Solid Waste as a Supplemental Fuel for Power Plants in North Carolina

An insignificant portion of the electricity generated in North Carolina is derived from either local or renewable sources. Most of the electricity used in the state is generated either by coal or nuclear power. Both of these fuels are becoming increasingly expensive, are unrenewable, and must be imported into North Carolina. A renewable source of energy would be preferred in that future supplies of these conventional fuels are uncertain. A local fuel source would be desirable because the chance of interruption of supply by national or international political events or by adverse weather conditions would be less likely, and an energy source possessing these characteristics might result in lower costs.

Municipal solid waste has been suggested as a resource that the urban areas of the state can supply which has these desirable characteristics. It is a material that is already collected by municipalities and private industries, and in the recent past the amount of municipal solid waste has tended to grow faster than the population. Also, its heating value is approximately half that of coal (5,000 or more BTU/lb for prepared solid waste versus about 11,000 BTU/lb for coal), and has been increasing as the composition of refuse changes. Although municipal solid waste is not truly a renewable resource, the majority of the materials which constitute it, such as paper, food, yard wastes, and other recoverable materials, are largely renewable.

Municipal solid waste is usually considered a nuisance rather than a resource. The typical system of collection and disposal of refuse in a landfill can be expensive and politically controversial. Aside from removing a potential health hazard, this system provides no positive or economic benefits to municipalities to offset the costs. An energy or materials recovery system would require a major capital expenditure and increased operating costs, but the system would provide revenues to offset part of those costs and would reduce the need for landfill sites and operations. Some other necessary conditions for a successful energy recovery system are sufficient levels of technical expertise, a willingness to implement a relatively new concept, and a volume of solid waste sufficiently high to justify the investments.

One important consideration is to determine which level of government is most appropriate for administration of the system. Local governments in North Carolina probably do not have the capability or desire to consider energy or materials recovery. They also may believe that such systems are feasible only in major metropolitan cities such as New York or Chicago. The state is probably unwilling to become directly involved in the collection or processing of solid wastes from municipalities because of the diversity of local conditions and the traditional role of local government in solid waste handling. However, multicounty planning regions are taking an increased role in organizing regional collection and handling systems which can take advantage of economies of scale. The particular regions in North Carolina which would be most suited for a refuse-derived fuel (RDF) system are discussed below.

There are a variety of technologies to convert solid waste into energy. These technologies result in any of five different energy products: electricity, steam (for direct use), solid fuel, liquid fuel, or gaseous fuel. All these approaches are being pursued and are in various stages of development in different parts of the country (see Figure 1). One particular system, the use of solid waste as a supplemental fuel to coal in power plants, is the focus of this article because it is already commercially operational in some U.S. cities and appears to be well suited to existing institutional arrangements. While it is not an ultimate solution to either energy or solid waste problems, the system is available now for use. An RDF system relies on relatively simple and conventional technology. The system generally requires a cooperative arrangement between electric utility companies and local collectors of solid waste. The arrangement operates to the advantage of both interests, as it provides additional fuel for power companies (and improves their relations with the local community) while it reduces landfill operations for the waste collectors. This article explores how this technology could be adapted to the needs of the state and to the technical and economic capabilities of the power companies which operate in the state.

Norman B. Axler is a second year student in the Department of City and Regional Planning of the University of North Carolina, Chapel Hill, concentrating in environmental planning. He recently coauthored, with David R. Godschalk, a study on the use of carrying capacity in planning. This report will be published by the American Society of Planning Officials in, spring, 1978.

The RDF System

The key to the RDF system is its reliance on conventional boiler technology. Prepared solid waste is used as a supplementary fuel in boilers that currently burn coal. Coal remains the primary fuel, with solid waste providing up to 20% of the heat input to the boiler, or up to about 35% of the fuel input by weight. Although many European and some U.S. systems burn 100% solid waste, these systems suffer from corrosion problems which are avoided by keeping solid waste as a supplement rather than the primary fuel. Corrosion problems occur because solid waste is non-homogeneous and burns unevenly. Since coal remains the primary fuel in the RDF system, virtually any existing coal-burning boiler can be adapted, with fairly minor modifications.

The most unfamiliar, and potentially expensive, part of the RDF process is the preparation of the refuse prior to burning. Figure 2 shows a typical system for preparing solid waste as fuel. Most coal-burning boilers in this country are designed to burn pulverized coal suspended in air for a short time. For the solid waste to burn in air along with the coal, it must be shredded into small particles, usually less than 1½ inches in diameter. Additionally, metals and glass are usually removed from the refuse by magnetic belts and by air classifiers which separate heavy from light materials. Removal of metals reduces corrosion and increases the heat value of the remaining waste on a per pound basis because the metal itself is incombustible. Removal also allows for resale of these materials, which can significantly reduce the net costs of processing the refuse.

