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Final Report

Coal Conversion Engineering Analysis
for
Central Hudson Gas & Electric Corporation
Danskammer Generating Station, Units 3 & 4

Contract No. DE-AC01-79RG10075
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1.0 INTRODUCTION

This report presents the results of a site inspection and engineering evaluation for the conversion of Central Hudson Gas & Electric Corporation's (CHG&E) Danskammer Generating Station, Units 3 & 4, from oil to coal firing. This report has been prepared for the Department of Energy, Office of Fuels Conversion to enable their environmental contractor, Environmental Assessment Corporation (EAC), to complete an Environmental Impact Report.

This report documents the results of a site inspection performed by AMAF to determine what equipment required for coal burning operation is in place at the site, the condition of this equipment, and the space available to install any new equipment required for coal burning operation. After the site inspection, an engineering evaluation was performed by AMAF to determine what modifications or new equipment would be required to permit coal firing in Units 3 & 4 in compliance with current environmental, health and safety regulations. The major systems evaluated in this report include the coal and ash handling systems, the primary air system, the boiler burners and the air pollution control equipment. Particular emphasis was placed on the condition of the onsite railroad trackage, the need for coal dust abatement, modifications to the boiler, effluent from the bottom ash system, ash and sludge transport, space requirements for ash and sludge dewatering, and the use of solvent refined coal. In addition, a brief review was performed of the project cost estimate and construction schedules prepared by CHG&E's consultants.

Engineering and economic data required to complete this report were developed from the following sources of information:

- Coal conversion data previously submitted by CHG&E to the New York State Public Service Commission and various federal agencies.
- Budget quotations from equipment manufacturers.
- AMAF's expertise in electric utility generating station systems design.
- Coal conversion reports previously prepared by CHG&E's consultants.

The Danskammer Plant is located on the west shore of the Hudson River in Roseton, New York. Unit 3 began commercial operation in 1959 as a coal fired unit and had a net capacity of 140 MW. Unit 4 began commercial operation in 1967 as a coal fired unit and had a net capacity of 235 MW. Both units were converted to oil in 1971. Current (1979) capacity ratings for Units 3 & 4 are 122 MW and 220 MW respectively.

2.0 SUMMARY

AMAF's evaluation of Units 3 & 4 at the Danskammer Station has concluded that it is technically feasible to convert these units from oil to coal firing. This evaluation is based on the following sources of information:

1. An inspection of the Danskammer Plant.
2. Discussions with CHG&E personnel during the site visit.
3. Review of correspondence, technical data and other exhibits on conversion of the Danskammer Plant that were previously submitted by CHG&E to state and federal agencies.
4. Review of coal conversion evaluation studies prepared for CHG&E by Gibbs & Hill, Inc. and EBASCO Services, Inc.

Although it is technically feasible to reconvert these units to coal burning operation, equipment modifications are required before coal firing can be resumed. Many of the modifications are required for compliance with air quality, water quality, and occupational health and safety regulations enacted since the plant stopped burning coal in 1971. The plant modifications discussed in this report for coal burning operation are based on the use of bituminous coal with a heating value of 12,000 Btu per pound, an ash content of 12% and a sulfur content of 2%. Rehabilitation or replacement of equipment is required in the following plant systems in order to resume coal burning operation:

- Coal Handling System
- Boilers
- Fly Ash Handling System
- Bottom Ash System
- Precipitators
- Stack

The modifications required for each system are discussed in detail in later sections of this report.

This report includes a discussion of the flue gas desulfurization (FGD) systems which may be required if the Danskammer Plant is converted to coal. The installation of an FGD system may be required in order to comply with New York State air quality regulations on sulfur dioxide emissions. The ambient air quality at the Danskammer Plant is influenced by the emissions from the adjoining Roseton Plant. When Units 3 & 4 are firing coal, the combined sulfur dioxide emissions from the Danskammer and Roseton Plants may exceed the levels permitted by the air quality regulations. An evaluation is underway to assess the combined effects of the Danskammer and Roseton Plants effluents on the ambient air quality standards and the results of this study will determine the need for an FGD system at the Danskammer Plant.

The most recent cost estimate and construction schedule for the conversion of the Danskammer Plant was prepared in 1978 by Gibbs & Hill. Assuming that no FGD system would be required, Gibbs and Hill estimated a direct project cost of \$42.3 million, not including CHG&E home office expenses, escalation and interest during construction. AMAF estimates that the direct cost of this project, in March, 1980 dollars, has increased to \$50.3 million. Installation of an FGD system would increase the direct project costs by \$50 million plus escalation and interest during construction. G&H estimated that 45 months would be required to complete engineering and construction. Based on equipment lead times obtained from equipment manufacturers, AMAF estimated that 45 months is the minimum amount of time required for completing the reconversion of Units 3 & 4. Licensing

activities will require an additional 6 to 12 months and these activities must be completed before starting detailed engineering. Additional time should also be allowed for equipment delivery delays. The total time required for licensing, engineering and construction is 57 months.

AMAF has evaluated the use of solid and liquid solvent refined coal (SRC) in the Danskammer Plant. The evaluation of solid SRC fuel assumed a heating value of 15,800 Btu per pound, an ash content of 0.1% and a sulfur content of 0.85%. The evaluation of liquid SRC fuel assumed a heating value of 16,400 Btu per pound, a density of 7.5 pounds per gallon and a 0.3% sulfur content.

