The Recycling Fund (Industry Support Programme) ISP-1617-06-001

Implementation of Food Waste Collection System for Catering Services

– Project Summary –

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Introduction

Food waste management is a critical global environmental issue and it is of particular importance in cities nowadays

Poor food waste management causes:

- loss of natural resources
- shortage of landfill sites
- public health issues
- air and water pollutions
- waste of recyclable energy and resources

Potential challenges

- The catering industry was generally willing to allocate 1-4% of total manpower or invest an extra 1-2% labour for the separation and collection of food waste[1]
- As studies show that only 2% of the food waste in Hong Kong is recovered and recycled annually

1. Eriksson M, Osowski CP, Malefors C, Björkman J, and Eriksson E. Quantification of food waste in public catering services–A case study from a Swedish municipality. Waste management 2017; 61: 415–422.

Automatic refuse collection systems

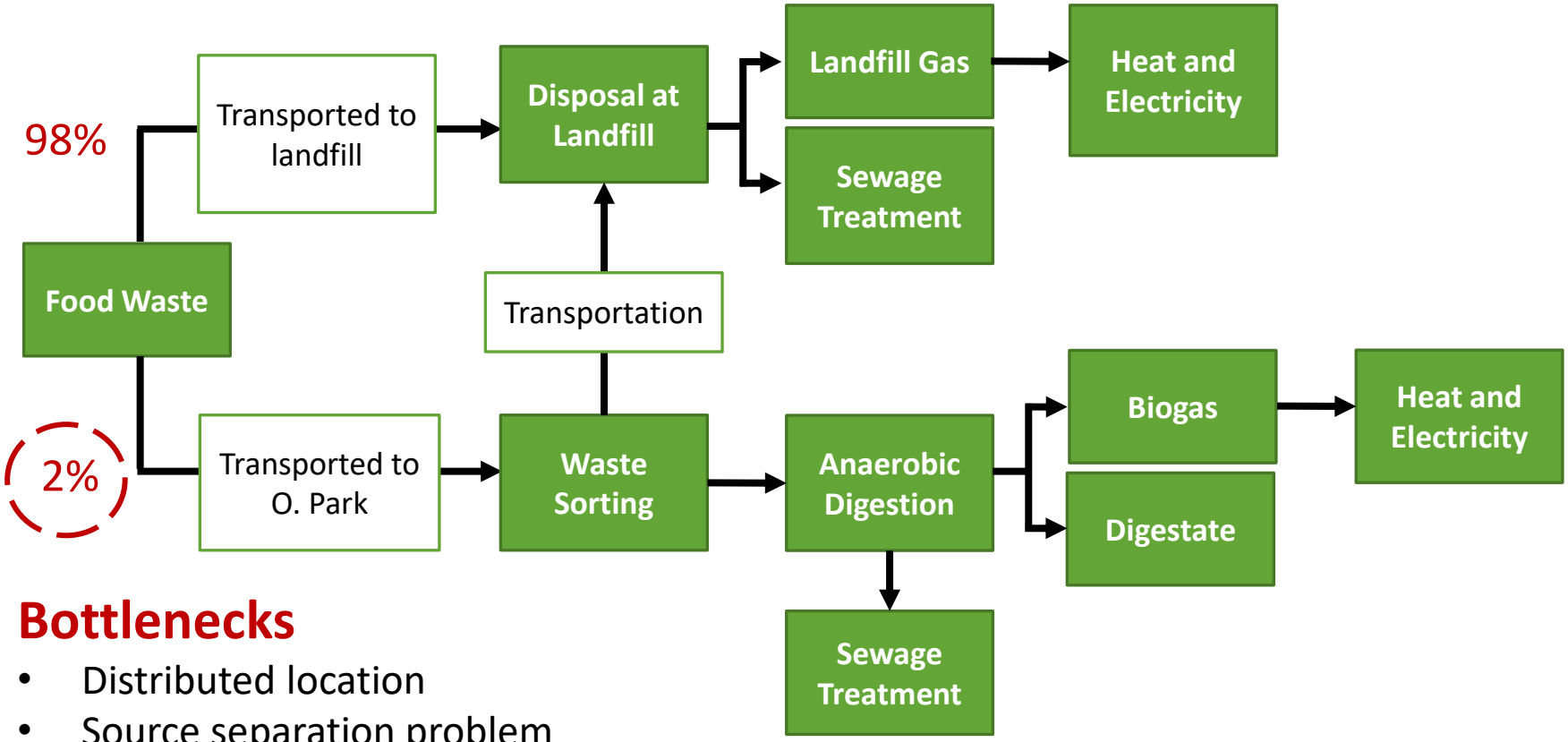
- Developed in Sweden in the 1960s
- Widely adopted in Europe and Asia to improve food waste collection capacity
- Reduce labour input through the automatic processes, such as the large-scale food waste collection system implemented for the catering facilities in the Hong Kong International Airport
- Collected of over 2,000 tonnes of food waste for recycling in 2017/18

In future:

- To yield further reduction in both volume and weight of the food waste to be handled, food waste dewatering is a practical way
- Currently, data on cost-effective food waste collection and management practices for small-scale catering and other food preparation facilities in East Asia is lacking

