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ENVIRONMENTAL RESEARCH BRIEF

Waste Reduction Activities and Options for a Fossil Fuel Fired Electrical Generating Station

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Abstract

The U.S. Environmental Protection Agency (EPA) funded a project with the New Jersey Department of Environmental Protection and Energy (NJDEPE) to assist in conducting waste minimization assessments at 30 small- to medium-sized businesses in the state of New Jersey. One of the sites selected was a facility which is a fossil fuel fired electricity generating station. A site visit was made in 1990 during which several opportunities for waste minimization were identified. Wastes are generated by several activities which are supportive of the operation of the station. Options identified for waste reduction included improved management of waste oil, changes in solvent usage, use of rechargeable batteries, and changes in painting practices. Implementation of the identified waste minimization opportunities was not part of the program. Percent waste reduction, net annual savings, implementation costs and payback periods were estimated.

This Research Brief was developed by the Principal Investigators and EPA's Risk Reduction Engineering Laboratory in Cincinnati, OH, to announce key findings of this completed assessment.

Introduction

The environmental issues facing industry today have expanded considerably beyond traditional concerns. Wastewater, air emissions, potential soil and groundwater contamination, solid waste disposal, and employee health and safety have become increasingly important concerns. The management and disposal of hazardous substances, including both process-related wastes and residues from waste treatment, receive significant attention because of regulation and economics.

As environmental issues have become more complex, the strategies for waste management and control have become more systematic and integrated. The positive role of waste minimization and pollution prevention within industrial operations at each stage of product life is recognized throughout the world. An ideal goal is to manufacture products while generating the least amount of waste possible.

The Hazardous Waste Advisement Program (HWAP) of the Division of Hazardous Waste Management, NJDEPE, is pursuing the goals of waste minimization awareness and program implementation in the state. HWAP, with the help of an EPA grant from the Risk Reduction Engineering Laboratory, conducted an Assessment of Reduction and Recycling Opportunities for Hazardous Waste (ARROW) project. ARROW was designed to assess waste minimization potential across a broad range of New Jersey industries. The project targeted 30 sites to perform waste minimization assessments following the approach outlined in EPA's *Waste Minimization Opportunity Assessment Manual* (EPA/625/7-88/003). Under contract to NJDEPE, the Hazardous Substance Management Research Center at the New Jersey Institute of Technology (NJIT) assisted in conducting the assessments. This research brief presents an assessment of the generation of fossil fuel fired electricity (1 of the 30 assessments performed) and provides recommendations for waste minimization options resulting from the assessment.

Methodology of Assessments

The assessment process was coordinated by a team of technical staff from NJIT with experience in process operations, basic chemistry, and environmental concerns and needs. Because the EPA waste minimization manual is designed to be primarily applied by the inhouse staff of the facility, the degree of involvement of the NJIT team varied according to the ease

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with which the facility staff could apply the manual. In some cases, NJIT's role was to provide advice. In others, NJIT conducted essentially the entire evaluation.

The goal of the project was to encourage participation in the assessment process by management and staff at the facility. To do this, the participants were encouraged to proceed through the organizational steps outlined in the manual. These steps can be summarized as follows:

- Obtaining corporate commitment to a waste minimization initiative
- Organizing a task force or similar group to carry out the assessment
- Developing a policy statement regarding waste minimization for issuance by corporate management
- Establishing tentative waste reduction goals to be achieved by the program
- Identifying waste-generating sites and processes
- Conducting a detailed site inspection
- Developing a list of options which may lead to the waste reduction goal
- Formally analyzing the feasibility of the various options
- Measuring the effectiveness of the options and continuing the assessment.

Not every facility was able to follow these steps as presented. In each case, however, the identification of waste-generating sites and processes, detailed site inspections, and development of options was carried out. Frequently, it was necessary for a high degree of involvement by NJIT to accomplish these steps. Two common reasons for needing outside participation were a shortage of technical staff within the company and a need to develop an agenda for technical action before corporate commitment and policy statements could be obtained.

It was not a goal of the ARROW project to participate in the feasibility analysis or implementation steps. However, NJIT offered to provide advice for feasibility analysis if requested.

In each case, the NJIT team made several site visits to the facility. Initially, visits were made to explain the EPA manual and to encourage the facility through the organizational stages. If delays and complications developed, the team offered assistance in the technical review, inspections, and option development.

