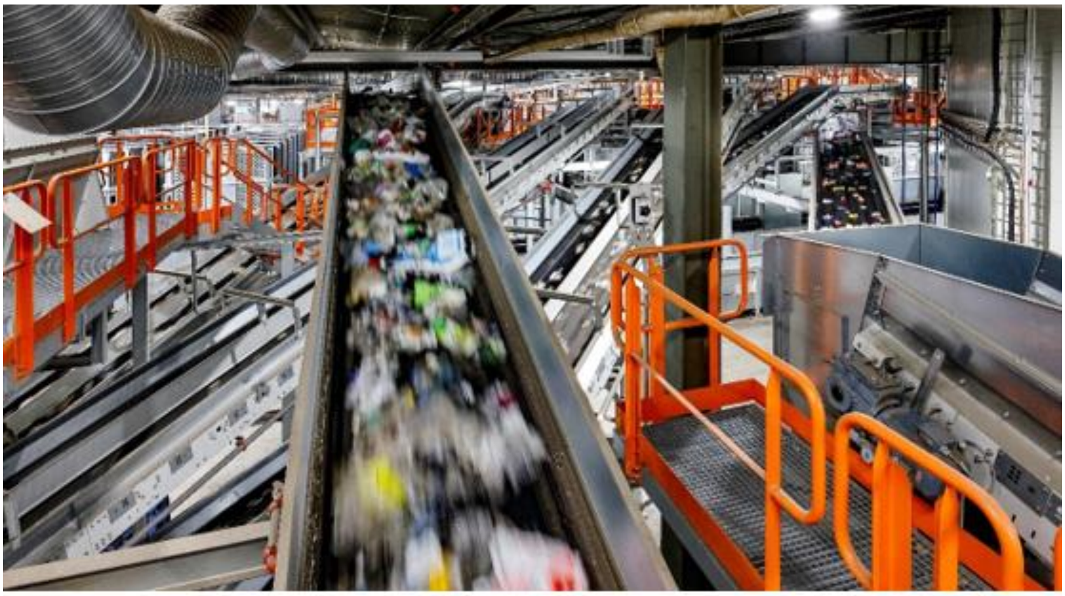
Advanced sorting technologies in the waste sector

Case studies compilation

IEA Bioenergy: Task 36

July 2024



Technology Collaboration Programme
by iea

Advanced sorting technologies in the waste sector

Case studies compilation

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IEA Bioenergy: Task 36

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Preface

This report is a case studies compilation on advanced sorting technologies for waste in the field of material and energy valorisation of waste within the framework of IEA Bioenergy Task 36. The purpose of this report, as all the work carried out by Task 36, is to showcase examples from which countries can get inspiration and support in implementing solutions in the waste/resource management and Waste-to-Energy sector that would facilitate their transition towards circularity. The case studies presented in this compilation were selected due to their relevance in the field of waste sorting technologies in their respective countries. However, IEA Bioenergy Task 36 does not endorse any commercial products that may be mentioned on this report.

IEA Bioenergy Task 36, working on the topic 'Material and Energy Valorisation of Waste in a Circular Economy', seeks to raise public awareness of sustainable energy generation from biomass residues and waste fractions including MSW as well as to increase technical information dissemination. As outlined in the 3-year work programme, Task 36 seeks to understand what role waste-to-energy and material recycling can have in a circular economy and identify technical and non-technical barriers and opportunities needed to achieve this vision.

See http://task36.ieabioenergy.com/ for links to the work performed by IEA Bioenergy Task 36.

Summary

The use of AI and digital tools will have an impact on the waste and energy sector. When applied to waste sorting, advance sorted technologies should allow to increase the type and number of materials that can be separated, improve quality, optimize process in terms of efficiency, time, and costs; but they will also reduce the need for humans (manual sorting) in this work environment as they will turn into mostly automatized processes, having a positive impact on social aspects. The use of cutting-edge technology results in a double environmental positive effect: (i) material is recovered to be sent to recycling preventing the extraction of virgin material/new resources; (ii) some of the material recovered escapes from being landfilled or incinerated and avoiding incineration of recyclable waste fractions such as fossil-derived plastics leads to a mitigation of the CO_2 emissions from the WtE plants limiting this pathway to unrecyclable fractions.

This report is a compilation of case studies highlighting the use of new technologies in the waste management industry for increasing material recovery of recyclable waste fractions that otherwise might go to energy recovery or be landfilled. The material sorted contributes to reach the recycling targets set by, for instance, EU. The cases included in this compilation are:

SITE ZERO (Svensk Plaståtervinning i Motola AB): The smart sorting technology in Site Zero, a state-of-the-art plastic sorting plant in Sweden, aims to realize a circular economy for plastic packaging. It has the capacity to receive all the plastic packaging generated by the Swedish households; and sorts mixed plastic packaging from households into 12 different fractions. The novelty of this plant relies on the combination of different technologies.

