EBC Solid Waste Management Program

Innovative Alternative Technologies to Manage Municipal Solid Waste
Welcome

John Horak

General Manager

E. L. Harvey & Sons, Inc.
Program Introduction & Overview

Gretchen Carey

Program Co-Chair & Moderator

Recycling & Organics Coordinator
LEED Green Associate
Republic Services
New Market Opportunities for Waste and Recycling in New England

Craig Stuart-Paul

CEO
Fiberight
New Market Opportunities

We Can.
Significant value creation must be realized from the non-recyclable fraction of MSW for waste processing to compete with US Landfill

Current recovery rates 20%-30%

Fiberight’s $35M investment in development and commercialisation assets has unlocked a platform to valorize solid waste

Recovery potential >80%
A fully integrated “end-to-end” solution

Delivering refined products from MSW
Vision

Fiberight process

Organic Carbon Feedstock

Waxy Oils

Recyclates & Residues
Vision

Lowest Cost Carbon

Biogas

Biofuels

Biochemicals
China’s New Market Dynamic is Here to Stay

More environmental compliance inspections on Chinese enterprises
Low numbers of approved imports
More import prohibitions to come
100% inspections
China to be self-reliant in recycling by 2020

Little demand for materials to be recycled...demand for commodities already recycled.

Presidential term limits eliminated
Government restructures:

MEP → MEE w/more power
Customs & AQSIQ merge

Environment a top strategic priority
From import ban to approved finished products
The Critical 10,000 Hours
In 2007, the Municipal Review Committee began planning for waste disposal options for when its WtE disposal outlet faced closure upon the expiration of an above-market electricity contract.

The MRC board sought a solution that could improve upon the region’s moribund recycling rate, respect Maine’s environment, and provide a secure disposal solution for up to 40 years.
Fiberight was awarded the MRC contracts following negotiations around a financeable, robust solution that included a 15-year “put or pay” contract.

Construction on the project commenced July 2017, and is on track for completion by the end of 2018.

Fiberight closed $70M in project funding 12/22/17 and is fully funded to complete the project.
Commercialization
Commercialization

Fiberight
Why Maine?

- High Tip Fees
- Constrained Disposal
- Solid Community Support
- Low-Cost Residue Disposal

The Perfect Platform for Optimization

- High Cost of Energy
- Engineered Fuel & Biomass Offtakes
- Great Sailing & Outstanding Lobster!
Fiberight's 3-Year Optimization Plan

- **2018**
  - Core Process Optimization
  - Core Fiberight Process

- **2019**
  - Hydrolysis & Plastics Bolt-Ons

- **2020**
  - Hydrolysis & Plastics Bolt-Ons
  - New Project(s) Construction

- **2021**
  - Higher Value Products
  - New Project(s) On Line

Tip Fees [net] → Rebates → Value Creation [$/Ton MSW]
Closing Thoughts

How is the landscape changing?

- Technology to unlock value from certain waste is here
- Integrated waste processing plants will be operating in the next 3 years
- Price competitive with WtE and disposal in markets where recycling is mandated
- Carbon or landfill taxation could change the dynamic
- Institutional investment is flowing into advanced waste projects

A viable 3rd alternative for waste disposal is emerging. It will take time to perfect, but will ultimately become part of an evolving waste disposal infrastructure
Thank You

We Can.
Layered Approach: Recycling Organics and Managing Municipal Solid Waste to Highest and Best Use

Debra Darby

Program & Marketing Coordinator
Organix Solutions
Layered Approach™
Recycling Organics To Highest and Best Use
Organics Are Recyclable

Organics Recycling

Source Separated Organics at Home

Local Gardens and Public Parks

Local Use

Locally Produced
Our Mission

To provide cost-effective and sustainable collection and treatment solutions that recover organic waste and maximize the potential value of recyclable feed stocks.
Organics Recycling is as EASY as 1-2-3
Patented Organix Co-Collection™

