Municipal Solid Waste-to-Energy

An environmental life cycle assessment perspective

WTE Plant
Copenhagen, Denmark
Source: The Telegraph 2011

Mass Burn WTE Plant
Millbury, MA
Source: wteplants.com/photos

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July 11, 2012

Acknowledgements

- MWH Global, Inc.
  - MWH US: Kevin Hoskins, Quentin Williams
  - MWH UK: Ronald Tize, Principal Process Engr., Manager Waste Treatment and Renewable Energy
- Center for Sustainable Infrastructure Systems
  - Dr. Arunprakash T. Karunanithi, Department of Civil Engineering University of Colorado Denver
- Austin Resource Recovery (City of Austin, Texas)
  - Bob Gedert, Director
  - Gretchen Kingham, Department Executive Assistant
  - Donald Hardee, Division Manager
  - Vidal Maldonado, Litter Abatement Division Manager

INTRODUCTION

- Introduction
- Description of Scenarios
- Methodology
- Results
- Discussion
- Moving Forward

What is the MSW Problem?

An Environmental Problem

Air

Soil

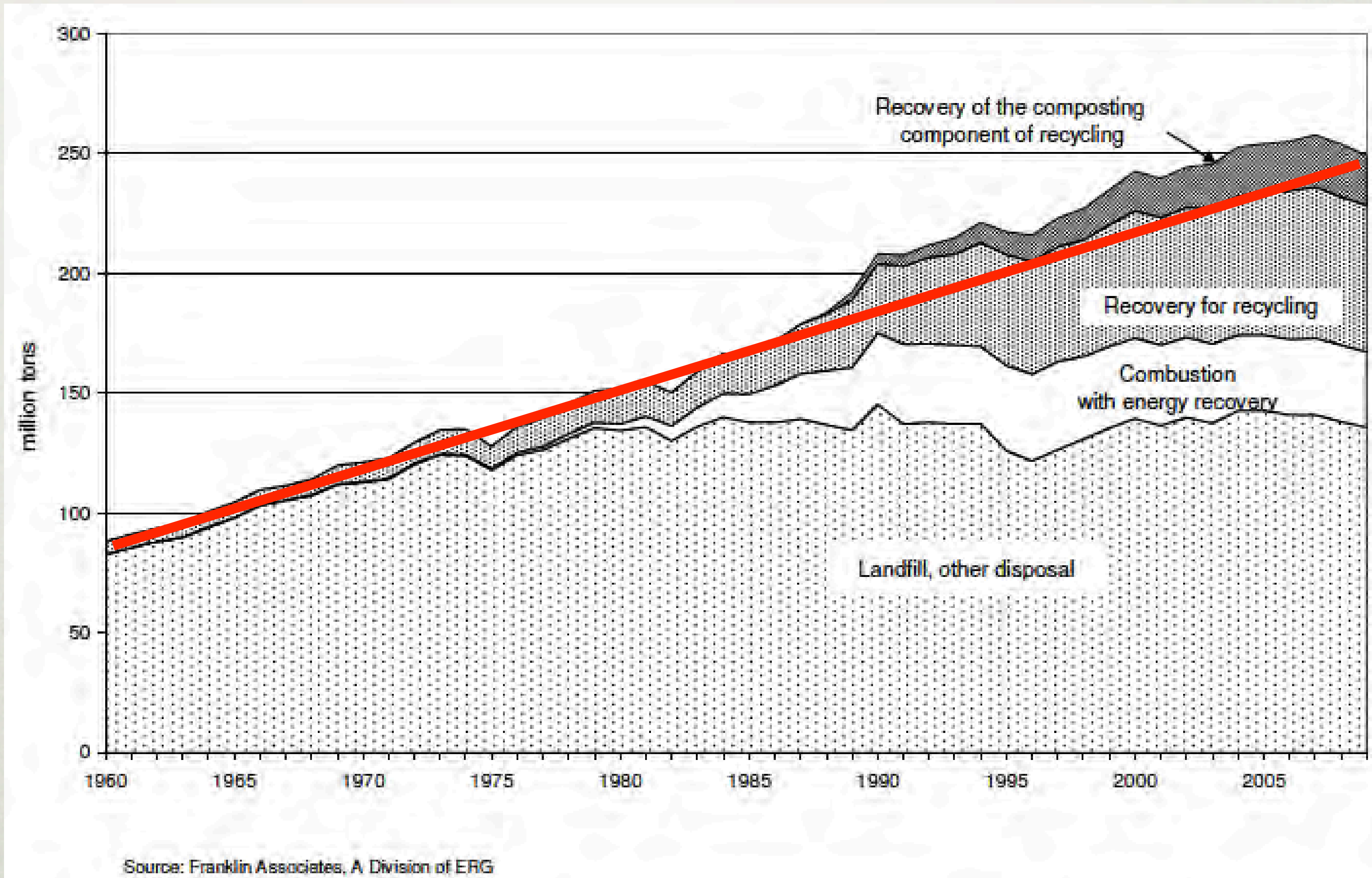
Groundwater

[Source](#)
[Lost In Translation 2009](#)