AMP ONE Cleveland (AMP): This facility is a showcase for the use of AI-powered sortation to increase recycling rates and economically recover recyclables in the USA. It sorts all traditional recyclable products (i.e. HDPE, PP), but also sorts custom streams such as bales by colour and opacity, pyrolysis feedstock, and methanolysis feedstock.

Abbreviations

AI - Artificial Intelligence

EPS - Polystyrene

HDPE – High density polystyrene

ISRI – The Institute of scrap recycling industries

MSW – Municipal solid waste

MRF – Material recovery facility

NIR - Near infrared

OCC - Old corrugated cardboards

PET – Polyethylene

PLC – Programmable logic controller

PP – Polypropylene

PRF- Plastic reclamation facilities

PS – Polystyrene

PVC – Polyvinyl chloride

UBC – Used beverage can

VIS – Visible images

WtE - Waste-to-Energy

Background

In a circular economy, materials can be recovered and upgraded to new high value products or reused keeping the material in-the-loop as long as it is safe from an environmental and health perspective. Developing and implementing smart sorting technologies in the waste management industry generates new possibilities to keep materials in circulation and create business opportunities[1].

Material recovery is key for diverting material from being landfilled in countries where this waste management approach remain among the most common. At the same time, the Waste-to-Energy (WtE) plants have been globally urged to take actions to reduce CO_2 emissions and the sector is looking for solutions to become more CO_2 neutral (or even negative). It is estimated that for each ton of waste burned, 0,7-1,7 tonnes of CO_2 are released depending on the type of waste feedstocks[2]. Fossil-derived material account for a significant part of the waste incinerated and, therefore, are responsible for fossil CO_2 emissions from the incineration plants[3]. The implementation of central sorting plants prior to incineration to sort out recyclable waste fractions such as plastic packaging would lead to both material recovery and reduction of fossil carbon dioxide emissions. WtE in the future should only be limited to non-recyclable waste streams.

The use of AI and digital tools will have an impact on the waste and energy sector. When applied to waste sorting, advance sorted technologies can expand the type of materials that can be sorted out, improve quality, optimize waste management processes in terms of efficiency, time and costs; but they will also reduce the need for humans (manual sorting) in this work environment as they will turn into automatized processes, having an impact on social aspects. The use of cutting-edge technology results in a double environmental positive effect: i) material is recovered to be sent to recycling preventing the extraction of virgin material/new resources; (ii) some of the material recovered escapes from being landfilled or incinerated and avoiding incineration of waste fractions such as fossil-derived plastics leads to a mitigation of the CO_2 emissions from the WtE plants while getting closer to limiting this pathway to unrecyclable fractions.

The use of new technologies applied to waste sorting has been one of the topics of interest for IEA Bioenergy Task 36 in the last years resulting in several publications in this field[4,5]. This report is a compilation of two case studies where IEA Bioenergy Task 36 wants to illustrate the use of new technologies based on AI and digital tools in the waste industry to provide solutions for increasing material sorting and recovery and hopefully reducing the climate impact of the waste management sector. The case studies presented in this compilation were selected due to their relevance in the field of waste sorting technologies in their respective countries. However, IEA Bioenergy Task 36 does not endorse any commercial products that may be mentioned on this report.

SITE ZERO (Svensk Plaståtervinning i Motola AB), is a state-of-the-art plastic sorting plant in Sweden with capacity to receive and sort most of mixed plastic packaging generated and source-sorted by the Swedish households; while AMP ONE Cleveland (AMP), is a showcase for a fully automated sorting facility using AI-powered sortation to increase recycling rates and economically recover recyclables in the USA.

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[1] IEA Bioenergy Task 36: Material and Energy Valorisation of Waste in a Circular Economy. Home - Task 36 (ieabioenergy.com) (Access. 10/04/2024).
[2] Pollution inventory reporting – incineration activities guidance note, available from: Pollution inventory reporting – incineration activities guidance note (publishing.service.gov.uk)(Access: 10/04/2024).
[3] Report: In-depth analysis of plastics in household residual waste and its potential for increased material recycling and reduced climate impact; Edo, M. et al. (2024). Link to the report. (Summary available in English). (Access: 10/04/2024).
[4] IEA Bioenergy Report: Sorting Technologies: Case study about MSW sorting facility in Norway; Edo, M. Meissner, R. Nilsson, J. (2022). Link to the report. (Access: 10/04/2024).
[5] IEA Bioenergy Report: Case study about MSW sorting facility in Italy – Eco+Eco Srl.; Ciceri et al. (2024). Link to the report. (Access: 10/04/2024).

Case 1: Site Zero – a state-of-the-art plastic sorting plant in Sweden

Site Zero aims to realize a circular economy for plastic packaging by sorting post-consumer plastic packaging into 12 different fractions with high quality/purity. Site Zero boasts over 60 Tomra Autosort machines, forming a 5 km sorting line equipped with sorting systems. Depending on the specific sorting task, each Tomra Autosort has a specific sensor configuration. The plant uses NIR/VIS, laser, GAIN (deep learning camera system) and electromagnetic sensors. Additionally, it is equipped with screening drums, ballistic separators, exhaust air technology, compaction systems, an intelligent bunker management system, fully automatic baling presses and digital process monitoring. Combined, this complex sorting system ensures both high recovery rates of targeted plastics and quality of the sorted fractions.

