AUTO-SORT: A Fully Automated Plastic Sorting System in Singapore

Reaching Singapore's goal for increasing the domestic recycling rate to 30% in the next 7 years

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Status Quo: Singapore's Garbage Disposal System

Tonnes of plastic Singapore produced in 2022

Percentage of plastics NOT recycled in 2022

Domestic recycling rate in 2022

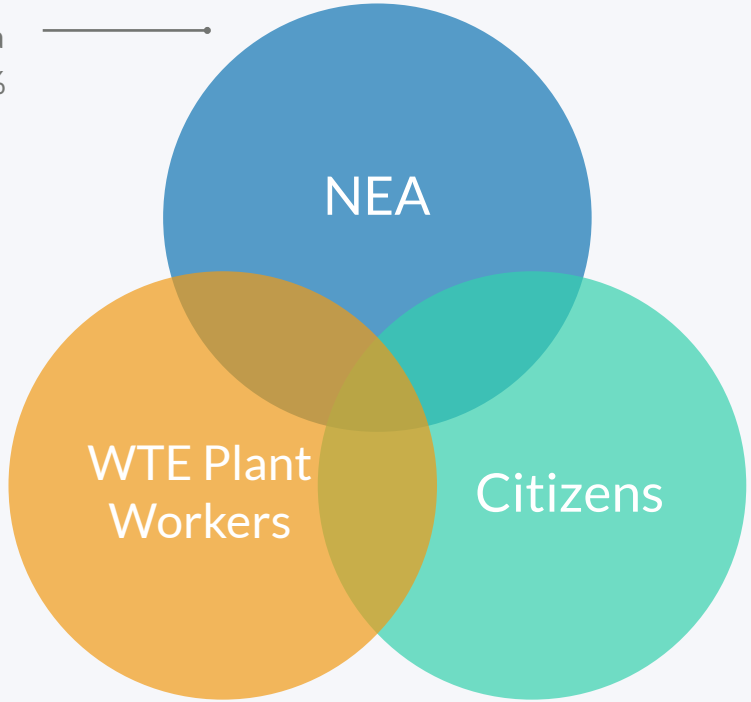
The Problem

Singapore's waste management system heavily relies on incineration, which is unsustainable because its only offshore landfill will be full by 2035 at its current rate of waste production (National Environment Agency, 2020).

Stakeholders

The **National Environmental Agency (NEA)** seeks to reach a domestic recycling rate of 30% by 2030.

WTE Plant Workers are put at risk by the carcinogens released from incinerating plastics.



Citizens need to sort out and cleanse recyclable waste, which is inconvenient.

Existing Waste Management Systems Don't Address The Problem

Pneumatic Conveyance Waste System

The PCWS is a completely automated waste collection system implemented by the Housing & Development Board at 38 residential blocks in Yuhua, Singapore. Trash is placed in chutes and is collected at a centralized bin centre using a vacuum-type underground pipe network. However, it does not sort out recyclables from general waste and therefore does not address the existing problem of recycling rates.

Materials Recovery Facilities (MRF)

MRFs are facilities where materials are separated, cleaned and sold to end-buyers. However, the vast majority of plastics are not transported to these facilities, as they are mistakenly put into general waste bins by individuals.

