Role of Food Packaging in Food Loss and Carbon Intensity

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Overview

Food Loss and Waste in U.S. Food Supply Chain

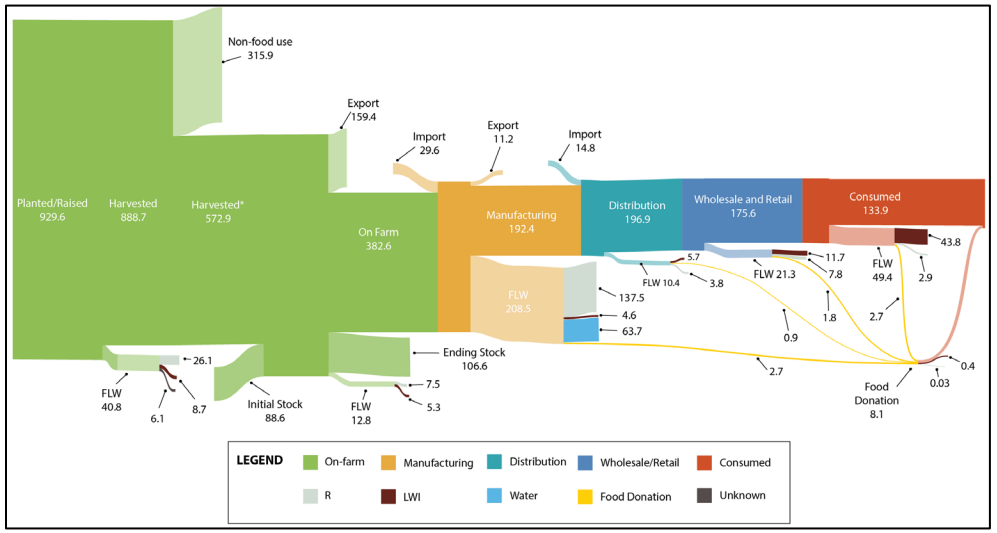
Energy Use & GHG Emissions of the U.S. FSC

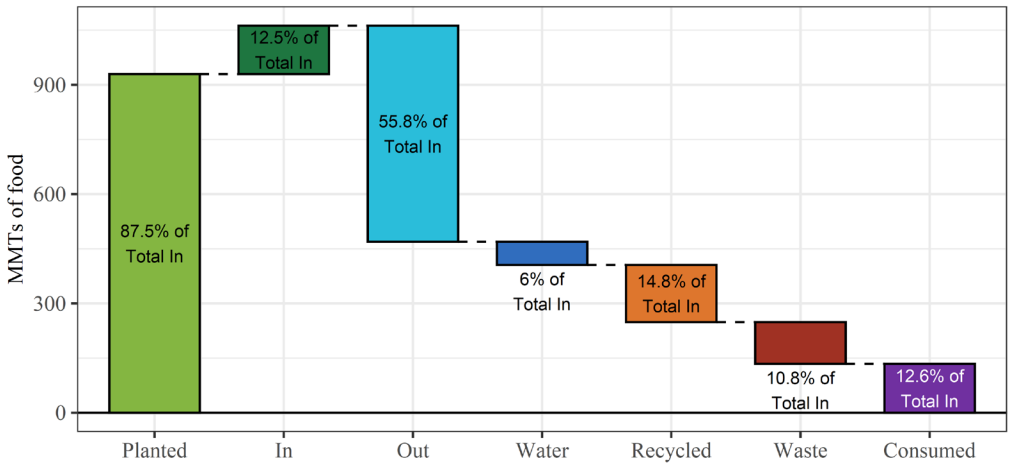
Household FLW & Packaging

Current IDEO StA/ORNL/UT-K Research

Food Loss & Waste in the U.S. Food Supply Chain

- The entire U.S. FSC is large and complex
  - Import/Export
  - Non-food use
  - Stock
- Food is lost or wasted at all stages
  - However - a lot of it is "recycled"
  - Except at consumer-facing stages…





