Feasibility Studies on Joint Crediting Mechanism Projects towards Environmentally Sustainable Cities in Asia

Report on
Project for developing a Low Carbon Society through "Waste to Energy Technology" in Penang, Malaysia

Global Environment Centre Foundation

March 2014

Project for developing a Low Carbon Society through

"Waste to Energy Technology" in Penang, Malaysia

Feasibility Studies on Joint Crediting Mechanism Projects towards Environmentally Sustainable Cities in Asia

-Summary-

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1. Objective

The purpose of this project is to improve the efficiency of the waste management policy in Penang State and to import green innovation technologies from Kawasaki City that are combined with energy production, thereby contributing to reduction of greenhouse gas (GHG) emissions in the State and realizing the "co-benefit" of mitigating severe waste management problems.

2. Project description

- Assess the contribution of the low-carbon waste treatment project to waste reduction and improvement of waste treatment.
- Study the feasibility of introducing Japanese legal institutions and technologies to the partner country, determine key contact persons, and ascertain the needs of the partner country relating to capacity development, etc.

In 2013, surveys were conducted to identify conditions for the utilization of advanced Japanese technologies that can potentially improve the efficiency of the existing waste management measures while enabling energy production in order to implement specific tasks for the year ahead.

≪Project's Organizational Chart≫

3. Solid waste management in Penang State

3.1. Policy

To implement and administer the planning and management of solid waste in an integrated, holistic, cost- effective, and environmentally-friendly manner through waste minimisation approaches moving towards the Zero Waste principle.

3.2. Targets

The following targets from 2011–2020 for the Solid waste management program have been agreed upon based on a consensus reached by representatives from the two local councils (Seberang Perai Municipal Council (MPSP), Penang Island Municipal Council (MPPP)), NGOs, and the private sector, as shown in the following tables:

- Waste Reduction & Recycling

Table 1: Targets for Waste Reduction & Recycling

Indicator	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Waste Generation kg/capita/day	1.5	1.35	1.21	1.09	0.98	0.88	0.78	0.72	0.64	0.58
Recycling Rates (%)	25	27	30	33	37	40	44	49	53	59

Source: PEMANDU SWM Lab, 2011

- Specific Waste Streams

Recycling targets for some of the larger and heavier waste streams were also determined as shown in the table below:

Table 2: Targets for recycling and recovering specific waste streams by 2020 (%)

Waste Stream	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Organic food waste	5	10	20	30	40	50	60	70	80	100
C&D waste				40	→					60
Marine clay				25	→					70

Source: PEMANDU SWM Lab, 2011

3.3. Solid Waste Sector Information

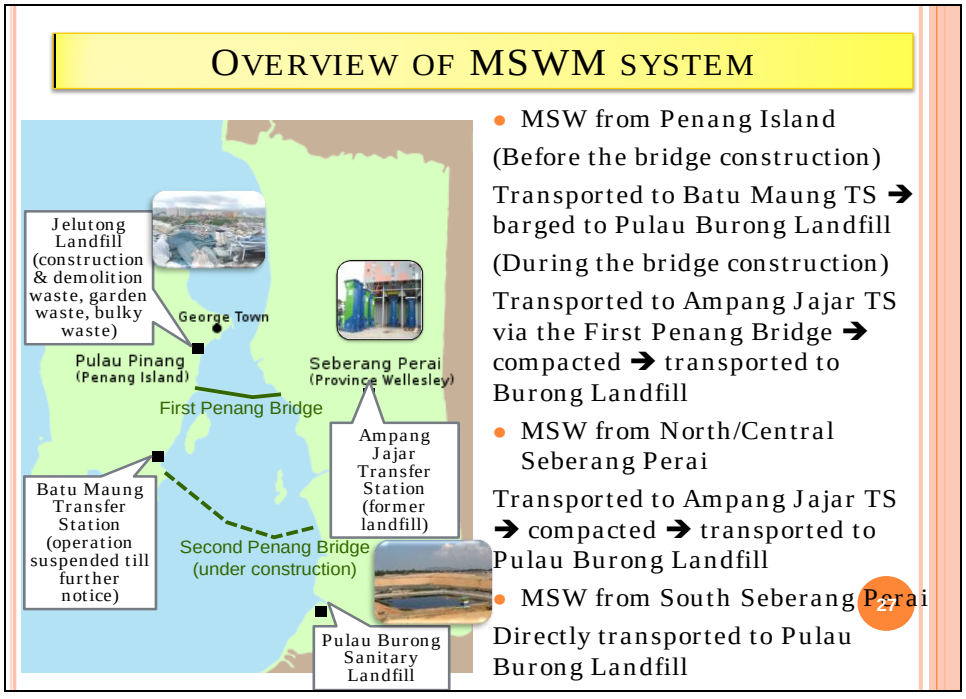
An overall view of the solid waste sector for the two local councils is shown in Table 3.

Table3: Solid Waste Sector Information for MPPP & MPSP, 2012

No.	Item	MPPP	MPSP	Unit
1	Quantity of waste generated annually	288,377	528,275	Tonnes/year

				(2012)
2	Quantity of waste generated daily	790	1447	Tonnes/day *(2012)*
3	Quantity of waste generated per capita	1.07	1.47	Kg/capita/day
4	Total number of households in the city	189,829	195,829	Households
5	Percentage of municipal budget used for solid waste sector	25	43	Percent
	Waste Composition**(Source: Derived from Satang Report 2003)*			
i	Organic	43	63	percent
ii	Paper	28	5	percent
iii	Plastic	15	17	percent
iv	Metal	5	4	percent
v	Glass	0	0	percent
vi	Other	6	11	percent

The following diagram provides an overview of the Municipal Solid Waste Management System in Penang.



4. Research

4.1. Activities

Schedule	Activities
26–28 June. 2013	1. Site visit

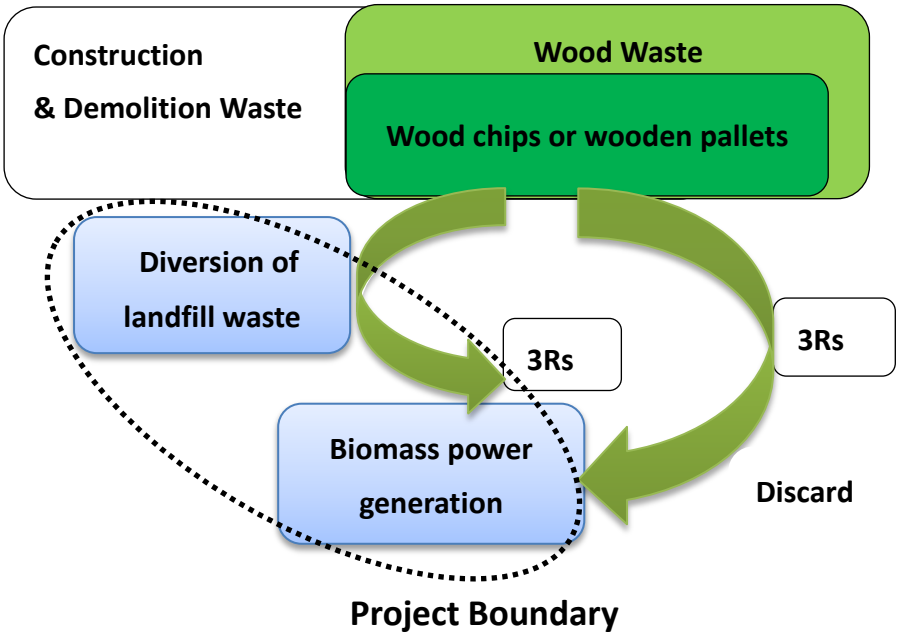
	➢ Landfill site ➢ Specific waste streams (construction and demolition waste, marine clay, organic food waste)
20–22 August 2013	1. Kick-off meeting 2. Site visit ➢ Waste transfer station and sanitary landfill site ➢ Waste recycling (recover resource, composting, food to food, etc.) ➢ 3R activities (shopping mall, community level, etc.)
10–13 September 2013	1. Training in Kawasaki City
21–23 January 2014	1. Workshop 2. Site visit ➢ Wood waste treatment ➢ Food waste generation and collection ➢ 3R activities (schools, hospitals)

4.2. Waste to Energy technology to be employed by the project activity

In the proposed project, biomass power generation using wood chips or wooden pallets will be introduced.

4.3. Reduction of GHG emission

- Biomass power generation using wood chips or wooden pallets
- Diversion of landfill wood waste



- Project Base (assumed case)

Activity	Conditions	Emission reduction
Biomass power generation	Rated power: 5,000 kw Capacity:91,000 t/year Generating efficiency: 24% LHV:13,000kJ/kg Operation day : 300 days	19,800 t/year
Diversion of landfill wood waste	Diversion amount from landfill sites:100 t/day Operation day : 300 days	95,130 t/year
Estimated reductions(tCO2)	-	114,930 t/year

- Explanation of methodological choices

Emissions reduction (ERy)	ERy =BEy－PEy ERy: Emissions reduction in year y (t CO2/year) BEy: Emissions in the baseline scenario in year y (t CO2/year) PEy: Emissions in the project scenario in year y (t CO2/year)
Baseline emissions (ERy)	BEy = BE_{CH4y}+BE_{ENy} ➢ BE_{CH4y} =Wy × CF_{CH4}× GWP_{CH4} Wy: Amount of landfill wood waste during the year y(t/year) CF_{CH4}: Emission factor for methane(tCH4/t) GWP_{CH4}:Global warming potential for methane(tCO2/tCH4) (Default value=21) ➢ BE_{ENy}=BEelec,y=EGy × EFelec BEelec,y: Baseline emissions from electricity generated utilizing the energy from biogas in the project activity and exported to the grid(tCO2/year) EGy : Amount of electricity generated utilizing the energy from biogas in the project activity and exported to the grid during the year y (MWh) EFelec: Emission factor for electricity generation in year y (tCO2/MWh)
Project emissions (PEy)	PEy=$PE_{EC,y}$+ $PE_{FC,y}$ ➢ Emissions from electricity and fossil fuel consumption at the

	biomass production plant and landfill sites in the year y(tCO2/year) PE_{EC}, $=EC_{PJy} \times EF_{elec}$ EC_{PJy}: Electricity imported from the grid (MWh/year) EF_{elec}: Emission factor for the grid(tCO2/MWh) ➢ $PE_{PEy}=FC_{i,y} \times NCVi \times EF_{fuel,i}$ $FC_{i,y}$:Fossil fuel consumption(t, kl, m3/year) NCVi : Net calorific value of fossil fuel (GJ/t, kl ,m3) $EF_{fuel,}i$: Emission factor for fossil fuel(tCO2/GJ)

Leakage: Emissions resulting from transport of wood chips or wooden pallets waste.

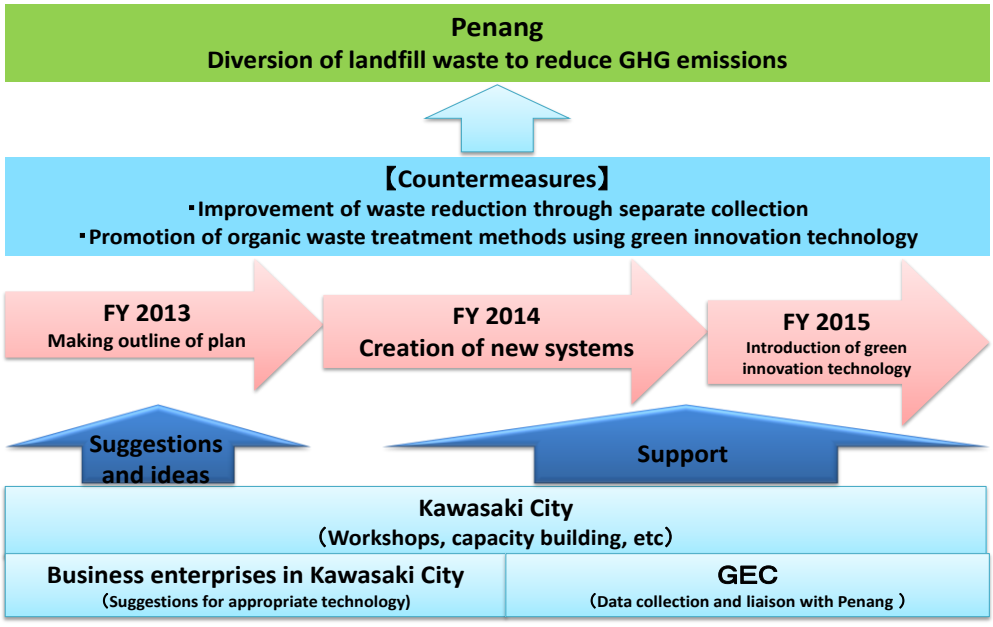
4.3. Co-benefit

- Promotion of resource recovery and recycling
- Reduction of environmental impact at the landfill sites
- Improvement of environmental education and incentive for 3Rs
- Creation of new employment under the new systems

5. Towards commercialization

Based on results of feasibility studies during 2014, specific commercialization of biomass power generation and other waste management technologies will be assessed 2015 onwards.

