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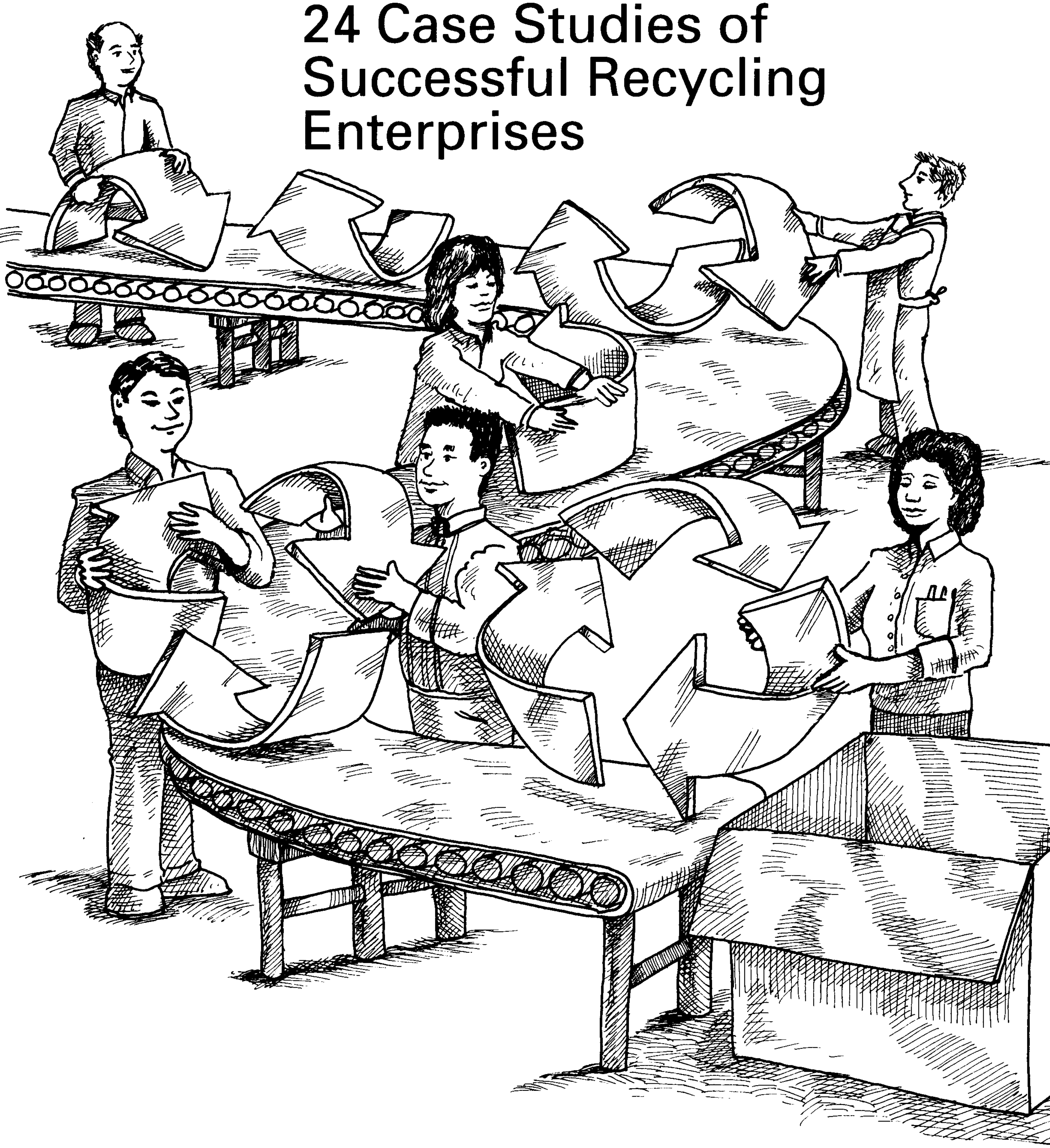
Manufacturing from Recyclables

24 Case Studies of Successful Recycling Enterprises



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ACKNOWLEDGMENTS

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Table of Contents

List of Figures

List of Tables

Case Studies Information Tables

Acronyms

ABS	acrylonitrile butadiene styrene
ACM	American Cellulose Manufacturing, Inc.
AEP	American Environmental Products, Inc.
AFT	advanced fiber technology
ASTM	American Society for Testing and Materials
Btu	British thermal unit, a measure of energy
C&D	construction and demolition debris
CEO	chief executive officer
CFC	chlorofluorocarbon
CPO	computer printout
EPA	U.S. Environmental Protection Agency
EPS	expanded or foam polystyrene
F	Fahrenheit
FDA	Food and Drug Administration
GSP	Garden State Paper Company
HCFC	hydrochlorofluorocarbon
HDPE	high density polyethylene
HGD	high grade deinking
HIPS	high-impact polystyrene
ILSR	Institute for Local Self-Reliance
IPC	intermediate processing center, also known as material recovery facility (MRF)
kW	kilowatt, a unit of energy
kWh	kilowatt-hour, a unit of energy consumed
LDPE	low density polyethylene
LLDPE	linear low density polyethylene
MCF	million cubic feet
MSW	municipal solid waste
MVRM	mechanical volume reduction machine
NA	not available

O&M	operating and maintenance
O-B	Owens-Brockway
O-I	Owens-Illinois
OCC	old corrugated containers
ONP	old newspapers
P&W	printing and writing paper
PDM	Pressurized Deink Module
PE	polyethylene
PET	polyethylene terephthalate
PP	polypropylene
PS	polystyrene
PVC	polyvinyl chloride
RAP	reclaimed asphalt pavement
RDF	refuse derived fuel
RSC	Recycling Systems Corporation
RUMAC	rubber-modified asphalt concrete
SBM	scrap-based manufacturing
SCS	Scientific Certification Systems
SOTA	state-of-the-art
STC	Stoneware Tile Company
TPD	tons per day
TPY	tons per year
UBC	used beverage container
VRM	volume reduction machinery
OMG	old magazines

Definitions

abc rubble	Asphalt, brick, and concrete rubble.
acrylonitrile butadiene styrene	A family of thermoplastics used to produce durable goods such as appliances, automobile parts, and telephone casings.
aggregate	Sized materials mixed with binders, either asphalt or cement, to form concrete.
asphalt	A heavy petroleum product refined to provide specifically engineered characteristics. Approximately 80 percent of the asphalt consumed in this country is used in pavements.
asphalt concrete hot-mix	A mixture of approximately 5 percent asphalt with 95 percent aggregate heated to about 300 degrees F. Hot-mix is used to pave the top layers of asphalt pavements.
bag paper	Type of paper used in the manufacture of paper bags.
beneficiation	The process of cleaning cullet of contamination.
bimetal container	A steel beverage container with an aluminum top.
bleaching	The process of purifying and whitening pulp by chemical treatment to remove or change existing coloring material.
blow molding	A process in which air is blown into a piece of molten plastic, pressing the plastic against the inside of a mold to shape it into a hollow form. Used to make bottles from HDPE and PP.
bond	A class of printing and writing papers made from bleached chemical wood pulps and/or bleached waste paper, often blended with cotton fibers. It is used for the printing of bonds, stock certificates, legal documents, and business letterheads, and other end uses requiring high quality paper.
book paper	A group of coated & uncoated papers suitable for printing books, magazines, brochures, and other general printing applications.
boxboard	Paperboard used to make folding cartons& setup (rigid) boxes such as cereal boxes and milk cartons.
bristol	A class of heavy weight papers used for graphic communications. End uses include file folders, greeting cards, tags, and soft bound book covers.
construction debris	Scrap material derived from the construction of commercial and residential structures.
corrugating medium	Paperboard that is used to form the fluted inner layer in a corrugated container. The medium is produced in rolls and then shaped into a continuous rolling wave (flutes) by a corrugating machine.
cover	A grade of heavy weight paper used as covering for books, reports, catalogs, and magazines.

cullet	Crushed scrap glass.
deinking	A process which removes inks and contaminants from wastepaper employing one or a combination of mechanical, chemical, enzymatic, or thermal treatments.
demolition debris	Scrap material derived from demolition of commercial and residential structures.
detinning	The process of chemically separating tin from tin-plated steel.
dispersion	The process of removing ink by dispersing it into particles small enough to become invisible.
dunnage	Packing material used in the protection of products during shipment.
expanded polystyrene	Foam polystyrene. Used to make products such as fast food containers, cups, packaging materials, and building insulation.
extrusion	The process of forming a product by forcing molten material through a die.
feedstock	Raw materials required for an industrial process
ferrous	Metals containing iron, such as steel.
fiber	Thread-like structures, usually derived from plants, used for papermaking & other uses. Fibers can also be derived from animal, mineral or synthetic sources.
fibreboard	Lightweight wallboard used for thermal and acoustical insulation.
plastic flake	Plastic that has been ground into small chips, generally between 1/4 and 1/2 inch in size.
flint	Clear glass.
flotation	The process of removing ink from wastepaper by causing ink particles to adhere to the air bubbles and rise to the surface as froth.
gaylord	A corrugated container with capacity to hold 32 cubic feet (240 gallons) of material.
glass tile	Tile in which glass is integrated with clay material.
hardboard	Construction paneling material made from reconstituted wood fiber.
high density polyethylene	Polyethylene in which the ethylene molecules are linked in long chains with few side branches. HDPE is more rigid than LDPE, and has greater strength, hardness, and chemical resistance. Examples of products made from HDPE include milk jugs, detergent bottles, certain kinds of grocery sacks, and garbage containers.
high grade deinking	Printed waste paper made from bleached chemical pulp, suitable for processing to remove inks and other contaminants for use in making recycled paper products, including high quality printing and writing paper.

high-impact polystyrene	Polystyrene to which rubbers have been added to increase the ability of the material to absorb impacts.
hydrapulper / pulper	A machine used to break up and defiber purchased pulp or waste paper in water to form a slurry.
hydromulch	Paper-based mulch that uses water in its application.
injection molding	A process of forming a product in which molten plastic is forced into a mold. Used to make a variety of products, including bottles from PET and PVC.
intermediate processor	A facility that receives material, often from an IPC, and processes it into feedstock suitable for an end product manufacturer.
kaofin	Sludge that consists of rejects from the various cleaning operations and wastewater treatment. It is approximately 50 percent clay from coated papers, and 50 percent short unusable fibers.
linear low density polyethylene	Similar to LDPE, but with only short side branches. LLDPE is manufactured at lower temperatures than LDPE.
linerboard	A type of paperboard used as the inner and outer surfaces of corrugated board. Corrugating medium is sandwiched between layers of linerboard.
low density polyethylene	Polyethylene in which the ethylene molecules are linked in a random fashion, with the main chains of the polymer having long and short side branches. LDPE is used for both rigid containers and plastic film applications.
market pulp	Pulp sold on the open market as a product.
mixed paper	A broad category consisting of various grades of waste paper.
molded pulp	Paper pulp molded into desired form. Used for nursery items, egg cartons, and packing material.
newsprint	A grade of paper containing high percentages of ground wood pulp, made specifically for use in the printing of newspapers.
offset	A coated or uncoated paper made with the characteristics most suitable for use in offset printing.
paper converting	The process in which the rolls of finished paper are cut and converted into finished products.
pelletizing	A process in which molten plastic is extruded through a die into small pellets.
plastic	Any of a large group of materials containing carbon, hydrogen, and other elements which can be formed into products using heat and pressure.
plastic lumber	An alternative to pressure treated wood, manufactured from various plastics.
poly-coated paper	Polyethylene coated boxboard used to make milk and juice cartons.

polyethylene	A polymer made from ethylene gas and produced in a range of densities. The most common type of plastic resin, PE is translucent in its natural state and has a waxy consistency.
polyethylene terephthalate	A thermoplastic material used to manufacture plastic soft drink containers and other rigid containers. PET has a high melting point, is clear in its natural state has a relatively high density.
polymer	A compound of high molecular weight made by combining many smaller molecules. The smaller molecules are linked by polymeric bonds.
polypropylene	A polymer formed by linking propylene molecules. PP has good resistance to heat and is used in flexible and rigid packaging, film, and textiles.
polystyrene	A polymer formed by linking styrene molecules. PS is used to make a variety of products including plastic cutlery and food containers. It is often used in its foamed state (see Expanded Polystyrene).
polyvinyl chloride	A family of co-polymers, also known as vinyl. PVC is used to make products such as pipes, bottles, upholstery, and automotive parts.
post-consumer	Recovered materials that have passed through their end-usage as a consumer item (derived from RCRA of 1976- Section 6002).
pre-consumer	Scrap material that has not been utilized by the end consumer (derived from RCRA of 1976- Section 6002). Materials recovered from waste generated through mining, manufacturing, and converting processes.
printing and writing	A broad category of coated and uncoated papers for such uses as photocopying, printing books, magazines and catalogs, and stationary.
pulp	A slurry consisting primarily of water and fibers which is used to make paper and other products.
pulp substitutes	The highest quality of waste paper available, generally consisting of completely unprinted scrap paper mostly generated by the mills and converters. Clean, unprinted or lightly printed waste paper that can be reused directly in the papermaking process with little or no preparation, such as envelope cuttings.
pulper/hydrapulper	A machine used to break-up cellulostic material into a slurry of fiber and water.
pulping	The process where fiberous materials are mixed with water to form a slurry for use in making paper and other products.
pyrolysis	A process in which material, such as rubber, plastic, or paper, is subjected to intense heat in the absence of oxygen.
recyclable	Material which is capable of being processed for subsequent use.
recycled content	The amount of secondary material in a product, expressed as a percentage of total feedstock used.

recycled	Material which has been reclaimed from the waste stream and remanufactured into a new product.
recycling	The process by which materials otherwise destined for disposal are collected, reprocessed or remanufactured, and reused.
regrind	Plastic products that have been reclaimed by shredding and granulating.
resin	The polymeric chains that are the basic building blocks of plastic products. While often used as a synonym for plastic, a plastic includes resin and additives such as colorants and impact modifiers.
rotational molding	A process in which plastic powder or liquid is placed in molds which are then rotated while being heated. The rotation coats the inside of the mold with molten plastic, which then cools in the shape of the mold. Used to make large, hollow products such as garbage containers.
scrap material	Discarded waste material suitable for reprocessing.
scrap-based manufacturing	An industrial process where part of the waste stream is used as raw material.
therm	A measure of energy, equivalent to 100,000 Btu.
tipping fee	Fee charged to haulers for delivering material at recovery or disposal facilities.
tissue	Thin, low weight paper used to manufacture such items as sanitary products, and wrapping material.
urban wood waste	Wood material recovered from an urban source such as wooden pallets, packing crates, and wooden utility spools.
value added	Dollar amount added to a ton of material by a manufacturing process.
vinyl	See polyvinyl chloride.

MANUFACTURING: THE CRITICAL LINK IN THE RECYCLING CHAIN

Background

Reduce, reuse, recycle. After the landfill closings and, incinerator moratoriums of the 1980s, the three Rs of solid waste management are becoming ingrained in the American psyche. But after reducing waste and reusing what is possible, what exactly is recycling? Setting bottles, cans and newspapers at the curb? Driving them to the local recycling center? Maybe buying stationery with recycled content? Yes, but these are only parts of the whole, only links in the recycling chain.

Communities first understood recycling as the collection of materials. Later, the intermediate processing center was recognized as an integral part of the whole, and more recently "buy recycled" campaigns have added to the growing definition of recycling. Now as recycling assumes a prominent role in municipal infrastructures, it must be understood as it exists — an entire system. Material — whether paper or plastic, glass or metal — is not recycled until it flows through the complete recycling process (as outlined in Figure 1). After a consumer's purchase, material is collected, sorted, and compacted for transportation. Material is shipped via rail, barge or truck to a manufacturer who turns the resource into a new product. The new product then follows the normal channels of commerce through a retailer back to the consumer. While intermediate stages, such as an additional processor or a wholesaler, may exist, the critical issue is that each link in the chain must be strong for the system to thrive.

Recycling-Related Manufacturing

The unsung hero in this scenario, however, is the recycling-related manufacturer. This operation makes new products using part of the waste stream as feedstock. For example, a recycled paper mill uses old newspaper to make new newsprint, and a steel mini-mill utilizes scrap steel in place of virgin ore. Because they provide markets for collected recyclable, scrap-based manufacturers allow recycling to exist.

In addition to reducing dependence on burn and bury facilities, the recycling-related manufacturer offers a community local economic development potential. In fact, manufacturers of recycled products hold a majority of the economic pay-off of the entire recycling process. Adding to the jobs and revenue that recycling collection and processing bring to an area, manufacturers of recycled products provide high-skill industrial jobs and sizable sales revenue to a community. These new factories hold the potential to revitalize a community's industrial sector, while diminishing

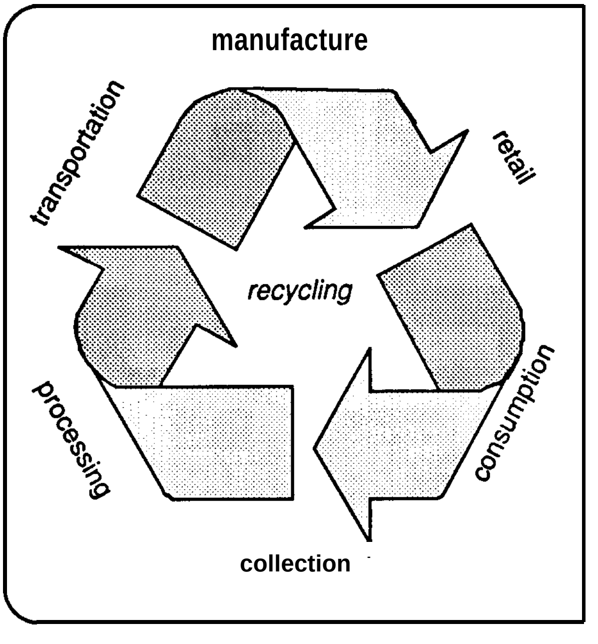


Figure 1: Recycling Material Flow A Continuous System

the local waste stream and buying locally-derived feedstock. These factories also preserve some of the value that has been added to the material through the original manufacturing process — value that would otherwise be destroyed through disposal.

Often smaller than virgin-based mills, a scrap based manufacturer tends to locate near sources of feedstock. In fact, manufacturing of recycled products offers a community the opportunity of self-reliance, as manufacturing feedstock is mined from a local source — the community recycling collection programs. In addition to the economic gains that new factories bring to a community, manufacturers of recycled products offer environmental benefits as well. Scrap-based enterprises require less energy, water and natural resources, and create less solid waste, air and water pollution than their virgin-based counterparts in nearly every case. Additionally, users of recycled feedstock reduce the need for, and the adverse impacts of, mining and harvesting virgin feedstock.

Recycled-Content Products

The current generation of manufacturers are only the pioneers, explorers who have scarcely scratched the surface of recycling's economic potential. These manufacturers demonstrate that secondary materials can replace a large number of the virgin raw materials currently used in this country. Table 1 shows numerous possibilities in scrap-based manufacturing. All the different products listed in the table are currently being made from recycled material. As processing and manufacturing technologies improve and demand for recycled products increases, this list will only expand.

For the purpose of this report, "recycled content" is defined as the amount by weight of scrap used divided by the amount of total feedstock used to manufacture a product.

Economic Development

Recycling systems, brought on-line over the past decade have diverted millions of tons of resources from disposal; however, fluctuations in market prices have meant unreliable revenue for these programs. To offset these market fluctuations, communities must work to capture a greater portion of the economic benefits derived from recycling. It is through remanufacturing of recovered material that communities stop viewing solid waste as a disposal burden and begin seeing it as an economic opportunity.

Instead of offering financial incentives to virgin-based industries, communities can attract scrap-based manufacturers by promising a steady, clean supply of low-cost feedstock. In return, the manufacturer of recycled products will turn what once was a liability into an asset, creating jobs, adding to the local tax base, and contributing to the growth of the local industrial sector.

Manufacturers of recycled products, like all industrial facilities, assist communities by providing jobs and generating taxable revenue. The remanufacture, however, creates these benefits not through processing virgin material, but by adding value to material already at hand. Jobs which these facilities provide and revenue which they generate (in the form of sales) are easy to measure, yet a full understanding of these economic benefits requires careful examination. The following scenario serves as an example of how a scrap-based manufacturer adds value to "waste," and how benefits accrue in the surrounding community.

A metropolitan area of 3 million people with an effective recycling collection system gathers 100,000 tons per year of old newspaper (assuming 155,000 tons are available,[1] and a state-of-the-art recovery rate of 64 percent[2]). With this material a city can follow one of two scenarios. The first option is to export the paper to a distant end market, while the second one is to utilize it as a local economic resource.

Choosing the second scenario, city officials work to attract a manufacturer that uses recycled feedstock — in this case a newsprint mill — to the town. This new plant will generate 220 manufacturing jobs (averaging an hourly wage of $12.60 per hour[3]), and contribute approximately $57 million annual gross revenue to the local tax base (figures based on existing plants in the U.S.). Additionally, the mill will save its host community $4 million a year in avoided disposal costs by diverting 100,000 tons of paper from the waste stream (assuming a $40 per ton tipping fee).

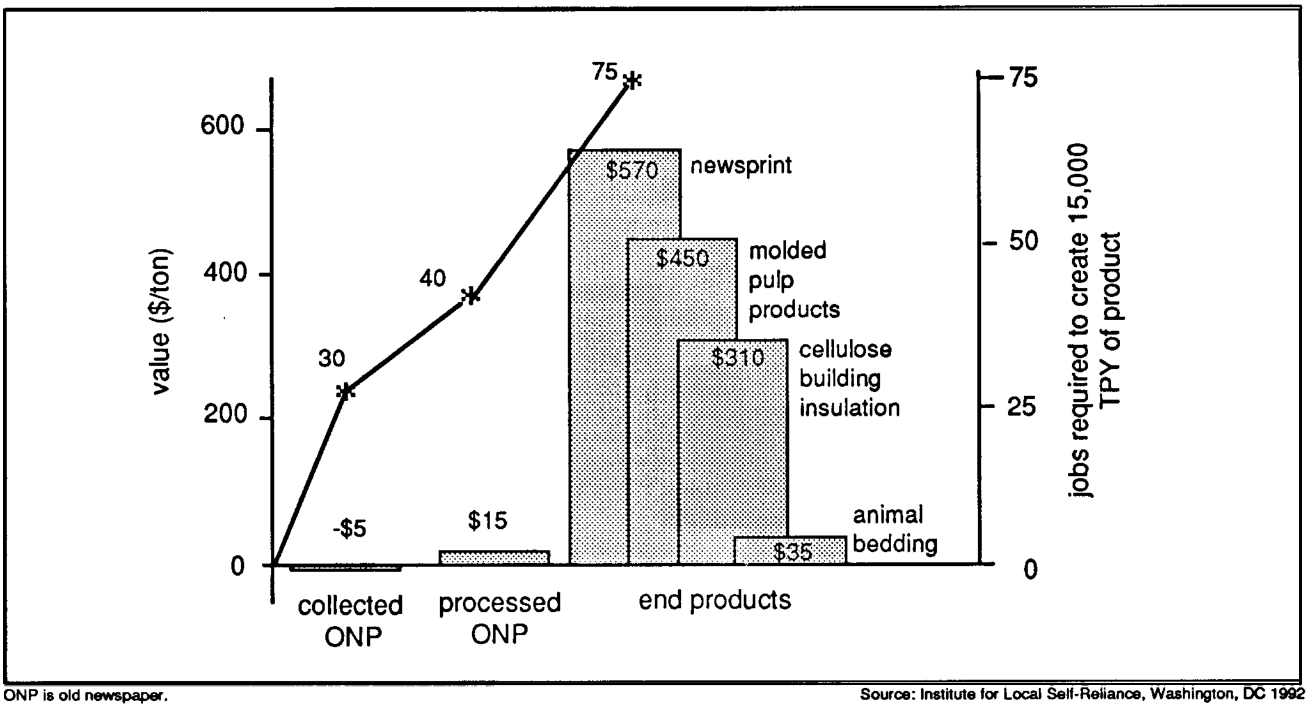
Figure 2 displays the value of old newspaper (ONP) at three points in the recycling loop, as well as the workers required to arrive at each stage. Collected ONP is worth little, in fact many communities pay mills to accept it. An intermediate processing center (IPC, also known as a material recovery facility or MRF) charges a $5 per ton tipping fee to a public or private hauler. The processor sorts and bales the paper, and sells it to the new mill for $15 per ton. At this stage, the processor has added $20 to the value of the material. Once it is manufactured into newsprint, however, the material sells for $570 per ton. Communities that rid themselves of recycled material before manufacturing deprive themselves of capturing future value added by the manufacturer of recycled products.

It is important to note that the "value added" does not directly indicate revenue recovered by the city, however, it does correlate to funds spent on jobs and services, which in turn translates into taxable revenue. When a manufacturer adds value to any material, it does so by means of labor and capital. When a scrap-based manufacturer adds value to a scrap material, the effect is magnified since the value is added to a former burden on the community. For this reason the term "value added to scrap" is used for this measurement of economic development potential. A full explanation of value added is contained in the Methodology Section.

In addition to value added, jobs created by manufacturing facilities provide an indication of economic development opportunities. The collection of recyclables employs approximately 30 people for every 15,000 tons of ONP collected per year.[4] Processing will require an additional ten,[5] and the newsprint mill will create 35 more jobs for every 15,000 tons processed annually. Again, with nearly half of the recycling system jobs existing at the manufacturing stage, it is the manufacturer of recycled products who adds substantially to the local economy.

Recycling of ONP is by no means limited to new newsprint as a product. Other products such as molded pulp packaging, cellulose building insulation and animal bedding all add value to ONP. Each product is manufactured by a separate process that adds a different amount of value to the recycled material. Figure 2 illustrates these differences.

Figure 2: Value of ONP Products and Jobs Generated by their Creation



ONP is old newspaper.

Source: Institute for Local Self-Reliance, Washington, DC 1992

Table 1: Opportunities in Recycling-Related Manufacturing

recyclable materials	sample products made from recycled materials
ASPHALT	
reclaimed brick and concrete	fill; road sub-base; aggregate; landfill cover
reclaimed asphalt pavement	asphalt concrete hot-mix; road sub-base
roofing shingles	pothole patch; hot-mix asphalt modifier
GLASS	
color sorted container cullet	glass containers; art glass; fiber glass insulation; pressed glass; tile; foam glass; aggregate; road sub-base; wastewater filter media
mixed container cullet	fiber glass insulation; pressed glass; tile; foam glass; aggregate; road sub-base; wastewater filter media
plate cullet	plate glass; art glass; fiber glass insulation; pressed glass; tile; foam glass; aggregate; road sub-base; wastewater filter media
METAL	
tin plated steel	tin and high grade steel; low grade steel
steel	I-beams; sheet; cans; automobile parts; fasteners
aluminum	sheet; cans; siding
other metals	pipes; additives; fixtures
PAPER	
pulp substitutes	printing and writing paper; tissue; paperboard; newsprint
high grade deinking	printing and writing paper; tissue; boxboard
old newspaper	newsprint; boxboard; bag paper; tissue; cellulose insulation; animal bedding; fiberboard; mulch
old corrugated containers	liner board; corrugating medium; bag paper; boxboard; tube stock; particle board; fiberboard; animal bedding; molded pulp; pencils; packaging fill
mixed paper	printing and writing paper; tissue; boxboard; fiberboard; molded pulp; animal bedding; roofing felt; ethanol
PLASTICS	
PET	soda bottles; textiles and fibers for furniture, pillows, comforters, jackets, sleeping bags and carpeting; packaging; shower stalls; paint brush handles; packaging strapping; plastic lumber
HDPE	detergent bottles; film bags; traffic cones; plastic cases; drainage pipes; waste and storage containers; plastic lumber
LDPE	trash bags; grocery bags; waste and storage containers; polyethylene modified asphalt concrete
PVC	pipe; floor tiles; urinal screen; containers; packaging film
PS	egg cartons; loose fill packaging; building insulation; trays; office supplies
PP	battery cases; boxes; flower pots; brooms
RUBBER	
whole tires	playground equipment; erosion control; artificial reefs and breakwaters; highway crash barriers
split tires	belts; floor mats; gaskets; snow blower blades, tail pipe hangers; shoe soles; dock bumpers
shredded tires	light weight gravel substitute; bulking agent for sludge comporting
ground rubber	asphalt rubber pavement; rubber modified asphalt concrete; polymer oil; rubber railroad crossing; other rubber and plastic products such as molded floor mats and plastic adhesives
WOOD	
wood	refurbished pallets or other wooden products; particle board; animal bedding; sweeping compound; mulch; compost; "chunckrete;" Timbrex®

Source: Institute for Local Self-Reliance, Washington, DC 1992

Stimulating Recycling-Based Production

Use of recycled material in manufacturing is expanding within many industries. Many state-of-the-art manufacturers are driving industries to higher levels of recycled content. However, as should be expected with any major industrial shift, scrap-based manufacturing is experiencing growing pains. The main issues facing manufacturers are (1) the availability of clean feedstock, (2) financing to construct new facilities, and (3) demand for their products. Governments can go a long way toward addressing some of these problems.

