21st Century Technology:
Recycling Game Changers on the Horizon

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RRT Design & Construction
Melville, NY- Milwaukee, WI- Baltimore, NY -Orlando, FL
Syracuse, NY- Vestal, NY- Philadelphia, PA-
www.rrtenviro.com
We build solid waste processing & recycling businesses
27 years of over 400 successful plants including over 80 complete greenfield operations
Experts in MRF plant operations, equipment, process engineering & construction

Ocean County, NJ
Single Stream MRF

New York, NY
Container & Paper MRF
What is the future?

- More Commingling
- More Materials
- Integration with Collection
- Automation
- Vertical Integration
- Private vs Public
- Economic Drivers
State of MRFs

- 600+
- 80/20 Rule
- Players
- Self-Driven
Core Issues

• Huge investments need to be spent/recovered
• Half of the people operating MRFs still lack confidence in the business
• 70% of our waste is unprocessed
• 50% of the waste processed is done poorly
• Relying on revenues to offsets costs confuses a fee based structure
• The PR of “zero waste” adds more confusion
Business Parameters

- Collection
- Processing
- Logistics
- Marketing
Business Parameters

Generator → Curb → Collect → Process → Ship → Market → End User
Business Parameters

Processing

- Throughput
- Recovery Rates/Residue Rates
- Staffing
- Maintenance
- Safety
- Material Grades & Quality
- System Availability
- Equipment Efficiency
MATURITY OF THE INDUSTRY

AGING OF THE PROCESS AND PROCESSING METHODS

INNOVATION
Business Parameters - Generator Trends

- Education - *Most places virtually non-existent*
- Mix Changes- *Less Fiber, Fiber Compositions, More Plastics, More non-recyclable plastics*
- Clean Loads/Dump & Bale- *shrinking opportunities*
Business Parameters - Generator
Business Parameters- Collection

- **Vehicle Types** - *transfer trailers, staging and yard tractors*
- **Automated** - *incoming contamination out of control*
- **Moisture** - *increasing issue for certain markets*
Business Parameters - Processing Trends

• **Throughput** - slowing down lines to improve quality/running more hours or running lines faster to “save money”.

• **Recovery Rates** - 90% was the standard, then 95% and now moved to 98.5%

• **Staffing** - adding labor to improve quality/cutting labor to save money.

• **Maintenance & Safety** - improving but the differences can be significant between plants
Business Parameters - Processing Trends (Systems)

- Complexity & Size - Fascination, justifications are weak
- Reliability - 85~90%, low
- Screens - Plateaued or declining
- Quality of Equipment - Unsubstantiated claims
- Access & Guarding - Greatly improved
- Environmental (Noise/Dust) - Significant work is needed
• **Effort to Market**- Increasing! Marketing demands more time such as deductions for quality and moisture

• **News**- will continue to be less available, ONP grade is gone

• **RMP**- Mixed paper grade is growing (hard or soft mix)

• **Prohibitives**- Waxed corrugated, wet strength, moisture, glass, non-fiber (plastics, metals, food), and FILM are growing problems

• **Cross Contamination of Products**- *Loss of $ most cases*
Business Parameters- Markets
How to make a bale look good
Business Parameters - Markets

Glass problems everywhere
Current Measures

• Plant audits and performance evaluations
• Moving toward a processing fee based model
• Shift away from sorting screens, modify what we have
• Re-balancing lines for the changes of the evolving ton
• Looking for better ways to deal with film
• Hub and spoke, transfer tons long distances
• Removal and simplification of equipment
• Removal and replacement with better equipment
• MRF closures and MRF stalls
Business Parameters

Generator → Curb → Collect → Process → Ship → Market → End User
## Game Changers: The real examples