In 2014, the project will contribute to building a waste management system to develop low-carbon cities in the Penang State. This includes drafting legal systems such as developing necessary laws and regulations.



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Project for developing a Low Carbon Society
through "Waste to Energy Technology" in Penang, Malaysia

1. Introduction

This proposal is written in response to the bi-lateral discussion of the Penang State Government with GEC, Kawasaki City, JFE and supported by MOE Japan.

The purpose of this proposal is to explore the possibilities of Waste-to-Energy projects and technologies that are appropriate to Penang through a feasibility study .

Reducing waste cannot succeed without a system that manages waste from the point of generation through to disposal. A more effective, integrated approach to material and resource efficiency is needed at every stage of production and consumption. Up to now, waste policies have tended to focus on end-of-pipe solutions by dealing with disposal rather than prevention.

There exists a direct link between the amount of waste we produce and our rate of economic growth. The long-term challenge is to break this link and achieve sustainable growth by learning how to use resources more efficiently — to produce more with less waste. The UNDP study on Structuring and Institutionalising Solid Waste Management in Penang (2007) recommended the resource recovery and composting approach instead of incineration. Hence, all policy directions would be based on this approach for development and implementation of the SWM for the State.

1.1. Project's Implementation Plan

The purpose of this project is to support the establishment of a waste management system for the realization of “low-carbon cities,” utilizing the close relationship and networks with the state of Penang. It is also our aim to transfer low-carbon technologies that use energy produced by biomass to Penang with support from enterprises in the Kawasaki waterfront area in partnership with enterprises in Kawasaki city. This system is expected to make the entire process—from sorted collection to final disposal—low carbon. In addition, necessary human resource development and institution building will be attempted with support from Kawasaki city. Sharing experiences, technologies, and knowledge of Kawasaki city, efforts to develop better conditions for low-carbon technologies owned by business enterprise will be made for the early implementation of the "Waste to Energy" project, with supports from Kawasaki city to streamline legal system and policies. Moreover, we try to contribute to the efforts to create low-carbon cities that can achieve co-benefit of the realization of low carbon by GHG emission reduction, waste volume reduction, and the reduction of air contaminants other than GHGs.

In 2013, surveys will be conducted to prepare conditions to utilize Japanese advanced technologies that can improve the efficiency of the existing waste management measures while enabling energy production with a view to practice specific tasks for the year ahead.

Figure1: Project's Organizational Chart

2. Solid Waste Management in Penang

2.1. Vision

To implement and administer solid waste planning and management in an integrated, holistic, cost effective and environmentally friendly manner.

2.2. Policy

To implement and administer solid waste planning and management in an integrated, holistic, cost-effective and environmentally friendly manner through waste minimisation approaches moving towards the Zero Waste principle.

2.3. Objectives

- To establish a comprehensive, integrated, cost-effective, sustainable and socially acceptable ISWM;

- To manage wastes through a more holistic and comprehensive approach than today's system, resulting in the conservation of natural resources and the creation of less waste and less pollution, and at the same time reducing the carbon footprint;

- To implement ISWM based on waste management hierarchy that shifts away from the "throwaway society," toward a system that promotes a reduction in the generation and toxicity of trash giving priority to waste reduction through effective waste minimisation strategies (3Rs) where wastes are treated as valuable raw materials and energy resources and waste diversion from the landfill via resource recovery and composting strategies, and efficient final disposal; and

- To adopt stable, long-term funding mechanisms that provide sufficient revenue for state and local programs while providing incentives for increased waste reduction and diversion.

2.4. Targets

The Performance Management & Delivery Unit (PEMANDU) was formally established on September 16, 2009 and is a unit under the Prime Minister's Department. The PEMANDU lab in 2011, on solid waste management has arrived at the following targets from 2011-2020 after consensuses by representatives from the two local councils, NGOs and private sector are shown in the following tables:

2.4.1. Waste Reduction & Recycling

Table 1: Targets for Waste Reduction & Recycling

Indicator	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Waste Generation kg/capita/day	1.5	1.35	1.21	1.09	0.98	0.88	0.78	0.72	0.64	0.58
Recycling Rates (%)	25	27	30	33	37	40	44	49	53	59

Source: PEMANDU SWM Lab, 2011

2.4.2. Specific Waste Streams

Recycling targets for some of the larger and heavier waste streams were also determined as shown in the table below:

Table 2: Targets for recycling and recovering specific waste streams by 2020 (%)

Waste Stream	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Organic food waste	5	10	20	30	40	50	60	70	80	100
C&D waste				40	→					60
Marine clay				25	→					70

Source: PEMANDU SWM Lab, 2011

2.5. Current Waste Management Practice

This section describes the infrastructure such as collection system, disposal system, and recycling system; local and national policy framework, financing mechanisms, institutional arrangements, and stakeholders roles and responsibilities.

2.6. Penang Island Municipal (MPPP) Council SWM System

For MPPP, SWM services fall within the jurisdiction of the Urban Services Public Health and Licensing (USPHL) Department. This Department is in-charge of providing SWM services from collection to transfer and disposal. It also includes managing outsourced services. According to MPPP, a total of 43 staff are directly involved in the providing the SWM services.

The Engineering Department and the Landscaping Section of the Development Planning Department are involved in related aspects of SWM. The Engineering Department maintains all MPPP vehicles including waste collection trucks, and also manages the drivers of these vehicles. It also manages the landfill at Jelutong, and the two weighbridges at Jelutong as well as at the transfer station at Batu Maung. The Landscaping Section accounts for a significant part of garden waste from roadside trimmings of trees and maintenance of the various landscaped areas under its jurisdiction. These are sent to the Jelutong Landfill.

2.6.1. Solid Waste Generation

SWM planning begins with an estimation of the amount of waste generated. This is usually based on the population in the study area. As SWM services are provided on housing units, translating the population into housing units usually begins there. Data for Penang Island shows that almost 80% of housing units are high density housing comprising flats, condominiums and apartments.

It is estimated that at least 600-800 tonnes of wastes are generated daily. The waste sources and the waste generation rate per capita are shown in Table 3. This estimate includes municipal waste from household, commercial, non-hazardous industrial and institutional sources. These are the solid wastes that went through the Batu Maung Transfer Station (BMTS) and then barged over to the Pulau Burong Sanitary Landfill. It does not include various waste fractions that are disposed at the Jelutong landfill, such as construction and demolition (C&D), garden waste or bulky wastes.

However, due to the construction of the Penang Second Bridge, barging operations to transfer waste to Pulau Burong ceased in the middle of 2011, municipal solid waste was transferred by land via the first Penang Bridge to the Ampang Jajar Transfer Station on the mainland.

MSW is collected by two major groups: (i) the MPPP; and (ii) the waste contractors. However, private individuals or firms also bring waste to the transfer stations or landfill site.

The current practice for waste collection is as follows:

- Household waste from landed properties – 3 times per week (except for Air Itam area, where daily collection is provided)
- Shop lots, commercial and high rise residential – daily
- Hawkers centre and wet markets – daily
- Institutional – daily

Certain premises such as industries and hotels have their own contractors to collect their garbage. The MPPP allows the practice but the appointed contractors must notify the Council as to their capability including their vehicle registration numbers. This is essential to monitor the garbage collected and disposed.

2.7. Seberang Prai Municipal Council (MPSP) SWM System

For MPSP, the SWM services are provided by MPSP's Urban Services Department. The Engineering Department (ED) and the Urban Planning & Landscaping (UPL) Department are also involved in the provision of SWM service. According to MPSP, they have 35 staff directly involved in the provision of SWM services.

The Urban Services is overall in-charge in terms of planning and managing SWM. Similar to MPPP, the ED also maintains and repairs MPSP's assets including MSW collection vehicles. The UPL, whose job is beautifying and maintaining gardens and landscaping, also contributes a significant part of garden waste from roadside trimmings of trees and maintenance of the various landscaped areas under its jurisdiction. These are sent to the Pulau Burong Sanitary Landfill (PB SLF). The MPSP estimates about 100 tonnes of green waste per day go to the PB SLF.

2.7.1. MPSP Solid Waste Collection

In Seberang Perai, the MPSP has divided the collection areas into three main zones - northern, central and southern, corresponding to the three districts.

Unlike the case of Penang Island, wastes in Seberang Perai are being collected by mainly by MPSP. Part of the waste collection and disposal contracts is outsourced to private contractors. Domestic waste is collected every alternate day. SWM service coverage, is 100% of Seberang Perai.

Both services were outsourced to local contractors (70%) and carried out by Council (30%).

Beginning 2013 MPSP gradually took over the solid waste collection activities due to the inefficient services provided by the contractors.

Current ratio of services outsourced to local contractors (40%) and (60%) carried out by the Council. However, MPSP targets to provide 100% coverage of solid waste collection and cleansing services covering 37 zones by 2014. About 1200 – 1500 metric tonnes of waste is collected daily and sent to the landfill.

2.7.2. Ampang Jajar Transfer Station

The site at Ampang Jajar was originally a landfill which started operations in 1988/89 but was officially closed in December 2001 when it reached its maximum capacity. All MSW from SPU and part of SPT are transported to the Ampang Jajar Transfer Station (AJTS). These wastes are compacted before being sent to the Pulau Burong Landfill for final disposal. For the surrounding areas especially for Seberang Perai Selatan, collection trucks directly transport MSW to the landfill.

In July 2011, this transfer station also receives domestic solid waste from the island and will continue to do so until the Batu Maung Transfer Station is in operation again.

2.7.3. Pulau Burong Sanitary Landfill

The Level 3 Sanitary Landfill is approximately 66 hectares of which 33 hectares are already in use. The landfill has a natural liner of clay soil and is operated using the semi-aerobic (Fukuoka) method. The current tipping fee charged at the landfill is RM20.20 (USD6.70) for both domestic wastes and industrial waste.

MPSP charges for tipping using an individual permit system issued to lorries carrying the wastes. The fee for a day's permit is RM20, irrespective of the number of trips made by the lorry to dispose the wastes at Pulau Burong.

The contractor, PLB Terang Sdn Bhd., has registered about 70 scavengers at the Landfill site. A fee of RM70 per person is levied and each person is issued with safety protection measures (e.g., gloves and masks). RM5 is charged for the registration card. Scavengers sell direct to recycling agents on site (Landfill). Out of the 70 registered scavengers, only 40 persons are considered active.

2.7.4. Recycling in Seberang Perai

MPSP implemented its recycling programme on 2 December 2000 following a directive from the Ministry of Housing and Local Government (MHLG). The main objective of this programme is to be a catalyst for the Government's aim to divert 30% of waste from the landfill. MPSP has organised various activities to promote recycling:

- As coordinator of the Recycling Programme, the MPSP has also provided various facilities, such as building 14 recycling collection centres. Thirteen (13) are sponsored by MHLG and one by MPSP.

- MPSP has also organised Recycling Carnivals at various shopping complexes to promote recycling and also exhibitions, quizzes, demonstrations and talks.

- 14 out of 31 of the collection centres in the communities are built by the MPSP using funds allocated by the MHLG. 17 others are financed privately or by NGOs.

The recycling rates achieved over the years are shown in Table 9 (page 46). It is important to note that the increase in recycling rates could be due to better information and for the later years, coverage by agents beyond the MPSP boundary, especially for some of the waste fractions.

Most of the major recycling operations and factories are located in Seberang Perai. Recyclable items collected from Penang Island are brought here for value added processing operations.