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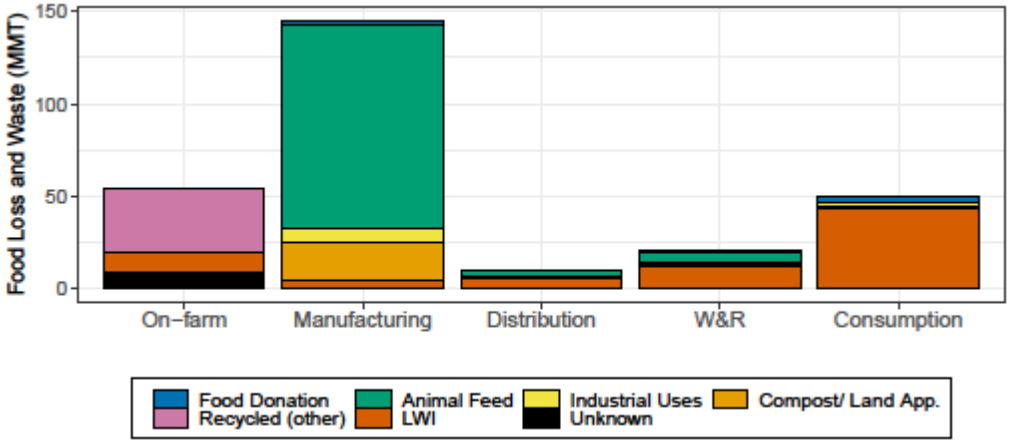
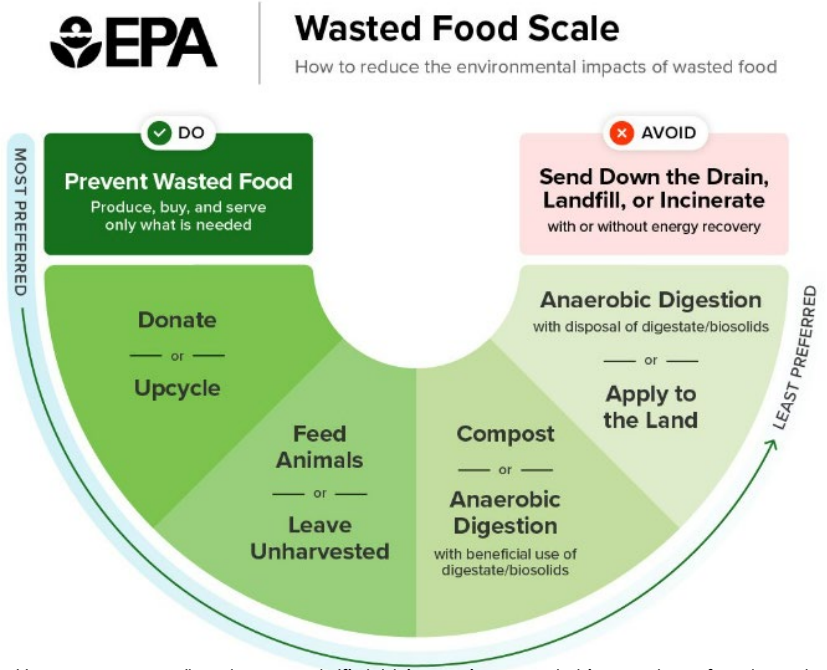
FLW in the U.S. FSC

- Some disposal pathways are better than others
- FLW at production stages tend more toward "recycle"
  - Anaerobic digestion & animal feed
- Consumption stage has a large amount that is truly wasted
  - Landfill, Incineration, Wastewater

