Many industrial plants generate a large volume of non-hazardous solid waste. These plants cannot operate without access to local sanitary landfills for solid waste disposal. However, many communities face a crisis with respect to landfill capacity. Reliable and affordable disposal of non-hazardous solid waste is a growing problem faced by industry. Many companies do not know the composition of their non-hazardous solid waste or their full cost of solid waste disposal. Opportunities to reduce solid waste volume and disposal cost may be missed.

In 1990, MEMC Electronic Materials, Inc. completed a solid waste study at its Spartanburg, South Carolina manufacturing facility. The company also began serious efforts at solid waste recycling. This paper discusses results through first quarter 1993.

MEMC ELECTRONIC MATERIALS, INC.

MEMC Electronic Materials, Inc. manufactures polished and epitaxial silicon wafers. Silicon wafers are the substrate, or base, on which microelectronic circuits (microchips) are made. MEMC is a world-wide producer of silicon with manufacturing plants in the United States, Europe, and Asia. MEMC's customers are the manufacturers of logic and memory microchips used in everything from computers and consumer electronics to automobiles and aerospace.

MEMC established company-wide environmental goals in 1989. These include a 50 percent reduction in the generation of priority waste by year-end 1996. The MEMC definition of "priority waste" includes recyclable solid waste materials that are landfilled.

Non-Hazardous Solid Waste Management

Silicon wafer manufacturing is a combination of chemical and mechanical steps. The non-hazardous solids wastes produced include scrap and offSpecification silicon, used packaging from raw materials and supplies, spent manufacturing supplies, trash, and wastewater treatment sludge. Office, maintenance, and support activities generate office waste, food waste, and various scrap metals, scrap plastics, and used machine parts. Construction activities generate construction debris.

Management of non-hazardous solid waste at the MEMC Spartanburg Plant is discussed below. The waste handling methods described are typical of large manufacturing plants.

* Presented at 11th Carolina Regional Conference on Environmental Law and Technology; June 21-23, 1993; Greenville, South Carolina (sponsored by Greenville, SC Chamber of Commerce & Clemson University College of Engineering)

Figures and tables follow text in order cited.
Landfilled Waste. The MEMC Spartanburg Plant accumulates solid wastes designated for sanitary landfill disposal in roll-off dumpsters provided by Waste Management of South Carolina. Waste Management services these dumpsters and hauls the contents to off-site landfill disposal. There are two, open-top "sludge bins" used to accumulate and haul dewatered wastewater treatment sludge. Each sludge bin has a capacity of 20 cubic yards. There are two enclosed dumpsters for non-hazardous solid waste from manufacturing, office, and support activities. Each "plant trash dumpster" has a 35-cubic yard working volume. The plant trash is loaded into the enclosed dumpsters with a hydraulic ram. The ram achieves 10 to 20 percent compaction of the waste material. Construction debris and maintenance related scrap materials are collected in a 40-cubic yard, open-top dumpster.

The MEMC wastewater treatment sludge consists primarily of silicon swarf from slicing, lapping, grinding, and polishing operations. The swarf contains finely divided silicon, silica, and aluminum grit. In addition to silicon swarf, the wastewater sludge contains lime and calcium fluoride from treatment of waste hydrofluoric acid. The sludge also contains biological wastewater solids from secondary treatment of process wastewater. The MEMC wastewater treatment sludge is non-hazardous and non-putrescible. The dewatered sludge solids concentration is from 30 to 40 percent by weight. The dewatered sludge is a special waste under South Carolina solid waste management regulations.

Chemical Drums and Containers. Empty chemical drums at the MEMC Spartanburg Plant are collected and segregated from other solid waste materials. Any residual chemical is removed to render the drums "empty" in accordance with RCRA regulations (40 CFR 261.7). The drums are either reused on site, returned for deposit, or sold for recycling. Empty non-deposit drums that contained acids, bases, or non-organic solvents are triple-rinsed prior to sale or reuse. Empty deposit drums, oil drums, and organic solvent drums are not rinsed. Empty chemical bottles and chemical carboys are segregated and triple-rinsed to remove any chemical residual. The rinsed chemical bottles and carboys are either sold for recycling or are landfilled.

Recycled Waste. Beginning in 1990, MEMC implemented recycling of several large volume solid waste materials. Cardboard for recycling is accumulated and stored in a 45-foot trailer provided by the Southern Paper Stock Company of Spartanburg, South Carolina. MEMC employees break-down cardboard boxes and stack them in collection cribs. MEMC warehouse personnel transfer cardboard from these cribs to the cardboard trailer. Southern Paper Stock replaces the cardboard trailer when full. Cardboard in the trailer is then sorted, baled, and stored at the Southern Paper Stock facility for subsequent sale to pulp and kraft board mills.

Mixed office paper is collected and stored for recycling in 110-gallon "recycle paper bins." These bins have wheels, handles, and lids. Twenty-five (25) recycle paper bins were initially provided by the Southern Paper Stock Company. MEMC subsequently purchased an additional 25 bins. MEMC employees collect office paper in blue "recycle paper cans" which are emptied into the larger recycle paper bins. MEMC janitorial personnel replace full recycle paper bins with empty bins then move the full bins to storage areas adjacent to plant loading docks. Southern Paper Stock collects and empties the full paper bins once every two weeks. The mixed office paper is then
sorted, shredded, baled, and stored at the Southern Paper Stock facility for subsequent sale to pulp and paper mills.