Minnesota Pollution Control Agency and Department of Revenue

- Compostable bags were flexible and strong enough to withstand compaction in a waste collection vehicle
- Single waste collection vehicle can collect both organic waste and MSW waste in a single trip
- Eliminating the need for multiple trucks on even a relatively small scale has a significant environmental impact

Utility Patent US 9,669,431 B2
Issued June 6 2017

- Patent covers the method of collecting and processing of compostable organic waste material
Green Bag Organix™
Compostable Bag Evolution

• Over 44 cities in Minnesota have implemented Blue Bag Organics – 4 rural communities starting this month

• Outside of Minnesota the program is marketed as Green Bag Organix

• Bags are the same. Just different color

• Cost Effective and sustainable curbside program
Layered Approach™
Recycling Organics To Highest and Best Use

Layer One
Organix Co-Collection™ and Automated Sorting Robot

Layer Two
Material Recovery; Removal of 2” Minus

Layer Three
BurCell® System processes remaining organics into engineered feedstock

Layer Four
Engineered feedstock to composting or anaerobic digestion
### Waste Characterization
#### Municipal Solid Waste – Minnesota 2013

#### Recoverable Materials
- Organic Materials: 31.0%
- Paper: 24.5%
- Fines: 10.5%

#### Traditional Recyclables
- Plastics & Metals: 9.8%

#### Non-Recoverable Materials
- Problem Materials & Glass/Electronics: 3.4%
- HHW/HW: 0.4%
- Other Waste/Other Plastics: 20.4%

Total: 100.0%

Layer One: Organix Co-Collection and Automated Sort

- Organix Co-Collection curbside program
- Co-collected bags are delivered to facility mid or end-point
- Automated sorting robot removes compostable bags
- See video of Waste Robotics sorting
Layer Two: Materials Recovery Facility
Recovery of 2” Minus Material

2” Minus Material

20% - 30% of the waste stream is captured on 40’ long trommel screens

Of this 20% - 30%, **57% is organic material** *

Removing this material allows for additional capacity and improved efficiencies for other downstream processing

*Woods End Laboratories, Inc. 2015 Study
Layer Three: BurCell® System
Benefits for MSW based Anaerobic Digestion and Compost Project

Figure 1: Residential MSW being loaded
Figure 2: Processed MSW
Figure 3: 2” Screen Organics

BurCell® System cycles unprocessed residential MSW Pilot Scale Testing at Delano, MN Facility
Video of BurCell System
Pilot Scale Testing
BurCell System
Coker Consulting Report

• Improves the biodegradation potential of recyclable feedstocks for both AD and Composting

• Modifies the physical and chemical characteristics of feedstocks to increase the surface area-to-volume ratio

• Increases the carbon-to-nitrogen ratio (reduces potential for odor)

Table 1: Carbon-to-Nitrogen Ratio*

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Pre- BurCell® System</th>
<th>Post- BurCell® System</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon-nitrogen ratio</td>
<td>17:1</td>
<td>47:1</td>
</tr>
<tr>
<td>Bulk density</td>
<td>944 lbs/cubic yard</td>
<td>1095 lbs/cubic yard</td>
</tr>
</tbody>
</table>

Table 2: Biochemical Methane Potential (BMP)*

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Pre- BurCell® System</th>
<th>Post- BurCell® System</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biochemical Methane Potential</td>
<td>1663.6 cubic feet CH₄ / dry ton</td>
<td>4357.0 cubic feet CH₄ / dry ton</td>
</tr>
</tbody>
</table>

*Pre-BurCell System is November 2012 lab analysis of 2” minus organics-rich fraction of municipal solid waste from a Delano, MN materials recovery facility. Post-BurCell System data is Sept. 2015 pilot testing of BurCell System output in a privately-owned anaerobic digestion/composting facility.
Layer Four: Organic Material
Processed Engineered Feedstock

Highest and Best Use

Valuable organic material that would be trapped in the waste stream beyond Layer Two and be destined for

Compost
Anaerobic Digestion
State Legislation Around Organics

1,2 Sources: BioCycle 2014a survey from 39 states that responded; 2014b Rhode Island legislation effective 2016.
3 Source: MSW Management, 2015
4 Source: BioCycle 2015, denotes states that have 1 or more communities with residential SSO program; are not state-wide.
Current linear waste disposal system should be transformed to support organics processing.

