Benefits and challenges of using LCA to advance sustainable waste and materials management

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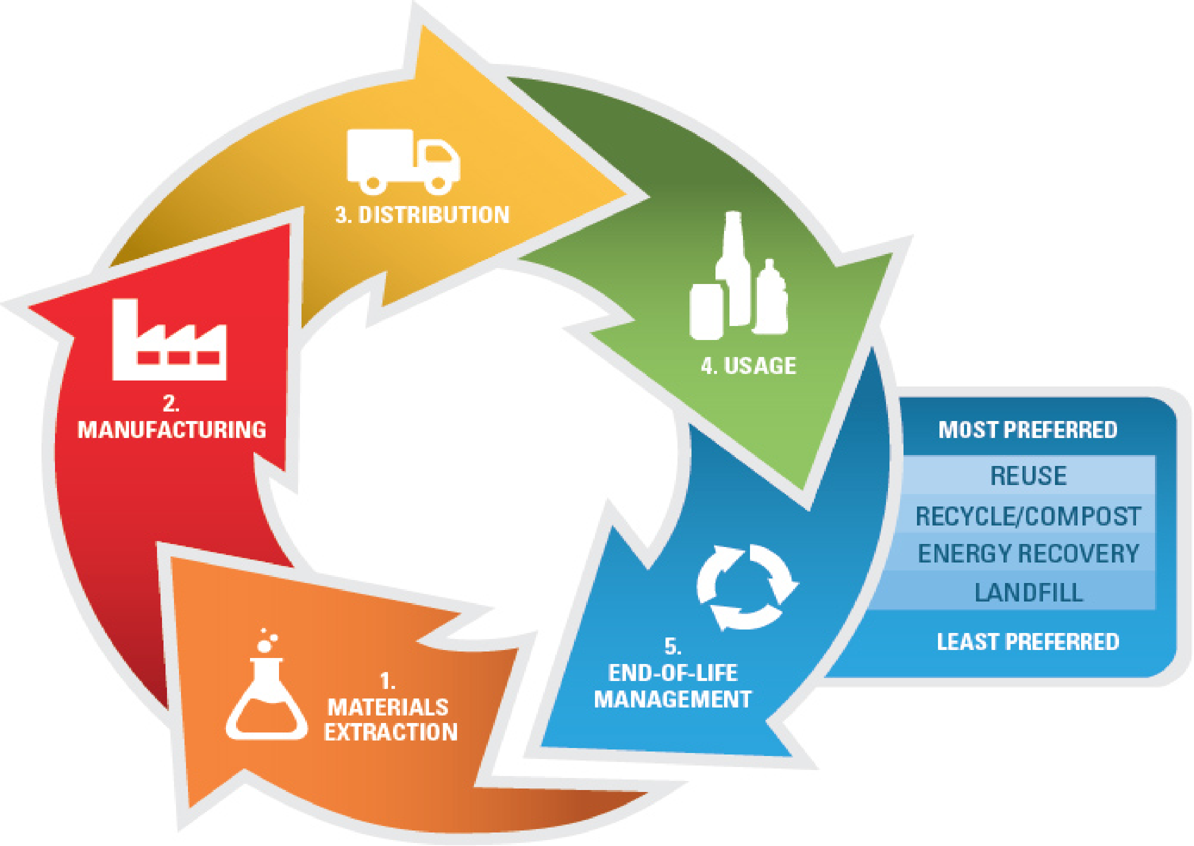
The Life-Cycle of "Stuff"

Comparing life-cycle energy use and environmental tradeoffs of different waste management options to inform sustainable materials management



Tools are available for evaluating the life-cycle environmental tradeoffs

- In the US, collaboration between US EPA, North Carolina State University, RTI International, and ERG has produced
  - Municipal Solid Waste Decision Support Tool (MSW DST) - available through https://mswdst.rti.org/
  - 2nd generation MSW DST (not yet named) – beta testing to occur in 2018
- Similar tools have been developed in other countries primarily in Europe
- Collaboration through the International Expert Group (IEG) on LCA for waste management has benefitted the US tool and the other tools from collaboration through IEG and efforts to compare and “validate” findings

