POWERPLANT PRODUCTIVITY IMPROVEMENT STUDY

Final Report
Project 2, Task 2

Benefits of Improved Powerplant
Reliability

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Prepared by:
Illinois Commerce Commission
527 East Capitol Avenue
Springfield, Illinois

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EXECUTIVE SUMMARY

In the last decade, the U.S. electric utility industry has faced substantial challenges brought about by rapid developments on several fronts. Increased load growth uncertainty, inflation, tight capital markets, licensing and siting delays, and stringent environmental constraints were further complicated in 1974 by the OPEC oil embargo and steeply rising fuel prices. As a result of these pressures, increased attention has been given to the more efficient use of existing generating units as an economic alternative to new construction, and as a mechanism for near-term reductions in scarce fuel consumption.

In March, 1975, a Federal Interagency Task Group recommended a thorough analysis of the benefits of improved powerplant reliability in terms of reduced consumption of scarce fuels, reduced utility capital requirements, deferred additions of new capacity, and reduced rates to consumers of electricity (Reference A). The US Department of Energy has since encouraged increased efficiency in the use of scarce fuels in the electric utility industry under a broad range of programs. The potential for reducing oil consumption nationwide through improvements in the productivity (availability) of baseloaded units has been shown to be significant. It has been estimated (Reference B) that a 5 percentage point improvement in forced and planned outage rates (FOR and POR) of large coal and nuclear units could result in a net reduction in oil consumption of 54 million barrels per year by 1985 in the Northeast and East Central Regions alone. A substantial cost savings potential was also reported. Subsequently, GE estimated oil savings rates for the MAIN/MARCA and

other NERC regions in terms of barrels per year per kilowatt for each percentage point improvement in FOR and POR (Reference D). In 1976, the Department of Energy (Federal Energy Administration) sponsored the development of a systematic methodology for the identification and analysis of candidate projects which a utility might undertake to improve baseload unit reliability (Reference C). This methodology also enabled the user to estimate a project's effect on the future performance of the unit. During its development, it was applied by DOE's contractor, Mechanics Research, Inc. (now System Development Corporation) at three utilities. In order to demonstrate and further validate the methodology, and to encourage increased powerplant productivity, in 1977 the Department of Energy sponsored cooperative study projects with the Ohio Public Utilities Commission and the Illinois Commerce Commission (ICC). Technical assistance was provided to the ICC by the Energy Resources Center, University of Illinois at Chicago Circle, (ERC) and Trident Engineering Associates, Inc., (Trident) a subcontractor. The DOE/ICC Cooperative study consists of the following major tasks.

- o Identification and documentation of current utility approaches to powerplant productivity in Illinois, based on a study of the four largest privately owned utilities in the state.
- o Application of the DOE developed methodology at Illinois Power Company Wood River 5 and Commonwealth Edison Company Quad Cities 1 and 2 units. A total of eight improvement projects were analyzed by Trident for their effect on unit performance.
- o Estimation of costs and benefits to the utility of the eight productivity improvement projects.
- o Comparison of current utility approaches to improvement of productivity with the DOE developed methodology to determine strengths and weaknesses of each.

- o Survey of historic productivity performance of powerplants in Illinois.
- o Analysis of current regulatory incentives and disincentives to improved powerplant productivity in Illinois and development of candidate regulatory incentive policies for consideration by the Illinois Commerce Commission.
- o Estimation of benefits to utilities and ratepayers in Illinois which would result from modest improvements in powerplant productivity in the state.

Objective of This Task

The objective of this task is to develop estimates of benefits which would accrue to utilities and ratepayers in Illinois under several utility productivity improvement scenarios. No attempt was made to determine the magnitude of improvement that could be made in Illinois utilities. The improvement scenarios selected are quite modest compared to estimates made by DOE, EPRI and others. The following cases are examined.

Case	Improvement Over Base Case	
	Forced Outage Rate (Percentage Points)	Planned Outage Rate (Percentage Points)
A (Base Case)	0	0
B	1	0
C	0	1
D	1	1
E	2	2

Benefits examined arose exclusively from reduced consumption of scarce fuels such as oil and gas, and greater reliance on more energy efficient and economical baseloaded coal and nuclear units. The estimation of benefits for this task was limited to the two largest investor-owned electric utilities in Illinois, Commonwealth Edison and Illinois Power. The results provide an indication to utilities and Illinois Commerce Commission staff of the approximate potential gross benefits of improved powerplant productivity.

Methodology

In order to estimate the effect of fuel consumption and load related

generation costs of hypothetical improvements in baseload unit planned and forced outage rates, Commonwealth Edison and Illinois Power used the PROMOD and PROCOS proprietary production cost simulation models. These models were run by the utilities first under base case POR and POR assumptions, and then under the assumed POR/POR improvements. Primary consideration was given to estimating fuel use and fuel cost differentials for the various cases studied. No attempt was made to estimate the costs which would certainly be incurred by the utilities in achieving the hypothetical POR/POR improvements. These costs could be substantial. As a result, the findings of this task constitute "gross benefits" only--that is, benefits prior to deducting costs. From other tasks in this study (Reference E) it was determined that cost-effective projects to improve the reliability (availability) of baseloaded powerplants do exist. Thus, opportunities to capture some of the gross benefits of improved availability are real. At the same time, it appears that the utilities are aware of many of these opportunities and are currently pursuing them.