Infrastructure is needed for organics recycling that supports commercial composting and anaerobic digestion.

Compostable Organic Waste

Benefits of Compost Use

• Sequesters carbon dioxide in soil preventing release into the atmosphere
• Increases soil moisture retention, reduces runoff into waterways
• Binds and degrades pollutants
• Reduces desertification - persistent degradation of ecosystems by variations in climate and human activities
• Diverting organic materials from MSW by reducing, recycling and composting are sustainable means to protect human health and the environment
Thank You.

Debra Darby, Program and Marketing Director
Debra.Darby@OrganixSolutions.com
Renescience – An Enzymatic Approach to the Recycling of Mixed Waste

Simon Chignell

Head of Project Development – United States
Ørsted Green Waste Solutions
Renescience - An Enzymatic Approach to the Recycling of Mixed Waste
Renescience is supporting Ørsted’s mission to create a world that runs entirely on green energy.

World’s largest Offshore Wind operation

Coal-free by 2023
Current state of the waste market in New England

Landfill closures

China sword – emphasis on quality

Long-term direction remains ‘zero waste’
A solution for **increased recycling** and green energy recovery to **divert from landfill and incineration** towards Zero Waste

Renescience contributes to Zero Waste by transforming the way we treat residual household waste, increasing recycling and generating green energy.
Renescience - the next-generation of waste treatment

1. Arrival
Bags are opened and waste is put into the reactor without pre-treatment

2. Liquification
Waste is mixed with warm water and enzymes inside the Renescience reactor

3. Separation
After up to 18 hours, all organic contents have been liquefied into a bioliquid. The remaining fraction goes into a ballistic separator

4. Anaerobic Digestion
Bioliquid generated produces green energy

5. Washing
Metals and hard plastic get washed and returned to the recycling stream

6. Final processing
Remaining fractions are processed to be used as engineered fuel

- High quality bioliquid
- Biogas plant
- Transport fuel
- Green gas
- Residual fraction is used as engineered fuel
- Hard plastic and metal is taken for reprocessing

Green power
Renescience – a sustainable solution using the full potential of organics

Using a patented enzymatic process, it can achieve better results

- Produces 60% more green energy
- 95% recycling of metals and plastics
- Up to 100% landfill diversion

Renescience process can enhance results from existing recycling programs

Lower impact on the environment relative to disposal alternatives

CO₂ emissions (kg/CO₂e)

Incineration: 332
Renescience: 78
Renescience Northwich - game-changing plant in the United Kingdom

- Facility treats 132,000 tons of waste per year
- Recycling of 3D plastic, ferrous and non-ferrous metals and inert materials
- Energy produced to supply up to 9,500 households

- Northwich – game-changing plant in the United Kingdom
Renescience is a new approach to mixed waste to help achieve Zero Waste

A zero waste solution for today’s market conditions:

**Economical**
- More renewable energy
- Competitive disposal cost / gate fee

**Practical**
- No additional sorting / collection required
- Simple solution to increase recycling

**Environmental**
- Low CO$_2$ footprint
- No adverse impacts at disposal sites
Innovation in Separation: Untapped Value from MSW

Peter Vinall

Co-Founder & President
Sustane Technologies, Inc.
Leading the world to **Zero Landfilled Waste**

Innovation in Separation: Untapped value from MSW

July 20, 2018

Peter Vinall
President
Sustane Technologies Inc.
Familiar?
Nova Scotia company that has developed disruptive technologies that deliver near complete separation and recycling of municipal solid waste (MSW)

