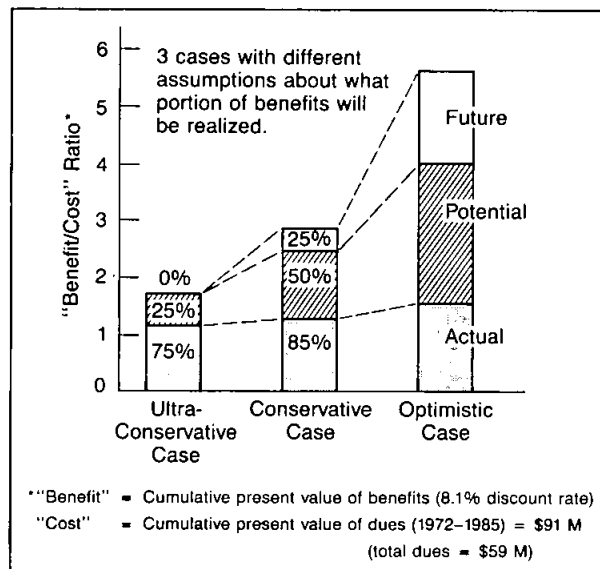
(only actual benefits included)
*Steam Generators Owners Group Products

Virginia Power

Virginia Power first identified a range of both one-time and per-year benefits for each application, distinguishing actual, potential, future, and indirect benefits as separate categories. The per-year benefits, mostly long term in nature, were treated as a 10-year annuity, which was discounted back to a lump sum equivalent that could then be added to the one-time estimates.

Averages of the high and low totals were compared with cumulative EPRI dues (total and present value) in these three scenarios, reflecting different assumptions on the fraction of benefits that would ultimately be realized by the company.

VIRGINIA POWER



United Power Assoc.

To represent its 15 member cooperatives, UPA selected 4 of the largest to participate with UPA staff in the Benefits Assessment Program. The figures for potential benefits include products planned to be used, those under consideration for near-term and future use, and those with industrywide and indirect value. Products with unquantifiable benefits were also identified.

UNITED POWER ASSOCIATION

| | <i>One-Time</i> | <i>Continuing/Year</i> |
|--------------------|-----------------|------------------------|
| Actual benefits | \$ 810,000 | \$ 416,000 |
| Potential benefits | \$1,528,000 | \$2,980,000 |
| 1986 EPRI Dues = | \$501,321 | |

This overview has presented each utility's aggregate benefit-cost results. In each case, total benefits are the result of a summation of the benefits attributed to each of many individual products, as discussed below.

B. Product Use Trends

In assessing the usefulness of EPRI products, utility reviewers were asked to consider them in various categories:

1. Products that were in actual use currently or that had been applied in the past
2. Products for which there were firm plans for implementation (in the near future)
3. Products that were perceived as having potential future use
4. A broad category of products that produced indirect benefits, industrywide benefits (which are difficult to allocate to individual utilities), intangible and unquantifiable benefits (as judged by reviewers)

In addition, reviewers were asked to identify products that were perceived as having no applicability, either now or in the future, given the situation of the particular utility.

As shown in table 2, utilities generally report a relatively small number of products to be in actual use. Out of a nominal total of 500 products, the highest number reported is 210 (PG&E), and the next highest is 172 (Florida P&L). Most of the other utilities report totals falling in the range between 40 and 140 products. However, when the products identified as potentially useful are added to this, the totals increase markedly, frequently by a factor of 2 or more.

One general observation is that the larger utilities, especially those that have been EPRI members for a long time, tend to be using a greater number of products. This is perhaps to be expected, given their greater resources and broader range of technological needs. However, the United Power Association (a cooperative that owns some coal-fired generation and whose total peak load is under 500 MW) shows a relatively high percentage (20%) of products actually or potentially in use, suggesting that the challenge of transferring R&D results to smaller utilities may in fact be solvable.

Table 2
NUMBER OF PRODUCTS IN USE AT EACH UTILITY

| | <u>ACTUAL AND FIRM PLANS</u> | <u>NEAR-TERM POTENTIAL</u> | <u>FUTURE POTENTIAL, INDIRECT AND JOINT OWNER*</u> | <u>BENEFITS** NOT QUANTIFIED</u> | <u>NOT APPLICABLE</u> |
|--------------|----------------------------------|--------------------------------|--|--|---------------------------|
| Athens | 16 | 10 | 4 | 8 | -- |
| Boston Ed | 102 | 30 | 99 | 117 | -- |
| Carol P&L | 55 | 38 | -- | -- | -- |
| Cleveland | 141 | 21 | 2 | 36 | -- |
| Con Ed | 138 | -- | -- | 88 | -- |
| Delmarva | 72 | -- | 126 | 58 | -- |
| Florida P&L | 172 | 22 | 174 | -- | 69 |
| Houston+ | 9 | 1 | -- | -- | -- |
| Lincoln | 58 | 19 | 24 | 36 | 53 |
| Nevada Power | 40 | -- | 139 | 43 | 20 |
| NYSEG | 20 | -- | 114 | 35 | 152 |
| NSP | 112 | -- | 139 | 76 | 181 |
| Pacific G&E | 210 | 59 | 77 | -- | 98 |
| Penn P&L | 99 | 71 | -- | -- | 262 |
| PSE&G | 124 | 31 | 67 | 8 | 71 |
| Puget Power | 89 | 113 | 13 | 97 | 66 |
| Salt River | 104 | 70 | 35 | 6 | 21 |
| SWEPCo | 37 | 25 | 41 | 41 | 247 |
| Texas | 98 | -- | 4 | -- | -- |
| United Power | 43 | 50 | 70 | 28 | -- |
| Virginia | 68 | 43 | 111 | 22 | -- |

(Each utility established its own approach to categorizing products, with different terminology and assumptions. These figures are a nominal attempt to present these data in summary fashion.)

+ Review considered only a limited number of products.

* Products in use at a plant in which utility is a part owner but not the operator.

** These products are also included under the previous three headings (i.e., "double-counted").

Which Products Are They?

It is rarely the same set of products that have been applied by the different utilities. (Data from 20 utilities were included in these analyses.) Of the working total of 507 products, 433 were cited as being in actual use by at least 1 of the 20 utilities. Sixty-six more were deemed potentially useful by at least 1 utility, leaving only 8 products that weren't cited.* Only about one-fourth of the products (119) were reported in actual use by 5 or more of the utilities, and only 5 products were cited by 14 or more utilities.

The pattern that emerges is that more products are in use at fewer utilities and that a few products are in use at many utilities. This is shown graphically in figure 2, which plots the number of products against the number of times each one was cited. Clearly, many of the products already in use by some utilities are viewed as potentially useful by others and are yet to be implemented. When actual and potential-use citations are taken together, the curve moves up substantially, and the total number of product citations almost doubles, from an average of 75 products per utility to about 150. The shape of the curve is the same, however, with only 18 products reaching 14 or more utilities. (The original data for this analysis appear in their entirety in appendix B.)

By themselves these data on the number of citations do not tell a complete story. Some products that were cited less often have only recently become available and are just beginning to be evaluated for application by more utilities. Other products are applicable on only a subset of utility systems around the country, so the absolute number of citations is not an adequate indication of their real success. A better, more relative measure is the success a product has with those utilities that could use it.

*One of the 8 was noted for indirect benefits by two utilities. The others may have been inappropriately defined as products, or may have been missed because of the small number of utilities in the sample. Detailed review of these data is ongoing.

FIGURE 2 - Distribution of Product Use

Products are ordered according to the number of utilities that cited the product as being in actual use and again with actual and potential citations taken together. For example, the fuel inventory model and UNIRAM were each cited as in actual use by 5 utilities and as potentially useful by 7 others. They thus rank along with 46 other products between numbers 73 and 119 on the "Actual Use" curve and between 28 and 45 on the combined curve.

With one exception (noted below), the most frequently cited products across the 24 utilities were all in transmission and distribution (T&D), notably zinc oxide arresters (cited by 17 utilities), Clor-N-Oil® (15), sulfur hexafluoride (SF₆) breakers (15), and transmission line design (EPRI's famous "red book") (14). All of these products (except Clor-N-Oil®) were in development from the earliest years of EPRI's funding, so their widespread acceptance should not be surprising. Also, because these products can potentially be applied in the millions across all utility T&D systems, their aggregate benefits should grow over time and perhaps exceed in dollar benefits the singularly large benefits one sees today in boiler tubes, condensers, pressurized water reactor (PWR) water chemistry, BWR pipe corrosion remedies, and other major products addressing problem areas afflicting existing fossil and nuclear power stations.

More-recent products developed by EPRI, such as the radio frequency (RF) monitor (for anticipating and avoiding generator failures), the UNIRAM code (which allows, among other features, the evaluation of performance and availability of advanced power plant units before they are actually built), and the fuel inventory model (whose use promises significant savings in the costly area of fuel planning), are all recognized for the likely benefits they will produce in the future. Amorphous steel transformers, which were cited twice with actual benefits (by utilities that have installed experimental prototypes), also received 11 potential (and 1 indirect) citations, indicating a widespread recognition of the future economic importance of this development.

Products that received only 1 (actual) citation should not be disregarded. For instance, the coal-gasification-combined-cycle (CGCC) system (Cool Water), which allows clean burning of coal, received only 1 actual citation, but 13 potential, indicating high interest in this first-of-a-kind 100-MW plant that offers a significant generation option for a future likely to have more stringent environmental constraints.

The product with the most actual plus potential citations (16 actual and 3 potential), shown on the figure as "boiler availability," actually represents a family of products, including manuals on the causes of boiler tube failure and on chemical cleaning of fossil plant parts, boiler tube mapping, and others.

Distribution of Product Use

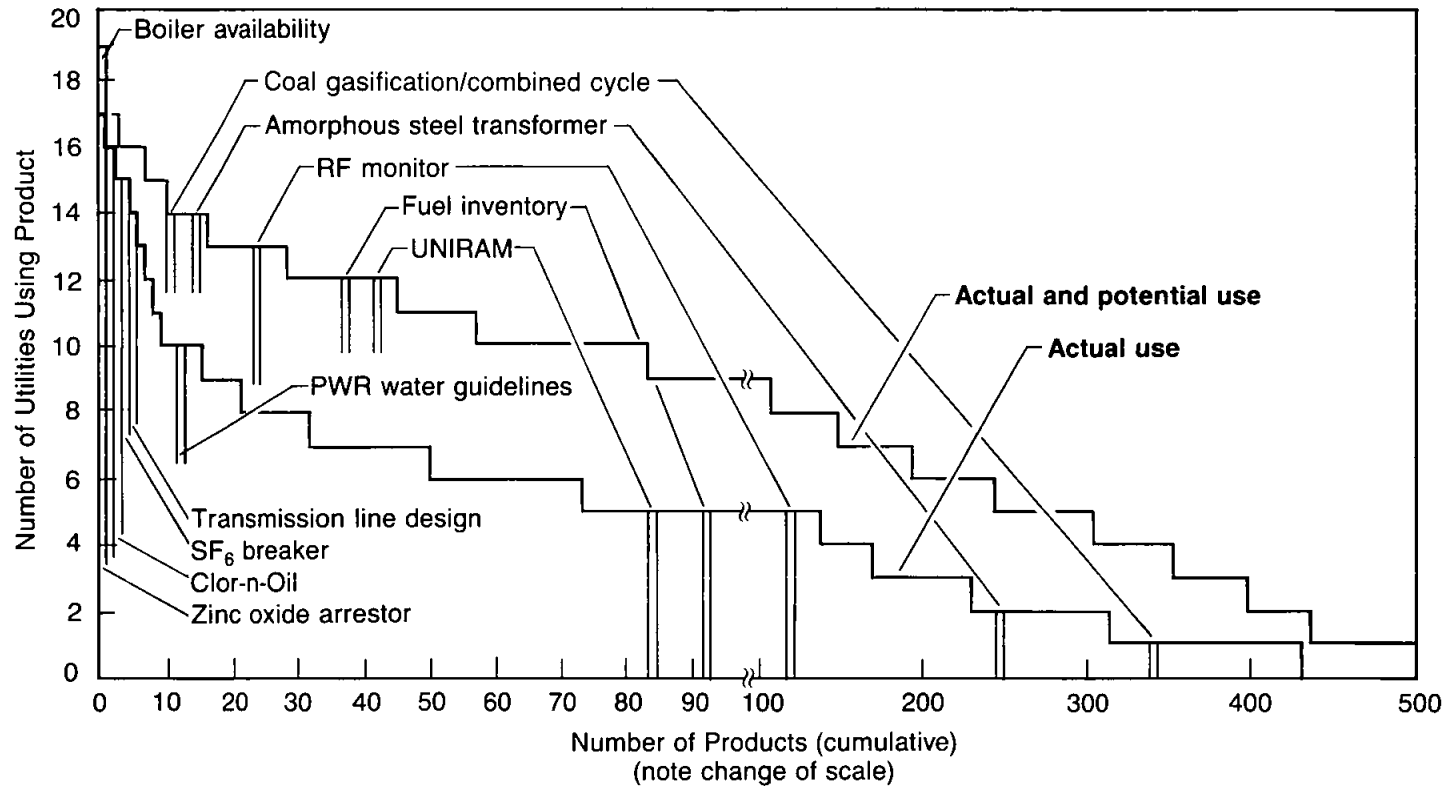


Figure 2

The Best-Sellers

Table 3a lists several dozen products that were the most successful in reaching the largest number of the utilities that could use them. As is evident, these products range from small hardware and test devices, reference manuals, and techniques all the way up to generation system components.

Since practically all utilities have T&D, it is not surprising that T&D products predominate. (The zinc oxide arrester, Clor-N-Oil® kit, the SF₆ puffer breaker, and the Transmission Line Design Reference Book were each cited in actual use 14 or more times.)

In the other categories, only a few products were cited often (the single highest actual plus potential count of 19 went to a group product, boiler availability, which includes manuals on boiler tube failure and chemical cleaning of fossil plant parts, the boiler tube mapping, and others).^{*} As an example of relative success, only 10 of the utilities included here have PWRs, and all 10 of them reported actual use of the PWR water chemistry guidelines, with several reporting benefits of \$40-\$150 million.

In general, products with broad applicability tend to generate more modest dollar benefits, though quantification results do vary widely. The same product might be assigned significant dollar benefits by a reviewer in one company and rated "not quantifiable" in another. The Clor-N-Oil® PCB detection kit is a good example. Of 15 utilities citing this product as being in actual use, 1 cited it as unquantified, but with a strong qualitative characterization of its benefit to the company. Other reviews assessed the benefits of Clor-N-Oil® in relation to the extent of the company's use (tracking somewhat the size of the utility), though estimates varied widely from a few thousand dollars to hundreds of thousands of dollars per year even for utilities of comparable size.

^{*}If this product had been originally split apart into several separate products, there would have been 8-10 users of each. This illustrates that the issues surrounding definition of products (and the small number of utilities in the sample) limit the level of detail at which it is appropriate to treat these data. Only general patterns can be reliably extracted.

Table 3a

BEST-SELLERS
WIDELY USED PRODUCTS

FUELS AND GENERATION

| | |
|--|----------------------------------|
| Acoustic monitors for nuclear power plants | Low-pressure turbine failure |
| ARMP nuclear fuel software | Nondestructive Evaluation Center |
| Boiler availability | PWR water chemistry |
| Coal gasification and combined cycle | RETRAN reactor software |
| Cycling fossil-fueled plants | Solid-particle erosion |
| Feedwater heaters and pumps | Steam turbine reliability |
| Human factors | Stress corrosion resistance |
| LOMI decontamination solvents | Superheater corrosion problems |
| | Valve tests |

TRANSMISSION AND DISTRIBUTION

- *Amorphous steel transformer
- *Clor-N-Oil® test kits
- *Contamination detector for distribution cables
- *Distribution planning and automation
- *Metal oxide surge arrester
- *PCB-disposal manual
- SF₆ puffer breaker
- Transmission line reference books
- Transmission line design software
- Substation-transmission line grounding
- *Wood pole treatment and repair

PLANNING AND END USE

- *Commercial cool-storage primer
- EGEAS software
- *Heat pump manual
- LMSTM (load management strategy testing model)
- *REEPS (residential end-use energy planning systems)

ENVIRONMENT

- *Air quality research in health effects
- Aqueous discharges
- Flue gas desulfurization chemistry and by-product disposal
- *Groundwater manual
- *PCB disposal manual
- Precipitator performance

*Products of particular interest to distribution-class utilities.

Clearly, a product might have solved a very expensive problem at one utility, have solved a less expensive one at a second, and be only under consideration for use at a third. Benefits were much easier to evaluate when a product application had been in place for some time. Some of these Best-Sellers were responsible for very large benefits, which means they also qualified as Big Winners.

Big Winners

Big Winners are those products found by one or more utilities to have very large benefits, on the order of millions or ten of millions of dollars. An analysis of the total benefit figures shows that each utility, without exception, found that between 60 and 90% of its benefits are due to as few as 5 to 15 products. Table 3b shows a list of some of these products. Notably, only a few of these products played a big-ticket role at more than one or two utilities.

While many of the Best-Sellers mentioned earlier are in T&D, many of the Big Winners are in generation. This is consistent with the observation that generation tends to differ regionally, and from utility to utility, giving rise to differing technological needs. At the same time, a problem with a generating facility can involve a huge amount of money, so the benefits can be very large, while being quite specific to that situation.

In terms of future technology, though interest was high in the fluidized bed combustion and CGCC, only a few utilities reported large potential savings, as such estimates depend on the making of assumptions about future implementation and further on the utility's decision whether to include these necessarily more speculative benefits.

The RF torsional monitor, another Big Winner, had actual benefits reported in excess of \$7 million by four utilities, while a number of other utilities reported it as a future potential application. The database supporting extended PWR fuel burnup was credited with about \$30 million at one utility, and in-service inspection training played a big part in several utilities' total benefits.

A number of utilities considered the Fuel Inventory Model, a relatively new product, to be of potential interest, though five utilities said they were already using it, and two of these quoted benefits of \$5 million and \$8.8 million, respectively.

Table 3b

BIG WINNERS
LARGE PAYOFF

| <u>FUELS AND GENERATION</u> | <u>TRANSMISSION AND DISTRIBUTION</u> |
|--------------------------------------|---|
| Atmospheric fluidized bed | Amorphous steel transformers |
| Boiler availability | High-voltage direct-current technology |
| Coal-cleaning technologies | NGH/Sub-synchronous resonance damping scheme |
| Coal gasification and combined cycle | SF ₆ puffer breakers |
| Condenser modifications | Transformer diagnostic tools |
| FGD construction materials | Wood pole fumigants and repair |
| Generator RF monitor | |
| Generator torsional monitor | |
| Induction heating process | |
| In-service inspection training | <u>PLANNING AND END USE</u> |
| Steam generator corrosion protection | COMMEND (commercial end-use energy forecasting model) |
| Steam turbine availability | Commercial refrigeration |
| Water chemistry guidelines | Fuel inventory model |
| Plant life extension | |
| | <u>ENVIRONMENT</u> |
| | Acid deposition research |
| | FGD chemistry |
| | Solid-waste environmental studies |

As this Big Winner pattern (i.e., products showing very large dollar benefits but at relatively few utilities) is so consistent, it tends to support the interpretation that large future potential benefits can be realized across the country if these products come to be used, to as great an effect, at more than just a few utilities.

Generic Industry Problems and Difficult-to-Quantify Products

Table 3c lists products that many utilities identified as having indirect (but often unquantified) benefits, as they address problems of industrywide concern; table 3d lists products to which many reviewers found it difficult to ascribe benefits, particularly those products of an informational character. These were frequently assigned very conservative dollar estimates or relegated to an intangible or unquantifiable category, as discussed below.

Table 3c

PRODUCTS ADDRESSING
GENERIC INDUSTRY PROBLEMS

ENVIRONMENT

Atmospheric physics-air quality
By-product study of PCBs
Electro-magnetic field effects
Solid waste leachates
Indoor air quality
PCBs: removal, worker safety,
toxicology, and disposal

FUELS AND GENERATION

Coal cleaning
Human factors
Instrumentation for monitoring
valve failures

TRANSMISSION AND DISTRIBUTION

Fail-safe surge arresters

Table 3d

DIFFICULT-TO-QUANTIFY PRODUCTS
(QUALITATIVE BENEFITS)

Construction lead time
Customer educational material
EPRI meetings
Handbooks, guides, reference manuals
Impact of EPRI R&D on regulatory and
legislative actions
Environmental programs (acid rain, etc.)
Information: seminars, newsletters, etc.
Laboratory facilities
(product life test evaluations)
Reliability improvements

C. Benefits Not Counted

Future Benefits

The benefits recorded during the Benefits Assessment Program, though substantial, represent just the tip of the iceberg. Not included in most of the quantifications, for instance, are the potential future benefits of current ongoing research. EPRI is developing many new products each year. However, the EPRI Benefits Assessment Program focused exclusively on completed R&D, in order to give the industry a benchmark from which to evaluate future results and to provide some measure of how successful or effective technology transfer efforts have been until now.

Options for the Uncertain Future

Future uncertainties for utilities raise the significance of R&D as a way of creating alternatives and options. Some options may be simply better information for planning, while others, as with new means of electricity generation, may be

critical to economic survival. Just reaching this stage after many years of work, for example, are gasification-combined cycle, fluidized-bed combustion, advanced heat pumps and amorphous steel, while further in the future are batteries for electric vehicles, highly efficient photovoltaics, advanced transformers, and improved power semiconductors.

There was frequent testimony from people in the utility industry on the importance of such R&D. During debriefing meetings, for instance, one of the utility coordinators said: "If you focus excessively on the ROI of past investment, and neglect the future, you begin to foreclose options. As options are closed off, utilities begin to relinquish control of their own destinies."

The Long View. "Counting only that which can be counted" excludes the importance of less tangible benefits and the value of work in progress.* The greater concern, however, is that such an approach obscures or distorts the relevance of long-range, high-risk research and might lead to an unwillingness to support R&D that is uncertain in outcome in favor of more certain prospective savings. Fortunately, this point was well appreciated by participants. There was often testimony from utility personnel stressing the need for long-range research and the value of indirect results. One utility report, for instance, says:

"This evaluation begins with a description of indirect benefits, e.g., reduced costs throughout the industry, enhanced technical skills, enlightened regulation and spin-off technologies. Such benefits are likely to be more significant than direct benefits like hardware and software, but indirect benefits are not reliably quantifiable, so they tend to be forgotten. To discourage such oversight, indirect benefits are given top billing in this report."

Industrywide Concerns. In addition to the difficulties encountered in evaluating indirect benefits, there was also hesitation in allocating shares of benefits resulting from research on industrywide issues. Major environmental issues, for instance--acid rain, solid-waste disposal, air quality, effects of electromagnetic fields, etc.--on which the industry expends considerable research effort, were usually put in an intangible or unquantifiable category by reviewers. Yet, everyone in the industry knows just how important these issues are to the economic health and perhaps survival of the industry (as we know it today).

*See, for example, chapter 2, "The Rational Model," in In Search of Excellence, Peters and Waterman, Harper & Row, 1982.

Sharing the Credit. Because many different R&D projects and programs contribute to greater availability and performance of plants and equipment, attempts to quantify EPRI's contributions were hampered because it is so difficult to pinpoint responsibility for specific improvements. Similarly, it is often difficult to apportion the credit when EPRI research has advanced the state of the art, making it possible for a manufacturer to go on to develop a product.

The Benefits Are More Important Than Counting Them

Each utility acknowledged the importance of these qualitative benefits, and everyone involved would have liked to find better and easier ways to include them. Perhaps, however, it may be of less concern that so many important kinds of benefits are simply not included, as long as the scope and direction of R&D, and the decision to fund it, are not subjected to a too-strict approach to benefit-cost.

D. Profiles of Utility Product Use

Five utility profiles are described briefly in the following pages. Though it was not a specific objective of the EPRI Benefits Assessment Program to study the different complexion of each participating utility, these profiles show that such analysis would be important in a broad technology transfer program. Size, geographic location, generation mix, special characteristics of the service territory, vintage of plants, load growth, management outlook on R&D, financial condition, current special problems, plans for future (or deferred) growth, timing--all factor into the product mix that is adopted. These factors clarify why certain products were Big Winners at this time and why others are expected to produce major benefits in the future. In short, though utilities do share many characteristics and generic problems, the benefits assessment results, as reflected in product use, demonstrate clearly that the utilities do not all face the same problems or opportunities. Thus, the Big Winners tend to be different from utility to utility and should differ over time in any individual utility as its needs and strategies change.

1. Pacific Gas & Electric. One of the largest utilities (14,224 MW peak), PG&E has a sprawling service territory embracing cities, deserts, and mountains, with a fast-growing population and with long lines strung out to acquire power by wire. A member since EPRI's inception, PG&E found that it has about 40% of known EPRI products in actual use. It

nevertheless, also found, as did almost all the participating utilities, that its benefits results were dominated by about a dozen of these products. In fact, only 13 products accounted for over two-thirds of total benefits, and a sizable fraction of that came from PWR water chemistry improvements plus the use of a computer model (CORA-II) of PWR corrosion transport. The delivery area also made strong showings with such products as pole stubbing, control of biological deterioration in wood poles, tree growth retardants, and zinc oxide surge arresters and transmission line design and testing (in anticipation of future transmission line construction). An aggressive program of adjustable speed motor drive installations and the use of Clor-N-Oil® PCB test kits were also clearly evident as part of this utility's strategy from the benefits projected from these products.

2. Carolina Power & Light. A very large utility in the fast-growing sunbelt Mid-Atlantic region, CP&L depends upon a combination of coal (66%) and nuclear (33%) (BWRs and PWRs) to meet its load requirements. With an aggressive conservation and load management program to reduce peaks and to defer new construction at least to the mid-1990s, CP&L found that the bulk of its benefits comes from the avoidance of plant shut-downs and increased efficiency and availability of its plants. The lion's share of the actual benefits in recent years (1981-1985) comes from a cluster of a dozen products all related to pipe cracking issues in a BWR. In addition, significant benefits in fossil plants (coal plants) come from the capability of carrying out power plant failure analyses and thus preventing lost megawatthours owing to tube leaks. Two other products on the Big Winners list have to do with analysis of turbine rotor remaining life (avoiding rotor replacements) and the use of EPRI safety-relief valve tests to meet Nuclear Regulatory Commission requirements. For the half-decade ahead, this same utility foresees a doubling of its benefits in these same broad categories (avoided plant shutdowns and increased efficiency and availability) plus benefits from better fuel inventory management. If the company elects to build a new coal power station in the 1990s,

it is likely to avoid going the scrubber route, since scrubbers are so costly, both in installation and maintenance. Thus, CP&L is closely following EPRI work on the new clean coal options--CGCC and fluidized bed combustion--although it did not attempt quantifications of the potential benefits of these options.

3. Virginia Power. Another very large IOU (8,895 MW peak) that also depends upon coal and nuclear (in this case a PWR) and has a small fraction in oil and other sources, this utility cites the majority of benefits stemming from improvements and refinements in power station operations but notes that large benefits were also realized in T&D operations. Virginia Power operates in three different states, with most of its customers located in a rapidly expanding urban corridor stretching from Washington, D.C., through Richmond to Hampton Roads, where it serves defense industry needs. In northern Virginia it derives its economic strength from government services, and in Richmond from a diversified and growing mix. All sectors--residential, commercial and industrial--jumped in the past two years, and the utility has experienced an above-average annual population and load growth rate. With a strategy of deferring major construction until the early 1990s, the utility planners look to load management, cogeneration, and research aimed at improving, extending, or refining power plant operations and at reducing T&D losses to meet the growing load needs. Nearly half the actual benefits come from the use of PWR water chemistry guidelines. Other Big Winners come from the use of gas-in-oil monitors on main step-up transformers, metal oxide surge arresters, chemical cleaning manual, creep life assessment techniques in boiler pressure parts, and changes in ASME code guidelines. In the future, this same utility foresees a wider range of products yielding benefits--e.g., amorphous steel transformer, which it plans to use for normal replacement and growth, various coal-related areas such as atmospheric fluidized bed, coal cleaning, vibration signature analysis, the cable follower, and others.

For this utility, as for many others, products related to the generation area are clearly paramount, but overall the delivery side also makes a good showing.

