# Life Cycle Risk Assessment: Evaluation of Energy-from-Waste Processes

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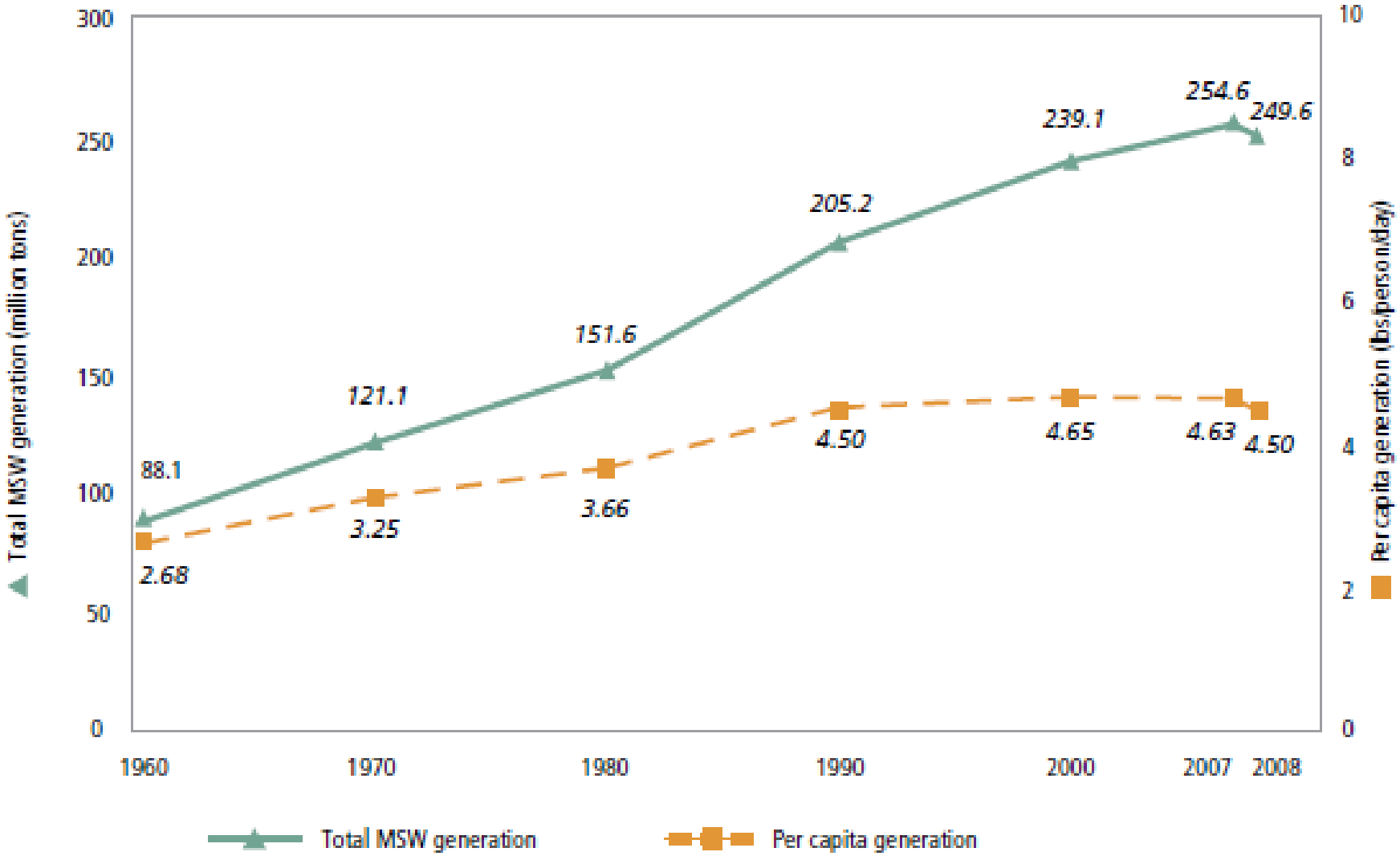
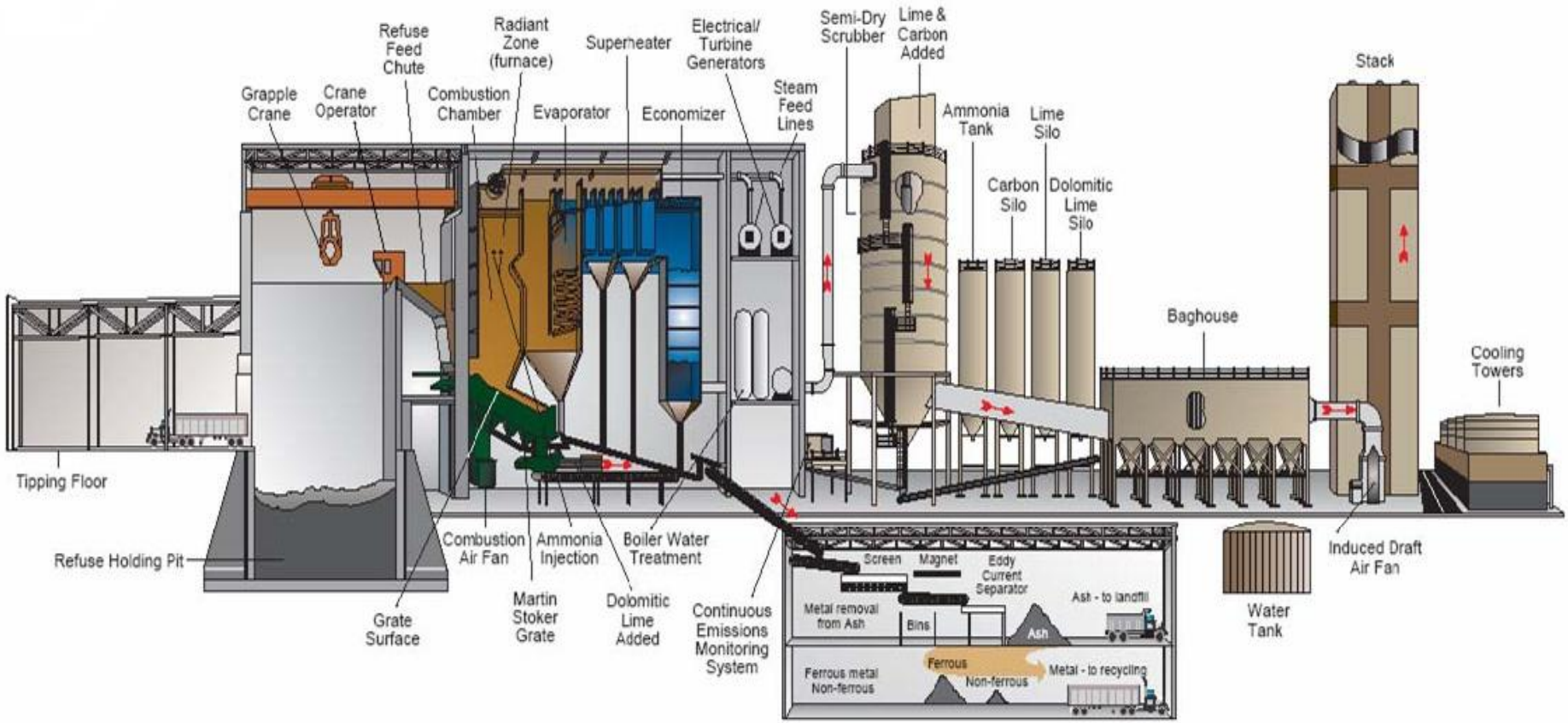
# 1. About Energy-from-Waste a.k.a. Waste-to-Energy