Key Findings and Conclusions

A summary of total cumulative fuel consumption differences by fuel type through 1990 for the four improvement scenarios is presented in Table 1 for Commonwealth Edison Company and Table 2 for Illinois Power Company. In all scenarios, liquid fuel consumption is reduced. Generation is shifted to the coal and/or nuclear units for which improved availability has been assumed. For a 2 percentage point improvement in both planned and forced outage rates, a total of more

Table 1

Commonwealth Edison Company
System Fuel Consumption

Cumulative through 1990

Case \ Fuel	Nuclear (mm BTU)	(1,000's)		#6 Oil (BBLs)	Peaking (Gals)
		High Sulfur Coal (tons)	Low Sulfur Coal (tons)		
A (Base Case)	7,862,263	38,764	145,294	59,568	328,172
Differences from Base Case					
B (1% FOR Improv.) (% Change)	65,577 0.83%	117 0.30%	(1,218) (0.84%)	(4,174) (7.01%)	(49,804) (15.1%)
C (1% POR Improv.) (% Change)	59,442 0.76%	95 0.25%	(1,073) (0.74%)	(4,016) (6.74%)	(36,858) (11.23%)
(1% FOR + POR D Improvement) (% Change)	124,712 1.59%	216 0.56%	(2,341) (1.61%)	(8,154) (13.7%)	(81,869) (25%)
(2% FOR + POR E Improvement) (% Change)	248,950 3.17%	369 0.95%	(4,997) (3.44%)	(15,191) (25.5%)	(139,912) (42.6%)

Note: Parentheses indicate decreases

Table 2

Illinois Power Company
System Fuel Consumption

Cumulative through 1990

(1,000's)

Case \ Fuel	Nuclear (mm BTU)	High Sulfur Coal (tons)	Low Sulfur Coal (tons)	#6 Oil (BBLs)	Peaking (Gals)
A (Base Case) (% Change)	641,139 -	67,942 -	14,361 -	8,316 -	133,925 -
Differences from Base Case					
B (1% FOR Improv.) (% Change)	(3,726) (0.58%)	407 0.60%	(475) (3.30%)	(682) (8.20%)	(125,262) (93.53%)
C (1% POR Improv.) (% Change)	(3,610) (0.56%)	398 0.59%	(545) (3.80%)	(617) (7.42%)	(14,549) (10.86%)
D (1% FOR + POR Improvement) (% Change)	(4,723) (0.74%)	1,587 2.34%	(1,265) (8.81%)	(1,547) (18.60%)	(39,333) (29.37%)
E (2% FOR + POR Improvement) (% Change)	(4,021) (0.62%)	(380) (0.56%)	(796) (5.54%)	(943) (7.82%)	(23,545) (17.58%)

Note: Parentheses indicate decreases

than 16 million barrels of #6 oil will have been saved by 1990 by the two companies. This is the result of improving 10,894 MW on the Commonwealth Edison system and 2,234 MW on the Illinois Power system.

Tables 3 and 4 summarize the cumulative gross benefits in 1978 dollars through 1990 for the four improvement scenarios for Commonwealth Edison and Illinois Power, respectively. For the two utilities combined, these gross savings range from \$83 million for a 1 percentage point POR improvement to \$346 million for 2 percentage point improvements in both POR and FOR.* In terms of their effect on ratepayers, these savings would be even greater since gross receipt taxes and other charges would be applied to a smaller generation cost base under the improvement scenarios. Caution must be exercised in the interpretation of these results, however, since they do not take into consideration the costs of achieving the improved performance. No attempt has been made to estimate the costs and it appears unrealistic to assume a "typical" or representative benefit-to-cost ratio for this purpose since observed Benefit to Cost ratios varied widely. The proportion of net benefits which would be passed on to ratepayers is largely dependent upon whether the utility is earning its allowed rate of return, and the frequency of rate case filings.

It was determined by both utilities that none of the improvement scenarios would lead to the deferment of any planned capacity additions by 1990.

*Estimates in 1978 dollars.

Table 3

Commonwealth Edison Company
System Fuel Costs

(\$ x 1,000)

Case	System Fuel Cost	Difference from Base Case	% Change from Base Case
A Base	\$11,684,742	-	-
B 1% FOR Improvement	11,595,196	(\$89,546)	(0.8%)
C 1% POR Improvement	11,609,770	(74,972)	(0.6%)
D 1% FOR + 1% POR Im- provement	11,522,960	(161,782)	(1.4%)
E 2% FOR + 2% POR Im- provement	11,376,230	(308,512)	(2.6%)

Notes:

Above costs represent cumulative estimated fuel costs for the period 1979-1990. Amounts are in 1978 dollars.

Parantheses indicate decreases

Table 4

Illinois Power Company
System Fuel Costs

(\$ x 1,000)

Case	System Fuel Cost	Difference from Base Case	% Change from Base Case
A Base	\$2,208,570	-	-
B 1% FOR Improvement	2,198,070	(\$10,500)	(0.48%)
C 1% POR Improvement	2,199,800	(8,770)	(0.40%)
D 1% FOR + 1% POR Im- provement	2,188,880	(19,690)	(0.89%)
E 2% FOR + 2% POR Im- provement	2,169,050	(39,520)	(1.79%)

Notes:

Above costs represent cumulative estimated fuel costs for the period 1979-1990. Amounts are in 1978 dollars.

Parentheses indicate decreases.

INTRODUCTION

Background

In 1974, the Federal Energy Administration (FEA) led an interagency Task Group which investigated the then current status of powerplant productivity (Reference A). Based on that study, it was determined that large coal-fired and nuclear generating units were operating below expectation. A subsequent study in 1975 by Mechanics Research, Inc.. (now SDC) under contract to FEA identified some underlying causes of lost productivity and defined possible corrective actions. A more comprehensive study was sponsored by FEA to develop analytic methods for the routine systematic analysis of cost and improved plant performance associated with plant improvement programs (Reference C).