Enhancing Food Waste Collection

Process diagram of food waste management in Hong Kong

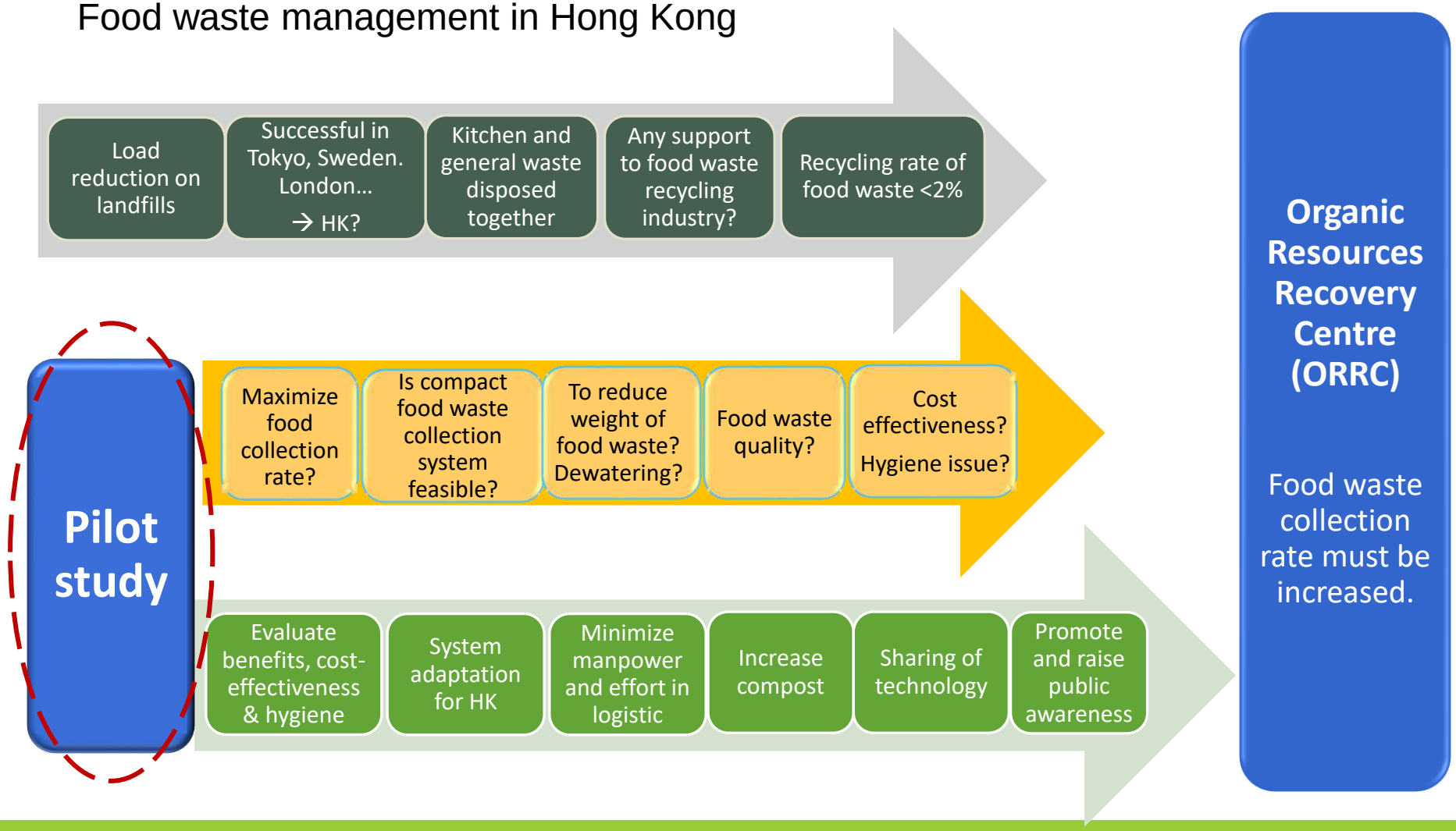


Bottlenecks

- Distributed location
- Source separation problem
- Transportation concern

Inputs from HKPolyU

Food waste management in Hong Kong



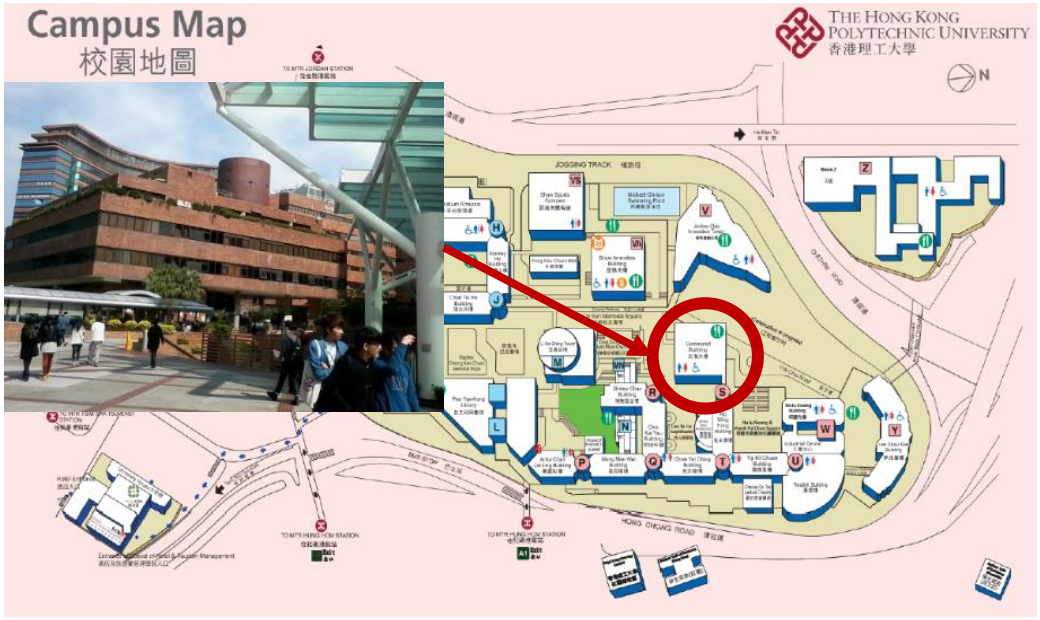
Project Objectives

In this project:

- We will evaluate the cost-effectiveness of a centralized food waste collection system as a replacement of the manual waste collection process
- We will evaluate the benefits of the collection system through lifecycle costing analysis, and to analyze behavioral changes of users

Project Background

- To facilitate efficient and cost-effective food waste collection and recycling on campus, a small-scale food waste collection system, first in Hong Kong and East Asia, has been installed for the catering facilities at The Hong Kong Polytechnic University.
- The system features a dewatering unit that can remove water content from food waste. System operation began on 5 July 2019.

