THE UNIVERSITY OF MELBOURNE

MERIT
MELBOURNE ENGINEERING RESEARCH INSTITUTE

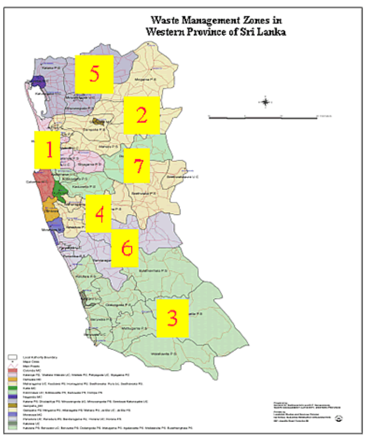
Wastes to Energy

Lu Aye

Acknowledgement

The presenter wish to thank the Waste Management Authority of Western Province of Sri Lanka for organising this workshop.

1. Colombo
2. Gampaha
3. Kalutara
4. Dehiwala Mt Lavinia
5. Negambo
6. Moratuwa
7. Jayawardanapura



Outline

MERIT MELBOURNE ENGINEERING RESEARCH INSTITUTE

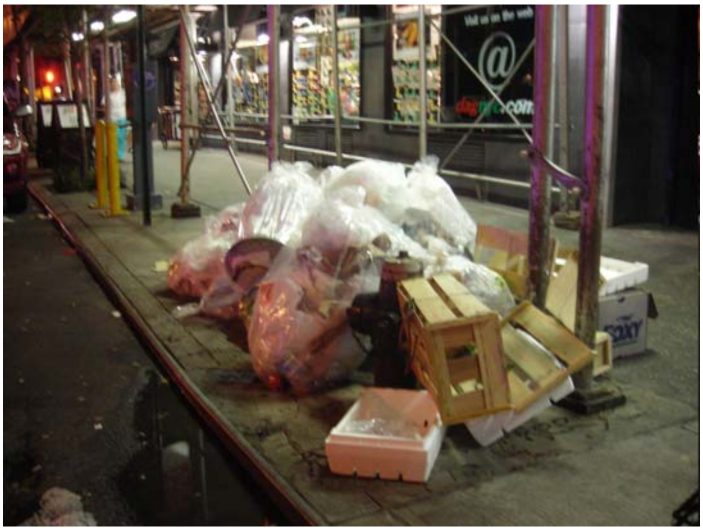
- Urban Solid Waste and social economic development stages
- Issues in Asian cities
- Collection efficiencies
- Typical waste characteristics
- Desired material-cycle
- Options available
- A case study: Management of market waste in Jakarta
- Discussions: desired end state or objective
- Workshop: SWOT analysis

We are not alone!

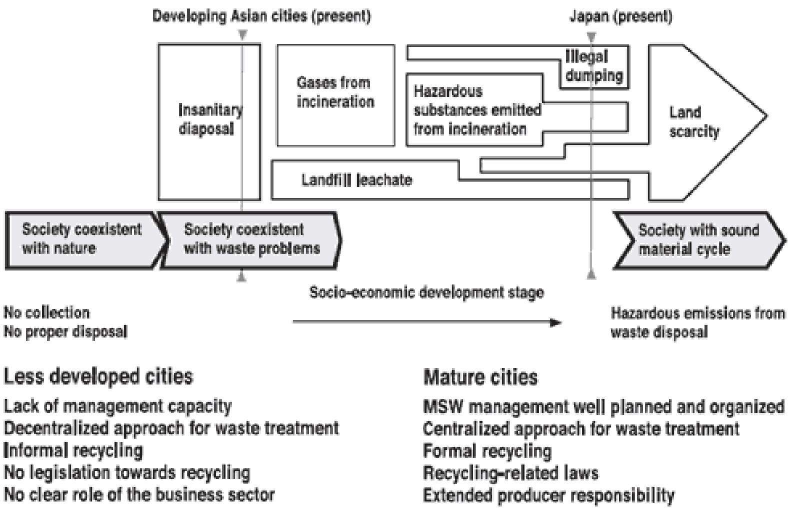
MERIT MELBOURNE ENGINEERING RESEARCH INSTITUTE

- Outside local grocery store in New York city at 38th St. and 3rd Ave. This is the way it looks everyday around 9:00 pm.

(Source: http://blogs.nyu.edu/blogs/scr243/makingmuseum/DSCN1247.JPG)



Urban solid waste



(Source: Mendes and Imura 2004)

Issues in Asian Cities
(Mendes and Imura 2004)

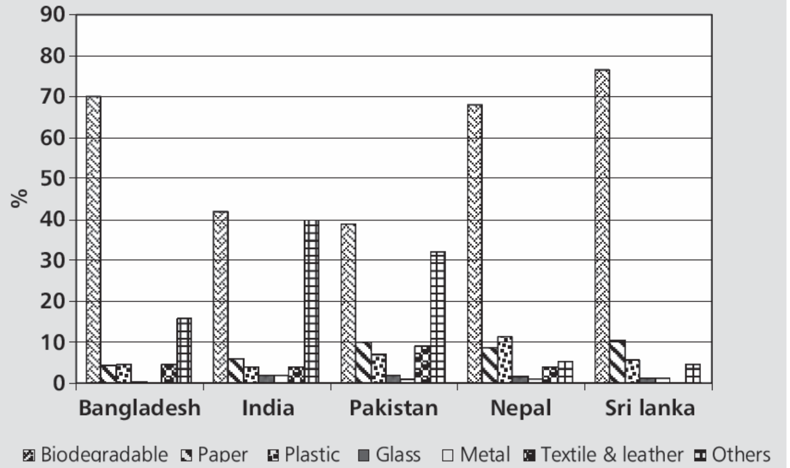
	Less developed cities	Rapidly developing cities
Examples	Dhaka, Kathmandu, Karachi, Phnom Penh	Beijing, Shanghai, Guangzhou, Bangkok, Kuala Lumpur, Manila
Trends	Population growth Urbanization	Population growth Urbanization Industrialization and economic growth
Urban characteristics	Mix of semi-urban and urban areas	Rapidly urbanizing and sprawling Number of irregular settlements such as slums and shanty towns
Barriers	Poverty Financial constraints Poor management capacity	Urban growth Low management capacity
GNI PPP per capita 2002	Less than 2000	2000-15,000
MSW generation per capita (kg/person/day)	0.3-0.7	0.5-1.5
Waste characteristics	High bulk density High organic content	Evolving or changing characteristics (transition)
Waste management	Priority to collection and transportation	Gradual improvement of final disposal
MSW collection rate (%)	<70	80-95

Typical waste compositions

	Less developed cities	Rapidly developing cities	Developed cities
Paper (%)[a]	3-10	10-25	20-50
Plastics (%)[a]	2-8	8-14	9-22
Ash, fines, others (%)[a]	2-62	6-18	3-10
Organics (%)[a]	35-80[b]	40-50	15-40
Moisture (%)	30-60	20-50	10-30
Bulk density or density (kg/m^3)	300-550	200-350	150-300

[a] Dry basis
[b] The waste in Chinese cities has a low organic content due to the high ash content.
(Source: Mendes, MR and Imura, H 2004)

Composition of MSW



Source: Zurbrügg, 2002; UNEP 2001c

Composition of urban solid waste (%)