Waste wood pallets and skids are accumulated and stored for recycling in a trailer provided by Quality Wood Recycling, Inc. of Newberry, South Carolina. MEMC warehouse personnel collect surplus pallets and stack them in the pallet trailer. Quality Wood Recycling replaces the pallet trailer when full. The capacity of a 40-foot trailer is about 200 pallets. The capacity of a 45-foot trailer is about 240 pallets. Quality Wood Recycling either repairs the waste pallets for resale or shreds the pallets and sells the shredded material for use as boiler fuel and mulch. Nails are removed from the shredded pallets by magnet prior to sale as boiler fuel or mulch.

Polystyrene packaging for recycling is accumulated and stored in a 40-foot trailer permanently parked at the MEMC Spartanburg Plant. Accumulated polystyrene is periodically transferred to trailers owned by Modern Polymers, Inc. of Cherryville, North Carolina. These Modern Polymers trailers are used for delivery and storage of new polystyrene packaging. When empty, the Modern Polymers trailers are used to ship back waste polystyrene for recycling. Modern Polymers sorts and grinds the waste polystyrene, keeps a portion of the ground material for its own reuse, and ships the remaining material to other polystyrene package fabricators.

Scrap metal (aluminum, bronze, brass, copper, stainless steel, carbon steel, copper wire, and aluminum wire) is accumulated and stored for recycling in a 20-cubic yard, drop-off bin provided by the Spartan Iron & Metal Corp. of Spartanburg, South Carolina. MEMC employees collect scrap metal and place it in the scrap metal bin. Spartan Iron & Metal replaces the scrap metal bin when full. The MEMC scrap metal is then sorted, graded, and stored at the Spartan Iron & Metal facility for subsequent sale to metal foundries.

Used product packages made of high density polyethylene (HDPE) and polypropylene (Polypro) are accumulated and stored for recycling in four, eight-cubic yard wire cribs. MEMC employees collect the used HDPE and Polypro packages and take these packages to the plastic cribs. When full, HDPE and Polypro plastics in the recycling cribs are transferred to trucks owned by the Laurens Vocational Rehabilitation Center in Laurens, South Carolina. The Laurens Center separates and grinds the plastic materials, then accumulates the ground plastic for sale as scrap.

Scrap and off-specification silicon is segregated, accumulated in drums, and sold. Some of the scrap silicon is mixed with quartz. The silicon and quartz are separated by an off-site contractor. The separated quartz is landfilled. Spent graphite machine parts and spent carbon beams are accumulated and stored in two, 25-cubic yard, concrete collection cribs. When full, the graphite crib contents are shipped to Schuler Industries, Inc. in Birmingham, Alabama for recycling. At Schuler Industries, the graphite parts are crushed, sized, and stored for subsequent sale to metal foundries.

With the exception of scrap silicon, spent graphite, and drums, the revenue MEMC receives from sale of recycled materials is small. Net revenue from sale of cardboard, office paper, and scrap metal is less than $500 per year. Net revenue represents total revenue less handling and transportation expense. To recycle plastic and polystyrene packaging, MEMC must give these materials away and schedule transportation on trucks that are deadheading back to the
Dickens and Cannon, Solid Waste
Page 4

recycled material processor. Landfill cost savings cover the expense of plastic and polystyrene recycling. MEMC's pallet recycler, Quality Wood Recycling, is an alternative pallet disposal service. Pallet recycling at the MEMC Spartanburg Plant costs about $4000 per year but saves more than $6500 per year in landfill disposal cost.

Solid Waste Study

Costs for solid waste disposal at the MEMC Spartanburg Plant are outlined in Figure 1. The figure data represent the net cost of solid waste hauling and landfill disposal per cubic yard of wastewater sludge, plant trash, and construction debris from 1989 through 1994. The 1994 disposal costs are projected based on proposed landfill price increases.

In 1990, the MEMC Spartanburg Plant experienced a large cost increase for non-hazardous solid waste disposal. Also in 1990, the South Carolina General Assembly began serious consideration of the Solid Waste Policy and Management Act. In response, MEMC undertook a solid waste study. The purpose of the study was two-fold:

1. Establish a baseline generation rate and composition for non-hazardous solid waste.

2. Identify opportunities to reduce the volume of non-hazardous solid waste landfilled.

The solid waste study included a cardboard and paper recycling trial. The baseline period for solid waste generation was 1st quarter (January - March) 1990.

In 1991, the South Carolina General Assembly passed the Solid Waste Policy and Management Act. The Act set a state-wide solid waste recycling goal of 25 percent and a landfilled waste reduction goal of 30 percent by 1996. The base year for these goals is 1993. The goals are measured on the basis of weight rather than solid waste volume. The Solid Waste Act also established minimum standards for non-hazardous solid waste management and requirements for state-wide and regional solid waste management plans.

RESULTS

Tables I, II & III and Figures 2 thru 6 document baseline solid waste generation and composition at the MEMC Spartanburg Plant. The tables and figures also document MEMC solid waste recycling efforts through first quarter 1993. The tables and figures illustrate the MEMC method of tracking non-hazardous solid waste generation and disposal cost. The results are discussed below.