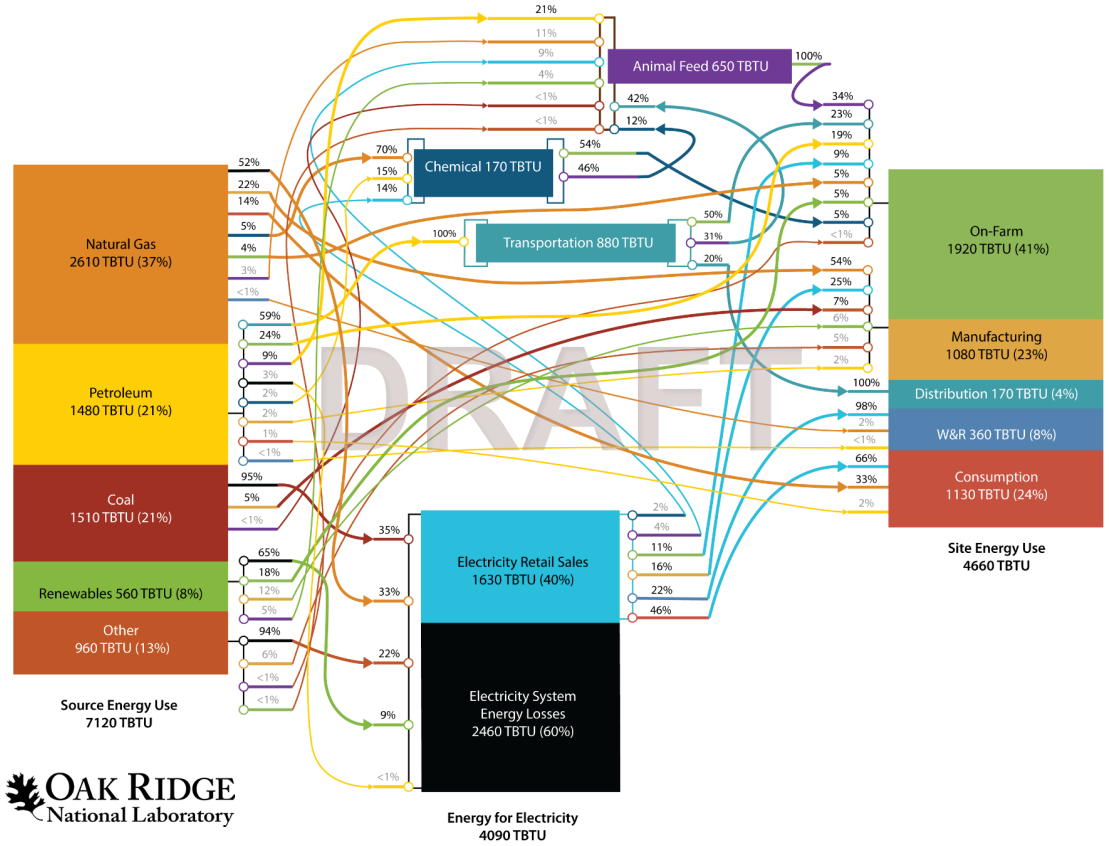


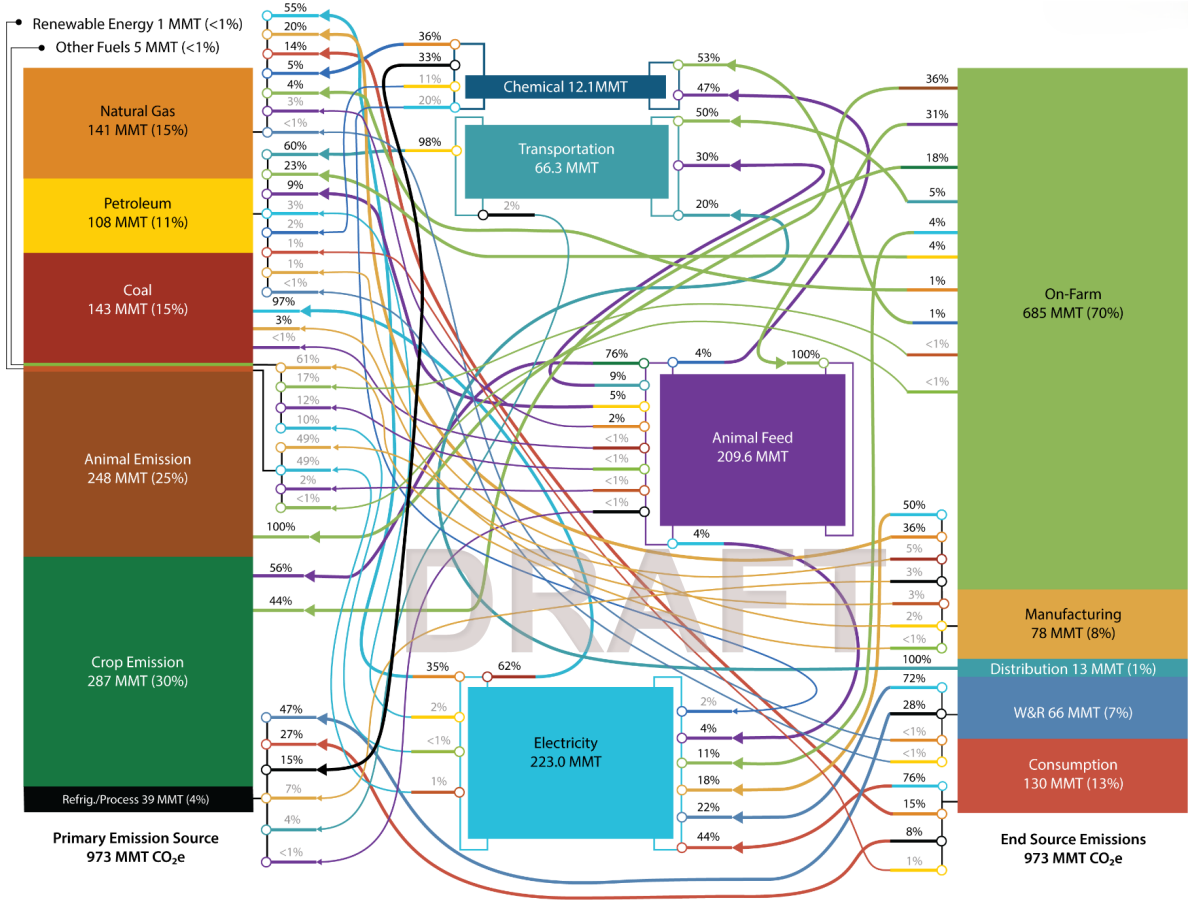


https://www.epa.gov/land-research/field-bin-environmental-impacts-us-food-waste-management-pathways

Energy & GHG Emissions of the U.S. FSC

- FSC takes a lot of energy & emits a lot of GHGs
  - 4660 TBTU site-energy, 7120 TBTU primary energy, 973 MMT CO_{2e}
- Farm – equipment, fertilizer/pesticides, animal feed, crop & animal direct emissions
- Consumer – cooking & refrigeration
- Electricity – generation & grid losses





