

# Food Waste Prevalence and Management Considerations in School Environments: Elementary to Collegiate

## Presenters:

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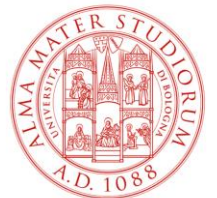
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Fabio De Menna, Ph.D., Junior Assistant Professor, UNIBO

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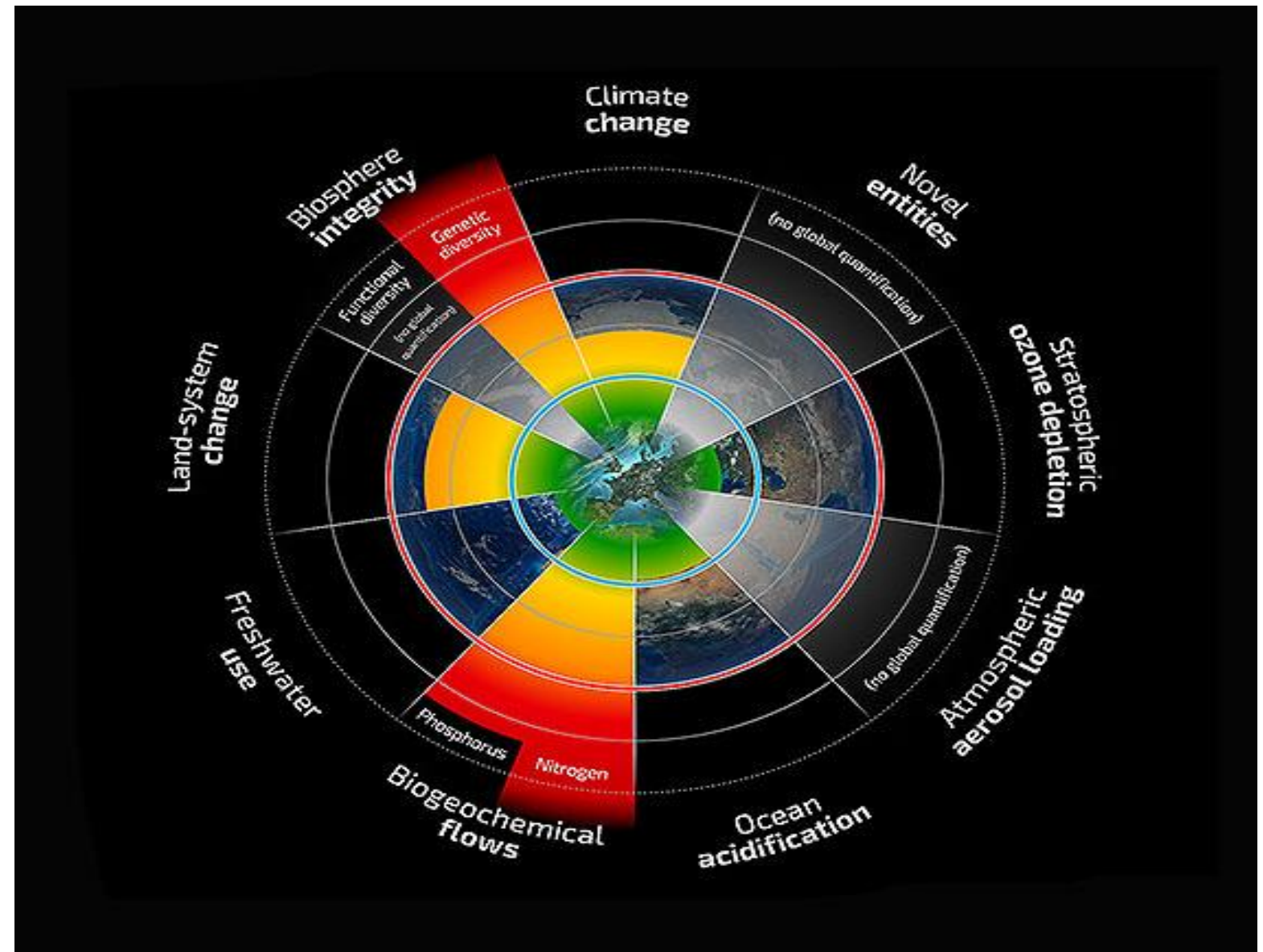
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UNIVERSITÀ DI BOLOGNA