Solid waste volume is easier to track than weight. MEMC uses volume (cubic yards) as the primary measure of solid waste generation, solid waste recycling, and landfill disposal cost. MEMC calculates the weight of solid waste materials from volume information using average material densities (lbs per cubic yard). The average density of MEMC waste materials is determined by trash sampling, from waste hauling invoices, and from invoices for recycled material sale.
Baseline Solid Waste Generation

Waste hauling invoices are used by MEMC to quantify the generation rate and disposal cost of plant trash, wastewater treatment sludge, and construction debris. Accounting and utility records are used to quantify the volume and value of waste materials that are recycled. Trash sampling and a review of accounting and manufacturing records were used in 1990 to identify major plant trash components and to quantify their generation rates.

The baseline generation of non-hazardous solid waste at the MEMC Spartanburg Plant from 1st quarter 1990 data was 13,300 cubic yards per year with a total weight of 3,378 tons. This information is outlined in Table I and Figure 2. Of the total waste generation, 12,160 cubic yards per year weighing 3,256 tons were landfilled. The remaining waste consisting of scrap silicon and empty plastic and steel chemical drums was collected and sold for recycling. The annual cost of solid waste disposal was $113,070 (Table III data, rounded). This was offset by $56,470 per year in revenue from sale of scrap silicon and empty chemical drums. The net, baseline cost of solid waste disposal including revenue from recycled material sale was $56,600 per year.

Plant trash was 66 percent of the landfilled solid waste volume and 23 percent of landfilled solid waste weight. Wastewater treatment sludge was 25 percent of the landfilled solid waste volume and 65 percent of landfilled solid waste weight. Wastewater treatment sludge was 57 percent of the baseline cost of solid waste disposal. In 1990, the unit cost for landfill disposal of wastewater treatment sludge was four times the unit price for trash and construction debris (see Figure 1 and Table III).

The baseline generation of plant trash from the MEMC Spartanburg Plant was 7980 cubic yards per year with a total weight of 740 tons. The baseline composition of MEMC plant trash is outlined in Table II and Figures 3 and 4. Waste packaging materials, waste office paper, and spent manufacturing supplies were the largest plant trash components. Waste cardboard and office paper were 30 percent of the plant trash volume landfilled; wood pallets and skids were eight percent; various HDPE and Polypro plastics were four percent; and waste polystyrene was three percent. Various low density polyethylene (LDPE) and vinyl plastic materials were eight percent of the landfilled plant trash volume. Used plastic bags and "bubble pack" packaging materials were the primary components of this waste category. Spent graphite machine parts and used stainless steel saw blades were one percent of the plant trash volume and four percent of the plant trash weight. Graphite parts and saw blades have potential high value if segregated and sold as scrap.

Recycling Trial

The solid waste study included a cardboard and office paper recycling trial during May and June 1990. The recycling trial was a success. During the trial, MEMC employees collected and recycled 85 percent of waste cardboard generated and 73 percent of waste office paper generated. The volume of plant trash was reduced by 24 percent. Based on success of the recycling trial, cardboard and office paper recycling were permanently established at the MEMC Spartanburg Plant.

One very important lesson was learned during the cardboard and paper recycling trial. Solid waste recycling is a large materials handling problem. It is
also a disruption to established waste handling routines. Although a success, housekeeping problems that arose during the recycling trial almost terminated this recycling effort. For the first several weeks, the cardboard collection cribs were used by some employees as trash cans. Some employees refused to breakdown cardboard boxes and left whole boxes stacked against the sides of the cribs. Other employees continued to throw boxes away and ignored the recycling program altogether. The initial number of recycle paper bins provided was inadequate for the volume of waste office paper being generated. Recycle paper bins throughout the Spartanburg plant were quickly filled and overflowing. A substantial management effort was required to overcome these problems. The success of the recycling trial was due largely to a majority of MEMC employees who felt recycling was a good idea and lent their support. They took time to clean up after others and contain the housekeeping mess. This allowed time for changes to make waste cardboard and office paper recycling work.

Volume Reduction Analysis

MEMC used the solid waste study results to classify the plant trash components identified in Figure 3 into three categories: readily-recyclable, potentially-recyclable, and not recyclable. The purpose was to target recycling efforts toward solid waste components that would obtain the greatest reduction in solid waste landfilled. An associated purpose was to identify scrap materials with potential high value for recycling.

Readily-Recyclable Materials. A recycling market exists and local brokers are available to take "readily-recyclable" materials. They are collected and sold in the form generated. The value of readily-recyclable materials is sufficiently high to pay for their handling and off-site transportation. Readily-recyclable waste materials generated at the MEMC Spartanburg Plant include cardboard, office paper, wood pallets and skids, scrap metal, used Tyvex clean room garments, and spent graphite machine parts. Brokers were found to buy these materials and provide equipment for material handling, material storage, and off-site transportation.