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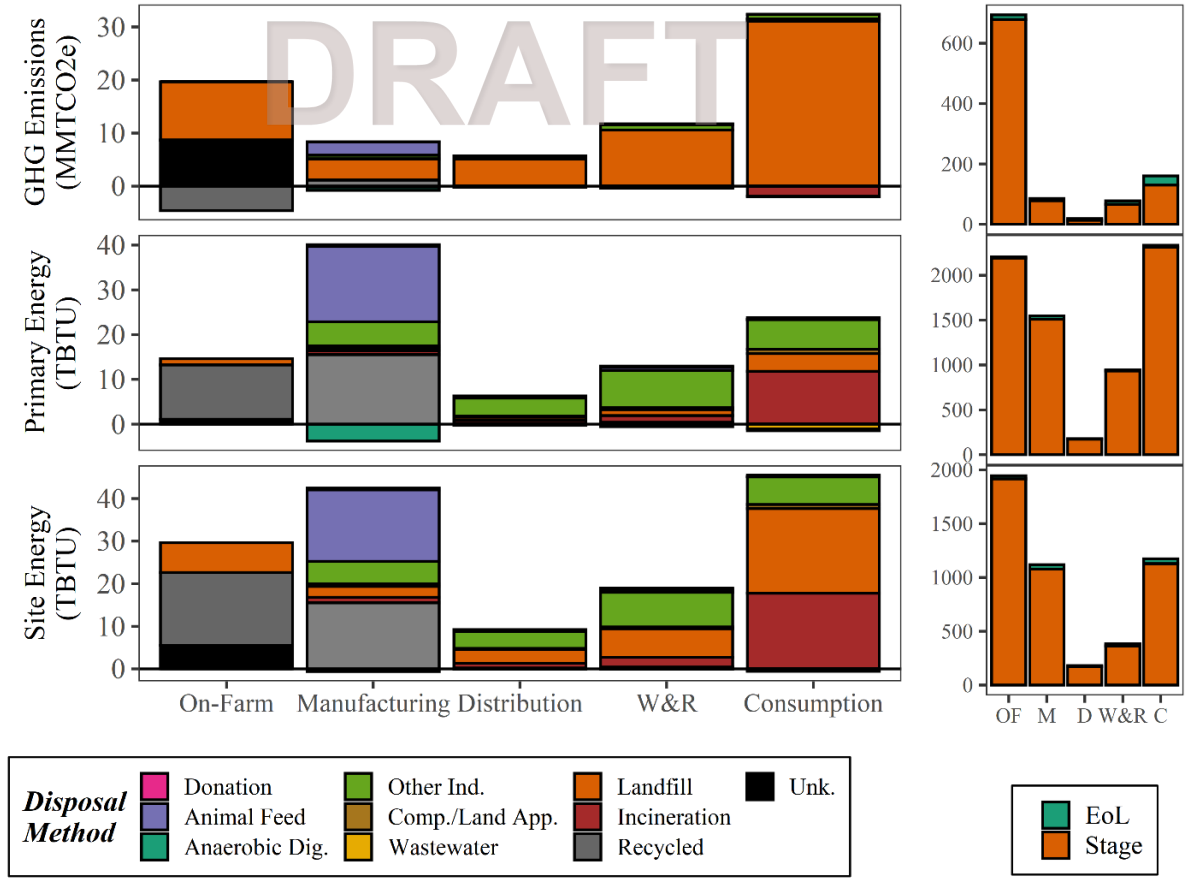
Energy & GHG of FLW

- Disposing of waste also takes energy & emits GHGs
- Reducing FLW can
  - Reduce energy need / GHG emissions of FLW management
  - Increase food availability / decrease food production need
  - Reduce energy need / GHG emissions of FSC



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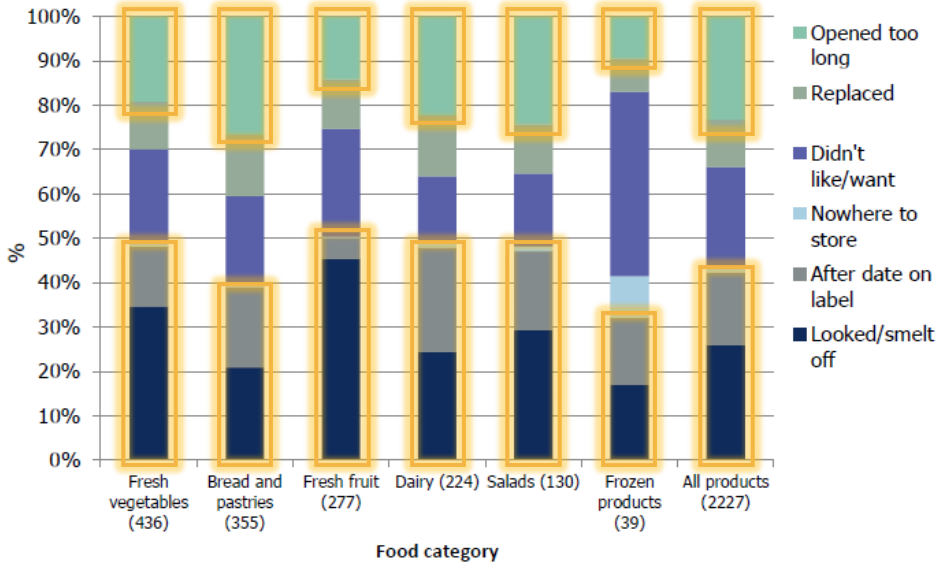
Why is household food wasted? Someone thought it went bad

- Food diary research
- Food "went bad" is one of the major causes of food being thrown out
  - Opened too long
  - Label Date
  - Looked/smelt off
  - Bought too much



Lyndhurst, B. (2011) Determining consumer understanding and use of date labels and storage guidance in order to reduce household food waste.

Table 2
Main reasons for food waste in the green and blue groups, how often waste occurs and the total amount of waste per week. The blue group displays a higher number for all of the three 'prepared too much'-reasons. The total amount of food waste from both groups during the week amounted to 104 kg.

