REPORT

Final Report

One Feasibility Study to Determine the Most Appropriate Waste Processing Options for Curaçao

Client:	Selikor
Reference:	BK1584-RHD-RP-0001
Status:	Final/1
Date:	18 February 2025

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Document title:	Final Report
Subtitle:	One Feasibility Study to Determine the Most Appropriate Waste Processing Options for Curaçao
Reference:	BK1584-RHD-RP-0001
Your reference	
Status:	Final/1
Date:	18 February 2025
Project name:	Studies-ihkv-BREF
Project number:	BK1584
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Date:	18-02-2025
Approved by:	Koen van Beekveld
Date:	18 February 2025
Classification:	Project related

This publication was funded/co-funded by the European Union. Its contents are the sole responsibility of Royal HaskoningDHV BV and Selikor NV and do not necessarily reflect the views of the European Union.

Funded by the European Union
Financé par l'Union européenne

Implemented by Expertise France
Mis en œuvre par Expertise France

In collaboration with GFDRR
En collaboration avec le GFDRR

List of Tables

List of Figures

Appendices

Abbreviations

Abbreviation	
C&D	Construction and demolition
GDP	Gross domestic product
GHG	Greenhouse gasses
MEO	Ministerie Economische Ontwikkelingen / Ministry of Economic Development
GMN	Ministerie Gezondheid Milieu Natuur) / Ministry of Health, Environment and Nature
HDPE	High density polyethylene
HDI	Human development index
IMF	International Monetary Fund
LDPE	Low-density polyethylene
LHV	Lower heating value
MSW	Municipal solid waste
PET	Polyethylene terephthalate
PP	Polypropylene
PS	Polystyrene
PVC	Polyvinyl chloride
PUR	Polyurethane
SIDS	Small Island Developing States
SDG	Sustainable Development Goals
WCS	Waste Characterization Study
WEEE	Waste electrical and electronic equipment
WTE	Waste to energy

Definitions

Term	Definition
Asbestos	A naturally occurring mineral commonly found in buildings that is now recognized as hazardous due to its link to serious respiratory illnesses.
Bottom ash	The inert residue left behind after the combustion of solid waste in waste-to-energy facilities, often containing minerals, metals, and other non-combustible materials.
Bulky waste	Waste consisting of large items, such as furniture, appliances, construction materials, and tires.
Bulky domestic waste	Bulky waste from households, such as furniture, appliances, or oversized objects.
Circular economy	A model of production and consumption, which involves sharing, leasing, reusing, repairing, refurbishing, and recycling existing materials and products as long as possible.
CLEAR	Selikor's database with weighbridge data.
Commercial waste	Waste collected and disposed of by commercial transportation companies and other companies. This does not include waste from Selikor trucks, except for Selikor trucks servicing separate clients ("afzet"). Within Selikor a different definition is being used: waste collected for a fee.
Compost	Organic waste that has decomposed by biodegradation under an aerobic atmosphere under controlled conditions. Compost is nutrient-rich fertilizer that also increases the organic content of soils. Sufficient organic content in soil improves fertility and avoids dehydration of the soil.
Construction and demolition (C&D) waste	Waste from construction, renovation, and demolition activities, including concrete, wood, metal, bricks, and other materials.
Debris	Smaller fractions of construction and demolition waste
Domestic waste	Waste generated from households, including kitchen scraps, packaging, paper, plastics, and other items typically disposed of in residential trash bins.
E-Waste	Waste from electrical or electronic devices, such as computers, smartphones, TVs, and other electronic equipment, often containing hazardous materials and requiring specialized disposal methods.
Ferrous metals	Magnetic metals consisting mostly of steel, but in small quantities nickel and cobalt.
Fines	Small material fragments resulting from waste screening.
Garden waste	Organic materials such as grass clippings, leaves, branches, and plant trimmings generated from gardening and landscaping activities. Also referred to as green waste and is a type of organic waste.

Grapple	A mechanical attachment mounted on specialized vehicles like waste collection trucks, featuring hydraulic hinged jaws or claws to lift large waste materials efficiently, including debris and scrap metal, aiding in the collection and transportation of bulky items.
Hazardous waste	Waste materials posing threats to public health or the environment due to toxicity, reactivity, or corrosivity, requiring special handling and disposal, such as chemicals, batteries, and medical waste.
High density polyethylene (HDPE)	A type of plastic variety frequently used in packaging and containers, known for its recyclability and ability to be reused multiple times. Examples: bottles, containers, pipes, and plastic lumber.
Incineration	Waste management process where solid waste is combusted at high temperatures, reducing its volume, and converting it into ash, gases, and heat.
Landfill	Designated site where waste is deposited.
Landfill gas	The gas generated in a landfill from the decomposition of organic waste. It is composed mostly of methane and carbon dioxide, with potential environmental and energy recovery implications.
Low-density polyethylene (LDPE)	A type of plastic known for its flexibility, toughness, and chemical resistance. It’s commonly used in packaging films, plastic bags, squeeze bottles, and various other applications.
Leachate	Contaminated liquid formed as water percolates through waste material, containing dissolved and suspended pollutants.
Liner	A barrier for a landfill made of impermeable materials. It is installed at the base and sides of a landfill to prevent the leakage of leachate and landfill gas into surrounding soil and groundwater.
Liquid waste	Waste in a liquid state.
Medical waste	Waste originating from hospitals and healthcare facilities, containing infectious substances, human pathological waste, human blood products, and discarded sharps.
Mixed waste streams	Waste streams from the collections of various types of waste materials combined, often requiring specialized sorting and processing methods for proper disposal or recycling.
Multiple linear regression	A statistical technique used to analyze the relationship between two or more independent variables and a dependent variable.
National Development Plan 2015-2030	Outlines the strategic goals and priorities for Curaçao's socio-economic growth and development for 2015-2030.
Non-bulky waste	Waste materials that are generally smaller than 40 cm, most often placed in plastic garbage bags, boxes, and small containers (e.g. 240 l containers).
Non-bulky commercial waste Selikor routes	Non-bulky waste collected by Selikor from businesses on specific routes on the island of Curaçao.

Non-bulky commercial waste from hotels	A waste category consisting of non-bulky waste collected from hotels.
Non-ferrous metals	Non-magnetic metals consisting mostly of aluminium, copper, zinc, stainless steel, and lead.
Other non-bulky commercial waste	A waste category consisting of bulky waste collected by private waste collection companies.
Other commercial bulky waste	A waste category consisting of non-bulky waste collected by private waste collection companies.
Organic waste	Biodegradable waste materials derived from plant or animal sources, including food scraps, yard trimmings, and other natural substances.
Polyethylene terephthalate (PET)	A type of plastic commonly used to make bottles for beverages and other liquid products, as well as for packaging various consumer goods.
Polypropylene (PP)	A type of plastic commonly used in packaging (margarine tubs and microwaveable meal trays) and textiles.
Polystyrene (PS)	A type of plastic used in products like foam packaging, disposable cups, and food containers. It's known for its lightweight and insulating properties.
Polyvinyl chloride (PVC)	A type of plastic widely used in construction, plumbing, and manufacturing for items like pipes, window frames, flooring, and packaging.
Polyurethane (PUR)	A type of plastic used in various applications such as foam insulation, furniture cushions, coatings, adhesives, and sealants due to its durability and flexibility.
Ramsar Convention	International treaty that aims to conserve and protect important wetlands around the world.
Recycling	The process of converting waste materials into reusable products to reduce the consumption of new raw materials, energy usage, and environmental impact.
Reuse	The reuse of a product multiple times without significant modification, either for the same purpose or for a different one.
Sanitary landfill	A site for the safe disposal of solid waste, where waste is compacted and buried in thin layers and covered with soil to reduce environmental pollution and health hazards.
Sewage sludge	Leftover solid, semisolid, or liquid waste from treating wastewater, usually containing organic matter, nutrients, and some pollutants. Also referred to as “biosolids”.
Solid waste	Any discarded material that is not in a liquid or gaseous state, such as household garbage, construction debris, or industrial waste.
Textiles	Materials made of fibers, such as cotton or polyester, used for making clothes, towels, and other fabric products.
Waste	Materials and objects that are unwanted or no longer needed and are disposed of.

Waste category	A waste stream, defined by method of collection, e.g., domestic waste from Selikor's vehicles. Waste categories do not overlap.
Waste-to-energy	A thermal waste treatment process that converts waste into energy to generate electricity or heat.

Report structure

Chapter 1 Introduces this Feasibility Study
Chapter 2 Concludes the conditions required for successful waste management on Small Island Developing States (such as Curaçao)
Chapter 3 Concludes the current situation for the island of Curaçao regarding waste management structure, recycling initiatives and waste policy and legislation
Chapter 4 Concludes the technical feasibility
Chapter 5 Proposes waste processing options solutions to achieve the project objective
Chapter 6 Concludes the financial feasibility of the proposed solutions
Chapter 7 Concludes the level of implementation readiness per waste processing option
Chapter 8 Proposes next steps to be taken

Summary

In 2022, Selikor NV received a grant from the EU-funded program RESEMBID for its project: “Transforming Waste into Value: Developing a Sustainable, Circular and Resilient Solid Waste Management Structure for Curaçao”. This report contains the outcomes of a feasibility study which is a part of Selikor’s RESEMBID project. This Feasibility Study determines the most appropriate waste processing options (WPOs) for Curaçao to significantly reduce landfilling. To do this, recycling and/or waste to energy solutions have been assessed.

Based on benchmark data, waste prevention and reuse programs are expected to play a minor role in reducing landfilling. Although this activity would be the most beneficial for society, this was not the focus point of this study due to its minor effect on reducing landfilling.

Furthermore, this project focused primarily on waste streams ending up in the landfill. Liquid waste, industrial Waste, and cruise ship waste are excluded from this study.

Like Curaçao, many islands or isolated areas cope with difficulties in solid waste management strategies. A literature study (chapter 2) showed that more than 80% of all small islands worldwide rely on landfilling. The most important reasons are the lack of economies of scale, low access to specialized labour to operate and maintain technology, and financial priorities within national budgets. Some nations use proven techniques such as small waste to energy plants, digestion of organic waste, or the production of solid recovered fuels. Furthermore, the study showed that most cost-effective solid waste management options include recycling and composting.

This study used the outcome of the previous Waste Characterization Study (2024) as input starting points for all waste fractions (Chapter 3). According to that study, 130 Kton of waste in Curaçao ends up at the Malpais Landfill each year. The study showed that in 2023 Curaçao recycled approximately 39% of all generated waste that normally ends at the landfill. Most recycling involves recycling of concrete debris. Curaçao aims for more recycling and less landfilling.

To reduce the amount of waste ending up in the landfill, a technological longlist has been drafted (Chapter 4). Based on a multi-criteria matrix and expert opinion, two solution directions have been identified:

1. Curaçao can invest in a waste to energy plant and sorting of non-combustible waste streams to reduce landfilling significantly. The remaining annual landfilling is expected to be +/- 40 Kton.
2. Curaçao can invest in improving recycling programs and initiatives to reduce landfilling. The WPOs included in this scenario are composting & chipping, an industrial recycling hub and pre-sorting of construction and demolition waste. The remaining annual landfilling is expected to be +/- 70 Kton

A combination of these two, recycling programs and a smaller waste to energy plant, is possible as well. This results in best of both worlds: maximum recycling and maximum decrease of landfilling. However, this requires additional financial funding and is considered unrealistic at this moment in time.

The actual internal operating costs and the external social and environmental impacts of landfilling has been estimated to be 80 – 100 ANG / ton. This is an average number. For example, real costs for disposing plastics, organic waste or metals are higher compared to minerals. These costs include direct landfilling costs, excessive costs of a highly utilized landfill, costs related to loss in tourist income and social/environmental effects due to leakages, pollution and landfill fires.

The financial analysis reveals that the actual costs of landfilling are higher than those for processing organic waste, recyclables, and mixed construction & demolition waste. Therefore, the current gate fee of 30 ANG at the Malpais Landfill should exceed the calculated gate fees for processing/treatment of these waste streams to stimulate the separate processing of them. Essentially, the financial analysis underscores the need for economic incentives to promote future alternative waste processing methods.

The financial assessment shows a positive business case for composting and chipping organic waste, under certain economic conditions. To process all other investigated waste streams, a net loss is expected. Waste treatment routes for other waste streams require additional revenues / incentives to result in a positive business case. These additional revenues are required to engage the private market to become involved in waste processing. These additional revenues are known as the "gate fee" (or "tipping fee").

Key project results per most promising WPO	Composting	Industrial Recycling Hub	C&D presorting	Waste to energy	Landfill
Amount of waste processed (-000) ton / year)	18.0	13.4	12.0	103.0	130.0
Amount of waste created (-000) ton / year)	-	1.3	2.4	27.3	-
Net landfill reduction (-000) ton / year)	**18**	**12**	**10**	**76**	**-**
Contribution to landfill reduction (volumetric)	Very High	Very high	Medium	Very high	n/a
Impact local environment (to current situation)	Very Positive	Positive	Medium	Positive	Negative
Net gate fee / net costs to process waste ANG/ton	**Positive business case**	**ANG 52**	**ANG 25**	**ANG 298**	**ANG 80**

The RESEMBID project title, "Transforming Waste To Value," only holds true for organic waste. For the rest of the waste streams, additional financing is required to process the waste. This project demonstrates the need for a gate fee (revenue) to cover waste processing expenses, and thus, to set economic conditions to enable initiatives via private companies. This is a general principle which is applicable globally.
Excluded from this statement are scrap metals, e-waste, clean, sorted concrete waste, and limited quantities of some paper/cardboard that are already recycled locally.

This study reveals that processing one ton of waste via waste-to-energy (WTE) would cost approximately 300 ANG/ton. Given the electricity prices on Curaçao, significant revenues can be generated from electricity, although they would be insufficient to cover both capital expenditures (CapEx) and operational expenditures (OpEx). Consequently, an additional gate fee is necessary to operate the WTE facility, which is consistent with practices in other countries. Theoretically, the minimum selling price of the electricity produced by WTE must be 0.77 ANG per kWh for revenues from electricity sales to cover all costs.

An implementation analysis has been conducted to define major milestones for the selected Waste Processing Options (WPOs). Organic waste processing via composting and chipping had the highest readiness for implementation score. This WPO doesn’t necessarily require change in legislation and law enforcement, although it would help. Remaining WPOs are still in the feasibility phase as they require additional clarification regarding legislation, governance model and sponsorship.

Other than composting and chipping clean organic waste, additional funding is required to convert other waste streams into resources. For waste fractions that can be recycled, (which are: paper / cardboard / plastics / aluminum cans / metals / minerals), estimations show that 25 to 52 ANG/ton would be needed to cover the basic facilities and operations. Companies will not make unprofitable investments. To achieve a viable business case, three options exist:

a. Increasing the gate fee at the Malpais Landfill such that the costs for landfilling (appr. 70 ANG/ton) are covered and, if necessary, ensuring that the required additional gate fee for the recycling route is competitive.
b. Funding recycling companies with governmental subsidies (as is the current temporary situation where the Ministry of Health, Environment and Nature is paying all landfilling gate fees). The costs of subsidies should be funded. The following funding options could be explored:
    1. Waste tax per tourist night and/or cruise ship arrival.
    2. Waste tax per ton on all incoming goods to cover their eventual waste disposal costs.
    3. New waste taxation on non-recyclable imported goods.
    4. Additional waste tax on imported goods that can be produced on Curaçao (e.g. compost, debris, certain mineral construction materials, etc.).
c. Other funding options are institutions such as development banks [e.g. the World Bank and the Inter-American Development Bank (IDB)]. They offer loans and grants for sustainable energy and waste management projects. Funds such as the Green Climate Fund (GCF) and the Global Environment Facility (GEF) provide financing specifically for projects that contribute to climate mitigation and adaptation.

To investigate funding for the waste to energy plant, firstly, discussions regarding a long-term electricity contract with Aqualectra are required. This contract should guarantee both revenues per kWh and a guarantee for offtake.
Countries that excel in waste recycling and reuse typically have a framework that meets the following three key conditions:

- a strong legal and regulatory framework,
- effective law enforcement, and
- effective financial incentives for the local situation.

Without these, achieving high recycling and reuse rates are not considered to be possible.

Even when less effort is put into recycling and most waste is treated in a waste to energy plant, a similar framework is required. Waste to energy still requires recycling of inert and unsuitable waste streams such as construction debris and tires. Without a sound framework, no companies will bid for a design, build, operate (DBO) contract or public-private partnerships (PPP).

The Ministry of Health, Environment, and Nature (GMN) was approached multiple times during the study, but has not responded to discuss and provide their input on these issues. However, this ministry must deploy and enforce solid waste management strategy and legislation. Without this, the current situation regarding waste management on Curaçao will not change.

The study ends by concluding and proposing actions for 2025. These actions include organizing **an official governmental conference regarding waste,** to align all stakeholders on the solid waste management strategy.
In addition to this, a **communication and education campaign** among all citizens and businesses will increase the general knowledge regarding waste disposal, product usage, prevention & reuse and recycling possibilities. This will pave the way for community driven waste processing and recycling options. Thirdly, **joining / organizing a regional Caribbean waste conference.** Teaming up with neighbouring islands could enable synergies, shared strategies and create common value.

This project answers the three key objectives set by the RESEMBID project:

1. To reduce the adverse ecological and social impacts of solid waste disposal on the island of Curaçao.

2. To investigate using waste in transition to renewable energy.
3. To formulate milestones and guidelines for further implementation of a circular and solid waste management strategy.

1 Introduction

Effective waste management is a critical issue for small island nations like Curaçao, which face unique challenges due to their limited land, resources, and logistical constraints. As global awareness of environmental sustainability grows, it becomes increasingly important for Curaçao to adopt innovative and efficient waste management strategies.

Being the local waste management company, Selikor N.V. (Selikor) is at the forefront of this effort, tasked with addressing the capacity limitations of their Malpais Landfill, the sole legal solid waste disposal site on the island. The current practice of landfilling is not only environmentally unsustainable, but also poses significant social and economic challenges. To tackle this issue, Selikor together with Royal HaskoningDHV conducted a comprehensive feasibility study to determine new and more appropriate waste processing options for Curaçao.

This study is part of RESEMBID, an EU-supported programme focused on Resilience, Sustainable Energy, and Marine Biodiversity. The programme provides crucial support to enable Curaçao to develop and implement waste management solutions that are environmentally sustainable, economically viable, and socially acceptable. This waste management project represents a pivotal step towards the island's sustainable development.

The overall objective of this RESEMBID project’s solid waste management structure study is to increase the availability of data and research for the following purposes:

1. To reduce the adverse ecological and social impacts of solid waste disposal on the island of Curaçao.
2. To investigate using waste in transition to renewable energy.
3. To formulate milestones and guidelines for further implementation of a circular and solid waste management strategy.

Key objective of the RESEMBID project: Select the most optimal waste processing option(s) for Curaçao

An optimal waste processing option is proposed as the main solution to achieve these higher-defined project objectives. This study explores and proposes the most suitable, effective, efficient, and affordable waste processing option(s).

This feasibility study project addresses **three key objectives**:

- **Identifying sustainable and cost-effective waste processing options** that align with Curaçao's unique small island context and waste characteristics.
- **Developing a financially viable and resilient waste management structure** that can adapt to future changes and challenges.
- **Ensuring the social acceptability of the chosen solutions,** considering the needs and concerns of local communities and businesses.

The study’s findings and recommendations presented in this report are intended to guide Selikor, policymakers and the community in their efforts to reduce waste, enhance recycling, and promote a circular economy on the island.

Project related

Within the project, the following stakeholders (A-Z) are considered:

1. Aqualectra
2. Residents of Curaçao
3. Local recycling companies
4. Ministry of Economic Development (Ministerie Economische Ontwikkelingen)
5. Ministry of Health, Environment, and Nature (Ministerie Gezondheid Milieu en Natuur)
6. Selikor N.V.

2 Approach and framework

To achieve the project objectives, the following main workflows have been agreed upon between Selikor and Royal HaskoningDHV:

1. **Literature review:** This involves examining the current waste fractions going to the Malpais Landfill, strategy and vision for Curaçao, and reflecting on the waste management systems of comparable islands.
2. **Review of local recycling companies:** Companies active in waste management and recycling are reviewed within the following main categories: organic waste, plastics, glass, metals/e-waste, paper/cardboard, and minerals.
3. **Technological scoping and review**: A multi-criteria analysis on the technological waste processing longlist has been conducted to define the most promising / optimal waste processing option(s) for the island of Curaçao.
4. **Scenario development and technical concept**: The most optimal waste processing option(s) are defined within a scenario for a solid waste management structure within the island of Curaçao.
5. **Economic comparison**: By means of financial modelling, financial conclusions are drawn from the scenarios.
6. **Feasibility assessment and implementation roadmap:** Risk assessments, roadmaps and next steps are defined to successfully implement the investigated scenarios.
7. **Conclusion:** The key objectives of this Feasibility Study are concluded.

2.1 Waste management hierarchy

The waste management hierarchy, often referred to as “Lansink’s Ladder,” is a framework that prioritizes waste management practices from most to least environmentally friendly. It provides a simplified structure that gives guidance for moving waste management towards a circular economy.

1. **Prevention**: Avoiding the creation of waste in the first place.
2. **Reuse:** Using items more than once before discarding them.
3. **Recycling**: Processing materials to make new products.
4. **Recovery:** Extracting energy or materials from waste that cannot be recycled.
5. **Disposal:** Safely disposing of waste that cannot be reused or recovered typically through landfills or specific storage facilities.

Figure 1: Waste hierarchy in EU Waste Framework Directive

2.1.1 Lansink's hierarchy of waste explained

1. Prevention: The best waste management solution, involving no additional materials or waste. Examples include avoiding food disposal, using reusable packaging, and sharing infrequently used items. Although not the focus of the study, societal development in prevention can reduce waste feedstock.
2. Reuse: The second-best solution, involving preparing products or packaging for reuse without altering their function. This includes cleaning, repairing, or refurbishing items. Examples include thrift stores for clothing and electronics. Like prevention, reuse is not the study's focus but can impact waste feedstock.
3. Recycling: The last option to keep materials within the circular economy. It involves extracting materials from products to create secondary resources. High-quality recycling produces materials like steel and glass, requiring source separation and large facilities. Low-quality recycling produces materials for limited functions and is easier to manage.
4. Recovery: Involves recovering energy from waste through treatment processes such as thermal conversion or digestion, converting it to electricity, heat or steam. Applied to separated or mixed waste streams unsuitable for recycling.
5. Disposal: Safely disposing of waste that cannot be reused or recovered typically in landfills or specially designed storage facilities.

2.2 Waste management on other Small Island Developing States (SIDS)

In the previous paragraph, a common waste strategy that is applied worldwide via Lansink's Ladder is described. However, waste management strategies for island states contain additional challenges. Therefore, to understand the challenges faced by islands, a literature review was conducted on the waste management issues in Small Island Developing States (SIDS). SIDS are often located in the Caribbean, Pacific, Atlantic, Indian Ocean, Mediterranean, and South China Sea regions. These countries share common sustainable development challenges, including small populations, limited resources, remoteness, susceptibility to natural disasters, and vulnerability to external economic shocks.

When focusing on waste generation in SIDS, one realizes that it is significantly influenced by factors such as Gross Domestic Product (GDP), the Human Development Index (HDI), population growth, and the number of tourists. The most common challenges regarding solid waste management structure are:

1. Inadequacy of suitable land
2. Limited potential for economies of scale
3. Limited local industrial activities
4. Exorbitant logistical costs
5. Restricted human resources, skilled personnel, and local contractors

Currently in many SIDS, illegal dumping and open burning are the most common options, preferred over more sustainable practices that focus on waste prevention, reuse and recycling. Investigating these options for materials such as plastics, glass, and metals could offer the islands additional economic benefits and would be beneficial in making a transition to a sustainable and circular economy. (Lionel P. Joseph, 2019)

However, recycling of waste fractions is less financially attractive due to the small scale and distance from customers, coupled with a lack of potential buyers for secondary raw materials on the islands. As a result, current waste management activities predominantly (80%) rely on landfilling, dumping at sea, and open burning. Some islands have successfully implemented incineration or Solid Recovered Fuels (SRF), however often face organizational difficulties for successful long-term operation.

Three additional lessons learned from waste management in SIDS by the Asian Development Bank

- **Waste collection:** Positive experiences with prepaid garbage bags, while other payment methods for waste collection are often less successful. Garbage bags are sold at an affordable price to households, covering waste management costs, including collection and disposal, either fully or partially. Different types of waste can be placed in bags of various colors to encourage waste separation and recycling. Only those prepaid bags with waste are collected on garbage collection day. Kiribati and Vanuatu have successfully implemented such a prepaid garbage bag system.
- **Deposit systems:** Positive experiences with deposit systems, but less positive experiences with market-based recycling approaches. In Palau, $0.10 is charged for each imported bottle, aluminum can, carton, and other rigid packaging. The government refunds $0.05 for each returned container, while the remaining funds are used to finance the recycling center and waste management system. Collected bottles and cans are baled and packed before being exported to the international recycling market. Collected cardboard is reused locally as stabilizers for organic composting. Some collected waste glass is transformed into handmade glassware by local artists.
- **Waste processing:** The semi-aerobic landfill as a less environmentally harmful alternative to regular anaerobic landfills. In this concept, a set of pipes is installed in a landfill with a waterproof bottom seal to collect and discharge leachate. These pipes also introduce air into the landfill. Information about the semi-aerobic landfill concept can be found here: https://www.city.fukuoka.lg.jp/kankyo/k-seisaku/hp/FM.html, https://www.city.fukuoka.lg.jp/data/open/cnt/3/25574/1/Fukuoka_method.pdf

United States Agency for International Development (USAID) advises the following measures and technical options for financing and implementing waste processing in low and middle-income countries:

- A tourist tax to finance waste processing by tourists.
- A property tax to (partially) finance waste collection and processing for residents.
- Composting when it produces a commercial product that can be sold as a soil improver.
- Production of landfill gas or biogas and using this gas to produce energy.

In conclusion, the success stories of solid waste management on Tilos, the Pacific islands, and Punta Cana demonstrate the effectiveness of tailored, community-focused approaches. Tilos' recycling and waste conversion program, the Pacific islands' regional cooperation for standardized waste policies and shared resources, and Punta Cana's integration of sustainable tourism with environmental conservation all highlight the importance of having a strategy, strong legislation, and community involvement. These examples provide valuable insights and inspiration for other regions aiming to achieve sustainable waste management.

2.3 Success stories in solid waste management on other islands

This section describes three examples that have been identified in the literature study as having successful solid waste management.

Example 1: Just Go Zero Tilos program

Tilos is a small Greek island, which is home to 600 residents and welcomes 9,000 tourists annually. The island has achieved remarkable results in solid waste management. It is reported that recycling efforts currently achieve 80% recycling of its waste streams (source: circulaireconomy.europa.eu). The remaining waste, approximately 20%, which cannot yet be recycled, is converted into Solid Recovered Fuels and exported to cement kilns. This approach eliminates the need for costly waste to energy plants. Tilos further claims it no longer landfills waste and have closed the landfill.

The key success factors on Tilos consist of an integral program focusing on the **four main topics:**

1. **Waste management**
- Source separation of plastic, aluminum, cardboard, and organic waste.
- Strong focus on prevention and reuse & repair of furniture and electrical equipment.

2. **Waste processing options**
- Centre for circular innovation: This facility is built on the former landfill and contains high-tech sorting techniques.
- Composting facility: 90% of all bio-waste produced on the island is composted.
- Production facility for Solid Recovered Fuels.

3. **Legislation and enforcement**
- Development of a local waste policy and effective legislation was crucial to reach zero waste to landfill.
- The project is supported by the national government.
- The island has been certified as “Zero Waste,” allowing it to claim several incentives and funding.

4. **Financing and cooperation**
- The project is financed by several governmental agencies. Additionally, private companies such as Polygreen are participating in the project.
- Awareness among the community and education programs have been set in place to improve residents’ behavior regarding waste.

Example 2: Establishing a regional recycling network for Pacific islands
Pacific islands encounter the same challenges, as described for other SIDS, for establishing successful solid waste management systems. The two main reasons for this are the remoteness of each island and the absence of an economy of scale. To tackle this problem, in 2003, the so-called regional cooperation for Pacific island countries was established. This cooperation focuses on three major objectives:

1. **Standardized waste policy among different islands:** Standardized waste policy mechanisms among islands create a better negotiation position regarding producer responsibility obligations, bans on certain single-use materials, and efficient legislation. Furthermore, standardized waste policy creates a foundation for centralized recycling exporting activities.
2. **Establishing a network to support financially efficient waste recovery and recycling initiatives:** This network increases economies of scale and supports making recycling a more economically viable solution.
3. **Shared expertise, knowledge, and network:** Shared expertise, knowledge, and network create more effective implementation of waste recycling initiatives and waste processing options such as composting.

Example 3: Green Punta Cana project in the Dominican Republic
The Green Punta Cana project is an ecofriendly initiative which integrally promotes sustainable tourism and environmental conservation in the Punta Cana region. Solid waste management structure plays a key role in focusing on sustainable tourism and environmental conservation. The intention of this project in the tourism industry is to deploy this program later in other sectors and communities of the country.

The most important aspects of the program are:

1. **Eco-Friendly resorts and sustainable development projects**: Many resorts and hotels in Punta Cana are adopting green practices. Examples consist of energy-efficient systems, waste reduction programs, sustainable landscaping and environmentally friendly materials.
2. **Local green market and plantation tours**: Tours such as the Punta Cana Green Market and Plantation Tour provide visitors with an opportunity to explore local agriculture. These tours highlight sustainable farming practices and allow visitors to sample locally grown produce like tobacco, pineapple, sugar cane, and cacao.
3. **Environmental conservation efforts**: Various organizations and businesses in Punta Cana are involved in conservation efforts, including beach clean-ups, coral reef restoration, and wildlife protection programs. These initiatives aim to preserve the natural beauty and biodiversity of the region.

2.4 Conditions for successful waste management for islands

As described in Paragraph 2.2, SIDS, such as Curaçao, face unique challenges in solid waste management compared to mainland states. This section outlines the conditions for a successful waste management structure within these constraints.

Government support and legislation:
A financially healthy recycling sector for waste management requires robust government legislation, effective law enforcement, and a viable business case for the collection, sorting, and recycling of materials. These conditions are essential for advancing towards a more sustainable waste management structure in any country, and Curaçao is no exception.

A viable business case means a sufficiently large gap between the landfill gate fee and revenues for recycling. This gap should cover at least the sum of costs of collection, sorting, and recycling. This requires sufficiently high landfill tipping fees, along with financial incentives, subsidies, and/or grants. If landfill fees are low or nonexistent, the need for subsidies or grants increases to encourage businesses to start recycling operations. Furthermore, to attract investors and secure contracts, business agreements must be protected by law, mainly through waste policy.

Source separation is inevitable to grow towards making recycling standard:
Source separation is essential for significant recycling rates on the island. The island Tilos shows that by separating plastic, aluminum, cardboard, and organic waste, high recycling rates can be achieved.

Investing in recycling stations near public areas such as supermarkets to facilitate waste separation is a first step to enhance recycling. Furthermore, balers, and compactors can streamline the recycling process, making it more efficient and less labor-intensive. This can help manage high volumes of waste and reduce operational costs. Finally, source separation at the household level will be the final step, which may take decades to be implemented effectively.

Public-private partnerships:
Collaboration between local businesses, hotels, recycling companies, and government entities such as Selikor is essential to enhance collection efforts and expand recycling programs. These partnerships can, for example facilitate the placement of balers in strategic locations, increasing the volume of separated waste collected. Contractual agreements between the private partner and the government, stimulated and protected by law, are a necessity. This is also the case for a waste to energy project.

Export and market expansion:
Improving port facilities and negotiating transshipment fees can make exporting recycled/separated waste more cost-effective. This can open new markets and increase the profitability of recycling operations on the island of Curaçao. If not possible, other financial metrices can be introduced to partly pay for the

transshipment fees. For example: **Establish a Fee for Importing Packaging Materials**: Impose a fee for importing packaging materials that can finance the excessive logistical costs of exporting recyclables.

Circular economy initiatives:
Integrating recycling into broader circular economy initiatives can enhance sustainability efforts. By promoting the use of recycled waste in local industries, Curaçao can reduce its reliance on imported raw materials and foster a more sustainable economy.

Community engagement, communication, and education:
Raising awareness about the importance of recycling and providing education on proper waste segregation is absolutely necessary to increase public participation. Community programs and incentives can encourage more businesses and households to recycle.

3 The current state of waste management on Curaçao

This chapter describes the current state of waste management on Curaçao. First, legislation and policies are outlined, followed by a description of the infrastructure. Then, waste-related studies are summarized, and finally insights are shared.

3.1 Waste management legislation and policy in Curaçao

Curaçao's waste legislation framework already sets the conditions for clean public spaces where no waste is dumped or intentionally littered. This has also been implemented and followed up on. This is a very positive step.
However, this legislation does not provide conditions for how and whether the collected waste shall be treated, recycled, or disposed of in a landfill.

Curaçao's approach to waste management is governed by a combination of national legislation and specific environmental policies. The primary legislative framework is encapsulated in the National Public Order Ordinance (Landsverordening Openbare Orde), which includes several key articles aimed at regulating waste disposal and ensuring public cleanliness. However, this legislation does not address the treatment, recycling, or final disposal of collected waste. Complementing this ordinance, is the Environmental Permitting Policy (EPP), which provides a more detailed framework for managing environmental impacts, including waste management, through specific guidelines and standards. This section explores the current legislative landscape, the stipulations of the EPP, and the existing gaps in waste management planning and implementation in Curaçao.

3.1.1 Waste management legislation as part of the National Public Order Ordinance

Waste legislation in Curaçao is currently restricted to the following articles in the National Public Order Ordinance.[1] The legislation specifies:

- Article 20: That waste cannot be littered along public roads.
- Article 26-1: That waste can only be transferred to companies with a permit for waste processing.
- Article 26-2: That waste collection by companies is only allowed if they have the appropriate permit.
- Article 26-3: That it is not allowed to store or dispose of waste on private property.
- Article 26-4: That it is not allowed to store or dispose of waste on public lands and roads.
- Article 30: That it is not allowed to transport waste such that the wind blows fine particles onto public roads.
- Article 40: Contains the conditions for presenting waste for collection.