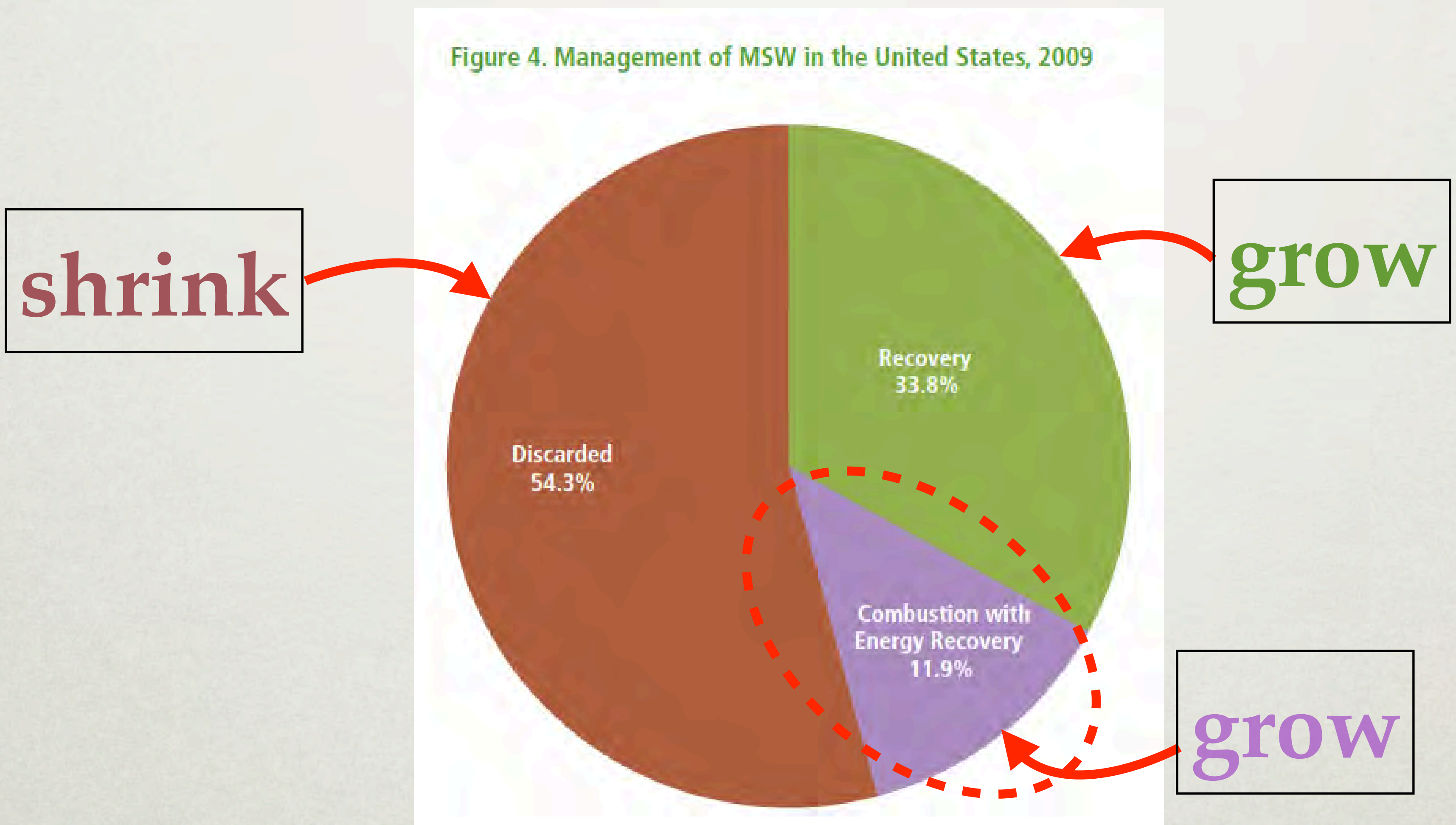
An ECONOMIC Problem

Source
Official PSDS 2011

A growing Problem



MSW Generation & Fate, 2009



Questions

- The scientific + technological + economic + political question

- **Research Question**

  What are the comparative human health and environmental impacts of the four most priment MSW treatment technology groups?

