# 8. Energy Recovery

The objective of this task is to characterize Pre-Processing System residuals for potential energy recovery and to identify potential energy markets for this material. Process residual materials with potential for energy recovery would be organic materials that have a low percentage of inert materials and moisture content. The Project Team researched cement kiln operators in the region in order to identify parameters for residuals that would be suitable for use as cement kiln fuel.

## 8.1 Recovery of RDF from the Pre-Processing System

Based upon the preliminary conceptual Pre-Processing System layout and Mass Balance developed and presented in Chapter 7 of this Report, RDF feedstock would be generated through the process described below. This feedstock would be produced as a result of processing incoming mixed waste and residue from the existing MRF through the Pre-Processing System.

Approximately 46 TPD of RDF could be generated through the Pre-Processing System, see Chapter 7. This material would be derived from the plus 9-inch primary trommel overs stream which would transfer across sorting stations for manual removal of OCC, mixed paper, film bags and reject materials. After sorting, the material would be conveyed to a slow speed shredder for reduction to a nominal 4-inch particle size, RDF material. After shredding, the 4-inch material would then be transferred by conveyors to a disc screen which would remove the minus 3/8-inch fraction superfines material. This material would have a low heating value and would include broken glass and other small inert materials.

Overs material from the disc screen would be a lighter and dryer material of primarily fiber and plastic materials and would have a more desirable heating value as a result of lower moisture. This material would be fed to a de-stoner to remove any remaining metals, rocks, stones, and broken glass from the feed stream to improve the fuel quality. The “heavies” stream from the de-stoner would be conveyed to a roll-off container for later transport to the landfill.

The “lights” material stream from the de-stoner would be conveyed past an overhead electromagnet for ferrous removal and then through an eddy current separator (ECS) for non-ferrous metals removal. Following ferrous and non-ferrous metal removal, the remaining fuel feedstock material would be stockpiled for marketing to fuel customers. A second shredder could be utilized to further reduce the final fuel to a size of 2 inches or smaller, depending upon the fuel specifications from the fuel customer.

In addition to the approximate 46 TPD of RDF that could be produced, approximately up to 18 TPD of large pieces of wood and tree limbs could be diverted from the Pre-Processing System off-site for further processing, such as a grinding operation, which would make the wood useful for RDF or as a bulking agent for composting. This could result in a total of approximately 60 to 65 TPD production of RDF fuel feedstock.

The RDF produced by the Pre-Processing System could potentially have the approximate composition and BTU values presented in Table 8-1. It must be noted that these values are preliminary estimates and further study, as discussed later in this chapter, would be required to establish the actual characteristics.

**Table 8-1 – Estimated Composition and Heating Content of RDF**

| Material | Approximate Heating Content, BTU/lb. | Potential Portion by Weight of RDF, % | Contribution to Heating Content, BTU/lb. |
|---|---|---|---|
| Paper | 8,000 | 50 | 4,000 |
| Wood | 8,000 | 20 | 1,600 |
| Plastic | 14,000 | 20 | 2,800 |
| Inorganic | 0 | 10 | 0 |
| **Total** | | | **8,400** |

## 8.1 Cement Kiln Opportunity

RDF (Refuse Derived Fuel) has different meanings for each user; so long as the waste material was derived from MSW it can be considered RDF. The heating values of the different components in MSW vary greatly. The proposed conceptual design for the Mojave Pre-Processing System includes an extensive effort to remove recoverable inerts (dirt, rocks, stones, metals, etc) and organics which will result in a higher BTU value than most RDF plants that use residential waste as an input.

More study would be needed to determine the expected heating value from Mojave's new facility but certainly it should exceed 8,000 BTU per pound. Past work by RRT has included the blending of certain industrial plastics and rubber to further increase these energy values. However, these materials were not found or specifically identified during the waste studies. They would need to sourced, processed and blended. All this would be the subject of further study should the recommendation be to proceed with the cement kiln industry as the RDF market.

The following sections summarize discussions held with four cement kiln operators:

- CEMEX – Rick Haverland (937) 609-8745
- Mitsubishi – Bub Biggs (760) 774-6883
- TXI – Steve Arment (760) 245-5321
- GeoCycle – Jade Baker (801) 821-6145

### 8.1.1 CEMEX

Mr. Rick Haverland, a senior project engineer based in the company's Ohio location, is familiar with the use of RDF, having been involved in various projects for approximately the past 30 years. CEMEX is a New York Stock Exchange firm, headquartered in Monterey, Mexico. The company's sales in 2007 exceeded $21 billion, and net income exceeded $2.4 billion.