3.1.2 Waste management policy

To require (large) companies to enhance in waste recycling (by source separation), existing legislation can be utilized. On Curaçao, the policy for waste and waste management is specified in the Environmental Permitting Policy (EPP).[2]

> *The goal of the Environmental Permitting Policy is to implement a basis for norms, guidelines and standards for controlling and subsequently reducing adverse environmental impacts and risks caused by activities of the refinery, oil terminal as well as other activities mentioned in the National*

[1] *Landsverordening Openbare Orde (P.B. 2015 no. 31)*
[2] *Environmental Permitting Policy annex to Ministerial Decision 11 August 2020*

Decree, enacting general regulations (landsbesluit, houdende algemene maatregelen) in article 1 of the Nuisance Ordinance Curaçao 6.[2]

The national Nuisance Ordinance Curaçao (*Hinderverordening*)[3] defines environmentally impacting activities as "any by human undertaken activity or action, whether or not bound to a fixed location, that has a business-like character or can be considered as such, as a result of which danger, damage, or nuisance to the environment may arise".[3] This means that the EPP could be applicable to virtually all activities on Curaçao, except for individuals such as households and tourists.

Currently, only two permits that fall under the EPP have been issued so far. The following subparagraphs describe the impact of seven key elements of the EPP.

1. **Developing a waste management plan**

The EPP states that a new Waste Management Plan is required and provides recommendations how to draft such a plan.

2. Waste prevention

The EPP states that a Waste Prevention Survey and Plan is required and provides recommendations how to draft such a plan.

3. Waste separation

The EPP mandates that hazardous waste must be stored and treated separately unless it is deemed unreasonable to do so. The storage and treatment conditions for non-hazardous waste are usually described in a company's Nuisance Permit. RHDHV's advice is that this should be phrased more stringently to: "The storage and treatment conditions must be described in the permit." This is essential to promote recycling and to ensure a level playing field among companies. The table below provides guidelines for mandatory separation.

Table 1: Guideline for reasonable waste separation by companies

Waste	Maximum quantities per week suitable for recycling
Paper and cardboard	0 kg
Electronic equipment	0 kg
Plastic films, (drinking) cups and other plastic waste	0 kg, ± 500 cups, 25 kg
Styrofoam (EPS)	1 container 240 litres (±30 kg)
Car tyres	5 tyres
Organic waste/swill	200 kg
Green (yard) waste	200 kg
Waste wood	40 kg (e.g. 2 pallets)
Packaging glass	½ container 240 litres (±30 kg)
Metals	40 kg
Debris (construction & demolition waste)	0 kg (incidental 1 m^3)

[3] *LANDSBESLUIT van de 9de juni 2017, no. 17/1429, houdende vaststelling van de geconsolideerde tekst van de Hinderverordening Curaçao 1994*

Textiles	40 kg
Rock (mineral) wool	25 kg
Process waste	Often relatively homogenous and clean waste. In case of larger quantities and/or concentrated releases, waste separation is reasonable or should be obliged

The table 1 provides the inspectorate for health, environment, and nature (*Inspectie Gezondheidszorg Milieu en Natuur* - GMN) with the tools to oblige to obey the law / follow the EPP for any company and add conditions to every permit. In practice many companies are operating without a permit and GMN might not consistently include (the same) separation rules in each permit. Permits issued before 2020 might not have been subject to the ex officio amendment.

4. Waste storage

Waste storage requirements in permits are not relevant for reducing landfilling on Curaçao.

5. Waste shipment

Waste shipment should comply with all relevant international waste shipment regulations.

6. Waste treatment

The EPP states that where waste cannot be prevented, the minimum standards of the Dutch Waste Management Plan (*Landelijk Afvalbeheerplan (*LAP3)) shall be adopted. If this policy would be really strictly implemented and enforced, it would mean that the landfill would have to refuse all truck loads arriving from companies with an environmental permit containing:

- (mixed) construction and demolition waste;
- mostly green (yard) waste;
- mostly cardboard;
- mostly soil;
- etc.

7. Waste registration

The last key element of the EPP regards waste registration by GMN for companies obliging the EPP. The registration should comply with an approach that works for all parties to become aware of their waste streams.

3.1.3 Waste management plan

The first waste management plan (WMP) was adopted when Curaçao was part of the Netherlands Antilles. It incorporated the principles of the Lansink Ladder, which have been adopted and are since being followed. A draft version of the second WMP (*Tweede Afvalstoffenplan*) was drafted in 2005, but was never officially published as a final WMP. Although outdated with regards to some data, the document can still be useful as the outline for a new National Waste Management Policy since Curaçao became a country in 2010.
As part of this Transforming Waste to Value project, a new National Waste Management Policy was developed in close coordination with GMN.

3.2 Current waste management infrastructure on Curaçao

The legal framework, together with current waste and market conditions on Curaçao, has led to the current waste management infrastructure. This waste infrastructure is described in more detail in the next sections.

3.2.1 The five waste collection routes on Curaçao

Waste on Curaçao is collected via 5 different routes.

1. **Selikor**

Selikor is a private company with all its shares owned by the Curaçao government and has the following main tasks:

- Operation of the Malpais Landfill;
- Route collection of residential waste from households;
- Route collection of residual waste in the city centers of Willemstad (Punda and Otrobanda);
- Cleaning up illegal dumpsites
- Cleaning up street litter
- Waste collection from companies on a contract basis.

Waste collection from companies is an open market with competition between private waste management companies.

2. **Private waste collection companies**

There are several private waste collection companies active on Curaçao. There is a limited number of larger professional companies with large compacter trucks and that also offer compactors for large companies such as supermarkets and hotels. These companies collect mostly mixed waste.

3. **Informal private waste collection companies**

There are also many smaller (informal) collection companies with small trucks. Their business concept is to provide a quick service where all waste from a certain location is removed and disposed of. Examples include waste from clearing vegetation, waste from house renovation, commercial waste, etc.

4. Recycling drop-off centers

Recycling centers in Curaçao are located near supermarkets where plastic bottles and aluminum cans can be deposited for recycling. They consist of a modified shipping container which contains Big Bags for each collected recyclable. The recycling centers are operated by Green Force and Green Phenix.
Remark: Terminology: ‘recycling drop-off centers’ indicates Waste Drop-off Zones for English speaking persons from Western countries.

5. Waste drop-off center

Selikor established a Waste Drop-Off Centre (*Milieustraat*) to facilitate the separation of various types of waste. The center aims to provide a convenient solution for waste segregation. Unfortunately, the facility is not being used very much by the public. Selikor used to provide small incentives to stimulate the public to separate their wastes, but discontinuation of these incentives has led to a drastic reduction in the public’s use of the center.

6. Illegal dumping

Currently, illegal dumping of waste is a major issue. Parallel to this project, GMN is investigating the reasons behind this criminal behavior.
One reason for illegal dumping is the economic advantages by avoiding paying the 30 ANG / ton gate fee. Based on several interviews, law enforcement does not always issue fines, or the fines are not sufficiently high to deter this criminal behavior.
If Curaçao wishes to enhance the solid waste management structure, illegal dumping should be forbidden by legislation.

3.2.2 Landfilling

History

Organized landfilling in Curaçao started in 1975 when the Curaçao government opened a non-engineered landfill at Koraal Specht. A non-engineered landfill means without, for example, a liner, leachate collection, or gas collection. Nevertheless, it was a great improvement since it was gated and controlled, including the registration of waste. In 1985 a new landfill located at Malpais was opened. A few years later in 1989, Koraal Specht was closed.[4] Koraal Specht is still operational as a transfer station and waste drop off center operated by Selikor.

Current landfilled quantities

Based on the WCS, an average of 129,000 tons of the approximately 213,000 tons waste generated annually on Curaçao is landfilled at the Malpais Landfill (see Figure 2). Figure 2 shows that significant amounts of solid waste are dumped illegally at different locations on the island, but most of the smaller illegal dumps are eventually cleaned up and transferred to the Malpais Landfill. It is estimated that annually 10,000 tons of waste is illegally dumped each year.

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[4] Selikor website

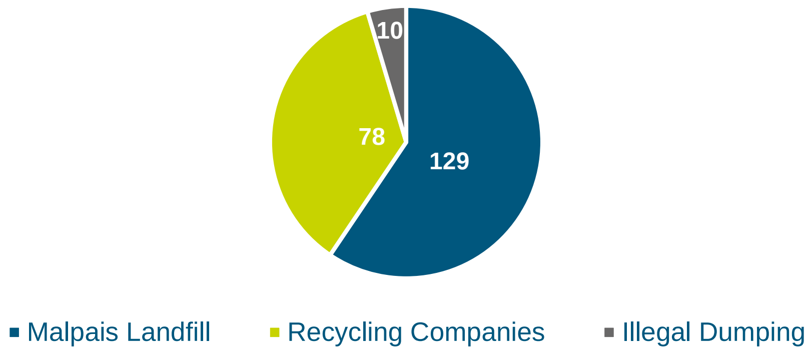


Figure 2: Tons x 1,000 of waste per year going to the landfill, recycling or Illegal dumped on Curaçao (2023)

Remaining capacity at the Malpais Landfill

Selikor estimates that the landfill will reach its maximum capacity in less than 10 years, necessitating the exploration of alternative waste management solutions. After 23 years of a declining waste generation trend (approximately 1% per year), a period with increased waste production is forecasted, fueled by a growing economy from 2024 up to 2029. After this period, waste generation may further increase or instead decrease, depending on economic scenarios (EcoVision, 2024). In 2002, the remaining landfill capacity was determined by Landmark N.V to be 10 million m³ when the permit conditions for the slope are applied, a maximum height of 70 meters is applied, and the total available area at the Malpais Landfill is used.

Since 2002, no update has been made regarding an estimate of the remaining landfill capacity. According to the original landfill design, approximately 10 to 15 years landfill capacity remains. It is however unlikely that those projections will have become reality. Since new landfill capacity requires legal and physical preparations, it is recommended that the current remaining capacity be determined with an updated measurement survey. This will enable Selikor to plan when preparations for new landfill capacity should be started to avoid the situation where landfill capacity is no longer available.

Financial management landfill

The gate fee for landfilling at the Malpais Landfill was introduced in 1996 at 30 ANG/ton. At the time this price level covered the operational cost for landfilling. The 30 ANG/ton has never been indexed for inflation. Previous studies conducted by Selikor have calculated the average cost of landfill operations to be 56 ANG/ton. Currently, these operational costs are even higher than 56 ANG/ton (based on cost price analysis studies conducted by Selikor in 2024).

The discrepancy between the landfill gate fee and the operational costs reveals that the Curaçao government, via Selikor, is unintentionally, but effectively subsidizing waste disposal by more than 26 ANG/ton. In October 2024 the landfill fee was set to 0 ANG/ton for two months and this period was later extended to the end of 2025. During this period, landfilling is being indirectly subsidized by the government, they now pay the 30 ANG/ton instead of the clients. Operating the landfill with a landfill gate fee that covers operational cost will speed up sorting for recycling on the island. Unfortunately, it will most likely also increase illegal dumping.

Another observation regarding financial management of the landfill is the absence of the economic residual value for the remaining landfill capacity, typically expressed in ANG per cubic meter (ANG/m³). Defining this value is crucial as it supports landfill decision-making based on financial figures. Two remarks: firstly, each cubic meter recycled or incinerated avoids these costs. Each significant alternative waste processing activity that reduces landfill volume should be compared to the avoided landfilling costs. Secondly, the expected economic residual value for the remaining landfill capacity for a new landfill will be much higher due increased investment costs and probably more stringent environmental measures that will have to be taken.

Efficient landfill management

The current landfill disposes all waste (temporarily) uncompacted or shredded. Operating compactors increase the average density of landfilled waste and reduces the costs per cubic meter remaining landfill capacity. Some waste streams, such as garden waste, are extremely bulky and could easily be shredded. For example, currently, all organic pruned vegetation is landfilled directly instead of being chipped prior. A chipping machine can reduce the volumetric size by 80%. The reason for direct landfilling without chipping is the additional costs for diesel and man-hours.

3.2.3 Waste quantities and composition on Curaçao

Quantities and composition of waste on Curaçao are (besides the legal framework and the market conditions) the most important drivers in local waste management. Therefore, it is essential to thoroughly understand the expected waste volume and characteristics on Curaçao when selecting the most optimal waste processing options. The quantities and composition of waste on Curaçao were determined in 2023 during the Waste Characteristics Study (WCS). The WCS is an important basis for this Feasibility Study. This subparagraph presents a small summary of the entire Waste Characterization Study reported in 2024 by EcoVision N.V.

The Waste Characterization Study for solid waste on Curaçao in 2023 investigated eight different waste categories being landfilled at the Malpais Landfill. The eight major categories are: non-bulky domestic waste, bulky commercial waste, garden waste, construction and demolition waste, non-bulky commercial waste, hotel waste, Selikor commercial routes and bulky domestic waste.

Figure 3 shows all eight investigated categories including the origin of the waste, their annual estimated tonnage, and percentage of all landfilled waste.

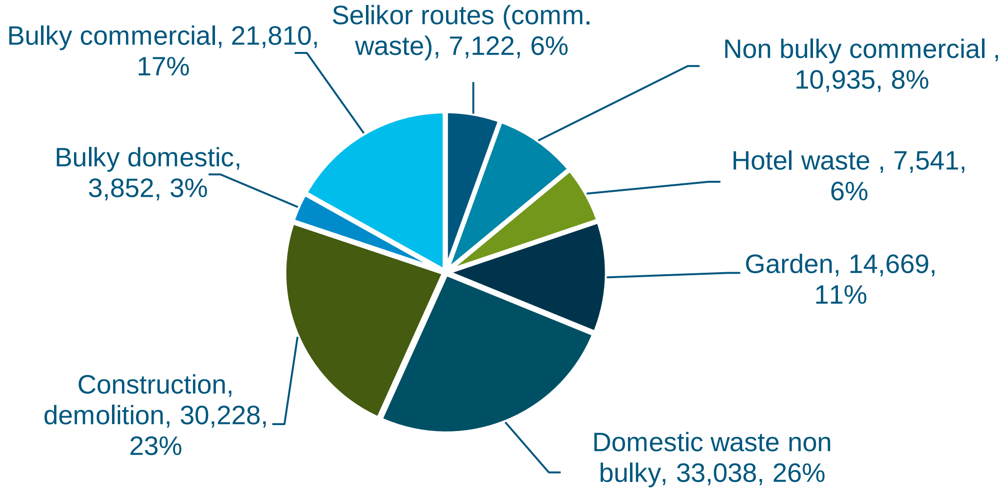


Figure 3: Estimated quantities for 8 waste categories disposed of at the Malpais Landfill based on the WCS 2024 ([ton/yr; [wt.%])

The WCS assessed not only the quantities per waste category, but also their composition. This allowed for the calculation of the average composition of landfilled waste. Subsequently the maximum quantity of each material that could be recovered for recycling purposes was determined. Figure 4 shows the quantity for each material landfilled at the Malpais Landfill ranked from largest to smallest.

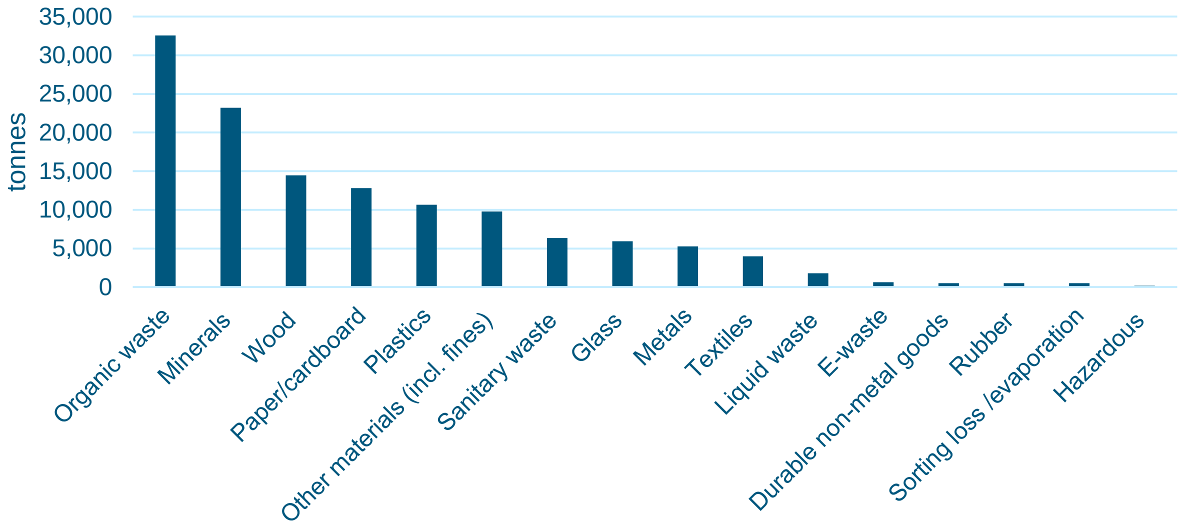


Figure 4: Waste fractions present in waste received at the Malpais Landfill in 2023

The eight waste categories are composed of different waste fractions. A cumulative insight is provided in Figure 4. The quantities in the figure are only theoretically available for recycling. Even in the event of a well-funded waste management infrastructure, many materials will not be suitable for recycling or are lost as sorting residue. For example, cardboard/paper may be too dirty for recycling, pieces of plastic may be too small to recover, etc. Nevertheless, a large gap exists for most materials between the potential and the actual quantities recycled that could be recycled on Curaçao as reported in the next section.

3.2.4 Recycling companies

The legal framework, the available waste, the gate fee for landfilling and all other market conditions have resulted in more than 10 active recycling companies on Curaçao. Their business varies from small scale to commercial scale implemented in other company operations. The following materials are recycled:

- glass,
- metals/e-waste,
- concrete debris,
- organic waste,
- paper/cardboard, and
- plastics.

Table 2 shows the most important recycling approximately ranked from high annual tonnage to low annual tonnage.

Table 2: Recycling companies active in Curaçao

Recycling companies	Feedstock	Produced recyclable
Heavy Mix Concrete	Source separated concrete debris	Recycled aggregates and sand
MijnMaatschappij Curaçao	Source separated concrete debris	Recycled aggregates and sand
Antillean Scrap Company	Source separated scrap metals	Scrap metals

Paradise Recycling	Source separated paper / cardboard	Paper / cardboard
Van Rumpt	Source separated paper / cardboard	Paper/cardboard
Green Force	Collected plastic bottles from recycling centers	PET bottles, #5 plastic and aluminum cans
Green Phenix	Collected plastic	Sends plastic to Green Force for further processing / exporting
Fuse	Source separated plastics	Construction materials replacing hardwood
Limpi	Source separated plastics	Souvenirs
Soltuna	Project development regarding recycling organic waste primarily from hotels / restaurants	Producing compost and local selling to hotels / garden companies

During the site visit, interviews were conducted with recycling companies that manage glass, paper / cardboard, plastic, organic waste, and C&D debris. The subparagraph below summarizes our findings from these interviews, as well as insights from our literature review on the waste fractions, (including metals and e-waste) per type of material.

3.2.4.1 Construction and demolition (C&D) debris

Construction and demolition waste contains predominantly mineral debris (e.g. concrete, pavestone, asphalt, etc.), wood, metals and plastics.

Current situation
Recycling of metals and concrete debris is well organized on Curaçao. However, recycling requires sorted waste streams consisting of close to 100% concrete, asphalt or scrap metals.

Two companies, Heavy Mix Concrete and MijnMaatschappij Curaçao, accept mono-streams of concrete debris and recycle this into sand and aggregates suitable for concrete products and other construction materials. These mineral recycling companies manage the entire recycling chain from waste to a product. It provides them cost savings by using waste as raw material and even exporting their final product to other Caribbean islands, such a Bonaire. For MijnMaatschappij, recycling concrete is a sideline to its production of construction materials from its mining operation at the Tafelberg.

Amongst others, Antillean Scrap Company and Efronix accept scrap metals sorted from C&D waste.

Challenges and opportunities
Much more recycling of C&D debris would be feasible. Debris that does not consist purely of concrete could be recycled for use in road foundations. Asphalt from road renovation could also be recycled into new asphalt roads. However, opportunities also exist for recycling glass and rubber (tires) for asphalt production. To increase recycling, a change in mindset of government departments is necessary to create win-win

situations so more materials are recycled and as such less primary resources would need to be purchased or locally excavated.

Dienst Openbare Werken (Public Works) manages the (road) infrastructure on Curaçao and is still reluctant to use recycled materials. This reluctance is given their responsibility, something which is not uncommon elsewhere in the world. However, because of this reluctance, MijnMaatschappij is exporting recycled construction materials to Bonaire instead of selling it on Curaçao.

Exporting recycled material by MijnMaatschappij is feasible because they are not hindered by excessively high transshipment costs, as they have their own port.

3.2.4.2 Metals/e-waste

Current situation:
Among others, the Antillean Scrap Company collects and sorts scrap metals. Recycling metals requires large quantities and industrial metallurgical plants, which are not present on Curaçao. Therefore, all scrap metals are exported.

Local recycling companies, such as the Antillean Scrap Company, collect and process metals and e-waste. These companies handle various types of metals and electronic waste, ensuring they are properly sorted and prepared for export.

Challenges and opportunities:

Although the collection and sorting of scrap metals function well, the waste landfilled at the Malpais Landfill still contains more than 5,000 tons/yr of metals, a large fraction of which would be suitable for recycling. Residents can drop off their metal and e-waste at designated locations, including Selikor's facilities, but this is rarely done. Recycling is predominantly carried out by businesses with significant volumes of scrap metals and the informal collection of bulky scrap metals at the disposal area on the Malpais Landfill.

Generally, landfilled metals consist of smaller items present in mixed waste. Their economic value, within the current constraints, is insufficient to justify more extensive collection or sorting efforts. Only approximately 1% of aluminum cans are collected for recycling via the recycling centers.

Opportunities for increased recovery of scrap metals include:

- Introducing a small deposit on cans, which could increase the recycling rate to up to 90% (based on deposit schemes in other countries).
- Expanding the current recycling centers to accept all types of scrap metals, not just cans.
- Paying residents a fee for recycling a certain quantity of metals. While local metal recyclers already pay a fee, this incentive is still not large enough for most individuals to make the effort to separate the metals and drop them off.
- Implementing separation equipment for ferrous and non-ferrous metals in a waste sorting plant.

3.2.4.3 Paper/cardboard

Current situation:

Recycling of paper and cardboard on Curaçao only occurs when businesses or individuals are able and willing to separate paper and cardboard at the source. In general, recycling companies collect source-separated paper/cardboard (baled and unbaled) without receiving a collection fee or paying for the recyclables. A fee for transporting the cardboard is sometimes charged. Therefore, given the constraints for paper/cardboard recycling, only companies that can provide sufficient volume without substantial contamination are serviced.

Challenges and Opportunities:

- Paper/cardboard cannot be recycled in Curaçao and must be exported to overseas paper mills. The shipping costs for paper/cardboard from Curaçao are relatively high, approximately ANG 4,000 per 40-foot container. Space in the port is expensive to rent and there is a shortage of containers. Transport costs are the most significant bottleneck.
- Recycling companies have had discussions with hotels to place balers, but instead of paying for the waste collection service, the hotels prefer to be compensated for their paper/cardboard waste. Collaboration with Selikor to use the Waste Drop-off Center (Milieustraat) at the Malpais Landfill has been considered to enhance paper collection efforts, but these collaboration efforts have not yet been successful.

3.2.4.4 Plastics

Current situation:

Recycling of plastic on Curaçao exists, but involves only a very small fraction of all plastics annually disposed of on the island. Recycling of polyolefins such as HDPE, LDPE, and PP is done on the island. This includes small-scale production of souvenirs (Limpi) and recently construction materials (Fuse). Fuse produces construction materials that replace hardwood with a sustainable recycled alternative. Given the list of possible durable goods such as planks, pergolas, flowerpots, and benches, a large part of these plastics can be recycled on the island when they are sorted for recycling. Fuse's operation started recently and faces several challenges, including upscaling feedstock supply and fine-tuning the production process to achieve full-scale production. Its current feedstock is sourced from both residents via recycling centers and businesses, such as supermarkets. A significant proportion of the recycled plastics are from packaging plastics. Fuse's plans include scaling up production to 10,000 planks per month and exploring the incorporation of other materials, such as glass and rubber into their products.

Recycling of PET is only feasible for PET bottles. PET bottle recycling is not present on Curaçao and as such, color-sorted PET bottles are exported. Green Force is the only company exporting PET bottles. In the past, Green Phenix used to export directly, but currently focuses on plastic collection and beach cleanups and send their plastics to Green Force.

Challenges and opportunities:

The challenges and opportunities differ per type of plastic. In Curaçao, only PET and polyolefins (such as HDPE, LDPE, and PP) are sorted for recycling. In countries that recycle plastics, recycling of plastics currently focuses on these polymers, which fortunately represent a large fraction of all plastics.

PET recycling; challenges:

- Although sorted PET bottles represent significant value per ton, this value is rather low per cubic meter of transshipment capacity due to their low density.
- Cheap transshipment destinations in the EU and US are avoided to prevent potential abuse through drug trafficking via shipping containers in Curaçao’s port. These incidents have unfortunately occurred in the past.
- Compared to competing suppliers of sorted PET, the Curaçao Port Services (CPS) charges container fees that are higher than the revenues for sorted PET.
- Shortage of containers for export.
- A limited number of decentralized recycling centers (collection points).
- Absence of sufficient public awareness for sorting PET bottles.

Opportunities:

- More recycling centers could increase the collection of PET bottles.
- An obligation via the EPP for businesses such as hotels, restaurants, and bars to sort PET bottles would increase recovery and enable recycling companies to request a fee for recycling.
- Reduced container fees. This reduction can be financed through:
    - A fee on imported containers that bring in (soon-to-be) waste materials.
    - The reduced landfilling costs due to recycling. Landfilling costs are much higher than the gate fee at the Malpais Landfill.

Recycling of Polyolefins such as HDPE, LDPE, and PP: Challenges:

- A successful balance between supply and demand. To be successful, Fuse or competitors require a stable supply of feedstock. On the other hand, sorting and collection companies require a stable demand for their products. Until now, a crescendo of supply and demand is missing. This situation will improve as soon as the public gains confidence in the recycled products and the recycling companies (e.g., Fuse) can offer certainty to sorting companies for demand.
- A limited number of decentralized recycling centers (collection points).
- Insufficient public awareness among residents and businesses for sorting PP and HDPE (bottles) at recycling centers.

Opportunities:

- More recycling centers could increase the collection of PET bottles.
- An obligation for larger companies, including supermarkets, warehouses, and hotels, to sort HDPE, LDPE, and PP would increase recovery and enable recycling companies to request/increase a fee for recycling.
- Collaboration with international brands to improve collection and recycling efforts through generating public awareness or financing more recycling centers. These efforts have been initiated in the past on a small scale with companies such as Coca-Cola.

3.2.4.5 Glass

Glass recycling can be divided into recycling of packaging glass or window glass into new packaging or window glass and recycling into construction materials such as asphalt, filler, and road foundation. For smaller quantities, recycled glass can be used to replace grit blasting substances.

Current situation:

True glass recycling is only possible via sorting plants for packaging glass or sorting plants for window glass. These plants are not present on Curaçao. Glass production sites are usually willing to used collected glass if the purity is sufficient. Recycling glass reduces feedstock costs and power consumption for glass production plants. The revenues for glass are in Europe approximately equal to sorting cost, but do not cover costs for collection and shipment. Therefore, there is currently no business case for the collection and export of packaging glass for glass recycling unless a country/company is willing to cover these costs. In the past, glass was collected and exported to a glass factory in Trinidad.

Recycling of glass as construction materials is easier and cheaper to organize. During the interviews, multiple companies have expressed their interest in using recycling glass in infrastructural building projects when this glass is offered free of charge. Existing stockpiles of glass waste at the Malpais Landfill could be recycled this way, but Selikor wants to be paid a fee for the glass waste, which makes the business case for glass recycling impossible. Because separate glass collection by Selikor increases costs and there is no demand for glass at the desired fee, Selikor still collects glass separately, but this is being stockpiled for potential future recycling.

Challenges and opportunities:

Challenges for true glass recycling:

- True glass recycling is expensive, because the facilities are not available on Curaçao and because the revenues for sorted packaging glass elsewhere are too low to cover collection, sorting and transshipment costs. Even when the transshipment costs are greatly reduced, it is not really a feasible route for Curaçao.

Challenges for recycling glass in construction material:

- Glass waste as feedstock for certain construction materials is generally used (worldwide) by major customers for construction materials. However, treatments such as washing and sorting lead to unfeasible business cases.

Opportunities for prevention of glass waste:

- Many glass packaging materials can be replaced by other packaging materials with less mass and better recycling opportunities. Glass packaging materials can, for example, be replaced with aluminum cans or PET bottles. Export of scrap aluminum cans is already a viable business case.
- Local reuse of imported glass bottles. In the past imported glass bottles were reused as bottles for another brand. This is an opportunity that would reduce the import of certain drinks that would use the waste glass bottles instead. However, it is not a solution to significantly reduce the total amount of glass waste.

Opportunities for recycling as construction material:

- Selikor should consider the avoided expenses for new landfill capacity as a revenue that covers the costs for collection of glass waste.
- Recycling of glass in construction materials is a feasible route for Curaçao if acceptance of recycled content in, for example, asphalt, concrete or road foundations is more widely accepted.
- The limited number of decentralized recycling centers (collection points) could be increased.
- Increase public awareness amongst residents and business for sorting glass.

History
Recycling glass as construction material or to replace sand occurred in Curaçao during several periods in the past, but now these companies have ceased their operations. Glass waste is no longer actively recycled. However, at the Malpais Landfill a substantial amount of glass waste is stored separately and could be used in future recycling operations.

In the past, there were more designated drop-off locations for glass waste, however now there are only 3 locations: the Sta. Rosa gas station, the recycling drop-off area at the Malpais Landfill, and at the Koraal Specht transfer station. Still there are ongoing efforts to use crushed glass, in road construction for example. These efforts were not successful due to a limited supply of glass waste which results from of the limited infrastructure/policy to collect glass waste separately.

Local reuse of glass bottles existed in the past when empty Heineken beer bottles were used to bottle soft drinks, until the soft drink producer switched to plastic bottles.

3.2.4.6 Organic waste

Organic waste recycling in Curaçao has been the subject of previous research, with initiatives aimed at converting organic waste into valuable compost. However, currently there are no large-scale composting initiatives, with existing efforts being small-scale. This section outlines the challenges and opportunities in this sector.

Current situation:
Organic waste recycling consists of composting or chipping to create woodchips or mulch. Currently, neither of these activities is widely practiced in Curaçao, with composting only happening on a very small scale. One development is by Soltuna, who is currently investigating the opportunity for commercial composting, intending to use garden and kitchen waste from hotels and restaurants as a feedstock.

Currently, all compost, potting soil, and woodchips/mulch are imported. The approximate price of imported compost ranges between 0.5 to 0.8 ANG per liter. (Kooyman, 2024). The price of woodchips varies depending on the application. Importing these does not only have economic disadvantages, as these products could be produced locally, but also risks introducing invasive species, which can be detrimental the local ecosystem and diversity.

Challenges
- Based on interviews, although the landfill receives much organic waste, this category is still dumped illegally in large quantities.
- Curaçao's climate belongs to the dry tropical region. Air moisture content is too low for natural composting (without use of an external water source). Therefore, the compost process requires fresh water which is scarce and expensive.
- Compared to other regions, Curaçao has a limited number of plant-based farms, so the amount of compost that would be needed is less.
- Currently, compost and woodchips/mulch are being imported, which increases price competition and reduces offtake opportunities by local consumers.
- Significant investment costs for a controlled composting facility.

Opportunities:
- Organic waste (approx. 30k ton/year) is 25% of all landfilled waste and is therefore an important waste fraction.

- Many vehicles transporting waste to the landfill contain 100% organic waste or wooden pallets. This makes it easier to separate this waste fraction.
- Wooden pallets can easily be chipped/shredded to produce woodchips of mulch.
- A composting operation in Aruba demonstrates that commercial composting is feasible in the dry tropical region with similar feedstock.
- Hotels, landscaping companies, and restaurants on Curaçao show willingness to participate in organic waste circularity. These parties can be involved in both providing the feedstock and receiving the compost. Soltuna is willing to organize this.

History

Compost is a crucial component for agricultural practices. In the past, Curaçao cultivated crops such as vegetables, beans, corn, and peanuts. However, this sector has declined due to the following:

- The agricultural workforce diminished due to industrialization.
- Small vegetable shops run by farmers were gradually replaced by large chain supermarkets, making the local agricultural business less favorable and leading to a decrease in the number of farmers.
- The cold chain supply for frozen imported goods has modernized, making it difficult for smaller businesses and local markets to compete.
- Outdated legislation currently regulates low pricing for local produce to keep food affordable. This disadvantages local farmers, as prices are so low that they earn far less from their produce compared to importers. Updating this legislation is necessary to balance the free market between imports and local production.

3.3 Opportunities and bottlenecks for increasing recycling waste materials

This section presents the results of the data analysis on recycling opportunities. Recyclable waste fractions have been identified and benchmarks about recycling ratios from benchmark countries have been used to calculate the potential of source and post-separation in Curaçao. A distinction has been made between non-bulky waste and bulky waste. Key findings are:

1. The maximum potential amount of recyclable waste has been calculated at 70,000 tons per year, with more than half consisting of minerals and organic waste.
2. For non-bulky waste, post separation will not be effective. Source separation is required to gain higher quality recyclable products which can be exported or recycled locally.
3. For bulky waste, post separation is possible to retain significant quantity of recyclables. However, source separation for bulky waste within Curaçao is still recommended since this results in better cost-effective recycling possibilities and has been done in the past.
4. Not part of the data analysis are tools, tableware and furniture which can be used second hand. We expect an additional reuse flow of 3,000 ton / year for this category.

