

OPERATIONAL COSTS OF BREAKDOWNS AT THE COMMERCE REFUSE-TO-ENERGY FACILITY

MATTHEW EATON AND JOE SMISKO
County Sanitation Districts of Los Angeles County
Commerce, California

ABSTRACT

The Commerce Refuse-to-Energy Facility (CREF) is a 380 ton per day municipal solid waste combustor that generates 10 MW net electric power. Various mechanical and operational problems can result in the loss of power production and the loss of refuse tonnage combusted as well as increase the need for auxiliary firing. A detailed study was performed to allocate the resultant costs to the equipment and operating conditions that result in reduced load, gas usage or outages and to determine trends of the costs. From the information obtained and summarized, resources can now be more accurately distributed to the problems.

INTRODUCTION

The CREF is a mass burn municipal waste combustor with energy recovery located in Commerce, California. The facility combusts 380 tons of mostly commercial refuse per day and generates 10 MW net electric power which is sold to Southern California Edison. The CREF is owned by the Commerce Refuse to Energy Authority, a joint powers authority formed between the City of Commerce and the County Sanitation Districts of Los Angeles County. The plant started up in late 1986.

The facility refuse processing system consists of a 1200 ton refuse storage pit and cranes with orange-peel type grapples for feeding refuse. The refuse is combusted on a Detroit Stoker reciprocating grate system. The boiler was furnished by Foster Wheeler and includes a natural gas burner for startup and shutdown. Air pollution control is achieved by anhydrous ammonia injection for NO_x control; powdered dolomitic limestone injection in the furnace and a semi-dry scrubber for acid gas control; and a fabric filter for particulate collection.

The bottom ash drops from the grates into a water filled ash extractor and is discharged from the extractor with a hydraulic ram. The bottom ash is then conveyed, screened and stored for disposal or treatment. The flyash is conveyed using enclosed drag conveyors to a dense-phase pneumatic conveyor, which then transports the flyash into a storage silo.

Availability is defined as the percent of time the generator is on-line during the year. The capacity factor is defined as the quantity of power generated as a percent of the maximum possible, or full load every hour of the year. Thus, forced and planned outages account for all of the lost capacity due to reduced availability and reduced load accounts for the difference between availability and the capacity factor. Some of this reduced load is also due to shutdown and startup for outages. Since startup of the plant in 1986, the causes and costs of forced outages have been recorded and trended because they have accounted for the majority of the lost capacity. In 1992 however, there was more lost production due to reduced load while on-line than from forced outages. As a result, a study was initiated to determine the causes of reduced load. As part of this study, total costs of reduced load and outages were determined, including lost refuse combustion and gas usage.

CALCULATIONS

In order to determine the reduced load causes, a form was developed for the operators to complete after each shift. On the form, the operator notes the equipment, system or other problem which prevented a shift capacity factor of 100% or which required natural gas usage. For shifts during which there was more than one problem, a ratio is

estimated between each cause. Although the percentages are estimates, they are accurate enough to reach valuable conclusions when totalled over the year.

The data collected from the operators were then analyzed to calculate costs of reduced production. The costs consist of reduced power sales, natural gas usage and reduced refuse combustion. Power sales and gas usage figures were obtained from plant instrumentation. Refuse tonnage not combusted was determined by calculating the refuse required to produce the power lost and by adding the equivalent quantity of refuse required to produce the heat generated by the gas burned. For all calculations it is assumed that all prices are constant and are based upon the average 1993 prices. The dollar figures are as follows: power is sold at \$0.11 per kWhr; natural gas costs \$3.85 per kscf; and the marginal tipping fee for refuse is \$24.00 per ton. These prices are in fact variable over the short term and long term, but assuming constant prices provides more accurate comparison of reduced load and outage costs over time. In addition, the usual objective of operation is to produce power at 100% capacity without using natural gas and therefore the calculations are reflective of overall performance. At certain times, however, the prices of power and natural gas are such that it becomes economical to run the plant on gas if necessary, a situation which occurs at the CREF 6% of the time. It could be useful to develop more detailed data collection such that these periods could be factored into the calculations.

Other costs and benefits of reduced load and outages, such as reductions or increases in chemical usage, were not included in the calculations. It is estimated that all other costs amount to less than 5% of the total of the costs mentioned above.

In addition to calculating reduced load costs, the total lost production costs of outages were calculated, including not only the lack of power production and refuse combustion while off line, but also the gas use and reduced load during startup and shutdown.

RESULTS

Table 1 shows the costs broken down into the type of incident resulting in lost production for calendar year 1993. It can be seen that reduced load resulted in almost as much cost as forced outages and amounted to nearly \$1,000,000. It is also worth noting that the average outage costs \$17,000 for shutdown and startup and \$1600 per hour of downtime. Startup and shutdown comprised approximately one-third of the total cost of the forced outages.

