CO-FIRING RDF AND COAL — AN UPDATE ON RESOURCE RECOVERY IN MONROE COUNTY

DONALD H. GRAHAM AND JOSEPH E. MACKEY, JR.
CH2M HILL, INC.
Rochester, New York

ABSTRACT

Monroe County completed another significant goal in their program of resource recovery by initiating the co-firing program at Rochester Gas & Electric’s Russell Station. Construction of the RDF handling facility is complete and modifications to the coal-fired boilers are underway.

This paper will discuss the financial, economic, and technical elements of this co-firing program. The point of view of the authors is that of a management consultant, working for Monroe County and coordinating with Rochester Gas and Electric Company during construction and testing of the receiving facility.

The topics discussed in this paper are the framework formed to contain the project as technical, financial, and economic issues direct the progress of the cofiring program.

INTRODUCTION

The Monroe County-Rochester Gas and Electric Company Coal/RDF Co-firing Program grew out of the original Monroe County Comprehensive Solid Waste Management Program, adopted by the County in 1973. A marketing study, including conceptual design, was completed by a division of Hercules Corporation (later to be acquired by CH2M HILL, Consultants) in 1977.

A contract was awarded to Raytheon Service Company for design and construction supervision of a 2,000-ton/day resource recovery facility (MCRRF), which began processing material in September 1979.

The County maintained control of the original of the program, through its Department of Solid Waste and their management consultants, CH2M HILL. An agreement was signed by Rochester Gas and Electric Company in 1976 to co-fire the RDF product provided at MCRRF in the existing coal boilers at their Russel Station plant. The development of this agreement into a working co-firing program is illustrated in this paper.

TASK ASSIGNMENTS

The various aspects of the cofiring program can be divided into three categories of responsibilities or tasks: User, Producer, and Consultant.

User tasks are typical for most fossil power generating stations:
1. Receive, handle, burn the fuel product (RDF and coal).
2. Conduct quality control functions on fuel received.
3. Effectively manage pollutants and contaminants.

The tasks of the Producers are less typical, due to the nature of the products:
1. Produce as high a purity of RDF and other products as technically and financially possible.
2. Perform accountable quality control activities, to document product compliance to preset standards.
3. Generate revenue, to support operating costs.
and occasionally reimburse capital costs.

The tasks of the Consultant are varied and often unconventional:
1. Assist in the evolution of revenue gathering criteria or "payment formulae."
2. Provide technical expertise on legal agreements.
3. Referee quality control samples and results.
4. Referee the accounting of cost sharing activities.
5. Provide coordination of the overall Solid Waste Program.
6. Analyze operations and maintenance activities required at both user and producer facilities (involved with cofiring RDF/coal) and coordinate specific instructions between plant personnel.
7. Coordinate and witness contractor functional tests of equipment and designer acceptance tests of the process itself.
8. Organize and conduct operator training activities.
9. Monitor, record, and later account for operating and maintenance expenses with cofiring.
10. Referee qualitative tests on cofiring the various fuel mixtures (coal and RDF).
11. Perform a technical and economic evaluation of the producer and user facility operations.
12. Recommend and evaluate the modifications necessary to the user and producer facilities.
13. Monitor environmental effects of the cofiring program.

It is important to note that the above tasks should be performed by a neutral third party, one which both the User and Producer feel comfortable with, especially in referee roles.

USER RESPONSIBILITIES

Rochester Gas and Electric began assessing their responsibilities to the cofiring project immediately after the 1976 agreement was signed. The general task of receiving, handling, and burning the new fuel mixture was addressed by their role as project engineers for the Russell Station handling facility design work (see Fig. 1). All aspects of the design were reviewed and approved by RG&E.

Careful consideration was given to facility layout, equipment selection, community relations, and methods of operation. The interface between existing boiler control and the new Atlas storage bin and feed system was selected to allow dual control areas and discrete boiler load control.
During the development of facility design and operating techniques, the need for advanced boiler grate construction and flexibility in operation surfaced. RG&E embarked upon research at other co-firing installations and hired the services of a boiler consultant for their facility. A series of tests are being conducted, to establish boiler performance, additional modifications required, and, most importantly, define a maximum allowable mixture percentage of coal and RDF.