3. Solid Waste Sector Information

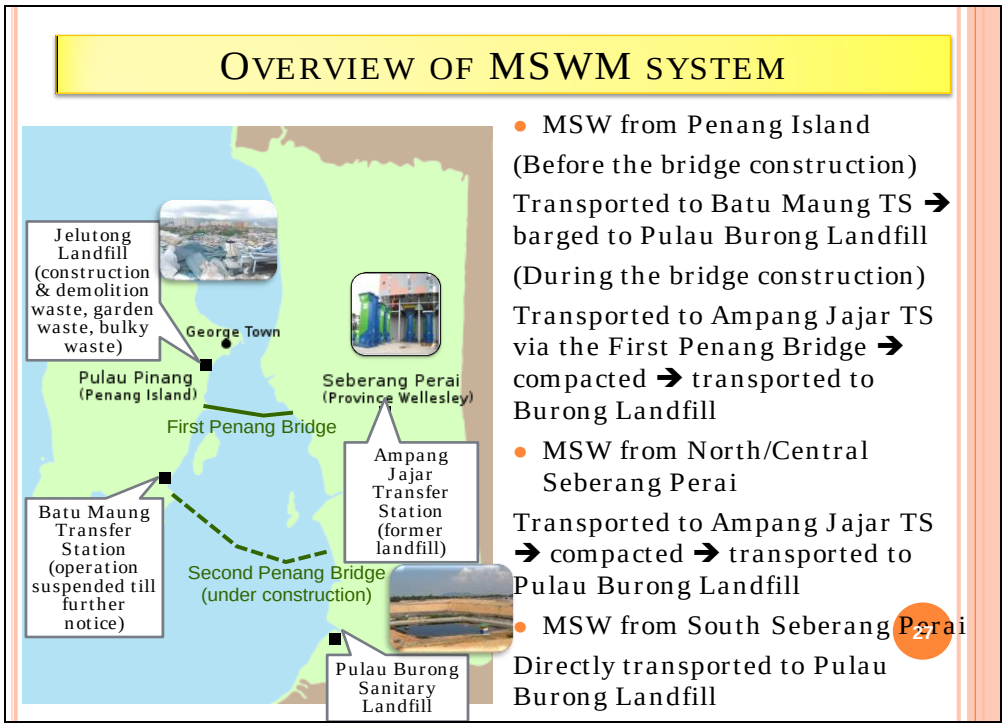
An overall view of the solid waste sector for the two local councils is shown in Table 3.

Table 3: Solid Waste Sector Information for MPPP & MPSP, 2012

Solid Waste Sector Information				
No.	**Item**	**MPPP**	**MPSP**	**Unit**
1	Quantity of waste generated annually	288,377	528,275	Tonnes/year*(2012)*
2	Quantity of waste generated daily	790	1447	Tonnes/day *(2012)*
3	Quantity of waste generated per capita	1.07	1.47	Kg/capita/day
4	Total number of households in the city	189,829	195,829	Households

Solid Waste Sector Information				
No.	**Item**	**MPPP**	**MPSP**	**Unit**
5	Percentage of municipal budget used for solid waste sector	25	43	Percent

The following diagram provides an overview of the Municipal Solid Waste Management System in Penang.



4. Data on Waste Management

4.1. Waste Composition Data

The waste composition data is shown in Table 4 below. Food waste, yard and garden waste including paper forms the major components of MSW.

Table 4: Waste Composition at landfill sites

Type of Waste	MPSP		MPPP	
	Tonnes	**%**	**Tonnes**	%
Food	605.84	50%	206.23	**33%**
Yard & Garden	148.99	12%	59.86	**10%**
Paper	54.12	5%	176.15	**28%**

Plastics	208.10	17%	89.89	**15%**
Textile/Rubber	38.48	3%	19.02	**3%**
Metal	43.36	4%	29.09	**5%**
Hazardous	2.69	0%	1.92	**0%**
Others	98.42	8%	37.74	**6%**
Total	**1,200.00**		**619.90**	

Source: Satang 2003

4.2. Estimated Food Waste Data

Another study estimates the food waste at about 806 metric tons per day (2013) and forecasted it to be 630 metric tons per day in 2020.

Year	Estimated Food Waste (TPY)	Estimated Daily Food Wood Waste (TPD)
2005	348,372	954
2006	379,624	1,040
2007	353,610	969
2008	345,223	946
2009	322,510	884
2010	319,872	876
2011	312,645	857
2012	303,438	831
2013	294,232	806
2014	285,025	781
2015	275,819	756
2016	266,612	730
2017	257,406	705
2018	248,199	680
2019	238,992	655
2020	229,786	630

Source: SERI estimates, 2011 adapted from MPPP & MPSP data 2005-2010

All these food waste accounts for up to 40-50% of MSW disposed at the Pulau Burong Sanitary Landfill. The removal of such waste from the landfill will further prolong its lifespan. Food waste can be potentially composted or processed into compost or liquid fertiliser but generally, the market for these poses a challenge to any producer. Food waste from non-halal sources can only be deemed halal after 45 days processing and used as fertiliser for food production purposes.

Currently food waste from domestic sources and food courts, restaurants and hawkers are co-mingled with other contaminants such as plastic material in the form of straws and plastic bags and wrappers as

well as heavy metals from the fluorescent lamps, used batteries and dry cells rendering them of lower quality. Such can only be used in golf courses and landscaping.

Currently, food waste is processed by the Bio-regen machine at schools, markets and hawker centres as liquid soil conditioners. Green waste is being processed into high quality compost on a pilot scale at the Ampang Jajar Transfer Station and soon at another site at Relau on Penang Island.

Another alternative for food and organic waste in general turn them into refuse derived fuel (RDF) for industrial or to later recover methane for waste to energy purposes from the landfill.

4.3. Other Waste Data

Data for other types of waste streams are shown in the table below.

Table 5: Other Waste Data from the Jelutong Dumpsite, Penang Island

YEAR	BULK WASTE /GREEN WASTE (metric tons)	Daily Average (metric tons)	CONSTRUCTION & DEMOLITION WASTE (metric tons)	Daily Average (metric tons)	EARTHWORK (EXCAVATION WASTE) (metric tons)	Daily Average (metric tons)	TOTAL (Metric Tons)	DAILY AVERAGE (Metric Tons)
2009	78,763.61	215.79	91,346.05	250.26	40,693.29	111.49	210,802.95	578
2010	17,278.41	47.34	180,401.93	494.25	155,859.07	427.01	353,539.41	969
2011	25,737.47	70.51	164,436.40	450.51	243,403.16	666.86	433,577.03	1,188.00

Source: MPPP 2012

C&D waste includes bricks, concrete, masonry, soil, rocks, lumber, paving materials, glass, plastics, aluminum, steel, drywall (gypsum), plywood (formwork), plumbing fixtures, electrical, and roofing materials. Some European countries have been practicing C&D waste management based on prevention (minimisation), recovery and restriction (reusing and recycling).

Developers and contractors are required by law to dispose C&D at the landfills. However, some are illegally dumped along roads, ravines and the countryside etc. by the haulers they engage instead of at the Jelutong or Pulau Burong landfills. There is no treatment of C&D waste as the current system of management does not require or make it mandatory for contractors to undertake such measures. Hence, there is little C&D recovery in Malaysia unlike countries like Japan or Denmark where C&D constitutes a certain percentage of construction material thus providing a ready market for such waste.

There is some information on C&D waste from the Jelutong landfill and also for Seberang Perai. In Jelutong, the estimate is 400 tonnes/day of construction waste and for Seberang Perai; the estimate is 100 tonnes/day. These estimates are provided by officers from both councils. However, there is no aggregated data being compiled by the Councils on indiscriminate dumping from complaints by citizens.

Table 6: Estimation of Construction and Demolition Waste in Penang, 2005-2025

C&D Waste (TPY)	2005	2010	2015	2020	2025
MPPP	438,840	477,943	516,390	553,526	**601,979**
MPSP	511,150	563,328	616,044	668,386	**726,892**
Penang	**949,990**	**1,041,271**	**1,132,434**	**1,221,912**	**1,328,871**

Source: estimated by UNDP Study Team, 2004
** C&D waste generation rate is 1.772 kg/cap/day based on Danish Waste 21 strategies 1998-2004*

In 2005, it is estimated that Penang has generated about 950,000 tonnes of construction and demolition waste (C&D), if the assumption of C&D waste generation rate is 1.772 kg/cap/day. By 2020, it is estimated that about 1.2 million tonnes of C&D waste will be generated.

5. Timeline in Penang

The timeline that has been proposed for Penang to implement a fully integrated solid waste management system is proposed in the table below. The most essential part of the timeline is the implementation of the waste separation at source with the accompanying laws and regulations. Proper infrastructure and collection mechanisms are also needed.

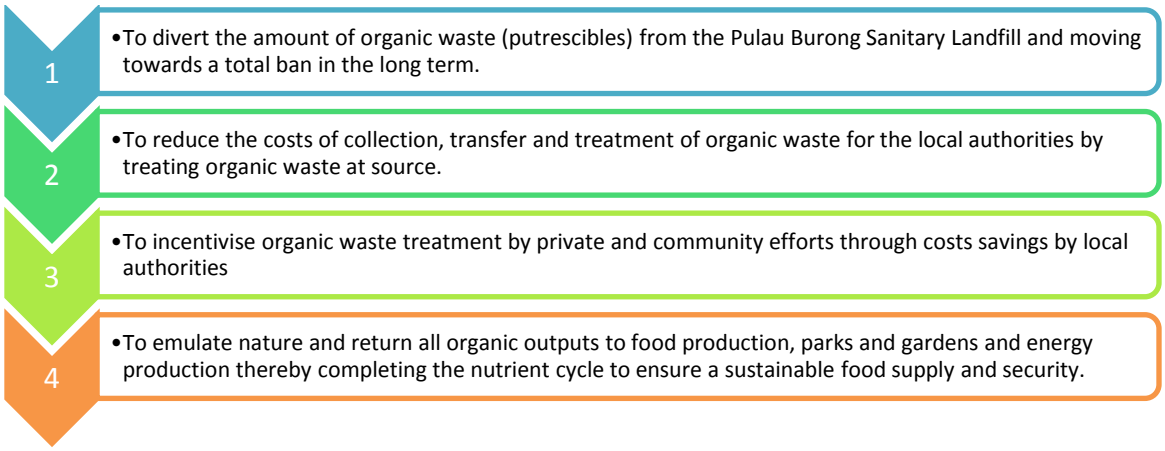
Table 7: Proposed Timeline for Implementation

Action Items	2013	2014	2015	2016	2017	2018	2019	2020	Responsible agency
Licensing of Recyclers									Licensing Dept, Urban Services Dept.
Registration of Collectors									Urban Services Dept.
Database of recyclers									Urban Services Dept., Computer Unit
Mandatory waste separation									Urban Services Dept., Enforcement Division
Enabling infrastructure									Local government
(landfill, transfer station, recovery facilities, buy-back)									Private Investors
Public									Urban Services Dept.

Action Items	2013	2014	2015	2016	2017	2018	2019	2020	Responsible agency
awareness									/NGOs/Media
Government support									Local government
Tax holiday									Federal government
Grants									
Soft loans									
Startup capital									
"Waste to wealth"									

5.1. Broad Strategies

The four main objectives that Penang is adopting for addressing the short-lived climate pollutant pollutants from municipal waste and landfills are illustrated in the diagram below:



Some of the broad strategies that have been identified to minimize waste in Penang are:

5.1.1. Focusing on the 3Rs (Reduce, Reuse, Recycling)

There should be emphasis on the 3Rs and waste minimization as it involves changing peoples' attitudes and present practices to minimize waste at the front end so that waste is reduced in the first place rather than treating it later.

5.1.2. Resource Recovery

Resource Recovery covers a wide array of activities ranging from the itinerant buyers going around neighbourhood in motorcycles, vans and trucks to bigger resource recovery centres like ESH Resource Recovery Sdn Bhd and the various paper mills, e-waste, plastic and aluminum recycling factories in Seberang Perai. It is estimated that there are over 200 recycling businesses

operating in Penang. There are 9 full recovery facilities for e-waste and 40 over for partial recovery.

5.1.3. Food waste processing &Composting

Organic waste, which makes up to 40-50% of the waste stream is separated and can be treated in various waste to produce compost, bio-fuel and other materials.

However, in order for the above to be efficiently carried out, two main criteria must be given emphasis to pave the way. They are:

5.1.3.1. Separation of Waste at Source

The best strategies to be adopted for Penang are the 3Rs and composting. However, the very basic and fundamental step to achieve the above strategies begins with the first step of Waste Separation at Source. No matter what technology the State chooses to treat waste and recover resources, waste separation is the basic step.

Waste Separation at source makes resource recovery more efficient as the resulting recyclable waste is drier, cleaner and lighter.

5.1.3.2. Public Education and Awareness

All the above activities in turn need wide spread public education and awareness campaigns. Interviewees proposed that sustained and continuous efforts be given to public awareness and education.

6. Approaches in Penang

The main approaches for Penang involves the implementation of waste reduction through 3R provision of comprehensive, standardize, efficient, quality and cost-effective SWM services, the establishment of legal, regulation and institutional framework for ISWM; the provision of efficient and effective SWM service delivery through privatization of collection, transfer and disposal. Penang has also to adopt environmentally friendly, cost-effective, proven SWM technology with priority to given to local innovation and solutions. Public education and awareness to achieve mind-set and attitude change continues to play an important and vital part in waste minimisation and resource recovery.