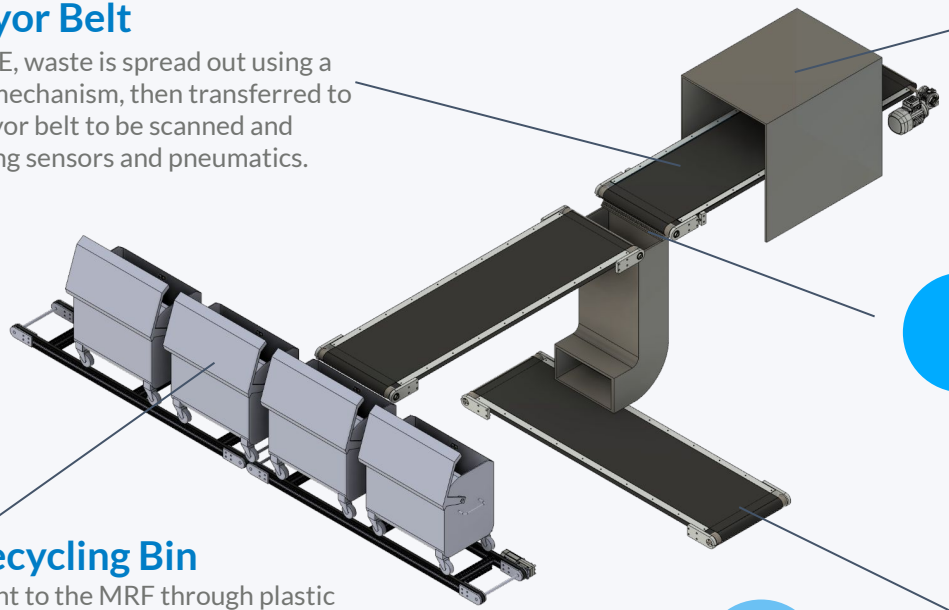
Foreign Country Solutions

According to the NEA,

"there are currently no local facilities [in Singapore] to recover contaminated plastics from domestic waste."

Other countries have different sorting systems, so Singapore can use those as reference designs. For example, the UK's AI waste sorting robot uses an robotic arm with suction cups to pick up and sort waste, which speeds up the sorting line and reduces labour cost. However, the disadvantages are that the garbage needs to be spread very far apart, the robot can only pick up one piece of garbage at a time, and Singapore has additional limitations such as the need for a compact system and a solution that can be integrated with their current waste disposal system.

Our Solution through CAD: Automated Plastic Sorting System



1 Conveyor Belt

At the WTE, waste is spread out using a vibrating mechanism, then transferred to the conveyor belt to be scanned and sorted using sensors and pneumatics.

2 Near-Infrared Sensor

Materials reflect infrared light which allows NIR sensors to record structure, material and position.

3 Pneumatic Sorting Mechanism

Pneumatic systems produce a jet of air to push plastics out of the general waste onto another conveyor belt, which lead to recycling bins

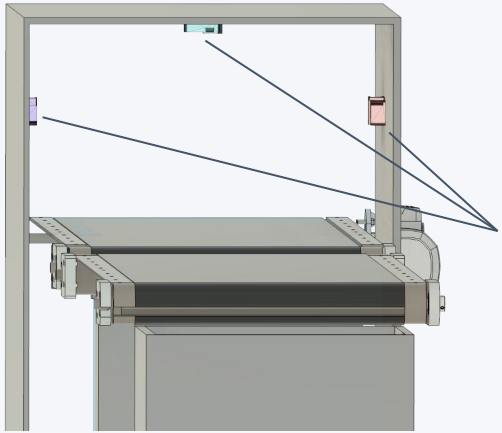
4 General Waste Belt

General, non-recyclable waste falls through a chute and onto a conveyor belt that leads to the incineration site.

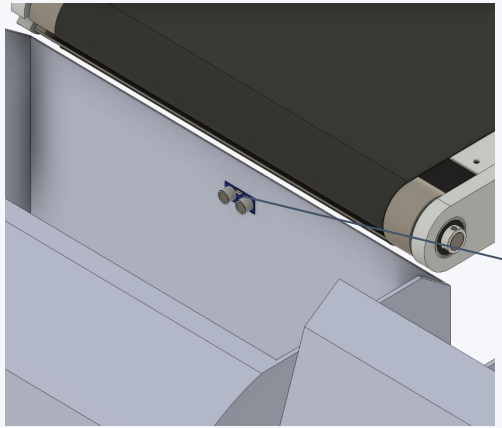
5 Plastic Recycling Bin

Plastics are sent to the MRF through plastic recycling bins which use ultrasonic sensors to detect if the bin is full and needs to be replaced. At the MRF, contaminated materials are shredded, cleaned and sent to recycling plants.

