Overview of Florida Electric Utilities Research and Development Programs

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Summary

This study presents data on research and development expenditures by Florida Power & Light, Tampa Electric, Florida Power, and Gulf Power. It does not attempt to identify the optimal level of R&D expenditures, the efficient mix of projects, or appropriate mix of internal versus external R&D. Rather, it surveys the actual outlays made by Florida electric utilities and discusses the implications of trends between 1976 and 1984. The Appendices contain detailed listings of utility R&D projects.

Utilities have tended to increase external R&D relative to that conducted internally. After rising for several years, real internal R&D, has fallen below 1976 levels. However, real outlays on external R&D (primarily through the Electric Power Research Institute) have risen 36 percent over the period. Between 1976 and 1984, total electricity revenues for the four investor-owned utilities increased at a rate of 14.3 percent per year, while total (nominal) R&D expenditures grew at 10.2 percent per year. Total reported R&D exceeded sixteen million dollars in 1984, reflecting a substantial investment in new areas of technology and applied research. In a number of documented cases, the payoffs to consumers have been substantial.

OVERVIEW OF FLORIDA ELECTRIC UTILITIES RESEARCH AND DEVELOPMENT PROGRAMS

The purpose of this study is to summarize and review recent trends in the research and development (R&D) expenditures of the four largest investor-owned electric utilities in the state of Florida. An awareness of these trends may assist electric utilities in making cost effective R&D decisions, including the identification of areas for investigation. By bringing the data together in one place, decision-makers may establish the appropriate mix of internal versus external R&D. The appendices list expenditures for each R&D project from 1976 through 1984. While such information is available in annual reports to the Federal Energy Regulatory Commission, a multi-year listing of project titles provides managers and regulators with a useful reference tool.

This paper is not intended to be analytical. It does <u>not</u> attempt to identify the optimal level of R&D expenditures (or ratio of R&D to sales), the efficient mix of projects (as between generation, transmission, or load research), or the appropriate combination of internal versus external performance of R&D. Rather, the overview underscores the need for careful consideration of each of these issues, since the level of funding, mix of projects, and combination of internal/external resources will affect the future costs of electricity delivery in Florida. The three issues are interrelated. For example, low level of R&D funding would probably be called for if all the research were

conducted internally by a staff that is too small to deliver results efficiently. More cost-effective R&D programs would warrant higher levels of funding since ratepayers would experience higher net benefits from associated cost savings. Research consortia often allow the achievement of economies of scale and scope that keep costs down. The electric utility industry has responded to such opportunities by creating a number of cooperative research organizations. Most of the reported R&D expenses for Florida consist of contributions to the Electric Power Research Institute (EPRI), an industry-sponsored organization. The internal expenditures cover a wide variety of projects of varying scope and complexity. Note that utilities have some latitude in deciding how to categorize expenditures, so the reported numbers are subject to some variation.[1]

Although R&D expenditures by Florida electric utilities constitute less than one percent of sales revenue, their long-run impact should not be underestimated. A successful R&D program often results in considerable cost reductions and improvements in operation in future years. We do not attempt to evaluate Florida electric utility R&D in terms of cost effectiveness; such analysis should be conducted in the context of a thorough examination of each utility's particular situation, including

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[1]Federal Power Commission, "Research and Development Accounting and Reporting," order no. 483, issued April 30, 1973, page 2. The revised definition indicates, in part, that research and development expenses shall include "all such costs incidental to the design, development, or implementation of an experimental facility, a plant process, a product, a formula, an invention, a system or similar items, and the improvement of already existing items of a like nature. . . . The term does not include expenditures for efficiency surveys, studies of management, management techniques and organization, consumer surveys, advertising, promotions, or items of a like nature." The definition has since been updated, however, to include demonstration activities.

generation mix and demand growth. Evaluations are in the domain of management audits. This report is only offered as an initial data collection effort, with the discussion of trends and patterns being interpretive, rather than evaluative. This report also attempts to draw attention to the importance of improving our understanding of how R&D programs affect productivity.

Data used as the basis for this review were obtained from the annual statements filed with the Federal Energy Regulatory Commission by Gulf Power Corporation, Tampa Electric Company, Florida Power & Light Company, and Florida Power Corporation, for the years 1976 through 1984. The focus will be on trends in overall research levels, the mix of projects, and the combination of internal/external performance. Some attention is also given to specific research topics within functional areas and inter-firm research cooperation.

Trends over Time

Research and development activities are generally classified as basic or applied research. Basic research involves exploration of new areas, resulting in the discovery of new knowledge. Applied research involves taking the results of basic research and applying that new knowledge to produce products or services to meet the needs of society. Essentially, basic research provides the theoretical underpinnings for new technological innovations, while applied research takes the next step in determining the feasibility of new technologies. As would be expected, the primary sources of basic research are universities and colleges, while industry is the main performer of applied research and development. In discussing the electric utility industry, then, it

should be recognized that almost all of their R&D expenditures fall into the category of applied R&D.

Departments engaged in supervising research and development activities receive annual budgetary allocations based upon two distinct but interrelated forces that affect the utility. The initial force to be considered will be termed the "macro" force, since it represents the impact of economic fluctuations in the service area. Interracting with the macro force is another set of forces within the utility, which may be called "micro" forces. Both provide incentives and dis-incentives that influence the level and mix of R&D expenditures.

Macro forces are exogenous and uncontrollable variables and utilities react to their presence. Since internal R&D expenditures are predominately discretionary, their pattern will correspond to the expansions and contractions occurring in the regional economy. R&D is not an essential function of the utility company, so as revenues decline due to a sagging economy (or as costs rise because of inflation), R&D activities will be one of the first areas to be affected. Rising interest rates, which increase the cost of capital, may transform a previously promising venture into one with a prohibitive cost. Note that the existence of inflation requires that R&D expenditures be price-deflated before any real (as opposed to nominal) trends can be determined.

External R&D expenditures, however, can be less discretionary than internal expenditures. External expenditures involving contributions to EPRI and various nuclear power groups are less discretionary and generally involve longer-term commitments to these organizations. Membership fees are usually related by some formula to the previous year's output,

revenue, or capacity--so consortia memberships represent relatively fixed costs. Guidelines for total R&D expenditures are frequently set by public service commissions.

Public utilities also react to research incentives provided by federal and state governments. Historically, a significant percentage of R&D expenditures has been dedicated to governmental production standards, such as those dealing with environmental regulations. In addition, research has been stimulated and encouraged with the provision of investment tax credits for certain ventures. The micro forces that determine R&D levels will be regarded as variables that are potentially controllable by regulators. For instance, each electric utility is faced with its own unique set of problems, stemming from their diverse economic sub-environments; to a great extent, these utility-specific issues determine the mix of R&D projects. A primary determinant of the level of R&D expenditures is the size of the utility, as reflected in its overall sales. To avoid problems of deflating R&D and revenue by price indices, the ratio of R&D to sales can be used as a rough proxy for the R&D intensity of utilities.

The amount of money spent annually on R&D by Florida's four largest electric utilities is significant--over $10 million each year since 1978. Of this, approximately 70-80 percent was spent by the state's largest electric utility, Florida Power & Light Company (FP&L). Table 1 presents total R&D expenditures and the annual rate of change of expenditures for each of the major electric utilities from 1976-1984. For each of the four utilities, the growth pattern of R&D funding over time is very erratic. These large year to year fluctuations may point out the discretionary aspect of R&D to the company. It may also indicate

Table 1

	1976	1977	1978	1979	1980	1981	1982	1983	1984
Tampa Electric									
Revenues	$301,364,357	$343,358,571	$395,919,251	$444,895,499	$509,279,822	$617,395,592	$573,760,712	$653,893,250	$693,526,492
Percent Δ	-	13.93%	15.31%	12.37%	14.47%	21.23%	(7.01%)	13.97%	6.06%
Total R&D	$1,203,285	$1,598,814	$1,561,553	$1,719,038	$1,990,841	$2,156,237	$2,085,604	$2,306,685	$2,259,201
Percent Δ	-	32.87%	(2.33%)	10.09%	15.81%	8.31%	(3.60%)	10.60%	2.06%
R&D as % Rev.	0.399%	0.466%	0.394%	0.386%	0.391%	0.349%	0.363%	0.353%	0.326%
Gulf Power									
Revenues	$153,992,467	$183,929,069	$214,220,192	$229,061,661	$268,714,420	$321,197,007	$357,355,444	$433,409,847	$470,099,974
Percent Δ	-	19.44%	16.47%	6.93%	17.31%	19.53%	11.20%	21.28%	8.47%
Total R&D	$863,274	$1,205,306	$1,053,366	$1,074,266	$1,045,747	$1,340,688	$271,831	$1,253,123	$566,975
Percent Δ	-	39.62%	(12.61%)	1.98%	(2.66%)	28.20%	(79.70%)	360.99%	54.76%
R&D as % Rev.	0.561%	0.655%	0.492%	0.469%	0.389%	0.417%	0.070%	0.289%	0.121%
FP&L									
Revenues	$1,181,093,000	$1,453,502,000	$1,634,111,000	$1,933,936,635	$2,347,278,058	$3,088,619,750	$2,940,833,348	$3,352,534,606	$3,939,928,747
Percent Δ	-	23.06%	12.43%	18.35%	21.37%	24.00%	(4.78%)	14.00%	17.52%
Total R&D	$3,764,011	$5,976,971	$7,356,792	$7,235,453	$11,647,672	$10,240,445	$9,434,657	$11,415,327	$13,086,300
Percent Δ	-	58.79%	23.09%	(1.65%)	60.98%	(12.08%)	(7.67%)	20.99%	14.64%
R&D as % Rev.	0.319%	0.411%	0.450%	0.374%	0.496%	0.336%	0.320%	0.340%	0.332%
FPC									
Revenues	$551,438,816	$656,137,958	$751,219,980	$835,493,243	$970,173,021	$1,278,297,207	$1,210,513,488	$1,337,169,499	$1,292,002,651
Percent Δ	-	18.99%	14.49%	11.22%	16.12%	31.75%	(5.30%)	10.46%	(3.38%)
Total R&D	$1,664,304	$1,194,911	$1,236,068	$830,682	$893,287	$1,771,347	$932,067	$409,031	$418,834
Percent Δ	-	(28.20%)	3.44%	(32.80%)	7.54%	98.30%	(47.38%)	(56.12%)	2.40%
R&D as % Rev.	0.302%	0.182%	0.165%	0.099%	0.092%	0.139%	0.077%	0.031%	0.032%

the large discrete funding changes that occur due the the completion of some projects and the beginning of others. For example, most of the 61 percent increase in total R&D expenditures by FP&L in 1980 is due to a new project concerning a coal-oil mixture test facility and related plant modification. The 1980 cost incurred for this project totals $3,645,346. However, mandated R&D outlays, such as water quality studies or emission controls, account for similar increases in other years.

Notice, also, the large variations that exist between companies. R&D as a percent of revenue serves as an index of how internal and external R&D expenditures have kept up with revenues from electricity sales. TECO has experienced a decline--from a high of 0.466 percent in 1977 to 0.326 percent in 1984. Nevertheless, the percentage change per year has been in the 10 percent range--somewhat less than revenue growth. Gulf Power has had a much more dramatic decline in the ratio, from a high of 0.655 percent in 1977 to 0.070 percent in 1982, to 0.112 percent in 1984. FP&L has also reduced its R&D as a percent of revenue--from a high of 0.496 percent in 1980 to 0.332 percent in 1984, a slightly greater share than TECO. Its total R&D expenditures were $13 million in 1984. FPC has the smallest ratio of R&D to revenue: 0.031 percent. While its electricity revenues are 33 percent of FP&L's revenues, its R&D expenditures are 3.2 percent of FP&L's outlays. Over the nine-year period from 1976 to 1984, growth in R&D expenditures has varied widely across firms. A combination of different financial conditions, corporate philosophies, and technological opportunities might explain the observed differentials. The numbers illustrate the

large extent to which R&D funding is dependent upon each utility's own particular situation and perceived usefulness of R&D for the company.

One interesting pattern emerges after the recession of 1981-82. After reaching a total R&D outlay of $14.6 million in 1980 and a peak of $15.5 million in 1981, R&D expenditures for the four firms fell to $12.7 million in 1982. By 1984, aggregate outlays reached $16.4 million--primarily due to continued FP&L R&D growth. Such developments illustrate the macro forces at work as well as some of the firm-specific micro forces that determine each company's R&D strategies.

Budgetary, accounting and project evaluation processes have also influenced R&D levels. For any given project, its scope and duration will depend upon the process by which it competes against alternative projects, receives its allocation of utility funds, and establishes its net worth to the firm. For example, requirements of the Public Utility Regulatory Policies Act have, no doubt, influenced the amount of rate research and load analysis, as government reports require such data.

The Internal/External Choice

R&D activities may be performed internally (within the firm itself), or externally (by another organization). The particular mix of internal versus external R&D depends upon several factors and, as we shall see, greatly differ for the Florida utilities. Factors that determine the internal/external mix of R&D include the specific research decisions made by the firm (such as types of research needed to fill gaps), number of projects to be performed, and the scale economies associated with specific projects. Another important factor is the actual research capacity of the utility. If resources are not currently

available in-house to perform all aspects of the required projects, the choice is between a longer build-up time or external contracts. Also, the availability and attractiveness of external sources plays a major part in the determination of an internal/external mix of R&D activities.

Given that the resources for performing a project are available both internally and externally, an analysis of the expected costs of performing various parts of the project under both options will ultimately determine whether it is more economical to do all, part, or none of the project internally. Other factors, such as previous experiences with internal versus external R&D projects, or the degree of generality (applicability to other firms) of a particular project will also influence R&D decisions.

Since 78 percent of the external R&D for the three EPRI member utilities went to the Electric Power Research Institute in 1980, the research priorities of that organization determine the particular areas to be emphasized. Since overviews of the EPRI program are readily available, we will not address the mix of external R&D. Suffice it to note that the research program is broadly supported by the entire industry, so the emphasis is on national issues, such as techniques for environmental compliance. A firm choosing not to contribute to EPRI can still obtain information and research through public documents. On the other hand, such utilities have no votes or influence when specific areas of emphasis are being determined. Those Florida utilities that do belong to EPRI actively participate in the formulation of research programs. In fact, some of the funds are returned to the utilities for on-site application research.

An analysis of internal and external R&D expenditures is presented in Table 2. For all companies except FPC, the bulk of R&D funding has been external. Just as with total R&D expenses, the growth patterns of internal and external expenditures within each company have been highly variable. For example, internal R&D for FP&L increased by 170 percent in 1978, dropped 33 percent in 1979, rose 278 percent for 1980, dropped 250 percent in 1981, and then dropped another 42 percent in 1982. Fluctuations in internal growth are primarily due to the large, discrete funding changes that occur when new projects are started and others finished. External changes are primarily due to the particular funding formula for EPRI, which depends on both total revenues and kwh generated.

