

# Recycling 101: The Fundamentals of Recycling Systems, Markets, and Economics

Natalie Starr and Ted Siegler  
DSM Environmental Services  
[www.DSMenvironmental.com](http://www.DSMenvironmental.com)

# Intended Audience

- Those new to recycling
  - Want a general overview
- Those who want an update on emerging collection and processing technologies
  - Focused on residential and commercial recycling

# Format and Content

## ➤ Fundamentals of

- Recycling Systems
- Markets
- Economics

## ➤ Open discussion throughout

- If I could learn only one thing about recycling before I leave it would be ...

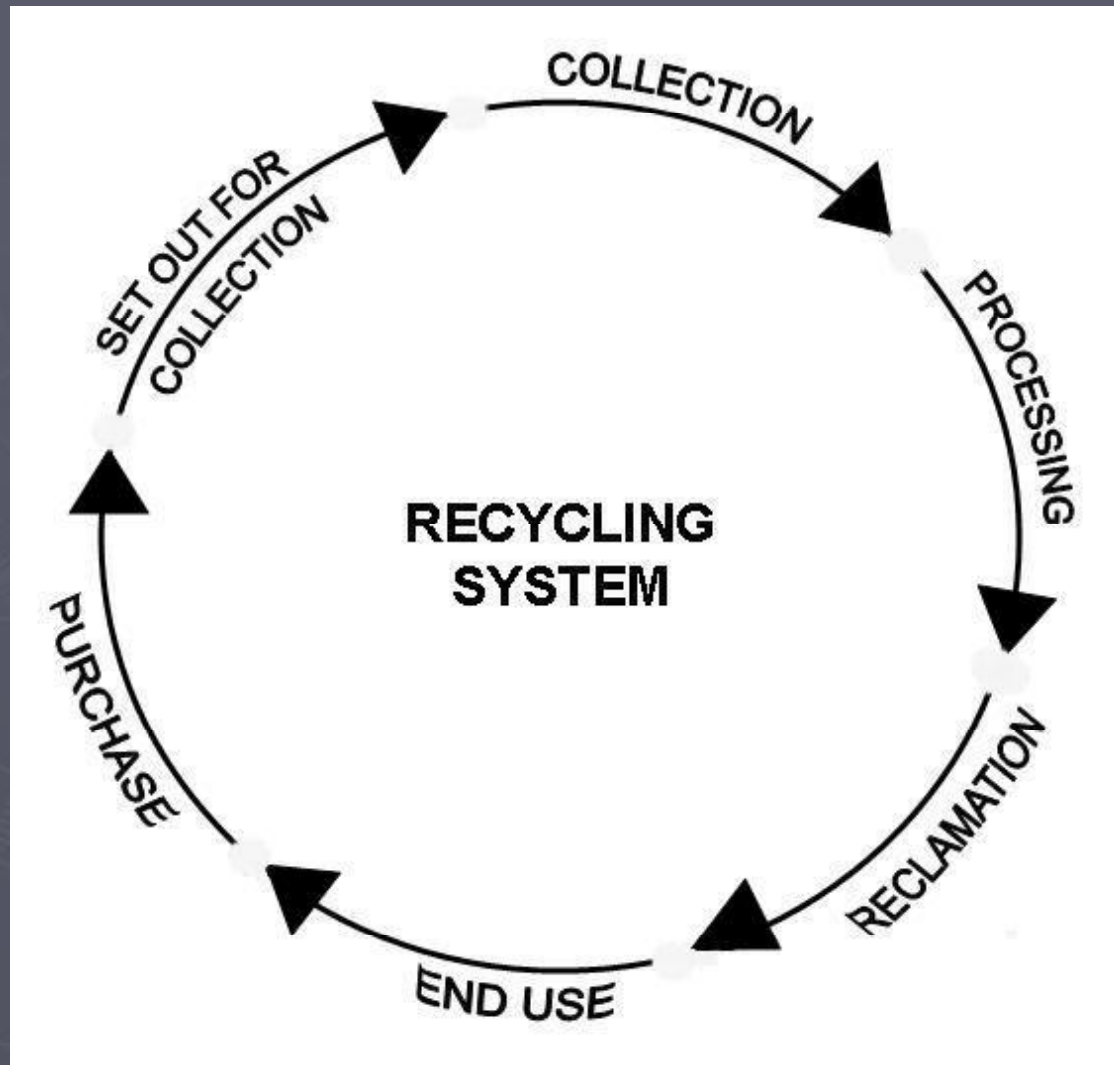
# What is Recycling?

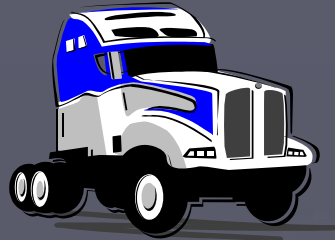
- Recovery of materials for use in another product that would otherwise be destined for disposal
- Different from reuse, where material is recovered and used “as is”
- Not to be confused with waste reduction where materials never enter the supply chain, nor generate GHG emissions from the point of extraction on

# Why is Recycling Important?

- Recycling reduces environmental impacts including GHG emissions:
  - Impacts from cutting, skidding, transporting, grinding, pulping, and producing paper are greater than those released to collect, process, transport, and re-pulp
  - 14 of 18 largest Superfund sites and 45% of all toxics released are associated with hard rock mining
  - Extraction and harvesting of resources is having a devastating effect on the earth's ecosystem including biological diversity

# System of Recycling





# Collection: First Step in Recycling

Collection represents 40 – 60% of total waste management costs (US EPA) and has the greatest environmental impact

# Types of Collection

- Individual transport to drop-offs
- Collection of source separated materials
  - At the household
  - At commercial, institutional, industrial facilities
- Dual stream collection
- Single stream collection



# Drop-Off Recycling

- Household
- Deposit Containers
- Small Businesses

# Drop-off Collection Equipment

- Igloos
- Dumpsters
- Roll-offs
- Small balers
- Reverse Vending Machines



Delaware Solid Waste Authority Drop-Off:  
Wide range of materials collected  
separately (from paper and containers to  
textiles and oil) until recently.