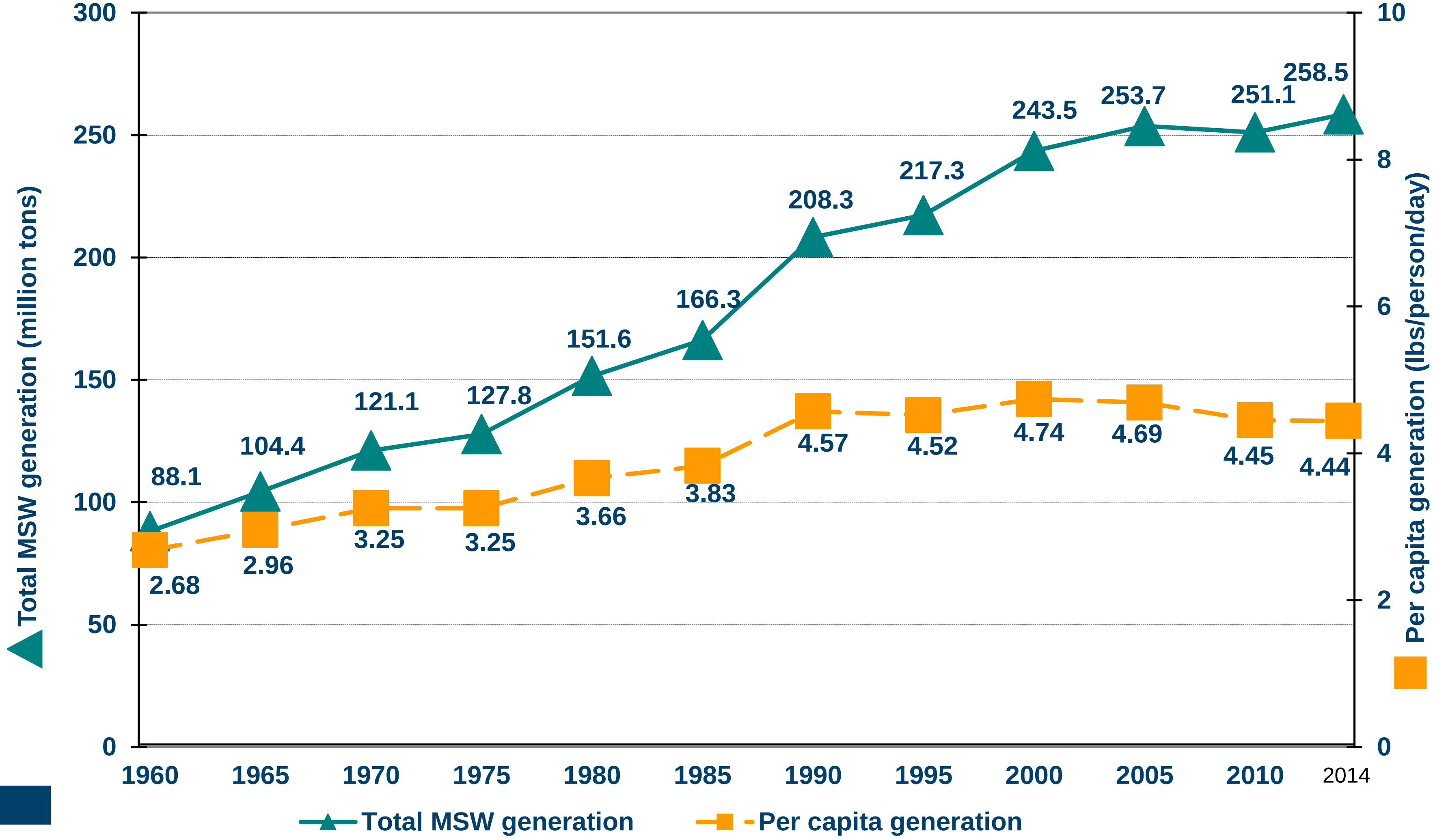
Benefits from using these tools

- Have standardized process for evaluation that is internally consistent and can reflect the net LCA environmental tradeoffs, costs, and other societal aspects for different options including collection, transport, processing, recycling, composting, digestion, combustion with energy recovery, and landfilling
- Assess the potential roles of specific technologies or strategies to meet policy goals
- Identify important system interactions and potential unintended consequences
- Consider uncertainties in prices for energy and materials, technologies, and policy to assess risks (and opportunities)
- Provides information to benchmark and track environmental performance over time
- Ability to evaluate the changes in life-cycle environmental tradeoffs based on future changes in the energy grid, waste quantity and composition, market prices for energy and materials – *these parameters can have profound impacts on the environment including climate, air and water*