- Combustion of municipal solid waste (MSW) = renewable power source because no new fuel sources are used other than the waste that would otherwise be sent to landfills

## Figure 1. MSW Generation Rates, 1960 to 2008




Source: USEPA EPA 520-F-009-021 Nov2009




Source: Covanta Energy

30

# 1. About Energy-from-Waste a.k.a. Waste-to-Energy

- In 2001, ~ 34 million tons (15 %) of MSW were processed using combustion
- Currently, U.S. has ~ 87 MSW EfW facilities
  - These facilities generate ~ 2,500 MW or about 0.3 percent of total national power generation
    - A new 2,000-3,000 MSW ton/day facility can generate 73 to 110 MW electricity

# 1. About Energy-from-Waste a.k.a. Waste-to-Energy

- Although EfW facilities are regulated to protect human health and the environment, potential adverse impacts to consider include:
  - Air emissions: GHG, PM10, NOx, Hg, Pb, dioxins
  - Water discharges
  - Solid waste generation: slag, ash
  - Traffic impacts: accidents, noise
  - Societal impacts: NIMBY, environmental justice
  - Worker impacts: dioxins and toxic metals during O&M

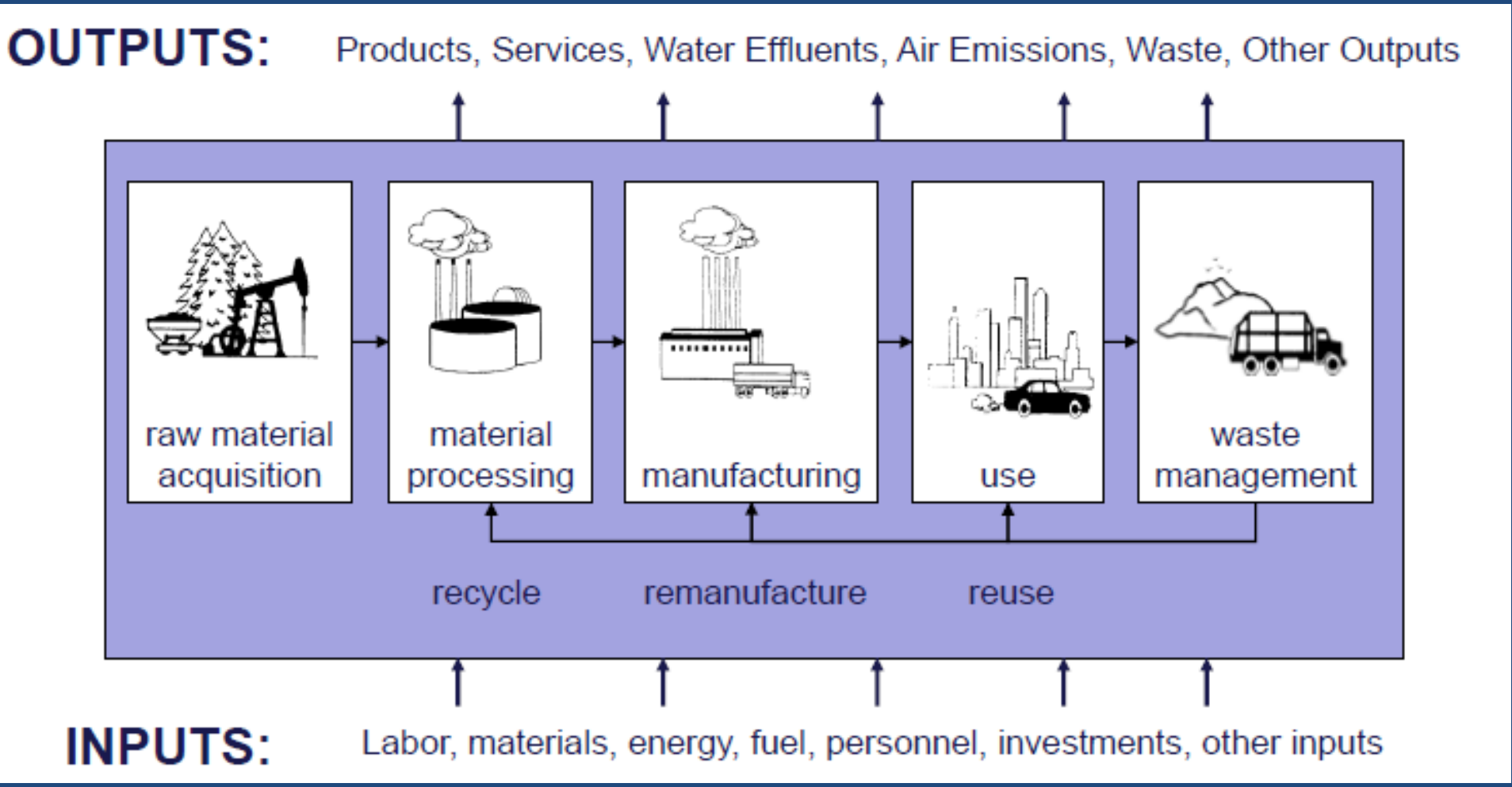
# 2. Research Questions a.k.a. What's the Problem?