Roll-off and  
mobile trailer





# Small vertical baler



# Reverse Vending

(Photo Source:  
TOMRA)



# Drop-Off Issues

- High participation when drop-off located where refuse is collected
- Low participation with curbside refuse collection
- Driving material to drop-off has costs, monetary and environmental
- Un-manned drop-offs can lead to high contamination rates
- Processing of material at drop-offs can be costly

# Issue of Special Trips is Critical

## ➤ Drop-Off Recycling

- Recent surveys in Knoxville, TN found that average recycler drives 150 miles per year to drop off recyclables

## ➤ Stand Alone Redemption Centers

- Recent MA surveys showed that special trips reduced value of nickel to 3 – 4 cents

## ➤ At Retail Locations

- Even at retail locations, people drive out of their way to recycle



# Collection of Source Separated Materials

## ➤ Household

- Rarely done anymore

## ➤ Commercial

- High volume/value, homogenous material

**CARDBOARD  
ONLY**

**NO  
TRASH**



**WARNING**

Proper disposal of cardboard boxes is essential for the health and safety of the community. Improper disposal of cardboard boxes can result in the following:

- Obstruction of traffic
- Fire hazard
- Environmental damage
- Injury to people and animals

For more information, please call 1-888-27-TRASH.

**WARNING**

Proper disposal of cardboard boxes is essential for the health and safety of the community. Improper disposal of cardboard boxes can result in the following:

- Obstruction of traffic
- Fire hazard
- Environmental damage
- Injury to people and animals

For more information, please call 1-888-27-TRASH.

*"We Know How To Do It"*

**BESTWAY**

**DISPOSAL  
SERVICES**

*Of New Hampshire*

**1-888-27-TRASH**

# Front Loader For Dumpsters



# Source Separated Issues

- Remain dominant collection system for commercial wastes
- Low residential capture rates
- Inefficient utilization of trucks and crews in residential collection applications
- Low residue rates
- Low processing costs
- Cleaner material

# Dual Stream

- Set out of mixed paper and commingled containers



# Dual Stream: Over the top dump



# Single Stream

- All materials collected together
- Often associated with rolling carts and automation





# Single Stream Issues

- High capture rates
- Can use refuse packer trucks
- Opportunities for co-collection
- Higher residue rates
- Impact on paper and plastic



# Co-Collection

- Single stream provides opportunity for co-collection of refuse and recyclables
- Benefits:
  - Fewer trucks
  - Lower environmental impact
  - Potentially lower system-wide costs
- Problems:
  - Sizing of compartments
  - Location of refuse and recycling tipping points



Automated  
Co-  
Collection

Split Truck  
Split Cart









Co-collection:  
Refuse and  
Single  
Stream





# Automated dual carts









# How Do You Measure Collection Success?

- Participation Rate
- Capture Rate
- Recycling Rates
- Cost
- Environmental
  - GHG Emissions (Carbon Footprint)
  - Other Emissions

# Definitions

## ➤ Participation Rate

- Percent of households who set out recycling
- Usually measured as monthly participation

## ➤ Capture Rate

- Percent of potentially recyclable material set out for recycling (as opposed to set out as refuse) from a participating household

# How Do You Increase Participation and Capture Rates?

- Simplify set-out requirements:
  - Single Stream
  - Carts (volume equal to refuse)
- Public education and promotion
  - Participation will decline over time without continued education and promotion
- Create economic incentives:
  - Pay-as-you-Throw (PAYT)
  - Recycle Bank/Reward System

# Problems with Using Recycling Rate to Measure Success

- Rewards big consumers
- Weight based
- No universal agreement on what materials count for recycling
  - Bulky wastes
  - Scrap metal
  - Junk autos
  - C&D debris

# Problem With Using Weight

- Source reduction is reducing the weight of materials
  - Plastic bottles substituted for glass bottles
  - Thin-walling of aluminum, steel, and plastic containers
  - Reduction in size and number of pages of newspaper
- Result can be declining recycling rate even with higher participation and capture rates

# Recycling Rate Quiz:

What was Your State's  
Recycling Rate last year?