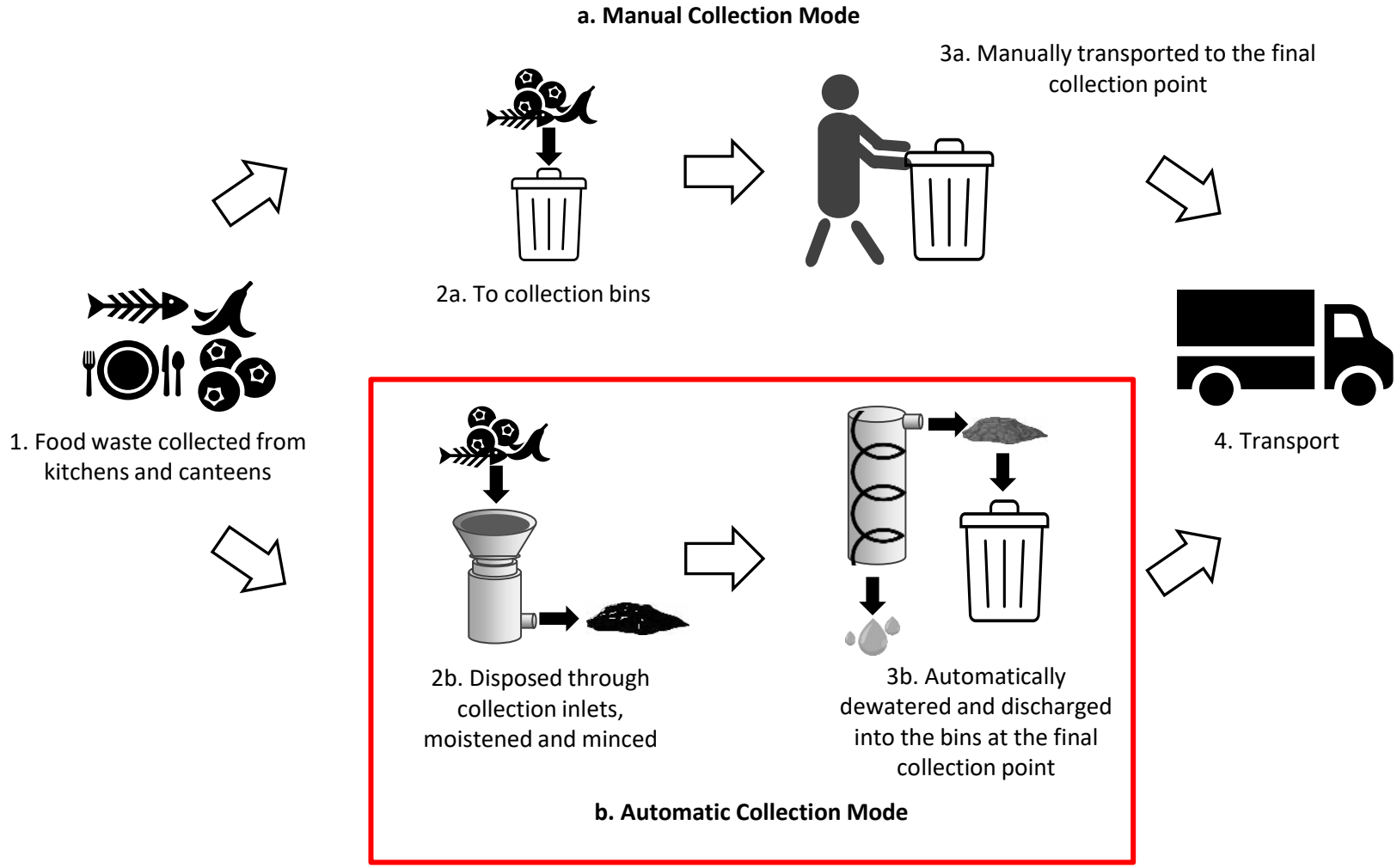


Targeted Location

	Communal Building	Seats	Food Served
4/F	Communal Staff Restaurant	250	Dim sum, Northern dishes, home-style dishes.
	Communal Student Restaurant	200	Noodles, congee, steamed rice and dim sum.
3/F	Communal Student Canteen	520	Fast-food items, bakery items, BBQ specialties.

- The facility opens about 13 hours a day and closes on public holidays. It serves a variety of foods and beverages, including Chinese and Western set meals, fast-food items, Chinese dim sum, BBQ specialties, vegetable dishes, noodles, bakery products and baked goods.

Food Waste Collection Methods



How to Improve?