- If the goal is to increase the use of renewable energy processes, then analysts and policy makers need a decision support tool that quantifies trade-offs between benefits and costs

# 2. Research Questions a.k.a. What's the Problem?

- Ideal decision support tool for evaluating trade-offs to human health and the environment = Life Cycle Assessment
  - Systems approach to quantifying inputs and outputs across life cycle of a product; evaluates cradle to grave impacts to human health and the environment
  - Standardized approach per ISO 14040:2006; goal and scope definition, life cycle inventory, life cycle impact assessment, interpretation
  - In use for several decades

# Example of life cycle of a product showing inputs and outputs to system



# 2. Research Questions a.k.a. What's the Problem?

- LCA is a popular method used to evaluate the env performance of MSW management systems
  - Cleary, J. (2009). Life cycle assessments of municipal solid waste management systems: A comparative analysis of selected peer-reviewed literature. *Environment International,* 35(8), 1256-1266. doi:10.1016/j.envint.2009.07.009
    - Results of stat analyses of energy use, acidification potential, and global warming potential appear to indicate that thermal tx scenarios have a better env performance than landfilling
    - However…

# 2. Research Questions a.k.a. What's the Problem?

- Cleary concludes that the number of human health and environmental impacts evaluated in LCAs of MSW should be increased
  - Need: comprehensive set of indicators
    - Human toxicity impacts
    - What about impacts to society, local community, workers?

# 2. Research Questions a.k.a. What's the Problem?

- The reason to evaluate and quantify these "externalities" and their associated impacts is to prevent problem shifting to other processes or to other personnel in the life cycle of EfW