Themelis' Waste Mgmt Hierarcy

Austin Project

Description of Scenarios

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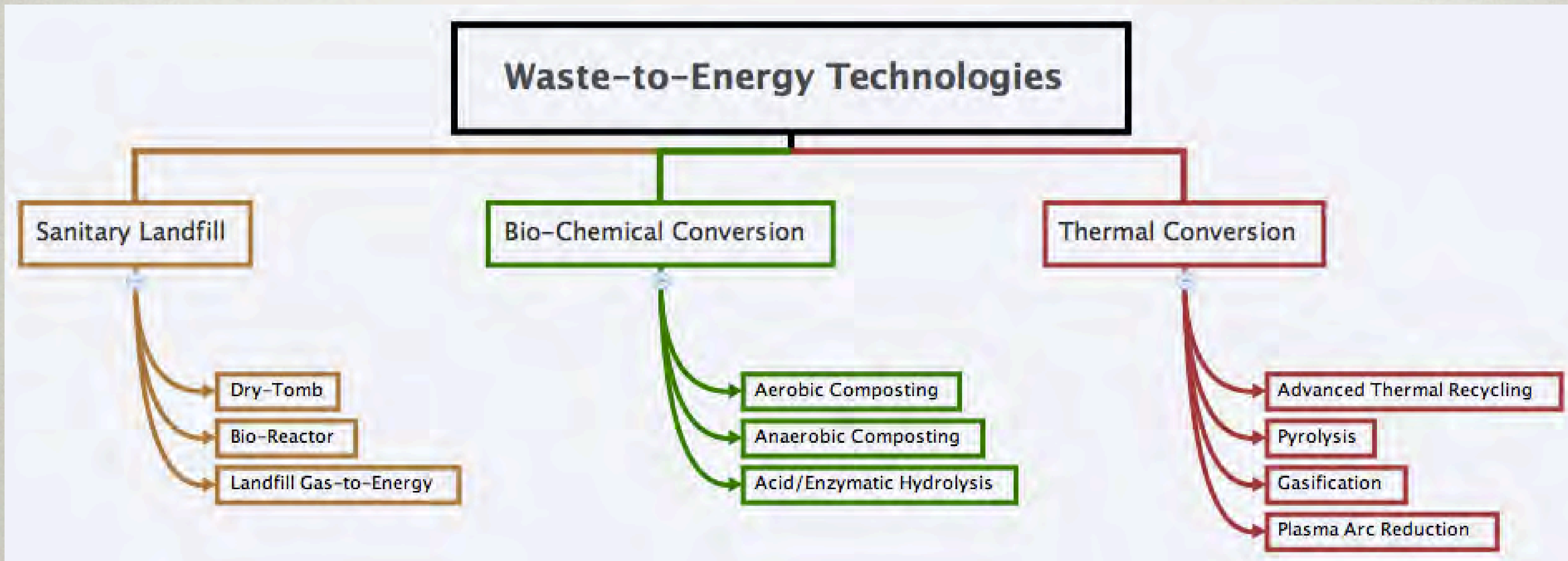
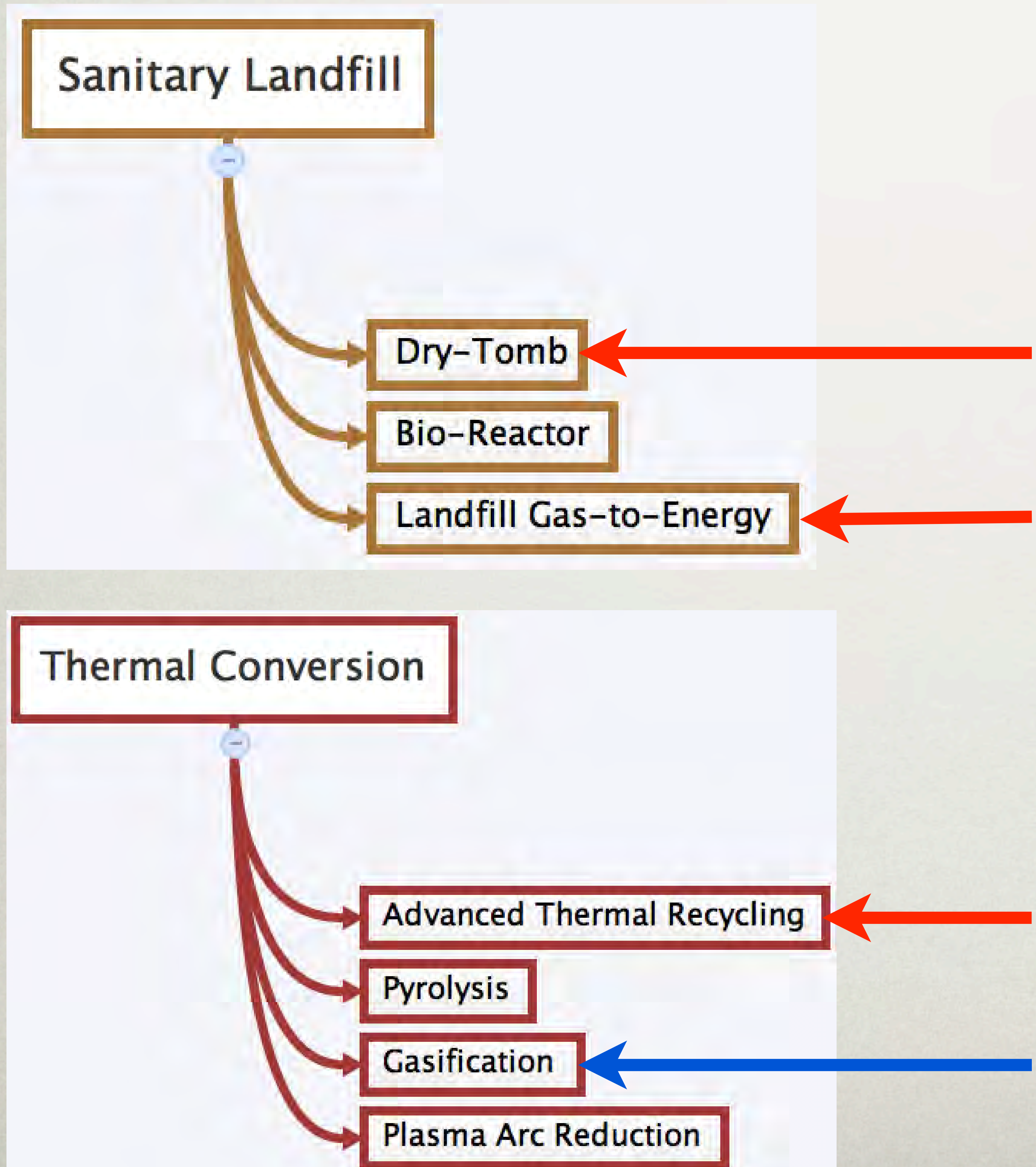
Paths to MSW Treatment



Technology Groups Considered



An environmental life cycle assessment of four MSW treatment technology groups

Methodology

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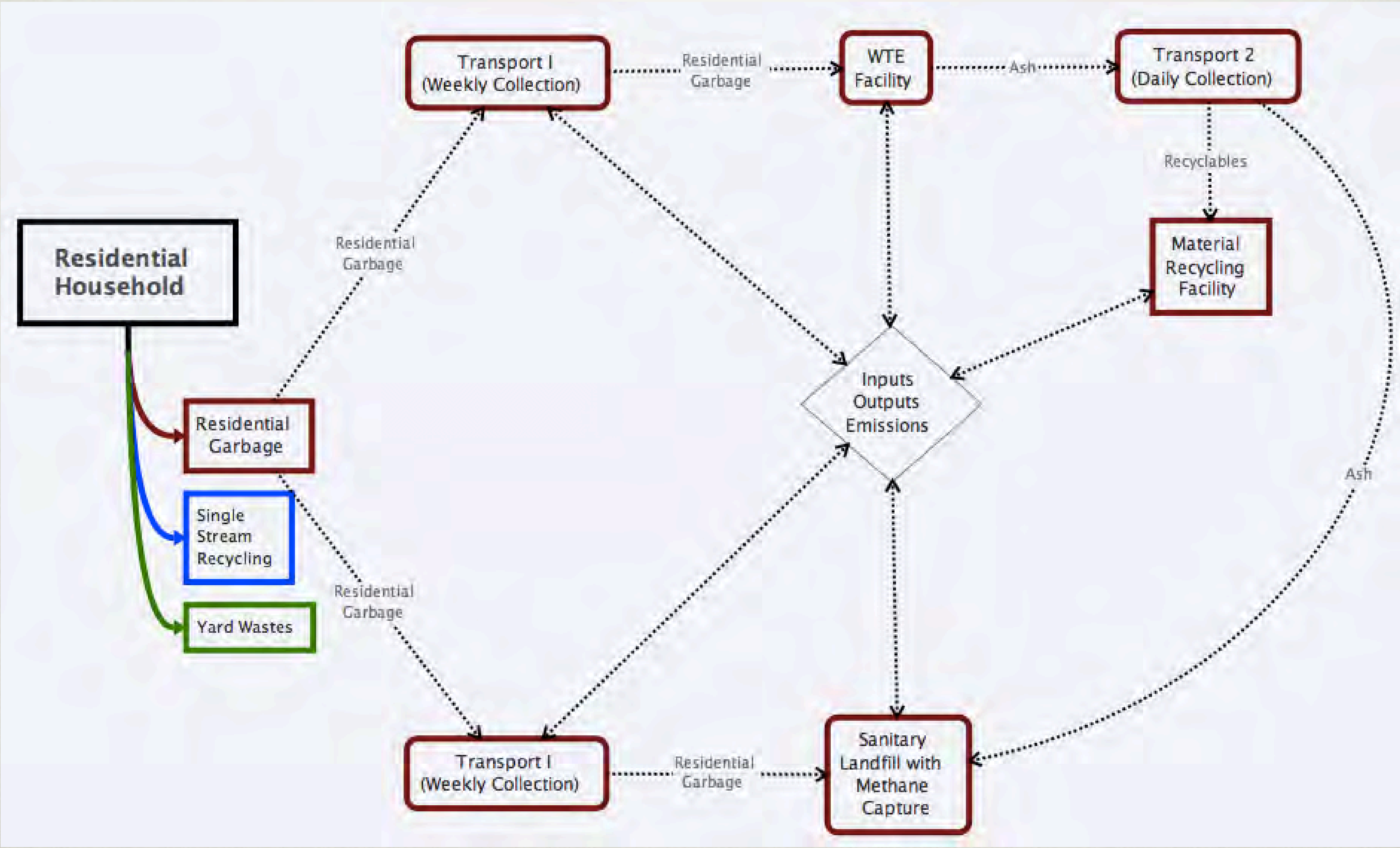
Assumptions

