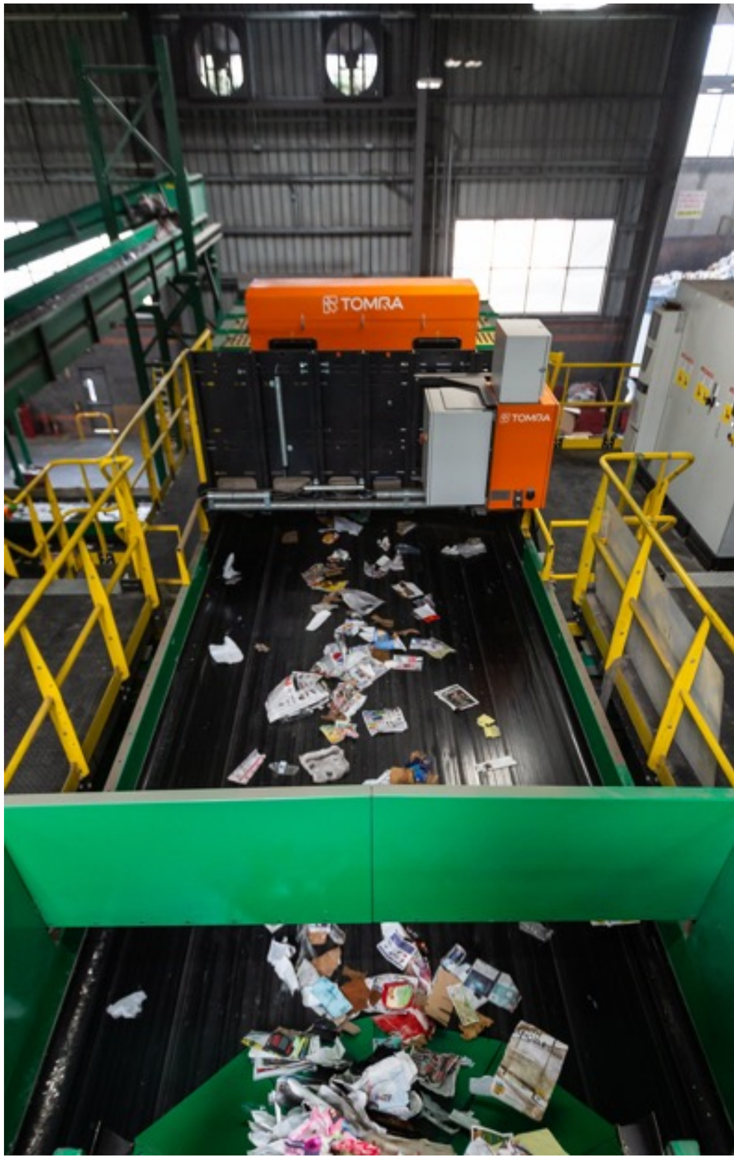
RECYCLING SYSTEMS MAKING THE CASE

NATIONAL ACADEMIES OF SCIENCE, ENGINEERING, AND MEDICINE
COMMITTEE ON MSW RECYCLING



TALKING POINTS OUTLINE

- Waste/Recycling Economics Across Recycling Value Chain
- Recycling Value Proposition – Making the Case
- Economies of Scale Across Value Chain
- Best Practices Across Recycling Processing Stages
- System Yield and Approaches to Increase Yield
- Best Practice Implications
  for States, Communities, Urban/Rural, Tribes

WHAT IS RECYCLING AND WHAT DOES IT REQUIRE?

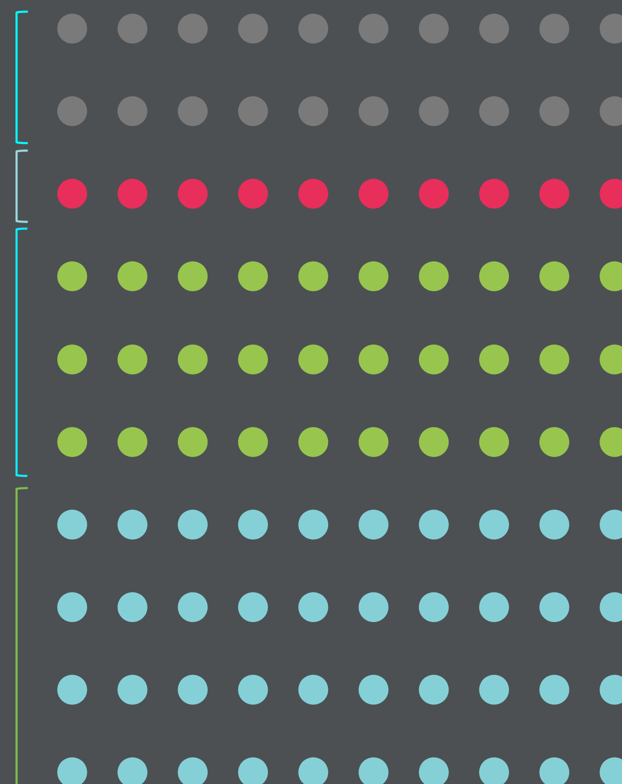
True recyclability starts with strong end markets that pull materials through the various phases of a recycling system to ensure economic sustainability

The degree to which end markets value a commodity bale and can reprocess the material has implications for recycling sortation and package design.