A much more clear idea of trends within and between companies can be seen in Table 3, which presents internal and external R&D expenditures as a percent of total R&D expenses. Table 3 reveals that currently almost all of Tampa Electric's R&D represents external projects via EPRI, while FPC relies almost exclusively on internally performed R&D. In contrast to these two extremes, Gulf Power and FP&L report a mix of internal/external R&D. Thus, Florida utilities have very different R&D strategies. A possible generalization is that larger utilities reach a critical size which permits them to conduct R&D efficiently internally. For example, Gulf, as part of the Southern Company system, is part of an organization with large-scale capabilities.

As for trends within companies, Tampa Electric has almost exclusively supported external R&D in each of the past seven years. Gulf has shown a shift towards externally performed R&D since 1976 (when

Table 2

	1976	1977	1978	1979	1980	1981	1982	1983	1983	1984
Tampa Electric										
Internal R&D	$15,777	$15,830	$101,009	$129,741	$43,247	$35,235	$18,580	$21,162	$21,162	$44,368
Percent Δ	-	0.34%	538.09%	28.44%	(66.67%)	(18.53%)	(47.26%)	13.90%	13.90%	109.66%
External R&D	$1,187,508	$1,582,984	$1,460,544	$1,589,297	$1,947,594	$2,121,002	$2,067,790	$2,285,523	$2,285,523	$2,222,608
Percent Δ	-	33.30%	(7.73%)	8.82%	22.54%	8.90%	(2.51%)	10.53%	10.53%	2.75%
Gulf Power										
Internal R&D	$407,968	$389,247	$289,867	$234,997	$259,129	$340,685	($42,107)	$133,106	$133,106	$196,087
Percent Δ	-	(4.59%)	(25.53%)	(18.93%)	10.27%	31.47%	(112.35%)	416.11%	416.11%	(47.32%)
External R&D	$455,306	$816,059	$763,499	$839,269	$786,618	$1,000,003	$313,938	$1,120,017	$1,120,017	$370,888
Percent Δ	-	79.23%	(6.44%)	9.92%	(6.27%)	27.13%	(68.86%)	256.76%	256.76%	66.89%
FP&L										
Internal R&D	$435,511	$825,635	$2,232,018	$1,489,255	$5,622,429	$1,606,787	$934,056	$1,047,107	$1,047,107	$981,249
Percent Δ	-	89.58%	170.34%	(33.28%)	277.53%	(249.92%)	(41.86%)	12.10%	12.10%	(6.29%)
External R&D	$3,328,500	$5,151,336	$5,124,774	$5,746,198	$6,025,243	$8,633,658	$9,454,657	$10,368,220	$10,368,220	$12,105,051
Percent Δ	-	54.76%	(0.52%)	12.13%	4.86%	30.21%	9.50%	9.67%	9.67%	16.75%
FPC										
Internal R&D	$240,817	$842,724	$1,241,840	$817,768	$880,373	$1,754,872	$914,567	$390,631	$390,631	$399,534
Percent Δ	-	249.21%	93.32%	(50.19%)	25.72%	41.42%	(50.73%)	(57.29%)	(57.29%)	2.28%
External R&D	$1,423,487	$352,187	($5,772)	$12,914	$12,914	$16,475	$17,500	$18,400	$18,400	$19,300
Percent Δ	-	(75.26%)	(98.83%)	213.37%	0.00%	21.61%	6.22%	5.14%	5.14%	4.89%

Table 3

	Internal	External
Tampa Electric		
1976	1%	99%
1977	≃0	≃100
1978	6	94
1979	5	95
1980	1	99
1981	2	98
1982	1	99
1983	1	99
1984	2	98
Gulf Power		
1976	56%	44%
1977	32	68
1978	28	72
1979	22	78
1980	25	75
1981	25	75
1982	≃0	≃100
1983	10	90
1984	35	65
FP&L		
1976	12%	88%
1977	14	86
1978	30	70
1979	21	79
1980	48	52
1981	16	84
1982	9	91
1983	9	91
1984	8	92
FPC		
1976	15%	85%
1977	71	29
1978	≃100	≃0
1979	98	2
1980	99	1
1981	99	1
1982	98	2
1983	95	5
1984	95	5

there existed an almost equal split between internal and external R&D funding), to 90 percent external funding in 1983.[1] The trend at FP&L initially was toward more internal R&D. The large jump in 1980 is mainly due to the start of a costly $3.6 million project requiring test facilities and plant modifications for a new coal-oil mixture, so this year may be atypical. Prior to 1980, FP&L had shown a tendency to provide about three-quarters of its total R&D budget toward externally performed activities. And since the 1980-82 recession, R&D outlays have shifted back towards external projects. Finally, FPC relied quite heavily on external R&D in 1976. During a period of financial troubles, it dropped out of the Edison Electric Institute/EPRI program. Management decided that internal R&D would be most productive.

Tables 4-12 provide a detailed accounting of external R&D for the years 1976 through 1982. The basic pattern of support to EEI/EPRI is clear. It should be noted that some funds categorized as internal R&D reflects cooperative ventures with others.[2] A number of studies sponsored under the auspices of the Florida Electric Power Coordinating Group were completed during this period. Such funding may have showed up as internal projects, yet they consisted of resources contributed to joint efforts.

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[1]The internal funding calculated for 1982 is inaccurate since it reflects internal reallocations which affect the expenditures for that year.

[2]In the case of FPC for the years 1976-1980, joint venture R&D contributors included: General Electric, American Heat Exchange Co., Petrolite Corp., Kaplan Industries, U.S. DOE, United Technologies, Inc., Droro Corp., Sea World, Inc., FP&L, and Tampa Electric Company.

Table 4

External Research and Development Expenses, 1976

	Gulf Power Company	Tampa Electric Company	Florida Power & Light Company	Florida Power Corporation
1. Research support to the Electric Power Research Institute	--	$869,281	$3,280,000	--
2. Research support to the Edison Electric Institute	$444,902	--	--	$194,428
3. Research support to nuclear power projects	--	--	--	--
4. Research support, other organizations	$10,404	$318,227	$48,500	$1,229,059
5. Total External R&D costs incurred	$455,306	$1,187,508	$3,328,500	$1,423,487
Total Internal and External	$863,274	$1,203,285	$3,764,011	$1,664,825
Total Sales Revenue	$153,992,467	$301,364,347	$1,181,093,000	$551,438,816
External R&D as % sales	0.296%	0.394%	0.282%	0.258%
Total R&D as % sales	0.561%	0.399%	0.319%	0.302%

Table 5

External Research and Development Expenses, 1977

	Gulf Power Company	Tampa Electric Company	Florida Power & Light Company	Florida Power Corporation
1. Research support to the Electric Power Research Institute	$568,760	$1,347,225	$5,106,885	--
2. Research support to the Edison Electric Institute	$76,640	--	--	--
3. Research support to nuclear power projects	--	--	--	--
4. Research support, other organizations	$170,659	$235,759	$44,451	$352,187
5. Total External R&D costs incurred	$816,059	$1,582,984	$5,151,336	$352,187
Total Internal and External	$1,205,306	$1,598,814	$5,976,971	$1,194,961
Total Sales Revenue	$183,929,069	$343,357,571	$1,453,502,000	$656,137,958
External R&D as % sales	0.444%	0.461%	0.354%	0.054%
Total R&D as % sales	0.655%	0.466%	0.411%	0.182%

Table 6

External Research and Development Expenses, 1978

	Gulf Power Company	Tampa Electric Company	Florida Power & Light Company	Florida Power Corporation
1. Research support to the Electric Power Research Institute	$608,803	$1,349,104	$5,101,774	--
2. Research support to the Edison Electric Institute	$76,645	--	--	--
3. Research support to nuclear power projects	--	--	--	--
4. Research support, other organizations	$78,051	$111,440	$23,000	$4,121
5. Total External R&D costs incurred	$763,499	$1,460,544	$5,124,774	$4,121
Total Internal and External	$1,053,366	$1,561,553	$7,356,792	$1,633,356
Total Sales Revenue	$214,220,192	$395,919,251	$1,634,111,000	$751,219,980
External R&D as % sales	0.356%	0.369%	0.316%	0.0%*
Total R&D as % sales	0.492%	0.394%	0.450%	0.217%

*0.0, due to rounding.

Table 7

External Research and Development Expenses, 1979

	Gulf Power Company	Tampa Electric Company	Florida Power & Light Company	Florida Power Corporation
1. Research support to the Electric Power Research Institute	$747,684	$1,489,240	$5,668,198	--
2. Research support to the Edison Electric Institute	$76,644	--	--	--
3. Research support to nuclear power projects	--	--	--	--
4. Research support, other organizations	$14,941	$100,057	$78,000	$12,914
5. Total External R&D costs incurred	$839,269	$1,589,297	$5,746,198	$12,914
Total Internal and External	$1,074,266	$1,719,038	$7,235,453	$830,682
Total Sales Revenue	$229,061,661	$444,895,499	$1,933,936,635	$835,493,243
External R&D as % sales	0.366%	0.357%	0.297%	0.002%
Total R&D as % sales	0.469%	0.386%	0.374%	0.099%

Table 8

External Research and Development Expenses, 1980

	Gulf Power Company	Tampa Electric Company	Florida Power & Light Company	Florida Power Corporation
1. Research support to the Electric Power Research Institute	$739,660	$1,935,957	$5,925,208	--
2. Research support to the Edison Electric Institute	--	--	--	--
3. Research support to nuclear power projects	--	--	--	--
4. Research support, other organizations	$46,958	$11,637	$100,035	$12,914
5. Total External R&D costs incurred	$786,618	$1,947,594	$6,025,243	$12,914
Total Internal and External	$1,045,747	$1,990,841	$11,647,672	$1,040,997
Total Sales Revenue	$268,714,420	$509,279,822	$2,347,278,058	$970,173,021
External R&D as % sales	0.293%	0.382%	0.257%	0.001%
Total R&D as % sales	0.389%	0.391%	0.496%	0.107%

Table 9

External Research and Development Expenses, 1981

	Gulf Power Company	Tampa Electric Company	Florida Power & Light Company	Florida Power Corporation
1. Research support to the Electric Power Research Institute	$927,279	$2,048,031	$8,310,077	--
2. Research support to the Edison Electric Institute	--	--	--	--
3. Research support to nuclear power projects	--	--	--	--
4. Research support, other organizations	$72,724	$76,847	$323,581	$16,475
5. Total External R&D costs incurred	$1,000,003	$2,124,878	$8,633,658	$16,475
Total Internal and External	$1,340,688	$2,156,237	$10,240,445	$1,771,347
Total Sales Revenue	$321,197,007	$617,395,592	$3,088,619,750	$1,278,297,207
External R&D as % sales	0.311%	0.344%	0.280%	0.001%
Total R&D as % sales	0.417%	0.349%	0.336%	0.139%

Table 10

External Research and Development Expenses, 1982

	Gulf Power Company	Tampa Electric Company	Florida Power & Light Company	Florida Power Corporation
1. Research support to the Electric Power Research Institute	$481,534	$2,081,164	$8,402,770	--
2. Research support to the Edison Electric Institute	($217,088)	--	--	--
3. Research support to nuclear power projects	--	--	--	--
4. Research support, other organizations	$49,492	$66,626	$1,051,887	$17,500
5. Total External R&D costs incurred	$313,938	$2,067,790	$8,402,770	$17,500
Total Internal and External	$271,831	$2,085,604	$10,388,713	$864,455
Total Sales Revenue	$349,200,713	$595,783,614	$3,040,436,853	$1,207,394,162
External R&D as % sales	0.592%	0.347%	0.270%	0.001%
Total R&D as % sales	0.597%	0.350%	0.341%	0.054%

Table 11

External Research and Development Expenses, 1983

	Gulf Power Company	Tampa Electric Company	Florida Power & Light Company	Florida Power Corporation
1. Research support to the Electric Power Research Institute	$1,036,166	$2,164,530	$8,898,075	--
2. Research support to the Edison Electric Institute	$14,922	--	--	--
3. Research support to nuclear power projects	--	--	--	--
4. Research support, other organizations	$14,000	$120,993	$1,470,145	$18,400
5. Total External R&D costs incurred	$1,120,017	$2,285,523	$10,368,220	$18,400
6. Total Internal and External	$1,253,123	$2,306,685	$11,415,327	$409,021
7. Total Sales Revenue	$427,256,325	$614,201,220	$3,213,155,076	$1,288,167,372
8. External R&D as % sales	0.262%	0.312%	0.323%	0.0014%
9. Total R&D as % sales	0.293%	0.375%	0.355%	0.032%

Table 12

External Research and Development Expenses, 1984

	Gulf Power Company	Tampa Electric Company	Florida Power & Light Company	Florida Power Corporation
1. Research support to the Electric Power Research Institute	$283,179	$2,142,132	$9,641,976	--
2. Research support to the Edison Electric Institute	$15,837	--	--	--
3. Research support to nuclear power projects	--	--	--	--
4. Research support, other organizations	$71,872	$80,476	$2,463,075	$19,300
5. Total External R&D costs incurred	$370,888	$2,222,608	$12,105,051	$19,300
6. Total Internal and External	$566,975	$2,266,976	$13,086,300	$418,834
7. Total Sales Revenue	$464,384,198	$690,432,940	$3,927,212,914	$1,297,134,085
8. External R&D as % sales	0.079%	0.322%	0.308%	0.001%
9. Total R&D as % sales	0.122%	0.328%	0.333%	0.032%

Similarly, services are obtained from various consulting firms (National Economic Research Associated, Battelle, and EBASCo), which are linked to R&D, in that technology transfer is involved. Costing methodologies, load forecasting models, and planning models are often obtained by utilities. Had the work been done internally, it might have been classified under R&D. However, external acquisition might not appear in the R&D budget, given the flexibility for accounting for such transactions. Internal acquisition of new analytical tools may not show up in the R&D budget either. For example, FPC has developed a sophisticated methodology for analyzing reliability, but this effort was categorized under system planning. These examples illustrate why "reported" R&D expenditures provide only a first cut for quantifying levels of effort. The payoff, which is of ultimate interest to managers, regulators, and consumers, is another issue altogether.

Mix of Internal R&D

Reports to FERC break internal expenditures into five basic categories related to functional areas of electric utilities: (1) generation; (2) system planning, engineering, and operation; (3) transmission; (4) distribution; and (5) environmental. Deriving trends from four firms over nine years is a difficult task. Specific issues arise, internal resources are allocated, and new priorities develop. Yet, one would expect expenditures to reflect changes in the relative importance of the five functional areas, where importance can be defined in terms of technological and commercial opportunities. A proxy for the latter might be the size of new investment going into each area, or related expenses.

No simple generalizations emerge from this initial survey of reported R&D. The four utilities report widely divergent levels of resources going to internal R&D. Even though trends in the mix for an individual firm may provide some insights into managerial priorities, it should be noted that reported R&D may not be the best indicator of innovative activity, since technology transfer can occur through other channels. Thus, Tables 13-16, which show the expenditures for each utility for nine years, need to be interpreted with care.

