Zero Waste as a vehicle to realise Green Economy in Southern Africa

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IPLA

IPLA Global Forum 2013 on Sustainable Waste Management for the 21st Century Cities - Building Sustainable and Resilient Cities through Partnership

City of Borås, Sweden, 9-11 September 2013

Outline

WASTE AS A RESOURCE

INTEGRATED WASTE MANAGEMENT

- National waste management strategy in South Africa and implementation of the waste hierarchy
- Brief description of available waste strategies for Local Authorities

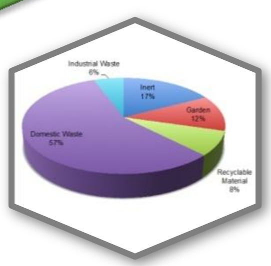
THE W.R.O.S.E MODEL

- Waste & Resource Optimisation Strategy Evaluation Model W.R.O.S.E
- Decision-making tool for assisting municipalities in the selection of appropriate waste management strategies

PPP EXAMPLES OF WTE PROJECTS

- Examples of Public Private Partnership waste projects in South Africa (KwaZulu-Natal Province)

CONCLUSIONS

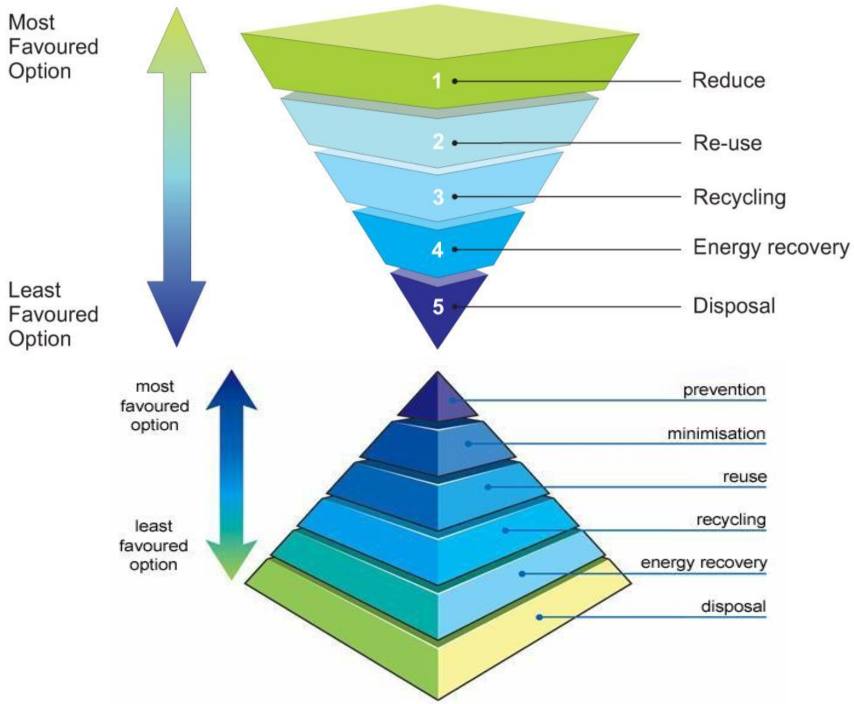


In South Africa...

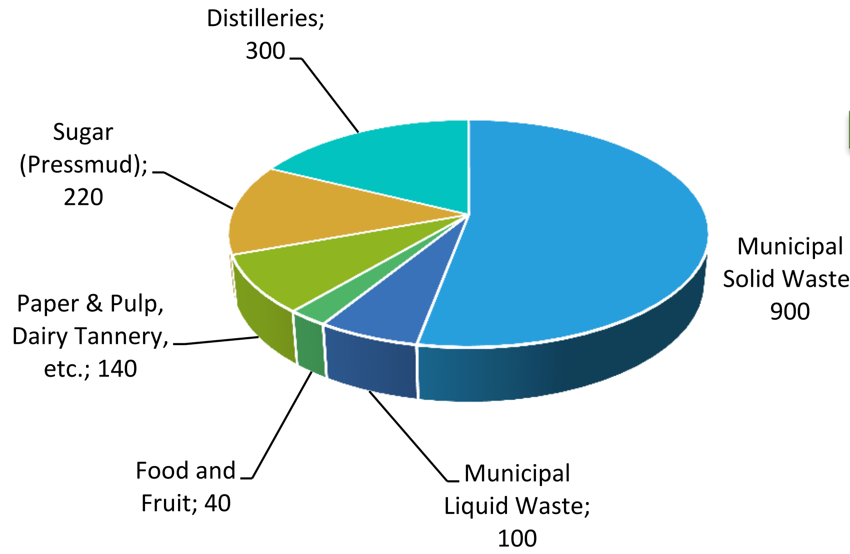
- 108 Mt total waste generated
- 98 Mt waste landfilled
- 10% approximate percentage of total waste that is recycled

(Source: DEA, 2012)

Waste Hierarchy



(source: National Waste Management Strategy of South Africa (DEA))



Energy recovery potential (MWe) of different wastes from urban and industrial sectors
(source: R. Kothari et al., Renewable and Sustainable Energy Reviews 14 (2010) 3164-3170

- According to the Danish Energy Agency, **calorific value of waste is on average 10.5 MJ/kg**
- This means that **4 tons of waste** can substitute **1 ton of oil** or **1.6 tons of coal**
- **1 ton of waste can produce 2 MWh for district heating and 0.67 MWh of electricity**

WASTE → RESOURCE

Component	Biodegradable?	Combustible?	Recyclable?
Paper & Card	✔	✔	✔
Yard / Green	✔	✔	✔
Kitchen	✔	✔	✔
Wood	✔	✔	✔
Textiles	(✔)	✔	✔
Metals	✖	✖	✔
Glass	✖	✖	✔
Plastic	✖	✔	✔
Stones / fines	(✖)	✖	(✔)

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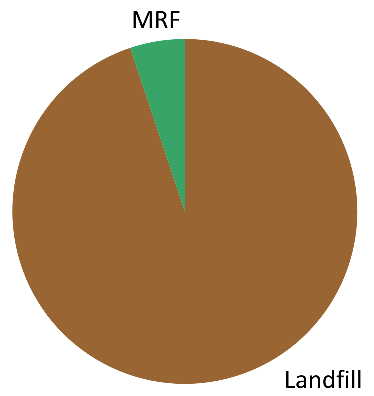
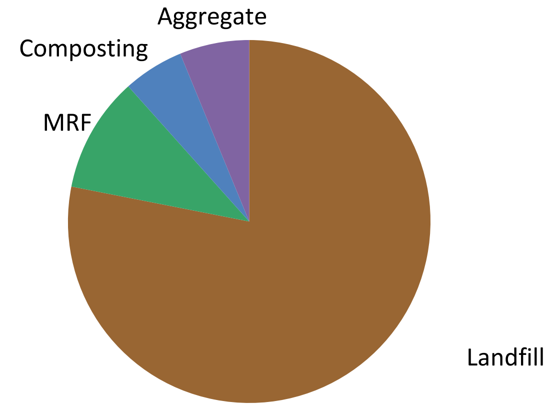
Developing a Landfill Waste Volume Reduction Strategy