At the present time, SRC derived fuels are not available in sufficient quantities for use as the regular fuel supply. Any use of SRC fuels would be limited to supplemental firing. In order to fire solid SRC fuel, modifications would be required to the pulverizers, burners and primary air system. If solid SRC fuel is stored in the coal pile area, additional dust abatement measures will be required. In order to fire liquid SRC fuel, modifications will be required to the burners and new storage tanks, pumps and piping will be needed to unload, store and transport the fuel to the boilers.

3.0 TECHNICAL EVALUATION

3.1 COAL HANDLING SYSTEM

The existing coal handling system was designed to receive coal by railroad car and distribute it to all four units. The basic system was installed in 1950, enlarged when Units 3 & 4 were constructed, and operated until 1971 when the plant was converted to oil firing.

Before the plant was converted, coal was delivered to the site in bottom unloading hopper cars and discharged by gravity into two track hoppers located at grade level. Conveyors transported the coal to the crusher building where the coal was reduced in size. After passing through the crusher house, the coal was transported by conveyors to the coal bunkers.

A motor operated tripper conveyor was used to load coal into the bunkers. Coal was removed from the bunkers and delivered to the pulverizers by means of coal feeders located at the bottom of the bunkers.

When coal was not required by the bunkers, it bypassed the crushers and was placed on the coal storage pile using the stack-out conveyor. Coal was taken from the storage pile, as required, using a reclaim hopper and returned to the crusher house using the reclaim conveyor.

AMAF inspected the accessible portions of the coal handling system in February, 1980, and found conditions similar to those previously

reported by CHG&E's consultants. Much of the system is intact, however, some of the components were removed or used for other services when the plant converted to oil. The following coal handling system components can be returned to service after overhaul:

1. Railroad trackage
2. Track hoppers
3. Car shaker
4. Conveyors to crusher house and bunkers
5. Crushers
6. Stack-out conveyor
7. Reclaim hopper
8. Tripper conveyor
9. Bunkers
10. Pulverizers

The coal feeders were removed to permit cleaning of the bunkers when the plant was converted to oil. The feeder motors have been removed for use elsewhere in the plant. CHG&E's consultant reported that the cost of repairing the coal feeders cannot be justified and recommended purchase of new feeders. AMAF concurs with this recommendation.

The railroad car thawing equipment has experienced significant deterioration from exposure to the elements. The cost of overhauling this equipment may dictate replacement with new thawing equipment.

The existing railroad trackage on the plant site requires significant tie replacement and realignment before it is returned to service. Much of this rehabilitation is required because no track maintenance was performed since the plant switched to oil in 1971. No new trackage is required for coal handling if the plant continues to use the existing railroad car unloading system.

Both locomotives owned by the plant for switching cars have not been operated since 1971. The cost of overhaul and the future availability of spare parts may dictate replacement of these locomotives, which are approximately 30 years old.

Additional modifications to the coal handling system will be required in order to meet the OSHA standards. These standards were enacted after the coal handling system was removed from service in 1971. Coal handling system modifications will be required to meet the OSHA standards for protection against exposed machinery hazards, airborne coal dust, and noise exposure. The coal handling system modifications required to bring the Danskammer Plant into compliance are typical of those required for a plant constructed prior to the passage of the OSHA standards.

It is anticipated that the installation of machinery guards throughout the coal handling system, where exposed hazards exist, will eliminate this problem. Airborne dust will be found in the thawing shed, the crusher building, and the tripper gallery. Dust abatement systems

will probably be required at each of these locations in order to meet the permissible dust exposure levels. Airborne coal dust in the thawing shed is produced when the railroad cars are unloaded and may be controlled by the use of water or a chemical solution which is sprayed on the coal as it is emptied from the cars. If the track hopper does not already have a spray system, a system can be installed in the existing hopper.

Airborne dust in the crusher building may be controlled by installing a dust collection system which will collect dust as it is produced at each transfer point. The dust laden air would be routed to a mechanical collector or bag filter where the clean air would be exhausted and the collected dust would be held for disposal. The collected dust will be transported to the ash disposal area. A similar system can be used in the tripper gallery. Dust collected by the tripper gallery system would be routed to the coal bunkers. Fugitive dust generated during stack-out operations can be reduced by installing a telescoping discharge chute on the end of the stack-out conveyor.

Noise abatement measures will be required in the thawing shed and in the boiler area near the pulverizers. The use of ear protection by employees working in these areas would be the most practical way to meet the intent of the noise exposure standards. Increasing the length of the thawing shed will reduce the offsite noise exposure from railroad car unloading operations.

After the Danskammer plant was converted to oil, a portion of the former coal storage area was used to locate a wastewater treatment system. The remaining portion of the original coal storage area is limited to a storage capacity of 40,000 tons (12 days supply) because of overhead transmission line clearance requirements. Additional coal storage space is required in order to provide reliable plant operation. The only

available area for additional coal storage is located across the tracks from the plant. This storage area would be used for dead storage and has a coal storage capacity of 170,000 tons, which is sufficient for 48 days operation. Coal would be transported between the plant and the dead storage area using rubber tired vehicles.