- 12%
- 21%
- 27%
- 61%
- 68%
- 72%
- Could be all of the above – you get what you count

# A Better Measurement: Recovery Rate

$$\text{Participation Rate} \times \text{Capture Rate} = \text{Recovery Rate}$$

Example:

*100 tons of newspaper available*

80% participation x 70% capture =  
56% of newspaper recovered

# Public Space Recycling

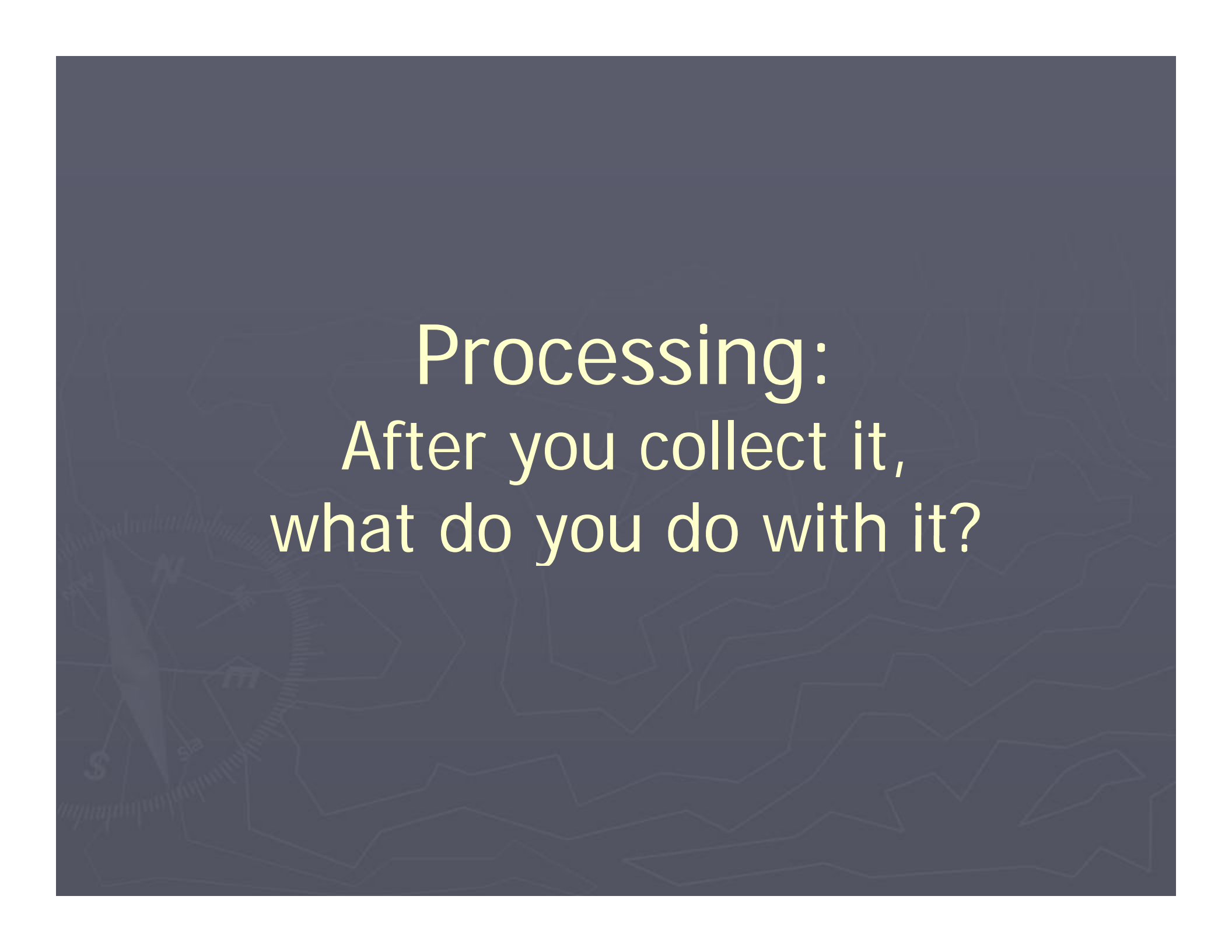
- Many cities are incorporating public space recycling into their recycling programs
  - Parks
  - Street Baskets
  - Rest Areas
  - Airports
  - Special Events



# Opportunities and Challenges

- Much of the material generated in public spaces is not recyclables
  - Coffee and soda cups
  - Fast food packaging
  - Food waste
  - Illegal disposal
- But there are materials that can be recycled
  - PET bottles
  - Newspaper



The background of the slide is a dark blue-grey color with a faint, light-grey topographic map pattern. The map features various contour lines and a compass rose in the lower-left quadrant. The compass rose has a needle pointing towards the top-left and is labeled with 'N' for North, 'S' for South, 'E' for East, and 'W' for West. The text is centered in a light yellow-green color.

Processing:  
After you collect it,  
what do you do with it?

# Types of Processing

- Source separated materials to:
  - Paper packing house
  - Scrap metal dealer
- Dual Stream materials recovery facilities
- Single Stream materials recovery facilities