The question of quality control also evolved during the facility design and construction period. Unfortunately, RDF is a difficult material to test and even more difficult to control in quality. Routine tests of key parameters are performed at MCRRF. The problems with material changes during packaging, shipment, and unloading, plus the difficult task of field testing at Russell Station, led RG&E to define certain criteria as key elements to accepting or rejecting incoming material as fuel (see Table 1). The parameters identified are moisture, heat value, and ash content, all of which affect boiler performance and appear least affected by the shipping methods envisioned. The final User task of pollutant and contaminant control was anticipated by RG&E both before and during the receiving facility design phase. Electrostatic precipitators are installed to handle normal fly ash materials in the boiler stack gases. RDF is not expected to seriously overload or compromise their effectiveness. Baghouse collectors are installed on the RDF transport and storage systems to control particulate emissions. An upgrading of the wastewater treatment plant, to handle boiler ash removal slurry water, was performed in 1979, with provisions for the increased load from RDF firing.

**PRODUCER RESPONSIBILITIES**

Monroe County anticipated sales of RDF to customers, such as RG&E, from the onset of their Solid Waste Program. Therefore, laboratory test facilities were included in the MCRRF design. Raytheon Service Company, the designer and operators of the facility, have remained active in the American Society for Testing and Materials (ASTM) committee activities, oriented towards establishing and standardizing test methods for RDF and other recovered products.

The first responsibility of the County is to produce a quality RDF on a reliable basis. Testing on the facility has progressed since late 1979 and a sustainable rate of 500-1000 tons per week of RDF is now being produced. The method of delivery, to RG&E and other customers, is enclosed transfer trailers.

As mentioned above, the task of accountable quality control was begun as personnel were assigned to test materials as soon as functional tests began in 1979. During the months of facility testing, hundreds of samples were analyzed in order to establish repeatability and afford an opportunity to improve methods before actual Producer records were compiled during the co-firing period (see Figs. 2a and 2b). Referee samples are now taken, by RG&E at MCRRF, to verify compliance to specifications and to provide information on the Raytheon tests.

Revenue gathering at MCRRF is performed in a variety of ways. Tipping fees are charged, via a computerized scale system at the tipping area. Revenue from bulk products (glass, ferrous, aluminum) is paid on a current market average basis. The costs to RG&E for purchase of RDF are based upon a fuel formula, which will be discussed later. Basically, the replacement heating value of RDF to coal, minus certain factors, represents the income from the product. All product sales are recorded on the County computer, as are operation and maintenance costs. The ability of the facility to sell products depends, naturally, on demand, quality, and reliable production.

### TABLE 1 PRODUCT SPECIFICATIONS*

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ash Content</td>
<td>17 percent (maximum)</td>
</tr>
<tr>
<td>Moisture Content</td>
<td>25 percent (maximum)</td>
</tr>
<tr>
<td>Heating Value</td>
<td>5000 btu/lbm (minimum)</td>
</tr>
<tr>
<td>Particle Size</td>
<td>100 percent &lt; 1 in. (2.54 cm)</td>
</tr>
<tr>
<td>Sulphur Content</td>
<td>0.4 percent (by weight)</td>
</tr>
</tbody>
</table>

**Rejection Criteria**

1. Sustained deviation from any parameter for two consecutive weeks.
2. Observable white goods, raw garbage, metals present in transfer trailers.

**Requalification Criteria**

1. Successive two-day, multi-sample compliance to all parameters.
2. Two week probation period, where deviation from previously failed parameter causes immediate rejection and restart of probation period.
3. Verification of MCRRF tests with RG&E tests on referee samples.

* Based on as-received basis.
MANAGEMENT CONSULTANT TASKS

The tasks assigned to the management consultant are often those he is specially qualified to perform or those of a sensitive nature (in respect to the User's or Producer's involvement). Many items are completed to a point where specific involvement from the Users and/or Producers is required.