To get a rough idea of the volume of solid waste that would be burned by a power plant using the RDF system, consider a typical modern power plant with a rated capacity of 2,000 megawatts. Assume an annual capacity factor of 60% (equivalent to running at full capacity 60% of the time) and a heat rate (the amount of heat input required to produce each kilowatt-hour) of 9,500 BTU/kwh, both typical figures for power plants. On an average day, the power plant would generate 28.8×10^6 kwh, and would require 273.6×10^9 BTU of heat input. If coal alone were used as a fuel, with an average heating

Figure 1

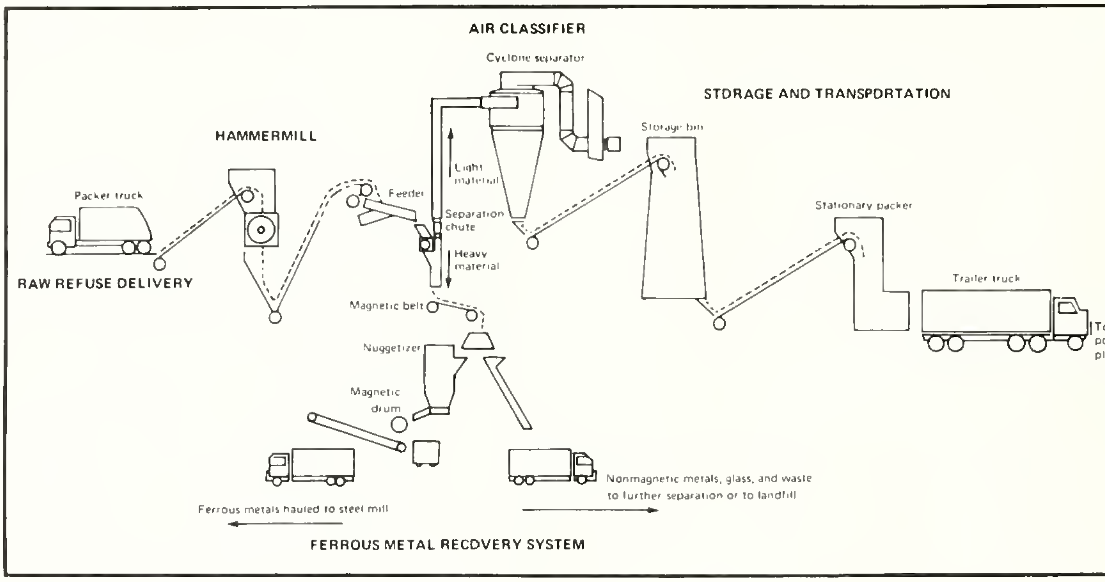
Energy Recovery Technology and Products

	TECHNOLOGY \ PRODUCT	ELECTRICITY	STEAM (for use other than generating electricity)	SOLID FUEL (for use other than in producing steam or electricity)	GASEOUS FUEL	LIQUID FUEL
COMMERCIALLY OPERATIONAL	WATERWALL COMBUSTION (MASS BURNING)	Used extensively in Europe and Japan	Braintree, Mass (O) Harrisburg, Pa (O) Norfolk, Va (O) Chicago, Ill (O) Nashville, Tenn (O) Portsmouth, Va (C) Saugus, Mass (S) Montreal, Can. (O) Quebec, Can (O)	N/A†	N/A	N/A
	(SEMI-SUSPENSION)	Hempstead, N Y (C) Dade Co.,Fla (D)	Hamilton, Ont (O) Tokyo, Japan (O) Akron, Ohio (D)	N/A	N/A	N/A
	SOLID FUEL (RDF)	St Louis, Mo (P O.) St. Louis, Mo (D) Chicago,Ill (C) Ames, Iowa (S) Milwaukee, Wis (C) Monroe County, N Y. (O)	Columbus, Oh (D) Akron, Oh (D)	Los Gatos, Cal (P.O.) Bridgeport, Conn. (D) E Bridgewater, Mass. (S) Palmer Twp., Pa (D)	N/A	N/A
DEVELOPMENTAL	PYROLYSIS GASIFICATION LOW BTU	Luxembourg (C)	Baltimore, Md (S) Grasse, France (C)	By-Product	Possible	N/A
	MED. BTU	Possible	Possible	N/A	S Charleston,W Va (P.O.)	N/A
	LIQUIFICATION	Possible	Possible	By-Product	N/A	San Diego County, Cal (P,C)
	CONVERSION LANDFILL	Los Angeles, Cal (O,P)	Possible	N/A	Los Angeles, Cal (O) Phoenix, Ariz (S)	
EXPERIMENTAL	REACTOR	Possible	Possible	By-Product	Franklin, Oh (P) Pompano Beach, Fla (P-D)	N/A
	WASTE FIRED GAS TURBINE	Menlo Park, Cal (P)	By-Product	N/A	N/A	N/A