Simultaneously, General Electric's Center for Energy Systems conducted a study for FEA on the benefits of improved powerplant reliability and productivity. An in-depth analysis examined the effects of a hypothetical 5 percentage point improvement in planned and forced outage rates on utility fuel consumption, generation costs, and capacity expansion alternatives for Detroit Edison Company, the New England Power Pool, and the Northeast Utilities Company. For the Northeast and East Central Regions (representing approximately 25% of the U.S. utility industry capacity) potential oil savings of 54 million BBL per year, valued at approximately \$1 billion dollars per year, were reported (Reference B). A similar but less in-depth analysis examined the national benefits from a like improvement. The benefits to the MAIN/MARCA regions were found to be 38

million equivalent barrels of oil and is annually valued at more than \$1 billion in 1990.

In order to further validate the systematic methodology and encourage improved powerplant reliability and productivity in Illinois, the U.S. Department of Energy sponsored a cooperative study with the Illinois Commerce Commission (ICC). Under the DOE/ICC program, eight candidate productivity improvement projects were selected and analyzed at Commonwealth Edison's Quad Cities units I and II, and Illinois Power's Wood River 5 unit.

This task consists of estimating the potential benefits of improved baseloaded unit reliability for the Illinois Power and Commonwealth Edison systems, under several forced and planned outage rate improvement scenarios. These companies are the two largest investor-owned electric utilities in the state and together account for approximately 80% of total electrical generation within Illinois.

Methodology

The selection of forced and planned outage rate improvement scenarios for this study was accomplished through discussions with utility representatives. A simultaneous improvement in both outage rates of 5 percentage points as used in the General Electric Study was considered to be unlikely for the Commonwealth Edison and Illinois Power systems. Instead, a maximum improvement of 2 percentage points in both planned and forced outage rates was selected. Although there is no analytical basis for this assumption, it was judged by both utilities to be close to the upper limit of attainable improvement. The scenarios examined were as follows:

Case A-

Base case analysis using currently projected planned and forced outage rates.

Case B-

1 Percentage point improvement in forced outage rates for baseloaded units. Improvement implemented over a two-year period.

Case C-

1 Percentage point improvement in planned outage rates for baseloaded units. Improvement implemented over two years.

Case D-

1 Percentage point improvement in both planned and forced outage rates for baseloaded units. Improvement implemented over a two year period.

Case E-

2 Percentage point improvement in both planned and forced outage rates for baseloaded units. Improvement implemented over a two year period.

In all cases, the study horizon for benefits calculation was 1990. Some departures were made from the methodology employed by General Electric in their study of benefits of improved reliability and productivity for FEA. GE used an optimal generation planning model in conjunction with a financial simulation model to perform their analysis. However, neither of the two participating utilities currently has an optimizing generation planning model on line. Instead, proprietary production cost simulation models were used by the utilities to examine the differential production costs for each of the four improvement scenario cases. The primary output of these models is fuel consumption by fuel type and fuel costs. General Electric found that, assuming an improvement in outage rates, a utility could either (1) accept a reduced loss of load probability

(LOLP) and hold future baseload generation additions fixed, or (2) hold LOLP constant and reduce the magnitude of future baseload generation additions. The use of a production cost simulation model to explore such alternatives, however, is unwieldy. For this study, each utility manually examined the possible reductions in future baseload generation additions and found that none existed. This finding is primarily the result of using a 2 percentage point improvement scenario instead of 5 percentage points as assumed by General Electric.

The approach followed in this task was to estimate benefits of improved productivity only. The cost of projects and plant improvements required to bring about the four scenarios was not considered in the results presented. Although the costs of seven candidate projects were estimated in a separate part of the ICC/DOE study, it is not feasible to extrapolate these estimates for this report. Since it has not yet been determined that the improvement scenarios themselves are realizeable, no information can be provided on the magnitude of net benefits (gross benefits minus costs). Estimates of gross benefits are nevertheless useful in demonstrating the relationship between small, realistic improvements in the planned and forced outage rates of baseloaded units and total system generation costs. Such information could assist utility personnel in better structuring internal programs to improve unit reliability.

Results

In terms of reduced scarce fuel consumption, results were greatest under scenario E (2 percentage point improvement in FOR and POR) as

was expected. For the Commonwealth Edison system, a reduction in peaking fuel consumption of 42% over the base case was reported.. In addition, #6 oil consumption was reduced by 25% over the base case level. These percentages refer to total consumption over the period 1979-1990. The peaking and #6 oil fuels were displaced by coal and nuclear generation in the Edison system.

Under scenario E the Illinois Power system achieved a cumulative (through 1990) reduction in peaking fuel consumption of more than 17% over the base case. Consumption of #6 oil was reduced by almost 8% over the base case level. Because the Clinton nuclear unit has not been completed, it was not improved in the scenario runs. The coal units in the Illinois Power system which were improved are subject to minimum loading constraints. Operation below these minima is technically undesirable. As a result, improvements in the availability of the coal units produce more frequent invoking of minimum loading constraints. When such constraints are encountered, the effect is to increase coal unit loading and decrease nuclear unit loading, even though average nuclear generation costs may be lower. This effect is also partially due to the fact that the nuclear unit availability was not improved in the scenario runs.

For both utilities combined, the estimated value of the scarce fuels saved is approximately \$346 million in 1978 dollars for the 2 percentage point FOR and POR improvement scenario. Of this total, approximately \$308 million is attributable to the Commonwealth Edison system and \$37 million to the Illinois Power system.

The results obtained under this task are reasonably close to those estimated for the MAIN/MARCA Region by General Electric (Reference D).

These are presented below for the Commonwealth Edison system for the year 1990.