CEMEX operates several cement kilns across the U.S., including the twin kiln operation in Victorville. The company regularly uses RDF in its kiln operation in Pennsylvania. Feedstock for that plant includes a combination of processed industrial wastes and on

occasion residuals generated by a local Materials Recycling Facility which processes municipal recyclables. The resulting RDF product includes a higher proportion of plastics than would be expected from RDF produced from mixed waste. The effect on heating value is that the RDF falls within a range of 10,000 to 13,000 BTU/lb. The Pennsylvania facility regularly uses RDF as part of its fuel supply, however, the kiln is shut down during the winter of 2009 for inventory control, reflecting the effects of the U.S. recession.

CEMEX has an aggregate plant located on Black Mountain Quarry Road in Apple Valley and a cement plant on North E Street in Victorville. The Victorville plant has three kilns and is the company's largest plant in the U.S. While currently running two kilns, this facility burns a maximum of 50 tons per hour (TPH) of coal. Addition of RDF at the rate of 65 TPD equates to less than 3 TPH, or about six percent of total fuel input.

If CEMEX were to use alternative fuels, they ideally would prefer a mix of RDF approaching 20 percent of total fuel input, roughly 10 TPH of alternative fuel for the Victorville kilns in order to make the project viable. The potential of the conceptual designed Pre-Processing System to provide only 65 TPD of the company's desired 240 to 480 TPD of alternative fuel would not, however, pose a fatal flaw to the project. CEMEX has had discussions with other suppliers of alternative fuels, including Burrtec Industries, and possibly others. CEMEX believes that the higher rate is needed to make an alternative fuels system economically viable.

CEMEX has a contract with Burrtec for Burrtec to supply wood waste recovered from yard waste collection programs. However the pneumatic feed system that CEMEX implemented at its Victorville kiln cannot handle the relatively high moisture content of the ground wood waste, forcing CEMEX to cease to accept this material. CEMEX would have to implement a mechanical feed system to feed wood waste and RDF. Further concern CEMEX expressed with using RDF produced from MSW is its low density, an issue that would need to be addressed during feed system design activities. Moisture content also affects production rates. An increase in moisture content causes a need to introduce more fuel (and air) into the kiln, and a limit exists on the fuel feed rate by way of air limitation (the kilns are induced draft [ID] fan limited).

Moisture content, density and RDF composition would be the technical issues to address during further investigation efforts. Heating content is not a direct problem, suggesting that heating content of conceptual RDF may be acceptable.

CEMEX estimates the following capital costs for a feed system for the kilns:

- $3 million for a feed system to feed one kiln and store RDF in trucks.
- $10 million for a feed system to feed two kilns and provide a storage building.

CEMEX has considered alternative fuels but in 2009, due to poor economic conditions, the company has had no capital budget for capital expenditures at their facilities for a minimum of two years, the period of softening of markets for the company's products, including the low level of production due to the general economic recession during 2009. Mr. Haverland noted that if the JPA was willing to pay for the $3 million to $10 million capital costs needed to accommodate RDF, CEMEX would be more likely to consider using RDF at the California plant in the future.

Another concern of CEMEX is that they do not have a permit to burn RDF. They do however have a permit to burn wood chips. Application for an air permit would have to be sought. Due to the concerns for the production of volatile organic compounds (VOCs) and acid gases from combusting MSW, modification of the company's existing air emission permit or granting of a new permit may require efforts that are greater than that required to obtain a permit to combust segregated wood waste.

CEMEX would require that RDF meet the following specifications:

- Heating Content - 7,000 to 9,000 BTU – Acceptable as long as low moisture content (less than 25 percent).
- Particle size: 2mm X 1 inch x 1 inch.
- 15% maximum ash content.

CEMEX estimated that the value of RDF would be in the range of +$10 per ton to -$10 per ton, based on fuel values in early 2009. The significant range was attributed to the conceptual level of the project at this time.

### 8.1.2 TXI

TXI is a public company based in Texas. The company has capacity to produce nearly 8 million TPY of Portland and other types of cement in operations primarily located in Texas and California. For FY 2008, the company reported net income of $87 million on sales of $1.03 billion.

Mr. Steve Arment indicated that TXI has a cement facility located in Oro Grande, north of Victorville. This facility burns approximately 250,000 TPY of coal, a value that equates to approximately 30 TPH, based on the kilns operating 24 hours per day throughout the year.

The RDF specifications that TXI would require:

- Heating Content - 10,500 BTU/lb, minimum
- No other specification requirements provided

TXI is concerned about confidentiality of their technology. TXI would consider meeting with the JPA or its consultants, however he requested information about our companies (history, references) and requested that we sign a confidentiality agreement. After that was completed, TXI would consider meeting with us to discuss the RDF subject further.