MSW Composition

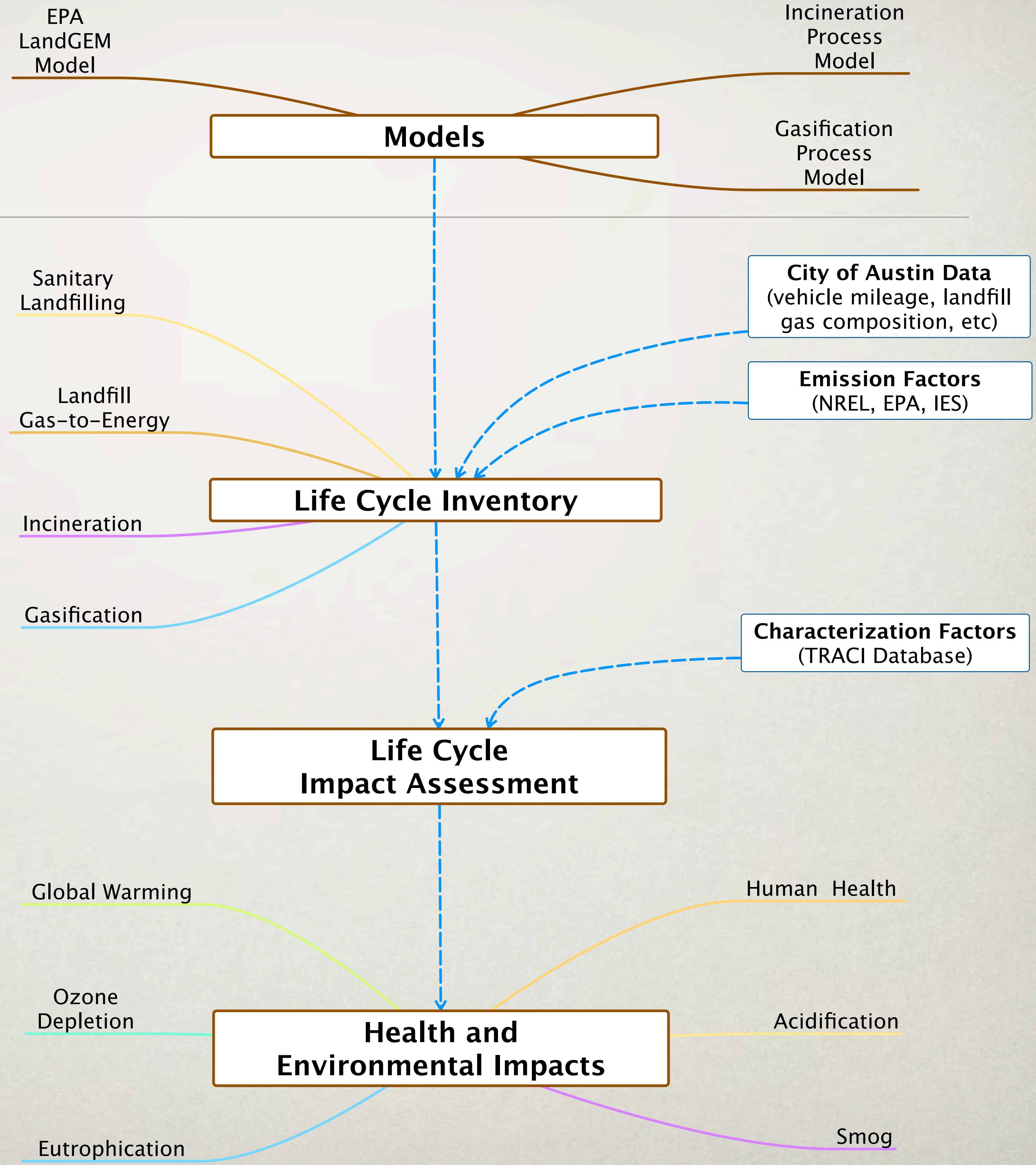
MSW	
[-]	[tons]
Food - Mixed	30,450.2
Glass	7,995.0
Metals	12,466.0
Misc. Inorganic Wastes	3,478.5
Other	3,105.1
Paper and Paperboard	23,611.7
Plastics	25,232.5
Rubber and Leather	5,846.0
Textiles	9,861.7
Wood	12,393.2
Yard Trimmings	0.0
Total	134,440.0