Because of the profound economic linkages between feedstock supply, remanufacture, and product demand, the best government recycling programs are those flexible enough to bring assistance where it is most needed. Depending on the current supply-and-demand status of a specific material, the best application of program assistance may be in either the collection, processing, shipping, manufacturing, marketing, or purchasing stages of that materials' lifecycle. Flexibility of such programs allows an opportunity to establish market equilibrium in these early stages of the recycling economy.

With this in mind, some states and localities have begun to develop recycling market-development offices that track current conditions and intercede as needed. These offices may administer grant or loan programs, provide information to procurement officials, offer technical assistance to recycling businesses, develop consumer education programs, or try to entice recycling businesses to locate in their region. In 1991 alone, seven such entities were developed to coordinate public and private market development activities.[6] These agencies may be able to help scrap-based manufacturers locate feedstock, financing, and product markets.

One method states have used to direct market development efforts is the creation of Recycling Market Development Zones (RMDZ). Would-be recycling enterprises are offered incentives such as grants, loans, tax breaks or credits, or technical assistance to lure them to an RMDZ. To qualify as a zone, a local government must submit applications to the state that are scored on factors such as available material, plans to attract and expand recycling businesses, local tax incentives, and available real estate. If a zone designation is awarded to the local community, then the state may provide low-interest finance loans of up to $1 million.

Conclusion

This examination of manufacturing from recyclables demonstrates the benefits a community can expect from localizing markets for its recyclable. Each case study serves as an example of recycling business adding to local economies. Commanding the pinnacle of the recycling symbol, the local manufacturer of recycled products is the critical link in the recycling chain.

Endnotes

1. *Characterization of Municipal Solid Waste in the United States: 1992 Update,* U.S. EPA, July 1992.
2. Brenda A. Platt, Naomi Friedman, Carolyn Grodinsky and Margaret Suozzo, *In-Depth Studies of Recycling and Composting Programs: Designs, Costs, Results, Volume III: Urban Areas,* Institute for Local Self-Reliance, Washington, DC, 1992
3. *1992 Lockwood-Post's Directory of the Pulp, Paper and Allied Trades,* Miller Freeman Publications, San Francisco, California, 1991.
4. Brenda A. Platt, et at.
5. *1992-93 Materials Recovery and Recycling Yearbook,* Governmental Advisory Associates, Inc., New York New York, 1992
6. Jim Glenn, 'The State of Garbage in America," *BioCycle,* May 1992, page 34.

A wide variety of scrap-based manufacturers already operate in this country, and their numbers are increasing. This growth is fueled by recycling collection programs, which generate a supply of discarded material, and demand-side policies. A study of how these facilities operate will be of interest to people in many sectors recycling coordinators can identify potential markets for their recovered materials; manufacturers will see improved feedstock quality from better educated suppliers; entrepreneurs can gain insight into successful operations; and economic developers can weigh the benefits a community might reap from such facilities. From all perspectives, these facilities can be counted on for economic development, waste reduction and a cleaner environment for the public.

The 24 case studies contained here represent a sample of state-of-the-art scrap-based manufacturers. The selection process by which companies were chosen for the study is discussed below.

Selection of Manufacturers

Initially, a database of manufacturers that utilize recycled materials was compiled. From this long list of several hundred, the 24 case subjects were selected, based on the following criteria:

1) *Feedstock diversity* The manufacturers chosen use a wide variety of materials from the waste stream. All major sectors are represented, while emphasis was placed on manufacturers using materials that account for a large percentage of the waste stream. For example, 11 of the 24 facilities *use* recovered paper, which accounts for 40 percent of MSW.

2) *High post-consumer and total recycled content.* The plants documented in the case studies use a higher percentage of post-consumer and total recycled content feedstock than most of their competitors. For example, Owens-Brockway's glass bottles have a 54 percent total recycled content with a 49 percent post-consumer content, as compared to the industry average of 25 percent total recycled content.

3) *High value products:* Operations that add the most value to their feedstock were preferred. For example, plants that make newsprint and cellulose insulation from ONP are favored over those producing lower-value animal bedding.

4) *Use of low-value or rarely-recycled materials:* Many of the 25 manufacturers are pioneers in using low-value discarded materials that are generally ignored by other manufacturers. For example, Marcal Paper Mills uses low-grade mixed paper to make high-value tissue products.

5) *State-of-the-art technology:* Processes that are a step up from the status quo were favored. For example, Cyclean, Inc.'s microwave technology allows it to make asphalt pavement from 100 percent recovered pavement. The previous generation technology only permitted the use of about 25 percent reclaimed asphalt in new pavement.

6) *Recycling level:* Plants that recycle material back into its original form (primary recycling level) promote sustainability by closing the material flow loop. For example, Patriot Paper Corporation uses old office paper to make new printing and writing paper (see Definitions section for more information).

Information Sources

Information and numbers presented in the case studies were either provided by the respective manufacturers, or were calculated by the researchers based on published company information or industry statistics. Assumptions and calculations are explained in table footnotes. Every effort was made to gather accurate, case-specific data. However, because of the dynamic nature of the industry, changing technology, and the proprietary nature of private companies, not all information was readily available. All manufacturers were provided the opportunity to verify the accuracy of their respective case studies.

Organization of the Case Studies

The case studies are categorized alphabetically according to the discarded material used at the facility. Each study consists of seven sections: company background, feedstock, process, products, economics, replicability and contacts. The content of each of these sections is summarized below.

Company Background

This section presents a brief history of the plant and its use of discarded materials. It may also include information on the parent company, and any special recognition the company may have received for its recycling efforts.

Feedstock

This section examines the raw material a plant uses, with an emphasis on the scrap component. It addresses issues related to sources, amounts, total recycled and post-consumer content of the feedstock, tolerance to contamination, and price paid for the feedstock. Frequently, the annual consumption of raw materials, along with the amount of post-consumer and total recycled content, will vary with consumer demand for the products. The numbers presented are average figures as furnished by the respective companies, unless otherwise noted. Prices paid for scrap material fluctuate depending on the supply levels, location of the plant, and the quality of the material. Therefore, prices are often reported as a range. In the feedstock information table, the total recycled content, post-consumer content and price paid per ton are weighted averages.

Process

In this section, the manufacturer's process is outlined as the material flows through the plant. Also included are the plant's capacity utilization factor, information on its waste generation and disposal, employment figures, scheduled operation, plant and warehouse size, and water and energy requirements. In some cases, details are lacking due to the proprietary nature of the manufacturing processes.

Formulas relevant to the process section are as follows:

$$\text{capacity utilization factor} = \frac{\text{production output rate}}{\text{production design capacity}}$$

$$\text{feedstock reject rate} = \frac{\text{feedstock input rate - production output rate}}{\text{feedstock input rate}}$$

Products

A profile of the finished products appears under this heading. This includes annual production rates, post-consumer and total recycled contents, sales figures, value added to scrap materials, and geographical markets for the products. Product awards and certifications are also highlighted.

Value added to a ton of scrap feedstock by the manufacturer (va_s) is the value added referred to in the text. This calculation is explained below. Two important factors are the recycled content and scrap reject rate.

$$va_s = content_{p,s} [(1 - \text{reject rate}_s)\, price_p - cost_s]$$

$content_{p,s}$ = recycled content of product (%)
= average percentage by weight of product that is recycled
= $F((input_s)(1 - \text{reject rate}_s),(output_p))$

inputs = input amount of scrap feedstock (tons, TPD, TTY, etc.)

reject rate_s = scrap reject rate (%)
= percentage of scrap input that ends up in the waste output of the manufacturing process
= $output_{w,s} / input_s$

$output_{w,s}$ = amount of output waste that is from scrap input (matched to $input_s$ units)
= $(output_{w,t})(content_{w,s})$

$output_{w,t}$ = amount of total output waste (matched to $input_s$ units)

$content_{w,s}$ = recycled content of waste output (%)
= average percentage by weight of waste that is recycled

$output_p$ = amount of product produced (matched to $input_s$ units)

$price_p$ = product price ($/ton)
= average price at which the manufacturer sells product

$cost_s$ = average price manufacturer pays for feedstock ($/ton)

Economics

This section explores costs and savings associated with establishing and operating a scrap-based enterprise. A table of economic information provides a breakdown of costs, including initial capital outlay, and annual operating and maintenance, labor, energy and feedstock costs. Cost per ton of production and sales per ton of production figures are also included in this table. These figures were either provided by manufacturers or calculated by the researchers. Initial capital cost figures should be applied cautiously, considering circumstances such as the year a plant was built, mergers and takeovers, and the restarting of an idle factory. Policies and legislation affecting the economics of the scrap-based manufacturer are discussed when applicable.

Replicability

This section discusses the company's plans for expansion, relocation, or licensing of its process. It also addresses the availability of the technology the plant uses, and notes any patents that would present an obstacle to imitators. Besides the physical and financial conditions that would be favorable to a plant, the limitations and obstacles to locating a new facility are also addressed.

Contacts

Here appear the name, address, and phone number of persons to contact for additional information.

CASE STUDIES

MATERIAL	CASE STUDY	LOCATION	PRIMARY PRODUCT
ASPHALT	Cyclean, Inc./ L.A. Bureau of Street Maintenance	Round Rock, TX/L.A, CA	asphalt concrete hot-mix
	Reclaim of New Jersey, Inc.	Kearny, NJ	asphalt paving material
GLASS	Optimum Art Glass, Inc.	Eaton, CO	colored sheet glass
	Owens-Brockway	Portland, OR	glass containers
	Stoneware Tile Company	Richmond, IN	glass-bonded ceramic tile
METAL	AMG Resources Corporation	St. Paul, MN	detinned steel
PAPER	American Cellulose Manufacturing, Inc.	Minonk, IL	cellulose building insulation
	American Environmental Products, Inc.	Elkwood, VA	cellulose products
	The Chesapeake Paperboard Company	Baltimore, MD	boxboard
	Fibreform Containers, Inc.	Germantown, WI	molded pulp packaging
	Garden State Paper Company, Inc.	Garfield, NJ	newsprint
	Homasote Company	West Trenton, NJ	structural fiberboard
	Marcal Paper Mills, Inc.	Elmwood Park, NJ	tissue
	Ohio Pulp Mills, Inc.	Cincinnati, OH	market pulp
	Paper Service Limited	Ashuelot, NH	tissue
	Somerset Fiber/ Recycling Systems Corporation	Cowpens, SC	paperboard
PLASTIC	Coon Manufacturing	Spikard, MO	plastic sheet
	Landfill Alternatives, Inc.	Elbum, IL	PS pellets
	Poly-Anna Plastic Products, Inc.	Milwaukee, WI	recycling bins
	Turtle Plastics Company	Cleveland, OH	floor mats, urinal screens
	Webster Industries	Peabody, MA	trash bags
RUBBER	Aquapore Moisture Systems	Phoenix, AZ	soaker hose
	Process Fuels, Inc.	Spokane, WA	polymer oil, fuel gas, steel
WOOD	Evanite Fiber Corporation	Corvallis, OR	hardboard

CYCLEAN, INC. / LOS ANGELES BUREAU OF STREET MAINTENANCE

Location:	Round Rock, Texas / Los Angeles, California
Start-up Date:	*1987*
Recycled Material Used:	reclaimed asphalt pavement
Products:	asphalt concrete hot-mix
Production Design Capacity:	1,300 TPD

COMPANY BACKGROUND

Street-maintenance crews in Los Angeles, California remove over 250,000 tons of reclaimed asphalt pavement (RAP) from the streets each year. Prior to 1987, the city's two asphalt plants recycled only 15 percent of this material into new pavement and landfilled the remainder. However, anticipation of a landfill shortage led city officials to seek alternatives.

Robert Nath, founder and chairman of Cyclean, Inc. of Round Rock, Texas, had approached the city of Los Angeles in 1983. After years of following the development of Cyclean's process, and hearing the technical, financial, and environmental arguments in its favor, the city decided to have Cyclean bring its technology to town. In 1987, Cyclean was granted the right to use the city's RAP to make new asphalt concrete. The city in turn agreed to purchase all of Cyclean's hot-mix and put it back on the streets. Although production quantities were initially low, Los Angeles has used approximately 200,000 TPY of 100 percent recycled asphalt-concrete hot-mix in each of the last three years. Plans for a second plant, in south Los Angeles, are now underway. The Los Angeles / Cyclean program was the recipient of Renew America's 1992 Environmental Achievement Award.

Nath founded Cyclean, Inc. in 1985. His innovative technology uses microwaves to make paving material from 100 percent recycled asphalt concrete. The recycled-content limit using conventional asphalt-recycling processes is about 25 percent, primarily because of concerns about air pollution and safety. The Cyclean process produces minimal emissions, according to its manufacturers.

Besides the highly successful program in Los Angeles, Cyclean has also completed work in Georgia, Michigan and Texas: in 1991 a project in Ashburn, Georgia cut the material cost in half by using 73,000 tons of RAP. The Texas Department of Transportation used 93,000 tons of RAP (with 10 percent virgin content) to pave 19 miles of Highway I-35 E. Michigan saved $500,000 on **a** three-mile stretch with Cyclean pavement. Cyclean has also taken its technology to the Netherlands, where one official said the product was "better than virgin hot-mix asphalt."

Table 2 Feedstock Information

material	consumption (TPY)	recycled content	post-consumer content	price paid/ton
reclaimed asphalt pavement	202,000	100%	100%	$0 [a]

[a] Cyclean pays nothing for the RAP. The city, however, saves approximately $3 per ton in avoided disposal costs.

Source: Institute for Local Self-Reliance, 1992.

Feedstock

RAP is essentially Cyclean's only feedstock. Cyclean recovers the asphalt & aggregate portions and rejects roughly one percent of this, consisting of fine particles generated in the process of stripping old asphalt pavement off the street. With over 6,500 miles of paved streets, Los Angeles has the largest municipal street system in the country. Every mile requires regular stripping and repaving. The City currently uses over 200,000 tons per year of reprocessed RAP, in approximately 80 percent of its maintenance projects (Table 2).

Cyclean's process also uses a petrochemical rejuvenating agent, and an anti-stripping agent. However, these account for only 0.5 percent by weight of the total mix.

Process

City crews stockpile old asphalt pavement near the plant. Cyclean screens the RAP to remove big chunks and unwanted fines. Oversized pieces are crushed and sent back through the screen. The desired particle size varies according to site conditions and the mix design requirements. The city uses the rejected fine particles, which account for about one percent of the incoming RAP, as backfill material.

The sized particles are conveyed to a warm-air drum dryer that heats the RAP to over 220° F, This process removes all moisture. A huge microwave oven then cooks the RAP for three minutes. Seven microwave generators allow the RAP to reach 300° F without burning the asphalt. Following the microwave treatment, rejuvenating and anti-stripping agents are added to the mix. A screw-type rib-

Table 3 Process Information

recycling level:	primary
feedstock input rate:	880 TPD [a]
production output rate:	870 TPD [a]
production design capacity:	1,300 TPD [a]
capacity utilization factor:	677.
feedstock reject rate:	1 %
waste generated:	fine gravel and asphalt mix
disposal methods:	backfill material
equipment:	screen, warm-air drum dryer, 7 microwave generators, mixer, storage silos
employment:	5 full time
scheduled operation:	5 days per week; one shift per day
area requirement:	3.5 acres
plant size:	21,780 square feet
warehouse size:	none
energy requirement:	30 million kWh per week of electricity
water requirement:	low

[a] Source: Institute for Local Self-Reliance, 1992. Assumes plant operates 230 days par year.

Source: Institute for Local Self-Reliance, 1992.,

Table 4 Product Information

products manufactured	production rate (TPY)	total recycled content	post-consumer content	estimated annual sales	gross revenue per ton	value added per ton
asphalt concrete hot-mix	200,000	100%	100%	$3,000,000	$15	$15

Source: Institute for Local Self-Reliance. 1992.

bon mixer stirs the materials and conveys them to a heated storage silo. The entire process takes approximately 10 minutes from start to finish.

The hot-mix is transported to the paving site and applied like conventional asphalt concrete. As the name implies, the mix must be hot when used — it cannot be stored or transported in an unheated truck for more than an hour. Thus, the plant can only provide paving for projects that are nearby.

The Los Angeles Bureau of Street Maintenance and Cyclean meticulously monitor the quality of the hot-mix. Cyclean has performed tests on four samples of the finished product every day for the past five years. In addition, tests have been performed on numerous 4-inch core samples cut from streets paved with the recycled hot-mix.

More information on the process used in the Los Angeles plant is presented in Table 3.

Economics

The use of Cyclean technology saves Los Angeles roughly $2 million per year in disposal fees, virgin materials, and transportation. The Bureau's total street-maintenance budget is about $41 million per year. Over the past five years, the city has reduced its use of virgin paving material by over 800,000 tons, saving approximately $8 million in materials and disposal costs.

At present, Cyclean sells its product to Los Angeles at $15 per ton for up to 180,000 tons per year, and $10 per ton for any amount above that. Negotiations are under way for next year's contract, in which the price of the hot-mix will be $16 per ton. This is approximately two-thirds the price of conventional hot-mix in the area.

Although the initial capital cost for a plant varies significantly with size and location, a plant similar to the one in Los Angeles requires an ini-

Products

The Cyclean process produces 100 percent hot-mix asphalt concrete that is on a par with virgin hot-mix. Hot-mix asphalt concrete consists of 5 percent asphalt and 95 percent aggregates, all heated to 300° F. The mix is used for paving the top surface of asphalt pavements. According to company representatives and the engineers at the Los Angeles Bureau of Street Maintenance, tests done in Los Angeles and Texas cannot discern any chemical or physical difference between Cyclean's recycled product and conventional, virgin asphalt concrete. Table 4 provides details on Cyclean's product.

Table 5 Economic Information

initial capital cost:	$3,000,000 (1987)
labor cost:	$140,000 to $200,000 per year
energy cost:	$420,000 to $600,000 per year
feedstock cost:	$0 per year
total O&M cost:	$1,400,000 to $2,000,000 per year
gross revenue:	$3,000,000 per year
capital cost/capacity:	$2,500 per TPD capacity
O&M cost/sales:	$7 to $10 per ton sold
gross *revenue/sales:*	$15 per ton sold

Source: Institute for Local Self-Relaince, 1992.

tial capital expenditure of $3 million. Operational costs range from $7 to $10 per ton of asphalt concrete produced.

The most significant portion of the operation and maintenance cost is the energy, at 30 percent. The feedstock is free, and the cost of the rejuvenating agent is minimal. With just five workers, labor accounts for 10 percent of the operating cost (Table 5).

Replicability

Cyclean, Inc. holds the patent to the Cyclean technology, and is interested in building new plants around the U.S. Plants of various sizes can be built to accommodate project needs. For small individual projects or test projects, Cyclean can build temporary plants on site which are mobile and easy to set up. For the Texas Highway I-35 E project, Cyclean was able to erect a plant and begin production within two weeks of the completion of site preparation.

Cyclean Inc., in collaboration with the U.S. Army Corps of Engineers, is currently researching the possibility of using its process to make hot-mix on the job site. This system would link up all the conventional and microwave equipment needed to recycle old asphalt in one continuous paving train, significantly decreasing the logistical, personnel and transportation costs.

Contacts

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ReClaim of New Jersey, Inc.

Location:	Kearny, New Jersey
Start-up Date:	1988
Recycled Material Used:	asphalt roofing debris
Products:	asphalt paving material pothole patch material hot-mix asphalt modifier
Production Design Capacity:	350 TPD

Company Background

Reclaim of New Jersey, Inc. is the sole subsidiary of Reclaim, Inc., a Tampa, Florida corporation founded in 1987 "expressly for the purpose of reclaiming and reusing non-hazardous, non-toxic asphalt roofing scrap." The company produces a number of asphalt based paving products at two New Jersey plants: one in Kearny, the other in Camden. The Kearny operation showcases the second generation of ReClaim equipment, and serves as the blueprint for future facilities.

The manufacture of paving products from recovered asphalt roofing material is based on a practice of shingle manufacturers, who for many years used production scrap, called "tab-ends," as paving material for driveways and parking lots. In the early 1980s ReClaim CEO, Jim Hagen, began investigating methods to turn roofing scrap into a low-cost paving material for truck lots and shipping yards. In 1988 the company began recycling operations as ReClaim of New Jersey, Inc., in Kearny. Today, Reclaim is the only state certified recycler of asphalt roofing material in the nation.

Reclaim executives chose New Jersey because of the state's commitment to diverting resources from incinerators and landfills. New Jersey's state recycling program requires roofers and demolition-waste haulers to deliver a portion of their demolition waste to certified recycling facilities. In September 1989, Reclaim's Kearny plant was the first facility to be certified as a "waste-diversion recipient" by the New Jersey Department of Environmental Protection. Local governments, therefore award "diversion credit" to haulers who take recovered material to ReClaim, as part of the State's mandatory recycling program. High tipping fees ($115 per ton at Kearny-area landfills) provide further incentive for haulers to take material to Reclaim.

ReClaim has received several awards for its efforts, including the 1992 Recycling Industry Outstanding Achievement Award, presented by the New Jersey Department of Environmental Protection and Energy; the 1992 Most Innovative Local Market Development Award from the National Recycling Coalition; Keep America Beautiful 1992 Recycling Award for Business and Industry; and a 1992 award of "Special Merit" from Renew America, a Washington, D.C.-based non-profit organization that identifies model operations working to "protect, restore and enhance the environment ."

Table 6 Feedstock Information

material	consumption (TPY)	recycled content	post-consumer content	price paid/ton
commercial roofing	48,600	100%	100%	-$64
residential asphalt shingles	30,800	100%	100%	-$64
manufacturers' scrap shingles	1,600	100%	0%	-$40
total roofing scrap	**81,000**	**100%**	**98%**	**-$64**

Source: Institute for Local Self-Reliance, 1992.

Feedstock

ReClaim of New Jersey, Inc. processes 300 tons per day of clean roofing scrap at its Kearny facility (Table 6). The feedstock is a mixture of various roofing (from flat roofs) material, the composition of which changes daily. However, Reclaim estimates that approximately 60 percent of the material arriving at the plant is post-consumer commercial built-up roofing, and 38 percent is post-consumer asphalt shingles. The remaining 2 percent is post-industrial asphalt shingles from a nearby shingle manufacturer. The plant accepts material on site, but also maintains twenty drop sites within New Jersey. From the drop sites, ReClaim distributes material to its two processing facilities.

The New Jersey Department of Environmental Protection limits the amount of contamination accepted at recycling facilities, and can revoke a facility's recycling certification if that facility accepts loads with more than 2 percent contamination. Therefore, Reclaim is careful about receiving anything but clean roofing scrap. While insulation (both foam and fiberglass) and nails do not interfere with the ReClaim manufacturing process and are not considered contaminants, brick, plastics, wood and asbestos tile are considered contaminants. In addition to rejecting contaminated loads, Reclaim charges haulers $150 per truckload for reloading contaminated material.

In August 1992, Reclaim began adding quarried aggregate to the reduced roofing material in production of its pothole patch. Because the asphalt roofing is processed before it is combined with the aggregate, the new product increases production capacity of the facility without altering the parameters of the plant. Because it is added off-site, aggregate is not listed as a feedstock in Table 6.

Processs

The production process at Kearny is based on simple material reduction and is accomplished mainly with two mechanical volume reduction machines (MVRM) modified to withstand the extreme wear caused by abrasive roofing scrap. ReClaim has succeeded with this process where other roofing asphalt processors have failed because of the durable and cost-effective MVRMs which they developed in-house.

As roofers unload material onto a receiving pile at the facility, workers inspect for contaminants. A bucket loader mixes the pile and loads it into the first "muncher," a modified MVRM that reduces material to a less than 6-inch size. This feedstock then runs through a second muncher before it is screened to specified size, dependent upon the end product. Oversized pieces are returned to the muncher, and ferrous metals (i.e., nails and wire) are magnetically removed.

ReClaim uses reduced roofing material in one of two ways: either marketing it as Econo-Pav® ground cover, or further processing it into other products. To make its pothole patch, RePave®, the company reduces the material to pea-sized pieces and mixes it with crushed stone aggregate and a proprietary emulsion mix. The roofing material and the emulsion mix blend bind with the aggregate, creating a cold-mix asphalt patch. ReClaim mixes the material in a three-to-one mixture thereby producing four tons of patch for every ton of roofing used.

ReClaim currently uses a mixer at a separate facility to combine the roofing material and stone for RePave®, shipping the roofing scrap from Kearny and the finished product back to the facility. The company also mixes the material in a facility adjoining the Kearny plant, significantly increasing production of RePave® (a projected increase of 200 tons per day).

Several major consumers of paving material are currently testing ReClaim's third product, ReActs HMA®, an asphalt "enhancer," and could be using the product early in 1993. To make ReActs® , ReClaim pulverizes the roofing material to a talcum powder consistency after which it is added to asphalt paving as a reinforced modifier.

ReClaim uses neither heat nor chemicals to prepare these end products. The entire operation, excluding the feedstock and product inventory, is enclosed within a 5,000 square foot building.

The Kearny plant employs six workers full-time one operating the MVRM, one running the loader, two sorting material inside, and two sorting incoming loads. The plant operates two shifts, five days per week (Table 7). Because the facility is covered, operations continue regardless of weather.

Products

In the four years since its inception, ReClaim has produced over 150,000 tons of Econo-Pav®, a low-cost pavement for industrial parking lots, fleet vehicle equipment yards, maintenance roads along railways, access roads to landfills, and for

Table 7 Process Information

recycling level:	secondary
feedstock input rate:	300 TPD scrap material
production output rate:	300 TPD
production design capacity:	350 TPD
capacity utilization factor:	86%
feedstock reject rate:	<2%
waste generated:	none
disposal method:	landfill
equipment:	two volume reduction machines (in-house design), dust collector, ferrous separator
employment:	21 full time; 3 skilled, 18 unskilled
scheduled operation:	270 days per year; 1 to 3 shifts per day (seasonal)
area requirement:	4 acres
plant size:	5,000 square feet [a]
warehouse size:	none [b]
energy requirement:	175,000 kWh per year of electricity
water requirement:	150 gallons per day

[a] Future plants will store products inside, requiring significantly larger plant size (25,000 square feet, according to ReClaim officials).
[b] Future plants will require 20,000 square feet of warehouse space.

Source: Institute for Local Self-Reliance, 1992

Table 8 Product Information

products manufactured	production rate (TPY)	total recycled content	post-consumer content	estimated annual sales	gross revenue per ton	value added per ton
ground cover substitute	68,900	100%	95°%	$70,000	**$1**	**$65**
pothole patch	48,600	25%	24%	$3,930,000	$81	$380
total	**117,500**	**69%**	**66%**	**$4,000,000**	**$34**	**$190**

Source: Institute for Local Self-Reliance, 1992.

muddy roadway stabilization (Table 8). The product is easy to apply and uses no heat or chemicals in its production or application. While Reclaim has thus far focused its efforts on Econo-Pav®, it now plans to devote an increasing share of the Kearny operation to the addition of two high-value products: RePave®, a "high-performance" pothole patch, and the ReActs® line, a collection of three asphalt pavement enhancers (modifiers).

RePave® has already been used to patch potholes in over 70 sites across New Jersey. Its marketing advantage over traditional cold-patch material is its increased tenacity. Road crews use cold-patch to temporarily patch potholes until warm weather permits the use of more permanent hot-patch repair. However, due to a number of factors, many of these "temporary" patches are left as permanent, or are re-patched year after year. RePave®, says the company, "has proven to be a superior, long lasting and durable cold mix material.... It can be applied in any type of weather and hardens so effectively that it does not push out, crack or break up from prolonged road wear." RePave® is available both in large quantities for sale to government divisions, and in small quantities for the home patch market. The product is sold retail in home improvement stores throughout the Northeast, Arizona, and southern California.

The ReActs® asphalt additive increases the "fibrous" characteristics of asphalt, extending its life, and providing a superior riding surface. Pavers mix the additive with asphalt in a one-to-ten ratio. The product is currently undergoing tests and should be available in the spring of 1993.

ECONOMICS

ReClaim generates revenue through tipping fees charged to haulers and roofers who pay ReClaim to accept roofing scrap (Table 9). Product sales currently generate little revenue for the company, although ReClaim expects significant revenue increases with the introduction of new, high-value products (RePave® and ReActs®).

The introduction of RePave® has increased both the value added to the roofing material and the value ReClaim receives for its products. Producing a ton of Econo-Pav® brings ReClaim $65 ($64 per ton tipping fee and $1 per ton sales revenue). A five gallon bucket of Repave® sells for $7.75 wholesale. ReClaim plans to increase production of the pothole patch to 50 percent of total production by mid-1993.

Table 9 Economic Information

initial capital cost:	$3,500,000 (1988)
labor cost:	$400,000 per year
energy cost:	$200,000 per year
feedstock cost:	– $5,000,000 per year
total O&M cost:	$2,000,000 per year
gross revenue:	$4,000,000 per year
capital cost/capacity:	$10,000 per TPD capacity
O&M *cost/sales:*	$17 per ton sold
gross revenue/sales:	$34 per ton sold

Source: Institute for Self-Reliance, 1992.