### 8.1.3 Mitsubishi

Mitsubishi Cement, an independent company based in Henderson, Nevada, has capacity to produce 1.7 million tons per year of cement at its Cushenbury facility, located on CA Hwy. 18 in Lucerne Valley. This is the company's only cement kiln operation. The facility has been operating since 1988.

Mr. Bub Biggs indicated they are interested in using RDF as a fuel however they would need to see a specification sheet on the RDF being produced to determine if they would be able to use it. They would also need to perform burn testing in order to determine the emissions for permitting purposes.

They would mix RDF with wood chips that they are currently burning and feed the RDF through their existing feed system.

The RDF specifications that Mitsubishi would require:

- No BTU or RDF size specification requirements provided except that they would want a minimal amount of plastic in the RDF. This was identified as their biggest issue with RDF.

A letter received from Mitsubishi expressing interest in using RDF is presented as Appendix F.

### 8.1.4 GeoCycle

GeoCycle has a cement kiln facility in Morgan, Utah, which is their closest facility to California. At this facility the company burns shredded tires producing over 11,000 BTU.

The company is not familiar with RDF but indicated they would need to review specifications on RDF being proposed to determine if the company would be able to use it. However this company also does not have specification requirements. Costs to transport RDF from the Victorville area to the company's facility, more than 500 miles from Victorville, would be a significant factor detracting from the economics of supplying RDF to GeoCycle.

### 8.1.5 Conclusions Regarding the Cement Kiln Opportunity

Four primary concerns were raised during discussions with kiln operators:

- The rate of production of RDF from the Pre-Processing System would be significantly lower than the demand of the cement kiln operators.

- Heating content desired by each of the operators is somewhat higher than that projected for production from Pre-Processing System residuals. RDF could be produced from mixed waste at approximately 8,400 BTU/lb as presented in Table 8-1. Operators contacted with indicated needs ranging from 7,000 to 9,000 BTU/lb as long as moisture content is below 25 percent (in the case of CEMEX); and up to 10,500 BTU in the case of TXI.

- The permitting aspect of burning RDF was a concern identified by the operators.

- Fuel feed system design requirements on the consumer's side need to be identified.

Given the number of potential users, and the results of discussions with the kiln operators, it is recommended that a detailed study of the potential quality of the RDF that could be produced be conducted prior to further study or conversations with the cement kiln contacts.

### 8.1.6 Next Steps for the Cement Kiln Opportunity

For a test, equipment of the type used to make RDF on a production basis, but on a smaller scale, would be implemented. Such test equipment, often referred to as "Demonstration Level," to differentiate it from laboratory scale equipment, would be constructed near the Victorville Landfill, to receive quantities of material appropriate for producing "test RDF". As the concept includes producing RDF from pre-processing system residuals, methods would be developed to produce RDF that would closely match pre-processing system residuals.

The RDF material produced from test would be shipped in quantities to the cement kiln(s) and the kiln(s) would conduct test burns. Several parameters would be assessed during the test burn: RDF feed properties and problems, combustion properties of the RDF (the contribution to the fuel requirements to meet output needs); air emissions data; the effect on the final product from the kiln, termed clinker; and possibly other parameters. The end-users will require the burn tests and resulting emissions data in order to agree to the use of the RDF product.

In 2003-2004, RRT, a GBB Team member, designed equipment to test RDF in the City of Edmonton, Alberta, Canada. Photographs of equipment for this test are presented below.

**Figure 8-1 - Metal Recovery Equipment, Edmonton, Alberta RDF Demonstration**

**Figure 8-2 - RDF Production Equipment Set Up for Test, Edmonton, Alberta**

Costs of approximately $500,000 were incurred for equipment lease and purchases, installation, and conduct of the test performed over a two-month operating period. Results from this test were successful to the point that they enabled the City of Edmonton to obtain a $30 million grant from the Canadian federal government to assist with capital costs to construct a waste gasification project. A brochure developed to describe this project is included as Appendix G. In 2009, this project is under construction but not yet in operation.

RDF test burns could also be conducted with other fossil fuel combustion systems, such as industrial or utility power plant boilers that burn coal and that have system capability to feed RDF, a low density material (due to high paper content) as an alternative to their existing fuel feed system. This capability must be met with separate fuel feed equipment as attempting to feed RDF in a mixture with coal is not technically feasible, primarily due to disparity in densities between RDF and coal, whether the boiler is combusting pulverized coal (suspension type boiler), or larger coal on a grate system.