Our mission is eliminating landfillsing worldwide, delivering a huge environmental benefit

- Patent granted in USA, European Union and others. Extensive trade secret IP.
- Main products are biomass pellets, synthetic diesel (internal use and sales), recyclables (metals, plastics)
- Nova Scotia Department of Environment formally recognized the Sustane process as recycling/diversion
- Chester, NS commercial project in late stage construction with start-up in Q4 of 2018
- Strong pipeline of projects due to intense interest across North America and globally
The Sustane process

- NOT incineration
- NOT gasification
- Makes clean fuel products and recyclable materials
- Low impact, thermo-mechanical processes

✓ 13 points of separation yields unprecedented purity
✓ Energy self-sufficient

Simplified process flows

- Core feedstock
  (MSW – after curbside recycling)

- Optional feedstock
  (Low value recycled film plastics)

- Shred/de-bond*
- Biogenic separation*
- Biomass cleaning*
- Biomass drying
- Proprietary separation*
- Pyrolysis & distillation*

- Recovered biomass fuel (Typ. 50%)
- Synthetic diesel

- Recovered metals (Typ. 5%)
- Recovered high density plastics (Typ. 5%)
- Inorganic residuals (Typ. < 10%)

* proprietary processes
Finally, a **CLEAN** way to **RECYCLE** MSW

### 200 tonnes per day MSW Case

**Sustane**
- Low capital (< $25m)
- Lowest operating cost
- Minimal environmental impact
- Most affordable
- Truly sustainable

### Incineration
- High capital (> $100m)
- High operating cost
- Reduced environmental impact
- Not affordable

### Landfill
- Low tech.
- Low operating cost
- High impact on environmental
- Not sustainable

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Assuming 50% Methane recovery (best case)
Energy products can be adjusted to the local markets

Core feedstock
(MSW – after curbside recycling)

Optional feedstock
(Low value recycled film plastics)

Option 1
Option 2

Gasification
Power generation

Sales options

Sustane Core Process

Energy products can be adjusted to the local markets

Core feedstock
(MSW – after curbside recycling)

Optional feedstock
(Low value recycled film plastics)

Option 1
Option 2

Gasification
Power generation

Sales options

Sustane Core Process
Chester commercialization project is nearing start-up!

- 70,000 tonne per year capacity
- MSW supply secured (20 years)
- Broke ground Q2 2017, start-up Q4 2018
- Equipment procurement and fabrication 95% complete
- Installation 75% complete
- 25 Employees - many higher skills
- Energy self-sufficient (25% of plastic derived diesel)
- Pellet offtake signed with power utility
- Plastic to diesel technology already built and testing underway
Chester Project – Nearing start-up
Equipment
GHG lifecycle analysis (Chester, NS at full capacity)

**Lifecycle Greenhouse Gas - Net Impact (70,000 tonne/yr MSW, Sustane vs Landfilling)**

- **CO2e reduction**
- **Net annual CO2e reduction**: 185,651 tonnes/year

- **Equivalent cars permanently removed from roadways**: 41,256

- **Sustane fuels replace fossil fuels**: 62,073
- **Recycling of materials**: 27,060
- **Elimination of landfilling (CH4)**: 103,713
- **Plant energy consumption**: 7,039
- **Plant construction**: 155

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Take-aways

- A new option for MSW
- Lower cost than landfilling
- MSW diversion level exceed 90%
- Flexibility for energy product outlet
- Phenomenal greenhouse gas attributes
- Scalable from 75,000 to over 300,000 tons per year
- Sustane owns and operates in exchange for a secure supply of MSW
Questions?
The Tinghu District Solid Waste Master Plan: Yancheng City, Jiangsu Province, China

George Aronson

Principal
CommonWealth Resource Management Corp.
The Tinghu District Solid Waste Master Plan
Yancheng City, Jiangsu Province, China