Potentially-Recyclable Materials. "Potentially-recyclable" solid waste materials are recyclable, but the market for the materials in the form generated is small or does not exist. The materials must be processed by MEMC or outside contractor to make them suitable for recycling. The value of potentially recyclable materials is generally insufficient to pay for their handling and off-site transportation. The cost of processing and transporting potentially-recyclable materials must be measured against the material's cost of landfill disposal. The landfill cost savings, if sufficiently high, may subsidize the cost to process and transport these materials. Potentially-recyclable materials generated at the MEMC Spartanburg Plant include various used HDPE and Polypro product packages, waste polystyrene packaging, clean plastic bags, and certain used paper products. Arrangements were made with MEMC's off-site scrap silicon processor (Laurens Vocational Rehabilitation Center) to take and process waste HDPE and Polypro plastics for recycling. Similar arrangements were made with MEMC's supplier of polystyrene packaging (Modern Polymers, Inc.) to take waste polystyrene packaging for recycling.

Volume Reduction Potential. Figure 4 is an analysis by volume and weight of recyclable components in the MEMC Spartanburg Plant trash. The data represent the 1st quarter 1990 baseline plant trash composition. The figure data
suggest that if all readily-recyclable and potentially-recyclable materials were diverted from landfill disposal, the MEMC plant trash volume could be reduced by 46 percent. The landfilled weight of plant trash could be reduced by 35 percent. MEMC used the Figure 4 data to prioritize and implement recycling of cardboard, office paper, wood pallets and skids, spent graphite parts, scrap metal, used HDPE and Polypro plastic packages, and waste polystyrene packaging material.

Wastewater Sludge and Construction Debris. MEMC also investigated options to reduce the volume of wastewater treatment sludge and construction debris. The MEMC wastewater sludge is not suitable for agricultural or other beneficial use. The volume and weight of sludge is fixed by the volume and characteristics of wastewater treated. Sludge drying and other volume reduction methods were evaluated and, at present landfill rates (Figure 1), are not cost-justified. The projected landfill cost savings from heat drying the MEMC sludge are from $40,000 to $60,000 per year. Equipment to accomplish heat drying costs at least $250,000 in new capital. Sludge heat drying also requires new air quality and wastewater construction permits from the South Carolina Department of Health and Environmental Control (SC DHEC).

To reduce landfill cost, MEMC is pursuing regulatory approval to use wastewater treatment sludge from the MEMC Spartanburg Plant as landfill cover in local sanitary landfills. If approved as landfill cover, the landfill fee for the MEMC sludge can be waived. MEMC would then only pay for wastewater sludge hauling.

Construction debris generation is a function of the level of capital construction at the MEMC Spartanburg Plant. Recyclable debris materials such as cardboard, wood pallets, and scrap metal are included in MEMC’s plant trash recycling program. Otherwise, there are limited opportunities to reduce MEMC’s generation of construction debris.

Dumpster Underfilling. An unexpected result of the solid waste study was determination that MEMC was seriously underfilling its plant trash dumpsters. The underfilling was equivalent to hauling 33 empty dumpsters per year to landfill disposal at an annual cost of $6400. Dumpster underfilling was attributed to three problems:

1. Incomplete compaction of the contents of the plant trash dumpsters. That is, less compaction than the hydraulic loading ram can achieve.
2. Hauling plant trash dumpsters on a fixed schedule regardless of how full or empty.
3. Disposal of large rigid objects such as wood pallets and broken furniture that wedge in the bottom of the plant trash dumpster, create large voids, and otherwise prevent full compaction of compressible waste materials by the hydraulic loading ram.

To eliminate dumpster underfilling, MEMC installed 3/4-full lights on the two plant trash dumpsters at the MEMC Spartanburg Plant. These lights were provided by Waste Management of South Carolina at a total cost of $600. The 3/4-full lights indicate when the hydraulic ram loading the dumpsters has reached 80 percent of its maximum hydraulic pressure. In addition, MEMC changed from scheduled to on-call pickup of the plant trash dumpsters. Prior to calling for pickup, MEMC waste management personnel verify that the plant trash dumpsters are actually full. MEMC also implemented wood pallet and
scrap metal recycling and banned disposal of pallets, scrap metal, broken furniture, and other large objects in the plant trash dumpsters. Broken furniture and other large waste objects that cannot be recycled are now taken to the MEMC construction debris dumpster.

**Volume Reduction Results**

Solid waste generation, solid waste recycling, and disposal cost information for the MEMC Spartanburg Plant through 1st quarter 1993 are summarized in Table III and in Figures 5 and 6. The data represent the results of effort to divert recyclable solid waste materials away from landfill disposal. Although the total generation of non-hazardous solid waste increased by 6.5 percent to 14,160 cubic yards per year, the landfilled volume of solid waste was reduced by 35.8 percent. The volume of plant trash landfilled was reduced by 68.4 percent and the weight of plant trash landfilled was reduced by 44.5 percent. The total weight of landfilled solid waste increased by 15 percent compared to the 1st quarter 1990 baseline period. The increased total weight of landfilled solid waste was due to a 39 percent increase in the volume and weight of wastewater treatment sludge. Construction debris generation in 1993 is similar to the 1990 baseline period.