In order to comply with the current water quality regulations, rainwater runoff from the existing and new coal storage piles, as well as the drainage from the thawing shed sump and the crusher building sump, must be collected and treated from suspended solids, oil and pH before it is released to the environment. Based on a one hour storm occurring once every 10 years, a collection basin of approximately 700,000 gallons is required for treatment of these waste streams. Assuming a basin depth of 10 feet, an area measuring approximately 94 feet by 100 feet would be required for the collection basin. Processing equipment required for treatment of this water would be located adjacent to the collection basin. New waste water sources produced by converting Units 3 & 4 to coal burning operation are summarized in Table 1.

Except for the pulverizers, the existing coal handling system is capable of handling solid solvent refined coal (SRC) without additional modifications. Additional dust abatement measures will be required to control fugitive emissions from the storage pile area. The pulverizer modifications required to handle SRC are discussed in more detail in Section 3.2 of this report.

TABLE 1

New Waste Water Sources
Resulting from Coal Conversion

<u>Source</u>	<u>Maximum Estimated Discharge (gallon)</u>	<u>Treatment Required</u>
Coal pile runoff	625,000	suspended solids, oil, pH
Thawing shed	32,000	suspended solids, oil, pH
Crusher building sump	14,000	suspended solids, oil, pH
Bottom ash system equipment drains	1,000	suspended solids, pH
Ash transport water	No discharge to the environment if water is recycled for process use.	suspended solids, pH
Sludge transport water	No discharge to the environment if water is recycled for process use	None if recycled. Suspended solids and pH if discharged to environment

NOTE: All waste water streams will be discharged to the Hudson River unless recycled for process use.

3.2 BOILER SYSTEMS

When Units 3 & 4 were converted to oil firing, some loss of generating capability was experienced due to low steam temperature. Subsequently, the Unit 4 reheater was modified to provide increased surface area. No modifications were made to Unit 3. Based on the original boiler performance data, Units 3 & 4 had net capabilities of 140 MW and 235 MW respectively when firing coal. Data submitted to the Federal Power Commission on FPC Form 67 for the calendar year 1974 indicated that Unit 3 was derated 10% or 14 MW, and Unit 4 was derated 5% or 12 MW, when firing oil. Although it is proposed to use coal of similar quality to the coal originally fired, some boiler modifications may be required at a later date based on the operating experience of the reconverted plant. A net increase in generating capability is not expected if Units 3 & 4 are reconverted to coal since the installation of additional air and water emissions control equipment will impose additional demands on the station auxiliary electrical system. Some derating may be expected if FGD systems are installed.

When Units 3 & 4 were converted to oil, new burners and ignition control systems designed for oil firing only were installed. This equipment must be replaced with burners and controls designed for coal firing. Oil firing capability can be retained after Units 3 & 4 are reconverted to coal, if the combustion control system modifications are designed and purchased on the basis of dual fuel capability. If necessary, to fire oil in the reconverted plant, a short outage (less than one week) would be required to change burners, fuel piping and control circuits.

Modifications to the primary air system include the replacement of missing and/or worn sections of piping, overhaul of the primary air fans and control circuit changes as required by the new combustion control system.

Due to the installation of new flue gas emission control equipment, new induced draft fans will be required. Modifications to the boiler controls will be required to control the new induced draft fans.

The use of solid Solvent Refined Coal (SRC) fuel in Units 3 & 4 would require replacement of the burners, modifications to the combustion control systems, modification or replacement of the coal pulverizers and modifications to the primary air system. Changing from coal to solid SRC, or vice versa, would require an outage each time the fuel supply was changed in order to make this equipment compatible with the new fuel supply. The plant does not have sufficient space to install duplicate pulverizers which would be needed to maintain alternate fuel capability at all times. Supplemental firing with SRC could be accomplished by modifying individual pulverizers to burn solid SRC. The number of pulverizers modified would be dependent on the ratio of SRC and coal to be fired.

AMAF contacted the manufacturer of the existing pulverizers to determine the modifications required to handle solid SRC. No information is currently available regarding the pulverizer modifications necessary to satisfactorily handle SRC fuel. One potential supplier of solid SRC fuel did experience

fouling of the pulverizers in a plant where he was conducting burn tests with SRC. Operating experience obtained during test burns indicates that the fuel temperature must be kept below 140°F.

Based on this limited test firing data, it appears that a colder than normal primary air design temperature is required to satisfactorily handle SRC fuel. Although this can be accomplished by reducing the steam flow to the preheater coils, the colder primary air temperature will result in a lower exit flue gas temperature with increased acid corrosion in the precipitator and stack breeching. Additional work beyond the scope of this project is required to satisfactorily determine all the modifications needed to burn SRC fuel.

Modifications required to use liquid SRC fuel would probably be limited to the burners and the combustion control systems. The extent of the boiler modifications required for liquid SRC fuel cannot be completely determined at this time; however, the properties of liquid SRC fuel are similar to the fuel oil supply currently used at Danskammer. Thus, it is anticipated that liquid SRC fuel would be handled with equipment similar in design to the equipment used for handling fuel oil.

3.3 FLY ASH HANDLING SYSTEM

The original fly ash collection systems for Units 3 & 4 removed ash from each boiler and precipitator hopper and transported the ash to an onsite disposal area. These systems have not been operated since the plant was converted to oil. There is no reason to refurbish the existing systems since the onsite disposal area is no longer available and the existing precipitators will be replaced with more efficient particulate removal equipment.