Existing manual approach:

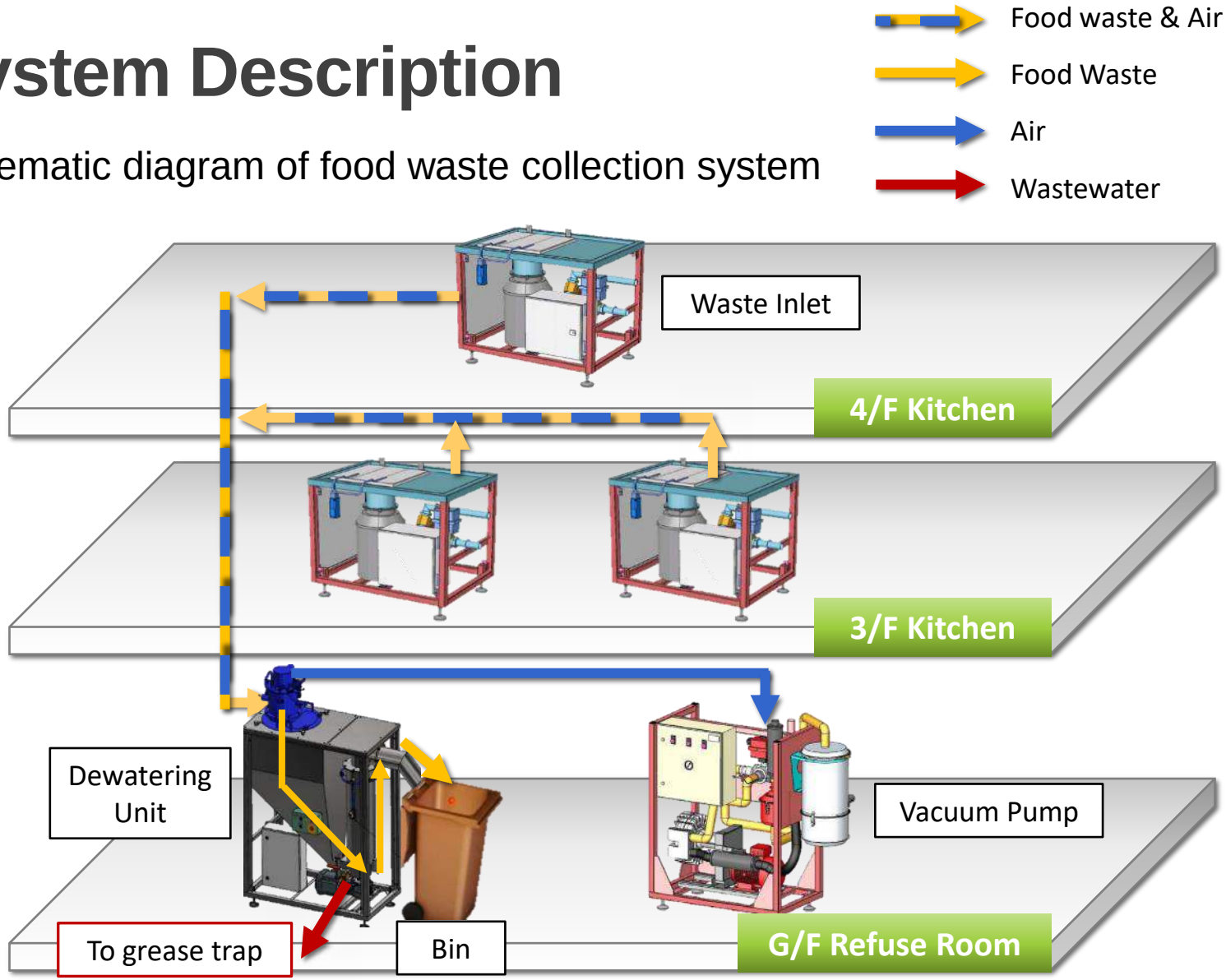
- The collection bins located in the kitchen and dining areas for food waste collection were manually delivered to the final collection point in the same building for waste pickup

New automatic approach:

- The collection bins located in the kitchen and dining areas for food waste collection were manually delivered to the final collection point in the same building for waste pickup
- Food waste was disposed through the collection inlets (each inlet could hold food waste up to a capacity of 6 L)
- Using the automatic approach, food waste could be collected at 180 L/hr

