Estimating Energy and Greenhouse Gas Emission Savings through Food Waste Source Reduction

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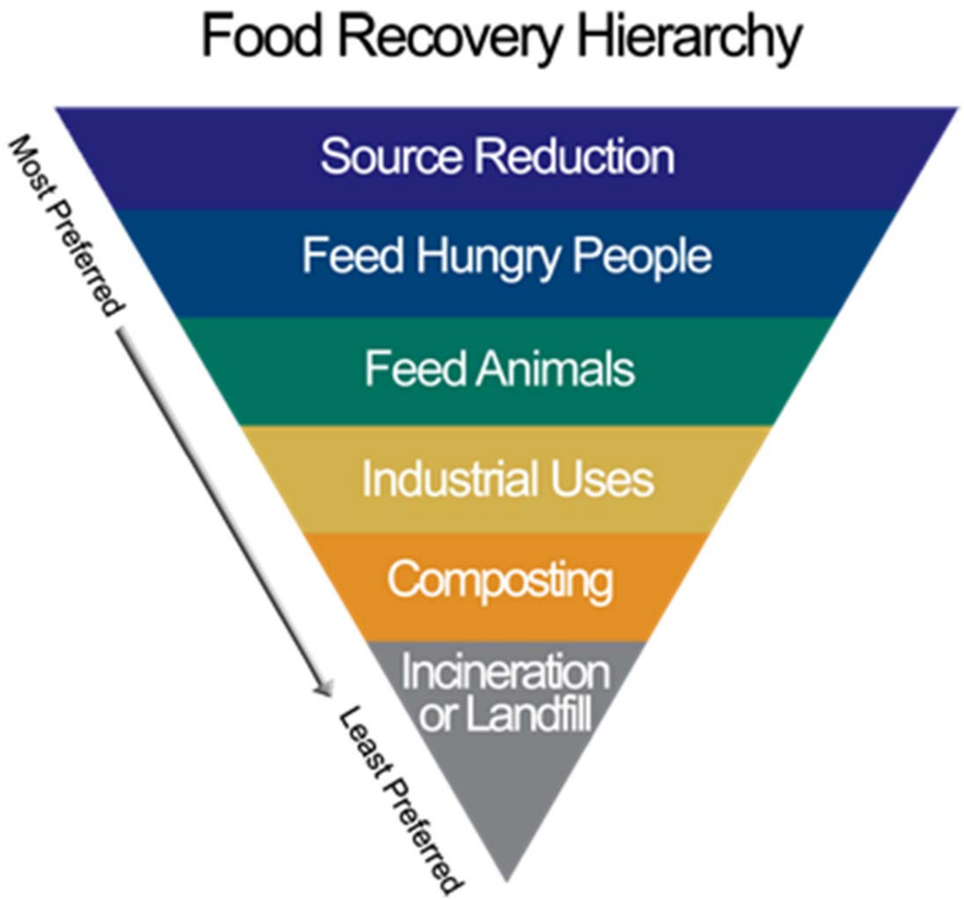
March 16, 2015

How Best to Manage Food Waste?

- Food waste is generated along the food supply chain, including at agriculture/livestock production, distribution, at retail, and consumers/end uses
- In 2012, food waste was 21.1% of MSW discards in the United States
- U.S. Environmental Protection Agency seeks to encourage food waste management according the Food Recovery Hierarchy
- The greatest preference is for avoiding food waste before it is generated (i.e., source reduction)



Drivers

- EPA wanted a way to evaluate the environmental benefits of food waste source reduction
- Interested in an option that was user friendly and could be used with their existing voluntary programs
- Solution: Develop factors with an existing tool, EPA's Waste Reduction Model (WARM)

What is WARM?

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- Waste Reduction Model (WARM)
- Developed by U.S. Environmental Protection Agency with support from ICF since 1998
- WARM calculates energy and GHG emissions of baseline and alternative waste management practices—source reduction, recycling, combustion, composting, and landfilling—for 54 common MSW and C&D materials types
- Available as a Web-based calculator and an Excel spreadsheet

WARM Waste Reduction Model

Encouraging Life-Cycle Thinking

What is WARM?