4. Moderate-Size Utilities. Among the moderate-sized utilities (2-6,000 MW peak), a number of different products were in the foreground, depending upon the generation mix of the company. One almost wholly dependent upon coal (NYSEG), found its Big Winner in a modelling effort associated with a new scrubber system. Another with a strong dependence on coal, but also with some oil and nuclear in its future (Pennsylvania Power & Light), found its Big Winner in the coal-cleaning techniques, followed closely by BWR operation training, an indication of its future concerns. It also made a serious effort to evaluate the benefits of EPRI's acid rain research products, which many utilities relegated to the intangible category. Still another moderate-sized utility (2,515 MW peak), Boston Edison, which draws two-thirds of its energy from oil and gas (no coal) and one-third from nuclear, serves a heavily populated urban-suburban area composed of 30 towns in the greater Boston area. It found that its major winners were a half-dozen products in the fossil generation area (having to do with boilers, condensers, feedwater heaters, pressure parts, etc.) and a major fraction in the nuclear area, most specifically with in-service inspection personnel training. This training helped BECo keep its Pilgrim nuclear plant on-line, deferring an outage for about six months while the company prepared for a regularly scheduled outage. Boston Edison stresses that its important benefits were not always in the big-dollar category, but in the broad cross section of the products being used.

5. Smaller Utilities (<1,500 MW peak). Among the smaller utilities, the individuality of Big Winners becomes even more pronounced, especially among those having little or no generation to take into account. For instance, one small utility (UPA) projected actual and potential benefits for more than 50 T&D products, having screened the electrical and delivery products with great care. There was also a good balance across environmental and relevant generation-related products.

The real Big Winner for that small utility arose not from delivery, however, but from its serious intent to manage future delivery with a product ideal for the harsh winters of its service territory--the low-cost heat storage furnace. For another small distribution utility (Athens Utility Board), load control was also a major issue (owing to rate structures for purchased power), but in this case it was load management planning. Among the very interesting Big Winner results was one smaller utility with a broad generation mix (Nevada) that found its major contributors in three forecasting and demand-side planning codes (REEPS, COMMEND and HELM). One of the company's major objectives, as stated in its final report, is "to continually improve design and operational techniques, to develop realistic models for load forecasting . . . and to develop demand-side management and conservation to minimize the need for building new generating facilities."

As of this time, the results of the EPRI-utility Benefits Assessment Program do not really provide a basis for assessing "market penetration." Given the fact that EPRI has managed thousands of projects since its inception in 1973 and given a major turn in direction around 1976-1978, when it began to emphasize more short-term, results-oriented R&D, the timeline of developing so-called products has really been only a half-dozen years. Even the definition of products, as indicated earlier, has been in rapid evolution over the past year and a half, as the list of 432 products grew to over 500, and the new 1986 product books show about 750 products (due in part to new products but also to a restructuring of the list based on the 1985 experience). The fact that there are now 750 products ready for application underscores the need for greater efforts at technology transfer--on the part of EPRI and on the part of the utilities--so that the entire electric utility industry can experience the leveraging impact of a centralized R&D organization.

E. The Future Potential of Benefits From R&D

The results as reported in the preceding pages point several times to the common theme of more benefits in the future. First, there was the doubling of the number of products cited when the potential category was added to the actual-use category. Whether in terms of the number of products at each company or in terms

of the higher penetration of the hundreds of products that were considered, the pattern is unmistakable. No one knows how high the curve in figure 2 could ultimately go, with the area under the curve representing the total market penetration attained.

Second, each utility's benefit totals are dominated by a few products, but not necessarily the same few products as at another utility. This result at least suggests that even a few more applications of these identified Big Winners could reap substantially higher dollar benefit totals across the industry.

Finally, there is the question of quantifying better. The unanimity across all participating utilities on the importance of the many indirect and intangible benefits of research again suggests that the overall benefit-cost results would be much greater if quantification dilemmas were solved. Ultimately, however, the issue is not in the benefit-cost ratios themselves, but in whether benefits are being realized. The answer on all counts is, once again, more attention by EPRI and utilities to technology transfer and to fostering innovation.

III. GENERAL CONCLUSIONS AND OBSERVATIONS

The 1985 Benefits Assessment Program provided a quantitative measure for the first time of the relevance and use of EPRI R&D by a cross section of the utility industry. The results indicate that:

- * Active utilities are getting a real quantifiable return on their investment in R&D as well as significant qualitative benefits.
- * The relative rate of return on R&D will increase over time with the wider application of both existing and new products.
- * Small utilities with limited resources can benefit from applying the results of a generic industry R&D program.

For the great majority of utilities that did not participate, there are some general observations which may be of interest. It appeared to the participants that utilities get more benefits from EPRI when they devote resources and priority internally to manage their investment in the R&D. Generally, these utilities have tried to ensure that communications, horizontal and vertical, are open, and have set up an internal organization for the purpose of technology transfer, assigning responsibility to a central coordinator who is aggressive and effective in identifying on an ongoing basis the right individuals and groups who are the potential users of specific R&D results. Also, there is usually an explicit companywide knowledge about the company's relationship to EPRI so that the utility staff feels a sense of participating in EPRI and takes advantage of having direct access to EPRI staff.

Finally, if the chief executive officer (CEO) of the utility vigorously and publicly expresses his support of R&D to the company's employees, they are more likely to implement innovations. Though this observation is not a measurable result of the 1985 Program, the impact of the CEO's attitude toward R&D was dramatically evident to the participants.

It is not clear that every single utility needs (or should wish) to carry out a full-fledged assessment (on its own or in cooperation with EPRI). The results of the 1985 Program can serve as a useful informational baseline or benchmark on which utilities can piggyback more modest in-house programs, as these results do represent the collective best judgments of several thousand engineers, managers, planners, plant operators, and other specialists in the industry. Though individual estimates on individual products may err on the high or low side, collectively the process produced a balance sheet of the benefits of a broad menu of R&D products, which indicates that a centralized, generically oriented R&D program is more than paying for itself now and potentially will do so even more in the future. The findings reported here for the 1985 program are being promulgated in several ways to ensure that the results become widely known throughout the utility industry.

Utilities may wish to consider another aspect of the Benefits Assessment Program. Though quantification by itself does not make technology transfer happen, an important by-product of the process is the raising of awareness within the utility about R&D products that are available to solve problems and to help address the utility's goals. Also, as the program goes forward, it becomes easier to identify means and opportunities to improve the utility's infrastructure for R&D utilization.

Based on the insights gained in 1985, and as one part of a more vigorous approach to technology transfer, EPRI will continue to support and develop the Benefits Assessment Program. In 1986 EPRI is already working with more member utilities. In each case, the goal is to tailor the program to the specific interests and needs of the utility, noting in particular whether the emphasis is to be on quantification or on goals for heightened awareness and utilization of EPRI products.

To make the process less burdensome and more efficient for utilities, and to make it possible for more utilities to undertake benefits assessments on their own (or with varying degrees of support from EPRI), work is continuing to streamline procedures and to orient the resource materials towards self-help.

Towards that end, EPRI has set goals for improvements in several areas:

- Product information which is clearer and easier to use.

- Revised worksheet forms with instructions.
- Guidance for reviewers on quantification techniques--tutorials and examples.
- Computer software to facilitate the product review process and quantification.
- Continued development of a database of product evaluations, as a tool to support utility programs and to enable EPRI to analyze product success.
- Strategies for utilities to follow-up on potential product applications on a continuing basis (with active EPRI involvement).

Progress has already been made on some of these items (as outlined in appendix D), as efforts continue on this evolving and important agenda for the industry.

INTRODUCTION TO THE APPENDIXES

This final report is designed to be read on a number of levels. The body of the report has provided an overview of the Benefits Assessment Program, its methods and resources, its major results in number of products adopted for use by utilities or projected for future use and an interpretation of these aggregate results, both in terms of dollar benefits and in product trends. There is also a listing of selected products (table 3) that could serve use as a more manageable starting point for a utility wishing to attempt a selective in-house benefits assessment.

Finally, these appendixes provide more detailed information:

- A--The actual Executive Summaries from the reports that were prepared by the individual participating utilities, showing their various perspectives, methods, and conclusions
- B--Extensive data on product assessment results, including Benefits database printouts for the entire 1985 Benefits Assessment Program
- C--A discussion of Benefit-Cost methodology
- D--Sample reference materials for future benefits assessments

Appendix A

Executive Summaries From the Utility Benefits Assessment Reports

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BENEFITS ASSESSMENT PROGRAM EXECUTIVE SUMMARY:
ATHENS UTILITIES BOARD

The Athens Utilities Board (AUB) along with 23 other EPRI members is participating in EPRI's Benefit Assessment Program. This program is part of a long-term plan for the transfer of technology and demonstration of benefit accrual to EPRI members as a result of their support of EPRI's R&D Program. Contained herein are the background and results of AUB's assessment.

EPRI offered to assist AUB in its internal review. Personnel from the Institute's Washington, D.C. and Palo Alto offices came to AUB in mid-November 1985 to discuss the program. It was determined at this meeting that AUB would look at the product lists in only three EPRI technical divisions--Energy Management and Utilization, Energy Analysis and Environment, and Electrical Systems. These three divisions encompass some 200 items/products out of 430 given on EPRI's then-current product list. The list of items was further reduced by setting aside those products related to TVA-provided services and activities. This reduced the product list to about 140 for first review.

AUB reviewed the items/products in order to quantify actual benefits realized to date by AUB as well as anticipated future benefits. All 140 items were reviewed by five members of AUB's staff (general manager, project manager, superintendent of operations, and project engineer) and it was found that 112 items warranted further investigation. Two AUB representatives then went to EPRI Headquarters (Palo Alto) in early December to meet directly with the various project managers and staff to assess and gather more information on the items under investigation. The results of this meeting reduced the number of products for final review to 50. It fell to the project manager and project engineer to evaluate the 112 items from the initial review, resulting in the reduction to 50 items, and then to conduct the benefits assessment on the final 50 items. The project manager gathered and assembled all the reports and data, and along with AUB's general manager produced the final report. This is in contrast to other utilities such as Virginia Power which had 27 coordinators and 135 reviewers involved in their benefits assessment program.

At AUB's request, Bill Coleman (EPRI Washington) meet with AUB staff on 1/8/86 to answer some final questions and to hear some of our results and comments. From the final review at AUB the list of 50 products was reduced to 31. These 31 products were placed into four categories. These categories are:

- (A) Products Currently 'In Use'
- (B) Products Definitely Planned Use for Future Use 'Future Certain'
- (C) 'Future Planned Use' Based on Post-Demonstration Results
- (D) 'Future Use' on a Need-Occurrence Basis Only

[Excerpts from text ...]

... In 1985 TVA formula contributions totaled \$27,915,985. TVA deducted 20% (\$5,583,117) for TVPPA and TVA research programs, and the remaining 80% (\$22,332,468) was sent to EPRI. The AUB's contribution for 1985 was:

$$\begin{aligned} & \$0.000226/\text{KWHR} * 439,317,330 \text{ KWHR} + 0.000920 * \$19,195,237 = \\ & \$99,258.72 + \$17,832.38 = \$117,118.10 \\ & 80\% \text{ of } \$117,118.10 = \$93,694.40 \\ & 20\% \text{ of } \$117,118.10 = \$23,423.60 \end{aligned}$$

... Because TVA performs generation and transmission services on behalf of AUB, much of the cost of AUB energy is attributed to TVA charges passed on in local rates. In fact, only 13% of AUB rates are attributable to Athens' own cost of service; 87% of Athens' electricity charges are directly attributable to TVA. ... Thus calculating the cost of the research which produced benefits directly to AUB, separate from any indirect benefits received through TVA, at 13% would come to \$12,145.07 instead of \$93,694.40 for 1985. ...

... It is AUB's opinion that at this time membership in EPRI is beneficial not only to AUB but to the industry as a whole and should be continued, but it must also be stated that more resources and research should be directed to solving problems, and developing equipment and operating strategies for utilities similar to AUB. ...

... These products are directly applicable to AUB and, therefore, of direct benefit to AUB customers, since operating costs are reduced whenever improvements are made to the AUB system. The combined value of category A and B benefits is \$535,360 over a five-year period beginning in 1985. The average annual benefits for the same period would be \$107,072, accrued from

implementation of EPRI products. This produces a five-year benefits-to-cost average of 7.98:1 for category A and B products combined compared to the average annual AUB-direct contributions assuming a 5% per year increase in contributions for the period 1985-89. ...

BENEFITS ASSESSMENT PROGRAM EXECUTIVE SUMMARY:
BOSTON EDISON

Boston Edison Company is an operating public utility engaged principally in the generation, purchase, transmission, distribution and sale of electric energy. The Company supplies electricity at retail to an area of approximately 590 square miles within 30 miles of Boston, encompassing the City of Boston and surrounding cities and towns. The Company was organized on December 26, 1885, and was incorporated in 1886. Thus, it is 100 years old and, indeed, it is presently (1986) celebrating 100 years of continuous service to its customers.

From its earliest years, and throughout the years since then, BECo has been and continues to be an industry leader in its commitment both to research and development and to helping the commercialization and bringing on-line of the innovative technologies and energy conversion systems which have helped and will help BECo and other utilities meet the (electrical) energy needs of its customers economically, reliably, with minimum damage to the environment and utilizing appropriate energy resources.

With this background of commitment to R&D and innovative technology development, it is not surprising that Boston Edison has, from the outset, also been a strong supporter of EPRI, both by its financial commitment and by its commitment to provide ongoing input and guidance to EPRI through the advisory committee structure. BECo personnel were actively involved in the formation of EPRI and have actively contributed since then in working with EPRI staff and other utility advisors to ensure that the programs which EPRI put in place did respond and continue to respond to the challenges and needs of the electric utility.

The Company also brings the employment of good business practices to its commitment to R&D, in that, while recognizing that not every R&D project carried out by central research organization, such as EPRI, is likely to be a winner or to have application for Boston Edison Company, it has the strong commitment to maximize the return on its R&D investment by utilizing as many as possible of the products resulting from EPRI's R&D programs and deriving bottom line benefits from

them. Thus, for a number of years the Company has had an active technology transfer program covering its R&D commitment and, especially, its investment in and commitment to EPRI.

It was against this background that BECo Chief Executive, S. J. Sweeney, in June 1985, accepted with enthusiasm the invitation of EPRI President, F. L. Culler, to become one of the EPRI member electric utilities participating in a formal Benefits Assessment Program covering the products which EPRI had produced over the years since 1973. The BECo executive and management team for the Program was appointed without delay and, following this, the Preplanning Meeting between EPRI and BECo management teams was held (in mid August). At this meeting the schedule was drawn up for the complete Benefits Assessment Program, including the Planning Meeting, the ranking of EPRI products, the completion of the Benefits Assessment Worksheets, the Profiling Workshop, the analysis phase, the Wrap-Up Meeting and the final report and follow-up.

One of the key meetings was the Planning Meeting which was well attended both by the coordinators of the involved departments and by the engineers who would be carrying out the assessments of the EPRI products. At this meeting, BECo President Sweeney made it clear that he strongly supported the Benefits Assessment Program, the prime goals or objectives of which were as follows:

- to make engineers throughout the Company aware of the resource that is EPRI--both its programs and projects which are directed to meet the needs of the utilities and the technical, advisory and consulting capability provided by EPRI staff,
- to demonstrate to BECo and to outside organizations, as appropriate and needed, that BECo is achieving a benefit-cost ratio greater than one and indeed, to help increase this ratio through the Benefits Assessment Program,
- to complement and help BECo's internal technology transfer program and to provide a snapshot in time of the effectiveness of this program with respect to EPRI, and
- to help broaden the horizons of BECo engineering and management personnel through greater awareness of the R&D process and an awareness of the real benefits that effective R&D programs can produce and should produce for utility companies.

The first major task under the Program was to rank or categorize all of the EPRI products in the EPRI Product List Publication. Then, Product Benefit Assessment Worksheets were completed for those determined to have at least potential interest

for BECo. In all, about 250 EPRI products were determined to have at least potential interest and application for BECo and about 350 Product Benefit Assessment Worksheets were completed and submitted on these products. These were distributed among the categories given below as follows:

| <u>EPRI Product Category Designation and Description</u> | <u>Number of Products</u> |
|--|---------------------------|
| A: EPRI Products - Actually in Use or Used by BECo | 72 |
| B: EPRI Products - Actual/Firm Plans for BECo Use | 30 |
| C: EPRI Products - Probable Use by BECo | 30 |
| D: EPRI Products - Possible Use by BECo | 99 |
| E: EPRI Products - Unquantified/Unquantifiable but Definite Benefits for BECo | 35 |

The following assumptions were used in calculating the benefits:

1. Adjustment for Inflation to 1985 Dollars: All benefit dollars were converted to 1985 dollars simply on the basis of the Gross National Product Implicit Price Deflator/Inflator.
2. Multiyear Benefits: For estimating multiyear or continuing benefits, in general, a conservative five-year benefit life was assumed.
3. BECo Contributions to EPRI: All of BECo's contributions to EPRI were also converted to 1985 dollars on the basis of the same Gross National Product Implicit Price Deflator/Inflator. In 1985 dollars, the total came to \$21,759,236.
4. Percentages of Benefits Assigned to BECo: Where the benefits to BECo were estimated to be less than or equal to \$5 million, all of the benefits were assigned to EPRI; however, where the benefits exceed \$5 million, only 50% of same was assigned to EPRI.
5. Benefits Difficult to Estimate/Quantify: Where it was difficult or impossible to estimate or quantify the benefits to BECo from an EPRI product, one of three actions was taken-- either no benefit was assigned (category E), the EPRI cost for the work leading to the product was used, or the cost of the report on the project to nonmembers of EPRI was used.

With these assumptions and inputs to the calculations, the benefits to BECo from the EPRI products listed in the categories noted above were estimated. These were as follows by category:

| | |
|----------------------|--|
| Category A | \$166,442,280 - In Use or Used |
| Category B | \$ 31,516,860 - Actual/Firm Plant to Use |
| Category C | \$ 11,171,290 - Probable Use |
| Category D | \$ 23,004,670 - Possible Use |
| Category E | Not Quantified/Quantifiable Use |

In turn, this enabled BECo to calculate the overall benefit-cost ratio for its commitment to and involvement in EPRI, namely, the total benefit to BECo from EPRI products identified through 1985, divided by BECo's total contribution to EPRI, also through 1985. In estimating this overall benefit-cost ratio, the Company decided that this (overall benefits-cost ratio) should be based only on those products which have been used or are being used by BECo, namely, those products in category A. It might be noted that, in addition to excluding the benefits to the Company from the products in categories B, C, D and E, this definition of benefits-cost ratio from the Company's involvement in EPRI does not take cognizance of the many other benefits which the Company has received and continues to receive through EPRI.

On this basis, a formal benefit-cost ratio of 7.65 was obtained for the Boston Edison Company involvement in and commitment to EPRI. This is a healthy figure indeed.

The product benefits contributing to it range in value from less than \$1,000 to greater than \$50 million and all of EPRI's six technical divisions are represented on the product list.

BECo's overall conclusion from its participation in the EPRI Benefits Assessment Program is that it was a tremendously worthwhile effort for the Company, one which produced many benefits, only one of which was the demonstration that BECo is obtaining a many-time-over return on its investment in and commitment to EPRI. Many factors contributed to this success of the EPRI-BECo BAP. Prime among these were the following:

- The real enthusiasm of BECo President and CEO S. J. Sweeney, and the fact that he communicated this enthusiasm in a clear manner, both through written communications and his comments at the Planning Meeting and the Profiling Workshop.
- The appointment of coordinators for each department which was involved in the Program, namely, those departments that had interest in or had application for any of the EPRI products.

- The enthusiasm and commitment shown by the many engineers in departments throughout the Company who were involved in ranking and evaluating the EPRI products and in completing the Product Benefit Assessment Worksheets.
- The help and guidance provided at all stages of the Program by EPRI staff and, in particular, by the EPRI team assigned to work with BECo on the Program.

Therefore, BECo is pleased indeed with its participation in the EPRI BAP and plans to incorporate regular updates of same into its Technology Transfer Program. Needless to say, it also recommends that every EPRI member company should consider participating in an EPRI Benefits Assessment Program. In spite of this, however, BECo has some reservations or concerns since, as presently structured, the EPRI BAP involves a very large, perhaps too large, commitment from both EPRI and the participating utility.

Therefore, while recommending that every EPRI member should indeed consider participating in an individual BAP, it is difficult to see how EPRI could carry out these individual BAPs for all its members and still fulfill its main duty or function, which is to carry out the central R&D program for U.S. electric utilities.

In turn, this leads to BECo's final conclusions and recommendations with respect to the EPRI BAP:

- Considerations should be given to holding Joint or Regional BAPs for groups of utilities.
- A detailed step-by-step BAP guide should be produced--for both first-time BAPs and repeat BAPs.
- The BAP process should be streamlined.

Overall, therefore, BECo strongly endorses the EPRI Benefits Assessment Program, but with the caution or reservation that the effort to carry out BAPs for member utilities should not jeopardize the continuation of EPRI's R&D Program for and on behalf of U.S. electric utilities.

BENEFITS ASSESSMENT PROGRAM EXECUTIVE SUMMARY:
CAROLINA POWER & LIGHT

This document describes an effort by Carolina Power and Light Company to characterize and quantify the levels of benefits derived from EPRI research completed to date.

This effort involved over 100 CP&L employees in a review of approximately 420 EPRI research products. This review screened these products and classified them according to actual use, potential use, and/or inapplicability. Of these 420 products, approximately 75 were assessed as having an actual or future use by CP&L and were subsequently selected for analysis of specific benefit and value.

This analysis was performed by Company personnel who were the actual users and/or beneficiaries of the research and it relied on their professional judgements and perceptions as to research value and benefit. Even though our assessment approach inherently excluded consideration of some important indirect benefits, the direct benefits quantified by our analysis were very significant in value.

Our assessment estimated that during the last five years (1981-1985), the Company derived a present value benefit of approximately \$91.2 million. This results in a discounted benefit-to-cost ratio of 2.9:1. During the next five years (1986-1990), our benefits assessment has estimated that we will realize benefits of approximately \$47.2 million from research already applied, and we have the potential for realizing total benefits approaching \$151.1 million from the application of all useful research completed to date. In that event, the discounted benefit-to-cost ratio would be 5.7:1.

BENEFITS ASSESSMENT PROGRAM EXECUTIVE SUMMARY:
CLEVELAND ELECTRIC ILLUMINATING COMPANY

FORWARD [BY SPONSORING EXECUTIVE VICE PRESIDENT]

Until about ten years ago, the electric utility industry had been a declining cost industry. In real dollar terms the cost of our product has declined throughout most of our history. Real rate increases are recent phenomena reflecting the dramatic escalation of capital costs, fuel costs, interest rates and regulatory intervention during the past fifteen years or so. The key to this long experience with declining costs has been technical progress. I am confident that technical progress will further enhance the value of our product by controlling production costs and improving the effectiveness and scope of end uses.

However, technical progress does not come easily or cheaply. This is a technically mature industry which is pushing at the frontiers of science and engineering. It is not practical or effective for individual companies to work toward independent solution of the many and difficult problems that need to be addressed. Thus, the industry created the Electric Power Research Institute, a unique experiment in cooperative research sponsorship. The Illuminating Company has supported the EPRI concept since its inception and the Company's executives continually challenge its employees to exploit the results of EPRI-sponsored research.

I have been pleased, though not surprised, as I have watched the result of this study develop. It shows that EPRI is clearly a sound investment, yielding great dividends for the industry and its customers. I encourage EPRI management to find in these results a note of appreciation and a challenge to do even more. I encourage our own employees to make EPRI a success by their continued support.

EXECUTIVE SUMMARY

In July of 1985, Cleveland Electric Illuminating Company (CEI) was asked by EPRI to participate in an intensive program to evaluate the benefits of EPRI membership. Some 50 CEI specialists and 12 EPRI representatives joined forces in a workshop in late September to begin to quantify those benefits. This evaluation is a continuing effort as new EPRI products and new needs develop daily. This report describes the general nature of EPRI membership benefits and provides an estimate of the value of specific, identified benefits. These results will be combined with results from other members in a report by EPRI staff to the EPRI Board of Directors.

This evaluation begins with a description of indirect benefits, e.g., reduced costs throughout the industry, enhanced technical skills, enlightened regulation and spin-off technologies. Such benefits are likely to be more significant than direct benefits like hardware and software, but indirect benefits are not reliably quantifiable, so they tend to be forgotten. To discourage such oversight, indirect benefits are given top billing in this report.

An expected value approach has been used to quantify benefits of the direct application of EPRI research results. Reviewers were asked to estimate anticipated or realized benefits and the probability that this estimated benefit level will be (or has been) realized. The product of these terms is the expected value or expected benefit.

The total expected benefit for projects yielding "modest" benefits is \$54,000,000. In addition, major benefits can be claimed with high confidence for BWR pipe cracking prevention (\$50-75 million), hydrogen control (\$9 million) and automated distribution planning (\$10 million). The total of these, \$123-148 million, is a likely range for direct benefits of our EPRI membership to date. CEI investment in EPRI to date is about \$35 million. Thus, the direct benefit, is likely to be at least four times the investment.

Possible additional savings could result from the use of SO₂ control research (\$55 million), decay heat removal (\$50 million) and gasification combined cycle (\$925 million). This last estimate credits EPRI with the total projected savings for IGCC over a conventional plant. EPRI's role in encouraging that technology is undeniably crucial, but some might argue that only a portion of the \$925 million is fairly attributable to EPRI.

A more detailed summary of these results is provided in figure 1, a probability distribution of EPRI benefits. That figure shows a realized benefit (100% probability) of about \$25 million and a 95% probability of 475 million. Benefits on the order of \$100 million are very likely and there is a 50% probability of benefits in the range of \$250 million. The huge total benefit of \$1.2 billion at 25% probability reflects the generous assessment of EPRI's role in IGCC technology. For those who are not comfortable with that assessment, the lower line shows the probability distribution without IGCC-related benefits. This lower line suggests a benefit limit of about \$440 million.

While the benefit estimates used for this analysis are approximate and the probabilities are subjective, the results support a very strong vote of confidence for continued EPRI participation. Many EPRI products are finding practical application at CEI and the Company is well tied in to the continuing stream of new products. Our participation in this benefits assessment program has actually strengthened those ties.

BENEFITS ASSESSMENT PROGRAM EXECUTIVE SUMMARY:
CONSOLIDATED EDISON

The Electric Power Research Institute (EPRI) was established in 1972 to perform scientific research relating to the production, transmission, distribution and utilization of electric energy. EPRI is funded primarily through payments by members, and Consolidated Edison (Con Edison) has been an active participant since its inception.

A Benefits Assessment Program was initiated in May 1985 to determine the value to Con Edison from participation in the EPRI program. Results of this assessment indicate that 60% to 70% of EPRI's strategic research elements contained in its 1985 R&D Program Plan apply to the Company's goals for 1985 and are important to current operations. The assessment also indicates that 65% to 80% of EPRI's strategic research elements are supportive of key objectives of the Company's Electric System Planning and Business Strategy and, therefore, are important to the future of the Company.

An assessment of the value of research products produced through 1984 indicates that a saving of about \$69.2 million has been achieved, reflecting a cost benefit ratio of about 1.6 to 1 when compared with the \$44 million the Company invested in the research from which the products were developed. This cost benefit does not include the value of products which could not be quantified.

Lastly, there are many other important but less direct benefits to the Company from its support of and participation in the Electric Power Research Institute, including the ready availability of technical experts and a credible, ever expanding body of scientific knowledge that can be used in numerous and varied settings for the benefit of the Company and its ratepayers.

BENEFITS ASSESSMENT PROGRAM EXECUTIVE SUMMARY:
DELMARVA POWER & LIGHT

An assessment of the cost effectiveness of EPRI research as applied at Delmarva Power & Light Company was conducted between November 1985 and February 1986. The program had three objectives:

- To promote and enhance technology transfer at Delmarva Power.
- To quantify and evaluate the cost effectiveness of our investment in EPRI.
- To provide feedback to EPRI for program evaluation.

All objectives were met. The benefit quantification results indicate that Delmarva is currently earning positive returns on its investment in EPRI and is expected to continue doing so. Moreover, future benefits are expected to be significantly greater relative to projected membership dues than benefits to date; therefore, returns are expected to increase. In addition, other important nonquantifiable benefits were identified.

[Excerpted from report ...]

CONCLUSIONS

Over 400 EPRI research projects were reviewed by Delmarva's technical staff. In doing so, it became evident that a significant level of awareness was present in most functional areas prior to the exercise. However, in certain areas the process did provide increased exposure to EPRI's work and led to an improvement in the ways that EPRI results are disseminated in the Company.

The program identified 59 EPRI products that have or have had an economic value to the Company, eight that will in the near future and 122 that potentially could. In addition five products were identified as being applied at the Salem plant by PSE&G.

Considering only the 59 products that have provided benefits to the company to date produces a benefit-to-cost ratio of roughly 1:1. The results suggest that it took nearly ten years to realize fully the benefits of EPRI membership and that we have entered a period where benefits will substantially exceed our investment. When the additional benefits of anticipated or potential product applications (tables 2 and 3) and the benefits realized at the Salem facility (table 4) are considered, it is clear that Delmarva's membership in EPRI is a cost-effective use of funds.