Solid waste recycling in 1st quarter 1993 avoids more than $27,500 per year in landfill disposal cost. Despite a significant increase in sludge disposal cost in 1993, MEMC was able to reduce the cost of landfilled waste disposal by $14,500 per year compared to the 1st quarter 1990 baseline period. The net annual cost of solid waste disposal including revenue from recycled material sale in 1993 is $40,400 per year. If the MEMC request to use wastewater treatment sludge as landfill cover at no fee is approved, the cost of sludge disposal will drop to $5.05/cu.yd. as compared to $19.75/cu.yd. indicated in Figure 1 and Table III. With wastewater sludge as landfill cover, MEMC’s 1993 cost of landfill disposal will decrease from $98,600 per year to $36,220 per year, a reduction of 63 percent.

Data for net revenue from MEMC solid waste recycling are included in Table III. Prices for recycled materials, especially cardboard, paper, and HDPE plastics, have deteriorated since the 1990 solid waste study. However, landfill cost savings from MEMC solid waste recycling continue to make the recycling efforts worthwhile. Figure 6 illustrates MEMC’s progress with recycling since 1990. In 1990, MEMC recycled 8.6 percent of its total solid waste volume. In 1993, MEMC recycling efforts divert 44.9 percent of solid waste volume away from landfill disposal. Recycling results by weight for 1993 are summarized in Table I. The weight results are skewed by the wastewater treatment sludge, which in 1993 accounts for 79.2 percent of MEMC’s total solid waste generation. Wastewater sludge disposal in 1993 is 85.0 percent of MEMC’s total cost of solid waste landfill disposal as indicated in Table III.

The actual reduction in plant trash volume and weight between 1990 and 1993 indicated in Tables I and III is greater than that predicted from the solid waste study as shown in Figure 4. Plant trash volume was reduced both by recycling and by eliminating dumpster underfilling. The weight of plant trash was reduced by recycling and by banning disposal of wood pallets, scrap metal, broken furniture, and construction debris in the plant trash dumpsters. The MEMC solid waste study under estimated the number of wood pallets and weight
of scrap metal and construction debris being landfilled with plant trash during the 1st quarter 1990 baseline period.

Waste Source Reduction

In addition to solid waste recycling, MEMC is pursuing waste source reduction to reduce its generation of non-hazardous solid waste. During 4th quarter 1990, MEMC completed conversion of its manufacturing production and material purchasing systems from off-line batch computer processing to on-line, real-time computer systems. This conversion greatly reduced the volume of paper required to track manufacturing production, purchase orders, and purchased materials distribution. The generation and collection of waste office paper decreased 33 percent between the June 1990 recycling trial and 1st quarter 1991. The new paper-less computer systems eliminated the use of 12 tons per year of paper forms.

In 1992, MEMC began reuse of polystyrene package materials and certain HDPE and Polypro product packages for internal product shipments between MEMC manufacturing plants. The potential cost saving from internal package reuse at the MEMC Spartanburg Plant exceed $200,000 per year. However, product quality considerations limit the number of times packaging materials can be reused and the products for which used packages are appropriate. MEMC is working with several major customers on design of reusable packages for products sold to these customers. Again, product quality considerations limit the opportunities for package reuse as well as for package redesign. It is important to note that all of the MEMC product package materials are recyclable. MEMC product packages are recycled by the majority of MEMC's customers.

SUMMARY

The MEMC Electronic Materials, Inc. manufacturing plant in Spartanburg, South Carolina reduced its volume of plant trash landfilled by 68.4 percent between 1st quarter 1990 and 1st quarter 1993. The corresponding reduction in the weight of plant trash landfilled is 44.5 percent. Overall, MEMC reduced the total volume of solid waste landfilled (plant trash, wastewater treatment sludge, and construction debris) by 35.8 percent. The MEMC recycling efforts avoid more than $27,500 per year in landfill disposal cost. The net cost of landfill disposal was reduced by $14,500 per year despite significant landfill price increases in 1993. Waste source reduction eliminated the use of 12 tons per year of paper forms. MEMC is pursuing regulatory approval to use its wastewater treatment sludge as sanitary landfill cover at no fee. The potential cost savings from using wastewater sludge as landfill cover exceed $62,000 per year.

The following are conclusions from the MEMC solid waste study and solid waste recycling efforts. The cost savings and avoidance described are based on 1993 recycling revenues and landfill rates.

1. Landfill cost avoidance is the greatest economic benefit of solid waste recycling. Net revenue from the sale of cardboard, office paper, and scrap metal is less than $500 per year. Recycling of these materials avoids more than $13,900 per year in landfill disposal cost.
2. Landfill cost savings can subsidize the cost of recycling low value waste materials. The MEMC Spartanburg plant spends about $4000 per year to collect and ship waste wood pallets and skids to recycling. Wood pallet and skid recycling avoids more than $6500 per year in landfill disposal cost.

3. Solid waste recycling is a large materials handling problem and disruption to established waste handling routines. Substantial management effort and the cooperation of employees are required to make solid waste recycling work at large industrial plants.

4. The majority of non-hazardous solid waste landfilled by MEMC is related to wastewater treatment and to packaging of raw materials and manufacturing supplies. Elimination and reuse of packaging materials is MEMC’s greatest short-term opportunity for solid waste volume reduction. Long-term solid waste volume reduction will require new technology to eliminate or reduce MEMC’s generation of wastewater treatment sludge.