*Operating status is designated as
P—Pilot or Demonstration
D—Design
C—Construction
O—Operational
S—Start-up
†N/A—Not Applicable

Source: Levy and Rigo 1976, p. 6

Figure 2
Processing Plant for Solid Waste, St. Louis Project



Source: Levy 1974, p. 7

could be provided by about 5,470 tons of prepared solid waste, with about 5,000 BTU/lb. More typically, solid value of 11,000 BTU/lb, then about 12,440 tons per day would be required. Alternatively, 20% of the heat input waste might provide about 10% of the heat input, for which 2,740 tons would be required. In this case, only 11,190 tons of coal would be required, resulting in a reduction of coal use by about 1,250 tons. At the approximate current price of coal, about $25 per ton, the coal savings, or the value of the solid waste as a fuel, would be $31,250 per day or $11,400,000 per year. Of course, extra costs associated with using the RDF must be subtracted from these values to determine the true value of the RDF to the utility.

For an individual 1,000 megawatt unit within the plant, the solid waste requirements would be half those above, or about 1,370 tons per day. For a boiler rated at 125 megawatts, which is about the smallest size unit an electric utility might have burning coal, the solid waste requirements would typically be about 170 tons per day, assuming the RDF accounts for 10% of the heat input to the unit.

These calculations are just for average days at the assumed operating rates. Since the usage of a utility's power plant will vary from day to day, some small amount of storage capacity must be available at the power plant.

U.S. Experience with RDF Systems

In April 1972, in St. Louis, Missouri, operations began on an RDF demonstration project with financial support from the U.S. Environmental Protection Agency. Prepared solid waste was fired in two Union Electric (UE) Company 125 megawatt boilers, providing approximately 10% of the heat input to the boilers. The RDF was processed at a location 18 miles from the power plant and transported in 75 cubic yard trailer trucks (U.S. EPA 1975, p. 36). Ferrous metals were recovered and resold. For every 100 tons of raw solid waste processed, approximately 7 tons of ferrous metals, at a 1974 value of $17 per ton, were recovered, and about 80 tons of usable RDF was produced (U.S. EPA 1974, p. 92). About 300 tons of RDF was fired per 24-hour day, but only on a 5-day per week basis, corresponding to refuse collection days.

The St. Louis facilities were constructed in 1971, and the design and construction costs amounted to $3.3 million. Operation and maintenance costs in the time period May 1972 to June 1975 amounted to $600,000, for a total cost up to June 1975 of $3.9 million, of which Union Electric paid about $950,000, or one quarter (U.S. EPA 1975, p. 87). Operation and maintenance costs for the period July 1972 to November 1974 were $5.90 per ton of solid waste processed, and $8.50 per ton of RDF burned (U.S. EPA 1975, p. 89). However, during this time, the facilities operated at only about 30% of their capabilities, resulting in higher unit costs than would occur during operation at design capacity.

In addition to the operating experience and cost data that the St. Louis project provided, environmental impacts of the system were evaluated as part of EPA's interest in the project. No health problems were reported due to handling of the waste materials. Air emissions were tested independently by the Midwest Research Institute (MRI) and by Union Electric (which tested particulates only). The MRI tests found that gaseous emissions (sulfur oxides, nitrogen oxides, hydrogen chlorides, and mercury vapors) "are not significantly affected by combined firing of waste and coal" (U.S. EPA 1975, p. 89). The MRI and UE tests did not agree on the existence of changes in particulates, so no conclusive statements can be presently made on this topic.

In August 1975, the city of Ames, Iowa, began operations on the first RDF system not funded by the federal government. While the technology was patterned on the St. Louis demonstration, an important institutional difference remained. The Ames boilers are owned by the municipality rather than by a utility company. The city invested $6.3 million, including land, equipment, and start-up expenses. During the year 1976, the plant processed only 41,000 tons of refuse, or less than half its planned capacity. First year operating expenses were $1.15 million, which was considered to be due to new operating experience. Revenues for the first year totalled $450,000, of which $100,000 was from resale of metals and $319,000 was a noncash revenue credit for the fuel value of the RDF (which the municipality delivers to itself). Net costs for the first year of operation amounted to $17 per ton of refuse (Even *et al.* 1977).

Projects of a higher scale are operating or being built in other locations around the country. A Milwaukee system, with refuse processing by the American Can Company and burning of RDF by Wisconsin Electric, has a rated capacity of 1,600 tons of refuse per day, but is reportedly not in full-scale operation yet. Chicago is starting to transform 700 tons of refuse per day into fuel pellets which it sells to Commonwealth Edison. Other cities involved in design or construction of RDF processing facilities include Rochester, N.Y., Bridgeport, Conn., St. Petersburg-Clearwater, Florida, and New York City.

