Ministry of Finance
Public Private Partnership Unit

Municipal Solid Waste to Energy

Technology Recommendations and Implementation Considerations

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Presentation to

Waste to Energy Ministerial Committee

14th of August 2012

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Meeting Objectives

- Communicate W2E criteria evaluation and tipping fee analysis results.
- Outline W2E implementation recommendations.
- Discuss the development of a W2E enabling framework.

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Presentation Overview

- Waste to Energy Rationale
- MSW Energy Recovery Options
- Analysis of W2E Deployment Scenarios
- Implementation Considerations
- Next Steps and Decisions Required: W2E Enabling Framework

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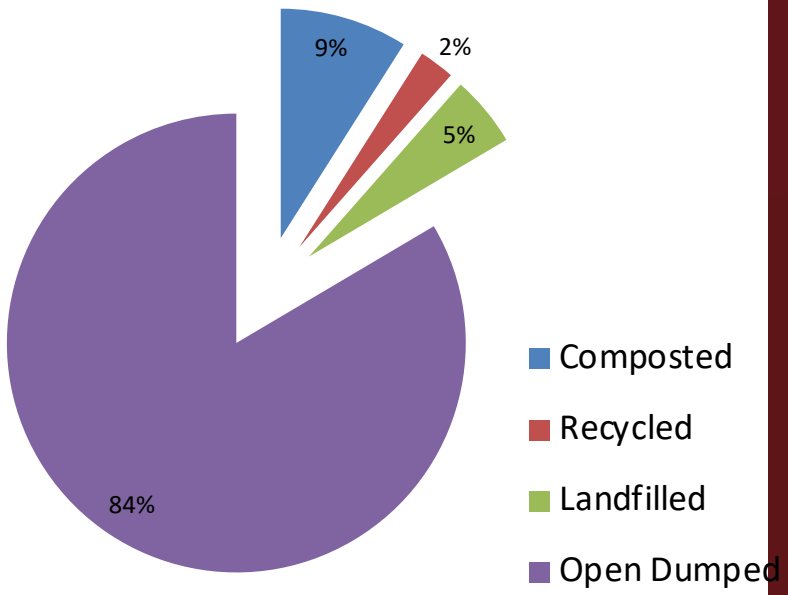
WASTE TO ENERGY RATIONALE

MSW TREATMENT AND DISPOSAL CHALLENGES
DIVERSE URBAN CENTER CHARACTERISTICS REQUIRE DIVERSE WTE SOLUTIONS
MSW VALUE FROM AN ENERGY PERSPECTIVE
W2E TECHNOLOGY DIVERSITY
W2E IS ABOUT WASTE MANAGEMENT NOT ENERGY PRODUCTION

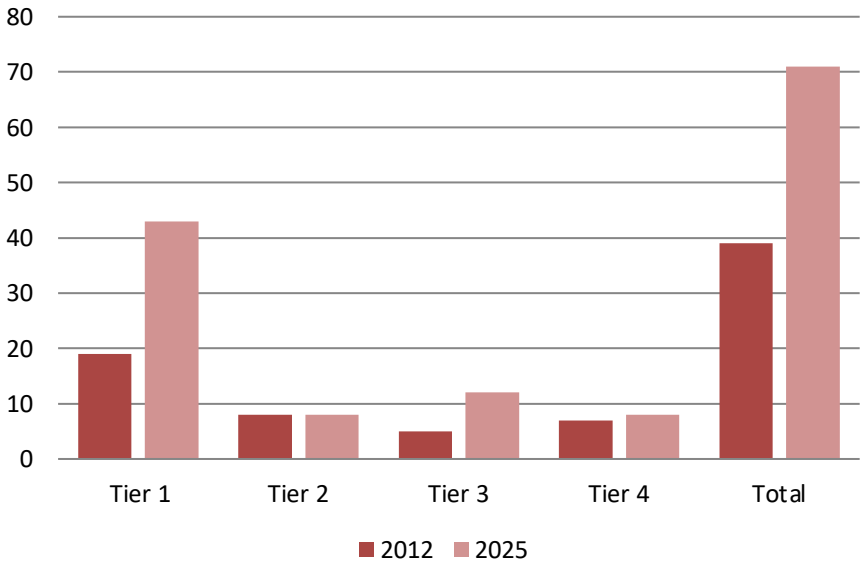
MSW Treatment and Disposal Challenges

Current MSW management systems need to be upgraded and expanded, to deal with increased capacity and reduce economic, health, social and environmental impact.

Reported MSW Treatment and Disposal



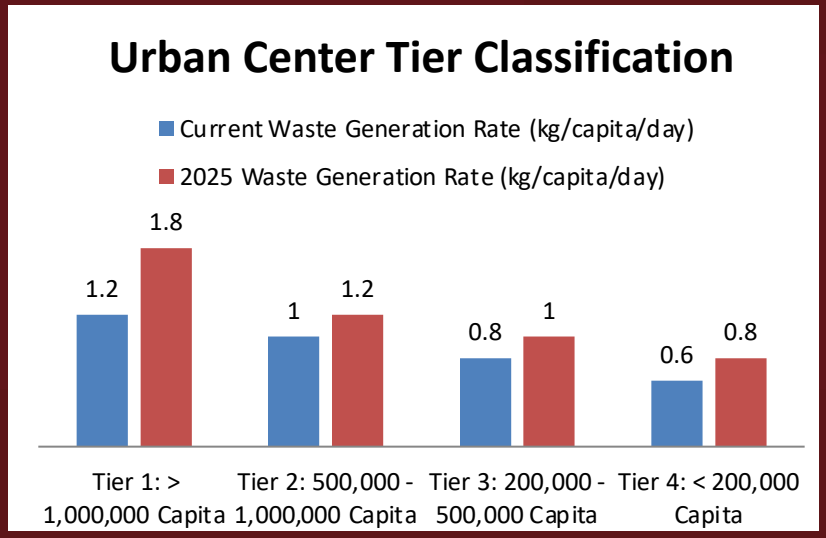
Total Daily Waste Generation from Identified Urban Centers

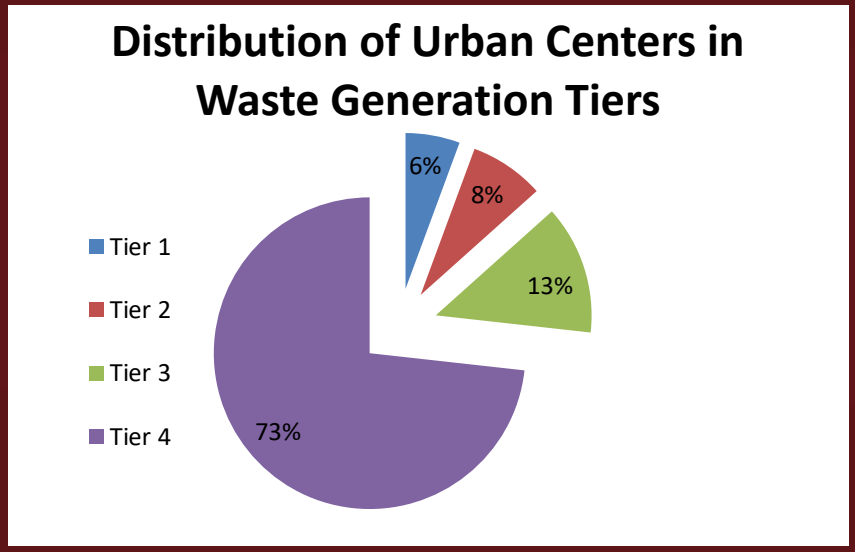


Source: "Country Profile on Solid Waste Management Situation In Egypt", Regional Solid Waste Exchange of Information and Expertise Network in Mashreq and Maghreb countries, July 2010

Diverse Urban Center Characteristics Require Diverse WTE Solutions

- Developed a Multi-tier model for urban centers to differentiate according to waste generation rates.





Different urban centers have different characteristics in terms of:
Size of urban center, relative distance and potential for agglomeration of waste from nearby centers, access to desert land within distance for treatment and/or disposal, availability of land for transfer station and/or material recovery facility near source of MSW.

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MSW Value from an Energy Perspective

- Each ton of MSW can generate between 150-550 kwatt.hr
- At a total current waste generation from identified urban centers of 14 Million tons MSW/year, W2E has potential to generate between 250 – 900 MWatt.
- At a projected waste generation of 25.6 Millions tons MSW/year in 2025, W2E has potential to produce between 400 - 1.600 MWatt.

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W2E Technology Diversity
A European Perspective

Route	Current Significance	Where in Europe?	Form of Energy	Status of Technology	Growth Potent.
WtE from residual MSW (incineration with energy recov)	ooooo	Throughout	Power, Heat	Mature	Yes, Regional
Incineration of RDF, SRF derived from MSW & CDM in Cement kilns, power plants etc	ooo	Denmark, Italy, Austria, Sweden, Estonia, Finland, UK	Power, Fuel replacer	Mature/ Being proven	Regional
Anaerobic Digestion from source-separated organic MSW	o	Italy, Estonia, Belgium, Denmark, France, UK	Biogas Power	Proven/ developing	yes
Anaerobic Digestion from Sorted organic fraction of MSW	o	Italy, Estonia, France	Biogas, Power	Proven/ developing	Regional yes
Incineration of Waste derived Biomass (eg wood)	oo	Denmark, Netherlands, Belgium	Power subsidised	Proven	Yes Regional
Landfill Gas Extraction	oo	Throughout Western Europe	Power, Biogas	Mature	Yes, Regional
Gasification & Pyrolysis	o	Few	Power, Syngas	Developing	?

Source: "Energy from Municipal Solid Waste: What is the current perspective?", Confederation of European Waste-to-Energy Plants, November 2010

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W2E is more about Waste than Energy

- There are cheaper and more scalable routes compared to W2E for energy generation.
- MSWM, a paid service, needs a new, sustainable treatment model.
- W2E can maximize value extraction from MSW, reduce costs, and build a sustainable treatment model that also contributes to national energy generation.