We see that Gulf Power reduced reported internal (nominal) R&D expenditures in dollar terms between 1976 and 1982 (from $408 thousand to $42 thousand), which implies an even greater reduction, in real terms, given R&D input price increases. By 1984, internal R&D rose to $196 thousand. Note that the combination of EPRI projects plus Southern Company R&D might compensate for this overall drop. The functional mix (shown in Table 13) shows a significant shift away from system planning applications to environmental R&D. Perhaps system planning activity has been reclassified over this period, so the ten-fold drop was a feature of accounting procedures, not actual activity. Clearly, however, environmental R&D is being given relatively more attention.

Deriving trends for Tampa Electric's internal R&D is difficult given the small dollar values involved. Table 14 shows distribution as one category receiving relatively large attention. However, these reported statistics clearly understate actual innovative activity, since, for example, participation in recent Florida Electric Power Coordinating Group activities (SO_2 study and the generation planning/reliability studies) claimed more internal resources than reported here. Management has some discretion in the classification of

Table 13

Gulf Power Company
Internal Research and
Development Expenses, 1977-1984

	1976	1977	1978	1979	1980	1981	1982	1983	1984
Generation									
Hydroelectric									
Fossil Fuel Steam									
Internal Combustion or Turbine									
Nuclear	$25,817	$8,299	$276	-	-	-	-	-	-
Unconventional Generation									
Siting & Heat Rejection									
SUBTOTAL	$25,817	$8,299	$276	$0	$0	$0	$0	$0	$0
System Planning, Engineering, & Operation	$230,316	$195,127	$252,931	$61,639	$20,322	$17,735	$24,241	$32,956	$31,678
Transmission									
Overhead									
Underground									
Distribution									
Environmental (Other than equipment)	$89,952	$184,846	$36,660	$164,148	$230,819	$289,586	($85,684)	$71,776	$94,684
Other (Classify items over $5,000)	$61,883	$975	--	$9,210	$7,988	$33,364	$19,336	$28,374	$69,725
Total Internal R&D	$407,968	$389,247	$289,867	$234,997	$259,129	$346,685	$42,107	$133,106	$196,087
TOTAL SALES REVENUE	$153,992,467	$183,929,069	$14,220,192	$229,061,661	$268,714,420	$321,197,007	$357,355,444	$427,256,325	$464,384,198
INTERNAL R&D AS % SALES	0.265%	0.211%	0.135%	0.103%	0.096%	0.108%	0.118%	0.031%	0.043%

Table 14

Tampa Electric Company
Internal Research and
Development Expenses, 1977-1984

	1976	1977	1978	1979	1980	1981	1982	1983	1984
Generation									
Hydroelectric									
Fossil Fuel Steam	$13,887	$ 9,969	$38,122	$14,049	$3,283	-	-	-	-
Internal Combustion or Turbine									
Nuclear	$ 1,005	$ 2,196	$ 1,106	$ 32	-	$627	-	-	-
Unconventional Generation									
Siting & Heat Rejection									
SUBTOTAL	$14,892	$11,138	$39,138	$14,081	$3,283	$627	$0	$0	$0
System Planning, Engineering, & Operation									
Transmission									
Overhead									
Underground									
Distribution	$738	$1,574	$48,339	$99,870	$33,785	$25,188	$7,734	$10,726	$966
Environmental (Other than equipment)	-	$1,083	-	$5,861	$1,428	-	-	-	-
Other (Classify items over $5,000)	$147	$1,281	$13,532	$9,929	$4,751	$5,499	$6,677	-	-
Total Internal R&D	$15,777	$15,830	$101,009	$129,741	$43,247	$31,314	$18,580	$16,202	$44,368
TOTAL SALES REVENUE	$301,364,357	$343,357,571	$395,919,251	$444,895,499	$509,279,822	$617,395,592	$573,760,712	$614,201,220	$690,432,940
INTERNAL R&D AS % SALES	0.005%	0.005%	0.026%	0.029%	0.009%	0.005%	0.003%	0.003%	0.006%

Table 15

Florida Power & Light Company
Internal Research and
Development Expenses, 1977-1984

	1976	1977	1978	1979	1980	1981	1982	1983	1984
Generation									
Hydroelectric									
Fossil Fuel Steam	$121,150	$5,082	$ 18,464	$268,972	$3,960,608	$205,393	$95,021	$135,618	$47,820
Internal Combustion or Turbine	-	-	$ 57,904	$120,409	$ 7,337	-	-	-	-
Nuclear	-	$337,125	$1,141,292	$192,558	$ 318,786	$ 4,185	$10	-	$7,000
Unconventional Generation	$ 20,005	$ 34,650	$ 40,114	$ 23,602	$ 82,192	$ 28,827	$35,296	-	-
Siting & Heat Rejection	$ 25,000	$ 4,113	-	-	-	$ 11,805	-	-	-
SUBTOTAL	$166,155	$380,970	$1,257,774	$605,541	$4,368,192	$250,210	$130,327	$135,618	-
System Planning, Engineering, & Operation	-	$5,108	$380,603	$341,770	$1,048,728	$868,004	$539,575	-	-
Transmission									
Overhead	$51,229	$98,044	$ 57,873	$211,514	$ 1,447	$189,150	$10,690	$10,151	$80,629
Underground	$ 6,357	$66,771	$274,384	$197,646	$50,885	$ 30,100	$71,926	$57,403	$121,160
Distribution	$81,581	$50,630	$46,544	$55,947	$75,321	$132,182	$63,521	$73,611	$100,355
Environmental (Other than equipment)	$28,081	$74,351	$102,310	$72,106	$32,821	$130,154	$126,768	-	$11,600
Other (Classify items over $5,000)	$102,108	$149,761	$12,530	$4,731	$42,304	$6,986	$4,312	$770,324	$624,455
Total Internal R&D	$435,511	$825,635	$2,232,018	$1,489,255	$5,622,429	$1,606,787	$934,056	$1,047,107	$981,249
TOTAL SALES REVENUE	$1,181,093,000	$1,453,502,000	$1,634,111,000	$1,933,936,635	$2,347,278,058	$3,088,619,750	$2,940,833,348	$3,213,155,076	$3,927,212,914
INTERNAL R&D AS % SALES	0.037%	0.057%	0.137%	0.077%	0.240%	0.052%	0.031%	0.033%	0.025

Table 16

Florida Power Corporation
Internal Research and
Development Expenses, 1977-1984

	1976	1977	1978	1979	1980	1981	1982	1983	1984
Generation									
Hydroelectric									
Fossil Fuel Steam	-	-	$551,196	$16,088	-	-	$303,126	$45,011	-
Internal Combustion or Turbine	-	-	$ 16,435	-	$114,924	-	-	-	-
Nuclear	-	$179,850	$366,893	$339,339	$338,597	$251,068	$ 96,392	$ 77	-
Unconventional Generation	-	-	$ 17,255	$11,770	$ 6,723	$810,134	$451,329	$73,839	-
Siting & Heat Rejection	-	-	-	-	$ 62	$ 334	$ 46,193	$28,650	-
SUBTOTAL	$0	$179,850	$951,779	$367,197	$460,306	$1,061,536	$896,671	$147,577	$0
System Planning, Engineering, & Operation	$45,683	$40,488	$386,612	$146,188	$387,218	$455,380	($177,960)	$77,613	$24,788
Transmission									
Overhead	-	-	-	-	-	$2,762	$1,034	-	-
Underground	-	-	-	-	-	-	-	-	-
Distribution	$2,706	$13,356	$82,459	$39,751	$7,791	$6,903	$9,119	$7,862	$17,541
Environmental (Other than equipment)	$192,949	$609,080	$208,385	$262,298	$169,007	$227,353	$472,244	$13,462	$91,150
Other (Classify items over $5,000)	-	-	-	$2,334	$3,761	$938	$13,013	-	-
Total Internal R&D	$241,338	$842,774	$1,629,235	$817,768	$1,028,083	$1,754,872	$914,567	$390,631	$399,534
TOTAL SALES REVENUE	$551,438,816	$656,137,958	$751,219,980	$835,493,243	$970,173,021	$1,278,297,207	$1,210,513,488	$1,288,167,372	$1,297,134,085
INTERNAL R&D AS % SALES	0.044%	0.128%	0.127%	0.098%	0.106%	0.137%	0.075%	0.030%	0.0003%

R&D-related activities, which may explain why R&D related to system planning is reported as zero, even though staff were probably engaged in innovative activity. Load research, for example, could fit here or in other expenditure categories.

FP&L, as the largest utility, has perhaps the broadest capabilities in the R&D area. For example, as seen in Table 15, unconventional generation had risen to $82 thousand by 1980, and the new coal-oil mixture experiments have been alluded to. Funding for internal nuclear R&D reached over one million dollars in 1978, but has dropped dramatically since. That year also saw a significant effort on underground transmission, needed in conjunction with rate cases. However, efficiency in generation has received substantial funding, with systems planning (especially load research and innovative rate experiments) growing in importance. Reported environmental R&D is relatively small, and presumably does not reflect the SO_2 study and other cooperative ventures.

Florida Power Corporation's internal R&D (Table 14) shows dramatic growth from 1976 to 1981. Environmental dropped to $169 thousand in 1980 and then rose to $472 thousand since its 1977 peak of $609 thousand. Systems planning and nuclear comprise the two main expenditure categories, the former reflecting load research (time-of-use and direct load control). But, again, as the possible result of the 1981-82 recession, most areas met with substantial cutbacks. In 1984, total internal R&D was less than $400 thousand for FPC. It must be noted that when comparing FPC, which primarily uses internal R&D, with the other three major utilities, no simple generalizations emerge.

Changes in Real R&D

Tables 17 and 18 are an attempt to glean information about real changes in external and internal R&D expenditures based on the data in Table 2. In Table 17, the data show a very large variation on a year-to-year basis with no evident trend. This could result from having many short-term projects with varying priorities from year to year. In addition, the internal R&D could be highly reflective of conditions in the macro-economy and, thus, be affected by the business cycle.

The data in Table 18 show that these firms have a stable commitment to external R&D and that, even though there may be some macro effects on R&D decisions, the variance in R&D spending is much smaller for external projects than for internal projects. This generally reflects the commitment to EPRI-supported R&D.

Types of Internal R&D Projects

To facilitate comparisons of research and development ventures undertaken by the four utilities, reported internal expenditures can be re-categorized into five classifications:

1. Nuclear expenditures, concerning the operation safety, siting, and feasibility requirements of nuclear power plants;

2. Solar expenditures, concerning operational procedures, data collection and assessment, and conversion studies for solar power sources;

3. Environmental expenditures, involving the abatement of air, water, and noise pollution, fish and wildlife protection, and land and reclamation and vegetation studies;

4. Engineering, including fossil fuel generation, systems engineering emphasizing direct load control and its analysis, system coordination, and operation efficiency;

5. Financial control, examining accounting procedures and the processing of information.

Table 17
Real Internal R&D Expenditures, 1976-1984, in 1972 Dollars

Year	Tampa Electric	Gulf Power	Florida Power & Light	Florida Power Corporation	Total Internal
1976	$ 11,921	$ 308,272	$ 329,084	$ 182,399	$ 831,676
1977	11,303	277,934	589,528	601,766	1,480,531
1978	67,151	192,705	1,483,857	1,083,123	2,826,836
1979	79,391	143,799	911,305	500,408	1,634,903
1980	24,238	145,235	3,151,232	576,215	3,896,920
1981	18,056	174,584	823,402	899,265	1,915,307
1982	9,111	20,500	451,496	417,848	898,955
1983	9,943	62,540	491,992	183,541	748,016
1984*	19,858	87,762	439,175	178,818	725,614

*Note: GNP price deflator: 1972 = 100, 1984 = 223.43.

Table 18
Real External R&D Expenditures, 1976-1984, in 1972 Dollars

Year	Tampa Electric	Gulf Power	Florida Power & Light	Florida Power Corporation	Total External
1976	$ 897,316	$ 344,042	$2,515,112	$1,075,628	$4,829,098
1977	130,299	582,691	3,678,272	251,472	5,642,679
1978	970,977	489,628	3,406,956	2,739	4,870,300
1979	972,522	513,565	3,516,214	7,902	4,070,203
1980	1,091,578	440,879	3,376,999	7,237	4,916,694
1981	1,086,913	512,454	4,424,340	8,442	6,032,149
1982	999,511	151,748	4,570,116	8,459	5,729,834
1983	1,073,872	526,249	4,871,597	8,645	6,480,363
1984*	994,767	165,997	5,417,827	8,638	6,587,229

*Note: GNP price deflator: 1972 = 100, 1984 = 223.43.

These categories reflect areas of interest to participants in the industry, although they may not be the areas of highest payoff. Detailed listings of individual project titles and associated funding are listed in the Data Appendix.

For the five categories noted above, expenditures related to nuclear power comprised approximately 30 percent of total internal R&D performed form 1976-1978; this percentage dropped to 20 percent for 1979, 10 percent for 1980, and in 1982 accounted for 5 percent. Nearly three-quarters of these projects were performed by FP&L, where the funds have been primarily allocated to resolve problems related to the efficiency and safety of existing nuclear generators. Research on the feasibility issues of future nuclear generation has been limited; plant availability and site location for future generators were explored in only two FP&L studies. Of course, EPRI has dealt with these issues in its research program.

Likewise, in its internal R&D, FPC has not focused on the long range issues concerning nuclear generation and has, instead, concentrated 28 percent of its total internal R&D budget since 1977 on the environmental, technical specifications, and fuel requirements of existing nuclear plants. However, in the three small ventures undertaken by Gulf Power, emphasis was on the long range planning aspects of nuclear power.

Internally performed R&D regarding the feasibility of "solar energy" has been minimal, receiving only 1.5 percent of expenditure allotment. FP&L's demonstration of a photovoltaic energy system's design feasibility and the subsequent data assessment cause the utility to be ranked as the leader in solar R&D. FPC's radiation monitoring stations

and Tampa Electric's solar conversion research have been the only remaining projects oriented toward the development of solar power. Of course, this small level of R&D may have been optimal from the consumers' viewpoint, if solar R&D will not affect utility operations until the year 2000, but citizens of the state might well be willing to pay for more demonstration studies in this area; thus, they might support additional cooperation with the Florida Solar Energy Research Center.

The range of "environmental R&D" has been vast. Protection of acquatic life has dominated the program; efforts to reduce water pollution affecting crabs, fish, snook, and manatees have been funded by FP&L, Gulf, and FPC (in its comprehensive environmental monitoring program). The reduction of air pollution has also received considerable attention, as evidenced by efforts toward both the de-sulfurization of fuel inputs (FP&L and Tampa Electric), and waste outputs (Gulf Power and FPC), and the recent Florida particulate study (reported only by FPC). Maintenance of the environment was extended to land reclamation and re-vegetation projects by FP&L and Tampa Electric, and also to heat and noise reduction studies by Gulf Power.

The "engineering aspects" of power generation have consistently absorbed nearly one half of internal R&D allocations. The load management studies of FP&L, Tampa Electric, and FPC, focusing on load analysis and direct load control, have constituted the bulk of these engineering projects. In 1980, FP&L began a very large project involving residential pricing and load control by telephone communication lines. This project is in conjunction with two of the major telephone companies in the state. These three utilities also report expenditures on increasing generator efficiency, through heat

loss reductions in operating units, condensers, and transfer cables, and through stress tests on vital generation components such as load-break elbows and pipe cables. Gulf Power has funded the engineering aspects of power system coordination quite heavily, and was the only utility to report expenditures on the refining and utilization of coal.