No sampling or laboratory analysis was undertaken as part of these assessments.

Facility Background

The facility is a fossil fuel fired electrical generating station. The facility has been in operation for approximately 30 yr and during this time has used coal, oil, and natural gas as fuel. The choice of fuel depends upon economic and environmental constraints and options. Wastes are generated by several activities which are supportive of the operation of the station. This report does not address any issues related to fuel burning or related to electricity generation.

Manufacturing Process

Conceptually, the manufacturing process at this facility is relatively simple. Fossil fuel is burned to generate heat which is used to turn liquid water into steam. The steam is used to power machinery which generates an electrical current. In order to carry out these operations, other critical support activities must take place. These activities include equipment maintenance and repair, painting and surface coating, wastewater treatment, and boiler service.

For this facility, it is instructive to consider more substantively the various aspects of these support activities.

There is a great deal of machinery in the facility which depends upon oil-based lubrication. The practice at the facility is to change the oil periodically. Waste oil of various types results from this practice. Some of the oil appears in the water treatment facility as a result of spills, accidental discharges, or leaks into cooling water. The oil is separated mechanically. Oil represents the largest waste stream at the facility.

As a function of maintenance and repair, as well as during the installation of new components, solvent-based degreasing of metals is a standard practice. Typically, degreasing occurs by immersion of the parts into a tank of chlorinated solvent followed by brushing of the part to remove any adhering grease or oil. The solvent is periodically sent offsite for disposal when it is no longer works effectively for degreasing.

A power station represents a relatively harsh environment for exposed metal surfaces. Consequently, frequent painting occurs. At this facility, the coating of choice is solvent-based paints, usually applied by brushing.

A power station is a large user of water. As a result of such use there are residuals from water treatment as well as cleaning of the equipment used in water handling throughout the process. In one sense, a major product of the facility is hot water and steam.

Existing Waste Management Activities

The company has already recognized the advantages and benefits of identifying and implementing waste reduction and pollution prevention practices. The use of catch basins or spill pans at the locations of frequent oil spills in order to catch the oil and facilitate its recovery and reuse, and the acquisition and use of a drum crusher with capability to capture any oil or other contents to allow for recovery and reuse illustrate this recognition on the part of the company.

Current waste management activities include sending waste oil and oil/water mixtures for offsite disposal at a cost of $0.10/gal for oil and $0.65/gal for oil-water mixtures. Accompanying this is a quantity of oily debris such as filter cartridges, contaminated soil, and drying agents. This is also sent out for disposal at various prices depending upon the material in question.

Waste solvent is sent for disposal at a cost of approximately $1.20/lb. The cost, however, is highly variable depending upon the frequency of the pick up and the amount of waste present at the time of the pick up.

The water treatment facility generates about 600 yd^3 of biological sludge, which is sent offsite for disposal at a cost generally of $200,000/yr. There is potential that application of the TCLP requirements may result in reclassification of the material as hazardous. In the event of such a reclassification, the disposal costs would be expected to increase substantially.

The chemicals and materials used for boiler treatment are recovered and sent offsite for disposal under the authority of contracted water treatment specialists. Although the facility pays for the service, the pricing does not include a breakdown of the waste handling costs.

Waste Minimization Opportunities

This particular assessment was a team effort on the part of company personnel and the NJIT participants. During the assessment process, the following waste streams were targeted:

- Oil and oil contaminated materials
- Degreasing solvents
- Solvents from painting and related activities
- Boiler treatment chemicals
- Wastewater treatment sludge
- Miscellaneous wastes

The waste oil stream is generated primarily from pump maintenance and from the oil/water separator at the wastewater treatment plant. Approximately 12,000 gal of waste oil is generated annually. Logical approaches for reducing this volume include extending the time period between oil changes and onsite reconditioning and reuse of some of the oil. The schedule for pump maintenance and oil change is based upon the recommendations of the equipment manufacturers and the experience of the technical staff. While some lube oil (such as turbine oil) is filtered to remove solids and reused when possible, the importance of the pumps to the operation of the facility and the relatively low cost of oil engenders a reluctance on the part of the production staff to risk pump failure for the sake of a marginal reduction in the quantity of waste oil.

In addition, there is a direct correlation between maintenance activities and the generation of filter cartridges. Generation of oily debris such as absorbent "diapers", speedy dry, and contaminated soil are related to small pump leaks and minor spills of similar nature.