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MSW ENERGY RECOVERY OPTIONS

OVERVIEW OF MSWM
MECHANICAL BIOLOGICAL TREATMENT
THERMAL TREATMENT
HYBRID BIOLOGICAL/THERMAL
SANITARY LANDFILL WITH GAS PRODUCTION
W2E SCENARIOS

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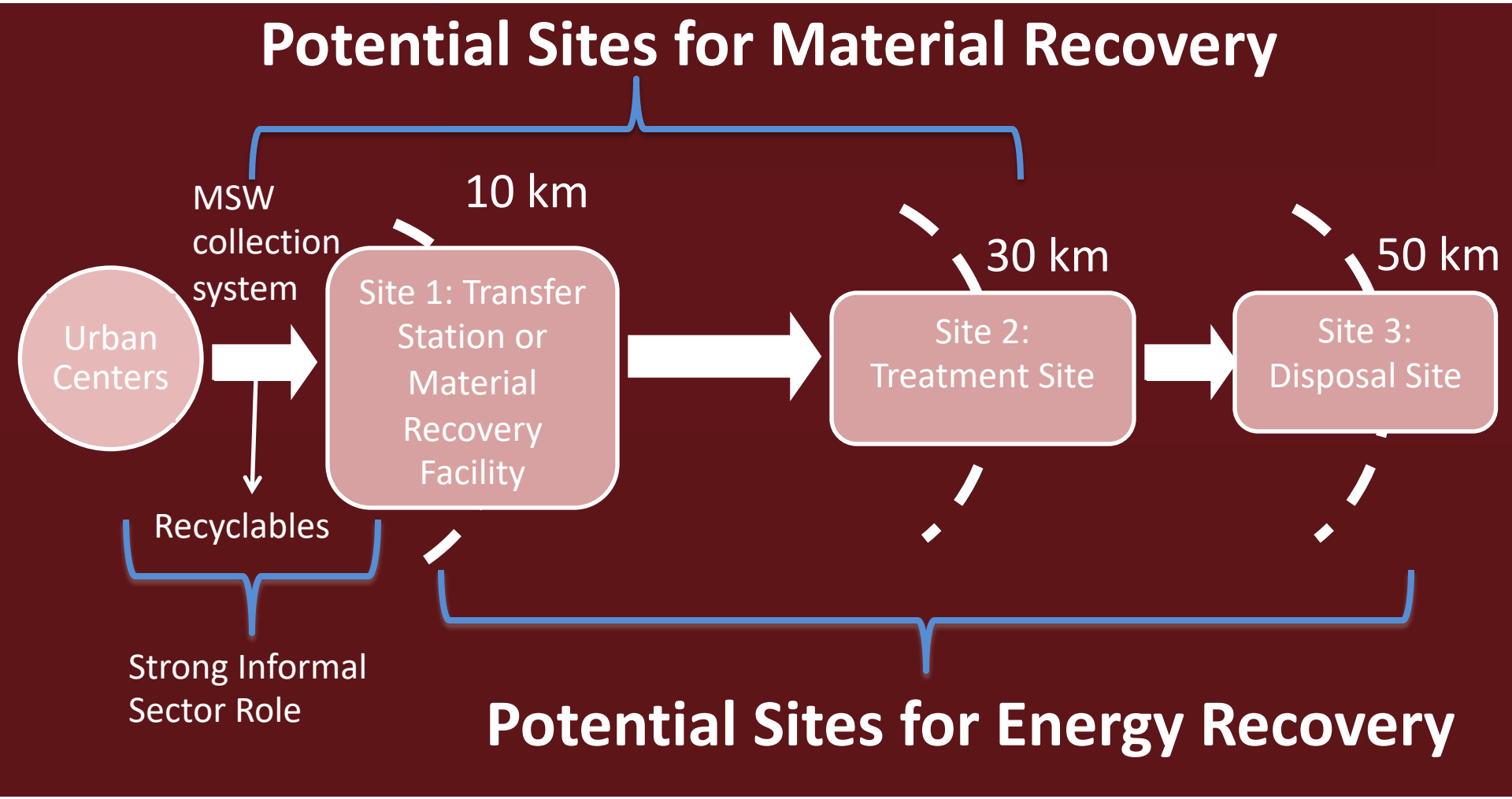
Municipal Solid Waste Management

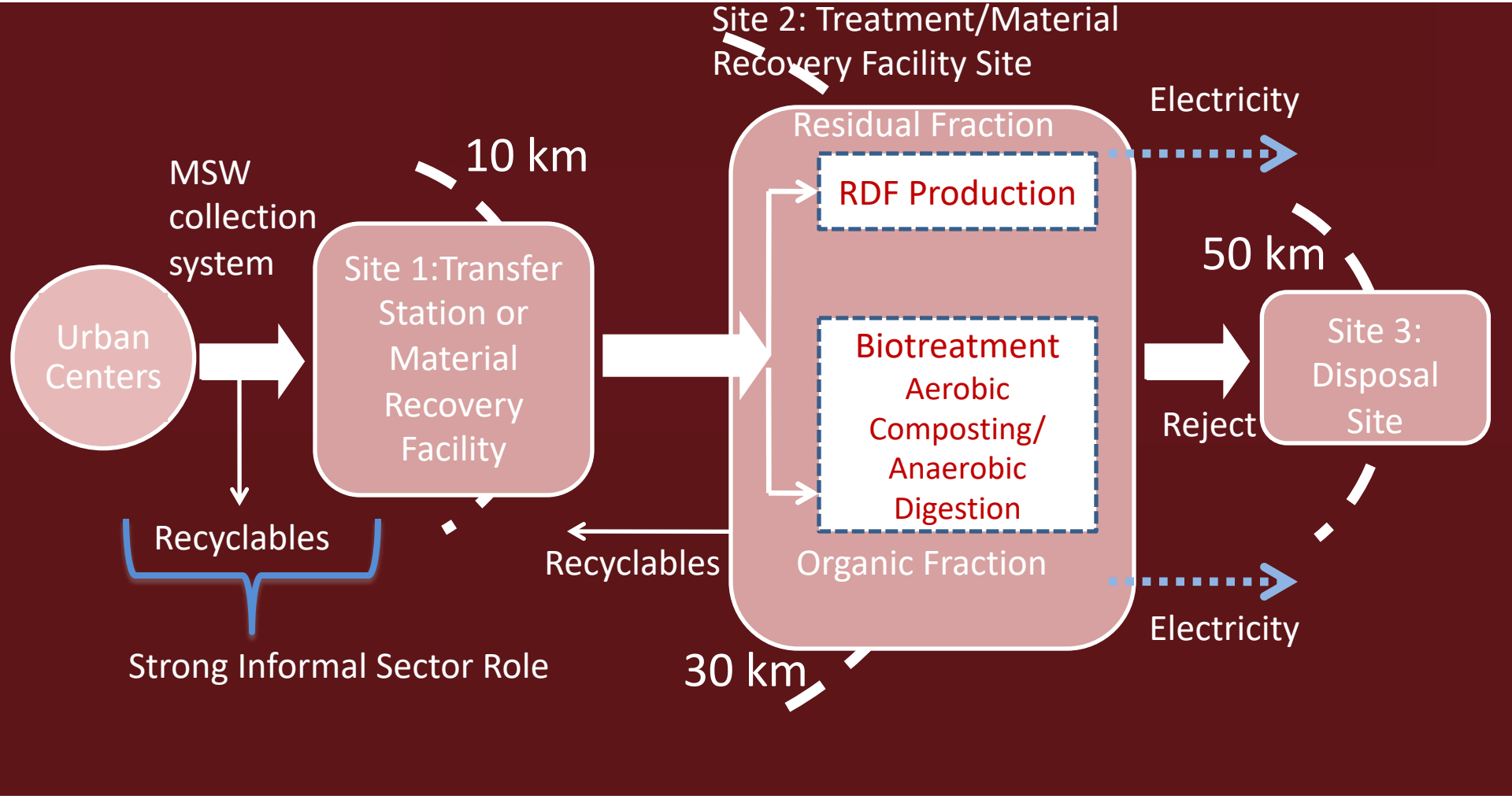


MSWM is a Supply Chain Problem.

W2E: Mechanical Biological Treatment

- In MBT technologies, organic and residual fractions are separated before treatment to optimize energy/material recovery
- The residual fraction is converted to Refuse Derived Fuel (RDF) that is used as an alternative fuel in the cement industry.
- The organic fraction can be converted to compost aerobically, requiring large land. Alternatively, the organic fraction can be anaerobically digested to produce biogas and digestate, a soil conditioner, with smaller land requirements.
- The reject from both processes is landfilled.
- MBT technologies are lower cost, have high land requirements and
- Supply Chain Considerations: Sorting at Transfer Station vs. Sorting at Treatment Facility

W2E: Mechanical Biological Treatment



Material Recovery Facility can be integrated with Transfer Station or with Disposal Site depending on land availability

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W2E: Thermal Treatment

Directly extract energy from waste via three potential routes:

- Combustion: mass burn waste to generate electricity with advanced emissions treatment system.
- Gasification: Heat waste with low oxygen to generate high quality gas then burn to generate electricity
- Pyrolysis: Heat waste in absence of oxygen to generate medium quality gas then burn to generate electricity.