To be truly recycled into new products that displace virgin material use, materials must successfully perform in Collection Programs, in the MRF and in End Markets

THE REALITY OF MUNICIPAL RECYCLING

Only about 70% of the US waste stream can actually be recycled or composted.



Recovery is:

- Ever changing part of waste stream
- Only possible below the line

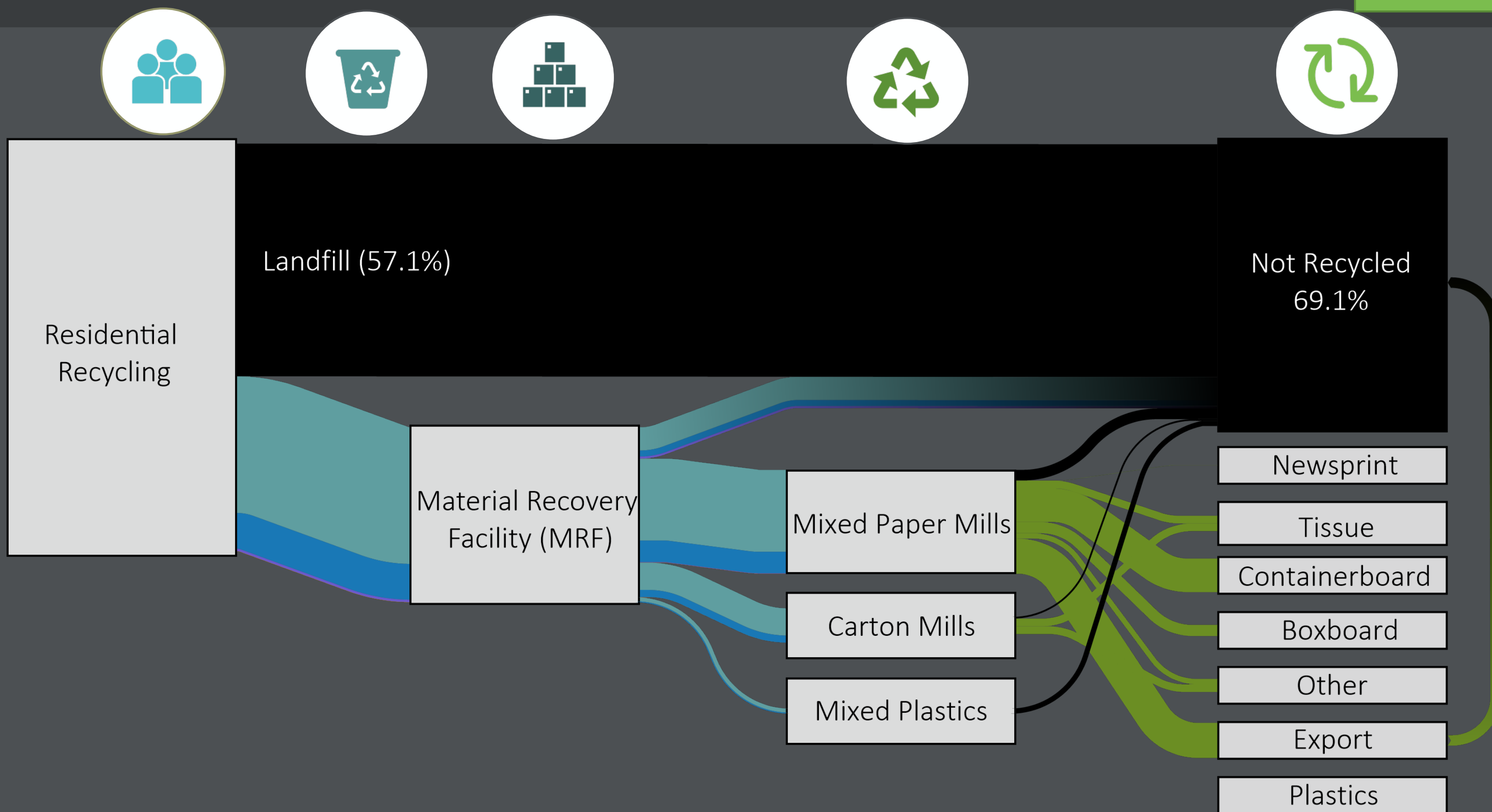
WASTE/RECYCLING ECONOMICS ACROSS VALUE CHAIN

- Waste is a cost
- You must pay to get rid of it
- It is a necessary public service for public health, safety, welfare
- Legitimate ways to avoid this cost – reduce, reuse, recycle
- Illegal ways to avoid – litter, illegal dumping, burn barrels, etc.
- Waste will create negative impacts on water, air, blight, etc.
- Regulations and responsible management mitigate these negatives