The proposed ISWM strategy for Penang is to embark on a resource recovery - organic composting objective. The rationale behind the objective is that removing organic waste will enhance the recycling because it reduces the co-mingled waste portion up to 40% of the total waste stream.

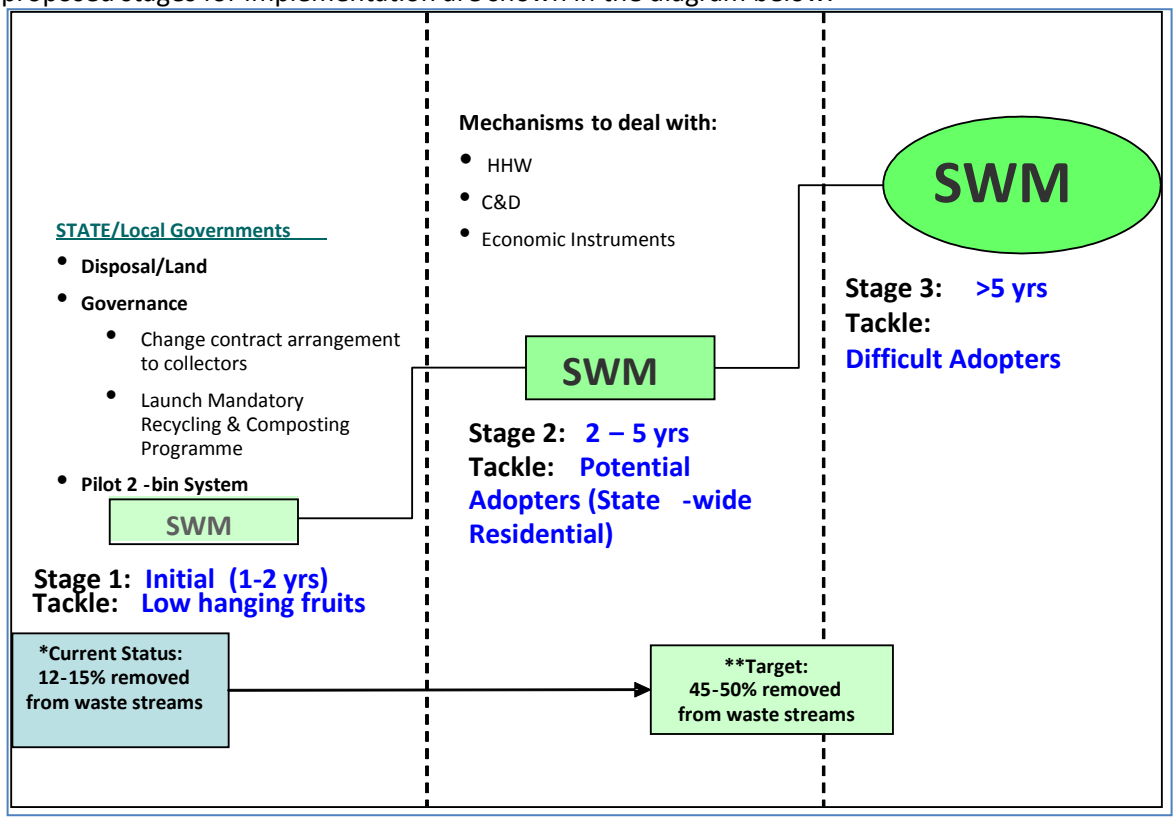
An important component of the recycling-composting strategy is to develop options and channels to facilitate organic waste segregation, and to have available technologies that can properly treat and handle the waste so that it can be managed in a safe and secured way. At the household level, it is vital that there are programmes for backyard composting of food and green waste. At the community level, suitable technologies are available, and proven city level composting technologies are available.

It is only by working out a suitable waste segregation program, devising a proper waste collection system that will handle segregated food/green/organic waste, and applying the appropriative and affordable technologies to treat the waste, that the entire system is technically feasible.

Three types of actions are required to achieve this objective, i.e.

1. Re-designing the waste management system to facilitate the collection of organic waste from identified priority groups into a material recycling oriented society;
2. Developing capacities in selected local communities, NGOs, etc. to increase the participation in organic waste separation, and sustaining this effort with a social program that aims at improving public awareness; and thus move towards a zero waste approach
3. Introducing economic incentives to improve the segregation of waste into "pure" fractions.

The proposed stages for implementation are shown in the diagram below.



STAGE 1: DEVELOPING A SOLID WASTE MANAGEMENT (SWM) POLICY FRAMEWORK (1-2 years)

In Stage 1, the current informal system of recycling and waste management would be replaced by a mandatory system implemented at the local authority level and thus a strong legislation framework to implement. All stakeholders in the SWM system are required to be licensed. With institutionalisation, all solid waste would have a proper channel in which it is collected, transported, treated and eventually disposed.

Action Items:

1. Build Capacity for Local Governments and to meet KPIs

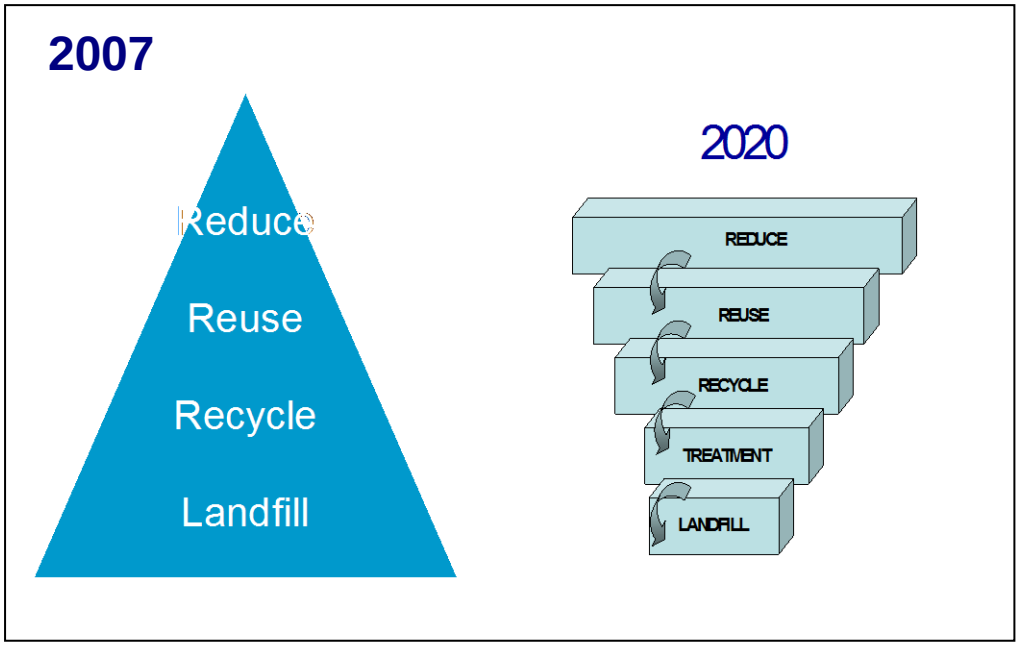
    - The government should build their capacity as a means to improving the overall performance of the SWM system, and thereby reduce overall cost. In the area of KPIs, the typical areas where KPIs could be developed include: customer service, collection, storage, transport, treatment and disposal. The capacities to better SWM and programmes should be developed in order to help the new institutions perform according to the new legislations. These would be in areas such as competitive bidding procedures, SWM planning, monitoring and evaluation techniques, data collection, supervision of concessionaire and contractors, etc.

    - The SWM body should develop templates and procedures, standards and guidelines to facilitate and support the local process to improve on SWM. It is important that specialised training programmes be designed to help LAs, state government and other institutions to support the new effort to manage SWM (and public cleansing). Hence, areas such as promoting public participation in recycling, data collection and analysis, handling and investigating complaints, managing the public's expectations and public relations may be new areas for officers tasked with SWM in the local governments.

2. Implement mandatory waste separation at source for major recyclable items (e.g. paper, cardboard, plastics, metal, glass and putrescibles) to be implemented by 2012.

    - The cost of SWM is high for both MPPP and MPSP and will keep rising, so all measures to reduce and minimise waste are necessary. The waste hierarchy principle, which seeks to reduce, reuse and recycle before treatment and disposal should be the main guiding principle. As such, waste minimisation is a core principle. Source separation would reduce "transaction cost" for recycling and also divert waste from the landfill. This should be adopted as one of the core SWM strategies. Waste Separation at source makes resource recovery more efficient as the resulting recyclable waste is drier, cleaner and lighter.

    - From the analysis of the existing situation of stakeholder groups, it can be observed that the existing waste hierarchy emphasises end of pipe solutions. However, the ideal situation entails a reversal of the present waste hierarchy whereby we should stress on waste minimisation as a beginning of pipe situation i.e. reduce waste generation rather than treating it afterwards. This involves a change of attitude, strategies and mechanisms. The main goal is to reverse the current waste hierarchy by 2020 as shown in the diagram below.



- An important component of the recycling-composting strategy is to develop options and channels to facilitate organic waste segregation, and to have available technologies that can properly treat and handle the waste so that it can be managed in a safe and secured way. At the household level, it is vital that there are programmes for backyard composting of food and green waste. At the community level, suitable technologies are available, and proven city level composting technologies are available.

- It is only by working out a suitable waste segregation program, devising a proper waste collection system that will handle segregated food/green/organic waste, and applying the right technologies to treat the waste, that the entire system is technically feasible.

- As alternative, the representatives from the 7 solid waste contractors on Penang Island during the PEMANDU SWM Lab proposed that "jumbo bags" be distributed to households for the collection of recyclables and the current green bins will be used to collect organic waste on every alternate day from households. These bags will be provided by the contractors who will then buy the recyclables from house to house.

3. Change contractual agreements of waste collectors to cater for collection of separated waste.

    - Contractual agreement with the current waste collectors must be changed to cater for waste separation at source.

    - One of the actions required to embark on this strategy is to revise the waste collection contracts. The local government will have to undertake this because the contracts are signed with them. Conceptually, this is not difficult. It does depend, however, on what is specified the contract. However, it could imply additional cost as equipment or additional services may have to be provided, e.g. more RORO bins, increased budgets for extra collection. Priority areas will be identified that will minimise the additional cost

for this service. It is important to realise that the increase in collection cost and effort will be counterbalanced by savings in the landfill, which is actual savings because more waste will be diverted away, and there will be less for final disposal.

- Currently, the contracts for waste collection in MPPP have just been awarded and MPSP has just closed the open tender for contracts and is in the process of evaluating the tenders. The current contractors are still using non-mechanised compactor units for collection. It would be in the interest of the after the current contract expires to implement the mechanised collection system which requires at most only two personnel to handle door to door collection in landed property residential areas. A GPS system should also be considered to track the movements of the trucks and also prevent illegal dumping in the case of parties (especially commercial enterprises) who engage their own private contractors to haul away their waste.

The schedule for collection may also vary in frequency and collection hours for different housing types and also sectors such as commercial, institutional, markets and food complexes may also be refined to ensure high KPIs. An example for such KPIs is shown in Table 10 below.

Table 8: Frequency and Collection Hours Different Types of Sources

No	Source	Frequency	Collection Hours	Remarks
1	Landed Properties and Residential Dwellings	Alternate Days	6.30am to 2.30pm	For collection is being done 'Daily' except Sunday
2	High Rise, Apartments, and Flats.	Daily (Except Sunday)	6.30am to 2.30pm	
3	Commercial, Institutional & Industrial	Daily (2x Daily)	6.30am to 2.30pm	
4	Markets & Food Complexes	Daily	6.30am to 2.30pm	'Multi Lift Bin' hauled twice daily for; i. Pulau Tikus ii. Campbell St iii. Batu Lancang. iv. Jelutong v. Perak Road vi. Tmn Tun Sardon Other markets and places only once.

It is proposed that collection commercial, institutional & industrial sector will be twice daily.

Bulk such as furniture and large household appliances and garden waste and yard trimmings are collected daily for residential areas except on Sunday. Collection hours are usually from 8.00am to 5.00pm.

4. Ensure that all infrastructures are ready to cater for the separated waste e.g. 2-syream system, buy-back centres, MRFs.

    - The capacities to better SWM and programmes should be developed in order to help the stakeholders perform according to the new legislations. All infrastructures must be ready to cater for the waste separation as source so that separated discards are recovered and not dumped into the landfill.