The payment formula is a case in point. The specific details of each condition considered in this formula have been negotiated with the User and the Consultant. Final review and acceptance is made by both the User and Producer. Specific conditions to the Monroe County situation are fuel replacement value, additional maintenance, effects on the boiler (its performance and on the station's availability), transportation costs, and other factors.

Legal agreements are another area of Consultant responsibility. Legal representatives from the User and the Consultant draft sections or schedules to the base agreement. In the case of RG&E and Monroe County, ten such schedules were formulated under this process, ranging from general conditions to RDF specifications, fuel formula inputs, and compensation for engineering services.

RDF Analysis

<table>
<thead>
<tr>
<th>Laboratory No.</th>
<th>Production Lot No.</th>
<th>Production Date</th>
<th>Sample Date</th>
<th>Sample Location(s)</th>
<th>Customer(s)</th>
</tr>
</thead>
</table>

RDF Particle Distribution

<table>
<thead>
<tr>
<th>Sq. Mesh Screen</th>
<th>WT% Passing</th>
</tr>
</thead>
<tbody>
<tr>
<td>4&quot;</td>
<td></td>
</tr>
<tr>
<td>2&quot;</td>
<td></td>
</tr>
<tr>
<td>1&quot;</td>
<td></td>
</tr>
<tr>
<td>3/4&quot;</td>
<td></td>
</tr>
<tr>
<td>1/2&quot;</td>
<td></td>
</tr>
<tr>
<td>1/4&quot;</td>
<td></td>
</tr>
<tr>
<td>1/8&quot;</td>
<td></td>
</tr>
<tr>
<td>20 Mesh Pan</td>
<td></td>
</tr>
</tbody>
</table>

Composition Analysis

<table>
<thead>
<tr>
<th>As Rec'd</th>
<th>Dry</th>
<th>Test Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Moisture
- Volatiles
- Fixed Carbon
- Sulfur
- Chlorides
- Ash Fusion
- Fusion Residue
- Density (lb/cu ft)
- BTU/lb
- BTU/lb (MAF)
- Metal Contaminants

Comments: ____________________________

FIG. 2a

FIG. 2a
This area is discussed in greater detail in a later section of this paper.

The impartial evaluation of test samples is a task specific to a third party (consultant). This evaluation is a basis for several legal and operational agreements as well as necessary information required for the co-firing program in general. Using approved procedures (e.g., ASTM E38), both User and Producer apply similar test methods to RDF product being shipped for burning. The Producer uses representative sampling techniques, applied to all stages of production. The User uses specific tests on random samples, shipped to the receiving area with the rest of the normal shipment. A mechanism was required to allow for the possibility of a poor sample without mandatory halt of fuel products. The solution became a preset tolerance to specifications, time for recheck of a suspected quality violation, and a suspension period to require requalification of the product to specification.

The same referee activity is required in relation to shared-cost accounting. For this project, legal agreements allow for protection of both parties against certain shared costs overruns. A close accounting of engineering, operations, and maintenance cost is required to settle accounts later in the project. Both Monroe County and RG&E have definite financial limitations to their involvement in the co-firing project.

The Consultant performs a task he is usually well suited for in maintaining a schedule of key events for the program, and detailed schedules of construction, startup, or special tests that are a part of the program. One such special test is the Evaluation Program, organized by RG&E and funded under grants and some cost sharing by RG&E and Monroe County. A detailed schedule is required, to allow timely completion of several events planned during actual firing tests of the boilers with RDF.

Operations and maintenance costs are funded by both User and Producer. Therefore, the Consultant must track and recommend changes, when

### RDF Process Variables

| Raw Waste Received | (Date) |
| Climate Conditions |       |
| Temperature (Ambient) | °F |
| Precipitation-Days Prior | "1 day |
| Rain/Snow | "2 day |
|            | "3 day |

| Process Operating Lines A/B |
| Infeed Rate (Ave) | TPH (A) |
| A/C Setting |       |
| RDF A/C Split |       |
| No. of Lot Samples |     |
| Gross Sample Lot | lbs |
| No. Lot Trailer Shipment |       |
| Lot Bill Lading Nos. |       |

**Notes/Comments:**

---

I/We hereby certify that the above results represents the sample herein described.