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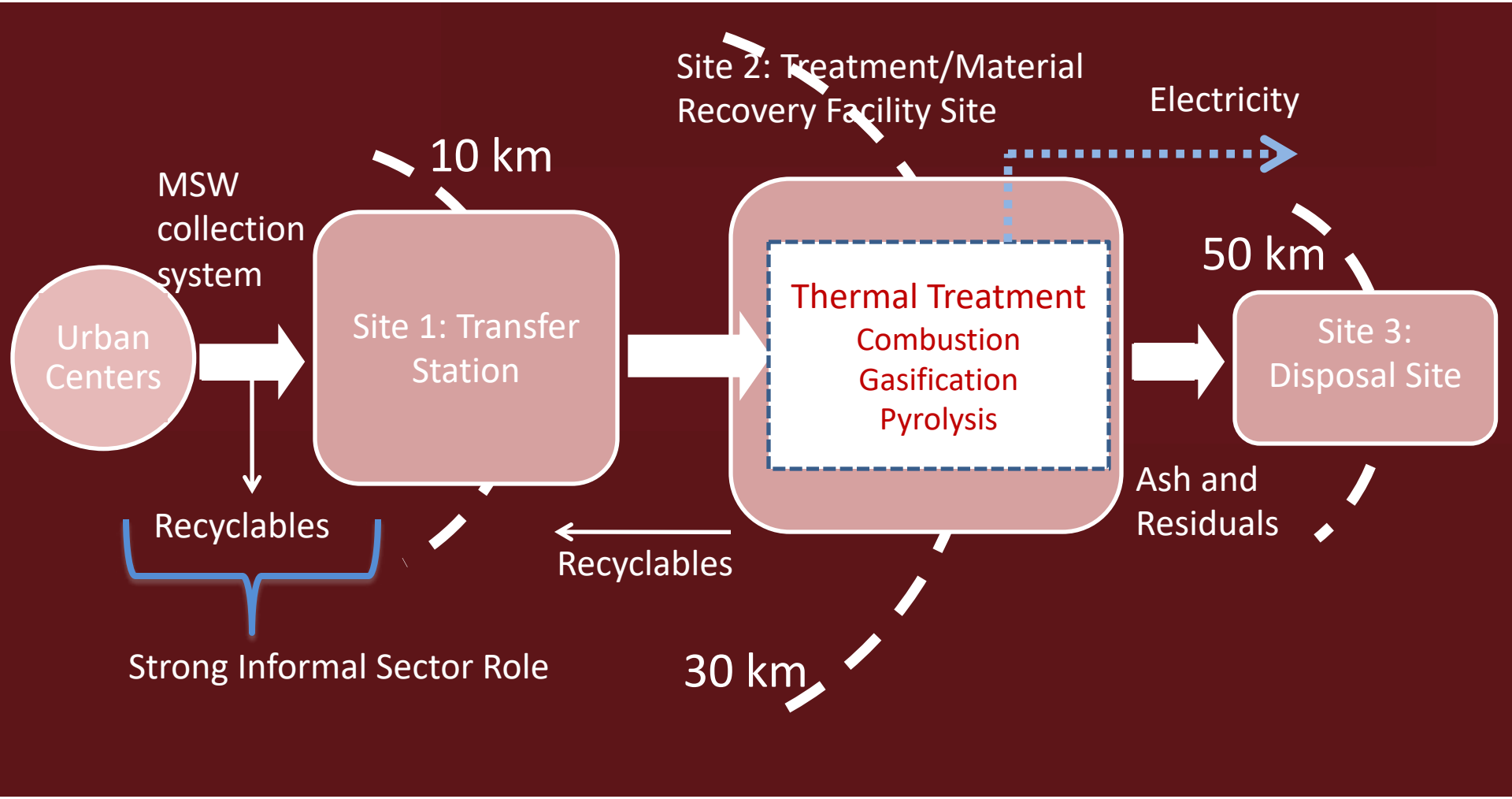
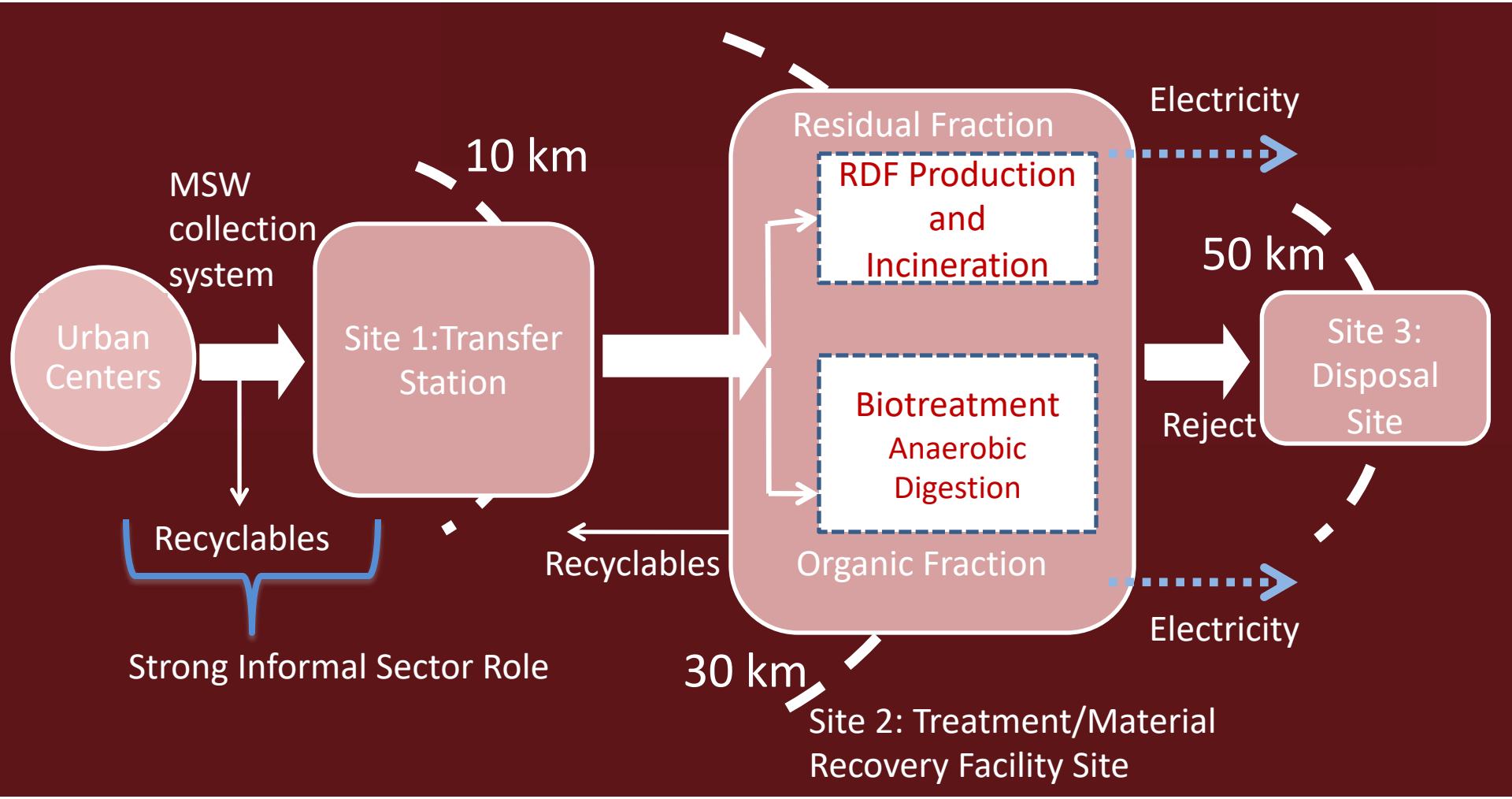
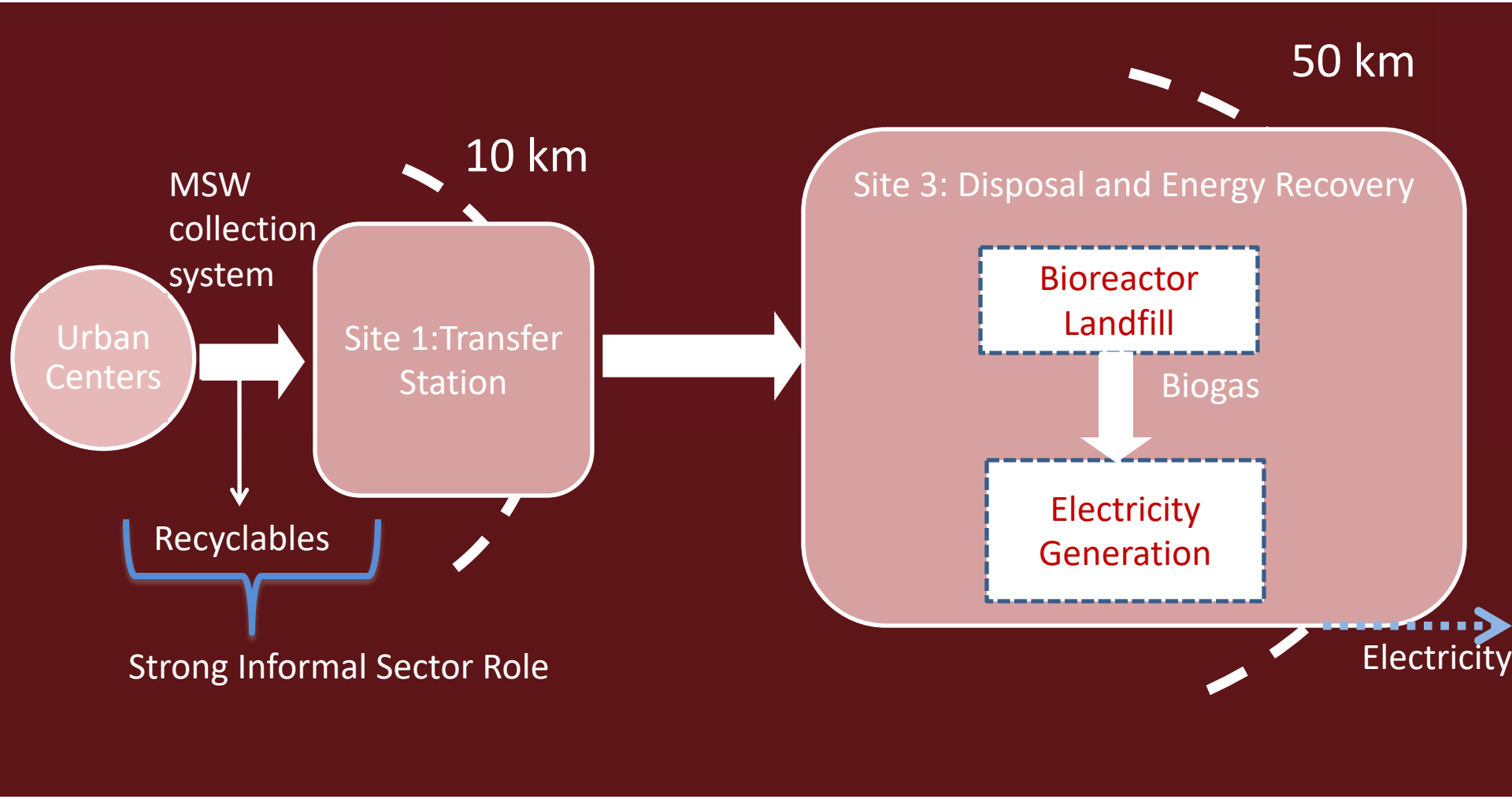
W2E: Thermal Treatment