System Description

Schematic diagram of food waste collection system



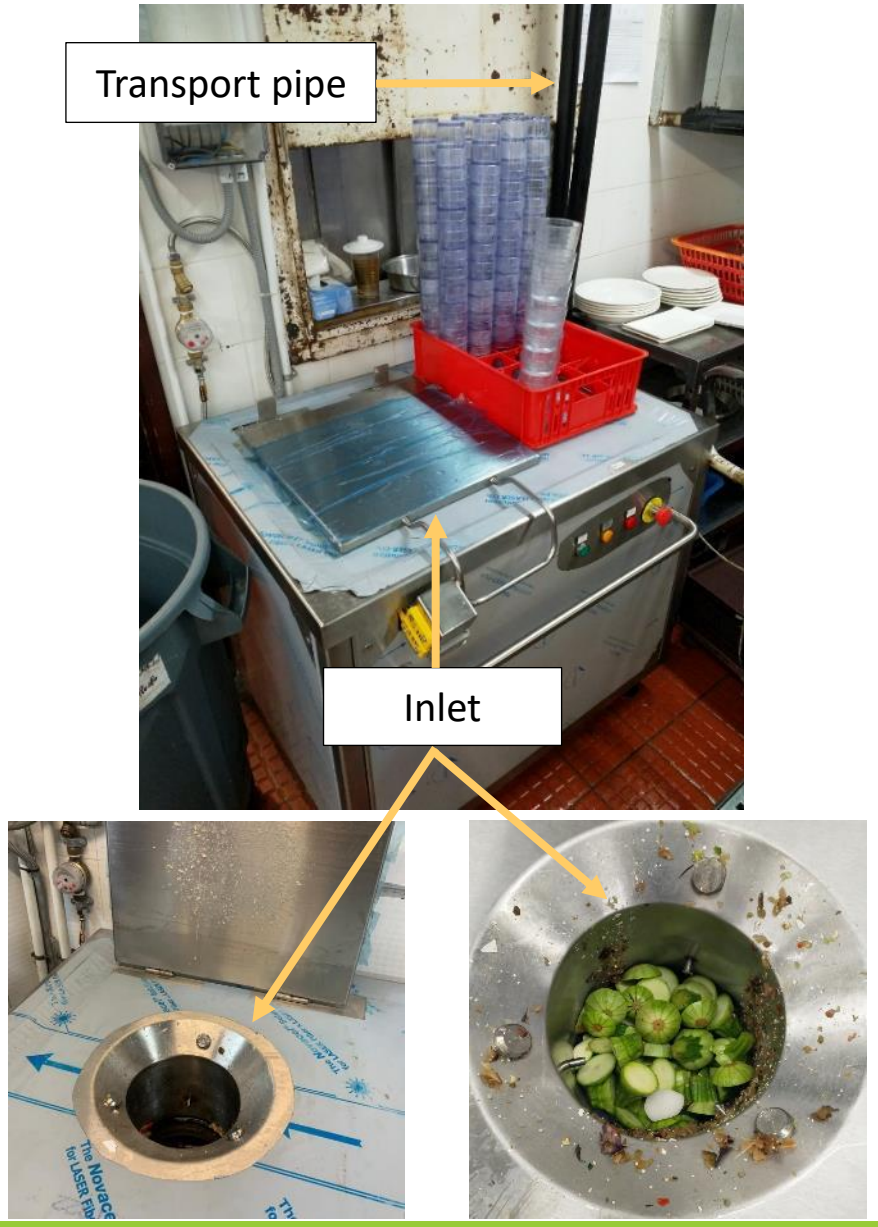
System Description

The system has 3 components:

- Waste inlets
- Vacuum pump
- Dewatering unit

Waste Inlets

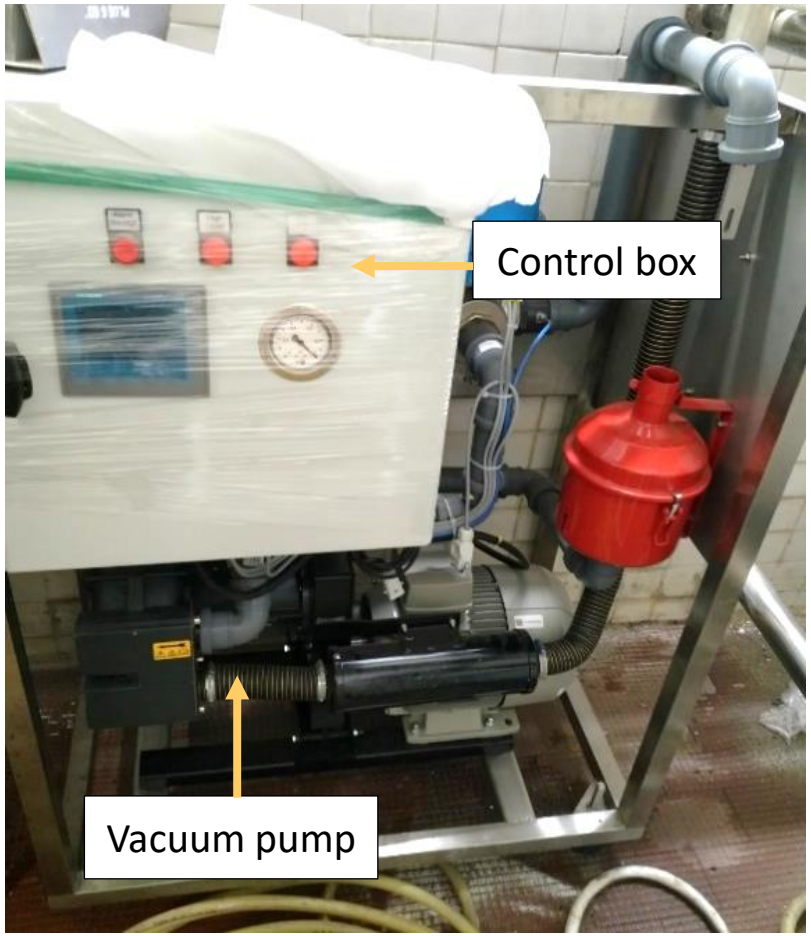
- Food waste is collected at bench units at kitchen, and is first broken down into smaller pieces by internal mincing machine
- Water is added to waste before transported by pipes
- Each inlet has 6L capacity and can process up to 180L of waste per hour



System Description

Vacuum Pump

- Suction force is created by the vacuum pump unit to transport food waste from upper floors to the dewatering unit on ground floor