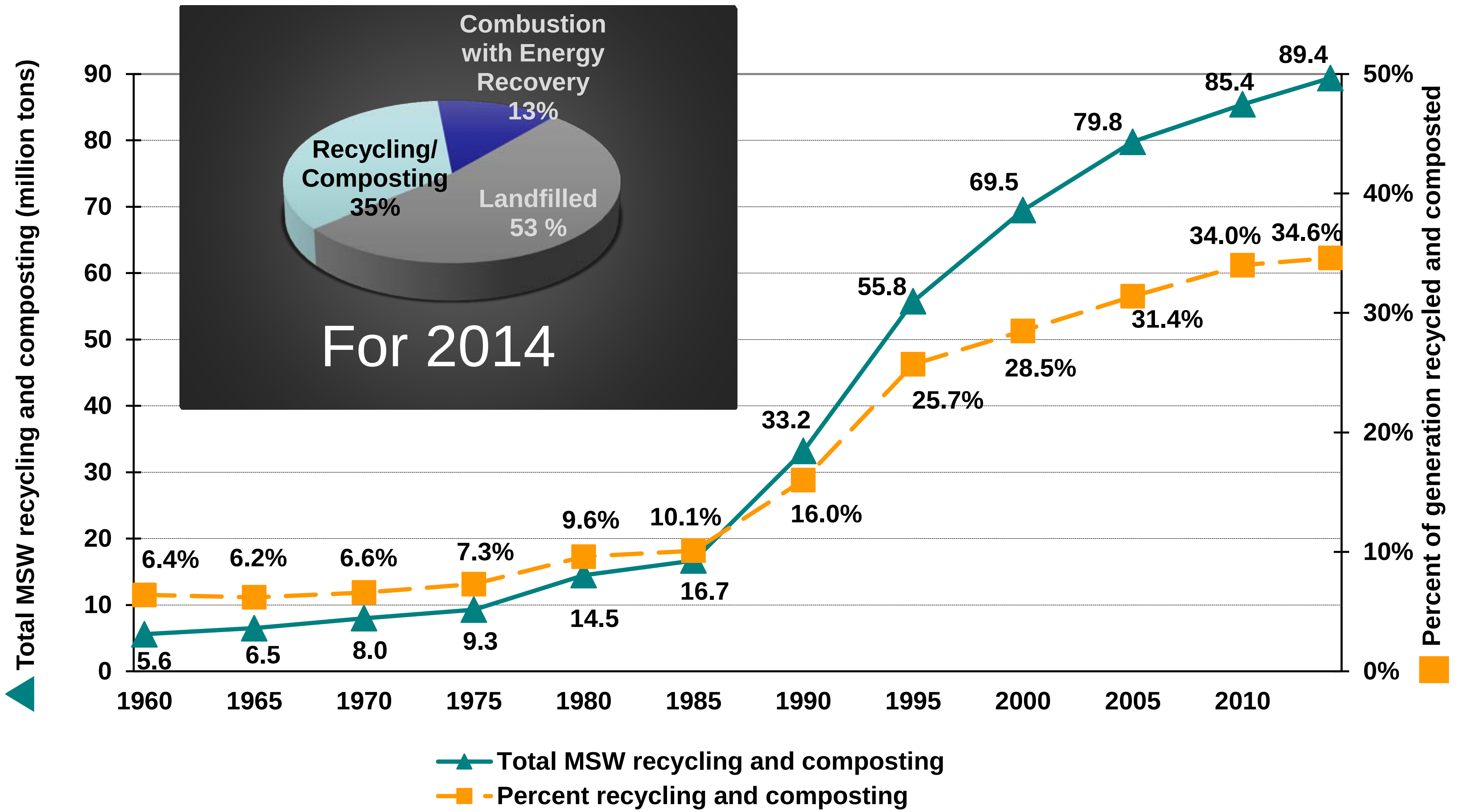
Challenges of using these tools

- LCA does not provide information for all key decision making aspects (e.g., job creation)
- Recognize that there are multiple metrics and priorities that differ across stakeholder groups
- Assisting communities in translating results into future plans
- Access to data on the parameters (cost and LCA environmental tradeoffs) that need to be tailored to local or regional values