# Overview of topics for today:

- Environmental impacts of agriculture and food production
- Mizzou – Campus Dining Waste Audit
- Elementary School Waste Audits:
  - Italian Elementary School Study, UNIBO
  - Columbia Public School Study, UNIBO & MU

Agriculture is the leading cause of disruption to nitrogen and phosphorous cycles and loss of biodiversity.

Agriculture and food production also contribute to greenhouse gas emissions and, thus climate change.



Steffen et al. 2015. **Planetary boundaries: Guiding human development on a changing planet.** *Science*. 10.1126/science.1259855

# Significant Fraction of Agricultural Production is Wasted

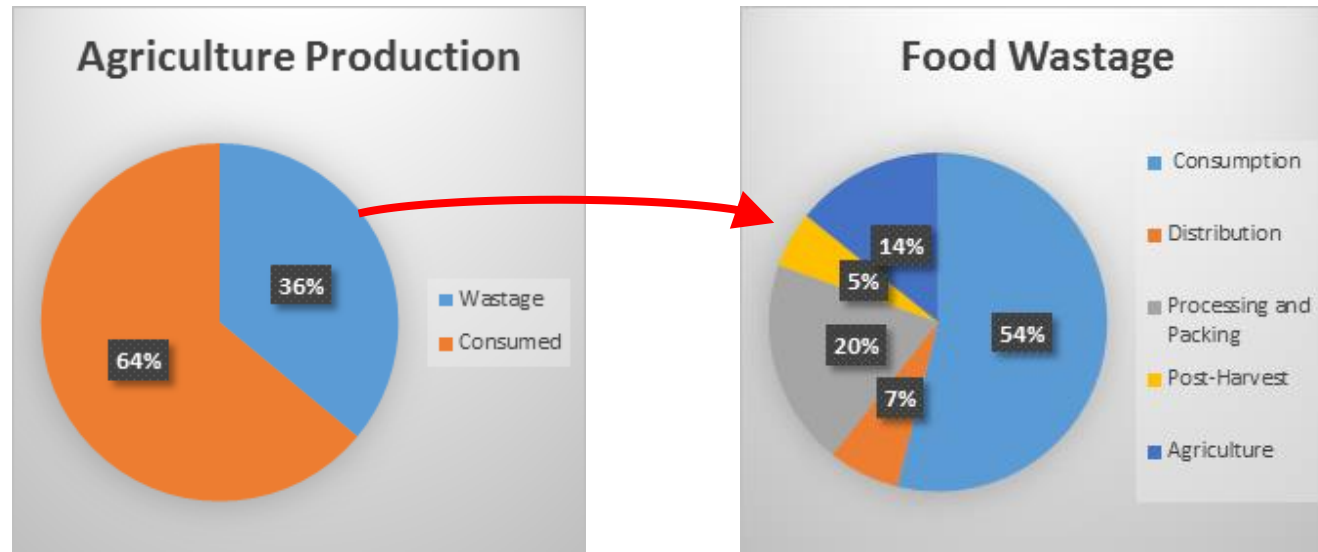
Food and Agriculture Organization (FAO) of United Nations Generates Estimates of Agriculture Production and Use\*

Recent FAO data suggest over one-third of production in North America is wasted

FAO data estimate fraction of waste that occurs at each phase of supply chain

- But data do not indicate how much was “unavoidable”

Beyond loss of food, we might view this waste as responsible for squandered upstream resources, and unnecessary environmental damage