Irrespective of cost-benefit considerations, Delmarva and the utility industry benefit in other, intangible ways from EPRI's existence. Such nonquantifiable research benefits are real and should not be overlooked in an assessment exercise such as this.

BENEFITS ASSESSMENT PROGRAM EXECUTIVE SUMMARY:
FLORIDA POWER & LIGHT

This report presents the results of a nine-month project to perform a general assessment of the benefits and costs of research products from the Electric Power Research Institute (EPRI) to Florida Power & Light Company (FPL). The project was directed by FPL's Advanced Systems and Technology Department (Research and Development) and supported by twenty-two Company departments plus staff from EPRI.

EPRI has been in existence a little over 13 years and has expended over \$2.2 billion in research. This work has resulted in some 437 research "products" for its electric utility members. Since joining the Institute, the Florida Power & Light Company has given EPRI \$72.9 million (1975-1985) or roughly 3.3 percent of the EPRI annual budget.

QUANTITATIVE FINDINGS

- 84 percent (368) of EPRI's research products have already produced benefits or are projected to produce benefits for FPL
- Total Realized Benefits to date from products Now in Use are estimated to equal \$132 million
- Projected ongoing Benefits from Products Now in Use equal \$626 million (present value)
- Total Present Value of all benefits (past and projected) equals \$989.5 million for an overall benefit/cost ratio of 13.6

QUALITATIVE FINDINGS

- FPL participation in the EPRI program is successfully contributing to the control of costs and risks, the resolution of environment and safety issues and the improvement of profitability in both the short and long term.
- EPRI-developed products are supporting other FPL research, engineering and analyses and providing Company engineers and managers a basis for more factual plans and decisions.
- Many Institute products have given FPL a basis for resolving potential operating, regulatory and planning problems before they become issues capable of adversely impacting the Company.

The study methodology involved development of benefit estimates using a simple one-page benefits assessment process. In addition, FPL performed discounted cash flow analyses where possible. The assessments identify both quantitative and qualitative benefits from EPRI products which are Now in Use, those which will have Probable Immediate Use and those which will have Probable Future Use. The project also identified those products which have No Application to FPL.

The study was designed to complement similar studies being done at twenty-three other electric utilities and will form the basis for follow-up work at both FPL and EPRI to further improve the long-range benefits of the Institute's work for FPL and its ratepayers as well as for other EPRI members.

BENEFITS ASSESSMENT PROGRAM EXECUTIVE SUMMARY:
HOUSTON LIGHTING & POWER

Many readers will recall a time when the Electric Utility Industry was subjected to severe public criticism because of its alleged negligence of research activity. As a result of the work of EPRI, that form of criticism is no longer heard. However, the Industry was never intended to be a philanthropic organization; on the contrary, its survival depends upon the profitable rendition of satisfactory service at an acceptable cost. Prudence requires that the relation between costs and benefits of EPRI research be kept under surveillance by the Management of a Utility.

This assessment of EPRI benefits is presented in three sections. The first one is described as a Macroscopic View. It attempts to place the subject of Research Benefits in broad perspective, and it encourages the reader to maintain contact with the realities of life when research is evaluated.

The second section, in contrast, is described as a Microscopic view. It describes several EPRI projects which have produced either certain short-term benefits suitable for quantitative expression, or else a potential for long-term benefits which are anticipated with such confidence that their values can be projected realistically in monetary terms.

We have selected only ten varied projects for the Microscopic View, and have demonstrated substantial individual benefits from these. There are presently over 1500 active EPRI projects. The cost of a comprehensive benefits assessment covering all of these would be prohibitive, and its value would be questionable.

The third section is a copy of the March 1985 presentation to the EEI Research Management Committee on the subject, "Assessing the Benefits of EPRI Research," by W. M. Menger of Houston Lighting & Power Company. Some duplication exists between the March 1985 presentation and section 2, the Microscopic View.

Although the Microscopic View is by far the more concise of the first two sections, no assessment can be considered to be fair or complete unless the more nebulous but nevertheless important Macroscopic View is kept in mind. Both aspects of research evaluation are commended to the reader.

BENEFITS ASSESSMENT PROGRAM EXECUTIVE SUMMARY:
LINCOLN ELECTRIC SYSTEM

The EPRI Benefits of Membership Assessment contained herein was undertaken to determine what the benefits-to-dues ratio was for 1985. The compiled information illustrates that continuing EPRI membership is fully justified.

The benefits-to-dues ratio for 1985 was 1.18 to 1, with Lincoln Electric System (LES) receiving \$390,298 worth of benefits to its \$330,402 dues investment. All benefits which were quantifiable were calculated on the Actual Cash Flow Savings to LES in 1985 or by the Annual Equivalent (Present Worth) Value of Extending the Life of Newly Installed Equipment. For actual cash flow savings, including one-time savings amortized over the life of the product, the carrying charge for transmission and substation equipment is 12% (6.5% interest, 2.5% depreciation, 2.5% O&M, 0.5% A&G). For distribution equipment we use our carrying charge of 15% (6.5% interest, 4% depreciation, 4% O&M, 0.5% A&G). For models, reports, and software we use the capital recovery factor of 25% (7.5% interest, 5 years).

Actual Annual Cash Flow Savings for 1985 amounted to \$314,803 and included utilizing 17 different EPRI products (pgs. 4 & 5). Annual Equivalent (Present Worth) Value of Extending the Life of Newly Installed Equipment amounted to \$75,495 and included utilizing three EPRI products (p. 5).

Two other categories were quantified but weren't included in the benefits-to-dues ratio because they either haven't been utilized or continuing future uses are merely speculative. Seven future projects identified (p. 6) have a Potential Annual Average Savings of \$901,500 and six future projects identified have a Potential One-Time Savings of \$865,000. Some of the products and projects benefits will undoubtedly be included in future assessments.

There are numerous categories of benefits which are non-quantifiable at this time. The major one included benefits derived at Cooper Nuclear Station utilizing EPRI-developed technology, even though Nebraska Public Power District, as operator of the plant, is not an EPRI member. Identified savings, for which LES is

currently requesting assistance from Nebraska Public Power District, could amount to million of dollars. A similar situation exists with regard to the Laramie River Station. Also, benefits derived from EPRI work in the environmental area are not quantified because of the difficulty of determining the cost of not having to comply with legislation or regulations because research showed they weren't necessary, for example.

The report contained herein makes three recommendations. They are:

- (1) Nebraska Public Power District and Basin Electric Power Cooperative should receive continuing encouragement from LES to become EPRI members;
- (2) A system to transfer EPRI technology more directly to LES staff should be developed and implemented. This project is currently underway through the office of the EPRI Technical Information Coordinator; and
- (3) This assessment should be an ongoing effort in order to continually monitor EPRI performance and analyze if continued EPRI membership is providing positive benefits to LES.

BENEFITS ASSESSMENT PROGRAM EXECUTIVE SUMMARY:
NEVADA POWER COMPANY

The assessment of Nevada Power Company's benefits of EPRI membership contained herein was undertaken to determine what the benefits to dues ratio was for 1985. The results of the study illustrates that continuing EPRI membership by Nevada Power Company is fully justified.

The benefits-to-dues ratio for 1985 was 3.0 to 1, with NPC receiving \$3,716,798 worth of benefits to its \$1,220,840 investment. All benefits which were quantifiable were either estimates of annual savings or one-time benefits in 1985.

Estimated annual savings for 1985 amounted to \$258,904 resulting from the application of 24 different EPRI products. One-time savings for 1985 amounted to \$3,457,894 and included utilizing 16 different EPRI products.

Two other categories were quantified but weren't included in the benefits-to-dues ratio because the associated products either haven't been utilized or continuing future use of these products is speculative. Application of 52 products in the future has a potential annual average savings of \$1,081,831 and 44 future products identified have a potential one-time savings of \$1,815,240. The benefits of these products will be included in future assessments.

There were 43 products which were judged to have either intangible benefit or unquantifiable future benefit. Further analysis will be done where possible to identify both quantitative and qualitative benefits of these 43 products.

The report contained herein makes two recommendations:

1. NPC staff should be made more aware of EPRI technology developments. This could be accomplished by having NPC's Technical Information Committee meet on a quarterly basis and by having NPC staff become more involved in the EPRI advisory structure.

2. EPRI performance should continually be monitored to determine if EPRI membership is providing positive benefits to NPC.

BENEFIT ASSESSMENT PROGRAM EXECUTIVE SUMMARY:
NEW YORK STATE ELECTRIC & GAS

EXECUTIVE FORWARD

As a result of a recommendation from EPRI's Board of Directors in early 1985, EPRI's Industry Relations & Information Services Group embarked upon a very ambitious effort aimed at performing Benefits Assessment Workshops at approximately two dozen utilities during 1985.

New York State Electric & Gas Corporation (NYSEG) was fortunate to be selected to receive one of these in-depth benefits reviews.

At the very outset, NYSEG wishes to commend EPRI for their good judgement in deciding to focus in on this area of concern. We implore EPRI to continue this effort, probably at a somewhat reduced level. Perhaps it could be said that the utilities should do this on their own and, hopefully, this will evolve but, until it does, we hope that EPRI will keep up the pressure in this most important area of transferring technology.

Due to NYSEG's very close working relationship with EPRI's IRIS Division, EPRI knew ahead of time that NYSEG has had a very active technology transfer system in place since 1982. EPRI was also familiar with NYSEG's Electric Research Value Assessment (ERVA) document. The ERVA program is a method of documenting the value to NYSEG of its application of finished research products (internally and externally developed). This continuously updated document has been in active use since early 1984.

Previous to the Benefits Assessment Workshop, NYSEG thought its benefits to funding ratio was 1/1. When EPRI's concerted efforts with NYSEG's people were completed, NYSEG's benefits to funding ratio was improved to 2/1. All of us who were active in this exercise are very pleased with this result.

EXECUTIVE SUMMARY

The purpose of this Benefits Assessment Workshop was to carefully review the array of EPRI finished products to determine their applicability to NYSEG's operations. As possible applications were located, they were assigned to a NYSEG person well experienced in the area of possible involvement.

When applications for EPRI products were located, they were either priced for the first time or located in NYSEG's ERVA document and the pricing was reassessed by the EPRI/NYSEG team. All value assessments have been amalgamated and appear in a later section of this report titled NYSEG's Assessment of EPRI's Products.

At this point it should be stressed that NYSEG has resisted pricing "maybe" or "possibly next year" types of project applications. Our well-established ERVA document has priced only one future savings project because that one is practically guaranteed. All other priced applications at NYSEG are "hard dollar" evaluations - savings that did happen in the recent past and savings that are happening today.

The fact that NYSEG has chosen not to try to price possible future applications or useful research that is unquantifiable (such as acid rain research) does not mean that we are totally ignoring these two categories. We have a chapter in ERVA for both categories.

As mentioned in the Executive Forward, this 1985 Benefits Assessment Workshop doubled NYSEG's ratio of benefits divided by our average annual funding of EPRI.

Regarding NYSEG's recommended actions by either EPRI or ourselves in the area of improvements in technology development or technology transfer, we have the following to offer. EPRI has done a remarkably good job of investigating areas of our business that might be improved by successful R&D. The quality of EPRI's output has rarely been challenged to the best of our knowledge. The improvements in technology transfer that are so badly needed are primarily the responsibility of the individual utility companies, not EPRI. There is, however, one area of improvement that we do recommend to EPRI. It is trying to develop a means of identifying perceived real winners - that should be put to immediate use by utilities - as opposed to basic research, research that failed to solve the problem, and research that might some day be put to use. The problem is all EPRI reports look the same. In other words, real (can use today) winners need to be highlighted at the final report stage.

BENEFITS ASSESSMENT PROGRAM EXECUTIVE SUMMARY:
NORTHERN STATES POWER COMPANY

Northern States Power (NSP) Company was one of over twenty utility companies who participated in this EPRI Benefits Assessment Program (BAP). Employees from virtually every operating department participated and played the key role in the completion of this intensive assessment effort. Each EPRI product was reviewed and evaluated by the appropriate employee closest to the company operation where that product was or could be used.

Of the 453 products reviewed, about 60% were useful in one way or another - previously used, currently in use, or with future potential for use by NSP.

In total one-time benefits of \$38,540,000 and continuing benefits of \$36,970,000/year were identified. While the continuing benefits may be realized over varying lengths of time, at least 3 years can be assumed as a conservative average for all. In this way we can identify almost \$150,000,000 in total benefits from EPRI R&D.

NSP has received many intangible benefits from the relationship and interplay with other utilities and EPRI technical personnel through our involvement in advisory groups and hosting of selected projects of special interest to our company. Continuance of such activity will keep our personnel on the cutting edge of technology research and development and better prepare us for utilizing an appropriate technology in our operations as it becomes commercially available.

This BAP activity has helped to develop an increased awareness and appreciation of the potential value of using EPRI R&D results in all areas of NSP operations.

The internal communications network established and experience gained in reviewing and evaluating EPRI R&D products in this BAP can be the basis for the establishment of an ongoing EPRI products assessment process.

It is apparent that from here on, in addition to our dollar contribution, NSP must continue to take an active part in EPRI's program--both in contributing to the planning and execution of its research and development mission and in making certain that the results get to the people who can evaluate and apply them.

BENEFITS ASSESSMENT PROGRAM EXECUTIVE SUMMARY:
PACIFIC GAS & ELECTRIC

The Pacific Gas and Electric Company (PG&E) conducted a Benefits Assessment Program between October 1985 and March 1986 to measure the value of Electric Power Research Institute (EPRI) research results.

Coordinators from twenty-four departments and each of the six regions synchronized the review efforts of two hundred fifty-six reviewers from the General Office, the six Regions, the Diablo Canyon Power Plant, and the Department of Engineering Research. EPRI supplied a descriptive listing of four hundred thirty-two research products available for use. Evaluation workshops were conducted at the PG&E (Company) General Office in San Francisco on November 25, 1985, with the support of fourteen EPRI specialists.

PG&E reviewers submitted over eight hundred fifty benefits assessment worksheets. The benefits assessment staff consolidated these reviews and conducted follow-up interviews with reviewers to further substantiate the evaluations.

One hundred seventy-one research products, out of the four hundred thirty-two submitted for evaluation, were found to be in actual use by the Company. Over half of these have been used as reference material. The Company plans to begin using twenty-nine other research products during the next three years. Fifty-nine products are also being considered for use. One hundred seventy-seven have potential for future consideration in the Company. About a hundred of the potential uses are additional applications of products the Company is already either using or planning to use. Ninety-eight products were of no recognizable benefit to the Company; forty-five of these applied to operations not relevant to the PG&E system.

This detailed study revealed that PG&E is receiving benefits well in excess of its contributions to EPRI. The ratio of benefits to costs ranges from 1.5:1 to 5.0:1 depending upon whether conservative or optimistic estimates of benefits are chosen. In addition, the Company can expect to gain significant additional

benefits from research work in progress. The Company and the industry also receive indirect benefits from EPRI that are discussed, but were impossible to quantify in a study such as this.

The Benefits Assessment Program provided documentation of actual and planned uses of EPRI research and identified products with potential benefits for future follow-up. The Company's technology transfer program was strengthened through participation in the Program.

BENEFITS ASSESSMENT PROGRAM EXECUTIVE SUMMARY:
PENNSYLVANIA POWER & LIGHT

INTRODUCTION

The Electric Power Research Institute was formed in 1972 to respond to government pressure to initiate a joint utility research effort. After EPRI was formed, it took several years to organize, get projects underway and begin to produce project results. Thus, 1985 marks about ten years of results from EPRI research projects. It is fitting that we review the value of these projects to PP&L from the standpoint of past benefits prior to 1985, those specifically gained during 1985, and projected future benefits of these projects for a period of at least ten years into the future.

Early in 1985, the Board of Directors of EPRI asked for an assessment of the benefits to utilities from the research projects done by EPRI. EPRI's Industry Relations and Information Service Group developed a systemized approach and conducted benefit assessment workshops to aid utilities in this endeavor.

PP&L embarked on the benefits assessment effort in October, 1985, with the objective of having the final report completed during the second quarter of 1986.

SUMMARY

The individual utility contributions to EPRI are based on a formula that includes the gross revenues and the kWh sales of each utility. PP&L has contributed a total of \$32,291,617 from EPRI's inception (1972) to the end of 1984. The 1985 contribution to EPRI (\$4,884,214) was assigned to TMI cleanup. The future PP&L contributions will change as PP&L kWh sales and gross income change of by some adjustment in the EPRI formula. It is anticipated that there would be a gradual increase in the PP&L contributions.

The cost of EPRI to PP&L (PP&L's commitment to EPRI) from 1972 to 1984 inclusive was:

| | |
|-----------------------------------|------------------|
| | \$32,291,617 |
| 1985 commitment (diverted to TMI) | <u>4,884,214</u> |
| Total | \$37,175,831 |

For the last several years, PP&L has made its own benefits assessment of the major EPRI projects benefitting PP&L. The benefits of only the major projects in 1985 almost equalled PP&L's contributions to EPRI.

The EPRI Benefits Assessment Program (BAP) analysis, which was a much more thorough analysis and included all EPRI projects completed by the end of 1985, showed a ratio of about 1-1/2 to 1 for PP&L benefits to cost during 1985. In addition, a benefit-to-cost ratio of over 2 to 1 per year for PP&L from 1986 on was projected for those projects completed by the end of 1985. These projected benefits are a result of research money already spent.

The benefits assessment evaluation process was completed by PP&L people with guidance from EPRI personnel. A very conservative approach was taken to evaluate the benefits, especially for those projects whose results are expected to be utilized over the period 1986 to 1995 inclusive.

The benefits accrued to PP&L:

| | |
|---|-----------------|
| prior to 1985 are about: | \$ 10.5 million |
| during 1985 are about: | \$ 7.0 million |
| from 1986 to 1995 inclusive are in excess of: | \$101.9 million |

The total gross benefits to PP&L derived to date plus PP&L's future expectations from the completed research are:

$\$10.5 \text{ million} + \$7.0 \text{ million} + \$101.9 \text{ million} = \119.4 million

Although the net benefits to PP&L from EPRI to date (end of 1985) are a negative number ($\$17.5 \text{ million} - \$37.2 \text{ million} = \$19.7 \text{ million}$), the next ten years of PP&L benefits from the completed research will far outweigh the costs to date:

$\$119.4 \text{ million} - \$37.2 \text{ million} = \$82.2 \text{ million net benefit to PP\&L's customers}$

[Excerpted from report...]

CONCLUSION

Only 20 to 30 years ago, suppliers of equipment to utilities did their own research and were in constant contact with utilities to find direction as to the needs of the utility industry.

Increased competition within this country and from world markets forced more competitive pricing, and thus, American manufacturers gradually got out of utility-oriented research work.

EPRI has partially filled this research vacuum, providing both direction for the utility research efforts and funding for individual research projects. Without EPRI or a similar organization, there would be very little effort focused on utility research needs.

In assessing the benefits from EPRI, it is a relatively easy task to evaluate specific completed projects in relation to their past worth to a specific utility. It is not as easy to evaluate the EPRI projects' future worth and probability of use of these projects. It is next to impossible to place a dollar value on the EPRI-coordinated utility effort that is focused on research. However, it is this latter effort that provides utilities with the direction and momentum which is not possible to achieve with only individual company effort.

Economic pressures plus pressures from utility regulatory bodies are making it difficult for utilities individually to plan for the future. The benefits assessment of EPRI projects provides a vehicle for justification to continue participation by PP&L in a coordinated research effort.

For PP&L, the EPRI benefits are adequate to project a continued increase in the ratio of benefit to cost for some time into the future.

If the total expected value of benefits to PP&L from EPRI projects completed to the end of 1985 (\$119.4 million) is divided by the total EPRI costs to PP&L by the end of 1985 (\$37.2 million), the benefit-to-cost ratio exceeds 3 to 1.

Therefore, it is anticipated that the benefit-to-cost ratio, which is about 1-1/2 to 1 for 1985, will gradually increase to and maintain a value greater than 3 to 1 in the future years.

RECOMMENDATIONS

The results of the EPRI/PP&L Benefits Assessment Evaluation lead to the conclusion that EPRI should continue to be supported by PP&L.

The projection of at least 3 to 1 benefits-to-cost in the near-term future should be sufficient evidence to pass the scrutiny of the Pennsylvania Public Utility Commission or any other group or agency seeking justification for these research expenditures.

If EPRI were to close its doors because of lack of utility participation, utilities such as PP&L would have to form some kind of research group to get major research projects accomplished. Without a joint research group, the duplication of research efforts would make research prohibitively expensive and therefore, few, if any, major projects would be done.

EPRI is a viable utility-supported research organization. If it is not as efficient as we would like or if it is not choosing projects according to PP&L desires, then it is up to PP&L representatives that interface with EPRI to insist on efficient operation of EPRI and clearly express PP&L's research needs to EPRI.

Therefore, I recommend that we continue PP&L's participation as a supporting member of EPRI and make every effort within PP&L to improve EPRI's effectiveness as a utility research organization and to improve the transfer of technology from EPRI projects to benefit PP&L.

BENEFITS ASSESSMENT PROGRAM EXECUTIVE SUMMARY:
PUBLIC SERVICE ELECTRIC & GAS COMPANY

Through this EPRI Benefits Assessment Program it was determined that PSE&G is utilizing, or has definite plans during 1986 to utilize 124 EPRI research products. This includes 2 products which were not on the original list provided by EPRI. This total is 28 percent of the 432 products EPRI made available for review. The total number of products in use or under current consideration for future use equal 35 percent of all products available for review.

It is expected that the benefits assessment process will be on-going. This report may not include the benefits for every EPRI product currently in use at PSE&G. Some benefits were identified after the deadline imposed for this report. These benefits will be included in a subsequent report.

It is estimated that between the years of 1973 and 1989 products now in use will save PSE&G approximately \$240,200,000. From 1986 through 1989 there is also the potential for an additional saving of \$6,000,000 from the application of products currently under consideration for use. Together, these two categories total \$246,200,000. An additional saving of as much as \$5,000,000 is possible through 1989 from the utilization of products which are not now under consideration for used, but which have potential for future consideration.

Throughout this report all dollars are expressed as current-year dollars, and were converted from 1985 dollars using the table reproduced in the Appendix. In some cases, totals may not agree due to rounding. In cases in which EPRI products are utilized by PSE&G on jointly-owned facilities, the PSE&G benefit is prorated for that portion of the facility which we own.

The ratio of the benefits already obtained 1973-1985 (\$129,450,000) to the cost of membership dues paid during the same period (\$57,927,000) is approximately 2.2:1. This does not include benefits from report literature, attendance at seminars and workshops, and membership on the EPRI advisory committees. This ratio increases to 4:1 when existing and future benefits through the year 1989 are included (\$246,200,000).

BENEFIT ASSESSMENT PROGRAM SUMMARY:
PUGET SOUND POWER & LIGHT CO.

INTRODUCTION

Over the past decade, electric utilities have endured escalating capital and operating costs resulting in significant upward pressure on customer rates. While some of the factors that contributed to these increases have abated, new technological and business challenges now face the industry. Not the least of these new challenges is how to respond to the technological and methodological innovations that are now available to improve the reliability of our systems, increase margins of safety, enhance efficiency, protect the environment and reduce cost. Many of these innovations have resulted from research, development and demonstration work done through the Electric Power Research Institute.

In 1985, Puget Sound Power & Light Co., in an effort to quantify the benefits of EPRI research, undertook a broadly based investigation of more than 450 individual EPRI research "products" to determine the extent they were being applied to benefit the Company and its customers. Over 50 Company employees assisted in evaluating "products" and members of the EPRI staff offered an analysis framework and guidance. The analysis was completed in April, 1986.

DISCUSSION

Although EPRI was founded in 1972 and research projects were initiated shortly thereafter, results in significant quantity did not begin to emerge until around 1978. Also, in the initial EPRI plan, the emphasis was on long-range problems. Because of these two factors, early benefits were difficult to document.

However, recognizing the importance of benefiting current utility customers, EPRI changed its emphasis to nearer-term results in the late 1970s. The combination of the flow of results from earlier projects and near-term emphasis for new projects has produced an increasingly large pool of beneficial information and products that is now being assimilated by the industry. Some of these results have been incorporated into Puget Power's system already and many more will be utilized in the future.

In addition to results used directly by Puget Power, many suppliers are now incorporating EPRI study-derived improvements in their products. Although indirect, these benefits flow through to customers in the form of a more reliable and efficient electrical supply.

Finally, and more subjectively, is the increased knowledge and information base that is becoming available to utility planners and engineers. Many more alternatives exist now than the industry can rapidly assimilate. But, over time, concepts developed by EPRI will be indirectly integrated into standard utility practices as new knowledge becomes diffused throughout the industry.

Research benefits are inherently difficult to quantify because research most often produces information and knowledge. This new information and knowledge, when integrated with existing data and experience, provides new conceptual frameworks, tests the validity of creative ideas and demonstrates innovative technologies and methods.

However, many of EPRI's research activities have, in fact, produced demonstrable dollar benefits. The figures presented in the next section represent the best estimates of a collective group of evaluators who are most familiar with the projects and how they were applied or may be applied in the Company. In general, project quantification tended to be conservative. Also, only 450 of well over 1000 EPRI "products" were even considered.

RESULTS

The Company does not have any nuclear resources but is a minority co-owner in five coal facilities. It is, thus, understandable that "actual" nuclear and coal benefits were not impressive. Based on a generalized assumption that the Company would require a 600-MW coal plant to be on line in 2006 with engineering to commence in 1996, it was estimated that approximately \$25 million in potential future benefits through 1999 would accrue to the Company.

Even if these coal plant benefits are ignored the cumulative, readily quantifiable, benefits through 1999 range between \$138 and \$152 million. Assuming Puget Power's continued participation in EPRI, the Company's total contribution for EPRI research to 1999 will be around \$76 million for a benefit ratio of 1.8 to 2.0 and considerably higher if new fossil or nuclear generation possibilities are considered.

Major benefits were documented in the use of "products" from the Electrical Systems, Energy Analysis & Environment and Energy Management & Utilization Departments. Some enabled Puget Power to do things more efficiently, safely and economically, while others provided knowledge to prevent costly missteps.

Going through the benefits assessment exercise yielded an additional unexpected result. Some of the evaluators who in the past had only a passing acquaintance with EPRI's work became quite interested in research results that had, to that time, escaped their notice. This has led to contacts with the EPRI staff and manufacturers of EPRI-developed equipment. This may well amplify our future benefits beyond current expectations.

CONCLUSION

It is reassuring, having gone through this limited exercise, to have verification that EPRI is providing benefits well in excess of cost. Intuition tells us that were we to do a more exhaustive study, many additional benefits could be documented and savings from those "products" already identified would increase.

BENEFITS ASSESSMENT PROGRAM EXECUTIVE SUMMARY:
SALT RIVER PROJECT

The Salt River Project initiated a Benefits Assessment Program (BAP) in August, 1985 to quantify the benefits of our membership in the Electric Power Research Institute (EPRI). This program provided SRP with the opportunity to examine the past, present, and potential uses of research products developed by EPRI and to estimate the cost benefits of those products to the company. These products cover a wide range of applications, including electric generation, transmission, distribution, environment, and end-use.

The program findings, which encompass observations and analyses from many SRP departments, show the company has achieved a return of 400 percent on its EPRI research investment. There is the expectation that these benefits from EPRI research will continue.

The program identified 180 EPRI products that have an economic value to the company. Of these, 104 products have a historical or present value. Seventy (70) products are judged to have the potential for application at SRP and will result in future cost benefits. The remaining 6 products have only an intangible benefit.

The 104 products with a past or present use show a one-time benefit of \$51 million. This represents a benefit-to-cost ratio of 4-to-1 when compared to SRP's \$12 million cumulative contribution to EPRI through 1985. Seventy percent (70%) of these benefits, or \$38 million, result from the application of EPRI research products to support the Coronado Generating Station unit 3 design efforts.

Twenty-six (26) products of the 104 show total recurring annual benefits of \$2.5 million to \$3 million. SRP's contribution to EPRI for 1986 is approximately \$2.4 million. These recurring annual benefits from established product use are sufficient to result in a slightly greater than 1-to-1 benefit-to-cost ratio. This ratio could be much higher if those products identified as having a potential application are implemented, and the estimated benefits are realized.

The 70 products with potential applications have one-time benefits of approximately \$2 million, and recurring annual benefits ranging from \$2.5 million to \$11 million per year.

The application of EPRI products at joint participation facilities was also considered. The results show an estimated cost savings to Salt River Project, on a one-time benefit basis, of approximately \$3 million, and recurring annual benefits of \$11 million. These results are based on a limited screening EPRI products uses, and are only indicative of EPRI research uses by the operating agents of these facilities.

RECOMMENDATIONS

Salt River Project should remain committed to research by the electric utility industry and continue full support to EPRI. Since our principal research emphasis has been through EPRI participation, we must increase our efforts to consider all available research products for application where appropriate.

