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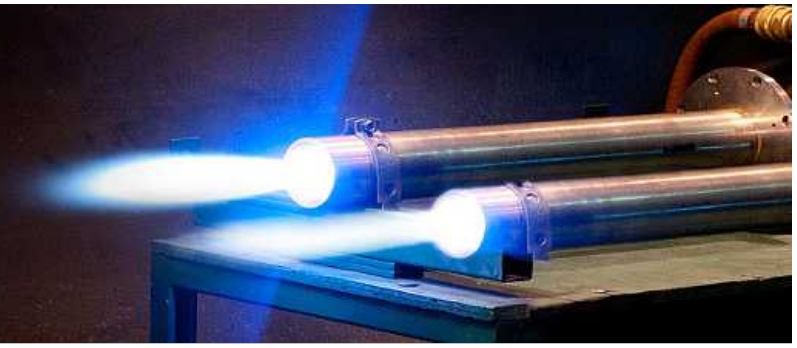

# ENG505 – Energy Technologies, Systems, and Applications

## Plasma Gasification for Energy Production and Material Reclamation

*Penny Avery (4143), Walter Fazio (2615), Melissa Myerly (6925), and Craig Tenney (6915)*

SANDIA R&A Document #xxxxxxx

U.S. DEPARTMENT OF ENERGY | NNSA

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# Waste

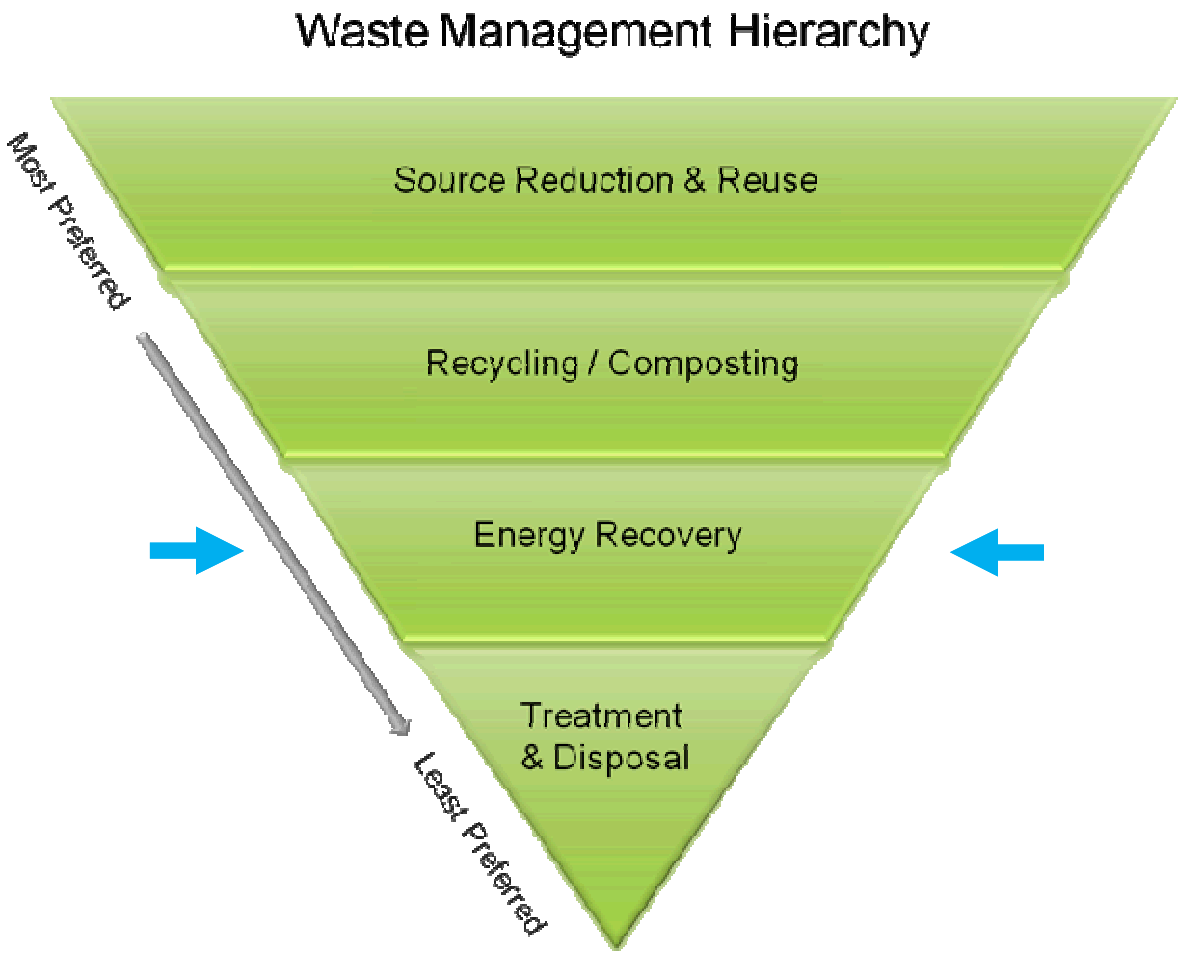