W2E: Hybrid Biological/Thermal



W2E: Sanitary Landfill with Gas Recovery: Bioreactor Landfill



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Waste to Energy Scenarios

1A. MBT with Composting and RDF (offsite use) integrated with Transfer Station

1B. MBT with Composting integrated with Material Recovery Facility and RDF production (offsite use)

2A. MBT with RDF (offsite use) and Anaerobic Digestion and onsite Electricity Generation integrated with Transfer Station

2B. MBT with Anaerobic Digestion and onsite Electricity Generation integrated with Material Recycling facility RDF production (offsite use)

3- MBT with Anaerobic Digestion, RDF production, and onsite Electricity Generation integrated with Material Recycling facility

4A. Direct combustion at Contour 10 Km

4B. Direct combustion at Contour 30 km

4C. Direct combustion at Contour 50 km

5- Gasification at Contour 30 Km

6- Pyrolysis at Contour 30 km

7- Bioreactor Landfill with LFG energy production

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ANALYSIS OF WTE DEPLOYMENT SCENARIOS

DECISION MAKING METHODOLOGY
RANKING EVALUATION RESULTS
TIPPING FEE ANALYSIS
CONCLUSIONS

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Decision Making Methodology

Two types of analysis:

- Weighted Criteria Evaluation Analysis: Each scenario is evaluated, primarily qualitatively, against environmental, social and technical criteria to provide a subjective but holistic evaluation of feasibility.
- Tipping Fee Analysis: Building on a conceptual design and the international experience, an estimate of tipping fee for each scenario, with a sensitivity analysis, provides an objective financial evaluation of feasibility through tipping fees.

Weighted Criteria Evaluation Analysis

- Conceptual design results and international experience used to evaluate each scenario against criteria in the following domains:
  - 1- Feedstock domain: suitability of technology to the local feedstock.
  - 2- Technology domain: suitability of technology to deployment in the local Egyptian context.
  - 3- Environmental domain: Impact of technology on the environment.
  - 4- Social domain: Impact of technology on society.
- Rankings of criteria by study team with inputs from the Egyptian Technical Committee on W2E.
- Ranking of scenarios against criteria to develop an overall

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Evaluation Criteria

Technology

- Maturity
- Local Experience
- Expansion Flexibility
- Local Manufacturing
- Shock Load Performance
- Scale Flexibility
- Shutdown duration
- Load on Public Utilities

Feedstock

- Effect of Moisture Content
- Effect of hazardous contaminants
- Flexibility in using Biomass from other Sources
- Feedstock Quality Risk

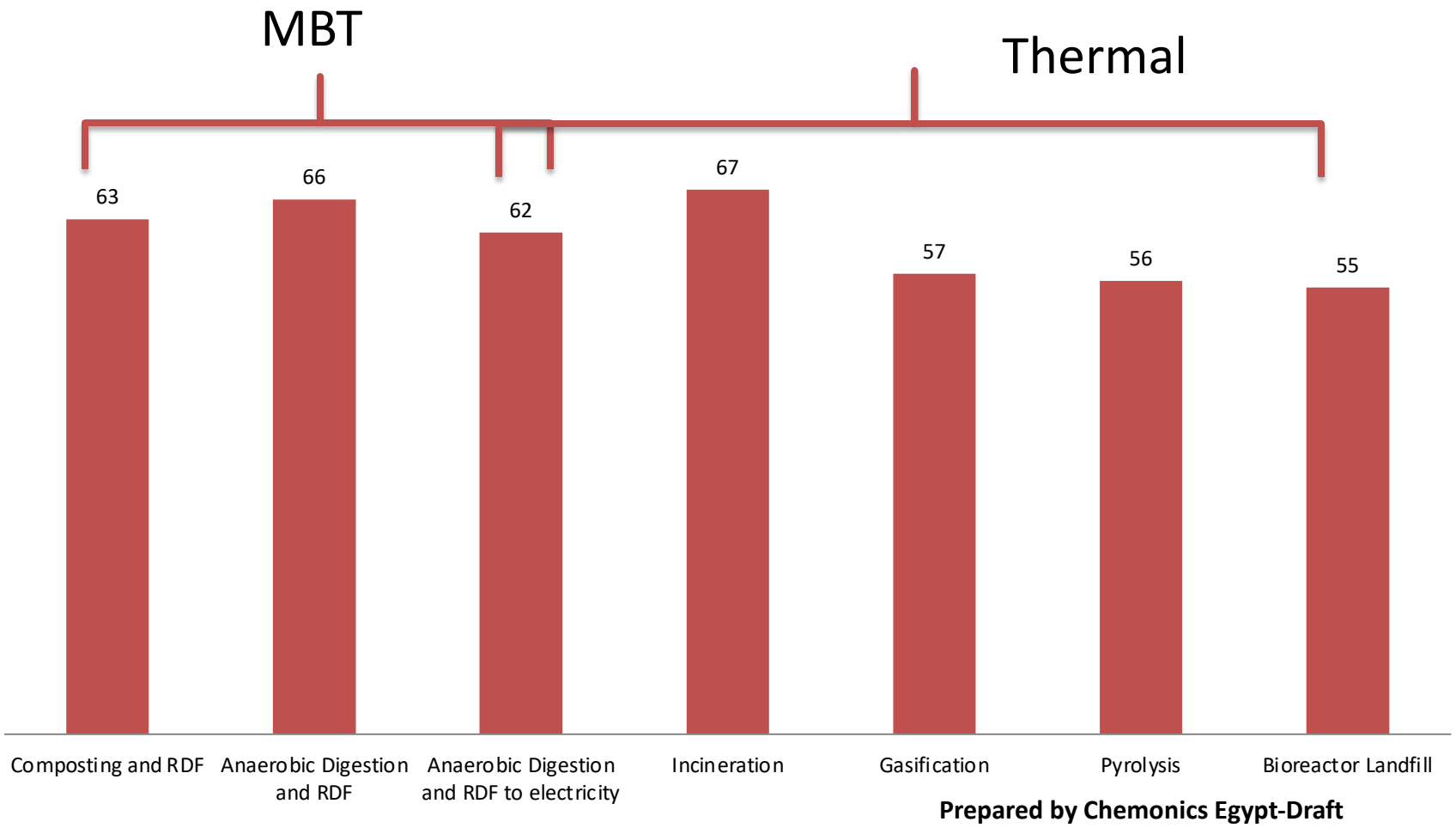
Environmental

- Impact at low Regulation
- Diversion of waste from landfill
- Net energy balance
- Carbon Emissions