Site Zero has the capacity to sort 200,000 tons of plastic packaging waste per year. By sorting 10 fractions of mono plastic and 2 mixed polyolefin fractions (laminates and multilayers), most of the plastic packaging from households can be sorted for recycling. Through more efficient sorting, and subsequent high quality plastic recycling[6], Site Zero contributes to a reduced climate footprint from plastic packaging and improves the opportunities to reach the Swedish recycling goals.

The smart sorting technology used at the state-of-the-art plastic sorting plant Site Zero allows the recovery of 12 different fractions (10 mono plastics and 2 mixed plastic) from plastic packaging from households.

Site Zero has a sorting capacity of 200,000 tons of plastic packaging per year – enough to receive all the plastic packaging from Swedish households.

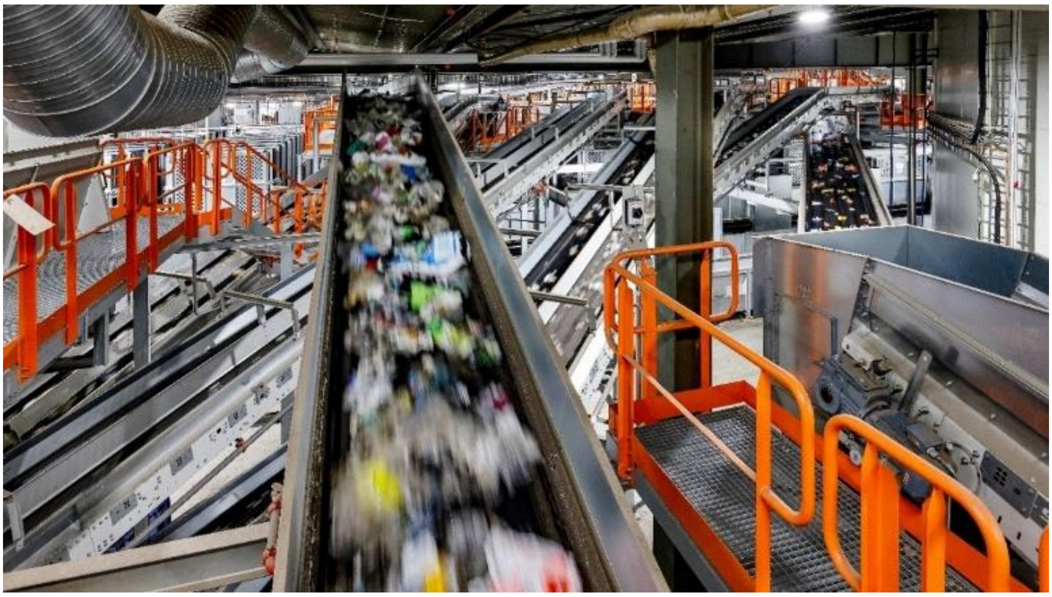

Figure 1. Site Zero, sorting line.

About the plant

[6] European Parliament legislative resolution of 24 April 2024 on the proposal for a regulation of the European Parliament and of the Council on packaging and packaging waste, amending Regulation (EU) 2019/1020 and Directive (EU) 2019/904, and repealing Directive 94/62/EC (COM(2022)0677 – C9-0400/2022 – 2022/0396(COD)).

Name: Site Zero.

Type of facility: A sorting and recycling plant for source-sorted household plastic packaging waste. From mixed household plastic packaging waste, 12 plastic fractions are sorted and sent for recycling externally. The plant also has capacity for in-house recycling of one fraction of mixed polyolefins through dry washing and agglomeration.

Owner/Operator: Swedish Plastic Recycling (Svensk Plaståtervinning i Motola AB), in turn owned by trade associations representing the packaging producers and the plastics industry.

Location: Site Zero is situated in Motala, Southern Sweden, a logistically strategical location between Stockholm, Gothenburg, and Malmö.

Capacity: It has an annual capacity of 200,000 tonnes (equally distributed into 2 sorting lines) and currently operates 24 h/day 5 days per week. Throughput of 42 tonnes of mixed plastic packaging waste per hour at full capacity.

In 2023, Size Zero treated 95,000 tonnes of mixed plastic packaging waste. With import of plastic packaging from neighbouring Nordic countries and extended kerbside collection system in Sweden under development until 2027, it is anticipated that the plant will reach full capacity utilization in 2026.

Site Zero has the capacity to receive and sort most of mixed, source-sorted plastic packaging from Swedish households, fulfilling the extended producer responsibility for approximately 8,500 business customers.