Base Case (1990)

$$\#6 \text{ Oil Consumed} = 3,253 \times 10^3 \text{ BBL}$$

$$\begin{aligned} \#2 \text{ Oil Consumed (in \#6 equivalent)} \\ \frac{43,929 (5.8)}{42 (6.2)} \times 10^3 = \frac{978 \times 10^3 \text{ BBL}}{4,231 \times 10^3 \text{ BBL}} \end{aligned}$$

Case "E" (1990)

$$\#6 \text{ Oil Consumed} = 2,116 \times 10^3 \text{ BBL}$$

$$\begin{aligned} \#2 \text{ Oil Consumed (in \#6 equivalent)} \\ \frac{22,732 (5.8)}{42 (6.2)} \times 10^3 = \frac{500 \times 10^3 \text{ BBL}}{2,616 \times 10^3 \text{ BBL}} \end{aligned}$$

From Table 5, 10,894,000 KW were improved by 4 percentage points.

$$\text{Oil Savings Rate} = \frac{(4,231 - 2,616) \times 10^3 \text{ BBL/yr}}{(4\%) (10,894,000 \text{ KW})} = \frac{0.37 \text{ BBL}}{\text{yr} - \text{KW} - \%}$$

$$\begin{aligned} \text{GE result for MAIN/MARCA Region in 1990 (Reference D, p. 4)} = \\ \frac{0.5 \text{ BBL}}{\text{yr} - \text{KW} - \%} \end{aligned}$$

II. ESTIMATION OF GROSS BENEFITS FOR COMMONWEALTH EDISON

Base Case Assumptions

The assumptions for the base case used in this study are representative of those currently in use at Commonwealth Edison for exploratory simulation studies over comparable time horizons.

The only modifications to base case assumptions were in planned and forced outage rates for the improvement scenarios. Table 5 contains a list of baseloaded units in the Commonwealth Edison system for which the improvement scenarios were run. Base case planned and forced outage rate assumptions are also listed in Table 5. Planned outage rate data for nuclear units is presented in terms of periodic refuelling/maintenance cycles rather than as a percentage.

Table 5

Commonwealth Edison Company
Base Case Assumptions

Unit/Capacity/Fuel	Forced Outage Rate (FOR)	Planned Outage Rate (POR)
Joliet 7 537 MW Coal		
Joliet 8 537 MW Coal		
Kincaid 1 606 MW Coal		
Kincaid 2 606 MW Coal		
Powerton 5 850 MW Coal		
Powerton 6 850 MW Coal	11.5%	9%
Will County 4 520 MW Coal	Composite Fossil FOR Weighted By Capacity	Composite Fossil POR Weighted By Capacity
Crawford 8 326 MW Coal		
State Line 4 318 MW Coal		
Waukegan 7 328 MW Coal		
Waukegan 8 358 MW Coal		
Dresden 1 207 MW Nuclear	9%	8 wk/12 mo.
Dresden 2 794 MW Nuclear	9%	8 wk/18 mo.
Dresden 3 794 MW Nuclear	9%	8 wk/18 mo.
Quad Cities 1 591 MW Nuclear	9%	8 wk/18 mo.
Quad Cities 2 592 MW Nuclear	9%	8 wk/18 mo.
Zion 1 1040 MW Nuclear	8%	7 wk/12 mo.
Zion 2 1040 MW Nuclear	8%	7 wk/12 mo.

Total MW Improved: 10,894

-- POWER PLANT PRODUCTIVITY IMPROVEMENT STUDY --

COMMONWEALTH EDISON COMPANY

BASE CASE FUEL CONSUMPTION (1000's)

<u>Year</u>	<u>Nuclear</u> (MMBTU)	<u>H.S. Coal</u> (TONS)	<u>L.S. Coal</u> (TONS)	<u>#6 Oil</u> (BBLs)	<u>Peaking</u> (GALS)
79	304,597	5,470	12,670	8,367	38,885
80	374,003	3,483	13,617	8,095	26,052
81	428,122	3,355	13,269	7,478	26,259
82	560,753	3,222	11,153	3,680	9,822
83	672,651	2,701	9,030	2,070	5,349
84	701,889	2,549	9,688	2,542	6,735
85	715,117	2,911	10,477	3,970	14,279
86	730,931	3,034	11,414	5,427	31,636
87	735,314	3,211	13,159	6,472	40,066
88	800,092	3,142	13,527	5,015	44,352
89	891,442	2,723	13,267	3,199	40,808
90	947,352	2,963	14,023	3,253	43,929
Totals	7,862,263	38,764	145,294	59,568	328,172

Table 5

POWER PLANT PRODUCTIVITY IMPROVEMENT STUDY

COMMONWEALTH EDISON COMPANY

BASE CASE GENERATION (1000's MWHRS)

	<u>Year</u>	<u>Nuclear</u>	<u>H.S. Coal</u>	<u>L.S. Coal</u>	<u>#6 Oil</u>	<u>Peaking</u>	<u>Emergency Purchases</u>	<u>Total</u>
	79	28,320	11,304	25,779	5,584	350	58	71,395
	80	34,975	7,252	27,229	5,420	212	45	75,133
	81	40,220	6,976	26,475	5,138	219	44	79,072
	82	52,816	6,684	22,074	2,525	71	25	84,195
	83	63,220	5,568	17,741	1,415	14	11	87,969
20	84	65,998	5,252	19,015	1,735	23	16	92,039
	85	67,286	6,009	20,671	2,726	114	35	96,841
	86	68,858	6,278	22,592	3,729	285	87	101,829
	87	69,302	6,653	26,234	4,462	359	122	107,132
	88	74,700	6,502	27,061	3,475	398	146	112,282
	89	82,797	5,624	26,438	2,236	376	145	117,616
	90	87,902	6,120	28,018	2,270	402	152	124,864