5. Develop a comprehensive data collection system

    - There is currently insufficient data to aid in planning for SWM, even for the two local authorities in Penang. There needs to be a much better organised system. With the new SWM framework, the priority must be for the new system, i.e. the Solid Waste Management Department, to develop an organised system of data

collection. The purpose of having this system is to help provide data for reviewing and evaluating its effectiveness and efficiency. This system will help reduce the future cost of waste management.

- Hence, a comprehensive identification of key data sources is important and measures should be set up to enable a better system of data collection and analysis so that planners are able to evaluate the overall performance of the new system.

Table 9: Type of Data and Parameters Required

No.	Type of Data	Parameters
1.	Waste Generation per Capita	• Population Growth • Quantity of waste generated • Quantity of recyclables collected
2.	Annual Recycling Rates / Rate of recovery of recyclables	• Quantity of waste generated • Quantity of recyclables collected (per day/ month /year)
3.	Savings due to waste diversion from the landfill	• Quantity of waste disposed in Landfill • Cost of disposal (including, collection, transfer and tipping fees at landfill)

6. Collect household hazardous waste (HHW) for safe disposal

- The issue of household hazardous waste can be resolved if the two local authorities can start the recollection of HHW. Currently, there is no mechanism for handling household hazardous substances in the municipal waste stream, even though the DOE manages scheduled wastes. The state and local governments in Penang recognise that HHW is a problem for the municipal waste stream because of the risk it poses to the environment and human health, but so far, throughout the whole country, HHW is an unresolved issue. Removal of HHW from the waste stream also ensures that any technology used to process the organic fraction into compost is **free of contamination** from heavy metals and other potentially health threatening substances.

- The first task is to define the products which contain such substances and then to try to find ways to measure the quantum in the waste stream. Household hazardous wastes include products that are poisonous, explosive, corrosive and flammable. Many common household products contain hazardous chemicals such as household cleaners, waxes, detergents, solvents, lead-based paints, pesticides, oil and grease, batteries, fluorescent tubes and bulbs, etc. It is also important to note that hazardous substances and wastes are generated by small contractors as well such as PVC tubings and pipes, and other wastes that are also commonly generated by households.

- Hazardous waste generally must be treated before it can be disposed. Kualiti Alam (KA) is the appointed scheduled waste concessionaire in Malaysia.

However, it is widely known that the practice is different from the prescribed procedures. The main reason for the lack of compliance is due to the high cost of scheduled waste management, and also the inconvenience to HHW generators.

- The MPPP had initiated household hazardous waste collection points in several supermarkets and wet markets in 2003. Fluorescent lamps, dry cell batteries and mobile phone batteries are collected by the MPPP and stored for future safe disposal by Kualiti Alam. Five wet markets and four supermarkets have placed special bins for the collection of HHW for the convenience of the public since 7 Jun 2003. MPSP has also a similar HHW programme where the items mentioned are also collected at recycling centres set up all over Seberang Perai. There were 30 collection centres for this purpose with 16 being operated by NGOs while 14 others are operated by MPSP. Similarly, these are also stored for future safe disposal by Kualiti Alam. However, the collection **stopped** as there were no budget provisions to send the collected HHW to KA for disposal.

- The best way to manage hazardous wastes is to reduce the amount of generation or at least to find a way to separate it out of the municipal waste stream. The current means of HHW management is certainly not satisfactory, and an institutional response is required to develop an integrated solution to this problem.

- Currently, most of the HHW in Penang ends up in the sanitary landfill. To avoid the disposal of these wastes into the landfill, the collecting HHW needs to be improved, expanded and publicised. Hazardous Waste collection depots for household hazardous items such as paints, oil, acids, aerosol cans, fertilisers, used medicines, etc. needs to be established to remove them from the waste stream. Collection of HHW should be revived as they are environmental and pollutants and contaminate domestic waste especially the organic waste faction. The contaminated organic waste makes low quality compost that cannot be used for agriculture.

  Currently, there is no mechanism for handling household hazardous substances in the municipal waste stream after the attempted collection a few years back by MPPP.HHW have associated risks that it poses to the environment and human health, but so far, throughout the whole country, HHW is an unresolved issue. The estimation of HHW in Penang is estimated in the table below:

Table 10: Estimation of Household Hazardous Waste Generated in Penang, 2005-2025 (tonnes/year)

HHW (TPY)	2005	2010	2015	2020	2025
MPPP	23,279	25,354	27,393	29,363	**31,933**
MPSP	27,115	29,883	32,680	35,456	**38,560**
Penang	**50,395**	**55,237**	**60,073**	**64,819**	**70,493**

Source: estimated by Study Team.
** HHW generation rate is 0.094kg/cap/day based on Danish Waste 21 Study 1998-2004.*

7. License recycling businesses under a special "recycling" category with mandatory data collection and submission to the local authorities.

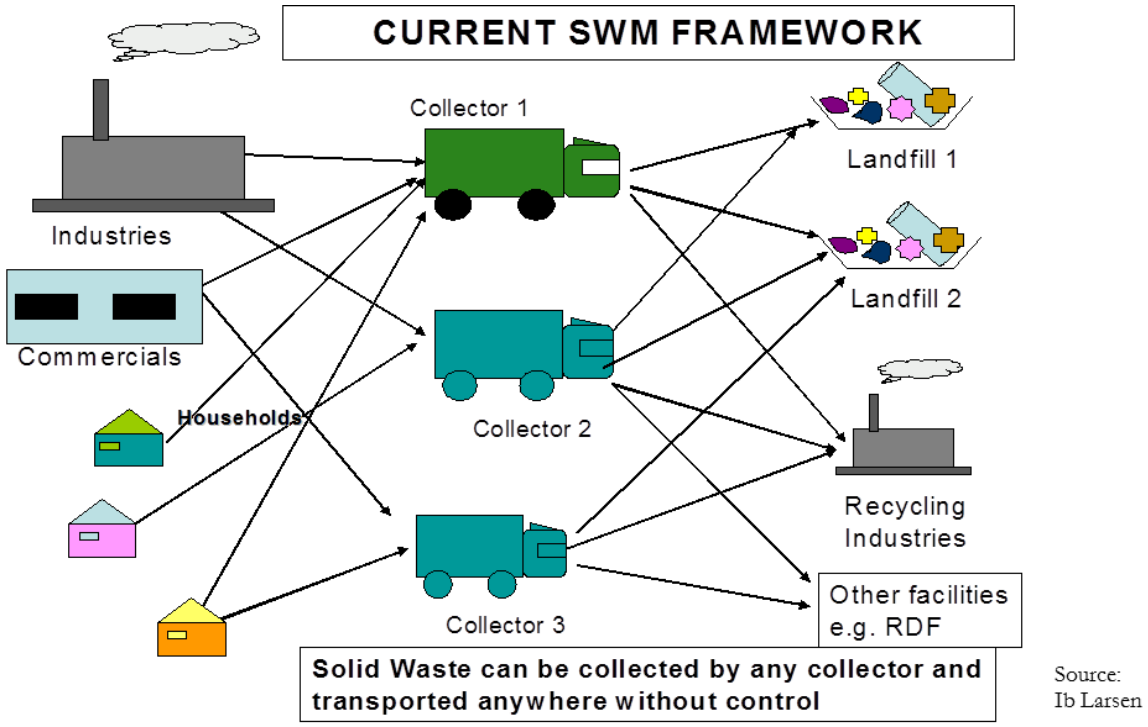


Figure 2: Current Waste Management System in Penang

Figures 2 and 3 show the key difference in terms of the currently practiced system of SWM (1) in Penang with that of the proposed new system (2). In the current system, waste can be collected by any collector, transported by any firm or vehicle, treated by any other party and disposed in any location. This is shown graphically in Figure 2.

Under the proposed new SWM framework, the entire SWM lifecycle will be licensed. From the point the waste becomes a controlled item, its travel path, means or mode of transport, the party collecting and transporting it, the place of disposal would have been determined (the SWM schemes). Figure 3 shows this graphically.

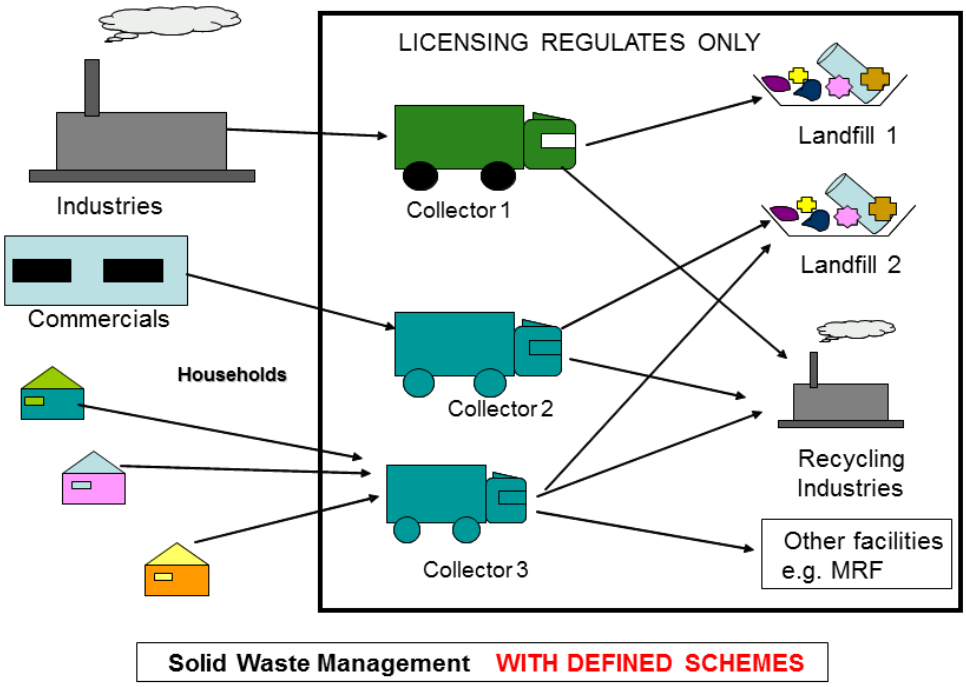


Figure 3: Proposed Waste Management System in Penang

- There are two important aspects of licensing. The first is a revenue function, and the second is permission to perform a service under conditions defined by the law. With regards to the revenue function, there are possibilities of raising the maximum revenue in some activities such as auctioning for the right to collect recyclables through the issuance of special "recycling" category. Part of the licensing requirement would be the mandatory submission of data and reports on a periodical basis.

8. Issue permits for collection of recyclables for CBOs (community-based organisations), NGOs, institutions and charitable organisations.

    - As for permission to perform a service, several classes of permits will be required, for CBOs, NGOs, institutions, charitable organisations in recycling. All players are expected to apply for permits.

9. Develop incentive schemes to encourage waste minimization and diversion of the various waste factions such as paper, plastics, ferrous and non-ferrous metals, glass e-waste & C&D.

10. Incentives are important instruments to influence behaviour. Good behaviour should be rewarded and bad behaviour penalised. Hence, if recycling is to be promoted, recycling activities should be supported and given incentives, while irresponsible behaviour such as excessive waste generation should be made to pay. The incentive system is part of a polluter pays principle, which translated means that the greater the amount of waste,

the higher the amount to pay. Although there is revenue potential in the incentive system, the main purpose is to discipline behaviour.

11. Finalise Payment Level and the Mode of Payment

    - Households should know how much they have to pay, and how payment should be made. The amount is important because households and other waste generators will react to the amount. Without this information, it is difficult to evaluate the impact of the new SWM bill. No doubt, the decision-making process will be difficult as it has to take into account the policies that the government is proposing (e.g. will there be a subsidy, will there be differential charging, will there be a phased full cost recovery mechanism, etc.) Answers to these questions are important in determining how much consumers have to pay. In the past, consumers are not informed about collection and disposal costs and how much of local government revenue goes to SWM or the concessionaires. But the longer the delay in announcing the payment, the less chance there is for people to react to it. The federal government has recently announced that solid waste charges may be imposed after a period under the new Act but they have stopped short of announcing when that would take place. However, the status quo will be maintained until such time the new system is appraised.

12. Implement changes for waste separation starting with easy adopters - targets that are easily achievablee.g. wet markets, hotels, hospitals and schools; food courts under municipal control. These targets are single point sources that are ready to participate in waste separation and are easy to manage with some legislation from the local authorities.

13. Continue and expand the public education and awareness programme in the communities and institutions such as schools and colleges. Awareness and public education can be carried out through the Environment Resource Centres that have been setup in every district. A good example of such a centre playing an effective role for the community is the one at Taman Desa Damai, Bukit Mertajam that has become a showcase for many other communities to follow suit.