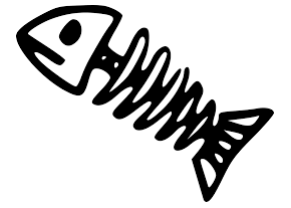


\* <http://www.fao.org/economic/ess/ess-publications/ess-yearbook/en/>

# Food Waste is more than a Waste Management Issue

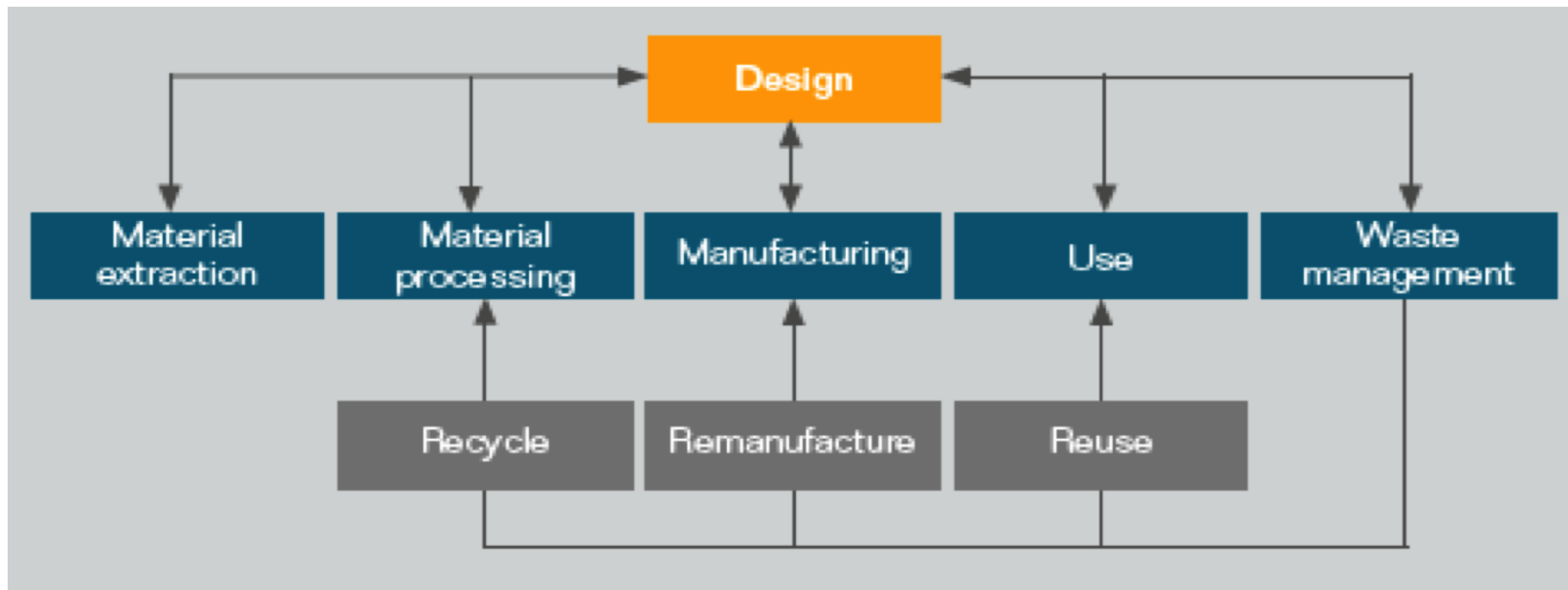
- **Air pollution:** Greenhouse gas emissions directly from agricultural activities are estimated to constitute about 9% of U.S. (EPA). Upwards of 20% for food products.
- **Water pollution:** Nutrient pollution of waterbodies → algal blooms (eutrophication) and depleted oxygen in waterbodies → death of wildlife.
- **Land availability:** Cropland covers over 50% of the land area occupied in the MO/MS River Basin, which reduces land available for other wildlife.
- **Human and animal health:** Pesticides, herbicides and fungicides are applied and migrate to water and soil posing risks to wildlife and humans.
- **Ethical:** Globally, one in nine people in the world today (815 million) are undernourished (UN, zero hunger target). Is food waste ethical?
- **Money:** when we waste food, we waste all money invested to get them, plus money to treat them. Globally estimated at USD 2.6 trillion.