RECYCLING VALUE PROPOSITION – MACRO BUSINESS CASE

- Economics and business case support a "bullish" long-term approach
- Quote from David Allaway's presentation makes case:
  - Oregon's statewide waste and recycling direct cost is $1B
  - Eliminating recycling would reduce that by $105M
  - But would increase indirect cost by $1.1B – essentially a 10x return
- Paying the full cost of diversion achieves these benefits
- Majority of that is actually redeployed waste management cost
- The incremental cost (above waste management cost) secures the benefit
- These are a public good across the commons – worth embedding in policy

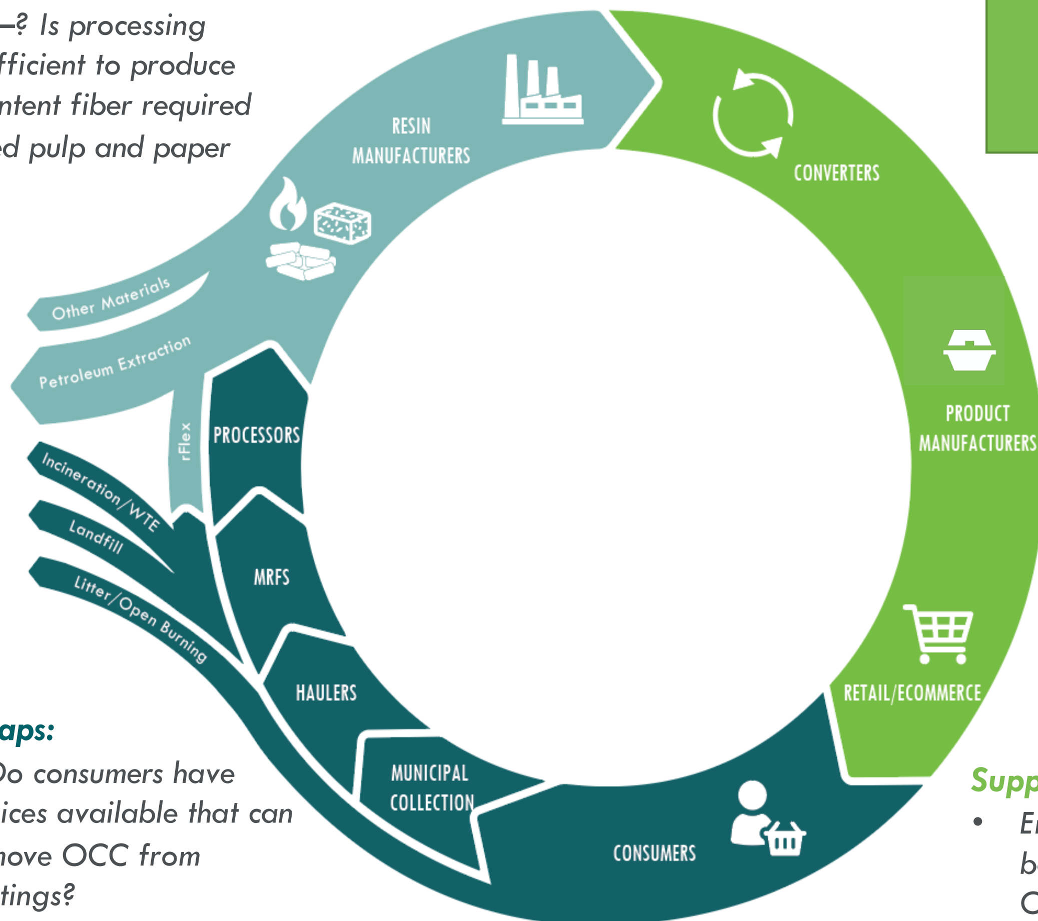
YIELD AND MIXED PAPER RECYCLING PROCESS



EXAMPLE: GAPS AND LOSS POINTS IN CIRCULAR VALUE CHAIN FOR FIBER

Supply Chain Gaps:

- *Processing –? Is processing capacity sufficient to produce recycled content fiber required by recovered pulp and paper mills.*