Table 7

Improvement Scenario Results
for
Commonwealth Edison

POWER PLANT PRODUCTIVITY IMPROVEMENT STUDY
COMMONWEALTH EDISON COMPANY
PRODUCTION COSTS (\$1000's)

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<u>Year</u>	<u>Total Case A</u>	<u>Case B</u>	<u>Decrease From Case A</u>		
			<u>Case C</u>	<u>Case D</u>	<u>Case E</u>
79	852,153	7,212	4,398	11,188	21,109
80	889,077	6,268	3,710	9,856	20,028
81	902,289	6,765	5,931	12,752	24,649
82	851,867	5,636	3,640	9,127	17,785
83	819,348	4,681	3,733	8,166	15,361
84	863,974	5,366	4,992	10,159	19,282
85	932,274	6,852	6,588	13,313	25,086
86	1,007,644	8,454	7,205	15,610	30,826
87	1,092,090	9,942	9,099	18,640	34,353
88	1,126,295	9,672	7,007	16,476	31,593
89	1,139,443	8,963	8,035	16,634	31,244
90	1,208,288	9,735	10,634	19,861	37,196
Totals	11,684,742	89,546	74,972	161,782	308,512

Table 8

POWER PLANT PRODUCTIVITY IMPROVEMENT STUDY

COMMONWEALTH EDISON COMPANY

CASE B FUEL CONSUMPTION (1000's)

<u>Year</u>	<u>Nuclear</u> (MMBTU)	<u>H.S. Coal</u> (TONS)	<u>L.S. Coal</u> (TONS)	<u>#6 Oil</u> (BBLs)	<u>Peaking</u> (GALS)
79	307,887	5,527	12,611	7,998	33,584
80	377,680	3,513	13,580	7,711	22,347
81	432,222	3,378	13,228	7,061	22,678
82	565,482	3,229	11,071	3,346	8,275
83	677,474	2,698	8,941	1,804	4,281
84	707,107	2,542	9,596	2,241	5,334
85	720,928	2,906	10,385	3,597	11,481
86	737,158	3,027	11,321	5,028	26,234
87	742,026	3,219	13,038	6,023	33,731
88	806,929	3,148	13,371	4,667	38,164
89	898,231	2,726	13,101	2,935	34,805
90	954,716	2,968	13,833	2,983	37,454
Totals	7,927,840	38,881	144,076	55,394	278,368

Table 9

POWER PLANT PRODUCTIVITY IMPROVEMENT STUDY

COMMONWEALTH EDISON COMPANY

CASE B GENERATION (1000's MWHRS)

<u>Year</u>	<u>Nuclear</u>	<u>H.S. Coal</u>	<u>L.S. Coal</u>	<u>#6 Oil</u>	<u>Peaking</u>	<u>Emergency Purchases</u>	<u>Total</u>
79	28,623	11,419	25,659	5,331	292	48	71,372
80	35,318	7,315	27,132	5,152	176	38	75,131
81	40,596	7,028	26,366	4,851	187	36	79,064
82	53,252	6,694	21,875	2,293	57	21	84,192
83	63,652	5,560	17,518	1,231	7	8	87,976
84	66,473	5,233	18,806	1,530	8	12	92,062
85	67,802	6,001	20,461	2,466	84	28	96,842
86	69,422	6,261	22,380	3,449	229	71	101,812
87	69,926	6,673	25,982	4,153	297	101	107,132
88	75,335	6,517	26,726	3,232	345	122	112,277
89	83,419	5,630	26,072	2,053	317	120	117,611
90	88,564	6,128	27,616	2,082	340	125	124,855

Table 10

POWER PLANT PRODUCTIVITY IMPROVEMENT STUDY
COMMONWEALTH EDISON COMPANY
CASE C FUEL CONSUMPTION (1000's)

<u>Year</u>	<u>Nuclear</u> <u>(MMBTU)</u>	<u>H.S. Coal</u> <u>(TONS)</u>	<u>L.S. Coal</u> <u>(TONS)</u>	<u>#6 Oil</u> <u>(BBLs)</u>	<u>Peaking</u> <u>(GALS)</u>
79	307,069	5,494	12,626	8,118	36,376
80	376,892	3,480	13,591	7,854	24,713
81	431,924	3,379	13,227	7,077	23,521
82	564,368	3,233	11,063	3,501	9,368
83	676,767	2,698	8,938	1,866	4,820
84	706,740	2,550	9,595	2,236	5,974
85	720,666	2,911	10,390	3,559	12,449
86	736,428	3,039	11,326	5,032	27,860
87	742,264	3,219	13,149	5,748	32,829
88	805,210	3,153	13,401	4,724	40,296
89	897,687	2,733	13,111	2,928	35,651
90	<u>955,690</u>	<u>2,970</u>	<u>13,804</u>	<u>2,909</u>	<u>37,457</u>
	7,921,705	38,859	144,221	55,552	291,314

Table 11

POWER PLANT PRODUCTIVITY IMPROVEMENT STUDY

COMMONWEALTH EDISON COMPANY

CASE C GENERATION (1000's MWHRS)

<u>Year</u>	<u>Nuclear</u>	<u>H.S. Coal</u>	<u>L.S. Coal</u>	<u>#6 Oil</u>	<u>Peaking</u>	<u>Emergency Purchases</u>	<u>Total</u>
79	28,550	11,356	25,686	5,415	329	56	71,392
80	35,245	7,241	27,163	5,252	196	44	75,293
81	40,575	7,023	26,372	4,856	189	41	79,056
82	53,146	6,705	21,850	2,402	69	25	84,197
83	63,595	5,554	17,536	1,272	11	10	87,978
84	66,438	5,251	18,807	1,524	20	15	92,055
85	67,798	6,009	20,461	2,439	94	33	96,834
86	69,367	6,285	22,400	3,451	241	82	101,826
87	69,953	6,670	26,155	3,960	288	111	107,137
88	75,184	6,525	26,807	3,272	359	137	112,284
89	83,369	5,643	26,094	2,044	322	133	117,605
90	88,672	6,129	27,559	2,029	330	136	124,855