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<th>Game Changer</th>
<th>Technology</th>
<th>Impact</th>
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<tr>
<td>Commingling Containers</td>
<td>Light-Heavy Separators (AirSort)</td>
<td>Collection</td>
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<tr>
<td>Automated Collection</td>
<td>Sideloaders</td>
<td>Collection</td>
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<tr>
<td>Batch Baling</td>
<td>Bale Doors</td>
<td>Processing</td>
</tr>
<tr>
<td>Automation</td>
<td>Eddy Current Separators</td>
<td>Processing</td>
</tr>
<tr>
<td>Automation</td>
<td>Optical Sorters</td>
<td>Processing</td>
</tr>
<tr>
<td>Single Stream</td>
<td>Paper Screens</td>
<td>Processing</td>
</tr>
<tr>
<td>RMP</td>
<td>OCC Screens</td>
<td>Processing</td>
</tr>
<tr>
<td>RMP</td>
<td>Mixed Paper Grade</td>
<td>Market</td>
</tr>
<tr>
<td>Metering</td>
<td>Drum Feeder</td>
<td>Processing</td>
</tr>
</tbody>
</table>
A Quick Look Back in Time & Game Changers
An elevated sort System
The AirSort™
A Quick Look Back in Time & Game Changers
Optical Sorting (glass, plastic & paper)
A Quick Look Back in Time & Game Changers
Single Stream Paper Screen
Single Stream Paper Screen 1997
How we see the MRF trend...
Batch Baling
Eddy Current Separator
Life Before Metering Drums
# Game Changers at MRF that didn’t take (examples)

<table>
<thead>
<tr>
<th>Game Changer</th>
<th>Technology</th>
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</thead>
<tbody>
<tr>
<td>Ferrous Containers</td>
<td>Shredders/Delabelers</td>
<td>Markets</td>
</tr>
<tr>
<td>Glass Color Sorting</td>
<td>Optical Sorters-Glass</td>
<td>Markets</td>
</tr>
<tr>
<td>Plastic Direct to Market</td>
<td>Granulators-Plastic</td>
<td>Markets</td>
</tr>
<tr>
<td>Bagging Recyclables at Curb</td>
<td>Debagger</td>
<td>Collection</td>
</tr>
<tr>
<td>Plastic Densification</td>
<td>Perforators</td>
<td>Shipping</td>
</tr>
<tr>
<td>Adding Textiles</td>
<td>Manual Sort</td>
<td>Processing</td>
</tr>
<tr>
<td>Adding Wood</td>
<td>Manual Sort</td>
<td>Processing</td>
</tr>
</tbody>
</table>
What is the future?

- More Commingling
- More Materials
- Integration with Collection
- Automation
- Vertical Integration
- Private vs Public
- Economic Drivers
Thoughts

• Huge investments need to be spent
• Half of the people operating MRFs still lack confidence in the business
• 70% of our waste is unprocessed
• 50% of the waste processed is done poorly
Game Changers!

- Robotics - Processing
- Screens - Processing
- Mixed Waste Processing - Collection
Robotics in Recycling

• **Who:** 4 companies so far
• **What:** QC Sorting
• **Where:** At end of the lines
• **When:** Next 5-10 years
• **Why:** Improve processing
Robotics Technology
Basic Principles

- Shape
- Height
- Material Type
- Color
- Orientation
- Location
Robotics Technology

• Unit based (just like manual) so TPH claims are not an accurate measurement
• Capital intensive with results cost neutral?
• Complicated
• Not ready for prime time yet, but getting there
• A good commodity run will drive this game changer so long as MRFs can simultaneously increase throughput
SADAKO Technologies
Wall-B

- Barcelona, Spain based company founded in 2012
- Wall-B model – arm suspended robot with suction tool
- Suitable for low to mid flow rates of waste: 1 – 2.75 TPH
- Technology intended to complement optical and manual sorters
- 20 picks/minute
PARTS
1. Camera box
2. Robotic Arm
3. Gasping tool (suction)
4. Artificial Intelligence to make everything work (not seen in the diagram)
- **2 units in use** at MRFs in Barcelona area
- Unit no. 3 to be installed during 2016
- Currently separates only PET
AMP Robotics