Electricity Generation in North Carolina

Almost all the electricity in the state is generated by two investor-owned utility companies, Duke Power and Carolina Power and Light. Both companies rely on coal for a majority of their electricity production. However, both companies have adopted policies of shifting to an increasing share of power generated by nuclear reactors over the next ten years. Carolina Power and Light's expansion plans include a mixture of coal and nuclear plants, while Duke Power plans to construct only nuclear power plants in the next ten years. While these decisions are subject to change as the result of economic changes or of government policies, they are reasonable to use as a basis for determining which power plant locations are likely to be suitable for using RDF. If the existing decisions stand, then the only power plants in the state which could use solid waste as a supplemental fuel are the existing coal-fired plants, with the exception of CP & L's planned Mayo plant in Person County.

There are currently fourteen power plants in the state that burn coal (some burn oil or gas in addition), ranging in size from 12.5 to 2,280 megawatts of capacity (see Figure 3). Some of these plants are old units with high operating costs that are used only at times of peak electrical demand. For an energy recovery system to be worth implementing, the power plant must be operating enough of the time to burn a substantial amount of solid waste, thereby achieving savings of large amounts of coal and paying back any capital costs of modifying boilers. A rule of thumb used by utility companies is that the plant is not suitable for burning solid waste unless it is used for at least 50 % of its rated annual capacity (Bostian 1976, p. 4). This is not a hard-and-fast rule and is subject to exceptions depending on the circumstances.

Figure 3

Existing and Planned Coal-Burning Power Plants

North Carolina, 1977

Plant	Location	Company	Rated Capacity MW	Net Generation GWH	Capacity Factor 1977
Allen	Belmont	Duke	1,140	5,217.5	52.3%
Belews Creek	Walnut Cove	Duke	2,280	12,388.7	62.0
Buck	Spencer	Duke	364	1,436.8	45.1
Cliffside	Cliffside	Duke	770	3,789.9	56.2
Dan River	Eden	Duke	272	982.4	41.2
Marshall	Terrell	Duke	2,025	10,218.6	57.6
Riverbend	Mount Holly	Duke	448	1,704.6	43.4
Asheville	Skyland	CP & L	394	1,876.5	54.4
Cape Fear	Moncure	CP & L	323	1,163.9	41.1
Lee	Goldsboro	CP & L	421	2,005.5	54.4
Roxboro	Roxboro	CP & L	1,735	8,540.8	56.2
Sutton	Wilmington	CP & L	598	2,218.0	42.3
Weatherspoon	Lumberton	CP & L	177	744.7	48.0
Mayo (planned)	Person County	CP & L 1-1982	720	----	---
		2-1985	720		
Roxboro (expansion)	Roxboro	CP & L 1980	720	----	---
Chapel Hill	Chapel Hill	UNC	12.5	32.7	29.9

Sources: Duke Power Company Steam Production Department; Carolina Power and Light Fossil Fuel Section; UNC Utilities Division

Three power plants owned by Duke Power—Buck, Dan River, and Riverbend—are unsuitable for energy recovery on the basis of their 1977 capacity factors. Four others—Allen, Belews Creek, Cliffside, and Marshall—are potential locations for an RDF system. Of these four, the Belews Creek and Marshall power plants are the newest and largest, and are used to higher capacities than the others. Because of their high efficiency, the usage of Belews Creek and Marshall is not likely to drop when and if new nuclear units become part of Duke's generating system.

For Carolina Power and Light, three existing coal-burning plants had 1977 capacity factors over 50%—Asheville, Lee, and Roxboro. The Brunswick nuclear plant had its first full year of operation in 1977. The Asheville plant, in CP & L's isolated service area in the western part of the state, is probably not greatly affected by the introduction of the Brunswick plant. The Roxboro plant is relatively new and is therefore less affected by the Brunswick plant than an older, marginally efficient plant. The three remaining coal-fired plants operated by CP & L all had 1977 capacity factors under 50%, tentatively screening them out. Weatherspoon's usage was the closest to 50%, making this small power plant a marginal possibility for an RDF system. CP & L's planned Mayo power plant would be a potential location for an RDF system in the near future.

Solid Waste Generation in North Carolina

Solid waste generation roughly parallels population levels, with urban residents generally generating more solid wastes per person than rural residents. In addition, a higher percentage of urban solid waste is collected by public agencies than rural solid waste. North Carolina does not have any large cities, but it does have a number of moderate sized cities. Most of these cities are located in the Piedmont section of the state. Of the located in the Piedmont and three are located outside seven Standard Metropolitan Statistical Areas (SMSAs) designated by the Census Bureau in the state, four are the Piedmont. The Fayetteville SMSA is closest to the Piedmont, located only about sixty miles from Raleigh. Raleigh forms one end of a crescent of cities in the Piedmont that extends to Charlotte-Gastonia area and continues into South Carolina. The total distance from end to end of the North Carolina portion of the urban crescent is about 160 miles.