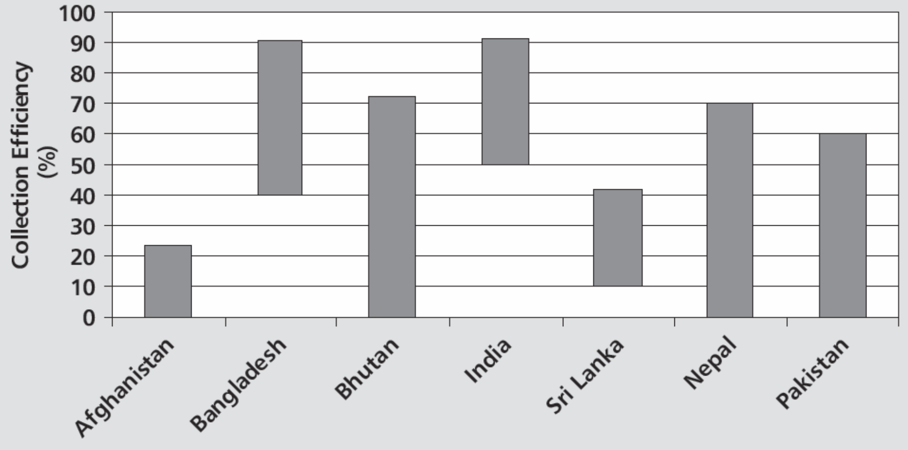
MERIT
MELBOURNE ENGINEERING RESEARCH INSTITUTE

Country	Organic waste	Paper	Plastic	Glass	Metal	Others
China	35.8	3.7	3.8	2.0	0.3	54.3
Hong Kong	37.2	21.6	15.7	3.9	3.9	17.6
Indonesia	70.2	10.9	8.7	1.7	1.8	6.2
Japan	17.0	40.0	20.0	10.0	6.0	7.0
Laos	54.3	3.3	7.8	8.5	3.8	22.5
Malaysia	43.2	23.7	11.2	3.2	4.2	14.5
Myanmar (Burma)	80.0	4.0	2.0	0.0	0.0	14.0
Philippines	41.6	19.5	13.8	2.5	4.8	17.9
Singapore	44.4	28.3	11.8	4.1	4.8	6.6
Sri Lanka	78.0	10.0	6.0	1.0	1.0	4.0
South Korea	31.0	27.0	6.0	5.0	7.0	23.0
Thailand	48.6	14.6	13.9	5.1	3.6	14.2

(Source: Mendes & Imura 2004, Visvanathan & Glawe 2006)

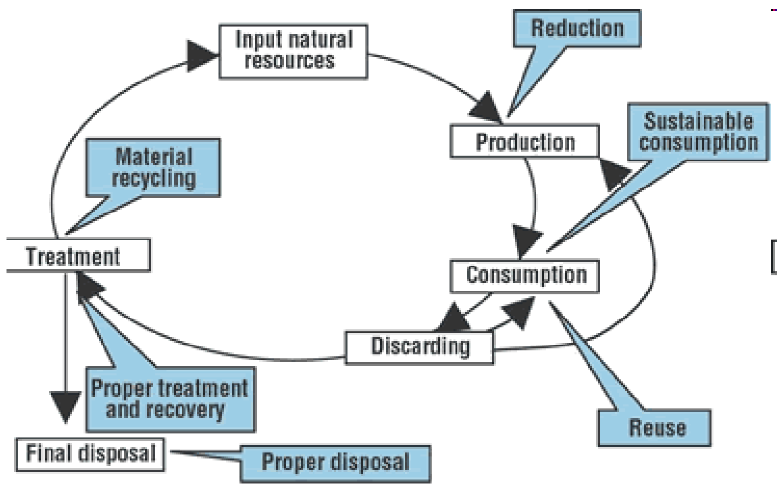
Collection efficiencies

MERIT
MELBOURNE ENGINEERING RESEARCH INSTITUTE



Source: UNEP 2003; Department of Energy (DoE) 2004; UNEP 2001a; AIT 2004; UNEP 2001b; WWF-Pakistan 2001

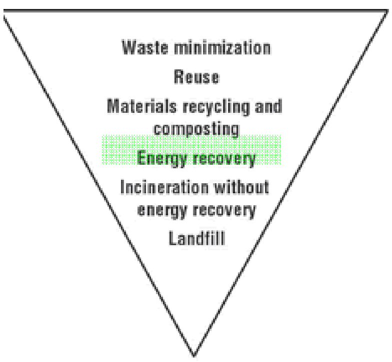
Desired material-cycle



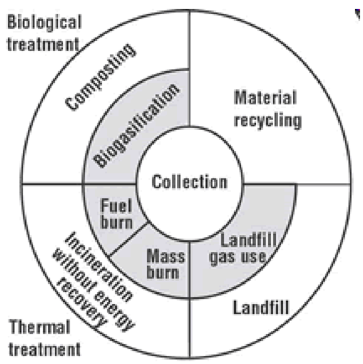
(Source: Mendes and Imura 2004)

Two main approaches for waste management
(Mendes and Imura 2004)

Waste hierarchy



Integrated approach

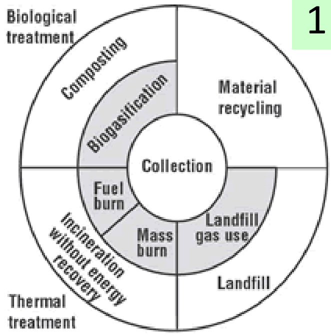


Material recycling

MERIT
MELBOURNE ENGINEERING
RESEARCH INSTITUTE

Waste hierarchy

Integrated approach



1

Material recycling

MERIT
MELBOURNE ENGINEERING
RESEARCH INSTITUTE

http://helptheenvironmentbyrecycling.info/wp-content/uploads/2009/10/ScrapMetalRecycling.jpg

http://helptheenvironmentbyrecycling.info/wp-content/uploads/2009/10/plastic-bottles.jpg

Council (local government) garbage collection service in Australia

MERIT
MELBOURNE ENGINEERING RESEARCH INSTITUTE

Waste management system

MERIT
MELBOURNE ENGINEERING RESEARCH INSTITUTE

Business Recycling School Recycling Household Recycling

http://www.visyrecycling.co.nz/recycling/household.html

Visy Recycling, Australia

(http://www.visy.com.au/recycling/index.php?id=33)

MERIT MELBOURNE ENGINEERING RESEARCH INSTITUTE

Per annum, Visy Recycling collects and processes more than 900,000 tonnes of paper and cardboard, about 450,000 tonnes of glass, more than 20,000 tonnes of plastic and about 5,000 tonnes of metals in Australia (http://www.visy.com.au/recycling/index.php?id=14).

Involving the poor in urban development

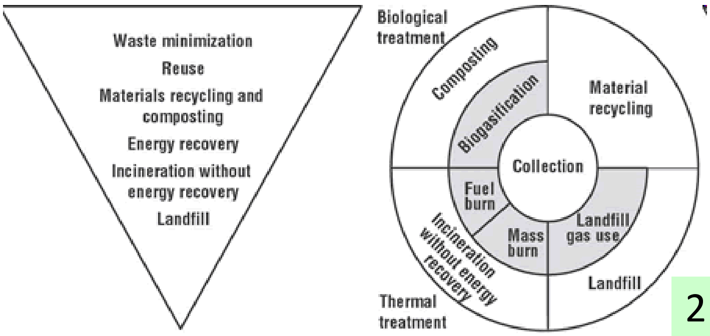
MERIT MELBOURNE ENGINEERING RESEARCH INSTITUTE

http://www.research4development.info/caseStudies.asp?ArticleID=50162

Engineered landfill & Landfill gas (LFG)