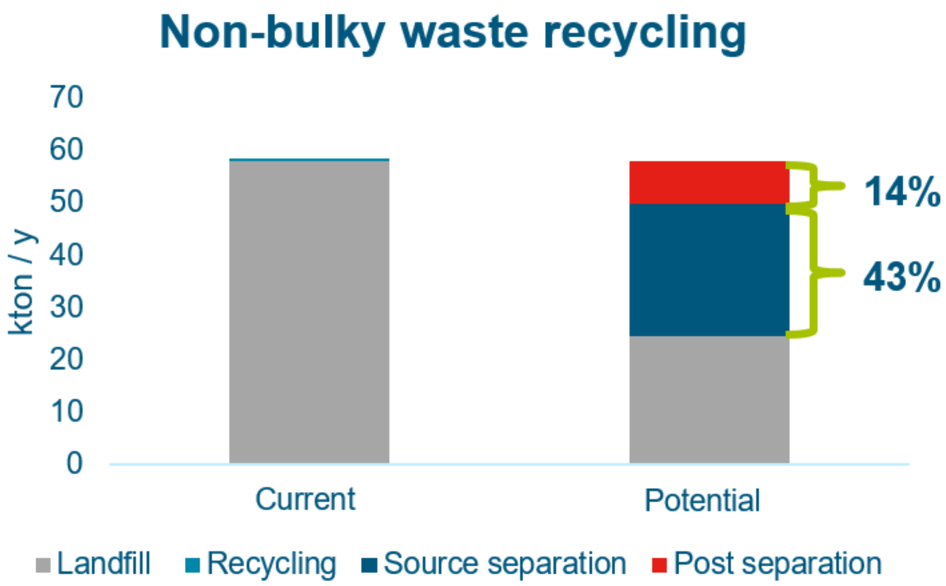


Figure 5: Non-bulky waste recycling opportunity

This can result in diverting up to 32,900 tons of waste annually from the landfill, saving valuable space:

Table 3: Recycling potential: non-bulky waste

Waste route	Recycling potential (ton / yr)
Organic waste	9,000
Higher quality plastics	2,200
Low quality plastics (post separation)	6,000
Paper	2,200
Cardboard	5,000
Metals / E-waste	3,500
Glass	4,000
Textiles	1,000

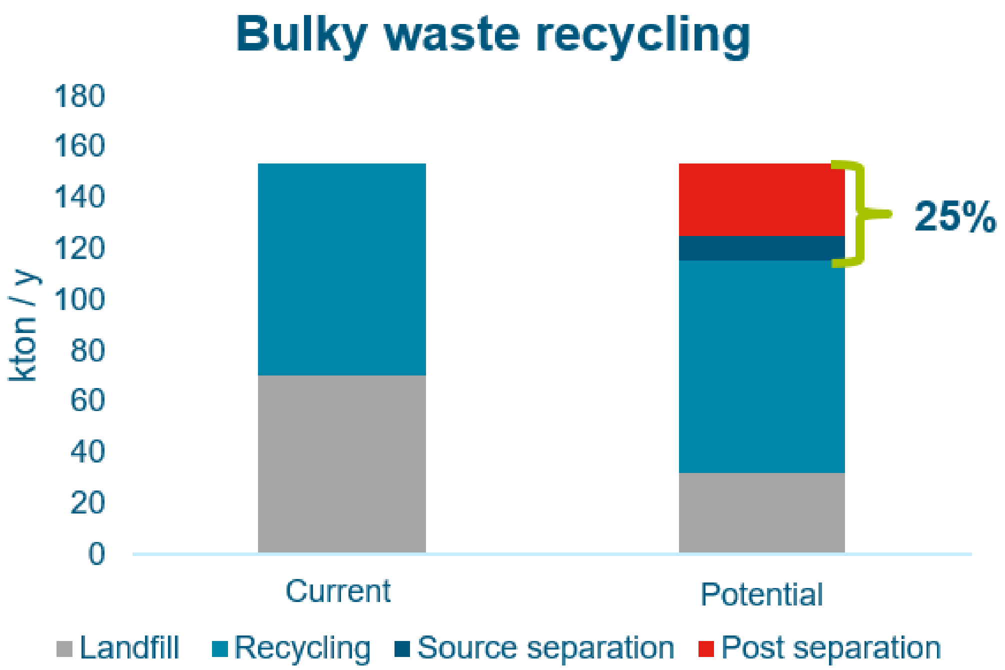


Figure 6: Bulky waste recycling

This can result in diverting up to between 34,500 – 35,500 tons of waste annually from the landfill, saving valuable space:

Table 4: Recycling potential: bulky waste

Waste route	Recycling potential (ton / yr)
Organic waste	9,000
Wood	2,500 high quality 3,500 low quality
Minerals	20,000
Metals / E-waste	3,000

3.4 Previous waste-related studies on Curaçao

During the literature study, previous research and initiatives related to waste management on Curaçao were examined. The following summary aims to provide an overview of the challenges and opportunities in transitioning towards a more sustainable waste management system. The most encountered subjects are **waste management plans, potential waste treatment scenarios, waste characterization** and **location studies**. The latter, however, is out of scope for this project.

3.4.1 Previous developments of comprehensive waste management plans

The law specifically regulating waste management came into force in 1996. This law covered various aspects of waste management, including a tipping fee of ANG 30/ton (US $16.67/ton) at the landfill. This law was an island-level ordinance when Curaçao was part of the Netherlands Antilles. When Curaçao became an independent country in in 2010, this law did not become part of the new legislative framework of the country Curaçao. As such, currently there is no law in Curaçao that specifically regulates waste management. A new draft waste law was prepared, but has not yet been approved by the government since it was drafted in 2013. The ANG 30/ton tipping fee at the Malpais Landfill has never been indexed (i.e. corrected by inflation) since 1996.

Several notable developments in waste management plans have occurred. The first Waste Management Plan (WMP) for Curaçao was finalized in 1996 and a second WMP was drafted in in 2005, but it was never formalized as an official policy by the government. The government's Doughnut Economy Compass Strategy briefly mentions waste management. However, these documents do not provide a sufficient basis for formal government regulation and policies regarding waste management.

Appendix E accompanying the ministerial decree (2020), from the Environmental Permitting Policy (EPP) report recommends that a comprehensive waste management plan should be implemented. This plan should detail the following aspects:

- types and amounts of waste
- separation and storage methods
- treatment processes (recovery/disposal)
- goals and objectives (KPIs)
- managerial responsibilities
- training and communication strategies
- on-site transport and logistics,
- monitoring, registration and evaluation procedures

The EPP also proposes general waste management requirements for future environmental permits and establishment processes. (Ministry of Health, Environment, and Nature, 2020).

3.4.2 Potential waste treatment scenarios

In recent years, Curaçao has conducted several studies on waste management. Notably, Royal HaskoningDHV[5] conducted two studies investigating the feasibility of building a waste to energy (WTE) plant. The most recent feasibility study on waste treatment dates from 2011. This study re-evaluated the findings of a 2003 study and proposed basic technologies and variants, including waste sorting and separation, thermal conversion, flue gas treatment, energy recovery and a potential digestion plant. The study considered two main scenarios for handling 140 kt of waste per year and one sub scenario:

- Scenario 1: Basic sorting and recycling with a WTE plant for the remaining fraction.
- Scenario 2: Improved sorting and recycling with a WTE plant.
- Scenario 2a: Incorporates a mechanical sorting plant to recover the organic fraction to be treated in a digestion plant.

In the above-mentioned studies, Royal HaskoningDHV concluded that converting waste into energy could significantly increase waste disposal tariffs. Such a facility could generate approx. 80,000 MWh per year (10 MW generator capacity), depending on the waste composition. Moreover, the Curaçao renewable energy strategy from 2016 also warns of high operational costs (maintenance, chemicals, disposal of residual waste, etc.) and depreciation, and therefore the net yearly income from electricity production is limited.

In addition, the 2018 National Energy Policy suggests building a 7−15 MW WTE facility by 2021. The investment, construction and operation of the facility should be done by a commercial company which will

[5] *Before 2012 known as 'Royal Haskoning'*

treat the waste supplied by Selikor for a certain gate fee and includes selling electricity (and possibly desalinized water) to the utility company Aqualectra. (The Ministry of Economic Development, 2018).

Based on the above described Built Own Operate Transfer (BOOT) contracts, Selikor frequently receives proposals from companies claiming they have a WTE business case. However, after reviewing the conditions, companies often withdraw their offers (Matthijs Hisschemöller (VU, 2009). Results so far anticipate a challenging business case if the expectation is to make a profit from a WTE plant.

3.4.3 Recent studies advising waste characterization

Reliable waste management studies are only possible if the composition and calorific value of the waste to be managed is clearly understood. Therefore, it was recommended to conduct proper inspection of household and commercial waste at the gate of the Malpais Landfill to substantially increase recycling possibilities. Additionally, conducting seasonal Waste Generation Studies (WGS) for the dry season and high tourism season is essential. (TNO, 2021)

At the end of 2023, a Waste Characterization Study (WCS) was conducted for Selikor as part of its ‘Transforming Waste to Value’ project, funded by the EU’s RESEMBID program, The study investigated the composition and weight of eight waste categories. (Ecovision, 2024) This WCS forms the basis of this Feasibility Study and its findings are used above in section 3.2.3 Waste quantities and characterization.

3.5 Conclusions about waste management in Curaçao

To enhance the efficiency and effectiveness of waste management in Curaçao, several key legislative measures are proposed. These measures aim to address current barriers and promote sustainable practices within the construction and waste management sectors.

Introduction of a comprehensive waste policy: The lack of a comprehensive waste policy creates uncertainty for investors in recycling companies and reduces the likelihood of positive investment decisions. Consequently, the absence of such a policy hinders recycling opportunities. The economic feasibility of waste processing options (evaluated later in this report) depends on parameters being set within a waste management policy. Based on discussions with recycling companies and our experience, the introduction of a waste management policy is crucial for establishing a successful solid waste management system in Curaçao. As part of Selikor’s Transforming Waste to Value project, a new waste policy is currently being developed in conjunction with the Ministry of Health, Environment and Nature.

Legislative measures related to soil, debris, and asphalt recycling:

a. **Introduction of mandatory source separation for concrete, soil, and metals in demolition projects**: It is recommended to introduce the obligation to separate specific recyclables at the source in demolition projects. Conversations with mineral companies have revealed that mixed construction waste significantly hinders the quality of recyclable debris.

b. **Recycled content requirement**: Mandating a minimum recycled content (e.g. of up to 30%) for foundation materials, asphalt, and concrete in all public tenders is recommended. This requirement would require contractors to utilize recycled materials, thereby increasing the demand for recycled debris. All governmental bodies and related entities should adopt this new requirement.

Legislative measures related to waste paper/cardboard, plastic, and aluminum recycling:

a. **Mandatory source separation**: Introducing mandatory source separation for waste paper/cardboard, PET bottles, and aluminum cans for medium to large businesses, including hotels and restaurants, is proposed. Source separation is crucial for the recycling progress. This obligation would enable recycling companies to increase their small collection fee, which can then help finance sorting and recycling if necessary. This facilitates positive cash flows and business expansion for local companies such as Paradise

Recycling, Green Force, and Green Phenix. Enforcement of the mandatory separation will present a challenge.

b. **Deposit system for one-way use aluminum cans, PET bottles, glass bottles, and crates**: A deposit system for these materials is recommended. Such a system would also collect these materials from households. A drop-off system is less expensive than a collection system, but is dependent on residents' willing participation. A deposit system has the potential to reduce litter, improve recycling rates, and over time, provide clean, uncontaminated recyclable streams that are more cost-effective to process. It is important to impose deposits for aluminum cans, PET bottles, and glass bottles simultaneously to prevent sales from shifting to packaging materials without a deposit. The downsides of such a system include the high costs for collection and the administrative burden associated with implementing a deposit system (such as determining the amount of the deposit).

More than 30 years ago, a deposit system for glass bottles was in place for locally produced beverages. This is still the case for bottled beers in Aruba.

Strategies for reducing various imported waste categories in Curaçao

Curaçao heavily depends on importing products, which indirectly leads to importing waste. Therefore, economic incentives are necessary to stimulate a transition from importing products to local production, thereby reducing waste. Creating economic triggers to import products that are easier to recycle is essential, such as:

a. **Tax or ban on glass packaging materials with alternatives**: Implement taxes or bans on the import of products packaged in glass that can be replaced with aluminum cans or PET bottles (e.g. beers, soft drinks, juices, etc.).

b. **Consider an import ban on products that can be replaced with compost and/or mulch**: Reassess import regulations for compost and mulch as soon as sufficient local compost and/or mulch production is available.

c. **Abolish capped prices for local food production to enhance food self-sufficiency for Curaçao**: Reconsider price caps on locally produced food, as these caps hinder local food production initiatives compared to imports. Locally produced food reduces dependency on foreign currencies, generates less waste, and increases the need for organic waste (compost), which can be produced locally from organic wastes.

d. **Ban single-use plastics**: A law banning single use plastics was passed by parliament, but has yet to be published to enter into force.

e. **Switch from glass bottled drinks in HDPE crates to aluminum canned drinks in cardboard boxes**: Importing HDPE crates containing glass bottles of sodas creates plastic and glass waste. This can be changed to importing aluminum cans in cardboard boxes for soft drinks. Another option would be to implement a deposit on these crates to ensure they will be returned instead of landfilled.

f. **Establish a fee for importing (EUR) pallets**: Impose a fee for importing (EUR) pallets that can finance excessive logistic costs for return transport. Another option would be to implement a deposit on these pallets to ensure they will be returned instead of landfilled.

g. **Establish a fee for importing packaging materials**: Impose a fee for importing packaging materials that can finance excessive logistic costs for the export of recyclables. For example: impose a fee per sea container with Curaçao as the final destination, regardless of the cargo. Since the export of recyclables is only a fraction of the total import, even in a favourable scenario, the amount per container would be quite small. This is relatively easy to organize, whereas an EPR system (extended producer responsibility) is very complex and expensive to set up.

h. **Ban or tax detrimental products**: Implement bans or additional taxes on products detrimental to Curaçao and its local ecosystem, replacing them with more eco-friendly alternatives (e.g. banning plastic clothespins, as wooden ones are an alternative).

Law Enforcement: Effective enforcement of laws is crucial for the successful functioning of a waste management system anywhere in the world. Without proper enforcement, residents and businesses that do not comply with the law will have an unfair advantage. In the absence of strict law enforcement. For example, contractors engaging in illegal dumping and mixing demolition waste would gain economic benefits at the expense of those following the law. This unfair advantage can cause waste management and recycling companies to go bankrupt, demotivates residents, and deteriorates the functioning of proper waste management.

Awareness and Education: Raising awareness and providing education are essential for embedding and understanding waste management at both individual and business levels. Positive results have been observed on the island where similar initiatives have been implemented. Gradually the business community is noticing a change in mindset within the government, but there is still a long way to go. Providing transparency about recycling initiatives helps, but this still has little influence on the government to move the needle towards a change in policies and to introduce new laws and regulations to promote waste separation and better waste management. To seek sustainable solutions, collaboration efforts must be clear. There needs to be a healthy business model or subsidies in place to propel sustainable efforts going forward. Increased general awareness and knowledge of waste separation, recycling and overall waste management is very necessary. As part of Selikor's Transforming Waste to Value project, a 3-month long awareness campaign on these issues will be implemented.

Challenges in Public and Business Cooperation: Several issues have been identified that hinder effective cooperation between the public, businesses, and waste management including:

a. The costs that Selikor incurs for waste collection and landfill management are only partly paid by the government. Consequently, a scarcity of funds results in austerity that deteriorates and/or jeopardizes both proper operations and maintenance. This reduces the availability of, for example, the waste drop-off zone, hazardous waste incinerator, and compactors at the landfill.

b. Insufficient government payments to Selikor create a strong focus on generating additional revenues (e.g. from commercial contracts including from recycling initiatives) to overcome the shortfall, even when anticipated revenues from recycling are not realistic. This need for additional revenues causes Selikor to request that recycling companies pay for sorted wastes that have no or hardly any positive cash flow. As a result, various recycling opportunities have not started. Many (temporarily) stored recyclable waste fractions (e.g., glass, HDPE, mixed construction waste, tires) are not being transferred to recycling companies, or are not recycled by Selikor itself, but remain stored at the landfill indefinitely.

Recycling activities influenced by international trading fees, such as plastics and cardboard, lack a stable business case and cash flow projection. This instability prevents fixed contracts being signed between Selikor and recycling companies. Investigating the use of "tolled contracts" is recommended. These contracts would base fees and returns on international recycling spot prices.

Although a clause could be included to ensure that companies set aside funds for cleanup in case of bankruptcy, currently most local recycling companies cannot finance this cleanup fund because they have insufficient solvency.

The 2024 WCS study indicated that cruise ship companies offload wastes in Curaçao that are highly source separated. However, due to the lack of agreements, often these sorted fractions currently end up in the landfill.

Financial Management: Solid waste management requires additional financial management instruments. Currently, there is a lack of economic instruments that promote reduced landfilling.

a. **Assess the strategic planning capacity for the landfill**: It is advised to assess the strategic value of the remaining landfill capacity in cubic meters. This value is typically expressed in remaining cubic meters (m^3). Defining this strategic planning capacity is important as it supports decision-making about the future of the landfill as such reduces the pressure to take measures and to make large investments. This allows for decisions and large expenditures to be deferred. The current cost for realizing an additional cubic meter of landfill capacity is much higher than the existing ANG 30/ton landfill gate fee. This means that Selikor (and indirectly the government) are subsidizing landfilling.

b. **Introducing a tax on the capped mineral aggregate selling price**: For Curaçao's economic strategic developments, we recommend exploring the consequences of adding a tax to the capped mineral aggregate selling price by the MijnMaatschappij. This tax increases the competitiveness of recycled aggregates and will increase the demand for them. Additionally, Curaçao or the MijnMaatschappaij might benefit more, and for a longer period, by exporting minerals from the existing "Tafelberg Mine" compared to selling them to the local market for less revenue per ton.

4 Technology selection

This chapter introduces a list of technologies that could be used to advance a sustainable circular economy for Curaçao and reduce the annual volume to be disposed of at the Malpais Landfill. Subsequently, a shortlist of recommended techniques will be created using multi-criteria assessment (MCA).
The technologies listed are limited to those used in the recycling or recovery steps of the waste hierarchy or involve management techniques that could be implemented by the Curaçao government. For recycling technologies, only sorting options will be evaluated. This means that, for example, the implementation of a glass smelter or a steel mill is beyond the scope of this report. At the end of this chapter, the three most promising techniques will be selected and elaborated upon in detail in Chapter 5.

This technology review focuses on:

- Waste management techniques (see section 4.1).
- Source separation techniques (see section 4.2).
- Post-collection sorting techniques (see section 4.3).
- Recycling techniques (see sections 4.4 and 4.5).
- Recovery techniques (see section 4.6).

4.1 Waste management techniques

The following are waste management techniques that are being considered, as they could be implemented on Curaçao:

1. Reducing logistics costs for exported recyclables.
2. Waste policy measure that obliges source separation at (larger) companies and hotels for paper/cardboard, aluminum cans, and plastics (e.g. PET bottles - shrink wrap plastics and PP should also be considered).

4.1.1 Reducing logistics costs for exported recyclables

One of the main reasons why materials such as paper/cardboard and PET bottles are not recycled more is due to the high container fees to export sorted recyclables for recycling abroad. Multiple recycling companies on Curaçao have indicated these container fees are the main reason that limits their efforts to collect lower quality recyclables. The collection and separation costs for those recyclables are higher and cannot be covered by their revenues once the total logistics costs are factored in, including the costs for shipping containers.

There are two options available to reduce the logistics costs:

- Imposing import responsibility for incoming containers. The Curaçao Port Services (CPS) fees for incoming containers should be imposed an EPR[6] fee. This could result in a 50% or even 80% cost reduction for recyclables. Financing via charging for incoming containers with imported goods seems fair, as imported goods are the main source of non-mineral waste being landfilled. A literature study has shown that positive results were achieved in other SIDS when implementing this.
- A 50% to 80% reduction of the container fees when exporting recyclables.

[6] *EPR = Extended Producer Responsibility*

Benefits:

- It becomes much more attractive for recycling companies in Curaçao to collect, sort, and export recyclables, as lower quality recyclables become profitable for collection by smaller companies, for sorting to specifications for lower qualities, or even for to pay for (larger quantities of) recyclables.
- The amount of recyclables (e.g. paper/cardboard, plastic [bottles], aluminum cans, and waste electrical and electronic equipment [WEEE]) being landfilled will reduce.
- The potential reduction of waste being landfilled is rather high because it becomes feasible to export a much larger fraction of paper/cardboard and plastics as recyclables.

Disadvantages:

- The cost of container shipments to Curaçao will increase or the profit margin of shipping companies will decrease.

Status in Curaçao:

- Not applied.

4.1.2 Mandatory source separation for companies

Most materials require well executed source separation to remain recyclable. Controlled environments, such as (larger) companies, are better equipped to separate at source.

Currently, the EPP offers GMN the opportunity to require companies applying for new nuisance permits to separate their waste. However, GMN is not obliged to implement this and most companies already have existing permits. Therefore, mandatory source separation is currently limited to a few companies that are obliged to sort due to their recent permit applications and a small number of larger companies that choose to sort voluntarily.

The current practice for Curaçao shows that, amongst others, supermarkets are successful in collecting cardboard for recycling. Their participation is however mostly voluntarily. This mostly voluntary participation has two disadvantages. Firstly, the recyclables from companies that do not voluntary participate are lost as they are mixed together with residual waste and are landfilled. Secondly, the recycling companies cannot request a fee to collect sorted recyclables. The recycling companies will therefore only collect from those companies where volume and quality are sufficient to cover the costs for quality control (sorting) and logistics to export to the final recycling company.

Mandatory source separation for companies will generates much larger volumes that can be upgraded to a higher quality recyclable.

It is not recommended to make this mandatory for all companies. Usually, it is applied for companies above a certain threshold and only for recyclables that are common for a certain type of business.
Table 6 shows an example for mandatory source separation that could be elaborated on when preparing the new waste management policy for Curaçao.

Table 5: Example mandatory source separation for companies

Type of business	Recyclables
Restaurants, bars, hotels, resorts	• PET bottles • Aluminum cans • Paper and cardboard • Shrink wrap
Offices, airport, companies with more than 5 employees	• Paper and cardboard • PET bottles and aluminum cans (to be discussed next phase) • Shrink wrap
Shops	• Paper and cardboard • PET bottles and aluminum cans (certain volume threshold required)
Companies with more than 5 employees	• Paper and cardboard
Companies that handle, sell or repair electric equipment electronic equipment and vehicles	• WEEE • Scrap metals
Construction and demolition companies	• Concrete, asphalt, soil, metals

The exact approach should be based on the current and expected possibilities for collecting and/or local recycling of recyclables and if needed, the export possibilities.

Benefits:

- It becomes feasible for local recyclers to charge a collection fee.
- It becomes much more attractive for recycling companies in Curaçao to collect, sort, and export recyclables. Because lower quality recyclables (also from smaller companies) then become suitable for collection so they can be sorted to meet specifications for lower qualities, or it may even become possible to pay for (larger quantities of) recyclables.
- The potential reduction of waste being landfilled is rather high because a much larger fraction of waste paper, plastic (bottles), aluminium cans, metals, and WEEE become available for export.

Disadvantages:

- This waste management technique requires active enforcement by the government.
- The disposal costs for companies will (slightly) increase, because source separation for smaller volumes is costlier than disposal in the landfill when all wastes and recyclables are mixed together.

Status in Curaçao:

- Not applied.

4.2 Source separation techniques

Source separation methods are not the prime scope of the scenarios that are evaluated, but the use of these methods can heavily influence the feedstock for those scenarios investigated in this feasibility study. Moreover, recyclables such as waste paper/cardboard, organic waste, and glass waste are only recyclable via source separation.

The following source separation techniques are considered that could be implemented on Curaçao:

- Source separation via house-to-house collection.

- Source separation via recycling centers for non-bulky waste.
- Source separation via a recycling center for bulky waste.

4.2.1 Source separation via house-to-house collection

Source separation via house-to-house collection is a method where recyclables are sorted at households or companies and subsequently picked up via a house-to-house collection route.

Benefits:

- It results in a reduction of waste being landfilled.
- The separated recyclable can be collected with little or no contamination that hinder recycling opportunities.
- The waste fractions such as waste paper/cardboard, glass, organic waste, textiles, etc. can be incorporated smoothly into existing available local recycling routes.
- If successfully implemented, the potential reduction of waste being landfilled is rather high because a much larger fraction of waste paper/cardboard, plastic (bottles), aluminium cans, metals, and WEEE become available for export.

Disadvantages:

- It requires a collection route for each source separated material. Separate collection routes are expensive, but separated recyclables can be collected with little or no contamination which increases recycling that hinders opportunities.
- The required quality depends on the motivation of people to sort correctly. Inadequate sorting by some people can ruin the quality of the entire batch of source separated material.
- The response (recovered amount) depends on the motivation of people to sort correctly.

Status in Curaçao:

- Not in use on Curaçao.
- Expectation by Selikor is that full source separation via house-to-house collection will be difficult to implement on Curaçao due to too little motivation and additional associated costs.

4.2.2 Source separation via recycling drop-off centers for non-bulky waste

Source separation by citizens and small businesses via recycling drop-off centers for non-bulky waste is a method where recyclables are sorted at households or companies and subsequently brought to recycling drop-off centers. These decentralized locations are, for example, located near supermarkets, waste management centers, or within a relatively small distance from populated areas.

Benefits:

- It results in a reduction of waste being landfilled.
- The separated recyclables can be collected with little or no contamination that would otherwise hinder recycling opportunities.
- It is based on currently available recycling techniques for numerous recyclables and currently is the only viable local recycling route. Source separation is required for waste paper/cardboard, glass, organic waste, textiles, etc. The required distance to drop off waste is shorter and people are therefore more likely to drop off their recyclables.
- The average quality is more likely to be sufficient because usually only environmentally conscious citizens make the effort to bring recyclables to a decentralize drop off point.

Disadvantages:

- The response (recovery) will be much lower because many households and companies do not separate at source and people are not willing or are unable to bring their waste to the recycling drop-off centers.
- The potential reduction of waste being landfilled is relatively low, unless there is a successful culture change regarding making efforts to separate waste, which would contribute to a circular economy.

Status in Curaçao:
Currently used in Curaçao for plastics PET, HDPE, PP and aluminum cans. A total of seven recycling centers are located near supermarkets in many areas on the island. Their Capex is usually financed via other stakeholders such as supermarkets, Coca Cola, Curaçao Cleanup, etc. Collection and maintenance of the centers is handled by Green Force and Green Phenix. The recycling centers function well, but a denser distribution could increase their throughput. The current recycling stations result in around 80 m^3 of plastic recycled per month through Green Force. Green Phenix, and Limpi collect annually together less than 50 ton.[7]

Additionally, the Clean Caribbean Coalition collaborated with the Ministry of Health, Environment, and Nature (*Ministerie van Gezondheid, Milieu en Natuur, GMN*) to the ban of plastic bags and other single-use plastics, such as cups and straws. In the beginning of 2024, Curaçao passed the “Plastic Law”. At the time of publishing this report, this law was not yet officially been published by the government. The law stipulates a nine-month transition period after which the use of foam containers, plastic cutlery, and plastic bags will be prohibited. However, biodegradable plastic bags, deemed more environmentally friendly, are exempt from this ban.

4.2.3 Source separation via recycling centres for bulky waste

Source separation via recycling centers for bulky waste is a method where recyclables are sorted at the households or companies and subsequently brought to a recycling center for bulky waste. Recycling centers for bulky waste generally consist of a high platform from which bulky (and/or non-bulky) recyclables can be placed in the corresponding containers. Each container should be well marked in order to be easily recognized. The number of containers depends on the number of recyclables that are sorted at source. This type of recycling center only functions well when supervised adequately.

Recycling centers for bulky waste are preferably located at a central location within a reasonable driving distance. A European city with a similar population to Curaçao usually has one recycling center for bulky waste.

In European countries 20 or more waste streams are separated. To motivate citizens and companies to sort, disposing of source separated recyclables is free and disposing of residual waste is charged a disposal fee

Benefits:

- It results in a reduction of waste being landfilled.
- The separated recyclable can be collected with little or no contamination that hinders recycling opportunities.
- It will be based on currently available recycling techniques, which for numerous recyclables are the only viable local recycling route. Source separation is required for waste paper, cardboard, glass, organic waste, textiles, etc.

[7] *Waste Characterization Study Curaçao – EcoVision - 2024*

Disadvantages:

- Compared to non-island nations, a relatively small number of bulk recyclables is suitable to be separated at source via a currently available recycling routes.

Status in Curaçao:

Currently used in Curaçao at the Malpais Landfill. Although the existing platform meets the requirements for a recycling center for bulky waste, it is however hardly used. The following issues hinder proper functioning of the recycling center for bulky waste:

- The average distance for households and companies to this recycling center is rather large and not more attractive than simply landfilling.
- Access is only possible via the Selikor's weighbridge resulting in further hindrance by the frequent queues.
- No supervision is present.
- There is a financial incentive to sort wastes (by avoiding the landfill gate fee – there is no charge for wastes brought to the center).
- No clear information signs are present indicating where to drop off each type of recyclable.

4.3 Post-collection sorting techniques

Post-collection sorting techniques are sorting techniques that extract recyclable materials from residual waste streams. Residual waste streams are combined wastes containing different types of waste that are not separated at the source. When landfilling 100% of wastes, differences will occur in the composition of residual waste streams. Two common examples:

1. Contractors and demolition companies generate construction and demolition waste. This waste is bulky and heavy. The collection vehicles and containers are designed for these tough conditions. On the other hand, compacting this waste stream during collection offers no benefits.
2. Households (and small companies) generate non-bulky household waste. This waste is non-bulky and has a low density. The low density and other material properties allow for compacting the waste to reduce collection costs.

These composition differences do not only influence the collection of these residual waste streams, but also set the starting points for a post-collection sorting plant.

For the configuration of a post-collection sorting plant on Curaçao, at a minimum, the following technical questions must be addressed:

- Which materials are present in the residual waste stream allocated to the configuration?
- Which materials are suitable for recycling on Curaçao or for export as a recyclable when derived from residual waste?
- Which materials cover the price gap between the landfill gate fee and the revenue (or recycling fee) for the recyclable on Curaçao and the additional sorting costs?
- What is the annual volume of this type of residual waste on Curaçao?
- What is the bulk density of the waste stream?
- What is the particle size distribution for 95% of the waste stream?
- How much sand and/or mineral debris is present?
- How much (fine) organic waste is present?

The answers to these questions determine the basis for designing an economically viable configuration.

Configuration of a waste sorting plant
A waste sorting plant is usually tailor-made. The configuration is the specific combination of separating and comminution techniques. Which techniques are used depends on the composition of the waste to be sorted and the recyclables to be extracted from the waste flow.

Table 7 identifies potential post-collection waste sorting plants that could be realized on Curaçao based on the collected residual waste streams. The table characterizes each type of waste stream. Subsequently it shows which waste streams could be combined in a single configuration for a sorting plant. Finally, the table shows which recyclables and/or solid recovered fuels (SRF) are commonly extracted at these plants. SRF is fuel derived from waste with a more specified composition than residual waste. Another name, RDF (refuse derived fuel), is also used, but this name can be confusing since it is also used for mixed waste that is sent to waste to energy plants.

Table 6: Identification of potential waste streams for post-collection sorting

Type of waste stream	Characterization waste stream	Sorting plant with a configuration dedicated for:	Target recyclables
Domestic waste, non-bulky	Non-bulky, low density, rich in plastic, paper/cardboard and organic waste	Non-bulky residual waste	Metals, plastics & SRF
Bulky domestic	Bulky, low density, rich in plastic, paper/cardboard	Bulky residual waste	Metals, plastics & SRF
Selikor routes (commercial waste)	Non-bulky, low density, rich in plastic, paper/cardboard and organic waste	Non-bulky residual waste	Metals, plastics & SRF
Non-bulky commercial	Non-bulky, low density, rich in plastic, paper/cardboard and organic waste	Non-bulky residual waste	Metals, plastics & SRF
Bulky commercial	Bulky, low density, rich in plastic, paper/cardboard	Bulky residual waste	Metals, plastics & SRF
Hotel waste	Non-bulky, low density, rich in plastic, paper/cardboard and organic waste	Non-bulky residual waste	Metals, plastics & SRF
Garden (yard)	Almost completely organic waste	No sorting required	Organic matter
Construction & demolition (C&D) waste	Bulky, high density, rich in mineral debris, wood, metals, and plastics.	C&D waste	Metals, mineral aggregate, wood, plastics & SRF

Sorting all available (mixed) residual waste streams on Curaçao requires the following three configurations for each type of mixed waste:

- Sorting non-bulky residual waste.
- Sorting bulky residual waste.
- Sorting C&D waste.

Regarding post-collection sorting, each configuration is assessed for each type of mixed waste in the following subparagraphs.

4.3.1 Sorting non-bulky residual waste

The configuration for sorting non-bulky residual waste depends on which materials are extracted from the waste streams. In general, the following three basic configurations are used:

- Biological treatment and mechanical sorting
- SRF (RDF) extraction
- Extraction of plastic & metal packaging materials

Biological treatment and mechanical sorting

Mechanical/biological treatment aims for a maximum reduction of landfilling and the extraction of recyclables, metals, minerals (i.e. debris, glass), and plastics. The extraction of plastics can be replaced by the extraction of SRF (i.e. a plastic/paper mix). The process generally starts with biological drying of the residual waste. This drying reduces the mass and makes the waste more suitable for mechanical sorting. After the drying stage, the selected recyclables and/or SRF are separated. The residue is either landfilled or sent to a WTE. Because low calorific materials (such as minerals), moisture, and high calorific materials (such as plastic and paper) are removed, the calorific value remains approximately equal and suitable for WTE. Biological treatment is an attractive solution if demand for SRF is available and the landfill or WTE capacity is limited. In Europe, this technique is applied with varying success. Guaranteed demand for the output is crucial.