Salt River Project should continue to assess benefits of EPRI research and to update research applications on an annual basis through a process to be developed.

Salt River Project should institute a program to ensure that research previously identified as having potential application be evaluated and placed in service, as appropriate, and the company continue to monitor research currently in progress to identify research areas of interest of the technical staff.

Salt River Project should seek to perform or participate in EPRI projects that address corporate or customer needs and which enhance the technical expertise and productivity of its professional staff.

BENEFITS ASSESSMENT PROGRAM EXECUTIVE SUMMARY:
SOUTHWESTERN ELECTRIC POWER COMPANY

The Electric Power Research Institute (EPRI) was established in 1972 to perform scientific research with respect to the production, transmission, distribution, and utilization of electricity. Research performed by EPRI is funded primarily through annual payments of its members. Annual payments are based on 80% annual kwh sales and 20% annual revenue. Southwestern Electric Power Company (SWEPCO) and the other Central and South West companies have been members since 1982.

A Benefits Assessment Program was initiated in July 1985 to estimate the value of EPRI research products to SWEPCO. Results of this assessment indicate 103 EPRI products are of value to SWEPCO. The value of 62 products was quantifiable in terms of significant dollar savings--past, present, and near future. The remaining 41 products were judged to have either intangible benefit or unquantifiable future benefit.

A total of 37 products, those used or in use on a one-time or continuing basis, achieved an estimated savings of \$7,695,250. This represents a benefit-cost ratio of about 1.8 to 1 when compared to the Company's \$4,300,345 contribution to EPRI through 1985. If savings from the remaining 24 products expected to be used by 1987 are also included, total projected savings will be \$17,265,048; and the benefit-cost ratio will be about 1.95 to 1 assuming SWEPCO's annual payments to EPRI increase by 2% per year in 1986 and 1987. In 1985 dollars the benefit-cost ratio calculates to be 1.85.

If it is assumed that it takes about four (4) years for a research project to produce a successful commercial product, there are still four (4) years worth of products yet to be developed by EPRI; and potential benefits from research projects stated over the past four (4) years are yet to come.

Utilization of products developed from research projects is only one of the many benefits the Company derives from its participation in the EPRI research program. Nevertheless, based on this single measure, the benefit far exceeds the total investment.

BENEFIT ASSESSMENT PROGRAM SUMMARY: TEXAS UTILITIES

OVERVIEW

This document reports the results of an analysis of the accrued benefits to the Texas Utilities Electric Company System (the System) from membership in the Electric Power Research Institute (EPRI). EPRI serves as the primary research and development (R&D) arm of the electric utility industry. Texas Utilities Electric Company and its predecessor companies (Dallas Power & Light Company, Texas Electric Service Company and Texas Power & Light Company) have been members of EPRI since its founding in 1972.

In April 1985, the EPRI Board of Directors, consisting of utility chief executives, requested that EPRI undertake a coordinated effort with interested utilities to assess the benefits of EPRI research activities as implemented by those utilities. The company was invited to participate in this effort, and chose to view it as an opportunity not only to support the EPRI Board, but also to provide senior management of the company with information useful for decisions regarding system R&D. EPRI provided valuable support to the company throughout the study.

RESULTS

The scope of the study was limited to assessment of benefits from existing or already planned applications of EPRI research results within the system and benefits which accrue to the company from EPRI's general contributions to the industry. Benefits which could be quantified in this study were so done, but certain important benefits could not be readily quantified. In evaluating the results reported below, it is important to keep the full spectrum of benefits in mind. The nature of the assessment process tends to focus attention on the numerically quantified benefits to the exclusion of qualitative results which have substantial long-term economic value.

Quantified Benefits

Direct quantified benefits from general EPRI membership are about twice the total cost of EPRI dues from 1972 to date, when compared on a 1985 present-worth basis. About three-fourths of total direct benefits represent reduction in fuel cost. These latter benefits are derived largely from research applications which increase the availability of lower production cost generating capacity. As the result, a greater proportion of total system output is realized from these lower cost production sources.

In addition to internal research applications, the System benefits from EPRI support of work in the environmental sciences which include subject areas of current concern to legislative and/or regulatory bodies. This support is intended to assure that an adequate scientific basis exists for legislative and/or regulatory decisions regarding the protection of public health and welfare and or environmental quality. To gain some indicator of the value of past studies to the System, costs avoided by the System as a result of EPRI work in several areas were analyzed. Certain judgements were required regarding benefits allocation and the probabilities of legislative or regulatory action. These analyses suggest that benefits in this area alone may well exceed the present value of the total System EPRI contributions to date.

In addition to benefits from general EPRI membership, the Company benefits from membership in the Steam Generator Owners Group (SGOG). These benefits are about three times the total cost of EPRI dues from 1972 to date, when compared on a 1985-present worth basis. SGOG is presently a separately funded EPRI-based research activity of interest to the segment of the industry owning certain types of nuclear capacity. SGOG efforts began when utilities with operating nuclear units began experiencing unexpected degradation in performance of steam generators in those units. Benefits from SGOG primarily result from research applications at Comanche Peak that should obviate the degradation of steam generator performance experienced by other utilities and the resulting need to replace steam generators after about 15 years of operation.

Basic engineering-economics present worth methods were used as the basis to produce the results described above. This placed benefit-to-cost analyses of specific research products or applications on a comparable basis. Assumptions adopted were carefully structured to produce consistent and conservative results.

Summary tables of quantified benefits, along with a general description of assumptions and methodologies, follow this report.

Unquantified Benefits

A number of EPRI-based benefits which are of strategic importance do not lend themselves readily to numerical quantification. These benefits provide options and flexibility in system planning, design, operations, and maintenance. This, in turn, leads to more optimum use of capital and operating resources. Even small improvements in this overall base can produce large economic benefits. Reasoned judgement would suggest that unquantified benefits are substantial in comparison with total research costs. Some strategic options are enhanced by the cumulative effects of applied research products where benefits have been quantified. A significant example of this is the unquantified value on a system basis of increases in availability of individual generating units.

Another important source of non-quantifiable benefits is what might best be termed "knowledge transfer." The technical knowledge base throughout the full spectrum of System technical functions has been increased as the result of EPRI activities. New knowledge has been acquired during efforts to resolve problems or explore new opportunities through direct contact with EPRI staff and contractors and through EPRI reference materials. Benefits of knowledge transfer also derive from interactions of System members of industry-EPRI advisory groups with both EPRI-staff and industry counterparts. Knowledge thus acquired becomes part of overall System resource capability and is routinely applied to continuing future benefit.

A variety of useful and meaningful analytical tools in the form of models and computer programs are presently in use within the Company. These programs allow accumulated knowledge to be put to work efficiently, permitting an expanded range of options to be evaluated quickly with greater confidence in the results. However, the only benefits quantified in this assessment were estimates of direct savings and improved efficiencies that use of the tools permitted.

CONCLUSIONS

The System and its customers have received large returns on research expenditures for EPRI research. Over the span of years since EPRI was founded, the present value of directly quantified benefits from EPRI-based research exceeds by several times the cost of EPRI dues. Further, the value of unquantified benefits are substantial in relation to research costs.

Thus, the primary conclusion and the conclusion of future importance is that the overall "EPRI process" has worked and worked well. EPRI-based benefits could not have been realized without a basis for meaningful determination of the technology needed by the industry, appropriate selection of relevant and potentially successful research activities, effective management of the ensuing research, and a mechanism for transferring the research results to the industry. Continued availability of new and useful technology requires a continued viable "EPRI process."

To maintain the proper focus on the effectiveness of the "EPRI process," it is important to carefully interpret assessment results. The nature of the assessment process inherently poses some risk for erroneous conclusions. This partly comes from the tendency, as noted earlier, to focus primarily on numerical results. This, in turn, tends to cause nonquantifiable benefits to be overlooked and thus to understate the value of EPRI contributions. Another adverse consequence of this tendency is undue focus and emphasis on easily quantifiable short-term results.

There is also a natural tendency to project or predict future effects from current results. The benefits for the System described in this report measure the effects of past decisions to apply completed research products. These benefits are unrelated to future research activities or decisions.

After having established a mechanism for assessing benefits quantitatively, a natural tendency also exists to repeat the process each year. Such annual assessments would have value only if a fairly linear quantifiable benefit-to-cost relationship existed over time, indicating that benefits accrue in the same orderly fashion in which costs are incurred. The results of this assessment indicate that such a relationship does not exist over the period of the year. Quantifiable benefits tend to come in quantum increments.

Finally, it should be noted that the assessment process itself produced side benefits for the System. As part of the process, EPRI supplied information on all available research "products." This helped focus awareness and attention on opportunities for beneficial applications which are not currently implemented or planned for implementation.

RECOMMENDATIONS

In terms of long-range significance, the key result of this assessment is the conclusion that the "EPRI process" has worked well. The same process is needed in the future. However, the process must be responsive to a changing and increasingly complex environment. Both industry leadership and EPRI must continue to provide vision and guidance within their respective spheres that fully takes into account the growing diversity within the industry. Equitable mechanisms must be developed, not only to accommodate needs common to the total EPRI membership, but those common to industry segments as well.

Continued effectiveness in the changing business and economic environments will require refinements in certain areas. Of particular importance, improved industry-EPRI processes are needed for evaluating both the relevance to future need and the potential for success of new research options. As part of the process, a continual review of research in progress is needed to assure that the initially perceived relevance still applies and that research findings justify continuation of effort. Effectiveness in this area will maximize economic and human resources, both by focusing initial investments productively and in terminating investments that subsequently prove to have limited potential benefit.

Continued industry support and effectively integrated planning will assure a framework within which EPRI can continue to provide needed cost-effective technology. EPRI has been effective in past years in identifying, prioritizing and selecting research activities that are responsive to industry needs, and in directing superior talent to the production of useful new technology. In addition EPRI has earned respect for scientific competence and objectivity. These attributes remain the determinants of whether research can continue to be translated to beneficial results.

EPRI should exercise great care in compiling the composite report of the individual utility assessments such as this one, to assure that the risks of erroneous conclusions and misinterpretation of results are minimized. To this end, reporting of results should carefully take into account the potential for erroneous conclusions discussed in the Conclusions section of this report.

The major direct benefit of the combined Benefits Assessment Program results can be the furtherance of technology transfer, and this should be the focus of this effort. From the information furnished by 25 utilities participating in the

Benefits Assessment Program, an important database of successful research applications can and should be developed. This database can be used by all members as vital resource information to further explore opportunities for technology transfer within their individual organizations. Such a database can also be useful in marketing EPRI membership to nonmember utilities.

The final recommendations are specific to Texas Utilities Electric Company. Company support of research has served the customer and other System publics well. The key findings from this assessment support the value of the Company's long-term view and its active involvement in EPRI research activities. Investments in R&D, made over the years, are now paying dividends. A key element has been the commitment to active and broad participation of System technical and executive personnel in EPRI activities, both at the organizational and informal levels. This broad strategic perspective supported by active participation should be continued.

The Company should continually evaluate R&D activities, but avoid the temptation to measure value solely over the short term and on a quantitative basis, except for specific research product applications. Some of the major potential benefits will be difficult to quantify. Contributions to Load Management would likely be an example. Other potential benefits from current research will be realized in future years. Evaluation should focus on the quality of EPRI research and its relevance to System near-term and strategic needs.

To optimize technology transfer, System processes in all functional areas should be reviewed and updated as needed to accommodate current operations and strategic direction. Given the System commitment to technology advancement, benefits will continue to flow from relevant, quality research.

BENEFIT ASSESSMENT PROGRAM SUMMARY:
UNITED POWER ASSOCIATION

United Power Association (UPA) with able assistance from the Electric Power Research Institute (EPRI) staff initiated a Benefits Assessment Program (BAP) in July, 1985 to assess the benefits of membership in EPRI. UPA had previously felt the need to quantify the benefits from EPRI research and development to justify payment of its annual dues. The systematic approach to quantifying benefits developed by EPRI was a great assistance in computing the dollar benefits and other intangible benefits.

UPA has been a full member of EPRI for only two years. It has taken some time to set up a distribution and information system to make the results of EPRI R&D available to all personnel who can make use of it. During the profiling workshop in which all the UPA and member system evaluators worked closely with EPRI technical staff, several of the UPA and member system personnel became aware of the full extent of research and development being carried out by EPRI. That is certainly a positive result from the BAP.

EPRI has developed over 400 products from its research and development activities in all six of its technical divisions. Products developed in the Coal Combustion Systems, Energy Analysis and Environment, Energy Management and Utilization and Electrical System Divisions were found to be of the most benefit to UPA while only a few products from the Advanced Power Systems and Nuclear Power Divisions proved to be of value. The initial screening of products indicated that approximately 170 products may be of benefit (actual or potential). Further analysis showed that 131 products had actual or potential dollar benefits, whereas another 30 products appeared to have potential benefits which were not quantifiable at this time. More than 30 products were identified, either directly or indirectly, as having a past or present value to UPA and/or its member distribution cooperatives. Another 100 products were judged to have the potential for application to UPA which will have future economic benefits.

Benefits may have a one time application, have an annual benefit for a number of years, may continue indefinitely, or a combination of the above. Of the products with a past or present value 14 have a one-time benefit of \$810,000. There are 22 products that show annual benefits totalling \$416,000.

The benefits from potential future applications are estimated to total \$1,528,000 for one-time benefits and \$2,980,000 for recurring annual benefits.

UPA should remain committed to support of a research and development program by and within the electric utility industry by (1) fully supporting EPRI; (2) supporting research by its trade association, National Rural Electric Cooperative Association and (3) performing such research as necessary on a local level. UPA should help direct the research of EPRI and NRECA by participating in their committee structures. Finally, UPA must attempt to reap maximum benefits by monitoring research results and applying all available products where appropriate.

BENEFIT ASSESSMENT PROGRAM EXECUTIVE SUMMARY:
VIRGINIA POWER

At Virginia Power, the EPRI Benefits Assessment Program was a six-month effort which was undertaken (1) to determine the levels of benefit derived from EPRI research; and (2) to identify the types of EPRI research which were of greatest value to the company.

The assessment effort relied heavily on the judgment and perceptions of the people within the company who were the users of the research "products" that EPRI produces.

During the assessment process, company personnel reviewed and evaluated more than 340 products produced by EPRI over the past five years. Reviewers were drawn from virtually every technically oriented department of the corporate offices; and approximately 135 individuals participated in the reviews.

As a result of their efforts, reviewers identified one-time benefits ranging from \$176.3 million to \$241.6 million, and per-year benefits which totaled between \$37.6 million and \$52.6 million.

Analysis of the benefit estimates indicates that the company could realistically expect a "benefits ratio" of 2.91 to 1 and an internal rate of return of about 42.3% on the EPRI research and development investments that it has made since 1972. From a business perspective, this level of return is extremely attractive, and is more than sufficient to justify continued EPRI support.

While it is difficult to provide a short summary of all the perspectives which can be applied to the assessment data, several observations are worthy of mention.

- First, in the area of identifying the types of research which were of greatest value, the assessment data indicates that the majority of company benefits were derived from research targeted at the improvement or refinement of power station operations; from the preservation, assessment, and extension of power station equipment life; and from the reduction of losses in the transmission and distribution plant.

- Second, the largest blocks of benefits were associated with research performed by EPRI's Coal Combustion Systems, Electrical Systems, and Nuclear Power Divisions. Smaller, but significant benefit amounts were derived from the Advanced Power Systems Division and the Energy Management and Utilization Division.
- Third, the majority of benefits were reported by power station related departments. Most came from Nuclear Operations Support, Maintenance & Performance Services, Fossil & Hydro Operations Support, and Power Station Engineering. Large benefit amounts were also reported by T&D Operations and Corporate Assessment.
- And fourth, average benefit totals were about 27% actual use, 44% potential, and 28% future benefits (figure IV-5).

Significant actual use benefits were related to water chemistry guidelines, chemical cleaning, use of gas-in-oil monitors on main step-up transformers, metal oxide surge arresters, creep life assessments, changes in ASME code guidelines, and erosion/corrosion of piping.

The bulk of the potential benefits were related to research and development work on amorphous steel for transformer cores, atmospheric fluidized bed combustion, coal gasification/combined cycle, coal cleaning, realism in ASME code changes, and the use of the "cable follower" tunneling system.

Benefits reported in future benefits classification were spread among a larger body of research areas. Large potential benefits were associated with steam bypass systems, vibration signature analysis, cycling of fossil fueled plants, fuel cells, customer battery storage, fabric filter research, coal-water slurry fuels, flue gas desulfurization, moisture removal from turbine piping, generator RF monitoring systems, and probabilistic risk assessment.

In this assessment of EPRI benefits, the benefit totals include only those applications which have a clearly defined and specific economic value to the company. It should be recognized, however, that there are very real benefits from EPRI research which cannot be directly quantified.

These "nonquantifiable" benefits are derived from improvements in the full range of utility functions, and are a result of greater knowledgeability, better management decisions, and the improved quality of regulations and laws which affect utility operations. While the magnitude of these benefits cannot be estimated with a significant degree of accuracy, it is conceivable that their value to the company could be as significant as the value of the quantifiable research applications which were identified.

To summarize, the EPRI Benefits Assessment Program at Virginia Power was successful in providing a sound basis for defining and understanding the value of EPRI research to the company's operations. The assessment results indicate that even with a very conservative set of assumptions, the benefits derived from EPRI participation are more than adequate to warrant the investment. The benefits assessment efforts satisfied all major program objectives, and assessment results provided clear indications that EPRI research is being used and does have a significant positive impact on the company's operations.

Appendix B
Product Use Tables

Table B-1 shows the complete list of products by title, with the data on product use citations used to develop the curves in figure 2 in the text.

1. Product Number: A 4-digit number was assigned to each product in the list, including those added during the course of the 1985 campaign. CAUTION: The 1986 product list (see appendix D) is substantially changed from this list. Many products have been added; some have been reorganized; and many products have different numbers from the number they had in 1985.
2. Product Name: This is a short version of the product name, which may not in all cases be sufficient to completely identify the product. This information can be made available, though the 1986 materials may be more helpful.
3. Times Cited: This is the total number of times that the product was cited (including as not applicable) by 1 of the 20 utilities in the database at the time of these analyses. The next three sections break down this total in different ways.
4. Product Application: These columns show how many times the product was cited as in actual use (ACT), potential use (POT), or indirect or industrywide use (IND) or as not applicable (N/A). For example, product number 1010 is the UNIRAM reliability/availability code that appeared in figure 2 and that was cited by five utilities as big in actual use and by seven utilities as being potentially useful.
5. Dollar Benefits: These columns tell how often the product total-dollar benefit estimate by the various utilities fell within a given range. Zero dollars means that the benefits were not quantified. "1+" means that the benefits fell between \$1,000 and \$50,000, where the next interval starts. From this table, one cannot determine which benefits values go with which

application category. For example, with UNIRAM, the two citations of \$1 million or greater could have been actual or potential benefits estimates.

6. The final three columns indicate whether the citations were for one-time benefits or for a continuing annual benefit for two or more years (or not quantified).

Note that the sum of the Product Application citations equals the total number, as does the sum of the Dollar Benefits citations and the sum of final three column entries.

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| PROD NO. | PRODUCT NAME | TIMES CITED | PRODUCT APPLICATION | | | | DOLLAR BENEFITS (\$1000) | | | | | NOT QUANT. | ONE TIME | CONT. |
|----------|--------------------------------|-------------|---------------------|------|------|-----|--------------------------|----|-----|------|-------|------------|----------|-------|
| | | | ACT. | POT. | IND. | N/A | 0 | 1+ | 50+ | 500+ | 1000+ | | | |
| 0000 | BAP85: NULL PRODUCT | 20 | | | | 20 | 20 | | | | | 20 | | |
| 1000 | TECHNICAL ASSISTANCE: APS | | | | | | | | | | | | | |
| 1001 | APS MISCELLANEOUS PRODUCTS | 1 | | 1 | | | 1 | | | | | 1 | | |
| TOTO | UNIRAM REL/AVAIL METHODOLOGY | 12 | 5 | 7 | | | 3 | 1 | 6 | | 2 | 3 | 2 | 7 |
| 1020 | FAILURE/REPAIR DATA, COAL PLNT | 9 | 2 | 6 | 1 | | 4 | 4 | 1 | | | 4 | 3 | 2 |
| 1030 | CGCG: COAL GASIFIER POWER SYS | 14 | 1 | 13 | | | 3 | 1 | 6 | | 4 | 3 | 6 | 5 |
| 1040 | COAL GASIFICATION SYSTEM GUIDE | 12 | 5 | 7 | | | 2 | 4 | 6 | | | 2 | 9 | 1 |
| 1050 | GT-CC RELIABILITY DATABASE | 11 | 2 | 9 | | | 5 | 3 | 2 | | 1 | 5 | 2 | 4 |
| 1060 | GE MARK IV GAS TURBINE CONTROL | 8 | 4 | 4 | | | 2 | 2 | 3 | 1 | | 2 | 2 | 4 |
| 1070 | GE QUIET GAS TURB COMBUSTOR | 7 | | 6 | | 1 | 4 | 1 | 1 | | 1 | 4 | 1 | 2 |
| 1080 | GAS TURBINE CORROSION CONTROL | 7 | 5 | 2 | | | 5 | | 2 | | | 5 | | 2 |
| 1084 | GATE: GAS TURBINE EVAL CODE | 1 | 1 | | | | | | 1 | | | | | 1 |
| 1090 | BLENDED RESID GAS TURB FUEL | 4 | | 3 | 1 | | 4 | | | | | 4 | | |
| 1100 | METHANOL SYNTH' FUEL GUIDEBOOK | 7 | 1 | 5 | | 1 | 3 | 3 | 1 | | | 3 | 4 | |
| 1110 | ENHANCED MAN-MACHINE INTERFACE | 8 | 2 | 5 | | 1 | 4 | 1 | 2 | | 1 | 4 | 1 | 3 |
| 1120 | MOBILE GEOTHERMAL FLUIDS LAB | 2 | | 1 | | 1 | 2 | | | | | 2 | | |
| 1130 | BIPHASE ROTARY SEPARATOR TURB' | 2 | | 1 | | 1 | 1 | | | | 1 | 1 | | 1 |
| 1140 | GEOTHERMAL UPSTR'M H2S REMOVAL | 3 | | 2 | | 1 | 3 | | | | | 3 | | |
| 1144 | GEOPRESSURED GEOTHERMAL STUDY | 1 | 1 | | | | | | | 1 | | | 1 | |
| 1150 | WIND TURBINE SITING GUIDE | 6 | 5 | | | 1 | 2 | 2 | 2 | | | 2 | 2 | 2 |
| 1160 | DISTRIBUTED WIND POWER EVAL | 7 | 3 | 3 | | 1 | 4 | 2 | 1 | | | 4 | 2 | 1 |
| 1201 | UTILITY INTERACTIVE PHOTOVOLT | 1 | 1 | | | | | 1 | | | | | 1 | |
| 1202 | SOLAR SURVEY | 1 | 1 | | | | 1 | | | | | 1 | | |
| 1203 | BIOMASS FOR ELECTRIC GENERAT'N | 1 | 1 | | | | 1 | | | | | 1 | | |
| 2000 | TECHNICAL ASSISTANCE: CCS | 1 | 1 | | | | 1 | | | | | 1 | | |
| 2001 | CCS MISCELLANEOUS PRODUCTS | 2 | | 2 | | | 2 | | | | | 2 | | |
| 2005 | ARAPAHOE TEST FACILITY | 9 | 5 | 2 | 1 | 1 | 4 | 1 | 3 | | 1 | 4 | 3 | 2 |
| 2010 | HIGH-SULFUR FABRIC FILTER | 4 | | 3 | | 1 | 3 | 1 | | | | 3 | 1 | |
| 2015 | HIGH-SULFUR TEST CENTER | 3 | | 2 | | 1 | 2 | 1 | | | | 2 | 1 | |
| 2020 | COOLING TOWER PERF TEST FAC | 7 | 1 | 4 | | 2 | 2 | 1 | 1 | | 3 | 2 | 3 | 2 |
| 2021 | WET/DRY COOLING TOWER PILOT PL | 5 | | 3 | | 2 | 3 | 1 | | | 1 | 3 | 1 | 1 |
| 2030 | PCB DISPOSAL MANUAL | 10 | 9 | 1 | | | 4 | 4 | 1 | 1 | | 4 | 3 | 3 |
| 2035 | PCDDS, PCDFS IN PCB FLUIDS | 9 | 8 | | 1 | | 3 | 2 | 2 | 1 | 1 | 3 | 2 | 4 |
| 2040 | REDUCING AIRBORNE PCB CONTAM'N | 4 | 2 | 1 | | 1 | 3 | | 1 | | | 3 | 1 | |
| 2045 | S-CUBED FIELD-PORTABLE PCB ANA | 7 | 2 | 4 | | 1 | 3 | 2 | 1 | | 1 | 3 | 1 | 3 |
| 2049 | CHEM DETOX OF PCB CAPACITORS | 2 | 1 | 1 | | | 1 | 1 | | | | 1 | | 1 |
| 2055 | COOLING WATER TREATMENT GUIDE | 8 | 3 | 5 | | | 2 | 3 | 3 | | | 2 | 4 | 2 |
| 2060 | CLGTWR & DRIVER COOL'G MODELS | 4 | 1 | 3 | | | 2 | | 1 | 1 | | 2 | 1 | 1 |
| 2065 | COOLING TOWER WATER TREAT EVAL | 5 | 1 | 3 | 1 | | 1 | 1 | 2 | | 1 | 1 | 1 | 3 |
| 2070 | VERA2D 84 FLOW/HEAT/MASS CODE | 5 | | 5 | | | 1 | | 1 | | 2 | 1 | 4 | |
| 2075 | SACTI CLG TWR PLUME MODEL | 7 | 3 | 3 | | 1 | 3 | 2 | | 1 | 1 | 3 | 2 | 2 |
| 2080 | TEFERI/POPPE CLG TWR PERF/PLUM | 5 | 1 | 3 | | 1 | 2 | 3 | | | | 2 | 2 | 1 |
| 2085 | CLG TWR MEASUREMENT METHODS | 6 | 1 | 3 | | 2 | 5 | | | | 1 | 5 | | 1 |
| 2090 | COOLING WATER INTAKES | 7 | 3 | 4 | | | 4 | 3 | | | | 4 | 1 | 2 |
| 2095 | TARGETED CHLORINATION | 8 | 3 | 4 | | 1 | 3 | 3 | | | 2 | 3 | 2 | 3 |