Design of the new fly ash systems for Units 3 & 4 will be influenced by the transportation mode(s) used to reach the ash disposal area and any onsite use of the fly ash for FGD sludge fixation. A separate system will be installed for each unit; however, common ash storage and vehicle loading facilities will be provided. Each system will remove ash from the boiler economizer hoppers and the precipitator or baghouse hoppers by vacuum and transport the ash to the collection equipment. From the collection equipment, the ash will be conveyed to the storage and vehicle loading facilities. Estimated design fly ash production rates are 127 tons per day for Unit 3 and 217 tons per day for Unit 4.

Two potential ash disposal areas have been identified for the Danskammer Plant. The first disposal area is a quarry north of the plant site on the west bank of the Hudson River; the second disposal area is located across the river from the plant site. Ash could be transported to the first disposal area by truck or pipeline and by truck or barge to the second disposal area. It should be noted that selection of the ash disposal site(s) for the Danskammer Plant has not been finalized.

Although truck transportation of fly ash would be viable for any disposal site, pipeline or barge transport can be evaluated only for specific ash disposal sites.

Unless onsite ash disposal facilities are available, most power plant fly ash handling systems are designed to handle the ash in dry form. The major advantage of the dry type ash handling system is the elimination of disposal problems with the ash sluice water. Due to the current water quality regulations, some plants that were originally designed with wet fly ash handling systems have been converted to dry systems.

The new fly ash systems for Units 3 & 4 will be dry type, vacuum-pressure systems. As discussed previously, separate ash handling systems for each boiler will remove ash by vacuum from the economizer hoppers and the precipitator or baghouse hoppers and transport the ash to the collection equipment. From the collection equipment, the ash will be conveyed under pressure to the ash storage silos. The ash storage silos are normally sized for storage of 64 hours of ash production at design plant load. Ash is normally discharged from the storage silos into trucks or railroad cars for transport to the disposal area. The storage silo unloading equipment will condition the ash for shipment in open top vehicles by adding a small amount of water to the ash to control fugitive dust during shipment.

If barge transportation is used to reach the disposal area, more ash storage capacity would probably be required to store the ash until a

barge is available for loading. Barge loading facilities would be used for handling both fly ash and bottom ash. The use of barge transportation is technically feasible from the viewpoint of handling ash at the site. The decision to use barge transportation must be based on the availability of ash disposal sites with barge access, the cost of the barge loading facilities at the plant site, the disposal site, and the direct transportation charges for barge shipments versus other modes of transportation.

If the quarry north of the plant site is used for ash disposal, the use of a pipeline for ash transport may be feasible. Fly ash would be removed from the economizer and precipitator hoppers by vacuum and conveyed to the collection equipment as noted previously. From the collection equipment, the fly ash would be conveyed under pressure to a mixing station where the ash would be mixed with water and the resulting slurry pumped to the disposal area. The mixing stations would also receive effluent from the bottom ash system and combine it with the fly ash slurry before pumping it to the disposal area. Containment of the ash contaminated water would be required at the quarry to prevent runoff. If not returned to the plant, treatment would be required before the sluice water can be discharged to the environment.

Installation of a pipeline would require purchase of a right-of-way on the west side of the Conrail tracks. Substantial rock excavation from the area adjacent to the railroad would be required to provide adequate space for installation and maintenance of the pipeline. Access

must be provided for periodic replacement of elbows and other fittings where changes of direction occur.

Based on observations made during the February, 1980, site visit, it is anticipated that the installation of a pipeline for transporting fly ash and bottom ash to the quarry would be more costly than transporting ash to the quarry by truck. In addition, the permits necessary to build the pipeline and dispose of the sluice water from the quarry in this aesthetically sensitive area may be difficult to obtain. For these reasons, installation of a pipeline for transporting ash to the quarry is not recommended.

3.4 BOTTOM ASH HANDLING SYSTEM

The original bottom ash handling systems for Units 3 and 4 removed ash from the boilers and transported the ash hydraulically to an onsite disposal area. Since the onsite area is no longer available, the system must be modified to transport ash to a new, offsite disposal area.

When the existing bottom ash systems were in service, ash was removed from each boiler through a refractory lined, water cooled bottom ash hopper. Upon leaving the ash hopper, the ash passed through an ash grinder where it was reduced in size. After leaving the ash grinder, the ash passed through a jet pump where the ash was mixed with water. The ash was conveyed to the disposal area via pipeline.

Although the existing bottom ash system cannot be used in its present configuration if Units 3 & 4 are reconverted to coal, portions of the existing system in the boiler building will be rebuilt and used in the new ash handling systems. Existing equipment to be rebuilt, or replaced with new equipment of identical design includes the ash hoppers, ash grinders and ash pumps.

Discussions with CHG&E personnel and a review of previous CHG&E consultants' reports indicate that the bottom ash hoppers can be reused if overhauled, the ash grinders should be replaced and new ash pumps must be purchased to replace the original pumps which have been scrapped. AMAF expects that some replacement of piping and fittings in the boiler building may

also be required. Estimated ash production rates are 22 tons per day for Unit 3 and 38 tons per day for Unit 4.