Presented to the EBC Solid Waste Management Program:
Innovative Alternative Technologies to Manage Municipal Solid Waste
The Tinghu District Solid Waste Master Plan
Yancheng City, Jiangsu Province, China
The Tinghu District Solid Waste Master Plan
Yancheng City, Jiangsu Province, China
The Tinghu District Solid Waste Master Plan
Yancheng City, Jiangsu Province, China
Feedstock: solid waste with 50% to 70% moisture (co-fired with 20% to 30% coal)
Air pollution control: duct lime injection with (undersized) electro-static precipitators
The Tinghu District Solid Waste Master Plan
Yancheng City, Jiangsu Province, China

Visible plume
The Tinghu District Solid Waste Master Plan
Yancheng City, Jiangsu Province, China
The Tinghu District Solid Waste Master Plan
Yancheng City, Jiangsu Province, China

- Canals for barges
- Residuals landfill
- Slurry/DP/AD
- 2500 tpd MWC
- Auto shredder and scrap metal processing
- MRF and/or MWP
- Plastics processing
- C&D/ABC processing
- Electric service line
- WWTP for liquids/sewage
- e-waste processing
Synova’s Solution for Waste-to-Energy

Bram van der Drift

Chief Technology Officer

Synova Power
POWER FROM WASTE IN FOUR STEPS

1. Pre-treatment
   - Remove water, glass, stones, metal, other recyclables

2. Gasification
   - Fluidized bed, 90%+ diversion from landfill

3. Gas cleaning
   - Tar and other contaminant removal, zero waste water

4. End Use
   - Highly efficient power via gas turbine or engines

Differentiated by proprietary technology
EFFICIENCY to POWER
higher than incineration

Net Electric Efficiency vs Power Output [MWe]

- MILENA / OLGA / engine
- MILENA / OLGA / gas turbine + steam turbine (IGCC)
- Incineration / steam turbine (waste)

- Synova plants
- High-efficiency incineration
- Conventional incineration
STEP 1: MAKING a SOLID FUEL: RDF

MSW reception

RDF: Refuse Derived Fuel

Recyclable materials

Mechanical separation

Manual separation
STEP 2: MAKING a GASEOUS FUEL (MILENA gasification)

- The Milena separates gasification and combustion into separate chambers within a single vessel.
  - In inner column, with little or no air, the feedstock quickly becomes gas at a relatively low temperature ~750°C.
- In outer chamber, carbon-rich particulate (char) and tars from downstream gas cleaning are combusted to fuel the process.
- Separate chambers mean CO\textsubscript{2} from combustion and N\textsubscript{2} from air feeding combustion do not mix with the syngas.
- The result is rich syngas with high energy per unit of volume, ideal for use in gas turbines, engines or for chemical processes.
- The rich syngas also means less volume to contain, clean and to compress, therefore less capital and expense.
- The drawback of low temperature gasification - more tars in the syngas - is solved by the OLGA gas cleaning system.
MILENA DOES NOT WASTE ENERGY

**energy production:**

\[
\text{fuel + air (} \lambda > 1 \text{)} \rightarrow \text{flue gas + heat}
\]

**energy consumption:**

\[
\text{fuel + heat} \rightarrow \text{gas + char}
\]

- Char and tar fuel the process (vs. posing disposal problems)
- No need to consume end product or add external energy source
### MILENA (and process) DESIGN based on many TESTS

<table>
<thead>
<tr>
<th>Material</th>
<th>Temperature</th>
<th>Additives/Processes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wood</td>
<td>650-950°C</td>
<td>With or without steam, sand or olivine as bed material, with or without additives (for different reasons), with OLGA, with or without BTX harvesting, with or without reforming and methanation, ... and various other processes and units</td>
</tr>
<tr>
<td>Contaminated wood</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Torrefied wood</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Straw</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grass</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Soya stalk</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sunflower husk</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rice husk</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MBM</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RDF (various)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Paper rejects</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wood/PolyStyrene</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wood/PolyEthylene</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plastic waste</td>
<td></td>
<td></td>
</tr>
<tr>
<td>High-ash coal</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lignin</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- H2, CO, CO2, CH4, C2H4, C3H6, C4H8
- Benzene, toluene, xylenes
- Tars
- H2S, COS, mercaptans, thiophenes
- NH3, HCN
- HCL
- Particles
STEP 3: CLEANING the GASEOUS FUEL (OLGA)