MERIT
MELBOURNE ENGINEERING RESEARCH INSTITUTE

Waste hierarchy & Integrated approach



2

Engineered landfill

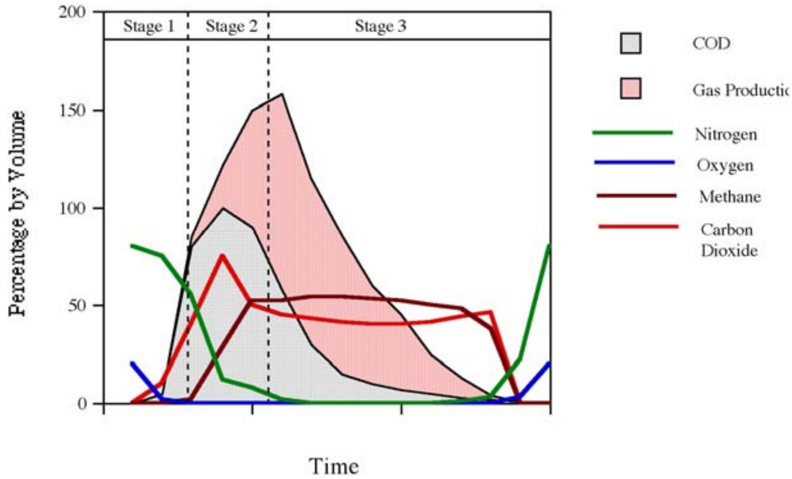
MERIT
MELBOURNE ENGINEERING RESEARCH INSTITUTE

- Engineered landfill: The Taylors Road Landfill (TRL, also known as the Lyndhurst Landfill) is located in Dandenong South, about 30 km south east of Melbourne, Victoria. It was the first fully engineered landfill in Australia!
- **1989** Company seeks permit for a sanitary facility at partially mined sand quarry at Taylors Road.
- **2009** Third monofill prescribed industrial waste (PIW) cell constructed. Community consultation begins on proposed soil processing facility.

http://www.sita.com.au/our-services/post-collections/landfill-management/taylors-road-landfill.aspx

Landfill gas recovery

MERIT
MELBOURNE ENGINEERING
RESEARCH INSTITUTE



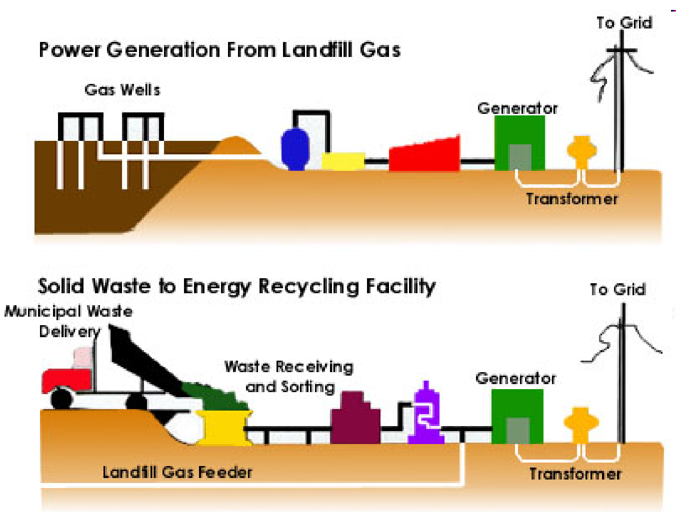
http://www.scu.edu.au/staff_pages/mcullen/fig9_4.gif

http://www.cleanenergycouncil.org.au/cec/technologies/bioenergy.html

MERIT
MELBOURNE ENGINEERING
RESEARCH INSTITUTE

Source: Research Institute for Sustainable Energy, http://www.rise.org.au

MERIT MELBOURNE ENGINEERING RESEARCH INSTITUTE

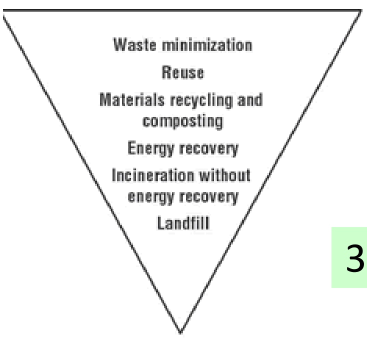


Lu Aye, 26 November 2009
engineering research for the benefit of society

Thermal treatments

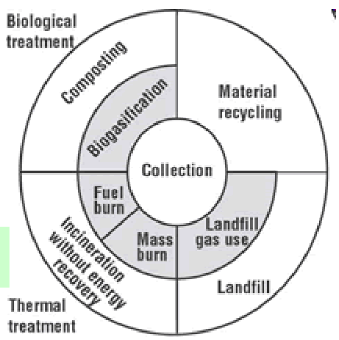
MERIT MELBOURNE ENGINEERING RESEARCH INSTITUTE

Waste hierarchy



Integrated approach

3



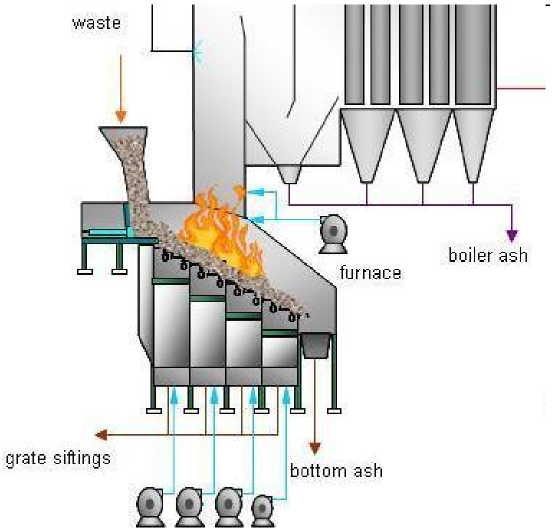
Lu Aye, 26 November 2009
engineering research for the benefit of society

Thermal treatment (mass burn)

MERIT
MELBOURNE ENGINEERING
RESEARCH INSTITUTE

Grate incinerator for domestic waste burning

http://www.winderickx.pl/waste_incinerators/UserFiles/Image/waste_incinerators/grate_grill_incinerator.JPG



24 of 70 Lu Aye, 26 November 2009 engineering research for the benefit of society

Thermal treatment (incineration)

MERIT
MELBOURNE ENGINEERING
RESEARCH INSTITUTE

Bolton
Location: Lancashire, UK
Operator: Greater Manchester Waste Ltd
Configuration: 1 x 10 MW
Operation: 2000
Fuel: refuse

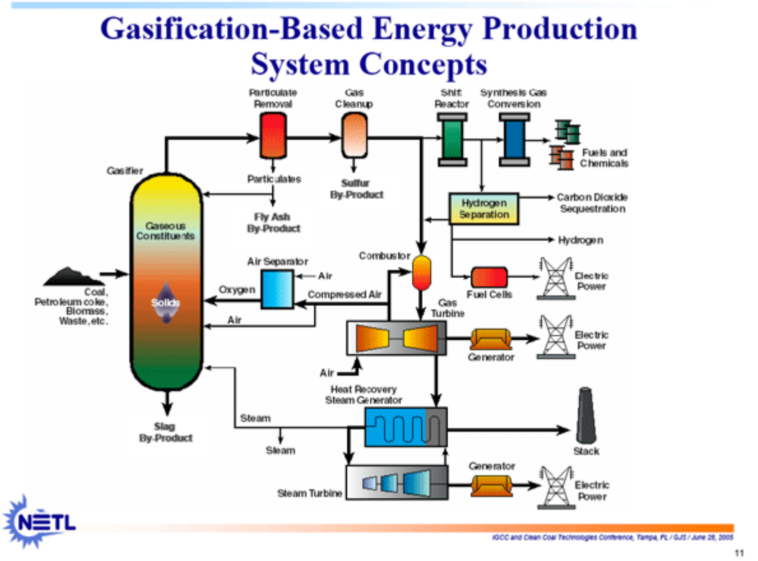
The plant was converted from a mass-burn incinerator to a waste to energy (WTE) plant in 2000. The capacity of the plant is about 120,000 tons MSW/yr.

http://www.industcards.com/Bolton.jpg

25 of 70 Lu Aye, 26 November 2009 engineering research for the benefit of society