SRF extraction

Extraction of solid recovered fuel (SRF) results in fuels that can be either used thermally for energy recovery or as feedstock for gasification preceding chemical recycling. SRF usually consists of either a mixture of paper and/or plastics that are no longer suitable for recycling or a homogeneous waste stream that meets the required specifications. SRF extraction can be combined with the recovery of other recyclables such as metals and plastics. SRF extraction reduces the volume of residual waste by 15% to 30% depending on the composition. It should be noted that the extraction of SRF reduces the average lower heating value of the residual waste, which, after extraction, might become less extractive for treatment in a WTE plant.

SRF is usually sold for heat production in for example cement kilns and district heating networks. In Europe, this technique is commonly applied, but SRF prices are frequently negative (i.e. a gate fee is required). The revenues for the sorted SRF are usually not enough to cover sorting costs unless a high gate fee is present for disposing of waste elsewhere. Guaranteed demand for the output is crucial.

5. Extracting plastic & metal packaging materials

Plastic and metal packaging materials can be sorted for recycling. This occurs only in countries where source separation is not desired or feasible and EPR schemes for packaging materials must meet their recycling targets. It is an expensive technique that reduces the weight of non-bulky waste by only 10% to 15%.

In Europe, this technique is sometimes applied, if other methods to meet the recycling targets are insufficient. The revenues for the sorted fractions are by far not enough to cover sorting cost unless a high gate fee is present for disposing of waste elsewhere.

Figure 7 shows in a mass balance the potential for a sorting plant for non-bulky residual domestic waste with the current composition of non-bulky waste from households on Curaçao. The process flow diagram is shown in Appendix N. It shows that only 11% of the waste could be diverted from landfilling.

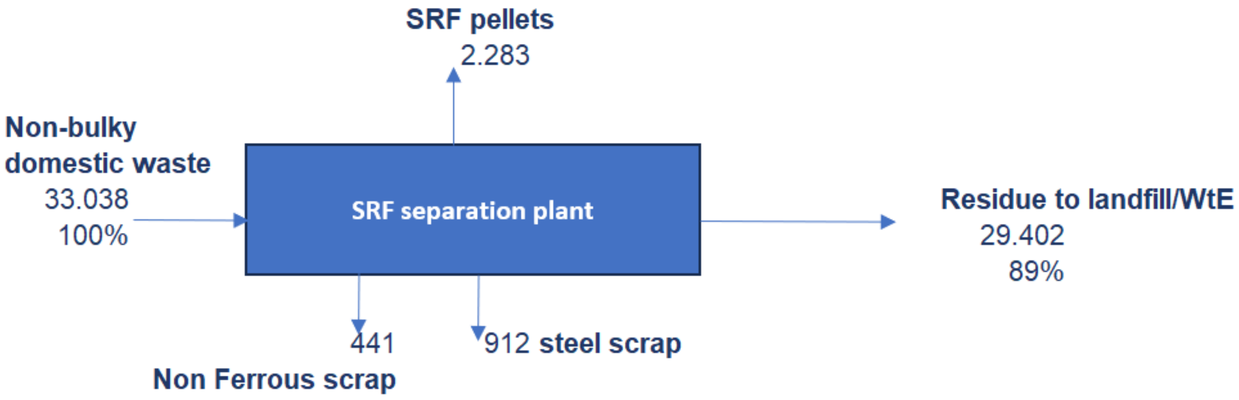


Figure 7: Mass balance (tons / year) for a sorting plant for non-bulky domestic waste (as indicated in the WCS)

Figure 8 shows in a mass balance the potential for a sorting plant for non-bulky residual commercial waste with the current composition of non-bulky waste from households on Curaçao. The process flow diagram is shown in Appendix O. It shows that only 15% of the waste could be diverted from landfilling.

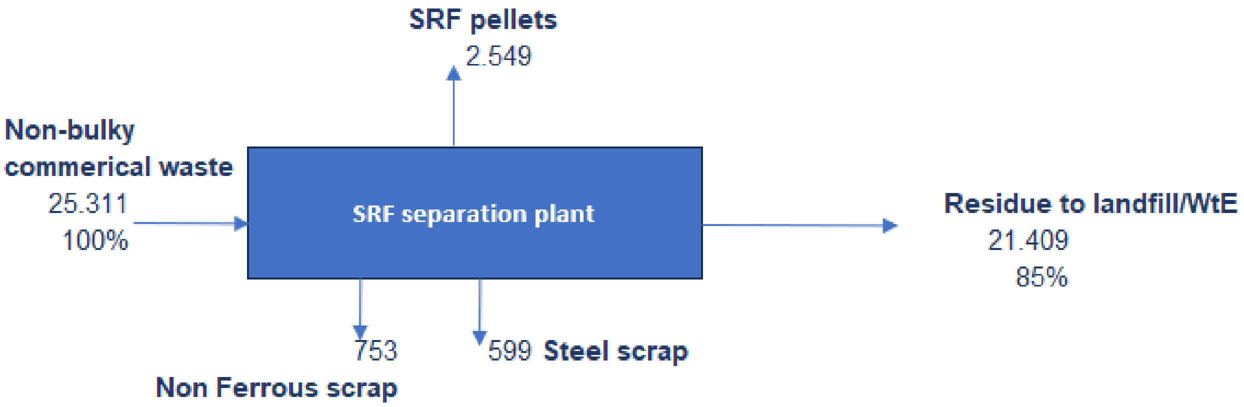


Figure 8: Mass balance (tons / year) for a sorting plant for non-bulky commercial waste (as indicated in the WCS)

Benefits of a sorting plant for non-bulky commercial waste:

- Source separation is not required.
- The sorting technique is proven technology.

Disadvantages:

- It is an expensive technique resulting in only a small reduction of waste being landfilled.
- Except for metals, most other separated recyclables do not have a high enough quality to create enough revenue for the business case of the sorting plant.
- Compared to non-island nations, a relatively small number of bulk recyclables is suitable for separation at source via an existing local recycling route.
- Post-collection sorting is either implemented when high gate fees are in place for either landfilling or incineration or when EPR schemes finance this recycling route.
- From the interviews conducted during the site visit on Curaçao, it became clear that high gate fees for either landfilling or incineration are unlikely to be realized.

- EPR schemes that force the packaging industry to finance recycling are unfortunately only feasible for large economies. The EPR scheme costs for meeting EPR targets outweigh the profits in a very small market. Producers will pull out of small markets if high EPR costs are imposed. This does not mean that producers do not take any responsibility at all on small islands. Coca-Cola for example has contributed to establishing recycling drop-off centers on Curaçao. The introduction of an enforced EPR scheme is therefore not very likely.

Status in Curaçao:

- Not present

4.3.2 Sorting bulky residual waste

Bulky residual waste is in most countries only a small part of residual waste. Due to the size of the waste components, it cannot be directly sorted in a sorting plant for non-bulky waste. The volume is usually too small to dedicate an entire waste sorting plant for this waste stream. The following three solutions are used to reduce the amount of waste from this waste stream being landfilled or incinerated:

- Manual separating by the disposers at a recycling drop off center for bulky waste.
- Sorting via a waste sorting plant normally used for construction and demolition waste.
- Comminuting in a shredder and sorting via non-bulky waste.

The most effective solution is manual separating at source. The two other technological solutions are sub-optimal and negatively affect the sorting process which the bulky domestic waste is added to.

Status in Curaçao:

- In Curaçao a recycling center for bulky waste is in use, but not effective in its operations due to the reasons mentioned in section 4.2.3.

4.3.3 Sorting construction & demolition waste

Construction and demolition (C&D) waste is waste that is generated at construction sites and/or during the demolition/renovation of buildings. It usually consists mostly of stony materials (e.g. concrete), wood, metals, and plastics.

Sorting C&D waste is common and is very successful in many countries. This type of sorting plant is designed for bulky waste with a large density that contains a large percentage of stony materials. Fractions are sorted using techniques such as screening, crushing, magnetic separating, wind shifting, and manual sorting. Depending on the input and the desired output, many configurations are possible. The most important fractions to be sorted are debris, scrap metals, and waste wood. Depending on local opportunities, other materials such as plastics and gypsum are also sorted.

The fractions that can be diverted from landfilling and/or incineration depends heavily on the composition of the C&D waste to be sorted. Where source separation at construction and demolition/renovation sites is practiced well, a large fraction of the C&D waste can be diverted from landfill. When no source separation is practiced, the sorting will result in a large residual waste stream. Usually sorting plants for C&D waste base their gate fee on the estimated percentage of recyclables that can be recovered.

Figure 9 shows in a mass balance the potential for a sorting plant for C&D waste with the current composition of C&D waste on Curaçao. The process flow diagram is shown in Appendix P. It shows that 77% of the C&D waste on Curaçao could be diverted from landfilling.

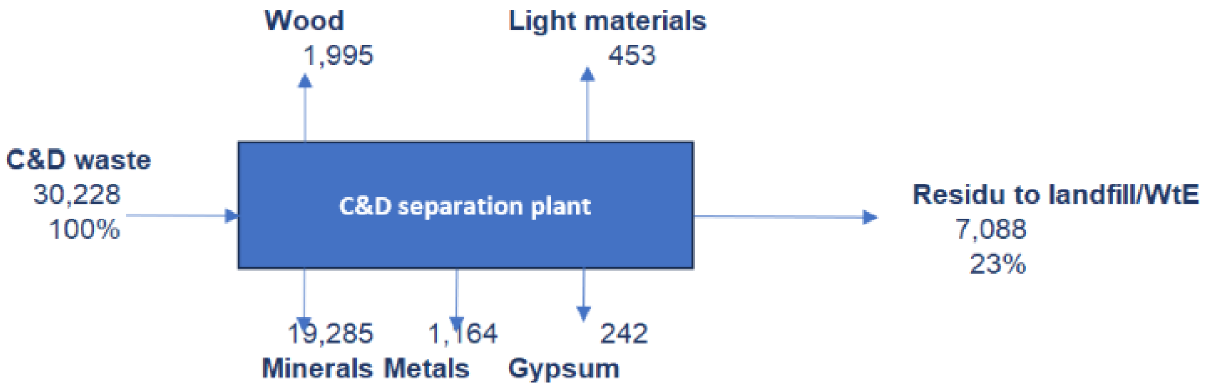


Figure 9: Mass balance for a construction and demolition waste sorting plant in tons / year

Benefits:

- The sorting technique, combined with its feedstock, is able to divert a large percentage from landfilling.
- The sorting technique is relatively inexpensive per sorted ton of waste.
- The sorting technique is robust.
- The sorting technique is proven technology.
- Possibility to generate small revenue flows (for clean minerals or charging a lower gate fee compared to the Malpais Landfill)

Disadvantages:

- Additional costs needed to cover the logistics and operational costs. To generate a positive revenue stream, additional funding / gate fee is most probably required.

Status in Curaçao:

- Not present. Only homogeneous source separated streams from C&D waste, such as debris and metals, are currently recovered for recycling on Curaçao.

4.4 Mechanical recycling techniques

Recycling techniques are methods that produce a product or are used as a raw material ready for direct use in products or in construction without further preparation.
Some recyclables are processed in conjunction with the production of primary resources. For example, steel and paper/cardboard are recycled in steel mills and paper mills, respectively. These large industrial complexes are typically located where there is a high concentration of feedstock or offtake, which is why they are usually not found on small island nations such as Curaçao. As a result, recyclables for these processes must be exported for recycling.
Other recyclables can be processed in small-scale production plants that match the scale of supply and demand of smaller island nations such as Curaçao. However, local industrial activity is still necessary to create demand for the recycled materials. This requires the presence of manufacturing industries, agricultural companies, and/or construction companies. Consequently, it is not surprising that the recycling of mineral aggregates is well-developed on Curaçao.
This feasibility study will explore the opportunities for recycling techniques for mineral aggregates, plastics, and compost.

The next section describes mechanical recycling techniques. The following recycling techniques are considered to have the most chance of being successfully implemented on Curaçao:

1. Crushing.
2. Plastic recycling.
3. Composting.

4.4.1 Crushing

Crushing is a technique which enables comminution of debris from building construction, demolition or renovation. Usually, the broken debris is sorted into fractions. Depending on their particle size, sifted distribution fractions can be added to asphalt, concrete, or used in road constructions. Crushers can work stand-alone in one or two crushing steps, but are also frequently integrated in sorting plants for construction and demolition waste.

Benefits:

- Crushing is relatively inexpensive per sorted ton of waste.
- Crushing is robust.
- Crushing is proven technology.

Disadvantages:
Building materials are not recycled for the unique properties of their different components. Glass, ceramic, and bricks are downcycled to aggregate. One opportunity arises from the limited potential to recycle glass as blasting material (e.g. for use in the local ship repair industry). However, this is a small application and would not result in a big reduction in landfilling.

Status in Curaçao:

- Both Heavy Mix Concrete B.V. and MijnMaatschappij operate a crusher for uncontaminated debris. The products are used in concrete goods and road construction. Both companies currently aim for the highest quality feedstock.

4.4.2 Plastic recycling

Plastic recycling involves converting used plastics into new products.

Preparing Recyclables for Recycling
All thermoplastic plastics can be recycled if the recyclate consists 100% of a single polymer. Additionally, 100% olefins (CxHy) can be recycled as mixed polyolefin (MPO). The main challenge in plastic recycling is obtaining plastics that consist of more than 99% of a single recyclable polymer. Therefore, plastic recycling requires a purification process. Even source-separated plastics of a single polymer contain a significant amount of other materials that need to be removed before recycling, such as moisture, labels, and product residues. However, some additives such as fire inhibitors, plasticizers, and mineral fillers cannot be removed.
The extent of purification that is required depends on the specifications of the intended product. Packaging materials that may come into contact with food have high-quality specifications, while plastic construction materials can often accept lower quality recycled plastic. The greater the quality gap between the input and output, the more complex and expensive the required recycling technology must be to achieve the required recyclable quality.
Remove the grey background in this section.

Plastic recycling

Once the plastic recyclate is on spec, it can be recycled directly. Two routes exist for direct production or r-granulate production. R-granulate => “regranulate”, “recycled pellets” or “recycled granules” are all raw materials for making plastic products. Both recycling routes usually use an extruder to recycle the plastics.

Benefits:

- Plastic recycling is a proven technology for many polymers, such as PE, PP, PVC, and PET.

Disadvantages:

- Plastic recycling is only profitable without subsidies or steep disposal costs when uncontaminated monomers can be collected in substantial volume. Sorting plastics for recycling from mixed waste without financial incentives is almost never feasible in a professional business case.
- Plastic recycling is very sensitive to the impact of contamination in the plastics.
- The costs for plastic recycling are more stable than the revenues. The revenues strongly depend on virgin plastic prices and the international market for recycled plastics.

Status in Curaçao:

Plastic recycling occurs on Curaçao, but only a small percentage of the disposed plastics is recycled.

- Green Force exports PET-bottles for recycling at a negative cash flow under the current conditions. The total weight of the PET they export is 30 ton/year and this is not even 2% of all PET bottles disposed of on Curaçao. The negative cash flows limits expanding their business to collect more PET bottles for recycling.
- Limpi operates a profitable business by making souvenirs from recycled plastics. The recycled volume (4 ton/year) is very small and is unlikely to substantially increase soon.
- Green Phenix currently operates with the assistance of RESEMBID grants.
- Fuse is highly dependent on plastic films, HDPE and PP which they themselves collect and which are also provided by Green Force.

4.4.3 Composting

Composting is a technique that converts organic waste into compost. Compost can be used as fertilizer and for soil improvement.

Many compositing techniques exist. They range from low-tech windrow composting to high-tech tunnel composting with forced and controlled ventilation. All techniques use natural processes where micro-organisms degrade organic materials in the presence of oxygen and sufficient moisture. Non-woody biomass and food residues will be completely converted into compost. This also applies for all fats, oils, sugars, and proteins in organic waste. Composting will not degrade true woody materials such as thick pieces of wood. Composting takes 4 to 8 weeks in tunnel composting and can take more than 16 weeks for window composting.

Benefits of composting:

- Composting contributes to a large reduction in landfilling.
- Composting enables closing the loop for nutrients in food production.
- Composting requires very limited energy.
- Composting is a low-tech technique.
- Composting requires relatively low investments.
- Composting is proven technology.

Disadvantages:

- Current local demand for compost is unknown and has to be further analyzed. The main demand for soil improvement materials is from individuals and hotels (e.g. for gardens and landscaping).
- Feedstock control at the beginning of the process is necessary. Only garden/yard waste does not work, while only kitchen/food waste does not work either.
- Agricultural activities (which could be an important user of compost) on Curaçao are limited compared to less arid countries.
- Uncontaminated organic waste on Curaçao is generally rather dry and requires additional water for composting. This required water volume is even higher if inexpensive low-tech windrow composting is applied.
- The most attractive feedstock for valuable compost is kitchen/food waste. This waste fraction, however, is difficult to obtain in large quantities without contamination that must be removed.
- The costs of managing a composting plant are relatively low, but in many countries a gate fee is necessary when private companies implement composting. This does not apply to farmers that upgrade/ compost their own organic waste.

Status in Curaçao:
Composting occurs in Curaçao, but only small volumes are composted by Vivians Nursery, who compost their own garden waste/plant clippings and then mix these into the soil used for garden maintenance. In 2000, a pilot-project was executed that showed a viable business case for composting 5,000 m3 per year.[8] Although the study was conducted 24 years ago, many conditions are still similar.

4.5 Chemical recycling techniques

Chemical recycling techniques focus on the recycling of hydrocarbons. The techniques convert molecular structures of materials to smaller molecules that can be used as feedstock to produce chemicals.

6. The following chemical recycling techniques are considered that could be implemented on Curaçao:

- Pyrolysis
- Gasification
- Biodiesel production

4.5.1 Pyrolysis

Pyrolysis is a process where a combustible material is heated in the absence of oxygen. Pyrolysis produces three products:

- Pyrolysis oil
- Char (solid residues)
- Non-condensable gases

The non-condensable gases are used to produce the required heat for the pyrolysis process. Pyrolysis oil can be used, for example, to replace naphtha in plastic production, but it can also be used to produce transportation fuels. Pyrolysis is most effective when pyrolyzing hydrocarbons that have low oxygen and nitrogen concentrations. All oxygen and nitrogen present in the feedstock will react and thus reduce the pyrolysis yield. Therefore, pyrolysis is mostly used for the chemical recycling of plastics.

Pyrolysis production is seen as one of the options to replace the virgin feedstock in the production of plastics and transportation fuels. Although many initiatives involving pyrolysis exist at the moment, only a limited number have been realized and are successfully operating at a commercial scale.

Benefits:

[8] *Composting groenafval hotel sector Curaçao – LVV, Vivian's Nursery and EcoVision - 2000*

- Suitable for plastics with contamination and additives.
- Suitable to upcycle plastics to virgin quality.

Disadvantages:
- Most efficient only for olefin plastics. This requires sorting plastics beforehand in an advanced sorting process. Less efficient feedstock may be used, but results in a much lower yield.
- Requires sorted plastics as feedstock, including strict quality specifications.
- Many initiatives announce and then fail to achieve their targets.[9] An important reason is the scarcity of suitable feedstock and technical challenges from broader feedstock composition.
- It is better to produce pyrolysis oil near the company using it as feedstock.
- It is a complex technology that requires skilled staff and supporting service companies.
- The potential to reduce the waste being landfilled is small.

Status in Curaçao:
- Not present.

4.5.2 Gasification

Gasification is a process where a combustible material is combusted with insufficient oxygen. Gasification produces two main outgoing flows:
- Syngas (a mixture of mostly CO, H_2, CO_2, and N_2).
- Ash (solid residues).

Once purified, syngas can either be used as a combustion fuel at higher temperatures with higher energy efficiencies or be used as hydrogen feedstock for the chemical industry. In theory, gasification has many benefits, but when using waste as the feedstock, many technical obstacles arise.

Benefits:
- High (theoretical) energy efficiency.
- Smaller flue gas treatment required.

Disadvantages:
- It is a complex technology that requires skilled staff and supporting service companies.
- Currently, it is not a proven technology for waste. Commercially viable operations with long lasting operations fueled on waste are limited to plasma gasification. Some operations started, but failed due to many reasons.[10]

Status in Curaçao:
- Not present.

4.5.3 Biodiesel production

Biodiesel production is the production of transportation fuel from biogenic materials. Biodiesel is regarded as a renewable fuel. Feedstocks for biodiesel are vegetable oils and oils/fats from meat processing. These oils are directly produced on farms, a by-product of the food industry or collected as used cooking oils.

Benefits:

[9] *https://luxresearchinc.com/blog/2024-is-the-year-the-pyrolysis-bubble-bursts/*
[10] *https://en.wikipedia.org/wiki/Gasification*

- Biodiesel is a fuel with a high energy density that can be used or exported easily.
- The conversion of vegetable oils to biodiesel is proven technology.

Disadvantages:

- The availability of used cooking oils on Curaçao is limited and as such substantial expansion based on waste streams from Curaçao is therefore not expected.
- The potential to reduce waste being landfilled is small. Since cooking oils are a liquid waste, they were excluded from the WCS which only considered solid waste. As such, no specific research has been conducted to determine the volume of waste vegetable oils being landfilled or produced in Curaçao.

Status in Curaçao:

- Energis opened its biodiesel production plant in June 2024 with a capacity of over 500,000 tons per year. The company plans to expand the processes further and greatly increase production capacity. The vast majority of their feedstock is imported.

4.6 Recovery techniques

Recovery techniques focus on utilizing waste when recycling is no longer feasible. A common approach is to recover energy from waste by using it partially as fuel in facilities such as waste-to-energy plants, cement kilns, power plants, and district heating plants. Another example of recovery is backfilling abandoned mine shafts and galleries, although this method is not applicable to Curaçao.

The following recovery techniques have been considered for potential implementation in Curaçao:

1. Cement/lime kiln
2. Waste-to-energy plant
3. Digestion

4.6.1 Cement/lime kiln

Cement/lime kilns can use solid recovered fuels (SRF) to replace fossil fuels in the production of cement or lime. The inorganic materials present in the SRF become part of the cement or lime. Therefore, the composition of SRF should be within contractually specified composition ranges. Additionally, the required particle size for SRF is fine because the kiln requires a fast combustion process. A benefit of the process in cement/lime kilns, is that the very high temperatures destroy all organic hazardous substances including Per-polyfluoroalkyl substances (PFAS).

If no cement kiln is present in a country, SRF could be exported to countries where cement/lime kilns have sufficient demand. In Europe, SRF often has slightly negative value. Gate fees are, however, much lower than for incineration in a WTE or disposal in a landfill.

Benefits:

- Waste treatment in a cement kiln only produces a small fraction of flue gas residues, no other residues.
- All combustible materials are converted to energy.
- Almost all inorganic materials are absorbed in the cement.
- All organic hazardous substances are destroyed.

Disadvantages:

- The potential to reduce waste being landfilled is relatively small, because many fraction in mixed waste are not suitable for cement production.
- It is a plant that requires economy of scale.
- A cement kiln requires sufficient nearby inexpensive mineral feedstock for the cement and/or lime.
- A cement kiln benefits from sufficient inexpensive fuel located nearby.
- It is a complex technology that requires skilled staff and supporting service companies.

Status in Curaçao:
- Not present.

4.6.2 Waste to energy plant

A waste to energy (WTE) plant uses untreated waste as fuel to produce energy (i.e. power, heat, and/or steam). Figure 10 provides a simplified flow diagram of a WTE plant.

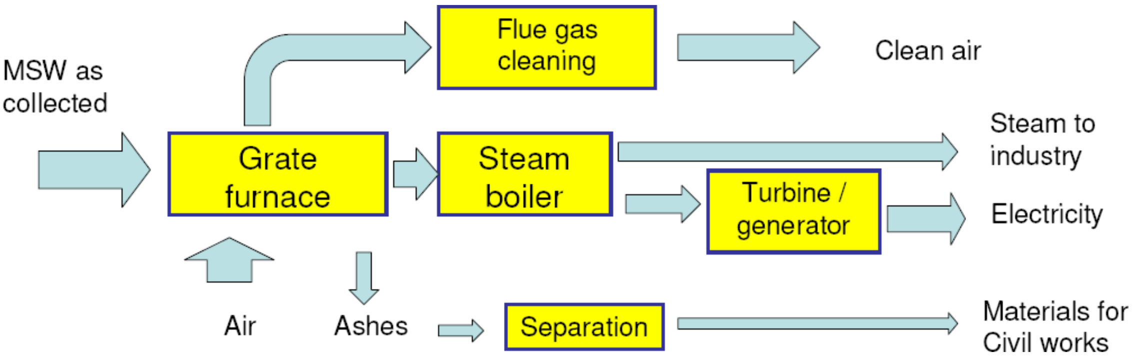


Figure 10: Schematic flow diagram of a waste to energy plant

For combustion of residual waste, a grate furnace is the most suitable technique as it can combust the widest range of materials. Nevertheless, a grate furnace is not suitable for rubber tires, mineral debris, dusty substances, lengthy ropes, pressurized containers, explosives, insulation foam, and rock wool.

Fluidized bed furnaces require feedstock with a specified particle size distribution and density. Therefore, fluidized bed furnaces are less suitable for residual waste. The list of undesired materials for fluidized bed furnaces is even greater than for grate furnaces.

Although a WTE plant incinerates all waste, all ashes produced will also remain. The total mass of the ashes is approximately 25-30% of the waste input, however the volume of the ashes is only 10% of the waste input.

Benefits:
- The potential to reduce waste being landfilled is large. Even when the ashes are landfilled, a volume reduction of 90% is achieved for all incinerated waste.
- Renewable power or heat is produced.
- Biological agents and infectious materials are destroyed.
- Except for some PFAS, most organic hazardous materials are destroyed.
- Emissions of methane (a potent greenhouse gas) produced in landfills, are avoided.

Disadvantages:

- It is an expensive technique that is only economically viable when the operator receives high fees for the produced electricity, heat, or steam, and/or when the gate fee is high enough to cover costs.
- The ashes are alkaline and reactive. When landfilled or used in construction material, additional safety measures will have to be taken to avoid negative impact on groundwater compared to traditional landfilling.
- It is a complex technology that requires skilled staff and supporting service companies.
- WTE plants have a large Capex and Opex.

Status in Curaçao:
- Not present.

4.6.3 Digestion

Digestion is a treatment process for organic waste. Digestion is a process in which organic matter is converted to CO_2 (carbon dioxide) and CH_4 (methane) in the absence of oxygen. This gas mixture is called biogas. Biogas can be combusted directly in a gas engine to generate power or heat. An alternative for biogas is to refine it into methane and sell it as a transportation fuel or even add it to a methane network. These alternative options are not feasible with the current infrastructure on Curaçao.
Besides this, digestion processes need homogeneous feedstock to have a controllable economical process. Digesting of mixed organic waste is considered technically risky and requires many stops and maintenance activities, and therefore not a preferred option in this study.
Digestion would be technically feasible for homogeneous waste streams such as manure or certain types of sludge.

Benefits:
- High quality renewable biogas can be produced.
- Energy from sugars, starch, and oil is recovered that would otherwise be lost during composting.

Disadvantages:
- The digestate (residue of digestion) still needs to be composted and sufficient organic matter for this post-composting must be available.
- It is a complex technology that requires skilled staff and supporting service companies.
- It is a sensitive process which can be disturbed by unexpected contaminants in the feedstock.
- The potential to reduce waste being landfilled is small.

Status in Curaçao:
- Not present.

4.7 Technical longlist including MCA

The preceding paragraphs have identified 17 techniques that could reduce the quantity of waste that is landfilled in Curaçao. The table below shows the summary of a multi-criteria analysis (MCA) that was executed to identify the most suitable techniques for Curaçao. The most suitable techniques have been selected on the following key criteria:

1. Landfill reduction potential
2. Level of feasibility (investment, operational complexity, technical complexity)
3. Level of availability feedstock and technical limits
4. Level of implementation complexity

The techniques that are highlighted Green have the largest potential to reduce waste to be landfilled on Curaçao. Appendix Q contains the entire MCA.

Table 7: Summary MCA of identified techniques to reduce landfilling on Curaçao

§	Technological option	Feedstock from waste	Currently present on Curaçao	Landfill reduction potential	Option to reduce landfilling on Curaçao and main motivation
4.1.1	Reducing logistical costs for exporting recyclables	Not applicable	No	**High**	**Yes, it requires no investment in waste management infrastructure.**
4.1.2	Obliged source separation for companies	Not applicable	No	**High**	**Yes, it requires no investment in waste management infrastructure.**
4.2.1	Source separation via house-to-house collection	Not applicable	No	**High**	No, not (yet) regarded as feasible to obtain sufficient quality.
4.2.2	Source separation via recycling centers for non-bulky waste	Not applicable	**Yes, but limited**	Rather limited	Yes, although additional reduction is feasible, the impact will be limited.
4.2.3	Source separation via recycling centers for bulky waste	Not applicable	**Yes, but not operational**	Very limited	Yes, but very limited impact
4.3.1	Sorting non-bulky residual waste	Non-bulky MSW	No	Rather limited	Yes, but not suitable within the current constraints on Curaçao.
4.3.2	Sorting bulky residual waste	Bulky MSW	No	Rather limited	Yes, but not suitable within the current constraints on Curaçao.
4.3.3	C&D waste sorting	C&D waste	No	**High**	**Yes, with a high impact and existing recycling routes on Curaçao**
4.4.1	Crusher	Mineral fraction C&D waste	**Yes**	**High**	Yes, already present including a high reduction
4.4.2	Plastic recycling	Sorted plastics	**Yes**	Rather limited	Yes, already present including a rather limited reduction potential
4.4.3	Composting	Green waste	Very small capacity	**High**	Yes, volumetric size of organic waste will decrease landfilling
4.5.1	Pyrolysis	Sorted plastics	No	Rather limited	No, no proven technology for waste at commercial scale
4.5.2	Gasification	Paper/plastic mixture	No	Rather limited	No, no proven technology for waste at commercial scale
4.5.3	Biodiesel production	Used cooking oils	Yes	Limited	No, feedstock will hardly be derived from waste on Curaçao.

4.6.1	Cement/lime kiln	SRF, tires, dried sludge	No	Limited	Yes, but not suitable within the current constraints on Curaçao.
4.6.2	Waste to energy	Non-bulky waste and combustibles residues	No	**High**	**Yes, but the costs per ton will be high and impact of ashes is a risk that must be managed**
4.6.3	Digestion	Green waste	No	Limited	No, the materials to be digested can also be composted anyways.

Via the MCA and workshops, four most promising techniques have been selected that can significantly reduce the quantity of waste landfilled on Curaçao and contain the highest chance of implementation success:

1. **Composting plant**
2. **Policy measure techniques**
    a. **Reducing logistical costs for exporting recyclables**
    b. **Obliged source separation for companies**
3. **C&D waste sorting plant**
4. **Waste to energy plant**

The **composting plant** will:
- Reduce organic waste
- Create additional biodiversity value
- Create opportunity for local compost production (instead of importing)

The policy measure **obliging source separation for companies** will:
- Generate more source separated recyclables from companies.
- Create the possibility for sorting companies to charge a gate fee for sorting waste streams, such a C&D waste that is currently not being sorted at construction/demolition sites
- Increase the possibility to charge a fee for collecting recyclables from companies that have to sort certain recyclables.

The policy measure **reducing logistical costs for exported recyclables** will:
- Reduce the gate fees for companies that separate at source;
- Enable recycling companies to expand sorting via additional recycling centers;
- Export collected recyclables without incurring a loss.

A **C&D waste sorting plant** will:
- Significantly reduce the quantity of (concrete) debris landfilled;
- Significantly reduce the quantity of metals landfilled;
- Possibly enable the export of other separated wastes and/or SRF.

A **Waste to energy plant** will:
- Significantly reduce the quantity of combustible waste landfilled;
- Generate additional renewable energy on Curaçao.

5 Technical scenarios

This chapter elaborates three scenarios that could represent future waste management on Curaçao. The first paragraph specifies which scenarios are selected and why they are selected.

5.1 Specification scenarios

5.1.1 Scenario 1: Baseline

The baseline scenario assesses the current situation as the point of departure for future waste management. Therefore, the scenario assesses the situation for Curaçao when no new measures for waste management are taken, no new waste legislation is adopted, no effective enforcement of illegal waste dumping is applied, no waste policies are adopted, and no investments in waste processing plants are made other than investments in additional landfill capacity when needed.

The baseline scenario assesses subsequently which waste streams will be recycled and which waste streams will be landfilled.
The baseline scenario is used to determine the effects of scenario 2 and scenario 3.

5.1.2 Scenario 2: Maximum recycling

The maximum recycling scenario aims to reduce landfilling without incineration of (mixed) waste using a combination of measures and investments.

This scenario consists of a combination of measures and waste processing techniques described in Section 4:

1. Mandatory source separation for companies (measure);
2. Reduced logistical costs for exporting recyclables (measure);
3. Obligating those soft drinks and beer only be available in aluminium cans (i.e. glass bottles prohibited) (waste processing technique);
4. Composting plant (waste processing technique);
5. C&D sorting plant (waste processing technique);
6. SRF scenario (waste processing technique).

5.1.3 Scenario 3: Waste to energy

The waste to energy scenario aims to reduce landfilling by incinerating combustible (mixed) waste in a WTE plant combined with a C&D sorting plant that separates recyclable metals and construction/demolition debris from combustible waste.

This scenario consists of a combination of three waste processing techniques:

1. WTE plant (via grate furnace)
2. Mandatory source separation for companies (measure);
3. C&D sorting plant

The waste to energy scenario is used to determine at what cost a certain amount of reduction of landfilling is feasible and that waste incineration in a local WTE plant can be realized as the main strategy to reduce landfilling. Beside the impact on the mass balance, the expected costs for investments in additional landfill capacity are assessed.

5.2 Concept development

In this section, the concept of each selected waste processing option is proposed and starting points are defined. Recall that for all concepts, additional conversations with associated stakeholders need to be held to validate or update this concept.