---

Authorized Signature | Company | Date

---

**FIG. 2b**
required, to satisfy legal agreements. Specific instruction of plant operators is required, due to the special nature of the equipment and outside factors (technical, financial, etc.) that affect operations and performance. A multimedia production was developed to assist in the training of plant personnel at Russell Station. Advantages of such a production are a clear, succinct presentation, ease of repetition to new employees or for retraining purposes, and the additional use of such material in a promotional or public education forum, thereby recovering some expense from the operations/maintenance budget.

Another task well suited for a consultant is developing, coordinating, and witnessing functional and acceptance tests. The contract between the owner and the contractor is usually quite specific concerning equipment “no-load” tests. The equipment at Russell Station is largely supplied by two manufacturers, and the testing is integrated in approach. The acceptance tests reflect the designer’s obligations and the manufacturer’s performance guarantees. A three-step acceptance procedure was dictated for the equipment: (a) a 14-hr continuous run of receiving, transfer and storage equipment; (b) a 24-hr continuous run of live storage and boiler feed systems; and (c) a sustained throughput of 2,500 tons RDF per week for two weeks (6 days/week). The consultant handles logistics (RDF supply, consumption in the boilers, etc.), documentation, approval and recommends modifications (as required) to the system in general.

The referee task of monitoring qualitative tests on co-firing is a third party function that impacts all phases of the program. The specific level of RDF firing depends on plant load handling, emissions release, ash handling, and many other factors.

The consultant also performs technical and economic evaluations of the RDF handling facility, as he is accustomed to performing for other similar facilities. Included in this effort are planned improvements at the facility, increased manpower, increased consumption of RDF (many facilities, such as Russell Station, can be expanded), and compliance to new environmental requirements.

Environmental monitoring is another area of consultant, rather than owner, expertise and responsibility. Noise, odor, appearance, dust, bacteria and toxins are emissions the User must be concerned with, as they affect public acceptance of the project. Russell Station, for example, is located in a residential area and must be aware of any changes the neighborhood would be exposed to and dislike. Special care was given the appearance of the facility, travel paths of the RDF and ash trucks and the noise levels present at the facility.

Finally, life cycle cost data is gathered and later applied in an analysis, which will forecast sensitive factors impacting the present program, the advisability of proposed changes and the various methods of optimizing future improvements and procedures.

**EVALUATION STUDY**

A mechanism for initiating the operating agreement, after acceptance testing, was developed by Monroe County and RG&E as the Evaluation Program. The primary objective of this study is to establish the maximum practical cofiring levels. Also, baseline data for the fuel formula and other local agreements is obtained.

The evaluation study will:
1. Summarize test results.
2. Identify problem areas.
3. Establish specific requirements to allow cofiring.
4. Provide financial data.
5. Recommend methods of optimizing RDF consumption.

Tests on the receiving and handling facilities include transportation analysis, RDF quality and availability and facility emissions. Tests on Russell Station include boiler emissions and boiler performance. Also, general examination of plant site aesthetics, personnel exposure to safety & health problems, equipment reliability and public reaction to the co-firing program are being conducted.

Assumptions made during this study are: (1) existing federal, state and local regulations govern operating conditions of the plant; (2) the study objectives are fluid and subject to change; and (3) it is possible that recommendations not to co-fire RDF may result and delay the co-firing program indefinitely.

Data being collected during this study will be used as a basis for data collection and economic projections of the co-firing program, as described in the following sections.

**DATA COLLECTION**

A management information system (MIS) is being utilized to track data, primarily cost information, during the entire program.

Perhaps the most important variable recorded is
RDF tonnage, or fuel replacement values in BTU's. This inputs directly to the fuel formula and dictates further operating and usage trends at the facility.