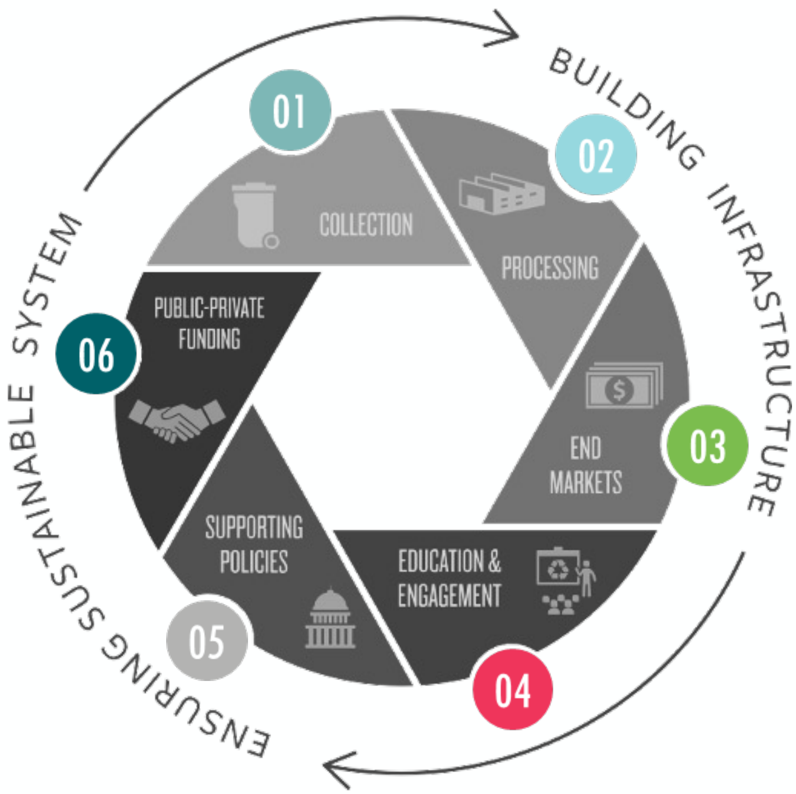
Supply Chain Gaps:

- *Collection – Do consumers have recycling services available that can efficiently remove OCC from residential settings?*
- *Are consumers educated and engaged?*

Supply Chain Gaps:

- *End Markets – Is the balance between MP and OCC supply regionally appropriate for the pulp and paper industry?*

END OF LIFE VALUE CHAIN:
KEY COMPONENTS OF SUCCESSFUL RECYCLING



01 **COLLECTION:** Collect and Capture

02 **PROCESSING:** Efficient processing multiplies results

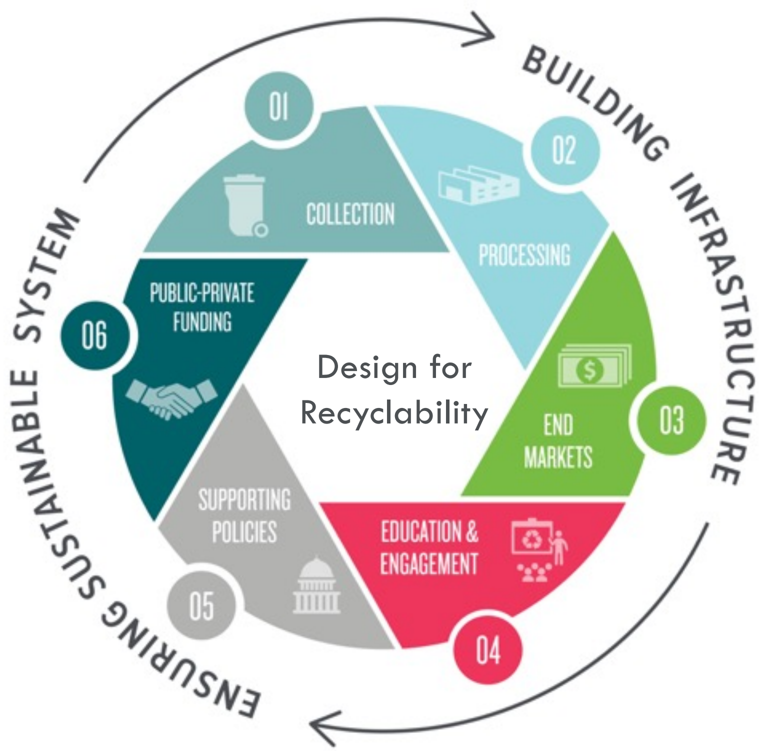
03 **END MARKETS:** Reclamation and Manufacturing

04 **EDUCATION & OUTREACH:** Consistent messaging tailored to demographics

05 **SUPPORTING POLICIES:** Local action that drives supply and increases demand

06 **PUBLIC-PRIVATE FUNDING:** Funding strategies to optimize co-investment

ELEMENTS OF A SUSTAINABLE RECYCLING SYSTEM



TRUE RECYCLABILITY

True Recyclability requires:

Collection – materials need to be collected whether through informal waste picking or formal curbside and drop off collection.