Table 12

POWER PLANT PRODUCTIVITY IMPROVEMENT STUDY
COMMONWEALTH EDISON COMPANY
CASE D FUEL CONSUMPTION (1000's)

<u>Year</u>	<u>Nuclear</u> (MMBTU)	<u>H.S. Coal</u> (TONS)	<u>L.S. Coal</u> (TONS)	<u>#6 Oil</u> (BBLs)	<u>Peaking</u> (GALS)
79	310,386	5,552	12,550	7,799	31,343
80	380,596	3,507	13,550	7,468	21,195
81	436,050	3,406	13,189	6,629	20,249
82	569,084	3,241	10,963	3,180	7,903
83	681,534	2,690	8,839	1,630	3,867
84	711,880	2,544	9,499	1,947	4,725
85	726,394	2,912	10,293	3,174	9,994
86	742,638	3,038	11,223	4,609	23,031
87	748,970	3,225	13,033	5,283	27,470
88	812,004	3,159	13,262	4,369	34,556
89	904,440	2,734	12,933	2,677	30,253
90	<u>962,999</u>	<u>2,972</u>	<u>13,619</u>	<u>2,649</u>	<u>31,717</u>
Totals	7,986,975	38,980	142,953	51,414	246,303

Table 13

POWER PLANT PRODUCTIVITY IMPROVEMENT STUDY

COMMONWEALTH EDISON COMPANY

CASE D GENERATION (1000's MWHRS)

<u>Year</u>	<u>Nuclear</u>	<u>H.S. Coal</u>	<u>L.S. Coal</u>	<u>#6 Oil</u>	<u>Peaking</u>	<u>Emergency Purchases</u>	<u>Total</u>
79	28,858	11,469	25,533	5,183	266	47	71,356
80	35,591	7,304	27,059	4,983	160	37	75,134
81	40,962	7,078	26,278	4,559	165	35	79,077
82	53,583	6,722	21,658	2,183	55	21	84,222
83	64,008	5,542	17,299	1,116	5	8	87,978
84	66,895	5,233	18,588	1,328	8	12	92,064
85	68,307	6,009	20,259	2,179	68	27	96,849
86	69,923	6,283	22,185	3,164	191	67	101,813
87	70,570	6,686	25,916	3,636	250	92	107,150
88	75,817	6,535	26,493	3,016	301	114	112,276
89	83,989	5,645	25,720	1,867	272	110	117,603
90	89,334	6,137	27,148	1,849	279	111	124,858

Table 14

POWER PLANT PRODUCTIVITY IMPROVEMENT STUDY

COMMONWEALTH EDISON COMPANY

CASE E FUEL CONSUMPTION (1000's)

<u>Year</u>	<u>Nuclear</u> (MMBTU)	<u>H.S. Coal</u> (TONS)	<u>L.S. Coal</u> (TONS)	<u>#6 Oil</u> (BBLs)	<u>Peaking</u> (GALS)
79	316,744	5,607	12,385	7,389	24,932
80	387,488	3,542	13,459	6,793	17,031
81	444,694	3,415	13,066	5,895	16,106
82	577,633	3,260	10,747	2,741	6,416
83	689,968	2,671	8,760	1,245	2,772
84	721,781	2,539	9,276	1,439	3,365
85	737,087	2,913	10,112	2,451	7,111
86	754,897	3,048	11,011	3,762	16,566
87	762,209	3,240	12,688	4,592	22,144
88	823,926	3,175	12,981	3,770	26,661
89	916,792	2,746	12,613	2,184	22,424
90	977,994	2,977	13,199	2,116	22,732
Totals	8,111,213	39,133	140,297	44,377	188,260

Table 15

POWER PLANT PRODUCTIVITY IMPROVEMENT STUDY

COMMONWEALTH EDISON COMPANY

CASE E GENERATION (1000's MWHRS)

<u>Year</u>	<u>Nuclear</u>	<u>H.S. Coal</u>	<u>L.S. Coal</u>	<u>#6 Oil</u>	<u>Peaking</u>	<u>Emergency Purchases</u>	<u>Total</u>
79	29,456	11,584	25,154	4,905	203	39	71,341
80	36,230	7,372	26,865	4,521	123	31	75,142
81	41,770	7,100	26,004	4,043	134	28	79,079
82	54,375	6,753	21,177	1,874	41	17	84,261
83	64,751	5,492	16,894	848	-	6	87,991
84	67,775	5,216	18,097	980	7	9	92,084
85	69,271	5,998	19,842	1,679	41	21	96,852
86	71,052	6,298	21,723	2,583	129	52	101,837
87	71,806	6,713	25,217	3,151	187	76	107,150
88	76,925	6,570	25,877	2,602	232	89	112,295
89	85,105	5,667	25,031	1,523	195	85	117,606
90	90,697	6,145	26,265	1,476	191	83	124,857

Table 16

III. ESTIMATION OF GROSS BENEFITS FOR ILLINOIS POWER

Base Case Assumptions

The base case assumptions used in this study are representative of those currently in use at Illinois Power Company for exploratory simulation studies over comparable time horizons. The only modifications to base case assumptions were in planned and forced outage rates for the improvement scenarios. Table 17 contains a list of baseloaded units in the Illinois Power Company system for which the improvement scenarios were run. Since the Clinton nuclear unit is not scheduled to come on line until 1982, its base case planned and forced outage rates were not changed in the improvement scenarios. Planned outage data is expressed in terms of the number of weeks of maintenance per year, averaged over the 5 or 6 year maintenance cycle of each unit.