The eThekwini Municipality

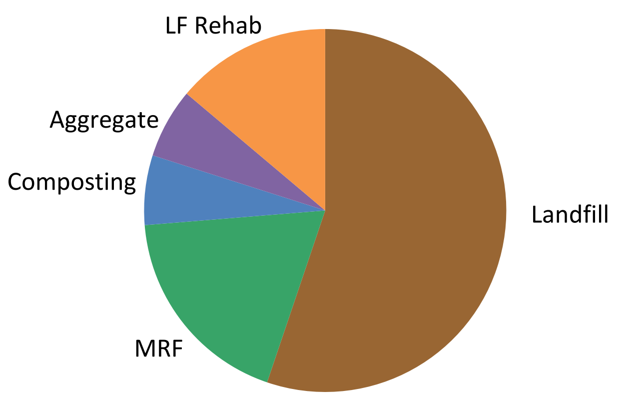
Phase 1A Volume Distribution



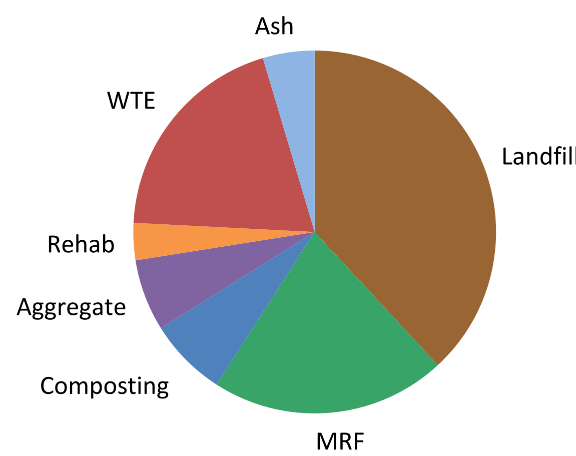
Phase 1B Volume Distribution



Phase 1C Volume Distribution

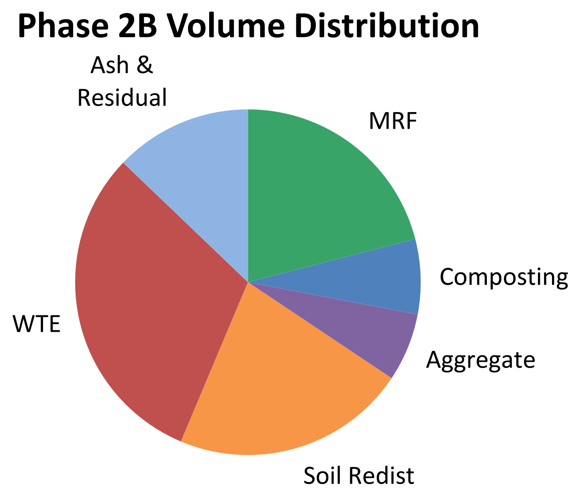


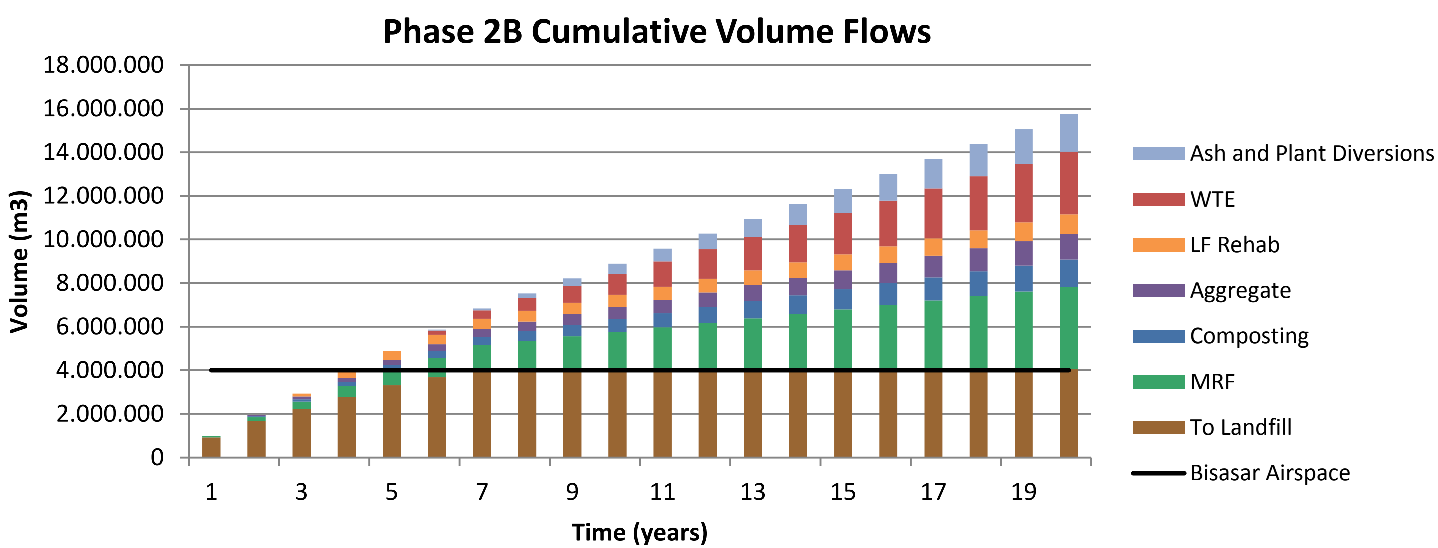
Phase 2A Volume Distribution



Developing a Landfill Waste Volume Reduction Strategy

The eThekwini Municipality





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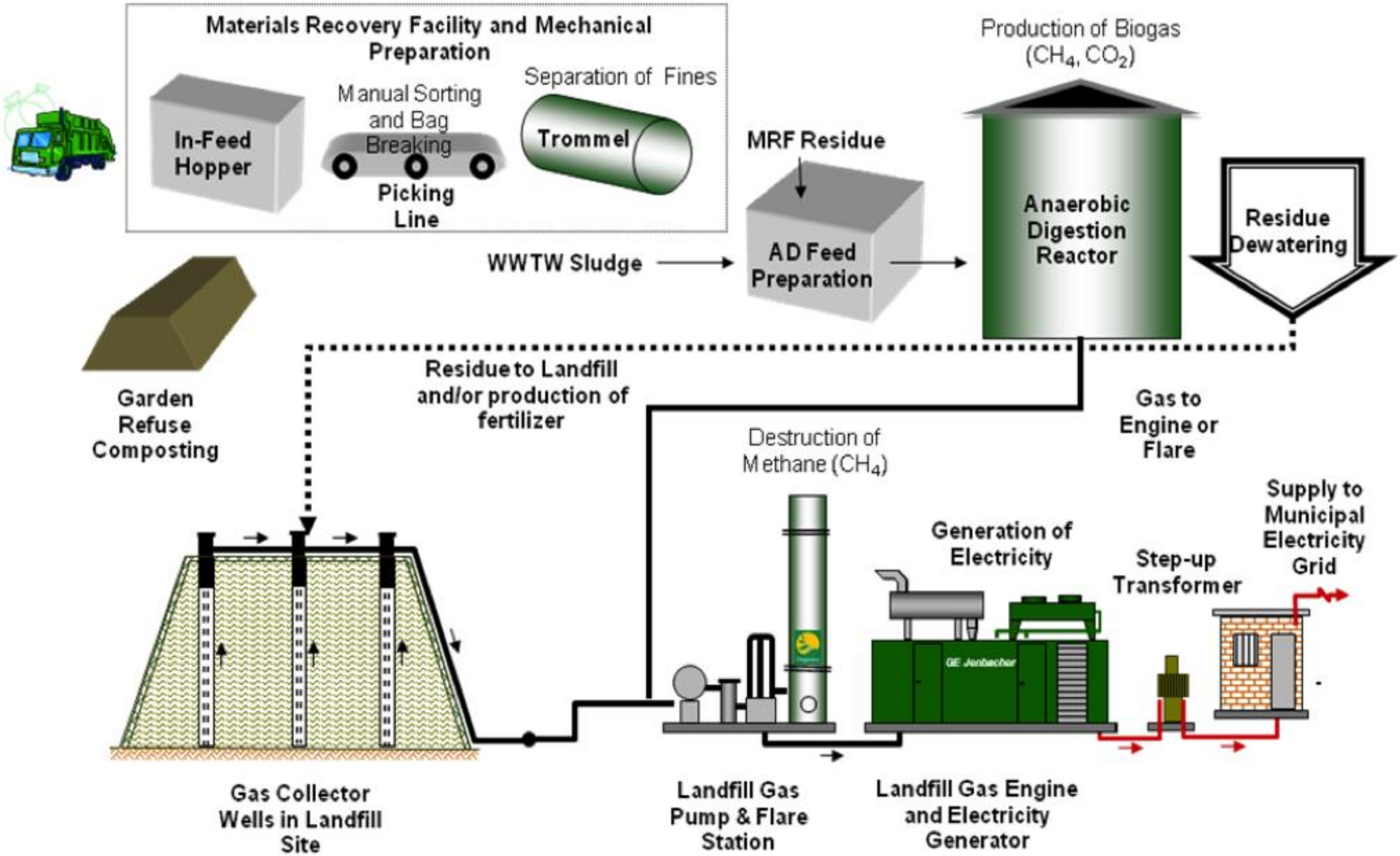
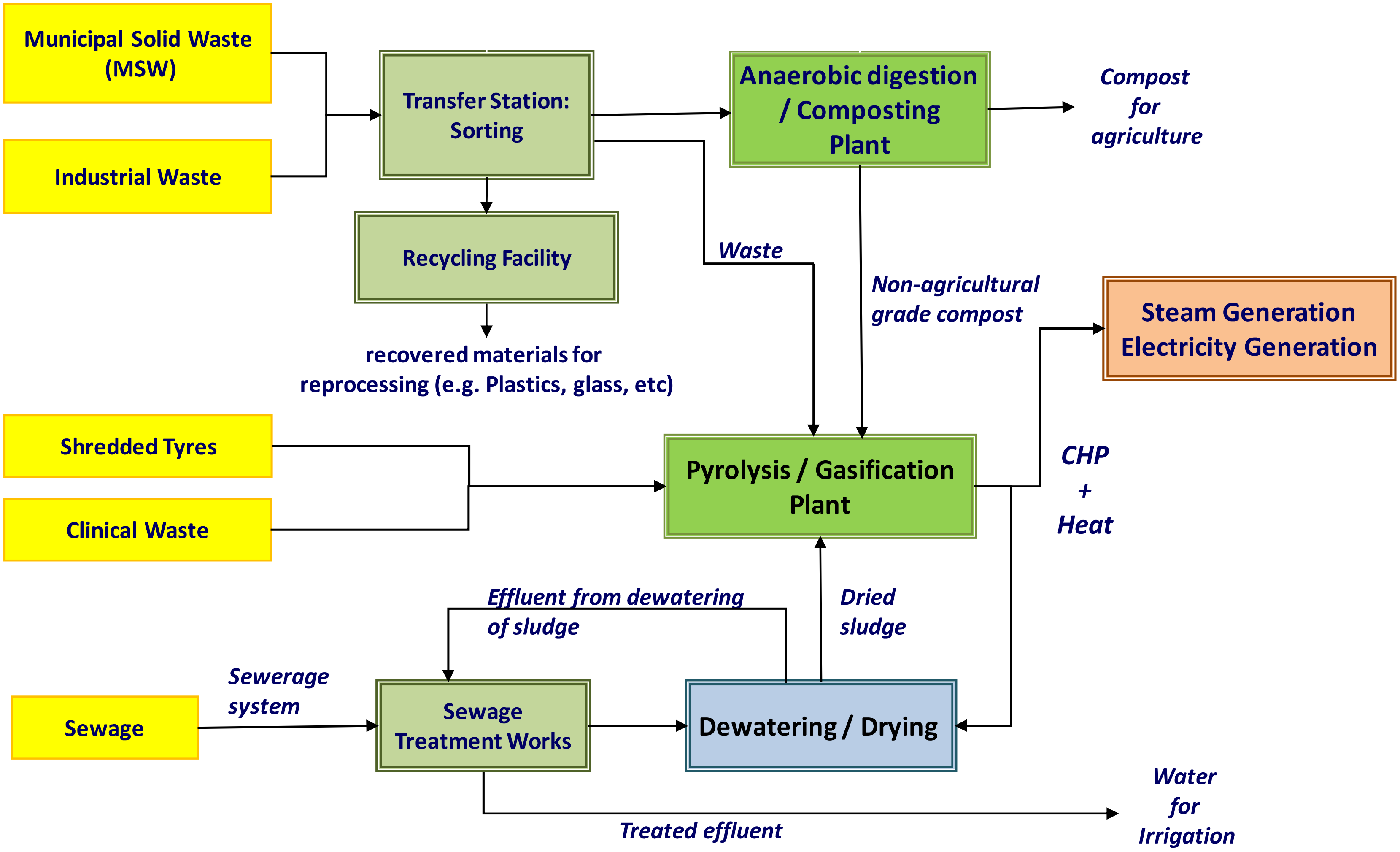
Integrated waste treatment system



CDM Landfill Biogas-to-Energy Project

- 1st CDM Landfill Biogas-to-Energy Project in Africa
- Bisasar Rd landfill - extracts approximately 350 m^3/hour, Component 1 produces approx. 9MWh
- Mariannhill landfill -180 m^3/hour is produced and an estimated 1775 m^3/hour by 2024. Approximately 900 kWh of electricity is generated

Integrated waste treatment system



Material Recycling Facilities (MRF)

JOB CREATION POTENTIAL

- A small dirty-MRF processing 160 to 250 tpd can employ up to 150 on a full time basis