**When we waste food we are causing a considerable set of disturbances for, effectively, no reason.**

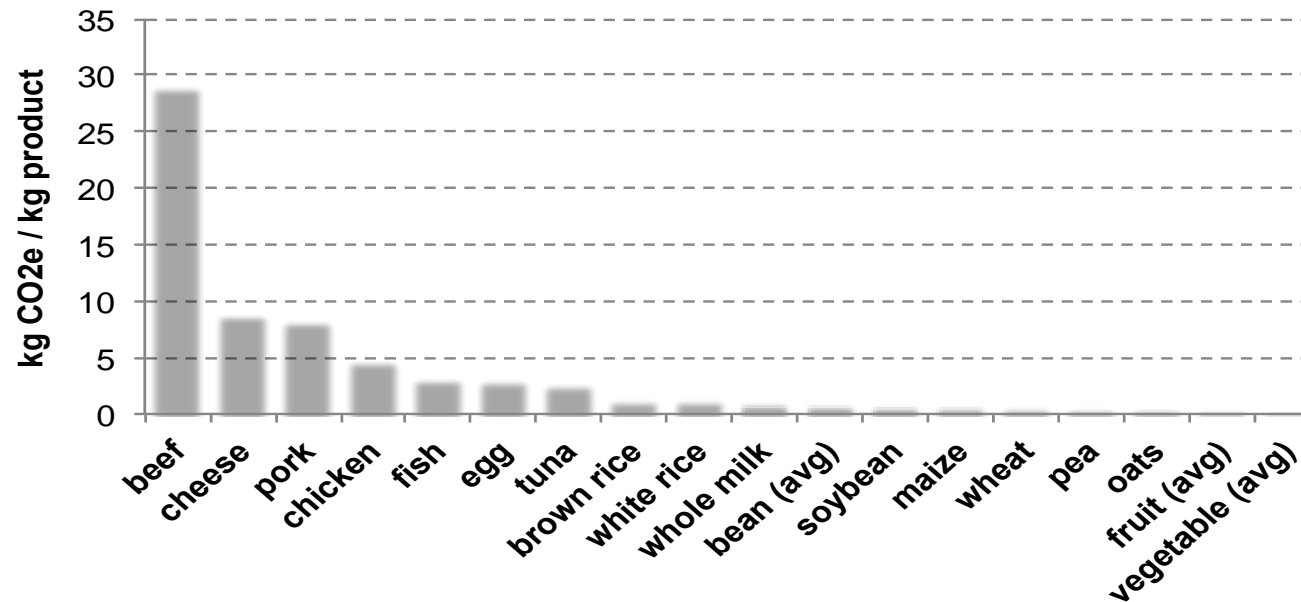


# How can we account for these upstream impacts?

**Life Cycle Assessment:** Analysis of the environmental consequences of an activity or product throughout its life cycle from raw material acquisition through production, use, end-of-life treatment, recycling and final disposal.



# Life Cycle Greenhouse Gas Emissions by Food Type



González, AD., B. Frostell and A. Carlsson-Kanyama. 2011. Protein efficiency per unit energy and per unit greenhouse gas emissions: Potential contribution of diet choices to climate change mitigation. *Food Policy*. 36:562-570.

GHG estimates include: farm operations, fertilizer manufacturing, and transport to a port.

Estimates do not include food manufacturing, transportation (between food manufacturers, warehouses, retail outlets, consumer trip to store), cooking, etc.

# Mizzou – Campus Dining Waste Audit

C. Costello, R.G. McGarvey, and E. Birisci

# Campus Dining Food Waste Study Overview

- Full collaboration with CDS, access to their food purchasing inventory software (CBORD).
- Four dining halls were evaluated.
- Audit occurred February 17 to May 16, 2014.
  - Pre-consumer, 2 phases:
    - Total weight and qualitative description of contents collected for 48 days.
    - Detailed inventory done on 8 days sorted food waste into: grains, fruits & vegetables, meat and protein and dairy (edible & inedible).
  - Post-consumer:
    - Collected 100 customer's plate waste each time.
    - 42 days: 21 lunches, 16 dinners, 5 breakfast.
    - Sorted waste into: beef, poultry, pork, dairy, eggs, fish, grains, fruits, and vegetables (edible & inedible).