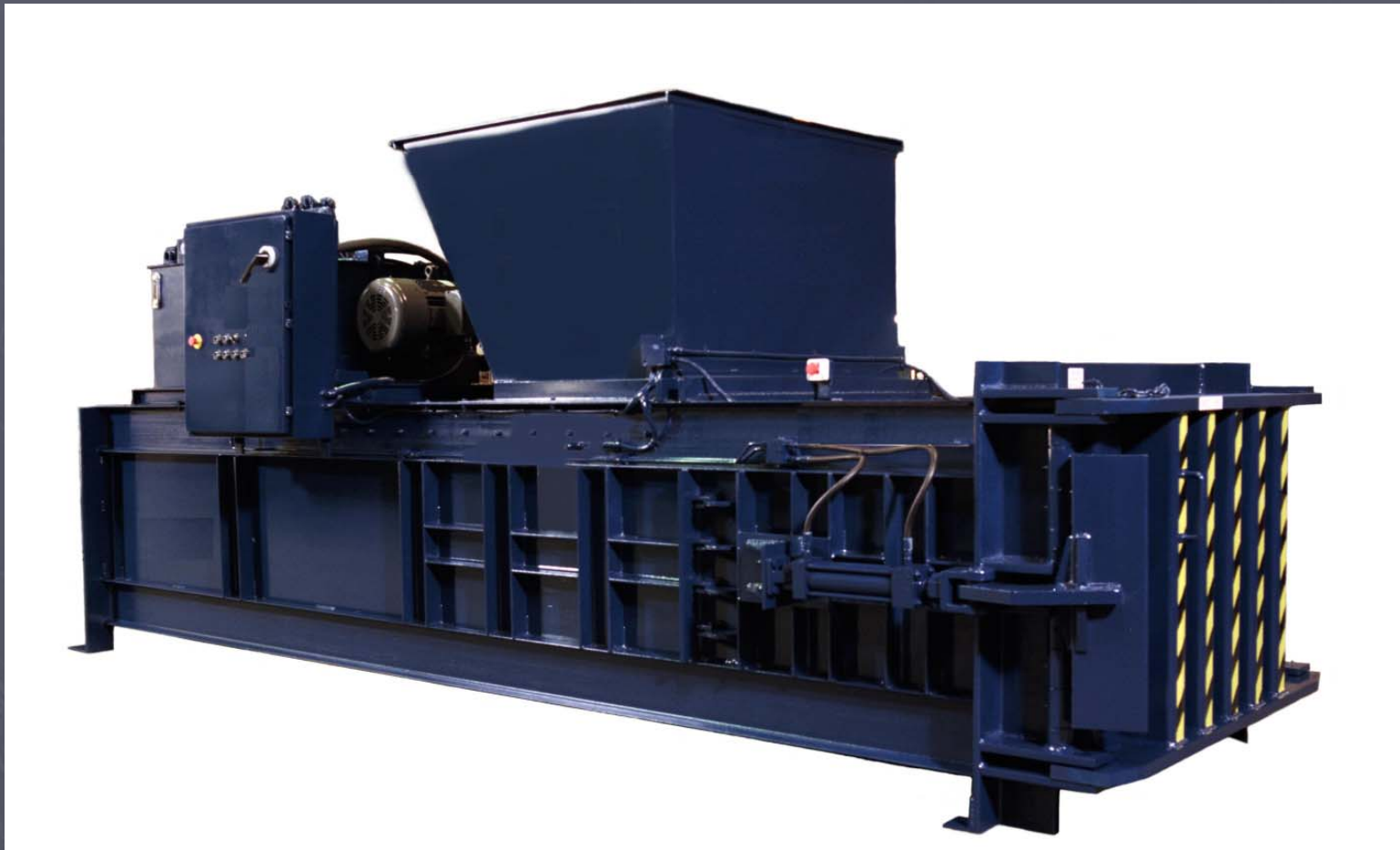


Minimal sorting  
Bale  
Ship truckload quantities

The image shows a vast industrial recycling facility. In the foreground, a large, rectangular bale of compressed cardboard is visible, with various labels and text such as "CUPS PLASTIC CUPS", "30 LBS GALAXY PLASTIC CUPS", and "ADAMS". The bale is made of flattened cardboard boxes. In the background, there are more bales of waste, including a large pile of plastic cups. A yellow forklift is visible in the distance, and the facility has a high ceiling with many lights. The floor is dark and covered with some debris.

# Key is High Density Baler

## *Typically Horizontal*





# Dual Stream MRFs

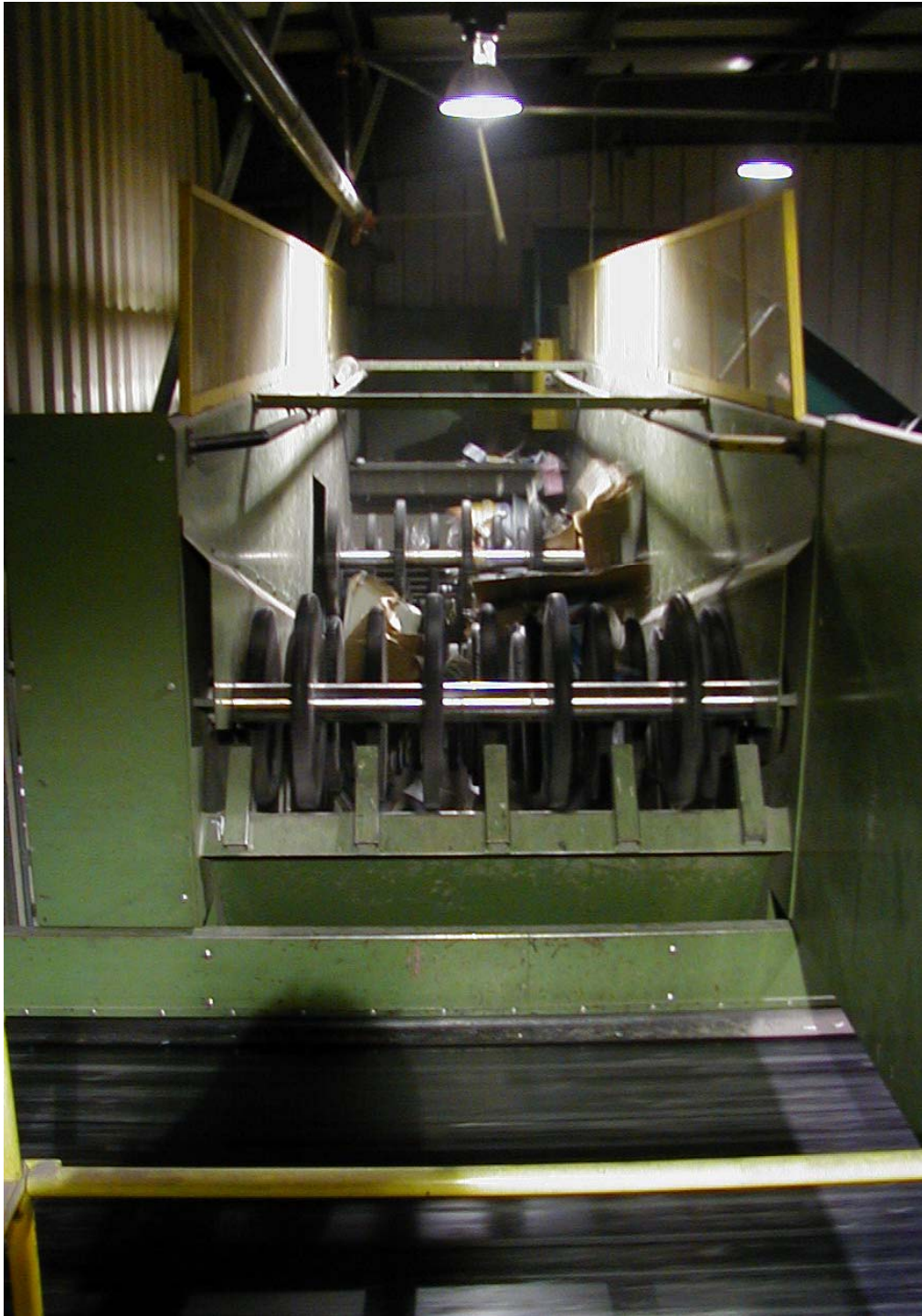
- Most common facilities used for curbside and drop-off materials (+/- 400 plants)
- Accept mixed containers and mixed paper
- Typically operate two lines
- Manual and mechanical separation
- Densification and sale to brokers
- Typically charge for containers, pay or revenue share for paper