Biological – Composting

VCU

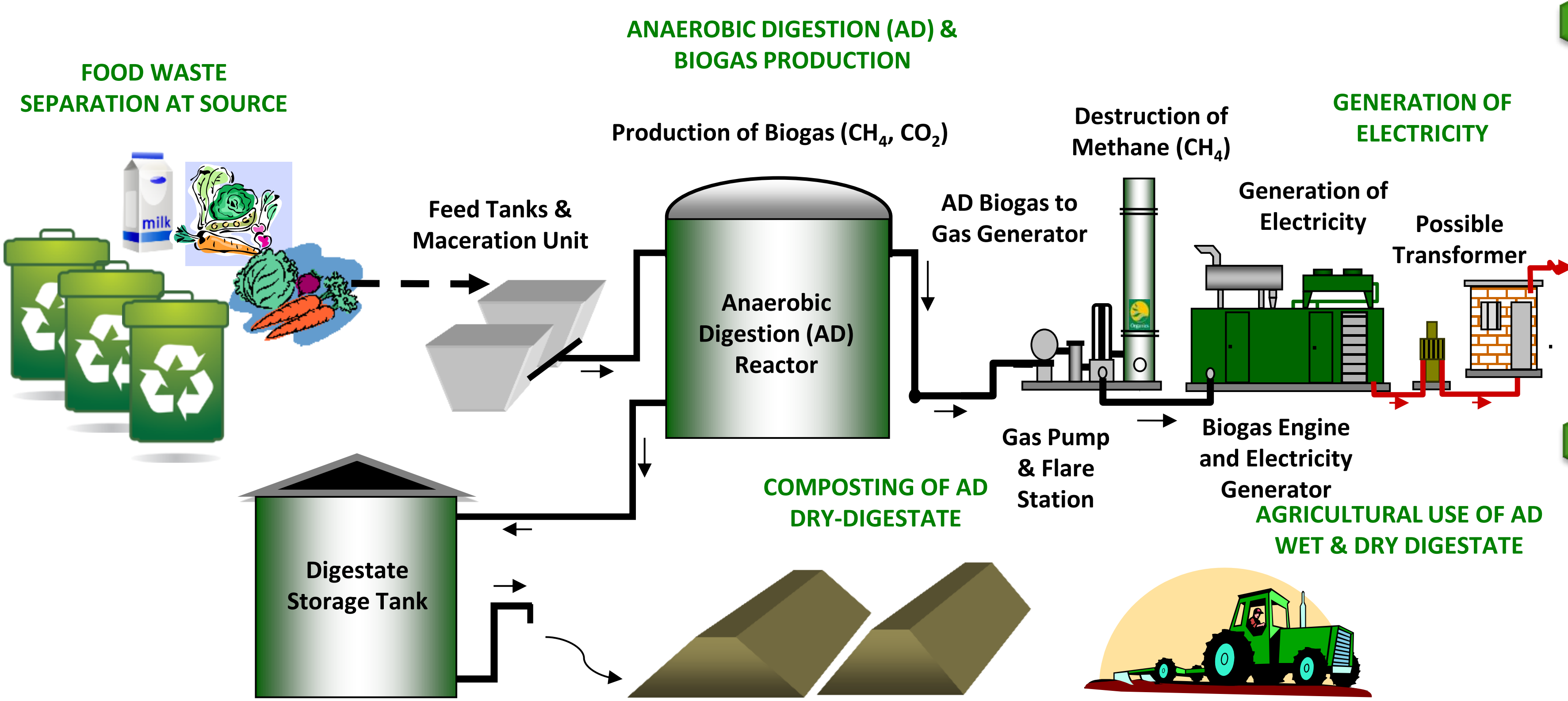
Open windrow

GiCom IVC

ASP

- **Throughputs-** from 500tpa to 150,000+ tpa (scalable, expandable subject to technology)
- **Cost of technology-** Affordable, (cheap) subject to plant compliance requirement (ABPR) and configuration
- **Energy balance-** Does not produce energy, nett energy user

Food Wastes AD



Schematic Layout: Proposed Anaerobic Digestion (AD) Food Waste Treatment Plant (not to scale)

Biological – Anaerobic Digestion (AD)

Clarke-Haase

UTS

Kuettner

- **Throughputs**- from 5,000~10,000 to 150,000+ tpa Subject to AD type, (scalable, expandable subject to technology)
- **Cost of technology**- Expensive, subject to plant compliance requirement (ABPR)
- **Energy balance**- Produces Biogas→Heat, Electricity, Vehicle Fuel, Industry,

JOB CREATION POTENTIAL

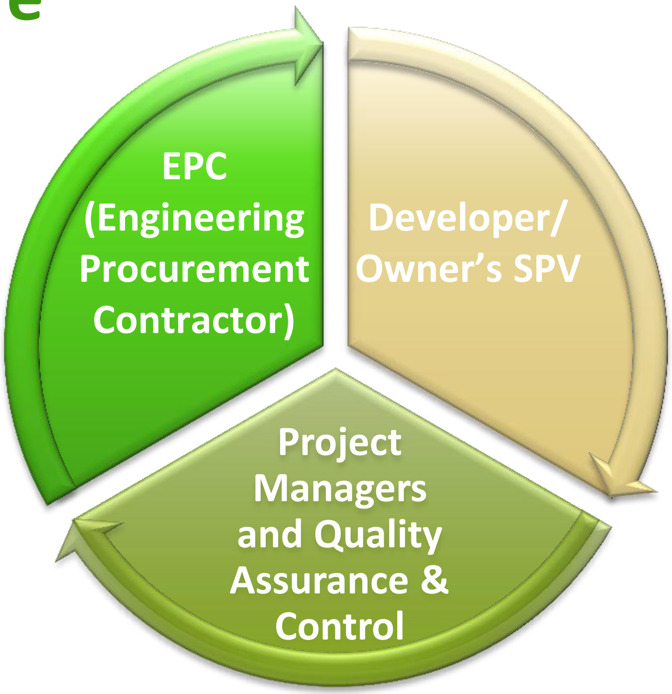
- 4 to 6 permanent jobs are created per ton of waste provided to an AD plant. An AD plant that treats 12k tpa (35tpd) could generate over 200 permanent jobs.

AD Bankability

Factor to be considered	*Wet AD*	*Dry AD (low solids)*	*Dry AD (high solids)*
Typical feedstocks	Low solids liquid products, dairy products, food waste only, fruits and vegetable	Food waste, fruits, medium and high solids liquid products, some green waste	Food waste, green waste (as bulking agent), fruit and vegetable, putrescible high solid content products
Flexibility in feedstock fluctuation	Low	Medium	High
Ease of expansibility	Low /None	Medium	High
Scalability	High: from 1,000 tpa subject to technology	Medium: from 5-8,000 tpa subject to technology	Medium from 8-10,000 tpa
Footprint required	Low	Medium	High
Outputs	Primarily Liquid digestate	Liquid and solid digestate	Primarily Solid digestate
OPEX	High	Medium	Low

Example: AD Plant – 12k tpa may realise up to 0.5MWe at a total capex of some R30-40m (approx. 2-3m EURO).

Project Structure



Project Programme

Thermal – Incineration or Pyrolysis and Gasification

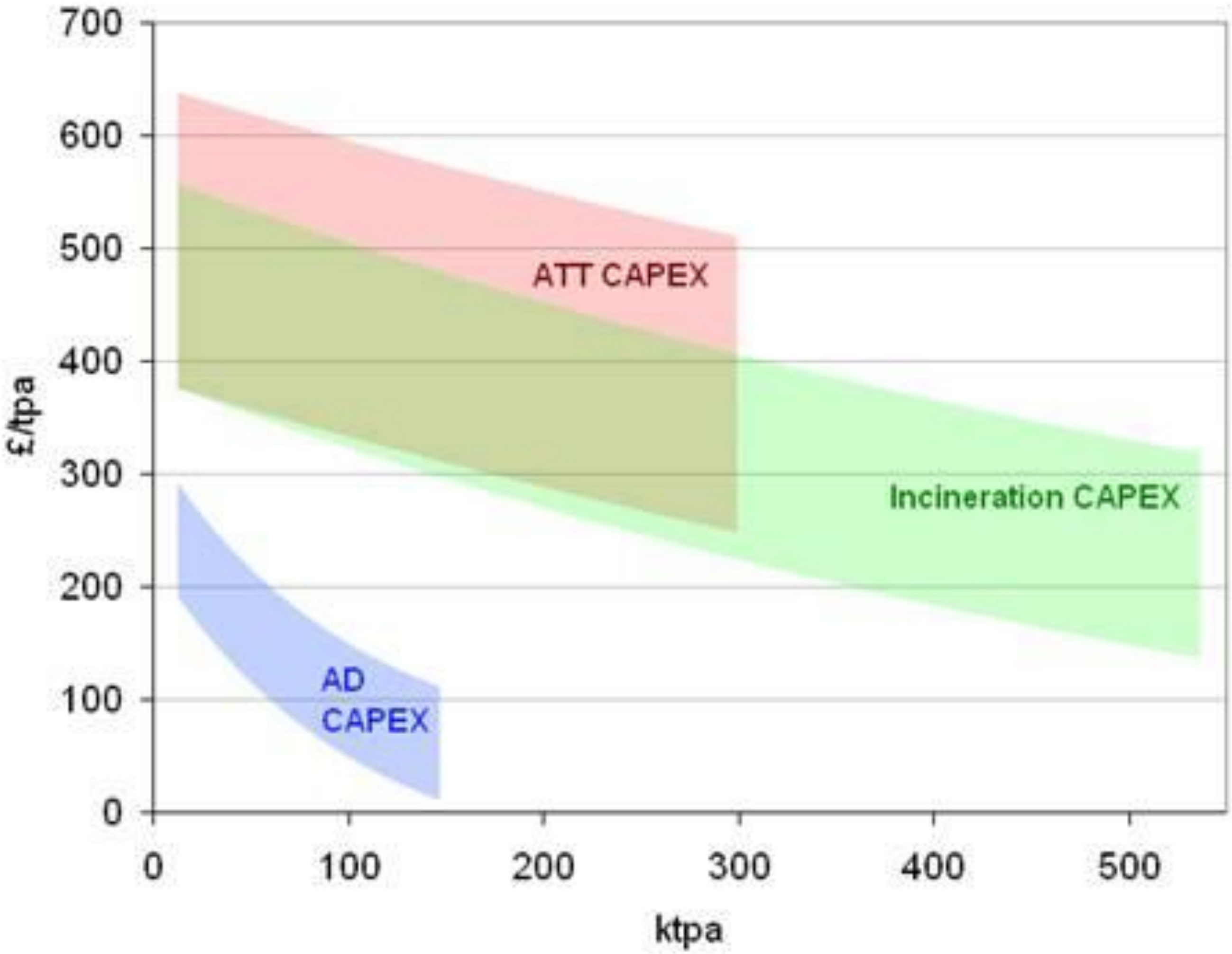
- **Basic Description**
  - Incineration is a thermal technology that involves complete combustion of waste with excess air/oxygen conditions
  - Gasification and Pyrolysis are thermal technologies that involve partial combustion of waste under reduced or no oxygen conditions