Design of the new bottom ash handling systems outside of the boiler building is contingent upon the location of the disposal area and the mode of transportation used to deliver ash to the disposal area. The most likely method to be used for transporting bottom ash to the disposal area will be open top dump trucks. Elevated dewatering storage bins will receive bottom ash and mill rejects from the plant and discharge the conveying water to a settling pond. When a dewatering bin is full, the ash/water flow to the bin will be stopped and the water in the bin will be drained to the settling pond. The ash will be discharged by gravity through the bottom of the dewatering bin into trucks for transport to the disposal area. Two dewatering bins will be provided with a combined ash storage capacity sufficient for 64 hours of full load operation of both units. In the event that rail transportation would be feasible due to a remote ash disposal area, this system could be used for loading railroad cars if the support structure is designed for railroad car clearance requirements. A typical elevated dewatering bin would measure 16 feet in diameter and 45 feet high.

If the quarry north of the plant site is used for disposal of ash, the bottom ash may also be conveyed by pipeline. Due to the amount of ash produced, the use of a pipeline solely for transport of bottom ash cannot be economically justified. A common pipeline system should be used to transport both bottom ash and fly ash. This system was previously discussed in Section 3.3.

Barges could be used for transport of bottom ash to remote disposal areas with water access. The use of barge transportation will require the installation of loading facilities at the plant site and unloading facilities at the disposal area. The cost of these facilities cannot be justified if barge transportation is used only for handling bottom ash.

Ash conveying water recovered from the settling pond will be recycled to the plant. The settling pond would be sized to provide a minimum of retention time of one day. The settling pond would have an estimated capacity of 1.3 million gallons of water and 35,000 cubic feet of sludge and measure approximately 100 feet by 200 feet. The recycled water must be chemically treated to control pH and prevent scaling. No discharge to the environment will occur under normal operating conditions; however, some water will be lost from the system when ash is unloaded from the dewatering bins or equipment is drained for maintenance. Fine material recovered from the settling pond will be transported by truck to the disposal area.

3.5 AIR POLLUTION CONTROL EQUIPMENT

3.5.1 PRECIPITATOR

Units 3 & 4 are presently equipped with electrostatic precipitators designed for a removal efficiency of 98% as determined by ASME test methods. The existing precipitators cannot meet the current New York State air quality regulations which limit particulate emissions to 0.1 pound of particulates per million Btu of heat input. A precipitator design efficiency of 99.2%, as determined by EPA Test Method 5, is required to meet these regulations. In order to meet this requirement, additional precipitator sections must be added to the existing precipitators if they are continued in service after the plant is converted to coal.

AMAF inspected the accessible portions of the existing precipitators in February, 1980, and found conditions similar to those previously reported by CHG&E's consultants. Due to the rooftop location of the Unit 4 precipitator, there is insufficient space to add the additional sections required to obtain the required 99.2% design efficiency. The existing precipitators will require extensive rehabilitation if the plant is converted to coal. The combined cost of rebuilding the existing precipitators, the installation of additional ducting and support steel is expected to be equal with the cost of completely new precipitators. For these reasons, the installation of new precipitators is recommended in lieu of rebuilding the existing units.

As discussed in more detail in Section 3.5.3, the installation of certain flue gas desulfurization (FGD) systems at the Danskammer Plant may determine the need for new precipitators as well as dictate the design requirements and the location of the new precipitators in Units 3 & 4. Most FGD systems considered for this plant would be located downstream of the precipitators, which will permit the design of the precipitators independently of the FGD system.

Design of the new electrostatic precipitators for Units 3 & 4, when the FGD system is located downstream of the precipitators, or if no FGD system is installed, will be based on the exhaust gas flow from each boiler and the amount of ash present in the flue gas. Based on flue gas flows of 400,000 CFM for Unit 3 and 670,000 CFM for Unit 4, and the coal analysis used for this study, the new precipitator will remove approximately 127 tons of fly ash per day from Unit 3 and 217 tons per day from Unit 4 when operating at design collection efficiency. Ash will be removed from the precipitator hoppers by the Fly Ash System, which was previously discussed in Section 3.3.

3.5.2 BAGHOUSE

As discussed in Section 3.5.1, the existing precipitators cannot meet the New York State air quality regulations for particulates if the Danskammer Plant is reconverted to coal. Baghouses can be installed at the Danskammer Plant as an alternative to new precipitators and achieve the required level of particulate removal.

Based on design flue gas flows of 400,000 CFM for Unit 3 and 670,000 CFM for Unit 4, and the coal analysis used in this study, the baghouses will collect approximately 127 tons of fly ash per day from Unit 3 and 217 tons of fly ash per day from Unit 4. Ash will be removed from the baghouse hoppers by the Fly Ash System, which was previously discussed in Section 3.3.

As discussed in more detail in Section 3.5.3, the installation of an FGD system will influence the design requirements and location of the baghouses in Units 3 & 4. The dry scrubber type FGD systems discharge the treated flue gas to the baghouse where fly ash and spent reagent are removed. The wet scrubber type FGD systems would be located downstream of the baghouse.

3.5.3 FLUE GAS DESULFURIZATION EQUIPMENT

Current New York State air quality regulations limit sulfur dioxide emissions to a maximum of 2.5 pounds of sulfur per million Btu heat input at any time and 1.9 pounds of sulfur per million Btu averaged over a three month period. The ambient air quality at the Danskammer Plant is greatly influenced by the emissions from the adjoining Roseton Plant. When Units 3 & 4 are firing coal, the combined sulfur dioxide emissions from the Danskammer and Roseton plants may exceed the level permitted by the air quality regulations. The results of an ongoing air quality study for the Danskammer Plant may dictate the installation of flue gas desulfurization (FGD) equipment if Units 3 & 4 are converted to coal.