Sensors Used in the System

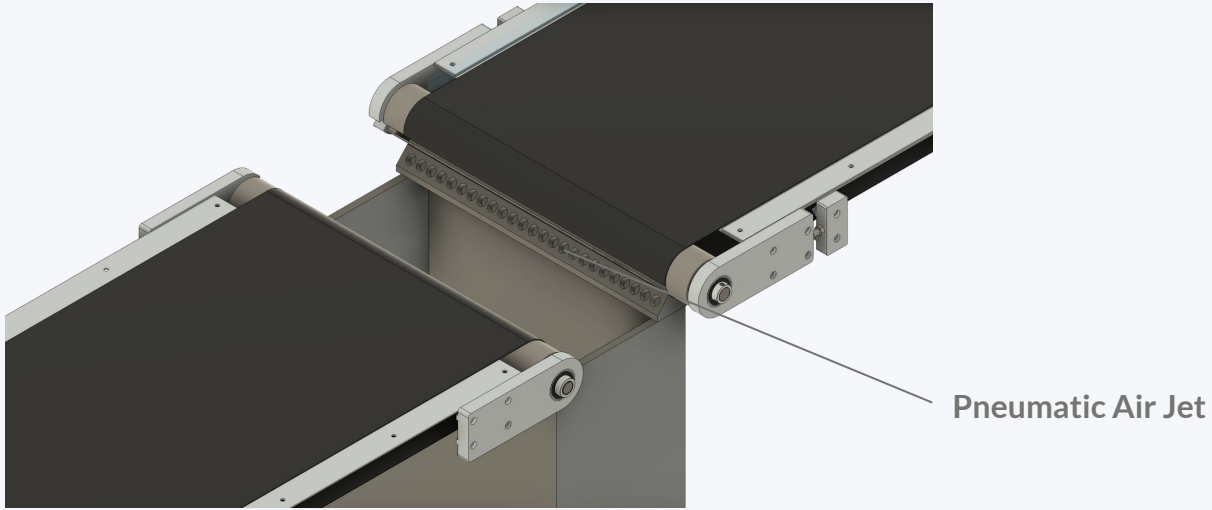


Near-Infrared (NIR) spectroscopy is a technique that uses the near-infrared region of the electromagnetic spectrum to measure the absorbance and scattering of light by samples. NIR spectroscopy allows for the determination of the types of plastic present by measuring the absorption of infrared radiation at different wavelengths. NIR machines are **faster** and have an accuracy of **95%** (Riba et al, 2023).