# Single Stream MRFs

- Accept all materials mixed together
- Mechanically and manually separate
- Largest growth in new processing plants
- Higher capital cost
- Higher operating costs
- Lower labor cost
- Allow lower cost collection





# Benefits of Single Stream Processing

- Collection of bottles and cans from commercial businesses/workplace
- Collection of bottles and cans and paper from public spaces
- Equipment can handle higher levels of contamination
  - Public space recycling typically results in high levels of contamination

# Marketing and End Uses



# Brokers, Reclaimers and End Users

- Brokers: Purchase and sell large volumes of separated materials
- Reclaimers: Further process separated materials
- End Users: Manufacturers such as paper and steel mills, plastic molders

# Reclaimers

## ➤ Primarily For Plastics

- Buy bales of separated plastics
- Wash
- Grind
- Remove contaminants
- Pelletize
- Sell to end users or compounders

# Glass Benefication Plants

- Serve similar function to plastic reclaimers
  - Purchase whole or broken glass
  - Grind
  - Remove contaminants
  - Sell to end users (may be affiliated with end user)
- Used to be glass bottle manufacturers only
- Now used to process glass from MRFs

# End Users

- Paper mills
- Glass bottle manufacturers
- Insulation manufacturers (glass or paper)
- Aluminum sheet producers
- Steel mills
- Plastic product producers
- End uses may be partially or totally of recycled commodities



# Paper Mills

- Different mills use different paper grades
  - Depends on what they produce
- Purchase baled material, by grade
- Break bales, re-pulp
- Screen and float out contaminants
- Bleach – depending on brightness of final product

# Paper Is A Commodity

- Global marketplace
- Price fluctuates with demand
  - Increased prices when paper mills operating at high capacity or high export demand
  - High demand for corrugated in spring for next Christmas
  - Compete with virgin pulp