There are two basic designs of FGD or scrubber systems available for installation at the Danskammer Plant, wet scrubbers and dry scrubbers.

The wet scrubber system was the first scrubber system to be developed and is presently operating in several electric utility generating stations.

The dry scrubber system is a new design which eliminates some of the waste disposal problems of the wet scrubber system. Although no dry

scrubbers are presently operating in this country, a dry scrubber is under construction at the Riverside Plant of Northern States Power Company. This scrubber is expected to begin operation in late 1980.

Wet scrubbers use a slurry of lime, soda ash or similar material to remove sulfur from the flue gas. A typical wet scrubber system consists of a spray tower, reaction tank, thickener, transfer pumps, and interconnecting piping. A typical wet scrubber system design proposed for

the Danskammer Plant would treat 275,000 CFM, or 25% of the total flue gas flow, at an efficiency of 90%. The remaining flue gas flow of 825,000 CFM would bypass the scrubbers. A small portion of the bypass flow will be used to reheat the clean flue gas leaving the scrubber. The scrubbers are normally located downstream of the precipitators. Based on the coal analysis used in this study, the estimated amounts of sludge produced by the wet scrubbers are 185 tons per day for Unit 3 and 300 tons per day for Unit 4.

Excess water is removed for the spent slurry by the thickener and recycled for process use. Concentrated sludge is discharged from the thickener and transported to the sludge treatment station for final treatment. For plants having an onsite disposal area, the sludge may be transported to the disposal area by pipeline. If the sludge is shipped to an offsite landfill, it is stabilized at the plant site.

If the quarry north of the Danskammer site is used for sludge disposal, the spent slurry may be transported by pipeline to the quarry. Space would be required at the quarry for the thickener and sludge stabilization equipment. A pipeline would be required to return water recovered from the thickener and the disposal area to the plant site. Rubber lined piping would be used to transport sludge to the quarry. This piping cannot be used to transport ash.

The major advantage of dry scrubbers over wet scrubbers is the use of the chemical reagent in dry, powdered form which eliminates water

disposal problems. The dry scrubber receives ash laden flue gas directly from the boiler for treatment. Commercial grade pebble lime is used as the reagent. Lime consumption is estimated at 75 tons per day for Unit 3 and 125 tons per day for Unit 4. A baghouse would be installed downstream of the scrubber to remove spent reagent and fly ash from the flue gas. Based on the coal analysis used in this study, the estimated amounts of fly ash and spent reagent produced by the dry scrubber, and removed to the baghouse, are 310 tons per day for Unit 3 and 515 tons per day for Unit 4.

The fly ash/reagent mixture is normally transported to the disposal area by truck. The mixture is conditioned with water at a rate of 50 gallons per ton of mixture to control dust during shipment. Although the mixture can be transported by pipeline, treatment and disposal of the conveying water would negate the major advantage of the dry scrubber.

Additional railroad trackage will be required to receive lime or other chemicals for operation of the FGD system. The amount of trackage required is dependent on the location of the unloading station and the number of cars to be received in a single shipment.

3.5.4 STACK

Each boiler in Units 3 & 4 is presently served by a separate stack located on the boiler house roof. The top of each stack is 240 feet above grade. Installation of the new air pollution control equipment needed for coal firing at the Danskammer plant will require construction of a new stack. Based on conceptual equipment arrangement drawings prepared by CHG&E's consultants, a common stack (chimney) can be used for Units 3 & 4.

Current New York State air quality regulations limit sulfur dioxide emissions to a maximum of 2.5 pounds of sulfur per million Btu heat input at any time and 1.9 pounds of sulfur per million Btu averaged over a three month period. Coal with a sulfur content of 2% could be fired at the Danskammer Plant with a stack height of 410 feet, as determined by Good Engineering Practice (GEP) calculations. (The influence of the adjoining Roseton Plant on Danskammer's sulfur emissions is presently under investigation. The results of this study may require the use of lower sulfur fuel or an FGD system.) The stack height determined by GEP calculations is normally 2.5 times the height of nearby structures for power plants and is the maximum height which may be used in filing air quality permit applications for a specific stack.

In order to provide adequate design margin, a 500 feet high stack, measuring 20 feet in diameter, is required to handle the combined 1.1 million CFM design flue gas flow from Units 3 & 4. The stack exit velocity would be 60 feet per second.

4.0 REVIEW OF COST ESTIMATES AND SCHEDULES

The most recent cost estimate and construction schedule for the conversion of the Danskammer Plant were prepared in 1978 by Gibbs & Hill. This information was prepared for CHG&E as part of Gibbs & Hill's re-evaluation study of the conversion of Units 3 & 4 to coal firing. The total estimated cost for reconversion of Units 3 & 4, in third-quarter 1978 dollars, was 42.3 million dollars. This estimate does not include CHG&E's home office expenses, interest during construction and escalation. This estimate assumed that an FGD system would not be required and that trucks would be used to transport ash to the disposal area.

The total time required for licensing, engineering, equipment procurement and construction was estimated by G&H to be 45 months. G&H estimated that a five month outage would be required for completion of construction in Unit 3 and a four month outage would be required for completion of construction in Unit 4.