Social

- Public Acceptance
- Jobs created

Scenario Evaluation Results: Rankings



Overall Normalized Scores of WTE Scenarios

Normalized Scale from 1-100. Higher Score indicate better performance

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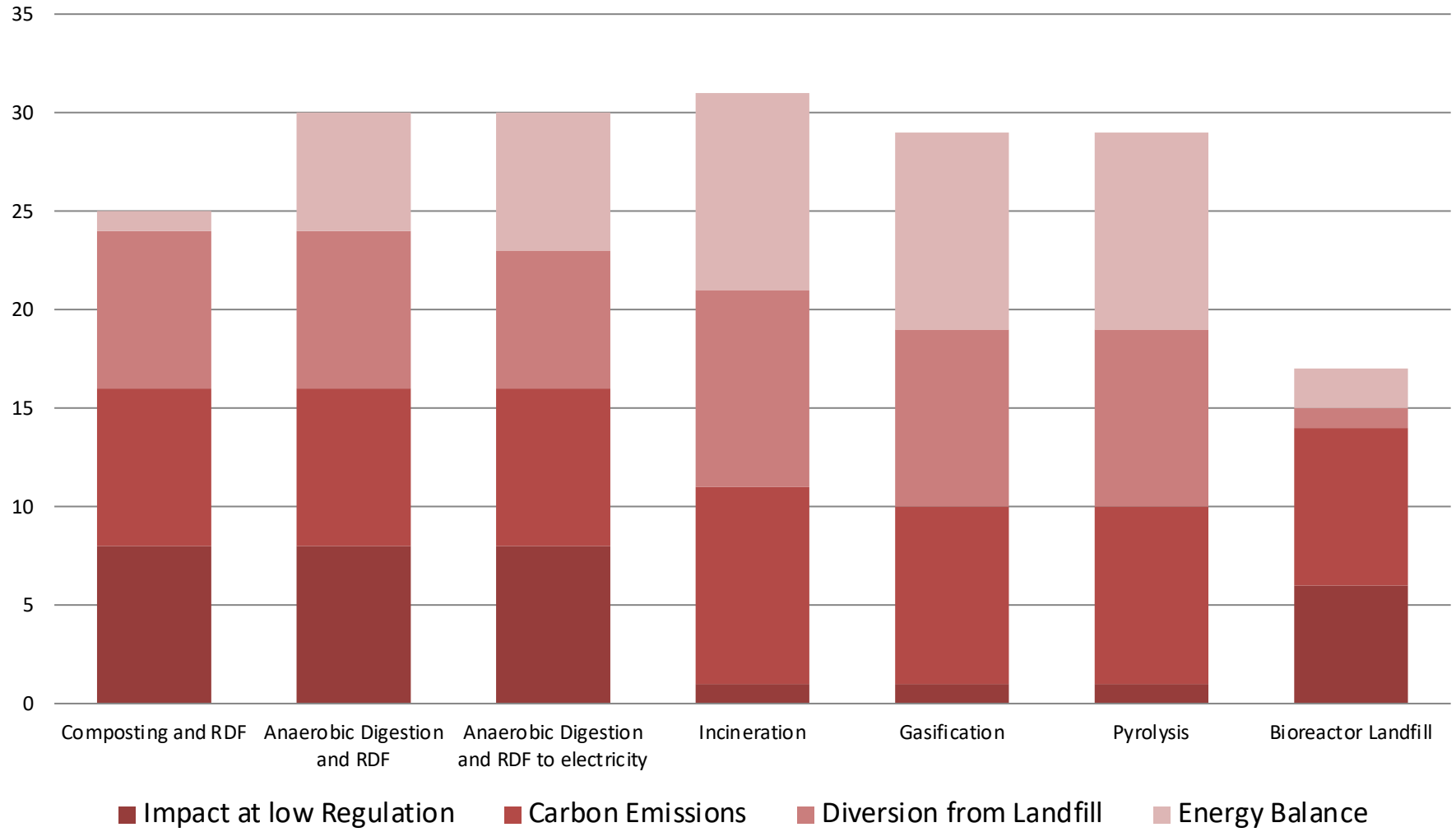
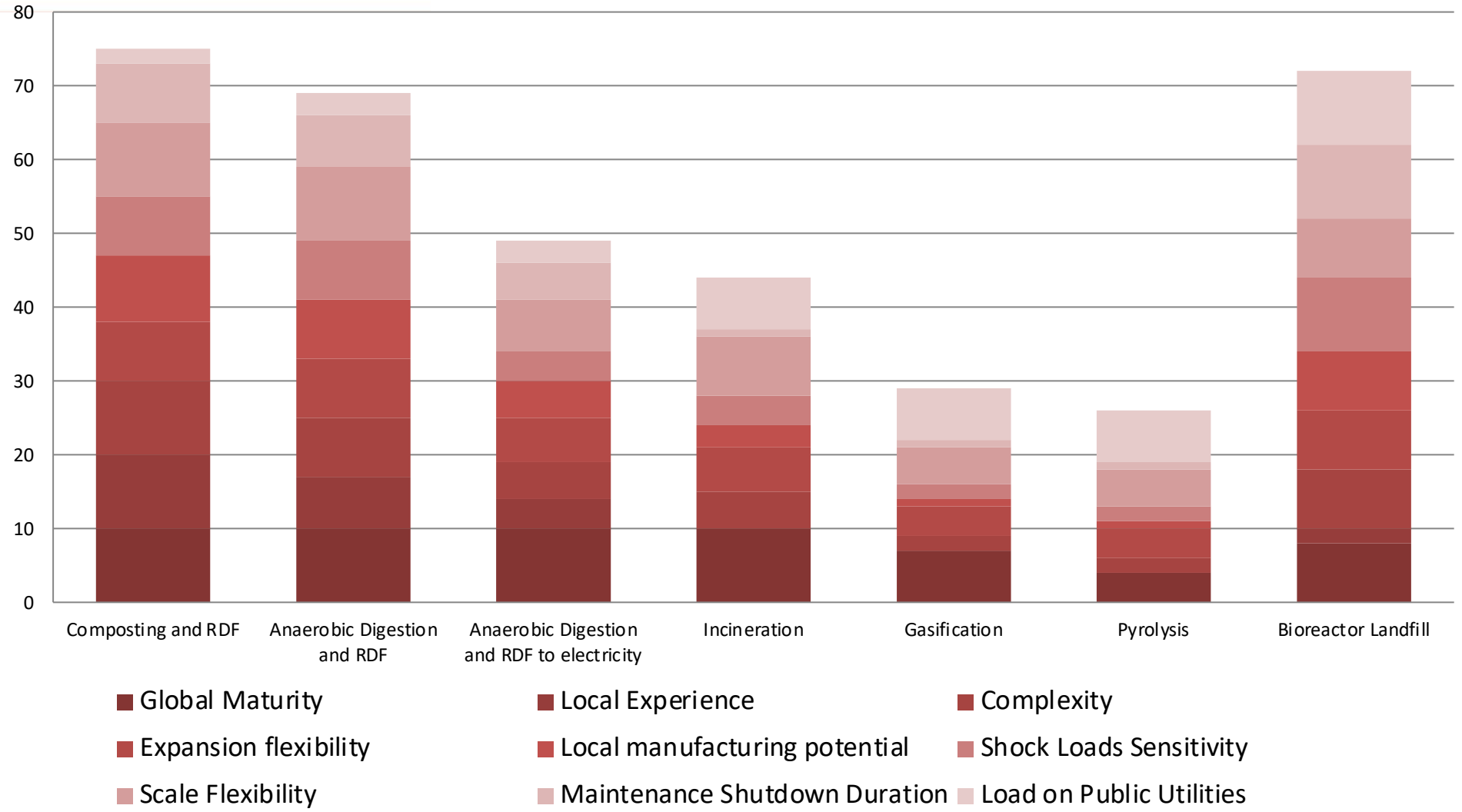
Scenario Evaluation Results: Rankings



Environmental Domain Performance

Normalized Scale from 1-100. Higher Score indicate better performance

Scenario Evaluation Results: Rankings



Technology Domain Performance

Normalized Scale from 1-100. Higher Score indicate better performance

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Tipping Fee Analysis

- Based on a conceptual level design of each scenario, tipping fee was estimated according to the assumptions in Annex 1.
- The Tipping Fee is calculated at Gate 1, Contour 10 km, and Gate 2, Contour 30 km.
- Sensitivity of results to:

1- Price of electricity in range of 0.4 – 0.8 EGP/Kwatt.hr

2- BOT duration in range of 20 – 30 years

3- CAPEX uncertainty for each scenario.