ReClaim has spent a significant amount of time and capital developing its production process. Together, research and development and new equipment expenditures make up a quarter of Reclaim's total costs. Twenty percent of O&M costs is spent on labor, and ten percent on energy costs.

Replicability

The production line at Kearny is Reclaim's second. In 1991 Reclaim completely replaced the manufacturing line, moving it to the Camden, New Jersey plant. Unlike the original line, which processed material outdoors, the new line at Kearny is completely housed, easing maintenance and reducing moisture content in the product. ReClaim management is currently planning a third and final round of improvements, which, with some processing adjustments, will render the operation fully ready for replication at other sites.

According to ReClaim, Inc. executives, the company is actively seeking expansion opportunities, and will soon take root in several locations. around the country. The company is seeking metropolitan areas (population over one million people) with landfills near capacity, high tipping fees, and strict environmental laws in force. Numerous attempts by other companies to copy Reclaim's process have failed due to inadequate technology, along with an incomplete understanding of the mechanical volume reduction process.

Contacts

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OPTIMUM ART GLASS, INC.

Location:	Eaton, Colorado
Start-up Date:	1989
Recycled Material Used:	container cullet plate cullet
Products:	colored sheet glass
Production Design Capacity:	3 TPD

Company Background

Robert and Kristine Wise began producing art glass in their Eaton, Colorado plant in February 1989, armed with the belief that small plants using post-consumer glass could be viable in both small and large communities. Kristine serves as president of Optimum Art Glass, Inc., and her husband, Robert, is plant operator and engineer. The Wises have been involved with glass making since 1976, but the leap to cullet as the primary feedstock came with the company's 1988 inception. The Eaton plant is their lone facility, but they are interested in some type of expansion to meet the growing demand for their product.

Optimum's plant was originally a grain-drying facility, and was later used to dry chicken manure. It stood idle for some time before Optimum converted it to an art-glass factory.

Feedstock

Optimum buys furnace-ready cullet from non-profit groups, recycling centers, and individuals in northeastern Colorado. Thirty percent of this is container cullet, and the remaining 70 percent is plate cullet (Table 10). According to Optimum's specifications, incoming cullet must be color sorted, free of labels and caps, and crushed to a 1/4-inch size. The Eaton plant was designed to handle up to three tons per day of cullet, but currently runs at one-third capacity. The feedstock is 97 percent recycled glass, with 87 percent post-consumer content.

Optimum uses more flint and green containers than amber ones at this time, primarily because today's glass artists are not using earth-tones. Green container cullet is used to make both green and blue art glass. Coloring agents are added to flint to create all of the other colors. Mixed-color cullet can be used in small quantities to make black glass. The plate glass — mostly trim waste or breakage from local window shops · is mixed with container glass.

Process

Optimum is continually refining its process, not only to improve efficiency and product quality, but also to reduce environmental impact. As a result, the manufacturing line has gone through many incarnations.

Table 10 Feedstock Information

material	consumption (TPY)	recycled content	post-consumer content	price paid/ton
plate cullet	168	100%	85%	$100
container cullet	72	100%	100%	$100
non-glass additives	7	0%	0%	≤$700
total	**247**	**97%**	**87%**	**$110**

Source: Institute for Local Self-Reliance, 1992.

Furnace-ready container and plate cullet is hoisted to the third level of the plant, where it's tipped into the feed hopper. Colorants and fluxing agents are added, and the mixture is melted at 2,100° F in one of two batch furnaces. The molten glass is ladled onto a sloping plane. Steel rollers flatten the gob of molten glass as it slides down the surface. The resulting sheets pass through a long annealing lehr, where controlled heating tempers the glass. The sheet is then trimmed and removed from the conveyor for storage.

Replacing virgin materials with cullet reduces melting time, yields a 30 percent energy savings, and provides a ready supply of batch material. Furnace life is also extended by using recycled material — Optimum rebuilds its furnaces every 12 to 15 months, but this costly undertaking would occur even more frequently if virgin feedstock were used. Optimum plans to add a new conveyor and glass crusher to improve feedstock handling and quality.

Optimum changes the color made in each furnace on a weekly basis, resulting in about 300 pounds of "drain glass," that is, mixed-color glass drained from the furnace. In the past, a nearby manufacturer had purchased this to make aquarium gravel, but it is presently landfilled. Approximately 2 percent by weight of the input materials (metals, ceramics, plastic, etc.) is also landfilled as waste. Table 11 outlines additional process information.

Table 11 Process Information

recycling level:	secondary
feedstock input rate:	1 TPD
production output rate:	1 TPD
production design capacity:	3 TPD
capacity utilization factor:	33%
feedstock reject rate:	2%
waste generated:	drain glass (300 pounds per week)
disposal methods:	landfill (seeking alternatives)
equipment:	drum hoist, feed hopper, 2 furnaces, rollers, annealing lehr
employment:	2 full time, 1 part time; 3 skilled
scheduled operation:	264 days per year; 1 shift per day
area requirement:	2 acres
plant size:	8,000 square feet
warehouse size:	6,000 square feet
energy requirement:	10.6 million kWh per year of electricity; 432,000 cubic feet per year of natural gas
water requirement:	590 gallons per day

Source: Institute for Local Self-Reliance, 1992.

Table 12 Product Information

products manufactured	production rate (TPY)	total scrap content	post-consumer content	estimated annual sales	gross revenue per ton	value added per ton
colored sheet glass	240	97%	87%	$150,000	$625	$510

Source: Institute for Local Self-Reliance, 1992.

Used cooling water from the rolling mill collects in a small settling pond. Rather than being sent into the sewer system, this water is used to water vegetation on the grounds. The Wises also enjoy the added serenity the body of water brings to the landscape.

The two batch furnaces use natural gas from a neighboring private energy company, and the facility's other energy needs are met by the local electric utility. The latest innovation on Optimum's drawing board is a digester that will consume local livestock manure and brewer's waste from a nearby brewery, as well as waste heat from the two glass furnaces. The resulting methane will be used to fire the furnaces and run an electrical generator. The organic material will go to a neighboring composting operation. The manure will cost approximately $1.75 per ton, while the brewer's waste will be free. The capital cost of the project is expected to be $365,000, much of which will be covered by a grant from the Colorado Office of Energy Conservation.

Currently, Robert Wise runs a single shift with the help of a part-time employee at a wage of approximately $8 per hour. In the future Optimum plans to run two shifts, with two full-time workers per shift. When the digester comes on line, an additional employee per shift will be required, totaling six full-time laborers in addition to a single administrator. Operating the plant on a single-shift basis requires 48 person-hours per week.

Products

Artists, architects, designers and hobbyists use art glass in windows, dishes, lamp shades, hanging artwork, jewelry, and many other decorative applications. Optimum's sheet glass suits a number of uses, but is used primarily in windows.

The company produces 240 tons per year of colored sheet-glass, which is sold internationally (Table 12). Other products under consideration or development include jewelry, high-quality giftware made from mixed-color cullet, and aquarium gravel made from drain glass.

Table 13 Economic Information

initial capital cost:	$400,000 (1989)
labor cost:	$13,200 per year
energy cost:	$10,800 per year
feedstock cost:	$27,200 per year
total O&M cost:	$60,000 per year
gross revenue:	$150,000 per year
capital cost/capacity:	$133,000 per TPD capacity
O&M cost/sales:	$250 per ton sold
gross revenue/sales:	$625 per ton sold

Source: Institute for Local Self-Reliance, 1992.

Economics

Economically, Optimum is well situated to capitalize on the expanding art-glass market. The initial capital cost in 1989 was $400,000. An additional conveyor and glass crusher will cost $15,000. The annual operating costs are $60,000. The cost breakdown per sheet of glass is dominated by overhead, labor and energy. On the revenue side, annual sales are $150,000 per year (Table 13). Optimum's pricing policy encourages cash payment up front, allowing the firm to be more liquid.

Currently, about half of Optimum's product is sold in Japan, and most of the remainder in North America. Robert Wise estimates that about 70 percent of the art-glass industry is composed of hobbyists, and the remainder, professionals. The company's twice annual presence at trade shows, combined with excellent word-of-mouth advertising, bring Optimum more demand than it can meet at current production rates.

Replicability

Optimum says its technology is replicable, and the Wises are very interested in expanding operations — Robert Wise envisions a similar plant on each coast. The $80 to $100 million-per-year international industry has natural limits, but Optimum senses potential growth in the rebuilding of churches in the former Soviet Union. Furthermore, the Chinese government has contacted Optimum to express interest in using the technology in a large facility in China.

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OWENS-BROCKWAY

Location:	Portland, Oregon
Start-up Date:	*1956*
Recycled Material Used:	container cullet
Products:	glass containers
Production Design Capacity:	600 TPD

Company Background

The Owens-Brockway glass container plant in Portland, Oregon has faced many challenges. It is smaller than average, and is charged with the task of using secondary material at a level well above industry norm. However, the plant continues to produce a wide variety of containers in three colors, while a number of its larger peers have been shuttered. In fact, this scrap-based manufacturing facility has excelled: Owens-Brockway recognized it as its Outstanding Plant of 1991.

Owens-Brockway (O-B) is a major subsidiary of Owens-Illinois (Toledo, Ohio), one of the world's leading manufacturers of packaging products. In 1987, Kohlberg Kravis Roberts & Company conducted a leveraged buy-out of Owens-Illinois, but now the company is again owned in the majority by public investors. Owning 22 of the nation's 73 glass-container plants, O-B is the largest glass-package maker in the U.S. It also leads in recycled glass usage — in 1990, O-B consumed 1.1 million of the 2 million tons of glass that was recycled in the U.S.

Feedstock

The O-B Portland facility purchases color-sorted, whole and broken container glass from a number of sources in the Pacific-Northwest (Table 14). Public and private recycling programs supply O-B with post-consumer material, while customers from the food industry, distributors and vendors sell pre-consumer glass to the plant.

The tolerable level of feedstock color-contamination varies with the color. Flint can tolerate no green or amber, but can contain less than 3 percent "water bottle blue." The amber cullet stream must be 95 to 100 percent amber or golden wine bottles, while green can tolerate any shade of green. The recycled content of amber bottles is a mix of 85 percent amber cullet and 15 percent green cullet. This is done in an attempt to absorb some of the current green cullet glut in the Pacific-Northwest; however, O-B officials emphasize that the color mixture must be precise, precluding use of mixed-color cullet.

O-B requests that all containers be empty and relatively clean. Labels and closures are acceptable, but the plant encourages the removal of metal lids. Glass containers used for toxic material (e.g., acid, insecticide) are accepted as long **as** they are triple-rinsed and residue-free. Loads of glass containing any ceramics, mirrors, plate

Table 14 Feedstock Information

material	consumption (TPY)	recycled content	post-consumer content	price paid/ton
flint cullet	42,368	100%	87%	$40
amber cullet	21,126	100%	92%	$20
green cullet	13,128	100%	92%	$10
sand	42,400	0%	0%	$34
soda ash	10,345	0%	0%	$115
limestone	10,330	0%	0%	$40
caustic soda	660	0%	0%	$365
salt cake	463	0%	0%	$111
iron pyrite (amber colorant)	17	0%	0%	$129
iron chromate (green coloranfi	9	0%	0%	$276
carbon (amber colorant)	9	0%	0%	$190
selenium	1	0%	0%	$10,000
total	**140,856**	**54%**	**49%**	**$40**

Source: Institute for Local Self-Reliance, 1992

glass, crystal, or other non-container glass contaminants are rejected.

Process

The Portland facility boasts a state-of-the-art cullet processing system largely of in-house design, that compliments its glass container production facility. Glass enters this system when a front-end loader loads the material into an infeed hopper. The glass travels up a conveyor to a magnet that removes gross ferrous items. Workers pick out other large contaminants, and the glass is crushed. After passing a second magnet, the crushed glass traverses a vibrating screen to sort out small pieces. Large pieces proceed to another crusher and vibrating screen, this one with a vacuum system that removes light-weight debris such as paper and plastic labels. A third magnet sorts small ferrous contamination at the end of the screen, where once again large pieces are sent back through the crush/screen stage.

Now just one set of contaminants remain: non-ferrous metals, including aluminum, lead and brass. The next stage, a $120,000 non-ferrous detection system, is the most recent addition to the facility. As glass falls off the end of a conveyor, a non-ferrous-sensor triggers a gate to divert the contaminants. As the furnace-ready cullet heads for storage, the reject stream travels through two more identical non-ferrous-detection stages. (The resulting metals and other contaminants are too intermixed to be marketable.) After its initial month of use the new system has resulted in a marked reduction of stones in the finished product.

Future additions to the cullet-processing system include a technology to handle ceramic contamination. This will involve either an optical ceramic-detection approach, or a fine-grind system, in which all cullet (including ceramic contamination) will be ground to the size of sand, vastly reducing the damage inflicted by the gravel-sized refractories.

O-B adds sand, soda ash, and limestone, along with several other materials in lesser quantity (see Table 14) to the cullet, and continuously charges its two active furnaces with this mix. The computer-controlled furnaces keep molten glass brewing at a depth of five feet and a temperature of 2,700° F.

Each furnace has two dedicated forming machines that produce bottles at a rate of 60 to 320 bottles per minute. Smaller containers, such as ten-ounce juice bottles, are made more quickly than larger ones, such as one-gallon apple cider

Table 15 Process Information

recycling level:	primary
feedstock input rate:	402 TPD
production output rate:	329 TPD
production design capacity:	600 TPD
capacity utilization factor:	55%
feedstock reject rate:	18%
waste generated:	metals, ceramic, paper, plastic and other contamination
disposal methods:	landfill
equipment:	beneficiation system, 4 furnaces (2 operational), 2 forming lines per furnace, annealing lehrs
employment:	300 full time; 120 skilled, 180 unskilled
scheduled operation:	350 days per year; 3 shifts per day
area requirement:	55 acres
plant size:	721,150 square feet
warehouse size:	400,000 square feet
energy requirement:	41,472,000 kWh per year of electricity; 6,309,857 therms per year of gas
water requirement:	55,700 gallons per day

Source: Institute for Local Self-Reliance, 1992

jugs. A precise gob of molten glass is projected into any one of 100 bottle or jar molds. Compressed air forms the internal shape of the container, which is ejected red-hot, and sent to the annealing lehr.

The lengthy lehr tempers the glass. The outsides of the cooled bottles are treated with a food-grade lubricant to reduce friction as they bump and grind down the conveyor. An automated inspection system detects imperfections that may lead to product failures, and routes those bottles back to the furnace. Depending on customer specifications, labels may be added at the plant.

Of the 300 full-time employees, over 265 are union members, earning an average wage of $11.80 per hour. Forty percent of all of the jobs at the plant are skilled positions (Table 15).

Products

This O-B facility makes containers for the food and beverage industry in the Pacific-Northwest. Two-thirds of its product is flint, 23 percent is amber and 9 percent is green (Table 16). The division between beer, beverage, and food containers is approximately equal.

What sets the facility apart from its competitors is the recycled content of its containers. With post-consumer content approaching 75 percent in its colored bottles and 40 percent in its clear containers, the Portland plant is well ahead of the 25 percent industry average.

These numbers help Owens-Brockway's Western Region plants achieve the following cumulative, weighted averages for post-consumer content, as certified by Scientific Certification Systems (Oakland, California): green, 47 percent; amber,

Table 16 Product Information

products manufactured	production rate (TPY)	total recycled content	post-consumer content	estimated annual sales	gross revenue per ton	value added per ton
flint containers	77,780	42%	40%	NA	NA	NA
amber containers	26,700	78%	74%	NA	NA	NA
green containers	10,620	78%	74%	NA	NA	NA
total	**115,100**	**54%**	**49%**	**$50,000,000**	**$430**	**$330**

Source: Institute for Local Self-Reliance, 1992.

42 percent; flint, 19 percent; and overall, 27 percent.

The recycled-content level of the plant's flint containers is currently limited by a shortage of quality cullet. Conversely, there is a glut of green cullet in the area, as there is in much of the U.S. While the Portland plant sets the industry standard at 78 percent recycled content for green and amber containers, plant representatives state that 90 percent is feasible for all colors. The last 10 percent of the feedstock must be virgin to maintain control over the chemical composition of the melt.

Economics

With two operating furnaces and $50 million in sales in 1991 (Table 17), the Portland plant is small compared to its competitors and many of its fellow 21 O-B plants (which netted $2.36 billion in sales in 1991). Because the facility was erected in 1956, the initial capital cost holds little information. Operating and maintenance costs, including energy and labor, are held as confidential by the company. However, labor is the biggest piece of the pie, at one and one-half times the feedstock cost, and over three times the energy cost.

The state-of-the-art cullet processing center has undergone numerous upgrades since the initial $500,000 construction in 1980, including a $60,000 vacuum-system overhaul in 1986, a $30,000 prescreen addition in 1990, and a $150,000 system up grade (including an electromagnet, crushers, and a picking building) in 1991. The $120,000 nonferrous detection system completed in late 1992 brings the total investment in the cullet-processing system to $860,000.

Replicability

Glass container manufacturing plants have been closing over the last ten years, even though the glass packaging industry has maintained its level of market share. Plant closures are due to consolidation of companies, increased production

Table 17 Economic Information

initial capital cost:	NA (1956)
labor cost:	$8,000,000 per year [a]
energy cost:	$2,000,000 per year (for electricity only) [a]
feedstock cost:	$5,600,000 per year
total O&M cost:	NA
gross revenue:	$50,000,000 per year
capital cost/capacity:	NA
O&M cost/sales:	NA
gross revenue/sales:	$430 per ton sold

[a] ILSR estimate.

Source: Institute for Local Self-Relianc, 1992.

levels of existing plants, increased automation, and relocation by U.S. companies to less developed countries to take advantage of cheaper labor and looser environmental regulations. Coupled with increased competition from the plastic, metal and paperboard container industries, many glass container plants are struggling.

So, despite the fact that the Portland facility could technically be replicated, the economics of building a new plant are prohibitive. What could be copied at existing plants, however, is the great success the Portland plant has had with the higher percentage of post-consumer recycled content in its products. With recyclers searching for markets, and glass makers bemoaning a shortage of quality cullet, room for improvement in the glass-recycling infrastructure clearly exists. Glass plants wishing to increase their cullet consumption can emulate the Portland plant's acquisition of feedstock, as well as its mechanical cullet processing system.

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STONEWARE TILE COMPANY

Location:	Richmond, Indiana
Start-up Date:	1988
Recycled Material Used:	furnace-ready plate glass furnace-ready windshield glass furnace-ready industrial scrap glass
Products:	glass-bonded ceramic tile
Production Design Capacity:	70 TPD

Company Background

Stoneware Tile Company (STC) has produced ceramic tile from discarded glass for 15 years. STC has continually improved its Richmond, Indiana facility with attention to its manufacturing process and feedstock, resulting in a more competitive product. Today, as the world's only producer of glass-bonded ceramic tile from post-consumer material, STC is gaining recognition and praise from the tile industry for producing high-quality and durable products.

The idea of making ceramic tile from discarded glass originated in the late 1970s as a method to lower fuel costs through reduced energy demand. However, problems with feedstock quality and a slower-than-expected rise in fuel costs limited initial attempts to produce tile from discarded glass.

CSC, Inc., a Chicago, Illinois holding company, purchased STC in 1988. The new owners revamped the company, moving the tile operation to Richmond, Indiana, and choosing beneficiated plate glass for feedstock According to Richard Moore, Plant Manager for STC, the consistency and reduced level of contamination in the new feedstock allowed the company to produce "a tile with a unique look, while remaining environmentally appropriate."

The tile has been well received by architects and designers. It has been used in such high-profile buildings as Chicago Bears Coach Mike Ditka's newest Chicago restaurant, and Team Disney's newest office complex outside of Orlando, Florida.

Feedstock

STC's feedstock includes plate glass, windshield glass, and industrial-scrap cullet that it purchases from a glass beneficiation company in Ashland, Kentucky. At the time of purchase the glass is free of contaminants, and has been reduced to a 200 mesh size. Clear glass is required for the majority of STC's tile, but tinted windshield glass can be used for the darker colors of tile. The other major feedstock is quarried clay. In the past, STC has used discarded ceramic material in the tile, but currently relies primarily on virgin clay.

At $200 per ton of cullet, the beneficiated glass is substantially more expensive than traditional ceramic material used in tile production, which can cost as little as $70 per ton (Table 18). STC incurs additional costs in shipping glass to the facility

Table 18 Feedstock Information

material	consumption (TPY)	recycled content	post-consumer content	price paid/ton
furnace-ready cullet	9,800	100%	30%	$200
virgin material	5,400	0%	0%	NA
total	**15,200**	**64%**	**19%**	**NA**

Source: Institute for Local Self-Reliance, 1992.

($30 per ton, according to company estimates). Company executives are examining alternative supplies of cullet, including in-house beneficiation systems for future plants.

Process

Although the production of glass tile is similar to that of clay-based tile, many of the distinctions are held confidential by STC. After mixing the cullet with quarried clay, STC kiln-fires the tile at 1,850° F, which is about 250° F below the kiln temperature for clay-based tile. The lower kiln temperatures result in significant energy savings for the facility. Table 19 summarizes the process information.

Table 19 Process Information

recycling level:	secondary
feedstock input rate:	62 TPD
production output rate:	56 TPD (30,000 square feet per day)
production design capacity:	70 TPD (38,000 square feet per day)
capacity utilization factor:	80 percent
process reject rate:	10 percent
waste generated:	scrap tiles, paper
disposal methods:	landfill, seeking alternatives
equipment:	furnace, kiln (other information on equipment NA)
employment:	NA
scheduled operation:	245 days per year; 3 shifts per day
area requirement:	7.5 acres
plant size:	42,000 square feet
warehouse size:	15,000 square feet
energy requirement:	NA
water requirement:	NA

Source: Institute for Local Self-Reliance, 199

Products

STC produces 56 tons per day of high-quality, glass-bonded tile. The product's lasting shine and ease of disinfecting make it appropriate for use in the architectural and decorative design of restaurants, hospitals, and office buildings.

Unlike traditional clay-tile manufacturers, who apply glass glazes to tile surfaces, STC incorporates glass into the tile body itself, so the luster remains even as the tile wears. The ultra-smooth surface is easy to disinfect, making it ideal for use in hospitals and restaurants. The tile has also been used in army bases, veterans hospitals, and business offices. In 1992 the Ceramic Tile Institute awarded STC the Diamond Award for superior tile quality.

One of STC's best selling products, Traffic Tile™, comes in more than 20 standard colors, and meets or exceeds performance standards set by the Tile Council of America, Inc. (Princeton, New Jersey) for facial dimension, warpage, wedging, abrasive hardness, water absorption, coeffi-

Table 20 Product Information

products manufactured	production rate (TPY)	total recycled content	post-consumer content	estimated annual sales	gross revenue per ton	value added per ton
ceramic tile	13,720	70%	300/0	NA	NA	$2,500 [a]

[a] ILSR estimate.

Source: Institute for Local Self-Reliance, 1992.

cient of friction, breaking strength, frost resistance, sheer bond strength, and shade variation.

Retail prices vary widely, depending on tile color and pattern. Suggested retail price of Traffic Tile™ ranges from $4.30 to $24.00 per square foot, according to STC. Seventy-five percent of STC sales comes from their standard tile, which retails for $5.60 per square foot. At 3.7 pounds per square foot, this tile is valued at over $3,000 per ton. Tile impregnated with customized color or texture (approximately 25 percent of sales) is more expensive (Table 20).

Economics

As the sole producer of scrap-based, glass-bonded tile, STC is at present keeping all economic and cost figures confidential. The company does estimate that it spends an average of 10 percent of total tile cost on shipping the heavy product and that moving operations closer to markets could reduce cost by as much as 3 percent.

Replicability

STC's Richmond operation is fully replicable, and the company has examined opportunities to expand operations. Although the Richmond site affords doubling of capacity, siting additional operations elsewhere could result in substantial reductions in delivery charges to the West Coast.

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AMG Resources Corporation

Location:	St. Paul, Minnesota
Start-up Date:	1989
Recycled Material Used:	source-separated ferrous cans magnetically-separated ferrous material
Products:	steel tin non-ferrous metals
Production Design Capacity:	130 TPD

Company Background

AMG Resources Corporation is the world's largest detinner of ferrous scrap, owning four domestic and four foreign-based mills. Its mill in St. Paul, Minnesota, however, varies from traditional detinning operations in one major respect: it was designed to process post-consumer, not industrial, tin-plate scrap. The St. Paul plant is smaller in design capacity than a traditional plant, and in 1989 was purposely built near a five-county solid-waste region that needed an end market for its ferrous scrap.

Contaminants inherent in ferrous derived from the municipal solid waste stream, such as food residue, paper, glass, and aluminum, pose the greatest challenge to detinning tin cans. These contaminants result in increased tin losses and residue generation, conflicting with current industrial detinning technologies. For this reason AMG developed a front-end cleaning system that produces a 97 percent ferrous input for the detinning process.

Feedstock

Feedstock for the AMG plant is divided into two types (Table 21). The first is source-separated material from recycling programs — curbside, drop-off, commercial and buy-back programs. The other is magnetically-separated ferrous material from the front end of solid-waste incinerators and composting operations. The source-separated material contains tin-plated steel food cans, bimetal beverage cans, and steel paint and aerosol cans. The magnetically-sorted portion contains all these, plus additional ferrous items that make their way into the waste stream. The source-separated material is more homogeneous and easier to process than the magnetically separated ferrous, requiring 75 to 80 percent less processing time than the magnetically-sorted portion.

Because quality control is extremely important to its process, AMG arranges long-term, stable contracts with reliable suppliers of feedstock, and works to help those suppliers meet AMG specifications. The primary goal is for incoming loads to reach 85 percent steel by weight. The material from recycling programs is typically 96 percent

Table 21 Feedstock Information

material	consumption (TPY)	recycled content	post-consumer content	price paid/ton
magnetically-separated ferrous	21,000	100%	100%	$0-20
source-separated ferrous	9,000	100%	100%	$30-50
total	**30,000**	**100%**	**100%**	**$9-29**

Source: Institute for Local Self-Reliance, 1992.

ferrous, while the magnetically-sorted portion is greater than 70 percent. Non-ferrous material is removed as the feedstock is processed, and the organic fraction is sent back to one of the incinerators.

Ninety percent of the feedstock comes from within Minnesota, with the majority of that originating in the five-county region. Some material comes from as far away as 300 miles. Most of the scrap arrives by truck, although rail access is available.

Process

Incoming feedstock is dumped on a tipping floor. A pedestal crane loads the material into hoppers that feed three inclined screw conveyors. Each conveyor passes through a vibrating picking station, where a worker removes heavy ferrous and copper armatures that may damage the shredder, as well as oil filters and other potentially hazardous items.

The material is next deposited in patented Cutler™ shredders designed specifically for post-consumer ferrous. Each contains two independent drives that give the impellers and cages a contra-rotating action. This causes cans to shred against each other, minimizing machine wear, and removing unwanted aluminum, paper, plastic, glass, dirt and organic material. A dust-retention system keeps the air around the work space clean.

The shredded metal drops through a zig-zag shaped air-classifier, in which suction pulls non-metallic material from the stream. These contaminants are baled in a hydraulic compactor, and returned to an RDF (refuse derived fuel) facility. The shredded metal drops into a cooling chamber, and is conveyed to a permanent double-drum magnet, where non-ferrous metals are eliminated. Marketable aluminum accumulates here.

Contaminants gone, the detinning begins. An operator on a Bobcat loader fills baskets with the cleaned scrap. The baskets are lowered into a tank of detinning solution at 170° F, which is electrified to remove the tin. A layer of foam that forms on top of the tank is an indicator: less foam means low aluminum content, and, therefore, lower chemical costs through increased operational control.

After two to five hours, the basket is raised and dumped at a rinsing station, where sodium hydroxide is removed. The final product is loose shredded material that may be formed into briquettes. Because of its density and known chemistry, it has high quality and low contamination.

Tin is recovered by stripping carbon steel cathodes that draw it from the solution. It is smelted to remove impurities such as lead, zinc and antimony, and then cast into high purity 100-pound ingots.

The detinning solution, which is 95 percent water, is continuously recycled. Water is replaced as needed, but no effluent is discharged.

The St. Paul facility employs 18 full-time and four part-time workers, four of whom are considered skilled laborers. A non-union, unskilled position starts at approximately $8 per hour (Table 22). All employees of the St. Paul plant are local residents, except the plant manager, who was imported from another AMG operation.

Table 22 Process Information

recycling level:	primary
feedstock input rate:	97 TPD
production output rate:	95 TPD
production design capacity:	130 TPD
capacity utilization factor:	73%
feedstock reject rate:	2%
waste generated:	organic material
disposal methods:	returned to RDF plant
equipment:	crane, hoppers, screw conveyors, shredders, dust-retention system, air classifier, conveyors, ferrous magnet, detinning tank, testing lab
employment:	18 full time, 4 part time; 4 skilled, 18 unskilled
scheduled operation:	312 days per year; 2 or 3 shifts per day
area requirement:	4 acres
plant size:	50,000 square feet
warehouse size:	included in plant size
energy requirement:	600,000-900,000 kWh per year of electricity; 10,500 MCF per year of natural gas
water requirement:	450,000 gallons per year

Source: Institute for Local Self-Rekiance, 1992.