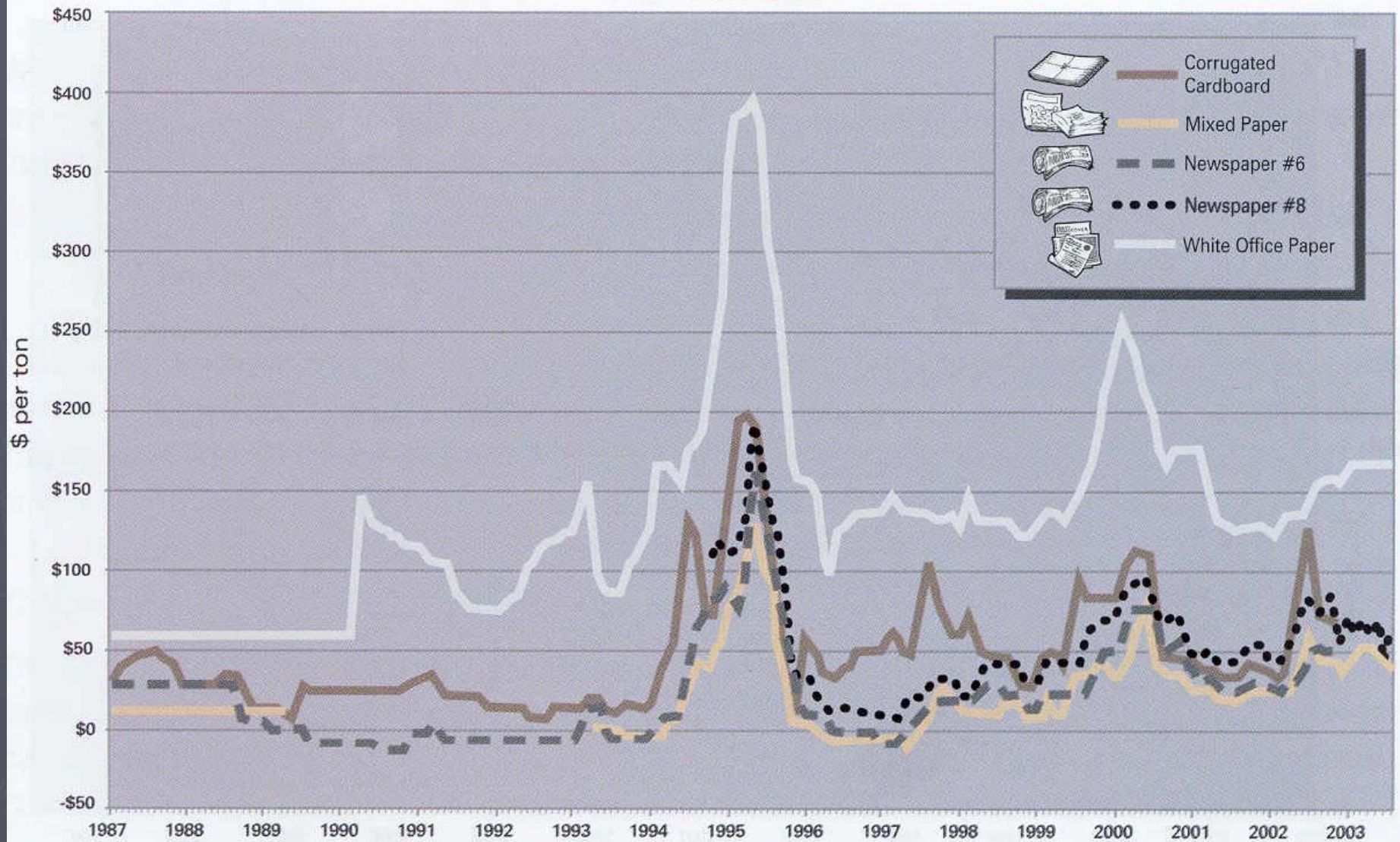
# Paper Recovery Rates

- 2008 Estimates (AF&PA):
  - Overall recovery of fiber estimated at 57%
  - Corrugated at 80%

# Source: DSNY BWPR

## Recycled Paper Prices

New York Region



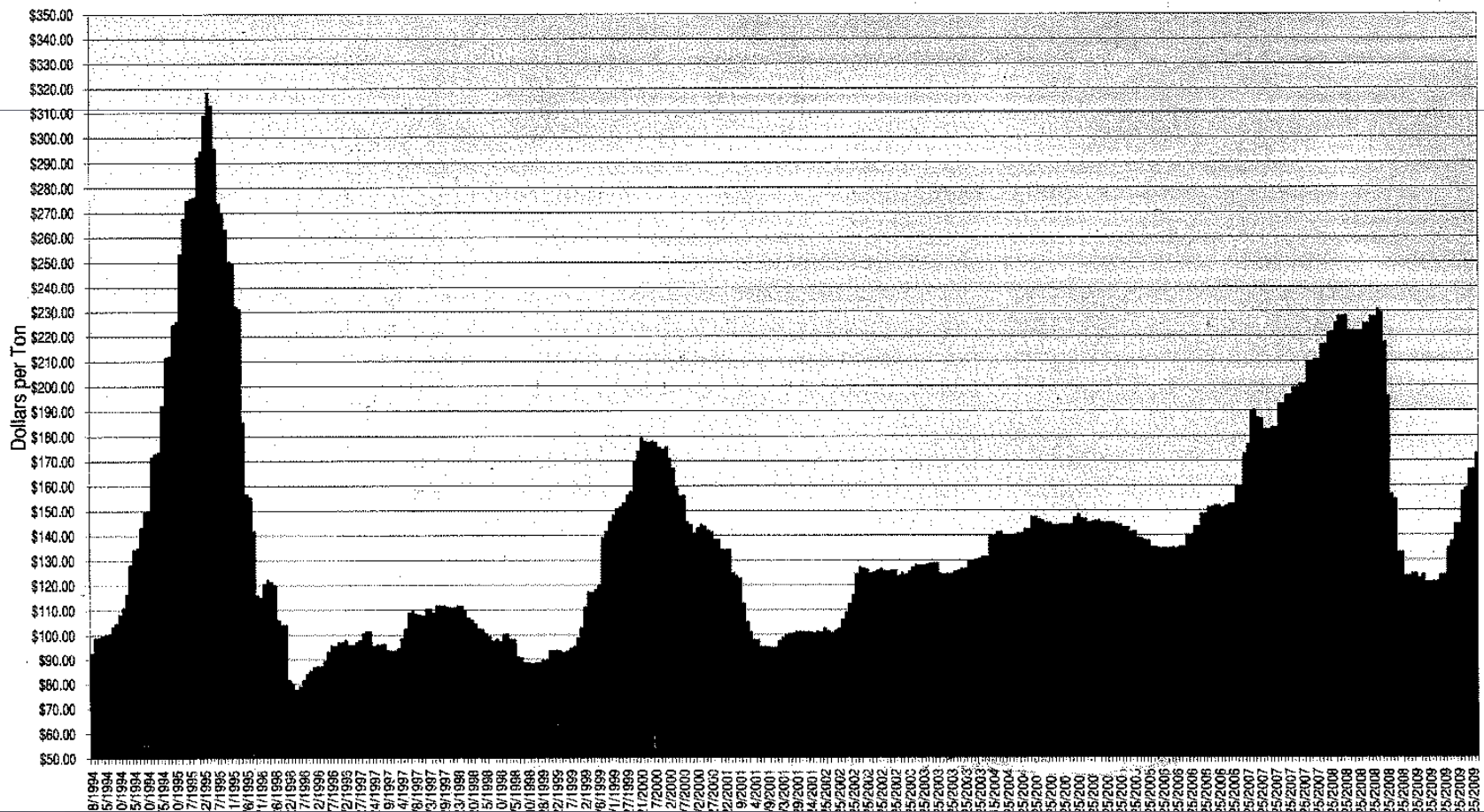
Source: Official Board Markets. See "Notes to Illustrations" for information on pricing data.