- Users should not blindly accept results; if results conflict with previous experience, it is critical that QA/QC and interpretation of results is conducted to ensure integrity of the results
- Importance of collecting updated waste composition as-generated and as-discarded
- Focus on facility emissions vs LCA. This is probably due to regulations being facility-based (e.g., GHG reporting rule in the US)

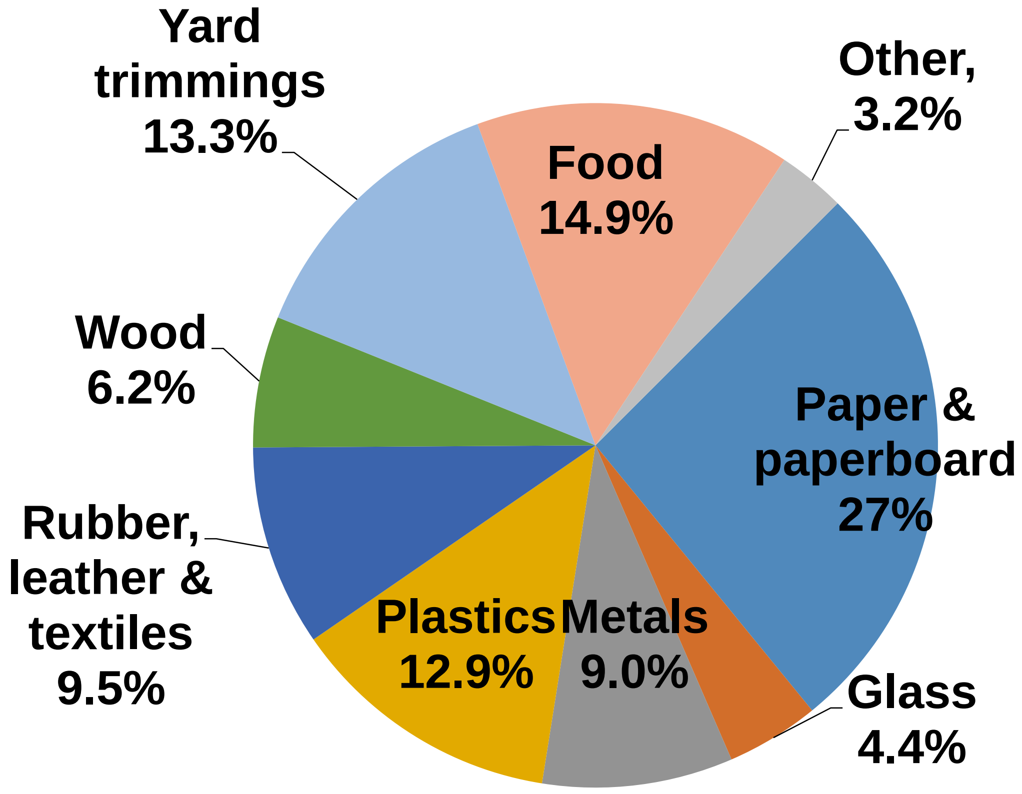
MSW Generation Rates, 1960 to 2014 - US EPA 2016 data



US MSW Management (USEPA data, 2016)