STAGE 2: EXPANSION (2-5 Years)

At the end of Stage 1, it is envisaged that the new SWM system has been implemented and the major problems of implementation would have been resolved. For example, the institutional coordination required to resolve household hazardous substances would have developed and mechanisms to collect such wastes developed and, the application of market based instruments to manage municipal waste or its fractions, etc. Public awareness programs are in place, and all necessary regulations have been developed to enable the state legislations to be implemented.

The social programmes in item 12, Stage 1 should be expanded even further. There should now be an increasing participation rate more social groups in recycling and waste segregation coupled with incentives for waste recycling and minimisation.

If data collection systems have not been set up earlier, these would be a priority at this stage of the implementation of the new SWM framework. Data are vital for planning but the system to analyse data so that it can be used for planning requires focus and effort as well as involvement of the institutions.

Action Items:

1. Develop relevant policies for different waste generators such as introducing a new vacuum waste collection system and static compactors for commercial complexes, wet markets and institutions that have to handle a voluminous amount of waste. Compaction at source makes collection and transfer of waste more efficient and cheaper.

2. Upgrading waste disposal systems for municipal & commercial food complexes. This involves the installation of food processing machines that can turn leftover food scraps and kitchen trimmings into useful products such as compost or liquid fertiliser.

3. Food waste /kitchen waste, green waste which forms a major proportion of organic waste should also be separated and collected from eating places/food courts, hotels, hospitals and wet markets as these can produce good quality compost or liquid fertilisers which technology that is currently available. Food waste may also be used to produce biogas for cooking purposes for farms, small community halls, hostels etc. A simple prototype is currently in operation at the Environment Resource Centre, Taman Desa Damai Bukit Mertajam. Used cooking oil should also be collected as they are a major source of pollutants in drains and waterways. Used cooking can be used as fuel for boilers, soap making or for biodiesel.

4. Develop specific approaches for “Potential Adopters”: high rise condominiums with management corporations; landed residential properties.

5. Develop approaches to deal with other difficult waste such as HHW such as fluorescent lamps, bulbs and C&D. HHW is currently collected but has to be disposed off via Kualiti Alam to the Bukit Nanas secured landfill in Negeri Sembilan. It is now timely to find ways and appropriate technology to process this waste locally.

STAGE 3: REPLICATION (> 5 Years)

If all goes according to plan, Stage 3 would be concerned with three main areas.

First, it would extend mandatory waste segregation to all the remaining groups that have not yet come into the mainstream. Social programmes would be developed for these groups from the experience of the earlier stages. Guidebooks and manuals for involving specific stakeholders, and Standard Operating Procedures (SOPs) would have been prepared and used. The greater involvement of the public and the development of social networks which is the strength of the Penang society, with the support of the private sector would have been demonstrated. Public awareness campaigns will be an on-going feature of this system. The Penang SWM Model of involving the public, specific types of stakeholders would be ready for replication beyond its borders.

Table 15 shows the per capita generation from the various sources on Penang Island.

Table 11: Estimate of Solid Waste Generation by Source, Penang Island

Source	Waste Generation rate (kg/c/d)	Amount of Waste (tonne/day)	Organic Waste (tonne/day)	Recyclable Waste (tonne/day)	Non-Recyclable Waste (tonne/day)
Household (HR)	0.91	400.7	143.1	194.5	63.2
Household (LR)	0.91	119.0	42.5	57.7	18.8
Household (Individual)	0.84	98.3	35.1	47.7	15.5
Industrial	1.5	246.4	6.6	234.1	5.7
Wet market (stall)	19.3	40.6	37.5	3.1	0.1
Hawkers stall	8.67	19.7	18.7	0.8	0.2
Hotel (room)	1.35	17.0	15.8	1.1	0.0
School	0.009	2.8	1.7	1.1	0.0
College	0.016	0.3	0.1	0.2	0.0
Hospital (Beds)	0.57	2.3	1.5	0.8	0.0
Hypermarkets (m2)	0.0013	0.9	0.2	0.7	0.0
Universities	0.99	14.9	11.7		11.3
Total		962.9	310.2	541.8	103.2

Source: estimated by Study Team, 2005

Based on the table above, priorities can be identified and strategies and SOPs can be worked out for each generating source.

Second, the government should at this stage examine ways to improve its financial bottom line. To ensure that any system is sustainable, it should be financially sustainable. However, to do this, it would require actions on two sub-components. The internal aspect is to improve the cost-effectiveness of the system. Of course, to do so will require technical improvements as well. On the financial side, contracts must be devised such that they deliver value. On the technical side, they must deliver the solutions required by the public. The second aspect is to discipline behaviour and actions of the public. More user pay and polluter pay schemes should be implemented both at the local and federal level. The system should move towards using more of such instruments to influence behaviour, particularly those who do not participate or behave for one reason or another.

Third, the local government must continuously improve the efficiency of the ISWM. This will require research and examining the data collected throughout the ISWM process, and to develop ways to further reduce waste, treat the waste and minimise wastes going for disposal.

In the third area, the local government will probably play a bigger role as efficiencies are mainly a local issue, although there could be system efficiencies that could be gained from better integration and management. Essentially, the local government's role is important in ensuring that the system is efficiently maintained and operated. Only in this way can the cost of SWM be minimised. Minimising cost has been a theme of this UNDP-Penang Study, and Stage 3 is the proper stage to undertake this.

Action Items:

1. "Hard Core" or "Difficult Cases": low rise flats without management corporations, roadside hawkers, hawker complexes, restaurants, and SMIs.

2. Extend mandatory waste segregation to all the remaining groups that have not yet come into the mainstream.

3. The government must continuously improve the efficiency of the integrated SWM by looking at cost reduction and recovery and better disposal techniques.

The phasing for the mandatory recycling programmes is shown in table 4 below.

Table 12: Phasing in Mandatory Recycling Programmes

Horizon	Types of Waste	Types of Solid Waste Producers
Hazardous waste		
Short term (within 2 years. This would allow for pilot testing mandatory recycling schemes and awareness-raising before the mandatory requirements be effective.)	Selected toxic waste: • Batteries; • Cell phones; • Fluorescent bulbs; • Pesticide cans.	**Mandatory for:** • **Hotels;** • **Hospitals;** • **Schools;** • **High rise buildings.**

Horizon	Types of Waste	Types of Solid Waste Producers
Medium term (from 2-4 years)	Selected toxic waste: • Batteries; • Cell phones; • Fluorescent bulbs; • Pesticide cans.	**Mandatory for all.**
Long term (from 4 – 7 years)	All toxic waste.	**Mandatory for all.**
Non-hazardous waste		
Short term (within 2 years)	Selected waste: • Paper; • Aluminium (cans); • Plastic bottles; • Glass; • Food and yard waste. • Used Cooking oil	**Mandatory for:** • **Hotels;** • **Hospitals;** • **Schools;** • **Wet markets;** • **High rise buildings.**
Short term (within 2 years)	• Waste tyres	**Mandatory for all.**
Medium term (from 2-4 years)	Selected waste: • Paper; • Aluminium (cans); • Plastic bottles; • Glass; • Food and yard waste.	**Mandatory for all.**
Long term (from 4 – 7 years)	**Additional recyclables may be added when financially or economically profitable.**	**Selected producers or all depending on the products and implementation costs.**

7. Technology Gaps and needs to achieving a Low Carbon Society

Penang State has implemented many solid waste management approaches with the ultimate aim of waste minimization and diversion from the landfill to achieve its SWM targets. However, Penang has still many technology and non-technology gaps to bridge before achieving its set targets.

Recycling rates are improving over the years (please refer to Table 13) demonstrating better and more efficient resource mechanism and systems that have been spearheaded by the private sector (both formal and informal) and the roles that NGOs, CBOs and actively play with the help and empowerment by the local authorities. However, current technologies employed should go beyond basic resource recovery operations to turn them into high quality products.

Resource recovery and the practice of the 3Rs at the community level are not major problems as there are plenty of recycling business and recovery facilities that take in recyclable items. However, there is a large technology gap when it comes to recovery of resources at the municipal level (mixed wasted at the transfer station and landfill). These two points involve large quantities of waste and need the appropriate, accessible and affordable technologies.

Table 13: Waste Generation and Recycling Rates

Year	Waste Disposed at Landfill Per Year (metric tons)			Recycling Per Year (metric tons)			Total Waste Generation Per Year (metric Tons)	Recycling Rate (%)
	MPPP	MPSP	Total	MPPP	MPSP	Total		
			A			B	C=(A+B)	B/C
2005	280,489	416,254	696,743	57,178	96,032	153,210	849,953	**18.03%**
2006	295,498	463,750	759,248	82,210	119,964	202,174	961,422	**21.03%**
2007	216,490	490,729	707,219	80,351	125,504	205,855	913,074	**22.55%**
2008	218,440	472,005	690,445	33,775	124,121	157,896	848,341	**18.61%**
2009	216,456	428,563	645,019	61,307	132,039	193,346	838,365	**23.06%**
2010	213,591	426,152	639,743	63,756	129,804	193,560	833,304	**23.23%**
2011	209,701	401,663	611,364	72,341	144,682	217,023	828,387	**26.20%**
2012	205,972	370,989	576,961	82,405	157,286	239,691	816,652	**29.35%**

Source:
Penang Island Municipal Council (MPPP), 2013
SeberangPerai Municipal Council (MPSP), 2013

7.1. Study visit

<table>
<tr><th>Schedule</th><th>Study visit</th></tr>
<tr><td>26-28 Jun 2013</td><td>

Jelutong landfill site
Specific Waste Streams (construction and demolition waste, marine clay, organic food waste)


Jelutong landfill site

Garbage truck

Marine clay
</td></tr>
<tr><td>20-22 August 2013</td><td>

Kick-off meeting
Waste transfer station and sanitary landfill site
Waste recycling (recover resource, composting, food to food, etc)
3R activities (shopping mall, community level, etc)


Kick-off meeting

Ampang Jajar transfer station

Pulau Burong Sanitary landfill site

Resource Recovery

Food to food Liquid fertilizer

Waste separation Community level
</td></tr>
<tr><td>21-23 January 2014</td><td>

Wood waste treatment
Food waste generation and collection
3R activities (school, hospital)


Wood waste

Composting of wood chips

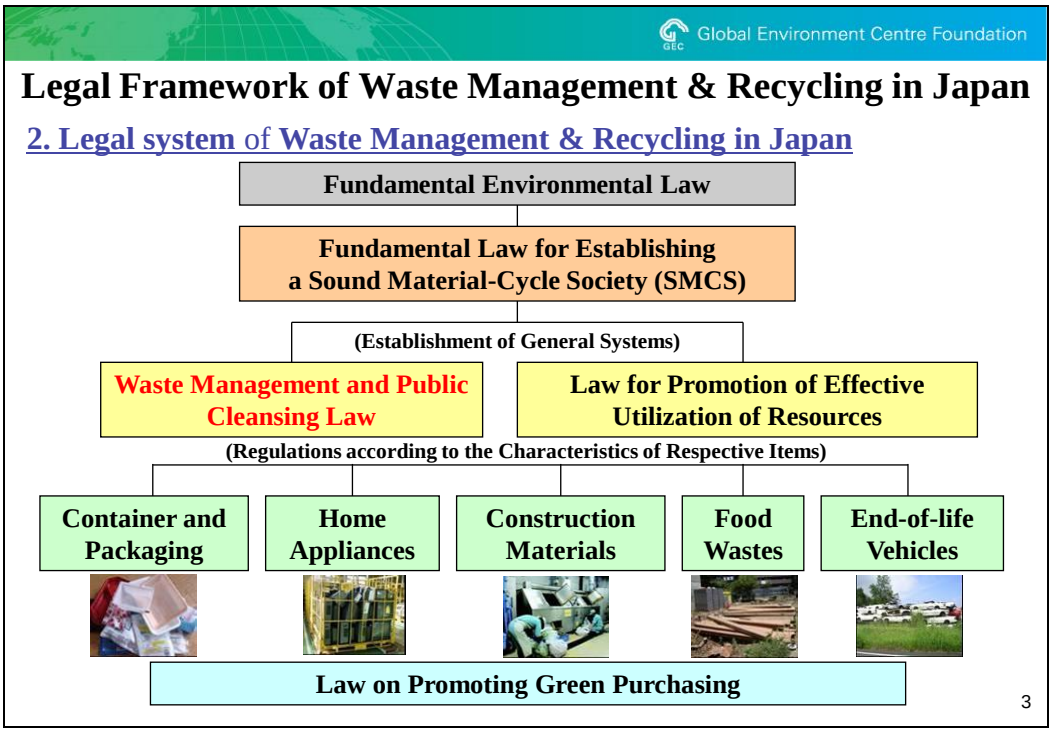
Food waste
</td></tr>
</table>

7.2. Assistance from Kawasaki City / JFE Japan achieving a Low Carbon Society

The Kawasaki City / JFE / MOEJ cooperation with Penang can further enhance the current ISWM system in the introduction of a new legal framework inorder to achieve an advanced waste separation collection system and public awareness; deal with some common household hazardous waste e.g. used fluorescent lamps, scale-up mass-composting technology and convert waste to energy from wood waste and other bio-mass. Some of the elements that should be included in the new ISWM plan with the aid of Kawasaki's innovative green technologies are described below. The comments are based on the field visit to the various operations to Kawasaki recently.