In order to address these waste sources without adversely impacting pump performance the following options were identified. The placement of additional small, regularly emptied catch basins or pans under pumps and connections with a history of developing leaks could reduce greatly the amount of cleanup debris and absorbent generated. The recovered oil can be added to the waste lubrication oil sent for offsite reclamation or, if suitable, can be returned to the equipment it came from.

The facility has indicated that equipment maintenance is a critical concern. A modified approach to oil changes can be developed which has the potential of protecting the operating integrity of the equipment while still reducing the volume of oil used. In situations where equipment is used intermittently, installation of a time-of-use meter on the equipment with oil changes being performed after a certain period of operation should reduce the total volume of oil used and still provide mechanical protection. Certainly for equipment which is used continuously, a static- or calendar-driven oil change schedule could be continued.

For some applications, synthetic lubricating oils have been found to afford extended times between changes. Reportedly, such oils have been evaluated at this facility and found not to extend appreciably the time between oil changes. Additional consultation with manufacturers of oils and of the equipment may result in the identification or development of a lubrication product with the necessary characteristics. It should be remembered, however, that such synthetic lubricants may not be amenable to recovery and reuse as is regular lubricating oil due to the nature of the formulation.

Oil/water mixtures are currently sent offsite for disposal at a cost of $0.65/gal. In contrast, waste oil can be sent for recovery at a cost of about $0.10/gal. It is recommended therefore that consideration be given to acquiring an oil/water separation capability such as a centrifuge. Such capability should reduce waste management expenses and reduce the volume of wastes sent offsite. The water produced by the separation process can be sent to the facility's wastewater treatment system.

The mechanical equipment at the facility requires frequent maintenance and repair in addition to oil changes. Frequently repair of various machine components requires degreasing of the affected part prior to the repair procedure. Typically, a chlorinated solvent is used to carry out the degreasing because it is fast and effective. A frequent goal of pollution prevention initiatives is to reduce the level of use of chlorinated solvents because they present potential risks both to human health and to the environment. Three possible options would decrease the use of chlorinated materials:

- Use of any solvent for degreasing can be reduced significantly by simple manual wiping of the part to remove gross oil and dirt. In addition to requiring less solvent or other chemical, such a procedure will result in a lengthening of the life of the degreasing bath by reducing fouling of the solution.
- Use of newer types of degreasing equipment such as ultrasonic degreasers can eliminate the need for an organic solvent by use of a heated caustic solution facilitated by ultrasound induced energy transfer.
- Frequently, substitutions can be made for the chlorinated solvents. These substitutes may include aliphatic hydrocarbons, terpenes, N-methyl-2-pyrrolidone and dibasic acid esters. None of these substitutes will work universally, however, one or more may be useful for any specific application.

Where use of chlorinated solvents cannot be avoided, consideration could be given to recovery and reuse of the solvents by purification through onsite distillation. This would require the addition of distillation capability and would result in the generation of a new waste stream—still bottoms. It can be predicted however, that this stream would be significantly smaller than the spent degreasing solvent stream.

Another significant solvent-containing waste stream results from painting and coating activities. Surface protection is a significant part of the maintenance activities at the facility. Reduction of solvent use by switching to water-based paints where performance requirements can be achieved is a plausible goal. Where an acceptable water-based substitute for a solvent-based coating cannot be readily identified, discussions with coating manufacturers should be held in order to communicate the need and request such a product. Such water-based coatings not only reduce the quantity of solvents which evaporate into the air at the facility, they lessen the need for additional solvents for area clean-up and equipment cleaning. Where spray painting technologies are used, a viable option is to consider use of newer technology equipment, particularly those using high volume-low pressure approaches.

The wastewater treatment plant at the facility produces sludge which is disposed of offsite. One waste minimization approach involves reducing the organic loading of the wastewater which goes to the plant, thereby reducing the quantity of sludge produced. There is a high correlation between the organic contaminant level in the water sent for treatment and in the plant. Reduction in the organic loadings will require a careful study of the sources of contamination entering the wastewater and development of a plan to reduce the levels of this contamination.

Although not defined as a waste minimization option, dewatering of this waste stream to reduce its volume was also considered. The sludge currently sent offsite now contains only about 30% solids. The quantity of waste can be reduced by removal of the water. Two possibilities for this type of water removal are sludge drying utilizing waste heat from the generation equipment or improved filter press operation.