5. Heat drying and other methods to reduce wastewater sludge volume by removing water are not cost-justified for the MEMC Spartanburg Plant at present landfill rates. The projected landfill cost savings from heat drying MEMC sludge are from $40,000 to $60,000 per year. Equipment to accomplish heat drying costs at least $250,000 in new capital. Sludge heat drying also requires new environmental permits for air quality and for wastewater treatment facility construction. MEMC’s best option to control landfill disposal cost is to obtain regulatory approval for use of MEMC wastewater sludge as landfill cover at no fee.

CREDITS

MEMC Electronic Materials, Inc. acknowledges assistance of the following recycling partners who make the MEMC solid waste recycling efforts work:

Southern Paper Stock Company of Spartanburg, South Carolina (cardboard and mixed office paper)

Quality Wood Recycling, Inc. of Newberry, South Carolina (waste wood pallets and skids)

Spartan Iron & Metal Corp. of Spartanburg, South Carolina (scrap metal)

Schuler Industries, Inc. of Birmingham, Alabama (spent graphite parts)

Modern Polymers, Inc. of Cherryville, North Carolina (polystyrene packaging)

Laurens Vocational Rehabilitation Center in Laurens, South Carolina (processing of scrap silicon and HDPE & Polypro Plastics)

Roebuck Plastics, Inc of Roebuck, South Carolina (sale of processed scrap silicon and plastics)
REFERENCES

A detailed discussion of the 1990 MEMC Solid Waste Study methods and results may be found in:

Net cost of solid waste hauling and landfill disposal based on average waste haul volume and density

**FIGURE 1. SOLID WASTE DISPOSAL COSTS FOR MEMC SPARTANBURG PLANT**

<table>
<thead>
<tr>
<th>Year</th>
<th>Sludge</th>
<th>Trash</th>
<th>Debris</th>
</tr>
</thead>
<tbody>
<tr>
<td>1989</td>
<td>$10.09</td>
<td>$3.55</td>
<td>$2.98</td>
</tr>
<tr>
<td>1990</td>
<td>$21.16</td>
<td>$5.56</td>
<td>$4.86</td>
</tr>
<tr>
<td>1991</td>
<td>$21.16</td>
<td>$5.56</td>
<td>$4.86</td>
</tr>
<tr>
<td>1992</td>
<td>$10.65</td>
<td>$5.56</td>
<td>$4.86</td>
</tr>
<tr>
<td>1993</td>
<td>$19.75</td>
<td>$4.33</td>
<td>$4.87</td>
</tr>
<tr>
<td>1994 est.</td>
<td>$26.75</td>
<td>$5.15</td>
<td>$6.13</td>
</tr>
<tr>
<td>Item</td>
<td>1st Quarter 1990 (Baseline)</td>
<td>1st Quarter 1993</td>
<td></td>
</tr>
<tr>
<td>----------------------------------</td>
<td>----------------------------</td>
<td>-----------------</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(a)</td>
<td>(b)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Volume, Volume, Weight,</td>
<td>Weight, Weight,</td>
<td></td>
</tr>
<tr>
<td></td>
<td>cu.yd./yr, fraction, tons/yr, fraction</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Landfilled Waste</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plant trash</td>
<td>7,980 65.63% 738 22.67%</td>
<td>2,520 32.29% 410 10.95%</td>
<td></td>
</tr>
<tr>
<td>Wastewater Sludge</td>
<td>3,040 25.00% 2,128 65.36%</td>
<td>4,240 54.32% 2,968 79.23%</td>
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</tr>
<tr>
<td>Construction Debris</td>
<td>900 7.40% 225 6.91%</td>
<td>800 10.25% 200 5.34%</td>
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</tr>
<tr>
<td>Quartz from pot scrap</td>
<td>240 1.97% 165 5.07%</td>
<td>240 3.14% 168 4.48%</td>
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</tr>
<tr>
<td><strong>Subtotal</strong></td>
<td>12,160 3,256</td>
<td>7,805 3,746</td>
<td></td>
</tr>
<tr>
<td>Recycled Waste</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scrap silicon</td>
<td>100 8.77% 69 56.56%</td>
<td>110 1.73% 75 18.52%</td>
<td></td>
</tr>
<tr>
<td>Spent graphite parts</td>
<td>0 0</td>
<td>45 .71% 14 3.46%</td>
<td></td>
</tr>
<tr>
<td>Plastic drums</td>
<td>600 52.63% 25 20.49%</td>
<td>603 9.49% 25 6.17%</td>
<td></td>
</tr>
<tr>
<td>Steel drums</td>
<td>320 28.07% 7 5.74%</td>
<td>121 1.90% 8 1.98%</td>
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</tr>
<tr>
<td>Steel drum shells</td>
<td>120 10.53% 7 5.74%</td>
<td>54 .85% 3 .74%</td>
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<td>Cardboard</td>
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<td>2,648 41.65% 132 32.59%</td>
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</tr>
<tr>
<td>Office paper</td>
<td>0 0</td>
<td>328 5.16% 29 7.16%</td>
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</tr>
<tr>
<td>Wood pallets</td>
<td>0 0</td>
<td>1,504 23.66% 68 16.79%</td>
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</tr>
<tr>
<td>Scrap metal</td>
<td>0 0</td>
<td>240 3.78% 37 9.14%</td>
<td></td>
</tr>
<tr>
<td>HDPE &amp; Polypro plastics</td>
<td>0 0</td>
<td>224 3.52% 10 2.47%</td>
<td></td>
</tr>
<tr>
<td>Polystyrene Packaging</td>
<td>0 0</td>
<td>480 7.55% 4 .99%</td>
<td></td>
</tr>
<tr>
<td><strong>Subtotal</strong></td>
<td>1,140 122</td>
<td>6,357 405</td>
<td></td>
</tr>
<tr>
<td><strong>Total Solid Waste</strong></td>
<td>13,300 3,378</td>
<td>14,162 4,151</td>
<td></td>
</tr>
</tbody>
</table>