## Example: McDonalds pancake breakfast

- The top & bottom of a styrofoam container that held the pancakes
- A plastic syrup container and its foil top
- A paper cup
- A plastic cup lid
- A plastic straw
- A plastic fork
- A plastic knife
- The plastic bag that held the fork and knife
- Some used napkins
- The paper tray liner or bag

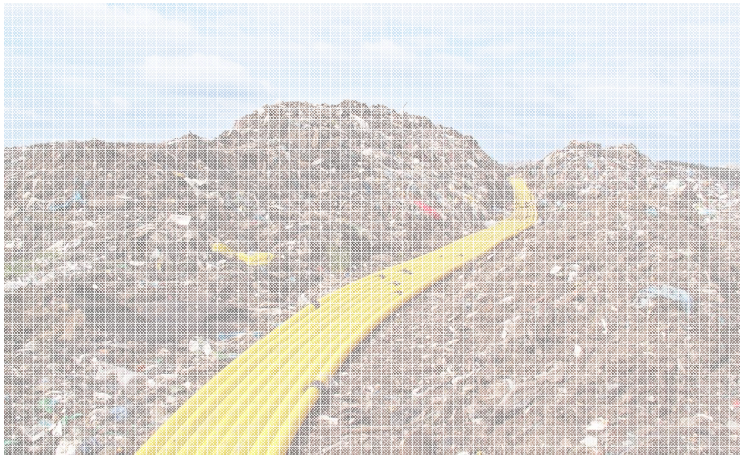
The average American generates 4.4 lbs of waste daily

**About 3 lbs is not recycled**

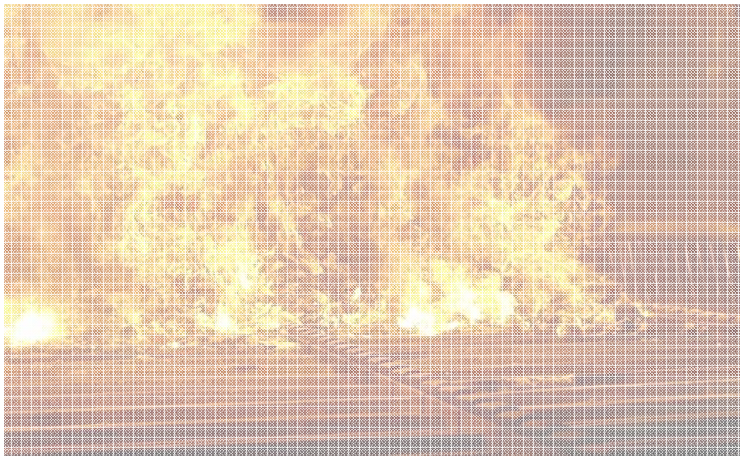
# Waste to energy (WtE)