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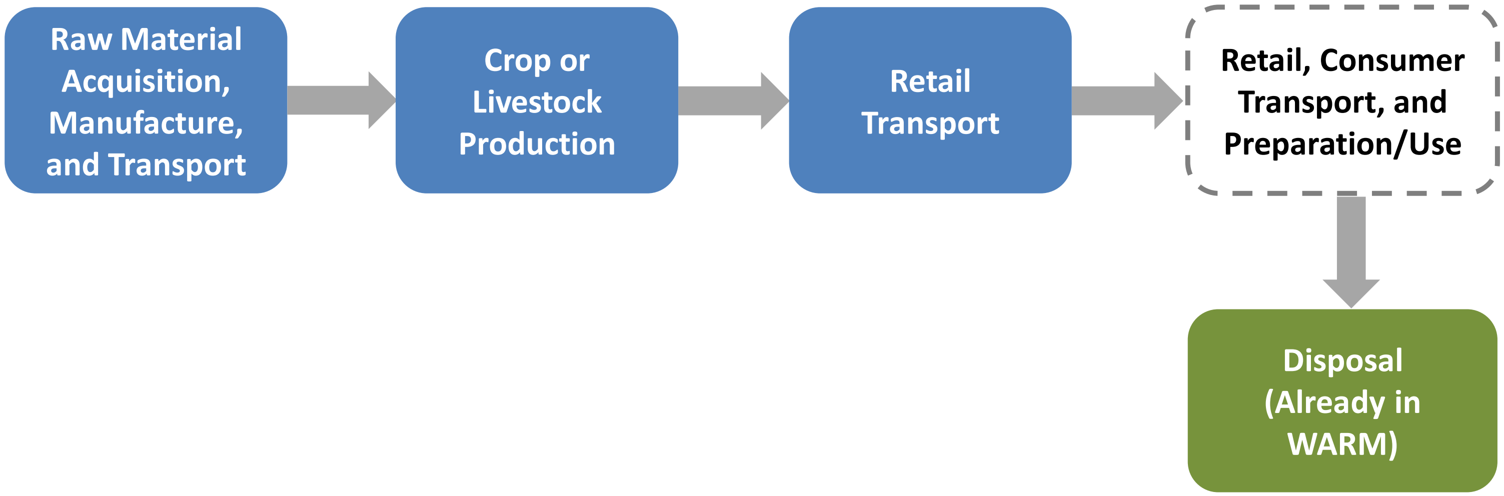
Steps 1 and 2. Baseline and Alternative Scenarios

	Baseline Scenario					Alternative Scenario				
Material	Tons Recycled	Tons Landfilled	Tons Combusted	Tons Composted	Tons Generated	Tons Source Reduced	Tons Recycled	Tons Landfilled	Tons Combusted	Tons Composted
Aluminum Cans				N/A	0					N/A
Aluminum Ingot				N/A	0					N/A
Steel Cans				N/A	0					N/A
Copper Wire				N/A	0					N/A
Glass				N/A	0					N/A
HDPE				N/A	0					N/A
LDPE	N/A			N/A	0		N/A			N/A
PET				N/A	0					N/A
LLDPE	N/A			N/A	0		N/A			N/A
PP	N/A			N/A	0		N/A			N/A
PS	N/A			N/A	0		N/A			N/A
PVC	N/A			N/A	0		N/A			N/A
PLA	N/A				0		N/A			
Corrugated Containers				N/A	0					N/A

Goals

- WARM previously included only a general “food scraps” waste type that did not address upstream impacts from food production (i.e., no way to model source reduction pathway)
- Provide users with a more flexible option for capturing energy and GHG impacts from different food types
- Create broad categories of food emission factors with wide appeal across the food service, restaurant and materials management industries
- This initial effort was focused on estimating upstream impacts to model source reduction of food
  - Future steps will create food type-specific factors for landfilling, composting, and combustion

Scope, Boundaries, and Functional Unit



- For consistency with WARM, scope excludes product use
- Environmental impacts limited to energy and GHGs
- Packaging waste is excluded, as it can be modeled separately using other material types in WARM
- Functional unit is one short ton of food at end-of-life

Challenges

- How best to represent national average practices?
  - Share of food types in the waste stream can vary significantly by season, food waste generator, geographic location, etc.
  - Upstream energy and GHG impacts can vary significantly by food type, geographic location, production practices, etc.
- What level of food type aggregation is most useful?
- How to apply consistent boundaries?