Reasons for waste from storage	Green group		Blue group	
	Number	Amount (kg)	Number	Amount (kg)
Food item gone bad	126	19	108	24
Passed "Best before date"	20	3.6	30	7.9
Packaging (too big, difficult to empty)	63	6.8	30	3.1
Bought too much	8	1.7	4	1.3
Reasons for waste from meals				
Prepared too much (not possible to save leftovers)	26	2.6	52	6.2
Prepared too much (do not want to save leftovers)	17	2.2	37	5.3
Prepared too much (was full, didn't taste well)	21	1.5	30	2.4
Saved leftovers not used in time	17	2.3	20	2.3
Children did not want to finish meal	56	2.6	38	3.4
Mistakes, other	10	0.9	12	0.6

Williams, H., Wikstrom, F., Otterbring, T., Lofgren, M., Gustafsson, A. (2012). Reasons for household food waste with special attention to packaging

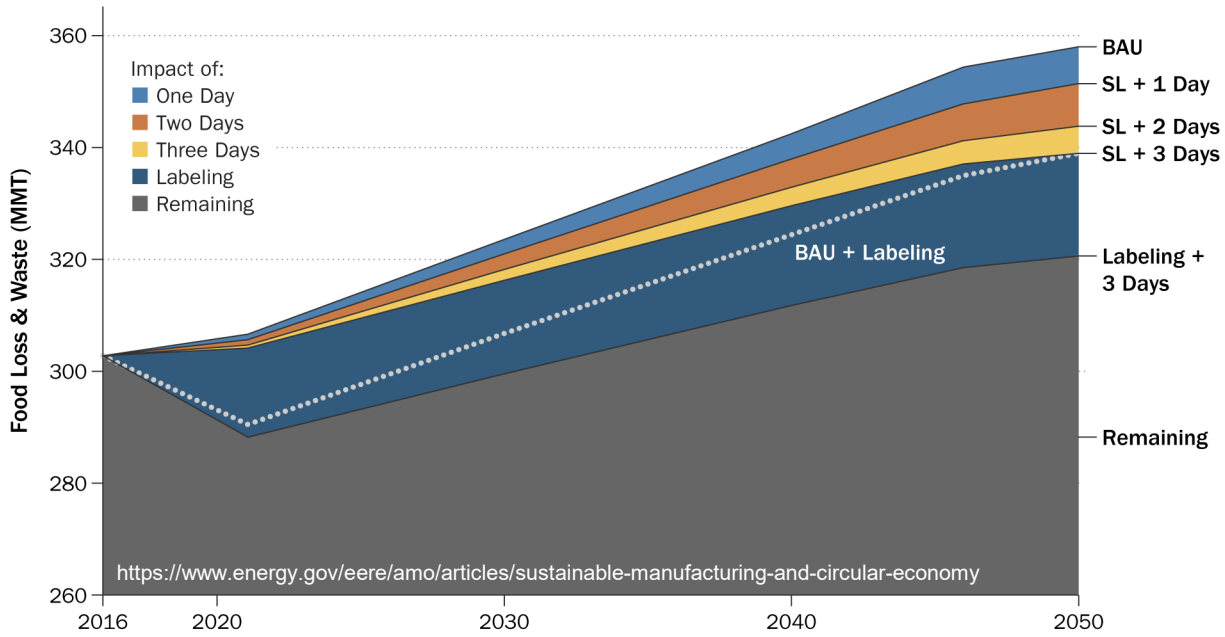
Table 6
Percentage of articles for which the respective reasons could be observed (% of the net mass of the food loss per assortment group), multiple reasons were possible.

Reason	Fruit & vegetables (%)	Dairy products (%)	Bread & pastry (%)	Others/unspecified (%)	∑ All assortment groups (%)
No apparent reason	1	1	2	3	1
Best before/use-by/sell-by date	18	78	98	57	34
Apparent flaws of the product	89	0	3	34	67
Part of the product is lacking	4	0	0	1	3
Damaged packaging	7	3	0	2	5
Breakage	0	18	0	9	3

Lebesorger, S., Schneider, F., (2014) Food loss rates at the food retail, influencing factors and reasons as a basis for waste prevention measures

Role of Packaging

- Food is packaged to protect it against the environment, **<u>extend its shelf life</u>**, guaranty quality, improve safety, and provide easy handling, storage, and transportation
- Common materials: plastics (mostly PP and PET), glass, metal, and paper → all considered part of Energy Intensive sectors!
- Improved labeling & extending shelf-life (agnostic of method) can have a profound impact on food waste generation