Assumptions

System Boundary & Material Flows



METHODOLOGY

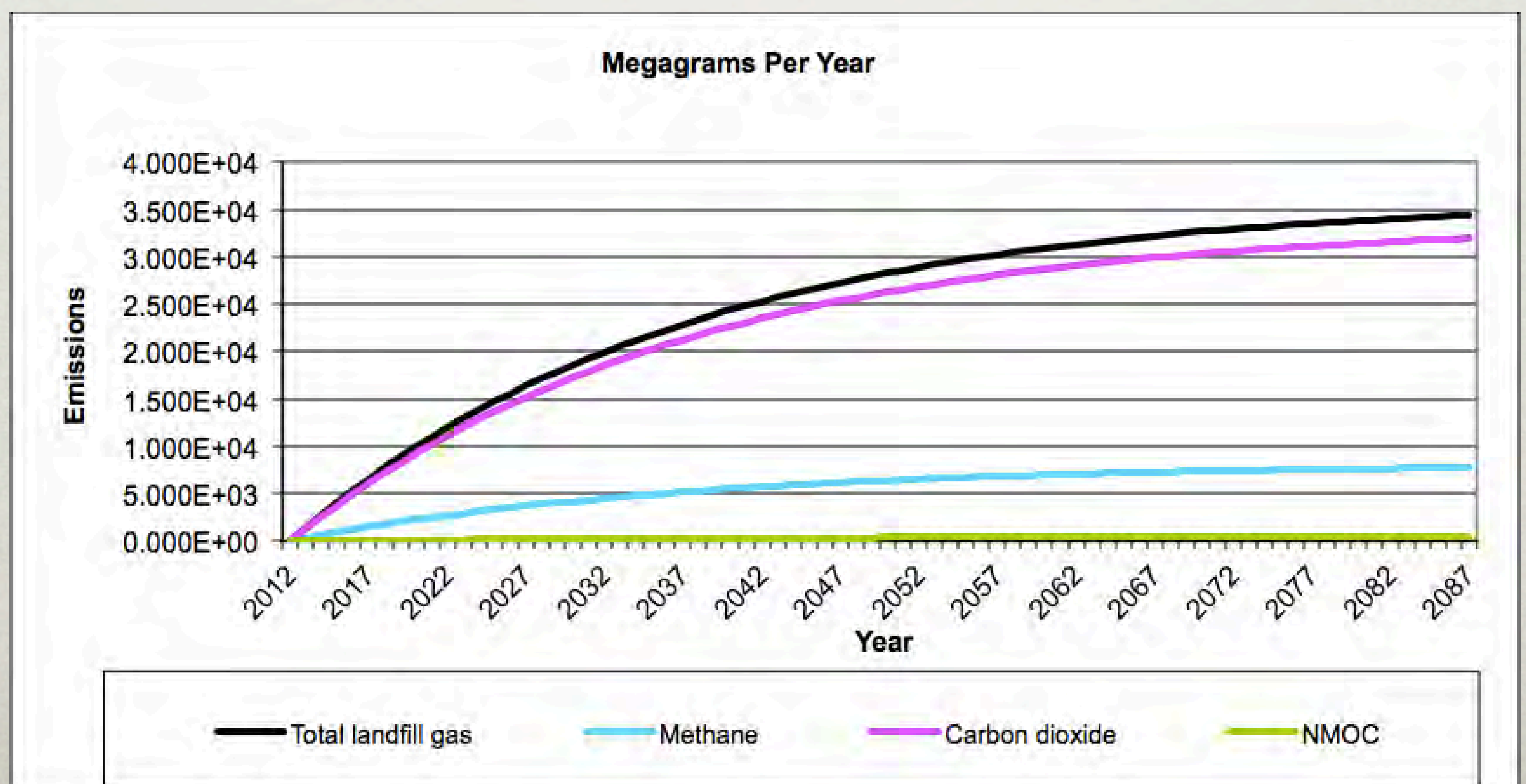


Process Simulations

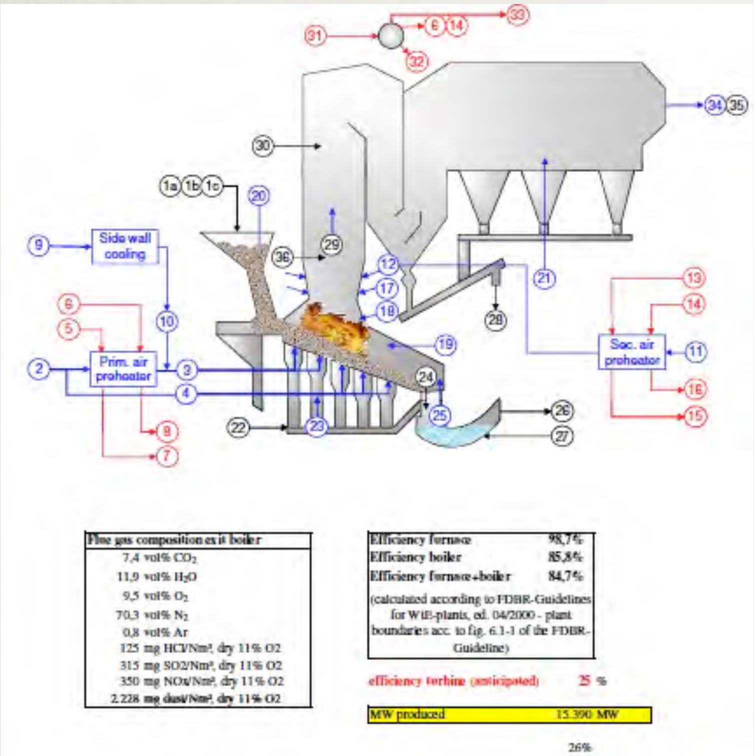
Sanitary Landfill & LFGTE

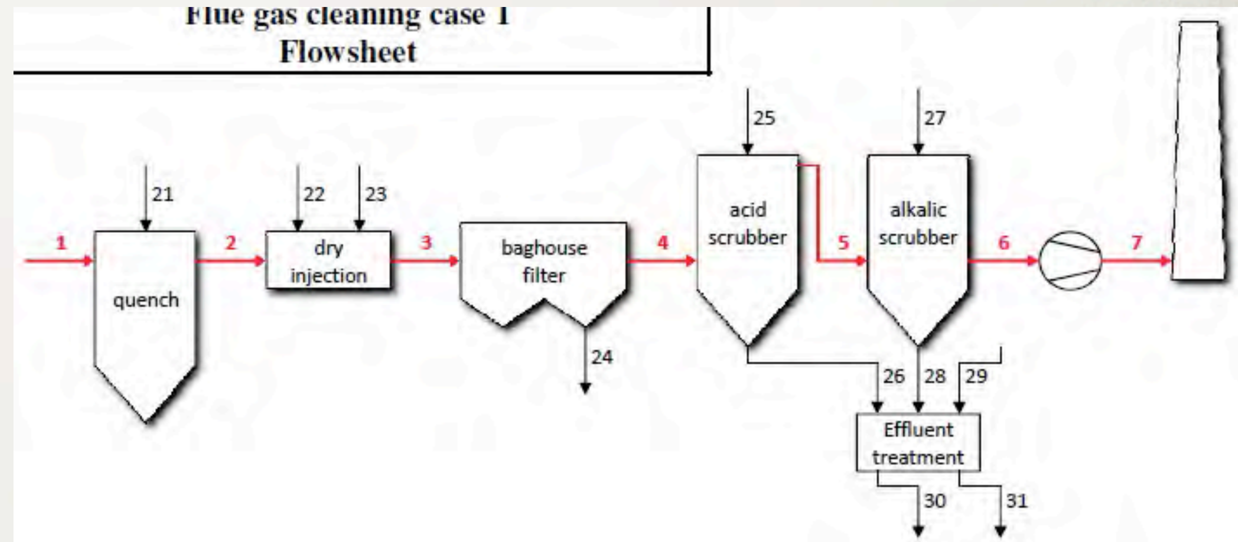
$$Q_{CH_4} = \sum_{i=1}^{n} \sum_{j=0.1}^{1} kL_O \left(\frac{M_i}{10} \right) e^{-kt_{ij}}$$

Q_{CH4}	=	annual methane generation in the year of the calculation (m^3/year)
i	=	1 year time increment
n	=	(year of the calculation) - (initial year of waste acceptance)
j	=	0.1 year time increment
k	=	methane generation rate ($year^{-1}$)
Lo	=	potential methane generation capacity (m^3/Mg)
Mi	=	mass of waste accepted in the i^{th} year (Mg)
t_{ij}	=	age of the j^{th} section of waste mass M_i accepted in the i^{th} year



Process Simulations
ATR & Gasification