7.2.1. Establishing a legal framework

During the visit Penang State Team was very impressed by comprehensive legal framework recycling laws that are already in existent in Japan. This will further improve our solid waste management system. The team has requested for a translation of the existing SWM and Recycling laws in Japan for the purpose of adapting it to the local Penang context and situation. The main legal framework work involves the fundamental source separation of waste law for the domestic and commercial sector followed by some of the more specific laws for different waste streams. This is clearly shown in the GEC slide below.



The Penang Government is keen to request Kawasaki City /MOEJ to share these laws with us. We are currently collecting and studying laws from various places so that these laws can be announced in early 2014.

7.2.2. Using Kawasaki's Innovative Technology for waste treatment and resource recovery

Japanese technologies are needed as second processes to convert discards into resources such shredded wood chips from green waste and construction wood waste. Without the an appropriate and affordable technology to further process the current waste recovered, the products will be of low quality and may not be sellable or command premium prices in the market place.

7.2.2.1. Fluorescent Lamp recycling

There are currently no used fluorescent lamp recovery and recycling facility in Malaysia and there is a dire need for one. The Penang State Government is keen on that such a facility be established in Penang that will cater for the northern states of Perlis, Kedah, Penang and Perak. It would probably be the first of its kind in the country.

7.2.2.2. Waste to Energy Projects

Penang also lacks technologies especially in area of waste to energy to take advantage of the Fit-in-Tariff system of the national government. The Dewan Rakyat (People's Assembly)in April 2011 passed the Advanced Renewable Tariffs (feed-in tariff) system and renewable energy targets which is to take effect beginning in September 2011 but was recently pushed back to 1 December 2011. The FiT program pays different rates depending on the type of renewable energy and the size of the facility. The highest rates RM 1.23 to 1.14 per kWh (C$ 0.40 to 0.37/kWh) are paid for solar PV with under 1 MW generating capacity. Municipal waste qualifies under the biogas category with 32 sen per kWh (<10kWH) with a 8 sen bonus /kWh for 16 years and also biomass especially if green waste can be treated with 31 sen per kWh (<10kWH) with a 10 sen bonus /kWh for 16 years.

So waste-to-energy technologies are important to the overall ISWM masterplan for Penang. The concessionaires for the transfer station and landfill have expressed keen interest in the feasibility studies of such plants to convert food waste, green waste and other bio-mass into bio-gas and energy. This is an area that needs to be seriously looked at.

Table 14: Renewable Tariffs for Energy Generation, Malaysia

Renewable Tariffs in Malaysia (Proposed for 2011)						
13-Aug-10						
			0.1997	1.261		
	Years	MYR/kWh	€/kWh	CAD/kWh	USD/kWh	Degression
Solar PV						
<4 kW	21	1.23	0.246	0.310	0.302	-8.0%
>4 kW<24 kW	21	1.20	0.240	0.302	0.295	-8.0%
>24 kW<72 kW	21	1.18	0.236	0.297	0.290	-8.0%
>72 kW<1,000 kW	21	1.14	0.228	0.287	0.280	-8.0%
>1 MW<10 MW	21	0.95	0.190	0.239	0.233	-8.0%
>10 MW<30 MW	21	0.85	0.170	0.214	0.209	-8.0%
Bonus for rooftop	21	0.26	0.052	0.066	0.064	-8.0%
Bonus for BIPV	21	0.25	0.050	0.063	0.061	-8.0%
Bonus for local modules	21	0.03	0.006	0.008	0.007	-8.0%
Bonus for local inverters	21	0.01	0.002	0.003	0.002	-8.0%
Biomass						
<10 MW	16	0.31	0.062	0.078	0.076	-0.5%
>10 MW<20 MW	16	0.29	0.058	0.073	0.071	-0.5%
>2 MW<30 MW	16	0.27	0.054	0.068	0.066	-0.5%
Bonus for gasification	16	0.02	0.004	0.005	0.005	-0.5%
Bonus for steam generation >14% effic.	16	0.01	0.002	0.003	0.002	-0.5%
Bonus for local manufacture	16	0.01	0.002	0.003	0.002	-0.5%
Bonus for municipal solid waste	16	0.10	0.020	0.025	0.025	-1.8%
Biogas						
<4 MW	16	0.32	0.064	0.081	0.079	-0.5%
>4 MW<10 MW	16	0.30	0.060	0.076	0.074	-0.5%
>10 MW<30 MW	16	0.28	0.056	0.071	0.069	-0.5%
Bonus for gas engine >40% effic.	16	0.02	0.004	0.005	0.005	-0.5%
Bonus for local manufacture	16	0.01	0.002	0.003	0.002	-0.5%
Bonus for landfill or seweage gas	16	0.08	0.016	0.020	0.020	-0.5%
Minihydro						
<10 MW	21	0.24	0.048	0.060	0.059	0.0%
>10 MW<30 MW	21	0.23	0.046	0.058	0.056	

Source: KETTHA (Ministry of Energy, Green Technology and Water)

This must be accompanied by formulating relevant laws and regulations that cover specific waste streams like those that have been developed in Japan over the years. The lack of such laws impedes the implementation of an effective and efficient solid waste management system in Penang.

7.2.2.3. C&D Waste

C&D is only profitable and viable if it is void of any form of contaminations as far as possible. It is one of the hardest waste stream to profitably separate mainly because its components comprises:

- Excavation waste and marine clay
- Concrete, mortar, sand stones, earth and bricks
- Metal
- Wood
- Plastics

- Broken glass and window panes
- Other organic waste
- Other mixed waste.

Based on the field trip to Kawasaki, we observed that there are technologies for C&D recycling in operation. This technology would be most useful for Penang's case and should be studied whether it is feasible or not.

7.2.3. JCM Mechanism

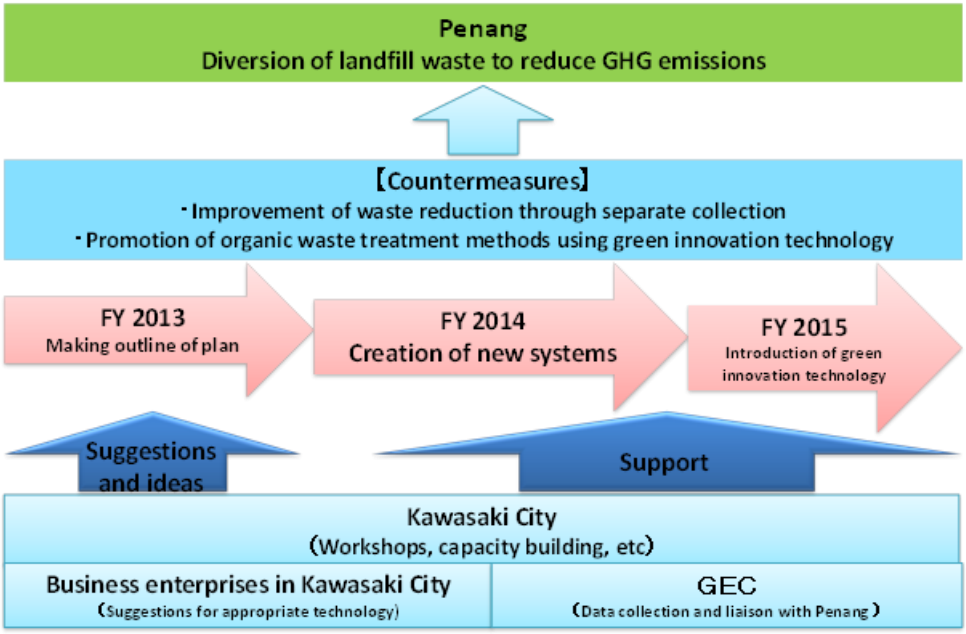
Penang would also benefit greatly from learning about the JCM mechanism and how Penang's Organic Waste Policy which stresses on organic waste diversion from the landfill and methane avoidance.

UNEP and the World Bank, in close cooperation with local partners including Penang State Government and civil society (private sector and non-profit organizations) will design and develop implementation plan based onresults based finance (RBF) programme to incentivize source separation. Results-based financing (RBF) is an umbrella term that includes output-based aid (OBA), provider payment incentives, performance-based inter-fiscal transfers, and conditional cash transfers. What these mechanisms have in common is the fact that a principal entity provides a financial or in-kind reward, conditional on the recipient of that reward undertaking a set of predetermined actions or achieving a predetermined performance goal. Resources are disbursed not against individual expenditures or contracts on the input side, but against demonstrated and verified results/outputs that are largely within the control of the recipient.

This World Bank activity can be incorporated with the JCM concept. We would like to request Kawasaki City's assistance to help us with this integration.

8. Proposed areas of study

The bilateral meeting between Penang State and the Japanese team on 11 September2013, has identified the following time line for the Project. The making of an outline plan starts in late 2013 and culminates with the introduction of green innovation technology in 2015.



The two main aims for the feasibility studies are:

1. Improvement of waste reduction by separate collection approach and the
2. Promotion of organic waste treatment method using Kawasaki's green innovation technologies.

From the outcome of the Penang State team's visit and training experience to Kawasaki from September 10th -11th, 2013; some of the concrete requests from the Penang State Government for feasibility studies are summarized below.

8.1. Software Component

The goal of achieving a low carbon society in Penang goes over and beyond the waste to energy approaches. In order to create a balanced, wholesome and holistic system some of the approaches / technologies that Penang State is keen on cooperation with Kawasaki City are:

1. Formulation of new fundamental laws and regulations at the municipal or state level by adopting and adapting the laws and regulations that already exist in Japan.
2. Carbon Challenge Kawasaki
3. Joint Carbon Mechanism for carbon trading
4. Networking and exchange of information between Penang and Kawasaki City communities to promote a material recycling society.

8.2. Hardware Component

1. Processing of used fluorescent lamps and other e-waste such as setting up a regional processing plant for Penang and Northern States of Peninsular Malaysia i.e. Perlis, Kedah, Penang and North Perak.
2. Setting up of smaller scale biomass processing plants using food waste, wood chips or wooden pallets for energy.
3. Second process technologies to value add shredded green waste and wood chips into fuel or green coal or RDF.
4. Processing of discarded wood from the construction & demolition waste (C&D)
5. Value-add to compost such as pelletisation for easier sale as fertiliser.
6. Small machines that process plastics into fuel e.g. Blest Co. Japan

9. Conclusion

Penang aspires to be Malaysia's first Green Manufacturing Hub and low carbon city in the country that will proudly showcase infrastructure, facilities, layout and operations that will address issues such as the reduction or avoidance of greenhouse gas emissions and other pollutants, energy management for sustainable energy consumption and water management for sustainable water consumption and pollution control of water ways.

We also wish to boast of facilities management and high performance buildings and factories (towards green building characteristic); the capacity to produce eco-labelled products/ eco-design products following Japan's example. This we believe can come from Kawasaki City's /Japan's vast experience and array of available technologies for waste treatment and waste to energy approaches.

Successful SWM Strategies and Programmes are dependent on 3 main factors:

- Willingness of the public and stakeholders to participate in Government programmes and projects and;
- Sustained Public Education and Awareness Campaigns to change attitudes by the Government
- Keen participation from the private sector.

The community and local authorities play very important roles in the project. Communities must express an interest in the project. Interest must come from the community so that ownership of the project by the community will ensure project sustainability. Local champions must be identified to initiate and provide leadership as well as to coordinate and implement the programmes and project on the ground.

In order for SWM programmes and projects to be successful, there must be seed money for the initial building of infrastructure and later on maintenance and operations either from the local authorities or funds from the multinational companies or the private sector who may be willing to support environmental projects.

The Local Authorities should formulate regulations and by-laws on encourage more compliance to waste separation at source and recycling activities.

Economic-based incentives and charges which are the penalty and reward systems; have been proposed by the respondents to encourage more recycling and resource recovery activities and to deter the use of undesirable items such as excessive use of plastics and Styrofoam.