Thermal treatment (gasification)

MERIT MELBOURNE ENGINEERING RESEARCH INSTITUTE

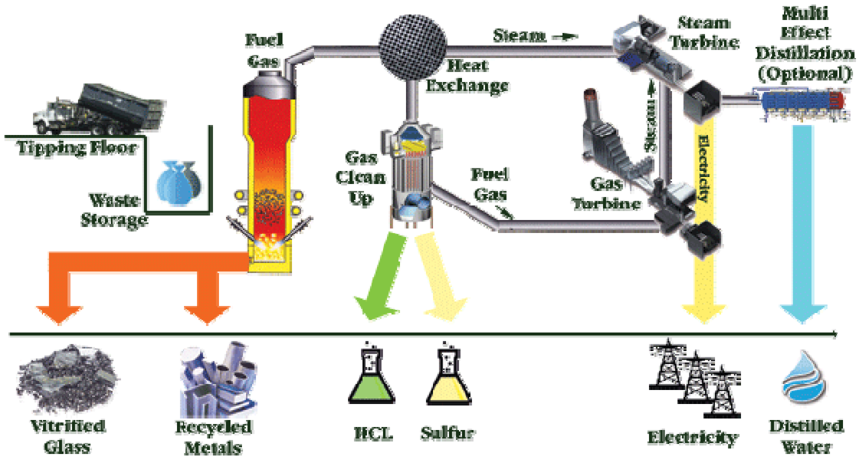


 Lu Aye, 26 November 2009 engineering research for the benefit of society

Thermal treatment (Plasma gasification)

MERIT MELBOURNE ENGINEERING RESEARCH INSTITUTE

http://www.drenergyservices.com/images/flowg_upkp.gif



 Lu Aye, 26 November 2009 engineering research for the benefit of society

Plasma gasification concern

MERIT MELBOURNE ENGINEERING RESEARCH INSTITUTE

Good for disposal of hazardous waste.

In 2004, the city of Honolulu, Hawai considered a plasma arc/torch proposal for processing municipal solid waste. The city's Department of Environmental Services evaluated the plasma process and found that using plasma arc/torch technology would significantly increase waste disposal costs without offering worthwhile environmental advantages.

http://www.honolulu.gov/refs/csd/publiccom/honnews04/plasmaarcrecommendations.htm

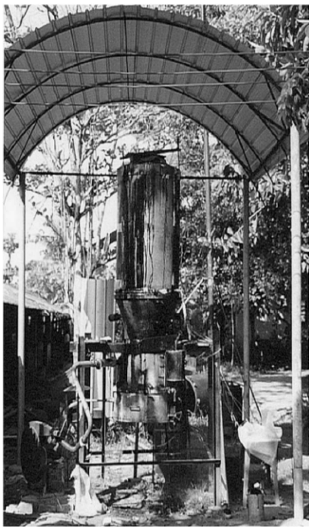
Thermal treatment, air gasification (Heat application)

MERIT MELBOURNE ENGINEERING RESEARCH INSTITUTE

The downdraft gasifier designed by the National Engineering Research and Development (NERD) Centre in Sri Lanka.

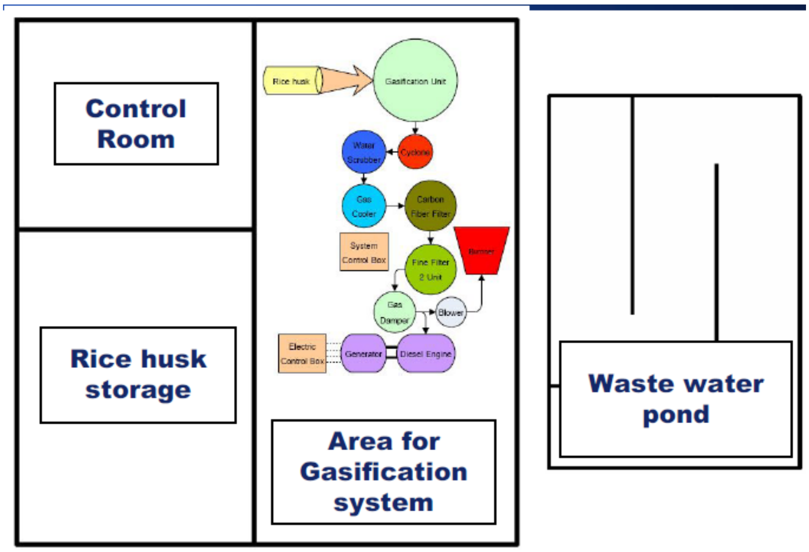
Feedstock: rubber wood

Source: T.H. Jayah, Lu Aye, R.J. Fuller, D.F. Stewart, 2003, Computer simulation of a downdraft wood gasifier for tea drying, *Biomass and Bioenergy*, vol. 25, pp. 459 – 469.



Thermal treatment, air gasification (Power application)

MERIT
MELBOURNE ENGINEERING RESEARCH INSTITUTE



 Lu Aye, 26 November 2009 engineering research for the benefit of society

Thermal treatment, air gasification (Power application)

MERIT
MELBOURNE ENGINEERING RESEARCH INSTITUTE

Chatchawan Chaichana, ERDI, Chiang Mai University

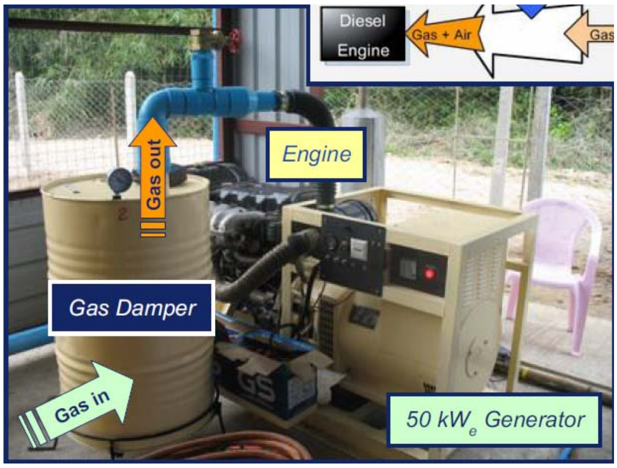
 Lu Aye, 26 November 2009 engineering research for the benefit of society

Air gasifier, Da Goon Diang, Burma

MERIT MELBOURNE ENGINEERING RESEARCH INSTITUTE

Study and Demonstration of Biomass Gasification for Electricity Project, Dr. Chatchawan Chaichana, Energy Research and Development Institute, Chiang Mai University