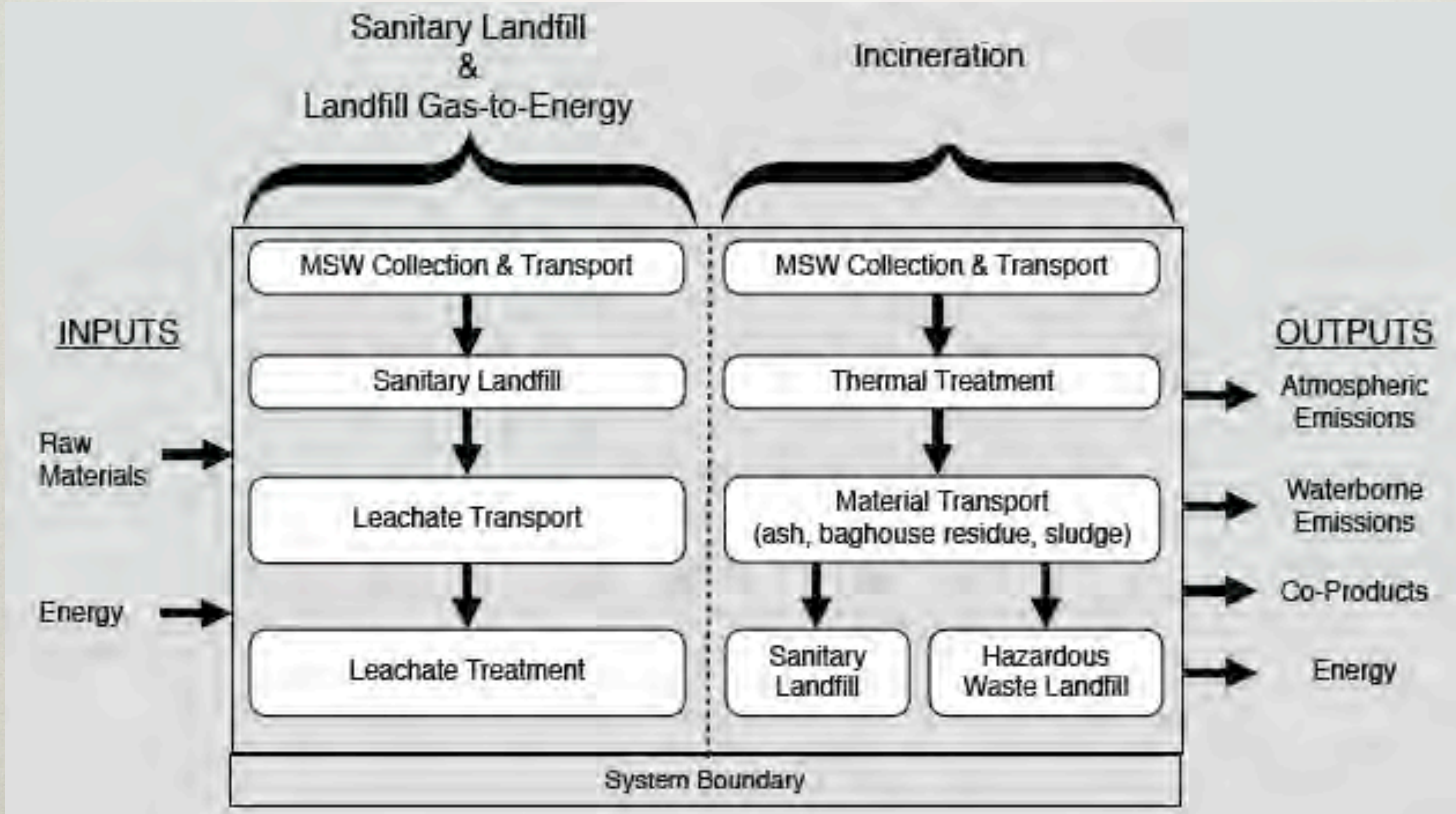
	Flow	Temp	Composition					Pollutants										
			CO_2	H_2O	O_2	N_2	Ar	HCl	SO_2	SO_3	HF	NOx	dust	Cd, Tl	Hg	As, …	dioxin
	Nm³/h	°C			vol%						mg/Nm³, dry 11% O2						ng
1	130 851	190	7,40%	11,90%	9,50%	70,39%	0,80%	125	301	14	0,0	400	2228	0,00	0,10	1,5	3,00
2	122 343	300	7,91%	5,77%	10,16%	75,28%	0,85%	125	301	14	0,0	400	2005	0,00	0,10	1,5	3,00
3	123 829	297	7,82%	5,72%	10,29%	75,31%	0,85%	25	150	3	0,0	400	3196	0,00	0,00	1,2	0,10
4	130 020	284	7,45%	5,49%	10,79%	75,41%	0,86%	25	151	3	0,0	400	5	0,00	0,00	0,1	0,00
5	149 986	58	6,46%	18,07%	9,35%	65,37%	0,74%	4	143	0	0,0	400	3	0,00	0,00	0,1	0,00
6	149 972	58	6,46%	18,06%	9,35%	65,38%	0,74%	0	11	0	0,0	400	2	0,00	0,00	0,1	0,00
7	149 972	58	6,46%	18,06%	9,35%	65,38%	0,74%	0	11	0	0,0	400	2	0,00	0,00	0,1	0,00