History: The first sorting line was inaugurated in 2019, as an answer to the identified need to improve sorting quality and capacity for household plastic packaging waste in Sweden. However, it soon became evident that sorting the four most common plastic types did not match the ambition to make all plastic packaging part of the circular economy. Hence, the plant was developed with a second sorting line, inaugurated in November 2023, following a three-year planning and construction phase. With the second sorting line, an expansion of the first one and an additional reject sorting to recover additional mono plastic packaging and multilayer packaging, Site Zero is now equipped to sort 12 fractions instead of 4.

Investment: About SEK 1 billion (2019-2023). The development of Site Zero has received funding from the Swedish Environmental Protection Agency (Natuvårdsverket) through the Climate Leap (Klimatklivet), a national initiative promoting emission reducing technologies and solutions, partly financed by a European development fund (NextGenerationEU).

KEY FACTS ABOUT THE PLANT

- The world's largest sorting and recycling facility for post-consumer plastic packaging
- Annual capacity: 200,000 tonnes
- Up to 95 % of plastic packaging sorted for recycling
- >90% purity of sorted fractions
- Fully automated sorting process with 5 km of conveyor belts and 60 NIR sensors

Waste streams

Type of waste streams handled: Source separated post-consumer plastic packaging and packaging recovered from household residual waste through material recovery facilities. The material has not gone through any treatment except for baling before it arrives to the plant. Site Zero receives most of the mixed plastic packaging which has been source separated by Swedish households.

Waste composition: Disregarding moisture content, around 75% of the incoming material is plastic packaging, and remaining 25% is other type of plastic than packaging (approx.10%) and other materials such as metals, textiles, paper/cardboard, organic waste etc. (approx. 15%).

Technology details

Brief description of the process: Mixed post-consumer plastic packaging waste enters the sorting process as bales. After the wires around the incoming bales have been removed, shredders and bag openers installed at the beginning of each sorting line are used to separate the compressed bales into individual packaging pieces. It is key for the efficiency of the sorting process that the material is well separated and evenly dispersed on the conveyor belts. Once the material has passed the shredders, magnets mounted above the conveyor belts remove magnetic metal objects.

The material stream is then separated in several sub-streams by size, through trommels with different-sized holes along the axis, followed by disc screens and vibrating screens separating and removing the smallest objects. The size-sorted material passes a combination of vacuums and ballistic separators to separate films/flexible plastic and rigid plastic. NIR-sensors in several steps are then used to detect targeted plastics as well as non-targeted material (e.g. paper) across the conveyor belt through Near-Infrared (aka NIR) light, and according to the reflected spectrum sort the targeted materials via pneumatic ejection. Depending on the specific sorting task, each NIR sensor has a relevant configuration. To increase quality of the sorted material, there are (at least) two step NIR-sorting for each fraction: the first step aims at picking out the targeted plastic fraction, the second step aims at identifying and removing anything that is not the targeted stream. The NIR-technology cannot distinguish black plastic from other contaminants, so lasers are used to detect and recover black plastic objects from the reject streams.

To improve the recyclability of the sorted material, cameras with AI (Tomra's technology GAIN - deep learning camera system) are used to remove certain packaging types in some of the mono streams (e.g. plastic packaging that might contain product residues which are problematic for the recycling process). The sorting line is also equipped with recovery units, which can detect and return incorrectly separated material to an earlier step in the sorting process.

Bunkers storing the sorted fractions are emptied automatically, and the sorted material is then re-baled.

List of key technological components:

- 2 shredders
- 4 bag openers
- 5 magnets for removal of wires and other magnetic metal objects
- 4 trommels, sieving the material through a drum screen with different-sized holes to separate the material by size
- 2 disc screens separating objects between 15 and 50 mm from the larger objects
- 2 vibrating screens removing pieces or objects smaller than 15 mm
- 8 vacuum units, separating larger pieces of film from rigid plastic through vacuums mounted over the conveyor belts
- 6 ballistic separators, separating the material into plastic film and rigid plastic
- 60 NIR – Tomra Autosort sensors with associated pneumatic ejection, identifying and sorting (ejecting) the different targeted plastic types
- 3 lasers – Tomra Laser Object Detection - for detection and recovery of black plastic
- 2 metal detectors
- 3 cameras with AI (GAIN - deep learning camera system), identifying and removing unwanted

objects in the sorted streams
- 4 balers

Innovative features: The technological setup in Site Zero is fully automated forming a 5 km sorting line equipped with over 60 Tomra Autosort machines and sophisticated sorter systems. The novelty lies primarily in the combination of technologies, the scale and the scope of the sorting. The plant uses NIR/VIS, laser, GAIN (deep learning camera system) and electromagnetic sensors. Additionally, it is equipped with an intelligent bunker management system, with fully automatic bailing presses and digital process monitoring.

Technology Readiness Level: TRL 9 since the whole system is fully implemented and operational at industrial scale.

Deployment environment: The technology applied at Site Zero could also be used by material recovery facilities, plastic recyclers, municipal plastic packaging waste sorting plants. Many of the technological components used at Site Zero are used widely across the waste management sector for separation and sorting of different materials.