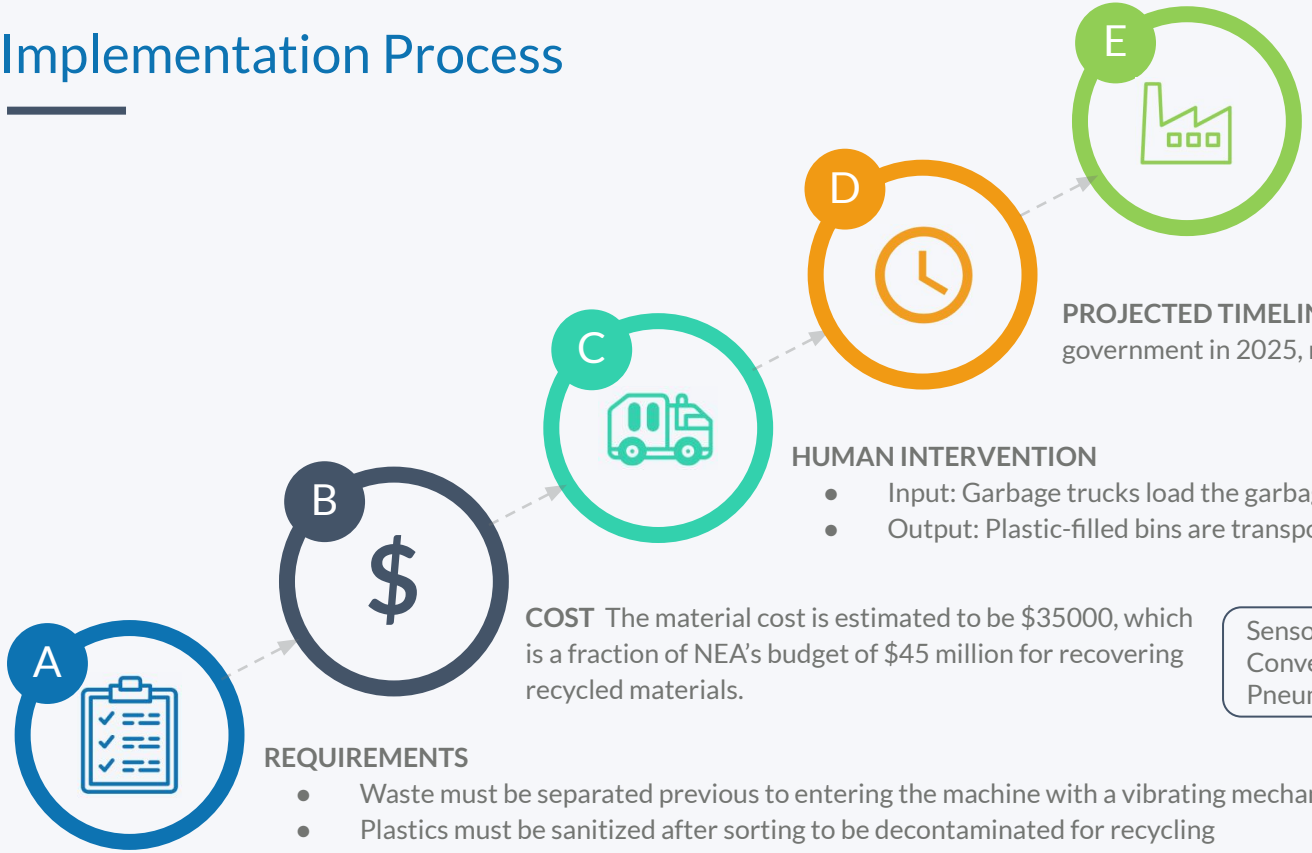
Ultrasonic sensors can be used to detect the fullness of containers. They are mounted near the top of a plastic bin and emit sound waves to determine the status of the container, such as full, empty, or half full. Ultrasonic sensors detect echoes of high frequency sounds bouncing off of a boundary. These sensors usually have an uncertainty level of 0.1 - 0.2% of the measured range according to ISO 9001:2015.

Pneumatic System Used for Sorting



The pneumatic system uses pressurized air to do work on objects. A row of closely spaced air jets are installed under the edge of the conveyor belt. If plastic is identified by the NIR sensors, it sends a signal to activate only the air jets under the object to push it across the gap and onto the opposite conveyor belt. The remaining non-plastics fall down the chute onto a separate conveyor belt that transports it to the incineration site. Pneumatic systems are relatively inexpensive and have low operating and maintenance costs due to its durability (IQS Directory, n.d.).

Implementation Process



REQUIREMENTS

- Waste must be separated previous to entering the machine with a vibrating mechanism
- Plastics must be sanitized after sorting to be decontaminated for recycling

COST The material cost is estimated to be $35000, which is a fraction of NEA's budget of $45 million for recovering recycled materials.

Sensor: $10 000
Conveyor belt: $ 100/m
Pneumatic System: $10 000

HUMAN INTERVENTION

- Input: Garbage trucks load the garbage into the Auto-Sort system
- Output: Plastic-filled bins are transported by trucks to MRFs

PROJECTED TIMELINE Refine product and propose to the government in 2025, release of product before 2030.

LOCATION The solution will be implemented at the four existing WTE facilities, prior to the process of non-recyclables being incinerated.

Summary

Pain Points in Waste Management

- 54% of plastics is misplaced into general waste bins
- Manual sorting is prone to error
- Robotic arms are slow, take up more space and have high maintenance costs

Our Solution

- A fully automated centralized plastic sorter in Singapore—no need for individual sorting
- NIR sensors sort more accurately than humans
- Air jets takes up less space, can operate simultaneously and have low maintenance cost

Our product will support Singapore's national goal for increasing their domestic recycling rate from 12% to 30% in 7 years. This leverages technology to improve waste management systems in Singapore, leading to national progress and a smarter nation.