5.2.1 Industrial recycling hub (to facilitate legislative actions)

To facilitate the maximum recycling scenario, additional recycling facilities on the island should be created. To process the increased recycling streams (caused by the recommended legislation), recycling processing on an industrial scale is required. Therefore, a centralized industrial recycling hub is proposed. In this recycling hub, existing companies such as Paradise Recycling, Green Phenix, Green Force and Fuse + Kooyman can maintain and expand their recycling activities. New companies (e.g. for secondhand tools or textiles) could also establish their business in the hub.

The industrial recycling hub would consist of a large area and one warehouse. Thereby, it is not intended to be accessible for individual citizens, but rather only for businesses. Incoming flows consist of recycling fractions source separated and collected by companies. Outgoing flows consist of (baled) waste fractions ready for export or local processing. By centralizing recycling activities in one area in Curaçao, centralized functions such as warehousing, office, manual sorting, weighing bridge, compacting, access and security can be combined, which reduces costs for the individual recycling companies.

Optionally, a recyclables drop-off center could be located next to the recycling hub where individuals can drop off recyclable waste fractions in a supervised area. This would create additional recyclable materials for the industrial recycling hub. Finally, this industrial recycling hub can also be combined with the C&D sorting plant.

Main activities in the industrial recycling hub consist of:

- Collecting or receiving recycling fractions from medium / large businesses and preparing them for export
- Collecting and processing recycling fractions from source separation activities (such as local recycling drop-off centers at supermarkets)
- Manual sorting of plastic fractions
- Manual sorting of aluminum cans

- Baling and compacting
- Storing of incoming and outgoing recyclables (to prepare for export)
- Educational activities

Main functions of the recycling hub consist of:
- Industrial area (including fence, gate and security cameras)
- Warehouse which consists of:
  - Simple manual sorting lines (mainly for plastics and aluminum cans)
  - Baling equipment
  - Compactors
  - Canteen and office
- Visitor center

The industrial recycling hub fits in the future industrial vision of industrial redevelopment in Curaçao
The industrial recycling hub can expand its business activities from processing municipal solid waste to commercial or industrial waste. Additional recycling businesses can be added to the industrial recycling hub. In this way, multiple sources of funding can be accessed.

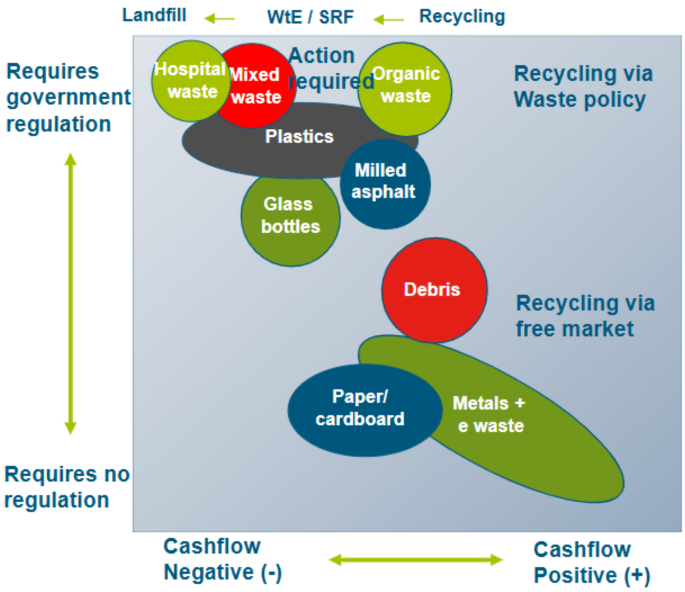
Organization and governance of the industrial recycling hub
To run the daily operations of the industrial recycling hub, additional conversations with recycling companies (as mentioned above), other related parties and governmental institutions are required.

It is suggested is to create one organization/corporation to be the owner of the industrial recycling hub. This entity handles the finance, administration, and facility management. Payment structure is difficult to define at this time. Especially with the lack of an existing, implemented waste policy in Curaçao and the low involvement of the responsible governmental body for the waste policy. Without this, most recyclable waste fractions don’t have a positive cash flow structure.
Under this current situation, the recycling organization/corporation might be developed following these **basic rules:**

1. The Government of Curaçao must recognize the need to increase recycling activities (to reduce landfilling). They are willing to pay/subsidize to facilitate this initiative.
2. The recycling hub should only be initialized together with a new waste policy that is implemented, and enforcement which is executed. Without government support, the outlook for success of the recycling hub is considered to be very low. (A new waste policy is currently being developed as part of the Transforming Waste to Value project.)
   a) Area or land lease costs must be minimized or avoided. Try to find land space that has no specific designation which can be provided by the government. If landlords must be paid, the outlook for success for this initiative is considered very low.
3. Recycling companies can use the centralized functions by paying small fees to the aforementioned organization/corporation. Additional conversations must be held to define payment structure between recycling companies and the organization/corporation to pay for the facility. (Flexible payment structures, whereby fees are based on international recycling trading prices should be considered.)
   b) The organization/corporation will function as the main contact with the government and government related businesses, who are stakeholders within the waste management structure.

c) A down payment/bond from each individual participating recycling company is suggested. This fee/bond would be used to clean the area and process waste left behind in the event of bankruptcy of a recycling company.

The following figure shows the current net cash flow status of different waste fractions. Only metals (including aluminium cans), e-waste and cardboard (sometimes) can be considered to have a positive cash flow. The rest of the waste fractions require political actions in order for recycling to become beneficial. Several political actions are proposed in this study. After this, calculations show that +- 13k ton MSW can be recycled within the recycling hub (which is 10% of the yearly waste being landfilled).



Waste route	Recycling potential (-000 ton)
Plastics higher quality	2.2
Paper	2.2
Cardboard	5
Metals / e-waste	3.5
Textiles	1
Second hand tools and furniture	2

Depending upon the success of recycling initiatives, up to 13 Kton can be recycled annually

Figure 11: Level of regulation dependent to business viability

5.2.2 Composting plant

Organic waste from gardens/yards and clearing/cutting vegetation results in green waste, which can be converted into compost, mulch and/or wood chips. The composting plant will sort green waste into two categories: waste directly suitable for conversion to compost, waste suitable for structuring the compost pile.

It is proposed to use the technique of composting tunnels with forced aeration and reduced moisture loss. This method not only produces high-quality compost, but also has the potential to reduce the volume of organic waste by up to 80%. An ancillary activity can be wood chipping. These chips can be used as mulch, compost material, or for other landscaping purposes.

Acceptance and preparation of incoming organic waste to ensure output of high-quality compost
Step 1: When starting a composting plant, only organic waste that has been source-separated by citizens or companies, such as gardeners and plant-based agricultural businesses, should be accepted. In the future, kitchen swill from hotels and restaurants, and poultry manure can be transformed into an effective organic fertilizer with an optimal nutrient ratio and high organic matter content. The exact addition rate of swill and poultry manure should be researched once the facility is operational.
Step 2: A visual inspection of incoming organic waste is crucial. Only uncontaminated waste streams should be accepted and this process should be supervised by an employee who has the authority to refuse contaminated loads.
Step 3: After inspection, the last remaining contaminants in the waste that was accepted can be removed manually or with a front loader to ensure the quality of the outgoing compost. Finally, the incoming waste can only include organic materials. Materials such as plastic or big rocks should be removed.
Step 4: Separation of three waste streams: one suitable for direct composting, one for structuring of the compostable material within the composting tunnel, and one for ancillary wood chipping.

Composting within tunnels under controlled conditions
The composting plant will consist of a main processing building with composting tunnels. Composting within the tunnels will be performed under controlled conditions, focusing on three key parameters: temperature control, moisture regulation, and aeration.

- Temperature control: Maintaining the optimal temperature accelerates the breakdown of organic matter by microorganisms.
- Moisture regulation: Moisture levels will be monitored regularly to ensure the composting material remains neither too dry nor too wet, as this can vary with different incoming waste.
- Aeration: Aerobic decomposition will be enhanced through regular turning or forced aeration, ensuring the compost remains well-oxygenated and to reduce the chance of foul smells.

Wood chipping as an ancillary activity
Coarse residues from composting can be used to produce wood chips. Wood chipping can be performed by feeding a chipper with a flywheel or drum, which will chip the wood into small pieces. The chipped wood is expelled from the machine and can be collected in a big bag. These wood chips can then be used as mulch, compost material, or for other landscaping purposes.

The primary activities at the organic waste treatment plant will include:
- Collecting, inspecting and separating of incoming wood and organic waste
- Loading of organic waste into composting tunnels or feeding the wood into a chipping machine
- Controlling tunnel temperature, moisture, and oxygen content
- Sieving out the oversized fraction and achieving the desired granularity at the end of the composting process during the maturation phase

- Storing of the compost during the maturing phase
- Packaging the compost

The primary functions at the organic waste treatment plant will include:

- Receiving and sorting area
- Composting area
- Maturing area
- Chipping area
- Packaging area
- Utilities room

Composting on Curaçao is an easy solution for organic waste

The proposed composting plant on Curaçao represents a significant step towards efficient organic waste management on the island. By collecting and preparing organic waste for composting in a controlled environment, the facility ensures production of high-quality compost. Eventually, with proper management and support from local stakeholders, this facility can provide a sustainable solution for managing organic waste on Curaçao. This can lead to improved soil quality for gardens and agriculture, and enhanced water retention within the soil. In addition, it eliminates the need for importing soil, compost, mulch, and wood chips, leading to less emissions from transportation.

Organization and governance for composting

Composting on Curaçao provides a solution for managing wood and organic waste, when supported by proper management. The current situation is not optimal for composting on the island. However, by implementing some adjustments, the business case can improve. Currently, imported compost is sold on the island for a price varying between 0.5 to 0.8 ANG/litre compost. However, locally sourced garden soil is already offered in local stores for lower prices (Kooyman, 2024). If laws are enforced to prohibit the import of compost, the business case for locally producing and selling compost improves, potentially resulting in a more profitable price.

To support this initiative, gate fees at the Malpais Landfill should be increased once the composting facility is operational. The government, in collaboration with the hospitality industry, CHATA, and local gardening and agriculture organizations/companies (such as Vivian’s Nursery and Soltuna), can play a crucial role in promoting and supporting local composting efforts.

5.2.3 Construction & demolition sorting plant

A construction & demolition (C&D) sorting plant is designed to process mixed waste from construction companies, contractors and demolition companies. The primary components of mixed C&D waste include debris (e.g. concrete, asphalt), scrap metals, waste wood, and plastics. The current practice for C&D waste is that valuable scrap metals are extracted manually from incoming C&D waste by informal waste sorters/collectors.

Incoming C&D waste, collected by companies and citizens, will contain various construction and demolition materials. The types of recyclables recovered depend on the materials that are sorted and the processed fractions that are ready for export or local use. The basic sorting configuration of homogeneous streams includes debris and scrap metals. As demand and revenues evolve, other fractions may be sorted.

A C&D sorting plant requires capex intensive investments; therefore, for this WPO two phases are proposed:

- Phase I: C&D presorting
- Phase II: C&D sorting plant

C&D presorting involves organized sorting of scrap metals and large pieces of concrete suitable for supply to the current local C&D recyclers such as Heavy Mix B.V and MijnMaatschappij B.V. The technique involves a crane and two dump trucks (1 for concrete debris and 1 for scrap metals). The crane removes the concrete and metals and place them in separate trucks. The financial motivation for sorting concrete in this scenario should not be to generate revenues for the extracted concrete, but to save precious landfill capacity. Additional conversations are required among stakeholders regarding organizing this process.

C&D sorting plant contains all the necessary machinery that can extract a much larger part of the recyclables present in C&D waste. A C&D sorting plant can extract ferrous metals using magnetic crossbelt overband separators, while non-ferrous metals are extracted using an eddy current separator. The sorting residue from this scenario will be a suitable combustible fraction for treatment in a WTE plant. However, this combustible sorting residue requires additional sieving to separate out sand and dust. For example, approximately 15% of C&D waste in the Netherlands consists of fines that are sieved out.

The following list describes the primary activities at a C&D sorting plant as described above.

The primary activities at the C&D sorting plant facility include:

- Pre-sorting: To create homogeneous streams (such as debris and wood) for the local market.
- Breaking: Reducing the size of larger C&D waste materials.
- First sieving and removing ferrous metals: Using a 300 mm drum screen to separate materials larger than 300 mm, followed by a overband magnet to remove steel/ferrous scrap.
- Second sieving: Using a double deck screen (20-75 mm) to further separate materials.
    - The now separated 75-300 mm fraction can then be separated using a wind shifter, crossbelt overband magnet, drum separator and manual sorting.
    - The fraction < 75 mm continues in similar steps described in the following list:
- Wind shifting: To separate light materials, such as paper and plastics.
- Drum separator: To separate the wood fraction.
- Crossbelt overband magnet: To separate steel/ferrous scrap.
- Manual sorting: To separate non-ferrous metals and gypsum/plaster.

The primary functions of the C&D separation plant facility will include:

- Presorting area: Equipped with two grapples for presorting and one grapple for feeding the breaking machine.
- Separation line: Includes sieves, magnets, eddy current separators, drum separators, wind shifting technology and manual sorting.
- Storage areas: Designated zones for incoming waste and for storing crushed and sorted fractions.

Enhancing material recovery through construction and demolition sorting

Recycling construction and demolition waste allows construction companies in Curaçao to achieve significant cost savings by not importing materials and instead using local recycled waste as raw material. For example, metals recovered by the C&D separation line are purchased by local scrap companies. Additionally, wood, minerals, and gypsum can be exported to other Caribbean islands, such as Bonaire. Furthermore, if new construction projects are obliged to use a minimum amount of recycled minerals, the local demand for recycled materials will increase, enhancing business viability.

Organization and governance of C&D sorting

Effective organization and governance are crucial for the successful operation of a C&D sorting plant. Ideally, the plant should be managed by a local C&D recycler (e.g. Heavy Mix or MijnMaatschappij) to ensure a secure market for the sorted materials. It is not advisable for Selikor to manage the plant, as not having control over the market poses a significant risk, such as finding reliable buyers for the sorted material. Selikor must consider that only a small fee to cover costs of pre-sorting C&D waste is appropriate. However, storing and processing C&D waste by local recyclers will save space in the Malpais Landfill. In the long run, this will result in reduced costs by utilizing the saved space for future landfilled waste.

Sorting C&D waste is inherently dusty, so the plant's location must be carefully considered. For the location it is also important to consider transporting logistics. The location is being investigated in an environmental/location study that was conducted parallel to this study.

Additional momentum for recycling C&D waste can be achieved by:

- Using high-quality debris for new concrete products (e.g. drainage pipes, curbstones).
- Utilizing lower-quality debris as foundation material for roads (with the approval of the government public works department).
- Recycling asphalt debris into new asphalt roads.
- Replacing diabase as a landfill cover material.
- Research the opportunities that exist for using recycled glass and rubber (tires) in asphalt production.
- Exploring the limited potential of using recycled glass as blasting grit. The quality of blasting grit is dependent to the application for glass, steel slag and cast iron. Although this is a small application, it might present a business opportunity for a local entrepreneur.
- To prevent illegal dumping of construction waste, a substantial landfill gate fee combined with stringent enforcement is necessary.

To boost recycling efforts, the government needs to adopt a mindset that fosters win-win situations where more materials are recycled, reducing the need for importing primary resources.

5.2.4 Waste to energy plant

A modern WTE plant with a capacity of 103,000 tons per year, basically combusts municipal solid waste (MSW) into bottom ash, heat and electricity. This facility will adhere to stringent European legislation, ensuring both environmental sustainability and operational efficiency. The plant will incorporate the latest grate furnace technology (based on previous studies), which is recognized for its reliability and effectiveness in processing MSW. The system will include advanced combustion control, flue gas treatment, and energy recovery systems.

The primary activities of the WTE plant facility include:

- Receiving MSW
- Combustion process (to at least 800 degrees Celsius)
- Treatment of gasses/emissions
- Generating electricity and low temperature heat
- Treating bottom ash

The primary functions of the WTE plant facility will include:

- Waste reception and bunkering system: This is where the incoming waste is dumped. A trained crane operator and/or partly automatic system ensures the furnace is fed with a constant mix of waste. It is suggested to separate industrial and domestic waste streams.
- Grate furnace system: Designed to handle a wide variety of waste types, ensuring complete combustion and minimal residual waste. The air intake, required for the combustion process, is connected to the bunker storage hall. In this way, unwanted odors will be burned and due to negative pressure in the storage hall, escape of unwanted odors outside will be minimized.
- Flue gas treatment: Equipped with state-of-the-art filters and scrubbers to meet the European Union's strict emission standards, significantly reducing pollutants such as NO_x, SO_x, and particulate matter. If lower standards used, significant CapEx reduction possible.
- Energy Recovery: The plant will convert waste into valuable energy, producing electricity and heat for local use.
- Compliance and monitoring: Continuous emissions monitoring systems (CEMS) will be installed to ensure compliance with all relevant regulations, providing real-time data to regulatory bodies.

Bottom ash

Bottom ash is the residual product from the combustion process. For this study, we have estimated that bottom ash output will be approximately 25% of the MSW input. Bottom ash consists of noncombustible materials such as fines, minerals, and metals. Due to the composition of the MSW, bottom ash contains a small fraction of hazardous materials, including (heavy) metals such as lead, cadmium, mercury, chromium, nickel and zinc. For this reason, bottom ash cannot be disposed at the current landfill. Due to the Malpais Landfill's design, the toxic materials could potentially leach into the soil and groundwater.

A secured, specially designed landfill is required to store the bottom ash. For the estimated 25 years lifespan of the WTE, initial estimates show that an additional 25,000 m^2 secured landfill is required to store the bottom ash.
Usually, bottom ash storage is located next to or close to the WTE plant to reduce transport movements.

This necessity advocates for the need to find applications for bottom ash, such as its use in road construction projects. This requires environmental studies and legislation.

Organization and governance

In this scenario, a WTE plant will be developed, constructed and operated according to a Public Private Partnership (PPP) contract. A PPP contract for a WTE plant typically involves the following key elements:

- Design, Build, Finance, Operate (DBFO): The private partner is responsible for designing, constructing, financing, and operating the WTE plant for a specific period.
- Risk allocation: Risks are shared between the public and private partners. For example, the private partner may handle construction and operational risks, while the public authority may manage regulatory and environmental risks.
- Revenue model: The private partner may generate revenue through tipping/gate fees for waste processing and from selling the energy produced. Tipping/gate fees are contractually arranged between the private partner and the government. Selling the energy is a contractual arrangement with the local electrical utilities distributor (Aqualectra).
- Performance standards: The contract includes specific performance standards and penalties for non-compliance to ensure the plant operates efficiently and meets environmental regulations.

5.3 Main waste processing design starting points

Based on reference projects, the main starting points for the feasibility study for the 4 WPO's have been defined. Table 9 contains an overview of the main design input values.

Table 8: Main starting points per WPO

	Waste to energy	C&D pre-sorting	Industrial recycling hub	Composting & chipping facility
Night / weekend shifts	YES	NO	NO	NO
Start development	2028	2026	2027	2026
Start operation	2034	2027	2028	2027
Land area (m^2)	45,000	10,000	15,000	10,000
Maximum height (m)	~45	~15	~10	~8
Buildings area (m^2)	10,000	no building	4,000	2,000
Max floor load (kN / m^2)	200	150	120	120
Processing indoors	YES	NO	YES	Partly
Operating hours / yr	8,000	2,150	2,150	2,150
Processing capacity per year (kton)	103	20 to 30	24	18
Power connection (MVA)	9	2	1	0.5
Average electricity usage (MVA)	0.9	0.8	0.2	0.2
Water usage m^3 / day (max)	5	6	1	8
Separate industrial wastewater flow	NO	NO	NO	NO

6 Financial analysis

In this chapter, the financial analysis for the four WPOs is presented and key insights on financial feasibility are given.

6.1 Financial starting points and assumptions

CapEx, OpEx, and revenue estimations have been made to assess the financial feasibility of the chosen WPOs. These estimations have led to the base case input values used in the financial discounted cash flow model, which is the standard to assess financial feasibilities. OpEx overhead includes periodic maintenance, IT systems, insurance, agreements with third parties, and consumables.

Table 9: Base case input values

Base case input values				
Waste processing option	**Waste to energy plant**	**C&D pre-sorting**	**Industrial recycling hub**	**Composting & chipping facility**
CapEx (-000)	ANG 378,000	ANG 2,000	ANG 2,150	ANG 850
Annual OpEx (-000) total	**ANG 23,386**	**ANG 613**	**ANG 1,330**	**ANG 690**
OpEx (-000) overhead	*ANG 15,496*	*ANG 75*	*ANG 200*	*ANG 100*
OpEx (-000) staff	*ANG 7,440*	*ANG 438*	*ANG 980*	*ANG 490*
OpEx (-000) land lease	*ANG 450*	*ANG 100*	*ANG 150*	*ANG 100*
Annual revenues (-000) total	**ANG 26,995**	**No revenue**	**ANG 892**	**ANG 770**
ferrous / non-ferrous metals	*ANG 595*		*ANG 892*	-
electricity	*ANG 26,400*		-	-
compost	-		-	*ANG 770*

Main fixed financial starting points

1. Output calculation is net costs of processed waste (ANG/ton). This is called the “gate fee” or “tipping fee”. This is the minimum fee that must be paid at the gate to process the waste.
2. Land lease price is 10 ANG / m^2
3. Price escalation level is 2.4% / year
4. Volume increase of the waste is included using the estimate from the Waste Characterization Study (2% annually)
5. Depreciation levels for CapEx is 20 years
6. Weighted Average Cost of Capital (WACC) is excluded. A break-even gate fee price is calculated
7. No taxation included since waste processing options don’t contain positive cash flows
8. Conversion rate EUR : ANG is 1 : 2

Waste to energy
A CapEx and OpEx estimation has been made with an accuracy level of 27%. RHDHV has utilized recent CapEx estimations from internationally renowned WTE suppliers. CapEx estimations for several utilities are based on recent past projects. Additionally, an average of utility requirements is assumed. A final utility overview is excluded from this feasibility study.
If a WTE plant is built, almost all revenues will be generated by selling electricity. Multiple attempts were made to include Aqualectra in defining the electricity price. After receiving no response of price indication, the project team concluded that 0.22 ANG / Kwh is a realistic base case electricity price as this is the price Aqualectra currently pays for electricity generated by privately owned wind mills on Curacao. This is the fixed yearly rate that the WTE operator would receive from Aqualectra.

C&D presorting
The C&D sorting plant has been divided into 2 phases. Phase 1 consists of a crane and necessary facilities. Phase 2 consists of a complete C&D sorting plant.
The CapEx and OpEx estimations were calculated for phase I: C&D presorting, but not for phase 2. Current components for the C&D presorting include a crane, concrete floor and small operator house. Mixed waste enters the C&D presorting plant via trucks. Crane operators sort out big pieces of concrete / minerals and unload these onto a separate truck. This additional truck brings the sorted residue to one of the existing breaking / sorting / sieving (mobile) units on the Island. The remaining residue (consisting of wood / plastic fractions / small particles) will be landfilled. No revenues are expected, but there will be a savings from reduced landfilling.

Industrial recycling hub
The CapEx and OpEx estimations are based on benchmark data. The industrial recycling hub consists of a warehouse and an outside storage area with basic equipment (e.g. conveyor belts, baler/compactor, fork lift).
Revenue models and estimates of additional revenue flows are very difficult to determine in this initial phase. Therefore, the base case consists of no revenues from other businesses operating in the industrial recycling hub. Possible rental fees of participants must be determined during future conversations. The existence of a waste-drop off zone should create small revenues (especially metals and e-waste). In the base case model, 600 tons of ferrous metals and 420 tons of non-ferrous metals + e-waste are assumed. 0 net revenues for other waste fractions is assumed due to too many unknown macro-economic factors.

Composting and chipping

The CapEx and OpEx estimations for composting and chipping are done based on benchmark data and expert opinions. The composting area consists of the functions described in section 5.
Revenue flows are expected from selling compost to hotels, gardening companies and farms for a relatively low price. In addition, compost can be sold to retailers. An average selling price of 80 ANG/ton for bulky compost is estimated. Compost can directly be loaded into trucks & trailers and sold. Optionally for certain customers, a packaging machine can be used to bag the compost for retail sale. They will pay additionally for this service.

Landfilling

To complete the financial analysis, the real costs for landfilling are estimated. The two most important cost categories are: operational costs and hidden costs. Hidden costs consist of the costs of environmental impacts from landfill use and a highly utilized landfill.

- Current real operational costs vary between (55 - 74 ANG/ton). Source: Selikor
- Hidden costs (this amount is very dependent on external factors and must be further defined). Our advice is to set the total non-internalized costs to at least 25 ANG/ton. Defining this cost factor is out of scope in this project.

Thus, in our opinion, real actual costs associated with landfilling are at least **80 to 100 ANG/ton.**

6.2 CapEx overview

The table below contains the CapEx breakdown for each WPO. The CapEx estimation is based on benchmark reference projects and local specifications. The average CapEx inaccuracy is 27%. This has been incorporated into the contingency calculations. Contingency in this phase of the project is required since much project information is yet not available and design decisions have not yet been made.

Table 10: CapEx breakdown

#	CapEx in thousands ANG (-000)	Waste to energy	C&D presorting (crane)	Industrial recycling hub	Composting & chipping facility
1	Site cost / land	*Excluded (lease of land included in OpEx)*			
2	EPC: fitting out cost / equipment / Bop.	ANG 207,000	ANG 1,200	ANG 265	ANG 40
3	Building, civil structure, landfill cell, outside and site preparation costs	ANG 83,000	ANG 250	ANG 1,250	ANG 550
4	Project support / permits / tendering and preparations	ANG 19,000	ANG 190	ANG 245	ANG 105
	Subtotal	ANG 309,000	ANG 1,640	ANG 1,760	ANG 695
5	Risk account / inflation	*Excluded (included in cash flow calculation)*			
6	Contingency (-20% + 40%) average = 27%	ANG 85,000	ANG 443	ANG 475	ANG 188

7	Negotiations (-5%)	ANG -15,000	ANG -82	ANG -88	ANG -35
	Subtotal	ANG 378,000	ANG 2,000	ANG 2,150	ANG 850

6.3 Financial results

The table below presents the results of the discounted cash flow model for various WPOs. In the base case scenario, three out of four WPOs result in negative cash flows. However, composting shows a small positive business case. To address the negative cash flows, a net gate fee or net costs to process waste is added, reflecting the actual costs of processing the waste. It is important to note that when the realistic costs of landfilling are included in this table, composting, recycling, and sorting construction and demolition (C&D) waste are less costly compared to landfilling.

Table 11: Key overview of the most promising WPOs

Key project results per most promising WPO	Composting & chipping facility	Industrial recycling hub	Construction & demolition presorting	Waste to energy	Landfill
Amount of waste processed (-000) ton / year	18.0	13.4	12.0	103.0	130.0
Amount of waste created (-000) ton / year	-	1.3	2.4	27.3	-
Net landfill reduction (-000) ton / year	**18**	**12**	**10**	**76**	**-**
Contribution to landfill reduction (volumetric)	Very High	Very high	Medium	Very high	-
Local environmental impact (compared to current situation)	Very Positive	Positive	Medium	Positive	Negative
Net Gate Fee / Net costs to process waste ANG/ton	**Positive business case**	**ANG 52**	**ANG 25**	**ANG 298**	**ANG 80**

6.4 Sensitivity analysis results

A sensitivity analysis is conducted to conclude financial sensibilities and to understand the effect of financial variances to the net waste processing costs. The results are shown in the table below.

Table 12: Sensitivity study results

Net costs processing 1 ton waste	Composting & chipping facility	Industrial recycling hub	Construction & demolition presorting	Waste to energy
Base case	ANG -	ANG 52	ANG 25	ANG 298
CapEx +25%	ANG 5	ANG 116	ANG 26	ANG 343
CapEx +40%	ANG 6	ANG 117	ANG 26	ANG 370
OpEx +25%	ANG 15	ANG 140	ANG 30	ANG 359
OpEx +40%	ANG 22	ANG 156	ANG 33	ANG 395
Revenue decrease -25%	ANG 32	ANG 78	No revenue	ANG 328
Revenue decrease -50%	ANG 42	ANG 104		ANG 358
Revenue increase +50%	ANG -	ANG 20		ANG 238

Composting

The base case net waste processing fee is calculated to be **0 ANG/ton**. This indicates that implementing this WPO without any governmental incentives is feasible. However, the sensitivity analysis reveals that any decrease in revenue or increase in CapEx or OpEx, can lead to negative cash flows. Revenue is the most critical financial factor for composting. Therefore, the priority in developing this WPO should be to continue discussions with feedstock suppliers and off-take stakeholders. The initial assumptions and starting points used in this study need to be updated and validated with the involved stakeholders. The relatively low financial sensitivity to CapEx and OpEx is due to the projected low-tech composting unit and the small team required to operate it.

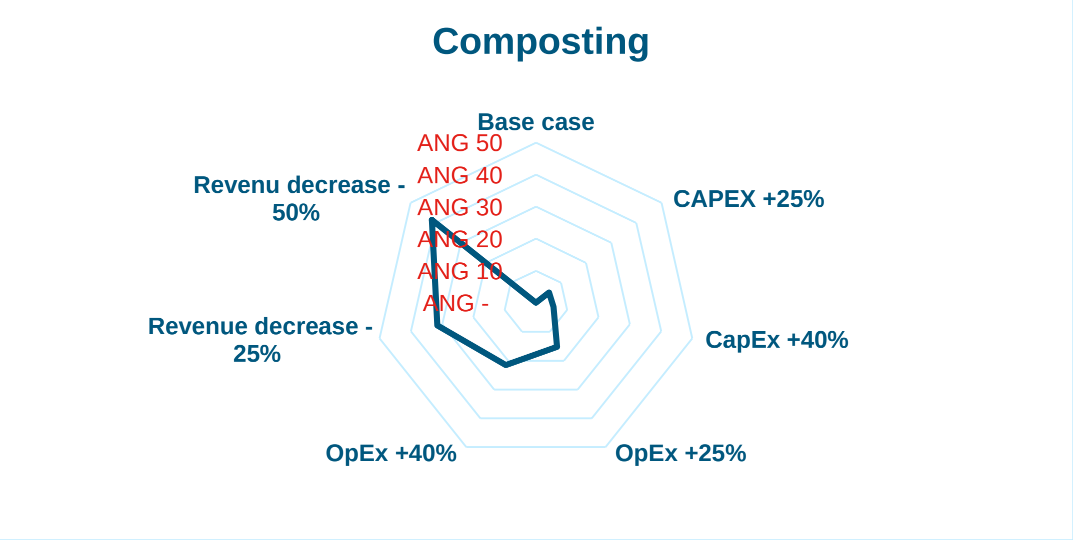


Figure 12: Visualization sensitivity analysis for composting

Industrial recycling hub

The base case net waste processing fee is calculated to be **52 ANG/ton**. As previously mentioned, projecting revenue for this industrial recycling hub is challenging, partly due to the anticipated additional metal fraction flow from individuals.

The highest sensitivity in the business case is related to OpEx. Therefore, the focus should be on exploring additional revenue streams, such as charging small fees for local companies establishing themselves in the hub.

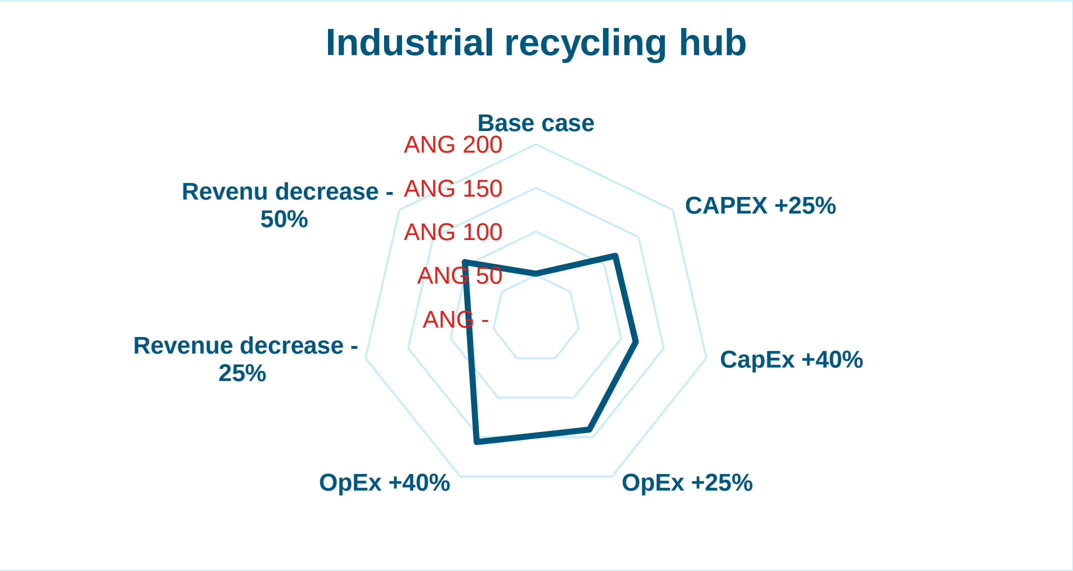


Figure 13: Visualization sensitivity analysis for the industrial recycling hub

Construction & demolition waste presorting

The base case net waste processing fee is calculated to be **25 ANG/ton.** This WPO contains the lowest financial risk of all WPOs.