## 8.2 Unprocessed Municipal Solid Waste for Direct Thermal Processing

Unprocessed Municipal Solid Waste in the U.S. has a heating value in the range of approximately 4,500 to 5,500 BTU/lb, depending on the amount of paper and plastics and moisture content. Other materials could be added to MSW to increase the heating content and therefore increase the output for the same quantity (in tons) processed each day, such as tires. One project routinely adds tires to increase heating content by 10 to 15 percent[i].

A typical direct thermal processing facility processing 750 tpd of MSW only will produce 500 to 550 KWh per ton of MSW, net of in-plant use of electricity, which would be approximately ten percent of gross electrical energy output. Such a facility would be constructed with a turbine-generator having a rating in the range of 20 MW. The capital cost for such a 750 tpd would be in the range of $170 million (2009 estimate), including development costs. Financing costs, such as interest during construction, and bond issuance costs, would be in addition to those costs.

Larger capacity facilities produce greater electrical output, however, toward the large end of the scale of such plants, approximately 3,000 tons per day, the gross and net output would be 100 MW and 90 MW, respectively, at most, using more costly power cycle elements, such as reheat. Reheat cycles and other possible design features are well proven as they are common in utility power plants in the capacity range of 300 MW and greater; they have not historically been used in facilities in the U.S. but have been employed in recent projects in Europe.

An important consideration among the direct thermal processing facilities described in this subsection is that they are mature technologies. Availability of these facilities is typically greater than 90 percent, that is, if the nameplate capacity is 750 TPD (273,750 tons per year), that the facility would be expected to process more than 246,000 tons per year. Availability at rates less than 100 percent is due to planned and unplanned outages for maintenance and repair, typical of any process plant.

The significant number of facilities operating in the United States, 89, is overshadowed by a greater number used in either of Europe or Japan. More than 70 percent of post-recycling waste generated in Japan is processed by direct thermal processing facilities. Table 8-2 presents a breakdown of U.S. facilities by technology; Table 8-3 presents a summary of direct thermal process facilities used worldwide.

**Table 8-2– Worldwide Population of Direct Thermal Processing Facilities**

| Location | Number of Facilities | Amount of MSW Managed by WTE as percent of Total MSW Generated |
|---|---|---|
| USA | 89 | 8 to 15 percent based on MSW reported by EPA and Biocycle data |
| Europe | 400 | Varies from country to country |
| Japan | 100 | 70 to 80 percent |
| Other nations (Taiwan, Singapore, China, etc.) | 70 | Varies from country to country |

Source: Integrated Waste Services Association

**Table 8-3 – Direct Thermal Processing Facilities in the U.S.**

| Technology | Operating Facilities | Daily Design Capacity (TPD) | Annual Capacity [1] (Million Tons) |
|---|---|---|---|
| Mass Burn | 65 | 71,354 | 22.1 |
| Modular | 9 | 1,342 | 0.4 |
| RDF -Processing & Combustion | 10 | 15,428 | 4.8 |
| RDF -Processing Only | 5 | 6,075 | 1.9 |
| RDF -Combustion Only | 5 | 4,592 | 1.4 |
| Total U.S. Facilities [2] | 94 | 98,791 | 30.6 |
| WTE Facilities | 89 | 92,716 | 28.7 |

Source: J.V.L. Kiser and M. Zannes, Integrated Waste Services Association, April 2004

[1] Annual Capacity equals daily tons per day (TPD) of design capacity multiplied by 365 (days/year) multiplied by 85 percent. Eighty-five percent of the design capacity is a typical system guarantee of annual facility throughput.

[2] Total Facilities includes RDF Processing facilities that do not generate power on site.

Other processing technologies could potentially use RDF, however they represent higher risk than direct thermal processes. An overview of other processing technologies is presented in Appendix H.

## 8.3 Conclusions and Recommendations

Cement kilns have an interest in using RDF as a fuel to supplement coal for manufacturing Portland cement. The next step in assessing the feasibility of combusting RDF would be to assess the potential heating value, chemical composition, and physical properties of the RDF that would be proposed for their use. In advance of the JPA implementing a pre-processing system that would produce residual that would be fed to a RDF production, a test system that would use loads selected by collection route could potentially be used. A determination of the adequacy of selected waste loads to use as surrogates for pre-processing residuals would be part of the planning for the test burn project. Heating content, moisture content, and density would be primary parameters for assessing adequacy.

RDF should be part of the long-term strategy that includes implementation of a pre-processing due to the opportunity that it represents and the fact that combustion of RDF has the potential to help coal-fuel users to meet the AB32 requirement for carbon dioxide ($CO_2$)/greenhouse gas (GHG) reduction.

---

[i] Source: Personal communication with Jeffrey Poulton, General Manager, Energy Recovery Operations, Inc., Joppa, Maryland, February (commonly known as the Aberdeen, Maryland Facility).