	flows (for 1 line)			
	residu/reactant	water	Temp	
	kg/h	m³/h	°C	T/y
21 *H2O (100%)*	0	-6,8		
22 *Ca(OH)2*	115,8			**926**
23 *activated carbon*	9,79			**78**
24 *residue*	376			**3007**
25 *water*		16,2		
26 *waste water*		0,2		
27 *NaOH*	20	0,2		**159**
28 *waste water*		0,2		
29 *CaO (100%)*	15	0,1		**117**
30 *filtrate*	21	0,5		**171**
31 *sludge*	39	0,0		**310**
			hours/y	**8000**

Overall stochiometry for acid removal:
on removed polluents
on incoming polluents

Water for quench	0,0 m3/h	
Water for wet scrubber	16,4 m3/h	
Waste water wet scrubber	0,0 m3/h	
Condensate	0,36 m3/h	
Nett water consumption	16,07 m3/h	385,8 m3/day
Heat exchange at cold temp	0,00 MW	
Total heat recovery 1 line	16,07 MW	
Temperature heating water to plant	0,00 °C	

Life Cycle Inventory + Life Cycle Impact Assessment



Results

Human Health & Environmental Impacts

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- **Results**
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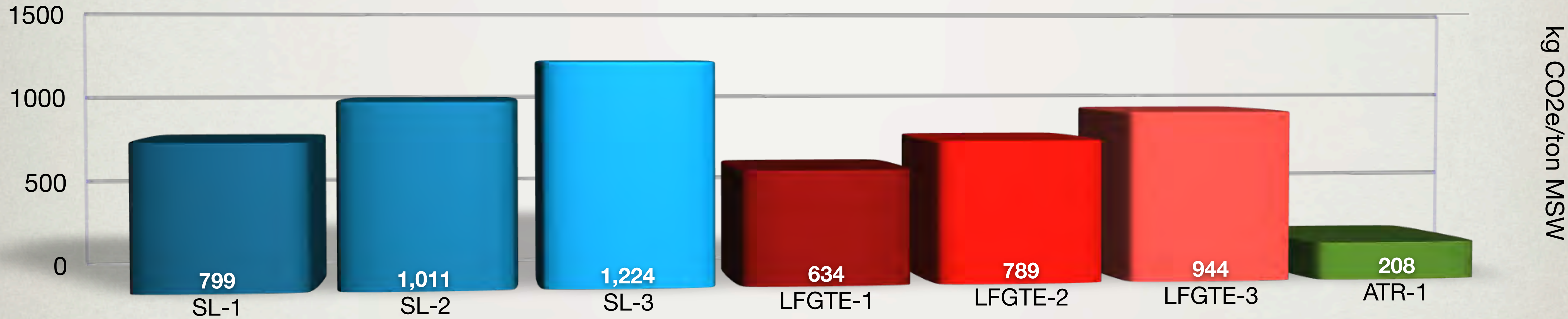
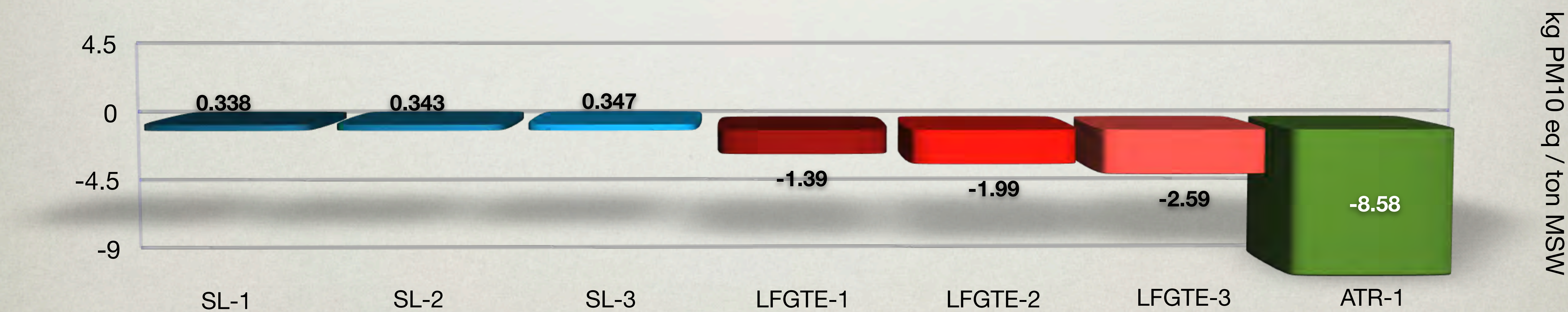
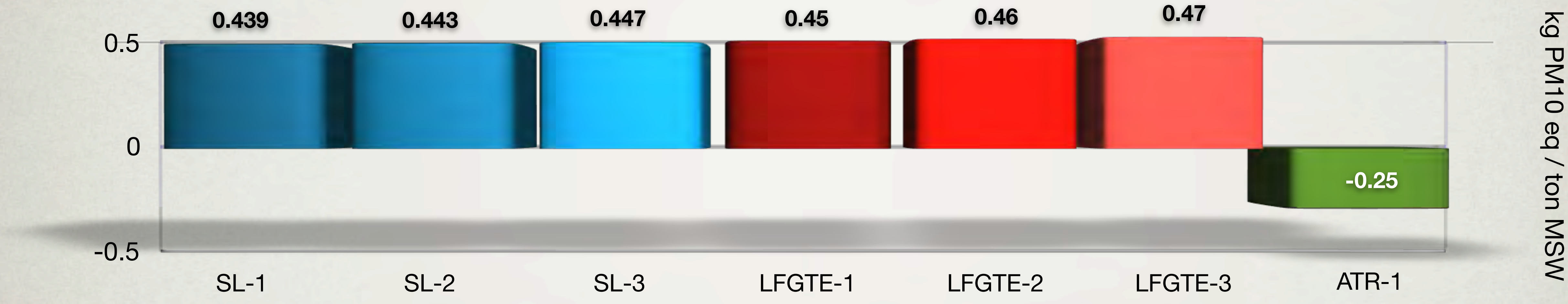
GLOBAL WARMING POTENTIAL