Products

The main product of AMG's detinning process is high-grade steel (Table 23). The quality of the steel is number-one dealer bundle or better, and is sold to integrated and primary steel mills from Minnesota to Louisiana, as well as foundries within the state and neighboring Wisconsin.

Salable by-products include tin, which is sold to a number of markets such as the solder, electronics, plating, chemicals, and even wine bottling industries. Tramp iron, aluminum, copper, and brass are sold to traditional scrap markets.

Economics

Feedstock and labor dominate the variable costs of the St. Paul operation (Table 24). Not figured into the feedstock costs, however, are the avoided disposal costs that would be borne by the feedstock suppliers. Considering this factor uncovers even greater economic benefits.

Replicability

AMG's St. Paul detinning facility is unique in that it is a small, modular plant designed to process post-consumer tin-plated steel. This new design allows AMG to take the plant to the feedstock, as opposed to the traditional approach of shipping feedstock to a large central facility.

Most of AMG's feedstock originates from a group of five counties in the St. Paul area. AMG estimates that, despite the flat market for its products, each of the 25 largest metropolitan areas

Table 23 Product Information

products manufactured	production rate (TPY)	total recycled content	post-consumer content	estimate annual sales	gross revenue per ton	value added per ton
steel	21,000	100%	100%	$2,730,000	$130	$110
tramp iron	7,500	100%	100%	$487,500	$65	$45
non-ferrous metals	1,440	100%	100%	$2,000,000	$1,400	$1,400
tin	60	100%	100%	$360,000	$6,000	$5,900
total	**30,000**	**100%**	**100%**	**$5,577,500**	**$190**	**$170**

Source: Institute for Local Self-Reliance, 1992.

in the U.S. could support a similar facility. The recovered post-consumer tin-plate scrap from a population of approximately one million can support a single module of the AMG process. AMG states that it is interested in maintaining long-term supply contracts with local sources, providing guaranteed markets in return.

AMG is currently building a detinning plant in Australia, as a joint venture with a steel maker. AMG's product will be fed to the adjacent steel mill. AMG holds worldwide patents on its process and some of its equipment. Low air emissions and lack of effluent discharge contribute to a timely siting process.

An obstacle to AMG's expansion comes in the form of steel plants, which, in an effort to bolster steel's recyclable image, have been buying cans at artificially high prices. This occurs despite the fact that tin contaminates the steel-making process. These higher prices are a short-term boon for can collectors, but they shrink the supply of feedstock for the more efficient AMG-type detinning facilities.

Table 24 Economic Information

initial capital cost:	$3,900,000 (1989)
labor cost:	$540,000 per year
energy cost:	$45,000 per year (electricity only)
feedstock cost:	$570,000 per year
total O&M cost:	NA
gross revenue:	$5,578,000 per year
capital cost/capacity:	$30,420 per TPD capacity
O&M cost/sales:	NA
gross revenue/sales:	$190 per ton sold

Source: Institute for Local Self-Reliance, 1992.

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AMERICAN CELLULOSE MANUFACTURING, INC.

Location:	Minonk, Illinois
Start-up Date:	1976
Recycled Material Used:	old newspapers old corrugated containers magazines office waste paper phone books
Products:	cellulose building insulation animal bedding hydro-mulch cellulosic absorbent
Production Design Capacity:	168 TPD

Company Background

Entrepreneur John Lohr first encountered American Cellulose Manufacturing (ACM), a cellulose building insulation manufacturer, in 1976, when trying to sell insurance to its plant in Minonk, Illinois. Ten years later, Lohr purchased the company, and moved the headquarters from Topeka, Kansas to Minonk.

The company is run by Lohr's daughter, Mary Beth Lohr-Baston. Under the direction of the Lohr family, ACM has diversified its product line, adding hydro-seed mulch and animal bedding in 1988, and an oil-absorbent product in 1991. According to vice-president George Villa, ACM's emphasis on innovation and diversification has allowed it to survive when much of its competition has not. In fact, ACM is the only remaining cellulose plant in Illinois out of 50 such facilities operating in 1976.

Feedstock

ACM accepts a wide range of scrap paper at its facility, including post-consumer magazines, newspaper, corrugated containers, and office waste paper (Table 25).

Because workers hand-sort material as it arrives in the plant, ACM accepts a greater mix of feedstock and rejects fewer loads of material than do similar operations. The degree of contamination that can be tolerated depends on the product being made. While ACM requires clean ONP and OCC feedstock to produce building insulation and absorbent material, it also utilizes "contaminated" feedstock — containing clay-coated paper and phone books — to produce animal bedding and mulch products. The company does not accept metal or plastic contaminates.

Collection of scrap paper within 90 miles of Minonk provides the cellulose plant with all the

Table 25 Feedstock Information

material	consumptlon (TPY)	recycled content	post-consumer content	price paid/ton
OCC, ONP, MP	21,800	100%	100%	$0

Source: Institute for Local Self-Reliance, 1992.

feedstock material it requires, with the majority coming from in and around Bloomington, Illinois (population 49,000, located 20 miles south of Minonk). This was not always the case. In the late 1970s a shortage of scrap paper in the Midwest forced ACM to buy feedstock from Texas at $100 per ton. Today the company gets most of its scrap paper for free, but will sometimes pay the shipping cost.

Process

ACM receives scrap paper in a holding bay, where workers sort and inspect the material by hand, picking contaminants out of the mix. The material runs through a hammermill, which reduces it to small pieces, ranging in size from 0.25 inches to 1.5 inch in diameter. A second machine screens the material and returns oversized pieces to the hammermill. ACM diverts a portion of the feedstock to a mill which produces paper pellets, used as oil absorbents and as kitty litter.

ACM manufactures all of its cellulose material on a single production line. This is feasible because the material used in each product is very similar, differing only in the size of the screens used and the type of feedstock accepted. While the company produces mulch and absorbent on a made-to-order basis, building insulation and animal bedding, enjoy continuous markets.

The plant operates one twelve hour shift per day, at night to take advantage of off-peak electricity rates (Table 26). A day shift packages the material and ships the products to market. ACM ships its insulation, mulch, and animal bedding immediately after production, limiting product inventory costs. The absorbent can be packaged according to preference, in one of 100 styles of casings made especially for the ACM product by an outside vendor.

Products

ACM manufactures four products at its Minonk facility: building insulation, hydro-seed mulch, animal bedding, and cellulose absorbent (Table 27). The animal bedding, building insulation, and mulch are standard to the cellulose industry, while the absorbent is an ACM spe-

Table 26 Process Information

recycling level:	tertiary
feedstock input rate:	84 TPD
production output rate:	NA
production design capacity:	168 TPD
capacity utilization factor:	<60%
feedstock reject rate:	negligible
waste generated:	plastic and metal contaminants
disposal methods:	landfill
equipment:	shredder, hammermill, pellet mill
employment:	13 full time
scheduled operation:	260 days per year; 1.5 shifts per day
area requirement:	7 acres
plant size:	33,000 square feet
warehouse size:	20 semi-trailers on-site
energy requirement:	NA
water requirement:	NA

Source: Institute for Local Self-Reliance, 1992

Table 27 Product Information

products manufactured	production rate (TPY)	total recycled content	post-consumer content	estimated annual sales	gross revenue per ton	value added per ton
absorbent	NA	90%	90%	NA	NA	NA
animal bedding	NA	100%	100%	NA	NA	NA
hydro-seeding mulch	NA	100%	100%	NA	NA	NA
cellulose building insulation	NA	80%	80%	NA	NA	NA
total	**<27,000 [a]**	**80-100%**	**80-100%**	**$500,000 [b]**	**NA**	**NA**

[a] ILSR estimate.
[b] 1989 figure.

Source: Institute for Local Self-Reliance, 1992.

cialty. ACM claims that its insulation is a superior insulator compared to similar products made from virgin material, and therefore more cost effective. Getting people to use the products, says ACM's Villa, "is really a matter of educating the public and changing industry specifications."

ACM's star product, The Oil Gone™ absorbent, is marketed for use in small applications incidental spills, truck rollovers, car accidents, and gas spills, as well as leaks and drips that occur in industry on a daily basis. The Oil Gone™ boasts a number of advantages over products made from virgin materials like clay, peat moss, petrochemicals, and corn cobs. The product is made from 100 percent recycled newspaper, is less expensive than other materials, and is non-toxic. Tests conducted by ACM conclude that their material is 50 percent more absorbent than the most popular oil absorbent (made of polypropylene), and close to four times as absorbent as certain virgin-material-based absorbents in use today. ACM reports that a 3"x 48" pillow of The Oil Gone™ absorbs 1.4 gallons of #2 fuel oil, while the 3M-brand Powersorb™ of the same dimensions absorbs 1.01 gallons. Other materials absorb between 0.36 and 0.76 gallons of the oil.

ACM products are used by different industries across the region. Industrial manufacturers, machine shops, fuel depots, marinas, emergency response groups, and others use absorbents to quickly absorb liquid spills. Animal bedding is used in Illinois horse stables and farms and in the dairy, beef, pork, and poultry industries. State and local highway departments, landscapers, and developers use ACM hydro-mulch, while regional building contractors and homeowners use Thermal Seal™ cellulose insulation in new home construction and retrofits.

ACM has experimented with other products made from recycled paper in the past, but found the likes of paper-based fireplace logs and worm bedding to be unprofitable. The company has plans to produce a cat litter from pelletized ONP with a higher absorbency and lower dust content than current clay-based products. ACM's cat litter will be available in 1993.

Economics

ACM received a $28,000 market development grant from the Illinois Department of Energy and Natural Resources for the purchase of the paper pelletizer in 1992. Beyond this, ACM holds much of its economic information as confidential (Table 28).

Replicability

The mulch, bedding, and insulation operation at ACM is fairly standard to the industry, and uses fully replicable technology. The manufacturing of the absorbent, however, requires knowledge and experience not readily available for replica-

American Environmental Products, Inc.

Location:	Elkwood, Virginia
Start-up Date:	1990
Recycled Material Used:	old newspaper old corrugated containers phone books
Products:	cellulose building insulation hydro mulch cellulose fiber asbestos replacement
Production Design Capacity:	200 TPD

Company Background

American Environmental Products, Inc. (AEP) was founded in 1990 by the Washington Resources Group to take advantage of new technology to produce a high-quality cellulose building insulation from recovered material available in northern Virginia. The insulation is made from low density cellulose, a material which promises to revolutionize the way Americans insulate their homes. Lightweight, highly insulative, and easy to install, the material insulates better than both traditional cellulose insulation and mineral fiber (fiberglass) material.

AEP is a wholly owned subsidiary of Washington Resources Group, an organization formed by Washington Gas Light Company in order to diversify the utility into energy related investments. According to Group executives, the organization has shifted emphasis from energy related diversification to focus on recent interest in environmentally sound products. In addition to its insulation, the company also makes a hydromulch and a cellulose fiber substitute for asbestos.

Feedstock

AEP consumes 120 tons per day of OCC, phone books, and newspaper (both ONP and over-issue — newspaper that is printed but not sold) and 20 tons per day of virgin material (Table 29). Virgin material includes talc, limestone (used in the asbestos-replacement product), and fire retardant (used in the cellulose building insulation).

AEP garners OCC and ONP (#6 and #8 baled) from communities in northern Virginia, and gets used phone books from phone companies in Virginia, Pennsylvania, and Maryland (550 tons in 1991). The plant uses approximately 50 tons per day of newspaper over-issue. Over-issue contains none of the clay-coated inserts often present in ONP and, therefore, makes superior insulation and asbestos-replacement material.

AEP pays up to $20 per ton (delivered) for over-issue, and between $7.50 and $12.00 per ton for post-consumer newspaper (baled and delivered). Phone books are accepted for free.

Table 28 Economic Information

initial capital cost:	$150,000 (1977)
labor cost:	NA
energy cost:	NA
feedstock cost:	$0 (for scrap)
total O&M cost:	NA
gross revenue:	$500,000 (1989)
capital cost/capacity:	$890 per TPD capacity
O&M cost/sales:	NA
gross revenue/sales:	NA

Source: Institute for Local Self-Reliance, 1992.

tion. The cellulose used to make the absorbent is carefully tested and selected by the company. ACM is considering expanding its operation outside of Minonk, but has no concrete plans to do so as of yet.

Contacts

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Table 29 Feedstock Information

material	consumption (TPY)	recycled content	post-consumer content	price paid/ton
ONP (over-issue)	13,000	100%	100%	$15-20
ONP (baled)	17,420	100%	100%	$7-12
phone books	520	100%	100%	**$0**
OCC	260	100%	100%	$15
virgin additives	5,200	0%	0%	NA
total	**36,400**	**86%**	**86%**	**NA**

Source: Institute for Local Self-Reliance, 1992.

Process

AEP receives feedstock in two bays, one containing over-issue news and the other (OCC and ONP. The facility accepts phone books separately for shredding in a specially built machine. All other material is shredded using standard shredders (Table 30).

A weigh-belt continuously weighs the newspaper as it emerges from a shredder to ensure that fire-retardant chemicals are added in exact proportion to the shredded newspaper. The weighing process is essential in order to ensure consistent product safety and performance. After weighing, the newspaper and additives are combined and sent through the fiberizer, manufactured by Advanced Fiber Technology (AFT), of Bucyrus, Ohio. The AFT machine reduces the paper into individual fibers, producing a low-density cellulose material with superior insulative qualities. AEP uses a large vacuum device to collect the excess dust from the process and reprocesses it into a mulch product.

Mulch is manufactured by sending OCC and ONP through a standard hammermill, reducing them to small pieces. Mulch is dyed green before packaging.

Packaging occurs on-site. Mulch is packaged in 50-pound bags, and insulation in 30-pound bags. The bags are loaded on semi-trailers for delivery to markets.

AEP tests both insulation and mulch continuously throughout production. Mulch is tested for color and consistency; insulation is lab-tested for settled density, starch content, and critical radiant flux — the radiant heat level below which insulation will not bum. To determine settled density of insulation, which affects the material's insulating qualities, lab personnel compact the cellulose material on a shaker that simulates prolonged settling. To calculate the starch content, which affects its resistance to pests, workers measure pH levels.

Lab workers test radiant flux by heating a bed of insulation to progressively higher radiant temperatures, then setting the hottest portion on fire. As the flame spreads towards cooler temperatures, chemicals within the insulation work to extinguish it. If the flame continues past radiant heat of 0.12 watts/cm^2, the insulation fails, and is made into mulch product. Radial flux is perhaps the most important test AEP performs. For years groups representing non-cellulose insulation manufacturers have questioned the flame resistance of cellulose. Testing for critical radiant flux ensures consistent flame resistance in all of the insulation. To ensure consistency AEP devotes five full-time employees to product testing. Tests are run on each of the two lines every two hours.

The company employs 100 workers earning an average wage of $8 per hour. AEP provides full benefits.

Products

Cellulose Insulation: AEP's insulation manufacturing process uses cellulose fiberization technology engineered by Advanced Fiber Technology. Fiberization separates individual newspaper fibers rather than grinding the material, resulting in a lower-density insulation than a hammer-milled product, and thus able to insulate a greater area using the same amount of material. The low density and increased adhesion of fiberized insulation means it can be blown into walls using one-third the water that hammer-milled insulation requires.

Table 30 Process Information

recycling level:	tertiary
feedstock input rate:	140 TPD
production output rate:	140 TPD
production design capacity:	200 TPD
capacity utilization factor:	70%
feedstock reject rate:	0%
waste generated:	none
disposal methods:	NA
equipment:	2 hammermills, 1 dust collector, 1 AFT Fiberizer®
employment:	100 full time, 5 part time; 12 skilled, 93 unskilled
scheduled operation:	260 days per year; 2 shifts per day
area requirement:	6 acres
plant size:	75,000 square feet
warehouse size:	NA
energy requirement:	NA
water requirement:	NA

Source: Institute for Local Self-Reliance, 1992.

For years pundits have extolled the virtues of cellulose for insulating homes. Unlike fiberglass, which allows air seepage through the wall, the loose-fill cellulose completely covers walls and ceilings. The difference is most apparent in wall sections where plumbing and wiring obstruct fiberglass batting: here, cellulose simply fills around such obstacles.

Installing cellulose inside walls has, till now, been cumbersome and expensive. Traditionally contractors used either a "drill and fill" method — drilling holes into the drywall and blowing in cellulose — or a "wet-spray application" — mixing insulation with water and blowing it between joists when wet then waiting for it to dry before applying drywall. By contrast, the low-density insulation produced by AEP adheres to wall joists with a modicum of water and requires no wait before drywall is applied. The company has designed a self-contained application system which allows two person teams to apply the insulation as quickly as they could install fiberglass bats (Table 31).

Mulch: AEP produces its hydro-mulch from recovered paper. At a separate facility some of the paper mulch is blended with grass seed and virgin mulch material — ground wood and bark. Sold as "Cellin Mulc," the product is used by

Table 31 Product Information

products manufactured	production rate (TPY)	total recycled content	post-consumer content	estimated annual sales	gross revenue per ton	value added per ton
hydro-mulch	18,200	100%	100%	$2,500,000	$140	$130
cellulose building insulation	9,100	80%	80%	$2,800,000	$310	$290
special fibers	9,100	90%	90%	$700,000	$77	$84
total	**36,400**	**93%**	**93%**	**$6,000,000**	**$170**	**$160**

Source: Institute for Local Self-Reliance, 1992.

Table 32 Economic Information

initial capital cost:	NA
labor cost:	$1,700,000 per year
energy cost:	NA
feedstock cost:	>$500,000 per year
total O&M cost:	NA
gross revenue:	$6,000,000 per year
capital cost/capacity:	NA
O&M cost/sales:	NA
gross revenue/sales:	$170 per ton sold

Source: Intitute for Local Self-Reliance, 1992.

highway departments and park services to assist turf growth alongside highways and other areas requiring large grass coverage.

Asbestos Replacement Fibers: Asphalt-roofing companies and rubber-products manufacturers are the primary markets for AEP's "custom fibers." These fibers are made of finely ground over-issue newspaper mixed with talc and limestone. They replace asbestos as a fibrous filler in asphalt roofing, caulking, and rubber products.

Economics

Annual sales for AEP is over $6 million (Table 32). Labor costs for 100 workers earning $8 per hour is approximately $1.7 million per year, while annual feedstock costs are more than $500,000. Further cost information is not available from the company.

Replicability

All technology used by AEP is fully replicable. Location near a major producer of newspaper is important in obtaining over-issue news in quantity. Advanced Fiber Technology's Fiberizer technology is currently used by nine cellulose plants around the country, according to Dick Leuthold, inventor of the technology.

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THE CHESAPEAKE PAPERBOARD COMPANY

Location:	Baltimore, Maryland
Start-up Date:	1910
Recycled Material Used:	mixed paper old corrugated containers old newspapers high grade deinked
Products:	boxboard
Production Design Capacity:	250 TPD

Company Background

James E. Smith, a box maker, founded The Chesapeake Paperboard Company in Baltimore in 1910. The company originally made paperboard from virgin pulp, but for economic reasons shifted to waste-paper after a few years. The recycling tradition at this family-owned mill has continued ever since. Today, James Smith's son and grandson produce boxboard from various grades of waste paper.

Boxboard manufacturers have traditionally used waste paper as their feedstock — many plants currently make boards with 100 percent scrap content. What makes Chesapeake noteworthy is that it uses only post-consumer waste paper, and can use almost any grade. The plant uses no chemical deinking agents, nor does it rely on clay coating to produce a clean board surface.

Besides Chesapeake, the Smith family also owns two converting mills in Maryland: one in Hunt Valley and the other in Millersville.

Feedstock

"If you can tear it we can use it," says Murrell Smith, Jr., executive vice-president of the company. The feedstock pile in Chesapeake's parking lot holds everything from junk mail, books and magazines, to OCC, ONP and computer printout. The only waste-paper grades Chesapeake doesn't accept are carbon paper, waxed paper, foil-lined paper and poly-coated paper.

Chesapeake takes pride in being a "generator friendly" company. Waste paper can be brought to the plant in any form: commingled or sorted, baled, loose or in boxes. Because the plant is located next to Interstate-95 and Baltimore Harbor, it is very accessible. Waste paper comes to the company from a variety of sources, including municipalities, brokers, organizations, and offices. The company may charge a tipping fee of up to $50 per ton for some of the low-grade paper, but a significant amount of the mixed paper is hauled in free of charge. Chesapeake pays $60 to $170 per ton for the higher grades (Table 33).

Table 33 Feedstock Information

material	consumption (TPY)	recycled content	post-consumer content	price paid/ton
mixed paper	49,400	100%	100%	-$50-0
high grade	24,700	100%	100%	$60-170
total	**74,100**	**100%**	**100%**	**-$13-57**

Source: Institute for Local Self-Reliance. 1992.

Chesapeake can use all this because the boards it makes have eight layers. High-grade paper (such as computer printout and white ledger) account for approximately one-third of the feedstock, and form the top layer of some boards. The bottom layer consists of ONP or OCC. The middle layers are low-grade mixed paper.

Process

Waste paper is dumped in the parking lot behind the mill. If incoming mixed paper contains a significant portion of high grades, workers sort the mix to upgrade the stock. The waste paper is manually fed into one of five hydrapulpers. A single continuous pulper processes low-grade paper for the filler, or inside layers of the board. Two batch pulpers handle the stock used for the front layer, and the remaining two pulpers produce the back layer. In the pulpers, paper is mixed with warm water and agitated to separate the fibers. Chesapeake does not use detergents or chemicals to clean its pulp, nor bleach to lighten it. Some soda ash is added to neutralize the pH. A ragger in the pulper removes heavy contaminants like metal, plastic and strings. The pulp then goes through several cleaning processes, including a centrifugal cyclone and vibrating screens.

Through a head box, the stock enters one of two paper machines. The paper forms on felts that roll around cylinders. Water is gradually squeezed out of the sheets through the felts. All eight layers are formed simultaneously, and are immediately pressed together. The board is dried with steam dryers, automatically cut to size, and sent to box-manufacturing plants. Because of the high-grade waste paper used to form the top layer, no clay is needed to produce a printing surface.

Less than 10 percent of incoming feedstock is rejected during the various cleaning stages. At present, this sludge is taken to an incinerator, but Chesapeake hopes to build a cogeneration facility in the near future. The plant's main energy source

Table 34 Process Information

recycling level:	secondary
feedstock input rate:	220 TPD
production output rate:	200 TPD
production design capacity:	250 TPD
capacity utilization factor:	80%
feedstock reject rate:	9%
waste generated:	sludge
disposal methods:	incinerator
equipment:	pulper, centrifugal cleaners, vibrating screens, refiners, 2 paper machines, dryers
employment:	190 full time
scheduled operation:	337 days per year; 24 hours per day
area requirement:	11 acres
plant size:	NA
warehouse size:	NA
energy requirement:	NA
water requirement:	NA

Source: Institute for Local Self-Reliance, 1992.

Table 35 Product Information

products manufactured	production rate (TPY)	total recycled content	post-consumer content	estimated annual sales	gross revenue per ton	value added per ton
boxboard	67,400	100%	100%	$20,220,000 [a]	$300[a]	$250[a]

[a] Assuming the average value of Chesapeake's boxboard is $300 per ton.

Source: Institute for Local Self-Reliance, 1992.

is natural gas, with number six fuel oil as a backup. The plant also has a wastewater-treatment system on site. Treated wastewater is discharged into the city sewer system. Table 34 summarizes Chesapeake's manufacturing process.

Products

Chesapeake manufactures boxboards with different surfaces: the top surface can be either white or kraft, and the bottom can be OCC or ONP. The thickness of the paperboard can range from 1/32nd to 1/16th of an inch. Chesapeake's products are used regionally by box manufacturing plants to make folding and set-up boxes. Chesapeake's manufacturing process adds a value of approximately $250 to each ton of wastepaper it consumes (Table 35).

Economics

Because the plant was started in 1910, its initial capital cost is not relevant today. But according to company executives, a similar mill would cost approximately $20 million, excluding land and buildings (Table 36). The family-owned company prefers to keep confidential all other information regarding costs and finances.

Table 36 Economic Information

initial capital cost:	$20,000,000 [a]
labor cost:	$6,500,000 [b]
energy cost:	NA
feedstock cost:	$2,600,000 per year [c]
total O&M cost:	NA
gross revenue:	$20,000,000 [d]
capital cost/capacity:	$80,000 per TPD capacity [a]
O&M cost/saies:	NA
gross *revenue/sales:*	$300 per ton sold

[a] This is an estimate for a similar plant today. The figure excludes the cost of land and buildings.
[b] Assuming average wage equivalent to the industry average, $12.60 per hour.
[c] Assuming average feedstock cost of $35 per ton.
[d] Assuming the average value of Chesapeake's boxboard is $300 per ton.

Source: Institute for Local Self-Reliance, 1992.

Replicability

Chesapeake uses conventional equipment to manufacture boxboard, so wherever both waste paper and buyers are in steady supply, the mill is replicable. Even if the supply of waste paper is limited, a smaller mill can be built. There are several boxboard mills operating in other parts of the country that produce a similar product with significantly lower capacity than Chesapeake's.

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Fibreform Containers, Inc.

Location:	Germantown, Wisconsin
Start-up Date:	1977
Recycled Material Used:	old newspaper mixed paper old corrugated containers
Products:	protective packaging products molded nursery products
Production Design Capacity:	10 TPD

Company Background

Fibreform Containers, Inc. began making containers for the nursery industry in 1977. Flower pots made from molded pulp had been developed some 10 to 15 years earlier and a lucrative market had grown up around the product. However, plastics soon began replacing molded pulp, and Fibreform turned to other products.

In 1980, the company began making dunnage, a packing material, to protect furniture and other appliances during shipment. Business has been especially brisk over the last few years, as the demand for environmentally friendly packaging has increased. The Fibreform facility currently runs at full capacity, producing both nursery products and protective packaging.

Feedstock

Fibreform accepts a wide variety of recovered paper at its facility (Table 37). Although the company collects most of its ONP and mixed paper from the Milwaukee area and receives corrugated material from a local box manufacturer, it has obtained material from other locations. At times, it has integrated such special items as excess IRS forms into its molded products.

Although the company can accept a wide range of paper, it lacks the necessary equipment to remove heavy contaminants such as metal and plastics from its paper and does not accept feedstock containing them. Since molded pulp does not require deinking, ink is not considered a contaminant.

Process

Incoming material is mixed with water in a hydrapulper, and broken down to a slurry. This pulp is poured into wire molds, through which the water drains. The resulting pieces are then baked to remove remaining moisture.

Fibreform builds molds for each of the shapes (forms) it produces. The company currently has over 150 different molds in stock and can make a new one for production runs over 2,000 pieces.

Table 37 Feedstock Information

material	consumption (TPY)	recycled content	post-consumer content	price paid/ton
ONP & mixed paper	1,560	100%	100%	**$0**
corrugated	1,040	100%	0%	$40-75
total	**2,600**	**100%**	**60%**	**$16-30**

Source:. Institute for Local Self-Reliance, 1992.

high degree of resiliency and cushioning. Although Fibreforrn sells a variety of stock corner and edge protectors, most sales consist of custom-design shapes to fit individual products, and it will make special molds for orders exceeding 2,000 pieces. Pieces can be dyed, left uncolored, or produced white by utilizing white feedstock.

Prices for standard packaging pieces run between $35 and $70 per 1,000 units for the small pieces, and $90 to $230 per 1,000 for large side-protectors. This translates to an average of $600 per ton of product (Table 39).

However, the company is currently avoiding small runs, because larger ones of up to one million pieces per mold are more cost-effective for the at-capacity facility.

The molded pulp manufacturing process requires a large amount of water. However, to minimize its demand on the public water supply, the company utilizes cisterns that store rain water from the roof and sump. Although the production process recycles all the water it captures (by returning it to the pulper), 85 percent of incoming water is lost to evaporation (Table 38).

Products

Fibreform makes molded pulp into both nursery containers and industrial packaging material. Production rates for these products vary with the seasonal demand for the nursery items.

Fibreform packaging comes in many shapes and sizes, including end caps, comer caps, trays and pads to protect items such as furniture, appliances and stereo speakers during shipping. Ribs integrated into the dunnage provide a

Table 38 Process Information

recycling level:	secondary
feedstock input rate:	10 TPD
production output rate:	10 TPD
production design capacity:	10 TPD
capacity utilization factor:	100%
feedstock reject rate:	1%
waste generated:	minimal
disposal methods:	landfill
equipment:	hydrapulper, molds, oven
employment:	28 full time; 10 skilled, 18 unskilled
scheduled operation:	260 days per year; 3 shifts per day
area requirement:	2.5 acres
plant size:	25,000 square feet
warehouse size:	none
energy requirement:	1,680,000 kWh per year of electricity; 220,000 therms per year of natural gas
water requirement:	2,300 gallons per day

Source: Institute for Local Self-Reliance, 1992.