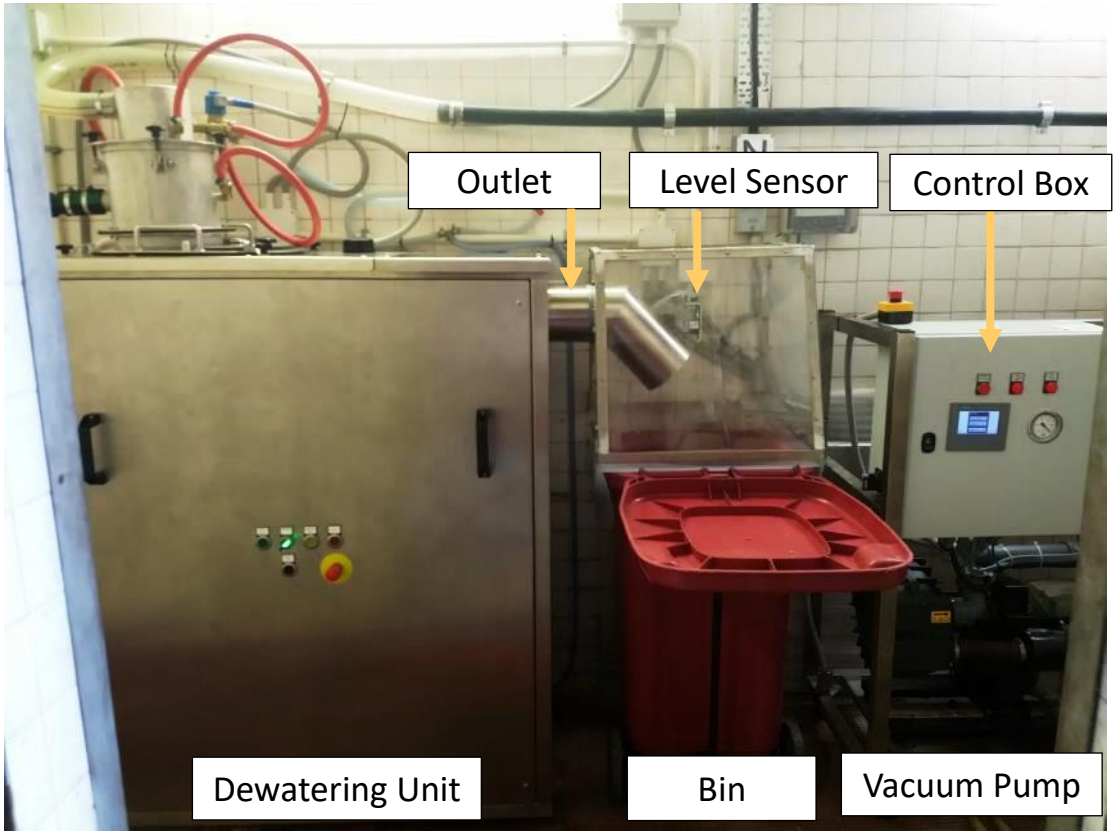
System Description

Dewatering Unit

- The dewatering unit presses waste up against a screw chamber
- The chamber rotates and presses wastewater out through a screen (3mm)
- The dewatering unit can process up to 220kg of food waste per hour

System Description

- Processed food waste is temporarily stored in collection bins (180L)
- Level sensor will notify staff when bin is over half full



* Although thermal dewatering could reduce the moisture content to 10%, it was not considered in this study due to its high energy demand and long processing time

System Operation

Step 1

- Disposal of sorted food waste at waste inlets

*Hover over to play the video

System Operation

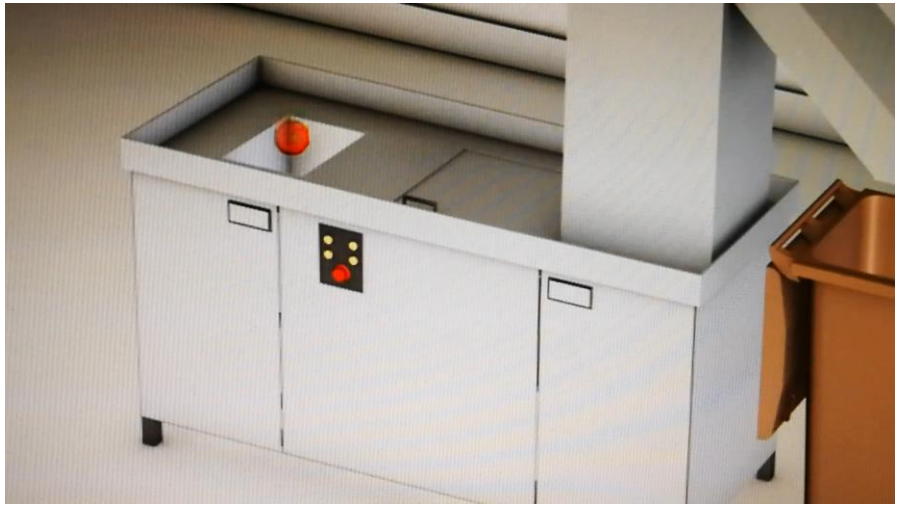
Step 2

- Close lid and start system by pressing the green button

System Operation

Step 3

- Dewatered food waste is collected by food waste bin at the food waste collection point



*Hover over to play the video

*Hover over to play the video

System Operation

Sample kitchen food waste

Food waste after mincing and dewatering processes

Data Collection

Data collection & system monitoring: July – November 2019

1. Food waste generation in PolyU
2. Weight and water content of food waste
3. Wastewater testing
4. System utilization
5. Users' behaviour

Food Waste Generation in PolyU

- Pre-consumption food waste produced in kitchen during food preparation
- Number of meals served
- Net weights of set meals
- Post-consumption food waste produced in dining area
- Customer interviews on food waste generation habit

Weight and Water Content of Food Waste

Daily output of the system

- Monthly waste data
- Number of bins used per day

} From food waste contractor

Water content of food waste

- Determined by dry weight experiment

Gather and weigh food waste samples

Place sample in oven

Weight dried sample

Wastewater Testing

Water samples are collected from dewatering unit each month for water quality tests:

- Oil and grease content
- Biochemical Oxygen Demand (BOD)
- Chemical Oxygen Demand (COD)
- Total suspended solids

*Waste water collected from dewatering unit is discharged to **grease trap**

System Utilization

- Activity log, electricity and water consumption of system are collected

Electric & Water Meter

	Data Log Example
Inlet Bench	No. of operations
	Mincer fault
	Electricity & water consumption
Pump	Pump fault
	Electricity consumption
Dewatering Unit	Pump / screw fault
	Electricity & water consumption

Maintenance log

System Control Panel

Month	No. of fault(s)	Description of fault
Jul-19	2	Clogging of one of the inlet units (once) and emergency button accidentally pressed by staff (once).
Sep-19	5	Dewatering unit clogged, leading to high levels of food waste in temporary storage tank.
Oct-19	2	Dewatering unit clogged, leading to high levels of food waste in temporary storage tank.
Mar-20	1	Transport pipe connecting inlet Unit 1 on 3/F kitchen came off loose.