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| PROD NO. | PRODUCT NAME | TIMES CITED | PRODUCT APPLICATION | | | | DOLLAR BENEFITS (\$1000) | | | | | NOT QUANT. | ONE TIME | CONT. |
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| | | | ACT. | POT. | IND. | N/A | 0 | 1+ | 50+ | 500+ | 1000+ | | | |
| 2099 | DECHLORINATION TECH MANUAL | 7 | 3 | 3 | | 1 | 4 | 1 | 2 | | | 4 | 3 | |
| 2105 | TRACE ELEMENT REMOVAL | 6 | | 4 | 1 | 1 | 4 | 1 | 1 | | | 4 | 1 | 1 |
| 2110 | WATER MGT FOR ZERO DISCHARGE | 7 | 1 | 5 | | 1 | 3 | 2 | | 1 | 1 | 3 | 3 | 1 |
| 2115 | AQUEOUS DISCHARGE SAMPLING | 10 | 8 | 1 | 1 | | 1 | 6 | 2 | | 1 | 1 | 5 | 4 |
| 2130 | GROUNDWATER MANUALS | 9 | 5 | 3 | | 1 | 3 | 3 | 3 | | | 3 | 2 | 4 |
| 2135 | UNSATID GROUNDWATER CODE | 6 | | 5 | | 1 | 3 | 2 | 1 | | | 3 | 2 | 1 |
| 2155 | FGD BYPRODUCT DISPOSAL MANUAL | 10 | 7 | 2 | | 1 | 4 | 3 | 3 | | | 4 | 5 | 1 |
| 2160 | SLUDGE/COST DISPOSAL COST CODE | 5 | | 4 | | 1 | 3 | 2 | | | | 3 | 2 | |
| 2165 | COAL ASH DISPOSAL MANUAL | 10 | 6 | 4 | | | 2 | 4 | 2 | 1 | 1 | 2 | 7 | 1 |
| 2170 | ASH/DAL ASH DISPOSAL COST CODE | 4 | 1 | 1 | | 2 | 2 | 1 | | | 1 | 2 | | 2 |
| 2175 | UPGRADE DISPOSAL FACILITY MAN | 9 | 5 | 4 | | | 4 | 3 | | 1 | 1 | 4 | 4 | 1 |
| 2180 | COAL WASTE ARTIFICIAL REEF | 2 | | 1 | | 1 | 2 | | | | | 2 | | |
| 2185 | COAL COMB'N BYPRODUCT USE MANL | 8 | 8 | | | | 1 | 3 | 3 | | 1 | 1 | 4 | 3 |
| 2190 | LOW VOLUME WASTE CHARACTERIZ'N | 7 | 4 | 1 | 1 | 1 | 2 | 3 | 2 | | | 2 | 4 | 1 |
| 2198 | LEACHATE CONTROL & MONITORING | 1 | 1 | | | | 1 | | | | | 1 | | |
| 2199 | FLUE GAS WASTE: REGULATIONS | 1 | 1 | | | | 1 | | | | | 1 | | |
| 2205 | FGD CHEM/METHODS HANDBOOK | 9 | 7 | 1 | | 1 | 2 | 3 | | 2 | 2 | 2 | 1 | 6 |
| 2210 | FGDLIQUFGD CHEMISTRY CODE | 6 | 3 | 2 | | 1 | 3 | 1 | 1 | | 1 | 3 | 2 | 1 |
| 2215 | FGD OP'NS/RELIABILITY IMPRVMT | 6 | 2 | 4 | | | 2 | | 1 | 1 | 1 | 2 | 2 | 2 |
| 2220 | FGD REAGENT/LIMESTONE PREP'N | 4 | 2 | | 1 | 1 | 2 | | 2 | | | 2 | 1 | 1 |
| 2230 | FGD DUCT CONSTRUCT'N MATERIALS | 7 | 4 | 3 | | | 2 | | 1 | | 3 | 2 | 3 | 2 |
| 2235 | STACK DESIGN/LIQUID RE-ENTR'NT | 5 | 3 | 2 | | | 1 | 1 | 2 | | 1 | 1 | 3 | 1 |
| 2240 | LEANING BRICK-CHIMNEY LINERS | 2 | | 2 | | | 2 | | | | | 2 | | |
| 2245 | FGD DAMPER OP'N & DESIGN | 5 | 2 | 3 | | | 2 | | | 1 | 1 | 2 | 1 | 2 |
| 2246 | FGD FAILURE CAUSE ANALYSIS | 4 | 2 | 2 | | | 2 | | 1 | | | 2 | 2 | |
| 2247 | CYCLIC REHEAT MATERIALS | 3 | 1 | 1 | | 1 | 2 | | | | 1 | 2 | | 1 |
| 2255 | CONTINUOUS EMISSION MONITORING | 12 | 8 | 1 | 2 | 1 | 4 | 7 | 1 | | | 4 | 5 | 3 |
| 2260 | ECONOMIC EVALUATION OF FGD | 7 | 4 | 3 | | | 2 | 3 | 1 | | | 2 | 3 | 2 |
| 2265 | RETROFIT FGD COST ESTIMATING | 7 | 4 | 3 | | | 3 | 2 | 2 | | | 3 | 2 | 2 |
| 2270 | LIMESTONE AND LIME FGD SYSTEMS | 7 | 3 | 3 | | 1 | 1 | 2 | 2 | 2 | | 1 | 2 | 4 |
| 2280 | SPRAY DRY FGD SYSTEM | 6 | 3 | 2 | | 1 | 1 | 1 | 2 | | 2 | 1 | 2 | 3 |
| 2285 | CYCLIC REHEAT MATERIALS | 1 | | | | 1 | 1 | | | | | 1 | | |
| 2290 | CHIYODA THOROUGHbred 121 FGD | 5 | 3 | 2 | | | 2 | | 1 | 1 | | 2 | 3 | |
| 2295 | STATUS/EVAL'N OF FGD SYSTEMS | 7 | 2 | 4 | | 1 | 2 | 4 | 1 | | | 2 | 4 | 1 |
| 2299 | QRI SERVICE & FGD SURVEY | 8 | 6 | 1 | | 1 | 3 | 5 | | | | 3 | 2 | 3 |
| 2305 | BAGHOUSE SONIC CLEANING GUIDE | 9 | 6 | 2 | | 1 | 4 | 1 | 1 | 1 | 1 | 4 | 3 | 2 |
| 2310 | FAB FILT FLUID DYNAMIC GUIDE | 8 | 1 | 6 | | 1 | 4 | 2 | | | | 4 | 3 | 1 |
| 2315 | FABRIC FILTER CONFERENCE | 7 | 2 | 3 | | 2 | 5 | 1 | | | 1 | 5 | 1 | 1 |
| 2320 | FAB FILT PERF MONITORING SYS | 4 | 2 | | | 2 | 4 | | | | | 4 | | |
| 2324 | SIDESTREAM SAMPL'G/FABRIC TEST | 3 | 2 | | | 1 | 1 | 1 | | 1 | | 1 | 2 | |
| 2330 | ESP MANUAL | 10 | 7 | 2 | | 1 | 4 | 3 | 2 | | 1 | 4 | 3 | 3 |
| 2335 | FLUE CONDIT'G WITH SODIUM, SO2 | 10 | 4 | 4 | | 2 | 5 | | 4 | 1 | | 5 | 4 | 1 |
| 2340 | ECONOMICS OF FABRIC FILTERS | 4 | 1 | 2 | | 1 | 1 | 2 | 1 | | | 1 | 3 | |
| 2345 | ESP/FAB FILT RELIABILITY GUIDE | 6 | 1 | 3 | 1 | 1 | 3 | 2 | | | | 3 | 2 | 1 |
| 2346 | FINE PART'CL MEASURE HANDBOOK | 7 | 4 | 3 | | | 3 | 2 | 2 | | | 3 | 2 | 2 |

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| | | | ACT. | POT. | IND. | N/A | 0 | 1+ | 50+ | 500+ | 1000+ | | | |
| 2347 | CASCADE IMPACTOR SYSTEM | 1 | 1 | | | | | | 1 | | | 4 | 1 | 1 |
| 2355 | SELECTIVE CATALYTIC REDUCTION | 6 | 2 | 3 | | 1 | 4 | 1 | | | 1 | 5 | 2 | 1 |
| 2360 | RETROFIT LOW NOX COMBUSTION | 8 | 1 | 7 | | | 5 | | 1 | | | 3 | | |
| 2380 | BAGHOUSE INJECTION OF SODIUM | 3 | | 2 | | 1 | 3 | | | | | 4 | 2 | |
| 2405 | INTEG'D ENVIRONMENTAL GUIDE | 6 | | 5 | | 1 | 4 | 1 | 1 | | | | | |
| 2500 | LIFE EXTENSION PROJECT | 1 | 1 | | | | | | | | 1 | | | 1 |
| 2505 | PRESSURE PARTS | 19 | 16 | 3 | | | 3 | 6 | 2 | | 7 | 3 | 3 | 13 |
| 2510 | DRUMS, HEADERS AND PIPING | 7 | 3 | 2 | | 2 | 4 | 2 | | 1 | | 4 | 3 | |
| 2515 | SUPERHEATER AND REHEATER | 13 | 5 | 6 | | 2 | 6 | 2 | 1 | | 4 | 6 | 2 | 5 |
| 2520 | BOILER TUBING GENERAL | 11 | 9 | 2 | | | 4 | | 4 | 1 | 2 | 4 | 1 | 6 |
| 2525 | SLAGGING AND FOULING | 7 | 3 | 4 | | | 2 | 1 | 1 | | 2 | 2 | 3 | 2 |
| 2530 | OTHER FUELS | 3 | 1 | 2 | | | 2 | 1 | | | | 2 | 1 | |
| 2531 | FLAME STABILIZATION | 1 | 1 | | | | | 1 | | | | | 1 | |
| 2555 | ROTOR RELIABILITY | 9 | 3 | 4 | 1 | 1 | 2 | 1 | 3 | | 2 | 2 | 4 | 3 |
| 2560 | BEARING SYSTEMS | 10 | 2 | 7 | | 1 | 3 | 1 | 2 | 1 | 2 | 3 | 4 | 3 |
| 2565 | SOLID PARTICLE EROSION | 17 | 7 | 9 | | 1 | 5 | 6 | 2 | | 4 | 5 | 7 | 5 |
| 2570 | LOW PRESSURE TURBINE FAILURES | 14 | 7 | 6 | | 1 | 6 | 2 | 3 | | 3 | 6 | 3 | 5 |
| 2605 | FANS | 12 | 5 | 7 | | | 5 | 2 | 2 | 1 | 1 | 5 | 4 | 3 |
| 2610 | PULVERIZERS AND COAL HANDLING | 9 | 5 | 4 | | | 4 | 3 | 2 | | | 4 | 4 | 1 |
| 2615 | PUMPS | 13 | 6 | 7 | | | 5 | 1 | 3 | 1 | 2 | 5 | 4 | 4 |
| 2620 | FEEDWATER HEATERS | 14 | 8 | 5 | | 1 | 5 | 2 | 3 | 1 | 3 | 5 | 5 | 4 |
| 2625 | TECHNOLOGY | 9 | 7 | 2 | | | 3 | 2 | 2 | 1 | | 3 | 5 | 1 |
| 2630 | CONDENSERS | 13 | 6 | 6 | | 1 | 5 | 2 | 1 | 1 | 3 | 5 | 5 | 3 |
| 2635 | INLEAKAGE DETECTION | 7 | 2 | 5 | | | 1 | 1 | 2 | 1 | 1 | 1 | 2 | 4 |
| 2640 | CORROSION CONTROL | 7 | 3 | 3 | | 1 | 5 | 1 | 1 | | | 5 | | 2 |
| 2645 | BIOFOULING CONTROL AND EFFECTS | 5 | 4 | 1 | | | 2 | 2 | 1 | | | 2 | 1 | 2 |
| 2655 | PLANT ROTATING EQUIPMENT | 9 | 5 | 3 | | 1 | 4 | 2 | | | 3 | 4 | 3 | 2 |
| 2660 | STEAM TURBINE COMPONENTS | 11 | 3 | 7 | | 1 | 4 | 3 | 1 | | 2 | 4 | 5 | 2 |
| 2665 | GENERATOR COMPONENTS | 4 | 2 | 2 | | | 1 | 1 | | 1 | 1 | 1 | 1 | 2 |
| 2670 | BOILER MONITORING | 9 | 3 | 6 | | | 4 | | 2 | 2 | 1 | 4 | 2 | 3 |
| 2675 | FOSSIL WATER CHEMISTRY CONTROL | 1 | 1 | | | | 1 | | | | | 1 | | |
| 2705 | ROTORS AND SHAFTS | 8 | 2 | 6 | | | 4 | 2 | 2 | | | 4 | 2 | 2 |
| 2755 | EXISTING PLANTS | 14 | 4 | 7 | | 3 | 5 | 3 | 3 | 2 | 1 | 5 | 3 | 6 |
| 2760 | NEW PLANTS | 5 | | 5 | | | 2 | 2 | | | | 2 | 3 | |
| 2805 | PLANT SYSTEMS | 12 | 5 | 6 | | 1 | 4 | 2 | 2 | 1 | 3 | 4 | 4 | 4 |
| 2810 | TURBINE CYCLING EFFECTS | 6 | 4 | 1 | | 1 | 2 | 3 | 1 | | | 2 | 4 | |
| 2815 | BOILER CYCLING EFFECTS | 7 | 3 | 3 | | 1 | 3 | 3 | 1 | | | 3 | 3 | 1 |
| 2820 | CONSTRUCTION | 5 | | 4 | | 1 | 3 | 2 | | | | 3 | 2 | |
| 2825 | PRIORITIES | 3 | | 1 | | 2 | 2 | | 1 | | | 2 | | 1 |
| 2830 | FOUNDATION DESIGN | 3 | | 2 | | 1 | 2 | 1 | | | | 2 | 1 | |
| 2835 | MATERIALS | 5 | | 5 | | | 3 | 1 | 1 | | | 3 | 1 | 1 |
| 2855 | AFBC: ATMOS FLUID BED | 12 | 6 | 5 | | 1 | 6 | | 3 | | 3 | 6 | 1 | 5 |
| 2860 | PFBC: PRESSURE FLUID BED | 6 | 1 | 5 | | | 5 | | 1 | | | 5 | 1 | |
| 2905 | COAL CLEANING TECHNOLOGY | 8 | 4 | 4 | | | 2 | 1 | | 1 | 4 | 2 | 3 | 3 |
| 2910 | COAL CLEANABILITY | 8 | 5 | 2 | | 1 | 4 | | 3 | | 1 | 4 | 2 | 2 |

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| | | | ACT. | POT. | IND. | N/A | 0 | 1+ | 50+ | 500+ | 1000+ | | | |
| 2915 | COAL INSTRUMENTATION | 6 | 1 | 5 | | | 2 | 1 | 2 | | | 2 | 4 | |
| 2920 | FUEL UTILIZATION | 9 | 5 | 4 | | | 2 | 2 | 2 | 1 | 2 | 2 | 6 | 1 |
| 3000 | TECHNICAL ASSISTANCE: EAE | | | | | | | | | | | | | |
| 3001 | EAE MISCELLANEOUS PRODUCTS | 1 | | 1 | | | 1 | | | | | 1 | | |
| 3009 | AIR QUALITY STUDIES | 1 | | 1 | | | | | 1 | | | | 1 | |
| 3010 | PMV&D: PLUME MODEL VALIDATION | 12 | 5 | 5 | 2 | | 6 | 2 | 3 | 1 | | 6 | 4 | 2 |
| 3020 | DIAL & ALPHA 1: REMOTE SENSING | 7 | 2 | 3 | | 2 | 4 | | 2 | | 1 | 4 | 1 | 2 |
| 3025 | HYDROGEN PEROXIDE IN ATMOSPHER | 5 | 2 | 2 | | 1 | 2 | 1 | 1 | | 1 | 2 | 1 | 2 |
| 3026 | CLOUD CHEMISTRY STUDIES | 3 | | 1 | 1 | 1 | 3 | | | | | 3 | | |
| 3030 | WRAQS: WESTERN REGIONAL AIR | 3 | 2 | 1 | | | 2 | | | | 1 | 2 | | 1 |
| 3035 | EASTERN VISIBILITY | 6 | 2 | 1 | 2 | 1 | 5 | | 1 | | | 5 | 1 | |
| 3040 | AIR POLLUT'N CLINICAL STUDIES | 8 | 1 | 4 | 3 | | 3 | 4 | | | 1 | 3 | 5 | |
| 3045 | SIX CITIES STUDY | 6 | 1 | 3 | 2 | | 5 | 1 | | | | 5 | 1 | |
| 3050 | BASIS/ NAT'L AMB AIR QLTY STD | 11 | 4 | 3 | 3 | 1 | 8 | 1 | 1 | | 1 | 8 | 3 | |
| 3055 | TOXICOL OF COMBUSTION PRODUCTS | 7 | 3 | 2 | 2 | | 3 | 1 | 1 | | 2 | 3 | 2 | 2 |
| 3060 | AIR QUALITY AND RISK | 12 | 4 | 3 | 5 | | 7 | 2 | 2 | | 1 | 7 | 3 | 2 |
| 3065 | NOX CONTROL: ASSESSMENT | 9 | 2 | 4 | 2 | 1 | 4 | 4 | | 1 | | 4 | 2 | 3 |
| 3070 | SOCIOECON EFFECTS OF PWR PLNTS | 7 | 4 | 2 | | 1 | 5 | 1 | 1 | | | 5 | 1 | 1 |
| 3075 | AIR POLLUTION MATERIALS | 6 | 1 | 2 | 2 | 1 | 5 | 1 | | | | 5 | 1 | |
| 3080 | INDOOR AIR QUALITY | 6 | 5 | 1 | | | 3 | 3 | | | | 3 | 2 | 1 |
| 3110 | RAQS: REGIONAL AIR QUALITY | 6 | 2 | 2 | 1 | 1 | 4 | 2 | | | | 4 | 2 | |
| 3115 | SURE: SULFATE REGIONAL | 6 | 1 | 3 | 2 | | 5 | 1 | | | | 5 | 1 | |
| 3120 | UTILITY ACID DEP STUDY | 7 | 2 | 4 | 1 | | 5 | 1 | 1 | | | 5 | | 2 |
| 3130 | ILWAS: INTEGRATED LAKE STUDY | 8 | 5 | 2 | 1 | | 3 | 1 | | | 3 | 3 | 2 | 3 |
| 3140 | ACID DEP'N EFFECTS ON CROPS | 4 | 2 | 1 | 1 | | 2 | | 1 | | 1 | 2 | 1 | 1 |
| 3150 | ADEPT: ACID DEP'N DECISION AID | 6 | 1 | 5 | | | 5 | | 1 | | | 5 | | 1 |
| 3199 | ACID DEPOSITION STUDIES | 8 | 3 | 2 | 3 | | 2 | 1 | | 1 | 4 | 2 | | 6 |
| 3210 | COOLING SYSTEM EFFECTS SERIES | 10 | 5 | 4 | 1 | | 5 | 1 | 2 | 2 | | 5 | 3 | 2 |
| 3310 | ROW/TRANS LINE EFFECTS | 10 | 4 | 5 | 1 | | 6 | | 4 | | | 6 | 2 | 2 |
| 3320 | HEALTH & BIOL EFFECTS E-M FLDS | 13 | 10 | 2 | | 1 | 3 | 4 | 4 | 1 | 1 | 3 | 7 | 3 |
| 3405 | TRACE ELEMENTS | 1 | 1 | | | | | 1 | | | | | | 1 |
| 3410 | SWES: SOLID WASTE ENVIRON STDY | 11 | 5 | 5 | | 1 | 4 | 2 | 3 | | 2 | 4 | 3 | 4 |
| 3420 | TERRESTRIAL MICROCOSM TEST | 6 | | 4 | 1 | 1 | 3 | 2 | | | 1 | 3 | 2 | 1 |
| 3430 | PCB RISK & DECISION SERIES | 8 | 1 | 4 | 1 | 2 | 7 | 1 | | | | 7 | 1 | |
| 3510 | OCCUP'L TOXICOL OF CHEMICALS | 9 | 4 | 4 | 1 | | 4 | 1 | 4 | | | 4 | 2 | 3 |
| 3520 | TOXIC PROFILES OF PSB SUBST'S | 7 | 6 | 1 | | | 6 | 1 | | | | 6 | 1 | |
| 3525 | HEALTH EFFECTS OF PCBs | 7 | 4 | 2 | 1 | | 6 | 1 | | | | 6 | | 1 |
| 3599 | LEGIONNAIRE'S DISEASE | 2 | 2 | | | | | 2 | | | | | 2 | |
| 3610 | FUEL SUPPLY SEMINARS | 12 | 10 | 2 | | | 5 | 5 | 1 | 1 | | 5 | 3 | 4 |
| 3620 | EFIAS: EPRI FUEL INFORMATION | 10 | 5 | 5 | | | 2 | 3 | 4 | 1 | | 2 | 3 | 5 |
| 3630 | FUEL SUPPLY ANALYSIS SERIES | 9 | 5 | 4 | | | 7 | | 1 | 1 | | 7 | | 2 |
| 3640 | RAILROAD ROUTING AND COSTING | 7 | | 6 | | 1 | 4 | 1 | | | 2 | 4 | 1 | 2 |
| 3650 | CMCM: COAL MINING COST MODEL | 7 | 2 | 5 | | | 3 | | 2 | | 2 | 3 | 1 | 3 |
| 3660 | FUEL INVENTORY MODEL | 12 | 5 | 7 | | | 3 | 3 | 3 | 1 | 2 | 3 | 4 | 5 |
| 3670 | FUEL CONTRACT MIX MODEL | 10 | 3 | 7 | | | 3 | 2 | 2 | 1 | 2 | 3 | 3 | 4 |

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| | | | ACT. | POT. | IND. | N/A | 0 | 1+ | 50+ | 500+ | 1000+ | | | |
| 3680 | FUEL BURN FORECASTING SYSTEM | 4 | | 3 | | 1 | 4 | | | | | 4 | | |
| 3701 | OVER/UNDER CAPACITY PLANNING | 7 | 4 | 3 | | | 3 | 2 | 2 | | | 3 | 3 | 1 |
| 3705 | TELPLAN: FINANCE/ENVIRO MDL | 8 | 1 | 4 | | 3 | 5 | 1 | 1 | | 1 | 5 | 1 | 2 |
| 3710 | TCM: TECHNOLOGY CHOICE MODEL | 8 | 2 | 5 | | 1 | 5 | 2 | | 1 | | 5 | 2 | 1 |
| 3715 | UTILITY PLANNING MODEL | 9 | 1 | 5 | 1 | 2 | 4 | 1 | 2 | 1 | 1 | 4 | 3 | 2 |
| 3725 | GENERATING CAPACITY IN U.S. | 9 | 4 | 1 | 2 | 2 | 5 | 3 | | | 1 | 5 | 2 | 2 |
| 3730 | CONSTRUCTION LEAD TIME STUDY | 9 | 1 | 7 | | 1 | 8 | 1 | | | | 8 | 1 | |
| 3740 | WSCID: WATER SUPPLY INFO | 7 | | 7 | | | 2 | 5 | | | | 2 | 4 | 1 |
| 3775 | FINANCIAL MANAGEMENT SERIES | 8 | 6 | 2 | | | 4 | 1 | 3 | | | 4 | 3 | 1 |
| 3780 | THE ATTRACTIVENESS CUBE | 11 | 4 | 4 | | 3 | 8 | 1 | 1 | | 1 | 8 | | 3 |
| 3799 | UMF: UTILITY MODELING FORUM | 2 | | 2 | | | 2 | | | | | 2 | | |
| 3820 | REEPS: RESIDENTIAL END USE | 13 | 4 | 8 | | 1 | 5 | 1 | 5 | 1 | 1 | 5 | 6 | 2 |
| 3825 | RETOU | 9 | 4 | 3 | 1 | 1 | 5 | 2 | 1 | | 1 | 5 | 1 | 3 |
| 3830 | COMMEND: COMMERCIAL END USE | 12 | 7 | 4 | | 1 | 4 | | 6 | | 2 | 4 | 4 | 4 |
| 3831 | SAMPLE METHODS | 1 | 1 | | | | | | 1 | | | | | 1 |
| 3840 | HELM: HOURLY ELECTRIC LOAD | 11 | 6 | 4 | | 1 | 2 | 1 | 7 | | 1 | 2 | 8 | 1 |
| 3850 | WENS: WEATHER NORMALIZATION | 11 | 4 | 6 | | 1 | 6 | 2 | 3 | | | 6 | 3 | 2 |
| 3875 | FORECAST MASTER | 10 | 4 | 3 | | 3 | 8 | 1 | 1 | | | 8 | 1 | 1 |
| 3890 | SMALL UTIL FORECAST GUIDE | 3 | | 2 | | 1 | 3 | | | | | 3 | | |
| 3899 | LOAD FORECASTING DATA QUALITY | 1 | 1 | | | | | | 1 | | | | | 1 |
| 3901 | DESIGN OF ALTERNATIVE RATES | 6 | 1 | 2 | 1 | 2 | 3 | 3 | | | | 3 | 3 | |
| 3905 | EURDS: ELEC RATE DESIGN STUDY | 9 | 8 | | 1 | | 4 | 3 | | 2 | | 4 | 3 | 2 |
| 3910 | RATE SURVEY | 9 | 4 | 2 | 1 | 2 | 6 | 2 | 1 | | | 6 | 2 | 1 |
| 3920 | EFFICIENT ENERGY USE | 10 | 6 | 3 | | 1 | 4 | 5 | | 1 | | 4 | 3 | 3 |
| 3925 | CONSERVATION PROGRAM IMPACT | 8 | 3 | 5 | | | 3 | 4 | | | 1 | 3 | 4 | 1 |
| 3930 | CASE STUDIES IN MARKETING | 4 | 1 | 3 | | | 1 | 3 | | | | 1 | 2 | 1 |
| 3935 | DEMAND-SIDE MGT GUIDEBOOK | 13 | 8 | 5 | | | 4 | 5 | 4 | | | 4 | 6 | 3 |
| 3950 | THE ELECTRIC ARM | 12 | 7 | 5 | | | 3 | 6 | 1 | 1 | 1 | 3 | 7 | 2 |
| 3955 | LOAD RESEARCH SERIES | 13 | 7 | 5 | | 1 | 4 | 8 | | | 1 | 4 | 4 | 5 |
| 3975 | LMSTM: LOAD MANAGEMENT | 13 | 9 | 4 | | | 4 | 3 | 4 | 2 | | 4 | 6 | 3 |
| 3980 | INTEGRATING FORECASTING MODELS | 6 | | 5 | 1 | | 3 | 2 | | | 1 | 3 | 2 | 1 |
| 3985 | COGEN 3: COGENERATION MODEL | 8 | 2 | 6 | | | 1 | 6 | 1 | | | 1 | 6 | 1 |
| 3990 | ESPRE: HVAC ANALYSIS | 8 | 2 | 6 | | | 3 | 4 | 1 | | | 3 | 4 | 1 |
| 3998 | WATER 1.0 CODE: DSM IMPACT | 1 | 1 | | | | | 1 | | | | | | 1 |
| 3999 | CUSTOMER RESPONSE TO LOAD MGT | 1 | 1 | | | | 1 | | | | | 1 | | |
| 4000 | TECHNICAL ASSISTANCE: EMU | | | | | | | | | | | | | |
| 4001 | EMU MISCELLANEOUS PRODUCTS | 3 | 1 | 2 | | | 2 | | 1 | | | 2 | | 1 |
| 4101 | FUEL CELLS IN SMALL UTILITIES | 6 | 1 | 3 | | 2 | 4 | 2 | | | | 4 | 2 | |
| 4102 | WESTNGHSE 7.5MW FUEL CELL PLNT | 8 | 2 | 4 | 1 | 1 | 3 | 5 | | | | 3 | 4 | 1 |
| 4103 | GENERIC 11 MW FUEL CELL PLANT | 10 | 5 | 4 | | 1 | 3 | 3 | 2 | 1 | 1 | 3 | 4 | 3 |
| 4104 | ASSESS PAFCS/COAL GASIFIER | 7 | | 4 | 1 | 2 | 3 | 2 | 1 | | 1 | 3 | 3 | 1 |
| 4105 | SYSTEM PLANNERS GUIDE | 9 | 1 | 6 | 1 | 1 | 3 | 4 | 2 | | | 3 | 4 | 2 |
| 4106 | FUEL CELLS ON UTILITY SYSTEM | 8 | | 6 | 1 | 1 | 3 | 3 | 2 | | | 3 | 3 | 2 |
| 4107 | 4.5 MW DEMO FUEL CELL PWR PLNT | 6 | 1 | 4 | | 1 | 3 | 1 | | 2 | | 3 | 3 | |
| 4121 | 6500 HEAT RATE POWER PLANT | 5 | 1 | 2 | 1 | 1 | 3 | 1 | | | 1 | 3 | 2 | |