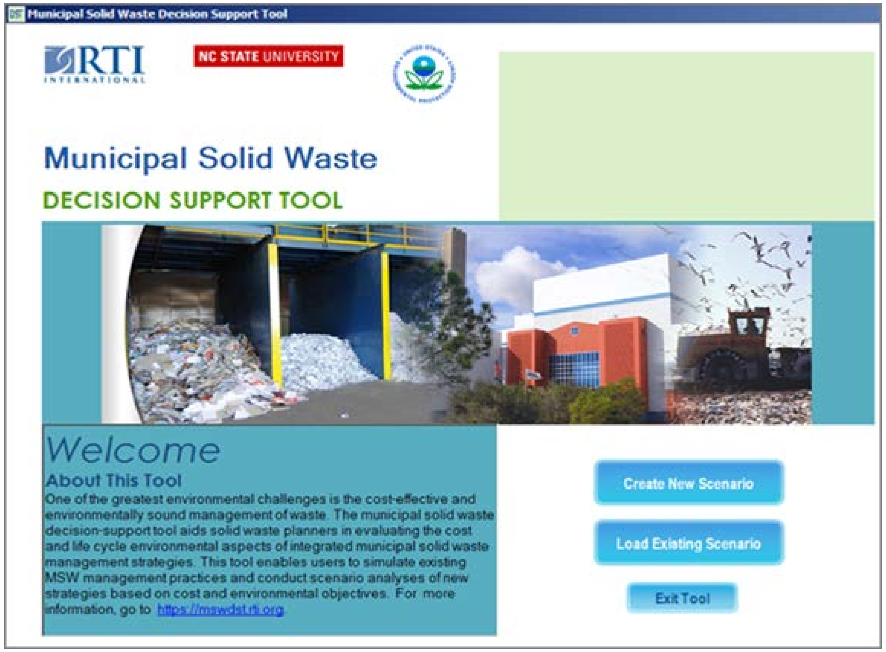
Total MSW Generation by material as of 2014 (US EPA data, 2016)



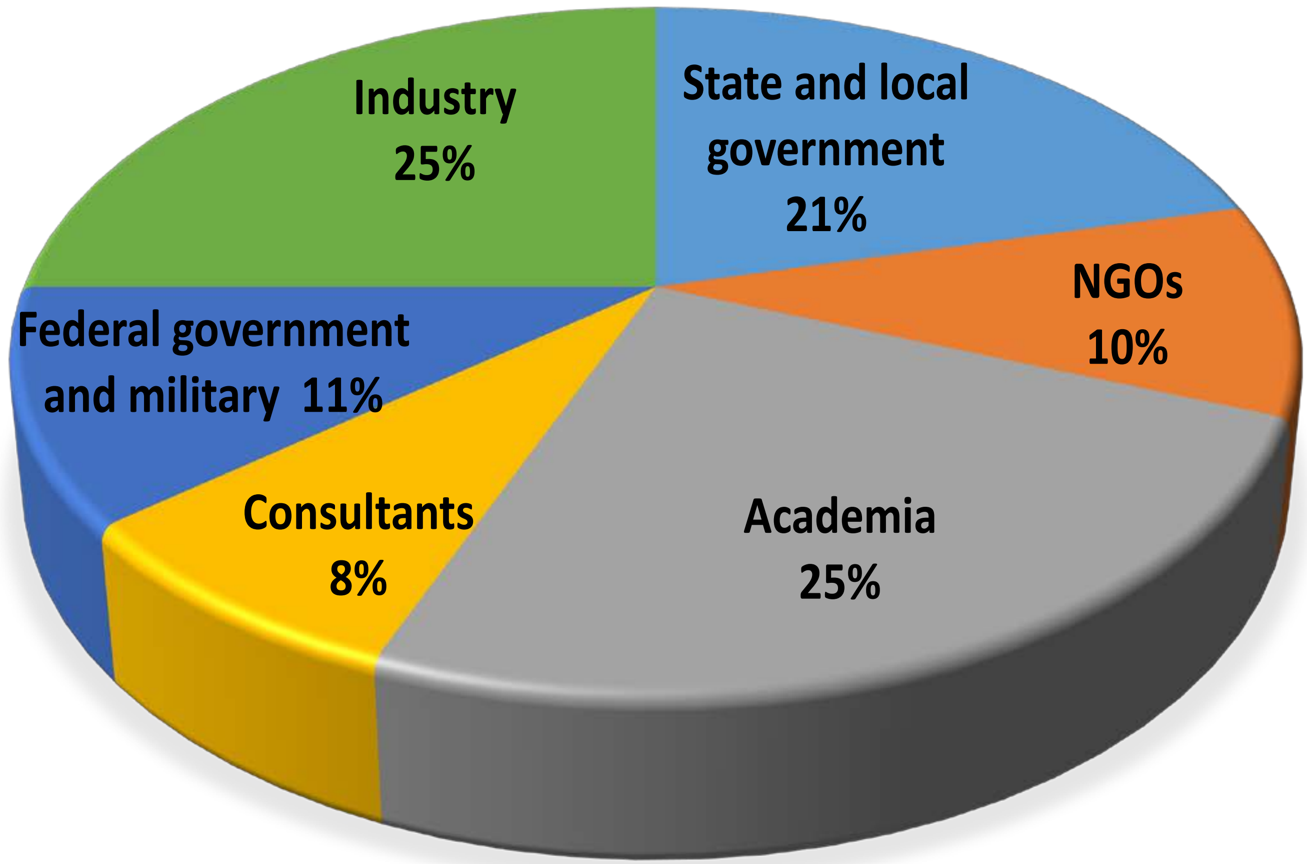
234 Million Metric Tons (before recycling, composting, or combustion with energy recovery)