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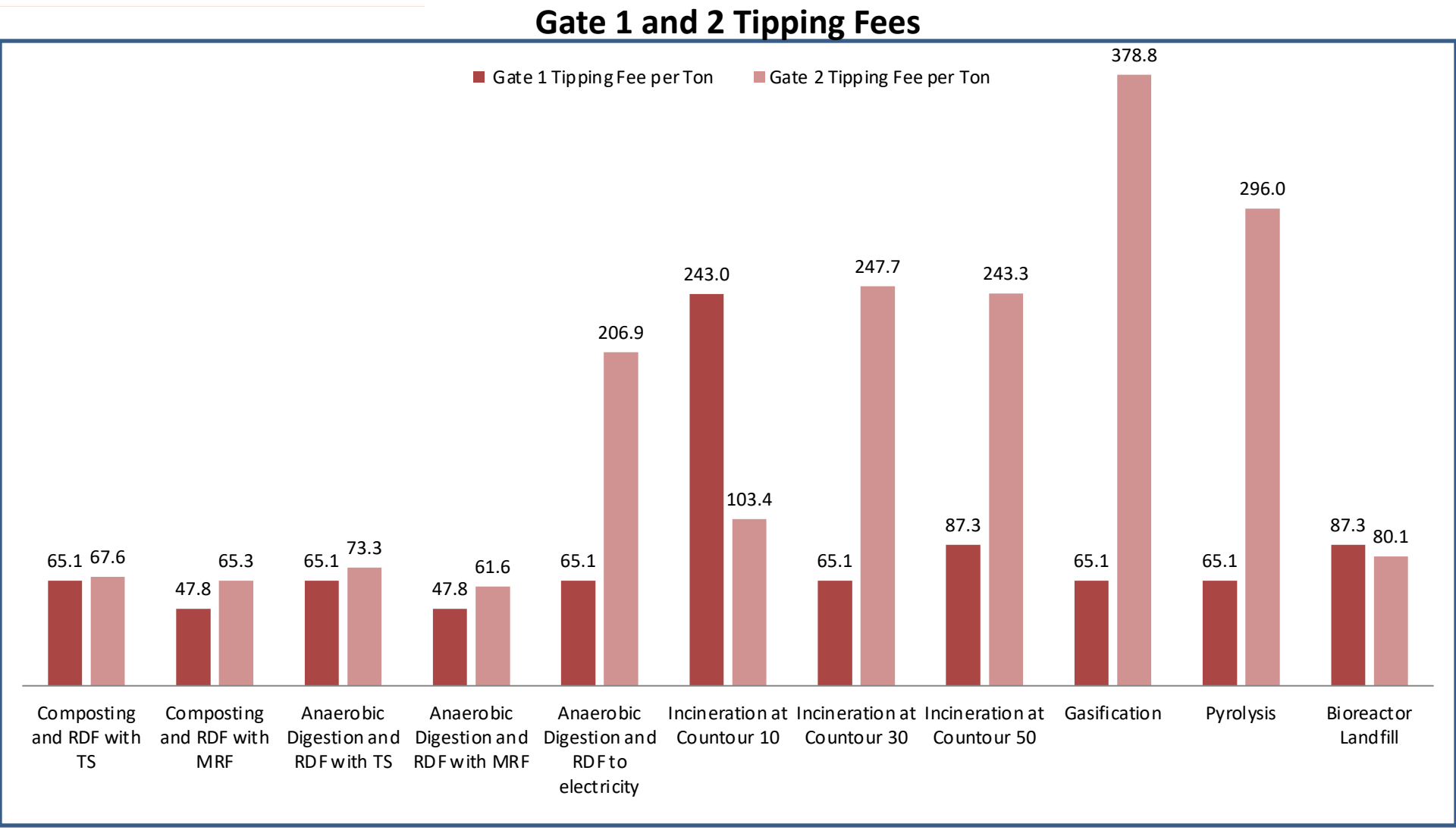
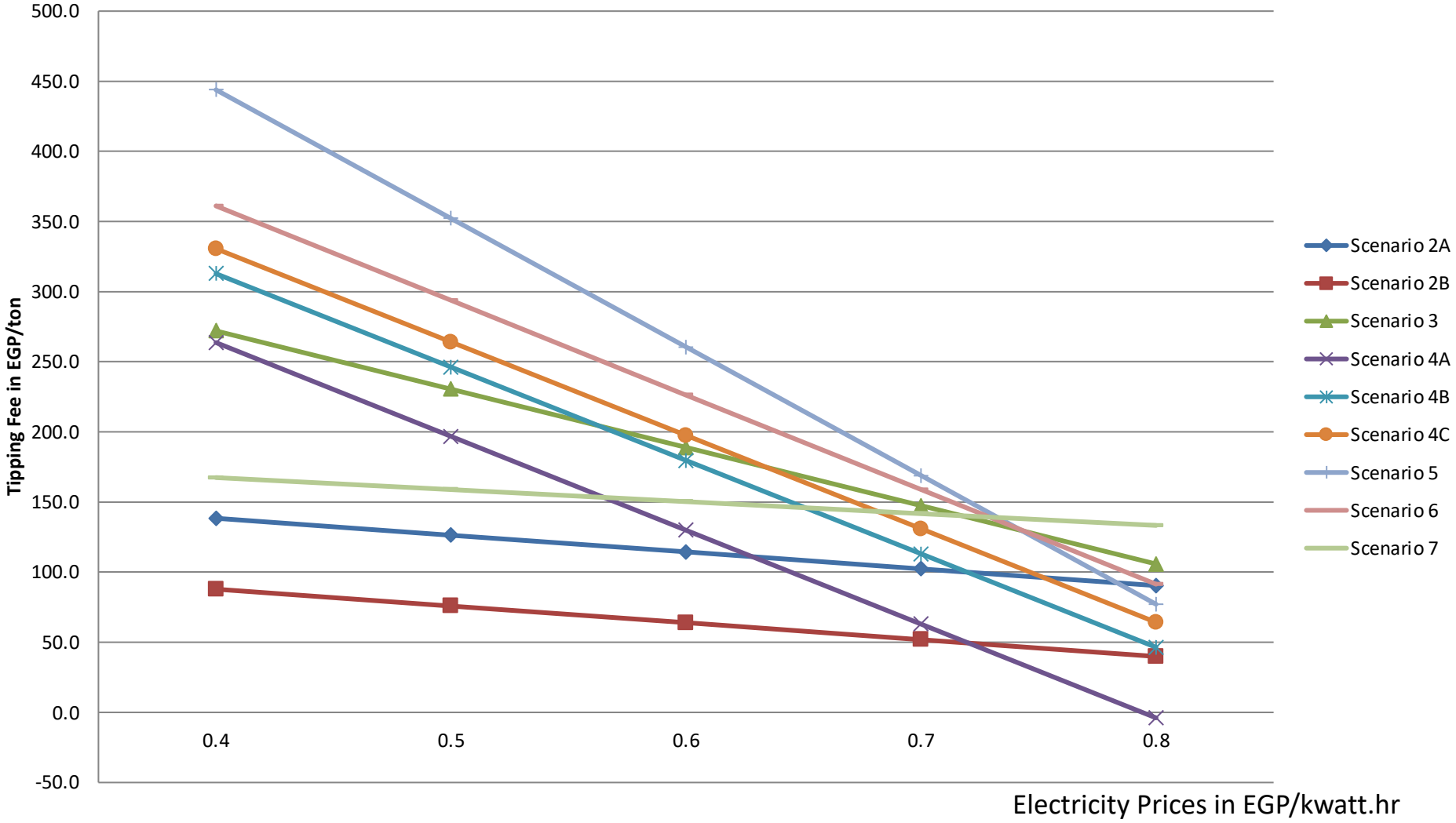
Tipping Fee Analysis: Results



Tipping Fee Analysis: Sensitivity

Sensitivity of Tipping Fee to Electricity Prices for W2E Scenarios



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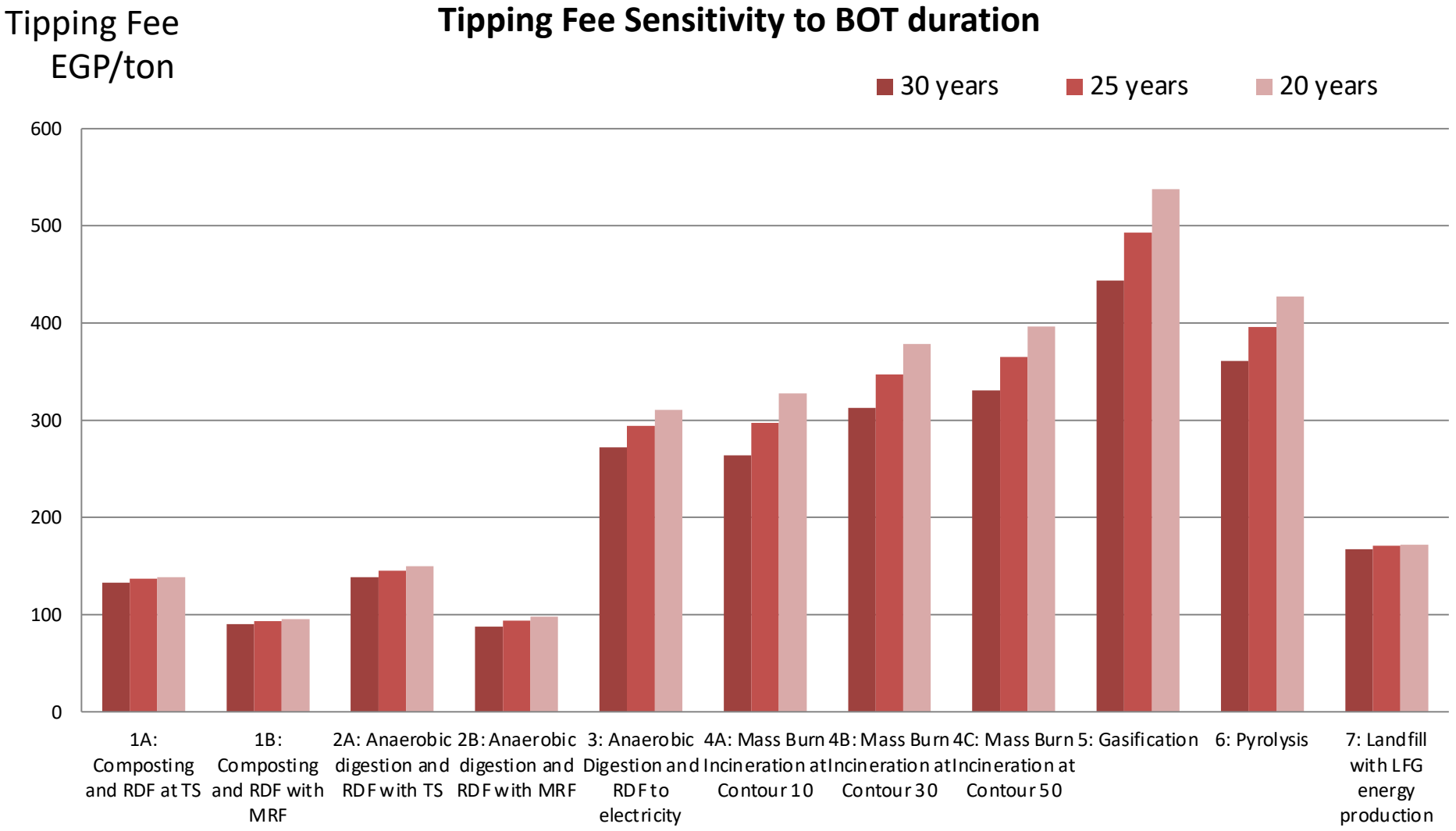
Tipping Fee Analysis: Sensitivity