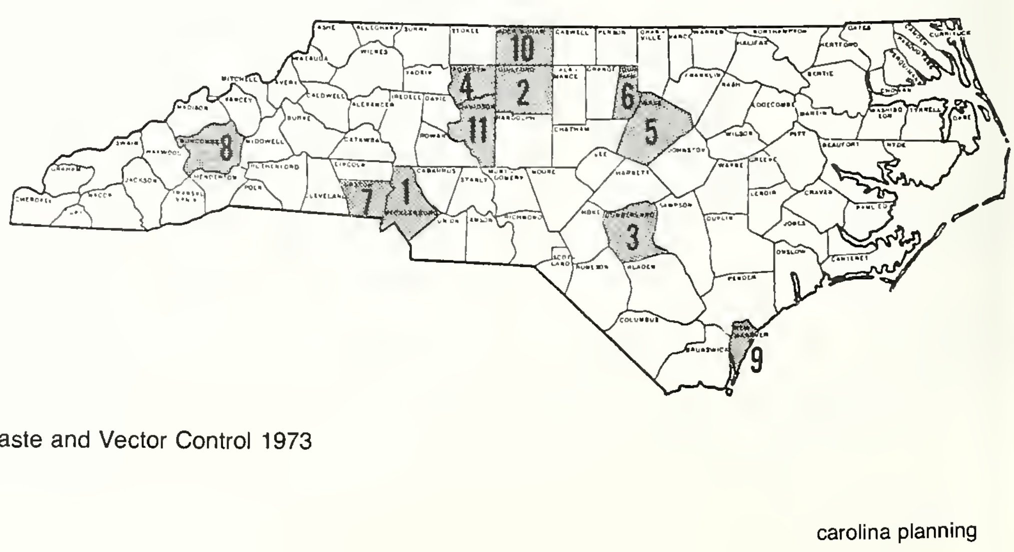
Estimates of solid waste generation in North Carolina should not rely on national averages but on local surveys which weigh samples and do not use volume to estimate weight. The only statewide, comprehensive survey of solid waste generation in North Carolina was made in 1967-68 (Office of Solid Waste and Vector Control 1975). The survey results give the quantities of solid waste collected by each county. The results of the survey are somewhat inaccurate because of the absence of weighing facilities at most waste disposal sites around the state. Nevertheless, in the absence of better data, the survey results give an estimate of solid waste generation for 1968. Of the eleven counties collecting over 100,000 tons per year (equivalent to about 275 tons per day in 1968), eight were located in the Piedmont section of the state (See Figure 4). Mecklenburg County, which contains the state's largest city, Charlotte, was by far the leading generator of municipal solid waste in the state, with over 400,000 tons per year, according to the survey. Several years later, a local survey based on detailed sampling showed that Mecklenburg County actually generated over 650,000 tons per year (Henningson, Durham and Richardson, Inc. 1972, p. TS-2).

Solid waste generation increases with population growth and with increases in per capita generation. Per capita generation of waste is related to level of production and consumption in the economy, to packaging practices, to the extent of reuse of products, and to the rate at which products become obsolescent or wear out. Historically, per capita generation rates have been rising each year in this country. However, it is not clear whether this trend will continue. But even if per capita

Figure 4

Counties in North Carolina Collecting over 100,000 Tons Solid Waste in 1968, in Rank Order

1. Mecklenburg
2. Guilford
3. Cumberland
4. Forsyth
5. Wake
6. Durham
7. Gaston
8. Buncombe
9. New Hanover
10. Rockingham
11. Davidson



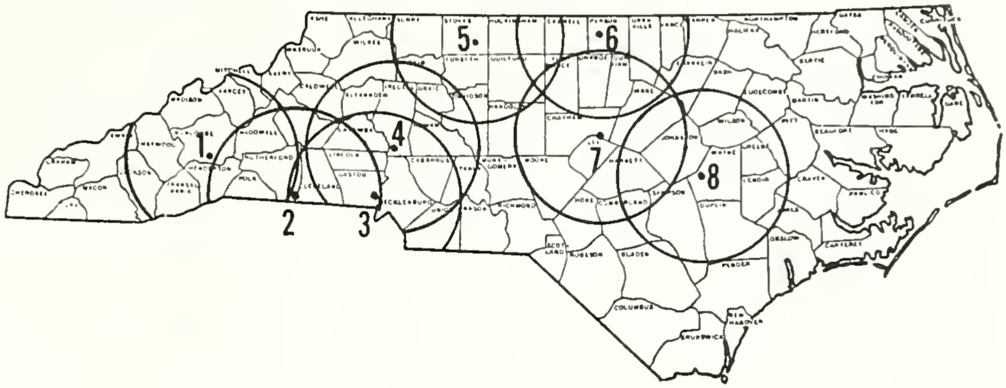
Source: Office of Solid Waste and Vector Control 1973