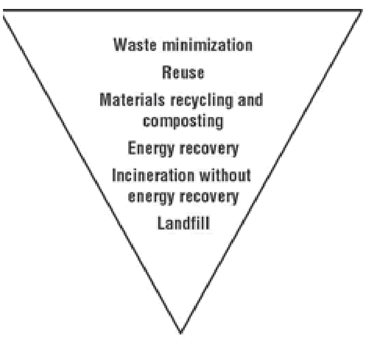
Feed stock: Rice husk



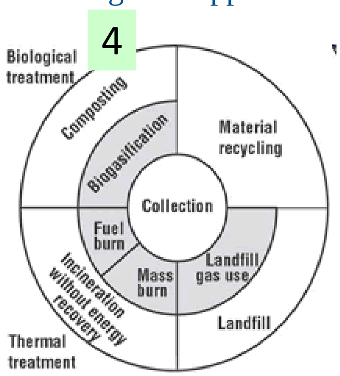
Biological treatments

MERIT MELBOURNE ENGINEERING RESEARCH INSTITUTE

Waste hierarchy



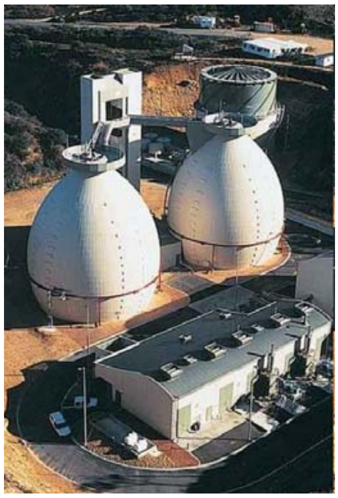
Integrated approach



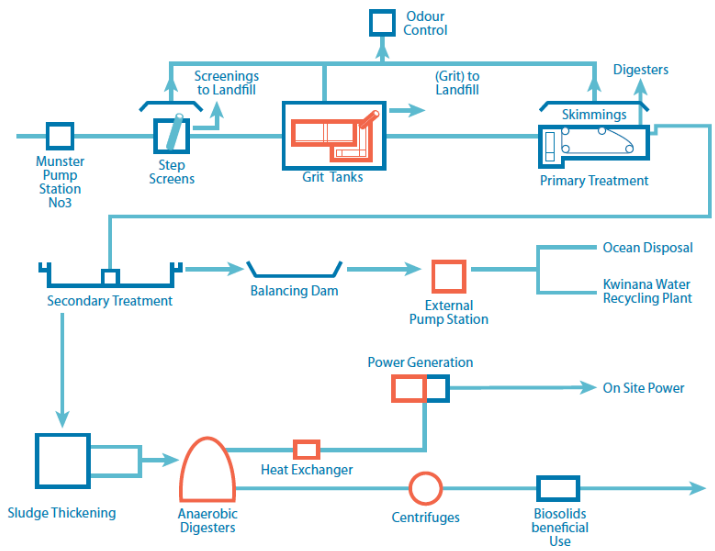
Biological treatment (bio gasification)

Bio gasification

- Egg-shape anaerobic digesters at Woodman Point rated at 1.8 MW (right)
- A component of the biogas installation at Berrybank farm © Museum Victoria Australia 1999



Woodman Point Wastewater Treatment Plant, Fremantle, Australia



Composting

MERIT
MELBOURNE ENGINEERING
RESEARCH INSTITUTE

Compost field
(http://www.unep.org/climateneutral/Portals/0/Company/Soil%20and%20More/Compost%20%20Field%202.JPG)

A case study

MERIT
MELBOURNE ENGINEERING
RESEARCH INSTITUTE

Source: Lu Aye and Elita Rahmarestia Widjaya 2006 ‘Environmental and economic analyses of waste disposal options for traditional markets in Indonesia’, *Waste Management* vol. 26, pp. 1180–1191.

doi:10.1016/j.wasman.2005.09.010

Composition of urban solid waste (%)

MERIT MELBOURNE ENGINEERING RESEARCH INSTITUTE

Country	Organic waste	Paper	Plastic	Glass	Metal	Others
China	35.8	3.7	3.8	2.0	0.3	54.3
Hong Kong	37.2	21.6	15.7	3.9	3.9	17.6
Indonesia	70.2	10.9	8.7	1.7	1.8	6.2
Japan	17.0	40.0	20.0	10.0	6.0	7.0
Laos	54.3	3.3	7.8	8.5	3.8	22.5
Malaysia	43.2	23.7	11.2	3.2	4.2	14.5
Myanmar (Burma)	80.0	4.0	2.0	0.0	0.0	14.0
Philippines	41.6	19.5	13.8	2.5	4.8	17.9
Singapore	44.4	28.3	11.8	4.1	4.8	6.6
Sri Lanka	78.0	10.0	6.0	1.0	1.0	4.0
South Korea	31.0	27.0	6.0	5.0	7.0	23.0
Thailand	48.6	14.6	13.9	5.1	3.6	14.2

(Source: Mendes, MR and Imura, H 2004, Visvanathan C & Glawe U 2006)

Introduction

MERIT MELBOURNE ENGINEERING RESEARCH INSTITUTE

- Interested in investigating traditional markets waste: (at that stage where ‘no treatment’, 2006)
- Highly organic compared with MSW
- More uniform waste composition
- less hazardous waste
- Institutionally, under formal management
- Would expect to have less burden in establishment of integrated waste management (IWM) if it is managed in a business scale

P. D. Pasar Jaya

MERIT MELBOURNE ENGINEERING RESEARCH INSTITUTE

- Local government company that manages traditional markets in Jakarta (151 markets)
- Wastes volume per day 1,200 m^3.
- 80% (weight) are predicted to be organics (i.e. biodegradable).

Aim and Objectives

MERIT MELBOURNE ENGINEERING RESEARCH INSTITUTE

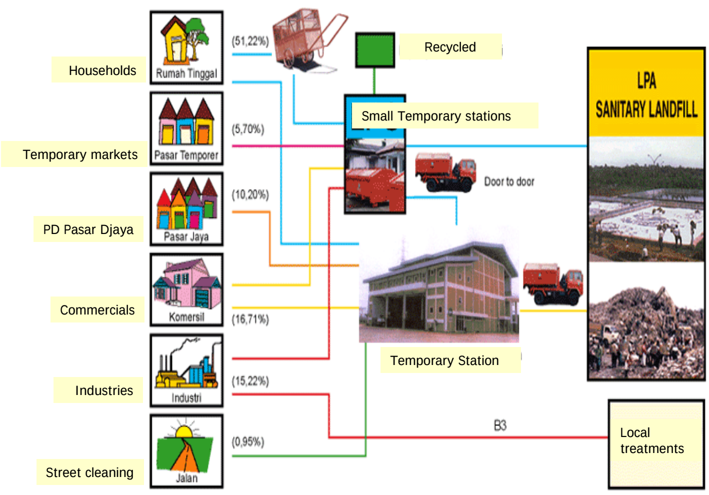
The aim is to compare options of waste management system from environmental, financial and economic aspects for traditional markets solid waste in Jakarta.

Objectives:

- To compare scenarios of waste management system from the global environmental point of view
- To estimate financial cost-benefit of each scenario
- To estimate economic cost-benefit of each scenario

Source of MSW in Jakarta

MERIT MELBOURNE ENGINEERING RESEARCH INSTITUTE



(Source : Cleansing Department DKI Jakarta 2004)

Methodology

MERIT MELBOURNE ENGINEERING RESEARCH INSTITUTE

- Preliminary study: data gathering, field observations and finding related references
- Literature review of the viable technologies
- Conducting Life Cycle Assessment of possible scenarios using the computer simulation model developed
- Simple financial and economic analyses

Existing waste management

MERIT
MELBOURNE ENGINEERING
RESEARCH INSTITUTE

Waste Collection

Transport

MERIT
MELBOURNE ENGINEERING
RESEARCH INSTITUTE

PD Pasar Jaya has a division, namely transportation, it transports wastes from 145 markets to municipality landfill, 5 markets managed individually their wastes.