In 1977, EBASCO Services was retained by CHG&E to evaluate the conversion of Units 3 & 4 to coal firing. EBASCO's total estimated project cost for reconversion of Units 3 & 4 in first-quarter 1977 dollars is 84.1 million dollars. This estimate includes interest during construction and escalation, and was based on starting the project in June, 1977, and initial coal firing in June, 1980. EBASCO's conversion study assumed that an FGD system would be required and the cost of the system is included in the estimate. EBASCO's estimate includes the cost of a pipeline to the quarry for ash and sludge transport and the cost of treatment facilities at the quarry.

EBASCO estimated the total time required for licensing, engineering equipment procurement and construction to be 37 months. No estimate was made of the outage time required for Units 3 & 4 to complete construction.

In order to determine current equipment lead times and prices, manufacturers of the major equipment required for coal conversion were contacted by AMAF. Estimated delivery and installation times were provided for the following equipment, as noted below:

Ash Handling Equipment	15 to 18 months
Precipitator	22 to 28 months
Stack	20 to 24 months
Baghouse	14 to 18 months
FGD System	24 to 36 months

The time period indicated above reflects the total time required between award of a purchase order and completion of equipment erection at the site. The lead time required for any piece of equipment is subject to change depending on market conditions. Due to the number of plants currently being evaluated for conversion to coal, it is recommended that the longest time indicated for each piece of equipment be used for any new construction schedules.

Based on the lead times listed above, AMAF estimates that reconversion of Units 3 & 4 will require 45 months for detailed engineering and construction. An additional 6 to 12 months would be required for

licensing activity prior to the start of detailed engineering. The need for an FGD system must be resolved prior to the start of detailed engineering in order to avoid delays in project completion.

Current (first quarter, 1980) equipment budget prices were obtained for the following equipment, using design conditions noted in Section 3 of this report:

Precipitators	\$6.1 million
Stack	2.1 million
Baghouses	6.3 to 6.8 million
FGD System	12.0 to 15.0 million

Review of the G&H estimate indicates that the cost of the precipitators has increased from \$2.8 million to \$6.1 million. This represents an apparent doubling of price by the same manufacturer since October, 1978. No increase in price was quoted, however, for the new stack. AMAF believes that a more accurate estimate of the current cost of the conversion may be obtained by taking the total estimated cost of the project quoted in the G&H report and escalating the cost at a rate of 12% per year. The estimated March, 1980 cost for the project as outlined in the G&H report should be increased from \$42.3 million to \$50.3 million. As noted in the G&H report, GHG&E's home office expenses, interest during construction, and escalation are not included. With the current inflation rate and cost of money, the amounts of money required for interest and escalation will represent a substantial addition to the estimated \$50.3 million direct project costs.

In the event that an FGD system is required, an increased direct project cost of \$40 million would be incurred with additional amounts of money required for escalation and interest.

APPENDIX A

CALCULATIONS

CALCULATIONS

1. Size and Area of Coal Pile

Assumptions

60 days storage

Coal Heating Value - 12,000 Btu per pound

Boiler Heat Input

- a. Unit 3 = 1238×10^6 Btu per hour
- b. Unit 4 = 2125×10^6 Btu per hour

Bulk Density of Compacted Coal = 60 lbs per cubic foot

Transmission line clearance limits coal pile height to 30 feet.

$$\begin{aligned}\text{Total Heat Input} &= 1238 \times 10^6 \text{ Btu/hr} + 2125 \times 10^6 \text{ Btu/hr} \\ &= 3363 \times 10^6 \text{ Btu/hr}\end{aligned}$$

$$\begin{aligned}\text{Coal Storage Required} &= 3363 \times 10^6 \frac{\text{Btu}}{\text{hr}} \times \frac{1 \#}{12,000 \text{ Btu}} \times \frac{24 \text{ hr}}{\text{day}} \times 60 \text{ days} \times \frac{1 \text{ ton}}{2,000 \#} \\ &= 201,780 \text{ tons}\end{aligned}$$

Total Area Required for Storage Pile

$$\begin{aligned}&= \frac{201,780 \text{ tons} \times 2,000 \#/\text{ton}}{60 \#/\text{ft}^3 \times 30 \text{ ft}} = 224,200 \text{ ft}^2\end{aligned}$$

Allowing 10% extra for sloping sides of pile,

$$\text{Area required} = 224,200 \text{ ft}^2 \times 1.10 = 246,620 \text{ ft}^2$$

2. Settling Pond Capacity & Dimensions

Assumptions

Coal Pile Drainage Area = 250,000 ft²

Storm Design Frequency = 10 years

Storm Duration = 1 hour

Peak Runoff Determined
from Bureau of Public
Roads Runoff Chart, which
is reproduced on the next
page

$$\text{Coal Pile Drainage Area in Acres} = \frac{250,000 \text{ ft}^2}{43,560 \text{ ft}^2/\text{acre}} = 5.74 \text{ acres}$$

$$\text{Coal Pile Runoff} = 1.0 \times 0.8 \times 29 \text{ CFS} = 23.2 \text{ CFS}$$

$$\begin{aligned} \text{Total Runoff in One Hour} &= 23.2 \frac{\text{ft}}{\text{sec}} \times 3600 \frac{\text{sec}}{\text{hr}} = 83,520 \text{ ft}^3 \end{aligned}$$

$$83,520 \text{ ft}^3 \times 7.48 \frac{\text{gal}}{\text{ft}^3} = 624,730 \text{ gal}$$