Figure 5

Approximate Truck Transport Limits Around Power Plants Potentially Suitable for Using Solid Waste as a Supplemental Fuel (50 mile radius around each power plant)

Power Plants Shown:

1. Asheville
2. Cliffside
3. Allen
4. Marshall
5. Belews Creek
6. Roxboro
7. Cape Fear
8. Lee



generation rates stopped rising, North Carolina's population growth would make solid waste an increasing resource.

Energy recovery systems must allow for variations in solid waste generation from day to day and from season to season. Solid waste is generally collected by public agencies on weekdays only. Most areas generate more solid waste in the summer than in the winter, with the difference made up largely of yard wastes. These variations mean the RDF system must anticipate variations in the heating value, moisture content, and recoverable materials in the solid waste. The waste processing system must also screen out bulky items which cannot be shredded, and potentially explosive items, such as gasoline or oil containers, which could ignite during the refuse processing.

Most communities dump these wastes into landfills, which occupy large amounts of land and are politically controversial. Few residents want the landfill to be located near them. The life of existing landfills can be extended by reducing the quantity of waste that is dumped there. Extending the life of a landfill means that the search for new sites can be delayed. Of the material used as input to an RDF system, only about 10% must be returned to a landfill. Of course, bulky items will still have to be sent to landfills.

Matching Solid Waste and Electric Energy Generation

The matching of energy markets with solid waste collection is based on the fuel needs of the power plants and the quantities of solid waste generated in an area. The link between these two factors is the system of transporting wastes from collection points to the processing site and power plant. In North Carolina, truck and rail are the only two methods available for transporting wastes. Trucks are currently used in North Carolina for transporting wastes to disposal sites because of the relatively short distances to landfills. The costs of truck operation limit the range of transport to roughly fifty miles (Dial 1973, p. 160). Beyond that distance, rail haul could be economical, although there are problems involved with rail haul that have discouraged its use. In recent years, rail haul of solid waste has been tested in several projects around the country, and the possibility of rail haul of solid waste in North Carolina as part of an RDF system should be briefly considered.

Rail haul is a more capital-intensive mode of transport than truck transport. In other words, the costs of rail haul do not double as the distance of the haul doubles because operating costs are only a small portion of the total. However, rail cars and other rail equipment are very expensive. Therefore, to make a rail haul of solid waste economical, a large quantity of waste is required. A typical rail car carries 60 to 100 tons of solid waste. If only 100 tons were being transported, the rail car would have to be attached to a regularly scheduled freight train. This scheme would be difficult to implement, as it would be difficult for the railroad company to assure regular and fast delivery of the solid waste. The other alternative is to hire a unit train that would carry only solid waste and deliver it to a specified location.

Martin estimates that the urban areas of the Piedmont crescent in North Carolina will generate between 5,000 and 13,000 tons per day in 1980 (1976, Appendices). If the actual figure is around 10,000 tons per day, this would theoretically be sufficient for over 100 rail cars in a unit train. However, collection of that quantity of solid waste from dispersal points would be difficult. The unit train would have to make stops at various points along the crescent to load solid waste into cars. A significant amount of truck transport would be needed to get the waste to the loading stations, which would be costly. The transfer stations required would also be costly.

The destination of such a unit train could be a processing plant in the Charlotte area. The processing plant could recover metals for resale and prepare wastes for burning in the Marshall and Allen power plants, located in the Charlotte area. With a combined capacity of 3,165 megawatts, the two power plants could burn up to 8,600 tons of solid waste per day, but would typically only be able to burn about 4,500 tons per day. This assumes that every unit in the two plants was utilized, which is unlikely. Unless new power plants were constructed which could assure that the solid waste could be burned, the market for rail transported solid waste would be insufficient to justify the costs of the rail haul. In addition, having the entire Piedmont crescent rely on two power plants for the utilization of its solid waste could be a problem when one or both of the plants are shut down for repairs or maintenance.

A more modest and decentralized system of transporting solid waste would rely entirely on truck transport and would generally be limited to a fifty mile one-way haul from origin to destination. By locating those power plants potentially suitable for solid waste firing on a map of North Carolina and drawing a circle equivalent to a fifty mile radius, the approximate boundaries of potential service areas for such a system can be determined (see Figure 5). The actual service areas may be less because of road configurations, political boundaries, and economic considerations. It can be seen that the Charlotte-Gastonia area could be served by several power plants in the area. The Belews Creek power plant could serve Winston-Salem, Greensboro, High Point, and possibly Burlington. Moncure, where the Cape Fear plant is located, is within fifty miles of Raleigh, Durham, Chapel Hill, and Fayetteville.