- **Throughputs-** from 500 tpa to 150,000+ tpa (easily scalable, expandable)
- **Cost of technology-** Expensive, subject to plant *emission compliance* requirement and type of technology
- **Energy balance-** Produces energy (subject to syn-gas usage), Pyrolysis requires input energy

EfW Bankability

Technology Category	Continuous Gasification- Staged Combustion	Gasification with Plasma Conversion	Batch Gasification- Syngas generation or Staged Combustion
Energy Generation Technology	Steam Turbines	Gas Engines	Steam Turbines or Gas Engines
Typical Feed Preparation	Minimal/No Significant Requirements	Moisture Reduction and removal of Recyclables	Removal of non-combustible materials and significant size reduction for homogeneity in process
Anticipated By-Products/Outputs	Bottom Ash – 12-15% wt Fly Ash – 8-10% by wt Includes particulate filter residues	Basalt like output – 12-15 % wt Scrubber Residue – 2-3% wt	Ash – 15-25% wt Includes particulate filter residues
Energy Usage	Parasitic Load ~10-15% of generated capacity	Parasitic Load ~30-40% of generated capacity	Parasitic Load ~12-18% of generated capacity
Energy Generation	Energy ~1.2 – 1.4MWe generated per tonne waste	Energy ~1.0MWe generated per tonne waste	Energy ~1.2 – 1.4MWe generated per tonne waste
Scalability	Moderate flexibility from 50 to 400+tonnes per day	Commercial scale ~100 to 200 tonnes per day	High flexibility from 1 to 100 tonnes per day
CAPEX	Moderate	Moderate to high	Moderate
OPEX	Moderate	Moderate to high	Low to moderate

AD & EfW Bankability



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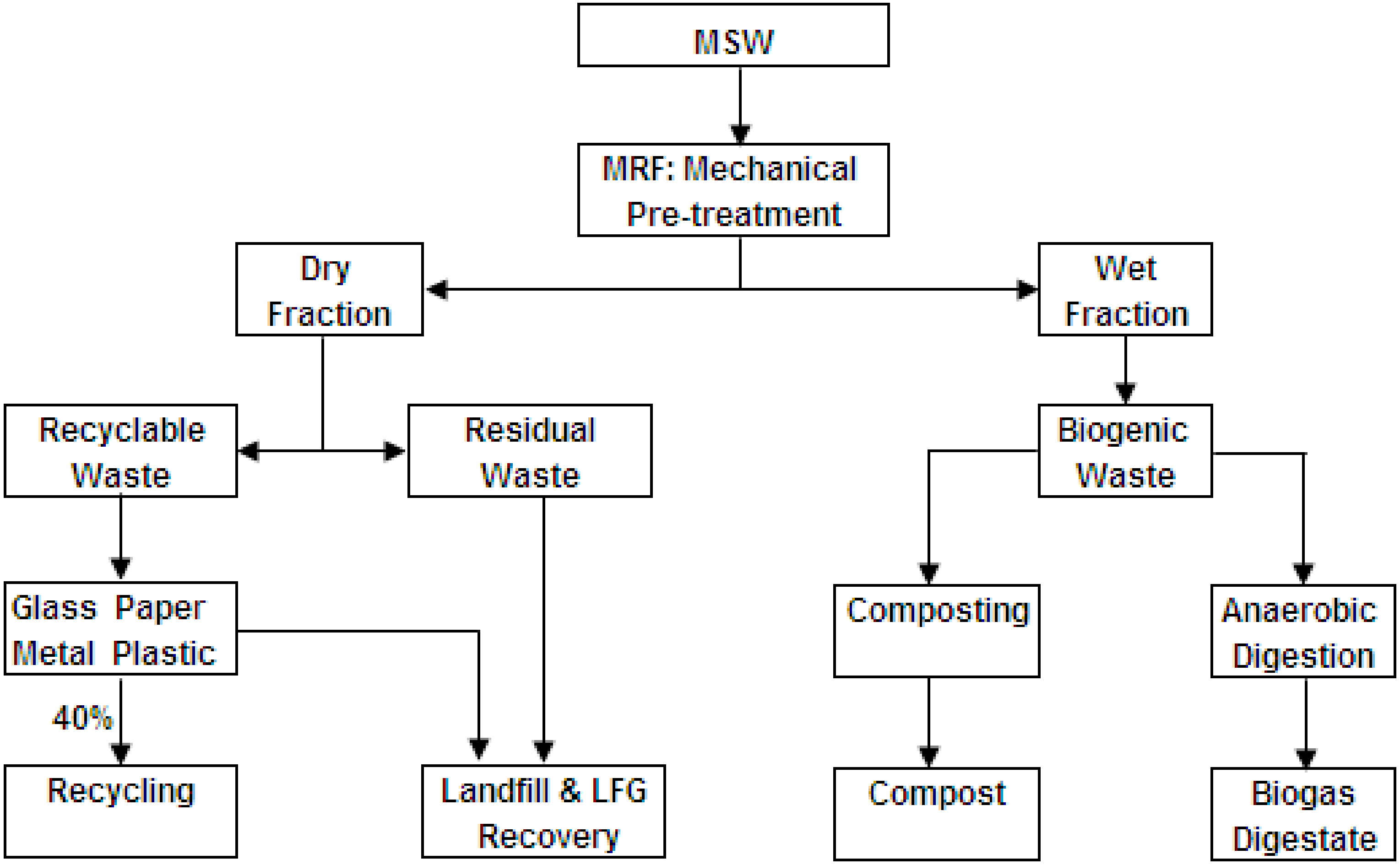
CONCLUSIONS

Scenario Analysis for Municipalities

- Zero Waste Model
- Assist LAs in formulating sustainable WM strategies
- Resource recovery (i.e., waste-to-energy)
- Quantitative assessment of GHG reduction & landfill space savings
- Waste stream analysis: “knowledge gaps”
- Financial feasibility leading to scenario analysis

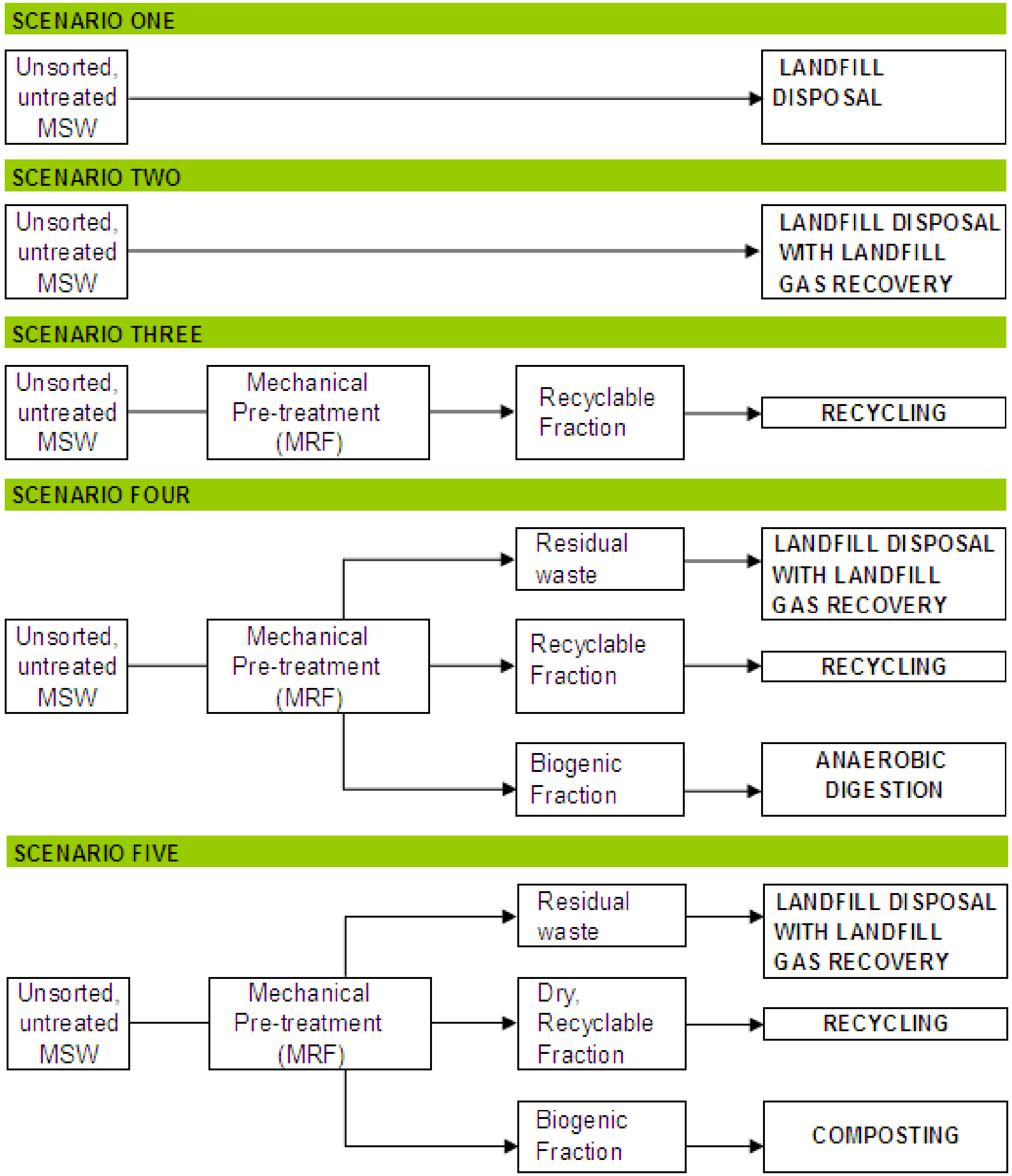
Dry-wet waste diversion model



WASTE MANAGEMENT STRATEGY	EVALUATION CRITERIA		
	Implementation Requirements	Technical Feasibility	Impacts to Environment & WM Systems
Source Separation	Public Participation. Provision of separate bins, or refuse bags. Weekly collection services.	Source separation of paper employed in most areas of eThekwini, better service delivery is required.	Initial separation reduces contamination of waste (increases quality for other strategies such as anaerobic digestion).
Landfill Gas Recovery	Landfill gas recovery systems & electricity generation equipment	Technically Feasible as landfill gas recovery has been implemented at eThekwini landfill sites	Reduction in emissions through energy production. Reduction of odours.
Composting	Capital cost varies, depending on type of composting method. Separation of biogenics	Technically feasible: composting is a well developed process.	Production of compost, which reduces use of chemical fertilisers.
Anaerobic Digestion	Significant capital investment. Separation of biogenics Legislation/Incentives. Creation of a market for AD products.	Many processes and technologies available. Potential for implement-ation under CDM.	Reduction in emissions through energy (biogas) production. Production of digestate for use as fertiliser or soil conditioner.
Thermal Treatment	Significant capital investment. Separation of combustible waste.	Further research into technologies such as pyrolysis required - not widely implemented.	Reduction in emissions through energy recovery if implemented. Emission of pollutants & heavy metal particulates
Recycling	Public participation. Greater incentives to strengthen recycling market.	Technically feasible. Recycling centres/prog-rams in place currently.	Preserves natural resources. Increased carbon sequestration.
Mechanical Biological Treatment	Combination of AD/ composting & MRF separation processes.	As above for AD & composting. Feasible: MRF at Mariannhill landfill.	As above for recycling & composting/anaerobic digestion.