**How can we enhance LCA methods to include all relevant impacts to human health and the environment?**

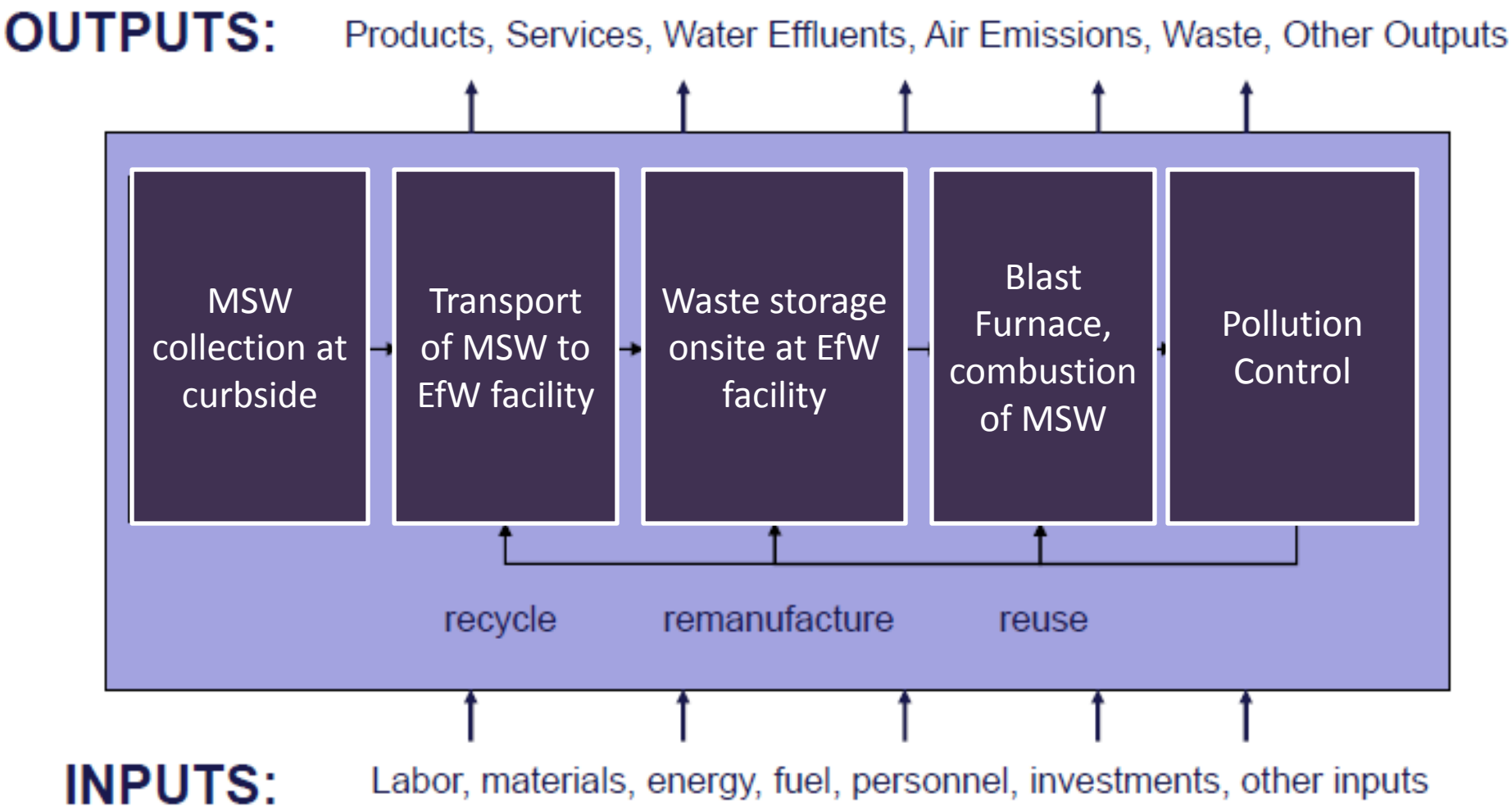
# 3. Methodology
# a.k.a. How to fix it

- Integrate social life cycle impacts into existing LCA methods
  1. Identify relevant human health and environmental impacts associated with EfW
  2. Determine inventory of inputs and outputs
  3. Characterize inventory data
  4. Quantify impacts

# 3. Methodology
# a.k.a. How to fix it

- **Example: Work Environment**
  1. Identify relevant occupational health impacts across all life cycle stages
     - MSW collection, transportation, tipping, O&M
       - Data source: Literature, Industry

# Example of life cycle of a MSW showing inputs and outputs to EfW system



# 3. Methodology
# a.k.a. How to fix it

2. Determine occupational health inputs and outputs to the EfW system
   - Worker demographics for each life cycle process
   - Injury, illness, fatality incidence for each process
     - Data source: Industry, U.S. Census Bureau, U.S. Bureau of Labor Statistics

# 3. Methodology
# a.k.a. How to fix it

3. Characterize inventory data
   - Determine number of occupational health events per amount of MSW managed using EfW
     - Data source: Data from Steps 1 and 2 plus U.S. Bureau of Labor Statistics data concerning duration of cases, weighting of injuries and illnesses, and standard life expectancy of worker population

# 3. Methodology
# a.k.a. How to fix it

4. Quantify occupational health impacts
   - Calculate the burden of occupational health impacts
     - Data source: Data from Step 3
     - End result: Work environment disability adjusted life year per the amount of MSW managed using EfW

# Thank You

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