The waste fleet utilises 62 relatively old dump trucks

On average 120.5 trips/day

Daily waste generation

MERIT MELBOURNE ENGINEERING RESEARCH INSTITUTE

Table 1. Daily solid waste generation in PD Pasar Jaya 2003

No	Area/Unit	Number of Markets within area	Waste Volume (m^3/day)		
			Total volume	Putrescibles	Non-putrescibles
1	Area 1 Tanah Abang	7	59.00	35.40	23.6
2	Area 2 Senen Blok III	12	78.00	46.80	31.2
3	Area 3 Pramuka	11	47.75	28.65	19.1
4	Area 4 Pal Merah	6	42.00	16.80	25.2
5	Area 5 Rawabadak	8	63.00	25.20	37.8
6	Area 6 Koja	9	49.50	19.80	29.7
7	Area 7 Glodok	11	52.50	21.00	31.5
8	Area 8 Cengkareng	8	36.50	12.30	24.2
9	Area 9 HWI	6	20.50	8.20	12.3
10	Area 10 Jembatan Merah	6	27.50	16.50	11.0
11	Area 11 Tomang Barat	7	48.00	19.20	28.8
12	Area 12 Cipulir	7	46.00	18.40	27.6
13	Area 13 Mayestik	7	61.50	36.90	24.6
14	Area 14 Pasar Minggu	6	49.00	29.40	19.6
15	Area 15 Tebet Timur	6	63.50	25.40	38.1
16	Area 16 Kramat Jati	5	48.00	28.80	19.2
17	Area 17 Sunan Giri	8	50.50	20.20	30.3
18	Area 18 Jatinegara	7	47.50	28.50	19.0
19	Area 19 Perum Klender	7	60.00	24.00	36.0
20	Area 20 Induk Kr Jati	1	250.00	150.00	100.0
	Total	**145**	**1 200.25**	**611.45**	**588.8**

Waste Composition

MERIT MELBOURNE ENGINEERING RESEARCH INSTITUTE

Table 2. Composition of traditional market waste in Jakarta

Component	% weight			
	Pasar induk Gede Bage Badung	Pasar Santa Jakarta	Pasar Caringin Bandung	Pasar Baru Bandung
Putrescibles	86.86	81.14	85.31	82.78
Plastics	3.37	5.09	7.03	7.05
Paper & cardboard	6.59	7.11	6.43	5.30
Wood	1.79	4.72	0.89	3.17
Glass and metal	1.08	0.81	0.34	0.67
Others	0.31	1.13	-	1.03

Sources : (Saptari 2004; Maharani 1998; Indiany 2002; Shanti 2002)

Waste composition

Table 3. Estimation of the waste composition from PD Pasar Jaya

Component	Percentage by weight (%)	Daily waste generation (kg/day)
Putrescibles	82.82	205 765.74
Paper and Cardboard	6.27	14 630.80
Plastics	5.89	15 574.27
Wood	3.40	8 453.33
Glass and metal	0.73	1 823.02
Others	0.89	2 204.56
Total	100.00	248 451.75

Importance of source separation

- The strategy for establishing IWM system: Source separation (Mc Dougall *et al*. 2001) – for developing countries, the successful of source separation can much reduce the cost of waste handling. Treating the organic waste will significantly reduce the pollution and health problems by removing the source of leachate, combustibles gases, odours and disease carriers.
- At this moment: Lack of motivations, less campaigns & educational program (Widiastuti 2000, Yudoko 2001).
- The key strategy of IWM establishment: source separation programs should be introduced clearly in line with the next proposed wastes handling.
- The recycling by scavengers in bins collection has good contribution to recycling program.

Proposed Waste Management

MERIT MELBOURNE ENGINEERING RESEARCH INSTITUTE

As high organics fraction in nature some of the potential handling methods based on viable technologies at that moment (2005) are:

- Aerobic digestion (composting): has been practiced in Indonesia in labour intensive scales.
- Landfill for electricity generation: private sector has proposed to involve.
- Anaerobic digestion (bio gasification): not applied yet for MSW in Indonesia.

Technical review

MERIT MELBOURNE ENGINEERING RESEARCH INSTITUTE

Aerobic digestion: Windrow Composting

- Labour intensive plants: capacity 4 m^3-24 m^3 (Wahyono, Sahwan & Suryanto 2003).
- Centralised plant: could utilise 134 kW wheel loader (capacity 200 tonnes/day) for entire process of pilling & turning and transportation within the plant (Cointreau-Levine 1995)

Landfill for electricity generation: conventional and landfill as a bioreactor (with leachate recirculation)

Anaerobic digestion for MSW at a large capacity:

- High solid one stage digestion: Dranco, Valorga
- Low solid two stage digestion : BTA

Life Cycle Assessment

MERIT
MELBOURNE ENGINEERING
RESEARCH INSTITUTE

Goal and Scope definition:

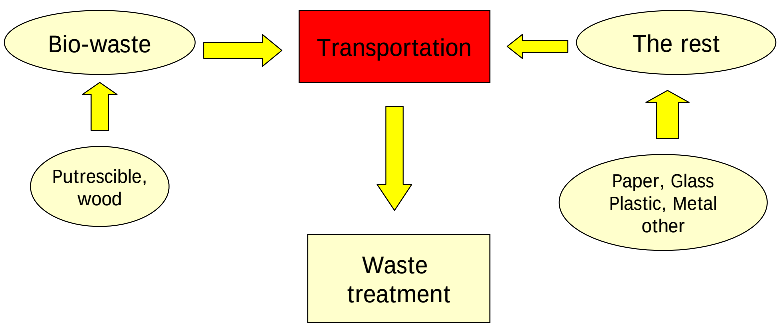
- Purpose: To compare the potential waste management systems (theoretical analysis)
- Functional unit: The management of 1 ton of traditional market waste in Jakarta

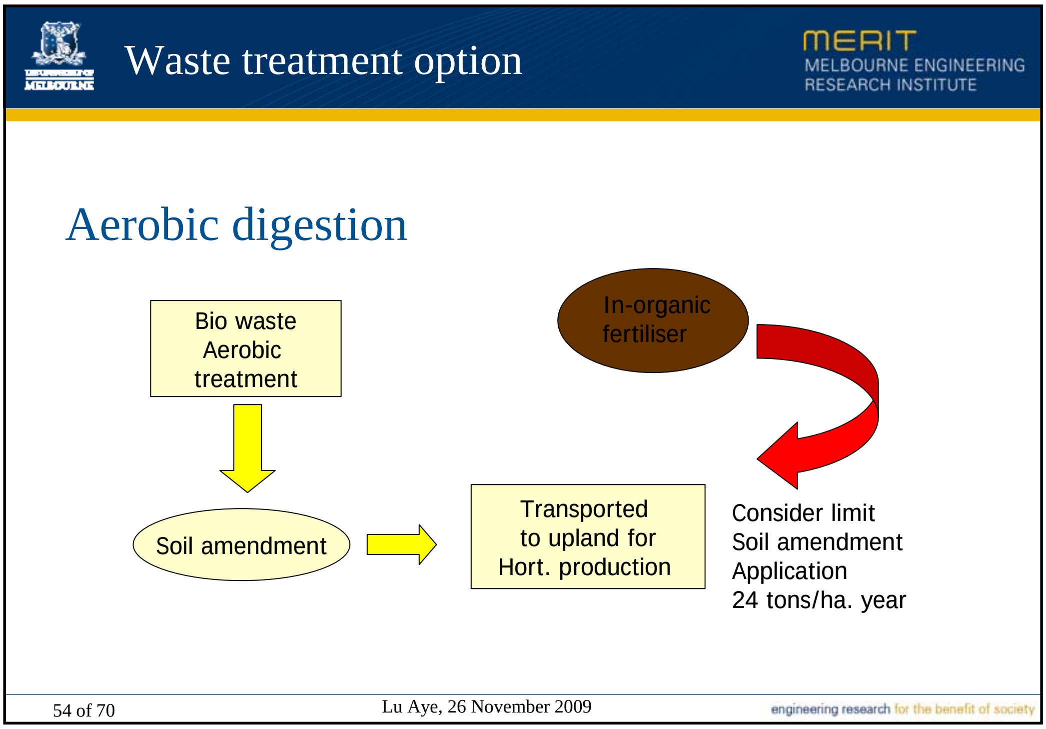
System boundaries:

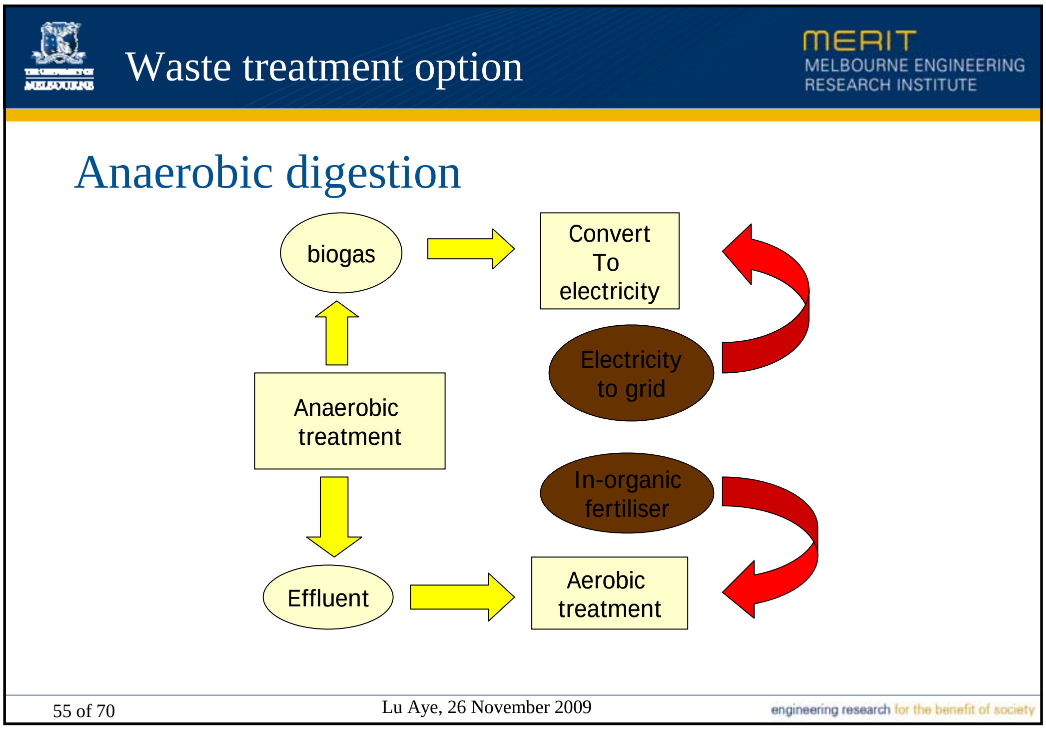
- Cradle: waste in collection bins at traditional markets under PD Pasar jaya management
- Grave: when waste become inert landfill material or is converted to air and/or water emissions or any secondary saleable material
- Breadth: ‘second level’ effects such as building of capital equipment ignored. For energy factors, the pre combustions are included in the model

Waste transportation

MERIT
MELBOURNE ENGINEERING
RESEARCH INSTITUTE



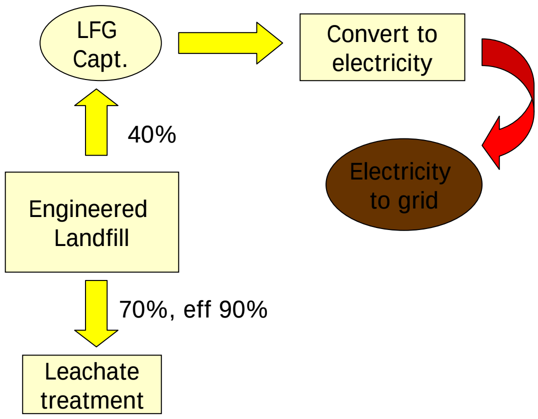

Waste treatment option
MERIT
MELBOURNE ENGINEERING
RESEARCH INSTITUTE
Aerobic digestion
Bio waste
Aerobic
treatment
In-organic
fertiliser
Soil amendment
Transported
to upland for
Hort. production
Consider limit
Soil amendment
Application
24 tons/ha. year
54 of 70
Lu Aye, 26 November 2009
engineering research for the benefit of society


Waste treatment option
MERIT
MELBOURNE ENGINEERING
RESEARCH INSTITUTE
Anaerobic digestion
biogas
Convert
To
electricity
Electricity
to grid
Anaerobic
treatment
In-organic
fertiliser
Effluent
Aerobic
treatment
55 of 70
Lu Aye, 26 November 2009
engineering research for the benefit of society

Waste treatment option

MERIT
MELBOURNE ENGINEERING RESEARCH INSTITUTE

Landfill gas (LFG) for electricity



Life cycle inventory data

MERIT
MELBOURNE ENGINEERING RESEARCH INSTITUTE

Energy inventory

Diesel oil: using Indonesian diesel oil inventory data provided at Australian Data base (SIMAPRO 5.1) created by Tim Grant (RMIT centre of design)

Electricity grid: using Australian database fractioned based on fuel basis (Coal (Vic) 53%, Hydro 14%, gas cogen 29 %, gas 3.6%, oil in IC engine 0.4%)

Life cycle inventory data

MERIT MELBOURNE ENGINEERING RESEARCH INSTITUTE

Emissions from dumping (IWM 2 data base):

- emission to air: LFG emission 100% not captured
- emission to water: 1% Organic carbon emitted as COD within landfill.

Emissions from Aerobic treatment (IWM 2 data base)

Emissions from Anaerobic treatment: Emission of electricity production from biogas (SIMAPRO 5.1) and fraction of emission from aerobic treatment

Emissions from Landfill for electricity production: 60% LFG not captured but under cap, emission from electricity production from biogas and 70% leachate collected with 90% efficiency of COD and N removal

Avoided products

MERIT MELBOURNE ENGINEERING RESEARCH INSTITUTE

Electricity from existing grid (190 kWh/ton putrescibles waste treated anaerobically and 108 kWh/ton waste landfilled)

The fertiliser application for producing organic horticulture product at upland (40 km from treatment plant. Application organic fertiliser in horticulture land should not be exceed 24 tons/year.ha

Life Cycle Impact Assessment

MERIT MELBOURNE ENGINEERING RESEARCH INSTITUTE

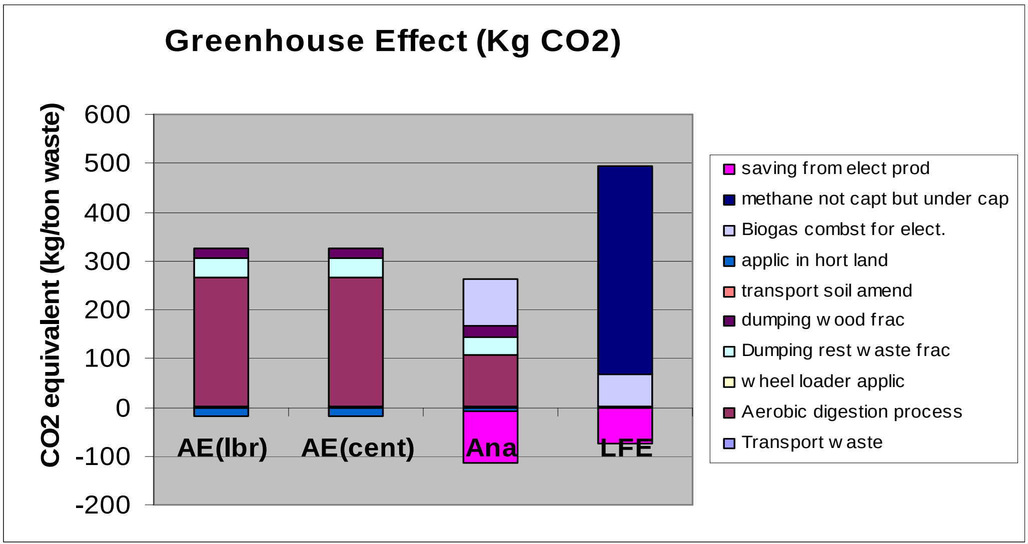
Table 4. Characterization using Eco indicator 95/Europe, version e