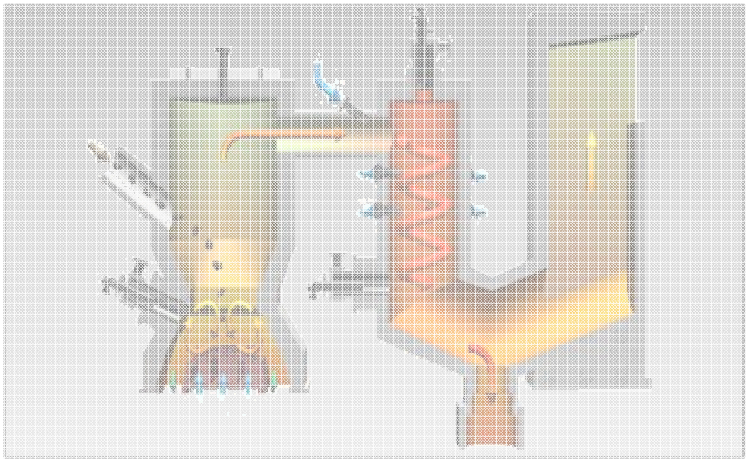
# Waste to energy (WtE)



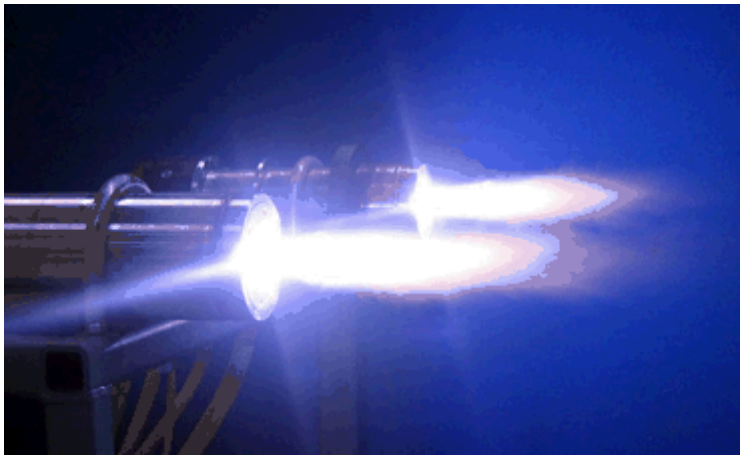
Landfill Gas Recovery



Incineration

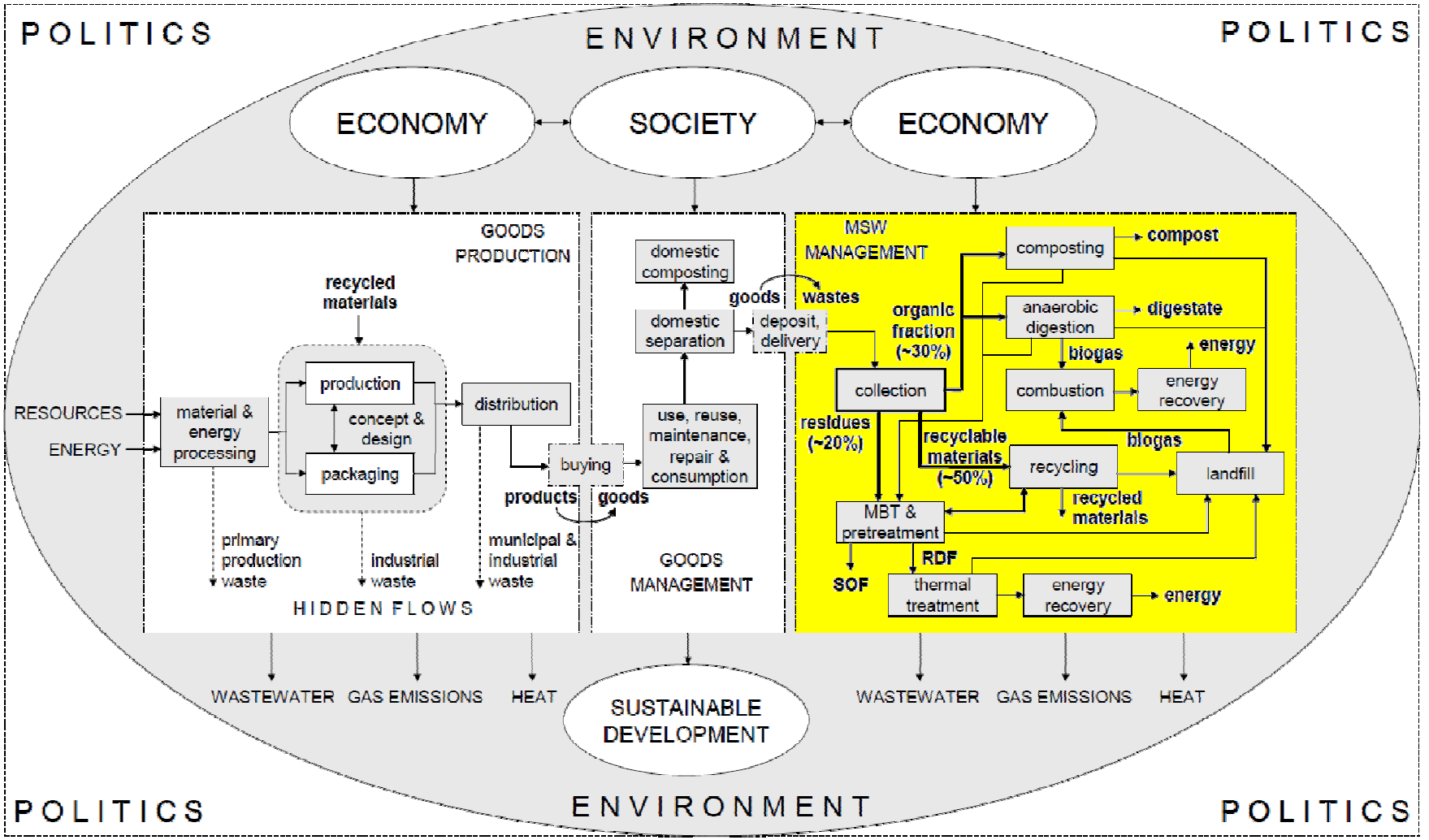