- Removes tars and particles efficiently, makes further cleaning conventional
- > 99.9% removal of unwanted tars (and particles)
- Lowers tar dew point from > 400°C to < 15°C, enabling transport via normal pipes
- OLGA allows the gasifier to be optimized for efficiency rather than tars
- Unlike alternatives, OLGA does this without compromises, e.g., high parasitic load
- OLGA consists of units which operate in virtually every refinery, at large scale
OLGA: NO WATER IN TAR and NO TAR IN WATER

Syngas cooler and cyclone: at these temperatures, tars and water-solubles stay in the gas phase, and **particulate is removed**

OLGA: at these temperatures, **tars are removed**, water solubles stay in gas phase

AQUA: water condenses and **water solubles are removed**, with no tar in the water
OLGA REMOVES TARS and PARTICLES

Before OLGA Gas Cleaning
(Gasified Waste As Used By Competitors, Flared For Illustration)

After OLGA Gas Cleaning
(Gasified Waste With Contaminants Removed, Flared For Illustration)
STEP 4: MAKING ELECTRICITY
SYNOVA PRODUCTS

1 - 1.5 MWe power production
30 tpd waste input
Modular design

8 MWe power production
160 tpd waste input
### SYNNOVA PLANTS (1)

<table>
<thead>
<tr>
<th>Reference</th>
<th>Operations</th>
<th>Feedstock</th>
<th>Results &amp; Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>40 kW Milena - OLGA - Engines, Chemicals</strong>&lt;br&gt;ECN Lab Facility Petten, Netherlands</td>
<td>2004 – to date (4500+ hours of operations)</td>
<td>Wide range of biomass and waste feedstocks</td>
<td>• Lab used for <em>first proof of MILENA – OLGA and applications</em>&lt;br&gt;• Actively used for testing of different downstream conversion and cleaning ‘back end’ units</td>
</tr>
<tr>
<td><strong>4.0 MW Fixed Bed Gasifier - OLGA - Reciprocating Engine</strong>&lt;br&gt;Engine Distributor Demonstration Plant Moissannes, France</td>
<td>2006 – 2007</td>
<td>Wood chips and pomace (grape residue)</td>
<td>• Successfully ran reciprocating engine on gas from biomass feedstock&lt;br&gt;• Role out of owner’s six intended biomass projects thwarted by economic downturn</td>
</tr>
<tr>
<td><strong>0.8 MW MILENA-OLGA-Engine, Turbine</strong>&lt;br&gt;ECN Pilot Plant Petten, Netherlands</td>
<td>2008 – to date (3000+ hours of operations)</td>
<td>Wide range of biomass and waste feedstocks</td>
<td>• Successfully ran feedstocks at actual field sizes, confirming MILENA – OLGA:&lt;br&gt;✔ scaled up predictably&lt;br&gt;✔ operated with RDF and a wide range of feedstocks</td>
</tr>
</tbody>
</table>
## SYNNOVA PLANTS (2)