What is the W.R.O.S.E model?

- **W.R.O.S.E. = Waste & Resource Optimisation Scenario Evaluation**
- WM Strategies: landfill, landfill gas recovery, recycling, AD and aerobic composting
- Evaluates GHG emissions reductions from applying waste diversion strategies
  - Emission factors developed by the US EPA for WM strategies and together with an estimated emissions factor for AD
- Microsoft Excel Spreadsheet Interface


SCENARIO ONE
Unsorted, untreated MSW
LANDFILL DISPOSAL
SCENARIO TWO
Unsorted, untreated MSW
LANDFILL DISPOSAL WITH LANDFILL GAS RECOVERY
SCENARIO THREE
Unsorted, untreated MSW
Mechanical Pre-treatment (MRF)
Recyclable Fraction
RECYCLING
SCENARIO FOUR
Residual waste
LANDFILL DISPOSAL WITH LANDFILL GAS RECOVERY
Unsorted, untreated MSW
Mechanical Pre-treatment (MRF)
Recyclable Fraction
RECYCLING
Biogenic Fraction
ANAEROBIC DIGESTION
SCENARIO FIVE
Residual waste
LANDFILL DISPOSAL WITH LANDFILL GAS RECOVERY
Unsorted, untreated MSW
Mechanical Pre-treatment (MRF)
Dry, Recyclable Fraction
RECYCLING
Biogenic Fraction
COMPOSTING

WROSE Model Input Screen

Microsoft Excel - wrose

	A	B	C	D	E	F
1	WASTE & RESOURCE OPTIMISATION STRATEGY EVALUATION MODEL					
2	W.R.O.S.E					
3	WASTE MATERIAL OR	Quantity of Waste Disposed/treated/diverted by (tons):				
4	WASTE FRACTION	LANDFILL	LANDFILL	RECYCLING	ANAEROBIC	AEROBIC
5		DISPOSAL	GAS REC		DIGESTION	COMPOSTING
6	Newspaper	5453				
7	General mixed paper (CMW)	7234				
8	Scrap Boxes & Cardboard (K4)	11402				
9	Low density polyethylene (LDPE)	2450				
10	High density polyethylene (HDPE)	1401				
11	Polyethylene-terephthalate (PET)	2037				
12	Polypropylene (PP)	1613				
13	Polyvinyl Chloride (PVC)	8				
14	Polystyrene (PS)	1101				
15	Glass	6861				
16	Steel Cans/Tins	4245				
17	Aluminium Cans	547				
18	Biogenic Food Waste	36608				
19	Garden Refuse: Green	637				
20	Garden Refuse: Wood	46				
21	Other	32287				
22	Total Waste Diverted/Disposed	113930	0	0	0	0

User enters waste fraction quantities to be diverted or disposed of by each strategy.

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WROSE Model Output Screen

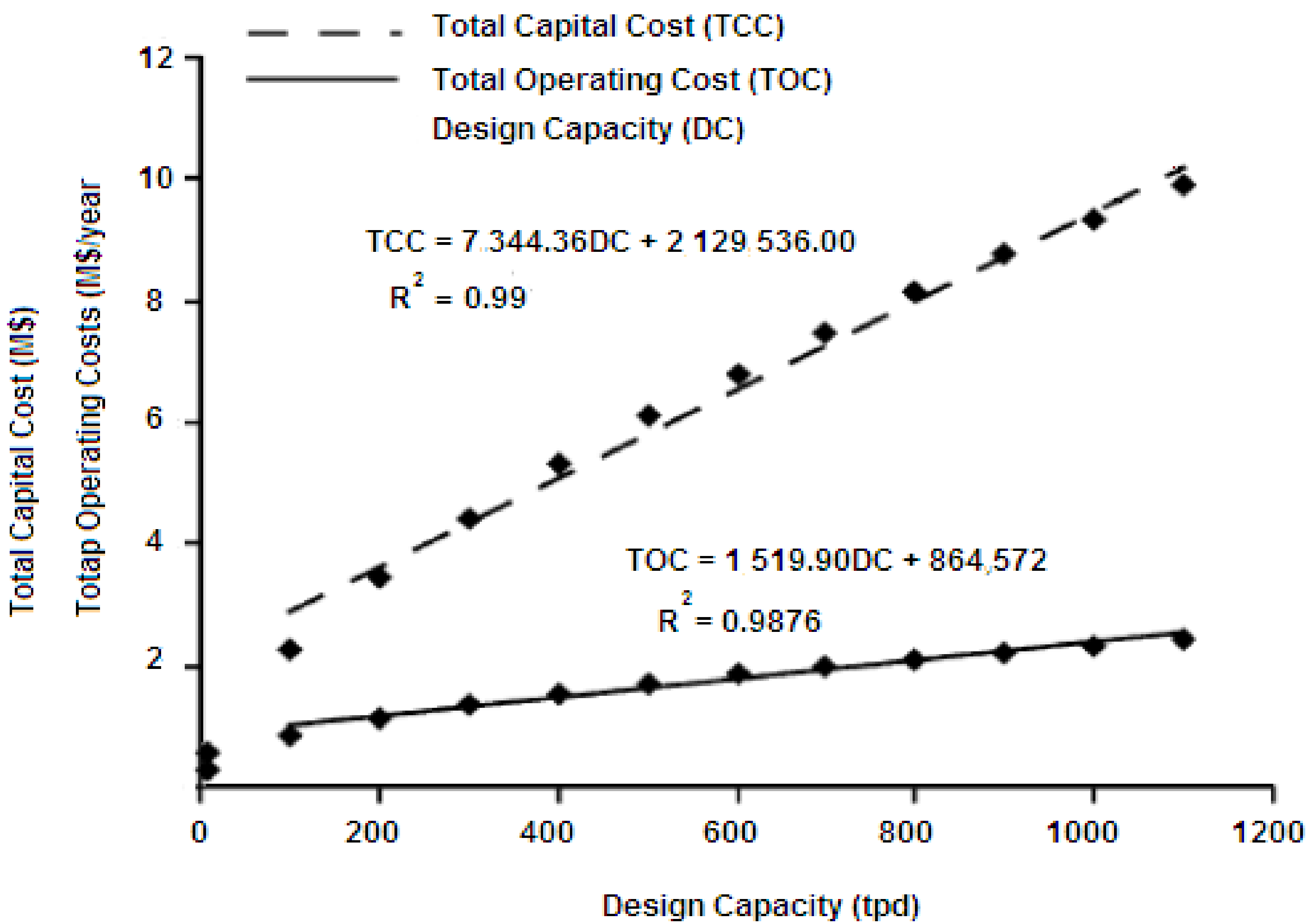
Microsoft Excel - wrose

File Edit View Insert Format Tools Data Window Help Adobe PDF

H8

	A	B	C	D	E	F
1	**WASTE & RESOURCE OPTIMISATION STRATEGY EVALUATION MODEL**					
2	**W.R.O.S.E**					
3	**WASTE MATERIAL OR**		**Greenhouse Gas Emissions/Reductions**			
4	**WASTE FRACTION**	LANDFILL	LANDFILL	RECYCLING	ANAEROBIC	AEROBIC
5		DISPOSAL	GAS REC		DIGESTION	COMPOSTING
6	Newspaper	0	-7092.87	0	-	-
7	General mixed paper (CMW)	0	-3747.84	0	-	-
8	Scrap Boxes & Cardboard (K4)	0	-5781.53	0	-	-
9	Low density polyethylene (LDPE)	0	108.03	0	-	-
10	High density polyethylene (HDPE)	0	61.77	0	-	-
11	Polyethylene-terephthalate (PET)	0	89.82	0	-	-
12	Polypropylene (PP)	0	71.12	0	-	-
13	Polyvinyl Chloride (PVC)	0	0.35	0	-	-
14	Polystyrene (PS)	0	48.55	0	-	-
15	Glass	0	302.52	0	-	-
16	Steel Cans/Tins	0	187.17	0	-	-
17	Aluminium Cans	0	24.12	0	-	-
18	Biogenic Food Waste	0	6456.55	-	0	0
19	Garden Refuse: Green	0	-435.35	-	-	0
20	Garden Refuse: Wood	0	-47.16	-	-	0
21	Other	0	1423.61	0	-	-
22						
23	**Strategy GHG Emissions/**	**0**	**-8331.14**	**0**	**0**	**0**
24	**Reductions ($MTCO_2eq$)**					
25	**Total GHG Emissions/Reductions (MTCO2eq)**					**-8331.14**

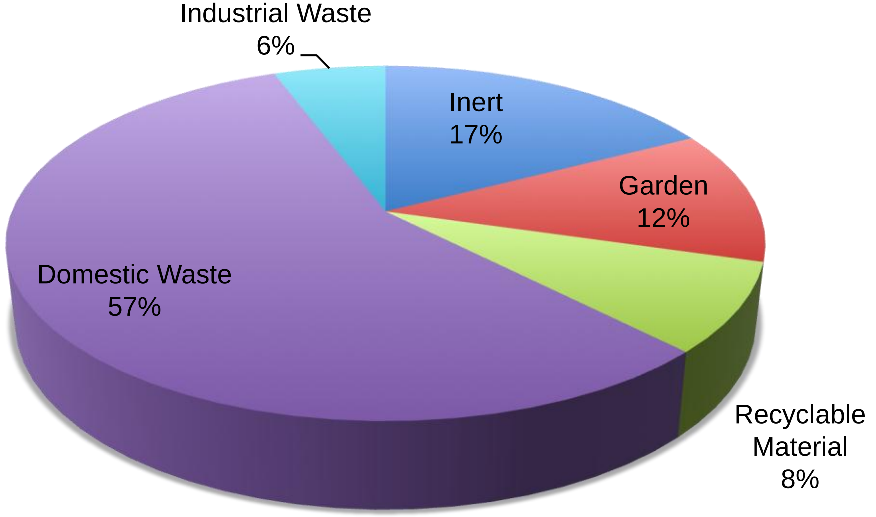
Capital & Operational Costs - MRF



Case Study: UMDM

- 7 local municipalities
- 5 landfills currently
- 1 003 084 people
- Population Growth: 0.87%
- Waste Growth: 1.088%
- 213 694 tonnes of Waste per year