Energy costs, operator salaries and maintenance costs, for the facility are important to life cycle costing, cost sharing and overall performance of the program.

Equipment running times and monthly throughput is recorded and scheduled maintenance performed when required. Also, analysis of equipment-assigned down time, maintenance costs and productivity will be made and input to acceptance test evaluations and warranty claims.

The MIS system also tracks revenues, debt service costs and capital investment costs. Naturally, the last category is large and represents most of the construction costs: (a) general building; (b) mechanical equipment; (c) electrical equipment; (d) engineering; and (e) start-up and test programs. The value of accurate cost records appears as late changes to the facility become necessary or advisable. Analysis of to-date expenditures will reveal the true proportions of such an additional expense.

**ECONOMIC PROJECTIONS**

As discussed earlier, life cycle cost analysis and other projections will assist in evaluating the present program and future changes to the program.

Inputs to the analysis are capital investment costs, operations and maintenance costs (fixed and variable), annual revenues, discount and inflation rates and sensitivity parameters. The MIS system can easily trap actual (and forecast) capital and O&M costs. Discount and inflation rates are peculiar to the User and Producer, which in this case are a utility and a municipal government. Annual revenues reflect RDF sales and deducts per the fuel formula. Fixed O&M costs are employee salaries, stock materials, facility maintenance costs, etc. Variable costs include power consumption, technician salaries, equipment maintenance, vehicle maintenance, etc.

Sensitivity parameters include variations to the discount and inflation rates, special discounts possible in the fuel formula, improvements to equipment that reduces variable O&M costs, etc.

**LEGAL AGREEMENTS**

A basic agreement was formed in 1976 to support the co-firing program. Two subsequent agreements were developed to support specific details of the program.

The basic agreement established the following criteria:

1. Producer obligations for processing and transporting the fuel product for co-firing at User boilers.
2. Producer obligations for developing a receiving, handling and delivery facility at the powerplant for the fuel product.
3. User obligations to burn the fuel product in the station boilers.
4. Producer and User responsibilities of disposal of residuals from the combustion process.

From these criteria, the Producer, User and Consultant tasks were formed. Monroe County built the recovery plant (MCRRF) and the receiving and handling facilities. RG & E modified the powerplant systems to allow combustion of the fuel product. Both parties agreed to an Evaluation Program, which establishes specific criteria for burning the RDF fuel product.

The second agreement concerns land use at the powerplant for siting and operating the receiving and handling facilities. The User agreed to provide access and a suitable location on a long-term lease basis.

The third agreement developed conditions under which the receiving and handling facilities will be operated and maintained. This agreement assigns O&M to the User, at the expense of the Producer. Operations personnel are provided by the User.

Design of the receiving facility was awarded to Raytheon Service Company. Construction management services were awarded to the Program Consultants, CH2M HILL. Design completed in 1978; contracts were awarded to two equipment systems vendors, for the handling and live storage systems, and to several general contractors.

Two key issues of the basic agreement are the fuel payment formula and fuel specifications. The basic agreement establishes the parameters of fuel quality, mentioned elsewhere in this paper. Two specific concerns of fuel quality are particle size and ash content.

The fuel payment formula (see Fig. 3) is based upon established coal costs, less certain fixed and variable costs. Input from the Evaluation Program will establish fuel burn rates and operating expenses; the increased administrative and general expenses to the user will be applied to the formula. Also, an annual capital recovery charge, or return of capital, is applied for modification costs required to the station. Finally, a charge for station usage, solely
Fuel = RDF Cost - \{C + M + O + A + PE + PC\}

Payment

RDF Cost = Market Price of Coal, Adjusted for RDF Heating Value
C = Return of Capital Charge
M = Maintenance Cost Factor
O = Operating Cost Factor
A = Administration/General Expense Factor
PE = Station Use Charge
PC = Coal Purchase Penalty Charge