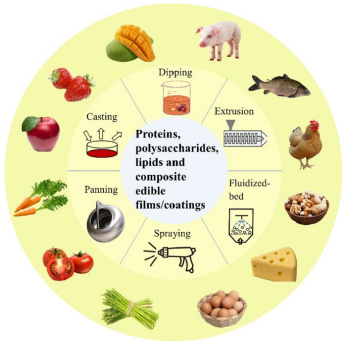
Types of Food Packaging

- Passive Packaging:
  - Puts product in sealed environment, can be optimized environment for increased life
  - Maybe be no/less new packaging added, but may require more processing
- Active Packaging:
  - Continues controlling packaging environment AFTER left facility (absorbers, scrubbers, emitters, temperature control, anti-microbial)
  - Current research focuses on expanding MAP, better emitters/scrubbers, active CO2, Intelligent Packaging (tells consumer if there is an issue with food)
  - Usually adds things that need to be made and thrown away, plus may need more processing
- Edible Coating:
  - Nothing to throw away
  - New research emphasizing use of waste materials
  - Requires additional processing to apply coating

https://commons.wikimedia.org/wiki/File:Kellogg_Company._Women_Inspecting_Filled_Boxes_of_Cereal_before_Boxes_Go_to_Sealer_(3903229587).jpg

https://link.springer.com/article/10.1007/s43555-023-00004-6

https://www.bluebite.com/packaging-labels/smart-packaging



https://link.springer.com/article/10.1007/s11483-023-09794-7

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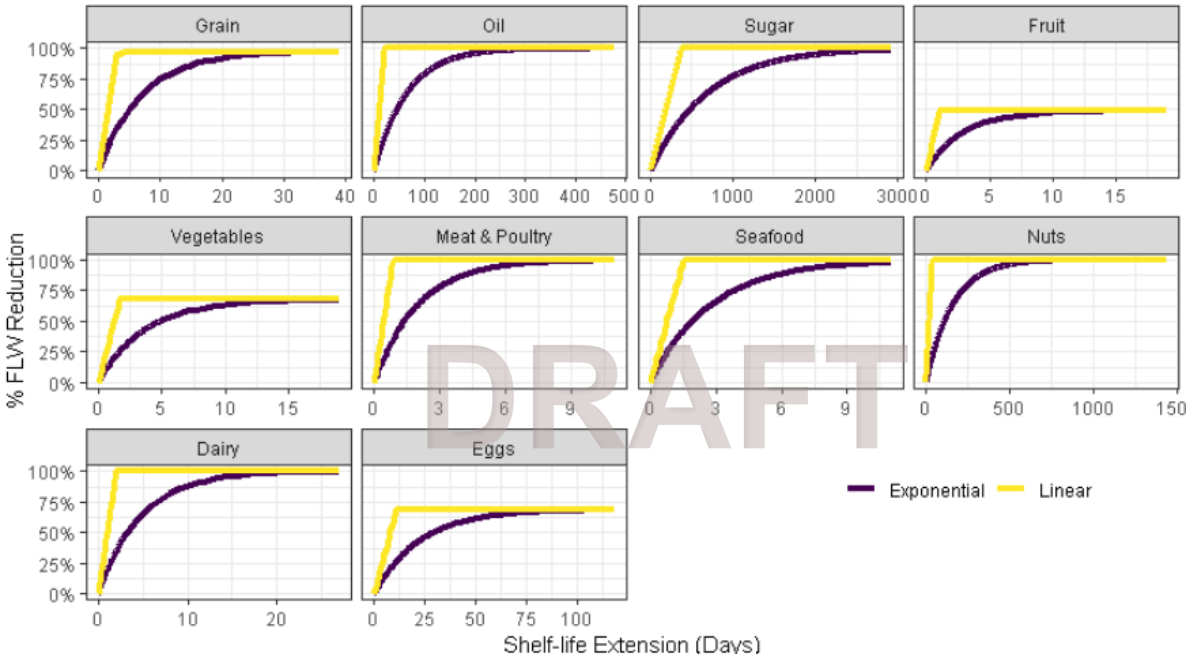
IEDO StA / ORNL / UT-K Analysis

- Calculation methodology for impacts of shelf-life increase
  - Understanding how much food could be wasted due to spoilage
  - Conversion of "shelf-life increase" to "% FLW Reduction"
  - "Trickle Up" Impact

	FLW (MMT)	% Perishable	%FLW Reduction with shelf-life extension 1-Day	2-Day	50-Day
Grain	7.88	100%	13 - 31%	25 - 63%	100%
Oil	1.28	0%	2 - 5%	3 - 9%	55 - 100%
Sugar	3.1	0%	0%	0 - 1%	7 - 13%
Fruit	9.13	44 - 51%	15 - 48%	25 - 49%	49 - 49%
Vegetables	12.79	49%	16 - 40%	29 - 68%	68 - 68%
Meat & Poultry	5.51	100%	40 - 100%	64 - 100%	100%
Seafood	0.68	0%	30 - 65%	51 - 100%	100%
Nuts	0.16	0%	1 - 3%	1 - 5%	28 - 100%
Dairy	6.91	68 - 84%	19 - 50%	35 - 100%	100%
Eggs	1.97	0 - 66%	3 - 6%	6 - 13%	61 - 69%



Around **28 to 31 MMT** of edible food was thrown out of **households** in **2016**, likely due to spoiling or perceived spoiling.