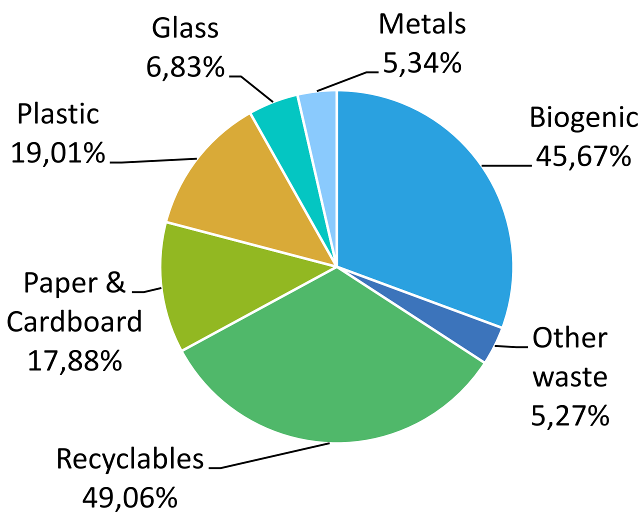
UMDM: Current Waste Generation



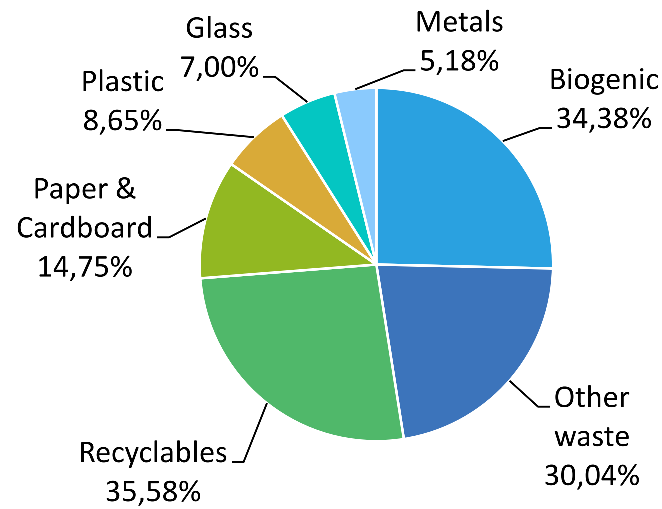
Phase A: Inception Report → Phase B: Draft Feasibility Study Report → Phase C: Final Feasibility Study Report → Phase D: Revised Final Feasibility Study Report