- Boulder, CO startup founded in 2015
- Delta and SCARA robots – robotic arms which can work with suction tools or grippers
- SCARA (suction): 50 picks/minute
- Delta (gripper): 80 picks/minute
- Recognizes and separates: cardboard, brick, wood, PET, HDPE and cartons
- Grippers customized for different materials and interchangeable
AMP Robotics

SCARA

Delta
AMP Robotics

• Suction uses up to 30 CFM of compressed air during one pick (15 CFM average)
• Maximum weight the robot can lift: 13 lbs. (below 6 lbs. optimum)
• SCARA belt speed: 80 feet/minute
• Delta belt speed: 200 feet/minute
• 1 pilot unit in the US installed in 2016
ZenRobotics

- Helsinki, Finland, founded 2007
- ZenRobotics Recycler – **two robotic arms** suspended above a conveyor belt
- ZRR uses a **gripper** to pick up and then toss material into chutes
- Each robot 2000 picks/hour (approx. 33 picks/minute) up to 11 lbs. Maximum weight lifted is 44 lbs.
- Purchase price: **$1M** (2 robotic arms + sensor enclosure + control system)
Bollegraaf Recycling Solutions

- Appingedam, Netherlands based company
- Represented by VAN DYK Recycling Solutions
- RoBB – detection module, sorting module and conveyor belt
- **Laser-guided system** to detect the height of waste and **suction** tool
- One robot: **4,000 picks/hour** (approx. **66 picks/minute**)
- Typical installation comes with **four robot arms (12,000 picks/hour)**
- Purchase price: **$1M** (2 robotic arms + sensor enclosure + control system)
Bollegraaf Recycling Solutions
Bollegraaf Recycling Solutions

Few units installed in Europe
# Robotic technologies at MRFs (today)

<table>
<thead>
<tr>
<th>Company</th>
<th>SADAKO</th>
<th>AMP Robotics</th>
<th>Zen Robotics</th>
<th>Bollegraaf</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technology</td>
<td>Suction</td>
<td>Suction/Gripper</td>
<td>Gripper</td>
<td>Suction</td>
</tr>
<tr>
<td>Picks/min per robot</td>
<td>20</td>
<td>50/80</td>
<td>33</td>
<td>66</td>
</tr>
<tr>
<td>Type of waste</td>
<td>PET</td>
<td>C&amp;D, Rigid Plastics, Plastic Containers, Paper</td>
<td>C&amp;D, Rigid Plastics</td>
<td>Plastics Containers &amp; Paper</td>
</tr>
<tr>
<td># of Installations</td>
<td>2</td>
<td>0</td>
<td>11</td>
<td>4</td>
</tr>
<tr>
<td>Cost (packaged as 2 robots)</td>
<td>Unknown</td>
<td>NA</td>
<td>$ 1 million</td>
<td>$ 1 million</td>
</tr>
</tbody>
</table>

*Cost excludes installation and “balance of plant”*
Robotics Summary

- Model is following the route of optical
- Sort speed per robot matches human; 50% of the time not sorting
- Well suited for quality control after optical sorting
- Higher purity results than optical
- Grippers and suction prone to wear and tear
- Expectation: We will see these as soon as low commodity prices break
Robotics Applications

• PET QC Sorter
• HDPE QC Sorter
• PP Sorter
• Aseptic Sorter
• OCC Sorter on Fiber Line
• Last chance sorter on residue line
Screens
Getting Rid of Screens

- Safety
- Downtime
- Parts Costs
- Dust
- Efficiencies Remain Low
- Throughput has Improved
- News is declining
Screen Alternatives?