Innovations in financial and data processing procedures is another R&D category to which funds have been allocated. In 1976, Gulf Power spent 12 percent of its internal research funds to facilitate the processing of general financial, payroll, and personnel data, and to streamline general accounting procedures. The FPC reliability analyses related to corporate planning models were apparently reported under other accounting categories.

This brief overview of project emphasis cannot substitute for a careful analysis of reported R&D expenditures. The appendix contains the raw data necessary for an initial consideration. The listings provide an informative set of project titles, but these cannot substitute for in-depth reviews of specific areas. For example, an FP&L report highlights the results of four projects with extremely high returns to the company and, thus, to consumers. One project tested the effectiveness of tree growth control chemicals on semi-tropical plant life in Florida. The $102,800 project yielded estimated savings of one-half million dollars per year. A small project ($20,510) tested the interchangeability of load break elbows; expected savings are approximately one million dollars. Another small scale project ($39,280) involving extreme wind criteria analysis for transmission line design has resulted in $5,600 per mile savings for tubular steel H-frame units and $45,000 per mile for concrete single poles. Finally, a $12,400

study of lightning current magnitude through distribution surge arresters had estimated savings of $1,600,000 over a five-year period.

The extreme savings represented by these "star" projects are not typical of all R&D, which, by its nature, is somewhat uncertain even at the applied end of the spectrum. However, the four FP&L projects illustrate the kinds of payoffs that can be obtained from R&D. These happened to be internal projects; EPRI research presumably yields similar savings to participating utilities for some projects. However, this overview of reported R&D by electric utilities does not address the important issue of cost-effectiveness of internal or external programs.

Cooperative Research

In a number of areas, Florida utilities have cooperated on large-scale research projects. Three such studies are described here to illustrate the strengths and limitations of cooperative R&D efforts: (1) the Florida Sulfur Oxides study, (2) the Peninsular Florida Generation Expansion Planning study, and (3) the Florida Electric Power Coordinating Group (FCG) Central Dispatch study. A common theme is that the desired information could not have been produced without the detailed involvement of individuals from each utility. Nor could the analyses and interpretation have been performed without some centralized coordination. The issues all went beyond the boundaries of particular service areas.

SO_2 Study. The first study involved environmental regulations. In May 1975, as a condition for postponing the application of more stringent sulfur dioxide emission limitations for steam generators

burning fossil fuels, the Florida Sulfur Oxides Study, Inc., (FSOS) was created by mandate of the Florida Department of Environmental Regulation (DER). Initial funding of $2 million was provided by the state's electric power firms with generating capacity. The FCG served as the conduit for collecting the data, although the project management was contracted out to an engineering consulting firm. An oversight committee was appointed to make decisions regarding contracts for particular studies, to evaluate those studies, and to make a recommendation to the DER regarding SO_2 emission policies. The goal was to ensure that potential solutions to the sulfur dioxide emissions problem would be based upon sound scientific, technical, and legal grounds, rather than some arbitrary standard that might not be cost-effective.

The final report concluded that existing Florida air quality standards were adequate, given the state of knowledge (plus a margin for error). FSOS demonstrated that economies of scale for cooperative research and development ventures probably existed where the participants were affected by a common problem. The expenditures by Florida's electric power industry also made possible the assembly of a group of expert consultants recognized in their respective fields. The quality of the final product would probably have been much lower had small, independent projects been undertaken.

The success of the FSOS study can be seen by the avoidance of unnecessarily stringent sulfur dioxide standards and the avoided compliance costs. Just as important were the improvements in data collection which were necessitated by careful scrutiny of previous procedures. Instruments at some sampling stations turned out to be

highly temperature sensitive, resulting in reduced accuracy of readings. Thus, the SO_2 study provided the impetus for much more careful measurement of pollutants and for improved analysis of socio-economic impacts. Currently, a follow-up project is being funded by the utility industry. From the standpoint of reported R&D expenditures, not all the firms have included their funding of SO_2 research under the R&D category.

Cooperation-Generation Expansion Study. In response to an order by the Florida Public Service Commission, a 1976 generation expansion planning study was undertaken by the Florida Electric Power Coordinating Group to compare methods of independent generation to "generation planning without regard to company boundaries." Gulf Power Company, Tampa Electric Company, Florida Power & Light Company, and Florida Power Corporation were among the twelve state utilities that participated in the study.

The FCG study concluded that jointly developed plans for generation expansion which assured reliable customer service yielded reduced revenue requirements of, on average, 1.66 percent. Savings varied from 0.62 percent to 2.45 percent, according to certain assumptions made concerning cost scenarios for nuclear, coal, and oil units. The report stressed that the modest potential savings should be evaluated in the context of various risk factors inherent in joint planning programs.[1] For example, joint planning (1) increases the risk of improper planning

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[1]Peninsular Florida Generation Expansion Planning Study, 1976-1980, FCG, July 1977, p. 7.

due to the natural diversity of, and differences in, the various utility systems, and (2) exacerbates financial risk by introducing financial inflexibilities that lock a utility into funding requirements that it may be unable to meet.

On the other hand, joint planning would make possible the purchase of larger base load units by smaller utilities, as these smaller utilities cannot justify building large base load units independently and, hence, must rely on smaller units. Joint planning, therefore, tends to offer more opportunities for potential savings to the smaller utility systems than to the larger utilities, while it offers savings to the customers of utilities in peninsular Florida.

The report, by its own admission, did not demonstrate any overwhelming advantages of either joint or individual planning methods, but, nonetheless, recommends continued cooperation among utilities in peninsular Florida in areas of generation expansion planning. Again, how the various utilities accounted for their resources devoted to the project is unclear. Also, the impetus for the study again was external to the industry. The cooperative efforts yielded useful information on gains and costs of alternative regulatory scenarios. However, the disproportionate effort devoted to modeling the technical/engineering features of joint planning showed up in the lack of careful economic analysis.

Central Dispatch Study. The Central Dispatch Study (CDS) was initiated in 1977 by the FCG in response to Phase II of Florida Public Service Commission Order 7080. Utilizing the existing Pennsylvania-New Jersey-Maryland Power Pool as a source of comparison for costing

procedures and organizational methods, the first part of the study analyzed potential savings that could be realized by peninsular Florida utilities from power pool participation. Part Two examined the procedures and costs necessary to "establish, implement, and operate" a central dispatch scheme. Sixteen FCG members participated in the study.

The thrust of the CDS was to determine specifications and capacities of all generating units available to serve the system's net customer load, so that decisions regarding (1) unit commitment, (2) economic dispatch, and (3) pool cost accounting for energy and capacity would be cost-effective. The optimal commitment of generating units to serve the state system's load involve a selection by the pool operator of the combination of base load, intermediate load, and peaking load units that would satisfy net customer load at least cost.

Quite expectedly, mismatches between an individual utility's load and its generation capabilities are prevalent in a power pooling scheme. Some utilities will be generating more than their net energy for load and some less, while some may not even be generating. In an economically efficient market, energy exchange among pool participants will equalize the incremental cost of generation for each participant. Average cost pricing is improper, as it contains the fixed "zero load" costs, which are irrelevant in determining the cost of the marginal unit of output. In a power pool, where multi-lateral transactions for energy occur, prices to participants are determined in the following way: The average selling utility's incremental cost and the average buying utility's decremental cost are calculated. A selling utility will price energy to pooling partners halfway between its incremental cost and the average buying utility's decremental cost. Likewise, a buying utility

will pay a price halfway between its own decremental cost and the average of sell utilities' incremental costs. This high-low approach represents one way of sharing the benefits of lower cost operations.

The findings of the CDS concerning unit commitment, economic dispatch, and power pool cost accounting represent one of the earliest attempts at an economics-oriented power pooling study. The FCG believes that Florida's electric utilities will experience economic benefits from membership in a power pool. Unfortunately, the lack of economic analysis again weakens the study results.

Of course, the success of the power broker system illustrates one of the strengths from more informal cooperation. The Task Force approach allows utilities to involve key personnel in a project without creating a new bureaucracy. Such ad hoc committees can easily be established and funded as needs arise. For example, in 1983, the Florida Legislature revised the Transmission Line Siting Act, requiring new regulations for protecting public health, safety, and welfare as they might be affected by high voltage transmission lines. The FCG and the Department of Environmental Regulation cooperated in the creation of an Electric and Magnetic Fields Science Advisory Commission. The utility-funded $160,000 study helped bring a panel of scientific experts together to evaluate the issues. Such efforts illustrate the public policy leverage gained through cooperative efforts.

ESEERCO--A Model for Florida?

The seven major investor-owned utilities in the state of New York have appreciated the benefits that only a centrally organized concerted research and development program will permit. Their cooperation in the

funding of the Empire State Electric Energy Research Corporation (ESEERCO) has fostered solutions to many problems peculiar to New York state.

A research consortium was initially inspired in 1960 to respond to the complexities of nuclear power generation. Thus, the Empire State Atomic Development Associates (ESADA) was formed by New York utilities to expedite the commercialization of atomic power. This program became the current ESEERCO in 1973, when research was extended to include all aspects of electrical energy relevant to the state. ESEERCO has since been considered as complementary to the independent R&D programs performed by each utility to meet individual needs, and to national organizations such as EPRI and DOE that perform the riskier long-term projects on behalf of the nation's utility industry.

Interaction between ESEERCO and independent research programs is frequent. Often, a project initiated by an individual utility is adopted by ESEERCO after expense and scope prohibit its continuation on a small scale. Likewise, projects are co-sponsored with national and federal agencies when appropriate. ESEERCO is thus considered an interface between the state's utilities and agencies such as the New York State Energy Research and Development Authority (NYSERDA), the DOE and EPRI.

Generally, however, ESEERCO independently undertakes the ventures that have direct application to state utility planning, and show promise for commercialization within ten years. R&D is categorized into four areas, each with its strictly defined goal: (1) nuclear generation, to develop cost-effective improvements in light water reactors; (2) fossil fuel and advanced generation, to develop coal beneficiation and

minimization of environmental externalities from conversions to coal; (3) electrical systems and equipment, to facilitate the installation, maintenance, and replacement of underground cable systems and high voltage overhead systems, for long distance energy transmission, and (4) environmental, to discover means to quantify environmental impacts and minimize their adverse effects.

Upon favorable evaluation of a potential project, a priority is attached based on its anticipated effect on the goals of ESEERCO and the state's power industry. As usual, availability of funds is the binding constraint when determining project scale, and the New York Energy Law requires the annual formal filing of a five-year R&D plan.

There are two aspects to the ESEERCO R&D program. The base program, involving the four project areas mentioned above, addresses the broad range of topics that typically interest member utilities. Recent policy has allocated constant percentages of available funds to these four areas, with nuclear power receiving 40 percent; fossil fuel and advanced generation, 20 percent; electrical systems and equipment, 25 percent; and environmental, 5 percent. The percentages are subjected to regular review, and presumably will be changed when conditions warrant.

The second aspect, a demonstration program, begins when a particular base technology is judged to merit a major effort. This program currently involves the construction and operation of a flue gas de-sulfurization facility treating flue gases from an on-line coal-fired generator.

New York state utilities have traditionally allocated approximately one percent of their regulated operating revenues to R&D. ESEERCO has consistently been able to garner 20 percent of these total R&D

expenditures, permitting an operating budget of $11.5 million for fiscal year 1979. Projections for future R&D expenditures by ESEERCO will rely upon the continuation of the "20 percent of 1 percent" allocation. Opportunities for joint participation by ESEERCO with EPRI and DOE frequently arise concerning demonstration projects. This sort of participation requires additional funding by member utilities, as well as adjustments in ESEERCO's program base.

The period of ESEERCO's existence has been too brief to expect all projects to have produced commercializable results with identifiable benefits. However, modest progress has been exhibited by the significant number of 'closed out' near-term projects that have been integrated into current systems operations. The following are most notable:

1. Nuclear generation. A remote steam generator maintenance device and acoustic equipment for leak detection in the reactor primary system are two projects with commercializable applications. A sensitive reactor coolant activity detection system to locate failed nuclear fuel, and a cyclic absorption system are successful projects that are not yet required by any regulatory authority.

2. Fossil fuel and advanced generation. An electro-packed bed unit for cleaning asphaltic fumes associated with the production of asphalt is now commericalizable.

3. Electrical systems and equipment. The five 'closed out' projects have spawned direct follow-up efforts which contributed to greater understanding in their respective areas. Most notable is a demonstration project, in process, aimed at evaluating a compact SF_6 gas insulated AC/DC conversion unit, and a high voltage DC cable and its associated components, both of which would provide information for a DC transmission system from Pleasant Valley into New York City.

4. Environmental. Concentration has been on water bodies such as the Hudson River, Lake Ontario, and Long Island Sound, collecting data so that standards may be set by regulatory agencies. This effort has yielded cost savings to customers when utilities are not forced to comply with unnecessarily stringent environmental standards.

Conclusions

At least three different modes for conducting R&D are available: competition, cooperation/coordination, and integration. As long as the generating systems are not in competition for serving different service areas, we observe internal R&D which can be shared, and external R&D through national organizations like EPRI and state groups like FCG. Cooperation is visible, although the extent of actual coordination appears to be haphazard, depending on external threats (as with the SO_2 effort) rather than internal opportunities.

A strong case can be made for concentrating more resources at the state level. Perhaps FCG would be the best vehicle, although it would need to alter its mission somewhat to take a long-term approach to projects. Presently, FCG would probably not support a general R&D effort. Their unstated philosophy seems to have been that coordinated studies should be conducted when specific problems arise. The independent efforts at load research, plus some cooperation, are perhaps the best evidence of need for greater coordination in particular areas of R&D. The cost savings from the sharing of methodologies and data are potentially great. In addition, with millions of dollars of trust fund money going into load research-related projects, a way of institutionalizing cooperation would add a local competition for state contracts. There are advantages of having those groups most familiar with the data participate in large scale cooperative ventures.

The FPSC should explore how cooperation might be better institutionalized. The paucity of research ventures involving the voluntary participation of electric utilities (participation in both the generation expansion study and the sulfur oxides study were mandated by

regulatory bodies) suggests that an evaluation of possible dis-incentives for research cooperation is warranted.

In any cooperative research venture, difficulties in the coordination of efforts invariably arise. Problems concerning the standardization of assumptions, research procedures, and data are best resolved through the creation of an effective project management team. Coordination attempts between utilities have often been too informal. A more formal effort at coordination and sharing of projects may help provide more information concerning all areas of the research. Our discussions with participants in the generation expansion planning study indicate that a disproportionate share of total project resources was devoted solely to technical issues, such as transmission limitations. Thus, the need is evident for a project management team that realizes the importance of the economic, as well as the engineering issues that concern research and development.