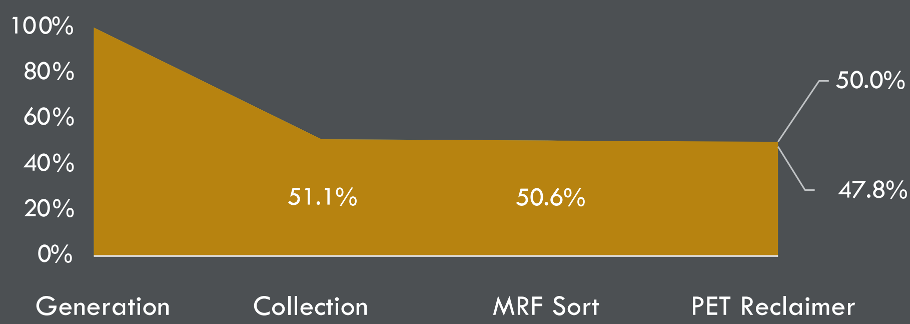
Sorting – whether through informal segregation or sortation in an advanced material recovery facility, materials need to be aggregated into a marketable commodity bales.

End Markets - create demand for recovered materials and ensure economic viability to reclaim materials for a new cycle of use.

Together, the performance of a package across Collection, Sorting, and in End Markets tells a story of its True Recyclability.

OVERALL RECYCLABILITY PERFORMANCE AND AT EACH STEP

OVERALL RECYCLING SYSTEM PERFORMANCE



- **Collection programs -** likely to capture 51.1% PET Bottles
- **Sorting facilities -** sort a majority of these bottles putting overall capture at 50.6% during sorting.
- **PET reclaimers –** successfully recycle PET bottles; effectively putting 47.8 - 50.0% of the recovered PET into new product.

ASSESSMENT STEPS

GRADING

COLLECTION PROGRAMS

74% list PET Bottles or PET as acceptable; "Widely Recycled"

A

SORTING COMPATIBILITY

Many MRFs have equipment and practices to separate out PET – some contamination

A

END MARKET COMPATIBILITY

PET reclaimers have appropriate equipment and practices to recycle PET into new PET. Package complies with APR guidelines for PET containers

A

LIKELIHOOD OF MISMANAGEMENT

Consistently among the most littered items in the U.S. Even at low leakage rates, PET bottle will accumulate in the environment.

D

COLLECTION – RECYCLING'S COSTLY CHALLENGE

Single-Family Homes:
68% of US households

2-4 Unit Buildings
8% of US households

Typically included in municipal curbside collection systems

5+ Unit Buildings
18% of US households

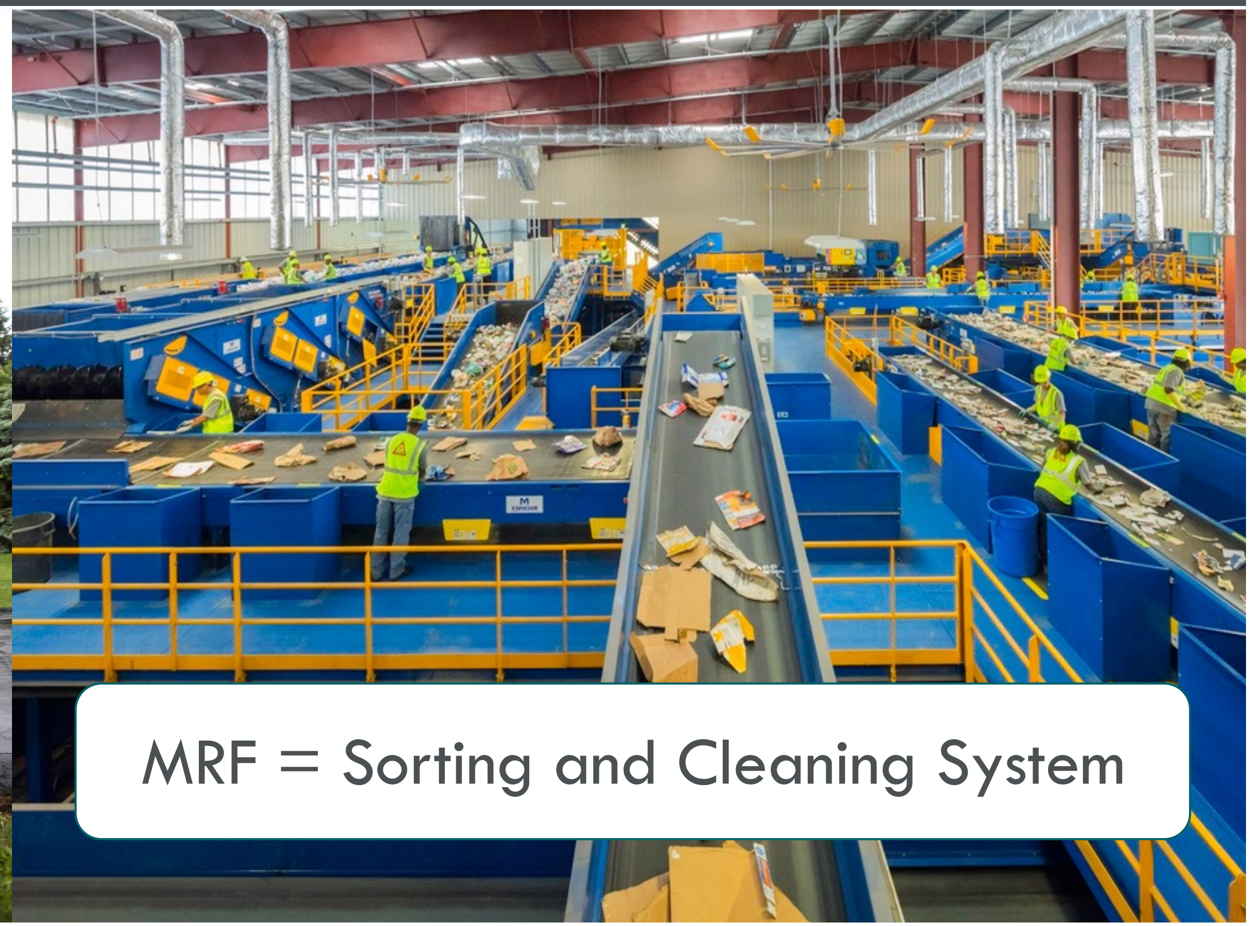
Mobile Homes or Other Housing Types
6% of US households