Users' Behaviour

- User behavior towards the system are surveyed and analyzed for any change with the implement of the system

Direct system users

- System usability, and changes in waste collection behaviour

Canteen managers

- Impact of the system on workflow, and health and safety conditions

Summary of Interview Outcomes Before System Implementation

Categories	Interviewees' responses
Management Practice	Not inconvenient • Part of day to day work when collecting and washing plates
	Little workload • One staff carrying a bin once per day (5 to 6 minutes per trip) • A bit more walking required to dispose food waste to collection bin
	Not time consuming • Manageable within working hours
Quantity of Food Waste	About one bin per kitchen area
Health and Safety	Little health and safety concerns • No injuries or health issues related to food waste collection • Little odor as waste is removed daily • Trays filled with food waste can be heavy and harder to handle, will ask others to help to carry trays if needed

Users' Comments After System Implementation

Categories	Interviewees' responses
Inlet capacity and location	Inlet is too small • Additional time is required for sorting out large items
	Inlet location is far away from food waste generation location • Inconvenient for transportation
	Changing the waste bin at refuse room is inconvenient
Inlet operation	Collection cycle at inlet is about 2 min • Cannot process large amount of food waste in short period of time (during peak hour)
Health and Safety	Some health and safety concerns • Pest was found near inlet bench and collection bin at refuse room • Odor issue when the bin is awaiting for collection • Detergents cannot be used for cleaning the inlet • Using hot water for degreasing raises safety concerns

Food Waste Generation

Overview of meal served

Meal	Quantity
Meal per day	4,363
Meals per seat per day	8.4

Food waste generation

Food waste	Quantity
Weight per day, m_1	13.9-29.2 kg/d
Weight per seat per day	0.019 kg/d/st
Volume	45.7-92.9 L

Meal served at various period

Period	Proportion	Meals per seat	Net weight
Breakfast (730-1100)	12-18%	1.3	0.39-0.6 kg
Lunch (1100-1430)	23-69%	3.8	0.42-0.72 kg
Afternoon tea (1430-1730)	11-17%	1.2	0.15-0.39 kg
Dinner (1730-2000)	8-42%	2.1	0.15-0.66 kg

Post-consumption Food Waste Composition

Categories	Grains	Vegetables	Non-vegetables
Composition	46%	36%	18%
Food waste items	a1. Rice a2. Toast a3. Noodles a4. French fries a5. Potato a6. Chinese bread	b1. Tofu puff b2. Winter melon b3. Onion b4. Cloud ear fungus b5. Chestnut b6. Broccoli b7. Carrot b8. Mushroom b9. Corn b10. Tofu b11. Green bell pepper b12. Eggplant b.13 Zucchini	c1. Sausage c2. Fish fillet c3. Salted egg c4. Red sausage c5. Chicken c6. BBQ pork c7. Spring roll c8. Pork rib c9. Fish stew c10. Ham

Food Waste Moisture Content and Volume

Average moisture content

- Food waste moisture content: 76%

Example Item	Moisture content
BBQ pork	33%
Fried rice	55%
Green pepper	91%
Eggplant	92%

- After dewatering: 64%

Waste compaction by system

- Volume reduction at inlet (after mincing): -60%
- Volume reduction after dewatering: -11%

Food Waste Collection

	Before System Operation (Only manual collection)	After System Operation^ (Both manual and automatic collection)	Change
Amount of food waste	205 kg/d	217 kg/d	+9%
Number of bins used	3.8 bins/d	2.9 bins/d	-24%
Bin volume	344 L/d	249 L/d	-28%
Handling efficiency*	0.58 kg/L	0.85 kg/L	+47%

^Usage of system not compulsory

*The food waste handling efficiency ρ (kg L^{-1}) is used to evaluate the performance of the two food waste collection approaches, given by $\rho = \frac{m}{v}$, where ***m*** (kg) and ***v*** (L) are the weight and bin volume of the collected food waste

Electricity, Water and Effluent

	Manual	Automatic
Electricity (kWh/kg)	0.005	0.027
Water (L/kg)	0.512	0.406
Collection bin transportation (bin/kg)	0.01	0.007

Effluent

- System average effluent quantity: 0.1 m3/ day
- Average effluent quality

	Quantity (mg/L)
BOD	5,408
COD	10,758
Oil & grease	164
Total suspended solids	3,038

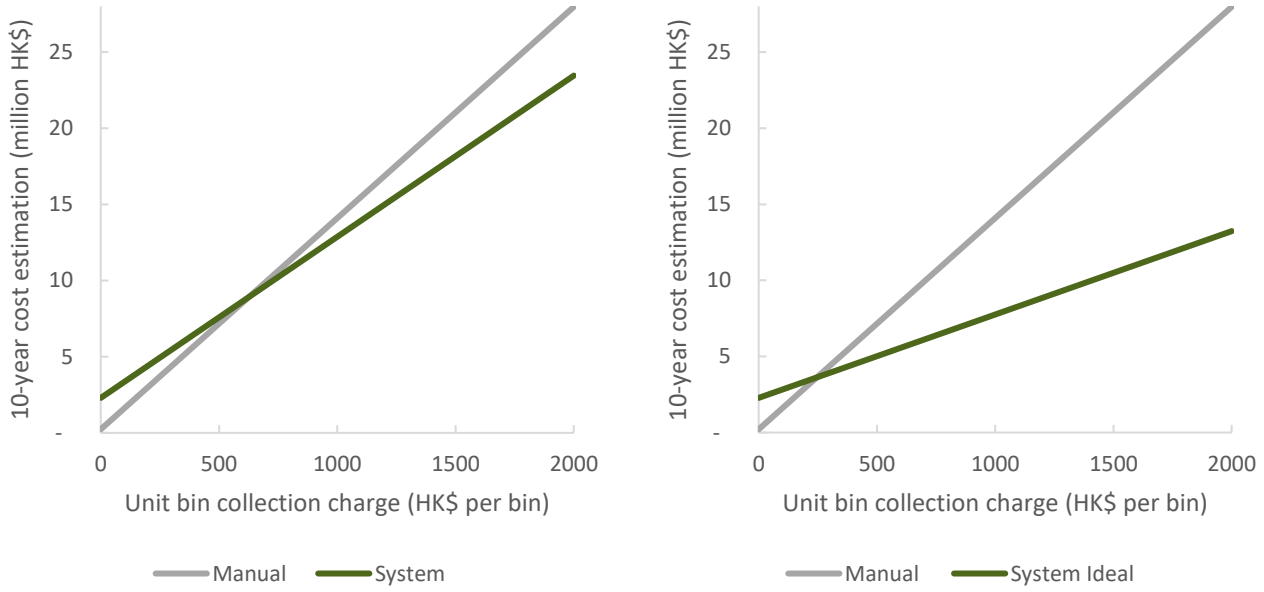
*All effluent is discharged to **grease trap**