Many of the cooperative efforts now lack continuity. Large joint studies between utilities must be well planned in advance in order to get useful results, and they should provide some type of foundation for future research. In this respect, projects can be planned toward the completion of some objectives and goals, and at completion toward extending the research into new areas. Quarterly or annual meetings at the top level (R&D vice presidents) to discuss what the issues will be five years into the future can help lay the groundwork for a major study three to five years down the road. Cooperation with the state's universities and major research centers can also yield dividends in terms of resource savings.

Finally, it is apparent that procedures for reporting research and development expenditures are not standardized. Funds allocated to the Florida Electric Power Coordinating Group were ignored on the Form 1 R&D statements by all four of the power companies, as were expenditures for the Florida Sulfur Oxide Study by Gulf Power and Florida Power & Light. These ventures may have been categorized as systems engineering, but since both projects have all relevant characteristics of research and development, they could have been reported as such. The absence of millions of dollars of such expenditures raises questions about the usefulness of current reported data. Some effort should be devoted at the state levels towards insuring better comparability among companies regarding reported R&D.

As regulators begin to use management audits and measures of input (and total factor) productivity, they will no doubt begin to make comparisons of R&D programs across firms. In particular, the Florida Public Service Commission has recently begun a new procedure, the Management Audit, in assessing the state's utilities. Florida Power Corporation was chosen as the first to be audited.[1] FPC does not sponsor EPRI. Rather, task forces are formed within the company to deal with specific problems as they arise. According to the Management Audit, with a cost reduction of 65 percent, the move away from EPRI "has had no detrimental effects upon the Company's ability to stay abreast of, and prepare to develop, new technologies" (Page XIV-5). FPC's primary strategy now is to seek cooperative participation arrangements

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[1]Arthur Young and Company, Tampa, Florida, completed the report in August 1980.

with companies having a specific expertise in an area of high priority for the Company.

The question that is raised from the audit's examination of Florida Power Corporation's R&D methods is whether other Florida utilities should follow suit, thus saving current customers millions of dollars (perhaps at the expense of future customers' higher bills). Some might conclude that Florida utilities and their needs are so diverse as to warrant individualized approaches to the R&D decision, including participation in EPRI and similar groups.

The concern with R&D programs is both inevitable and desirable, given the growing share of resources being devoted to the development and testing of new technologies. Note, however, that regulators should not focus on simple ratios, like R&D divided by sales, when evaluating managerial performance. It will be necessary to perform much more detailed analyses of individual projects, economic conditions present during their initiation, perceived technological opportunities, and results of the entire R&D portfolio. To facilitate cost-benefit analyses (and to keep track of their own programs) utilities will need to document their projects very carefully and relate the projects to the overall objectives of their R&D programs.

The reasons for avoiding simple comparisons of reported R&D are many. For example, some generating units are purchased under turn-key contracts, with any associated R&D built into the price. In other instances, the utility may purchase comparable R&D externally or conduct it internally. Similarly, some firms classify testing as R&D while others account for the same activity differently. Finally, a firm in a growth posture faces different technological opportunities than one with

fairly stable demand. One would expect the different payoffs to R&D to be reflected in different levels of funding, if all else is equal.

Similar issues arise when comparing operating utilities of holding companies across states. Although state regulators will be extremely sensitive to a company in their jurisdiction contributing to sister firms, some types of general R&D could benefit other operating companies. Just as site selection for system expansion will take into account economic and regulatory conditions in the alternative states, R&D programs may depend on scale economies or specialized skills available in a particular utility.[1] Thus, the projects reported by one operating utility may not reflect the total division of labor within the system.

Regulatory procedures further complicate comparisons. Some states have permitted environmental expenditures to be classified as R&D, on the basis that the associated technology was not proven. Also, about half the state PUCs allow R&D to be capitalized. (Whether it is permitted in a particular case is another matter.) Expensing versus capitalization is a thorny issue. Clearly, reported R&D may be a function of whether it is given treatment viewed by the utility as "favorable."

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[1]Smoothing cash flows in particular utilities, timing expenditures to coincide with base years for rate cases, and taking advantage of differential state accounting rules may also result in shifting R&D projects among utilities associated with holding companies. Smith (1975, Table 6) cites examples of R&D allocations which may have involved such motivations.

Besides making people aware of broad regulatory issues, this study presents five recommendations, based on work to date:

1. Electric utilities ought to publicize their R&D programs to a greater extent. Consumers are probably not aware of the scope of research funded by utilities. Projects need not (and should not) be presented as panaceas which will immediately lower customers' bills, but as evidence that utilities are searching for ways to cut costs and improve service.

2. Utilities ought to have well developed research priorities reflecting the needs of each company. These priorities should be revised periodically at top-level meetings, so that alternative programs receive adequate attention.

3. Annual meetings ought to occur under the auspices of the FPSC; these should bring together key R&D decision-makers from throughout the state.

   Annual reports, including project titles and summaries, would be distributed in advance and would serve as the basis for discussion. Rapid dissemination of research results would be enhanced and duplication of effort might be reduced.

4. Areas for potential cooperation ought to be identified by the FPSC to ensure some uniformity regarding methodological approaches. For example, load research would appear to be one area warranting closer coordination. Common data formats would facilitate cooperative research. The creation of an R&D organization along the lines of ESEERCO ought to be considered for Florida, or perhaps for the Southeast.

In conclusion, this report is offered as a convenient data source for reported R&D expenditures. The points raised here regarding internal R&D trends and the gains from cooperation reflect the author's views, and not those of any organization sponsoring the Public Utility Research Center. Furthermore, the favorable view towards R&D found here may be partly due to a predisposition towards such activity, since our research center could stand to gain if greater emphasis were given to R&D. Nevertheless, the size of the budgets involved and the potential gains from cost-effective R&D programs make this topic one which warrants much more attention from regulators and utility managers alike.

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Table A-1
R&D Classification from FERC Form 1

R&D Classifications:

A. Electric R, D,& D performed internally

(1) Generation

a. Hydroelectric
i. Recreation, fish, and wildlife
ii. Other hydroelectric
b. Fossil fuel steam
c. Internal combustion or gas turbine
d. Nuclear
e. Unconventional generation
f. Siting and heat rejection

(2) System planning, engineering, and operation

(3) Transmission

a. Overhead
b. Underground

(4) Distribution

(5) Environment (other than equipment)

(6) Other

(7) Total cost incurred

B. Electric R, D, & D performed externally

(1) Research support to the Electric Research Council or the Electric Power Research Institute

(2) Research support to Edison Electric Institute

(3) Research support to nuclear power groups

(4) Research support to others

(5) Total cost incurred

Table A-2
Reported R&D Expenditures

Florida Power & Light Company, 1976

A(1d)	Analysis of siting requirements for floating nuclear plants	$ 50,000
	Surveillance and diagnostics measurements performed at the Turkey Point Nuclear Plant	71,150
A(1e)	Demonstration of photovoltaic energy system design feasibility	20,005
A(1f)	Acute thermal tolerances of marine organisms	25,000
A(3a)	Test and study of new and existing horizontal line post insulators to improve mechanical load protection	51,229
A(3b)	Study of attenuation of pressure waves induced in high pressure oil-filled pipe cable by electrical faults	6,357
A(4)	Tree growth control on the semi-tropical plant life	41,637
	Heat rise tests on 1,000 KC mil cross-linked polyethylene insulated primary cables	23,525
	Interchangeability testing of loadbreak elbows	16,419
A(5)	Pilot study of tertiary treatment of sewage waste water effluents, utilizing algae in subtropical areas	21,000
	Feasibility study and engineering of PCB waste disposal system	7.081
A(6)	Uranium recovery from phosphate	2,593
	Stone crab mariculture feasibility project	20,000
	Evaluation of the extraction of uranium from Florida phosphate tailings materials	24,215
	Bait shrimp commercial feasibility project	59

Florida Power & Light Company, 1976 (con't.)

	Macrobrachium development, Phase I	$ 45,000
	Other items less than $5,000 (6 items)	10,241
B(1)	Support of EPRI research	3,280,000
B(4)	Natural state plasma prototype fusion reactor conducted at the University of Miami, also supported by the National Science Foundation	25,000
	Role of micro-organisms in the recovery of oil, co-sponsored with the Engineering Foundation of New York city and the National Science Foundation	5,000
	Lighting research through Illuminating Engineering Research Institute	8,500
	Energy technology economics program	10,000
Total A (Internal)		$ 435,511
Total B (External)		$3,328,500
Total R, D, and D Expenditures		$3,764,011

Table A-3
Reported R&D Expenditures

Florida Power & Light Company, 1977

A(1b)	Continuous monitor of condenser efficiency	$ 2,333
	Continuously calculate the heat rate of an operating unit	1,964
	Continuously monitor opacity and density of stack exhaust gas	785
A(1d)	Surveillance and diagnostics measurements to improve nuclear plant availability	10,820
	Evaluation of RETRAN reactor safety analysis	1,305
	Development of resolutions to nuclear steam generator problems to minimize replacement costs and outages	325,000
A(1e)	Assessment of solar data collected at two FP&L sites	8,478
	Demonstration of a low output windmill for electric generation	8,017
	Demonstration of photovoltaic energy system design feasibility	15,315
	Investigate ocean thermal gradients	2,840
A(1f)	Biological control of aquatic seagrasses in cooling water canal system	4,113
A(2)	Testing new designs of ground clamps for fault current	5,108
A(3a)	Recording and analysis of the frequency spectrum of transients on transmissions lines	14,529
	Test and study of new and existing horizontal line post insulators to improve mechanical load protection	14,238
	Analysis of extreme wired criteria for transmission lines	39,277
	Testing tubular steel foundations and concrete pole connection	30,000

Florida Power & Light Company, 1977 (con't.)

A(3b)	Study of attenuation of pressure waves induced in high pressure oil-filled pipe cable by electrical faults	$ 4,645
	Determine the effect of load cycles of different load factors and emergency load currents on the conductor and insulation shield temperature	33,160
	Determine the effect of oil oscillation on conductor temperatures in high pressure oil underground cable	28,966
A(4)	Tree growth control on semi-tropical plant life	50,830
A(5)	Study tertiary treatment on sewage waste water effluents, using algae	4,000
	Determine feasibility of using microorganisms to de-toxify PCBs used to insulate transformers	5,000
	Sampling water sediments to determine extent of PCB pollution and identify sources	44,857
	Feasibility study and engineering of PCB waste disposal system	6,338
	Management and utilization of waste heat	4,000
	Bacteriological de-sulfurization of oil assessment	10,156
A(6)	Stone crab mariculture feasibility project	(20,000)
	Evaluate extraction of uranium from Florida phosphate tailings materials	11,881
	Determine feasibility of growing fresh water shrimp in an intensive culture system	146,630
	Evaluate attic ventilation and analyze heat gain characteristics of Florida roofs	4,500
	Other projects under $2,000	6,750
B(1)	Support of EPRI research	5,106,885
B(4)	Lighting research through Illuminating Engineering Research Institute	8,500
	Assign energy consumption coefficients to Florida residential subgroups	5,000

Florida Power & Light Company, 1977 (con't.)

Fusion-fission breeder reactor study	$ 25,000
Waste management study	5,951
Total A (Internal)	$ 825,635
Total B (External)	$5,151,336
Total R, D, and D Expenditures	$5,976,971

Table A-4
Reported R&D Expenditures

Florida Power & Light Company, 1978

A(1b)	Continuous monitor of condenser efficiency	$ 4,295
	Continuously calculate the heat rate of an operating unit	3,353
	Continuously monitor opacity of stack exhaust gas	3,527
	Development of a multipoint flue gas sampling system	7.289
A(1c)	Determination of cost effective fuel for Putnam combined cycle power plant	10,404
	Integration of low-BTU gas production and combined cycle electric generation study	47,500
A(1d)	Development of resolutions to nuclear steam generator problems to minimize replacement costs and outages	1,126,250
	Evaluation of RETRAN reactor safety analysis	2,518
	Evaluation and application methodology of the Cobra IV code	5,380
	Evaluate extraction of uranium from Florida phosphate tailings materials	7,144
A(1e)	Demonstration of low output windmill for electric generation	2,801
	Assessment of solar data collected at two FP&L sites	37,313
A(2)	Testing new designs of ground clamps for fault current	2,796
	Load research analysis	20,191
	Test residential and commercial customer acceptance of direct load control	357,616
A(3a)	Recording and analysis of the frequency spectrum of transients on transmission lines	57,873
A(3b)	Study of attenuation of pressure waves induced in high pressure oil-filled pipe cable by electric faults	5,989

Florida Power & Light Company, 1978 (cont'd.)

	System to monitor the pipe type cable sidewall pressure during cable pulls	$ 295,214
	Determine the effect of oil oscillation on conductor temperatures in high pressure oil underground cable	73,181
A(4)	Tree growth control of semi-tropical exotic trees	19,411
	Interchangeability testing of loadbreak elbows	4,910
	Study the mechanisms of concentric neutral corrosion on URD cable	5,376
	Obtain the wave shapes and magnitude of lightning surges on distribution lines	4,441
	Study the lightning current magnitude through distribution surge arresters	12,406
A(5)	Bacteriological de-sulfurization of oil assessment	3,638
	Determine feasibility of growing fresh water shrimp in an intensive culture system	26,660
	Development of a technology to propagate snook in large numbers	14,841
	Aerial census of manatees during winter and summer	33,188
	Study the interaction of warm water effluent and manatee distribution around FP&L power plants	23,983
A(6)	Evaluate attic ventilation and analyze heat gain characteristics of Florida roofs	4,731
	Twelve other projects under $2,000	7,799
B(1)	Support of EPRI research	5,101,774
	Lighting research through Illuminating Engineering Research Institute	8,500
	Energy Technology Economics program	9,500
	Assign energy consumption coefficients to Florida residential subgroups	5,000
Total A (Internal)		$2,232,018
Total B (External)		$5,124,774
Total R, D, and D Expenditures		$7,356,792

Table A-5
Reported R&D Expenditures

Florida Power & Light Company, 1979

A(1b)	Development of a reliable multipoint flue gas sampling system	$ 48,935
	Develop combustion techniques to reduce sulfur trioxide production, reduce opacity, and permit operation poorer grades of fuel	14,773
	Develop best available microprocessor hardware for use in instrumentation and controls of pneumatic power plants	5,826
	Development of low BTU gasification technology	195,000
	Coal-oil mixture test facility and plant modification	4,438
A(1c)	Determination of which fuel is the most cost effective for the Putnam combined cycle power plant	120,409
A(1d)	Development of resolutions to nuclear steam generator problems to minimize replacement cost and outages	170,000
	Investigation of hydriding titanium condenser tubes	12,223
	Evaluation and application methodology of the Cobra IV code	10,335
A(1e)	Demonstration of a low output windmill for electric generation	2,508
	Assessment of solar data collected at two FP&L sites	21,094
A(2)	Testing new designs of ground clamps for fault current	8,172
	Load research analysis	7,589
	Testing residential and commercial customer acceptance to direct load control	293,856
	Residential pricing and load control project	32,153
A(3a)	Recording and analysis of the frequency spectrum of transients on transmission lines	20,273
	Develop an augered concrete filled anchor to hold 80,000-120,000 lbs. working load	24,165

Florida Power & Light Company, 1979 (con't.)