*a* - data from waste hauling, recycling, and utility records expressed as annual volume

*b* - data from waste hauling records or calculated from annual volume using bulk material densities determined by field sampling
Table II  Plant Trash Composition, 1st Quarter 1990 Baseline  
MEMC Electronic Materials, Inc. - Spartanburg Plant

<table>
<thead>
<tr>
<th>Item</th>
<th>(a) Volume, cu.yd./yr</th>
<th>(a) Volume fraction</th>
<th>(b) Weight, tons/yr</th>
<th>(b) Weight fraction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cardboard</td>
<td>1,636</td>
<td>20.50%</td>
<td>82</td>
<td>11.08%</td>
</tr>
<tr>
<td>Office paper</td>
<td>716</td>
<td>8.97%</td>
<td>63</td>
<td>8.51%</td>
</tr>
<tr>
<td>Wood pallets &amp; skids</td>
<td>664</td>
<td>8.32%</td>
<td>67</td>
<td>9.05%</td>
</tr>
<tr>
<td>HDPE &amp; Polypro plastics</td>
<td>323</td>
<td>4.05%</td>
<td>15</td>
<td>2.03%</td>
</tr>
<tr>
<td>Polystyrene packaging</td>
<td>272</td>
<td>3.41%</td>
<td>2</td>
<td>.27%</td>
</tr>
<tr>
<td>Spent graphite parts</td>
<td>86</td>
<td>1.08%</td>
<td>26</td>
<td>3.51%</td>
</tr>
<tr>
<td>Saw Blades</td>
<td>5</td>
<td>.06%</td>
<td>4</td>
<td>.54%</td>
</tr>
<tr>
<td><strong>Subtotal</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3,702</td>
<td>46.39%</td>
<td>259</td>
<td>35.00%</td>
</tr>
<tr>
<td>Paper products (c)</td>
<td>980</td>
<td>12.28%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sheet plastics (d)</td>
<td>656</td>
<td>8.22%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rubbish &amp; food waste</td>
<td>1,636</td>
<td>20.50%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other materials (e)</td>
<td>1,006</td>
<td>12.61%</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Subtotal</strong></td>
<td></td>
<td></td>
<td>481</td>
<td>65.00%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>7,980</td>
<td></td>
<td>740</td>
<td></td>
</tr>
</tbody>
</table>

a - data from trash sampling and stores inventory records expressed as annual volume  
b - calculated from annual volume using bulk material densities determined by field sampling  
c - paper and wool kraft products other than cardboard and office paper  
d - LDPE, HDPE, and vinyl plastic bags; bubble pack foam  
e - spent and used manufacturing supplies, misc. scrap metal, and other materials not included in other categories
### Table III  Solid Waste Calculations

MEMC Electronic Materials, Inc. - Spartanburg Plant

<table>
<thead>
<tr>
<th>Item</th>
<th>1st Qtr 1990 (Baseline)</th>
<th>1st Qtr 1991</th>
<th>1st Qtr 1992 (b)</th>
<th>1st Qtr 1993</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Disposal cost (net revenue) per cu. yd. (a)</td>
<td>Annualized cost, cu. yd./yr (revenue)</td>
<td>Disposal cost, cu. yd./yr (revenue)</td>
<td>Annualized cost, cu. yd./yr (revenue)</td>
</tr>
<tr>
<td>Landfilled Waste</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plant trash</td>
<td>$5.56</td>
<td>$44,389</td>
<td>$30,469</td>
<td>$17,319</td>
</tr>
<tr>
<td>Wastewater sludge</td>
<td>$21.16</td>
<td>$64,326</td>
<td>$64,750</td>
<td>$43,026</td>
</tr>
<tr>
<td>Construction debris</td>
<td>$4.86</td>
<td>$4,374</td>
<td>$3,621</td>
<td>$3,499</td>
</tr>
<tr>
<td>Quartz from pot scrap (c)</td>
<td>$0.00</td>
<td>$90.00</td>
<td>$90.00</td>
<td>$90.00</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Recycled Waste</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scrap Silicon</td>
<td>($445.00) ($445.00) ($445.00) ($445.00)</td>
<td>100 ($45,500)</td>
<td>120 ($53,400)</td>
<td>98 ($43,610)</td>
</tr>
<tr>
<td>Spent graphite parts</td>
<td>($90.00) ($90.00) ($60.00) ($60.00)</td>
<td>0 ($0)</td>
<td>20 ($1,800)</td>
<td>42 ($2,490)</td>
</tr>
<tr>
<td>Plastic drums</td>
<td>($14.65) ($14.65) ($14.65) ($14.65)</td>
<td>600 ($8,790)</td>
<td>630 ($9,210)</td>
<td>603 ($8,834)</td>
</tr>
<tr>
<td>Steel drum shells</td>
<td>($4.50) ($4.50) ($4.50) ($4.50)</td>
<td>120 ($540)</td>
<td>110 ($495)</td>
<td>115 ($518)</td>
</tr>
<tr>
<td>Cardboard</td>
<td>($2.20) ($2.20) ($2.20) ($2.20)</td>
<td>0 ($0)</td>
<td>1,590 ($318)</td>
<td>2,176 ($435)</td>
</tr>
<tr>
<td>Office Paper</td>
<td>($5.00) ($5.00) ($5.00) ($5.00)</td>
<td>0 ($0)</td>
<td>400 ($200)</td>
<td>234 ($0)</td>
</tr>
<tr>
<td>Wood Pallets</td>
<td>$2.53</td>
<td>$518</td>
<td>$2,189</td>
<td>$3,925</td>
</tr>
<tr>
<td>Scrap Metal</td>
<td>($2.26) ($2.26) ($2.26) ($2.26)</td>
<td>0 ($0)</td>
<td>0 ($0)</td>
<td>240 ($62)</td>
</tr>
<tr>
<td>HPPE &amp; Polyprop Plastics</td>
<td>$0.00</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
</tr>
<tr>
<td>Polystyrene Packaging</td>
<td>$0.00</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Subtotal</td>
<td>$12,160</td>
<td>$113,069</td>
<td>$98,839</td>
<td>$8,095</td>
</tr>
</tbody>
</table>