Corrosive solids, cleaners and descalers are used as boiler cleaning agents. In many cases, alternate procedures such as use of a less toxic blast medium in place of the corrosive cleaning agents may reduce or eliminate the need for the corrosive material. Additional evaluation of the potential changes in effectiveness, labor costs, and disposal costs must be performed in order to assess the pollution reduction potential of such an approach.

The large number of batteries used at the facility, largely for flashlights, suggests that the use of rechargeable nickel-cadmium batteries may be a realistic option. However, the capital expense for the batteries and chargers may slow adoption. It is suggested that a controlled experiment using a subset of workers and flashlights be tried initially in order to determine the magnitude of the savings, both economic and environmental, which may be obtained. If nickel-cadmium batteries are used, then when they must be discarded, their disposal should be carefully coordinated with a recycling/reuse procedure for such products. It would seem particularly appropriate for an electrical utility to be involved in such a demonstration with rechargeable batteries.

The type of waste currently generated by the plant, the source of the waste, the quantity of the waste, and the annual treatment and disposal costs (where known and available) are given in Table 1.

Table 2 presents the opportunities for pollution prevention which were identified during the assessment. The type of waste, the minimization opportunity, and the possible waste reductions, are presented in the table. When available or estimable, the associated savings, implementation costs and payback times are also given. Savings may include not only avoidance of costs for waste management, it may also include credits for raw materials which are recovered or not lost. Therefore, the total savings may be greater than the present costs for waste disposal.

It should be noted that the economic savings of the minimization opportunity, in most cases, result from the need for less raw material and from reduced present and future costs associated with waste treatment and disposal. It should also be noted that the savings given for each opportunity reflect the savings achievable when implementing each waste minimization opportunity independently and do not reflect duplication of savings that would result when the opportunities are implemented in a package. Also, no equipment depreciation is factored into the calculations.

Regulatory Implications

On the surface, the waste reduction opportunities at this facility seem relatively free of regulatory implications. However, there are at least two areas where regulatory concerns have significant impact on decision making. In the area of waste oil, it would seem that this would be an ideal location for onsite burning of such materials for energy recovery. However concerns about necessary air permit modifications and hazardous waste status of the oil make it unlikely that the facility would proceed with the option. Therefore the waste oil will probably continue to be sent offsite for disposal. Second, a facility such as this is subjected to another type of regulatory involvement. Specifically the rate setting board which can penalize the facility economically for too much down time in electrical generation. Such possibilities discourage changes such as alternative oil change schedules and alternative boiler maintenance procedures because of great uncertainty about resulting equipment reliability.

This Research Brief summarizes a part of the work done under cooperative Agreement No. CR-815165 by the New Jersey

Table 1. *Summary of Current Waste Generation*

Waste Generated	*Source of Waste*	*Annual Quantity Generated*	*Annual Waste Management Costs*
Waste Oil	*Oil changes, spills, and leaks*	*12,000 gal*	*$1,200 to 7,800*
Waste Solvent	*Parts degreasing and paint solvent*	*1,200 lb*	*1,600*
Wastewater Treatment Sludge	*Organics in wastewater*	*600 yd^3*	*200,000*
Contaminated Water	*Boiler cleaning and conditioning*	*100 tons not annual every 5-8 yr*	*hidden costs included in contract estimate $20,000*

Table 2. *Summary of Recommended Waste Minimization Opportunities*

Waste Stream Reduced	Minimization Opportunity	Annual Waste Reduction Quantity	Annual Waste Reduction Percent	Net Annual Savings	Implementation Cost	Payback Years *
Waste Oil	Expand use of drip pans	50 gal	0.4	$50	$100	2
	Extend period between oil changes by timing use	1200 gal	1.0	1300	2000	1.5
Waste Solvent	Wipe parts manually	100 lb	8.5 (This option would generate oily rags to be disposed of or laundered.)	100	100	1
	Change to alternative	Not necessarily any but should result in lower levels of toxicity.				
	Ultrasonic degreasers	1,200 lb	100	1600	5000	3.1
Wastewater Treatment Sludge	Reduce organic loading to treatment facility	estimate 60 yd^3	10	20,000	Not known without detailed survey of sources	
Boiler Cleaning Water	Investigate dry cleaning technology	Up to 100 tons, but requires study before implementation. Solid waste would result.				

* Savings result from reduced raw material and treatment and disposal costs when implementing each minimization opportunity independently.

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