Conventional Gasification

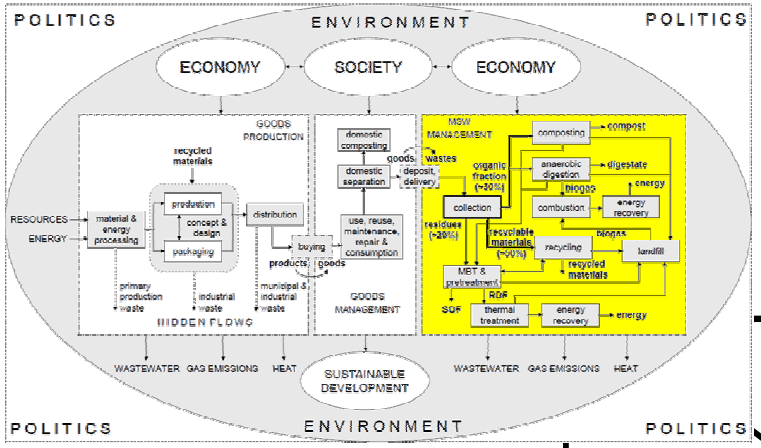


Plasma Gasification

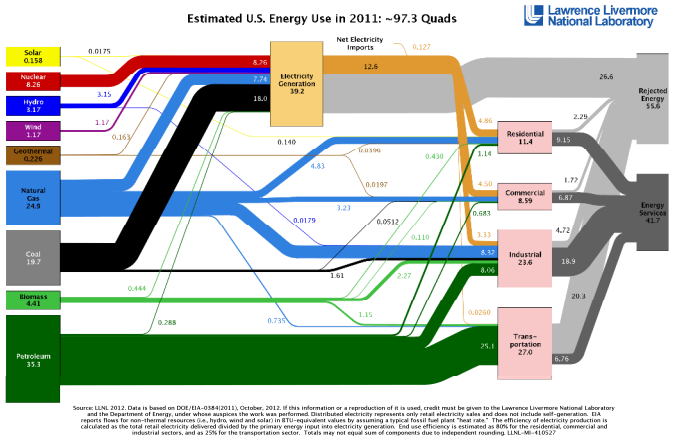
# Systems perspective



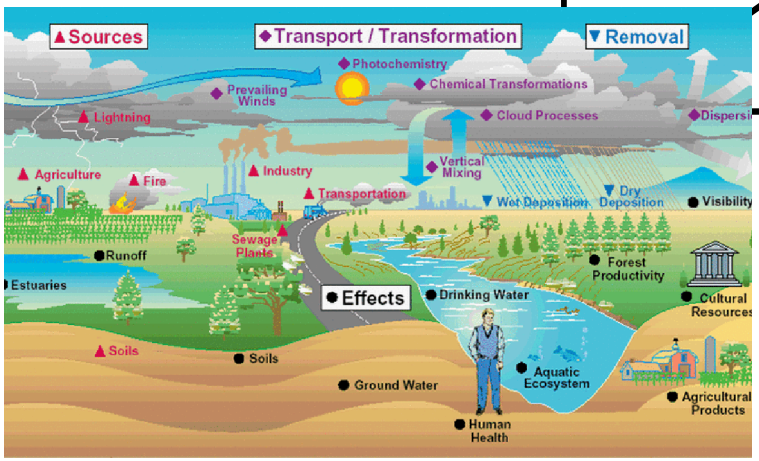