Table 39 Product Information

products manufactured	production rate (TPY)	total recycled content	post-consumer content	estimated annual sales	gross revenue per ton	value added per ton
dunnage	1,820	100%	60%	$1,100,000	$600	$570
flower pots	780	100%	60%	$700,000	$900	$870
total	**2,600**	**100%**	**60%**	**$1,800,000**	**$690**	**$660**

Source: Institute for Local Self-Reliance., 1992.

Fibreform products are intended to replace folded corrugated and expanded polystyrene packing blocks, as well as open up new market niches. Unlike expanded polystyrene, dunnage made from molded pulp contains no blowing agents, and can be recycled along with ONP. Fibreform's markets are generally national in scope, however it currently exports to Australia, covering the markets of a similar facility that was recently shut-down due to fire.

Economics

Initial capital cost for the replication of the Germantown facility would run between $1.5 and $2 million, although the current facility, built in 1977, cost less. Operation and maintenance costs are low compared to the initial capital outlay, according to the company.

Fibreform reports spending $10,000 per month on natural gas and $7,000 per month on electricity (Table **40).**

Replicability

All the technology at Fibreform is fully replicable, and the company is actively seeking expansion opportunities. In 1986, it provided technological assistance in the construction of a similar facility overseas.

A new facility costing $2 million would realize a pay-back period of three or four years, according to Fibreform. Ideally, a plant would be located near an industrial center with high levels of demand for molded pulp dunnage products.

Contacts

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Table 40 Economic Information

initial capital cost:	$1,750,000 (1992)
labor cost:	$650,000 per year
energy cost:	$204,000 per year
feedstock cost:	$62,400 per year [a]
total O&M cost:	NA
gross revenue:	$1,800,000 per year
capital cost/capacity:	$175,000 per TPD capacity [a]
O&M cost/sales:	NA
gross revenue/sales:	$690 per ton sold [a]

[a] ILSR estimate.

Source: Institute for Local Self-Reliance, 1992.

GARDEN STATE PAPER COMPANY, INC.

Location:	Garfield, New Jersey
Start-up Date:	1961
Recycled Material Used:	old newspaper
Products:	newsprint
Production Design Capacity:	640 TPD

Company Background

Garden State Paper Company, Inc. (GSP) is the first mill in the world to commercially produce 100 percent recycled newsprint from old newspaper. In the 1940s, Richard B. Scudder, publisher of a major metropolitan newspaper, was troubled by the amount of old newspaper that was being discarded and began experimenting with ways of making new paper from old. This led to the inception of the Garden State Paper mill on the banks of the Passaic River in Garfield, New Jersey in 1961. Fifteen years later, Garden State Paper was producing more than 10 percent of the newsprint made in the United States, all from recovered newspaper. Media General, Inc. purchased Garden State Paper in 1970.

Feedstock

GSP gets its ONP from municipal recycling programs and volunteer collection drives. The paper is sorted and prepared at the Bruno & D'Elia recycling centers, a GSP subsidiary, to meet the quality requirements of the mill. GSP can only use newspaper that is dry, clean and free of contaminants such as phone directories, old magazines, junk mail, and cardboard. Bruno & D'Elia has a pricing system that varies depending on the delivery arrangements made with each supplier, as well as the ONP grade.

Newsprint mills in general have a varied pricing structure for ONP. Prices can vary over a range from a low of negative $60 per ton (tip ping fee) to as much as $50 per ton paid to the source. GSP holds its feedstock prices as confidential (Table 41).

Process

Trucks unload ONP onto the mill floor. Workers dump loose paper onto a vibrating conveyor that carries it to one of two pulpers. Baled newspaper is carried from the warehouse to the pulpers on lift trucks. In the pulpers, warm water and deinking chemicals are mixed with the paper, and rotor blades break it down to fibers. The pulpers produce 900 tons of pulp daily.

To remove heavy contaminants, the pulp passes through several screening stages. It is next

Table 41 Feedstock Information

material	consumption (TPY)	recycled content	post-consumer content	price paid/ton
ONP	280,000	100%	100%	NA

Source: Institute of Local Self-Reliance, 1992.

washed on rotating cylinders. During this process water passes through screens on the rollers, carrying away fine fibers and ink particles, and leaving behind long, reusable fibers. At this point the stock consists of 0.5 percent fiber and 99.5 percent water. The GSP deinking process does not involve dioxins or any other toxic by-products.

The pulp is fed into one of two paper-making machines: a Fourdrinier or a Papriformer (Table 42). The Fourdrinier has a screen loop that circulates at more than 25 miles per hour. Pulp is spread on this screen, which then passes over hydrofoils and vacuum boxes that remove some of the water. The machine has been modified with the addition of a 50-ton former with a second screen. The Papriformer has two converging screens that move at more than 30 miles per hour, as water is drawn through the screen both above and below the sheet. In the Papriformer, the paper travels only six feet during the entire forming process.

The damp paper is pressed over steam-heated rollers to reduce moisture content from 80 percent to 7 percent. It is then squeezed between

Table 42 Process Information

recycling level:	primary
feedstock input rate:	800 TPD
production output rate:	640 TPD
production design capacity:	640 TPD
capacity utilization factor:	100%
feedstock reject rate:	20%
waste generated:	sludge, fiber fuel
disposal methods:	landfilled, burned for energy recovery
equipment:	pulper, screens, washers, Fourdrinier and Papriformer paper-making machines, rewinding and slitting machine
employment:	450 full time
scheduled operation:	364 days per year; 24 hours per day
area requirement:	NA
plant size:	NA
warehouse size:	NA
energy requirement:	134 million kWh per year of electricity [a]
water requirement:	7,000,000,000 gallons per day [a]

[a] Figure from the 1992 ***Lockwood-Post's Directory of the Pulp, Paper and Allied Trades.***

Source: Institute for Local Self- Reliance, 1992.

Table 43 Product Information

products manufactured	production rate (TPY)	total recycled content	post-consumer content	estimated annual sales	gross revenue per ton	value added per ton
newsprint	240,000	100%	100%	NA	NA	NA

Source: Institute for Local Self-Reliance, 1992.

steel rolls (calendered) to produce a smooth finish.

The entire process, from dumping the newspaper loads to wrapping the rolls of finished newsprint, is computer controlled.

The short fibers captured in the recycling process, known as fiber fuel, are currently dewatered and burned as fuel. Wastewater generated by the manufacturing process is treated by the Passaic Valley Sewage Authority.

Products

GSP's sole product is its 100 percent recycled newsprint. This paper is competitive in quality, brightness and price with its virgin counterpart (Table 43).

Economics

Much of GSP's financial information is considered proprietary. The company's sales of recycled newsprint increased in 1991 in spite of the sluggish economy. Due to the fact that the mill is more than 30 years old, initial capital costs are not pertinent. However, GSP has recently invested over $25 million in process improvements.

Wastewater treatment costs rose 57.7 percent in 1991 to $6.8 million per year. This was offset by cost control measures and a 1 percent decline in total energy costs.

The plant's proximity to its markets has resulted in a low cost for collecting overissue newsprint from publishers and printers. Additionally, this closeness to markets helps customers contain their transit-damage and inventory costs.

Replicability

The technology used by GSP is proprietary, but it can be licensed. Currently, four newsprint mills in the United States and Mexico are either licensees or equity affiliates of GSP, including FSC Paper (Alsip, Illinois), Southeast Paper (Dublin, Georgia), Pronapade (San Luis Potosi, Mexico) and Smurfit Newsprint of California (Pomona, California). Urban communities offer a dependable source of raw material, as well as a steady product market, to such a mill.

A new subsidiary of Garden State Paper, GSP Technologies Group, which formed in 1991, offers its expertise to other companies in the papermaking industry around the world. It lends assistance with mechanical, chemical and environmental problems related to recycling paper, as well as technical assistance with new mills and mill conversions.

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HOMASOTE COMPANY

Location:	West Trenton, New Jersey
Start-up Date:	1909
Recycled Material Used:	old newspaper
Products:	structural fiberboard roofing insulation packaging material
Production Design Capacity:	350 TPD

Company Background

Homasote Company was founded in 1909 by Eugenius Outerbridge, whose family ran a successful shipping operation out of Newfoundland, Canada. Working for the company in England at the turn of the century, Eugenius stumbled upon the Sundealia Company (Sunbury, England), which was using discarded textiles and paper to make a home-construction board. Envisioning a market for the product in the United States, Outerbridge purchased the process for $4,000 and set up the Agasote Millboard Company on the site of an old paper plant in Trenton, New Jersey.

Eighty years later, the re-named Homasote Company remains at this site, and is the nation's oldest manufacturer of recycled-paper building material. The company has expanded markets for its board by adding color choices, urethane insulation, lamination, and a die-cutting processes that makes packing dunnage; however, the basic board remains the same.

Feedstock

Homasote Company pulps between 250 and 350 tons of ONP per day. This paper comes from numerous sources, including the Mercer and Burlington County (New Jersey) recycling programs. The facility accepts the material loose or in bales. Clay-coated magazines and other non-ONP grades of paper are considered contaminants. Homasote also purchases polyisocyanurate, a material used to create foam insulation (Table 44).

Process

Homasote receives both baled and loose ONP. Baled ONP is briefly stored inside prior to pulping, while the loose material is dumped directly onto a conveyer feeding into a hydrapulper. The hydrapulper produces a slurry by beating the ONP fibers in heated water. A drag line removes non-paper debris as the slurry is mixed with weather- and fire-resistant additives (formaldehyde- and asbestos-free).

A 400 ton per day pulper operates continuously — three shifts per day — for five day periods. A second hydrapulper, with a 200 ton per day capacity, kicks in when demand is up, or when the larger machine is being repaired.

Siphons carry the finished pulp from holding tanks to molds that are 8' x 12' and 8' x 14', and 11 inches deep. The molds close, extracting most of the

Table 44 Feedstock Information

material	consumption (TPY)	recycled content	post-consumer content	price paid/ton
ONP	70,000 [a]	100%	100%	NA
polyisocyanurate	NA	0%	0%	NA
total	**NA**	**NA**	**NA**	**NA**

[a] ILSR estimate.

Source: Institute for Local Self-Reliance, 1992.

water, and reducing the thickness of the board. Conveyers carry the formed sheet through a computer-controlled press, which extracts more water and establishes the desired thickness. From the time it is poured to the time it emerges from the dryer, an 8' x 12' Homasote® board loses 598 gallons of water, all of which are collected and returned to the pulper. Production of the Homasote® board produces no wastewater.

Workers laminate, shave and trim the finished boards as needed. Boards to be used for packing dunnage or insulation are carried to a separate section of the facility where they are die-cut and laminated to order.

Homasote Company employs 250 workers 160 at the plant, and 90 in the office (Table 45).

Products

Turn-of-the-century railroad-car manufacturers were the first to use Homasote products. The board's versatility, light weight, insulating qualities and resistance to weathering also made it popular for a variety of building uses. In World War I the U.S. Army used Homasote® board to build field hospitals, and on Admiral Byrd's 1929 expedition to Antarctica, 56 men lived in huts built from the material.

Homasote's main product remains remarkably similar to its original one first produced in 1909. It can be sawed, drilled and fastened like other boards, yet is a superior insulator to wood, gypsum, and other materials. Homasot® on walls, ceiling or floors (beneath carpeting) provides thermal and sound insulation, as well as cushioning. Roofers use the board beneath tar roofing.

In the 80 years since its inception, Homasote has diversified its product line, adding laminates, surface textures, specialized die-cuts and an insulating

Table 45 Process Information

recycling level:	secondary
feedstock input rate:	250-350 TPD
production output rate:	NA
production design capacity:	350 TPD
capacity utilization factor:	NA
feedstock reject rate:	2%
waste generated:	plastics, wire, non-ONP paper
disposal methods:	landfill
equipment:	2 hydrapulpers, 5 "formers" (presses and dryers)
employment:	250 full time
scheduled operation:	230 days per year; 3 shifts per day
area requirement:	26 acres
plant size:	600,000 square feet
warehouse size:	NA
energy requirement:	NA
water requirement:	NA

Source: Institute for Local Self-Reliance, 1992.

Table 46 Product Information

products manufactured	production rate (TPY)	total recycled content	post-consumer content	estimated annual sales	gross revenue per ton	value added per ton
building board	NA	100%	100%	NA	NA	NA
insulated building board	NA	75%	75%	NA	NA	NA
packaging material	NA	100%	100%	NA	NA	NA
total	**<70,000 [a]**	**NA**	**NA**	**NA**	**NA**	**NA**

[a] ILSR estimate.

Source: Institute for Local Self-Reliance, 1992.

urethane foam. Today the company manufactures a wide range of products for use in construction, renovation, roofing and product shipping (Table 46).

In 1970, Homasote introduced Pak-Line®, a reusable packaging material that companies use to ship parts between plants. Pak-Line® is molded to fit specific electronic parts, film rolls, steering mechanisms, and other products. Pak-Line® material provides a firm cushion for transit, and then, unlike traditional materials, can be dismantled, returned and reused up to 40 times. Ultimately, it can be recycled with ONP.

Economics

The current domestic downturn in home and commercial construction has curtailed production at the Homasote facility. However, the versatility of the board has allowed the company to diversify its product line into non-construction products.

Homasote currently holds all economic information proprietary.

Replicability

If demand for Homasote® board increases, Homasote is prepared to increase capacity of the West Trenton facility by 35 to 40 percent. According to company executives, increasing the capacity at the current plant would involve minimal capital investment compared with siting a second facility.

The forming line at Homasote is made up of custom-designed equipment that is unique to the Homasote® product. Individual elements, although capital intensive, are replicable.

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MARCAL PAPER MILLS, INC.

Location:	Elmwood Park, New Jersey
Start-up Date:	1939
Recycled Material Used:	mixed paper
Products:	bath tissue facial tissue paper towel napkin
Production Design Capacity:	305 TPD

Company Background

In 1932, Nicholas Marcalus, an Italian immigrant and self-taught engineer, founded Marcalus Paper Manufacturing Company in Bloomfield, New Jersey, and began producing rolled, waxed paper. Within a few years the company had moved to Elmwood Park and was converting jumbo rolls of tissue into finished products. In 1941, the plant started making its own tissue from virgin pulp. Then in 1947, in order to cut down on production costs and dependency on outside pulp suppliers, Marcalus built a plant that converted wastepaper to pulp.

Since the construction of that first recycling machine, the Marcalus family has kept the company on the forefront of recycling by constantly refining and updating its equipment. In 1978, the company vastly increased its efficiency by replacing old paper machines with new high-speed machines. It is currently completing a three-year, $20 million expansion project, which was spurred by a $3 million low-interest loan from the New Jersey Department of Environmental Protection, and the sale of $13.3 million in tax-exempt bonds issued by the State of New Jersey.

Today, Marcal is a fully-integrated paper company that uses a variety of waste papers to produce 100 percent recycled-content napkins, bath tissues, facial tissues and paper towels for both retail and commercial markets. Besides its main plant in Elmwood Park, the company owns smaller converting plants in Augusta, Georgia; Chicago, Illinois; and Springfield, Ohio. The Chicago plant makes waxed paper and bags for the commercial sector, while the Georgia and Ohio plants make place mats and napkins, with an emphasis on custom printing for the food-service industry. Not all the products made at these plants are manufactured from recycled paper.

Feedstock

Marcal is one of the few domestic paper manufacturers capable of using low-grade, mixed waste paper. The company's fleet of 50 tractors and 100 trailers bring in commingled magazines, catalogs, color inserts, junk mail, envelopes (with or without plastic windows), office paper, non-metallic wrapping paper, books, school paper and telephone directories. Most of the 600 supplier

Table 47 Feedstock Information

material	consumption (TPY)	recycled content	post-consumer content	price paid/ton
mixed paper	104,000	100%	100%	$0
pre-consumer printed material	56,000	100%	0%	NA
total	**160,000**	**100%**	**65%**	**NA**

Source: Institute for Local Self-Reliance, 1992

communities are located in New Jersey, New York and Pennsylvania. Marcal does not use newsprint, old corrugated containers, kraft bags, plastic bags, carbon paper or blue print.

Marcal hauls loose or baled waste paper free of charge from schools, offices, libraries, institutions and community recycling programs. However, beyond a radius of approximately 250 miles, suppliers share the transportation costs. To bring in more paper, Marcal's Municipal Outreach Recycling Program sponsors one-day recycling events, school programs, and other public presentations. Recently Marcal teamed up with a janitorial and paper-products firm to provide businesses in New York and New Jersey with free recycling bins. Marcal also has a drop-off box at its plant.

Quality control at the community level is rarely a problem. If unacceptable paper comes in, it's either delivered to an appropriate recycler, or landfilled. If a community provides a large quantity of unacceptable material or contaminants, Marcal returns the load at the community's expense.

Marcal uses approximately 160,000 tons of waste paper per year in its production (Table 47). Currently, post-consumer, mixed paper constitutes approximately 65 percent of that feedstock, although this varies from day to day. The balance is pre-consumer scrap, predominantly printing plant overruns and errors. The company intends to shift to 100 percent post-consumer paper in the near future, and is confident it can maintain the quality of its products.

Process

Marcal's trucks bring mixed paper from various post-consumer sources and unload it on a tipping floor. Here, it is combined with pre-consumer paper, and loaded onto a conveyer that deposits the stock in one of several pulpers. The paper is mixed with hot water and detergents to defiber it and start the deinking process. The resulting slurry has a fiber consistency of approximately 18 percent.

Marcal has two deinking lines, each consisting of several pulpers and various types of cleaning, washing and screening equipment. The company uses standard and company-enhanced cleaning technologies, including flotation devices and centrifugal-action cleaners, in combinations that have been developed in-house through many years of experience.

Some of Marcal's products are lightly bleached to restore whiteness. For environmental and economic reasons, the company stopped bleaching with chlorine gas in 1991. Marcal still uses hypochlorite to bleach facial tissue, but is replacing it with more benign agents.

Clean stock enters one of three high-speed paper machines, which make tissue at a rate of 6,000 feet per minute. The stock, which has a fiber content of 0.3 percent, is sprayed onto a screen, through which the water is drained. A continuous sheet of tissue exits the paper machine and enters a Yankee Dryer, which uses steam heat to reduce the moisture content to 4 to 6 percent. The dry tissue is wound onto jumbo rolls and sent to converting machines that slit, rewind, sheet, fold and pack the finished products. Marcal's bundling system wraps multi-roll packages of tissue

Table 48 Process Information

recycling level:	tertiary
feedstock input rate:	443 TPD
production output rate:	263 TPD
production design capacity:	305 TPD
capacity utilization factor:	86%
feedstock reject rate:	41%
waste generated:	kaofin sludge
disposal methods:	60% landfill, 20%. shale-substitute for cement manufacture, 20% composting
equipment:	pulpers, screens, cleaners, refiners, paper machine, Yankee Dryer, converting machines
employment:	1,100 full time
scheduled operation:	361 days per year; 3 shifts per day
area requirement:	65 acres
plant size:	1,250,000 square feet
warehouse size:	included in plant size
energy requirement:	NA
water requirement:	432,000,000 gallons per day

Source: Institute for Local Self-Reliance, 1992.

and towel in a plastic casing, saving 20 percent storage space compared to corrugated boxes. Marcal products are delivered to markets in the company's own trucks, which return with mixed waste paper.

Marcal has a 25 year contract to buy power from a new, 65-megawatt co-generation plant, located at the Elmwood Park site. The plant produces both steam and electricity from natural gas. Marcal's water comes from the Passaic River. Most of its wastewater is treated and recycled within the mill, and the excess water is discharged into the Passaic Valley Sewer Authority system. The mill also produces kaofin sludge. Kaofin, which consists of rejects from the various cleaning operations and wastewater treatment, is approximately 50 percent clay from coated papers, and 50 percent short, unusable fibers. About 60 percent of this waste is now landfilled, 20 percent is used as a shale-substitute in cement manufacturing, and 20 percent is dried and composted to make a soil additive. Marcal is continuing its efforts to divert by-products to beneficial uses.

Marcal has 1,100 employees (800 of whom are union workers) at its New Jersey facility. Table 48 provides a summary of Marcal's operating process.

Products

Marcal is a regional paper company whose aggressive marketing program reaches from Maine to Florida. The company produces over 200 brand-coded versions of facial tissue, napkin, towel and bath tissue. Generally, bath tissue accounts for 45 percent of production, and paper towel for 35 percent. The remainder is split evenly between napkin and facial tissue (Table 49). Marcal previously made feminine-hygiene products but for economic reasons ceased their production a few years ago. Marcal markets approximately half of its products under its own name. Commercial users consume an additional 40 percent, and the remaining 10 percent are branded with grocery-chain or wholesalers' names.

Although product post-consumer content varies with the availability of feedstock and the type of product, all of Marcal's products meet the U.S. EPA recommended guidelines for minimum post-consumer content in recycled paper products. These guidelines affect the use of federal funds to purchase paper products.

Table 49 Product Information

products manufactured	production rate (TPY)	total recycled content	post-consumer content [a]	estimated annual sales	gross revenue per ton	value added per ton
bath tissue	42,750	100%	40%	NA	NA	NA
paper towel	33,250	100%	20%	NA	NA	NA
napkin	9,500	100%	30%	NA	NA	NA
facial tissue	9,500	100%	20%	NA	NA	NA
total	**95,000**	**100%**	**65%**	**NA**	**NA**	**$700 [b]**

[a] The figures shown are a minimum, as content varies with feedstock availability. The mill as a whole uses approximately 65 percent post-consumer feedstock.
[b] Assuming average value of Marcal's tissue is $1,300 per ton and the average price for the pre-consumer feedstock is $250 per ton. Both numbers are ILSR estimates based on information provided by other similar tissue mills.

Source: Institute for Local Self-Reliance, 1992.

Economics

Due to the competitive nature of the tissue industry, this family-owned business prefers to keep proprietary all information regarding costs and company finances (Table 50). Marcal's total annual gross revenue for all four of its plants is approximately $200 million.

Table 50 Economic Information

initial capital cost:	NA
labor cost:	$40,000,000 [a]
energy cost:	NA
feedstock cost:	$14,000,000 [b]
total O&M cost:	NA
gross revenue:	NA
capital cost/capacity:	NA
O&M cost/sales:	NA
gross revenue/sales:	NA

[a] Assuming an average wage equivalent to the industry average, $12.60 per hour
[b] Assuming the average price of pre-consumer feedstock is $250 per ton.

Source: Institute for Local Self-Reliance,1992.

State policies have benefited Marcal and contributed to its success. Beside recycled product procurement policies across the nation stimulating demand, the state of New Jersey loaned Marcal $3 million for its current expansion project.

Replicability

Although the configuration of Marcal's deinking process is proprietary, the technology is available in the marketplace. The market for tissue products is relatively stable. However, because the industry is dominated by a few major producers, competition is fierce and barriers to entry are high. A small plant in a good location would find a ready supply of feedstock because, at present, very few mills are equipped to use commingled, mixed paper. Furthermore, the number of recycling programs collecting mixed paper is increasing, keeping the price low.

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Ohio Pulp Mills, Inc.

Location:	Cincinnati, Ohio
Start-up Date:	1965
Recycled Material Used:	poly-coated paper
Products:	market pulp
Production Design Capacity:	50 TPD

Company Background

Ohio Pulp Mills, Inc. began operation in 1965 as Amberley Corporation, with the intention of recycling plastic-coated paper packaging waste. The original plan was to recover the plastic and discard the paper fiber, but recovering the fiber soon proved more profitable.

Robert Mendelson, owner of Donco Paper Supply Company, a Chicago paper brokerage firm, bought the Ohio Pulp plant in 1970. At the time, the mill was using many waste-paper grades to produce 10 tons per day of pulp. The resulting pulp was low grade and lacked consistency.

After assuming the reins of the mill, Mendelson installed new equipment and experimented with different feedstock. In 1971, the mill started using scrap from diaper manufacturers, such as Procter & Gamble and Kimberly-Clark. This scrap proved to be an excellent resource and became the mill's primary raw material. But the practice had to be abandoned in 1978 when the diaper manufacturers began adding super-absorbent chemicals to their diapers.

Today, this small pulp mill in the suburbs of Cincinnati uses poly-coated packaging waste to produce high-quality pulp. Recent modifications to its screening process allow it to use post-consumer milk cartons, making it one of the few mills in the country with this capability. In 1988, the company initiated a pilot program to recycle milk and juice cartons from the Cincinnati public schools.

Feedstock

Ohio Pulp's sole feedstock is various forms of poly-coated paper: cup stock, food board, milk cartons and kraft bags with plastic liners (cement bags, for example). Most of these materials come from major packaging manufacturers, including International Paper and Georgia-Pacific.

The mill incorporates up to 50 percent post-consumer stock, depending on customer specifications. On average, about 18 percent of the feedstock consists of used milk and juice cartons. This number is steadily increasing due to demand for pulp with high post-consumer content. Most of the milk and juice cartons come from curbside collection programs, retirement homes and about 60 schools in the Cincinnati area, but some arrive from as far away as Canada. Ohio Pulp has recently started collecting milk cartons from schools in Buffalo and Rochester, New York.

Poly Recyclers, another company owned by Mendelson, collects and processes the post-consumer milk and juice cartons coming from the

Table 51 Feedstock Information

material	consumption (TPY)	recycled content	post-consumer content	price paid/ton
pre-consumer poly-coated paperboard	10,000	100%	0%	$85
milk and juice cartons	2,200	100%	100%	$275
total	**12,200**	**100%**	**18%** [a]	$119

[a] This is an average figure. Actual post-consumer content varies from 0 to 50 percent, depending on customer specifications.

Source: Institute for Local Self-Reliance, 1992.

Cincinnati area. Used milk and juice cartons are collected and processed frequently because residual milk sours and residual juice develops mold. As a result, collection and processing costs for the post-consumer cartons are high: approximately $200 per ton for the Cincinnati area pilot program and about $300 per ton for the cartons arriving from further away (Table 51). If the cartons were to be separated and collected by waste haulers as part of the normal waste collection routine, the price of the feedstock could be lower.

Process

Depolying technology to remove plastic coating from paper is not a new concept. A handful of companies, including Ohio Pulp, have been doing it for almost 30 years. While these mills depend primarily on packaging manufacturers for their feedstock, Ohio Pulp distinguishes itself by using a significant percentage of post-consumer milk cartons.

Every lunch period, kindergarten through eighth grade students in the Cincinnati area empty out their gable-topped milk or juice cartons and pitch them into plastic bags placed in the cafeterias. Poly Recycles collects these cartons several times a week and takes them to its plant, located next to Ohio Pulp, where they are ground, washed and baled. Most of the raw materials coming from further

Table 52 Process Information

recycling level:	primary
feedstock input rate:	36 TPD
production output rate:	30 TPD
production design capacity:	50 TPD
capacity utilization factor:	60%
feedstock reject rate:	17%
waste generated:	polyethylene
disposal methods:	sold to plastic-lumber manufacturers and landfilled
equipment:	pulper, screens
employment:	30 full time; 15 skilled
scheduled operation:	340 days per year; 3 shifts per day
area requirement:	3 acres
plant size:	20,000 square feet
warehouse size:	10,000 square feet
energy requirement:	2,300,000 kWh per year of electricity
water requirement:	14,580 gallons per day

Source: Institute for Self-Reliance, 1992.

Table 53 Product Information

products manufactured	production rate (TPY)	total recycled content	post-consumer content	estimated annual sales	gross revenue per ton	value added per ton
market pulp	10,200	100%	18%[a]	$4,600,000[b]	$450[b]	$260[c]

[a] This is an average figure. Actual post-consumer content varies from 0 to 50 percent, depending on customer specifications.
[b] Assuming the average value of the pulp produced is $450 per ton.
[c] Assuming the average feedstock price is $119 per ton.

Source: Institute for Local Self-Reliance, 1992.

away are ground, washed and baled before they arrive at the plant. The processed scrap is taken across the plant to Ohio Pulp Mills.

At Ohio Pulp, the ground feedstock is fed into a hydrapulper, which agitates the material with water. Most of the polyethylene floats to the top where it is skimmed off and baled. The slurry passes through several screens to remove the remaining plastic bits. Virtually all the inks used on the cartons are washed off with the polyethylene. The clean pulp is thickened to about 50 percent moisture, and formed into 1,300 pound bales for sale to paper mills. Ohio Pulp does not have deinking equipment, and uses no chemicals or bleaching agents.

The polyethylene coating amounts to less than 20 percent of the incoming feedstock. Ohio Pulp sells about 25 percent of the recovered poly to plastic-lumber manufacturers, and landfills the rest due to lack of markets. Water used by the mill is filtered and recirculated. Details of the operation at Ohio Pulp are summarized in Table 52.

Products

Ohio Pulp produces two types of pulp. White pulp, which accounts for approximately 95 percent of production, retains strong, bright fibers, and commands a high price in the market. Paper mills use it to make printing-and-writing paper, and high quality tissue. Although the mill has the ability to make pulp from 100 percent post-consumer scrap, it cautions that the resulting pulp is of slightly lower quality and higher price. Because of the high collection and processing cost of post-consumer milk cartons, Ohio Pulp charges a premium for pulp with high post-consumer content. The mill's pulp contains up to 50 percent post-consumer fibers depending on customer specifications.