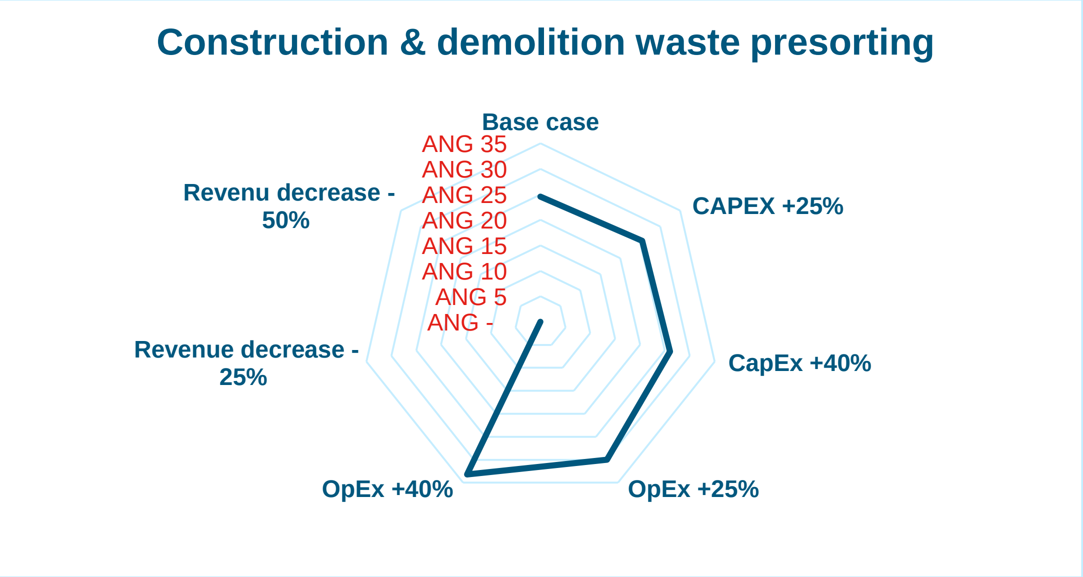


Figure 14: Visualization sensitivity analysis for C&D waste presorting

Waste to energy

The base case net waste processing fee is calculated to be nearly 300 ANG/ton. Additionally, WTE is very expensive in terms of both CapEx and OpEx, which is why the financial sensitivity is high for both aspects. A goal seek function indicates that the electricity price for WTE should be 0.77 ANG per kWh to avoid additional gate fee expenses.

There are possibilities to increase electrical rates, given the current electricity rates for citizens are up to 0.80 ANG per kWh (rate are adjusted monthly).

For comparison, in 2025, the energy regulator on Curaçao set the price to purchase electricity from solar installations at 0.25 ANG per Kwh.

It might be worth considering an increase in the selling price of electricity to cover the costs of WTE, since this generates constant electricity and solves the existing waste issues. Wind and solar do not generate constant electricity.

Selling price (Kwh)	Gate fee WTE
ANG 0.22	ANG 298
ANG 0.33	ANG 238
ANG 0.44	ANG 178
ANG 0.55	ANG 117
ANG 0.66	ANG 57
ANG 0.77	ANG -

Table 13: Iteration of electricity selling price versus gate fees

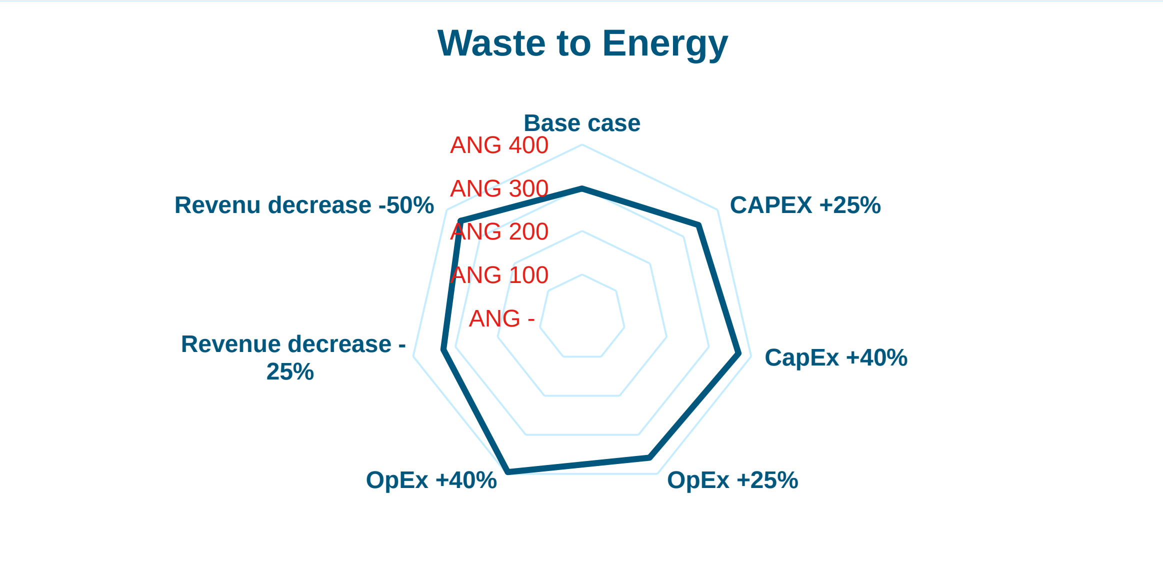


Figure 15: Visualization sensitivity analysis for WTE

6.5 Conclusion

The "Transforming Waste to Value" RESEMBID project demonstrates that this transformation is currently only feasible for organic waste fractions without any additional funding. For other types of waste, additional funds are required for processing (including the current landfilling method). The cost, known as the "gate fee" or "tipping fee," is calculated per ton of waste and represents the minimum amount in ANG needed for processing. This situation is comparable to other countries.

The financial analysis reveals that the actual costs of landfilling are higher than those for processing organic waste, recyclables, and C&D waste presorting. Therefore, the gate fees paid at the Malpais Landfill should be aligned with the calculated fees for processing these waste types. Essentially, the financial analysis underscores the need for economic incentives to promote alternative waste processing methods.

Initial calculations indicate that processing one ton of waste via WTE would cost approximately 300 ANG/ton. Although significant revenue is generated from electricity, it is insufficient to cover both CapEx and OpEx. Consequently, a higher gate fee is necessary to operate the WTE facility, which is consistent with practices in other countries. Theoretically, the minimum selling price of electricity must be 0.77 ANG per Kwh to generate "value from waste" via WTE.

7 Feasibility assessment

Feasibility is assessed from the perspective of a commercial project developer who must navigate and adapt to the existing and evolving policy landscape. A feasibility analysis usually covers six categories of project development, as shown in Figure 15, viewed through the lens of a commercial project developer. These categories are expanded to include a seventh category: Policy Landscape. Since effective waste management has consistently been proven to be dependent on a robust policy framework, this additional category is crucial for a comprehensive feasibility assessment.

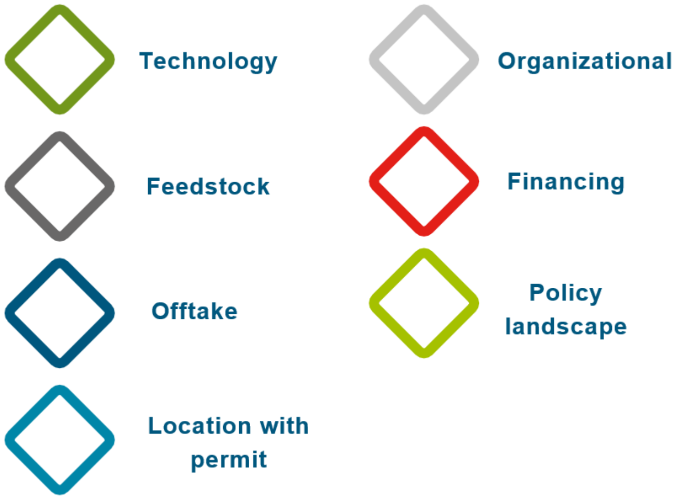


Figure 16: Categories of project development

The feasibility of the Waste Processing Options (WPOs) is assessed using a three-step approach:

1. **Maturity**: This step ranks the maturity level of each selected WPO. The maximum number of points is 35, indicating that all technologies are fully mature and ready for construction and operation.
2. **Gaps & Milestones**: This step defines and describes the gaps which must be overcome by milestones to reach the maturity level of 35 points. Each point below 35 represents one milestone. Consequently, a milestone roadmap can be created.
3. **Project Risks and Countermeasures**: This step identifies the risks towards implementation from stakeholders to the WPOs and vice versa, and outlines countermeasures.

7.1 Project deployment roadmap

Each WPO needs to undergo actions and complete stages before it can become operational. To get from current maturity to envisioned maturity, (i.e. WPOs in operations), the WPO deployment roadmap is split in 3 phases.

The implementation of the WPO involves three main phases:

1. **Feasibility Phase**:
    - **Objective**: Research the WPO across six categories, including the policy landscape, to determine feasibility.
    - **Stakeholder Involvement**: Stakeholders express interest and sign letters of intent.
    - **Outcome**: An organization with the necessary resources and a clear development plan.
    - **Maturity Range**: 18–26 points.
2. **Development Phase**:
    - **Objective**: Actively develop the WPO, addressing major milestones to reduce risks.
    - **Outcome**: A project with a ready-to-execute plan and all necessary resources.
    - **Maturity Range**: 27–34 points.
3. **Construction & Operation Phase**:
    - **Objective**: Mature the WPO for construction and operation.
    - **Outcome**: A fully operational WPO.
    - **Maturity Range**: 35 points.

The maturity is further detailed below in section 7.2.

7.2 WPO maturity

Each option is rated on a scale from 0 (not mature) to 5 (fully mature). For this project, RHDHV uses the standardized Project Development Rating Index (PDRI) methodology, which is generally used in industrial development projects. This rating can later be applied to the maturity of each WPO.

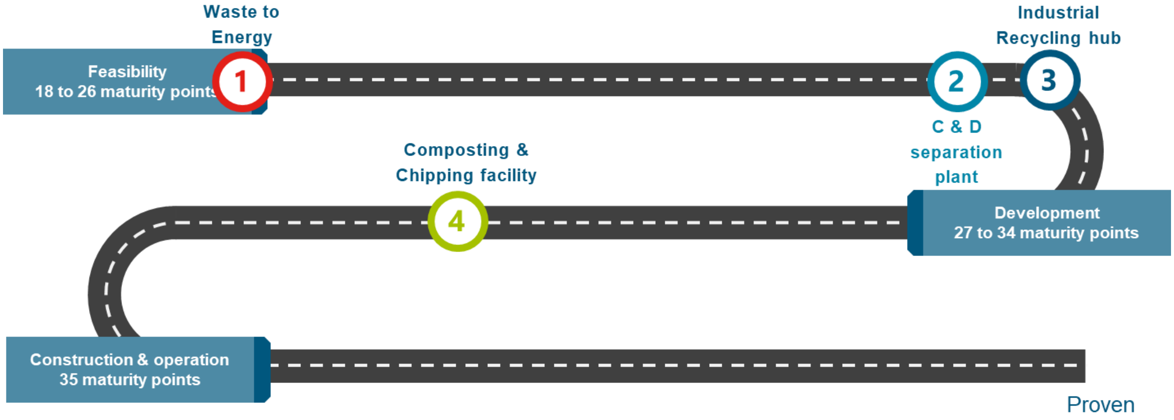
Category Maturity Definitions:

1. **Technology**: The level of applicability of the technology in Curaçao for the same capacity at comparable economic and competitive levels.
2. **Feedstock**: The level of suitability, flexibility, and availability of feedstock for the required WPO.
3. **Offtake**: The level for potential offtake on or off the island for all flows coming out of the process route.
4. **Location with Permit**: The level of availability of a suitable location on the island with the necessary permitting framework, plus location-specific permits for activities. (This is also being investigated in the Environmental / Location Study that is being conducted concurrently).
5. **Organizational**: The level of adaptability of the organizational format and availability of a suitable workforce during the asset lifecycle.
6. **Financing**: The level of difficulty to finance the WPO. This is based on the total weighted gate fee for commercial operations over a 25-year period, including possible landfill expansion, compared to the envisioned all-encompassing cost of 80 to 100 ANG for landfilling.
7. **Policy Landscape**: The level of required updates and complexity in governmental waste policy and the stability of enforcement related to implementing the WPO.

A fully complete case has 35 points, based on seven categories with a maximum of 5 maturity points each. The following maturity levels are the result of a workshop session held with four Royal HaskoningDHV specialists involved in the project. For the location and permit category, the workshop included both EcoVision NV (who conducted the Environmental / Location Study) and Royal HaskoningDHV.

Table 14: Overview maturity level per WPO

	Waste Processing Option			
6 Category Project Development Area 7th Policy Landscape	**Waste to energy**	**C&D presorting**	**Industrial recycling hub**	**Composting & chipping facility**
Category	**Maturity level 5= mature - 0= not available**			
Technology	3	5	5	5
Feedstock	4	5	2	5
Offtake	2	5	4	5
Location with permit	1	3	4	5
Organisational	2	3	3	4
Financing	1	3	4	5
Policy landscape	2	2	2	3
Total maturity score	**15**	**26**	**24**	**32**



The composting and chipping facility is far closer to maturity with the industrial recycling hub and the C&D waste presorting following closely behind. The waste to energy route is not at the feasibility stage yet due certain boundary conditions that need to be in place before the deployment route can start. For example, updated waste policy, plans regarding organization and governance and agreements regarding financing.

7.3 Milestones & roadmap

Based on the maturity level identification in section 7.2, this section identifies Boundary Conditions (B) and Milestones (M). A second workshop session focusing on Location with Permit was held with four Royal HaskoningDHV specialists involved in the project and EcoVision.

In the second part of the workshop, milestones are identified by first assessing the number of gaps that need to be bridged to make a WPO operational for 25 years. These milestones were then placed in order on the roadmap. The milestones are organized by phase and order of execution. Achieving milestones earlier can facilitate reaching other milestones by reducing project risks and building trust. Therefore, while earlier achievement is possible, the latest expected completion date is assumed.

The roadmap starts based on the current maturity of each WPO, with the goal of reaching the "Proven" status, where the WPO is fully functional in Curaçao as intended. Each milestone is shown on the roadmap as a diamond in the same color as the category shown at the beginning of this chapter.

A score of 5 points means there are no milestones that need to be reached. For each unmet milestone per category, a point is deducted from 5, with the lowest score being 1.
The following number of milestones is the result from the workshop:

Table 15: Score overview amount of milestones required

	Waste Processing Option			
	Waste to energy	C&D waste presorting	Industrial recycling hub	Composting & chipping facility
Category	**Points per item, 5 points is no major milestones**			
Technology	1	3	4	4
Feedstock	3	5	4	5
Offtake	2	5	5	5
Location with Permit	1	2	4	5
Organisational	2	3	3	4
Financing	1	4	3	4
Policy landscape	1	4	4	5
Total score gaps	11	26	27	32
Number of Milestones (M)	**24**	**9**	**8**	**3**

7.3.1 Boundary conditions Waste to Energy

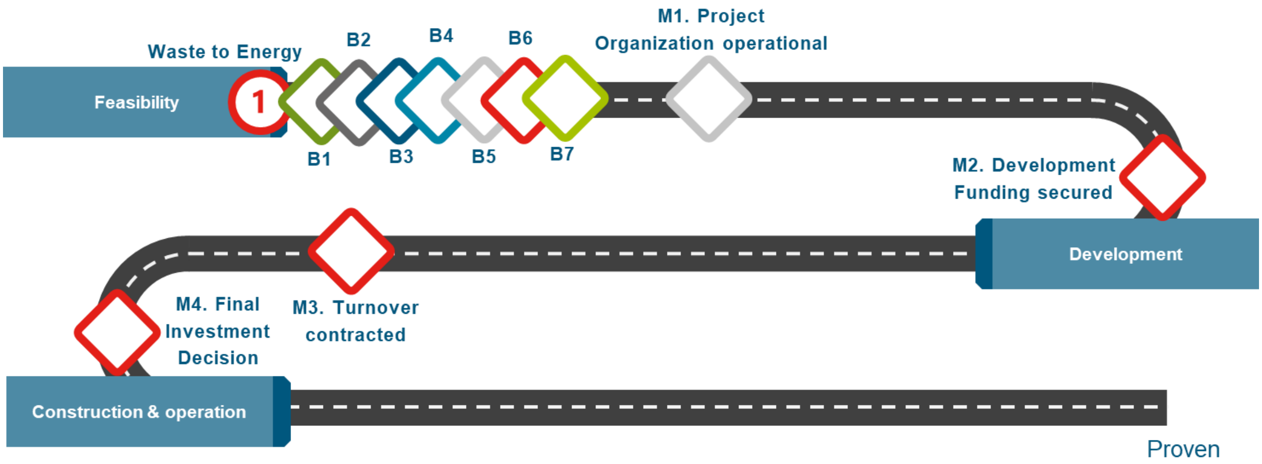
The Waste-to-Energy (WTE) project is at the beginning of the feasibility stage, with a result that over 20 milestones are required to reach readiness for construction and operation. The following overview contains major milestones to reach the "development phase":

1. B1. Proven WTE technology: Start with concept engineering and program of requirements.
2. B2. Proven waste composition: Predictable supply of feedstock in terms of quality, feedstock intake costs and agreements, and quantity. After implementing other WPOs and waste policies, the main changes in feedstock are expected to become predictable.
3. B3. Safe ash disposal allocated: Allocation for bottom and fly ash disposal in place.
4. B4. Designated location: A site appointed for building and operating the WTE plant. This was identified during the Environmental / Location Study.
5. B5. Project development capability: Organizational setup showing an organization is willing to undertake WTE development.
6. B6. Feasibility funding: Financing available for the first phase to establish the project organization for the entire project cycle.
7. B7. Proven policy landscape: Effective and enforced waste management regulations. This is required to develop large investments projects such as WTE and to attract (foreign) investors.

Overall, the following milestones are interdependent, primarily focusing on financing to achieve milestones in other areas:

- **M1. Operational project organization**: An organization that executes all phases. Appendix H contains examples of ideas on how to do this.
- **M2. Secured development funding**: Covering project development costs to reach the Build, Design, and Operate phase.
- **M3. Contracted turnover for 20 years**: Guaranteed electricity offtake price, security, and future gate fee plan.

- **M4. Final Investment Decision**: For the last phase of deploying the Build, Design, and Operate phase.



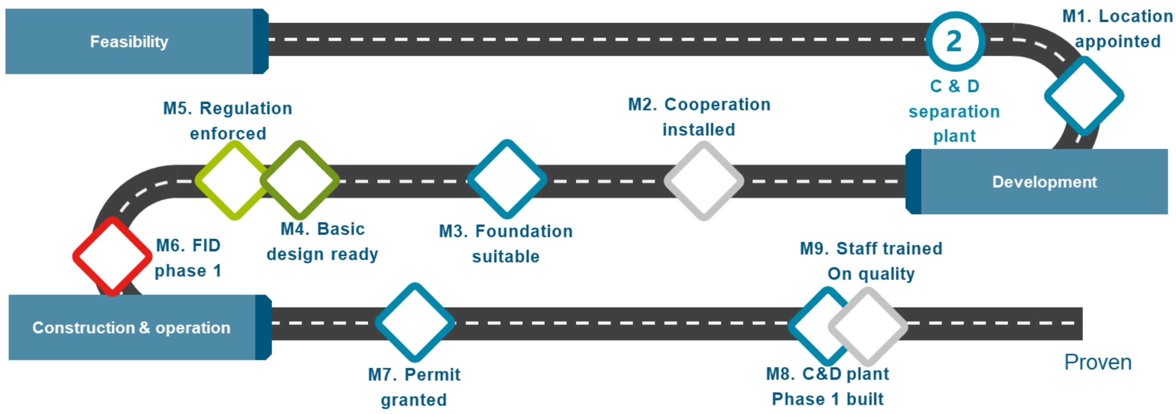
7.3.2 Milestones C&D waste presorting

For completing the C&D presorting, 9 milestones (M) must be reached. The main value chain from feedstock, to technology, to offtake is already mature. The following milestones are identified:

1. M1. Location appointed for the activities, specifically taking into account dust formation
2. M2. Cooperation achieved: a reliable organization is created for cooperation on the island with incentives for a higher recycling rate
3. M3. Local location parameters agreed upon (such as suitable foundation, traffic congestion plan, dust / noise studies)
4. M4. Basic design ready: design the C&D presorting facility in 2 deployment phases of serial processes
5. M5. Legislation and regulations enforced. For example, no illegal dumpsites allowed, checks regarding source separation during large construction and demolition projects, high gate fee (>100 ANG) for mixed C&D waste brought to the landfill
6. M6. Final Investment Decision phase 1
7. M7. Permit granted: permit is granted for operations, specifically dust formation will be challenging
8. M8. C&D plant phase 1 built
9. M9. Quality staff trained: instruct & train staff on quality management

The Financing and Policy landscape milestones go hand in hand, as the policy landscape requires enforcement of existing regulations (M5), which establishes the requirement for recycling and thus creates a financial incentive. The major financing milestone is reaching the required investment to deploy the first phase, known as the final investment decision (M6).

The order of the major milestones for the C&D presorting begins with the appointment of the location (M1) before reaching the development stage. Next, cooperation is established (M2), the foundation is found suitable (M3), the basic design is completed (M4), regulations are enforced (M5), and the final investment decision for phase 1 is reached (M6). This culminates in reaching the construction and operation phase. Finally, the permit is granted (M7), the C&D presorting plant (phase 1) is built, and the staff is trained on quality before the C&D presorting plant is proven.

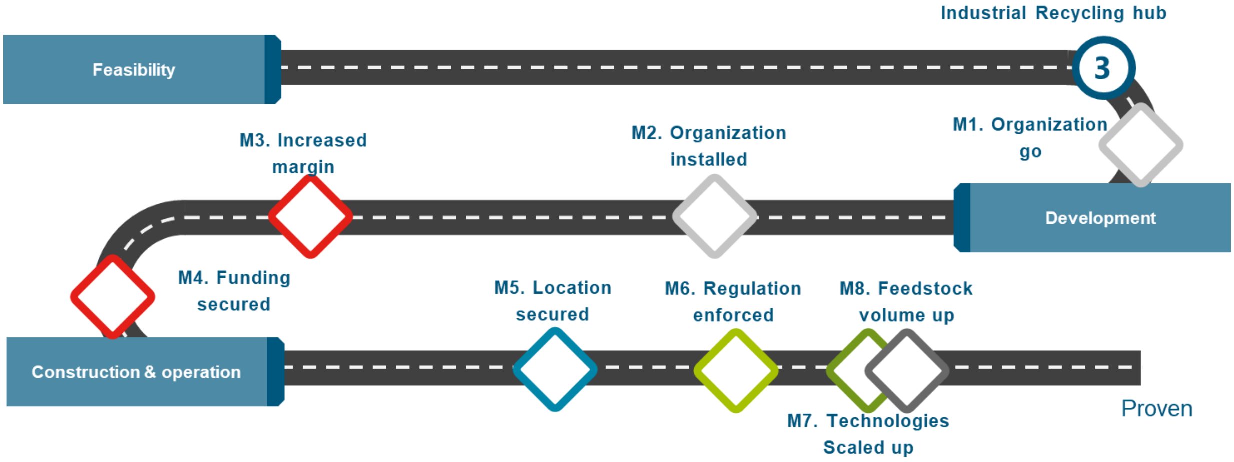


7.3.3 Milestones Industrial Recycling Hub

Recycling is already happening in Curaçao, but not yet on an industrial scale in a hub format. For completing the industrial recycling hub, 8 milestones must be reached. The following milestones (M) are identified to reach operation of the Industrial Recycling Hub.

- M1. Establish organization: agree on the type of organization for deployment
- M2. Organization installed and governmental model agreed upon
- M3. Increased margin: to decrease costs or to increase offtake price. For example, additional taxation on incoming shipping containers containing products/goods can be used to pay for outgoing containers filled with recycled materials.
- M4. Funding secured: initial investment secured to allow start of operations by developing the location with minimum requirements. Sponsors, such as large multinationals and government, may be willing to contribute.
- M5. Location secured
- M6. Waste policy updated and regulations enforced, such as periodically checking for source separation at companies. Increase gate fee for recyclable materials at the Malpais Landfill (>100 ANG). With these in place, recyclable materials are much more likely to be brought to the industrial recycling hub.
- M7. Technologies and material handling methods ready to handle higher volumes.
- M8. Increased feedstock volume: increase volume of feedstock supply by requiring companies above a certain size to source separate recyclables (policy landscape).

The 2 categories with 2 milestones are: organization and financing. The organizational type is based on existing recyclers cooperating on the location by sharing utilities & capabilities. Note that the policy landscape has great influence to increase the margin and make the business case viable.
The order of the major milestones starts with establishing the organization and installing it (M1 and M2). However, before reaching M2, increasing the margin (M3) should already be in place. Similarly, before funding can be secured (M4), securing the location (M5) and enforcing regulations (M6) should already be in place. Finally, technologies are scaled up (M7) followed by increasing feedstock volume (M8), before the Industrial Recycling Hub is proven.

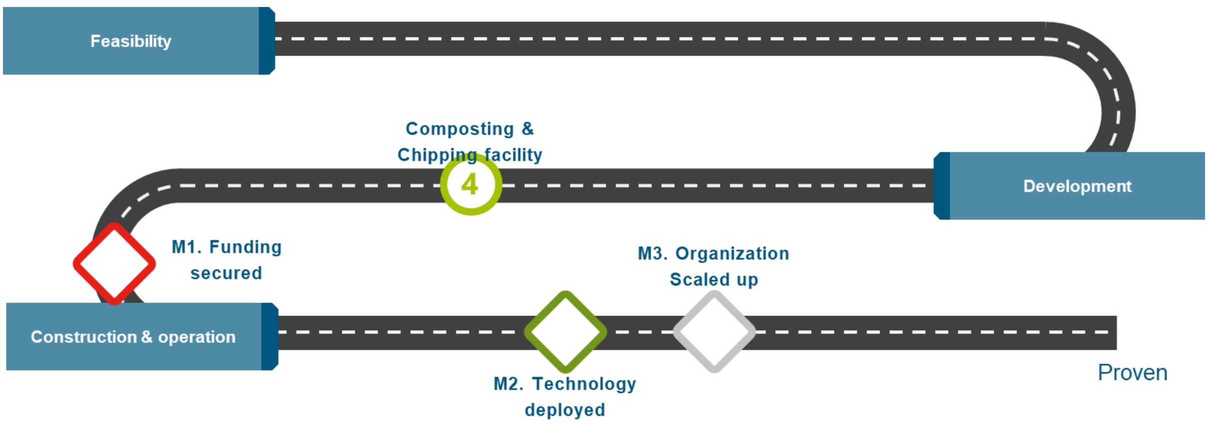


7.3.4 Milestones Composting & Chipping Facility

For completing the composting & chipping facility, 3 milestones must be reached. For each category there is only 1 milestone to reach. The following milestones are identified:

- M1. Funding secured: secure funding for the construction phase.
- M2. Technology deployed: scaling up with current or elsewhere available technology.
- M3. Organization in place and governmental model ready: Operational staff recruited and ready.

An updated waste policy and enforcement of regulations for organic waste that obliges that organic waste can no longer be landfilled. Composting is a good alternative to turn waste into value.



7.4 Risk implementation analysis

In this section, an initial risk analysis is conducted for the 4 WPOs.
Risks affecting the realization and operation of each WPO are categorized into internal and external risks.

1. External risks: Risks from outside affecting WPOs
2. Internal risks: Risks caused by the WPOs affecting island stakeholders

7.4.1 External risks

Risk	Impact	Counter measure	Source	Affected
Scaling up offtake is likely slower than the potential scaling up of feedstock supply causing piling up of compost/mulch.	Large storage of readily available compost and financial under performance due to delayed sales.	1. Line up potential offtakers at a discount for minimum viable quantity. 2. Per offtaker, test on a smaller scale; the offtake based on existing capacity. 3. Improved execution of policy measures at the moment when offtake becomes available.	Sustainability initiatives, specific offtakers of compost.	Compos-ting & chipping
Cooperation between the parties for joint collection is not yet achieved on an organizational level and this can prevent starting up and agreeing on a ready to invest business case.	Investment in collection not secured as pre-agreement regarding collection is required.	1. Pre-investment covered by government, backed by a joint or 3rd party that ensures site setup, collection and redistribution.	Sustainability initiatives, specific organization	Industrial recycling hub
Recycling initiatives can stagnate if WTE requires a minimum amount of feedstock.	Insufficient amount of feedstock received or continuous improvement of waste management structure stagnates.	Establish a cooperation model with Selikor for feedstock supply and the benefits of higher amount of reuse and recycling.	Waste management structure, feedstock	Waste to energy
Simultaneously implementing the WPOs for other flows affect the feedstock composition for both more and less energy in the feedstock.	For developing and operating a WTE plant a predictable feedstock composition is required. Without a predictable feedstock composition, the WTE plant cannot	1. First implement the WPOs C&D presorting, industrial recycling hub and composting and chipping. 2. Monitor developments in small scale WTE 3. Monitor composition of potential WTE feedstock	WPOs C&D separation, industrial recycling hub and composting & chipping, feedstock	Waste to energy

	be effectively designed.			
Deployment times are long and investment size is large for WTE. Other waste management initiatives might become feasible earlier and are favored for implementation.	Risk of losing the investment in feasibility and potential deployment.	1. Accept the risk as it serves the purpose of landfill reduction. 2. While creating boundary conditions for WTE, keep them open for other options. 3. Monitor WTE developments that become feasible for the island.	Waste management structure	Waste to energy

One general risk was identified as being specifically applicable for island economies the size of Curaçao, which is applicable for each party or WPO in each category:

Risk	Impact	Counter measure	Source	Affected
The economy of scale for each WPO is determined based on one organization operating the WPO with the risk of forming a monopoly. Multiple parties operating the same WPO does not reach the required economy of scale for feasible operation.	WPOs will act as monopolist or other stakeholders see this risk and obstruct deployment.	Allow for a cooperation model with long term rights that allow commercial operation within boundaries.	Economy of scale in waste management	All WPOs*

*Assuming that each WPO is deployed in only 1 case.

7.4.2 Internal risks (WPOs affecting existing sustainability initiatives)

Among the interviewed local companies executing sustainability initiatives, there is a strong opposition to waste incineration, with a focus instead on creating sustainable recycling practices. There is advocacy for stronger recycling laws and government led initiatives to support local recycling infrastructure.
In this risk group, risks are identified per sustainability initiative with WPOs being the risk source. The sustainability initiatives are grouped per feedstock type.

Risk	Impact	Counter measure	Source	Affected
Products from the C&D presorting are a competing flow.	Higher supply can result in lower turnover for existing parties active in recycled aggregates and sand.	1. Involve these parties in the C&D waste value chain 2. Actively engage parties for higher usage amount	C&D waste presorting, offtake	Recycled aggregates and sand
Pressure on available feedstock quality due to obliged increased source separation	Lower quality going to the international market can negatively affect the price.	Involve the paper / cardboard recyclers in the industrial recycling hub.	Industrial recycling hub	Paper / cardboard
High supply of compost in the local market will reduce pressure on compost prices.	Business case may not be viable anymore in the short-term resulting in a financing gap.	Develop offtake market in line with planned supply.	Composting & chipping facility, offtake	Organic waste

7.4.3 Internal risks (WPOs affecting waste management structure)

Implementing a WPO can potentially create side effects, which could have a (positive or negative) impact on Curaçao's overall waste management structure.
The table below contains the outcome of a first risk assessment for this category.

Risk	Impact	Counter measure	Source	Affected
Reduced waste streams results in loss of income	Reduced turnover and required operational change for collection companies and / or Selikor	1. Establish performance indicators that benefit reuse and recycling and that help Selikor adapt. 2. Regarding feedstock supply of C&D waste, industrial recycling and WTE align with Selikor on organizational setup for joint operation.	All WPOs, feedstock	Selikor's Malpais Landfill operation
Separate collection of flows is required and more strict registration	Additional costs for collection results in less attractive business case	Provide incentives for informal waste collection companies to perform source separation and to provide logistical services to WPOs. Stimulate citizens to source separate (for example organic waste)	Composting & chipping, C&D waste presorting and WTE	Informal private waste collection companies
In the industrial recycling hub there is joint operation, including a weighbridge	Larger flows to handle in cooperation with other recyclers with different composition requires a change in operational habits.	Integrate the recycling centers existing value chain into the industrial recycling hub.	Industrial recycling hub, organizational	Recycling centers

Not included in the effects from or to the WPOs, but certainly relevant coming from the policy landscape: parties will source separate in the event that they have to pay additionally for bring waste to the C&D presorting facility or they will lean towards illegal dumping.

7.5 Conclusions

The WPO **composting and chipping** is clearly ahead of other WPOs as its maturity is in the development phase with 3 milestones to reach operations. It is the only WPO not dependent on the policy landscape regarding waste, but could benefit greatly by being supported by the waste policy landscape.

Both the WPOs **industrial recycling hub** and **construction & demolition presorting** plant are in the feasibility phase. To reach operations, 8 to 9 milestones still need to be reached. Both WPOs are dependent on a supporting waste policy landscape that is enforced and provides the conditions to allow for commercial operations. These two WPOs require the development of a cooperative organization that has the sole rights to operate, but monopoly abuse must be managed.

The WPO **waste to energy** is not mature enough to go into the feasibility phase as several boundary conditions first need to be in place. With 7 boundary conditions required to be in place and other WPOs affecting the WTE, the WTE is dependent on the government for starting the deployment route.

8 Next steps

This chapter details the necessary steps to operationalize Waste Processing Operations (WPOs) in Curaçao. The process begins by identifying the most experienced and suitable stakeholders to lead the deployment. The table outlines the initial tasks to progress along the roadmaps described in Chapter 7. To facilitate deployment, various funding options and partnership types are discussed. Additionally, considerations for the waste policy landscape are addressed to support the deployment. The final step involves establishing the deployment timeline for each WPO, based on achieving specific milestones in each phase.

8.1 Mature stakeholder & initial tasks

Using the maturity of WPOs, milestones, roadmap, and risks outlined in Chapter 7 as a foundation, the initial tasks for stakeholders to take the lead are described below. Ideally, the most experienced stakeholders should initiate these tasks. If there is a gap among existing waste or recycling stakeholders, a commercial project developer can step in to move the deployment roadmap along. Examples of such developers include: property owners, companies from other sectors, or firms that develop projects to later transfer to operators upon completion.

8.1.1 Stakeholders with initial tasks for waste to energy

Due to the limited maturity and fragmented responsibilities among different parties on the island, there is no single stakeholder with significant expertise in WTE. Outside of Curaçao, commercial project developers have the most expertise in developing WTE plants, but they only engage when the necessary (pre) conditions are met. Therefore, the Government is the primary stakeholder, especially given the focus on reducing landfill use.
To achieve operational status, the following table outlines the suggested initial actions for each major milestone, along with their respective stakeholders.