Integration with existing waste treatment plants: Large Swedish WtE plants treating residual household waste have shown an increasing interest in Material Recovery Facilities (MRF) as a pre-treatment to remove plastic packaging from the incoming waste before incineration. There is currently one MRF operational in Sweden (Brista Material Recovery Facility in Märsta) and several more are being built. Beyond source separated plastic packaging, the new sorting line in Site Zero is adapted to efficiently sort plastic packaging waste recovered from these MRFs, thereby serving as an enabler for extended MRF capacity. As almost 50 % of household plastic packaging in Sweden currently ends up in the residual household waste, this is an important complement to the existing system for source separated collection.

> The novelty of this plant relies primarily in the combination of technologies.

Performance metrics

Sorting efficiency: Up to 95 % of the plastic packaging in the incoming waste can be sorted out for recycling. An average purity[7] of more than 90 % for the mono plastic fractions.

Throughput: 42 tonnes of mixed plastic packaging waste per hour at full capacity.

Technical challenges during operation: High risk of fires, especially in the shredders, primarily due to high occurrence of batteries in the incoming material. Both sorting lines are therefore equipped with a sophisticated fire detection and protection system.

The whole process is fully automated and digitally monitored to promote efficiency. Material blockage can occur but is handled through regular service and good process monitoring, and weekly planned production stops for maintenance.

Flexibility of the system: The system tolerates 20-30 % impurities – other materials than plastic, non-packaging, etc.

[7] Correctly sorted material in the targeted fraction.

Site Zero has improved sorting efficiency from 47% in the first sorting line to up to 95 % of the plastic packaging in the current plant, doubling the material recovery rate.

Recovered materials /products

Type of material recovered: Rigid PP, rigid PE, flexible PE, flexible PP, transparent PET trays, transparent PET bottles, coloured PET bottles, EPS, PS, PVC, two grades of mixed polyolefin laminates.

What are these materials used for? The sorted mono plastic fractions are sent for high quality recycling at EUCertPlast[8] certified recyclers in Europe. However, some fractions, like EPS, are new to the market in the form of post-consumer plastic from households, and suitable sorting qualities and recycling processes are currently tested and evaluated in collaboration with European recyclers.

The good quality of the sorted mono fractions enables high quality recycling, allowing the recyclate to be used in the production of new packaging or other plastic products where the recycled material directly substitutes virgin material.

The mixed polyolefins can be turned into an agglomerate or be used more or less directly, in the production of thick-walled products like pallets or cable drums. These material streams are also tested in different research and development projects together with chemical recycling partners.

About by-products/reject fraction: The incoming material contains on average 25% of non-packaging and non-plastic materials. Magnetic metals are separated and sent for recycling. Other combustible materials – along with plastics with size smaller than 15 mm and sorting losses - end up in the so-called reject fraction and is sent for energy recovery within Sweden.

Environmental impact

Site Zero contributes to increased resource efficiency as well as reduced climate impact from waste handling of post-consumer plastic packaging through diverting fossil, recyclable material from incineration to recycling.

Material recovery rates: By targeting the most common plastic types used in packaging applications, the extensive sorting system can capture up to 95% of plastic packaging in the incoming material. With a well-designed plant, where missorted material is recovered back at the beginning of the process and even the smallest plastic objects (down to 15 mm) will be sorted.

Approx. 80 % of the incoming plastic packaging material can be sorted out in one of the 10 mono fractions (PE film, PP film, HDPE, PP, transparent PET bottles, coloured PET bottles, PET trays, PVC, EPS and PS). An additional 10-15%, of predominantly laminates, are recovered and sorted out as mixed polyolefins. Mono materials slipping past the initial sorting and the recovery units can also be recovered in the mixed fractions.

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[8] European Certification of Plastics Recyclers | EuCertPlast (Access 15/02/2024)

About energy: The sorting process requires electricity. Internal logistics are carried out with electric forklifts, a diesel wheel loader and a small container truck.

The reject fraction is sent for energy recovery in combined heat and power WtE plants in Sweden. Recovered metals are sent for recycling.

Climate impact & emissions: Swedish Plastic Recycling calculates its climate impact according to the Greenhouse Gas Protocol and the results for 2022 reads as[9]:

1. Scope 1: 7.2 tonnes CO_2-eq
2. Scope 2 (market-based): 28 tonnes CO_2-eq
3. Scope 3: 17360 tonnes CO_2-eq

These figures correspond to sorting approximately 95,000 tonnes of mixed plastic waste (including material contaminants). Scope 3 includes emissions from activities throughout the value chain – from the point where the packaging becomes waste, to the end-of-waste stage where sorted and recycled plastic has become a new secondary raw material.

Swedish Plastic Recycling has performed a carbon footprint analysis on the sorting system – and subsequent recycling - in comparison with a waste management system with only energy recovery, and a waste management system promoting downcycling (co-recycling of mixed plastics into a plastic composite product). The results are presented in a policy brief from IVL Swedish Environmental Institute[10], and implies that high quality recycling entails the lowest carbon footprint, through reducing incineration of plastic waste as well as enabling substitution of virgin plastic.