1st Generation tool for identifying more sustainable strategies for managing MSW materials and discards

- In ~2002, a prototype MSW DST was available for use to simulate existing MSW management practices and conduct scenario and optimization analyses of new strategies based on cost and environmental objectives
- In 2012, it was converted to and made available as a down-loadable desktop application
- The tool is freely available including multiple design options for MSW collection, transport, transfer, materials recovery, composting, waste-to-energy, and landfill disposal
- Has been used in over 300 studies by industry, academia, World Bank, NGOs, and state and local government



Distribution of Usage of 1st Generation Tool*



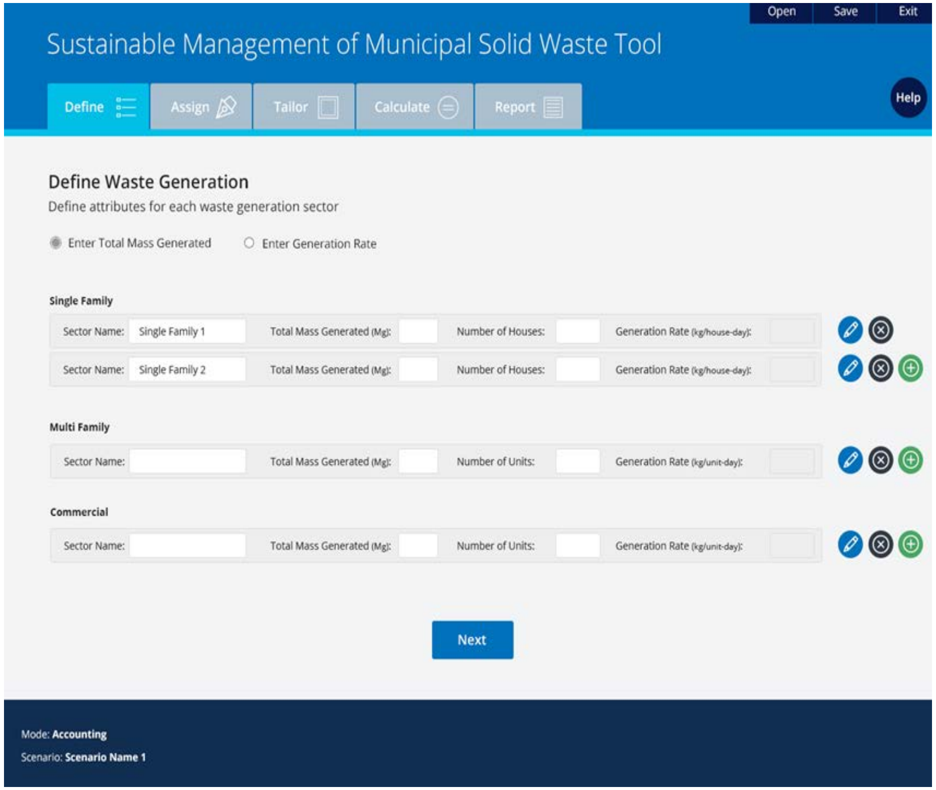
*Over 400 downloads since 2012

Progress of 2nd Generation Tool

- All process models have been updated and anaerobic digestion has been added
- Results visualization capability is being developed to track performance and communicate potential benefits of more sustainable strategies to community leaders
- Accounting and optimization mode
  - accounting mode is currently available
  - optimization mode is being added using open source solver
- Process models being translated to OpenLCA as part of the Federal Commons
  - provides detailed documentation of process models, transparency, and access to code
- Ability to dynamically reflect changes over time for the energy grid mix and waste composition and quantity