There is a need to promote public education and also to raise awareness on SWM issues on a sustained basis as to be information rich like in Japan. Courses for politicians and decision makers are also necessary to ensure political will and correct policies and regulations are formulated to ensure a sustainable environment. Ultimately, the policy should be able to bring about a change in attitude of the public in attitude and behaviour on solid waste management through public education and awareness programmes for sustainability.

We believe that Kawasaki City's cooperation in assisting us establish a new system of laws, technology and capacity building will help Penang will become a very important player regionally and internationally with the implementation of the eco-town project to turn it into a Low Carbon City and in the broader context towards GREEN ECONOMY & GREEN GROWTH.

Based on the recent workshop held on 21 January 2014, at Bilik Mutiara Level 52, KOMTAR, Penang; the stakeholders have come to a conclusion that although a number of proposals have been forwarded in this paper, the focus of the feasibility study would be on the following:

1. Hardware component : Biomass Waste to Energy from wood chips or wooden pallets
2. Software component : Formulation of new fundamental laws and regulations at the municipal or state level

9.1. Reduction of GHG Emission

9.1.1. Description of the Project Boundary

GHG reduction is calculated based on cases assumed regarding operations in the following two categories.

1. Biomass power generation using wood chips or wooden pallets
   By reducing and recycling wood waste from construction waste, methane gas to be emitted from landfill sites will be reduced as the amount of waste to be sent to landfill will be reduced.
2. Diversion of landfill wood waste
   When wood waste from construction waste is not reduced or recycled, the waste will be utilized as biomass energy to generate electricity.

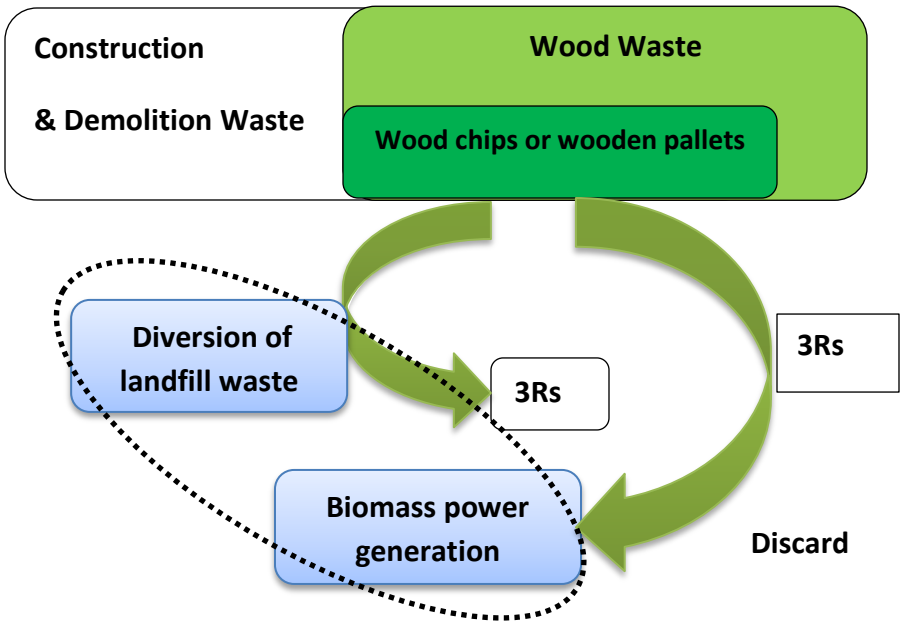


Figure4: Project Boundary

Project Base (Assumed case)

Activity	Conditions	Emission reduction
Biomass power generation	Rated power:5,000kw Capacity ： 91,000t/year Generating efficiency:24% LHV:13,000kJ/kg Operation day :300days	19,800t/year
Diversion of landfill wood waste	Diversion amount from landfill sites:100t/day Operation day :300days	95,130t/year
Estimated reductions(tCO2)	-	114,930 t/year

9.1.2. MRV Methodology

- ERy =BEy-PEy

  ERy: Emissions reduction in year y (t CO2/year)

  BEY: Emissions in the baseline scenario in year y (t CO2/year)

  PEy: Emissions in the project scenario in year y (t CO2/year)

- Baseline Emissions

  $BE_y=BE_{CH4y}+BE_{ENy}$

BE_y	Emissions in the baseline scenario in year y (t CO2/year)
BE_{ENy}	BE_{ENy} =BEelec,y=EGy × EFelec BEelec,y:Baseline emissions from electricity generated utilizing the energy from biogas in the project activity and exported to the grid(tCO2/year) EGy:Amount of electricity generated utilizing the energy from biogas in the project activity and exported to the grid during the year y (MWh) EFelec:Emission factor for electricity generation in year y(tCO2/MWh）
BE_{CH4y}	BE_{CH4y}=Wy × CF_{CH4}× GWP_{CH4} Wy: Amount of landfill wood waste during the year y(t/year) CF_{CH4}:Emission factor for methane(tCH4/t) IPCC 2006 Guidelines for National Greenhouse Gas Inventories GWP_{CH4}:Global warming potential for methane(tCO2/tCH4) (Default value=21)

◆ Project Emissions

PE_y=$PE_{EC,y}$+ $PE_{FFC,y}$

PEy	Project activity direct emissions in the year y (tCO2/year)
$PE_{EC,y}$	Emissions from electricity consumption at the biomass production plant and landfill sites in the year y(tCO2/year) PE_{EC}, =EC_{PJy}×EF_{elec} EC_{PJy} ：Electricity imported from the grid (MWh/year） EF_{elec} : Emission factor for the grid(tCO2/MWh)
$PE_{FC,y}$	Emissions from fossil fuel consumption at the biomass production plant and landfill sites in the year y (tCO2/year) PE_{PFy}=FCi,y ×NCVi ×EFfuel,i FCi,y ：Fossil fuel consumption(t, kl, m3/year) NCVi : Net calorific value of fossil fuel (GJ/t, kl ,m3) EFfuel,i : Emission factor for fossil fuel(tCO2/GJ)

◆ Leakage

Emissions resulting from transport of wood chips or wooden pallets waste

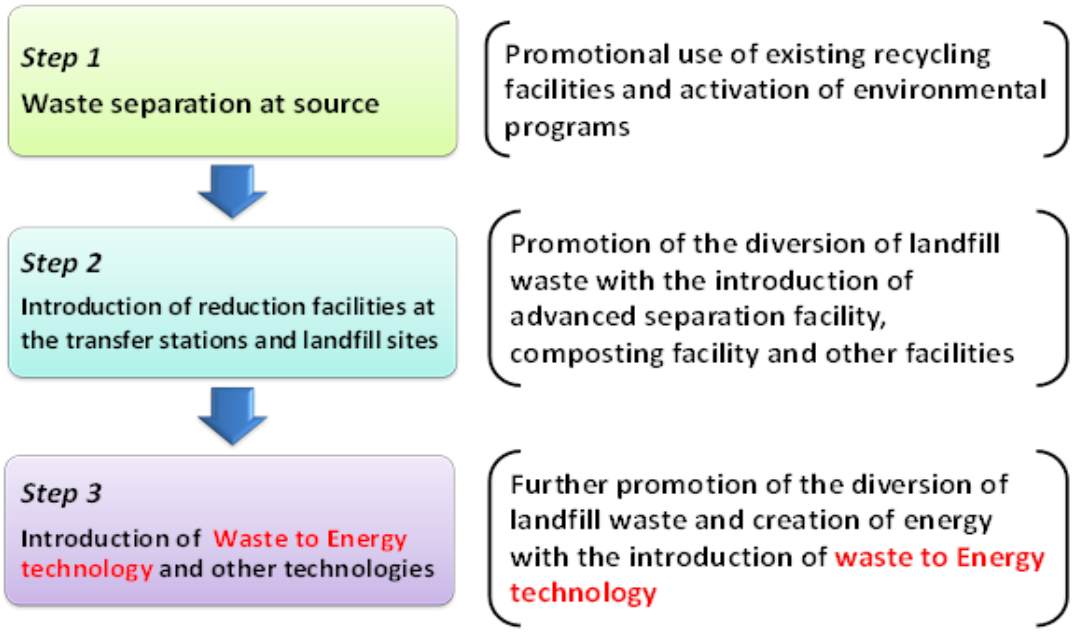
9.1.3. Co-benefit

- Promotion of resource recovery and recycling
  Sorting waste at the point where waste is produced will promote resource recovery and recycling.
- Reduction of environmental impact at the landfill sites
  As the amount of waste sent to landfill will be reduced, environmental impact at landfill sites such as seepage water contamination and offensive odor will be reduced.
- Improvement of environmental education and incentive for 3Rs
  Excellent facilities for sorting, reducing and recycling waste and biomass power generation systems can provide environmental education for organizations including schools. Announcement and recommendation of advanced operations will serve as incentives for other operators.

- Creation of new employment under the new systems
  Promotion of waste reduction and recycling expands resource recovery and recycling markets. The introduction of biomass power generation systems leads to new employment.

9.2. Toward Commercialization

The process for commercialization of Biomass Waste to Energy from wood chips or wooden pallets is as follows;



9.2.1. Project Organization

The project of biomass power generation with wood waste can be managed by the existing waste service companies. However, considering stable operations with facility maintenance cost, information disclosure and power generation operations, we suggest that the management of this project is run by public corporations in partnership with the government of Penang, Seberang Perai or Penang Island and Malaysian companies. We expect that the international consortium between the public corporations and Japanese companies will bring technical support in running the facilities and investment required in training and operations.

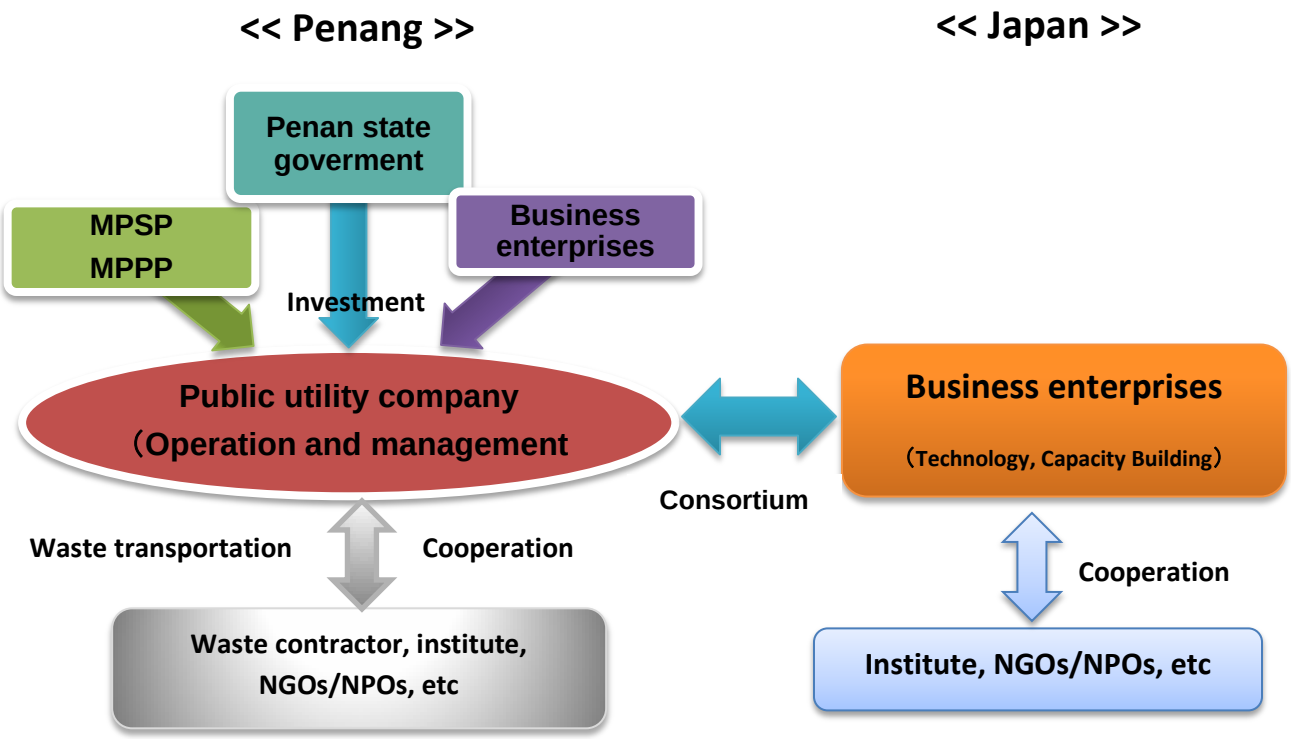


Figure 5: Project Organizational Chart (Proposal)