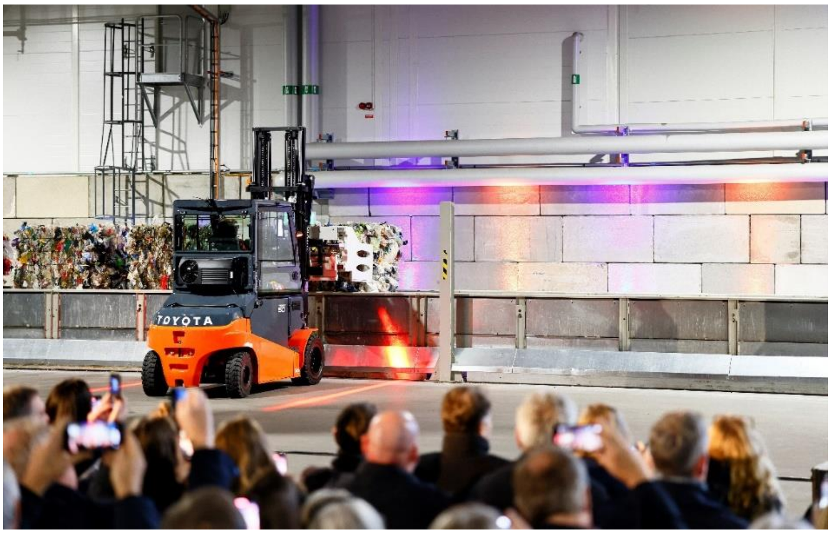

Figure 2. Site Zero plant. Inauguration of line 2 on the 15th of November 2023.

[9] Svensk Plaståtervinning, Hållbarhetsrapport 2022. Link: https://www.svenskplastatervinning.se/hallbarhet/ (Only available in Swedish) (Access: 05/01/2024)
[10] IVL Swedish Environmental Institute, Policy brief: Högvärdig plaståtervinning – vad är nyttan och hur kommer vi dit? (2022) Link: httpurnkbseresolveurnurnnbnseivldiva4089.pdf (Only available in Swedish). (Access: 15/02/2024).

Societal considerations

Job creation: The plant has helped to create approx.115 local and regional jobs since 2018.

Community involvement: Since the opening of the first sorting line, in 2019, the facility has had more than 4000 local, national, and international visitors. Represented among those visitors are packaging producers and brand owners, plastic recyclers and converters, academia, media, public sector, NGO:s, politicians and locals.

Case 2: AMP ONE Cleveland - a fully automated AI-powered sorting plant in the USA

The AMP ONE plant outside of Cleveland (Ohio, US) aims to recover recyclables in waste streams that otherwise would be lost to landfill despite the demand for high-quality recycled content from consumer-packaged goods companies. For more than three years, the technology provider AMP was testing the capabilities of AI and automation to direct facility design, with a focus on lowering the cost of recycling while maximizing yields in terms of both recovery and quality, resulting in the technical solution AMP ONE. AMP's Cleveland facility is a showcase for sorting technology.

AMP's Cleveland plant has a capacity for up to 55,000 tons waste per year across a variety of mixed feedstocks. It sorts a variety of recycling products, such as HDPE, OCC (Old corrugated cardboards), PP, and UBC (used beverage can). It also sorts advanced and custom feedstocks such as bales by colour and opacity, pyrolysis feedstock, and methanolysis feedstock. The facility contributes to a reduced climate footprint by diverting material from landfill.

AMP ONE outside Cleveland is a showcase for a fully automated sorting facility using AI-powered sortation to increase recycling rates and economically recover recyclables.