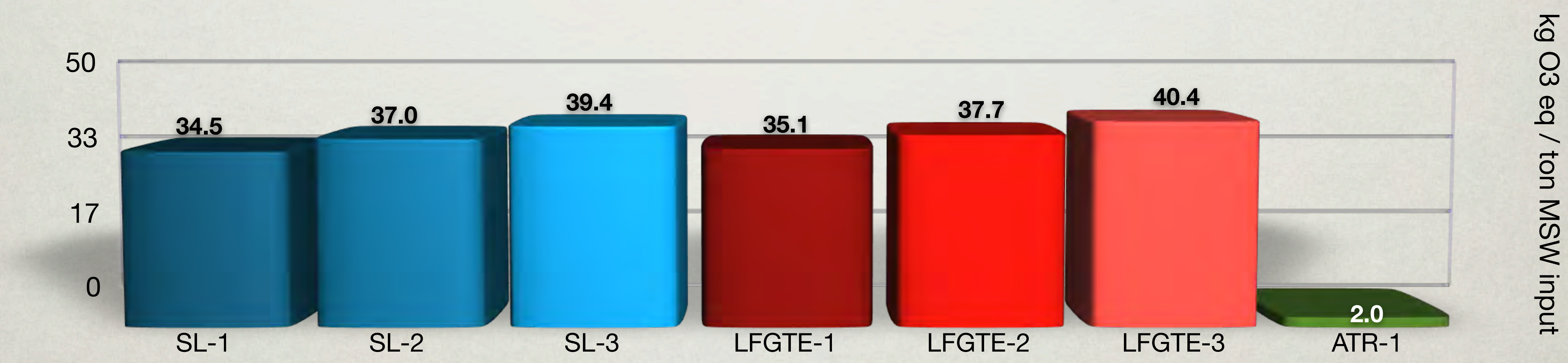
HUMAN HEALTH



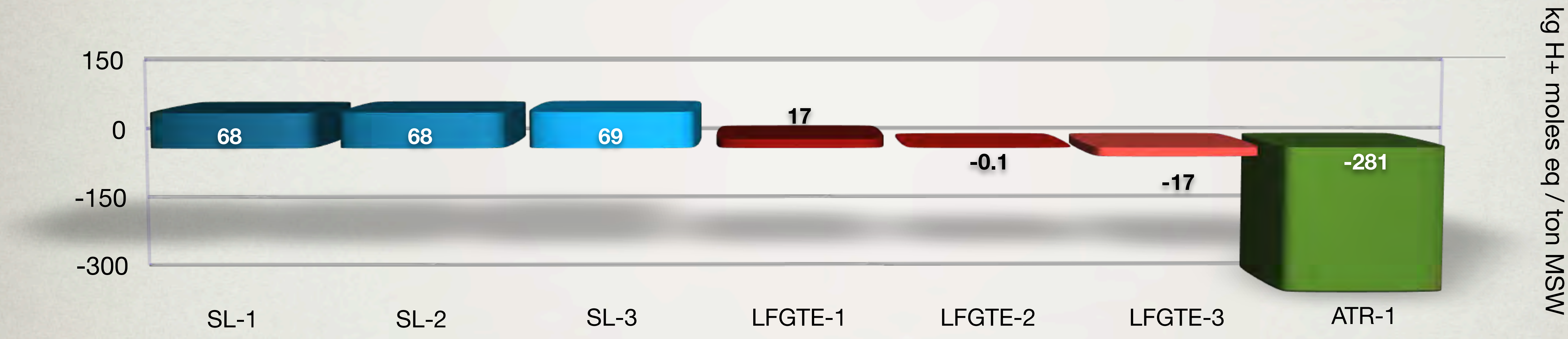
EUTROPHICATION



SMOG



ACIDIFICATION



OZONE DEPLETION

Discussion

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Discussion

- Modern advanced thermal recycling technologies are, generally speaking, technologically and environmentally superior to “old” incineration technologies
- Thermal treatment technologies show consistently better environmental performance vis-a-vis sanitary landfills and landfill gas-to-energy

Moving Forward

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Moving Forward

- Incorporate of a gasification analysis
- Consider other metrics: Energy efficiency, diversion rates, capital costs (general figures), and estimated revenue (tonnage basis)
- Consider the public education piece (social science)

Questions?

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