	Develop a vertical vibratory installed anchor to hold a 60,000 lb. working load at a 45Π angle	$ 31,124
	Develop a directional indicator for repetitive transient aults on transmission lines	2,420
	Determine the detrimental effects of aedlean introduced resonant vibration on conductors and insulators	9,370
	Development of additional and alternative methods to reduce the effects of insulator contamination on transmission line insulators	124,162
A(3b)	Study of attenuation of pressure waves induced in high pressure oil-filled pipe cable by electrical faults	14,563
	System to monitor the pipe type cable sidewall pressure during cable pulls	87,556
	Determine the effect of oil oscillation on conductor temperatures in high pressure oil underground cable	83,047
	Develop a system to predict cable life for direct buried primary cable	12,480
A(4)	Develop a system to predict cable life for direct buried primary cable	17,815
	Heat rise test to determine the ampacity of the distribution cable	2,374
	Study the mechanisms of concentric neutral corrosion on URD cable	29,963
	Obtain the wave shapes and magnitude of lightning surges on distribution lines	2,583
	Determine the ampacity of existing fabricated substation aluminum bus connections	3,212
A(5)	Aerial census of manatees during winter and summer	31,968
	Study the interaction of warm water effluent and manatee distribution around FP&L power plants	24,232
	Develop a method to reduce turtle entrapment at St. Lucie plant	15,906
A(6)	Seven other projects under $2,000	4,731

Florida Power & Light Company, 1979 (con't.)

B(1)	Support of EPRI research	$5,668,198
B(4)	Lighting research through Illuminating Engineering Research Institute	8,500
	Energy Technology Economics program	10,000
	Synthetic Fuels program	9,500
	Design of gas cooled nuclear power plants	50,000
Total A (Internal)		$1,489,255
Total B (External)		$5,746,198
Total R, D, and D Expenditures		$7,235,453

Table A-6
Reported R&D Expenditures

Florida Power & Light Company, 1980

A(1b)	Biologically remove nutrients from sewage water with water hyacinth system and integrate final product into energy production	$ 65,764
	Test performance of a 5kw peak photovoltaic system	14,355
	Determine the effect of AC current and combinations of AC and DC currents in the corrosion of underground steel structures	12,384
	Survey the service area of FP&L for the acidity of precipitation	173,582
	Design and field test a new bog shoe shear and bending type load	494
	Perform field evaluation of a new outdoor insulation material polysil	8,890
	Develop a methodology for investing the effect of power system resonant	34,942
	Develop best available microprocessor hardware for use in instrumentation and control of pneumatic power plants	1,023
	Develop combustion techniques to reduce sulfur trioxide production, reduce opacity, and permit operation	3,346
	Develop a multipoint flue gas sampling system	482
	Coal oil mixture test facility and plant modification	3,645,346
A(1c)	Develop and test an oil burner capable of operating on high asphaltene fuel oil with lox-no_x combustion on power boilers	5,516
	Determine which fuel is the most cost effective for the Putnam combined cycle power plant	1,821

Florida Power & Light Company, 1980 (con't.)

A(1d)	Develop techniques of corrosion control in water-boxes that will not cause hydriding of the titanium condenser tubes	$ 18,786
	Development of resolutions to nuclear steam generator problems to minimize replacement cost and outages	300,000
A(1e)	Continuation of solar data collection at two FP&L sites	4,453
	Demonstration of a low output windmill for electric power production from Florida wind power	4,239
	Solar load management installation at Perrine Service Center	73,500
A(1f)	Produce comprehensive statistical data on fault currents as experienced on primary distribution system	9,852
A(2)	Telephone communication/residential pricing and load control project	951,760
	Testing new designs of ground clamps for fault current	5,448
	FP&L/FPC joint load management project	91,520
A(3a)	Recording and analysis of the frequency spectrum of transients	1,447
A(3b)	Develop a system to predict cable life for direct buried primary cable	$ 19,078
	Oil oscillation in existing HOP underground cable system to alleviate hot spots on conductors	2,911
	System to monitor the pipe type cable sidewall pressure during cable pulls	13,121
A(3)2	Develop additional and alternative methods to reduce the effects of insulator contamination on transmission line insulator	31,477
	Determine the detrimental effects of aedlean induced resonant vibration on conductors and insulators	838

Florida Power & Light Company, 1980 (con't.)

	Develop an augered, concrete-filled, 80,000-120,000 lb. anchoring system	1,768
A(4)	Determine the existing ampacity of fabricated substations aluminum bus connections	7,985
	Study the mechanisms of concentric corrosions on URD cable	10,991
	Obtain the wave shapes and magnitude of lightning surges on distribution lines	1,275
	Study the mechanisms of concentric neutral corrosion on URD cable	26,910
A(5)	Develop a method to reduce turtle entrapment at the St. Lucie plant	31,330
	Aerial census of manatees during winter and summer	3,491
A(6)	Transformer insulating fluid test to develop substitute for askerels (PCBs) supplement	11,511
	Evaluation to return reactor safety analysis	1,296
	Test various operating modes using combinations of solar and load management hardware	24,203
	Determine the feasibility of heating water with an integral heat pump/water tank unit to reduce peak loads and operating costs	5,294
B(1)	Support of EPRI research and general R&D management administrative expenses	$ 5,925,208
B(4)	Design of gas cooled nuclear power plants	100,035
Total A (Internal)		$ 5,622,429
Total B (External)		$ 6,025,243
Total R, D, and D Expenditures		$11,647,672

Table A-7
Reported R&D Expenditures

Florida Power & Light Company, 1981

A(1b)	Evaluate advantages of using microprocessor-based subsystems in pnuematically instrumented units retrofits, Phase I	$ 1,596
	Combustion, heat transfer, ash deposit, and pollutant emission characteristics of coal oil mixtures	95,228
	Examination of extraction and hydrotreating of oil from eastern shale	25,000
	Theoretical studies of chemical cleaning of coal	1,676
	Small scale testing flame retardant coated cables	24,737
	Putnam plant dual fuel capability optimization	58
	High asphaltene and low NO oil burners	56,675
	Project team for fuels research and development	424
A(1d)	Evaluation of RETRAN reactor safety analysis code	2,677
	Small scale testing flame retardant coated cables	10
	Corrosion investigation on titanium tubes and their metallic coupling to a muntz metal tube sheet	1,498
A(1e)	Wind generator experiment	1,437
	Solar data collection and assessment	1,887
	Solar heating and cooling of the Perrine Service Center	3,337
	Solar/load management installation at Perrine Service Center	20,088
	Photovoltaic system experiment	2,078
A(1f)	Acid rain survey of FP&L service area	11,805

Florida Power & Light Company, 1981 (con't.)

A(2)	FP&L/FPC joint load management project	$ 68,302
	Residential air infiltration study	10
	Telephone communications/residential pricing and load control projects	681,113
	60 HZ TWACS be-directional power line communication project	116,683
	Field test five residential heat pump water heaters	1,896
A(3a)	Recording and analysis of the frequency spectrum of transients on transmission lines	2,640
	Detrimental effects of conductor insulator system vibration at mechanical resonance	189
	Reduce contamination effects on transmission line insulators	78,102
	New method of personal protective ground application	24,890
	Field evaluation of a new outdoor insulation material (polysil)	23,465
	New concrete bog shoe design	17,816
	Polymer concrete poles and substation structures	40,000
A(3a&b) A(4)	PCB substitute of transformer insulating fluid	2,048
A(3b)	Cooling system for potheads and splices for underground transmission lines	30,100
A(4)	Cause and mitigation of corrosion in underground steel structures caused by AC currents	58,842
	Cable life prediction	33,976
	Neutral corrosion of URD cable	31,435
	Ampacity of fabricated aluminum bus connectors	7,929
A(5)	Thermal tolerance of crocodile hatchlings	19,222
	Turtle behavior in electric fields	30,932
	FCG acid rain precipitation study, Phase II	80,000

Florida Power & Light Company, 1981 (cont'd.)

A(6)	General research and development and administrative expenses	$ 6,986
B(1)	Support of EPRI research and general research and development management administrative expenses	8,310,077
B(4)	Energy technology economics program	11,000
	FP&L support for Gas Cooled Reactor Associates (GCRA)	150,000
	HTGR site selection study, Florida, Phase I	150,330
	Development of CWM equipment	12,251
Total A (Internal)		$ 1,606,787
Total B (External)		$ 8,633,658
Total R, D, and D Expenditures		$10,240,445

Table A-8
Reported R&D Expenditures

Florida Power & Light Company, 1982

A(1b)	Theoretical studies of chemical cleaning of coal	$ 1,235
	Small scale testing of flame retardant coated cables	70,159
	High asphaltene and low NO oil burners	(8,142)
	Project team for fuels research and development	629
	Multipoint fuel gas sampling systems development	670
	Evaluate advantages of using microprocessor based subsystems in pneumatically instrumented unit retrofits, Phase II	9,130
A(1b&d)	Turbine-generator torsional vibration monitoring	(274)
A(1d)	Small scale testing of flame retardant coated cables	10
A(1e)	Solar data collection and assessment	2,126
	Solar heating and cooling of the Perrine Service Center	13,082
	Solar/load management installation at Perrine Service Center	20,088
A(2)	FP&L/FPC joint load management project	8,080
	Residential Air Infiltration study	(11,940)
	Telephone communications/residential pricing and load control projects	397,866
	60 HZ TWACS bi-directional power line communication project	117,025
	Cause and mitigation of corrosion in underground steel structures caused by AC currents	28,544
A(3a)	Recording and analysis of the frequency spectrum of transients on transmission lines	5,313
	Reduce contamination effects on transmission line insulators	636

Florida Power & Light Company, 1982 (cont'd.)

	Field evaluation of new outdoor insulation material (Polysil)	$ 4,055
	Development of directional indicator for repetitive transient faults on transmission lines	(313)
A(3a&b)	PCB substitute of transformer insulating fluid	919
A(3b)	Cooling system for potheads and splices for underground transmission lines	71,926
A(4)	Cable life prediction	38,771
	Neutral corrosion of URD cable	13,184
	Ampacity of fabricated aluminum bus connectors	11,566
A(5)	Thermal tolerance of crocodile hatchlings	3,468
	FCG acid rain precipitation study, Phase II	123,300
A(6)	General research and development and administrative expenses	9,501
	General R&D management and administrative expenses	3,362
B(1)	Neutral corrosion of URD cable	9,478
	Support of EPRI research and general research and development	8,402,770
	Putnam plant dual fuel capacity optimization	1
B(4)	FP&L support for Gas Cooled Reactor Associates (GCRA)	165,000
	Development of CWM equipment	11,700
	University of Florida, coal dispersion combustion research program	10,000
	Polymer concrete poles and substation structures	1,619
	FCG acid rain precipitation study, Phase II	176,667
	Radio tracking of manatees	27,622
	Turtle behavior in electric fields	11,200
	Turtle behavior in electric fields, Phase II	48,000
	Sanford single burner combustion test of coal slurry fuel	34,716

Florida Power & Light Company, 1982 (con't.)

Combustion tests of cleaned coal COW and CWM	$	139,702
Synthetic fuels program		9,500
Methods of identifying dislocations in the integrated coal and transportation market for FP&L		4,708
Photovoltaic system experiment		11,361
FP&L support for steam generator owners Group II		302,000
Corrosion investigation on titanium tubes and their metallic coupling to a muntz metal tube sheet		376
Applicability of "bubble" leasing concept of the FP&L system		25,039
Modification of turtle behavior phase II		23,558
Combustion, heat transfer, ash deposition and pollution emission characteristics of concentrated coal water slurries		39,640
Total A (Internal)	$	934,056
Total B (External)	$	9,454,657
Total R, D, and D Expenditures	$	10,388,713

Table A-9
Reported R&D Expenditures

Florida Power & Light Company, 1983

A(1b)	High asphaltene and low no_x oil burners	$ 34,737
	Evaluate advantages of using microprocessor based subsustetms in pneumatically instrumented unit retrofits, Phase II	80,866
	Project team for fuels R&D	20,015
A(3a)	Fault location on high pressure oil-filled pipe type cables by the oil pressure wave method	6,031
	Recording and analyiss of the frequency spectrum of transients on transmission lines	2,620
	New method of personal protective ground application	1,500
A(3b)	Neutral corrosion of underground residential cable	6,045
	Cooling system for potheads and splices for underground transmission lines	51,358
A(4)	Padmounted switch cleaner for cleaning energized 15kV and 23 kV padmounted switches	23,940
	Evaluation of polymer concrete insulating materials (Polysil and other polymer concrete systems)	7,710
	Feasibility of removing polychlorinated biphenyls from transformers in below grade distribution vaults	5,693
	Investigation of fiber optic members for FP&L use	4,738
	Communication system for remote capacitor switching	5,242
	Cause and mitigation of corrosion in underground steel structures caused by alternating currents	26,288
A(6)	Telephone communications/residential pricing and load control project	249,945
	General research and development management administrative expenses	343,020

Florida Power & Light Company, 1983 (con't.)

	Solar heating and cooling of the Perrine Service Center	$ 952
	Residential air infiltration study	11,845
	60 HZ TWACS bi-directional power line communication project	83,122
	Utility planning model	81,440
B(1)	Support of EPRI research	8,898,075
B(4)	commercial stored cooling air conditioning system demonstration	94,562
	Swimming pool circulation system energy efficient optimization study	20,136
	Support for steam generator owners group II	292,000
	Polymer concrete poles and substation structures	10,315
	Support for Gas Cooled Reactor Associates	175,000
	Photovoltaic system	4,074
	Transient stability analysis for security analysis conditions	11,100
	Coal water mixture feasibility and optimization study	32,626
	Combustion/deposition test program for micronized coal-water slurry fuel	2,116
	Methods of identifying dislocations in the integrated coal and transportation market for FP&L	30,702
	Evaluation of hydrogen production alternatives	15,000
	Transmission line construction and maintenance impacts on freshwater wetlands	8,525
	PCB research, Phase I	13,680
	Applicability of "bubble" licensing concept to the FP&L system	3,658
	Utilization of coal/oil ash for artificial reefs	936

Florida Power & Light Company, 1983 (con't.)