Frequently excluded from municipal curbside collection systems

Source: U.S. Census Bureau, 2019 American Community Survey 1-Year Estimates

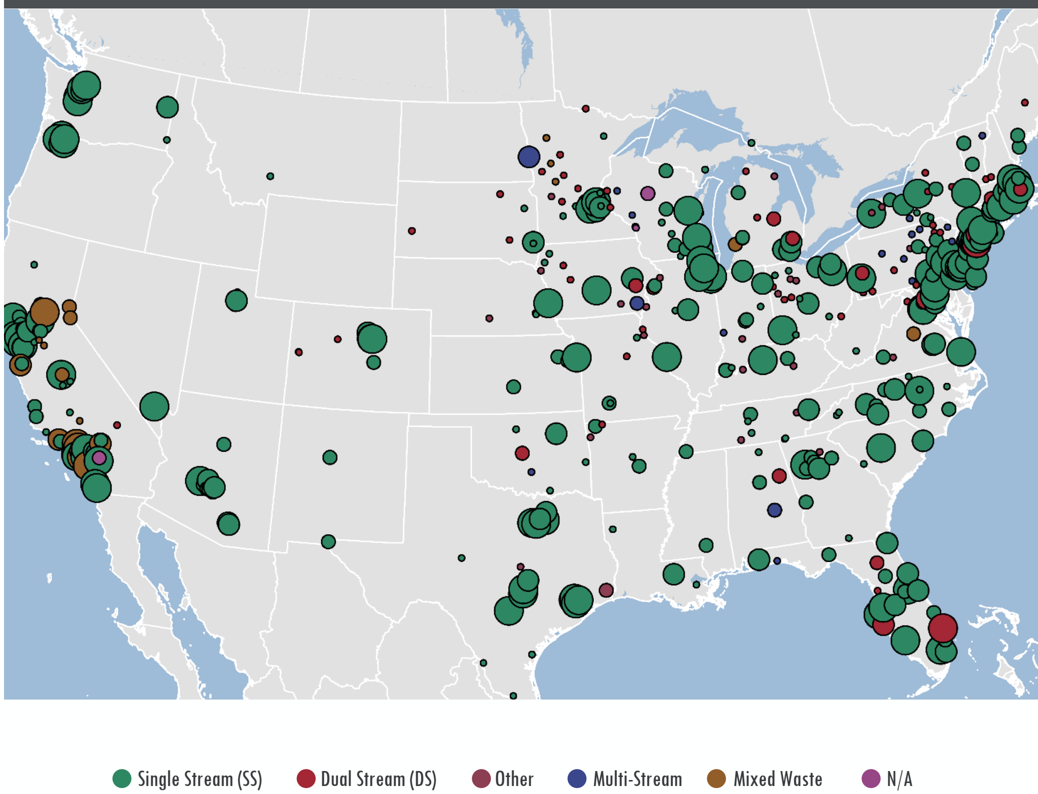
SINGLE STREAM RESIDENTIAL
CONVENIENCE & CLEANING TO GET TO A COMMODITY

Single Bin Collection

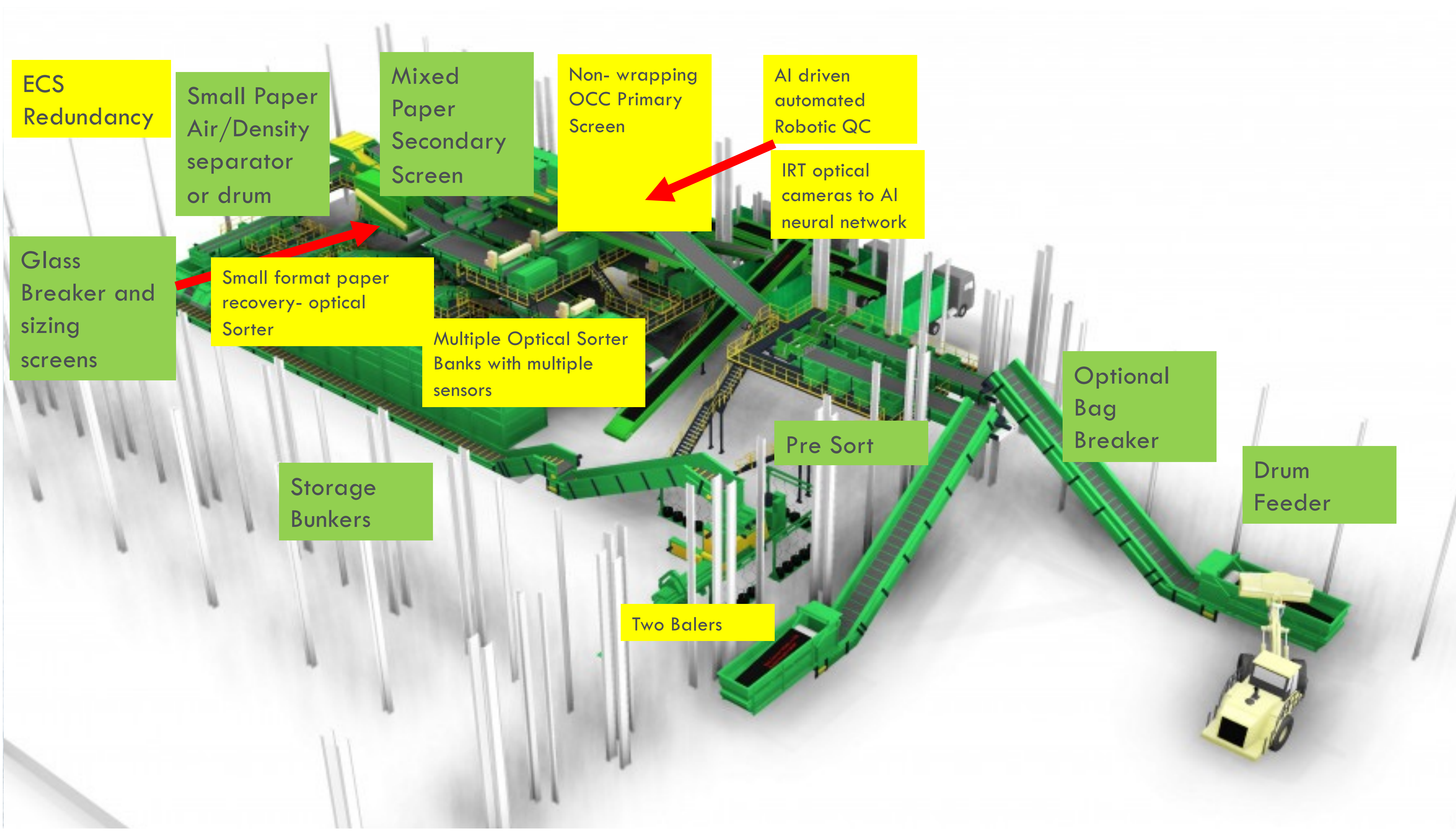


MRF = Sorting and Cleaning System

MATERIAL RECOVERY FACILITIES (MRFs)



MRF SIZE	% TONS SS	% TONS DS	% TONS MULTI	% TONS OTHER	% TONS MIXED	% TONS N/A
SMALL	2.3%	1.0%	0.2%	0.5%	0.3%	0.0%
MED-SMALL	11.4%	1.6%	0.4%	0.4%	0.6%	0.8%
MED-LARGE	19.5%	0.9%	0.3%	0.0%	0.7%	0.0%
LARGE	52.0%	2.6%	0.0%	0.0%	3.7%	0.7%
TOTAL	**85.2%**	**6.1%**	**0.9%**	**0.9%**	**5.3%**	**1.5%**


ECS Redundancy
Small Paper Air/Density separator or drum
Mixed Paper Secondary Screen
Non- wrapping OCC Primary Screen
AI driven automated Robotic QC
IRT optical cameras to AI neural network
Glass Breaker and sizing screens
Small format paper recovery- optical Sorter
Multiple Optical Sorter Banks with multiple sensors
Optional Bag Breaker
Pre Sort
Drum Feeder
Storage Bunkers
Two Balers