# Systems perspective



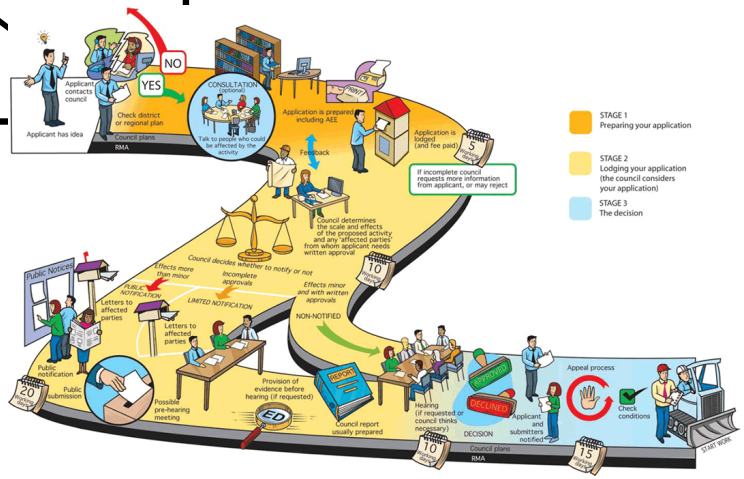

Materials Lifecycle




Energy




Environment




Policy/Regulations

# Our objective

- To ask:

From a systems perspective,

**when**

**where**

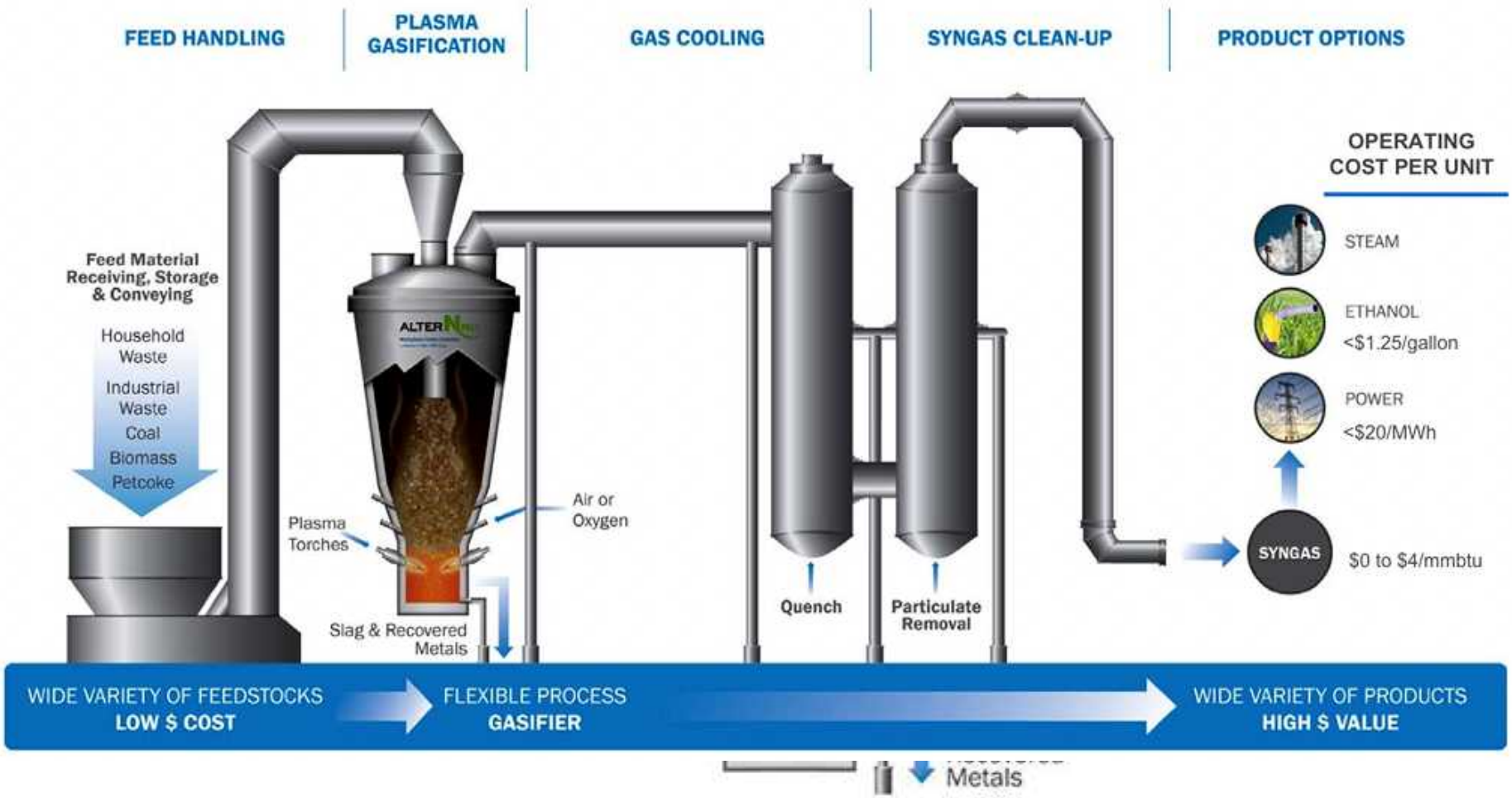
**how**

**to what extent**

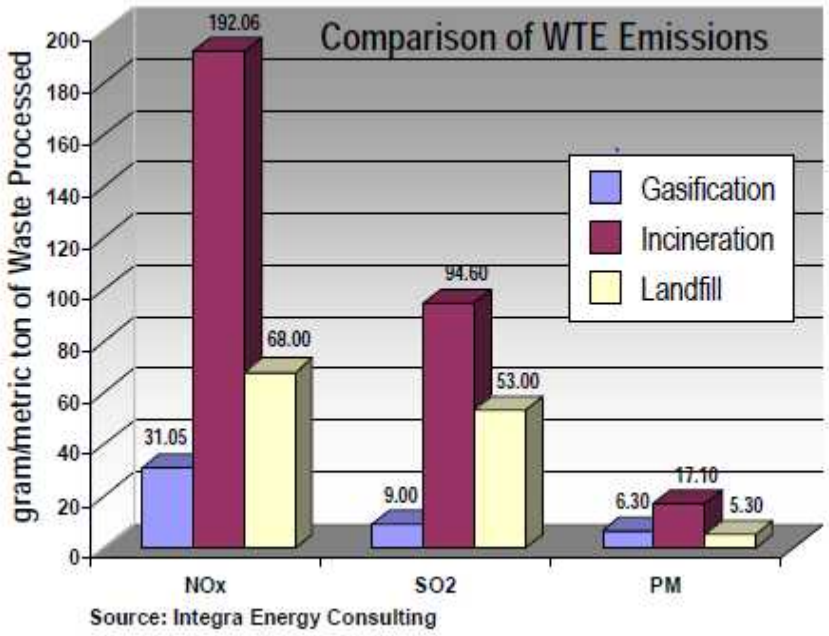
does it make sense to employ PG?

- Evaluate the technology from a Sandia systems standpoint

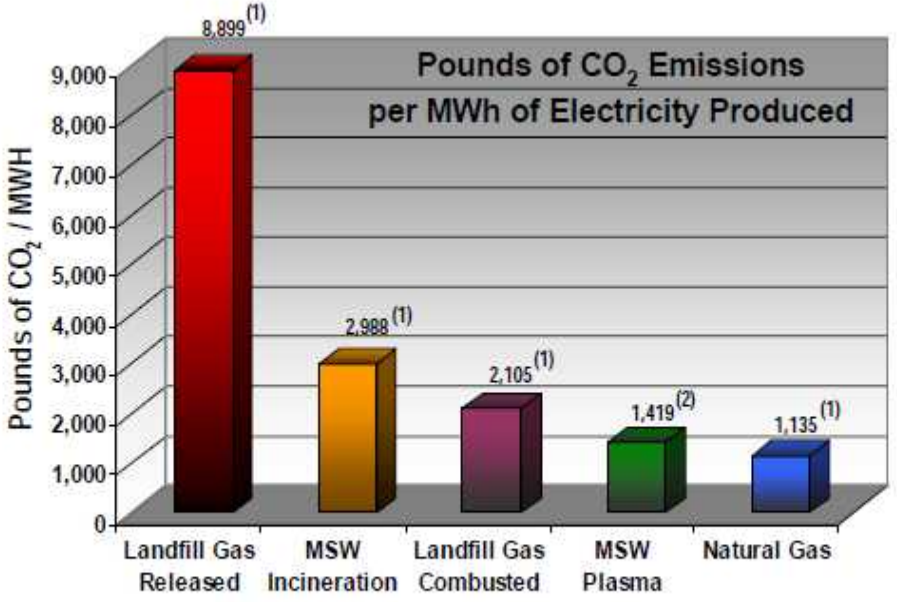
# Plasma gasification process



# Air Emissions Comparison of Waste Management Solutions



Source: Integra Energy Consulting



Source: (1) EPA Documents: www.epa.gov
(2) Complete conversion of Carbon to CO2;
MSW material & heat balance, Westinghouse Plasma Corp.

# Air Emissions

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Demonstration Source Tests of Plasco Energy Plasma Arc Gasification of 110 tpd of MSW

| Emissions ($mg/N\text{-}M^3@7\%O_2$) | Measured | USEPA Standard |
|---|---|---|
| PM | 12.8 | 20 |
| HCl | 3.1 | 40.6 |
| $No_x$ | 150 | 308 |
| $So_x$ | 26 | 85.7 |
| Hg | .0002 | 50 |
| Dioxins/furans ($ng/N\text{-}m^3$) | .009245 | 13 |

It has been demonstrated that the higher temperatures plasma gasification waste-to-energy process provides for substantial conversion of the organic constituents of the waste and therefore significantly reduces the likelihood of downstream dioxin formation.