Base case fuel consumption by BTU for coal, nuclear, and oil is presented in Figure 1 for the Illinois Power Company,

Table 17

Illinois Power Company
Base Case Assumptions

Unit	Forced Outage Rate (FOR)	Planned Outage Rate (POR Average Over Cycle)
Baldwin 1 605 MW Coal	8.4%	7.4 weeks/yr
Baldwin 2 605 MW Coal	7.6%	7.4 weeks/yr
Baldwin 3 605 MW Coal	10.1%	4.8 weeks/yr
Wood River 5 389 MW Coal	11.9%	5 weeks/yr
Clinton 1* 950 MW Nuclear	10.5%	6 weeks/yr

Total MW Improved: 2232

*Clinton unit scheduled for operation in 1982.

POWER PLANT PRODUCTIVITY STUDY
Illinois Power Company
Btu Output by Fuel Type for Base Case

Figure 1

Improvement Scenario Results
for
Illinois Power

POWER PLANT PRODUCTIVITY IMPROVEMENT STUDY

ILLINOIS POWER COMPANY

BASE CASE FUEL CONSUMPTION
(thousands)

<u>Year</u>	<u>Nuclear</u> (MMBtu)	<u>H.S. Coal</u> (TONS)	<u>L.S. Coal</u> (TONS)	<u>#6 Oil</u> (BBLS)	<u>Peaking</u> (GALS)
1979	0	6,255	1,306	840	14,163
1980	0	6,266	1,378	961	16,650
1981	0	6,366	1,468	913	14,666
1982	6,185	6,298	1,453	894	16,489
1983	66,110	5,221	1,093	577	6,995
1984	55,921	5,642	1,197	830	10,745
1985	61,880	5,603	1,146	603	9,219
1986	61,517	5,522	1,125	535	7,312
1987	61,441	5,535	1,153	455	7,446
1988	96,784	5,290	1,162	818	16,421
1989	115,290	4,977	924	408	5,660
1990	<u>116,011</u>	<u>4,967</u>	<u>956</u>	<u>482</u>	<u>8,159</u>
TOTALS	<u>641,139</u>	<u>67,942</u>	<u>14,361</u>	<u>8,316</u>	<u>133,925</u>

Table 17

POWER PLANT PRODUCTIVITY IMPROVEMENT STUDY

ILLINOIS POWER COMPANY

CASE B FUEL CONSUMPTION
(thousands)

<u>Year</u>	<u>Nuclear</u> (MMBtu)	<u>H.S. Coal</u> (TONS)	<u>L.S. Coal</u> (TONS)	<u>#6 Oil</u> (BBLs)	<u>Peaking</u> (GALS)
1979	0	6,311	1,242	701	571
1980	0	6,295	1,325	914	1,130
1981	0	6,436	1,466	883	1,449
1982	6,176	6,311	1,413	803	1,508
1983	65,658	5,065	908	387	340
1984	55,485	5,603	1,147	745	676
1985	59,787	5,641	1,186	705	655
1986	61,939	5,741	1,186	646	428
1987	62,073	5,841	1,261	625	827
1988	95,618	5,122	952	374	462
1989	115,191	5,029	873	359	315
1990	<u>115,486</u>	<u>4,954</u>	<u>927</u>	<u>492</u>	<u>302</u>
TOTALS	<u>637,413</u>	<u>68,349</u>	<u>13,886</u>	<u>7,634</u>	<u>8,663</u>

Table 18

POWER PLANT PRODUCTIVITY IMPROVEMENT STUDY

ILLINOIS POWER COMPANY

CASE C FUEL CONSUMPTION
(thousands)

<u>Year</u>	<u>Nuclear</u> (MMBtu)	<u>H.S. Coal</u> (TONS)	<u>L.S. Coal</u> (TONS)	<u>#6 Oil</u> (BBLS)	<u>Peaking</u> (GALS)
1979	0	6,339	1,224	681	9,708
1980	0	6,245	1,357	944	16,127
1981	0	6,390	1,469	931	14,452
1982	6,180	6,352	1,392	744	11,128
1983	65,528	5,078	899	383	4,345
1984	55,553	5,616	1,109	765	11,374
1985	59,828	5,630	1,179	732	12,213
1986	61,970	5,693	1,212	681	12,065
1987	62,091	5,869	1,257	607	9,901
1988	95,499	5,192	894	343	4,781
1989	115,246	5,008	881	387	4,929
1990	<u>115,634</u>	<u>4,928</u>	<u>943</u>	<u>501</u>	<u>8,353</u>
TOTALS	<u>637,529</u>	<u>68,340</u>	<u>13,816</u>	<u>7,699</u>	<u>119,376</u>

Table 19

POWER PLANT PRODUCTIVITY IMPROVEMENT STUDY

ILLINOIS POWER COMPANY

CASE D FUEL CONSUMPTION
(thousands)