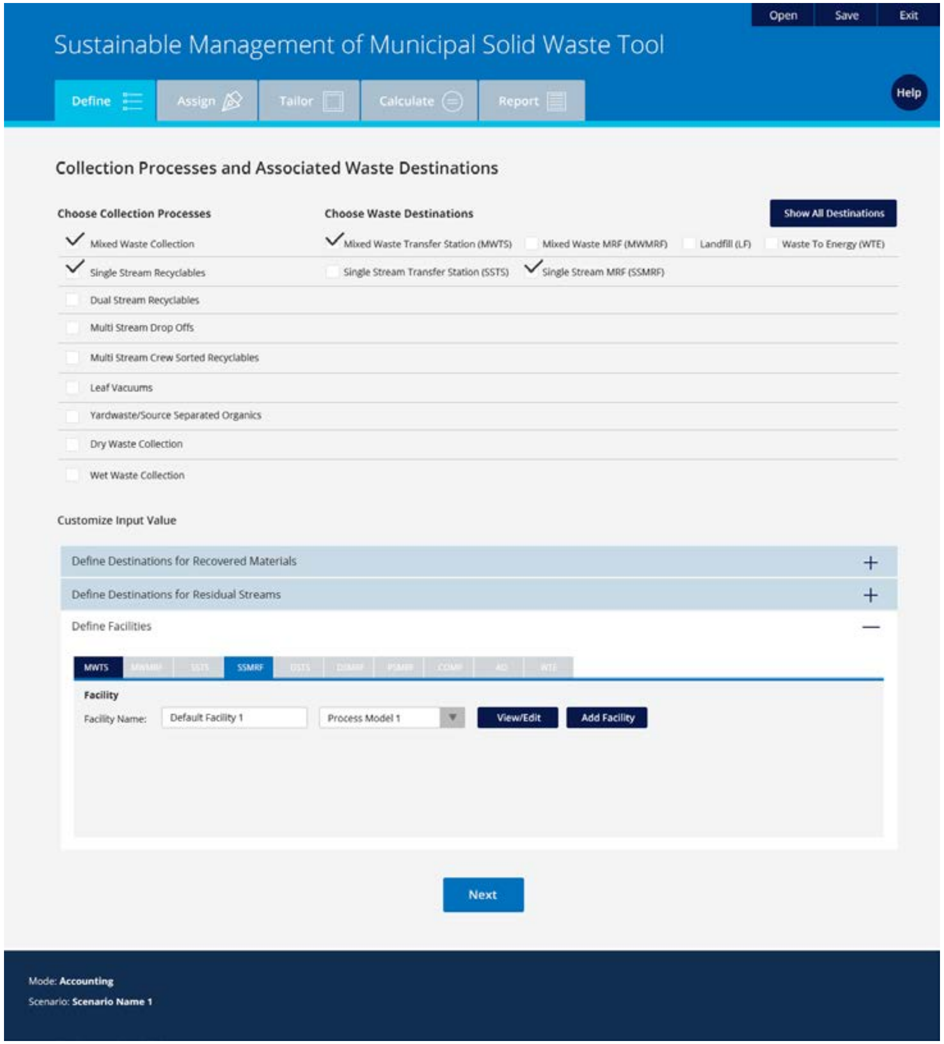
2nd Generation Tool Features

- Updated life-cycle based process models and addition of new process models (e.g., anaerobic digestion) based on research conducted by NCSU
- Estimate of metrics for cost, life cycle energy and environmental tradeoffs, and societal aspects (e.g., land usage)
- Cost is based on full cost accounting
- Environmental metrics include GHG emissions, waterborne pollutants, air pollutants, and associated impacts



2nd Generation Tool for Optimizing MSW as a Resource

- Landfills and other process models are challenging to model due to the difficulty in measuring fugitive emissions, temporal and spatial variability in emissions, changes in the design and operation of the waste management process and changes in waste composition
- Stakeholder review and engagement is considered of critical importance to ensure that tool answers needs of solid waste management planners
- Research to be completed and 2nd generation tool released in 2019



Example of a Community Dashboard

Source: http://environmentaldashboard.org/brd/

Community Waste Sector Dashboard

<u>Possible dashboard parameters</u>:

- Amount of waste generated
- Percentage of waste recycled/composted
- Landfill diversion rates for communities seeking zero waste to landfills
- GHG emissions (and/or emission savings)
- Criteria pollutant emissions (and/or savings)
- Energy consumed and/or recovered
- Transportation (e.g., number of truck miles)
- Total system cost
- Revenues from sale of materials and energy
- Energy consumptions or savings with recycling and other process models

*Could also report system totals and by-process results

Total Waste Generated
450,000 pounds per day
(4.5 lb/person/day)

Recycling Rate
25%
(including amounts recycled and composted)

CO_2 Emissions
10,000 tons CO_2-eq
(including CO_2 and methane)

Energy Recovered
100 MW
(including WTE and landfill gas-to-energy)

Recent Publication from S. Thorneloe

- Authored the section on solid waste management in the 9^{th} edition of the Perry's Chemical Engineering Handbook –