**Subtotal**

- **Total solid waste**: 13,300 $56,599 13,320 $32,687 13,639 $8,775 14,162 $40,421
- **Landfilled fraction (volume)**: 91.43% 71.92% 59.35% 55.11%
- **Recycled fraction (volume)**: 8.57% 28.08% 40.65% 44.89%

**Landfill cost avoided by recycling (based on cost of plant trash disposal)**: 
- $6,338 $20,794 $30,822 $27,526
- $0 $14,230 $49,225 $14,522

**Landfill cost reduction (1990 base year)**: $Sludge @ $10.65 $53,106

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**Notes:**

- **a** - effective landfill or alternative disposal rate from solid waste hauling records; net revenue is revenue from sale of recycled materials less handling & transportation.
- **b** - 1st Qtr. 1992 data represents 1992 actual results corrected for polystyrene and quartz.
- **c** - 1990 quartz data are actual, quartz data for 1991 - 1993 calculated from total silicon scrap (31% Si, 69% SiO2); quartz disposal included in net revenue for scrap silicon.
BASELINE SOLID WASTE GENERATION
MEMC SPARTANBURG PLANT
13,300 cubic yards/year

Quartz 2%
Sludge 25%
Constr. Debris 7%
Trash 66%

LANDFILLED WASTE
12,160 cubic yards/year

Steel Drums 39%
Plastic Drums 53%
Scrap Silicon 9%

RECYCLED WASTE
1140 cubic yards/year

1st Quarter 1990 Annualized
$56,600 net annual disposal cost
including revenue from recycling

FIGURE 2. BASELINE SOLID WASTE GENERATION, MEMC SPARTANBURG PLANT
BASELINE PLANT TRASH COMPOSITION
MEMC SPARTANBURG PLANT
7980 cubic yards/year

Office Paper 9%
Wood Pallets 8%
Cardboard 21%
Paper Products 12%
HDPE Plastics 4%
LDPE/Vinyl Plastics 8%
Polystyrene 3%
Other Materials 14%
Rubbish/Food Waste 21%

1st Quarter 1990 Annualized
Prior to recycling efforts;
all material landfilled

FIGURE 3. BASELINE PLANT TRASH COMPOSITION, MEMC SPARTANBURG PLANT
BASELINE PLANT TRASH COMPOSITION
MEMC SPARTANBURG PLANT
Recyclable Materials - Volume & Weight

Volume Analysis
7980 cubic yards/year

Weight Analysis
740 tons/year

1st Quarter 1990 Annualized
Recyclable solid waste materials from	rash sampling and recycling trial

FIGURE 4  BASELINE PLANT TRASH COMPOSITION,  RECYCLABLE MATERIALS VOLUME & WEIGHT,  MEMC SPARTANBURG PLANT
1993 SOLID WASTE GENERATION
MEMC SPARTANBURG PLANT
14,160 cubic yards/year

LANDFILLED WASTE
7805 cubic yards/year

RECYCLED WASTE
6360 cubic yards/year

1st Quarter 1993 Annualized
$40,400 annual disposal cost
including revenue from recycling

FIGURE 5  1993 SOLID WASTE GENERATION,  MEMC SPARTANBURG PLANT
NON-HAZARDOUS SOLID WASTE -- MEMC SPARTANBURG
ANNUAL VOLUME IN CUBIC YARDS

1st quarter data expressed as annual volume, 1990 base year. Recycled materials include office paper, cardboard, wood pallets, HDPE plastics, polystyrene, scrap metal, silicon, graphite, & drums

FIGURE 6 SOLID WASTE RECYCLING - MEMC SPARTANBURG PLANT