Comparison of Waste Streams

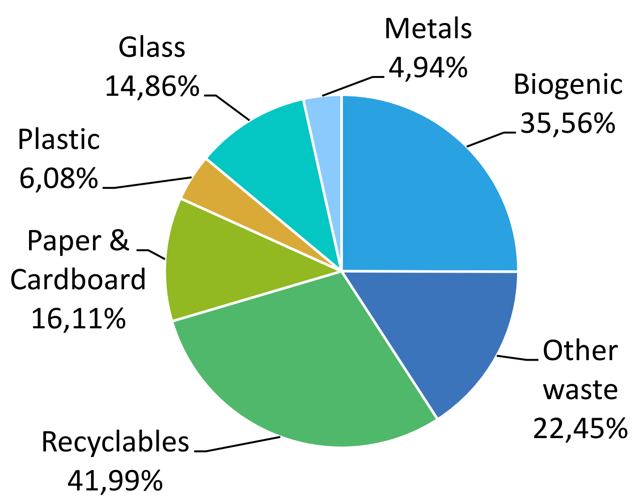
eThekwini Household



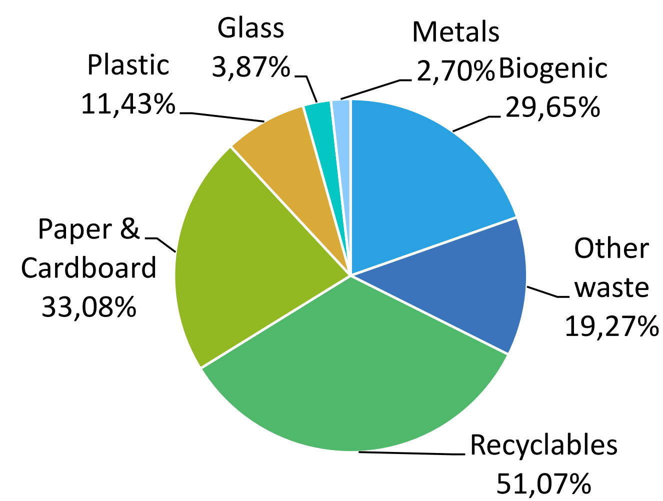
UMDM Household



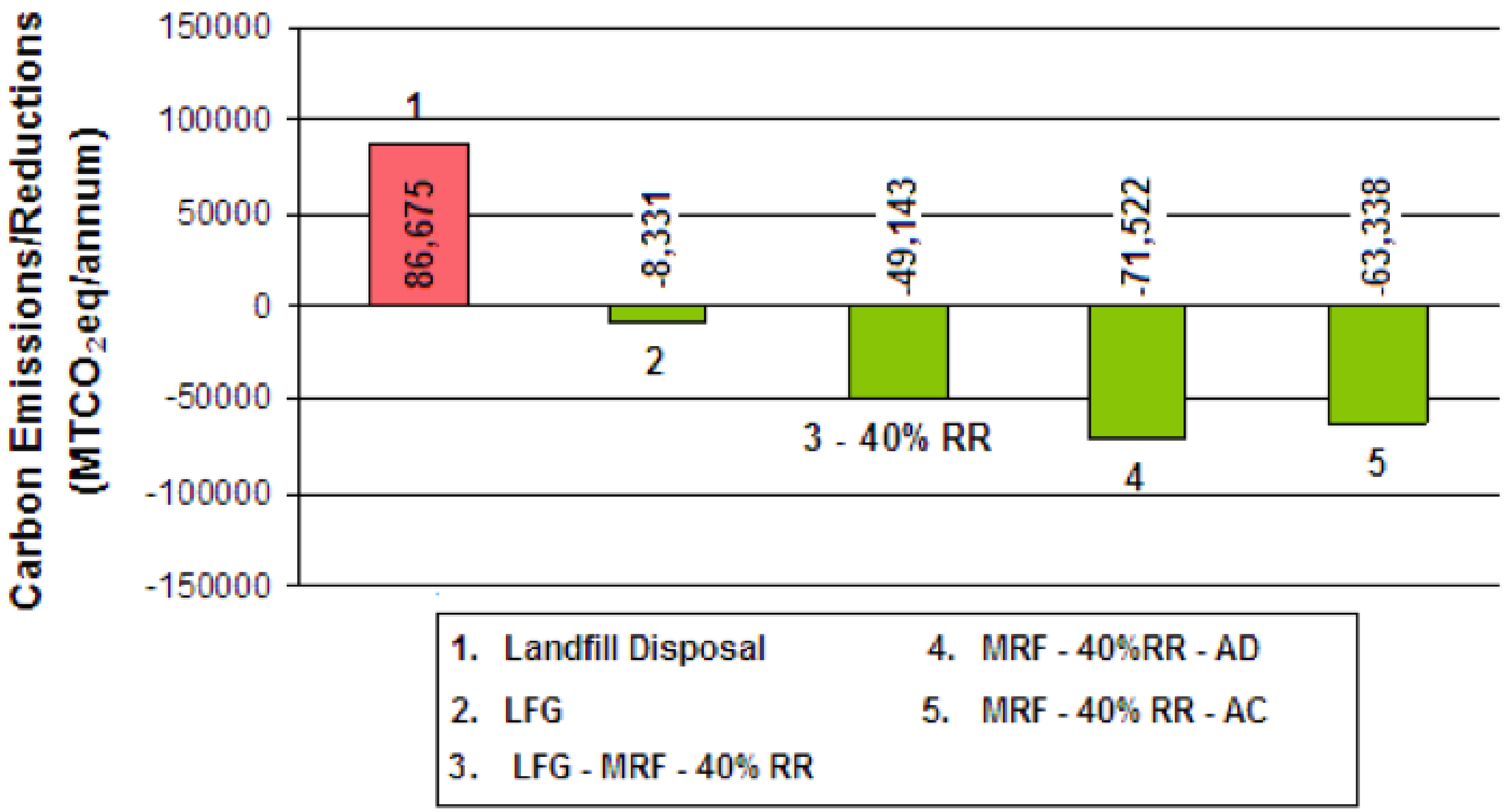
eThekwini Commercial



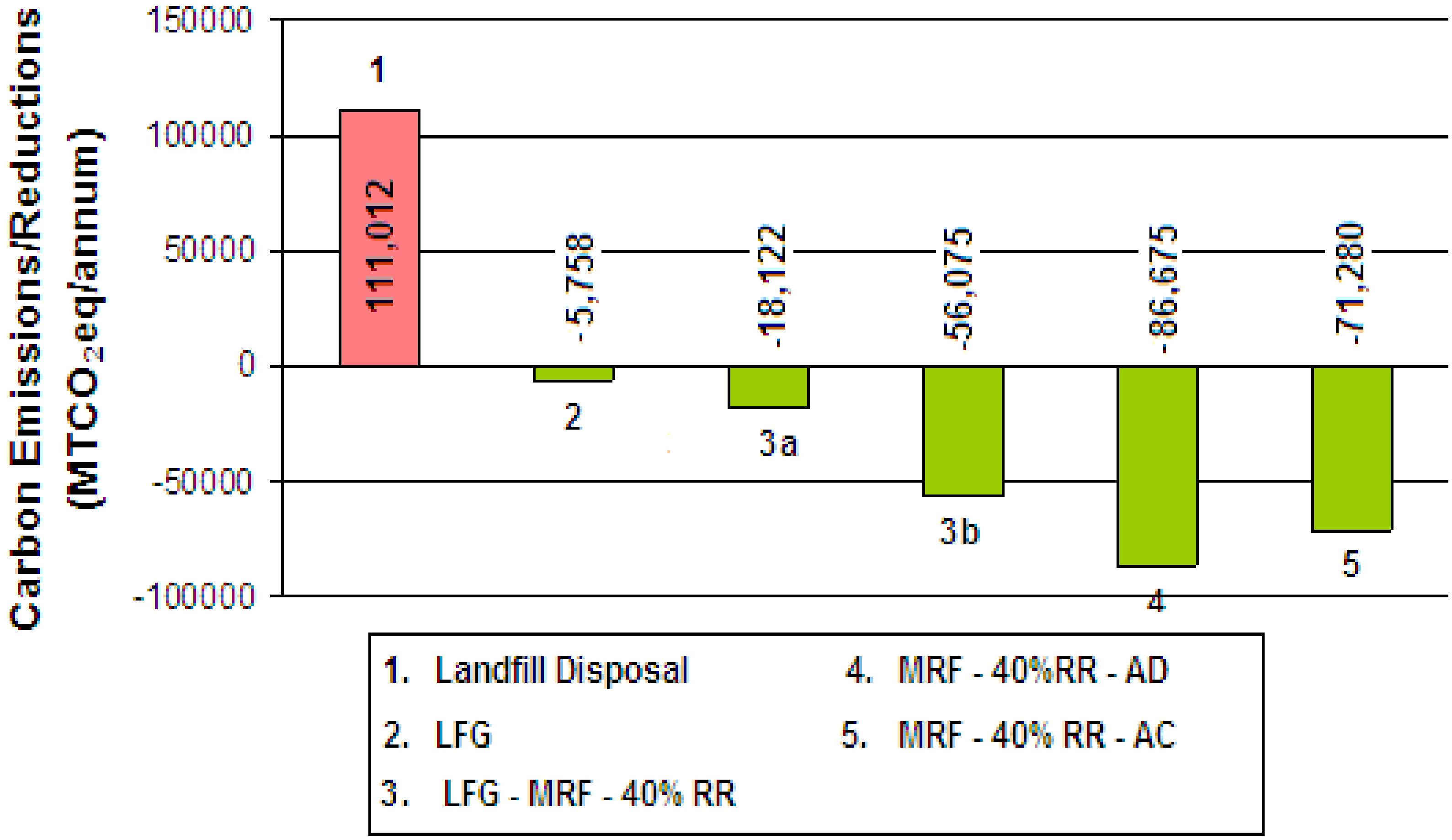
UMDM Commercial



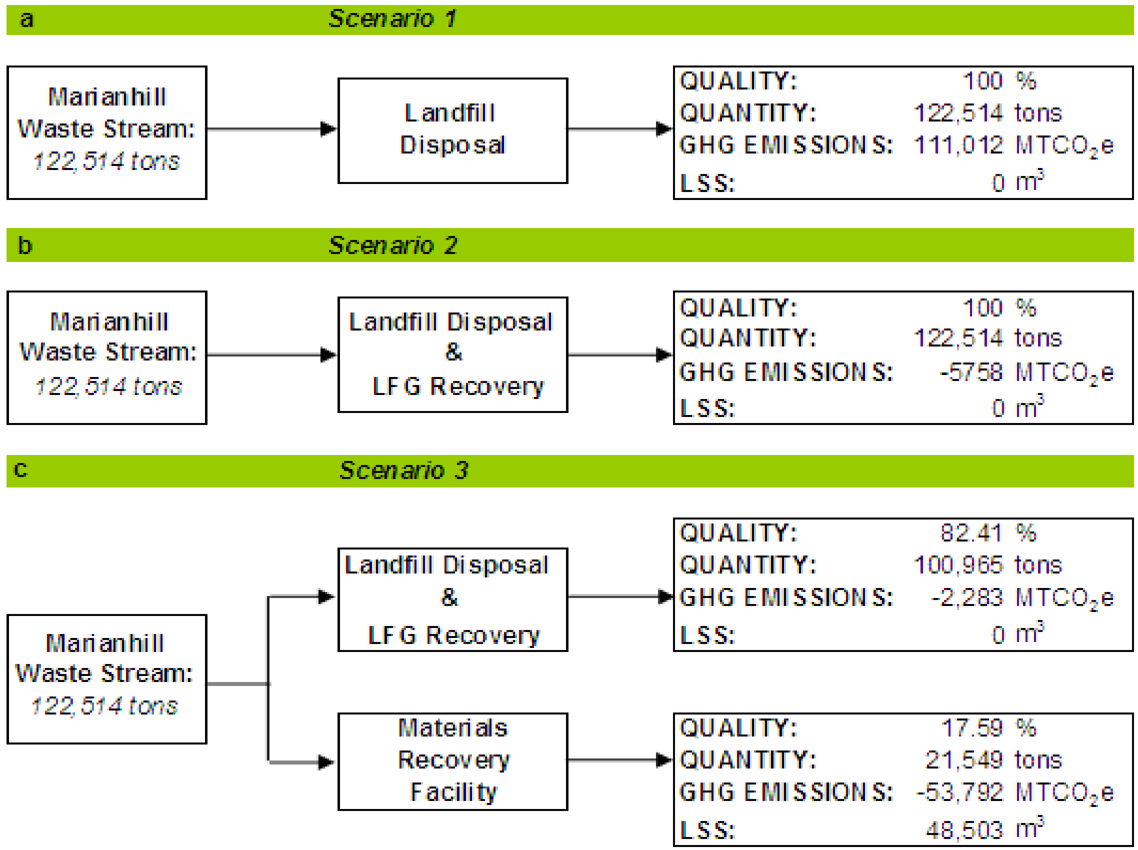
Assessment of New England Road



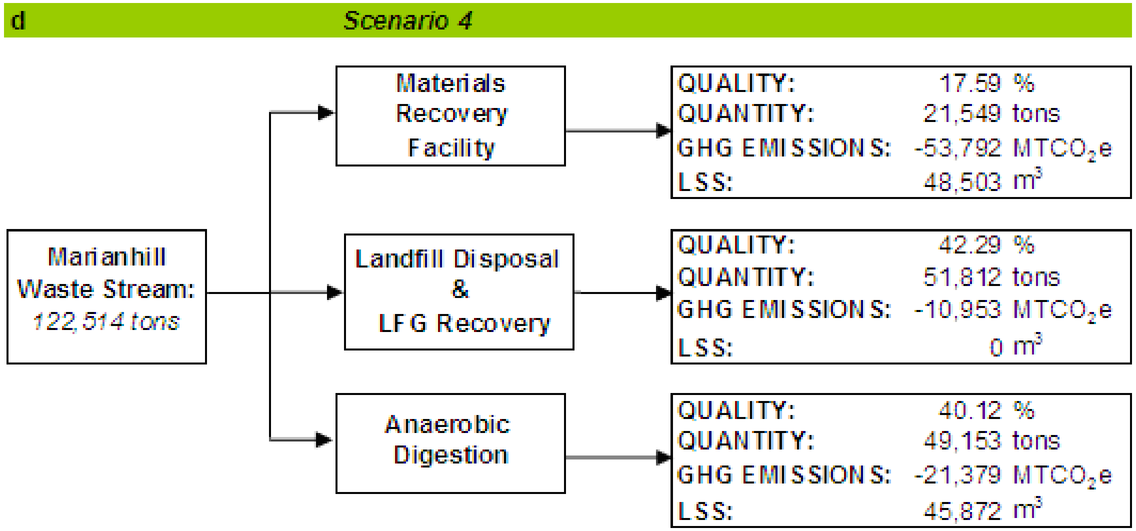
Assessment of Marianhill Landfill

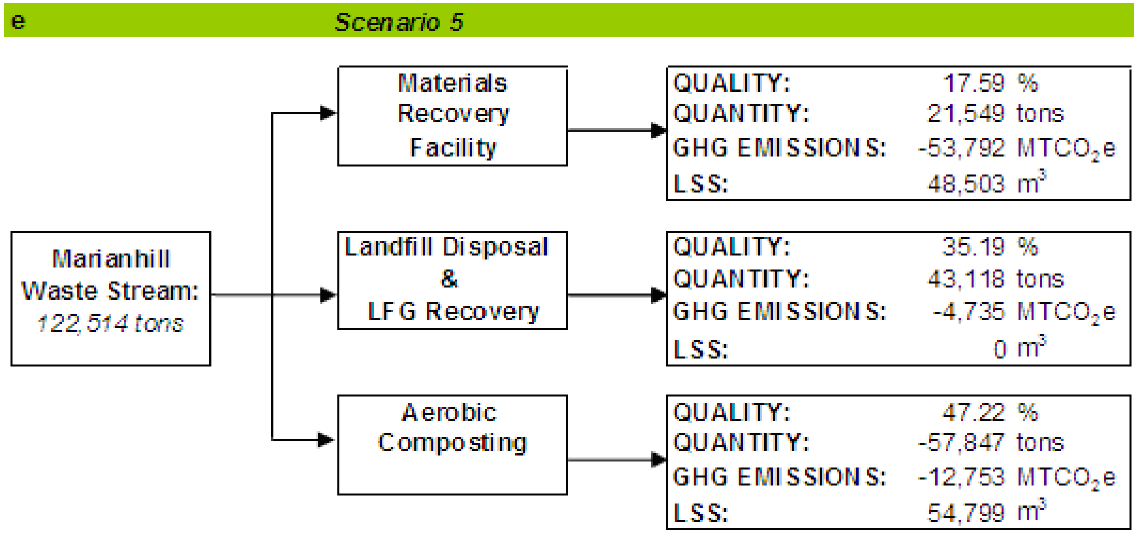


Marianhill Waste Stream



Marianhill Waste Stream





Marianhill Economic Analysis

Strategy	Quantity Managed/ Produced	Rate	Capital Cost (R)	Operating Cost (R/annum)	Income/Savings (R/annum)
1. LANDFILL DISPOSAL & LFG RECOVERY					
Landfill Gas Recovery System	0.50 MW		1,100,000		
Landfill Disposal operations	122,514 tons	138 R/ton		16,906,932	
Landfill Gas Recovery operating costs	7,051,800 kWh	0.018$/kWh		866,758	
Sale of Electricity	7,051,800 kWh	0.047$/kWh			2,263,201
Certified Emission Reductions	5,758 $MTCO_2e$	14$/$MTCO_2e$			550,458
Total			**1,100,000**	**17,773,690**	**2,813,659**
2. MRF & RECYCLING					
Materials Recycling Facility Capital Cost	385 tpd	30,668 $/tpd	33,848,875		
Materials Recycling Facility Operating Cost	385 tpd	2,815$/tpd		9,899,276	
Sale of Recyclables	21,549 tons	R/kg			19,598,660
Landfill airspace savings	47,122 m^3	62.5R/m^3			2,945,125
Total			**33,848,875**	**9,899,276**	**22,543,785**
3. ANAEROBIC DIGESTION					
Anaerobic Digestion Plant Capital Cost	49,153 tons	15.24$ million	104,066,340		
Anaerobic Digestion Plant Operating Cost	49,153 tons	28.2$/ton		9,465,084	
Sale of electricity	18,128,413 kWh	0.047$/kWh			5,818,124
Sale of Compost	29,492 tons	250R/ton			7,372,950
Certified Emissions Reductions	21,379 $MTCO_2e$	14$/$MTCO_2e$			2,043,797
Landfill airspace savings	45,872 m^3	62.5R/m^3			2,867,000
Total			**104,066,340**	**9,465,084**	**18,101,871**
4. AEROBIC COMPOSTING					
Composting Facility Capital Cost	57,847 tons	2E+06R/180tpd	3,066,667		
Composting Facility Operating Cost	57,847 tons	152.05R/ton		9,123,000	
Sale of compost	43,385 tons	250R/ton			10,846,313
Certified Emissions Reductions	12,753 $MTCO_2e$	14$/$MTCO_2$			1,219,182
Landfill airspace savings	54,799 m^3	62.5R/m^3			3,424,938
Total			**3,066,667**	**9,123,000**	**15,490,433**