Example

RDF Production = 150,000 tons/year
RDF Cost = $19.00/ton ($0.79/MMBTU)
C = $0.28/ton ($3,000,000 @ 12%, 20 years)
M = $1.50/ton
O = $5.00/ton
A = $0
PE = $0
PC = $0

Fuel = 19.00 - \{0.28 + 1.50 + 5.00 + 0\}
Payment = $12.22/ton

FIG. 3

to support the cofiring program (rather than purchase of economical power from other sources) will be applied if ever necessary. This last charge could include station derating, forced outages, or other similar effects, due to co-firing. The philosophy of this portion of the agreement is to establish a no-loss, no-gain situation for the User and their rate payers.

A mechanism for resolving disputes to the above agreements was provided for in the base agreement. A Board of Final Review was established as a definitive authority to settle disputes. Prior to convening this board, both parties are required to exercise reasonable efforts to work out problems in a cooperative manner. This would include rescheduling fuel deliveries, modifying fuel specifications, alteration of equipment, etc. Historical plant data, Evaluation Program test results, station functionability and similar criteria will be used to judge the co-firing program performance.

The Board of Final Review, made up of a User advocate, Producer advocate, and neutral third party, has been charged to reflect on three basic issues, in determining resolution to a particular dispute:

1. Intended technical and economic abilities of both parties towards the program at its present state.
2. Significant detrimental effects imposed on the powerplant and alternative remedies.
3. Contravention of environmental laws, at any fuel consumption level, with the present system design.

BOILER TESTS

The responsibility for developing and conducting the boiler tests at Russell Station belongs to Rochester Gas & Electric Company. Prior to actual boiler tests, the Evaluation Program will conduct logistical tests on the receiving, handling, storage and boiler feed systems. This evaluation period will identify potential station problems and allow the boiler tests to proceed with advance knowledge of special operating problems and limitations.

The performance parameters monitored during the boiler tests include:

1. Fuel characteristics.
2. Combustion air and flue gas analysis.
3. ASME efficiency test data.
5. Ancillary equipment operating data.

Fuel characteristics include ultimate analysis of coal and RDF, ultimate analysis of ash, chemical analysis of ash, RDF composition analysis, RDF sizing analysis, acid/base ratio test and slagging/fouling indices for both coal and RDF.

Combustion air tests include excess air measurements and temperature tests. Flue gases are analyzed for precipitator performance and constituent content as well as temperature.

The ASME power test code PTC/4.1-1979 will be applied for the first time to the Russell Station boilers. Preparations to support this test included installation of gravimetric feeders, additional indicating devices and revised methods of inventory control in the coal handling yard.

In addition to the ASME tests, individual heat and energy balances will be conducted for major equipment items. Operating data for ancillary systems will be recorded to account for any unforeseen effects the co-firing program may have on the station systems.

DISCUSSION

Performance tests for the receiving facility and station boilers are now being conducted. RDF is being fired in all four boiler units of Russell Station, including Boiler #3 which has been equipped with bottom dump grates. Operation of the RDF receiving and conveying system has gone smoothly, with only minor blockages and instrument adjustments required. Performance of the 1,700-ft (518 m) pneumatic transport line has been quite satisfactory, despite two changes in elevation and several bends in the pipe configuration. Tests are underway to measure wear in both the transport line and boiler feed lines.

At present, a staff of six people is utilized in operating the receiving/handling equipment. This includes a manager, foreman, equipment operator, yard hand, truck operator and mechanic. Environmental effects appear negligible at this time and community acceptance of plant operations and the program in general is good.

Current capital cost for the program at this time
is $15 million: $12 million from Monroe County for receiving/handling facilities and $3 million from Rochester Gas & Electric for boiler, feed system and station improvements. The evaluation program, estimated at $2 million, is underway and will continue into 1984. Funding for this project is also being provided by Empire State Energy Electric Research Company (ESEERCO), and New York State Research and Development Agency (NYSERDA).

**Key Words**

Combustion
Environment
Life Cycle Costing
Public Utility
Refuse Derived Fuel
Utility Boiler