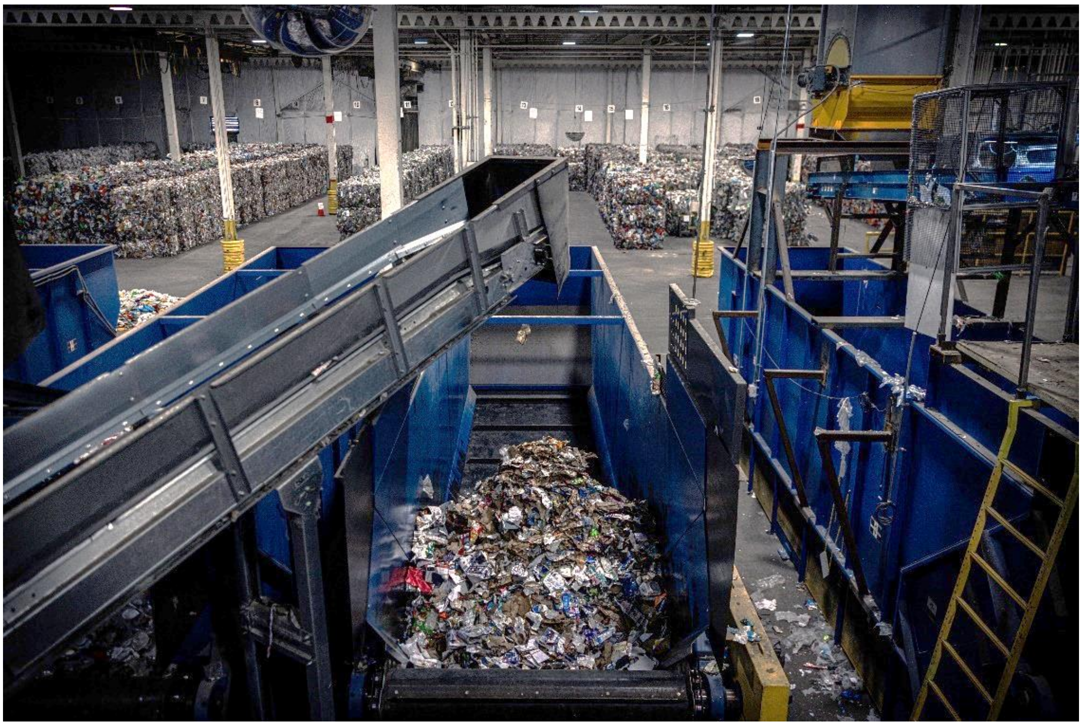

Figure 3. AMP ONE Cleveland facility.

About the plant

Name: AMP ONE or AMP processing facility outside Cleveland.

Type of facility: Fully automated smart sorting plant.

Owner/Operator: AMP owns and operates the plant.

Location: Solon, (Ohio, US).

Capacity: It has an annual capacity 50 ktons and can operate between 8 and 18h/day, up to 6 days per week. Depending on the feedstock, it supports throughputs up to 18 tons per hour.

Technology provider: AMP Robotics Corporation (AMP)[11].

History: AMP launched its first AI-powered sortation facility in Denver in 2020 focused on economically processing recyclable mixed plastics, paper, and metals sourced from residue supplied by MRFs and other material providers. After that, AMP brought online additional facilities powered by its application of AI for material identification and advanced automation, one being AMP ONE in Cleveland. AMP ONE systems are also installed at Recycling and Disposal Solutions of Virginia (RDS) facilities in Greenville, North Carolina, and Portsmouth, Virginia.

KEY FACTS ABOUT THE PLANT

- Facility processing material entirely with AI, without manual sortation
- Annual capacity 50,000 tonnes
- Recovering the majority of material at > 95% uptime
- First facility of its kind in the country sorting landfill-bound residues from multiple types of recycling infrastructure

Waste streams

Type of waste streams handled: AMP's Cleveland facility can process a varying set of input feedstocks, ranging from MRF residues to single-stream recycling, mixed plastics, and some specialized feedstocks of consumer-packaged goods. It can adapt its configuration to best optimize for value per hour for the material it is processing, allowing it to maintain a small footprint and cost, while servicing multiple infeed types in the course of a production day, with minimal downtime.

Waste composition: These compositions vary across the gamut, ranging as high as 50-60% fibre and cardboard, or entirely plastics. Cleveland also processes feedstocks such as mixed retail bales or MRF film bales, sometimes with compositions of as much as 60% film by mass. It also handles residue streams such as plastic reclaimer residues and MRF residues, with similar versions of the

[11] AMP Corporation. Link to website: Home (ampsortation.com) (Access 16th of February 2024).

technology supporting the processing of commercial and industrial and even municipal solid waste. Its adaptability is one of its greatest strengths as a secondary sortation facility.

Its flexibility is one of its greatest strengths as secondary sortation facility.

Technology details

Brief description of the process: AI technology works by perceiving images of recyclable materials on conveyor belts. Looking for specific colours, shapes, textures, logos, and more, the system recognizes patterns correlated with material type. The AI platform digitizes these images and uses the data generated to infer in real time the recyclable materials and contaminants in sortation environments. The AI then guides the sortation device to direct the target material to the appropriate destination.

List of key technological components:

- The AMP One facility in Cleveland is equipped with 11 bunkers, fed primarily by AMP Jet. The AMP Jet technology is a pneumatic ejector powered by AI that can sort a robust range of materials at very high throughput. It has a compact quality control step, allowing for a primary sorting and clean up step all within a compact layout. The AMP Jet, leveraging AMP's proprietary artificial intelligence platform and machine learning algorithms, can detect errors and dynamically adapt to maximize recovery while maintaining purity on a variety of different sorted feedstocks, all without recalibration. AMP Jet can use its downstream camera to further optimize its tuning to adapt to the aerodynamic properties of a given material that it may be harvesting.

- The facility also has an AMP Vac, an AI-powered system that removes thin film, which is combined with an AMP Microjet to showcase an over-belt film harvesting and quality control solution capable of producing pyrolysis specification feedstocks.
-
- There are more than 30 different cameras in the facility, which enable material harvesting and continuous waste characterization, as well as monitoring of the plant. These cameras enable tracking of the quality of sorted material, observing residue and infeed compositions continuously, detecting anomalies in performance, and much more. They drive smart capabilities such as dynamically adjusting the sort to keep colour balance within a PET bale, automatically detecting and alerting on jams or sort performance issues, and dynamically controlling how to recirculate material to maximize value. Additionally, they enable bunker purity and mass monitoring, which is a valuable feature for communicating around purity and what supplier went into a given bale, in the case of any disputes over finished goods.