Table 2 details all equipment and operation related reduced load and outages costs in 1993. Each problem is separated into both outage costs and reduced load costs and each is broken down into the quantities of lost power,

TABLE 1 COSTS OF LOST POWER PRODUCTION IN 1993

Event	Cost 1000's ¹	% of Total
Reduced Load	\$998	35
Forced Outages ¹	1,116	39
Downtime	777	27
Shutdown/Startup	339	12
Planned Outages ²	766	27
Downtime	715	25
Shutdown/Startup	51	2
Total	2,880	100 ³

Notes:

1. There were 20 forced outages resulting in a total downtime of 469 hours.
2. There were 3 planned outages resulting in a total downtime of 440 hours.
3. Total does not equal 100 due to rounding.

TABLE 2 DETAILED BREAKDOWN OF REDUCED LOAD AND OUTAGE COSTS IN 1993

Description ¹	Code ²	Lost Power, MWhrs	Nat. Gas Usage, kscf	Lost Refuse, Tons	Cost 1000's	% of Total
Planned Outages	O	5,309	2,514	7,188	\$766	27
Waterwalls	O	3,443	7,541	5,180	532	18
Grate System	O	2,503	5,027	3,726	384	13
Refuse	R	1,241	11,173	2,610	242	8
Wet Refuse	R	1,016	6,510	1,905	183	6
Ash Extractor	O	648	1,676	997	102	4
Ash Extractor	R	466	5,936	1,133	101	4
Grate System	R	419	5,601	1,042	93	3
SOX Hourly	R	428	3,559	874	82	3
Fans	O	489	1,676	789	79	3
Miscellaneous	R	276	2,951	621	57	2
CO Hourly	R	236	2,755	552	50	2
Drag Conveyors	R	192	2,122	438	40	1
Refuse Cranes	R	183	1,992	415	38	1
SOX Daily	R	115	1,273	263	24	1
CO Daily	R	105	1,020	227	21	1
Miscellaneous	O	98	838	202	19	1
Refuse Rams	R	84	1,105	207	18	1
Fans	R	58	782	145	13	0
Ash Conveyors	R	59	758	144	13	0
Feed Chute	R	35	1,320	162	13	0
Baghouse	R	62	519	127	13	0
Totals		17,464	68,647	28,946	2,880	100

Notes:

1. See text for explanations.
2. "O" represents outage related costs, "R" represents reduced load related costs.

lost refuse, and natural gas use. Details of the problems which contributed to each category are described below.

Planned Outages

For the purposes of this paper, planned outages are defined as those outages which are intended for general maintenance on many parts of the plant as opposed to those which are attributable to only one project or repair. There were three planned outages in 1993 resulting in 440 hours of downtime. Projects completed during the 1993 planned outages included overlay of 750 sq ft of the waterwalls, replacement of the charging rams, and repair of the scrubber casing.

Waterwalls

The plant was shut down nine times by tube leaks resulting in a total downtime of 229 hours. The leaks occurred on all four walls, either on the nose sections of the front and back walls or between 10 and 15 feet from the grates on the side walls. Numerous waterwall tube protection measures, including Inconel overlay and various refractory types and configurations have been attempted to prevent failures each with varying degrees of success.

Grate System

The six grate-caused outages were the result of several random causes. Three were due to broken bolts or welds on the support structures, two were failures of the charging rams, and one was a result of missing grates. In previous years, a much larger proportion of grate related outages was attributable to missing grates. Reduced load and gas usage caused by grates generally occurs when repairs are made while on-line, typically hydraulic or electrical repairs.

Refuse

This category is used whenever the operator can not achieve full load due to combustion difficulties not related to a specific problem with equipment. This usually occurs when the refuse has a high moisture content or a large amount of unburnable material, or there is a hidden problem preventing good combustion. One cause could be leakage of air into the furnace which prevents the full amount of combustion air being added, thereby resulting in poor mixing of the air with the refuse and combustion gasses. Large amounts of household refuse also may result in lost production which would be classified as a "refuse" problem. Hidden equipment malfunctions which create reduced load situations that may be called refuse problems include stalling grates, small waterwall tube leaks, and minor ash extractor problems.

Wet Refuse

Only incidents whereby water is added to the refuse after disposal by the consumer are included in this category. Rain is the primary cause of "wet refuse."

Ash Extractor

The two outages caused by the ash extractor occurred when the glands on the hydraulic cylinders failed. The glands have also been replaced while on-line, resulting in reduced load and gas usage. The majority of reduced load in this category results from stalls or jams, a situation which is exacerbated when combustion is not ideal and unburnt material overloads the extractor.

SOx and CO Hourly and Daily

The CREF must meet hourly and daily emissions limits for NOx, SOx and CO. If the plant emissions are approaching a limit for one or more pollutants as the end of an hour or day approaches, the operator must reduce load and possibly use the gas burner in order not to exceed the limit. In 1993, reduced load due to SOx was initially a major problem but was reduced to almost nothing by the end of the year. CO became the primary emissions related reduced load cause in the last half of 1993. Reduced load classified under "CO" and "refuse" are directly related, as poor combustion results in greater CO emissions.