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| | | | ACT. | POT. | IND. | N/A | 0 | 1+ | 50+ | 500+ | 1000+ | | | |
| 4122 | MCFC VERIFICATION | 6 | 1 | 4 | | 1 | 4 | | 1 | | 1 | 4 | | 2 |
| 4123 | COMPARE MCFC & GAS TURBINE | 9 | 2 | 5 | | 2 | 6 | 3 | | | | 6 | 2 | 1 |
| 4151 | ON-SITE HYDROGEN PRODUCTION | 9 | 2 | 5 | | 2 | 5 | 4 | | | | 5 | 4 | |
| 4152 | SLX HYDROGEN GENERATOR | 1 | | | | 1 | 1 | | | | | 1 | | |
| 4153 | MRKT POT'L ELECTROCHEM PROCESS | 2 | 1 | 1 | | | 1 | 1 | | | | 1 | | 1 |
| 4201 | CUSTOMER-APPLIED BATTERY | 14 | 5 | 8 | | 1 | 5 | 5 | 3 | | 1 | 5 | 7 | 2 |
| 4202 | LEAD ACID BATTERY TEST | 6 | 1 | 4 | | 1 | 3 | 3 | | | | 3 | 3 | |
| 4203 | 500 KWH ZINC CHLORIDE BATTERY | 6 | 1 | 4 | | 1 | 4 | 2 | | | | 4 | 2 | |
| 4210 | PRELIMINARY DESIGNS OF CAES | 10 | 3 | 6 | | 1 | 3 | 4 | 2 | | | 3 | 6 | 1 |
| 4249 | BEST FACILITY | 1 | 1 | | | | 1 | | | | | 1 | | |
| 4251 | ECON SCR'NING LOW HEAD HYDRO | 10 | 4 | 6 | | | 1 | 9 | | | | 1 | 7 | 2 |
| 4252 | SMALL HYDRO DEVELOPMENT | 7 | 3 | 4 | | | 1 | 4 | | | | 1 | 3 | 3 |
| 4253 | HYDROPOWER RELIABILITY STUDY | 6 | | 6 | | | 3 | 2 | 1 | | | 3 | 2 | 1 |
| 4254 | HYDRO REVIEW MAGAZINE | 5 | 3 | 1 | 1 | | 2 | 1 | 2 | | | 2 | 1 | 2 |
| 4255 | COMPETITIVE HYDRO MODEL TESTS | 5 | 1 | 3 | 1 | | 3 | 1 | 1 | | | 3 | 1 | 1 |
| 4301 | HEAT PUMP MANUAL | 14 | 10 | 4 | | | 4 | 6 | 2 | 1 | 1 | 4 | 8 | 2 |
| 4302 | AIR/GRND HEAT PUMP PERFORMANCE | 12 | 8 | 4 | | | 5 | 5 | | | 2 | 5 | 4 | 3 |
| 4303 | SURVEY OF HEAT PUMP LIFE | 9 | 4 | 5 | | | 4 | 4 | 1 | | | 4 | 4 | 1 |
| 4304 | HEAT PUMP PERF DATABASE | 10 | 5 | 4 | | 1 | 5 | 4 | 1 | | | 5 | 4 | 1 |
| 4305 | HEAT PUMP WATER HEATERS | 14 | 9 | 5 | | | 8 | 5 | 1 | | | 8 | 4 | 2 |
| 4306 | HEAT PUMP EDUCATIONAL MATER'LS | 10 | 6 | 3 | 1 | | 4 | 5 | 1 | | | 4 | 4 | 2 |
| 4341 | SOLAR DOMESTIC HOT WATER MAN'L | 10 | 4 | 6 | | | 6 | 4 | | | | 6 | 2 | 2 |
| 4342 | COMMER'L REFRIGERAT'N WORKSHOP | 4 | 4 | | | | 1 | 2 | 1 | | | 1 | 2 | 1 |
| 4343 | RESIDENTIAL PASSIVE SOLAR | 9 | 4 | 5 | | | 5 | 3 | 1 | | | 5 | 2 | 2 |
| 4344 | ACTIVE SOLAR RESIDENTIAL TESTS | 10 | 5 | 4 | 1 | | 6 | 3 | 1 | | | 6 | 3 | 1 |
| 4349 | COMMERCIAL SOLAR WATER HEAT'G | 1 | | 1 | | | 1 | | | | | 1 | | |
| 4351 | LOADSIM CODE | 11 | 2 | 8 | | 1 | 8 | 3 | | | | 8 | | 3 |
| 4352 | LOAD MGT TECHNOLOGY REVIEW | 13 | 9 | 4 | | | 5 | 6 | 1 | | 1 | 5 | 6 | 2 |
| 4353 | SURVEY OF UTILITY END USE | 16 | 10 | 5 | 1 | | 7 | 7 | 1 | 1 | | 7 | 4 | 5 |
| 4354 | LOAD MGT CONTROL STRATEGIES | 13 | 8 | 3 | | 2 | 6 | 5 | 1 | 1 | | 6 | 6 | 1 |
| 4355 | COMMERCIAL COOL STORAGE PRIMER | 15 | 13 | 2 | | | 6 | 7 | 2 | | | 6 | 5 | 4 |
| 4356 | HEAT STORAGE FURNACE | 9 | 6 | 2 | | 1 | 3 | 1 | 3 | 1 | 1 | 3 | 2 | 4 |
| 4357 | RESID'L THERMAL STORAGE PERF | 10 | 5 | 5 | | | 5 | 2 | 2 | | 1 | 5 | 2 | 3 |
| 4358 | COMM'L COOL STOR'G PERF/TRENDS | 10 | 5 | 5 | | | 6 | 4 | | | | 6 | 4 | |
| 4359 | CUSTOMER AND STAFF EDUCATIONAL | 6 | 4 | 2 | | | 3 | 3 | | | | 3 | 1 | 2 |
| 4360 | LOAD MGT METHOD LOWERS COSTS | 7 | 3 | 3 | | 1 | 3 | 4 | | | | 3 | 3 | 1 |
| 4401 | LIGHTING HANDBOOK | 6 | 3 | 3 | | | 1 | 3 | | 2 | | 1 | 3 | 2 |
| 4402 | REFLECTIVE FILMS FOR LIGHTS | 7 | 4 | 2 | | 1 | 3 | 3 | 1 | | | 3 | 4 | |
| 4403 | TECH BRIEFS ON APPLIANCES | 7 | 2 | 5 | | | 3 | 4 | | | | 3 | 3 | 1 |
| 4451 | EMPS CODE | 6 | 5 | 1 | | | | 4 | 2 | | | | 4 | 2 |
| 4452 | EDUC MATR'L BUILDING ENERGY | 10 | 6 | 2 | | 2 | 4 | 6 | | | | 4 | 4 | 2 |
| 4461 | INDOOR AIR QUALITY MANUAL | 13 | 6 | 6 | | | 4 | 6 | 2 | 1 | | 4 | 5 | 4 |
| 4462 | INFILTRATION/ENERGY USE/AIR QY | 10 | 6 | 4 | | | 4 | 4 | 2 | | | 4 | 3 | 3 |
| 4463 | INDOOR AIR QUALITY R&D DATA | 5 | 2 | 3 | | | 3 | | 2 | | | 3 | | 2 |
| 4501 | METAL FAB SUBSCRIPTION SERVICE | 6 | 3 | 3 | | | 2 | 2 | 1 | | 1 | 2 | | 4 |

| PROD NO. | PRODUCT NAME | TIMES CITED | PRODUCT APPLICATION | | | | DOLLAR BENEFITS (\$1000) | | | | | NOT QUANT. | ONE TIME | CONT. |
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| | | | ACT. | POT. | IND. | N/A | 0 | 1+ | 50+ | 500+ | 1000+ | | | |
| 4502 | CENTER FOR METALS FABRICATION | 6 | 2 | 4 | | | 3 | 3 | | | | 3 | 1 | 2 |
| 4503 | TECHNICAL COMMENTARIES | 9 | 5 | 4 | | | 4 | 4 | | | | 4 | 2 | 3 |
| 4504 | ELECTROTECHNOLOGY STATE OF ART | 6 | 3 | 3 | | | 2 | 2 | 2 | | | 2 | 3 | 1 |
| 4505 | TECH BRIEFS/ELECTROTECHNOLOGY | 5 | 4 | 1 | | | 2 | 2 | 1 | | | 2 | 2 | 1 |
| 4551 | TRANSIENT VOLTAGE SUPPRESSORS | 11 | 7 | 3 | | 1 | 4 | 6 | 1 | | | 4 | 4 | 3 |
| 4552 | ADJUSTABLE SPEED MOTOR DRIVE | 11 | 5 | 6 | | | 2 | 3 | 3 | | 3 | 2 | 3 | 6 |
| 4599 | ADVANCED PROCESS CONTROLS | 1 | 1 | | | | | 1 | | | | | | 1 |
| 4601 | ECM CONSERVATION CODE | 9 | 2 | 6 | | 1 | 3 | 3 | 2 | 1 | | 3 | 2 | 4 |
| 4602 | DUAL ENERGY USE SYSTEMS (DUES) | 7 | 3 | 4 | | | 1 | 5 | | | | 1 | 6 | |
| 4603 | COPE COGENERATION CODE | 9 | 2 | 7 | | | 3 | 5 | | | | 3 | 6 | |
| 4604 | COGENERATORS DATA BASE (CDB) | 6 | 1 | 4 | | 1 | 1 | 5 | | | | 1 | 5 | |
| 4605 | COGENERATION CASE STUDIES | 9 | 3 | 5 | | 1 | 5 | 3 | 1 | | | 5 | 4 | |
| 4606 | GUIDE/SMALL COGENERATION SYS | 8 | 3 | 5 | | | 3 | 4 | 1 | | | 3 | 3 | 2 |
| 4607 | RESTAURANT WASTE HEAT RECOV'RY | 10 | 5 | 3 | | 2 | 5 | 4 | | 1 | | 5 | 2 | 3 |
| 4608 | DISTRICT HEATING DES/ANAL | 4 | 2 | 1 | | 1 | 3 | 1 | | | | 3 | | 1 |
| 4609 | COGENERATION DEVELOPER'S HNOBK | 5 | 2 | 3 | | | 3 | 2 | | | | 3 | 2 | |
| 4610 | INDUSTRIAL PARK DESIGN/ANAL | 6 | 1 | 3 | | 2 | 5 | 1 | | | | 5 | 1 | |
| 4651 | RANGE METER/ELECTRIC VEHICLE | 2 | 1 | 1 | | | 1 | | | | | 1 | 1 | |
| 4652 | ELECTRIC VEHICLE TEST MANUAL | 3 | 1 | 2 | | | 1 | 1 | 1 | | | 1 | 1 | 1 |
| 4653 | BEDFORD ELEC' VAN TEST/EVAL | 5 | 3 | 2 | | | 2 | 2 | | 1 | | 2 | 3 | |
| 4654 | EFFECTS OF EV ON UTILITIES | 8 | 4 | 4 | | | 2 | 3 | 3 | | | 2 | 3 | 3 |
| 4655 | EV COMMERCIALIZATION SUPPORT | 4 | 2 | 2 | | | | 3 | 1 | | | | 3 | 1 |
| 5000 | TECHNICAL ASSISTANCE: ES | | | | | | | | | | | | | |
| 5001 | ES MISCELLANEOUS PRODUCTS | 4 | 2 | 2 | | | 3 | 1 | | | | 3 | 1 | |
| 5010 | PCB DETECTOR HORIBA MESA 200 | 11 | 4 | 6 | | 1 | 4 | 4 | 1 | 1 | 1 | 4 | 2 | 5 |
| 5020 | PCB TEST KIT: CLOR-N-OIL | 16 | 15 | 1 | | | 4 | 4 | 4 | 2 | 2 | 4 | 1 | 11 |
| 5030 | PCB, PCDF & PCDD RESEARCH | 5 | 3 | 2 | | | 3 | | 2 | | | 3 | 2 | |
| 5040 | PCB NEWSLETTERS & SEMINARS | 12 | 11 | | | 1 | 3 | 4 | 4 | | 1 | 3 | 3 | 6 |
| 5050 | WECOSOL TRANSFORMERS | 12 | 1 | 9 | | 1 | 8 | 2 | 1 | | 1 | 8 | 2 | 2 |
| 5060 | AMORPHOUS STEEL TRANSFORMERS | 14 | 2 | 11 | | 1 | 5 | 1 | | 2 | 5 | 5 | 5 | 4 |
| 5070 | GAS-IN-OIL TRANSFORMER MONITOR | 13 | 3 | 9 | | 1 | 6 | 2 | 2 | | 3 | 6 | 2 | 5 |
| 5080 | ACOUSTIC DISCHARGE DETECTOR | 17 | 7 | 10 | | | 9 | 2 | 5 | | 1 | 9 | 4 | 4 |
| 5090 | ZINC OXIDE GAPLESS ARRESTER | 17 | 17 | | | | 4 | 2 | 6 | 3 | 2 | 4 | 1 | 12 |
| 5100 | FAILSAFE SURGE ARRESTER | 13 | 1 | 9 | | 1 | 9 | | 2 | | 2 | 9 | 1 | 3 |
| 5101 | LIGHTNING CURRENT MAGNITUDES | 1 | 1 | | | | 1 | | | | | 1 | | |
| 5110 | SF6 1-PRESSURE PUFFER BREAKERS | 15 | 15 | | | | 4 | 1 | 5 | 1 | 4 | 4 | | 11 |
| 5120 | CURRENT LIMITING PROTECTOR | 12 | 1 | 7 | | 4 | 11 | | 1 | | | 11 | | 1 |
| 5130 | ICE RELEASE COATINGS | 8 | 2 | 6 | | | 7 | | | 1 | | 7 | | 1 |
| 5140 | NGH SUBSYNCH RESON DAMP METHOD | 6 | 1 | 5 | | | 3 | 1 | 1 | | 1 | 3 | 2 | 1 |
| 5150 | STATIC VAR CONTROLLER | 10 | 3 | 3 | | 1 | 6 | 2 | 2 | | | 6 | 3 | 1 |
| 5194 | INTERFERENCE IN WATTHOUR METER | 1 | 1 | | | | | 1 | | | | | | 1 |
| 5195 | REDUCED VOLTAGE EFFECTS | 1 | 1 | | | | | | 1 | | | | | 1 |
| 5196 | TRANSFORMER OIL CHARGING | 1 | 1 | | | | 1 | | | | | 1 | | |
| 5197 | PRAM/HISRAM DIST REL'TY MODEL | 2 | 2 | | | | | 1 | 1 | | | | 1 | 1 |
| 5198 | SCALE CODE FOR LOSS EQUATIONS | 3 | 2 | | | 1 | 2 | | 1 | | | 2 | | 1 |

| PROD NO. | PRODUCT NAME | TIMES CITED | PRODUCT | | APPLICATION | | DOLLAR BENEFITS (\$1000) | | | | | NOT QUANT. | ONE TIME | CONT. |
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| | | | ACT. | POT. | IND. | N/A | 0 | 1+ | 50+ | 500+ | 1000+ | | | |
| 5199 | UDPM DISTRIBUTION PLANNING MDL | 5 | 4 | 1 | | | 2 | | 1 | | 2 | 2 | | 3 |
| 5210 | GATL/SCA GROUNDING CODES | 14 | 7 | 7 | | | 5 | 3 | 4 | 1 | | 5 | 1 | 8 |
| 5220 | ACPIPE CODE: INDUCED VOLTAGES | 13 | 7 | 6 | | | 7 | 4 | 2 | | | 7 | 4 | 2 |
| 5230 | MULTI-FLASH/LIGHTNING PERF TL | 9 | 4 | 5 | | | 3 | 4 | 1 | | 1 | 3 | 2 | 4 |
| 5240 | ES/EM EFFECTS OF TRANSM'N LINE | 9 | 7 | 1 | 1 | | 1 | 3 | 3 | | 2 | 1 | 2 | 6 |
| 5250 | PADLL/DRILLED PIER FOUNDATIONS | 14 | 10 | 4 | | | 8 | 2 | 3 | | 1 | 8 | 2 | 4 |
| 5260 | POLEDA80 WOOD TRANS STRUCTURES | 13 | 9 | 4 | | | 5 | 2 | 3 | 1 | 2 | 5 | 1 | 7 |
| 5261 | FOUNDATIONS FOR TRANS LINES | 3 | 2 | 1 | | | 3 | | | | | 3 | | |
| 5270 | BIOLOGICAL DETERIORATION/POLES | 12 | 6 | 6 | | | 2 | | 2 | 2 | 6 | 2 | 1 | 9 |
| 5280 | GROUNDLINE REPAIR FOR POLES | 11 | 3 | 7 | | 1 | 5 | 1 | 2 | 1 | 2 | 5 | 1 | 5 |
| 5290 | CHEM TREE GROWTH RETARDANT | 13 | 4 | 8 | | 1 | 6 | 1 | 2 | | 4 | 6 | 2 | 5 |
| 5300 | EHV/UHV TRANS LINE DESIGN | 16 | 14 | 1 | | 1 | 6 | 1 | 8 | | 1 | 6 | 1 | 9 |
| 5310 | COMPACT TRANSMISSION LINE | 12 | 8 | 4 | | | 7 | 1 | 1 | 1 | 2 | 7 | 1 | 4 |
| 5320 | WIND-INDUCED CONDUCTOR MOTION | 13 | 11 | 2 | | | 6 | 5 | | | 2 | 6 | 2 | 5 |
| 5330 | TLMRF | 13 | 7 | 5 | | 1 | 9 | 1 | 1 | | 2 | 9 | 1 | 3 |
| 5335 | POLYSIL INSULATORS | 3 | | 3 | | | 2 | | 1 | | | 2 | | 1 |
| 5340 | TLOP OPTIMIZATION CODE FOR TL | 5 | 4 | 1 | | | 3 | | | 1 | 1 | 3 | | 2 |
| 5399 | BROD12/BROFLX BROKEN-WIRE CODE | 5 | 2 | 2 | 1 | | 5 | | | | | 5 | | |
| 5410 | WALTZ MILL UG CABLE TEST FAC'Y | 14 | 6 | 4 | 2 | 2 | 5 | 1 | 5 | 2 | 1 | 5 | 4 | 5 |
| 5420 | HPOF CABLE HANDBOOK (PIPE) | 10 | 2 | 3 | | 5 | 8 | 1 | 1 | | | 8 | | 2 |
| 5430 | RESTRAINTS FOR CABLE JOINTS | 9 | 2 | 2 | | 5 | 8 | | 1 | | | 8 | | 1 |
| 5440 | CABLE INSULATION CONTAM DETECT | 13 | 6 | 4 | 2 | 1 | 5 | 2 | 4 | 1 | 1 | 5 | 1 | 7 |
| 5450 | MOLDED EXTRUDED-CABLE SPLICES | 12 | 1 | 8 | | 3 | 9 | 2 | 1 | | | 9 | 3 | |
| 5460 | SEMICONDUCTING JACKETS FOR URD | 10 | 4 | 2 | 1 | 3 | 7 | | 1 | 1 | 1 | 7 | 1 | 2 |
| 5470 | SHORT URD CABLE CODE | 8 | 2 | 2 | | 4 | 6 | 2 | | | | 6 | 2 | |
| 5480 | CABLPU L CODE AND HANDBOOK | 16 | 12 | 4 | | | 5 | 1 | 8 | | 2 | 5 | 2 | 9 |
| 5490 | CABLE FOLLOWER REPLACES URD | 14 | 3 | 11 | | | 6 | 3 | | 1 | 3 | 6 | 2 | 6 |
| 5500 | WATER JET CONCRETE CUTTER | 9 | | 7 | | 2 | 7 | 1 | 1 | | | 7 | | 2 |
| 5510 | UG OBSTACLE DETECTOR/MAPPER | 9 | | 8 | | 1 | 7 | | 2 | | | 7 | | 2 |
| 5520 | SOIL THERMAL PROPERTY ANALYZER | 9 | 1 | 5 | | 3 | 7 | 1 | 1 | | | 7 | | 2 |
| 5596 | HPOF CABLE ECON EVAL | 2 | 1 | 1 | | | 2 | | | | | 2 | | |
| 5597 | SELF-CONTAINED/HPOF CABLE COST | 3 | 1 | 1 | 1 | | 2 | 1 | | | | 2 | 1 | |
| 5598 | ENVIRO IMPACT/UG TRANSMISSION | 3 | 2 | 1 | | | 3 | | | | | 3 | | |
| 5599 | CATHODIC PROTECTION/UG CABLE | 4 | 2 | 2 | | | 2 | | 1 | | 1 | 2 | | 2 |
| 5610 | TURBINE/GEN SHAFT MONITOR | 10 | 3 | 6 | 1 | | 1 | 3 | 2 | | 3 | 1 | 5 | 4 |
| 5620 | TORSION FATIGUE MONITOR/SHAFTS | 7 | 2 | 5 | | | 2 | 1 | | | 3 | 2 | 3 | 2 |
| 5630 | MACHINE CONSTANT PREDICTION | 6 | 1 | 4 | | 1 | 4 | 1 | | | | 4 | 1 | 1 |
| 5640 | STATOR COIL WEDGE TIGHTNESS | 7 | | 7 | | | 2 | 3 | 2 | | | 2 | 3 | 2 |
| 5650 | ON-LINE ELEC GEN RF MONITOR | 13 | 6 | 7 | | | 5 | | 3 | | 5 | 5 | 3 | 5 |
| 5660 | MOTOR OPNS WITH CUT-OUT COILS | 8 | 1 | 7 | | | 1 | 2 | 3 | 1 | 1 | 1 | 4 | 3 |
| 5670 | POWER ANGLE INSTRUMENT | 4 | | 4 | | | 1 | 3 | | | | 1 | 2 | 1 |
| 5710 | EGEAS GEN EXPANSION CODE | 10 | 5 | 4 | | 1 | 5 | 3 | 2 | | | 5 | 3 | 2 |
| 5720 | VAROPT VAR OPTIMIZATION CODE | 9 | | 8 | | 1 | 5 | 1 | 3 | | | 5 | 1 | 3 |
| 5730 | TRADE POWER TRANSFER CODE | 7 | 1 | 4 | 1 | 1 | 3 | 3 | | | 1 | 3 | 2 | 2 |
| 5740 | HVDC LINKS IN AC SYSTEMS/HNDBK | 4 | 1 | 3 | | | 1 | 2 | 1 | | | 1 | 1 | 2 |

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| | | | ACT. | POT. | IND. | N/A | 0 | 1+ | 50+ | 500+ | 1000+ | | | |
| 5750 | SYSTEM SEPARATION IMPACTS | 7 | 2 | 4 | | 1 | 4 | 1 | 1 | | 1 | 4 | | 3 |
| 5760 | COMPONENT OUTAGE DATA ANALYSIS | 10 | 2 | 8 | | | 5 | 2 | 2 | | 1 | 5 | 1 | 4 |
| 5770 | BASIC RELIABILITY INDICES | 8 | 5 | 3 | | | 1 | 4 | 1 | | 2 | 1 | 3 | 4 |
| 5780 | GENREL/GENERATOR RELIABILITY | 6 | 1 | 5 | | | 2 | 3 | 1 | | | 2 | 1 | 3 |
| 5790 | SYREL/TRANSMISSION RELIABILITY | 12 | 2 | 8 | | 2 | 8 | 3 | 1 | | | 8 | 1 | 3 |
| 5800 | DYNAMIC EQUIVALENTS/STABILITY | 11 | 4 | 6 | | 1 | 5 | 1 | 5 | | | 5 | 3 | 3 |
| 5810 | DYNAMIC LOAD CHARACTERISTICS | 7 | | 5 | | 2 | 5 | | 1 | | 1 | 5 | | 2 |
| 5820 | ETMSTAB/TRANSIENT/MIDTERM STAB | 9 | 2 | 5 | | 2 | 5 | 3 | 1 | | | 5 | 3 | 1 |
| 5830 | AESOPS/LOW FREQ OSCILLAT'N | 6 | 2 | 1 | | 3 | 5 | | 1 | | | 5 | | 1 |
| 5840 | HARMFLO/HARMONIC POWER FLOW | 11 | 5 | 6 | | | 7 | 2 | 2 | | | 7 | 2 | 2 |
| 5850 | RELAY/PROTECTION ENGINEERING | 11 | 3 | 8 | | | 4 | | 5 | 1 | 1 | 4 | 1 | 6 |
| 5860 | FULSCH CODE: FUEL SCHEDULING | 3 | | 1 | | 2 | 2 | | | | 1 | 2 | | 1 |
| 5861 | TRANSIENT EFFICIENCIES/PWR PLT | 1 | 1 | | | | 1 | | | | | 1 | | |
| 5870 | POWER PLANT PERFORMANCE | 5 | 2 | 3 | | | 3 | | | | 2 | 3 | | 2 |
| 5880 | OPERATOR TRAINING SIMULATOR | 4 | 3 | 1 | | | 2 | | 2 | | | 2 | | 2 |
| 5890 | HUMAN FACTORS GUIDELINES | 9 | 6 | 3 | | | 3 | 2 | 3 | 1 | | 3 | 3 | 3 |
| 5898 | LOAD FLOW CONTINGENCY ANALYSIS | 1 | 1 | | | | 1 | | | | | 1 | | |
| 5900 | SOFTWARE DEV/MAINT GUIDELINES | 5 | 2 | 2 | | 1 | 3 | 2 | | | | 3 | 1 | 1 |
| 5990 | ES COMPUTER PROGRAMS, GENERAL | 8 | 5 | 2 | | 1 | 4 | | 3 | | 1 | 4 | | 4 |
| 6000 | TECHNICAL ASSISTANCE: NP | | | | | | | | | | | | | |
| 6001 | NP MISCELLANEOUS PRODUCTS | 3 | 1 | 2 | | | 2 | | 1 | | | 2 | 1 | |
| 6305 | HYDROGEN COMBUSTION DATABASE | 4 | 1 | 3 | | | 2 | | 1 | | | 2 | 2 | |
| 6310 | FULL-SCALE VALVE TESTS | 7 | 7 | | | | 2 | | 3 | | 2 | 2 | 4 | 1 |
| 6315 | COUPLE SAFETY VALVE CODE | 3 | 1 | 2 | | | | 3 | | | | | 3 | |
| 6320 | PRESSURIZED THERMAL SHOCK | 4 | 1 | 2 | 1 | | 2 | | | | 2 | 2 | 2 | |
| 6325 | STG THERMAL-HYDRAULICS CODE | 3 | | 3 | | | 1 | 2 | | | | 1 | 2 | |
| 6330 | PORTHOS FLOW-INDUCED VIB CODE | 3 | 2 | 1 | | | 1 | 1 | | | | 1 | 1 | 1 |
| 6335 | REACTIVITY CHANGE MONITOR | 3 | 1 | 2 | | | | | 2 | 1 | | | 1 | 2 |
| 6340 | SPDS SAFETY PANEL DISPLAY | 4 | 3 | 1 | | | 1 | 1 | 1 | | | 1 | 3 | |
| 6345 | MMS: MODULAR MODELING SYSTEM | 5 | 4 | 1 | | | 3 | 1 | | | 1 | 3 | 1 | 1 |
| 6350 | FAULT TREE EVALUATION CODE | 5 | 3 | 2 | | | 3 | | 1 | | 1 | 3 | | 2 |
| 6355 | PLANT AVAILABILITY AIDS | 5 | 3 | 2 | | | 4 | | 1 | | | 4 | 1 | |
| 6360 | TURBINE MISSILE RISK | 4 | 2 | 1 | | 1 | 3 | 1 | | | | 3 | 1 | |
| 6365 | SYSTEM RELIABIL/AVAILABILITY | 4 | 4 | | | | 2 | 1 | 1 | | | 2 | 1 | 1 |
| 6370 | SOCRATES/PLANT SPECIFICATIONS | 2 | | 2 | | | 1 | | | | 1 | 1 | | 1 |
| 6380 | EQHIST SEISMIC PATTERN CODE | 1 | | | | 1 | 1 | | | | | 1 | | |
| 6385 | CAFTA FAULT TREE MANIPULATION | 1 | | 1 | | | | 1 | | | | | 1 | |
| 6390 | RELIABILITY-CENTERED MAINT'NCE | 4 | 1 | 3 | | | 3 | 1 | | | | 3 | 1 | |
| 6395 | SHARP/HUMAN ERROR/PLANT SAFETY | | | | | | | | | | | | | |
| 6405 | PRA DOCUMENTATION GUIDE | 2 | 1 | 1 | | | 1 | 1 | | | | 1 | 1 | |
| 6415 | UNDESIREABLE SYST INTERACTIONS | 2 | | 2 | | | 1 | 1 | | | | 1 | | 1 |
| 6420 | HUMAN/HARDWARE INTERACTIONS | 2 | 1 | 1 | | | 1 | | | | 1 | 1 | | 1 |
| 6425 | STRUCTURAL ANALYSIS CODE | 5 | 3 | 2 | | | 3 | 1 | | | 1 | 3 | 2 | |
| 6430 | STEALTH CONTINUUM MECH CODE | 3 | 1 | 1 | | 1 | 2 | | 1 | | | 2 | | 1 |
| 6497 | PIPE DAMPING AND SNUBBERS | 1 | | 1 | | | | | 1 | | | | 1 | |