Selecting Food Types to Model in WARM

- Narrowed down to six final food categories, selected based on:
  - Their usefulness and practicality to WARM users
  - The share of total U.S. food waste stream the materials would individually and collectively comprise
  - The availability of relevant, high-quality LCI data
  - Practicality of emission factor development
- Food waste types modeled:
  - Beef
  - Poultry
  - Grains
  - Bread
  - Fruits & Vegetables
  - Dairy Products

Relative Shares of Food Waste in MSW

Table 1: Share of Total 2010 U.S. Food Waste Stream Represented by Materials to be Modeled in WARM

Food Types Modeled in WARM		**Share of U.S. Food Waste in 2010**
Grains	Wheat	5.3%
	Corn	1.3%
	Rice	1.2%
	Total	*7.8%*
Fruits & Vegetables	Potatoes	8.1%
	Tomatoes	7.9%
	Citrus	6.1%
	Melons	2.7%
	Apples	2.4%
	Bananas	2.0%
	Total	*29.3%*
Red Meat	Beef	5.5%
Poultry	Chicken	6.5%
Dairy	Fluid Milk	7.3%
	Yogurt	0.6%
	Cheese	1.2%
	Other dairy	1.6%
	Total	*10.3%*
All Food Materials to be Modeled in WARM		**59.4%**

Data Used in This Analysis

- **Primary inputs**
  - LCI data gathered from recent LCA studies, databases, and publicly-available industry sources
  - Energy for crop and livestock production, processing (when appropriate), and on-farm transportation
  - Non-energy inputs (animal feed, seeds, fertilizers, pesticides, etc.)
- **Secondary inputs**
  - LCI data gathered mainly from the U.S. LCI Database and EcoInvent
  - Energy from production of primary inputs and transport to farm
  - Non-energy emissions from upstream production of primary inputs
- **Other direct emissions**
  - Enteric fermentation
  - Soil emissions
  - Retail transport
  - Food wasted during production (final estimated is scaled to account for losses during production)

Representativeness

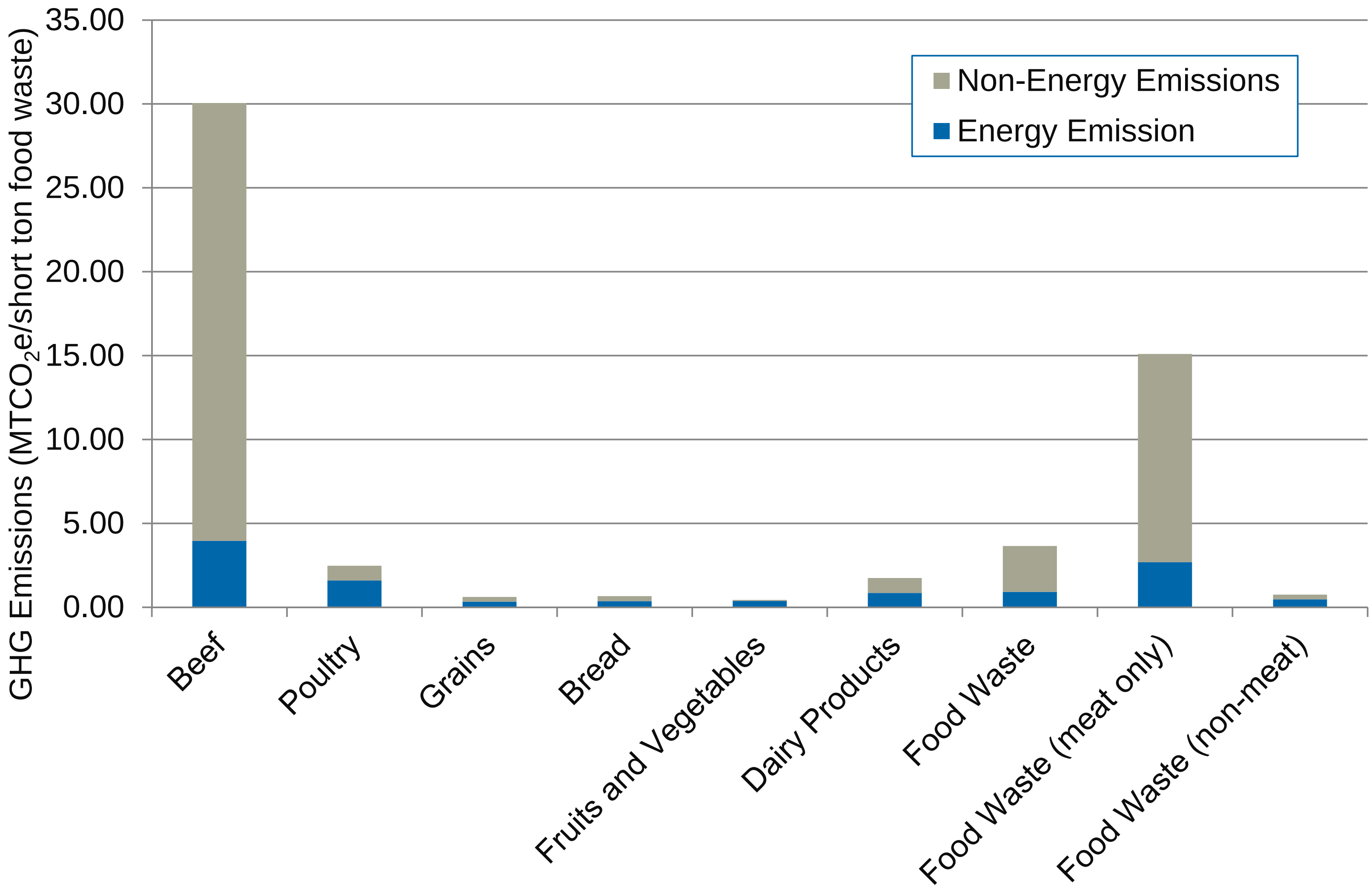
- ICF sought to use data sources that were most representative of current, national average practices
- For fruits and vegetables, did not include processing (e.g., apples to applesauce) due to lack of comprehensive data and because all fruit and vegetable types modeled are commonly purchased unprocessed
- National average data on grains processing not available
- With the exception of bananas, assumed production in United States using conventional (i.e., non-organic) farming practices
- Did not consider differences in production impacts across different breeds, varieties, or types components of each food waste category (e.g., assumed Fuji apple production was representative of other varieties)