Lifecycle Cost Analysis

Cost (HK$)	Manual Collection	System Collection	System Ideal Case	Remarks
Storage bin	6,857	6,857	6,857	HK$480/ bin; replaced once every 3.5 years
System	N/A	1,070,800	1,070,800	Inlet, vacuum, dewatering units, pipes
Installation	N/A	588,000	588,000	Installation, T&C, project management
Retrofitting	N/A	93,100	93,100	Wall, grease trap, electrical and water points
Installation cost	6,857	1,758,757	1,758,757	
Labor	219,000	219,000	219,000	Wage: HK$60/ hr; Labour input: 1hr/ day
System operation	N/A	34,675	274,845	Water and electricity: HK$1/ operation Reference tariff Electricity: HK$1.28/ kWh (non-residential) Water: HK$9.05/ m^3 (domestic tier 4) No. of operations System collection: 9.5/ day System ideal case: 75.3/ day
Maintenance	N/A	268,300	268,300	21-month warranty period: HK$39,200 3rd year: HK$24,000 (+5% each year onward)
Waste collection charge	19,223,820	14,670,810	7,588,350	Bin collection fee: HK$1,386/ bin Manual collection: 3.8 bins/ day System collection: 2.9 bins/ day System ideal case: 1.5 bins/ day
Operation cost	19,442,820	15,192,785	8,350,495	
Overall cost	19,449,677	16,951,542	10,109,252	
Cost per kg of waste	**26.8**	**21.4**	**13.9**	

Payback Period

	System Collection		System Ideal Case	
Initial system cost (HK$)	1,751,900		1,751,900	
Discount rate	0%	10%	0%	10%
NPV (HK$)	746,235	-216,904	7,588,530	3,987,390
Payback period (year)	**7.0**	**11.4**	**1.9**	**3.1**



Comparison of 10-year food waste collection cost with varying unit collection charge by waste contractors (HK$ per bin) Left: study case; Right: ideal case

Reported Issues and Recommendation

Issue	Description	Recommendation
Inlet capacity and location	• Size and capacity of the inlet units are too small • Location of some inlet units is inconvenient	• Replace 50mm transport pipes to wider 200mm pipes • Increase inlet capacity so it can process a larger volume of food waste per batch (if space permits) • Inlet units placed close to food waste generation sources or incorporated in work benches for convenience, e.g. the food preparation and dish washing areas in kitchens • Break large food waste items (e.g. whole chicken bones) into smaller pieces before disposal at inlet
Inlet operation time	• Each cycle of inlet operation is too long • Catering staff do not have additional manpower and time for the disposal procedure	• Replace 50mm transport pipes to wider 200mm pipes to shorten the processing time required to break down food waste as they can be transported in bigger pieces without clogging the system
Waste bin collection	• The practice of replacing waste bins at refuse room after system implementation is inconvenient to catering staff	• Switch dewatering unit with collection tank to eliminate the need for catering staff to replace waste bins

Reported Issues and Recommendation

Issue	Description	Recommendation
Pest and hygiene	• Flies and cockroaches are found around the inlet bench units at kitchens and around the collection bin in refuse room	• Apply insect repellent on the interior and back of panels of inlet units • Cover or enclose waste collection bin to prevent pest infestation and odour leakage during collection process • Switch dewatering unit with collection tank for better odour control
Odour problem	• Processed food waste gathered by the collection bin has created odour problems at refuse room	• Provide hot water supply to wash and flush food scraps out of inlet units • Provide ventilation at refuse room to remove odour and heat • Switch dewatering unit with collection tank for better odour control • Regular washing and maintenance of temporary storage tank and screw press of dewatering unit

Summary of Results

Increase in amount of food waste collected

- from 6,036 kg per month (199 kg per day) to 6,767 kg per month (217 kg per day)

Decrease in number of waste bins for food waste collection

- from 3.8 to 2.9 bins per day
- in the ideal system usage scenario: reduce to 1.5 bins

✓ reduces cost of food waste collection in the long run

✓ reduces number of trips to ORRCs with less number of bins

✓ lower cost encourages the collection of food waste and deliver to ORRCs

Reduce waste volume by about 60%

Reduce moisture content of food waste by 12%

System collection provide around 13% cost savings

- The 10-year cost estimation
  - manual collection: HK$19,499,677
  - system collection (in this study): HK$16,951,542
  - system ideal case: HK$10,109,252

Future Research Potential

Environmental aspect

- Food waste collection rate within the C&I sector
- Diversion of food waste from landfill to organic resources recovery facilities

Social aspect

- Willingness and understanding of caterers on food waste recycling
- Technology transfer on food waste collection among the C&I sector

Economic aspect

- Cost-effectiveness of food waste collection system
- Capacity and efficiency in handling of food waste

Acknowledgement

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