– Introduced concept of materials management versus "waste" management – also discussed use of material and energy balances when calculating materials management

– Introduced issues with incidence waste management and changing challenges to waste infrastructure for coastal areas and other low-lying regions where increased flooding and high precipitation events are becoming more common

Notes

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For further information on these tools refer to the tools section at this EPA web address:

http://www.epa.gov/land-research/models-tools-and-databases-land-and-waste-management-research

Or access to tools and further information can be found on the project websites: https://mswdst.rti.org/

** This presentation has gone through the EPA clearance process but does not necessarily reflect the opinions and policies of the EPA.*

References

- International Partnerships for Sustainable Resource Management. Exploring Elements for a Workplan (2008- 1020). UNEP/IRM/SC/0711/06
- Levis, J. W., Barlaz, M. A., DeCarolis, J. F., Ranjithan, S. R. (2014). A Systematic Exploration of Efficient Strategies to Manage Solid Waste in U.S. Municipalities: Perspectives from the Solid Waste Optimization Life-Cycle Framework (SWOLF). *Environ Sci Technol.*48(7): 3625-3631, DOI: 10.1021/es500052h.
- Levis, J. W., Barlaz, M. A., DeCarolis, J. F., Ranjithan, S. R. (2013). A generalized multistage optimization modeling framework for life cycle assessment-based integrated solid waste management. *Environ. Modell. Softw.*, 50(2013): 51-65, DOI: 10.1016/j.envsoft.2013.08.007.
- Thorneloe, Susan A., Section 22C, Management of Solid Wastes, accepted for publication in the 9th edition of ***Perry's Chemical Engineer's Handbook*** – in press - to be published by McGraw Hill (2018)
- US EPA, 2009. Sustainable Materials Management: The Road Ahead; https://www.epa.gov/sites/production/files/2015-09/documents/vision2.pdf
- **USEPA, 2017. Municipal Solid Waste Decision Support Tool Version 2.0 – Methodology Report, EPA/600/X-17/353**