Impact category	Unit	life cycle aerobic (centralised)	life cycle aerobic (lbr intensive)	life cycle anaerobic	life cycle landfilled energy
greenhouse	kg CO2	308	308	148	418
ozone layer	kg CFC11	x	x	x	x
acidification	kg SO2	-0.128	-0.129	-0.494	-0.304
eutrophication	kg PO4	-1.33	-1.32	-0.509	0.0177
heavy metals	kg Pb	-9.88E-04	-0.000988	-0.000449	-3.73E-05
carcinogens	kg B(a)P	-7.49E-08	-7.50E-08	-3.99E-06	-2.72E-06
winter smog	kg SPM	-0.0541	-0.0541	-0.516	-0.339
summer smog	kg C2H4	0.0248	0.0246	0.0368	0.276
pesticides	kg act.subst	x	x	x	x
energy resources	MJ LHV	-122	-122	-509	-315
solid waste	kg	58.9	58.9	58.9	240

60 of 70 Lu Aye, 26 November 2009 engineering research for the benefit of society

GHG Emissions

MERIT MELBOURNE ENGINEERING RESEARCH INSTITUTE



61 of 70 Lu Aye, 26 November 2009 engineering research for the benefit of society

Major environmental impacts quantified

MERIT MELBOURNE ENGINEERING RESEARCH INSTITUTE

- Greenhouse gas emissions
- Acidification
- Eutrophication
- Photochemical oxidants

Sensitivity analysis

MERIT MELBOURNE ENGINEERING RESEARCH INSTITUTE

Table 5. Sensitivity analysis 10% and 30% putrescibles wastes are dumping in rest-waste

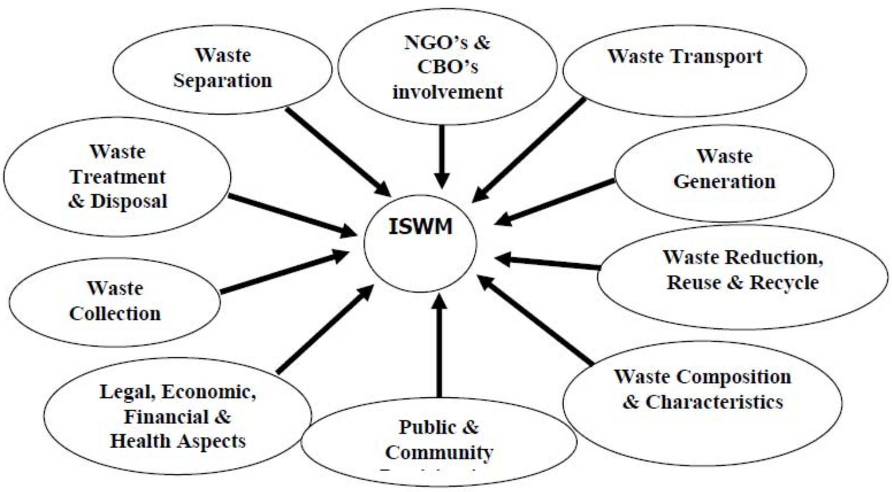
Impact category	Unit	life cycle aerbc (cent) 10% sens	life cycle aerbc (cent) 30% sens	life cycle landfilled energy
greenhouse	kg CO2	361	468	418
ozone layer	kg CFC11	x	x	x
acidification	kg SO2	-0.114	-0.0859	-0.304
eutrophication	kg PO4	-1.19	-0.927	0.0177
heavy metals	kg Pb	-8.89E-04	-0.000691	-3.73E-05
carcinogens	kg B(a)P	-6.74E-08	-5.24E-08	-2.72E-06
winter smog	kg SPM	-0.0487	-0.0378	-0.339
summer smog	kg C2H4	0.0666	0.15	0.276
pesticides	kg act.subst	x	x	x
energy resources	MJ LHV	-110	-85.7	-315
solid waste	kg	58.9	58.9	240

Findings

- Options investigated
  - Composting in labour intensive local plant (CPL)
  - Composting in centralised plant (CPC)
  - Biogas production (BGP)
  - Engineered landfill for electricity generation (LFE)
- LFE has the highest environmental impacts among the options compared; LFE has significantly less impacts than open dumping
- BGP has the lowest environmental impacts except for acdification
- CPC has highest potential for success. It has the highest benefit to cost ratio and moderate environmental impacts.
- Supports from the market management and the local government would be the keys to the success.

MERIT
MELBOURNE ENGINEERING RESEARCH INSTITUTE

Integrated Solid Waste Management
(Glawe *et al*. 2006)



References

Cointreau-Levine, S 1995, *Private Sector Participation in Municipal Solid waste Service in developing Countries*, The International Bank for Reconstruction and Development, Washington D.C.

Indiany, N 2002, *Studi alternatif pengelolaan sampah pasar induk caringin*, Department of Environmental Engineering, Institute of Technology Bandung, Bandung.

Maharani, W 1998, *Studi Pengelolaan Sampah Pasar Traditional (Studi kasus : Pasar Santa, Jakarta Selatan)*, Department of Environmental Engineering, Institute of Technology Bandung, Bandung.

McDougal, F, White, P, Franke, M & Hindle, P 2001, *Integrated solid waste management : a life cycle inventory*, 2nd edn, Blackwell Science.

Mendes, MR and Imura, H 2004 'Eastern prospect: Municipal solid waste management in Asian cities', Waste Management World, Vol 5, July- August 2004.

Saptari, G 2004, *Studi pengelolaan sampah pasar tradisional dan alternatif pengembangan : studi kasus pasar induk gede bage Bandung*, Department of Environmental Engineering, Institute of Technology Bandung, Bandung.

Sophia, S 2002, *Studi analisis pengelolaan sampah yang dibuang ke tempat pembuangan sementara pasar kota Bandung*, Bandung.

Visvanathan C and Glawe U 2006 'Domestic solid waste management in South Asian countries: A comparative analysis, *Reduce, Reuse and Recycle: The 3Rs in South Asia* presented at 3R South Asia Expert Workshop, Kathmandu, Nepal, August 30th to September 1st, 2006

Wahyono, S, Sahwan, F & Suryanto, F 2003, *Menyulap sampah menjadi kompos : system open windrow bergulir*, Pusat Pengkajian dan Penerapan Teknologi Lingkungan BPP Teknologi, Jakarta.

Widiastuti, H 2001, 'Private sector involvement in integrated urban solid waste management : lessons from metropolitan melbourne, Victoria, to be recommended for Bandung, Indonesia', M Eng Sc thesis, The International Technologies Centre, The University of Melbourne

Discussions

MERIT
MELBOURNE ENGINEERING
RESEARCH INSTITUTE

Short term desired objectives?

Long term desired objectives?

SWOT analysis

MERIT MELBOURNE ENGINEERING RESEARCH INSTITUTE

* Strengths: attributes of the option that are helpful to achieving the objective.
* Weaknesses: attributes of the option that are harmful to achieving the objective.
* Opportunities: external conditions that are helpful to achieving the objective.
* Threats: external conditions which could do damage to the objective.

Further information

MERIT MELBOURNE ENGINEERING RESEARCH INSTITUTE

Lu Aye
Renewable Energy and Energy Efficiency Group
Department of Civil and Environmental Engineering
Melbourne School of Engineering
The University of Melbourne
Victoria 3010
AUSTRALIA

Room: D210, Engineering
Tel: +61 3 8344 6879
Mob: +61 402 553 960
Fax: +61 3 8344 6868
email: lua@unimelb.edu.au
URL: http://www.civenv.unimelb.edu.au/about/webpage.php3?login=lua

MERIT
MELBOURNE ENGINEERING
RESEARCH INSTITUTE

The end.