Methodology

1. Material inputs from LCI data were organized, normalized into units per functional unit of food, and then matched to existing processes within the EcoInvent and U.S. LCI databases
2. SimaPro LCA software used to assess cumulative energy demand by fuel type and non-energy GHG emissions
3. Using LCI data on material inputs, non-energy emissions from fertilizer application were calculated using IPCC methodology and added to the non-energy emissions
4. Retail transport* energy and emissions were calculated based on tonne-kilometers per average shipment tracked by the U.S. Census Bureau's Commodity Flow Survey

* For dairy, fruits and vegetables, beef, and poultry, non-energy emissions of fugitive refrigerants were also added at this stage

Results



GHG Emissions (MTCO$_2$e/short ton food waste)
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
Non-Energy Emissions
Energy Emission
Beef
Poultry
Grains
Bread
Fruits and Vegetables
Dairy Products
Food Waste
Food Waste (meat only)
Food Waste (non-meat)

Key Findings

- Beef production is significantly more energy and GHG intensive than non-meat food types
- Largest share of emissions from grain production comes from irrigation and fertilizer
- Bread had 8% higher emissions than a weighted average of grains, indicating processing energy has a modest impact
- However, cheese and ice cream had significantly higher emissions than milk, likely due to processing energy requirements
- Results were consistent with results in primary studies; most differences due to changes in boundaries and carbon coefficients used

Outcomes

- Energy and GHG emission factors are available in WARM for the current food waste categories:
  - Beef
  - Poultry
  - Grains
  - Bread
  - Fruits and vegetables
  - Dairy products
  - Food waste [weighted average]
  - Food waste (meat only) [weighted average]
  - Food waste (non-meat) [weighted average]
- Developing an approach for estimating GHG emissions from food donation and anaerobic digestion of food waste
- Factors expected to be used by other EPA tools/programs (e.g., WasteWise, Food Recovery Challenge)

Data Gaps & Challenges

- Potential variation in production impacts across different breeds, varieties, or types within a general food category
- Limited LCI data for some upstream materials (e.g., a weighted average of nitrogen fertilizer)
- National average processing data available for only dairy and beef
- Fluctuation in irrigation needs year-by-year

Questions?

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Food Categories and Data Sources

- **Grains and Bread –** USDA LCA Digital Commons Database (USDA 2013)
- **Fruits & Vegetables**
  - Potatoes – ecoinvent LCI Database
  - Tomatoes, citrus, melons, apples – University of California-Davis Agricultural Cost & Return studies
  - Bananas – Dole Comprehensive Carbon Footprint Assessment (Luske 2010)
- **Dairy –** LCA of Fluid Milk Consumed in the U.S. (Thoma et al. 2010)
- **Beef –** National Cattlemen's Beef Association "More Sustainable Beef Optimization Project"
- **Poultry –** LCA of US Broiler Poultry Sector (Pelletier 2008)