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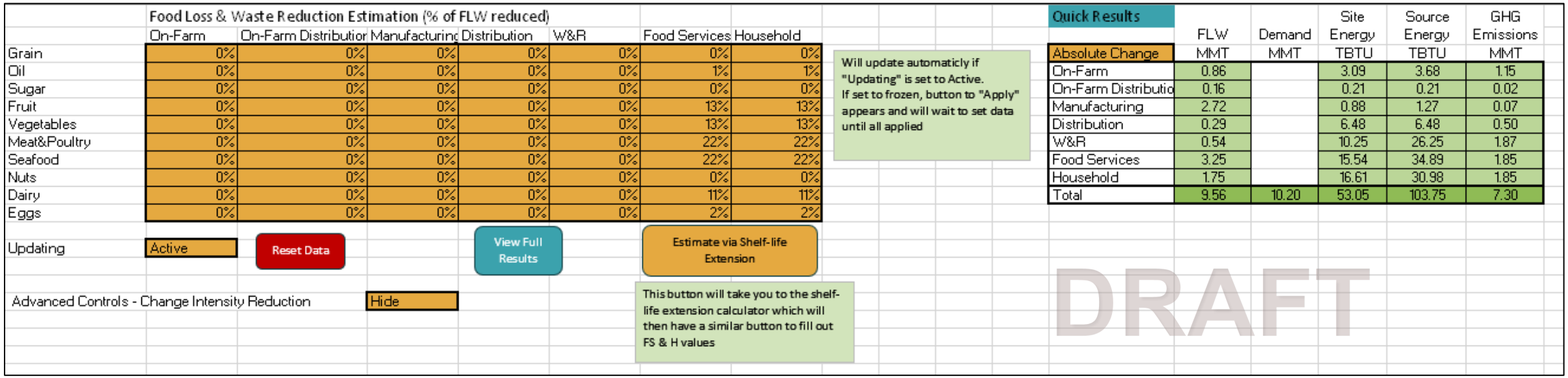


Food Loss & Waste Reduction Estimation (% of FLW reduced)

	On-Farm	On-Farm Distributior	Manufacturing	Distribution	W&R	Food Services	Household
Grain	0%	0%	0%	0%	0%	0%	0%
Oil	0%	0%	0%	0%	0%	1%	1%
Sugar	0%	0%	0%	0%	0%	0%	0%
Fruit	0%	0%	0%	0%	0%	13%	13%
Vegetables	0%	0%	0%	0%	0%	13%	13%
Meat&Poultry	0%	0%	0%	0%	0%	22%	22%
Seafood	0%	0%	0%	0%	0%	22%	22%
Nuts	0%	0%	0%	0%	0%	0%	0%
Dairy	0%	0%	0%	0%	0%	11%	11%
Eggs	0%	0%	0%	0%	0%	2%	2%

Updating: Active

Reset Data

View Full Results

Estimate via Shelf-life Extension

Advanced Controls - Change Intensity Reduction: Hide

Will update automaticly if "Updating" is set to Active. If set to frozen, button to "Apply" appears and will wait to set data until all applied

This button will take you to the shelf-life extension calculator which will then have a similar button to fill out FS & H values

Quick Results

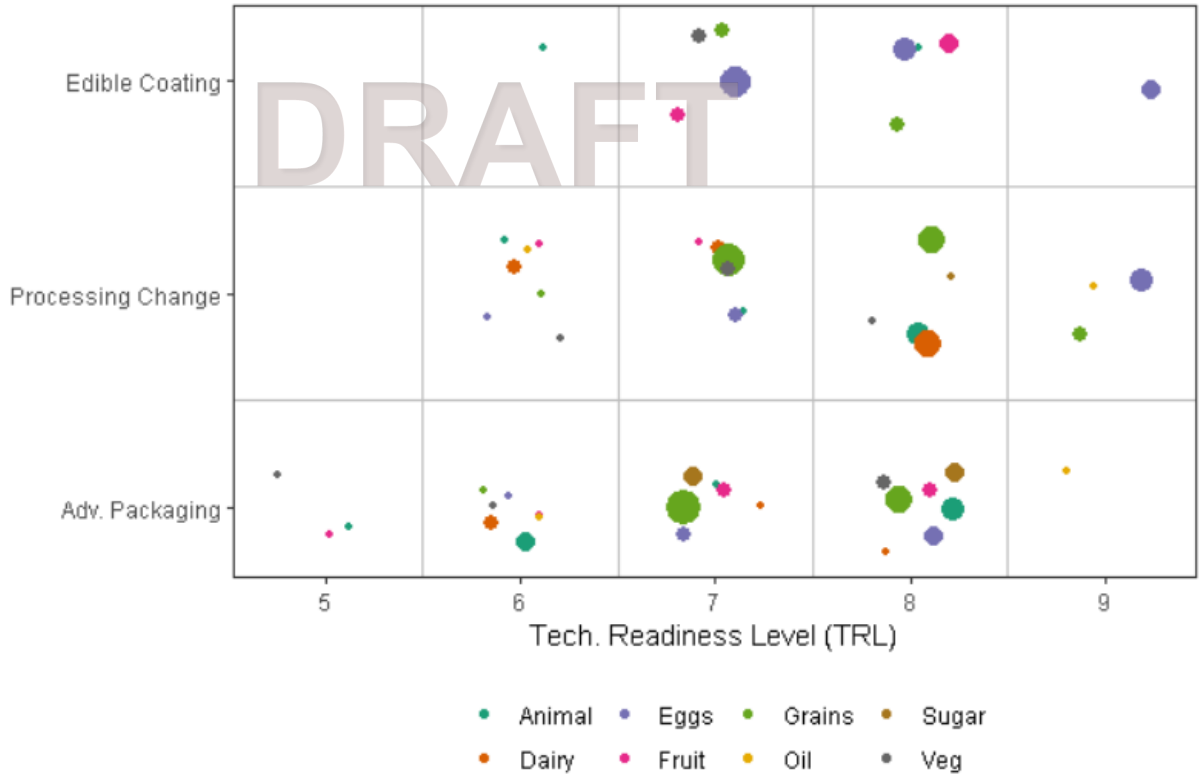
Absolute Change	FLW MMT	Demand MMT	Site Energy TBTU	Source Energy TBTU	GHG Emissions MMT
On-Farm	0.86		3.09	3.68	1.15
On-Farm Distributio	0.16		0.21	0.21	0.02
Manufacturing	2.72		0.88	1.27	0.07
Distribution	0.29		6.48	6.48	0.50
W&R	0.54		10.25	26.25	1.87
Food Services	3.25		15.54	34.89	1.85
Household	1.75		16.61	30.98	1.85
Total	9.56	10.20	53.05	103.75	7.30