| PROD NO. | PRODUCT NAME | TIMES CITED | ACT. | POT. | IND. | N/A | DOLLAR BENEFITS (\$1000) | | | | | NOT QUANT. | ONE TIME | CONT. |
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| | | | | | | | 0 | 1+ | 50+ | 500+ | 1000+ | | | |
| 6498 | DECAY HEAT REMOVAL | 2 | | 2 | | | | | | | 2 | | 2 | |
| 6499 | STATION BLACKOUT DATABASE | 1 | 1 | | | | | | | | 1 | | 1 | |
| 6501 | FORCED OXIDATION BY H2O2 | 1 | 1 | | | | | | | | 1 | | | 1 |
| 6505 | ARMP FUEL RELOAD MGT CODE | 7 | 6 | | 1 | | 2 | | 2 | 1 | 1 | 2 | 3 | 2 |
| 6510 | RETRAN REACTOR TRANSIENT ANAL | 8 | 8 | | | | 2 | 1 | 4 | 1 | 2 | 2 | 3 | 3 |
| 6515 | SIMULATE NUCLEAR FUEL PERF | 4 | 4 | | | | | 2 | 1 | | 1 | | 3 | 1 |
| 6520 | VIPRE THERMAL-HYDRAULICS ANAL | 6 | 5 | 1 | | | 2 | 2 | 2 | | | 2 | 2 | 2 |
| 6525 | DATATRAN FOR DATA MGT | 3 | 2 | 1 | | | 1 | | 1 | | | 1 | 2 | |
| 6530 | RASP LWR FUEL RELOAD CODE | 6 | 3 | 3 | | | 2 | 3 | 1 | | | 2 | 4 | |
| 6535 | FREY ANALYZES LWR FUEL | 2 | 1 | | | 1 | 2 | | | | | 2 | | |
| 6605 | IMPROVED BWR FUEL ASSEMBLY | 4 | 2 | | | 2 | 2 | 1 | | | 1 | 2 | 1 | 1 |
| 6610 | EXTEND BWR FUEL CHANNEL LIFE | 6 | 2 | 2 | | 2 | 4 | 1 | | 1 | | 4 | 1 | 1 |
| 6615 | EXTEND BWR CONTROL BLADE LIFE | 5 | 1 | 3 | | 1 | 3 | 1 | | | 1 | 3 | 1 | 1 |
| 6620 | EXTEND BWR FUEL BURNUP | 4 | | 3 | | 1 | 3 | | | | 1 | 3 | | 1 |
| 6625 | EXTEND PWR FUEL BURNUP | 2 | 1 | | 1 | | | 1 | | | 1 | | 1 | 1 |
| 6630 | FUEL ROD PERFORMANCE CODES | 5 | 3 | 2 | | | 2 | 1 | 2 | | | 2 | 2 | 1 |
| 6701 | NDE AND ISI MISCELLANEOUS | 1 | 1 | | | | 1 | | | | | 1 | | |
| 6705 | NDE CENTER | 8 | 7 | 1 | | | 4 | 1 | 1 | 1 | 1 | 4 | 3 | 1 |
| 6710 | ISI TRAINING | 7 | 6 | 1 | | | 1 | 1 | 1 | 1 | 3 | 1 | 4 | 2 |
| 6715 | AUTOMATED US PIPE SCANNER | 5 | 4 | 1 | | | 2 | 1 | | | 2 | 2 | 2 | 1 |
| 6720 | INTRASPECT/AUTOMATED IMAGING | 4 | 1 | 3 | | | 4 | | | | | 4 | | |
| 6725 | MINAC: RADIOGRAPHIC INSPECTION | 5 | 5 | | | | 3 | | 1 | 1 | | 3 | 2 | |
| 6730 | TRANSDUCER INSPECTS BWR PIPES | 5 | 5 | | | | 2 | 2 | | | 1 | 2 | 2 | 1 |
| 6735 | PIPE FLAW EVALUATION | 5 | 3 | 1 | | 1 | 4 | | | | 1 | 4 | 1 | |
| 6740 | IRRADIATED CRACK ARREST DATA | 4 | 2 | 1 | 1 | | 2 | | 1 | 1 | | 2 | 1 | 1 |
| 6745 | STRUCTURAL INTEGRITY DECISIONS | 1 | 1 | | | | 1 | | | | | 1 | | |
| 6750 | EDDY CURRENT SIGNAL ANALYSIS | 3 | 2 | 1 | | | 2 | | | | 1 | 2 | | 1 |
| 6755 | ULTRASONIC UNDERCLAD DETECTION | 3 | 1 | 2 | | | 2 | | | 1 | | 2 | 1 | |
| 6765 | HIGH TEMP ULTRASONIC MONITOR | 3 | | 1 | | 2 | 3 | | | | | 3 | | |
| 6770 | ALN-4060 SCC DETECTOR | 3 | 1 | 2 | | | 3 | | | | | 3 | | |
| 6775 | LPHSW REDUCES SCC | 3 | 1 | 1 | 1 | | 2 | | | | 1 | 2 | 1 | |
| 6780 | REACTOR VESSEL MATERIAL | 1 | | 1 | | | 1 | | | | | 1 | | |
| 6785 | IRRADIATED MATERIAL DATA BASES | 5 | 3 | 2 | | | 2 | 2 | | 1 | | 2 | 2 | 1 |
| 6790 | PICEP/PWR FLOW RATE CALC | 3 | 1 | 1 | 1 | | 2 | 1 | | | | 2 | 1 | |
| 6795 | FRACTURE HANDBOOK: PIPING | 5 | 3 | 2 | | | 2 | 2 | 1 | | | 2 | 3 | |
| 6800 | STEAM GENERATOR NDE GUIDELINES | 4 | 3 | 1 | | | 2 | | 1 | | 1 | 2 | 2 | |
| 6805 | STG EDDY CURRENT DETECTOR | 8 | 5 | 3 | | | 7 | | 1 | | | 7 | | 1 |
| 6905 | INDUCT'N HEATING STRESS RELIEF | 4 | 3 | 1 | | | 2 | | 1 | | 1 | 2 | 1 | 1 |
| 6906 | EROSION AND CORROSION | 1 | 1 | | | | | | | | 1 | | 1 | |
| 6910 | LPHSW REDUCES SCC | 2 | 2 | | | | | 1 | | | 1 | | 2 | |
| 6915 | STRESS CORROS'N RESISTNT ALLOY | 5 | 4 | 1 | | | 4 | | | | 1 | 4 | | 1 |
| 6920 | BWR PIPE CRACKING MITIGATION: | 4 | 4 | | | | 1 | | | | 3 | 1 | 3 | |
| 6925 | BWR HYDROGEN WATER CHEMISTRY | 5 | 5 | | | | 3 | | | | 2 | 3 | 1 | 1 |
| 6930 | EXTEND WELD OVERLAY LIFE | 3 | 1 | 2 | | | 3 | | | | | 3 | | |
| 6935 | BWR APPLICATION & TRAINING | 4 | 3 | 1 | | | 2 | | | | 2 | 2 | 1 | 1 |

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| PROD NO. | PRODUCT NAME | TIMES CITED | PRODUCT | | APPLICATION | | DOLLAR BENEFITS (\$1000) | | | | | NOT QUANT. | ONE TIME | CONT. |
|----------|--------------------------------|-------------|---------|------|-------------|-----|--------------------------|----|-----|------|-------|------------|----------|-------|
| | | | ACT. | POT. | IND. | N/A | 0 | 1+ | 50+ | 500+ | 1000+ | | | |
| 6940 | KINETIC BOND FOR TUBE JOINTS | 6 | | 6 | | | 5 | | 1 | | | 5 | 1 | |
| 6945 | IMPROVE CORROSION RESISTANCE | 4 | 1 | 2 | 1 | | 2 | | | | 2 | 2 | | 2 |
| 6950 | THEDA PREDICTS STG PLUGGING | 2 | | | 1 | 1 | 2 | | | | | 2 | | |
| 6955 | PWR WATER CHEM/AVAIL GUIDELINE | 10 | 10 | | | | 5 | 2 | | | 3 | 5 | 4 | 1 |
| 6960 | IMPROVED CONDENSATE POLISHER | 6 | 5 | 1 | | | 3 | 1 | | 1 | 1 | 3 | 2 | 1 |
| 6965 | PWR WATER CHEM/AVAIL RECOM'ND | 7 | 4 | 2 | | 1 | 7 | | | | | 7 | | |
| 6970 | PWR WATER CHEM/AIR INLEAKAGE | 7 | 7 | | | | 5 | 1 | | | 1 | 5 | 1 | 1 |
| 6975 | STEAM GENERATOR CHEM CLEANING | 5 | 2 | 1 | | 2 | 4 | | | | 1 | 4 | | 1 |
| 6980 | PWR WATER CHEM/IMPURITY REMOVL | 7 | 5 | | | 2 | 5 | | | | 2 | 5 | 1 | 1 |
| 6985 | BWR WATER CHEM GUIDELINES | 6 | 5 | 1 | | | 4 | 1 | | | 1 | 4 | 1 | 1 |
| 7105 | LOW-LEVEL WASTE DISPOSAL CODE | 7 | 3 | 4 | | | 3 | 3 | | | 1 | 3 | 3 | 1 |
| 7110 | LLW DISPOSAL FACILITY HANDBOOK | 5 | 1 | 1 | 2 | 1 | 4 | | 1 | | | 4 | 1 | |
| 7201 | HUMAN ENGINEERING GUIDELINES | 3 | 3 | | | | 2 | | 1 | | | 2 | 1 | |
| 7205 | COMPUTER DISPLAY GUIDELINES | 5 | 2 | 3 | | | 3 | | | 1 | | 3 | 1 | 1 |
| 7210 | ENVIRO QUALIFICATION GUIDEBOOK | 7 | 2 | 5 | | | 4 | 2 | 1 | | | 4 | 3 | |
| 7215 | NEW FUEL SUPPORT PIECE GRAPPLE | 3 | | 1 | | 2 | 2 | | | | 1 | 2 | | 1 |
| 7220 | ICE JACKET REDUCES HEAT STRESS | 5 | 5 | | | | 2 | | 2 | | 1 | 2 | 1 | 2 |
| 7230 | EXTEND TURBINE DISC LIFE | 6 | 3 | 3 | | | 4 | 1 | | | 1 | 4 | 2 | |
| 7235 | EXTEND TURBINE ROTOR LIFE | 8 | 4 | 3 | | 1 | 3 | 1 | 1 | 2 | 1 | 3 | 4 | 1 |
| 7240 | BIGIF CRACK ANALYSIS PROGRAM | 6 | 3 | 1 | 1 | 1 | 3 | 1 | 2 | | | 3 | 1 | 2 |
| 7245 | REMOTE RECONNAISSANCE VEHICLE | 2 | 1 | 1 | | | 1 | 1 | | | | 1 | 1 | |
| 7250 | MAIN STEAM LINE PLUG | 3 | 1 | 1 | | 1 | 1 | 1 | 1 | | | 1 | 2 | |
| 7255 | ACOUSTIC VALVE POSITION MONITR | 7 | 6 | 1 | | | 3 | 1 | | 1 | 2 | 3 | 2 | 2 |
| 7260 | VALVE SEAT HONING TOOL | 2 | | 1 | | 1 | 2 | | | | | 2 | | |
| 7261 | VALVE STEM PACKING | 1 | 1 | | | | 1 | | | | | 1 | | |
| 7265 | COOLANT PUMP (MCP) REL. GUIDE | 3 | 2 | 1 | | | 1 | | 1 | 1 | | 1 | | 2 |
| 7270 | HOOD FOR HELIUM LEAK TESTING | 7 | 4 | 3 | | | 4 | | 1 | 1 | 1 | 4 | | 3 |
| 7271 | ON-LINE LEAK SEALING METHODS | 1 | 1 | | | | | 1 | | | | | | 1 |
| 7275 | GENERATOR ARCING DETECTOR | 5 | 3 | 2 | | | 3 | | | | 2 | 3 | 2 | |
| 7280 | INSTRUMENT MEASURES IMPURITIES | 5 | 2 | 2 | | 1 | 5 | | | | | 5 | | |
| 7285 | HIGH TEMP OXIDATION MONITOR | 3 | | 3 | | | 3 | | | | | 3 | | |
| 7290 | GAS ANALYZER REDUCES CORROSION | 5 | | 1 | 1 | 3 | 5 | | | | | 5 | | |
| 7295 | CALIBRATING RHODIUM DETECTORS | 1 | | | | 1 | 1 | | | | | 1 | | |
| 7300 | MOBILE SURVEILLANCE SYSTEM | 1 | | 1 | | | | | 1 | | | | 1 | |
| 7605 | EQUIPMENT QUALIFICATION DATA | 5 | 3 | 1 | | 1 | 3 | 1 | 1 | | | 3 | 1 | 1 |
| 7606 | GENERATION AVAIL'Y INFO SYS | 1 | 1 | | | | 1 | | | | | 1 | | |
| 7705 | STAIN. STEEL FEEDWATER VALVE | 7 | 2 | 5 | | | 5 | 1 | | 1 | | 5 | 1 | 1 |
| 7710 | ACIDITY CONTROL IN PWR COOLANT | 4 | 3 | 1 | | | 1 | | 1 | | 2 | 1 | 1 | 2 |
| 7715 | ELECTROPOLISHING PROCESS | 5 | 1 | 3 | | 1 | 3 | 1 | | | 1 | 3 | 1 | 1 |
| 7720 | LOMI DECON PROCESS | 7 | 2 | 4 | | 1 | 4 | 1 | 1 | | 1 | 4 | 2 | 1 |
| 7725 | REMOTE MOBILE SCABBLING VEHIC. | 1 | | 1 | | | 1 | | | | | 1 | | |
| 7730 | IMPROVED DECONTAMINATION AGENT | 4 | 1 | 2 | | 1 | 3 | | 1 | | | 3 | | 1 |
| 7735 | GAMMA RAY SPECTROMETER SYSTEM | 5 | | 2 | 1 | 2 | 5 | | | | | 5 | | |
| 7951 | AVAILABILITY ENGINEER'G METHOD | 1 | 1 | | | | | | 1 | | | | | 1 |
| 7992 | LAYUP OF PLANT EQUIPMENT | 1 | 1 | | | | | | | | 1 | | | 1 |

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| PROD NO. | PRODUCT NAME | TIMES CITED | PRODUCT | | APPLICATION | | DOLLAR BENEFITS (\$1000) | | | | | NOT QUANT. | ONE TIME | CONT. |
|-------------|--------------------------------|----------------|---------|------|-------------|-----|--------------------------|----|-----|------|-------|---------------|-------------|-------|
| | | | ACT. | POT. | IND. | N/A | 0 | 1+ | 50+ | 500+ | 1000+ | | | |
| 7993 | BWROG IGSCC | | | | | | | | | | | | | |
| 7994 | MISC AGGREG'D NP PROD - AU/AP | 1 | 1 | | | | | | | | 1 | | | 1 |
| 7995 | MISC AGGREG'D NP PROD - PN/PF | 1 | | 1 | | | | | | | 1 | | | 1 |
| 7996 | STG SGOG PWR | 3 | 2 | 1 | | | 2 | | | | 1 | 2 | 1 | |
| 7997 | APPENDIX A: HNDBK/GUIDEBOOK | 2 | | 2 | | | 1 | | 1 | | | 1 | 1 | |
| 7998 | APPENDIX B: COMPUTER CODES | 4 | 2 | 2 | | | 1 | 2 | | | 1 | 1 | 3 | |
| 7999 | APPENDIX B: PATENTS LIST | | | | | | | | | | | | | |
| 9000 | TECHNICAL ASSISTANCE: EPRI | 3 | 3 | | | | 2 | | | | 1 | 2 | 1 | |
| 9001 | ADVISORY AND OTHER COMMITTEES | 1 | 1 | | | | 1 | | | | | 1 | | |
| 9002 | USER GROUPS | 2 | 1 | 1 | | | 1 | | 1 | | | 1 | | 1 |
| 9003 | INFORMATION OF VALUE | 6 | 5 | 1 | | | 3 | | 2 | | 1 | 3 | | 3 |
| 9004 | COMM MATERIALS: EPRI JOURNAL, | 2 | 2 | | | | 2 | | | | | 2 | | |
| 9005 | TAG | 2 | 2 | | | | | 2 | | | | | 1 | 1 |
| 9006 | ISSUES IDENTIFICATION: P-4143 | 1 | 1 | | | | | 1 | | | | | | 1 |
| 9010 | EPDB: ELECTRIC POWER DATABASE | 1 | | 1 | | | | 1 | | | | | | 1 |
| 9200 | CROSS-DIVISION MISC. PRODUCTS | 1 | | 1 | | | 1 | | | | | 1 | | |
| 9201 | COMPUTER CODES: GENERAL | 2 | 2 | | | | 1 | | | | 1 | 1 | 1 | |
| 9202 | PCB-RELATED STUDIES AGGREGATED | 4 | 2 | 1 | 1 | | 3 | | 1 | | | 3 | | 1 |
| 9999 | THE "ORPHANAGE" * * * * * | | | | | | | | | | | | | |

Appendix C

Total Benefits and Costs

Over the course of the campaign, a number of generic methodological and conceptual issues arose regarding:

- The totalling of benefits and costs
 - Over time
 - Across various categories and contexts of research product utilization
- The quantification of benefits of R&D

Total Benefits and Total Costs

Table C-1 summarizes six general distinctions that can be made in calculating costs and benefits of EPRI R&D to a utility. Four apply to benefits, and four apply to costs (two apply to both).

Table C-1

VARIOUS APPROACHES TO ESTIMATING COSTS AND BENEFITS

| <u>Benefit</u> | <u>Cost</u> | <u>Approach</u> |
|----------------|-------------|--|
| x | | ● Actual versus potential |
| x | | ● Probabilistic "expected" benefit |
| | x | ● Only "completed R&D" portion |
| | x | ● Include other participation costs |
| x | x | ● Cumulative versus per-year time series |
| x | x | ● Present-value versus nondiscounted |

"Benefits" in the present context are those costs saved or avoided by a utility through the application of products and results of the EPRI R&D program. In the Benefits Assessment Program, utilities reviewed products and estimated dollar benefits where appropriate. The context or nature of the benefit ranged from specific engineering cost savings actually being realized to the more-speculative future potential benefits that would occur if and when something was applied, and to the situation in which a product isn't in actual use within the company but important benefits are nevertheless being realized (e.g., industrywide).

The first two items in table C-1 indicate approaches to combining these various kinds of benefits. Some utilities tended to consider only actual benefits while others included some or all of the potential and indirect benefits, on the basis of scenarios with varying degrees of confidence in the estimates. In its most general form, this approach involves assigning probabilities as to whether the benefits will indeed be realized and obtaining an "expected" value.

"Costs" are the dues paid over the years by the utility to support the EPRI program. Thus, in determining the cost factor of the benefit-cost ratio, some companies took into account all of their EPRI dues payments since the beginning of the utility's membership (for some, this went back to 1973) whereas for others the costs were assigned as starting in recent years. One company (Con Ed) ascribed only 72% of its total cumulative payments to EPRI as having contributed towards completed research, as distinct from the monies paid in the last several years that have gone to support research still in progress.

Other participation costs were considered in some instances. These included the time and travel expenses of advisory participation or other direct expenses. (Implementation costs of individual products were netted out in the benefits evaluations.)

Costs and benefits occur over time, so much in each year. The treatment given this time dimension ("time value of money") varied considerably from company to company. In adding one-time and continuing benefits, some companies averaged continuing benefits for only a few years before adding them to one-time benefits; some took a formal present-value approach, while others simply listed the continuing benefits year by year as a time series. Generally, the same approach was taken to benefits and to costs in any given report.

So, although there was some commonality in approaches, these significant differences make it less meaningful to attempt comparison of the overall values for the benefit-cost ratio reported by the different participating utilities.

Product Benefits

Underlying the total benefit figures, of course, are the individual assessments, product by product, adding another source of variation among the various utility reports: individual reviewers used different "yardsticks" in assessing both usefulness and benefits of individual products. For instance, a product such as a manual or guide might be valued strictly on its direct purchase price (e.g., \$25) by one reviewer; it might be considered as significant by another reviewer for having allowed the utility to avoid hiring a consultant (e.g., worth \$50 to \$100,000); and for a third reviewer, the same document is seen as crucial in saving the utility from expenditures on the order of a million dollars or more. Thus, there were wide ranges in the degree of conservatism vis-a-vis comfort with the making of assumptions (the key to any benefits calculation) among and within utilities.

A major point to note is that a large share of EPRI products are informational in character; these include references, guidelines, test data, training, workshops, seminars, planning documents, computerized databases, telephone and personal "consulting," and updates on the state of art of technical and scientific areas. The utility reviewers were often perplexed how to assign value to products of this type. This is not surprising--workers in all knowledge industries have long recognized the difficulties in evaluating the role of information in decision making--but for the Benefits Assessment Program it meant that the EPRI and utility staff frequently had to deal with subjective judgments rather than with more objective engineering-economics. Recognizing the difficulty, EPRI staff attempted to provide more information about informational products and to debrief utility reviewers about what role EPRI information played in their specific situational decision making (comparing what "probably would have happened without" the EPRI product available with the outcome that actually did occur). This proved to be one of the most challenging aspects of the campaign.

Appendix D

Reference Materials for Benefits Assessments

EPRI is developing a set of self-help materials to help utilities to undertake benefits assessments on their own (or with varying degrees of support from EPRI).

Some of these documents (or samples) appear in the following pages:

Page

D-5 EPRI Product Assessment Work Sheet (BAP-302)

D-7 Work Sheet Instructions for EPRI Product Assessment Work Sheet (BAP-305)

D-9 1986 Product List (sample pages)

This product list, 85 pages long, serves as a convenient tool for utilities to screen products for benefits assessment and/or for application on their system. Sections of this list appear as the table of contents in each of the 1986 EPRI product books. The EPRI research project number(s) indicates which projects led to the development of the product. A technical staff contact is also identified.

CAUTION: Product numbers frequently are different from the product numbers used in 1985 (which appear in appendix B of this report).

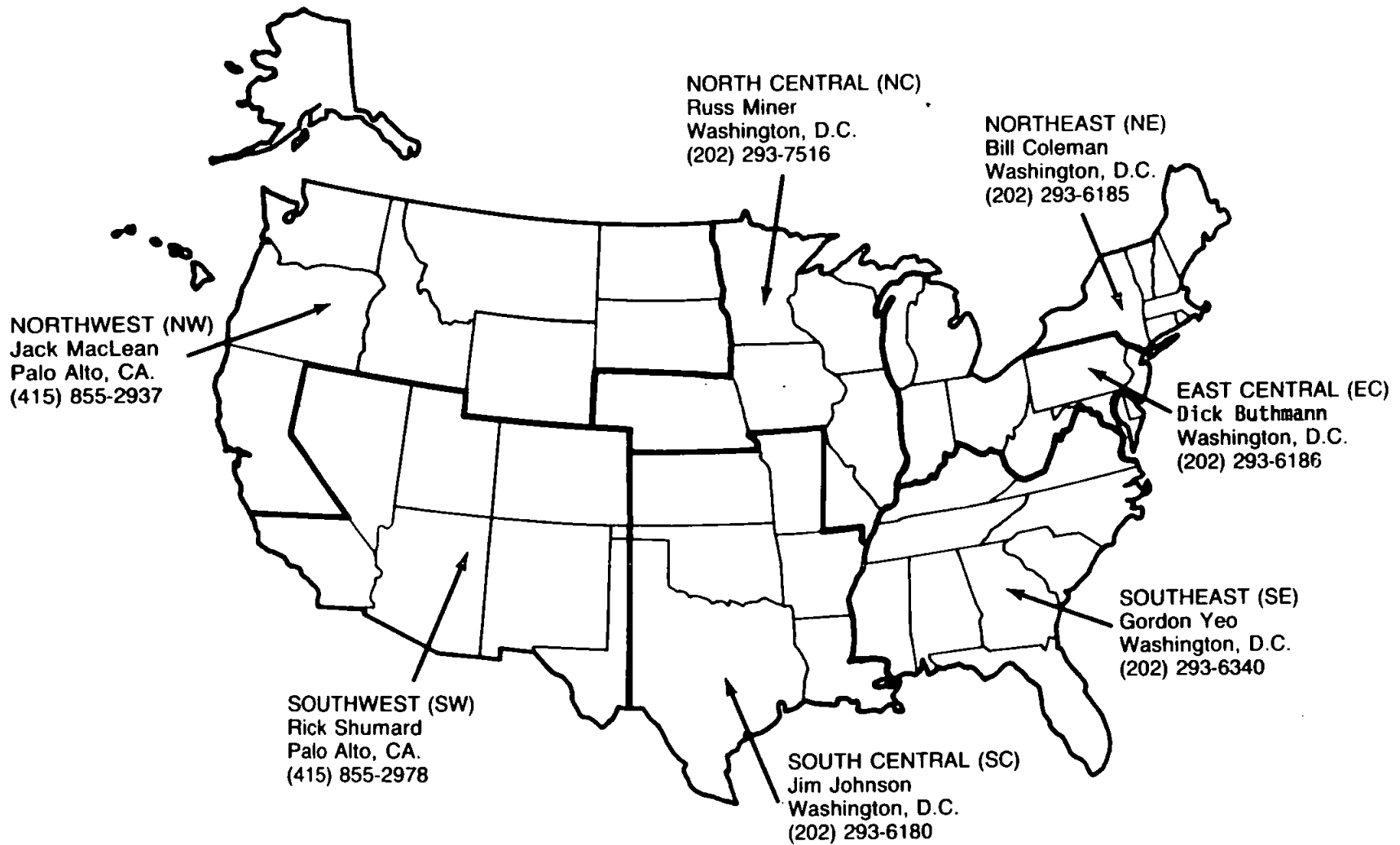
D-13 1986 Product Book (sample pages)

The Product Book provides one-page descriptions of each product listed on the Product List. A sample benefits calculation appears on the back page of most product sheets. Currently the books are organized by EPRI technical division or department. Ways to organize the material by research categories are being explored, as some topics reach across EPRI organizational units.

D-19 Estimating Indirect Benefits of EPRI Environmental R&D: Summary (BAP-304)

A technique to circumvent the difficulties in quantifying indirect benefits, still under development, was first proposed during the 1985 campaign. A brief synopsis of the approach is given here.

Guidance on the use of these materials can be obtained through an EPRI Member Services Regional Manager (see map, page D-3) or through the EPRI Benefits Assessment Program Office (415) 855-2740.



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(utility)

BAP-302 (5/86R)

6. DESCRIBE HOW PRODUCT APPLIED; What Problem Solved (or why not applicable):

[illegible]

9. BENEFITS ☐ not quantifiable ☐ not quantified because: _____

10. Prepared by _____ Dept. _____ Phone _____ Date _____

The worksheet was developed to provide the product reviewer with a framework and format to facilitate the assessment of benefits obtained by the company from the use of a particular EPRI product. Examples of benefits assessments writeups for individual products are available to indicate ways to approach the evaluation.

1. PRODUCT NAME and 2. PRODUCT NUMBER

In most cases, these will be readily obtained from the Product List and Product Books, which list and describe the many products of EPRI research. Even if the product doesn't appear in the Product List, an assessment can still be done -- use information such as RP number or research report number to identify the product, or specify the product in whatever way seems appropriate.

3. PRODUCT APPLICATION

The six categories distinguish different circumstances of product usage by the utility:

- The first two are for products that are already in use, or for which there are firm plans to use.
- The next two describe nearterm or future potential applications -- products that are being or will be considered for possible future use.
- Indirect (Benefits) applies in situations where the product isn't actually being used within the company, but where benefits are nevertheless being realized indirectly. For example, air quality research may influence environmental control legislation, which can have an impact either very specifically (an actual plant that would've required retrofit) or more generically in terms of probable future requirements.
- Not Applicable - This is intended to help determine which products are relevant in which parts of the industry and for what reasons. It isn't suggested that worksheets be filled out across whole categories of generically not-applicable products (e.g. if the company has no coal-fired generation or transmission lines) but rather for those individual products which don't apply for less obvious reasons (e.g. climate, or system equipment incompatibility).

4. NATURE OF BENEFIT

In addition to benefit category. The "nature" of the benefit describes in general terms the context of the product application, and how the benefit occurred. Six choices are provided (more than one might apply in some instances):

1. Cost avoidance - cost is not incurred that otherwise would have been incurred
2. Cost savings - a lower cost is incurred than would have been incurred
3. Strategic issue - a decision is made differently than otherwise
4. Regulatory issue - a regulatory outcome is different than would otherwise have occurred
5. Reference - a reference or information tool provides information or guidance
6. Joint owner/pool - the operator of a jointly-owned power plant receives benefits that can be assigned to all owners in proportion to their ownership of the plants, or the benefit is a fraction of the benefit occurring for a group of neighboring utilities.

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5. BENEFIT DUE TO INCREASE/DECREASE IN:

Each time a product is used, the benefit will be obtained through a change in some observed parameter, either a direct cost, or some technical variable. This section provides a list of several parameters and costs that the product might have affected. For each product, check one or more of the parameters or costs that apply (as a first step in deciding how the benefits might be quantified).

6. HOW PRODUCT APPLIED; What Problem Solved (or why not applicable):

A brief paragraph is usually sufficient to describe the product application -- what was the problem and how did the product help solve it -- what would have happened if the product hadn't been available -- what difference the product made (or could make).

If not applicable (see above item #3), very briefly, why?

7. BENEFIT TO COMPANY - QUALITATIVE OR QUANTITATIVE - Assumptions:

This section of the worksheet provides a place to state explicit assumptions about the quantitative or qualitative impact of EPRI's product on the parameters or costs identified above, by identifying either the incremental change in those parameters or costs, or by identifying the absolute level of those parameters or costs for scenarios with and without the product available.

In some cases it may be appropriate to attribute to EPRI some fraction of the total benefit which the company is getting. For example, the EPRI work may have been partially but not entirely responsible for the result. In other instances, it's useful to assign a probability that the same benefit would have been realized without the EPRI product being available, and weight the benefit accordingly.

If the exact magnitude of benefits is uncertain, it's possible to make alternative assumptions and to calculate a range of benefits.

8. ESTIMATED \$ BENEFITS

To summarize the results of the benefits calculations, this box provides for entry of a time-series of \$ benefits. A one-time savings would appear simply as the single (or range) benefit value, along side the year it occurred. A continuing savings would appear as a series of values with the respective years of occurrence.