Major milestone	Stakeholders	Initial action
B7. Policy landscape proven, complete & operating successfully	Government	Updated and implemented waste policy. Policy enforcement executed
B1. An understanding of WTE technology on Curaçao	Government	Monitor WTE technologies deploying in comparable settings and learning from other island states that are further ahead in deploying WTE.
B2. Waste characterization fixed	Government Composting & chipping Industrial recycling hub C&D separation plant Selikor	Act on implementation strategy for other WPOs and monitor the resulting waste composition.
B3. Safe ash disposal allocated	Selikor	Appoint a location for sanitary landfill cell deployment.

B4. Location is appointed	Government	Appoint one of the recommended locations from the Environmental / Location Study
B5. Project development capability is mature	Government	Monitor other WPOs and analyze which commercial project developer is suitable.
B6. Feasibility funding	Government	Government frees up funding for the feasibility funding

8.1.2 Stakeholders with initial tasks in construction & demolition presorting

Source separation of C&D waste already occurs in Curaçao, but it can be enhanced by establishing a central location with well-organized logistics. The responsibility for C&D presorting is shared between parties involved in recycling aggregates and sand, and Selikor. The Government is the main stakeholder for securing a location with the necessary permits for this type of operation.
Given their combined expertise, in this feasibility study (and in the table below) these stakeholders are considered as one entity, referred to as: Curaçao C&D Separation. The first task is to establish this organization. To achieve operational status, the following table outlines the suggested initial actions for each milestone, along with their respective stakeholders.
The initial action to form a joint organization requires collaboration from both existing local companies involved in recycled aggregates and sand, as well as from Selikor and/or the government. All parties are essential to equally contribute towards establishing a unified vision. Therefore, the milestones are combined into one cell as joint actions on different topics.

Major milestone	Stakeholders	Initial action
M1. Location is appointed M2. Cooperation achieved M6. Final Investment Decision phase 1	Selikor / Government	For either the government or Selikor to appoint the location for developing a C&D presorting facility, considering the activities with dust formation and logistics.
	Parties source separating for recycled aggregates & sand	Start by aligning with Selikor regarding roll out roles.
	Government	1. Guarantee execution of policy measures at moment when offtake becomes available. 2. Establish performance indicators that benefit reuse and recycling and help Selikor to adapt. 3. Allow for a cooperation model with long term rights that allow commercial operation within boundaries.
	Curaçao C&D separation	Jointly setup the envisioned financial model as a single island operator.
M3. Foundation suitable	Curaçao C&D separation	Perform location specific parameter studies
M4. Basic design ready	Curaçao C&D separation	Request Design & Built quotations for the 2 phase C&D presorting facility.
M5. Regulation enforced	Government	Turn waste guidelines into policy and plan for enforcement alongside WPO development.
M7. Permit granted	Curaçao C&D separation	Guarantee execution of policy measures at moment when offtake becomes available. Establish performance indicators that benefit reuse and recycling.
M8. C&D presorting facility phase 1 built	Curaçao C&D separation	Depending on earlier actions.
M9. Staff trained regarding quality	Curaçao C&D separation	Depending on earlier actions.

8.1.3 Stakeholders with initial tasks for the industrial recycling hub

Recycling is already taking place in Curaçao, but not yet on an industrial scale in a hub format. The stakeholders most advanced in developing an industrial recycling hub are those involved in sustainability initiatives and the existing recycling companies that process source separated recyclable materials.
To achieve operational status, the table below outlines the suggested initial actions for each major milestone, along with their respective stakeholders.

Major milestone	Stakeholders	Initial action
M1. Organization	Sustainability initiatives, executing organization, existing recycling companies	Align with sustainability initiatives and Government on establishing an executing organization. Follow the setup of this organization.
	Government	1. Guarantee execution of policy measures at moment when offtake becomes available. 2. Establish performance indicators that benefit reuse and recycling and help Selikor to adapt. 3. Allow for a cooperation model with long term rights that allow commercial operations within boundaries.
M3. Increased margin	Sustainability initiatives, executing organization, existing recycling companies	Negotiate for better outgoing rates for shipping containers
	Government	Implementation of methods to cover cost by taxing incoming materials or preventing the export of empty containers that could be used for exporting recyclables.
M4. Funding secured	Sustainability initiatives, executing organization, existing recycling companies	Develop a business plan with the amount of investment and align with financing parties (note that some technical input is required for the type of location).
	Government, commercial project developer	Pre-investment covered by the government or backed jointly by a 3rd party that ensures site setup, collection and redistribution.
M5. Location secured	Government - by supporting local recycling companies	One of the recommended locations from the Environmental / Location Study is made available for development.

8.1.4 Stakeholders with initial tasks for composting and chipping

The stakeholder most mature on composting is among the sustainability initiatives: the existing composter that has land available and prepared. Based on conversations with EcoVision and Soltuna, a few private parties are initiating composting and are chipping green waste. The scale of these local initiatives is very small.
To reach operations, the suggested initial actions to reach each major milestone are listed with their respective stakeholders in the table below.

Major milestone	Stakeholders	Initial action
M1. Funding secured	Sustainability initiatives, executing organization, existing composter	Line up potential clients for compost / offtake agreements
	Sustainability initiatives, offtakers, hotels	Test the compost on a smaller scale and explore offtake certainty.
	Government	1. Guarantee execution of policy measures at moment when offtake becomes available. 2. Establish performance indicators that benefit reuse and recycling and help Selikor to adapt. 3. Allow for a cooperation model with long term rights that allow commercial operations within boundaries.
	Selikor landfill operation	Support policy landscape on reuse and recycling awareness to prevent landfilling of organic waste.
M2. Technology deployed	Sustainability initiatives, executing organization, existing composter	Start by requesting quotations for the required scale up.
M3. Organization scaled up	Sustainability initiatives, executing organization, possible existing composting initiatives	Make use of incentives during ramp up of the facility to stimulate source separation of organic waste.

8.2 Partnerships

Depending on each WPO, a unique form of partnership is proposed to manage activities and structure governance.

- For the C&D waste presorting WPO, a joint venture can be established to manage the organization.
- For the industrial recycling hub, a cooperative partnership is more suitable, as explained in section 5.2.1.
- The composting plant can exist as a private entity.
- For the waste to energy plant, a public-private partnership is proposed. More detail regarding developing the governance for this WPO is discussed in Appendix G.

The benefits of implementing an industrial recycling hub include centralized operations. Establishing a dedicated recycling center will streamline processes, enhance efficiency, and reduce costs associated with waste management. The hub can be managed centrally by a cooperative, ensuring local stakeholder involvement and fostering community support. The center can also provide job opportunities and training programs, equipping the local workforce, including youth, with skills in recycling and waste management. While there are inherent risks to partnerships — such as market volatility, regulatory challenges, and operational hurdles — these can be mitigated through strategic planning, stakeholder collaboration, and robust risk assessment practices. Engaging with local communities, especially the youth and universities, and continuously adapting to regulatory landscapes, will help ensure the long-term viability of the hub.

Delete the grey background in this section

Change of mindset is required and insights into sustainable development creating awareness on the necessity of working together and pooling resources to make change possible. Stakeholders must come to an agreement between local parties on ways to work together through cooperation. Developing policies, laws and regulations, tax incentives, funding and grants can only go so far. In the end to make the WPOs feasible, the responsibility lies with local stakeholders, the community at large, government and the private sector alike.

8.3 Funding sources and suggestions

As mentioned earlier, various funding options are available. The feasibility of each WPO will determine the most suitable financing method.

For a negative business case, the government can incentivize stakeholders through policies, subsidies, and grants. Direct funding can come from budget allocations or special environmental and sustainability funds. Subsidies and tax incentives can also encourage investments in sustainable technologies.

For a positive business case, stakeholders can seek private sector and capital market financing to promote entrepreneurship within Curaçao's circular economy and recycling sectors. Establishing an investment fund dedicated to recycling initiatives and circular economy activities is recommended. This sustainable fund, offering Green Bonds, can attract various stakeholders, including the public, pension funds, commercial banks, NGOs, and industry players. Collaboration in such a fund provides access to capital and expertise, sharing costs and risks, and promoting innovative technologies. The fund's objectives include promoting sustainable practices, encouraging recycling and waste-to-value initiatives, and generating stable returns for investors. It can also foster community engagement by involving local communities, especially the youth, in recycling efforts.

International financing options are also available. Institutions such as development banks, the World Bank, and the Inter-American Development Bank (IDB) offer loans and grants for sustainable projects. Funds such as the Green Climate Fund (GCF) and the Global Environment Facility (GEF) provide financing for climate-related projects. Reducing landfilling reduces the production of methane (a potent greenhouse gas), so improved waste management also relates to climate change. Platforms such as the International Renewable Energy Agency (IRENA) and the Small Island Developing States (SIDS) DOCK offer technical support.

Community involvement is crucial for successful WPO implementation. Crowdfunding campaigns and local investment initiatives can promote community ownership. Companies can also contribute through recycling credits, ensuring their materials are recycled, often under Extended Producer Responsibility schemes. However, this route is complex and expensive to organize. If Curaçao aims to explore this route, collaboration with other island states is highly recommended.

By leveraging these diverse funding sources and strategies, Curaçao can secure the resources needed to implement sustainable waste processing technologies and reduce the environmental impact of waste management.

8.4 Policy landscape, legal and regulatory considerations

The considerations and recommendations regarding legal and regulatory framework on Curaçao in this section apply to all WPO scenarios. They also offer to improve the performance of the baseline scenario in which no additional waste processing capacity is realized on behalf of Selikor and/or the government.

Countries that excel in waste recycling and reuse typically have three key base conditions: a strong legal and regulatory framework, effective enforcement of laws and regulations, and financial incentives. Without these three in place, achieving high recycling and reuse rates is challenging. These three conditions are discussed in the following sections.

8.4.1 Legal and regulatory framework

The current legal and policy framework in Curaçao is incomplete, as a Waste Management Plan and a Waste Prevention Survey and Plan are lacking. While policies on waste treatment and separation exist, they could be more effective.

Recommendations for inclusion in a waste prevention policy:

- Replacing glass packaging with aluminum cans.
- A tax on imported goods to pay recycling/disposal at end of life.
- Charge for exporting empty containers to minimize exporting empty containers that could be used for exporting recyclables.

Recommendations for inclusion in a waste processing policy:

- Adopt only the suitable minimum standards from LAP3 for Curaçao and make them mandatory for all companies.
- Assessing all 80+ minimum standards in LAP3 is beyond this feasibility study's scope.

Recommendations for inclusion in a waste separation policy:

- Include mandatory waste separation for companies of a certain size, including those without an environmental permit or with an existing permit.
- Use Table 9.2 in the EPP, but only include waste fractions with viable local recycling routes or those that reduce landfilling.
- Consider replacing materials that are hard to recycle with materials that can be recycled. For example: EPS, rock wool, and process waste, as recycling these on Curaçao is unlikely.
- It might become mandatory to separate/recycle other waste fractions in the future when recycling becomes feasible locally.
- A nice to have option would be to register incoming separated waste at the Malpais Landfill.

The table below provides a more realistic version of the EPP table, with fewer obligatory waste streams but applicable to more companies.

Table 16: Proposed obligatory waste separation

Waste fraction	Maximum quantity per week	Should be obliged to reduce landfilling
Paper and cardboard	0 kg	Yes
Waste of electric and electronic equipment	0 kg	Yes

Waste fraction	Maximum quantity per week	Should be obliged to reduce landfilling
Plastic PET bottles	0 kg	Yes
Car tires	5 tires	Yes
Metals	0 kg	Yes
Debris	200 kg	Yes
Organic waste	200 kg	Not yet, no viable recycling route exists
Waste wood	40 kg (e.g. 2 wooden pallets)	Not yet, no viable recycling route exists
Plastics films	0 kg	Viable recycling route exists (via FUSE)
Packaging glass	30 kg	Not yet, no viable recycling route exists
Textiles	40 kg	Not yet, no viable recycling route exists

8.4.2 Financial incentives in the legal and regulatory framework on waste

The only financial incentive on Curaçao to reuse or recycle waste, other than for scrap metals and e-waste, is to avoid paying the gate fee at the Malpais Landfill. Between 1996 and September 2024 this landfilling fee was ANG 30 per ton.

Reusing and recycling waste avoids the gate fee at the landfill and those saving could finance recycling in case the revenues for recycling are insufficient to cover the costs. This financial incentive combined with the restriction on illegal dumping in the National Ordinance on Public Order makes recycling of paper/cardboard, metals and concrete economically viable.

Since September 2024, the landfill gate fee in Curaçao was reduced to 0 ANG/ton. Instead of clients paying the gate fee, now the government pays this fee to Selikor. This change led to a tremendous amount of additional waste being brought to the landfill (compared to average annual volumes – 80% extra in 2024). Besides this, since then much more mixed waste is being brought to the landfill, as sorting and transporting waste separately is no longer cost-effective.
If this 0 ANG/ton gate fee remains in place, expectations of the remaining landfill capacity must be adjusted. A shorter timeframe must be considered for potential landfill expansion.
However, the 0 ANG/ton gate fee is also expected to have benefits, such as a decline in illegal dumping, as dumping is no longer an economic advantage.

The current cost of landfilling in Curaçao has been estimated at between 55 - 74 ANG/ton. If the landfill gate fee remains 0 ANG/ton, the government effectively ends up subsidizing landfilling, making waste separation and recycling less economically appealing for companies.

Economic hidden costs of landfilling
Finally, the current economic impact of continuation with landfilling is missing. These societal costs are required to evaluate alternative waste processing routes. The hidden landfill costs include but are not limited to:

1. Cost of landfill expansion or relocation due to reached landfill capacity limits.
2. Cost of environmental impact for landfill use (such as water pollution, ocean pollution, disasters such as fires which currently occurs in several SIDS, such as Bonaire, Curaçao and Sint Maarten).

3. Additional costs as the end of the remaining landfill capacity approaches. Due to this ending capacity, landfill accessibility and ease of use decreases. As a result, additional costs are anticipated for:
    a. Selikor's operational costs (more time spent and additional wear & tear)
    b. Possibility for illegal dumping increases because the landfill becomes less "user friendly"
    c. Overall costs to society (e.g. tourists' and citizens' perception of Curaçao regarding waste management)

Actual costs of landfilling

The actual costs of landfilling include:

1. Current actual operational costs vary between 55 - 74 ANG/ton (source: Selikor).
2. Hidden costs (this amount is very dependent to external factors and must be defined. Our advice is to at least set the total hidden costs to 25 ANG/ton).

Thus, in our opinion, the actual costs associated with landfilling will be at least between 80 - 100 ANG/ton. Therefore, increasing the **landfill fee to 80 - 100 ANG/ton** could significantly boost recycling efforts subsequently reducing landfilling (if adequate enforcement to prevent illegal dumping is in place).

8.4.3 Enforcement of the legal and regulatory framework on waste

Although most Curaçaoan companies and citizens properly dispose of their waste, illegal dumping remains a significant waste management issue. The current level of enforcement and cultural habits are insufficient to prevent illegal dumping at a landfilling gate fee of 30 ANG/ton. Increasing the landfill gate fee, as is done in many countries to encourage recycling and reuse, would likely increase illegal dumping without additional enforcement measures. Effective enforcement is crucial for this strategy to work, requiring additional inspection staff.

Currently, there are only four governmental environmental inspectors. It's unclear how much time they dedicate to illegal dumping. This number is clearly insufficient. Additional enforcement agents could be easily financed, as less illegal dumping would result in additional landfill gate fees and reduced cleanup costs. Unfortunately, the benefits and costs of enforcement are rarely considered together, but are often considered only as costs with no benefit beyond fines. However, the benefits of enforcement are much greater in the long-term.

8.5 Follow up actions 2025

Progressing Curaçao's solid waste management structure by implementing WPOs is a multiple phased approach and involves actions by many stakeholders. This section suggests the next actions to put in place to move towards final decision making.

An official governmental conference regarding waste should be organized in 2025. During the conference, key persons from at least GMN, Selikor and potentially MEO should be present. Besides this, smaller workshops can take place with existing recycling companies to discuss the C&D waste presorting and the industrial recycling hub. The minimal agenda topics should include:

1. Discuss the outcome of this feasibility study, align among the two main waste management directions:
    a. Waste to energy plant
    b. Circular waste management via recycling
2. Outline and discuss a solid waste management strategy for Curaçao
3. Agreement on responsibilities and objectives for adopting the new waste management policy
4. Assign project leads and sponsors to progressing implementation of the new solid waste management structure
5. Share ideas regarding organizing the WPOs and defining the next steps

A communication and education campaign targeting all citizens and business will increase general knowledge regarding waste disposal, product usage, prevention & reuse and recycling possibilities. This will pave the way for community driven waste processing/recycling options. This will boost the volume of recyclables to existing recycling companies and thus, reduce waste being landfilled. Part of the RESEMBID Transforming Waste to Value project is a three-month public awareness campaign, which is currently being developed.

Initiate and/or join a Caribbean waste conference: teaming up with neighbouring islands/SIDS could enable synergies, shared strategies and create common value.

8.6 Conclusion and next steps

One conclusion is that the **composting and chipping** WPO can be operational within 5 to 12 months. This can be achieved by existing composting parties developing a business plan to scale up, with support from compost and mulch consumers such as hotels to ensure offtake.

The initial steps for WPOs regarding recycling should start in parallel:

1. The government should turn waste guidelines (EPP and waste policy) into enforceable policies aligned with individual WPO capacity. They should grant the right to process/recycle waste, with reuse and recycling performance indicators, to WPO operators over a long term.
2. Existing recycling companies, including those handling construction & demolition waste, plastics, and cardboard/paper, should form a cooperative to operate the **industrial recycling hub** as a single entity.
3. Selikor should join the cooperative, contributing location and operational knowledge for the **construction & demolition waste presorting** WPO.

For the **waste to energy** WPO, the government must ensure the necessary boundary conditions are in place to start the feasibility phase. The deployment phase should be handled by a commercial project developer experienced in similarly sized waste to energy projects in other regions.

To make WPO business cases viable and finance-ready, the government should develop a comprehensive waste policy landscape. This includes enforcing mandatory waste separation by companies and increasing the landfill gate fee to at least 80 – 100 ANG for certain waste streams.

Once these initial steps are taken and WPOs become commercially viable, funding will become available for the final construction and operation phases. Funding for recycling and composting WPOs is available on the island, for example from local banks or businesses, while larger investments for waste to energy will require a funding structure and attraction of foreign investors. This however, should start with government support to meet boundary conditions, alongside developing the waste policy landscape.

The timeframe to implement the WPOs ranges from 1 to 2.5 years for the industrial recycling hub and construction & demolition waste presorting. The waste to energy WPO will take about 5 years to start the deployment phase, given the time needed to establish boundary conditions.
No WPO can be implemented by a single stakeholder in Curaçao. Therefore, cooperation across the value chain is essential for the development of each WPO.

End of report

Next sections contain appendices

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A. Appendix Economic instruments to shape the solid waste management economic system

Economic instruments	Status Netherlands	Status in Curaçao	Implementation success	Impact for Curaçao
RM taxes	Not in use	Not in use	Market must be large enough to change products. Therefore, not applicable to Curaçao.	Increase of tax revenues and consumer prices
Eco-taxes	Used for waste disposal and energy use	Not in use		Increase of tax revenues and consumer prices
EPR fees	Used for packaging materials, E&E equipment, cars, tires, batteries, textile	Not in use	Market must be large enough for brand owners to remain active in the market. Therefore, probably not applicable to Curaçao.	Increase in consumer prices
Deposit refunds	Obligatory for plastic bottles and metal cans for non-milk containing drinks. Voluntary schemes for glass beer bottles, pallets, beer kegs, IBC containers, etc.	Not in use	Market must be large enough for brand owners to remain active in the market. Therefore, probably not applicable to Curaçao.	Slight increase in consumer prices
Green certificates	No single dominating certificate governs the market.	Not in use	Unclear	Uncertain
Incineration / disposal taxes	EUR 39.24 EUR / ton for landfilling and WTE, but not for SRF.	30 ANG / ton total gate fee	Very effective if sufficient enforcement avoids illegal waste dumping to avoid taxes.	Increase of tax revenues and in consumer prices
Waste collection taxes	55% of the municipalities use differentiated collection fees. In general, a (additional) fee must be paid for every container emptied or bag collected. Each municipality chooses its own approach	Not in use	Not known	Increase of tax revenues and in consumer prices
Tax rebates	Materials that are not landfilled or incinerated are exempted from the taxation regarding landfilling/disposal	No in use	Successful on Curaçao. A large amount of construction debris is recycled instead of landfilled. Partly due to not having to pay the disposal fee.	Decrease of revenues

B. Appendix Legislative instruments to shape the solid waste management system

Legislative instruments	Status Netherlands	Status in Curaçao	Implementation success	Impact on scenarios / volumes for Curaçao
National waste management policy	This instrument (LAP/CMP) shapes, together with enforcement, the recycling sector including most steps for improvement. Regarding waste management policy, the Netherlands is far ahead of the minimum required level in the EU.	Absent since 10-10-10	Yes	Increased security of supply for WTE or a separation plant.
Producer responsibility	Only implemented when enforced by the EU or demanded by an industrial sector	Not in use	Yes, but a difficult path for a small country to demand it from industry.	Some products may no longer be available.
Ban single use plastic	Introduced via implementation EU SUP legislation.	Curaçao is working towards implementing a law	Not yet successful	Plastic materials will partly be replaced by paper/cardboard alternatives that generate more residual waste.
Obligation to include a certain % recyclate in each PET product	30% for plastic packaging in 2030 (EU PPWR)	Not in use	Not yet implemented	Restrict import from countries that do not meet this requirement. Import from USA would become more difficult.
Ban certain plastic bottles if (beverage) metal cans can be used instead.	Not in use, but in use in Denmark, for example	Not in use	Not yet implemented	A significant reduction in the 6,000 tons of glass landfilled annually. For metal cans, a complete recycling route is feasible via a deposit system.
A tax for every arriving shipping container to cover the shipping costs for shipping recyclables (e.g. to Miami and/or Rotterdam).	Not applicable for the Netherlands	Not in use	Not yet implemented	This could be a way to overcome the difficult position for Curaçao to connect with recycling companies that can purchase recyclables produced on Curaçao.

C. Appendix Project success criteria

Commercial / supply chain

- Focus on local applications for recyclables/energy. Understanding the market
- Focus on local recycling/reuse initiatives for significant volumes
- Protection of current initiatives
- Scope waste (future) volume routes: WCS. Included in this study: local waste routes / recycling routes. Excluded: Illegal dumping
- Out of scope: Additional source separation. Impossible to reach significant sourcing % during implementation. However, some waste routes (such as garden/yard waste) can be considered as a significantly “separate source.” Work with these current conditional settings.
- Importing waste from neighboring islands (SIDS) → Not a focus of this feasibility study, but not excluded
- Waste collection routes based on current Selikor system for MSW in Curaçao
- Preferred location option: 1 centralized location. Composting could be an exception

Process & building

- Waste Management Processing Plant (WMPP)
- Rough main location search data required for location study. More accurate location search data was available later during the study
- Waste collection containers => Best Available Techniques in similar countries
- WTE and waste sorting => Best Available Techniques and Proven Technology
    - *e.g. grate furnace complies with BAT. Fluidized bed furnace does not.*
- Prioritizing technology → Focus on less CapEx / OpEx intensive solutions

Project related

Environmental, social & governance (ESG) & legal

- Out of scope for this feasibility study: the development of a waste management policy and legislation requirements (however, legislation gaps / recommendations included in this report).
- Proposed activities are compliant with local environmental legislation regarding waste treatment and waste storage
- General limitations due to permit conditions
- Differentiated approach for (mainly) WTE-option and (mainly) recycling options
- Environmentally significant zones included in location selection (e.g. air & noise contours, risk zones)
- No consultation with external stakeholders (for location considerations)
    - This study regarded as confidential and politically sensitive.
- Output from this part of the project is crucial input for any future EIA and permitting procedure
- Theoretically a maximum of 7 locations for 3 WPOs

Financial

- Landfilling gate fee not increased in +25 years. Possibility to increase the gate fee is minimal
- External financing includes: gate fee, energy revenues, a combination of i.e. tourist tax, water bill, electricity bill, government funding
- Excluded in study: price negotiations

Organizational / politics

- Step - wise implementation. Use modularity if possible
- Partnership contracts set to world standards: Design – Build – Operate contracts
- Create local ownership and understanding of proposed solutions
- Position proposed solutions on the political agenda
- Success requires a >20-year period with guaranteed waste supply for the investments in new facilities
- Success requires a >20-year period with guaranteed revenues for the investments in new facilities

D. Appendix Waste Characterization Data

Summary of data from the 2024 Waste Characterization Study

Waste composition as received (grouped)	Total waste received at the Malpais Landfill (tons/yr)	Waste collected for recycling on Curaçao (tons/yr)
Organic waste	32,573	3
Minerals	23,194	51,579
Wood	14,481	0
Paper/cardboard	12,804	200
Plastics	10,649	39
Other materials (incl. fines)	9,775	6,475
Sanitary waste	6,349	0
Glass	5,943	0
Metals	5,284	23,437
Textiles	4,009	0
Liquid waste	1,788	0
E-waste	640	600
Durable non-metal goods	530	0
Rubber	516	0
Sorting loss / evaporation	494	0
Hazardous	167	730
Total	**129,195**	**83,063**

E. Appendix Landsverordening Openbare Orde

Definition waste:
alle voorwerpen of stoffen waarvan de houder zich ontdoet, voornemens is zich te ontdoen of moet ontdoen, behalve ten behoeve van hergebruik;

Art. 20
1. Het is verboden afval of resten van etenswaren, bussen, papier of andere voorwerpen of stoffen neer te leggen, te werpen of zichtbaar achter te laten op of aan de openbare weg.

Artikel 26
1. Het is verboden afvalstoffen over te dragen of ter inzameling aan te bieden aan een ander dan de door de Minister van Gezondheid, Milieu en Natuur aangewezen inzameldienst, tenzij deze beschikt over een geldige vergunning als bedoeld in het tweede lid, dan wel anders dan op een door de inzameldienst aangewezen stortplaats of overslagstation, te storten.
2. Het is een ander dan de inzameldienst verboden zonder of in afwijking van een vergunning van de Minister van Gezondheid, Milieu en Natuur, van derden afvalstoffen in te zamelen. De houder van een vergunning draagt deze tijdens het inzamelen steeds bij zich en toont deze op verzoek van degenen bij wie hij inzamelt.
3. Het is verboden:
a. fecaliën of andere afvalstoffen op open of gesloten erven te storten of te verbranden;
b. mest-, vuilnis- of ashopen op open of gesloten erven aan te brengen of te hebben;
c. anders dan tijdens of onmiddellijk voor of na het verrichten van werkzaamheden puin, afbraak, kalk-, klei- of zandhopen op open of gesloten erven aan te brengen of te hebben;
d. vee te begraven;
e. huisdieren in het openbaar te doden.
4. Onverminderd het eerste en derde lid is het verboden op of aan de openbare weg:
a. fecaliën of andere afvalstoffen te storten of te verbranden;
b. metalen te bewerken anders dan ten behoeve van een aantoonbare bedrijfsmatige activiteit;
c. anders dan tijdens of onmiddellijk voor of na het verrichten van werkzaamheden puin, afbraak, kalk-, klei- of zandhopen aan te brengen of te hebben;
d. enig vee of huisdier te verbranden of te begraven, of het lijk te plaatsen.
5. Bij ministeriële regeling met algemene werking, kunnen nadere regels worden gesteld ter uitvoering van dit artikel.

Artikel 30
1. Het is verboden op de openbare weg:
b. puin, afbraak, kalk, aarde, klei, zand, mest, zaagsel, krullen, spaanders, los stro, pakhooi, as, slijk of andere afvalstoffen anders te vervoeren dan in vervoermiddelen, die zodanig zijn ingericht en worden gebruikt dat het storten of wegstuiven van de inhoud voorkomen wordt;

Artikel 38
Het is verboden om injectiespuiten of onderdelen daarvan zoals naalden, reservoirs, zuigers of daarop gelijkende voorwerpen op of aan de openbare weg dan wel in afvalbakken achter te laten.

Artikel 40
Het is verboden op of aan de openbare weg voorwerpen, waarin zich afvalstoffen bevinden:

a. te plaatsen of te hebben anders dan behoorlijk afgedekt en anders dan onmiddellijk tegen het perceel of de wand;
b. op een andere dag dan die waarop de inzameldienst volgens het normale schema het afval ophaalt, te plaatsen of te hebben, tenzij de inzameldienst een wijziging in het schema publiekelijk bekend heeft gemaakt;
c. te hebben op zondag of op een met de zondag gelijkgestelde dag als bedoeld in de Arbeidsregeling 2000;
d. te doorzoeken, om te halen of uit te storten;
e. te plaatsen of te hebben, indien die voorwerpen, reeds voor hetzelfde doel gebruikt zijnde, niet zodanig zijn gereinigd, dat zij geen stank verspreiden.

F. Appendix Planning

The planning below is based on first identifying the main works streams and then making an estimation on the duration.

Planning Waste to Energy

The planning is split into 2 parts. To get to the boundary conditions and the phases after.

Project main work streams and boundary conditions for waste to energy,

The following main work streams are established for reaching the boundary conditions.

Category	Boundary condition	Main work stream
Policy landscape	B7. Policy landscape proven, complete & successfully operating	Enforce existing regulations, develop regulations regarding WTE and actively support the roll out of the policy landscape regarding other WPOs.
Technology	B1. WTE technology proven	Monitor WTE technologies deploying in comparable settings and learn from other SIDS that are further ahead in deploying WTE.
Feedstock	B2. Waste composition proven	Deploy other WPOs and monitor the composition of residual waste being landfilled
Offtake	B3. Safe ash disposal allocated	Develop either a sanitary landfill cell to the point of a Final Investment Decision or ensure long term export is arranged.
Location	B4. Location appointed	Select a location that is suitable and viable for development. Ensure there is a long-term location commitment.
Organization	B5. Project development capability is mature	In line with B2. - ensure other WPOs are operational and keep the project development capability.
Financing	B6. Feasibility funding	Government to free up funding for the feasibility funding.

High level project planning and timelines

The deployment planning for WTE is split in 2 overall phases: 1. Reaching the boundary conditions and 2. Developing the waste to energy plant. The second phase is more complex than a wind energy tender on

Curaçao and is assumed to take 2 years longer due to the impact on the island. The first phase of reaching the boundary conditions is the most uncertain and therefore different moments are included to re-evaluate the direction. The average duration per boundary condition is determined based on reference cases to reach this point in other areas. A range is not mentioned due to the high uncertainty, shorter duration than mentioned is expected to have a positive effect (that is reducing the duration) on other duration periods.
The total duration is estimated to take on average 5 years with the highest dependency on WTE technology becoming mature for the same scale island capacity and economy.

Boundary condition	Main work stream	Duration	Start moment	Critical path
B7. Policy landscape proven, complete & successfully operating	Enforce existing regulation, complete regulation regarding WTE and actively support the roll out of the policy landscape regarding other WPOs.	2 years	T0	Yes
B1. WTE technology proven	Monitor WTE technologies implemented in comparable settings and learn from other SIDS that are further ahead in deploying WTE.	5 years	T0	Yes
B2. Waste composition proven	Deploy other WPOs and monitor the composition of residual waste being landfilled	2 years	Other WPOs proven	Yes
B3. Safe ash disposal allocated	Develop either a sanitary landfill cell to the point of Final Investment Decision or ensure long term export is arranged.	2 years	T0	No
B4. Location appointed	Select a location that is suitable and viable for development. Ensure there is a long-term location commitment.	1 year	T0	No
B5. Project development capability mature	In line with B2., ensure other WPOs are operational and	1 year	T0	No

	keep the project development capability.			
B6. Feasibility funding	Government to free up funding for the feasibility funding.	1 year	B7	Yes

In Western Europe countries, WPOs are publicly led and funded. However, in the current governmental environment, solid waste management structures cannot be prioritized or led by the government.

G. Appendix Main conditions for future terms of references

Overview of starting points

The following starting points regarding the tender procedure are taken into consideration:

- the contract will be a Finance Built Operate Transfer (FBOT) contract;
- the tendering procedure will be based on European Regulations;
- a “not public procedure” will be followed, this means that a pre-selection of bidders will be executed based on a project definition document (public tender);
- there will be three bidders selected which will be invited to tender;
- for the complete tender procedure and the reporting to the client, English will be used.

Additional to the tender activities, the execution of following activities by the client are also important:

- political agreement by the government on plant location and strategy for project development;
- start discussions with potential subsidy funds (such as Interreg) and the preparation of requests for subsidies;
- start negotiations with electricity companies, regarding rates for supply of electricity;
- define the procedure for environmental permitting and environmental impact assessment, including public consultation.

The results of these activities are of decisive importance to the feasibility of the project.

Description of the project phasing and activities

The following five project phases can be distinguished:

<u>Phase 1: Pre-selection of potential contractors</u>

- selection of the tendering project team (composed of the client’s employees and eventual consultants);
- preparation of a project definition document including selection criteria and overview of data to be submitted by potential contractors (public tender);
- public announcement;
- evaluation of received documentation and references;
- pre-qualification of potential bidders (maximum three).

<u>Phase 2: Tendering</u>

- preparation of a Terms of Reference (TOR) document;
- sending TOR to selected bidders;
- communication procedures with bidders (pre-bid meetings);
- receipt and acceptation of proposals.

<u>Phase 3: Preparation of proposals by bidders</u>

- bidders will prepare a proposal based on the TOR;
- there will be a clarification meeting with bidders to answer the questions and give additional information if needed.

<u>Phase 4: Evaluation of proposals</u>

- technical, financial and legal evaluation of the proposals;
- communication procedures with bidders (clarification meetings);
- preparation of an evaluation report;
- presentation of the evaluation results to the client and stakeholders;
- contract award advice to the client;
- motivated rejection of bidders not selected.

Phase 5: Contracting
- decision on contract award by the client;
- finalize contract agreements with the selected bidder by the client.