Track Hopper Sumps

Based on 50 cars per train, each car measures 10 feet X 50 feet
Cars receive 2" of rain in transit

$$\text{Water collected} = 50 \text{ cars} \times 50 \text{ ft} \times 10 \text{ ft} \times \frac{2 \text{ ft}}{12} = 4,166 \text{ ft}^3$$

$$4,166 \text{ ft}^3 \times 7.48 \frac{\text{gal}}{\text{ft}^3} = 31,162 \text{ gal}$$

7-18. Bureau of Public Roads Chart. The Bureau of Public Roads analyzed flood-frequency reports published by the Soil Conservation Service based on runoff records from small agricultural watersheds. The result was a runoff chart useful for watersheds up to 1000 acres in size. The chart (Fig. 7-3) includes factors to adjust peak runoff for land use, rainfall intensity, and frequency. Fig. 7-3 must be used with caution, since some of the factors are tentative and subject to change; revisions of the chart are to be expected. It will be noted that the chart is not applicable to the western portion of the United States.

7-19. The Rational Method. One of the most common methods of estimating runoff from a drainage area is the rational method. Its popularity is due to the fact that it combines engineering judgment with calculations made from analysis, measurement, or estimation. The method is based upon the direct relationship between rainfall and runoff, and is expressed by the equation

$$Q = CIA \quad (7-2)$$

where Q = runoff, in cubic feet per second

C = a coefficient representing the ratio of runoff to rainfall. Typical values of C are given in Table 7-1

I = intensity of rainfall, in inches per hour for the estimated time of concentration.

A = drainage area in acres. The area may be determined from field surveys, topographical maps, or aerial photographs

In view of the preceding discussion of the many variables involved in the rainfall-runoff relationship, shortcomings of this method are apparent. Application of the method should be confined to relatively small drainage areas (up to 1000 acres, according to some authorities).

TABLE 7-1

COEFFICIENTS OF RUNOFF TO BE USED IN THE RATIONAL FORMULA

Type of Drainage Area	Coefficients of Runoff, C
Concrete and bituminous pavements	0.70-0.95
Gravel or macadam surfaces	0.40-0.70
Impervious soil	0.40-0.65
Impervious soils, with turf*	0.30-0.55
Slightly pervious soils*	0.15-0.40
Pervious soils*	0.05-0.10
Wooded areas (depending on slope and cover)	0.05-0.20

* For slopes from 1 to 2 per cent.

RAINFALL FACTOR (RF): See Figure 7-3 (b)

EXAMPLE

FREQUENCY FACTORS (FF)

Frequency, years	5	10	25	50
Factor	0.6	0.8	1.0	1.2

100 acres near Nashville, Tenn.,
design frequency 10 years

Solution: (see equation on graph)
 $Q_{10} = 1.2 \times 0.8 \times 190$
 $= 180$

ACCURACY OF BASIC DATA DO
NOT JUSTIFY CARRYING MORE
THAN TWO SIGNIFICANT FIGURES
(a)

Fig. 7-3. Peak rates of runoff from small watersheds in eastern and middle western area of the United States. (Courtesy Bureau of Public Roads.)

2. Settling Pond Capacity & Dimensions (continued)

Crusher Bldg. Sump

Intermittent stream, estimated to average 10 GPM

$$10 \text{ GPM} \times 60 \frac{\text{min}}{\text{hr}} \times 24 \frac{\text{hr}}{\text{day}} = 14,400 \text{ gals}$$

Total Settling Pond Capacity

$$624,730 \text{ gal} + 31,162 \text{ gal} + 14,400 \text{ gal} = 670,292 \text{ gal}$$

USE 700,000 GAL FOR DESIGN

Basin Dimensions

$$700,000 \text{ gal} \times \frac{1 \text{ ft}^3}{7.48 \text{ gal}} = 93,583 \text{ ft}^3$$

Assume a basin depth of 10 feet

$$\text{Basin Area} = \frac{93,583 \text{ ft}^3}{10 \text{ ft}} = 9,358 \text{ ft}^2$$

Use 94 ft X 100 ft for initial siting work. Adjust basin dimensions to suit site conditions

3. Ash Settling Pond Capacity & Dimensions

Assumptions

Total estimated water flow to settling pond is 900 GPM and is based on removal of ash once per hour

One day retention time

Pond is used for bottom ash system only

20% extra volume allowed for sludge buildup

Pond Capacity

$$\text{Water volume} = 900 \frac{\text{gal}}{\text{min}} \times 60 \frac{\text{min}}{\text{hr}} \times 24 \frac{\text{hr}}{\text{day}}$$

$$= 1,296,000 \text{ gal}$$

$$1,296,000 \text{ gal} \times \frac{1 \text{ ft}^3}{7.48 \text{ gal}} = 173,262 \text{ ft}^3$$

Sludge volume = 20% of water volume

$$= 173,262 \text{ ft}^3 \times .20 = 34,652 \text{ ft}^3$$

$$\text{Total pond capacity} = 173,262 \text{ ft}^3 + 34,652 \text{ ft}^3 = 207,914 \text{ ft}^3$$

Basin Dimensions

Assume A basin depth of 10 feet

$$\text{Basin area} = \frac{207,914 \text{ ft}^3}{10 \text{ ft}} = 20,791 \text{ ft}^2$$

Use 100 ft X 200 ft for initial siting work. Adjust basin conditions to suit site conditions