The remaining 5 percent of production is brown pulp, made from poly-coated kraft paper, is also of high quality, and is used to make linerboard and some specialty products. Table 53 summarizes relevant information about the market pulp manufactured by Ohio Pulp.

Economics

Ohio Pulp prefers to hold confidential all information regarding cost of operation. Approximate operating costs, and the cost of energy, labor and feedstock, based on ILSR calculations, are shown in Table 54. The cost for feedstock is the most significant portion of the operation and maintenance cost, at about 40 percent. Recent modifications to the plant, which included new screens and a water treatment system, cost the company $500,000. The company pegs its annual sales at over $4.5 million.

Replicability

The market for pulp made from poly-coated paper is expanding for two reasons: more schools

Table 54 Economic Information

initial capital cost:	$7,000,000 to $15,000,000 [a]
labor cost:	$786,000 per year [b]
energy cost:	$113,000 per year [c]
feedstock cost:	$1,500,000 per year [d]
total O&M cost:	$3,750,000 per year [e]
gross revenue:	$4,600,000 per year
capital cost/capacity:	$140,000 to $300,000 per TPD capacity [a]
O&M cost/sales:	$370 per ton sold [b]
gross revenue/sales:	$450 per ton sold

[a] Estimate for a similar-size mill built today, provided by Ohio Pulp Mills, Inc.
[b] Assuming an average wage equivalent to the industry average, $12.60 per hour.
[c] Assuming energy cost is 3 percent of O&M cost.
[d] Assuming average feedstock cost of $119 per ton.
[e] Assuming feedstock cost is 40 percent of O&M cost.

Source: Institute for Local Self-Reliance, 1992.

and recycling programs are collecting milk cartons, and the resulting pulp is of high quality. Ohio Pulp is very interested in expanding to new locations if a market can be found for its products. Any new mill will be completely financed by Donco Paper. The supply of pre-consumer scrap will be limited in areas where no manufacturer of poly-coated packaging exists. But if milk carton collection programs continue to grow, and collection and processing costs can be decreased, post-consumer feedstock will be plentiful. According to Donco Paper, if the national milk and juice carton recovery rate reaches 35 percent, there will be enough fiber to manufacture 175,000 tons per year of pulp. The machinery involved in the pulpmaking process is readily available.

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PAPER SERVICE LIMITED

Location:	Ashuelot, New Hampshire
Start-up Date:	1883
Recycled Material Used:	mixed paper
Products:	packaging tissue toilet tissue napkin
Production Design Capacity:	30 TPD

Company Background

For over 100 years, Paper Service Limited has been producing recycled paper in a small plant in the village of Ashuelot, New Hampshire. The mill has been run by the O'Neal family since Clarence O'Neal took over operations in 1908. Then, the plant used waste cotton, silk, linen, and flax to produce silk tissue paper for packaging and writing. Eventually the plant switched to Scandinavian pulp, then in 1940, switched to waste paper, and has been manufacturing tissue from waste paper ever since.

Today Clarence O'Neal's grandson, Gary O'Neal, operates the mill. However, little besides the management has changed. Paper Service still makes its papers the old-fashioned way, using neither bleaching nor chemical deinking. The only leading edge technology in the mill is its pollution-control equipment, notably a natural wastewater treatment system that discharges clean water into the adjacent Ashuelot River.

Paper Service makes all of its products from 100 percent post-consumer waste paper, mostly mixed low grades. Because of its environmentally friendly manufacturing process, Paper Service was the first company authorized by New York State to use the "New Generation" recycling emblem in its products. The company is also the recipient of the first *Ecologue Award for an Earth Conscious Company*, presented by IEG/International Environmental Group, publishers of *Ecologue, The Consumer's Guide to Environmentally Safe Products.* To spread the word on recycling, the mill welcomes tours from schools and community groups. Last year nearly 1,000 school children visited the plant and its wastewater treatment facility.

Feedstock

Paper Service is one of only two tissue mills whose entire product line is made from 100 percent post-consumer waste paper. The plant accepts newspapers, glossy inserts, office paper, copy and fax paper, computer printout, unbound books and magazines, some junk mail, and kraft grocery bags. The mill does not use carbon and plastic-coated paper, envelopes with plastic win-

Table 55 Feedstock Information

material	consumption (TPY)	recycled content	post-consumer content	price paid/ton
magazines	1,170	100%	100%	$0-50
other mixed paper	1,170	100%	100%	$0-50
computer paper	780	100%	100%	$300
newspaper	780	100%	100%	$0-50
total	**3,900**	**100%**	**100%**	**$80**

Source: Institute for Local Self-Reliance, 1992.

dews, corrugated containers, books or magazines with glued bindings, waxed or metallic-embossed papers, or wet-strength paper.

The company has little trouble getting feedstock, which it receives from a variety of sources — municipalities, brokers, volunteers and landfills. About 60 percent of the feedstock comes from a Massachusetts broker, who collects waste paper from the Boston area. The rest comes from other parts of New England.

While a few municipalities pay the mill as much as $30 per ton to take their paper, Paper Services pays other sources up to $300 per ton for certain grades of paper. On average, the company pays approximately $80 per ton for feedstock (Table 55). Because the mill does no bleaching, high grade post-consumer paper is required for some of its brighter products — computer paper makes up 20 percent of the feedstock.

PROCESS

All paper that is trucked to the plant or left in the plant's drop-off box is hand sorted to remove excessive contamination. The mixed paper is then fed into a hydrapulper, where it is mixed with water and agitated. The mill has three hydrapulpers, but only one is currently in operation. Paper Service uses no chemicals or detergents to clean the pulp, but uses polymers to float some of the contaminants. FoIlowing the pulping operation, the stock passes through a centrifugal cleaner and vibrating screens to remove further

Table 56 Process Information

recycling level:	tertiary
feedstock input rate:	13 TPD
production output rate:	10 TPD
production design capacity:	30 TPD
capacity utilization factor:	33%
feedstock reject rate:	23%
waste generated:	sludge
disposal methods:	landfill on site for later use as fill material
equipment:	hydrapulper, centrifugal cleaners, vibrating screen, refiner, paper machine, dryer, converting machines, wastewater clarifier, lagoons
employment:	35 full time, 5 part time; 6 skilled, 34 unskilled
scheduled operation:	300 days per year; 3 shifts per day
area requirement:	50 acres
plant size:	200,000 square feet
warehouse size:	100,000 square feet
energy requirement:	200,000 gallons per year of No. 6 fuel oil
water requirement:	110,000 gallons per day

Source: Institute for Local Self-Reliance, 1992.

Table 57 Product Information [a]

products manufactured	production rate (TPY)	total recycled content	post-consumer content	estimated annual sales	gross revenue per ton	value added per ton
packaging paper	2,950	100%	100%	NA	NA	NA
napkin	30	100%	100%	NA	NA	NA
bath tissue	20	100%	100%	NA	NA	NA
total	**3,000**	**100%**	**100%**	**$3,000,000**	**$1,000**	**$690 [b]**

[a] Assuming production rate is one-third of capacity.
[b] Assuming an average feedstock price of $80 and an annual sales of $3 million.

Source: Institute for Local Self-Reliance, 1992.

contaminants. The slurry is then introduced into a refiner to separate the fibers.

The clean stock enters the paper machine, which produces rolls of tissue. These are then converted into finished products. The company owns three paper machines but, again, only one is currently used.

Paper Service taps the adjacent Ashuelot River for all of its water needs. About 20 years ago the company invested $3.5 million in a wastewater treatment system to minimize the mill's environmental impact. A small amount of phosphoric acid is first added to the wastewater to neutralize the pH. The water then flows into a clarifier, where heavy particles settle. Water then enters a series of oxygenated lagoons, where aquatic plants and organisms use natural, biological processes to remove contaminants from the water. Additional contaminants sink to the bottom of the lagoons. The lagoons are also home to several types of fish, ducks, otters and other wildlife. Water from the lagoons is reused in the mill, and the excess goes back into the Ashuelot River, cleaner than it was when it left. Paper Service's boiler burned wood chips in the past, but for economic reasons, now uses Number 6 fuel oil.

The sludge generated by the plant, which consists mostly of clay with some wood fibers, is landfilled near the lagoons and later used as filler material. The company has installed several wells to monitor ground water in the area. According to company sources, water contamination has never been a problem.

Paper Service currently has 35 full-time and five part-time employees. When operating at full capacity, the mill employs 110 full-time and 20 part-time workers. The average wage for the workers is $8.50 per hour.

Information about the process used by Paper Service is summarized in Table 56.

Products

Paper Service manufactures 100 percent post-consumer tissue products. Although the company is equipped to make packaging tissue, bath tissue and napkin, at present napkin and bath tissue production is very low due to low demand in a slow economy. Almost 99 percent of its current products is wrapping and packaging tissue (Table 57). The mill makes eight types of these, in roll and sheet form, and in several colors.

Paper Service sells exclusively to commercial users throughout the U.S. The company also exports some of its products to Costa Rica, Canada, Norway and other countries.

Economics

Because the plant was built over 100 years ago, the initial capital cost is not applicable today. The company estimates that nowadays the initial capital cost for a similar mill would be between $30 million and $50 million. Aside from the wastewater treatment system, no major modifications have been made to the plant in recent years.

Although Paper Service has been a profitable business for over 100 years, the recent recession has slowed sales. The company has laid-off over half its work force, and at one point the production rate had dropped to 20 percent of capacity. The company attributes this to a depressed economy, loss of some major contracts, the public's fascination with white and bright products, and an influx of products bearing a "recycled" claim.

The annual operating cost for the plant at full capacity is approximately $3.5 million. At one-third capacity, it is about $1.7 million. Even at this modest sum, the plant is not earning a profit because of all the unused capacity. However, because the plant is relatively small, it only takes a few major contracts to restore profitability. To Paper Service's benefit, Sears Roebuck and Company recently sent a letter to all its suppliers, encouraging them to use Paper Service's packaging tissue.

High local energy costs and a labor-intensive process make Paper Service's products slightly more expensive than those produced by larger, virgin-stock mills. At $0.37 per 1000-sheet roll, bath tissue costs about 15 percent more than a comparable virgin product. Paper Service's packaging paper costs approximately $0.45 per pound, which is comparable to other mills' paper, but generally slightly higher than polystyrene packaging. According to management, prices for all the products could decrease by 10 percent if the plant were at full capacity.

Energy and labor account for approximately 60 percent of the operation and maintenance cost, while feedstock cost is the next significant portion, at 20 percent (Table 58).

Table 58 Economic information [a]

initial capital cost:	$30,000,000 to $50,000,000 [b]
labor cost:	$500,000 per year
energy cost:	$500,000 per year
feedstock cost:	$312,000 per year
total O&M cost:	$1,700,000 per year
gross revenue:	$3,000,000 per year
capital cost/capacity:	$1,000,000 to $1,700,000 per TPD capacity
O&M cost/sales:	$570 per ton sold
gross revenue/sales:	$1,000 per ton sold

[a] Assuming production rate is one-third of capacity.
[b] Estimate for a new mill of similar capacity provided by the management of Paper Service Limited.

Source: Institute for Local Self-Reliance, 1992.

Replicability

The technology used by Paper Service is fully replicable. The initial and operating costs are also fairly low. However, because of the dominance of a few big companies in the tissue industry, stable markets for the products (local governments, institutional and commercial users) are necessary to ensure profitability. As for feedstock, very few mills compete for mixed paper, and a medium-size city with a population of 300,000 could provide all the waste paper required by a mill of this scale.

The wastewater treatment system at Paper Service requires more land than conventional systems, because of the lagoons. However, the system results in low water requirements and especially clean effluent.

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Somerset Fiber/Recycling Systems Corporation

Location:	Cowpens, South Carolina
Start-up Date:	1992
Recycled Material Used:	old corrugated containers
Products:	linerboard corrugated medium bag paper
Production Design Capacity:	280 TPD

Company Background

In 1990, a small group of paper-industry veterans founded Recycling Systems Corporation (RSC) with the intent of building mini-mills for making 100 percent post-consumer paper. These mills are designed to have a low capital cost, and to produce paper that is cost- and quality-competitive with virgin mills. RSC's current focus is on mills that use OCC to make light-weight kraft grades. The initial result of this venture is Somerset Fiber, a plant owned by the international packaging company, LinPac Group.

RSC is a developer/contractor for minimills that have about one-fourth the production capacity of a regular linerboard mill. The company will assist prospective owners in every phase of the project, from site selection to initial mill operation. Once the owner secures approval and funding for a project, RSC will supervise design and construction, provide the operating management, and even market the output.

The LinPac Group, one of the world's largest packaging manufacturers, was founded 32 years ago in the United Kingdom. With headquarters in Lincolnshire, U. K., the company has plants all over Europe and the U. S., making a variety of paper, plastic, molded-pulp and metal packages. In the U.S., Linpac owns four corrugated-sheetboard plants besides Somerset. These are located in Greensboro, North Carolina; Atlanta, Georgia; Dallas, Texas; and Los Angeles, California.

The design and construction of Somerset was completed in 18 months. Although the plant is now managed by LinPac, representatives from RSC remain on-site as consultants, concentrating on marketing, waste paper supply, solid waste disposal, and business management.

Feedstock

Somerset's only feed stock is OCC (Table 59). Brokers collect this from within a 150-mile radius of the plant, and deliver it by truck or rail. About 70 percent of the OCC comes from grocery stores, 20 percent from textile mills and other industrial

Table 59 Feedstock Information

material	consumption (TPY)	recycled content	post-consumer content	price paid/ton
OCC (Grade #1 PSIA)	98,000	100%	100%	$4050

Source: Institute for Local Self-Reliance, 1992.

sources, and 10 percent from local landfills, where it is salvaged from commercial loads.

RSC does not anticipate a feedstock shortage, because there are no other nearby mills that use OCC, nor is all the OCC being recovered from the waste stream. RSC is working with local governments that own landfills to separate OCC from commercial waste before disposal.

Process

Baled OCC arriving by truck or rail is weighed and dumped on a tipping floor. Workers break the bales and load the feedstock onto a conveyer that carries it to a hydrapulper (a Black Clawson pulper similar to those used in many recovered-fiber mills). The loading rate is constantly monitored by an operator using a computer-controlled system.

The hydrapulper agitates the OCC with water to defiber the feedstock and produce a slurry. The pulper also removes some heavy contaminants such as bale wire and plastic, that account for about 3 to 5 percent of the input. A "debris rope" removes strings, wires and rags. Other rejects from the hydrapulper are diverted into a trash well. The remainder of the slurry, which is about 3 percent solids, proceeds to a cleaning device called the Liquid Cyclone™, which uses centrifugal action to remove smaller, high-density contaminants.

The accepted stock is then stored before it is passed through a series of approximately 20 different cleaning steps, including Black Clawson's Ultra-V™ vertical-pressure screens, Ultra-Clone™ forward cleaner and X-Clone™ through-flow centrifugal cleaners. The clean stock is thickened to 4 or 5 percent solids, then refiners grind it into individual fibers. Ready for the paper machine, stock is stored in the machine tank.

Table 60 Process Information

recycling level:	primary
feedstock input rate:	275 TPD
production output rate:	250 TPD
production design capacity	280 TPD
capacity utilization factor:	89%
feedstock reject rate:	9%
waste generated:	sludge, plastic, bale wire
disposal methods:	landfill
equipment:	pulper, screens, cleaners, refiner, paper machine, dryer
employment:	61 full time; 16 skilled, 45 unskilled
scheduled operation:	355 days per year; 2 shifts per day
area requirement:	12 acres
plant size:	100,000 square feet
warehouse size:	included in plant size
energy requirement:	50,000,000 kWh per year of electricity, 300,000 MCF per year of gas
water requirement:	250,000 gallons per day

Source: Institute for Local Self-Reliance, 1992.

Table 61 Product Information

products manufactured	production rate (TPY)	total recycled content	post-consumer content	estimated annual sales	gross revenue per ton	value added per ton
linerboard	NA [a]	100%	100%	NA	NA	$260 [b]
bag paper	NA [a]	100%	100%	NA	NA	$300 [c]
total	**88,750**	**100%**	**100%**	**$25,000,000**	**$280**	**$270 [d]**

[a] Production rate for individual products vary with consumer demand.
[b] Assuming average feedstock price is $45 per ton, and average value of product is $330 per ton.
[c] Assuming average feedstock price is $45 per ton, and average value of product is $375 per ton.
[d] Assuming average feedstock price is $45 per ton, and average value of products is $350 per ton.

Source: Institute for Local Self-Reliance, 1992.

Stock enters the paper machine through a head box, which pressurizes the flow and spreads it onto 180-inch-wide forming wires. The wires, which travel at approximately 875 feet per minute, form a two-ply sheet. This continuous sheet enters two presses that reduce the moisture content from 60 to 50 percent. The paper is further dried by a series of 25 steam-heated rollers. It is wound on 23-ton rolls, which are then re-rolled on 2- to 3-ton rolls. Samples from every roll are tested for a variety of properties, including strength, porosity, smoothness, and basis weight. The finished product is transported to container plants by truck or rail.

The plant has a natural-gas boiler to produce steam, and a primary wastewater treatment facility, consisting of a screen and a clarifier. About 80 percent of the effluent is reused, and the rest enters the municipal sewer system. Sludge is dewatered with a filter press, and is landfilled. Table 60 summarizes Somerset's manufacturing process.

Products

Although Somerset is equipped to produce lightweight linerboard, corrugated medium and bag paper, the plant ran only corrugating medium for its first four months. The mill is now switching to other grades, a relatively simple transition that requires only different chemical additives. In 1993, Somerset will produce linerboard and bag paper. Table 61 provides details about Somerset's products.

The company expects the demand for lightweight corrugated containers to increase because of recent changes in Rule 41 of the American Trucking Association, which governs the corrugated box industry. This rule, which specifies the weight required to meet the bursting-strength requirement, was revised in 1991 to allow the use of lighter weight paper.

Somerset sells its corrugated medium and linerboard to corrugated-box plants nationwide. Some of its products are sold to LinPac's box plants.

Economics

RSC claims that a mini-mill (250 tons per day) can be built for approximately $160,000 per daily ton of capacity, on a good site. This is well below the paper-industry norm of $300,000 to $500,000 per daily ton of capacity. Feedstock availability and utility costs heavily influence operating costs. Somerset's estimated annual sales are $25 million.

Approximate operating costs, based on ILSR calculations, are shown in Table 62. The cost of feedstock is the main operation and maintenance cost, at approximately 30 percent. Be cause OCC is delivered to the plant by brokers, there is no transportation cost involved. Design innovations that minimize water and energy costs add to Somerset's competitive edge.

Replicability

Although the mini-mill concept is new to the U.S. paperboard industry, the technology has been successfully used in Europe and is replicable. Over 80 percent of the mill's equipment is conventional — it is the mill's creative use of this equipment that makes it state-of-the-art.

RSC plans to build many more mini-mills similar to the Cowpens facility. The company is currently siting a 375 ton per day, $80 million linerboard mill in Prewitt, New Mexico. The mill, which will be named McKinley Paper Company, is scheduled to start operation by early 1994. RSC also plans to apply the mini-mill concept to folding-boxboard and newsprint production.

Table 62 Economic Information

initial capital cost:	$40,000,000 to $50,000,000
energy cost:	$3,000,000 per year [a]
labor cost:	$1,600,000 per year [b]
feedstock cost:	$4,400,000 per year [c]
total O&M cost:	$15,000,000 per year [d]
gross revenue:	$25,000,000 per year
capital cost/capacity:	$140,000 to $180,000 per TPD capacity
O&M cost/sales:	$170 per ton sold
gross revenue/sales:	$280 per ton sold

[a] Assuming energy cost is 20 percent of O&M cost.
[b] Assuming an average wage equivalent to industry average, $12.60 per hour.
[c] Assuming feedstock cost is $45 per ton.
[d] Assuming feedstock is 30 percent of O&M cost.

Source: Institute for Local Self-Reliance, 1992.

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Coon Manufacturing

Location:	Spickard, Missouri
Start-up Date:	1974 (started accepting scrap in 1987)
Recycled Material Used:	natural color high density polyethylene
Products:	plastic sheet and related products rotational molded plastic products
Production Design Capacity:	14 TPD

Company Background

In 1985, following a fifteen year history of manufacturing propane delivery units, farm machinery, and various plastic products, entrepreneur Bill Coon began research and development on a process to manufacture recycled-plastic sheeting for use in building applications. In 1987, Coon Manufacturing began production of the sheets using unprocessed post-consumer plastic as a feedstock.

In 1991, Coon built a prototype wash system on the theory that its manufacturing process would operate more cheaply and efficiently if the post-consumer plastic scrap was free of paper and clean. Furthermore, since clean post-consumer plastic flakes were in high demand among other manufacturers, Coon would be able to sell for additonal profit any surplus materials not needed in its operations. The performance of the prototype wash system exceeded expectations, and the company began operating a full-scale production system, which began operating in January 1992. The company currently produces dies and plastic-processing equipment, manufactures plastic sheet from post-consumer scrap, and makes rotational-molded products from industrial scrap.

Feedstock

Coon Manufacturing purchases bales of post-consumer natural HDPE bottles (milk and water jugs) from municipal residential recycling programs (Table 63). The plastic is trucked to Coon from distances of up to 500 miles, primarily from communities in Missouri, Iowa, Illinois, Tennessee, and Minnesota.

The company also uses natural-colored industrial scrap HDPE to manufacture its rotational-molded products. Currently, this rejected material is purchased in gaylords from another rotational molding operation. Because it is already clean and ground, Coon buys it for nearly three times what it pays for post-consumer bottles.

Process

As bales of post-consumer HDPE arrive at the plant, they are mechanically broken and loaded onto a conveyor, and contaminants such as glass, aluminum, and steel are manually removed. Coon Manufacturing then grinds the plastic into flakes, washes and dries them, then stores the flakes for later use or for sale to other manufacturers.

Table 63 Feedstock Information

material	consumption (TPY)	recycled content	post-consumer content	price paid/ton
natural HDPE milk bottles	960	100%	100%	$160
ground natural HDPE (industrial)	104	100%	0%	$440
total	**1,064**	**100%**	**90%**	**$187**

Source: Institute for Local Self-Reliance, 1992

Currently, the Coon wash system operates at half capacity due to a shortage of drying capacity (Table 64). The wash system requires four workers per shift, and needs 2,500 square feet of space, plus 7,500 square feet for material storage.

On the sheet-extrusion line, an extruder melts the clean, dry post-consumer flakes with an added coloring agent. This thick liquid is forced between two rollers that press it into sheet form. This system requires 3,000 square feet of space for machinery and feedstock. Inventory requires an additional 8,000 square feet, half of which is currently outside. The sheet-extrusion system requires one worker and one supervisor per shift, and must run three shifts per day, five days per week to be cost effective.

The rotational-molding system starts with the melting of finely-ground, industrial scrap HDPE. The molder rotates so that the molten plastic coats the inside of the mold. The result is a hollow product such as a trash can or dog house. This system requires two workers and one supervisor per shift, and must run three shifts per day to be cost effective. It requires 5,000 square feet under roof for the equipment, with an additional 5,000 to 10,000 square feet of outdoor storage. The company could run post-consumer plastic through its rotational molding system if it had equipment to grind the post-consumer flake into a powder.

Products

The primary products from Coon Manufacturing's sheet extruder line are 4' x 8' and 4' x 10' sheets of plastic (Table 65). The sheets, which range in thickness from 0.025 to 0.625 inches, are used as a substitute for wood in pallets and a variety of building applications, such as wall, floor and roof covering.

The company also extrudes plastic profiles in the sizes 1" x 2" and 2" x 4," with varying lengths. Coon also fabricates these profiles into a variety of products, including furniture.

With its rotational molding equipment, Coon has the capacity to produce over 30 products, including gas tanks, water reservoirs, animal feeders, dog houses, buckets, helicopter seats, pans, 18-gallon curbside containers, and 2-cubic yard dumpsters.

Lumber, concrete, and steel companies are the direct competitors of plastic manufacturers like Coon. Coon's products enjoy many advantages over their wooden competitors: a resistance to moisture-related problems such as rotting and oxidation, as well as reduced maintenance requirements. Coon Manufacturing holds that the unique characteristics of its building materials — especially their immunity to moisture — make them more suitable to a variety of end uses than traditional products.

Economics

Initial capital investment costs totalled $689,000. Coon Manufacturing is currently able to produce products predominately for midwest markets, with some of its products enjoying sales throughout North America (Table 66). Product variety ensures a seasonally stable demand while the use of previously-owned equipment (Coon purchased most of its equipment used) allows for low start-up expenses.

Coon Manufacturing sells its products to construction companies, lumber yards, and other retail markets. Because some consumers buy directly from the company's storage yard, end users of Coon's products include not only contract builders, but urban and rural consumers as well. The markets for these products are rapidly expanding, and the company is constantly developing new products for manufacture.

Table 64 Process Information

recycling level:	tertiary	
feedstock input rate:	wash system:	4.8 TPD
	sheet extrusion system:	3.7 TPD
	rotational molding system:	0.4 TPD
production output rate:	wash system:	4.6 TPD
	sheet extrusion system:	3.7 TPD
	rotational molding system:	0.4 TPD
production design capacity:	wash system:	13.3 TPD
	sheet extrusion system:	6.1 TPD
	rotational molding system:	1.2 TPD
capacity utilization factor:	wash system:	35%
	sheet extrusion system:	61%
	rotational molding system:	33%
feedstock reject rate:	wash system:	4%
waste generated:	bottle caps, paper and metals from pre-wash sorting	
disposal methods:	landfill	
equipment:	wash system: bale buster, shredder, grinder, conveyor, blower, air separation system, auger, holding bins, dryer, washing unit	
	sheet extrusion system: grinder, blender, extruder, dryer, conveyors, dies, plastic testing equipment	
	rotational molding system: rotational molder, chiller, cooling tower, molds	
employment:	wash system:	3 full time
	sheet extrusion system:	6 full time
	rotational molding system:	6 full time
	administrative/sales:	7 full time
	total:	22 full time
scheduled operation:	wash system:	260 days per year; 1 shift per day
	sheet extrusion system:	260 days per year; 3 shifts per day
	rotational molding system:	260 days per year; 1 shift per day
area requirement:	5 acres	
plant size:	13,000 square feet, enclosed 22,000 square feet, outside storage	
warehouse size:	included in plant size	
energy requirement:	550,000 kWh per year of electricity; 30,000 gallons per year of propane gas	
water requirement:	36,000 gallons per year	

Source: Institute for Local Self-Reliance, 1992.

Table 65 Product Information

products manufactured	production rate (TPY)	total recycled content	post-consumer content	estimated annual sales	gross revenue per ton	value added per ton
extruded sheets	960	100%	100%	$1,152,000	$1,200	$990
rotational molded products	104	100%	0%	$364,000	$3,500	$3,100
total	**1,064**	**100%**	**90%**	**$1,516,000**	$1,400	$1,200

Source: Institute for Local Self-Reliance, 1992.

Table 66 Economic Information

initial capital cost:	$689,000 (1987-92)	
	wash system:	$200,000
	sheet extrusion system:	210,000
	rotational molding system:	150,000
	support equipment:	75,000
	land and buildings:	54,000
labor cost:	$390,000 per year	
	wash system:	$206,000 per year
	sheet extrusion system:	155,000 per year
	rotational molding system:	29,000 per year
energy cost:	$55,400 per year	
	electricity:	$37,400 per year
	propane:	18,000 per year
feedstock cost:	$199,360 per year	
total O&M cost:	$968,640 per year	
	wash system:	$521,000 per year
	sheet extrusion system:	406,000 per year
	rotational molding system:	41,640 per year
gross revenue:	$1,516,000 per year	
capital cost/capacity:	wash system:	$17,300 per TPD capacity
	sheet extrusion system:	39,300 per TPD capacity
	rotational molding system:	137,500 per TPD capacity
O&M cost/sales:	wash system:	$434 per ton sold
	sheet extrusion system:	423 per ton sold
	rotational molding system:	400 per ton sold
gross revenue/sales:	$1,400 per ton sold	

Source: Institute for Local Self-Reliance, 1992.

Labor costs account for over one-third of Coon's operating expenses. Feedstock costs are approximately half that amount.

Replicability

Currently, only a few companies in the U.S. manufacture products from 100 percent scrap plastic, representing a very small portion of the total plastic product market. Many of today's virgin plastic products can be made from recycled resin using a Coon-type process, indicating its growth potential of recycled resins' share of the plastic market.

Coon Manufacturing is currently seeking to expand its operations to other locations and is looking to license its systems to other companies. Recoverable HDPE scrap from a population of one million is enough feedstock to support a facility the size of the current Coon plant. The company is also interested in joint ventures with other companies or community development corporations.

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LANDFILL ALTERNATIVES, INC.