<table>
<thead>
<tr>
<th>Reference</th>
<th>Operations</th>
<th>Feedstock</th>
<th>Results &amp; Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>4.0 MW ECN CFB-OLGA-Engine</strong>&lt;br&gt;Chicken Producer’s Commercial Plant Tondela, Portugal</td>
<td><strong>2010 - 2011</strong>&lt;br&gt;(owner entered insolvency)&lt;br&gt;<strong>2014 - 2015</strong>&lt;br&gt;(Leased by DRT for 2 years to run RDF)</td>
<td>Chicken manure / wood chips (2010-2011)&lt;br&gt;RDF (2014 -2015)</td>
<td>• <strong>DRT successfully demonstrated WtE capability at scale of SMM</strong>&lt;br&gt;✓ RDF feeding system&lt;br&gt;✓ Fluid bed gasifier of ECN design (MILENA precursor)&lt;br&gt;✓ OLGA&lt;br&gt;✓ Caterpillar 3516 engine</td>
</tr>
<tr>
<td><strong>4.5 MW MILENA-OLGA-Engines</strong>&lt;br&gt;Soya Processor's Commercial Plant Washim, India</td>
<td><strong>2017 - to date</strong></td>
<td>Soya stalks</td>
<td>• <strong>Successfully commissioned</strong> by Thermax and DRT, producing electricity out of Soya stalks&lt;br&gt;• Current level of operations is dependent on soya harvest&lt;br&gt;• Validates applicability to “electric islands”</td>
</tr>
</tbody>
</table>
Thank You!

www.synovapower.com
A Powerful & Intelligent Robotic Revolution

Rainer Rehn

Chief Compliance Officer
ZenRobotics Ltd.
A Powerful & Intelligent Robotic Revolution
New smarter technologies are needed to meet the requirements of today
How does a ZenRobotics HP work?

1. ZRR Sensor unit scans the waste stream.
2. ZenRobotics Brain control software analyses data and controls the robots.
3. ZenRobotics Brain identifies materials, objects and gripping points.
4. ZenRobotics Smart Gripper picks the desired objects.
5. Robots sort multiple fractions in one spot.
Why robots?

Robots like jobs that are Dirty, Dull and Dangerous!
Autonomous operations 24/7

- Increase recovery
- Maintain high purity
- Minimize manual sorting
- Maximize capital efficiency
Designed for waste processing!

- Robust design suited for waste
- Adapts to various sorting needs
- Proven technology
Unlimited number of fractions

Construction & Demolition Waste
Wood sorting (A-grade, B-grade, C-grade)
Rigid Plastics (By polymer, color, shape)
MSW (Quality Control, Reject Recovery)
Textiles

Commercial & Industrial Waste
Scrap Metals
Sorting bags by color
QC of LPW, DMR

What’s your sorting task?
The right robot for each sorting task

ZenRobotics Heavy Picker (HP) for heavy & bulky waste

ZenRobotics Fast Picker (FP) for small & light materials
ZenRobotics HP
ZEN Robotics

Heavy Picker [https://youtu.be/hUKNTaPQwBc](https://youtu.be/hUKNTaPQwBc)

Fast Picker [https://youtu.be/5UIs-kFtqGA](https://youtu.be/5UIs-kFtqGA)
ZenRobotics FP

AUTONOMOUS QUALITY CONTROL IN MRF’S
RESIDUE RECOVERY
POSITIVE SORTING OF DMR / MSW

✓ Designed for recycling!
✓ Modular & compact design
✓ Install as multiple successive systems
✓ Easy to install, fits most conveyors widths
✓ 4000 p/h, 67 p/min
ZenRobotics FP

✓ Replaces manual labor
✓ Increases recovery
✓ Superb sorting quality
✓ Sorts unlimited number of fractions
✓ Makes 24/7 operation of entire plant possible
100% designed for recycling

- Heavy duty H-bot robot arm
- Collision-resistant mechanisms
- Entirely designed for waste sorting
- Survives dust, dirt & hard work

One unit: 4000 p/h = 67 p/min
Compact & modular

- Fits hand sorting cabin dimensions
- Small overall footprint
- Designed for installation as multiple successive systems

Two units: 8000 p/h = 133 p/min
Invincible picking power

- Vertical stroke 18” - lifts the objects high high over other material, no swiping
- Picks using powerful anti-clog ejector
- Designed for dirty conditions
- Work area of each arm 75” x 24”
- Can be tailored