DRAFT

ORNL/UT-K has developed a calculator where users can enter data regarding shelf-life extension for different food commodities and receive estimations on %FLW, food demand (yield), energy, and GHG emission reductions

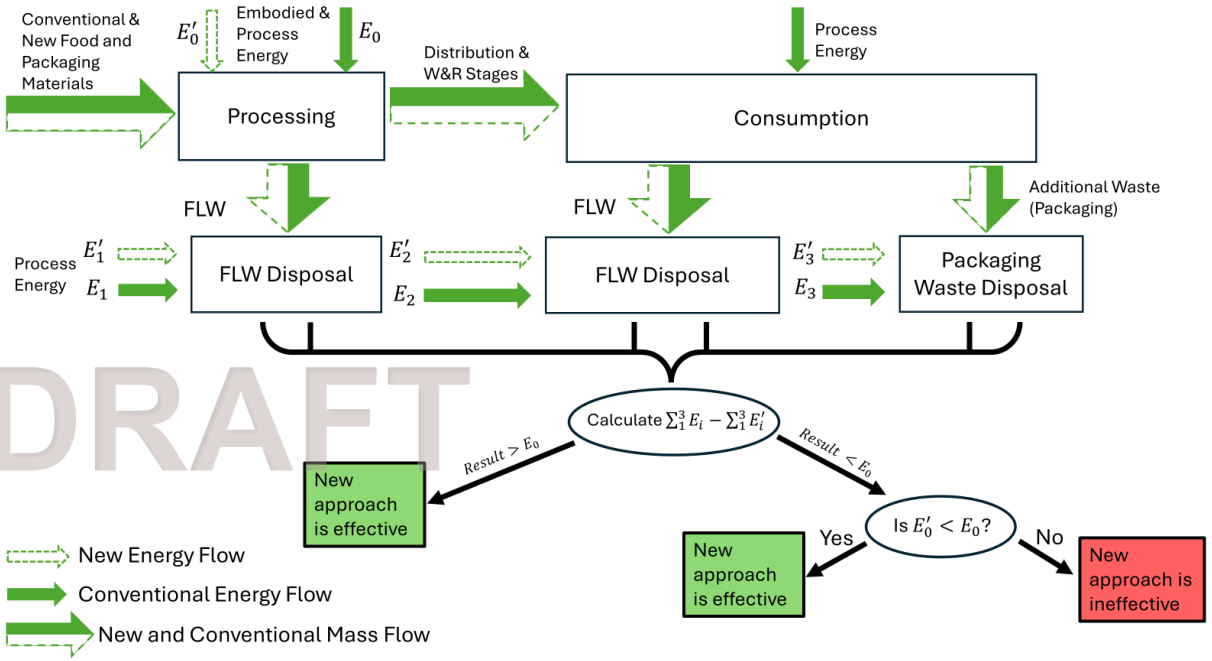
IEDO StA / ORNL / UT-K Analysis

- Literature review of studies between 2015 – 2023 regarding food packaging to increase shelf-life
  - Some studies date 2007 – 2014 to find higher TRL
  - High focus on grains, dairy, eggs, several high TRL options
  - Many potential packaging options in TRL 6 – 7
  - Advanced options (TRL 9) are more processing; Low TRL are more packaging



IEDO StA / ORNL / UT-K Analysis

- Quantifying impact of packaging: What needs to be understood when you analyze a new food packaging technology/ process?
- Utilizing LCA methodology on larger system <u>boundary</u>
  - Include impacts of packaging AND changes to FSC
  - Introducing to Food scientists
- Constraints on LCA of food packaging:
  - Clear description of new materials required
  - New materials without LCI
  - No clear impact on shelf-life



Assessment criteria (satisfy any of these two):
- Save more energy than it consumed
- Cost less energy than conventional tech

Recommendations

- Promotion of mid-range TRL packaging options
- When exploring new packaging options –
  - Introduce LCA to food scientists / packaging studies
  - Clear impacts on shelf-life extension are useful to LCA studies
  - Expand system boundaries to include BOTH impact on FSC and of packaging
  - Understand the changes to processing and new materials introduced
  - Better LCA data for new materials

Questions?

If you have additional questions, please email me at armstrongko@ornl.gov