Source: Paper Stock Report  
(1994 – 2009)

## Average national scrap paper prices

The mean prices paid by paper mills for 18 commonly-traded grades of scrap paper across the U.S. Prices are per short ton, FOB seller's dock, based on bi-weekly surveys conducted by *The Paper Stock Report*



# Recovered Paper and Paperboard End Uses

(Source: AF&PA 2008)

- Roughly 6 percent goes into newsprint
- 36 percent is exported
- 30 percent is made into containerboard
- Remainder to other uses
  - Writing paper, cellulose insulation, egg cartons, roofing papers

# Steel

- Heavy Iron
  - Light Iron
  - Steel Cans
  - Other metals
- 
- Steel mills typically only buy from brokers, not MRFs
  - Charge of scrap metal depends on type of furnace (electric arc, basic oxygen)

# Aluminum

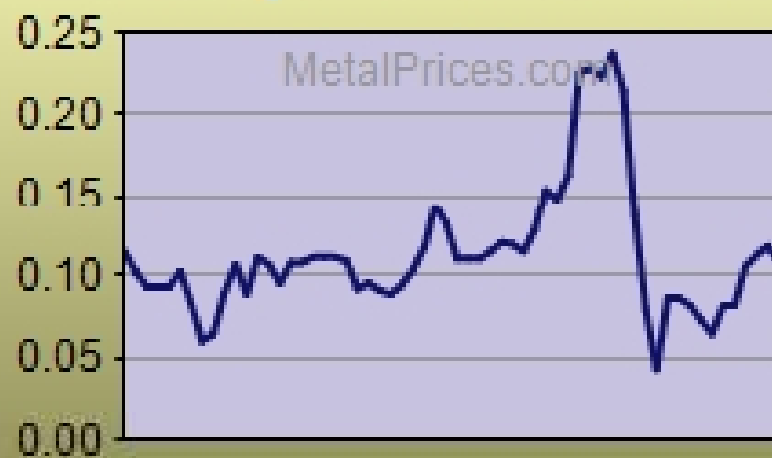
- Highest value municipal material
- Takes ½ energy to make new aluminum from scrap aluminum
- Scrap prices driven by:
  - Bauxite prices
  - Cost of electricity
  - Aluminum demand



# Five year index

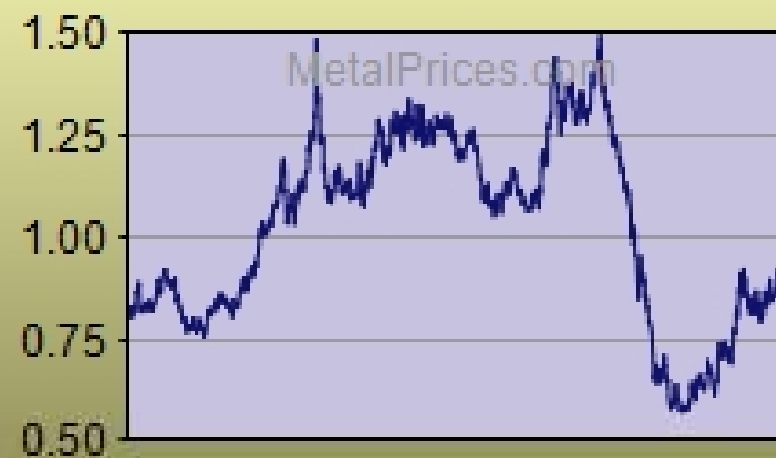
(Source: Metalprices.com)

**Scrap Iron - #1 HMS  
Chicago Mill - 5 Years - \$/LB**



08 Nov, 2004 - 12 Oct, 2009

**LME Aluminum Settlement 5 Years -  
\$/LB**



01 Dec, 2004 - 30 Nov, 2009

# Glass

- Lowest value material – but highest weight
- Bottle-to-Bottle
  - Flint
  - Amber
  - Green
- Green has low value – too much imported beer and wine
- Aggregate largest end use
- Fiberglass new use, but requires low contamination

# Plastic

## ➤ Different From Other Materials

- Typically purchased ready for application from reclaimer
- Very low tolerance for contaminants
- Very low tolerance – in many cases – for multiple grades
- Very low tolerance for wrong melt index within single grade
- Typically does not go back to bottles

# Other Materials/Other Markets

- Organics
- Electronics
- Textiles (carpet and clothing)
- Other Plastic Containers
- Plastic Film
- C&D materials