New England Economic Analysis

Strategy	Quantity Managed/ Produced	Rate	Capital Cost (R)	Operating Cost (R/annum)	Income/Savings (R/annum)
1. LANDFILL DISPOSAL & LFG RECOVERY					
Landfill Gas Recovery System	0.50 MW		1,100,000		
Landfill Disposal operations	113,930 tons	138 R/ton		15,722,340	
Landfill Gas Recovery operating costs	7,051,800 kWh	0.018 $/kWh		866,758	
Sale of Electricity	7,051,800 kWh	0.047 $/kWh			2,263,201
Certified Emission Reductions	8,331 $MTCO_2e$	14 $/$MTCO_2e$			796,448
Total			**1,100,000**	**16,589,089**	**3,059,649**
2. MRF & RECYCLING					
Materials Recycling Facility Capital Cost	385 tpd	30,668 $/tpd	33,848,875		
Materials Recycling Facility Operating Cost	385 tpd	2,815 $/tpd		9,899,276	
Sale of Recyclables	17,740 tons	R/kg			15,714,260
Landfill airspace savings	39,774 m^3	62.5 R/m^3			2,485,875
Total			**33,848,875**	**9,899,276**	**18,200,135**
3. ANAEROBIC DIGESTION					
Anaerobic Digestion Plant Capital Cost	36,608 tons	13.26 $ million	90,545,910		
Anaerobic Digestion Plant Operating Cost	36,608 tons	32.4 $/ton		8,099,278	
Sale of electricity	13,501,616 kWh	0.047 $/kWh			4,333,202
Sale of Compost	21,965 tons	250 R/ton			5,491,200
Certified Emissions Reductions	-15,922 $MTCO_2e$	14 $/$MTCO_2e$			1,522,172
Landfill airspace savings	34,164 m^3	62.5 R/m^3			2,135,250
Total			**90,545,910**	**8,099,278**	**13,481,824**
4. AEROBIC COMPOSTING					
Composting Facility Capital Cost	37,291 tons	2E+06R/180tpd	2,000,000		
Composting Facility Operating Cost	37,291 tons	152.05R/ton		6,082,000	
Sale of compost	27,968 tons	250R/ton			6,992,063
Certified Emissions Reductions	8,221 $MTCO_2e$	14 $/$MTCO_2e$			785,944
Landfill airspace savings	34,865 m^3	62.5 R/m^3			2,179,063
Total			**2,000,000**	**6,082,000**	**9,957,070**

WASTE AS A RESOURCE

INTEGRATED WASTE MANAGEMENT

- National waste management strategy in South Africa and implementation of the waste hierarchy
- Brief description of available waste strategies for Local Authorities

THE W.R.O.S.E MODEL

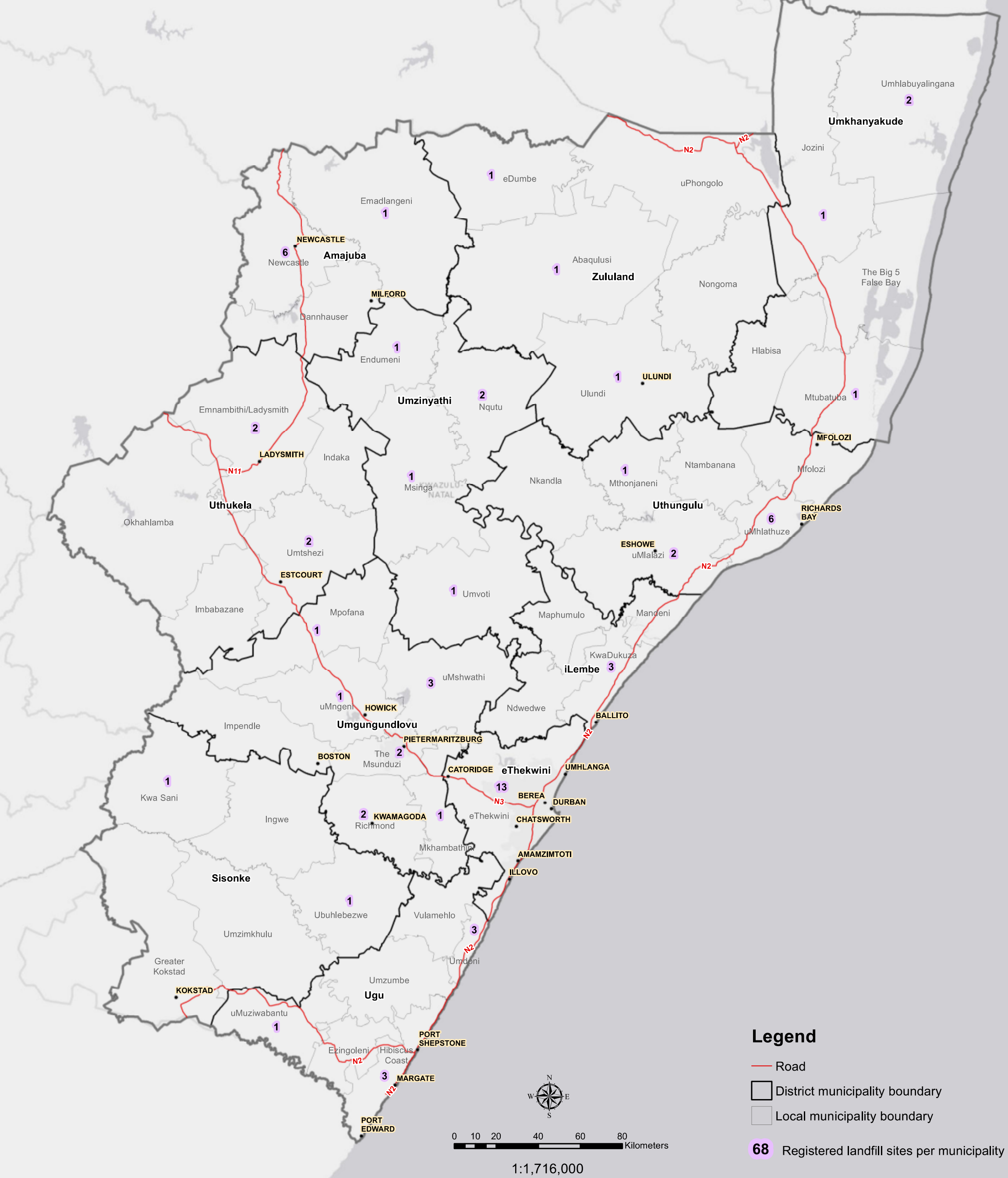
- Waste & Resource Optimisation Strategy Evaluation Model W.R.O.S.E
- Decision-making tool for assisting municipalities in the selection of appropriate waste management strategies

PPP EXAMPLES OF WTE PROJECTS

- Examples of Public Private Partnership waste projects in South Africa (KwaZulu-Natal Province)

CONCLUSIONS

Potential for Landfill Biogas-to-Energy…



Anaerobic Digestion of Food Waste

- Partnership: UKZN-Don't Waste Services-THRIP
- **0.5 MW (12 MWh) AD Plant** on Howard College Campus – to process 40-60 tons of macerated food waste and food processing waste per day
- Emissions reduction = approx. 18 000 tons of CO_2 eq. per annum
- Digestate/compost material = approx. 95 tons per month

- Partnership: DubeTrade Port-UKZN-THRIP (Dti)
- **0.5 MW (12 MWh) AD Plant** in the AgriZone – to process 35-40 tons of macerated food waste and food processing waste per day
- Emissions reduction = approx. 15 000 tons of CO_2 eq. per annum
- Digestate/compost material = approx. 95 tons per month

Energy Recovery from Farm Waste

Biomass potential in KwaZulu-Natal, South Africa

High levels of animal husbandry with poor waste management practices

- Significant quantities of organic waste available
- Significant potential to reduce current GHG emissions
- Paradigm shift: Waste as an opportunity!

Anaerobic Digestion of Food Waste

- Prefeasibility study conducted using Induced Blanket/Bed Reactor AD Plant and industry standards for Biogas production from cow manure
  - Biogas used to run gas powered electrical generators – electricity used for farm/dairy operation (financial benefit)
  - **Reduced GHG emissions**
- **NOT Financially feasible under baseline assumptions**
  - Cows kept in open pastures **(no waste collection),** and rotary dairy system highly efficient **(low level of waste collection)**

Advanced Rotary Dairy system with cow retention time of approx. 11 minutes

Prefeasibility Assessment – Piggery AD Plant in Ashburton, KZN

- 5000 pigs producing approx. 9000 tonnes of wet organic waste per annum
- Biogas yield of 694m^3 per day
- Energy output per year approx. 342 168 kWh

FINANCIAL FEASIBILITY IDENTIFIED

- Energy cost offset = internal rate of approx. return 7%

Waste-to-energy in rural SA

- Case study UKZN-WRC Project (k5/1955)
- New application to LOTTO for 10 small AD plants (Mkuze Game Reserve)
- Objective: improve living standards in rural households through integrated waste, water and energy sustainable technology solutions
- Integrating rainwater harvesting, livestock fodder production and biogas generation in rural areas of South Africa
- 4 pilot study households in each province

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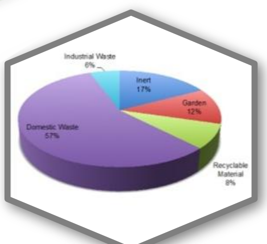
CONCLUSIONS



Conclusions

- Need for GIS mapping of regional landfills
- Comprehensive waste stream analysis and carbon footprint assessment required to develop projects
- Need for an integrated sustainable waste management decision-making framework for local authorities
- Need for ad hoc capacity building within municipalities
- Scenario and Technology Assessment (through the use of tools like WROSE) prior to financial commitment, towards a sound bankable feasibility report
- Streamline success of projects through the creation of synergic special purpose vehicles between private and public actors

THANK YOU

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