- These AI-powered cameras also enable AMP's ability to characterize material as it is run through the system, allowing the owner to understand the composition and value of each supplier as they run that supplier's material. This capability is critical for managing a supply strategy, negotiating price, and more.

- AMP One's AI is powered by real-world dataset of recyclable materials. The AI platform has seen 150 billion objects and is consistently retrained by machine learning to maximize for its performance across a changing material stream, including recognition capabilities such as colour, opacity, food-use, and brand.

Figure 4. AMP Jet harnesses AI to deliver speed, accuracy, and flexibility in sorting operations.

Innovative features: Automation in recycling drives consistency, as AI-driven systems can work 24/7. Consistency also results in higher quality of recovered commodities. In addition, this technology allows to work in areas and on materials where volumes do not warrant a human because they can multitask and target a variety of materials in lieu of just one or two.

AMP claims this technical solution is overall lower cost than legacy MRFs because the company's innovations replace larger-footprint, traditional sorting equipment, including more expensive sensors designed to address specific subsets of sorting challenge.

Deployment environment: This technology could be deployed in MRFs or plastic reclamation facilities (PRFs) as retrofit solutions. However, it is mainly thought for creation of modern MRFs based on the latest in AI-powered software and automation, that enable communities to increase recycling access by lowering capital and operating cost barriers.

Integration with existing waste treatment plants: This technology could be used as retrofit solutions for existing recycling infrastructure.

Performance metrics

Sorting efficiency: AMP ONE comfortably recovers over 90 % of the target materials, while maintaining ISRI-grade A quality[12] and tracks the composition of every final product bale.

Throughput: This size of system supports up to 18 tons per hour across mixed plastics, MRF residue, reclaimer residues, and other mixed feedstocks of waste. Similar designs support municipal solid waste and single stream recycling.

This facility can dynamically reconfigure its process flow to optimally match the feedstock, allowing it to achieve a wide range of speeds and capacities. For example, it can process up to 20 tons per hour of mixed plastic and plastic residue feedstocks, depending on the composition of the material. It can also handle fibre and film-heavy feedstocks at lower speeds.

Technical challenges during operation: Operating a secondary facility that needs to characterize its feedstock, adjust its sort to optimize extraction of valuables from that material, and inform the operator on how to bid for that material is complicated. This has led to the need for robust internal tooling to evaluate feedstock composition and value, and to support plant reconfiguration intelligently. These dynamics create a system that is highly capable and flexible but is not always simple to operate. However, secondary business models commonly fail due to lack of visibility into material value, and the optimal sorting, sourcing, and sales strategy.

Flexibility of the system: The system utilizes computer vision at every inflow and outflow to monitor its mass balance and performance in terms of recovery and value per hour. It can be reconfigured to sort different materials, often without downtime, and is ideal for handling a variety of feedstocks at once. This allows the plant to characterize each load of supply as it is run, and help operators plan run schedules and configurations to maximize value. A custom programmable logic controller (PLC) enables adaptation of each component's settings to match its baling, infeed, and sort tasks. Smart detection enables early warnings of issues in performance, or equipment or jam issues.

> The facility consistently recovers well over 90% of targeted materials.

Type of material recovered: PET (ISR[12]), PET (clear & Custom colour), feedstock for methanolysis and pyrolysis, HDPE (natural, coloured, clear and custom colour), UBC, OCC, mixed paper, films, and other custom products.

What are these materials used for? The sorted fractions are sent to conversion processes such as mechanical recycling, chemical recycling (pyrolysis), as well as metal and pulp mills. They can be used as colour-specific pellet, food-use materials, and other specialized manufacturing feedstock.

About by-products/reject fraction: The rejected fraction varies depending on the feedstock. AMP conditions unrecyclable material first for shipment to a WtE plant, only disposing of hazards, extremely small items that pass through screening, and items undesirable for waste-to-energy (such as glass). The facility produces very little waste.

[12] ISRI - The Institute of Scrap Recycling Industries. Institute of Scrap Recycling Industries | ISRI (Access 5/04/2024).

Environmental impact

Material recovery rates: The facility recovers over 90% of targeted materials.

Climate impact & emissions: In 2023, AMP ONE avoided nearly 13,000 metric tons of greenhouse gas emissions, by taking materials bound for landfill and reintroducing them into recycled commodity supply chains, providing low-carbon feedstocks as an alternative to virgin materials.

Societal considerations

Job creation: The facility has created 18 full-time jobs regional to Cleveland, where workers are able to work in an advanced manufacturing setting with training on robotics systems.

Community involvement: This type of plant allows the creation of advanced manufacturing jobs to disproportionately disadvantaged communities where solid waste infrastructure is typically located.

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