Locations:	Elburn, Illinois
Start-up Dates:	1988
Recycled Material Used:	polystyrene fabrications
Products:	polystyrene granules polystyrene pellets
Production Design Capacity:	6 TPD

Company Background

James Frank and Bill Roberts founded Landfill Alternatives, Inc. in 1988 with the goal of recycling excess industrial expanded polystyrene (EPS or foam PS). While manufacturers of EPS products have always reused some of their in-house scrap, much of it still goes to landfills. Today, Landfill Alternatives is able to accept post-consumer EPS due to the donation of an EPS wash system by Amoco Foam Products which Landfill Alternatives redesigned to operate at a higher throughput. in 1992, Landfill Alternatives was the only Self-sustaining for-profit processor of post-consumer EPS in the U.S.

Feedstock

Landfill Alternatives uses approximately 1.65 million pounds per year of scrap EPS, half of which is post-consumer material (Table 67). The company pays 4 cents per pound ($80 per ton) for industrial scrap it receives from packaging fabricators. Post-consumer EPS comes from school and commercial food-service operations, churches, special events, municipal recycling programs, and building contractors who use EPS insulation. The company requires incoming post-consumer material to be free of food waste (except what sticks to the material), mold and free contaminants.

Landfill Alternatives collects post-consumer scrap EPS from within a 40-mile radius of its plant, charging suppliers 39 cents per mile plus $10.50 per hour for the driver, regardless of the load size. Since December 1991 it has also charged suppliers an additional 15 cents per pound for all food-service material to cover some of the cleaning expenses. The cleaning charge is intended to motivate suppliers to remove food and non-PS material from the shipment, as well as to help offset the company's washing cost of 20 cents per pound. Landfill Alternative's suppliers calculate that the total tipping fee *per meal* is between 0.25 cents and 1.33 cents. Suppliers outside the forty mile radius ship to the company at their own expense.

Process

Post-consumer EPS arrives at the plant in bales or bags which are initially stored outside. Once inside, a worker manually sorts the material to remove the large contaminants and to

Table 67 Feedstock Information

material	consumption (TPY)	recycled content	post-consumer content	price paid/ton
EPS fabrications	830	100%	50%	$80

Source: Institute for Local Self- Reliance, 1992.

separate high impact-strength PS (e.g., cottage cheese containers and other non-foam PS) from low impact-strength PS (foam PS). In addition, colored feedstock can be separated from uncolored. Landfill Alternatives rejects approximately 3.5 percent of the post-consumer feedstock and 0.5 percent of industrial feedstock (Table 68). The sorted EPS is fed into the washer/dryer system.

The wash line, which has been in operation since June 1991, consists of a single unit that washes and dries up to 65 pounds of EPS per hour. Batches take about ten minutes to dry after which the material is introduced to the densifier, which heats the EPS to about 270° F. The heat, along with a vacuum, releases air and any residual blowing agent from the foam, and compacts it into granules with an average bulk density of 33 to 35 pounds per cubic foot.

Efficiency-oriented modifications to the Landfill Alternatives facility include improvements made to the washer/dryer and to the densifier system. The company upgraded the washing line by installing more reliable components, an improved sorting system and high-velocity sprays (to reduce water consumption). It also made system changes to increase the rate of throughput.

Products

Landfill Alternatives produces EPS granules made from 50 percent post-consumer and 50 percent industrial scrap. The company also markets other processors' recycled and non-recycled EPS pellets.

Landfill Alternatives produces EPS granules at its facility and subcontracts the production of EPS pellets, which are made from the granules. Although granules and pellets usually consist of 50 percent post-consumer and 50 percent industrial scrap (Table 69), on special request, the company can manufacture any combination of industrial

Table 68 Process Information

recycling level:	primary
feedstock input rate:	3.3 TPD
production output rate:	3.3 TPD
production design capacity:	6.0 TPD
capacity utilization factor:	54%
feedstock reject rate:	2%
waste generated:	blowing agent, organic food waste, various non-EPS materials
disposal methods:	blowing agent vented to atmosphere, organic waste into sewage system, non-EPS materials landfilled
equipment:	washer/dryer, densifier
employment:	9 full time, 4 part time; 1 skilled, 12 unskilled
scheduled operation:	250 days per year; 2 shifts per day
area requirement:	0.5 acres
plant size:	5,000 square feet
warehouse size:	NA
energy requirement:	180,000 kWh per year of electricity; 83 MCF per year of natural gas
water requirement:	575 gallons per day

Source: Institute for Local Self-Reliance, 1992.

DOLCO PACKAGING COMPANY

location:	Decatur, Indiana
start-up date:	1972, 1990 (accepted scrap)
recycled material used:	polystyrene pellets (2 TPD)
products:	foam polystyrene egg cartons (8 TPD)
design capacity:	50 TPD
gross revenues:	$14,000,000 per year
gross revenue/sales:	$1,600 per ton sold
employment:	145 full time

BACKGROUND

Dolco Packaging was the first manufacturer to use post-consumer material in EPS egg cartons after successfully arguing its case with the U.S. Food and Drug Administration (FDA). Dolco argued that because the eggshell separates the food from the egg carton these products should be exempt from the standard prohibiting post-consumer plastics in packaging that may contact food. Although falling short of exempting the container from the regulation, the FDA sent Dolco a letter of "non-objection" in March 1990, making it the first plastic food package to receive tacit approval to use post-consumer EPS in food containers.

Dolco began production of egg cartons using post-consumer EPS in June 1990. The company operates four facilities: Decatur, Indiana; Lawrenceville, Georgia; Dallas, Texas; and Wenatchee, Washington.

Feedstock

Dolco Packaging receives clean pelletized polystyrene fromprocessors for which it pays $800 to $900 per ton. The packaging manufacturer initially purchased all of its post-consumer EPS from Landfill Alternatives. Then in 1991, the National Polystyrene Recycling Company (NPRC), a consortium of eight major PS manufacturers, opened a post-consumer PS recycling facility near Chicago. Dolco now purchases much of its feedstock from NPRC, but continues to purchase significant quantities from Landfill Alternatives.

Delco also works with its retail customers, primarily supermarket chains, to collect post-consumer PS packaging through in-store recycling bins. The company works with the retailer to get the collected material to a PS reprocessing plant from which Dolco purchases feedstock. The company also purchases ground PS compact-disc cases, which it feeds directly into its extruder without repelletizing.

Process

Dolco uses the same production process to produce egg cartons from scrap polystyrene as it uses for virgin polystyrene feedstock, except that Dolco uses a pre-extrusion auger-screw to mix together the scrap and virgin pellets. The company uses a non-CFC, non-HCFC blowing agent to form its EPS sheets.

Dolco Packaging has addressed recycling issues throughout its entire operation since 1989. The company currently uses or recycles 99.5 percent, by weight, of its incoming material. The small loss is in the form of blowing agent and unusable contaminants. Between 1989 and 1991, the Decatur plant reduced the amount of material it sends to the landfill by about 70 percent.

Source: Institute for Local Self-Reliance, 1992.

Table 69 Product Information

products manufactured	production rate (TPY)	total recycled content	post-consumer content	estimated annual sales	gross revenue per ton	value added per ton
PS pellets& flakes	813	100%	50%	$650,000	$800	$700

Source: Institute for Local Self-Reliance, 1992.

and post-consumer scrap, up to 100 percent post-consumer. The company sells most of its production to Delco Packaging for use in egg containers (see p. 113) and to Amoco Foam Products, which uses the EPS to manufacture insulation board from 50 percent recycled EPS (25 percent post-consumer).

Delco Packaging manufactures foam PS egg cartons from 25 percent post-consumer EPS. The company also includes a limited amount of post-consumer EPS in its other products, such as dunnage trays and cushioning, each containing 25 percent post-consumer scrap. Delco plans to increase the post-consumer content in egg cartons made at its Wenatchee, Washington plant to 40 percent by the end of 1992.

Delco incorporates post-consumer EPS into only 10 percent of its egg cartons because of color limitations. Extra storage silos needed for separate colors of post-consumer EPS make storing more than one color prohibitively expensive.

A major factor affecting the use of post-consumer EPS in finished products is the differing melt flow rate — an ASTM designation measuring the rate at which melted material flows through orifices of standard size — between the various resins. Unlike melt flow rates for virgin resins, which are easily controlled, flow rates for post-consumer material is dependent on the individual flow rates of the incoming material.

Because current extrusion operations are gauged for a specific flow rate, the relatively high melt flow rate of recycled EPS (around 3.5 grams per ten minutes compared to flow rates between 1.7 and 2.0 for virgin resin) is of concern to companies using the recycled resin. While some of Landfill Alternative customers accept plastic with flow rates as high as 12, others, such as Delco Packaging, have difficulty with flow rates exceeding 5. To keep flow rates low, Landfill Alternatives identifies the incoming material — with individual flow rates ranging from 1 to 50 — and mixes them to obtain desired rates for the flaked finished product. Pelletizing EPS further increases flow rates.

Table 70 Economic Information

initial capital cost:	$400,000 (1988)
modifications cost:	$30,000 (1989-1991)
labor cost:	$115,000 per year
energy cost:	$16,500 per year
feedstock cost:	$66,400 per year
total O&M cost:	$413,000 per year
gross revenue:	$650,000 per year
capital cost/capacity:	$67,000 per TPD capacity
O&M cost/sales:	$510 per ton sold
gross *revenue/sales*	$800 per ton sold

Source: Institute for Local Self-Reliance, 1992.

Economics

The operating costs for Landfill Alternatives are presented in Table 70. The market price for recycled PS pellets is between 35 and 45 cents per pound. Egg cartons containing 25 percent post-consumer PS sell for $1.00 to $1.50 per pound, representing $0.15 to $0.27 in value added to each pound of feedstock.

Future expenses for Landfill Alternatives include replacing the current densifier system with a technology expected to reduce operating costs.

Replicability

The Landfill Alternatives facility can be replicated in most parts of the country if feedstock is available within a 40- to 60-mile radius. Since the technology is relatively small-scale, it is not limited to large urban centers. Landfill Alternatives is interested in siting new facilities in Kansas City or Atlanta, but is awaiting sufficient demand for its product from nearby PS resin users. The company expects recycled-content and procurement legislation to help build these markets. Because all the equipment now used is "off-the-shelf," the company could have a new plant operational within six weeks of signing a lease on a building.

Expanding markets for post-consumer PS pellets depends largely on the willingness of the FDA to issue additional "non-objection letters" allowing recycled material to be used in food-contact packaging. Recently the FDA issued a similar letter of non-objection allowing companies to market post-consumer PET produce containers. PS manufacturers are now seeking FDA non-objection for additional products. According to Delco officials, perceived contamination problems make the largest potential market — meat trays — the least likely to gain non-objection status.

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POLY-ANNA PLASTIC PRODUCTS, INC.

Location:	Milwaukee, Wisconsin
Start-up Date:	1988
Recycled Material Used:	polyethylene terephthalate high-density polyethylene high-impact polystyrene polycarbonate acrilonitrile butadiene styrene acrylic
Products:	high-density polyethylene recycling bins flakes and pellets of other resins
Production Design Capacity:	3.5 TPD for recycling bins

Company Background

Marty Forman, president and founder of Poly-Anna Plastic Products, Inc., began his career in recycling with Forman Metal Company, a scrap metal firm founded by his father. In 1988, Forman expanded the business to include plastics, and founded Poly-Anna.

In 1991, Forman approached Engineered Plastics (Menomonee Falls, Wisconsin), a custom plastic-molding company with the idea of making and marketing recycling bins made from post-consumer HDPE. At first, Engineered Plastics was reluctant, but reconsidered its stance when the Wisconsin legislature began work on a recycling bill. Using Engineered Plastics' existing equipment, the two companies began experimenting with Poly-Anna's recycled material, and eventually developed a recycling bin made from 100 percent post-consumer HDPE, which Poly-Anna introduced in October 1991.

Feedstock

Poly-Anna buys recyclable plastics both for its own consumption and for sale to other companies. Post-consumer materials comes from municipal recycling programs, private recyclers, and waste haulers. These materials include PET soda bottles, HDPE milk jugs and detergent bottles, PVC bottles, and commingled plastics (Table 71).

Incoming PET bottles must be baled and consist of at least 95 percent 2-liter soda bottles. All colors are acceptable, and they may include HDPE base cups and labels, however, Poly-Anna will generally pay more for bales of clear PET. All bales must be completely free of PVC contamination.

Although the company once accepted both natural and mixed colored HDPE bottles, it has recently shunned mixed-color HDPE due to declining end-markets. Natural HDPE bottles must

Table 71 Feedstock Information

material	consumption (TPY)	recycled content	post-consumer content	price paid/ton
PET	750	100%	100%	$50
natural HDPE	375	100%	100%	$90
HIPS	200	100%	0%	NA
PC	150	100%	0%	NA
ABS	125	100%	0%	NA
acrylic	75	100%	0%	NA
total	**1,675**	**100%**	**67%**	**NA**

Source: Institute for Local Self-Reliance,1992.

be rinsed and capless, although labels are acceptable. Again, no PVC contamination is allowed.

In addition to post-consumer materials, the company buys virtually any scrap plastic from local industrial sources. Some examples of these materials include: vinyl, polyethylene film, and high-impact polystyrene, as well as PVC from window-casing manufacturers, and polycarbonate and acrylic from local display-sign manufacturers.

Poly-Anna pays the current market price for baled natural HDPE bottles and baled PET soda bottles, but does not usually pay for other post-consumer materials (nor does it usually charge a tipping fee). Poly-Anna pays shipping costs for feedstock that meets its specifications.

Process

Manufacturing the recycling bins from scrap HDPE involves three companies, each performing a separate function in the process. Poly-Anna sorts and bales the HDPE containers which are then sent to M.A. Industries for decontamination. The bins are formed at Engineered Plastics in Wisconsin and delivered to Poly-Anna which markets them. The production process for each company follows below and is detailed in Table 72.

Poly-Anna:

Workers sort incoming bales of bottles by resin type. PVC is the most difficult contaminant to remove due to the similarity of PET and PVC bottles. Bales containing PVC bottles require manual sorting. Next, workers break the bales into a hop per. The bottles feed onto a conveyor belt and pass through a metal detector that removes cans (both ferrous and non-ferrous), but ignores small objects like bottle caps.

The conveyor belt drops the bottles into a 100-horsepower granulator, which produces 3/8-inch flake. The flake is carried via cyclone blower to a gaylord. A bag house on the blower catches the plastic dust, which is recycled separately. The company also has a small grinder yielding a 1/4-inch flake, which Poly-Anna uses for smaller batches and special runs, like grinding plastic wire-casing. Poly-Anna sends HDPE flakes, that will eventually become the recycling bins, to M.A. Industries near Atlanta, Georgia.

M.A. Industries

M.A. Industries uses a flotation separator (or "float/sink classifier") to remove contaminants such as PET, PVC, and aluminum from the material sent from Ploy-Anna. The flakes are then sent to a scrubber that washes them and removes glues and labels. The scrubber discharges the clean flakes through a dewatering screen to recover the washing liquid, which the company treats and reuses. A second float/sink classifier removes any remaining contaminants from the flakes, a spin dryer dries them, and an extruder forms them into pellets.

The decontamination process has a capacity of 2,000 pounds per hour and requires three to five operators, depending on the type and cleanliness of the feedstock. It uses 15 gallons of water per minute , requires 330 horsepower, and needs 8,04)0 Btu per hour of natural gas for the dryer.

Engineered Plastics

As HDPE pellets arrive from M.A. Industries, workers load them into a hopper above the injection-molding equipment. The hopper feeds the pellets and a colorant into a chamber which melts the pellets to a syrupy consistency. Engineered Plastics injects the molten HDPE into the recycling

Table 72 Process Information

recycling level:	secondary
feedstock input rate:	1.5 TPD [a]
production output rate:	0.12 TPD [b]
production design capacity:	0.96 TPD [c]
capacity utilization factor:	13%
feedstock reject rate:	5% (for post-consumer material)
waste generated:	PVC, paper, metal and other waste
disposal methods:	landfill
equipment:	conveyor, grinders, wash/dry system, injection molder
employment: P-A. P. P.:	4 full time
M.A.I.:	5 full time per shift (HDPE line only)
E.P.	2 full time (for 1 injection molder)
scheduled operation:	250 days per year; 1 shift per day [d]
area requirement:	2.5 acres [d]
plant size:	10,000 square feet [d]
energy requirement P-A. P. P.:	246 kW of electricity
M.A.I.:	8,000 Btu per hour of natural gas
E.P.:	NA
water requirement:	15 gallons per minute (M.A. Industries) [e]

[a] Poly-Anna collects 750,000 PPY of HDPE.
[b] 45,000 lbs. of curbside containers from September 1991 through May 1992.
[c] Based on projected sales.
[d] Poly-Anna only.
[e] Both Poly-Anna and Engineered Plastics have low water requirements.

Source: Institute for Local Self-Reliance, 1992.

bin mold at pressures approaching 20,000 psi. Cooling lines, built into the mold, begin to solidify the resin as soon as it enters the mold. The mold is opened and the product is ejected.

The HDPE resin used to make blow molded milk and detergent bottles is not designed for the injection molding process. As a result, Engineered Plastics molded triangular ribs into the sides of the bins to prevent warping as they cool. Engineered Plastics uses the same injection-molding equipment to make virgin products, however, the heat and pressure settings must be reset for the different characteristics of the material.

Injection molding equipment can produce 1,440 bins daily (6,900 pounds), however, Engineered Plastics currently molds only as many bins as Poly-Anna's customers have already ordered.

Table 73 Product Information

products manufactured	production rate (TPY)	total recycled content	post-consumer content	estimated annual sales	gross revenue per ton	value added per ton
recycling bins	240	100%	100%	$460,000 [a]	$1,900	$1,700
PET [b]	713	100%	100%	$477,700 [c]	$700	$670
HIPS [b]	200	100%	0%	$94,000 [c]	$470	$470
PC [b]	150	100%	0%	NA	NA	NA
ABS [b]	125	100%	0%			
HDPE [b]	116	100%	100%	$48,720[c]	$420	$420
Acrylic [b]	75	100%	0%	NA	NA	NA
total	1,619	100%	66%	>$1,080,420	NA	NA

[a] Based on average sales price of $4.60 per bin and projected sales of 100,000 bins.
[b] May be in either flake or pellet form.
[c] Based on median sales price for flakes, as quoted in *Plastics News,* March 9, 1992, page 23.

Source: Institute for Local Self-Reliance, 1992.

Products

Poly-Anna's primary product is an 18-gallon curbside recycling bin made from 100 percent post-consumer HDPE collected from residential sources. The company designed the bins to nest within each other as well as to be cross-stackable. They can be made with or without drain holes, and may be custom-stamped with a city or company logo. As a further service, Poly-Anna can ensure that a municipal customer receives bins made from bottles that were collected in that municipality. Each green, gray or black bin weighs about 4.8 pounds and contains the equivalent of 35 to 40 detergent bottles.

The company also sells industrial and post-consumer plastics in flake or pellet form (Table 73). The value added to the material is between 10 and 15 cents per pound for flakes (between $200 and $300 per ton), and approximately 25 cents per pound ($500 per ton) for pellets.

Economics

Poly-Anna does not pay for the mixed-color HDPE bales that it uses to produce the recycling bins. The operating cost for the grinding of this material is approximately 10 to 12 cents per pound. Poly-Anna purchases back the clean, flaked HDPE from M.A. Industries for 25 to 30 cents per pound. Subtracting the value of the material sold to M.A. Industries (5 to 6 cents per pound) yields a total cost of approximately 22 cents per pound (Table 74).

No new equipment was needed for M.A. Industries and Engineered Plastics to process the recycled HDPE. Poly-Anna paid $300,000 for the bin mold with the help of a $125,000 grant from the Wisconsin Department of Natural Resources.

It costs Poly-Anna about $2.20 to mold each bin — at 4.8 pounds per bin, that's about 46 cents per pound. Considering that the original cost of the feedstock was nonexistent, all of this 46 cents is considered value added. If the cost of the material purchased from M.A. Industries is included, the value-added figure drops to roughly 30 cents per pound. The finished bins sell for roughly 10 percent more than a comparable product made from entirely virgin HDPE, in part due to the currently depressed prices for virgin HDPE.

Table 74 Economic Information

initial capital cost:	$150,000 for plant; $300,000 for mold
labor cost:	NA
energy cost:	NA
feedstock costs:	NA
total O&M cost:	$125,000 per year (includes all materials)
gross revenue:	$460,000 per year from recycling bins
capital cost/capacity:	$125,000 per TPD capacity
O&M cost/sales:	$77 per ton sold
gross revenue/sales:	$1,917 per ton of recycling bins sold

Source: Institute for Local Self-Reliance, 1992.

Replicability

The Poly-Anna Plastic Products operation can be replicated wherever sufficient source material and a custom plastics-molder are available.

Although the company's sales are growing, low virgin-resin prices mean sales of recycled plastic and recycled-plastic products are less than might otherwise be expected. The potential national demand for recycling bins is between 30 million and 40 million bins per year. Poly-Anna expects to develop injection molds for new products that might have larger markets with more growth potential. The company may also acquire its own plastic washing and drying system, although it has no firm plans to do so at the present time.

Because the bin mold was developed with funding from a state grant, Poly-Anna must make the technology and technical drawings of the mold available for a nominal fee. It would then cost about $300,000 to replicate the mold. Representatives of Poly-Anna and Engineering Plastics will provide technical assistance to anyone wishing to make the bin mold or any other injection-molded product.

The company is also interested in entering into joint ventures with other organizations to manufacture injection-molded products from 100 percent post-consumer plastic. A complete processing operation with a capacity of 20 million pounds per year would be most cost effective. Equipment and real estate for such an operation would cost approximately $2 million.

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Turtle Plastics Company

Location:	Cleveland, Ohio
Start-up Date:	1980
Recycled Material Used:	polyvinyl chloride high-density polyethylene polyethylene terephthalate
Products:	floor mats urinal screens resin pellets
Production Design Capacity:	6.5 TPD

Company Background

Thomas Norton, a retired agent for a lighting manufacturer, was bored with retirement, and wanted to make a contribution to society. In 1980, he purchased a $30,000 plastics-separation system and founded Cleveland Reclaim Industries, Inc., a company which pelletized PVC scrap from automobile-trim and sold it to manufacturers. However business was slow due to consumers' concern over the source and quality of the scrap plastic. So, in 1985, Norton founded Turtle Plastics Company to manufacture his own end products from the scrap PVC.

Rather than make a large investment in technological research and development, Norton emphasized marketing and sales in developing Turtle Plastics. He hired over 100 sales agents, produced a catalogue, and advertised in national trade publications, focusing on markets in the janitorial, safety, industrial, floor-covering, and food-equipment fields. In 1991 Turtle Plastics sold 400,000 pounds of floor tiles, and boasted sales of more than $700,000.

Floor tiles proved the best product for three reasons: (1) they had an established market; (2) they can be a dark color — mixed post-consumer PVC is generally dark; and (3) they can be injection-molded, a process that is forgiving of feedstock inconsistencies.

Feedstock

Turtle receives scrap PVC from both post-industrial and post-consumer sources (Table 75). Auto trim manufacturers and medical-supply manufacturers supply industrial scrap to the facility while PVC swimming pool liners and intravenous bags arrive from the post-consumer waste stream. In addition to the scrap material, Turtle adds colorants (primarily black) and silicone carbonate (obtained from the cleaning of industrial boilers) to its products. The company uses silicon carbonate to make a non-skid coating on the floor tiles.

Material received from the makers of automobile trim is black or gray, is made with industrial-

Table 75 Feedstock Information

material	consumption (TPY)	recycled content	post-consumer content	price paid/ton
industrial-scrap PVC	750	100%	0%	$ 0
post-consumer PVC	25	100%	100%	$100
PET, HDPE	250	100%	100%	$0
total	**1,025**	**100%**	**27%**	**$2**

Source: Institute for Locl Self-Reliance, 1992.

scrap PVC, and is often contaminated with polyester film and adhesive tape. Medical sources supply a cleaner PVC material. This material includes transparent, rigid yellow and blue containers, and rejected intravenous (IV) bags. Post-consumer sources of PVC are usually contaminated with dirt and sand, and require washing. Turtle has also begun to collect used IV bags from local hospitals, although it can't use those that held body fluids or hazardous pharmaceuticals.

In addition to material it uses in its products, Turtle receives post-consumer HDPE and PET from curbside collection programs in the Cleveland area which it separates in its small-scale materials recovery facility. Turtle has recently begun to experiment with post-consumer polystyrene for some new products. The PS comes in pellet form from processors who wash and pelletize used fast-food containers. Overall the facility rejects 5 percent of the industrial scrap it receives, and 10 percent of the post-consumer material, which a private hauler trucks to a landfill.

Process

As scrap PVC arrives at the plant, workers hand separate the automobile trim and medical-industry scrap by color — black, gray, clear, yellow, and blue. The sorted material is shredded, then ground and deposited in a gaylord. Although Turtle ships the gaylords to an injection-molding company to form the products, it retains ownership of all the molds and of the finished products.

The PVC swimming pool liners go through a shredder, then are washed and dried before passing through an extruder and pelletizer. Turtle sells PVC it can't use to other manufacturers for use in manufacturing shoe soles, fishing poles, lounge-chair parts, and other products.

Floor tiles produced on-site are given a non-skid coating at Turtle's facility. A worker uses a paint roller to spread epoxy on the them, then sprinkles them with silicone carbonate. The coated tiles dry for 24 hours. The company plans to automate this process soon.

A portion of the Turtle operation functions as an intermediate processing center (IPC). The company processes and pelletizes PET and HDPE scrap for other manufacturers. The IPC, designed by Turtle and located in the plant, accepts bags of commingled recyclable and separates glass, metal and plastics, for sale to manufacturing operations.

Turtle has two patented wash systems an older one for the PVC swimming pool liners, and a new one for the post-consumer PET and HDPE. The ground material goes through an off-the-shelf classifier that uses gravity to remove metals and other heavy contaminants. A blower then transports the plastic to a holding vat, which feeds a washer — an enclosed canister that agitates the plastic in hot water. A gas-fired dryer removes the moisture.

The entire system requires about 185 kW of electrical service (Table 76). The plant uses about 500 million Btu of natural gas per year for space and water heating. Of this, the dryer burns about 150,000 Btu per year.

Products

Turtle makes its Turtle Tiles® from 100 percent scrap PVC (Table 77). The product is an injection-molded, 12-inch square, 3/4-inch thick

Table 76 Process Information

recycling level:	tertiary/primary (products/pellets)
feedstock input rate:	3.4 TPD
production output rate:	3.2 TPD
production design capacity:	6.5 TPD [a]
capacity utilization factor:	49% [a]
feedstock reject rate:	6%.
waste generated:	assorted waste from MRF system and rejected scrap
disposal methods:	landfill
equipment:	grinders, shredders, gravity separator, washer/dryers, baler
employment:	10 full time, 13 part time; 2 skilled, 21 unskilled
scheduled operation:	300 days per year; 1 shift per day
area requirement:	3 acres
plant size:	55,000 square feet
warehouse size:	NA
energy requirement:	444,000 kWh per year of electricity; 500 million Btu per year of natural gas
water requirement:	low

[a] Includes IPC, based on plastic's current share of IPC input (23 percent).

Source: Institute for Local Self-Reliance, 1992.

interlocking tile, designed to absorb impacts and vibrations. Most of the tiles are made from scrap automobile trim. While black is the most common color, Turtle Tiles also come in gray, yellow, blue, red, orange, and purple, depending on the feedstock color. Turtle produces some of its tiles with a silicone carbonate non-skid grip surfacing. All the tiles are comparable in quality to similar products made from virgin materials.

The company also makes urinal screens, named "Oui-Oui Skreen." These are injection-molded from black or blue PVC, and have an added scenting material. Both the floor mats and the urinal screens are marketed in the U.S. and internationally.

Turtle also processes post-consumer PET and HDPE, which it markets to other processors and manufacturers in both flake and pellet form. It also sells about 15,000 pounds of surplus PVC

Table 77: Product Information

products manufactured	production rate (TPY)	total recycled content	post-consumer content	estimated annual sales	gross revenue per ton	value added per ton
floor mats	200	100%	10%	NA	NA	NA
urinal screens	1	100%	10%	NA	NA	NA
PVC pellets	511	100%	0%	NA	NA	NA
PET & HDPE pellets	238	100%	100%	NA	NA	NA
total	**950**	**100%**	**27%**	**$1,000,000**	**$1,100**	**$990**

Soure: Institute for Local Self-Reliance, 1992.

Table 78 Economic Information

initial capital cost:	$30,000 (1980)
modification cost:	$500,000
labor cost:	$290,000 per year [a]
energy cost:	$28,000 per year [a]
feedstock cost:	$2,500 per year
total O&M cost:	NA
gross revenue:	$1,000,000 per year
capital cost/capacity:	$4,600 per TPD capacity
O&M cost/sales:	NA
gross revenue/sales:	$1,100 per ton sold

[a] ILSR estimate.

Source: Institute for Local Self-Reliance, 1992.

per year. Turtle is in the process of developing products made of recycled PS, including license plate frames, six-inch rulers, and office-paper recycling trays.

Economics

Tom Norton started Cleveland Reclaim in 1980 with $30,000 of combined bank loans and personal funds. Over the years, Turtle has added $500,000 worth of equipment and plant modifications (Table 78).