Dewatering and fixation of oil fired ash and sludge wastes	$ 20,378
Oil ash sludge stabilization demonstration	122,845
Determination of the combustion heat transfer, ash deposition, and pollutant emission characteristics of concentrated coal-water slurries, Phase II	40,847
Particulate emissions from high asphaltene fuel flames	80,443
Florida Coordinating Group acid rain precipitation study, Phase III	136,306
FCG acid precipitation study, Phase IV	161,037
Radio tracking of manatees	17,428
Modification of turtle behavior, Phase II	145,824
Behavioral osmoregulation and temperature tolerance of hatchling American crocodiles	14,350
Miscellaneous	257
Total A (Internal)	$ 1,047,107
Total B (External)	$10,368,220
Total R, D, and D Expenditures	$11,415,327

Table A-9.1
Reported R&D Expenditures

Florida Power & Light Company, 1984

A(1b)	Project team for fuels R&D	13,137
	Integrated boiler/turbine control system	25,643
A(1d)	Evaluate advantages of using microprocessor-based subsystems in pneumatically instrumented unit retrofits, Phase II	$ 9,040
	High temperatures primary system monitoring for pH, hydrogen, and redox potential	7,000
A(3a)	Fault location on high pressure oil-fired pipe type cables by the oil pressure wave method	10,960
	Recording and analysis of the frequency of transients on transmission lines	2,747
	SF6 puffer breaker 145kV, 50kA rating	45,000
	New hot stick methods for transmission maintenance	1,055
A(3b)	Cooling system for potheads and splices for underground transmission lines	74,710
	Hot impulse test of reduced wall 138kV, 2000 kcail conductor hpof pipe type cable	46,450
A(4)	Padmounted switch cleaner for cleaning energized 15 kV and 23kV padmounted switches	(5,885)
	Evaluation of polymer concrete insulating materials (polysil and other polymer concrete systems)	21,088
	Feasibility of removing polychlorinated biphenyls (PCBs) from transformers in below-grade distribution vaults	39,080
	Investigation of fiber optic members for FPL use	3,724
	Cause and mitigation of corrosion in underground steel structures caused by alternating currents	30,578
A(5)	Fine particulate matter, physical and chemical characteristics	11,600

Florida Power & Light Company, 1984 (cont'd.)

A(6)	Telephone communications/residential pricing and load control project	34,888
	General research and development, management administrative expenses	543,288
	Solar heating and cooling of the Perrine Service Center	22,730
	60 Hz TWACS (two-way automatic communication system) bidirectional power line project	1,549
	Utility planning model	22,000
B(1)	Support of EPRI research	9,641,976
B(4)	Passive home components	4,000
	Commercial stored cooling/air conditions system demonstration	17,196
	Swimming pool circulation system energy-efficient optimization study	40,264
	Terrafix stream crossing	32,605
	Terrafix marsh crossing	43,000
	FPL support for Gas Cooled Reactor Associates (GCRA)	185,000
	Photovoltaic system	2,802
	Transient stability analysis for security analysis conditions	12,700
	Coal/water mixture feasibility and optimization study	1,107,681
	Combustion/deposition test program for micronized coal/water slurry fuel	27,443
	University of Florida coal dispersion combustion research program	1,000
	Effect of carbon dioxide/water on physical and chemical properties of coal	88,351
	Characterization of cleaning of candidate coals for FPL oil-backout applications	51,493
	ESEERCO coal/water slurry loop tests, Phase II	29,242

Florida Power & Light Company, 1984 (cont'd.)

Transmission line construction and maintenance impacts on freshwater wetlands	32,793
Impacts of subaqueous cable installations upon tidal wetlands	27,494
Polychlorinated biphenyls (PCB) research, Phase I	12,000
Chlorine toxicity in field tests	24,644
Utilization of Coal/oil ash for artificial reefs, Phase I	43,542
Dewatering and fixation of oil-fired ash and sludge wastes	24,522
Oil ash sludge stabilization demonstration	23,157
FCG acid precipitation study, Phase IV	221,504
Air quality effects on terrestrial vegetation	176,000
Combustion, heat transfer, pollutant emission and ash deposition characteristics of concentrated coal/water slurries, Phase III	42,363
Particulate emissions from high asphaltene fuel flames, Phase II	50,002
Utilization of oil/coal ash for artificial reefs, Phase II	36,700
FCG acid precipitation study, Phase IV-A	60,000
Radio tracking of manatees	9,769
Modification of turtle behavior, Phase II	35,555
Miscellaneous	253
Total A (Internal)	$ 981,249
Total B (External)	$12,105,051
Total R, D, and D Expenditures	$13,086,300

Table A-10
Reported R&D Expenditures

Florida Power Corporation, 1976

A(2)	Load management research	$ 45,683
A(4)	Lightning protection research program	2,706
A(5)	Anclote post-operational ecological monitoring program	192,428
B(2)	Fast breeder reactor research	194,428
B(4)	Research of heated discharge plume in Gulf environs of Crystal River plant	20,928
	Pre-operational radiological research program in the Crystal River plant site area	32,317
	Research relative to the Public Utility Research Center at the University of Florida	8,946
	Florida Electric Power Coordinating Group, Sulfur Dioxide study	187,264
	Anclote post-operational ecological monitoring program	903,382
	Environmental research on radioactivity in the vicinity of the Crystal River plant	61,754
	Load management research	5,706
	Lightning dissipation system	6,240
	Lightning protection research program	2,522
Total A (Internal)		$ 240,817
Total B (External)		$1,423,487
Total R, D, and D, Expenditures		$1,664,304

Table A-11
Reported R&D Expenditures

Florida Power Corporation, 1977

A(1d)	Environmental technical specifications	$ 179,850
A(2)	Solar radiation monitoring station construction and operation	15,254
	Load management	25,234
A(4)	Lightning protection research program	102
	Ampacity test on substations	1,851
	Cable capacity research program	375
	Fire retardant cable test	10,978
A(5)	Anclote post-operational ecological monitoring program	605,094
	Investigate storm tracking system	3,986
B(4)	Pre-operational radiological research program in the Crystal River plant site area	7,171
	Environmental research on radioactivity in the vicinity of the Crystal River plant	8,129
	Research related to the Public Utility Research Center at the University of Florida	9,393
	Florida Electric Power Coordinating Group, Sulfur Dioxide study	327,494
Total A (Internal)		$ 842,724
Total B (External)		$ 352,187
Total R, D, and D, Expenditures		$1,194,911

Table A-12
Reported R&D Expenditures

Florida Power Corporation, 1978

A(1b)	Coal/oil composite for Crystal River plant site	$ 471,086
A(1d)	Environmental technical specifications	366,893
A(2)	Solar radiation monitoring station construction and operation	16
	Load management research program	24,078
	Bi-directional load management research program	348,319
	Residential air conditioning load study	14,199
A(4)	Lightning protection research program	(86)
	Ampacity test on substations	5,054
	Rockland substation, insulator environmental test	12,062
A(5)	Investigate steam tracking system	219
B(4)	Environmental research on radioactivity in the vicinity of the Crystal River plant	3,859
	Research related to the Public Utility Research Center at the University of Florida	12,914
	Florida Electric Power Coordinating Group, Sulfur Dioxide study	(22,545)
Total A (Internal)		$1,241,840
Total B (External)		$ -5,772
Total R, D, and D Expenditures		$1,236,068

Table A-13
Reported R&D Expenditures

Florida Power Corporation, 1979

A(1b)	Cost study of com fuel	$ 16,076
	Demonstration of coal/oil mixture	12
A(1d)	Environmental technical specifications	339,339
A(1e)	300 KW photovoltaic project	4,742
	Biomass methane/diesel electric project	7,028
A(2)	Uni-directional load management research program	25,352
	Bi-directional load management research program	78,743
	Residential air conditioning load study	6,804
	Fuel cell demonstration project	1,062
	Cooling storage demonstration	20,077
	Solar radiation monitoring station II	1,217
	Distr. voltage regulator for energy conservation	6,350
	Experimental condenser cleaning demonstration	6,583
A(4)	Ampacity test on substations	1,406
	Rockland substation insulator environmental test	167
	Phase I lightning study	16,490
	DeBary substation power transformer heat recovery	21,688
A(5)	Testimony and consultation concerning Anclote post-operative ecological monitoring	233,651
	Crystal River, NPDES environmental study	28,647
A(6)	Fuel additives and effects on mileage	2,334

Florida Power Corporation, 1979 (con't.)

B(4)	Environmental research on radioactivity in the vicinity of the Crystal River plant	$ 12,914
Total A (Internal)		$817,768
Total B (External)		$ 12,914
Total R, D, and D Expenditures		$830,682

Table A-14
Reported R&D Expenditures

Florida Power Corporation, 1980

A(1c)	Biomass methane/diesel electric project	$114,924
A(1d)	Crystal River environmental technical specifications	338,597
A(1e)	Unconventional 100 KW photovoltaic project	3,800
	Unconventional fuel cell demonstration project	56,737
	Unconventional OTEC biofouling heat exchange test, Bartow plant	00
A(1f)	Heat rejection development and demonstration, heat pipes	62
	Heat rejection experimental condenser cleaning demonstration	00
A(2)	Uni-directional load management research	257
	Bi-directional load management research	46,635
	Residential air conditioning load study	1,866
	Electric utility system planning studies for OTEC Power Integration	65,406
	Load management project, telephone lines	37,996
	Distr. voltage regulator for energy conservation	615
	Demonstration of coal/oil mixture	24,745
	Heat pump water heater and BTU meter	588
	Utilization of wood waste, Suwannee River plant	13,840
	Coal gasification/re-powering project, Higgins plant	13,602
	Bulk power reliability assessment	8,912
A(4)	Ampacity test on substations	442
	Rockland substation, insulator environmental test	657

Florida Power Corporation, 1980 (con't.)

	Phase I lightning study	$ 2,417
	Power transformer heat recovery DeBary substation	2,305
	Life expectancy of polyethylene extruded di-electric power cables	1,528
A(5)	Anclote post-operative ecological monitoring	(244)
	Crystal River NPDES environmental study	56,737
	Florida particulate study	42,905
	Anclote 1 and 2 monitoring programs	41,283
A(6)	Fuel additives and effects on mileage, fleet services	24
	Cooling storage demonstration	3,001
	Field test of on-site meter reading and billing system	736
B(4)	Research related to the Public Utility Research Center at the University of Florida	12,914
Total A (Internal)		$880,373
Total B (External)		$ 12,914
Total R, D, and D Expenditures		$893,287

Table A-15
Reported R&D Expenditures

Florida Power Corporation, 1981

A(1d)	Crystal River environmental technical specification	$251,068
A(1e)	Fuel cell demonstration project	23,311
	Installation of wood waste gasifier, Suwannee plant	733,852
	100 KW photovoltaic project	1,234
	Biomass methane/diesel electric project	4,727
	Wind/electricity demonstration	47,010
A(1f)	Ultrasonic effects on heat transfer	334
A(2)	Uni-directional load management research	106,659
	Bi-directional load management research	23,428
	Residential air conditioning load study	253
	Electric utility system planning studies for OTEC power integration	1,204
	Load management research, telephone lines	12,862
	Bulk power reliability	30,823
	Heat pump ice maker/water	388
	Coal gasification/re-powering project, Higgins plant	279,763
A(3a)	Extreme wind criteria analysis for transmission line design	2,762
A(4)	Ampacity test on substations	1,939
	Lighting study, Phase I	2,545
	Distr. voltage regulator for energy conservation	2,419
A(5)	NPDES environmental study, Crystal River	11,841
	Florida Particulate study	15,595

Florida Power Corporation, 1981 (con't.)

	Anclote 1 and 2 monitoring programs	$ 60,157
	Acid rain study	139,760
A(6)	Sludge, solid fuel mixtures	938
B(4)	Research related to the Public Utility Research Center at the University of Florida	16,475
Total A (Internal)		$1,754,872
Total B (External)		$ 16,475
Total R, D, and D Expenditures		$1,771,347

Table A-16
Reported R&D Expenditures

Florida Power Corporation, 1982

A(1b)	Mineral recovery from fly ash	$ 302,660
	Fuel qualities improvement	97
A(1d)	Crystal River environmental technical specification	96,392
A(1e)	Installation of wood waste gasifier, Suwannee plant maintenance program	66,315
	Gasifier reciprocating generator	446
	Fuel cell demonstration project	7,370
	Installation of wood waste gasifier, Suwannee plant	373,875
	Wind/electric demonstration	3,712
	Wind/electric generation monitoring	57
A(1f)	Ultrasonic effects on heat transfer	30,598
	Flame additive study	15,595
A(2)	Uni-directional load management research	22,678
	Bi-directional load management research	6,917
	Residential air conditioning load study	35
	Load management research, telephone lines	5,086
	Heat pump water heater and BTU meter	651
	Bulk power reliability	42,579
	Heat pump ice maker/water	491
	Coal gasification/re-powering project, Higgins plant	(256,397)
A(3a)	Extreme wind criteria analysis for transmission line design	1,034
A(4)	Phase I lighting study	9,119

Florida Power Corporation, 1982 (con't.)

A(5)	Crystal River dredge spoil recolonization	$ 3,716
	Anclote 1 and 2 monitoring programs	35,032
	Acid rain study	133,496
A(6)	Sludge, solid fuel mixtures	13,013
B(4)	Research related to the Public Utility Research Center at the University of Florida	17,500
Total A (Internal)		$914,567
Total B (External)		$ 17,500
Total R, D, and D Expenditures		$932,067

Florida Power Corporation, 1983 (con't.)

B(4)	Research related to the Public Utility Research Center, University of Florida	$ 18,400
Total A (Internal)		$390,631
Total B (External)		$ 18,400
Total R, D, and D Expenditures		$409,031

Table A-17
Reported R&D Expenditures

Florida Power Corporation, 1983

A(1b)	Minerals recovery from fly ash	$ 37,446
	Fuel qualities improvement	7,565
A(1d)	FPC environmental technical specification required by U.S. Nuclear Regulatory Commission	77
A(1e)	Waste gasifier maintenance program, Suwannee plant	54,245
	Wood gasification, Phase II	6,122
	Magnetic water treatment	5,907
	Fuel cell demonstration project, Bartow	19,885
	Wind/electric generation monitoring	3,426
A(1f)	Flame additive study	8,765
	Ultrasoic effects and heat transfer	3,263
A(2)	Uni-directional load management research	32,284
	Bi-directional load management research	1,719
	Load management project telephone lines	(84)
	Bulk power reliability	43,694
	Heat pump ice maker/water heater	508
A(4)	Circuit breaker overload test	3,325
	Ampacity test substation series equipment	4,537
A(5)	Crystal River dredge spoil recolonization	11,116
	Anclote H2 monitoring programs	2,269
	Acid rain study	144,562

Table A-17.1
Reported R&D Expenditures

Florida Power Corporation, 1984

A(1e)	Wood gasification, Phase II	$ 50,510
	Magnetic water treatment	27,240
	Transformer heat recovery	17,923
	Conventional to fluidized bed boiler retrofit	56,358
	Externally fired combustion turbine study	17,370
	Fuel cell demonstration project, Bartow	79,205
	Wind/electric generation monitoring	(3,219)
A(2)	Bulk power reliability	24,788
A(4)	Circuit breaker overload tests	4,430
	Lake Tarpon substation, digital metering	10,563
	East Clearwater substation, LTC control	2,548
A(5)	Crystal River dredge spoil recolonization	9,586
	Acid rain study	81,564
A(b)	Battery storage evaluation program	4,872
	Electric vehicle development	15,796
B(4)	Research related to the Public Utility Research Center, University of Florida	19,300
Total A (Internal)		$399,534
Total B (External)		$ 19,300
Total R, D, and D Expenditures		$418,834