To give an idea of the set-up and contents of the TOR, a preliminary table of content of the TOR is found below. Based on our experience with these kind of projects, we have to emphasize the importance of a thorough and well defined TOR document. In this way problems during construction and operation can be prevented.

This document shall clearly describe the following aspects:
- project background;
- basis of design (starting points);
- scope of work;
- tender procedures and set-up of tender documents;
- conditions of contract (e.g. FIDIC based);
- guarantees and test procedures;
- terms of payment (during engineering, construction and operation);
- technical and environmental requirements for plant design;
- requirements regarding operation and maintenance;
- documentation and manuals;
- requirements for transferring the plant to the client.

Such a TOR will provide a good basis for transparent and comparable bids, a proven state of the art plant design, proper quality of components, as well as clear contractual conditions.

H. Appendix PRELIMINARY CONTENT OF TOR

Side Letters

- Invitation to Tender
- Acknowledgement of Receipt of Tender Documents

Section A: Project Description

A.1 Background of the Project
- Current waste management
- Future waste management
- Local environmental policy
- Potential subsidies

A.2 Basis of Design
- Waste data
- Plant capacity
- Technology selection
- Environmental conditions
- Site assessment data

A.3 Scope of Work
- Finance
- Engineering, procurement and construction
- Operation and maintenance
- Transfer and handover

Section B: Tender Documents

B.1 Instructions to Tenderers
- Project organisation
- Tender conditions
- Contract award criteria
- Tender content
- Tender evaluation
- Time schedule

B.2 Contract Forms
- Form of tender
- Form of undertaking EPC works
- Form of undertaking operation and maintenance
- Form of undertaking concession
- Insurance over declaration
- Performance guarantees
- Directors certificate of legitimate ender
- Price breakdown form

B.3 Documents to be submitted with Tender
- Tender design description
- Consideration of alternatives
- Design calculations
- Drawings of tender design
- References for tender design
- Specification of process characteristics
- Operation and maintenance
- Performance guarantees
- Price breakdown schedules
- Information on the company (such as organisation structure, financial figures etc.)

Section C: Conditions of Contract

C.1 General Conditions (FIDIC Sliver Book for EPC/Turnkey Projects)
- Definition of employer and contractor
- Materials and workmanship
- Defects liability
- Variations and adjustments
- Risk and responsibility
- Insurance
- Force majeure
- Claims, disputes and arbitration

C.2 Particular Conditions
- EPC works
- Operation and maintenance

C.3 Guarantee Test Procedures
- Process performance guarantees
- Guarantee tests
- Conformity/non-conformity

C.4 Terms of Payment EPC Works
- Price breakdown schedule
- Valuation of ordered variations
- Contract price fluctuations
- Schedule and method of payment

C.5 Terms of Payment Operation and Maintenance
- Operating cost breakdown
- Costs components (fixed time, flow dependent, load dependent, additional charges)
- Valuation of ordered variations
- Contract price fluctuations
- Schedule and method of payment
- Financial cost model
- Schedule of major plant replacements
- List of spare parts
- Waste formula

Section D: Technical Requirements

D.1 Requirements regarding the EPC Works

- Present situation
- Overall process design
- Waste treatment and storage
- Furnace and boiler design
- Steam/water cycle and power generation
- Flue gas treatment
- Residue treatment and disposal
- Environmental requirements
- Civil and infrastructural works
- Architectural works
- Electrical, control and instrumentation
- Utility design
- Health and safety
- Codes and standards

D.2 Documents during EPC Works

- Works programme and time schedule
- Project progress reports
- Quality assurance and control
- Preliminary design
- Final design
- As built documentation
- Operation and maintenance manuals

D.3 Requirements regarding the Operation and Maintenance

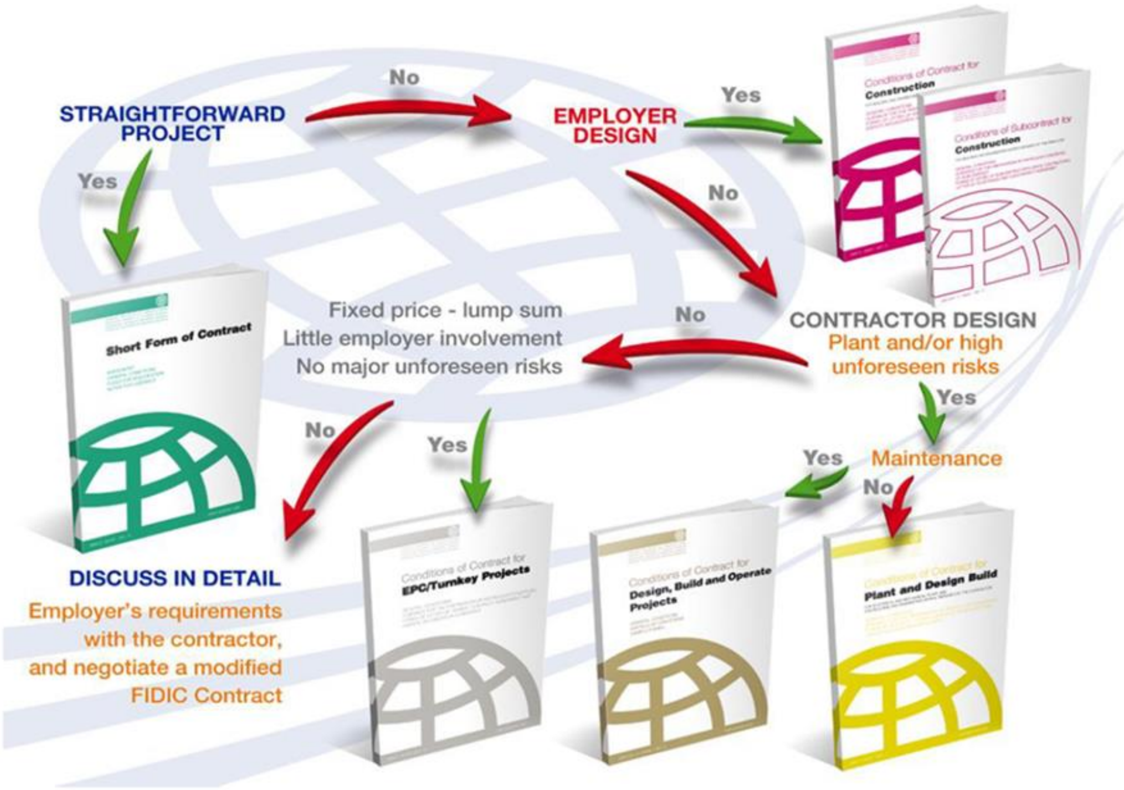
- Performance standards
- Failure modes
- Recording procedures
- Health and safety
- Operational services
- Compliance with license requirements
- Maintenance of plant
- Operation and maintenance personnel
- Procedures and administration
- Monitoring and testing
- Quality assurance
- Environmental management
- Training of employer’s operators
- Handover of the plant to employer

D. 4 Documents during Process Tests and Operation and Maintenance

- Operation and maintenance logs
- Reports on process tests
- Operation and maintenance reports
- Revised operation and maintenance manuals
- Emergency procedures

Section E: Attachments

- Waste data (amount and composition)
- Feasibility study
- Logistical study
- Site assessment study
- Site location drawings



I. Appendix Planning C&D separation plant

Main project work streams

The following main work streams are identified to reach each major milestone:

Category	Major milestone	Main work stream
Location	M1. Location appointed	Either the government or Selikor appoints the location (see Environmental / Location study) for the C&D waste presorting plant development considering the activities with dust formation and the logistics.
Organization	M2. Cooperation achieved	Start with aligning with stakeholders on roll out followed by agreement on rights, procedures and obligations.
Location	M3. Foundation suitable	Perform a location study on the suitability of a C&D waste presorting plant, get input from technology on required loads and dust formation.
Technology	M4. Basic design ready	Creation of the first concept design followed by a basic design for deployment in 2 phases of the serial process.
Policy landscape	M5. Regulation enforced	Turn waste guidelines into enforceable policy and where needed, complete the guidelines.
Financing	M6. Final Investment Decision phase 1.	Develop a business plan with amount of investment and align with financing parties - note that some technical input is required for obtaining the right quotations.
Location	M7. Permit granted	Apply for a permit within the policy framework with the intended activities that involve dust formation.
Technology	M8. C&D waste presorting plant phase 1 built	Purchase and install the phase 1 equipment involving mainly the cranes and modifications to the existing logistics.
Organization	M9. Staff trained on quality	Training staff on how to select desired fractions with the cranes to obtain good quality materials and what quality is required for viable offtake by the offtake partners.

Location dependency for handling, logistics and feedstock certainty is high and should enable other stakeholders to join before installing the cooperation.

J. Appendix High level project planning and timelines

The duration to get the C&D waste presorting plant into operation is estimated to be between 16 and 31 months, but is highly dependent on the speed of achieving the first 2 milestones and efficiencies gained in the process.
The high level project planning below is determined per work stream on the required start & finish moments in which the critical path is taken as the overall limiting factor for total duration. The shortest duration is described, if the duration is not on the critical path, a longer period is feasible. T0 is taken as the moment of start from the current situation with an initiator taking the first step.

Major milestone	Main work stream	Duration	Start moment	Critical path
M1. Location appointed	Either the government or Selikor appoints the location for C&D waste presorting plant development taking into account the activities with dust formation and logistics.	2 – 4 months	T0	Yes
M2. Cooperation installed	Start aligning with stakeholders on roll out followed by agreement on rights, procedures and obligations.	3 – 4 months	T0	Yes*
M3. Foundation suitable	Perform location study on the suitability of a C&D waste presorting plant, get input from technology supplier on required loads and dust formation.	2 – 4 months	M1	Yes
M4. Basic design ready	Creation of the concept design followed by basic design for deployment in 2 phases of the serial process.	4 – 8 months	T0	No
M5. Regulation enforced	Turn waste guidelines into enforceable policy and where needed, complete the guidelines.	4 – 12 months	T0	Yes
M6. Final Investment Decision phase 1.	Develop a business plan with amount of investment and align with financing parties, note that some technical input is required for obtaining the right quotations.	3 – 9 months	M2 Note that multiple milestones are a prerequisite.	Yes
M7. Permit granted	Apply for a permit within the policy framework with the intended activities that involve dust formation.	4 – 9 months	M4	Yes

M8. C&D waste presorting plant phase 1 built	Purchase and install the phase 1 equipment involving mainly the cranes and modifications to the existing logistics.	4 – 6 months	M6	Yes
M9. Staff trained on quality	Training staff on how to select desired fractions with the cranes to obtain good quality materials and what quality is required for viable offtake by the offtake partners.	2 – 4 months	M5	Yes

* Achieving the cooperation is in principle not on the critical path, but due to it having a big effect on creating the driving force for implementation, it basically enables reaching the other major milestones as it takes over/incorporates the role of the initiator.

K. Appendix Planning industrial recycling hub

Main project work streams for the industrial recycling hub

The following main work streams are identified to reach each major milestone:

Category	Major milestone	Main work stream
Organization	M1. Organization going	Align with sustainability initiatives and Government on an executing organization. Follow the setup of the organization.
Organization	M2. Organization achieved	Setup formal structure with agreed stakes, obligations and procedures.
Financing	M3. Increased margin	1. Negotiate for better outgoing shipping rates for containers 2. Policy landscape, implementation of methods to cover cost by charging a tax on incoming materials/goods or preventing the export of empty containers that could be used for exporting recyclables.
Financing	M4. Funding secured	Develop a business plan with the amount of investment and align with financing parties, note that some technical input is required for the type of location.
Location	M5. Location secured	Appoint a location and secure this via contracts and allow required changes following operations.
Policy landscape	M6. Regulation enforced	
Technology	M7. Technologies scaled up	Implement existing technologies with a higher capacity with location specific technologies in place.
Feedstock	M8. Feedstock volume up	Enforcing source separation and setting up the logistics for handling.

The initial milestone of getting the organization going will direct and influence the other work streams. Need to keep monitoring the roll out.

L. Appendix High level project planning and timelines

The total duration for implementing the industrial recycling hub is estimated to take between 12 and 22 months.
The high level project planning is determined per work stream on required start & finish moments during which the critical path is taken as the overall limiting factor for the total duration. The shortest duration is described, if the duration is not on the critical path, a longer period is feasible. T0 is taken as the moment of start from the current situation with an initiator taking the first step.

Major milestone	Main work stream	Duration	Start moment	Critical path
M1. Organization go	Align with sustainability initiatives, Selikor and Government on the executing organization. Follow the setup of the organization.	2 – 4 months	T0	Yes
M2. Organization installed	Establish a formal structure with agreed upon stakes, obligations and procedures.	2 months	M1	Yes
M3. Increased margin	1. Negotiate for better rates for outgoing shipping containers 2. Policy landscape, implementation of methods to cover cost by charging a tax on incoming materials/goods or preventing empty export or preventing the export empty containers that could be used for exporting recyclables.	3 – 6 months	M1	Yes
M4. Funding secured	Develop a business plan with the amount of investment and align with financing parties, note that	3 – 6 months	M2 (M3 & M5 need to be in place to finish)	Yes

	some technical input is required for the type of location.			
M5. Location secured	Appointing a location and securing this via contracts and allowing required changes following operations.	3 – 6 months	M2	No
M6. Regulation enforced	Waste guidelines are turned into enforceable policy.	3 – 6 months	M2	No
M7. Technologies scaled up	Implement existing technologies with a higher capacity with location specific technologies in place.	2 – 4 months	M4 M5 and M6 need to be in place	No
M8. Feedstock volume up	Enforcing source separation and setting up the logistics for handling.	3 – 6 months	M6	Yes

The organizational setup deliberately has a short duration as a long duration for establishing a direction takes the focus off an effective roll out. The interdependency between the major milestones is high and making progress on one major milestone enables reaching others (e.g. a lower container export price improves the business case and makes funding more easily accessible).

M. Appendix Planning composting & chipping

Main project work streams for composting and chipping

The following main work streams are identified to reach each major milestone:

Category	Major milestone	Main required work stream
Financing	M1. Funding secured	Develop a business plan
Technology	M2. Technology deployed	Select, purchase, and/or build the composting technology.
Organization	M3. Organization scaled up	The initiator that is in place attracts staff for operation.

In the business plan the highest amount of work is expected to focus on a scale up plan for offtake and determine the turnover based on this value. The cost part of the business plan is mainly dependent on the investments to be made and to be financed.

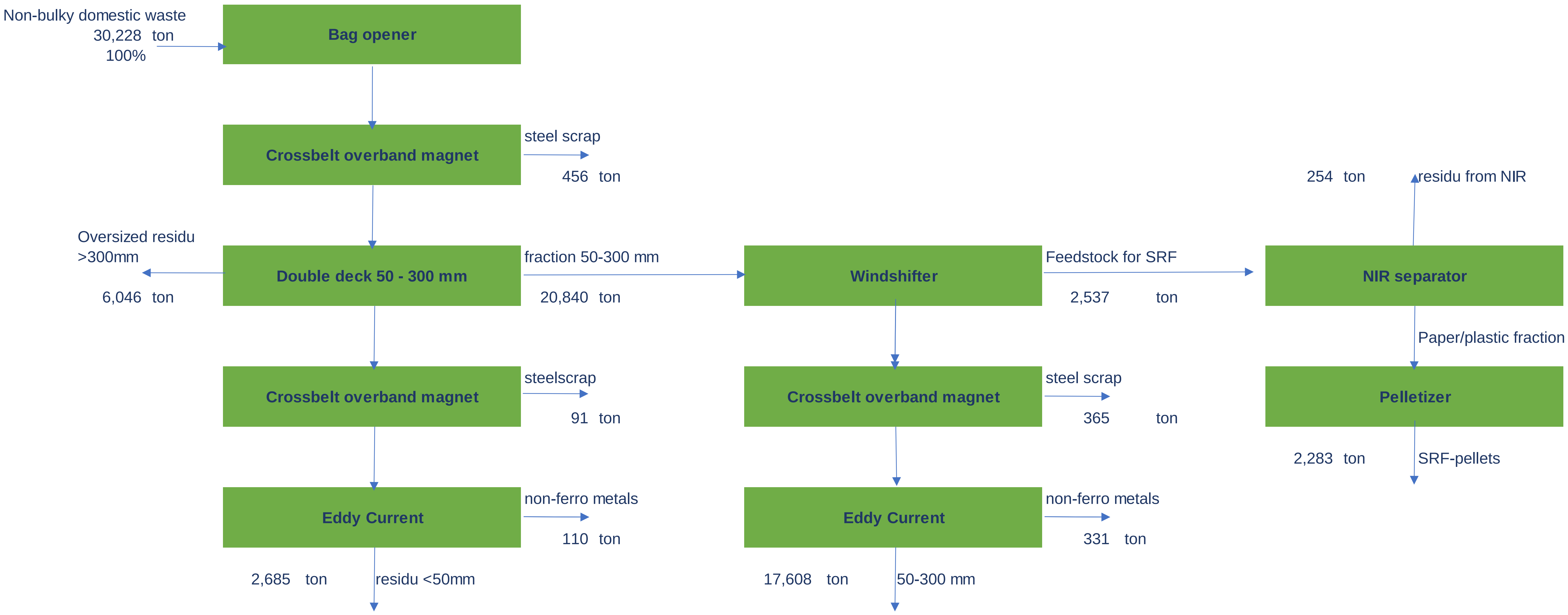
High level project planning and timelines

The total implementation time for composting & chipping is feasible between 5 and 12 months.
The high level project planning is determined per work stream on required start & finish moments in which the critical path is taken as the overall limiting factor for the total duration. The shortest duration is described, if the duration is not on the critical path, a longer period is feasible. T0 is taken as the moment of start from the current situation with an initiator taking the first step.

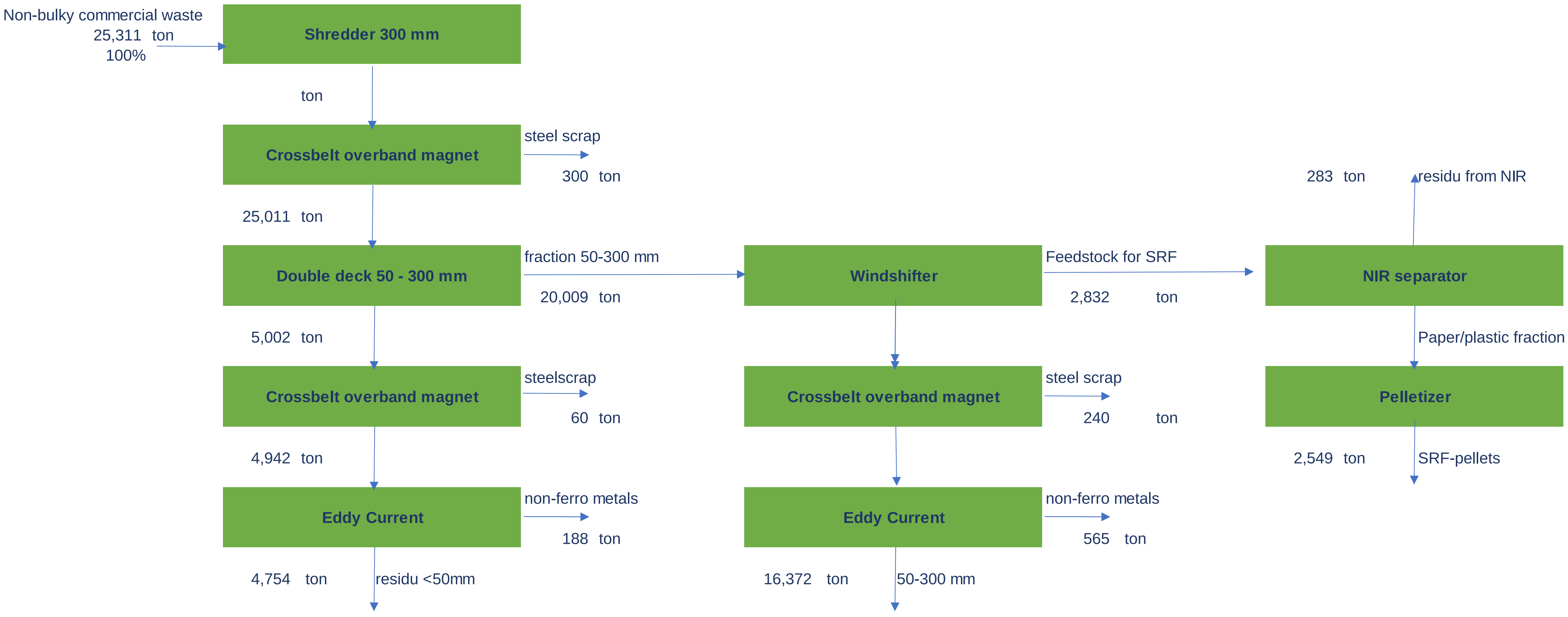
Major milestone	Main work stream	Duration	Start moment	Critical path
M1. Funding secured	Develop a business plan	2 – 6 months	T0	Yes
M2. Technology deployed	Select, purchase, and/or build the composting technology.	3 – 8 months	T0	Yes
M3. Organization scaled up	The initiator in place attracts & trains staff for operations.	2 – 4 months	M1	Yes

The interaction between the work streams allow for some overlap (e.g. staff can be selected during the building phase of the composting technology).

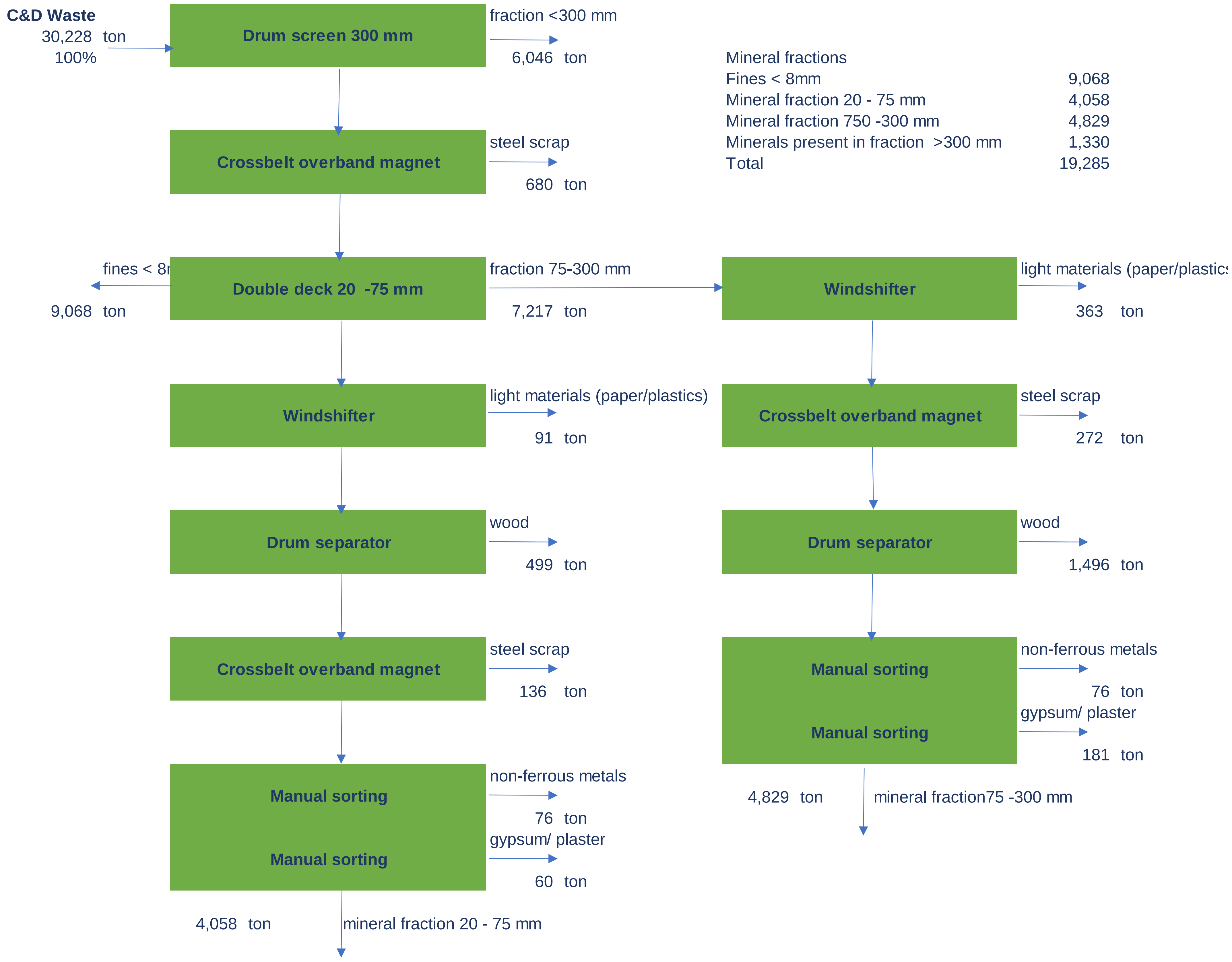
N. Appendix Process flow diagram sorting non-bulky domestic waste



O. Appendix Process flow diagram sorting non-bulky commercial waste



P. Appendix Process flow diagram presorting C&D waste



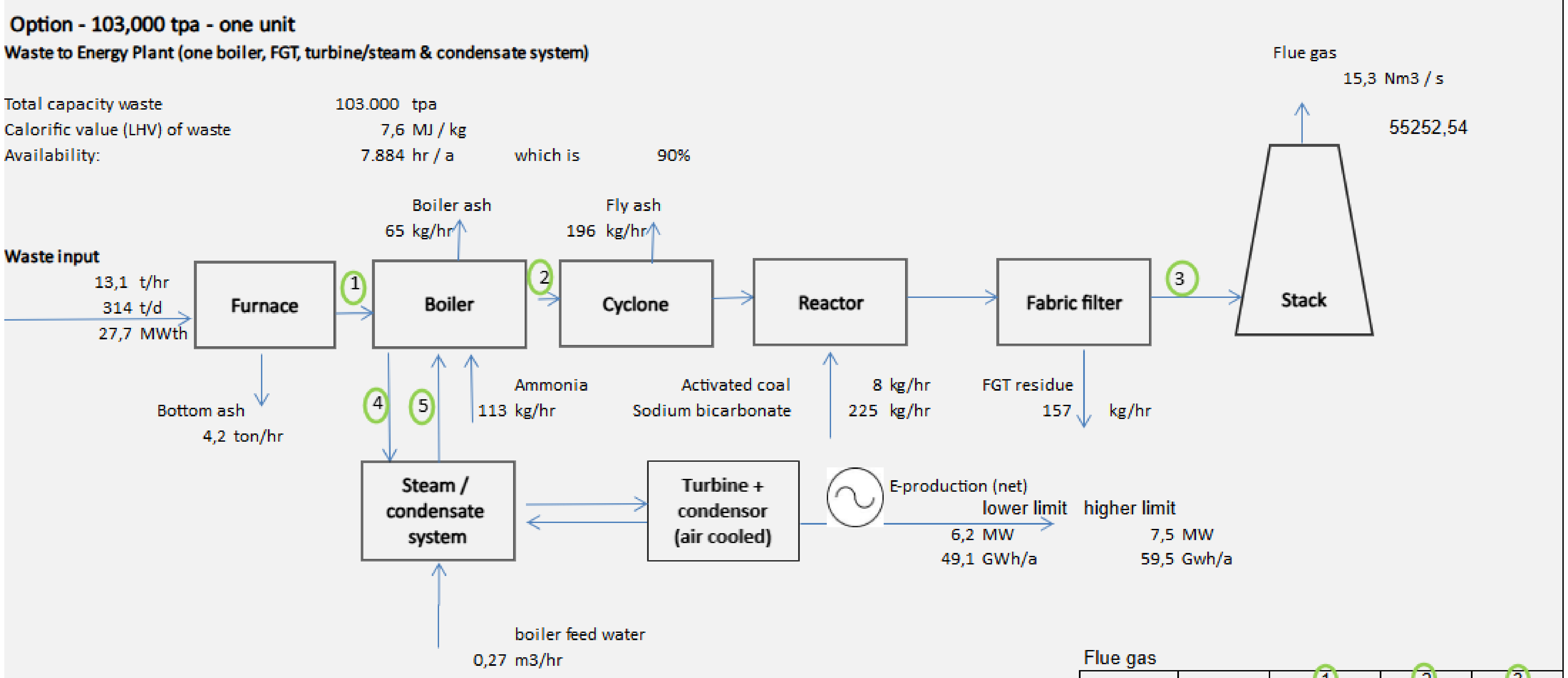
Mineral fractions	
Fines < 8mm	9,068
Mineral fraction 20 - 75 mm	4,058
Mineral fraction 750 -300 mm	4,829
Minerals present in fraction >300 mm	1,330
Total	19,285

Q. Appendix Technological long list

§	Technological option	Feedstock from waste	Waste hierarchy	Currently present on Curaçao	Feedstock should be source separated	Complexity of the technique	TRL	Output	Landfill reduction potential	Output can be fully absorbed by the Curaçao market or recycling companies	Export feasible	CapEx	OpEx	Route probably requires a gate fee	Option to reduce landfilling on Curaçao and main motivation
4.1.1	Reducing logistical costs for exported recyclables	Not applicable	Recycling	No	N.a.	**Low**	TRL9	N.a.	**High**	-	N.a.	N.a.	N.a.	N.a.	Yes, but requires no investment in waste management infrastructure.
4.1.2	Obliged source separation for companies	Not applicable	Recycling	No	N.a.	**Low**	TRL9	N.a.	**High**	Partly	N.a.	N.a.	N.a.	N.a.	Yes, but requires no investment in waste management infrastructure.
4.2.1	Source separation via house-to-house collection	Not applicable	Recycling	No	Yes	**Low**	TRL9	Recyclables	**High**	No	Potentially yes	**Low**	High	N.a.	No, not (yet) regarded as feasible to obtain sufficient quality.
4.2.2	Source separation via recycling centers for non-bulky waste	Not applicable	Recycling	**Yes, limited**	Yes	**Low**	TRL9	Recyclables	Rather limited	**Yes**	N.a.	**Low**	**Very low**	No	Yes, although additional reduction is feasible, the impact will be limited.
4.2.3	Source separation via recycling centers for bulky waste	Not applicable	Recycling	**Yes, not operated**	Yes	**Low**	TRL9	Recyclables	Very limited	**Yes**	N.a.	**Low**	**Very low**	No	Yes, but very limited impact
4.3.1	Sorting non-bulky residual waste	Non-bulky MSW	Recycling	No	No	**High**	TRL9	Plastics, metals, and SRF	Rather limited	No	Yes (metals)	**High**	Relatively high	**Yes**	Yes, but not suitable within the current constraints on Curaçao.
4.3.2	Sorting bulky residual waste	Bulky MSW	Recycling	No	No	**High**	TRL9	Plastics, wood, metals, and SRF	Rather limited	No	Yes (metals)	**High**	Relatively high	**Yes**	Yes, but not suitable within the current constraints on Curaçao.
4.3.3	C&D waste presorting plant	C&D waste	Recycling	No	No	Average	TRL9	Mineral aggregates, metals and potentially others	**High**	**Yes**	N.a.	Rather high	Relatively high	**Yes**	**Yes, with a high impact and using existing recycling routes on Curaçao**
4.4.1	Crusher	Mineral fraction of C&D waste	Recycling	**Yes**	No	Average	TRL9	Mineral aggregates	**High**	**Yes**	No	Rather high	**Low**	No	Yes, already present including a high reduction
4.4.2	Plastic recycling	Sorted plastics	Recycling	**Yes**	Yes	Average	TRL9	Plastic products	Rather limited	**Yes**	Not without support	Rather low	Rather low	Not for good quality	Yes, already present including a rather reduced potential
4.4.3	Composting & chipping plant	Organic waste	Recycling	Small capacity	Yes	**Low**	TRL9	Compost	**High**	Not yet	No	**Rather low**	**Low**	**Yes**	Yes, but the impact will be limited due to a small demand for compost.

§	Technological option	Feedstock from waste	Waste hierarchy	Currently present on Curaçao	Feedstock should be source separated	Complexity of the technique	TRL	Output	Landfill reduction potential	Output can be fully absorbed by the Curaçao market or recycling companies	Export feasible	CapEx	OpEx	Route probably requires a gate fee	Option to reduce landfilling on Curaçao and main motivation
4.5.1	Pyrolysis plant	Sorted plastics	Recovery/ recycling	No	No	**High**	**TRL7**	Pyrolysis oil	Rather limited	No	**Yes**	**High**	**High**	**Yes**	No, no proven technology for waste at commercial scale
4.5.2	Gasification plant	Paper/plastic mixture	Recovery/ recycling	No	Yes	**High**	**TRL7**	Syngas	Rather limited	No	No	**Very high**	**High**	**Yes**	No, no proven technology for waste at commercial scale
4.5.3	Biodiesel production plant	Used cooking oils	Recovery	Yes	Yes	**High**	TRL9	Biodiesel	Limited	No	**Yes**	**High**	**High**	No	No, feedstock will hardly be derived from waste on Curaçao.
4.6.1	Cement/lime kiln	SRF, tires, dried sludge	Recovery/ recycling	No	No	**High**	TRL9	Cement	Limited	No	Yes	**Very high**	**High**	N.a.	Yes, but not suitable within the current constraints on Curaçao.
4.6.2	Waste to energy plant	Non-bulky waste and combustibles residues	Recovery	No	No	**High**	TRL9	Energy	**High**	**Yes**	N.a.	**Very high**	Low	**Yes**	Yes, but the costs per ton will be high and the impact of ashes is a risk to be managed
4.6.3	Digestion	Organic waste	Recovery	No	Yes	**High**	TRL9	Biopower and digestate	Limited	Yes and unknown	No	Rather high	**Low**	**Yes**	No, the materials to be digested would have been composted anyway.

R. Appendix Mass balance calculation waste to energy plant



Flue gas

		1	2	3
Temp	C	1200	180	150
Flow	m3/s	83	25,5	23,8

Steam / condensate

		4	5	
Temp	C	410 °C	40 °C	
Pressure		55 bar	0.12 bara	
Flow	kg/s	7,5	7,5	