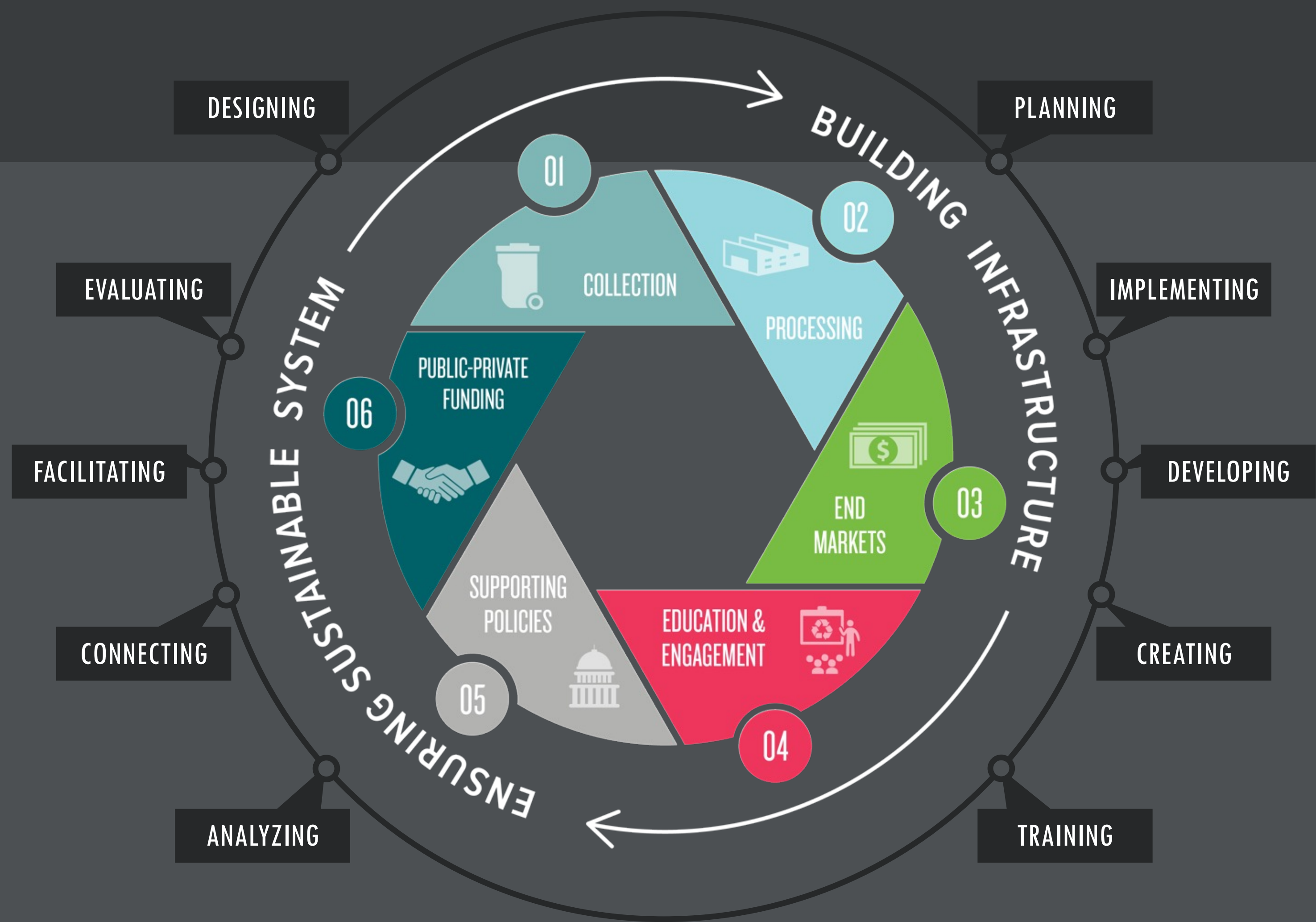

Source: https://www.amprobotics.com/amp-clarity

ADVANCED AUTOMATED SORTING TECHNOLOGIES

- High Speed Opticals – single/dual eject
- Robotics
- Artificial Intelligence
- Image Recognition in Front of Bots/Opticals
- Ballistic Separators
- Non-Wrapping Screens
- Air Knives
- Digital Watermarking
- Fluorescent Markers
- Chemical Recycling (various technologies)

APPLICATIONS ACROSS THE PROCESSING VALUE CHAIN

- Super Drop-offs at Local Level
- Localized Tipping to Lower Collection Costs
- Hub and Spoke - Aggregation to Move to Better Economies of Scale Downstream
- Scalping to Harvest Value – e.g. Fiber Baled – rest shipped
- Full Service MRFs With High Automation
- Secondary Processing – PRFs, glass beneficiation, small format processing, chemical recycling
- Integrated Processing and Production with high value commodity creation – e.g. pellets
- Pre-processing/front end cleaning and feedstock prep at end market (mill, manufacturer, etc.)



BUILDING INFRASTRUCTURE
ENSURING SUSTAINABLE SYSTEM
01
COLLECTION
02
PROCESSING
03
END MARKETS
04
EDUCATION & ENGAGEMENT
05
SUPPORTING POLICIES
06
PUBLIC-PRIVATE FUNDING
DESIGNING
EVALUATING
FACILITATING
CONNECTING
ANALYZING
PLANNING
IMPLEMENTING
DEVELOPING
CREATING
TRAINING

RRS
recycle.com

Jim Frey, CEO
frey@recycle.com
734-417-4415