<u>Year</u>	<u>Nuclear</u> (MMBtu)	<u>H.S. Coal</u> (TONS)	<u>L.S. Coal</u> (TONS)	<u>#6 Oil</u> (BBLs)	<u>Peaking</u> (GALS)
1979	0	6,420	1,178	593	7,836
1980	0	6,405	1,257	828	11,439
1981	0	6,534	1,380	821	10,568
1982	6,171	6,467	1,315	656	8,924
1983	65,488	5,123	868	354	3,697
1984	55,428	5,703	1,054	701	10,877
1985	59,805	5,770	1,100	596	9,005
1986	61,973	5,819	1,140	589	8,573
1987	62,169	5,934	1,224	512	8,149
1988	95,360	5,227	865	346	4,265
1989	114,974	5,090	830	330	4,095
1990	<u>115,048</u>	<u>5,037</u>	<u>885</u>	<u>443</u>	<u>7,164</u>
TOTALS	<u>636,416</u>	<u>69,529</u>	<u>13,096</u>	<u>6,769</u>	<u>94,592</u>

Table 20

POWER PLANT PRODUCTIVITY IMPROVEMENT STUDY

ILLINOIS POWER COMPANY

CASE E FUEL CONSUMPTION
(thousands)

<u>Year</u>	<u>Nuclear</u> (MMBtu)	<u>H.S. Coal</u> (TONS)	<u>L.S. Coal</u> (TONS)	<u>#6 Oil</u> (BBLs)	<u>Peaking</u> (GALS)
1979	0	5,162	1,206	659	9,136
1980	0	6,295	1,325	914	14,998
1981	0	6,443	1,440	880	12,906
1982	6,175	6,404	1,362	697	9,820
1983	65,559	5,101	882	368	4,022
1984	55,521	5,651	1,091	737	10,670
1985	59,804	5,672	1,155	698	11,474
1986	61,955	5,729	1,192	649	11,379
1987	62,073	5,898	1,241	588	8,892
1988	95,386	5,216	878	337	4,472
1989	115,122	5,035	866	369	4,596
1990	<u>115,523</u>	<u>4,959</u>	<u>927</u>	<u>477</u>	<u>8,015</u>
TOTALS	<u>637,118</u>	<u>67,562</u>	<u>13,565</u>	<u>7,373</u>	<u>110,380</u>

Table 21

POWER PLANT PRODUCTIVITY IMPROVEMENT STUDY

ILLINOIS POWER COMPANY

PRODUCTION COSTS
(thousands)

<u>Year</u>	<u>Case A</u>	<u>Differential from A</u>			
		<u>Case B</u>	<u>Case C</u>	<u>Case D</u>	<u>Case E</u>
1979	\$146,570	\$ 690	\$1,560	\$2,240	\$3,890
1980	178,130	1,290	(10)	1,290	4,550
1981	195,400	1,460	450	1,930	4,430
1982	211,110	1,460	2,510	3,880	5,380
1983	145,870	570	690	1,250	1,730
1984	166,800	890	460	1,300	2,180
1985	178,680	910	(100)	870	3,560
1986	204,760	920	(560)	400	2,840
1987	231,520	780	1,850	2,770	4,130
1988	176,520	700	2,000	2,560	2,950
1989	177,590	490	(100)	480	1,710
1990	<u>195,620</u>	<u>340</u>	<u>20</u>	<u>720</u>	<u>2,170</u>
TOTALS	<u><u>2,208,570</u></u>	<u><u>\$10,500</u></u>	<u><u>\$8,770</u></u>	<u><u>\$19,690</u></u>	<u><u>\$39,520</u></u>

Table 22

DISCUSSION OF RESULTS

From the results presented in this report, it is clear that rewards to utilities are significant for improving the productivity of baseloaded units. From other reports in this study, it was determined that opportunities exist for the cost-effective reduction of planned and forced outage rates through plant improvement projects. Whether the 2 percentage point improvements can be achieved in a cost-effective manner has not been examined. Increased utility awareness of productivity improvement potential and benefits is moving the industry in this direction, however. It may be noted that even if the cost of increased productivity just equals the estimated gross benefits, there are substantial benefits to the US economy which result from reduced consumption of scarce, imported fuels and greater reliance on coal and/or nuclear generation. Thus, increased baseload unit availability translates into an immediate benefit to ratepayers even if it does not appear as a reduction in rates.

In general, if an electric utility is able to implement a cost-effective plant improvement which increases the reliability of a baseloaded unit, some savings will be passed on to consumers through lower rates. In many cases, this effect will be direct and immediate. If, however, a utility is earning less than its allowed rate of return, the impact on the consumer may be less direct. Rates may eventually be influenced in this case through the improved financial health of the utility. The resulting benefits for the consumer are no less real.

Although over the twelve year time horizon of this study, neither Commonwealth Edison nor Illinois Power was able to identify any capacity additions which might have been deferred as a result of the improvement scenarios, many existing units will operate over a much greater time period. Eventually, perhaps 15 to 20 years hence, it may be possible to defer or eliminate some planned new unit in Illinois. This possibility is brought about by the greater contribution existing units may make to meeting load if existing units are available a greater percent of each year. Such a deferral would provide very substantial benefits to Illinois ratepayers which would accrue in addition to those stemming from reduced generation costs as considered in this report. To examine such possibilities efficiently requires an optimizing type generation planning model which was not available for this report. Currently, both utilities are in the process of implementing such models.

APPENDIX

REFERENCES

- A. A Report on Improving the Productivity of Electric Powerplants, Federal Energy Administration, March, 1975.
- B. Study of Benefits of Improved Powerplant Reliability and Productivity, Phase 2 Report: Analysis of Two Utility Systems and Regions", Dept. of Energy, HCP/B60792-02, February, 1978.
- C. Powerplant Productivity Improvement Study, U.S. Department of Energy, February, 1978. HCP/B60830.
- D. Study of Benefits of Improved Powerplant Reliability and Productivity, Phase 3 Report, National Analysis, Center for Energy Systems, General Electric Co., December 30, 1977.
- E. Demonstration of DOE Methodology (Project 1, Task 2), Illinois Powerplant Productivity Improvement Study, U.S. Department of Energy.