Fans

This category refers to breakdowns of the overfire, underfire or induced draft fans. The only failure in 1993 was of the induced draft fan motor outboard bearing. When the motor failed, it was replaced with an undersized spare. The spare prevented the full amount of combustion air resulting in reduced load during the two days it was in place. The plant was brought off-line when the primary motor was initially replaced with the spare and then when the primary motor was reinstalled after it had been rebuilt.

Other Equipment Classifications

The remaining classifications all refer to breakdowns of equipment which forced either outages or on-line repairs that resulted in reduced load or gas usage.

Table 3 groups the failures of 1993 into categories based upon the equipment or operation aspect causing the failure, including both outages and reduced load and combining similar types of equipment breakdowns or operation problems. From this table it can be seen that efforts should be directed at preventing waterwall tube failures, reducing grate system breakdowns and improving combustion. Reducing these three items by 25% will result in a savings of over \$350,000, or 3% of annual revenue.

The effectiveness of efforts to increase on-line capacity factors is indicated by trending the causes of reduced load as shown in Figure 1. For example, in the latter half of 1992 and early 1993, reduction of load to meet SOx emissions limits was resulting in costs of over \$600,000 per year. As it became apparent that this was not a transient problem, experiments with plant operation were performed to develop a solution to SOx induced reductions of load. By tracking reduced load costs as various changes were implemented, it was found that the most effective option was simply excluding refuse from one particular transfer station. This decreased the cost of reductions in load for SOx control to less than \$50,000 per year. Figure 1 also shows the seasonal nature of some reduced load causes including ash extractor, combustion (includes the

TABLE 3 SUMMARY OF BREAKDOWN COSTS IN 1993

Description	Cost 1000's	% of Total Cost
Planned Outages	\$766	27
Waterwall Tubes	532	19
Grate System	477	17
Combustion Problems	425	15
Ash Extractor	203	7
APC/Emissions	188	7
Conveyors/Cranes	122	4
Fans and Pumps	92	3
Other	75	3
Totals	2,880	100

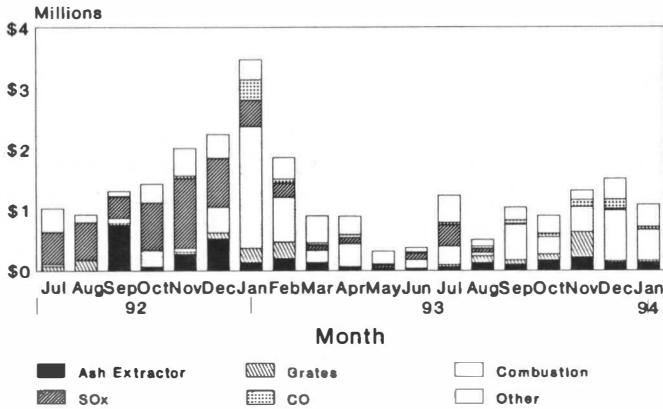


FIG. 1 REDUCED LOAD COSTS BY MONTH ANNUAL RATE IN 1993 DOLLARS

“refuse” and “wet refuse” classifications described above) and CO, primarily due to rain.

Once the reduced load and outage costs were detailed for 1993, previous years were analyzed to determine estimates of similar costs incurred. The outage hours from planned and forced outages, and therefore power and refuse lost during downtime, were readily available as was

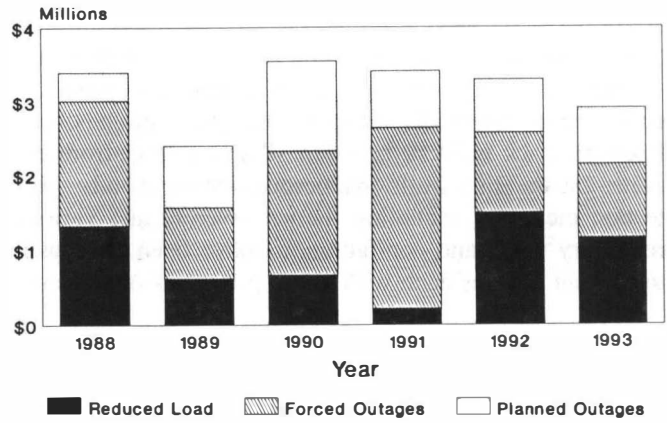


FIG. 2 REDUCED LOAD AND OUTAGES TOTAL ANNUAL COSTS IN 1993 DOLLARS

the total power not produced and total gas usage. Estimates were made to determine the allocation of lost power and gas used to either reduced load or that which occurred during shutdown and startup for outages. Figure 2 shows the trend of reduced load and outage costs over the past six years. As more data is compiled, a more useful graph showing the trends of the operational costs of equipment breakdowns can be developed.

CONCLUSION

Determination of the true total cost of outages and reduced load and allocating these costs to the equipment or operation resulting in the drop in production allows for more accurate appropriation of resources to the problems causing the greatest cost. In addition, more accurate determination of the cost effectiveness of capital improvements or maintenance changes is possible.