Operating expenses for the IPC are about $220,000 per year, including $139,000 for labor, $30,000 for rent, $25,000 for utilities, $12,000 for maintenance, $12,000 for waste disposal, and $3,000 for insurance. Operating expenses for the washing and grinding systems are not available. Natural gas energy costs run approximately $2,000 per year and electrical costs are estimated at $26,000 per year.

Replicability

The technology that Turtle uses in its Cleveland plant can be employed wherever sufficient feedstock is available (sufficiency will vary depending on the product manufactured). The economic viability of this type of plant is based on minimum annual sales of $500,000, although products with a particularly low per ton value may require higher sales volume.

In addition to considering purchasing new processing lines, Turtle is exploring the market viability of other injection molded products it could make without investing in new equipment. Although Turtle is not considering any specific sites, the company is interested in building new facilities close to sources of raw materials, either alone, or in joint ventures.

Turtle is marketing its 20 ton per day IPC system through its subsidiary, the Magnificent Machinery Company. The company has already sold one to a major national waste-hauling firm. The system sells for $295,000, installed, and the customer is responsible for freight and unloading expenses.

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WEBSTER INDUSTRIES

Location:	Montgomery, Alabama
Start-up Date:	1978
Recycled Material Used:	low-density polyethylene linear low-density polyethylene high-density polyethylene
Products:	trash bags
Production Design Capacity:	100 TPD

Company Background

Webster Industries was founded in 1957 by Chelsea Industries, a Boston-based plastics manufacturer, to produce trash can liners and food bags. In 1978, Webster bought a facility in Montgomery, Alabama, and installed its proprietary technology for producing trash bags from recycled plastic. An $8 million investment by Webster in July, 1992 expanded the facility, adding state-of-the-art post-consumer recycling technology and new bag-making equipment. The company is in the process of expanding and improving its second facility in Macomb, Illinois, which also uses recycled material.

Feedstock

Webster's suppliers include material recovery facilities, scrap plastic brokers, plastics manufacturers and large-scale users of plastic-film products. Webster has a purchasing department that specializes in helping businesses and industries establish plastics-collection programs that include minimal sorting and cleaning. As other manufacturers utilize Webster's existing scrap sources the scrap prices rise. Webster then locates new, lower-cost sources that help Webster maintain its competitive cost advantage.

The company accepts LDPE, LLDPE, and HDPE in many forms. Post-consumer LDPE includes pallet wrap, stretch wrap, merchandise bags, and light-duty agricultural film (such as greenhouse film). Industrial scrap is primarily LDPE and LLDPE, usually from discarded rolls of stretch wrap, film products rejects, and chunks of plastic that are produced when manufacturing equipment is started up. The HDPE is mostly post-consumer scrap, including rigid oil, detergent, and shampoo bottles. The feedstock can arrive either loose or baled (Table 79).

The price Webster pays for feedstock varies considerably, depending on the cleanliness of the material. The price of feedstock affects the mix of resins that goes into a particular batch.

Webster's state-of-the-art wash system allows the facility to handle material that is contaminated with grit and dirt. The facility also forgives small amounts of incompatible resins, bottle caps, bits of paper, and an occasional soda can. However, Webster does not accept material contaminated with toxic substances, such as pesticides. The

Table 79 Feedstock Information

material	consumption (TPY)	recycled content	post-consumer content	price paid/ton
LDPE, LLDPE, HDPE	25,000 [a]	100%	50%	NA
virgin materials	NA	0%	0%	NA
total	**NA**	**NA**	**NA**	**NA**

[a] ILSR estimate based on the fact that the two existing Webster facilities use approximately 50,000 tons per year, and one facility would use half of that total.

Source: Institute for Local Self-Reliance, 1992

company prefers to use dirty plastics that it can clean itself, as this results in a higher value added to the material at the plant.

While some products, such as the Renew™ trash bags, are made of 100 percent recycled plastics, others are made from a blend of recycled and virgin material. Each year, Webster's two facilities use approximately 100 million pounds of recycled plastic, half of which is post-consumer.

Process

The following process description is valid for a typical plant that Webster would operate using its latest technological innovations. Workers begin by unloading trucks into an area set aside for manually sorting material by color, type, and cleanliness. The sorted material is fed into a state-of-the-art cleaning system.

The cleaning system combines equipment made by Sorema, a machine manufacturer, with the company's own technology. The system removes non-compatible resins and non-plastic contaminants, cleans the material, and grinds it. Non-compatible resins generally account for about 5 percent of the dirty scrap feedstock — the plant rejects 2 or 3 percent of the total incoming

Table 80 Process Information [a]

recycling level:	tertiary
feedstock input rate:	100 TPD
production output rate:	93 TPD
production design capacity:	100 TPD
capacity utilization factor:	93%
feedstock reject rate:	7%
waste generated:	wood, paper, incompatible plastic resins, soil, grit
disposal methods:	landfill
equipment:	baler, grinder, shredder, cutter, wash system, Sorema system, pelletizer, blown-film extruder, co-extruder, bag-making equipment
employment:	>500
scheduled operation:	350 days per year; 3 shifts per day
area requirement:	17 acres
plant size:	150,000 square feet
warehouse size:	included in plant size
energy requirement:	NA
water requirement:	low

[a] ILSR estimates for a typical Webster-like plant.

Source: Institute for Local Self-Reliance, 1992.

Table 81 Product Information

products manufactured	production rate (TPY)	total recycled content	post-consumer content	estimated annual sales	value added per ton
Renew™ bags	15,000	100%	30%	NA	NA
Good Sense™ bags	15,000	50%	15%	NA	NA
other bags	NA	varies	varies	NA	NA
total	**NA**	**NA**	**NA**	**NA**	**NA**

Source: Institute for Local Self-Reliance, 1992

stock. The wash water is cleaned, filtered, and reused, thus, only a minimal amount of water needs to be added daily.

After emerging from the wash, the flakes are extruded into pellets. The recycled-resin pellets are then mixed with the virgin pellets (if necessary), pigments, and scents, and are fed into a blown-film extruder. The extruder blows the plastic into a tube-shaped bubble, which then collapses. The flattened tube is then heat-sealed and perforated to form rolls of plastic bags.

During the two decades of plant operation, the company has made modifications to the process, the most recent of which is the addition of the wash system in 1992. Table 80 provides more information on Webster's manufacturing process.

Products

Webster produces several types of plastic trash bags, which are sold under various brand names. Renew™ bags are made from 100 percent scrap plastic, at least 30 percent of which is post-consumer waste. The Good Sense™ bag has a minimum of 50 percent scrap plastic, at least 30 percent of which is post-consumer waste. The company expects to increase the post-consumer content in both bags to 60 percent of total scrap content by 1993. Other companies contract with Webster to make a number of other products; the total recycled and post-consumer contents of these vary according to the client's specifications (Table 81).

Economics

Webster holds confidential specific economic information. However, if built today, a similar facility would cost between $4 million and $8 million. Most figures listed in Table 82 are estimates based on industry averages.

Table 82 Economic Information

initial capital cost:	$4,000,000 to $8,000,000 (1992)
labor cost:	$10,000,000 per year [a]
energy cost:	NA
feedstock cost:	NA
total O&M cost:	NA
gross revenue:	NA
capital cost/capacity:	$40,000 to $80,000 per TPD capacity [a]
O&M cost/sales:	NA
gross revenue/sales:	NA

[a] ILSR estimate.

Source: Institute for Local Self-Reliance, 1992.

Replicability

Although the bag market is currently stable, Webster's market share is expanding. To meet this growth in demand, the company has announced two major modifications at its Montgomery plant. The first — the addition of its cleaning system – will allow the company to increase production capacity for recycled plastics by more than 40 percent. And the second expansion — addition of a high-molecular-weight bag technology — will increase the total bag-making capacity by 50 percent.

Future plans include a possible expansion of its Macomb, Illinois plant, and locating new facilities at other locations.

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Aquapore Moisture Systems

Location:	Phoenix, Arizona
Start-up Date:	1985
Recycled Material Used:	ground rubber
Products:	soaker hose
Production Design Capacity:	>25 TPD

Company Background

Aquapore Moisture Systems was founded to develop and distribute environmental watering products. Efforts to achieve that goal, beginning in 1981, have resulted in a highly successful line of Moisture Master soaker hose and drip watering products.

The company's commitment to quality and using recycled material has helped make it the leading manufacturer of soaker hose. Aquapore has received certification from Scientific Certification Systems, a non-profit testing company formed to verify recycled content and environmental product claims.

Feedstock

Aquapore uses two main ingredients to manufacture its soaker hoses. Finely ground rubber from scrap tires accounts for 65 percent of the feedstock. A crumb-rubber producer grinds the rubber to meet Aquapore's specifications, and delivers the fine crumb in large sacks. The other major ingredient in the hose is finely-granulated virgin polyethylene (PE), which is shipped by truck or rail and stored in silos.

The price of both feedstocks can vary considerably; the figures listed in Table 83 are based on recent regional market prices and ILSR estimates.

Process

Workers empty sacks of ground rubber into a hopper. The PE is piped in from the silos. These materials are fed into an extruder. The extruder mixes and melts the materials, and then forces them through a die to form the tube-shaped hose.

The hose is then cooled and rolled to appropriate lengths. Workers coil the segments around spools, and a sample is taken in regular intervals for quality-control tests. All rejected material is reground and fed back into the extruder.

Workers then attach fittings for connection to faucets or other hoses, coil the hose, and attache label cards and plastic tie fasteners. Thus packaged, the hose is stored in a warehouse area (which constitutes about half of the inside building space), pending sale to retail outlets.

Although approximately 10 percent of the water used by the plant evaporates and is replaced each day, annual water use is minimal, and constitutes

Table 83 Feedstock Information

material	consumption (TPY)	recycled content	post-consumer content	price paid/ton [a]
ground rubber	4,160 [b]	100%	100%	$460-540
polyethylene	2,240 [b]	0%	0%	$480-1,000
total	**6,400**	**65%**	**65%**	**$467-701**

[a] Prices based on recent regional market prices,
[b] ILSR estimate.

Source: Institute for Local Self-Reliance, 1992.

a negligible part of the total operating rests. Table 84 summarizes Aquapore's manufacturing process.

PRODUCTS

Soaker hoses are ideal for watering plants, flowers, gardens and trees. Easy to install, they simply attach to a faucet or garden hose. Because water seeps slowly and evenly through the porous walls of the hose, water use is reduced by up to 70 percent. This also means water is not lost to evaporation or runoff. Soaker hoses promote healthy plant growth because water is delivered direct] y to plant roots. Table 85 provides more details on Aquapore's product.

Table 84 Process Information

recycling level:	secondary
feedstock input rate:	26 TPD [a]
production output rate:	26 TPD [a]
production design capacity:	NA
capacity utilization factor:	NA
feedstock reject rate:	0%
waste generated:	OCC
disposal methods:	recycled
equipment:	extruder, cooling bath, automatic cutter, silos
employment:	80 full time manufacturing; 15 skilled, 65 unskilled; 20 full time sales and administrative
scheduled operation:	extruder: 250 days per year; 3 shifts per day assembly stations: 250 days per year; 2 shifts per day
area requirement:	NA
plant size:	75,000 square feet
warehouse size:	45,000 square feet
energy requirement:	1,000,000 kWh per year [a]
water requirement:	low

[a] ILSR estimate.

Source: Intitute for Local Self-Reliance, 1992.

Table 85 Product Information

products manufactured	production rate (TPY)	total recycled content	post-consumer content	estimated annual sales	gross revenue per ton	value added per ton
soaker hose	6,400 [a]	65%	65%	NA	NA	$2,000 [b]

[a] ILSR estimate.
[b] ILSR estimate based on a $500 per ton cost for ground rubber, a $10 per hose retail price ($5,000 per ton), and 50 percent of the retail price going to the manufacturer ($2,500 per ton).

Source: Institute for Local Self-Reliance, 1992.

Table 86 Economic Information

initial capital cost:	<$10,000,000 [a]
labor cost:	$2,000,000 per year [a]
energy cost:	$50,000 per year [a]
feedstock cost:	$3,000,000 to $4,500,000 per year [a]
total O&M cost:	NA
gross revenue:	NA
capital cost/capacity:	$30,000 per TPD capacity [a]
O&M cost/sales:	NA
gross *revenue/sales:*	NA

[a] ILSR estimate.

Source: Institute for Local Self-Reliance, 1992.

Replicability

Aquapore is the dominant manufacturer in the rapidly expanding rubber soaker hose industry. The company expanded its existing facility in 1992, and an additional 5,000 square feet of office space is currently in the planning stage. Contingent on continued market growth, the company may consider opening additional facilities in other locations over the next several years. The parameters of these plants would be similar to the Phoenix facility.

Economics

The initial capital expense to build a facility similar to the Aquapore plant is less than $10 million. All information on operating expenses is proprietary, but some ILSR estimates are provided in Table 86.

Approximately 90 percent of Aquapore's sales comes from consumer hoses sold through hardware and home-improvement retailers. The remaining 10 percent includes small commercial customers, overseas sales, and industrial applications, such as aeration hoses for aquiculture. A 50-foot hose retails for between $9 and $14 ($4,500 to $7,000 per ton).

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PROCESS FUELS, INC.

Location:	Spokane, Washington
Start-up Date:	1995 (projected)
Recycled Material Used:	scrap tires
Products:	polymer oil fuel gas scrap metal
Production Design Capacity:	polymer oil 2,880,000 gallons per year fuel gas: 4,320,000 therms per year scrap metal: 6 TPD

Company Background

Joseph Munger, previously a principal owner of a mechanical-contracting firm, founded Process Fuels, Inc. (PFI) in January 1988. After more than four years of research and testing, PFI has developed the Tyrecycle® process, which converts scrap tires into two high-value products: polymer oil and fuel gas. The technology permits 97 percent of a scrap tire to be recycled.

Three pilot plants that use the Tyrecycle® process have been built in Spokane, Washington, with capacities of 100 pounds per hour, one ton per hour, and six tons per hour. The products from these plants have passed performance tests at two independent laboratories. The company is now finalizing plans to construct its first two full-scale plants in the state of Washington. The first will be operating near Spokane in early 1995, and the second one should be running in western Washington later the same year. The projects have received the support of the Washington State Department of Trade and Economics. PFI has also talked to several industrialists from Japan, Korea and Taiwan about the possibility of exporting the technology to Asia. This case study focuses on the soon-to-be-completed Spokane plant.

Feedstock

PFI plants accept all kinds of scrap tires, including bias ply, radial and steel-belted radials. Although the Spokane facility has equipment to shred and granulate tires to remove metal and fiber, the plant will also accept chipped tires from tire processors.

The proposal facility is expected to consume 2.88 million tires per year. Washingtonians discard approximately 5 million tires per year, and many more lie in stockpiles around the state. The two plants in Washington will consume all the scrap tires produced in the state, and will also draw as well from neighboring states.

The tipping fee for tire disposal in Washington ranges from $1.00 to $2.50 per tire. PFI will charge $0 to $1 per tire at its Washington plants (Table 87).

Process

The reduction of discarded rubber to its basic elements (oil, carbon black and gasses) by pyroly-

Table 87 Feedstock Information

materiel	consumption TPY	recycled content	post-consumer content	price paid/ton
scrap tires	28,800 [a]	100%	100%	-$100-0

[a] Assuming each tire weighs 20 pounds.

Source: Institute for Local Self-Reliance, 1992

sis — a thermal process conducted in the absence of oxygen — is not a new concept. The process has been studied for many years and many variations have been proposed. But thus far, the resulting products have been of low quality, and the technology has not proven economically feasible. At present, there are no full-scale, commercially viable scrap-tire pyrolysis facilities in the U.S.

According to its developers, the Tyrecycle® process is not pyrolysis, but rather a "pyrolyptic/gasification system." The operating temperature in the Tyrecycle® process is low compared to pyrolysis, and unlike pyrolysis, it produces no carbon black. Tyrecycle® produces cross-linked polymers that are suspended in oil.

As whole tires arrive at the plant, workers first run them through conventional shredding equipment. The shredded tires are then granulated to remove metal and fibers. Metal, which accounts for approximately 8 percent of the feedstock, is recovered and sold to recyclers. The ground rubber is introduced to a reactor, where the pyrolyptic/gasification process converts it into an oil-laden gas. This mixture is fed into a condenser that separates the oil from the gas.

Ash, produced as a by-product of the pyrolyptic/gasification process, is the only waste product of the process. According to its developers, the process does not produce any emissions or impact the environment.

Table 88 Process Information [a]

recycling level:	primary/tertiary (polymer oil/fuel gas)
feedstock input rate:	80 TPD
production output rate:	78 TPD [b]
production design capacity:	8,000 gallons per day of polymer oil; 12,000 therms per day of fuel gas; 6 TPD of scrap metal
capacity utilization factor:	100%
feedstock reject rate:	3%
waste generated:	ash
disposal methods:	landfill, seeking alternatives
equipment:	shredder, grinder, reactor, condenser
employment:	24-27 full time; 13 skilled
scheduled operation:	360 days per year; 20 hours per day
area requirement:	5-6 acres
plant size:	11,000-16,000 square feet
warehouse size:	product storage included in plant size; scrap tires stored in open stockpiles
energy requirement:	2,340,000 kWh per year of electricity
water requirement:	low

[a] All information pertains to a two-module plant similar to the plants to be built in Washington.
[b] ILSR estimate.

Source: Institute for Local Self-Reliance, 1992.

PFI uses a modular system in its Tyrecycle® plants. A facility can have between one and four modules. This system allows plant operators to tailor a plant's production to fluctuations in sup ply and demand. Each module has the capacity to consume two tons of discarded rubber per hour.

A two-module plant requires approximately 2.34 million kWh per year of energy. If a cogeneration facility existed on site, this requirement could be met with less than 10 percent of the gas produced, meaning the facility could be energy self-sufficient (Table 88).

Products

The two major products of the Tyrecycle® process are polymer oil—a rubber compounder—and fuel gas. The polymer oil, called Superflex 2000®, represents 43 percent of the output, while the fuel gas constitutes 46 percent of the output. Approximately 8 percent of the output is metals recovered from the tires, and the remaining 3 percent is ash (Table 89).

The polymer oil consists of organic compounds found in tire rubber and degradation products thereof, as well as the rubber polymer matrix itself. This oil can be used to replace Flexon 766, a rubber extender / plasticizing agent used for manufacturing rubber. It can also find markets in the plastic and adhesion industries, and as a wet asphalt binder.

Researchers have also indicated the potential for new markets for the oil due to certain unique properties of this material. Tests conducted at the Hauser Laboratories in Boulder, Colorado have concluded that when the PFI polymer oil is used in the EPDM (ethylene-propylene diene monomer) rubber-formulating process, the resulting rubber has better engineering properties than rubber made from virgin materials using the same process. Tensile strength appears to increase by approximately 50 percent, and elongation by almost 100 percent. The new product also performs well in cold-weather applications.

PFI expects major petrochemical companies such as AMOCO, Shell, DOW Chemical, Quantum and Formosa Plastic Corporation to be the main consumers of the polymer oil.

The gas, which has a high caloric value similar to natural gas, can be used by cogeneration plants and power plants. The estimated energy content of the gas is 950 to 1,000 Btu per cubic foot.

PFI estimates the polymer oil will sell for $2.00 to $3.50 per gallon. When the fuel gas is used to produce electricity, its value will be approximately $1 per tire. The metal is worth about $50 per ton. The company expects to earn a gross revenue of $3.25 to $4.00 per tire.

Table 89 Product Information

products manufactured	production rate	total recycled content	post-consumer content	estimated annual sales	gross revenue per ton	value added per ton
polymer oil	2,880,000 gallons per year	100%	100%	$6,000,000	NA	NA
fuel gas	4,320,000 therms per year	100%	100%	$3,000,000 [a]	NA	NA
scrap metal	2,300 TPY	100%	100%	$115,000	NA	NA
total	**27,936 TPY**	**100%**	**100%**	**$9,115,000**	**$330[b]**	**$320 [b]**

[a] Assuming a small cogeneration plant for internal power use (96 percent efficiency) and a commercial cogeneration facility with 60 percent efficiency.
[b] Assuming a tipping fee of $0.50 per tire.

Source: Institute for Local Self-Reliance, 1992.

Table 90: Economic Information [a]

initial capital cost:	$7,500,000 (1993)
labor cost:	$720,000 per year
energy cost:	$0 [b]
feedstock cost:	-$1,440,000 per year [c]
total O&M cost:	$3,300,000 per year
gross revenue:	$9,115,000 per year
capital cost/capacity:	$96,000 per TPD capacity
O&M cost/sales:	$120 per ton sold
gross revenue/sales:	$330 per ton sold

[a] Including forecasts.
[b] Energy cost is zero because all of the necessary energy will be provided by the in-house regeneration plant.
[c] Assuming a charge of $0.50 per tire at the plant.

Source: Institute for Local Self-Reliance, 1992.

According to PFI, a four-module plant can be built in one year, and a one-module plant can be operable within six months. The management of PFI is confident that the investment on a Tyrecycle® plant can be recovered within three years of starting the operation.

Replicability

After spending over $1.5 million in developing and testing the Tyrecycle® process, then designing a commercial plant, the company is now prepared to market the results. PFI will license its technology to separate corporations, or will consider entering partnerships. The tire-shredding and cogeneration technologies are available in the open market.

Economics

The initial capital cost for a plant that uses the Tyrecycle® process will range from $3.5 million to $15 million, depending on the number of modules in the plant and the location. The Spokane facility is expected to cost approximately $7.5 million, of which $2.5 million is for the commercial cogeneration facility. The estimated annual operating cost for the plant is $3.3 million (Table 90).

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Evanite Fiber Corporation

Location:	*Corvallis,* Oregon
Start-up Date:	*1942* (started accepting scrap in 1968)
Recycled Material Used:	wood chips from pallets, shakes and utility spools industrial plywood scrap
Products:	hardboard
Production Design Capacity:	120 TPD

Company Background

In the 1940s, Chapman Brothers, a hardboard manufacturer, set forth to manufacture products from the abundant timber resources of the Pacific Northwest. As the availability of timber shrank and urban areas around Corvallis expanded, the company adapted by switching to discarded wood to make its hardboard. In the 1970s, the company, now part of the Evanite Fiber Corporation, began using ply-trim, a by-product of plywood production. In 1991, the company began accepting wood waste from the Portland, Oregon waste stream, and it plans to continue increasing the amount of discarded wood it uses.

The switch to an urban feedstock source was the direct result of dwindling production of plywood in the Pacific Northwest. In December 1990, Evanite's supply of feedstock dropped dramatically as six of its eight ply-trim suppliers closed (ply-trim was Evanite's major feedstock). In a search for an alternative feedstock, the company formed a partnership with Bilet Products, Inc. (Portland, Oregon), and founded Wood Exchange, a business devoted to collecting and processing urban wood waste — specifically wooden shipping pallets — into wood chips. Wood Exchange now supplies these chips to Evanite.

The company has been operating at capacity for two years, while many other Pacific-Northwest manufacturers have been hurt by both a dwindling supply of lumber, and soft demand for construction materials. Its success contradicts the myth that a decline in natural-resource extraction means lost manufacturing jobs. The company has shown that hardboard manufacturers can successfully replace virgin resources with wood waste generated in urban areas.

Feedstock

Evanite's hardboard product currently contains 48 percent urban wood waste, 45 percent ply-trim, and 5 percent virgin wood chips (Table 91). Additional inputs are wax and resin binders. Evanite receives approximately 65 percent of its urban wood fiber from Wood Exchange, a pallet refurbisher and scrap wood processor which produces wood chips from shipping pallets, shakes and utility spools from the Portland area (see side bar, page 138).

High levels of grit in the wood waste have increased wear on machinery, limiting recycled content to the current level. However, Evanite is

Table 91 Feedstock Information

material	consumption (TPY)	recycled content	post-consumer content	price paid/ton
urban wood waste	21,000	100%	100%	$35-45
ply-trim	19,500	100%	0%	$35-45
virgin wood chips	2,400	0%	0%	$75-95
wax	1,025	0%	0%	$300-400
resin	950	0%	0%	$250-350
total	**44,875**	**90%**	**48%**	**$48-62**

Source: Institute for Local Self-Reliance, 1992.

developing machinery to clean incoming wood chips, thus reducing machinery wear. The company believes this will allow it to use 100 percent urban wood waste. Evanite screens ply-trim to remove oversized pieces.

Process

Ply-trim, urban wood chips & virgin wood chips are combined and run through a digester that steams the wood under pressure. The wet material runs through a series of disc refiners, also known as defibrators, which separate the individual fibers. After resin and wax binders are added, the resulting slurry proceeds to the forming line.

Evanite forms hardboard on a continuous conveyor. A head box lays a thick mat of fiber slurry on the conveyor. As the mat progresses down the conveyer, vacuums and rolling presses extract much of the water. The board is given a final wax spray, trimmed, and placed in a large press at 400° F to extract the remaining moisture. When the board emerges from the press, the surface is sprayed with water to raise the moisture level from zero to approximately four percent to ensure it does not swell or buckle during use.

Evanite removes approximately four percent of the feedstock as contamination. Heavy contaminants are caught by string traps in the pipes

Table 92 Process Information

recycling level:	secondary
feedstock input rate:	125 TPD
production output rate:	120 TPD
production design capacity:	120 TPD
capacity utilization factor:	100%
feedstock reject rate:	4%
waste generated:	oversized ply-trim, waste effluent
disposal methods:	ply-trim is landfilled or sold as fuel
equipment:	shaker, 2 cyclones, digester, 2 disc refiners, vacuums, rollers, conveyors, 2 presses, humidifier
employment:	90 full time; 90 skilled
scheduled operation:	360 days per year
area requirement:	10 acres
plant size:	NA
warehouse size:	NA
energy requirement:	4,000,000 therms per year of natural gas
water requirement:	250,000 gallons per day

Source: Institute for Local Self-Reliance, 1992.

Table 93 Product Information

products manufactured	production rate (TPY)	total recycled content	post-consumer content	estimated annual sales	gross revenue per ton	value added per ton
hardboard	43,000	90%	48%	$12,000,000	$280	$230

Source: Institute for Local Self-Reliance, 1992.

and riffles in the headbox, while fine fibers are removed in the wastewater treatment system. The Evanite process uses 250,000 gallons of water per day. Evanite employs 90 full-time workers. On average, workers make $11.00 per hour plus an estimated $3.85 per hour in benefits (Table 92).

In 1991, Evanite invested $500,000 in a joint venture to start Wood Exchange. Wood Exchange sends 90 percent of its hogged wood to the Corvallis facility, charging between $30 and $40 per ton.

Products

Evanite manufactures hardboard, a low-cost construction material used as paneling and pegboard. Hardboard comes in two thicknesses, 1/4 inch and 1/8 inch, and in a variety of finishes. Evanite sells the board for an average of $100 per thousand board feet, which translates to $300 per ton (Table 93).

Economics

A dramatic rise in landfill tipping fees in the Portland area (from $5 per ton in 1985 to $62 per ton by 1991) has motivated generators of wood waste to seek alternative disposal methods. Portland General Electric, for example, saves $75,000 per year in avoided landfill fees by delivering 24 to 30 tons per week of spent utility spools to Wood Exchange (Table 94).

WOOD EXCHANGE

location:	Portland, Oregon
feedstock:	urban wood waste — wooden pallets, shakes, and utility spools (80 TPD)
products:	refurbished pallets (8 TPD) wood chips (72 TPD)
production capacity:	32,000 TPY (15 tons per hour)
initial capital cost:	$1,500,000 (1991)
gross revenue:	$734,000 per year (estimate)
employment:	12 full time

Wood Exchange was founded in 1991 by Evanite Fiber Corporation and Bilet Products, Inc. to provide a feedstock for Evanite's Hardboard Division, as' well as to divert wood from the Portland waste stream. The facility refurbishes and resells an average of 500 shipping pallets per day. Irreparable pallets, along with spools delivered to the facility by utility companies, are processed in a hog grinder into wood chips. Wood Exchange recovers an average of one ton per day of scrap metal (nails, etc.), which it sells to local scrap markets. The company charges a tipping fee of $15 per ton of wood waste, and sells wood chips to Evanite for $35 per ton, adding $50 of value to each ton of scrap it processes.

Source: Institute for Local Self-Reliance, 1992.

Table 94 Economic Information

initial capital cost:	$30,000,000 [a]
labor cost:	$2,800,000 per year [b]
energy cost:	NA
feedstock cost:	$2,500,000 per year
total O&M cost:	$9,600,000 per year
gross *revenue:*	$12,000,000 per year
captial cost/capacity:	$250,000 per TPD capacity
O&M cost/sales:	$220 per ton sold
gross revenue/sales:	$280 per ton sold

[a] For a similar plant if built today.
[b] ILSR estimate.

Source: Institute for Local Self-Reliance, 1992.

Replicability

The Corvallis facility is fully replicable using standard technologies. However, current environmental regulations, and increasingly expensive wastewater treatment would necessitate modifying the process to use less water. Although the Corvallis facility is opcrating at full capacity, current markets for hardboad do not warrant a second or expanded operation. Company estimates place the cost of a new plant at $30 million

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