How well would this system match the needs of the power plants with the flow of solid waste from the service area? The Belews Creek power plant, with a capacity of 2,280 megawatts, could burn 3,000 tons of solid waste per day assuming 10% heat input supplied by RDF. The Piedmont Triad Council of Governments has made projections of 1980 solid waste generation of 1,494,700 tons per year, or an average of 4,095 tons per day (Piedmont Triad COG 1973, p. 13). However, it is unlikely that all the waste from the region can be collected and transported to the Belews Creek location because of transportation costs. Of all solid waste generated in the region, 54% or 2,230 tons per day is expected to be in Guilford and Forsyth Counties, which have urban areas not far from the Belews Creek plant. At these levels of waste generation, economies of scale should be realized in the processing operations, resulting in lower unit costs than were present in either St. Louis or Ames, Iowa. This would not eliminate solid waste disposal problems in the Piedmont Triad region, but it would significantly reduce the volume of material for disposal.

The Charlotte area has the Marshall (2,025 megawatts) and Allen (1,140 megawatts) plants to serve it. The Cliffside plant (770 megawatts) is an additional potential user of Charlotte's solid waste, but its location is less favorable than the other two plants. Together, the Marshall and Allen plants could burn about 4,500 tons of solid waste per day. A single refuse-processing plant located between the two power plants could supply RDF to both and would be assured of a use for the RDF even if one of the power plants were shut down. These plants are made up of small units ranging in size from 165 megawatts to 650 megawatts. Therefore, any amount of RDF less than 4,500 tons could be easily handled by utilizing only selected units or by increasing the input of RDF to those units. A 1972 survey of Mecklenburg County's solid waste collections, which was probably

A Refuse-Derived Fuel (RDF) system would extend the life of landfills.

Photo by Blair Pollock

more accurate than the state's 1968 estimate, showed that the county generated about 1,800 tons of solid waste per day. By 1980, that figure was expected to increase by over 50 percent, which would amount to 2,700 tons per day just from this one county (Henningson, Durham and Richardson, Inc. 1972, p. TS-2). With other portions of the region, including Gastonia, Kannapolis, Statesville, and other communities contributing some solid waste, the quantity of RDF available would be sufficient to keep the Marshall and Allen units burning RDF.

Power plants in North Carolina owned by Carolina Power and Light also have opportunities for burning solid waste as supplemental fuel, even though these power plants are not located in the heart of the Piedmont crescent. The plants owned by CP & L tend to be smaller in size than those of Duke Power, and they serve the electrical demands of a more dispersed population. Energy recovery systems for these smaller CP & L plants could become economical, especially if the price of coal rises substantially, and serve the needs of CP & L and the municipalities in its service area. Thus, although RDF systems are not currently as attractive to CP & L as to Duke Power, the possibilities for such systems should still be explored.

The Lee plant in Wayne County has the potential for serving a largely rural population. Its 421 megawatt capacity could burn up to 1,100 tons of solid waste per day. In Wayne County and the six counties immediately surrounding it, about 720 tons per day were generated in 1968. By 1980, that figure will be much higher and would easily be sufficient to fuel the Lee plant. However, if existing collection systems are widely dispersed in this rural county, transportation costs may rule out this system.

The Asheville area has the potential of being served by the CP & L plant at Skyland. Rated at 394 megawatts, the plant could burn up to 1,100 tons per day of solid waste. In 1968, the four counties of Buncombe, Haywood, Henderson, and Transylvania generated about 740 tons per day. By 1980, those counties will probably be generating around 1,000 tons per day. Once again, however, waste generation and collection may be too dispersed in this area to justify a centralized refuse processing system.

The Roxboro plant (and the planned Mayo plant) in Person County is a large, modern, and efficient coal-burning power plant. These characteristics suit it to use in an RDF system. However, the distance of the plant to Durham or Burlington, the nearest urban areas, is thirty miles or over. The high transport costs that would be involved would be substantial, but this still might prove to be a feasible location for an RDF system.

The Cape Fear power plant at Moncure is in a favorable location for having an assured supply of solid wastes for its burners. With its rated 323 megawatt capacity, it could burn up to 900 tons of solid waste per day at a 20% RDF fuel input rate.

Wake, Durham, and Orange counties generated about 1,100 tons per day in 1968. With Lee, Chatham, Harnett, and Cumberland (including Fayetteville) counties added in, over 2,000 tons of solid waste was generated in the vicinity of Moncure in 1968. Considering population growth, the Moncure plant could be assured of sufficient supply of solid waste. Unfortunately, the usage of the Cape Fear plant is too low to be consistent with the needs of the RDF system, so it cannot be considered a prime candidate.