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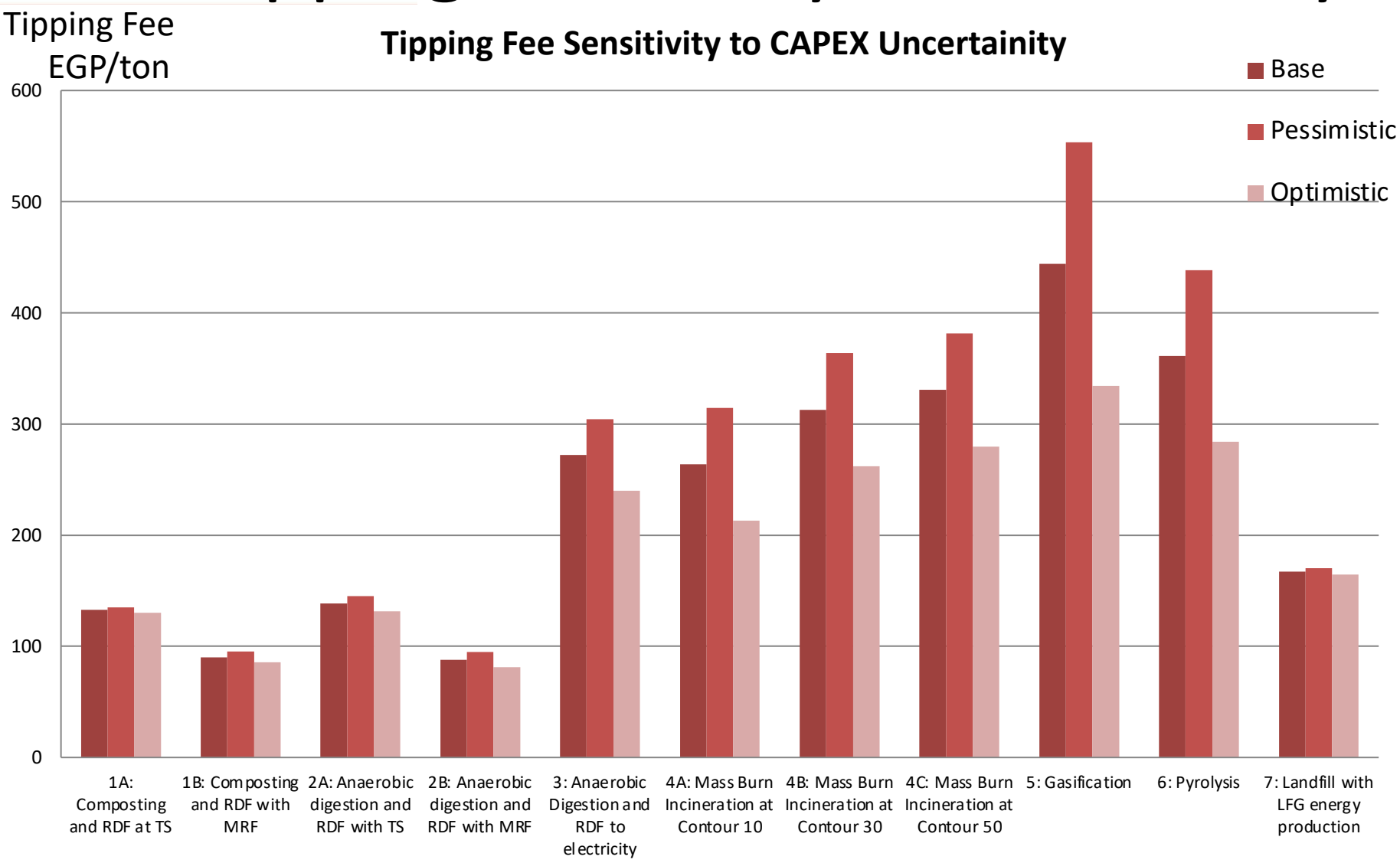
Tipping Fee Analysis: Sensitivity



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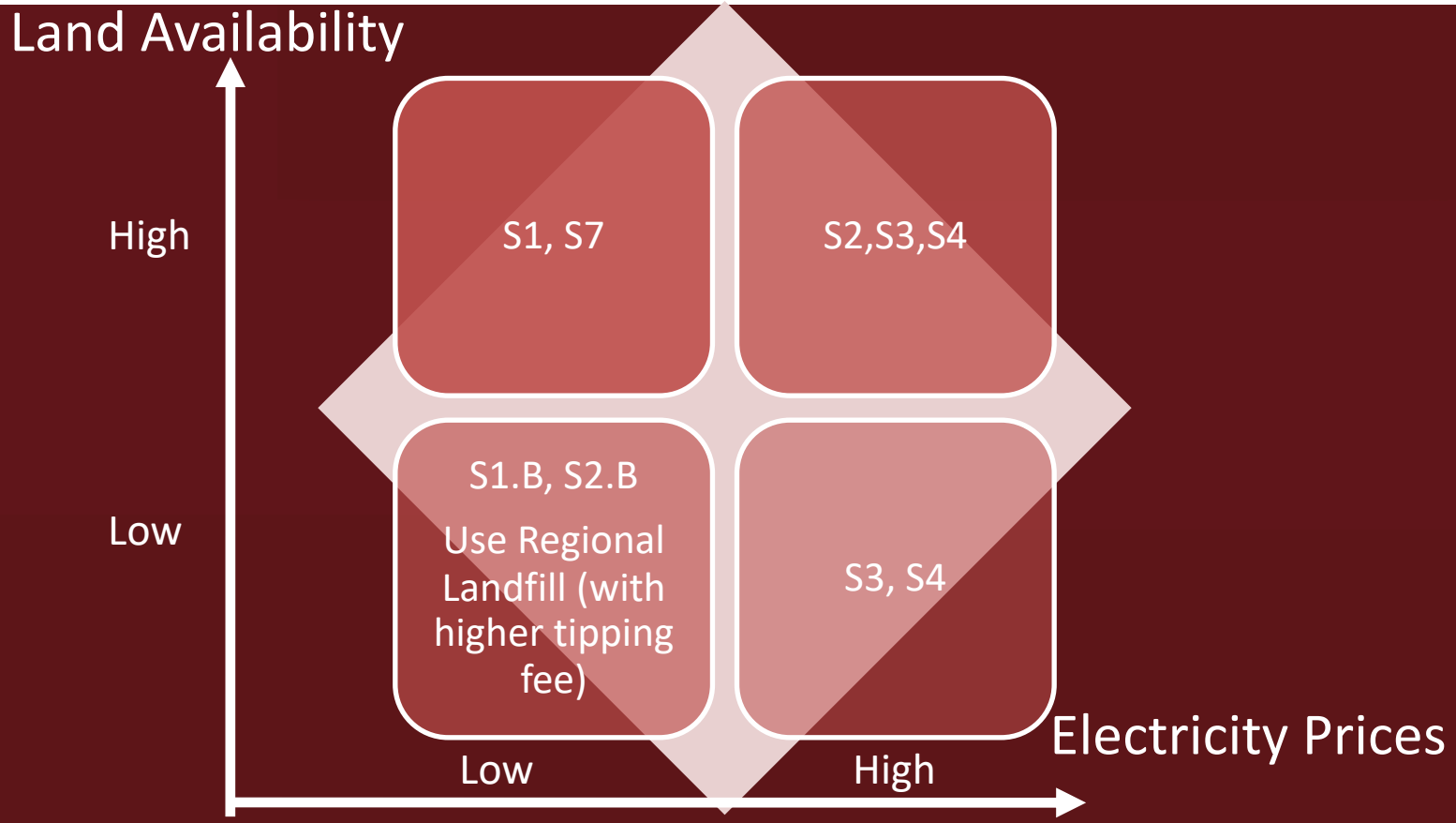
Analysis Conclusions

- Pyrolysis and gasification are currently infeasible but might become important in the future
- MRF Integration improves financial feasibility
- Tipping fees are very sensitive to electricity prices, and relatively insensitive to BOT duration. Electricity price trajectory sets comparative financial technology performance.
- There is a clear trade-off between land availability and tipping fee.

Thus: There is no one technological solution. Detailed feasibility analysis should consider more than one technology.

Analysis Conclusions



Scenarios recommended under combinations of different electricity and land availability levels.

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IMPLEMENTATION CONSIDERATIONS

URBAN CENTER TIER /TECHNOLOGY LOCATION MATCHING

PPP POTENTIAL PROJECTS: TIER 1

PPP POTENTIAL PROJECTS: TIER 2

TIERS 3 AND 4 RECOMMENDATIONS

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Location Matching

- The location matching tables summarize which technology scenarios are applicable depending on type of available land.

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Location matching

	S1	S2	S3	S4	S7 (only for regional use)
Urban Tiers	1,2,3,4	1,2	1,2	1,2	1,2,3,4
If Land available only at contour 10	Not Possible	Not Possible	Not Possible	Possible	Not Possible
If Land available only at contour 30 to 50 km	Possible	Possible	Possible	Possible	Possible
If Land available only at contour 50 km ++	1B	2B	Not Possible	Not Possible	Use regionally

PPP Potential Projects: Tier 1

Based on information communicated by Ministry of Finance and Cairo Governorate on available land and sites allocated to MSW treatment by Presidential Decrees, technologies were matched according to site features.

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PPP Potential Projects: Tier 1

	Urban Center	Estimated current MSW generation, ton/day	Site allocated by Presidential Decree	Proposed Scenarios
1	Cairo North	2,200	Yes	1B, 2B, 4B,
2	Cairo West	1,000	To be combined with Cairo North	
3	Cairo East	3,900	Yes	1B,2B, 4B
4	Cairo South (A)	1,900	Yes	Extension of existing scenario 1A, 1B, 2A,2B
5	Cairo South (B)	1,300	To be combined with Cairo South (A)	Combine with Cairo South (A)

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PPP Potential Projects: Tier 1

	Urban Center	Estimated current MSW generation, ton/day	Site allocated by Presidential Decree	Proposed Scenarios
1	Cairo North	2,200	Belbis site 1	1B, 2B, 4B,
2	Cairo East	3,900	To be combined with Cairo North	
3	Cairo West	1,000	Kattameya site	1B,2B, 4B
4	Cairo South (A)	1,900	New site in Korrayemat	Extension of existing scenario 1A, 1B, 2A,2B
5	Cairo South (B)	1,300	To be combined with Cairo South (A)	Combine with Cairo South (A)

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PPP Potential Projects: Tier 1

	Urban Center	Estimated current MSW generation, ton/day	Specified treatment and disposal site	Short listed scenarios for detailed feasibility study
5	Giza North	1,300	Fayoum Rd site	1B,2B,3,7
6	Giza South	3,000	To be combined with Giza North	
7	6th October Urban Cluster	3,500	El Wahat Rd site	1B,2B,3,7
8	Alexandria West	3,500	No data available	
9	Shubra Al Khayma Urban Cluster	1,900	Belbis site 2	1B,2B,3,7

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PPP Potential Projects: Tier 2

	Urban Center	Estimated current MSW generation, ton/day	Specified treatment and disposal site	Short listed scenarios for detailed feasibility study
1	Tanta Urban Cluster	620	no	2B,3,4A
2	Al Mahala Al Kubra Urban cluster	570	no	2B, 3,4A
3	Damietta Urban Cluster	800	Expansion of existing site in Shata	1B, 2B, 3
4	Mansoura Urban Cluster	950	Potential site in Alabsho	1B,2B,3
5	Al Zakazik Urban Cluster	530	no	2B,3,4A
6	Port Said Urban Cluster	630	Expansion of existing site	1B,2B,3

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PPP Potential Projects: Tier 2

	Urban Center	Estimated current MSW generation, ton/day	Specified treatment and disposal site	Short listed scenarios for detailed feasibility study
7	Alexandria Central	870	Data not available	
8	Alexandria East	770	Data not available	
9	Suez Urban Cluster	550	Expansion of existing site	
10	Assiut Urban Cluster	590	Expansion of existing site	1B,2B,3,7

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NEXT STEPS AND DECISIONS REQUIRED

AN ENABLING FRAMEWORK FOR W2E
A FREE MARKET FOR WASTE

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A New Paradigm for MSW Management Required

- The old paradigm: waste is a liability
  - Collection, treatment and disposal services driven by government financing and regulation
  - Results in an inefficient, regulation-driven industry with high cost and low quality of service.
- The new paradigm: waste is a valuable resource with versatile uses
  - Treatment and disposal driven by an attractive business model, driven by tipping fee subsidy or higher electricity prices.
  - Treatment and disposal create a sink at the end of the supply chain, driving collection and transfer to more efficiency by creating financially attractive demand.