Table A-18
Reported R&D Expenditures

Tampa Electric Company, 1976

A(1b)	Sulfur removal process	$ 13,887
A(1e)	Solar conversion research, University of Delaware	1,005
A(4)	Rome substation cable research	368
	Tampa city underground cable research	370
B(1)	Electric power research	869,281
B(4)	Coal research	2,222
	National Economic Research Association	269,236
	Sulfur removal process	19,769
Total A (Internal)		$ 15,630
Total B (External)		$1,160,508
Total R, D, and D Expenditures		$1,176,138

Table A-19
Reported R&D Expenditures

Tampa Electric Company, 1977

A(1b)	Sulfur removal process	$ 4,513
	Hydrastep research, boiler drum level	5,184
A(1e)	Solar conversion research	2,196
A(4)	Rome substation cable research	1,574
A(5)	Re-vegetation study, Bay Bottoms	1,083
A(6)	Energy Research Group, Florida Sulfur Oxide study	791
	Southeast solar energy study	491
B(1)	Electric power research	1,347,225
B(4)	Energy Research Group, Florida Sulfur Oxide study	195,200
	Illumination Engineering Research Institute	1,251
	Sulfur removal process	29,932
	Re-vegetation study, Bay Bottoms	9,384
Total A (Internal)		$ 15,832
Total B (External)		$1,582,992
Total R, D, and D Expenditures		$1,598,824

Table A-20
Reported R&D Expenditures

Tampa Electric Company, 1978

A(1b)	Sulfur removal process	$ 2,757
	Hydrastep research, boiler drum level	35,365
A(1e)	Southeast solar energy study	979
	Solar conversion research	37
A(4)	Lightning location study, DOE	34,324
	Rome substation cable research	196
	Stroke counters, DOE	11,210
	Transient recorder, DOE	503
	Load management project	2,106
A(6)	Solar heating and cooling, commercial	2,068
	Land reclamation using flyash	3,226
	Electric power research	1,945
	Energy research group, Florida Sulfur Oxide study	6,294
B(1)	Electric power Research	1,349,104
B(4)	Sulfur removal process	2,160
	Coal pipeline study	3,368
	Illumination Engineering Research Institute	1,287
	National coal policy project	1,000
	Energy research group, Florida Sulfur Oxide study	85,446
	Re-vegetation study, Bay Bottoms	7,751
	Land reclamation using flyash	3,226

Tampa Electric Company, 1978 (cont'd.)

Total A (Internal)	$ 101,010
Total B (External)	$1,453,342
Total R, D, and D Expenditures	$1,554,352

Table A-21
Reported R&D Expenditures

Tampa Electric Company, 1979

A(1b)	Sulfur removal process	$ 5,934
	Hydrastep research, boiler drum level	8,115
A(1e)	Solar conversion research	32
A(4)	Lightning location study	29,878
	Rome substation cable research	46
	Stroke counters, DOE	10,841
	Transient recorder, DOE	9,328
	Load management project	49,777
A(5)	Re-vegetation study, Bay Bottoms	3,386
	EPRI flue gas conditioning	5,861
A(6)	Electric power research	4,165
	Land reclamation using flyash	4,355
	Storage assisted air condition	1,409
B(1)	Electric power research	1,489,240
B(4)	Sulfur removal process	9,196
	Illuminating Engineering Research Institute	1,345
	Energy research group, Florida Sulfur Oxide study	66,156
	Storage assisted air condition	20,000
Total A (Internal)		$ 133,127
Total B (External)		$1,585,937
Total R, D, and D Expenditures		$1,719,064

Table A-22
Reported R&D Expenditures

Tampa Electric Company, 1980

A(1b)	Big Bend SO_2 pilot plant	$ 2,752
	Hydrastep research, boiler drum level	48,664
A(4)	Distribution transformer noise levels	7
	Three phase correlation formula	8,236
	Lightning location study, DOE	8,329
	Stroke counters, DOE	738
	Load management project	26,844
A(5)	EPRI flue gas conditioning	7,527
A(6)	Land reclamation using flyash	1,365
	Storage assisted air condition	3,037
B(1)	Electric power research	1,939,026
B(4)	Illuminating Engineering Research Institute	1,409
	Center for Strategic and International Studies	1,000
Total A (Internal)		$ 107,499
Total B (External)		$1,941,435
Total R, D, and D Expenditures		$2,048,934

Table A-23
Reported R&D Expenditures

Tampa Electric Company, 1981

A(1d)	Big Bend SO_2 pilot plant	$ 627
A(4)	Distribution transformer noise level	4
	Three phase correlation formula	9,411
	Lightning location system, DOE	7,495
	Load management project	8,278
A(6)	Solar commercial heat and cool	265
	Storage assisted air condition	5,234
B(1)	Electric power research	2,048,031
B(4)	Florida acid disposition study	75,375
	Illuminating Engineering Research Institute	1,472
Total A (Internal)		$ 31,314
Total B (External)		$2,124,878
Total R, D, and D Expenditures		$2,156,192

Table A-24
Reported R&D Expenditures

Tampa Electric Company, 1982

A(4)	Three phase correlation formula	$ 5,927
	Lightning location system, DOE	1,807
	Load management project	750
A(5)	Florida acid disposition study	4,639
A(6)	Electric power research	5,457
B(1)	Electric power research	2,001,164
B(4)	Illuminating Engineering Research Institute	1,525
	Florida acid disposition study	65,101
Total A (Internal)		$ 18,580
Total B (External)		$2,067,790
Total R, D, and D Expenditures		$2,086,370

Table A-25
Reported R&D Expenditures

Tampa Electric Company, 1983

A(4)	Lightning location system, DOE	$ 747
	Load management project	4,960
A(5)	Florida acid disposition study	9,979
A(6)	Electric power research	5,476
B(1)	Electric power research	2,170,006
B(4)	Fuel cell user group	2,350
	Illuminating Engineering Research Institute	1,574
	Florida acid disposition study	111,593
Total A (Internal)		21,162
Total B (External)		2,285,523
Total R, D, and D Expenditures		$2,306,685

Table A-25.1
Reported R&D Expenditures

Tampa Electric Company, 1984

A(4)	Lightning location system, DOE	$ 966
B(1)	Electric Power Research	2,142,132
B(4)	Fuel cell user group	1,196
	Illuminating engineering Research Institute	1,641
	Florida Acid Deposition study	77,639
	(Internal cost)	43,402
Total A (Internal)		$44,368
Total B (External)		$2,222,608
Total R, D, and D Expenditures		$2,259,201*

*Unamortized accumulation = $35,218.

Table A-26
Reported R&D Expenditures

Gulf Power Company, 1976

A(1d)	Nuclear power generation, long range planning	$ 25,847
A(2)	Financial model	5,008
	General accounting standardization project	14,091
	Payroll/personnel information project	17,888
	Customer accounting	8,904
	General accounting, program development	21,059
	Power system coordination center project, plus federal and state income tax	173,391
	Double alkali scrubbing system	47,723
	Dry absorption scrubbing system	41,721
	Catalytic, Inc., coal solvent refining process	11,845
	Acid scrubbing system (Chiyoda)	57,460
	Utilization of coal, studies	4,617
A(5)	Air quality studies	60,750
	Water quality studies	7,128
	Noise studies	14,756
	Cooling tower plume studies	3,305
	Heat rejection	1,906
	Environmental impact of waste discharges from flue gas de-sulfurization system	2,107
A(6)	Energy conservation and use	1,344
	Distribution system order project	45,724

Gulf Power Company, 1976 (con.t.)

	Engineering applications	$ 10,450
	Three other projects, each under $5,000	4,365
B(2)	Liquid metal fast breeder reactor project	76,640
	Research subscription	368,262
B(4)	Public Utility Research Center, University of Florida	10,404
Total A (Internal)		$ 581,389
Total B (External)		$ 455,306
Total R, D, and D Expenditures		$1,036,695

Table A-27
Reported R&D Expenditures

Gulf Power Company, 1977

A(1d)	Nuclear power generation, long range planning	$ 7,844
	Miscellaneous (One item)	455
A(2)	Flue gas de-sulfurization, dilute sulfuric acid scrubbing	32,028
	Solvent refining of coal, pilot plant project	10,659
	Data center, system design and program development	133,652
	Utilization of coal studies	5,439
	Miscellaneous projects (Five items)	13,349
A(5)	Crist, Unit no. 6, Apollo project	82,865
	Air quality studies	64,710
	Water quality studies	5,261
	Environmental impact of waste discharge from flue gas de-sulfurization systems	11,029
	Noise studies	13,930
	Miscellaneous projects (Four items)	7,051
A(6)	Other miscellaneous (One item)	975
B(1)	Electric Power Research Institute	568,760
B(2)	Edison Electric Institute, LMFBR project	76,640
B(4)	Florida Electric Power Coordinating Group, air study fund, Environmental Committee assessment	163,515
	Public Utility Research Center, University of Florida	7,144
Total A (Internal)		$ 389,247
Total B (External)		$ 816,059
Total R, D, and D Expenditures		$1,205,306

Table A-28
Reported R&D Expenditures

Gulf Power Company, 1978

A(1d)	Nuclear power generation, long range planning	$ 276
A(2)	Chemical discharges	7,228
	Flue gas de-sulfurization, forced oxidation limestone	43,671
	Solvent refining of coal	10,248
	Thermal and fluid flow analysis	6,122
	Utilization of coal studies	6,719
	Data center, system design and program development	177,557
	Miscellaneous projects (Eight items)	1,386
A(5)	Crist, Unit no. 6, Apollo project	33,629
	Miscellaneous projects (Two items)	3,031
B(1)	Electric Power Research Institute	608,803
B(2)	Edison Electric Institute, LMFBR project	76,645
B(4)	Florida Electric Power Coordinating Group, air study fund, Environmental Committee assessment	67,929
	Public Utility Research Center, University of Florida	9,822
	Regional Science and Engineering Conference, University of Florida	300
Total A (Internal)		$ 289,867
Total B (External)		$ 763,499
Total R, D, and D Expenditures		$1,053,366

Table A-29
Reported R&D Expenditures

Gulf Power Company, 1979

A(2)	Chemical discharges	$ 6,846
	Solvent refining of coal	8,453
	Thermal and fluid flow analysis	16,883
	Utilization of coal studies	6,467
	Hot precipitator project	7,171
	Other (Nine items, each less than $5,000)	15,819
A(5)	Crist, Unit no. 6, Apollo project	164,148
A(6)	Other (18 items, each less than $5,000)	9,210
B(1)	Electric Power Research Institute	747,684
B(2)	Edison Electric Institute	76,644
	Florida Electric Power Coordinating Group, environmental assessment	5,000
	Public Utility Research Center, University of Florida	9,822
	Other (One item under $5,000)	119
Total A (Internal)		$ 234,997
Total B (External)		$ 839,269
Total R, D, and D Expenditures		$1,074,266

Table A-30
Reported R&D Expenditures

Gulf Power Company, 1980

A(2)	Solvent refining of coal	$ 11,275
	Other (Nine items, each less than $5,000)	9,047
A(5)	Crist, Unit no. 6, Apollo project	(42,269)
	Water quality and solid waste disposal	12,110
	Thermal and fluid flow analysis	7,978
	Hot precipitator project	15,491
	Pulse energization system	31,099
	High sulfur coal baghouse pilot project	200,000
	Other (Five items, each less than $5,000)	6,410
A(6)	Long range technological developments	7,988
B(1)	Electric Power Research Institute	739,660
B(4)	Florida Electric Power Coordinating Group, environment	37,136
	Public Utility Research Center, University of Florida	9,822
Total A (Internal)		$ 259,129
Total B (External)		$ 786,618
Total R, D, and D Expenditures		$1,045,747

Table A-31
Reported R&D Expenditures

Gulf Power Company, 1981

A(2)	Solvent refining of coal	$ 9,742
	Utilization of coal studies	3,193
	Scholz plant roadway paving	4,800
A(5)	Water quality and solid waste disposal	13,066
	Thermal and fluid flow analysis	8,807
	Crist, Unit no. 7, precipitator project	70,029
	Pulse energization system	46,891
	Hot precipitator project	6,054
	Plant Daniel related expenses	136,407
	Flue gas de-sulfurization	895
	Other (16 items, each less than $5,000)	7,437
A(6)	Long range technological developments	11,828
	Smith plant garbage burning	18,495
	Other (11 items, each less than $5,000)	3,041
B(1)	Electric Power Institute	927,279
B(4)	Florida Electric Power Coordinating Group, environment	60,194
	Public Utility Research Center, University of Florida	12,530
Total A (Internal)		$ 340,685
Total B (External)		$1,000,003
Total R, D, and D Expenditures		$1,340,688

Table A-32
Reported R&D Expenditures

Gulf Power Company, 1982

A(2)	Solvent refining of coal	$ 11,866
	Utilization of coal studies	3,159
	Special research programs	9,216
A(5)	Water quality and solid waste disposal	24,697
	Thermal and fluid flow analysis	10,802
	Plant Daniel related expenses	(123,918)
	Other (Six items, each less than $5,000)	2,735
A(6)	Long range technological developments	19,336
B(1)	Electric Power Research Institute	481,534
B(2)	Edison Electric Institute	(217,088)
B(4)	Florida Electric Power Coordinating Group, environmental	32,636
	Southern Research Institute, precipitator testing	3,556
	Public Utility Research Center, University of Florida	13,300
Total A (Internal)		($ 42,107)
Total B (External)		$313,938
Total R, D, and D Expenditures		$271,831

Table A-33
Reported R&D Expenditures

Gulf Power Company, 1983

A(2)	Solvent refining of coal	$ 12,366
	Utilization of coal studies	4,229
	Special research programs	16,361
A(5)	Water quality and solid waste disposal	19,251
	Thermal and fluid flow analysis	14,251
	Plant Daniel related expenses	36,036
	Other (Three items, each less than $,5,000)	2,238
A(6)	Long range technological developments	18,959
	Southern Company Services, general services	9,415
B(1)	Electric Power Research Institute	1,036,166
B(2)	Committee for Energy Awareness	14,922
B(4)	Florida Electric Power Coordinating Group	54,929
	Public Utility Research Center, University of Florida	14,000
Total A (Internal)		$ 133,106
Total B (External)		$1,120,017
Total R, D, and D Expenditures		$1,253,123

Table A-34
Reported R&D Expenditures

Gulf Power Company, 1984

A(2)	Solvent refining of coal	$ 23,293
	Utilization of coal studies	8,385
A(5)	Water quality and solid waste disposal	39,691
	Thermal and fluid flow analysis	30,246
	Plant Daniel related expenses	18,529
	All other (9 items, each less than $5,000)	6,218
A(5)	Instrumentation and technical support studies	30,472
	Long range technological developments	36,782
	All other (2 items, each less than $5,000)	2,471
B(1)	Electric Power Research Institute	283,179
B(2)	Committee for Energy Awareness	15,837
B(4)	Florida Electric Power Coordinating Group (Environmental and transmission special studies)	57,172
	University of Florida (Research Center)	14,700
Total A (Internal)		$196,087
Total B (External)		$370,888
Total R, D, and D Expenditures		$566,975