"% Probability of Benefits" This is a technique some utilities have used in the past, where an overall probability is assigned by the reviewer to describe the likelihood or degree of certainty that the benefits will actually be realized (past benefits should be 100% in most cases).

Current \$ or Constant \$, Current Present Value etc. The company may establish guidelines for the economic calculations. Otherwise, simply indicate what approach was taken in the calculations.

9. BENEFITS not Quantifiable or not quantified because:

In cases where an actual \$ quantification has not been done, it is helpful to know specifically why.

10. Prepared by: the name of the person preparing the review.

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| NO. | RP NO. | PRODUCT NAME | MANAGER/EXT | STATUS/NOTES/CONTACT |
|--|-------------------------------|---|--------------------------|----------------------|
| * 0000-0999 * BAP86: EPRI PRODUCT LIST * | | | | |
| 0000 | A | BAP86: NULL PRODUCT. EVERY STUDY BEGINS WITH "NULL" | RHODES DUSTY 2835 | |
| * 1000-1024 * RELIABILITY & AVAILABILITY * | | | | |
| 1010 | 1461-01 | UNIRAM RELIABILITY/ AVAILABILITY ASSESSMENT METHODOLOGY FACILITATES POWER PLANT R/A ANALYSIS | WEISS JERRY 2495 | |
| 1015 | 1800-01 | AVAILABILITY ANALYSIS HNDBK: PREDICTION OF RELIABILITY, AVAILABILITY, & MAINTAINABIL'Y FOR COAL GASIFICATION-BASED & GAS TURBINE BASED POWER PLANTS | WEISS JERRY 2495 | |
| 1020 | 0239-02 | COMPONENT FAILURE AND REPAIR DATA FOR COAL-FIRED PLANTS COMPREHENSIVE RELIABILITY DATA FOR TYPICAL COMPONENTS OF A MODERN PLANT | WEISS JERRY 2495 | |
| * 1100-1149 * HUMAN FACTORS * | | | | |
| 1110 | A TPS-715 | ENHANCED MAN-MACHINE INTERFACE TYPES OF HUMAN ERRORS AND POTENTIAL PREVENTIVE MEASURES TPS77-715 | WEISS JERRY 2495 | |
| * 1150-1199 * POWER SYSTEM PLANNING * | | | | |
| 1170 | 2029-16 2699-05 2699-07 | PROMOD III COMBINED CYCLE MODULE: COSTING MODEL FOR COMBINED CYCLE & GASIFICATION- COMBINED CYCLE GENERATION EXPANSION ANALYSES | LEWIS ALLISON 2814 | |
| 1180 | 2029-13 2699-04 | PHASED GASIFICATION-COMBINED CYCLE PLANNING DATA BOOK DESIGN, PERFORMANCE, AND COST DATA FOR EVALUATION OF BENEFITS OF PHASED GCC ADDIT'N | GLUCKMAN MIKE 2493 | |

STATUS CODES: A) ALREADY IN USE B) ACTUAL PLANS TO USE C) POSSIBLE FUTURE USE
 D) NEED MORE INFO E) NOT APPLICABLE

| NO. | RP NO. | PRODUCT NAME | MANAGER/EXT | STATUS/NOTES/CONTACT |
|---|--------------|---|----------------------------|----------------------|
| 3640 | SUBHEAD | FUEL TRANSPORTATION (PRODUCTS 3641 - 3649) | | |
| 3642 | 1219-03 | RAILROAD ROUTING AND COSTING SYSTEM FINDS ROUTES AND ESTIMATES THE COST, TIME AND ENERGY USE OF SUCH ROUTES | ALTOUNEY EDWARD 2626 | |
| 3644 | 1219 1983 | CTPS: COAL TRANSPORTATION PLANNING SYSTEM TOOLS TO DESIGN COAL TRANSPOR- TATION SYSTEM FROM SUPPLY POINT TO DEMAND REGION | ALTOUNEY EDWARD 2626 | |
| 3650 | SUBHEAD | FUEL PLANNING AND MANAGEMENT (PRODUCTS 3651 - 3659) | | |
| 3652 | 1009 | COAL MINE COST MODEL ESTIMATE OF UNDERGROUND AND SURFACE COAL MINING COSTS | DELSON JERRY 2619 | |
| 3654 | 2314 | UTILITY FUEL INVENTORY MODEL EVALUATES ALTERNATIVE FUEL INVENTORY POLICIES | CHAPEL STEPHEN 2608 | |
| 3656 | 2359-20 | CONTRACT MIX: FUEL CONTRACT MIX MODEL FOR EVALUATING AND SELECTING FUEL CONTRACTS/STRATEGIES | MUELLER HOWARD 2745 | |
| 3658 | 2359-23 | FUEL BURN FORECASTING SYSTEM UNIT-BY-UNIT LONG-RUN PROBABILISTIC FUEL BURN FORECASTS | MUELLER HOWARD 2745 | |
| 3690 | SUBHEAD | WATER RESOURCES (PRODUCTS 3691 - 3699) | | |
| 3692 | 1603-02 | WSCID: WATER SUPPLY COMPUTERIZED INFORMATION DIRECTORY | ALTOUNEY EDWARD 2626 | |
| * 3700-3799 * INTEGRATED PLANNING METHODS * | | | | |
| 3720 | SUBHEAD | INVESTMENT OPTION EVALUATION METHODS (PRODUCTS 3721 - 3729) | | |

STATUS CODES: A) ALREADY IN USE B) ACTUAL PLANS TO USE C) POSSIBLE FUTURE USE
 D) NEED MORE INFO E) NOT APPLICABLE

| NO. | RP NO. | PRODUCT NAME | MANAGER/EXT | STATUS/NOTES/CONTACT |
|---------------------------------|---------|--------------------------------|-------------|----------------------|
| 4763 | 0211 | CONSERVATION | BRAITHWAITE | |
| | 1050 | DISSEMINATES INFORMATION ON | STEVE | |
| | 1940 | CONSERVATION TO UTILITIES AND | 2606 | |
| | 2050-11 | OTHERS | | |
| | 2152-01 | | | |
| 4764 | 0435 | RATE DESIGN | SMITH | |
| | 0863 | PROVIDES UTILITIES WITH MORE | BILL | |
| | 0864 | EFFECTIVE METHODS OF RATE | 2415 | |
| | 2050-07 | DESIGN | | |
| | 2381-05 | | | |
| | 2440 | | | |
| 4799 | A | TECHNOLOGY SUPPORT MEDIA - | GELLINGS | |
| | | DEMAND-SIDE MANAGEMENT | CLARK | |
| | | EDUCATIONAL AND INFORMATIONAL | 2610 | |
| | | MATERIAL | | |
| * 4800-4849 * MARKETING SUPPORT | | | | * |
| 4801 | 1537 | MARKETING | LEWIS | |
| | 2045 | SUPPORT UTILITIES IN PLANNING, | LARRY | |
| | 2050-11 | IMPLEMENTING, AND EVALUATING | 8902 | |
| | 2547 | THEIR MARKETING ACTIVITIES | | |
| | 2671 | | | |
| 4802 | 1216-09 | COMMERCIAL SECTOR DATA | FARUQUI | |
| | | ANALYSIS TECHNIQUES | AHMAD | |
| | | PROVIDES A PRIMER ON SURVEYING | 2630 | |
| | | AND SAMPLING TECHNIQUES | | |
| 4803 | 0757 | IMPACT OF ELECTRIC VEHICLES | LEWIS | |
| | 1145 | EVALUATES PROBLEMS AND | LARRY | |
| | 1524-03 | POTENTIAL FOR ELECTRIC | 8902 | |
| | 2381 | VEHICLES | | |
| * 5000-5049 * PCB | | | | * |
| 5010 | 1713-01 | DESKTOP PCB DETECTOR | TAHILIANI | |
| | | PERMITS A SCREENING TEST ON | VASU | |
| | | TRANSFORMER OIL TO DETERMINE | 2315 | |
| | | THE PRESENCE OF PCBS | | |
| 5020 | 1713-01 | CLOR-N-OIL PCB SCREENING KIT | TAHILIANI | |
| | | REDUCES THE NEED FOR | VASU | |
| | | EXPENSIVE LABORATORY TESTS | 2315 | |
| 5030 | 2028-01 | REMOVING PCBS FROM TRANSFORMER | ADDIS | |
| | 2028-03 | OIL | GILBERT | |
| | 2028-13 | LARGE SCALE PCB REMOVAL FROM | 2286 | |
| | 2028-14 | TRANSFORMER OIL | | |

STATUS CODES: A) ALREADY IN USE B) ACTUAL PLANS TO USE C) POSSIBLE FUTURE USE
D) NEED MORE INFO E) NOT APPLICABLE

| NO. | RP NO. | PRODUCT NAME | MANAGER/EXT | STATUS/NOTES/CONTACT |
|------|---|--|-----------------------------|----------------------|
| 7155 | S198-01 | GUIDELINES FOR CLEANLINESS DURING CONSTRUCTION PROVIDES RECOMMENDATION TO MINIMIZE CONTAMINATION OF PWR STEAM GENERATORS DURING CONST. | WELTY CHARLES 2783 | |
| 7160 | S112-01 S112-02 S116-91 S132-04 S132-05 S132-10 S158-01 S170-01 0623-02 1171 | PWR SECONDARY WATER CHEMISTRY GUIDELINES PROVIDE OPERATING PROCEDURES TO MAXIMIZE LIFE EXPECTANCY OF STEAM GENERATORS | WELTY CHARLES 2783 | |
| 7165 | S301 | TUBE INSPECTION GUIDELINES PROVIDES FOR NONDESTRUCTIVE EXAMINATION OF PWR STEAM GENERATORS | OLDBERG TERRY 2416 | |
| 7170 | S115 | EDDY-CURRENT DETECTOR INSPECTS PWR STEAM GENERATORS | OLDBERG TERRY 2416 | |
| 7180 | S105-01 | RADIOGRAPHIC TUBE INSPECTION PROBE PROVIDES A MEANS TO EVALUATE SUPPORT PLATE INTEGRITY | OLDBERG TERRY 2416 | |
| 7185 | S306 S307 | PLANT AND STEAM GENERATOR OPERATING GUIDELINES PROVIDES OPERATING GUIDELINES TO SUPPORT THE SECONDARY WATER CHEMISTRY GUIDELINES | WELTY CHARLES 2783 | |
| 7190 | S119-02 S183-01 S209-01 S302-18 S302-21 S309-01 | IMPURITY REMOVAL GUIDELINES PROVIDES GUIDELINES FOR STEAM GENERATOR CREVICE FLUSHING | WILLIAMS C LAMAR 2789 | |
| 7195 | S187-01 S306-07 S306-15 | DISSOLVED GAS MONITORING SYSTEM HELPS LOCATE SOURCES OF CONDENSER AIR IN-LEAKAGE | WELTY CHARLES 2783 | |

STATUS CODES: A) ALREADY IN USE B) ACTUAL PLANS TO USE C) POSSIBLE FUTURE USE
 D) NEED MORE INFO E) NOT APPLICABLE

1210 - COAL GASIFICATION-COMBINED CYCLE POWER SYSTEMS

Environmentally Clean, Efficient, Cost-Effective Coal-Based Power Systems

Conventional direct coal-fired power plants require large capital commitments and long lead times and require troublesome flue gas scrubbers to limit SO₂ emissions, affecting plant availability and producing large quantities of waste sludge.

PRODUCT

Texaco-based integrated gasification-combined cycle (IGCC) power system offering short construction time, an option for phased installation, and modular addition capability to conserve capital and more closely match load growth; high availability providing a potential for reduced reserve margin; lower SO₂ and NO_x emissions and less water and land use than the conventional direct-fired coal-steam approach with stack gas scrubbing; comparable capital and electricity cost and higher efficiency versus coal-steam plants.

BENEFITS

The short lead time and phased installation capability of IGCC systems provide the ability to minimize "at-risk" capital (coincidentally minimizing interest during construction), afford the flexibility to take advantage of "low-cost" and "available" natural gas and petroleum fuels for as long as this situation persists, and allow for rapid response to changes in load growth and/or fuel prices. The extremely low SO₂ and NO_x emissions make IGCC systems an ideal solution to acid rain concerns, and the very low non-hazardous solid wastes produced avoid the high disposal costs normally encountered in current conventional utility coal plants with scrubbers.

APPLICATIONS

A 100 MW commercial-scale module using the Texaco gasification process has been successfully operating since mid-1984 at Southern California Edison's Cool Water generating station. PEPCO has included a phased IGCC plant, utilizing Texaco or another competing gasification process, in its 10-year construction budget,

with a planned start-up in the mid-1990's. Several other utilities are conducting generation expansion analyses to evaluate the potential of phased IGCC and a number are carrying out site-specific design studies.

AVAILABILITY

Coal gasification and related process licenses are available from Texaco and other developers. Process and power equipment are marketed by various suppliers. Technical support for interested utilities is available from EPRI, as well as process developers and equipment suppliers.

PUBLICATIONS

AP-2487, AP-3232, AP-3876 Cool Water Coal Gasification Program - Annual Progress Reports, July 1982, October 1983, January 1985 AP-3486 Cost and Performance for Commercial Applications of Texaco-Based Gasification-Combined Cycle Plants, Vols. 1 and 2, April 1984

EPRI TECHNICAL CONTACT:

Tom O'Shea (415) 855-2488,

Mike Gluckman (415) 855-2493

EPRI PROJECTS:

RP1459-1; RP2029-10

EXAMPLE SOURCE: Benefits Assessment (CEI)

| | | | |
|---|--|--|---|
| 1. PRODUCT NAME: Coal Gasification-Combined Cycle Power Systems | | | |
| 2. PRODUCT NUMBER: 1210 | | | |
| 3. PRODUCT APPLICATION (Check one): | | 4. NATURE OF BENEFIT (Check all that apply): | |
| <input checked="" type="checkbox"/> Actual past/present use | <input checked="" type="checkbox"/> Potential/future | <input type="checkbox"/> Cost avoidance | <input type="checkbox"/> Regulatory issue |
| <input type="checkbox"/> Firm plans to use | <input type="checkbox"/> Indirect (Benefits) | <input checked="" type="checkbox"/> Cost savings | <input type="checkbox"/> Reference/update |
| <input type="checkbox"/> Potential/nearterm | <input type="checkbox"/> Not applicable (Why?) | <input type="checkbox"/> Strategic issue | <input type="checkbox"/> Joint owner/power pool |
| 5. BENEFIT DUE TO INCREASE/DECREASE IN: | | | |
| <input type="checkbox"/> Capital cost | <input checked="" type="checkbox"/> O and M cost | <input type="checkbox"/> Reliability/availability/outages | |
| <input checked="" type="checkbox"/> Construction leadtime | <input checked="" type="checkbox"/> Heat rate | <input checked="" type="checkbox"/> Environmental/financial risk | |
| <input type="checkbox"/> Equipment life | <input type="checkbox"/> Losses | <input type="checkbox"/> Occupational health and safety | |
| <input type="checkbox"/> Improved dispatch | <input type="checkbox"/> Fuel cost | <input type="checkbox"/> Info. quality and availability | |
| <input type="checkbox"/> Labor productivity | <input checked="" type="checkbox"/> Emissions | <input type="checkbox"/> Quality of reg./legis. decisions | |
| <input type="checkbox"/> Quality of decisions | <input type="checkbox"/> Revenues | <input type="checkbox"/> Other | |

DESCRIBE HOW PRODUCT APPLIED; What Problem Solved;

Cleveland Electric Illuminating Co. has utilized extensive data developed by EPRI on design, cost, and performance of GCC plants in carrying out studies of generation expansion options to meet future CEI capacity requirements.

BENEFIT TO COMPANY -- QUALITATIVE OR QUANTITATIVE -- ASSUMPTIONS:

Use of the information developed by EPRI has resulted in actual savings to date, in the form of reduced costs for consultant services, estimated at \$400,000. The availability of GCC technology as a future generation option provides an opportunity for enormous potential future savings. CEI planning studies estimate lifetime savings for a GCC plant of \$925 million (1985 present worth) compared to a conventional direct coal-fired plant with scrubbers. While the portion of these savings attributable to EPRI is uncertain, it is believed that an extraordinary level of benefit is appropriate recognition of EPRI's contribution to this technology. When and if this option will be applied on the CEI system also remains uncertain.
Current savings = \$400,000
Potential future savings = up to \$925,000,000

3654 - UTILITY FUEL INVENTORY MODEL

Evaluates Alternative Fuel Inventory Policies

Factors such as frozen coal, unseasonable weather, electricity demand changes, and coal mine strikes are not easy to predict, thus creating the need for fuel stockpiling. Coal and oil inventories rise from 1.2 B in the early 1970s to 9 B in early 1980s.

PRODUCT

UFIM is a methodology and modeling system that performs formal cost-benefit analyses of the following problems: uncertain fuel deliveries and fuel burn; seasonality; supply disruptions of varying severity, warning times, and possible durations; and nonlinear shortage costs. The modeling approach uses a hybrid of stochastic simulation and dynamic programming techniques. UFIM is flexible and easily adjusted to specific utility systems.

BENEFITS

In the past, decisions relating to fuel inventory targets and supply and demand uncertainties were made based on company history, experience, and intuition. UFIM gives utilities an analytical basis for setting inventory levels that balance the cost of holding a larger inventory level to ensure against emergencies versus the cost of smaller inventory with possibility for reduced fuel burn.

APPLICATIONS

Consumers Power Company stated that UFIM saved them a minimum of 500,000 per year at one coal-fired plant. Tampa Electric, along with fifteen other companies actively participated in the model development. There is an active UFIM users group with 80 members.

AVAILABILITY

EPSC, Version 2.0, available for mainframes, with PC version to be released in late 1986.

PUBLICATIONS

EA-4079-CCM, Utility Fuel Inventory Model: Version 1.0, August 1985.

EPRI TECHNICAL CONTACT:

Steve Chapel, (415) 855- 2608; Steve Wan, (415) 855-2741

EPRI PROJECTS:

RP2314

EXAMPLE SOURCE: Benefits Assessment Worksheet

| | | |
|--|--|--|
| 1. PRODUCT NAME: Utility Fuel Inventory Model | | |
| 2. PRODUCT NUMBER: 3654 | | |
| 3. PRODUCT APPLICATION (Check one): | | 4. NATURE OF BENEFIT (Check all that apply): |
| <input type="checkbox"/> Actual past/present use | <input type="checkbox"/> Potential/future | <input type="checkbox"/> Cost avoidance <input type="checkbox"/> Regulatory issue |
| <input type="checkbox"/> Firm plans to use | <input type="checkbox"/> Indirect (Benefits) | <input checked="" type="checkbox"/> Cost savings <input type="checkbox"/> Reference/update |
| <input checked="" type="checkbox"/> Potential/nearterm | <input type="checkbox"/> Not applicable (Why?) | <input type="checkbox"/> Strategic issue <input type="checkbox"/> Joint owner/power pool |
| 5. BENEFIT DUE TO INCREASE/DECREASE IN: | | |
| <input type="checkbox"/> Capital cost | <input type="checkbox"/> O and M cost | <input type="checkbox"/> Reliability/availability/outages |
| <input type="checkbox"/> Construction leadtime | <input type="checkbox"/> Heat rate | <input type="checkbox"/> Environmental/financial risk |
| <input type="checkbox"/> Equipment life | <input type="checkbox"/> Losses | <input type="checkbox"/> Occupational health and safety |
| <input type="checkbox"/> Improved dispatch | <input checked="" type="checkbox"/> Fuel cost | <input type="checkbox"/> Info. quality and availability |
| <input type="checkbox"/> Labor productivity | <input type="checkbox"/> Emissions | <input type="checkbox"/> Quality of reg./legis. decisions |
| <input type="checkbox"/> Quality of decisions | <input type="checkbox"/> Revenues | <input checked="" type="checkbox"/> Other |

DESCRIBE HOW PRODUCT APPLIED; What Problem Solved:

The utility may use the Fuel Inventory Model to reduce the costs associated with fuel inventory holding or fuel shortages. UFIM performs cost-benefit analyses which allow the utility to balance the cost of holding a larger inventory against the cost of possible reduced fuel burn with a smaller inventory.

BENEFIT TO COMPANY -- QUALITATIVE OR QUANTITATIVE -- ASSUMPTIONS:

1. Current utility fuel costs are \$300 million/year (1985\$).
2. Improved inventory management, including reductions in replacement power purchases, will allow the utility to save 0.5 to 2.5% of annual fuel costs.
3. The UFIM program has a 30% probability of being implemented by 1988.
4. Fuel costs escalate at 4%/yr. after 1985.

Net benefit = \$300 million/yr. x (1.04)³ x (.5-2.5%) x 30% =
\$506,200/yr.- \$2,530,944/yr. (1988\$)

5020 - CLOR-N-OIL- PCB SCREENING KIT

With 20 million oil-filled transformers to screen for PCB contamination, the utility industry cannot afford slow, costly laboratory tests.

PRODUCT

A small, disposable, low-cost test tube kit is now available to perform tests in the field for as little as \$5 per sample. The CLOR-N-OIL- PCB Screening Kit (two test tubes with premeasured reagents and a pipette) uses a color-forming reaction to show the presence of PCBs in transformer oil samples.

BENEFITS

Using CLOR-N-OIL-, utility personnel can perform PCB screening in about five minutes in the field or in the repair shop. By screening out samples with under 50-ppm PCB, the kit eliminates the need to test about two-third of all oil samples. Estimates suggest that the kit could save the utility industry \$500 million.

APPLICATIONS

There are hundreds of utilities using these kits. And our industry, as a whole, is using them at a rate of over 50,000 kits per month.

AVAILABILITY

- Dexsil Chemical Corporation
295 Treadwell Street
Hamden, CT 06514
Ted Lynn (302) 288-3509

PUBLICATIONS

Off-the-Shelf 4410 F/C: "CLOR-N-OIL- PCB Screening Test Kits."

First-Use 4222F: "Quick and Easy Field Testing for PCBs: CLOR-N-OIL-."

EL-3766, vols. 1 & 2, Field Determination of PCB in Transformer Oil, October 1984.

EPRI TECHNICAL CONTACT:

Vasu Tahiliani (415) 855-2315

EPRI PROJECTS:

RP1713-1

EXAMPLE SOURCE: Hypothetical Benefits Calculation

| | | | |
|---|--|--|---|
| 1. PRODUCT NAME: CLOR-N-OIL- PCB SCREENING KIT | | | |
| 2. PRODUCT NUMBER: 5020 | | | |
| 3. PRODUCT APPLICATION (Check one): | | 4. NATURE OF BENEFIT (Check all that apply): | |
| <input checked="" type="checkbox"/> Actual past/present use | <input type="checkbox"/> Potential/future | <input checked="" type="checkbox"/> Cost avoidance | <input type="checkbox"/> Regulatory issue |
| <input type="checkbox"/> Firm plans to use | <input type="checkbox"/> Indirect (Benefits) | <input checked="" type="checkbox"/> Cost savings | <input type="checkbox"/> Reference/update |
| <input type="checkbox"/> Potential/nearterm | <input type="checkbox"/> Not applicable (Why?) | <input type="checkbox"/> Strategic issue | <input type="checkbox"/> Joint owner/power pool |
| 5. BENEFIT DUE TO INCREASE/DECREASE IN: | | | |
| <input type="checkbox"/> Capital cost | <input checked="" type="checkbox"/> O and M cost | <input type="checkbox"/> Reliability/availability/outages | |
| <input type="checkbox"/> Construction leadtime | <input type="checkbox"/> Heat rate | <input checked="" type="checkbox"/> Environmental/financial risk | |
| <input type="checkbox"/> Equipment life | <input type="checkbox"/> Losses | <input checked="" type="checkbox"/> Occupational health and safety | |
| <input type="checkbox"/> Improved dispatch | <input type="checkbox"/> Fuel cost | <input type="checkbox"/> Info. quality and availability | |
| <input type="checkbox"/> Labor productivity | <input type="checkbox"/> Emissions | <input type="checkbox"/> Quality of reg./legis. decisions | |
| <input type="checkbox"/> Quality of decisions | <input type="checkbox"/> Revenues | <input type="checkbox"/> Other | |

DESCRIBE HOW PRODUCT APPLIED; What Problem Solved:

During an oil spill emergency response, a field usable kit to determine if the oil is contaminated above 50 ppm saves:

- A. unnecessary work on cleanup procedure;
- B. overtime work for the cleanup crew in an emergency;
- C. avoidance of needless paperwork;
- D. avoidance of disposition cost of contaminated soil.

The screening test eliminated expensive GC test on 80% of the oil samples.

BENEFIT TO COMPANY -- QUALITATIVE OR QUANTITATIVE -- ASSUMPTIONS:

Assumptions: 30 spills/year

Savings from the four categories in (a) above is \$1200/spill.

The cost of PCB analysis including the transportation costs, paperwork, analysis of results and follow-up to place an appropriate sticker on the equipment is \$60/test.

The cost of doing the Clor-n-Oil test and placement of appropriate label all in one go is \$10/test.

1. Estimated benefit $\$1,200/\text{spill} \times 30 \text{ spills/yr} = \$36,000/\text{yr}$

2. Estimated benefit for 1000 samples = $(1000 \times 60) - (1000 \times 10) = \$38,000/\text{yr}$

Total Benefit = $\$36,000/\text{yr} + \$38,000/\text{yr} = \$74,000/\text{yr}$

ESTIMATING INDIRECT BENEFITS OF EPRI ENVIRONMENTAL R&D: SUMMARY*
(BAP-304)

Indirect benefits are realized from certain kinds of research when the results are applied broadly on behalf of the industry at large rather than by a single utility.

For example, EPRI R&D on short-term respiratory health effects of sulfates has played a key role in showing that a short-term ambient air quality standard for sulfates was not needed to protect "sensitive subjects" like asthmatics, since they were not adversely affected by sulfate concentrations higher than the existing standard. This R&D was directly used by the Utility Air Regulatory Group in testifying to the Environmental Protection Agency (EPA) that an ambient standard for sulfates would be costly and unnecessary. Many utilities and their customers benefitted indirectly from the ensuing decision by EPA not to issue an ambient standard for sulfates--but few utilities directly participated in the regulatory process that led to that decision.

This type of indirect benefit often results from environmental research because a few key hearings or decisions in key states or regulatory agencies set the precedent for future actions. Thus, utilities benefit from environmental research even when they do not directly use, support, or even know about specific products of that research.

Clearly, EPRI research is not the only information that is made available to regulatory decision makers. No one group can claim that its efforts produced an overriding effect on the extraordinarily complex policymaking process of state and federal agencies with their many intertwining interests and influences. However, in the absence of EPRI R&D, past regulatory actions might have had very different outcomes. In addition, unnecessary potential future regulatory actions might be

*Currently undergoing update and revision, this informal document will be available upon request.

more likely to occur and could be more costly without EPRI's vigorous research program. Moreover, EPRI research has shown the need for actions to protect sensitive ecological systems when that need was not previously recognized. EPRI research saves ratepayers and stockholders both through reduction in unnecessary regulation and in effective demonstration of measures to protect the environment where they are required.

The process by which EPRI R&D is utilized in activities that lead to indirect benefits for utilities can be outlined as follows. Based on a thorough understanding of the science underlying a given environmental problem, scientifically credible research results developed by EPRI can be used in the policymaking process. EPRI research is utilized through U-groups, trade organization committees, peer-reviewed literature, joint cooperative research with regulatory bodies, presentations by EPRI staff and contractors at professional meetings or informal gatherings, and advice given to utility staff members. Thus, through information shared by group members, EPRI research influences potential future environmental regulations.

The extent of the influence and the cost implications of these regulations are obviously difficult to analyze quantitatively. To provide an approximate and useful tool for analysis, a method was developed for calculating the cost implications and the incremental benefit that would result if EPRI's research caused a 1% change in either the cost or the likelihood of the potential regulations. Summary information for such calculations was provided for indirect benefits of research for six environmental areas: acid deposition, solid waste, air quality, electric and magnetic fields, occupational health, and surface water.

The calculation of benefits proceeds as follows. First, the research activities are identified along with the key pending potential environmental regulations to which they are relevant. An estimate is made of the potential impact of that regulation in physical terms (e.g., a 12-million+ tons/yr reduction in SO₂ emissions; a 15% increase in the acreage required for transmission line right-of-way), together with a low and high range of control costs that would be needed to meet the requirements of that legislation.

To estimate the industrywide benefit, the cost range is multiplied by an estimate of the probability that EPRI's research influenced past regulations (or will influence proposed regulations) in one of two ways: the research reduces the cost of control or changes the probability that the legislation or regulation is

promulgated. This national benefit is then prorated to an individual utility according to the amount of affected plant capacity owned by that utility (e.g., megawatts of pre-New Source Performance Standards coal capacity, or miles of high-voltage transmission line, etc.).