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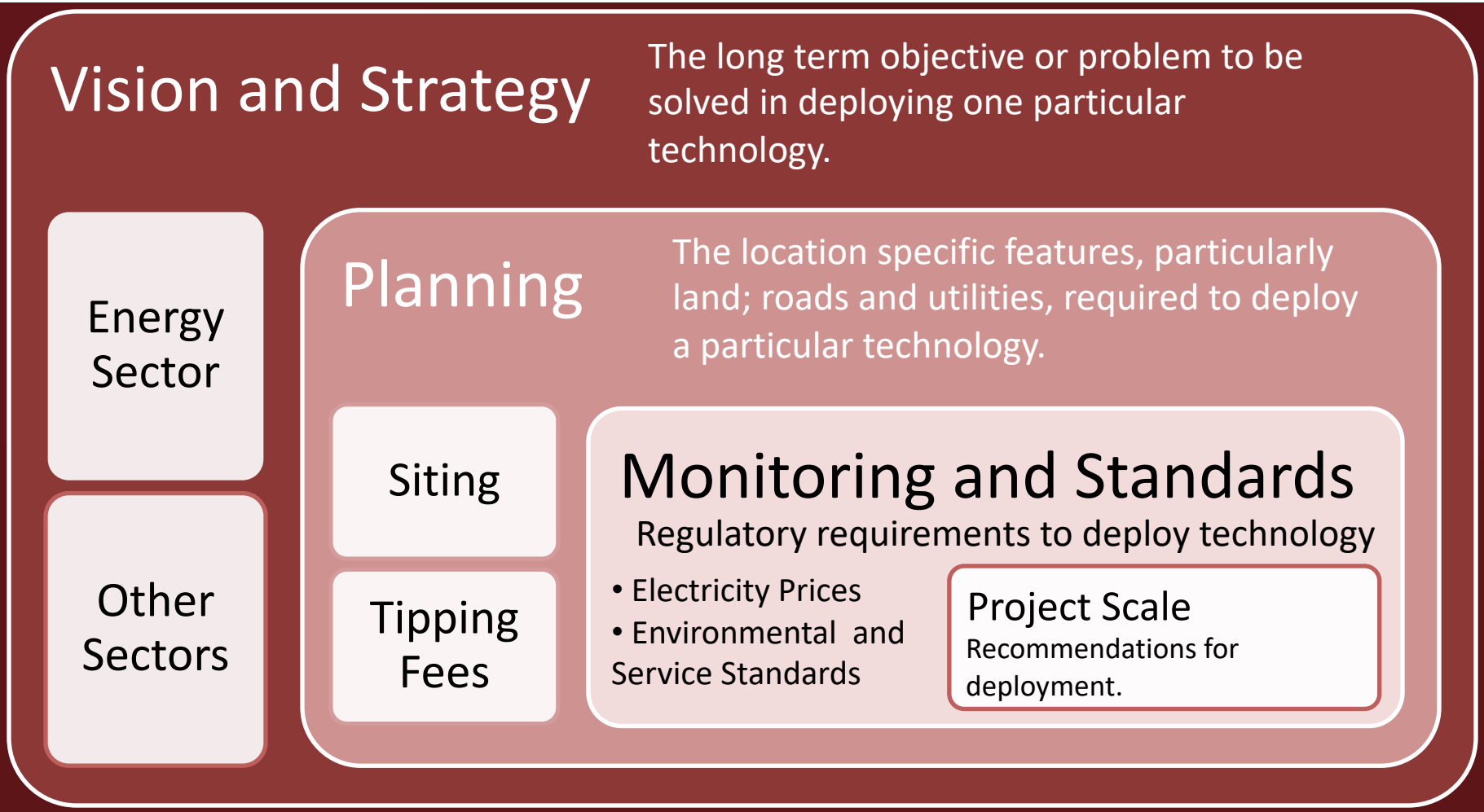
Next Steps and Decisions Required

- W2E technologies require an **enabling framework** to maximize their added value.
- W2E technologies **can impact many sectors**, not just the waste management sector: agriculture, renewable energy, transportation, environment, scientific research and waste water treatment. Framework must be explicitly linked to externalities and national strategic plans.
- W2E technologies **planning is a local governance decision**: governorates must be directly involved in planning.
- W2E technologies require **service and product standards as well monitoring and regulation processes.**

An Enabling Framework for W2E Technologies



The following figures for each W2E technologies are based on the analysis done by the study team for W2E technologies assuming 1000 tons of mixed MSW per day

S1: Composting and RDF

Vision

Creating an attractive market for MSW by providing the cement sector with a solid fuel alternative and agricultural sector with compost.

Cement Sector: consumer of RDF

Agricultural Sector: Consumer of compost,

Supplier of Biomass

Thermal power stations: potential consumers of RDF

Planning

All sites require access to high quality roads and utilities, including water, diesel and electricity.

More than 100 Feddanes at Contour 30 km

Monitoring and Standards

- Standards for RDF and Compost

Project Scale:

Allow expansion at all tier levels

S2: RDF and Anaerobic Digestion

Vision

Creating an attractive market for MSW by providing the cement sector with a solid fuel alternative, the agricultural sector with compost and the national grid with electricity.

- Cement Sector: consumer of RDF
- Thermal power stations: potential consumers of RDF
- Waste Water Treatment Sector: Supplier of Sludge for digestion
- Agricultural Sector: Consumer of compost, Supplier of Biomass

Planning

All sites require access to high quality roads and utilities, including water, diesel and electricity.

- More than 60 Feddanes at Contour 30 km
- Subsidy Financing via Tipping Fees

Monitoring and Standards

- Standards for RDF and Compost made from digestate
- IPP Regulations and electricity prices

Project Scale

- Limit initial number of projects to 1-2 to test success
- Consider government Equity at 20% to encourage investors
- Combine gates 1 and 2

IPP: Independent Power Providers

S3: Hybrid Thermal/MBT

Vision

Creating an attractive market for MSW as an electricity source, and build the infrastructure for energy recovery from all types of waste, while producing compost for the agricultural sector.

- Energy Sector: Buyer of Electricity
- Agricultural Sector: Consumer of compost, Supplier of Biomass
- Waste Water Treatment Sector: Supplier of Sludge for digestion

Planning

All sites require access to high quality roads and utilities, including water, diesel and electricity.

- More than 60 Feddanes at Contour 30 km
- Subsidy Financing via Tipping Fees

Monitoring and Standards

- Strict, independent environmental monitoring
- IPP Regulations and electricity prices

Project Scale

- Limit initial number of projects to 1-2 to test success
- Consider Government Equity at 20% to encourage investors

IPP: Independent Power Providers

S4: Mass Burn Incineration

Vision

Creating an attractive market for MSW as an electricity source, and build the infrastructure for energy recovery from all types of waste.

Energy Sector: Consumer of Electricity

Agricultural Sector: Supplier of Biomass

Planning

Site must have access to electricity grid.

Preferably 10 Feddanes at Contour 10 km

Subsidy Financing via Tipping Fees

Monitoring and Standards

- Strict, independent environmental monitoring
- IPP Regulations and electricity prices

Project Scale

- Limit initial number of projects to 1-2 to test success
- Consider government Equity = 20% to encourage investors

IPP: Independent Power Providers

S5/S6: Gasification and Pyrolysis

Vision

Creating an attractive market for MSW as a source of liquid fuel and electricity, and building capacity for future conversion of all types of waste.

Energy Sector

Agricultural Sector

Planning

Site must have access to electricity grid.

Around 5 Feddanes at Contour 10 km

Monitoring and Standards

- Strict, independent environmental monitoring
- IPP Regulations and electricity prices
- Clear ongoing evaluation of results.

Project Scale

- Small scale (50-100 tpd) pilot to build local capacity
- Consider government owned project

IPP: Independent Power Providers

S7: Bioreactor landfill

Vision

Upgrading the existing landfills and optimizing planned projects for energy recovery to develop a more value-extracting disposal solution for all types of waste.

Energy Sector: Consumer of Electricity

Agricultural Sector: Beneficiary of Disposal Service

Planning

Site requires access to high quality roads and to the electricity grid.

More than 100 Feddanes at Contour 50 km

Monitoring and Standards

• IPP Regulations and electricity prices

Project Scale

- Focus on planned landfill projects and upgrading accessible landfills
- Encourage regionalization of landfills

IPP: Independent Power Providers

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Open Discussion

Annex 1: Tipping Fee Analysis Assumptions

General Model Assumptions:	
Inflation Rate	11%
Tax Rate	20%
Design Capacity (tons per day)	1,000
Operating Days per year	365

Depreciation Assumptions	
Civil Works	3%
Electromechanical Works	7%
Rolling Stock	10%

Annex 1: Tipping Fee Analysis Assumptions

Financing & Discounting Assumptions	
Debt	
Debt Equity Ratio	70%
Interest Rate on Loans	11%
Loan Repayment Period	5
Loan Grace Period	
Equity	
Risk Free Required Rate of Return	8%
Risk Premium (Political, Economic, and Industry)	6%
Risk Adjusted Required Rate of Return	14%
Weighted Average Cost of Capital (WACC)	12%