Four units 16 000 p/h = 267 p/min
Monitor and control your robots

- Easy access to site-specific performance data
- Online analysis of the waste stream and sorting results
- Key performance information for controlling and optimizing your production
- Easily accessed online anywhere in the world on your PC, tablet or smartphone

*) Available for HP models in 2018
Based on years of experience in real life

ZenRobotics – the worldwide market leader with proven technology
Over 10 Billion picks - and counting!
Robots installed all over the world!
Recon Services, Austin, Texas

Award-winning waste sorting

- ‘C&D Recycler of the Year 2018’ (The Construction and Demolition Recycling Association, CDRA)
- ‘Texas Environmental Excellence Award, TEEA, by Texas Commission on Environmental Quality

- Hybrid sorting: simultaneous positive and negative sorting
- ZenRobotics Heavy Picker (2 arms)
- Sorting task: inert, metals, plastics, wood, cardboard, trash
- Very high throughput
V8, Singapore

• ZenRobotics HP 3 (three arms)
• State-of-the-art Facility
LVHE Environmental Technologies
Jiangsu, China

- 2 x ZenRobotics HP 3 (6 arms in total!)
- Multiple robots for maximal efficiency
Sunshine Groupe
Melbourne, Australia

- State-of-the-art plant, virgin waste & landfill mining
- First plant with three armed ZRR (1 x ZRR3)
- Sorting task: wood, inert, metals, plastics
Remeo (former SUEZ), Helsinki Finland

- Plant capacity: 15-20 tons / hour
- Plant area: 42m x 25m
- Plant power consumption: 60-80 kW
- 2 x ZenRobotics Heavy Picker (1+2 arms)
- Sorting task: C&D (metals, wood, stone, rigid plastics)
- Possibility to run 24/7
- Low operating cost
- The most energy-efficient sorting station in the world
Carl F
Malmö, Sweden

- Simple and efficient process
- Two robot arms (1 x ZRR2)
- Sorting task: wood, inert, metals, plastics
- Runs every night unmanned until all waste is processed
Veolia
Vittrolles, France

- State-of-the-art plant
- Two robot arms (1 x ZRR2)
- Sorting task: wood, inert, metals, plastics
- Plant designed for 24/7 operation
How to train your own robot

Training principle:
1. Pick by hand 50 – 500 objects of the fraction you want to have sorted
2. Tap “Train” on the touch screen
3. The system will ask you to give the fraction a name. Type name on touch screen
4. Put the hand picked objects on the sorting belt and let the system scan them
5. Tap “Memorize”. That’s it!
6. The ZenRobotics Brain will now create its own algorithms of how to identify the desired category of objects

*) Available for HP models in 2018
Is it for your company?

Yes! ZenRobotics is suitable for all companies who want to benefit from efficient and flexible robotic waste sorting.

At ZenRobotics you can choose the correct robot model for each task!

Join the world leader in robotic sorting!
ZenRobotics Ltd.

- Founded in 2007
- ZenRobotics is the world leader in robotic waste sorting technology
- Since 2009 full focus on waste sorting
- In 2018 40+ employees
- Robots sold to 12 countries
- Privately held company owned by management, employees, and long-term private equity investors
How do I get my own ZenRobotics?

1. For North American solutions-Plexus Recycling Technologies;
   - Jeff Tucker 720-979-5687
     - SVP Plexus j.tucker@plexusrt.com
     - Marcel Vallen 720-480-0080
     - CEO m.vallen@plexusrt.com

2. See the robots LIVE at one of our reference sites

3. **RENT- LEASE – BUY** options and financing available

   For more information call or email us.
   Or visit [www.zenrobotics.com](http://www.zenrobotics.com) or [www.plexusrt.com](http://www.plexusrt.com)

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Someday our grandchildren will ask us what we did with their future…
We’re working on intelligent answers right now...

Josef Heissenberger (1955 – 2014)