# Other environmental metrics

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**basis:**
**1kg MSW**

| | water consumption (g) | air emission of organics (g) | air emission of dust (g) | water emission of suspended solids (g) | landfill volume (m^3) |
|---|---|---|---|---|---|
| **landfill** | **0** | **1.20E-01** | **2.70E-02** | **0.03** | **1.43E-03** |
| **incineration** | **175.2** | **2.00E-03** | **4.90E-02** | **6.79** | **2.70E-04** |
| **biological** | **70.8** | **1.60E-03** | **3.32E-02** | **1.23** | **4.90E-04** |
| **plasma gasification** | **151.2** | **1.20E-04** | **0** | **0** | **0** |

Herva, 2013

# Waste to electricity

| | net production kWh/ton | income $/ton | |
|---|---|---|---|
| landfill gas | 41 to 84 | 2 – 4 | Kaplan et al, 2009 |
| incineration | 470 to 930 | 23 – 46 | Kaplan et al, 2009 |
| plasma gasification | 680 | 34 | NYC, 2004 |

- plasma gasification
  - plasma torch uses 15-20% of electricity generated (Arena, 2012)
  - 40% less efficient than conventional gasification (Janajreh et al, 2013)

# “Tipping fees”

- landfill
  - $18 per ton in ID
  - $105 per ton in MA
  - $49 per ton U.S. average for large landfills
  - $200 to $300 per ton in Japan and Europe (Byun et al, 2012)
- incineration
  - $69 per ton (Byun et al, 2012)
  - $25 to $100 per ton (TWB, 1999)
- plasma gasification
  - $110 per ton (100 tpd design, Byun et al, 2012)
  - $75 to $85 per ton (3000 tpd design, NYC, 2004)

# Summary

Sandia National Laboratories

| Parameter | Landfill | Incineration | Plasma Gasification |
|---|---|---|---|
| Safety | + | - | ++ |
| Security | ++ | + | - |
| Reliability | ++ | + | - |
| Sustainability | - | + | ++ |
| Cost effectiveness | ++ | + | - |
| Resiliency | ++ | - | + |

# Summary

Sandia National Laboratories

| Parameter | Weight Factor | Landfill | Incineration | Plasma Gasification |
|---|---|---|---|---|
| Safety | 1 | + | - | ++ |
| Security | 1 | ++ | + | - |
| Reliability | 1 | ++ | + | - |
| Sustainability | 1 | - | + | ++ |
| Cost effectiveness | 1 | ++ | + | - |
| Resiliency | 1 | ++ | - | + |
| **SCORE** | | **9** | **4** | **5** |

# Summary

Sandia National Laboratories

| Parameter | Weight Factor | Landfill | Incineration | Plasma Gasification |
|---|---|---|---|---|
| Safety | 1 | + | - | ++ |
| Security | 1 | ++ | + | - |
| Reliability | 2 | ++ | + | - |
| Sustainability | 1 | - | + | ++ |
| Cost effectiveness | 3 | ++ | + | - |
| Resiliency | 1 | ++ | - | + |
| **SCORE** | | **15** | **7** | **5** |

# Summary

| Parameter | Weight Factor | Landfill | Incineration | Plasma Gasification |
|---|---|---|---|---|
| Safety | 2 | + | - | ++ |
| Security | 1 | ++ | + | - |
| Reliability | 1 | ++ | + | - |
| Sustainability | 3 | - | + | ++ |
| Cost effectiveness | 1 | ++ | + | - |
| Resiliency | 1 | ++ | - | + |
| **SCORE** | | **10** | **6** | **11** |

# References


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- Arena, Waste Management 32 (2012) 625-639
- Janajreh et al, Energy Conversion and Management 65 (2013) 801-809
- Byun et al, Thermal Plasma Gasification of Municipal Solid Waste (MSW), Chapter 7 in Gasification for Practical Applications (2012) 183-210
- Kaplan et al, Environ. Sci. Technol. 43 (2009) 1711–1717
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