# Buy Recycled

- At the end of the day, a company's decision to use recycled materials comes down to:
  - Cost
    - How does scrap compare to virgin after including cost to clean up contaminants
  - Consumer demand
    - If you MUST have bright white, ultra soft tissue paper – it might not be recycled
    - If construction materials not readily available, may not be purchased for the job



# Why Buy Recycled

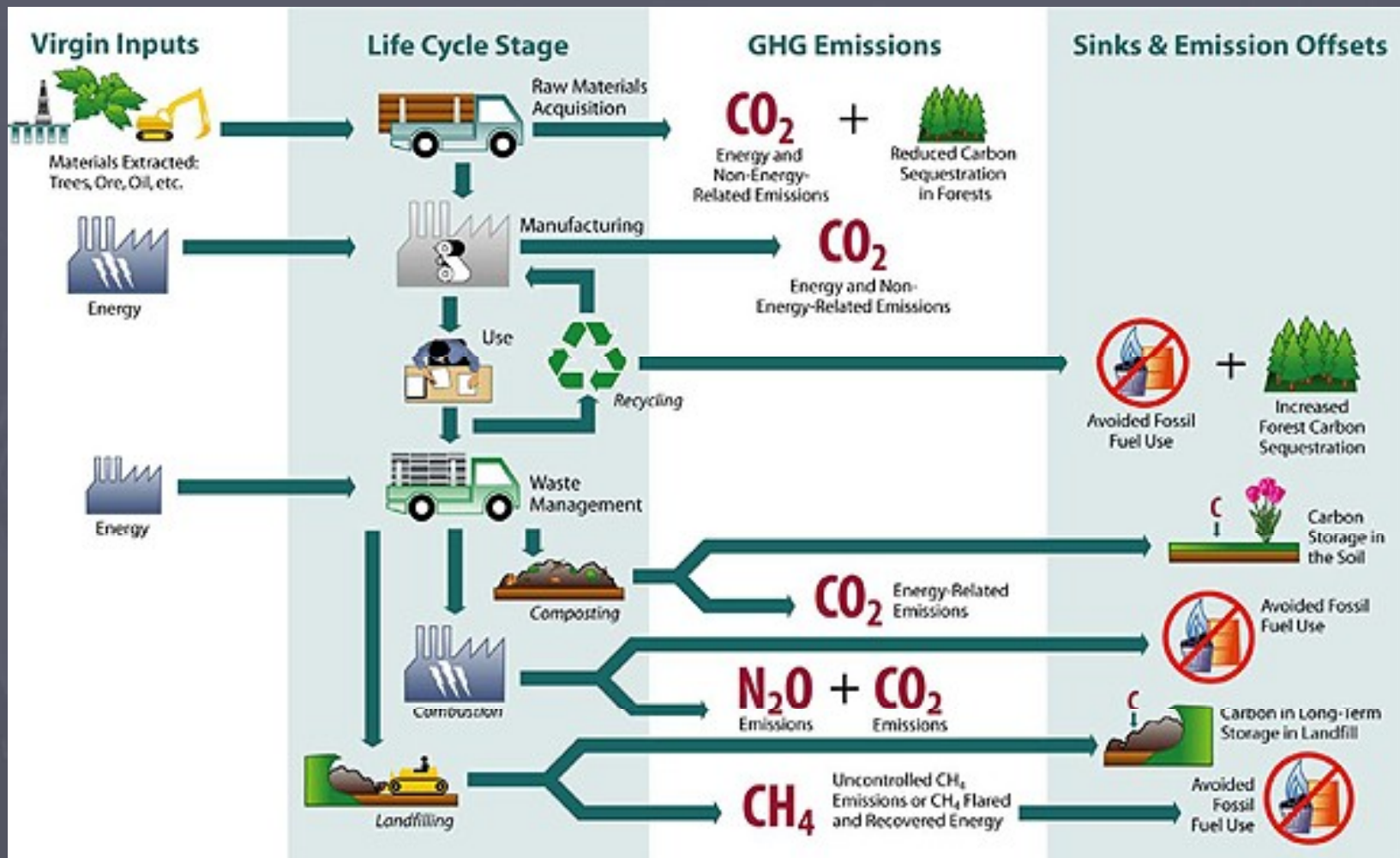
- Global Warming
- Resource Depletion
- Environmental Degradation

# Global Warming

- In most cases the Greenhouse Gas Emissions from recycling are less than for virgin material use
- Trees cut down for paper no longer are available for carbon absorption
- Carbon released to cut, skid, transport, grind, pulp, and produce paper is greater than carbon released to collect, process, transport, and re-pulp.

# Recycling reduces the need to extract and convert resources to new products

(Source: EPA)



# Resource Depletion

➤ Petroleum

➤ Bauxite

➤ Iron Ore

➤ Trees

# Environmental Degradation

- Hard rock mining represents 45 % of all toxics released and 14 of 15 largest Superfund sites (Source: American Retroworks)
- Cutting trees leads to increased road building, soil erosion, and water degradation
- Impacts associated with drilling, pumping, and transporting oil



# Organics Recovery

- In contrast to materials recycling, GHG emissions impact of organics recovery is primarily associated with the reduction of methane generation at the landfill
- Methane is 23 times more potent GHG than carbon
- Organics decomposition are primary source of methane generation in landfills

# But

- It is not a given that recycling is better for the environment. We need:
  - Efficient collection systems to reduce transport impacts
  - Low contamination to reduce processing inputs and wastes
  - Efficient manufacturers – shipping recyclables and products with recycled content back to China significantly reduces the global warming benefits!