- Reduce angle to horizontal - less agitation, size driven
- Ballistic Separators
- Make one paper grade
- Optical Sorters
Ballistic Separators: Early Applications

• Brini System- 1994
• Bezner- Inclined Sorting Machine 1996
• KWS- circa 1998
• Stadler- SIMS/Hugo Neu 2010
Simple Inclined Belt

Feed

Non-flat fraction

Flat fraction
Advanced Inclined Belt

Feed

Flat material discharge

Motion of belt

Rolling material discharge

Angle of incline $\beta$
City of Phoenix
Ballistic Separators-Today
Ballistic Separators-Today

Individual “Paddles” or “Slats”
Eccentric-crankshaft
Substantial agitation
Includes screening capability
Ballistic Separators-Today

- Can be stacked
- Can be angle adjusted
- NO WRAPPING
- NO DUST
- Throughput limitations
Vendors

- Hartner (BRT/Eggersmann) - Germany
- Komptech - Austria
- Machinex - Canada
- McLanahan - Pennsylvania
- Parini - Italy
- Stadler - Germany
Hartner/Metaltech
McLanahan
Ballistic Separator - Features

- Angle Adjustment
- Fans
- Covers
- Stacking
- 3 sorts
- Screening sizes of 2 inches to 4 inches.
- Widths of 5 ft. to 17 ft.
- Different paddle styles, widths and numbers
Call it a ‘dirty MRF’ or not, a single-bin system can work
Mixed Waste MRF Defined (aka “Dirty MRF”)

- Processes municipal solid waste to recover recyclables
- Uses similar equipment, processes & techniques as single-stream
- Includes special equipment unique to dealing with garbage
- Liberates, rough separation by shape and size & then more precise separation into target commodity materials
- Offers opportunity for organics recovery & alternative energy
The Need for a Business Case (1)

<table>
<thead>
<tr>
<th>Considerations</th>
<th>Mixed Waste</th>
<th>MRF</th>
</tr>
</thead>
<tbody>
<tr>
<td>% Non-recyclables after processing</td>
<td>80-90%</td>
<td>10-20%</td>
</tr>
<tr>
<td>% Recyclables recovery</td>
<td>80-90%</td>
<td>95-98%</td>
</tr>
<tr>
<td>Recyclables from market area</td>
<td>95+%</td>
<td>25-50%</td>
</tr>
<tr>
<td>Sizing of plant (residential only)</td>
<td>3-4x</td>
<td>x</td>
</tr>
</tbody>
</table>
The Need for a Business Case (2)

The math at this time is complicated, unsupported, political & volatile

- Data is not real
- Variables from location to location is high, no standard
- This is really about garbage, not recycling. Garbage is about $
- Tipping fees & economy affect flow, commodity prices affect everything

We are years away from knowing the costs....think back to MRFs & how long it took to understand those costs...
On the Other Hand...

**Mixed waste processing vs. landfill is a compelling debate**

<table>
<thead>
<tr>
<th></th>
<th>Landfill</th>
<th>Mixed Waste Diversion</th>
</tr>
</thead>
<tbody>
<tr>
<td>% Recyclables recovered</td>
<td>0</td>
<td>10%</td>
</tr>
<tr>
<td>% Organics recovered for further</td>
<td>0</td>
<td>25-35%</td>
</tr>
<tr>
<td>processing into biogas</td>
<td></td>
<td></td>
</tr>
<tr>
<td>% Materials recovered for further</td>
<td>0</td>
<td>45-55%</td>
</tr>
<tr>
<td>processing into RDF</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Remaining work</td>
<td>Minimal</td>
<td>Need:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- AD plant with answers for digestate</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- RDF plant with combustion component</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Landfill for residues</td>
</tr>
</tbody>
</table>
Concluding MWP Comments

- MWP is a high-value proposition for multi-family streams & rural communities

- MWP should not be thought of an alternative but rather as an incremental & complimentary tool for traditional source-separation, curbside recycling

- Be prepared: arguments about this subject often have little to do with recycling but rather with other institutional factors and of course, $ 

- MWP is effective in producing a variety of rich streams suitable as inputs to other processes; contaminated organics, mixed plastics & a refuse derived fuel (RDF)

- Create Realistic recycling goals

- Focus should be on MRF contamination levels
The MRF of Tomorrow
Technology Game Changers!

MRFs

— Ballistic Separators on Single Stream
— Optical Sorters on Fiber
— Robotics for containers complimenting Optical

Mixed Waste Processing MRFS

— Organics for Energy Recovery & Treatment
— Alternative Materials for Energy Recovery & Treatment