Conclusion

This article has described a commercially operational technology for generating electricity from municipal solid waste. The technology is developed to the point where prudent utility companies and municipalities can make reasonably secure investments. The economic considerations which will determine the feasibility of refuse-derived fuel systems will vary from area to area, depending particularly on the cost of landfill operations, the quantity of solid waste collected, the cost of processing facilities, and the markets for fuel in utility or municipally-owned power plants. Establishment of such an energy recovery system begins with a dialogue among the interested parties.

This analysis of North Carolina power plants and solid waste generation patterns indicated that the Charlotte and Greensboro-High Point areas are the two urban areas of the state best suited to development of an RDF system. Duke Power Company has just completed an initial study for the city of Greensboro of an RDF system using the Belews Creek power plant. Details of the study are not available while it is being evaluated by the city, but the system is based on a capacity of 1,000 tons per day. Although both units at Belews Creek would be modified to burn RDF, only one of the two units at Belews Creek would burn solid waste at any one time. Processing facilities would be operated by the city, while Duke Power would have only twelve hours storage capacity (500 tons) and would pay the city for the heating value of the fuel provided.

In the Charlotte area, a solid waste management study has just been initiated which will consider a RDF system among a variety of disposal and recovery alternatives. The study is being conducted by the Charlotte office of Henningson, Durham and Richardson, the consulting engineering firm which designed the Ames, Iowa refuse processing plant. Because of the existence of several efficient coal-burning plants in that area, a variety of different arrangements of an RDF system are possible and should be considered by that study.

Although these two areas might be best for the first RDF systems in the state, other areas will become feasible locations if trends favorable to energy recovery continue or accelerate. Foremost among these trends would be an increase in the price of coal. The extent to which the state's power companies switch to nuclear power will also affect the feasibility of RDF systems. If more nuclear power plants are introduced into the electrical generating system, the coal-burning plants will be used less often, and RDF systems will become less attractive. Another factor which will affect the economic feasibility of RDF systems is the price which recoverable metals will bring. These prices have recently been low, probably due to the general slowness of the economy.

In determining the feasibility of an RDF system, it should be remembered that not all the costs of landfill disposal or the usage of coal can be translated into dollars and cents. As waste continues to accumulate at increasing rates, the difficulty of finding landfill sites that are acceptable politically and economically will increase. After the implementation of an energy recovery system, solid waste may cease to be perceived as "garbage" and would become a valued element of the electric generating system of an area.

References

Bostian, R.W. 1976. "Supplemental Heat from Refuse Derived Fuel." Remarks to N.C. Advisory Council on Resource Recycling, Solid Waste Management and Litter Control. Courtesy of Duke Power Company.

Dial, Clyde. 1973. "EPA Plans for Rail Haul Demonstration." *Sanitary Landfilling Conference.* Office of Solid Waste Managment, U.S. Environmental Protection Agency. SW-5p.

Even, J.C., S.K. Adams, P. Gheresus, A.W. Joensen, J.L. Hall, D.E. Fiscus, and C.A. Romine. 1977. *Evaluation of the Ames Solid Waste Recovery System, Part 1.* Cincinnati: Municipal Environmental Research Laboratory, Office of Research and Development, U.S. Environmental Protection Agency.

Henningson, Durham and Richardson, Inc. 1972. *Areawide Solid Waste Management Study for City of Charlotte and County of Mecklenburg, North Carolina.*

Levy, Steven J. 1974. *Markets and Technology for Recovering Energy from Solid Waste.* U.S. Environmental Protection Agency. SW-130.

Levy, Steven J. and H. Gregor Rigo. 1976. *Resource Recovery Plant Implementation: Guides for Municipal Officials–Technologies.* U.S. Environmental Protection Agency. SW-152.2.

Martin, Samuel R. 1976. *A Regional Alternative for Recovery of Energy and Materials Resources from Urban Solid Wastes in the Piedmont Crescent–North and South Carolina.* Unpublished departmental paper. Department of City and Regional Planning, University of North Carolina at Chapel Hill.

Office of Solid Waste and Vector Control, Department of Human Resources. 1973. *North Carolina Solid Waste Management Plan.* State of North Carolina.

Piedmont Triad Council of Governments. 1973. *Regional Solid Waste Management Study–Phase II.*

U.S. Environmental Protection Agency. 1974. *Resource Recovery and Source Reduction, Second Report to Congress.* Office of Solid Waste Management Programs. SW-122.

______. 1975. *Resource Recovery and Waste Reduction, Third Report to Congress.* Office of Solid Waste Management Programs. SW-161.