Pre-consumer food waste from one dining hall on one day.



Undergraduate students sorting post-consumer food waste.  
Photo by Nick Brenner. <http://mizzoumag.missouri.edu/2014/08/greener-garbage/>

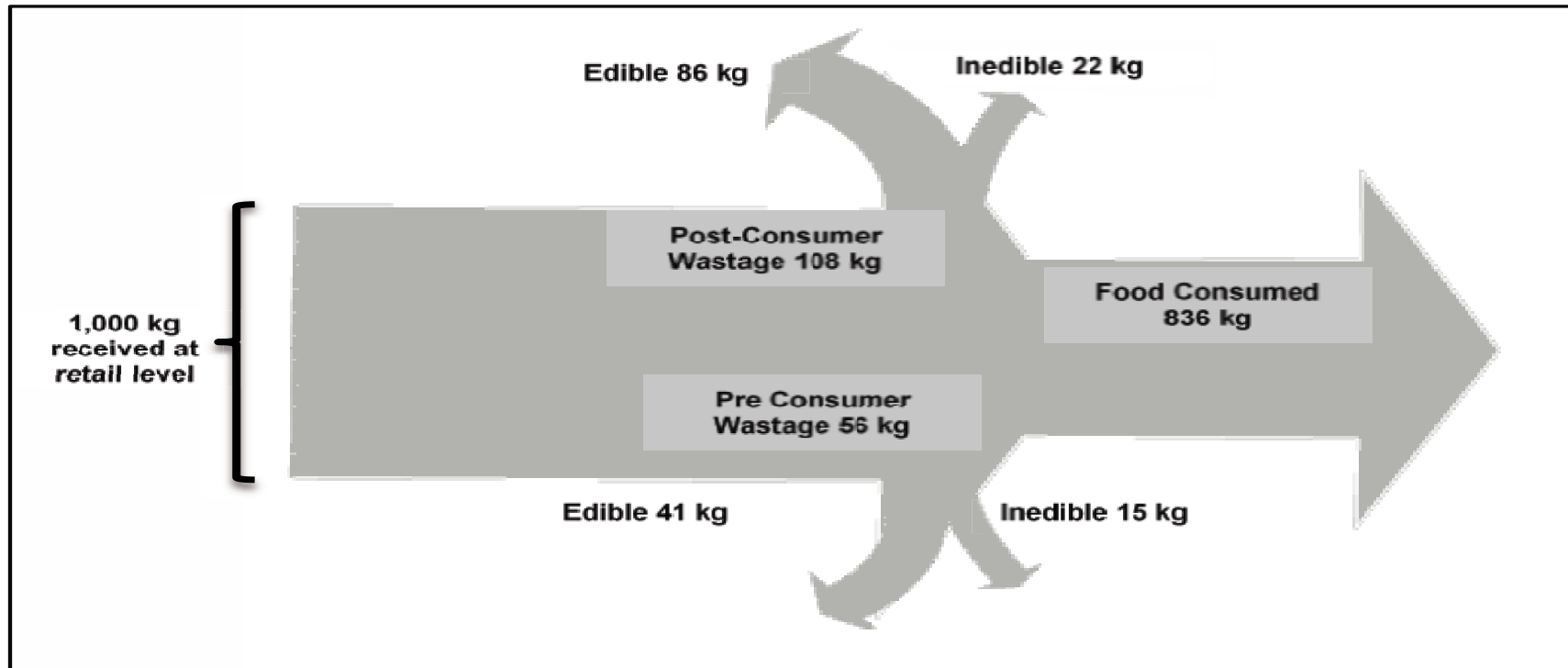
**Food Materials** Sort the material into the primary ingredients, by edible and inedible, and weigh each:

| Category    | Edible (g) | Inedible (g) | Description of Organic Material |
|-------------|------------|--------------|---------------------------------|
| Grains      |            |              |                                 |
| Beef        |            |              |                                 |
| Other meats |            |              |                                 |
| Dairy       |            |              |                                 |
| Fruit       |            |              |                                 |
| Vegetables  |            |              |                                 |
| Other       |            |              |                                 |
| Other       |            |              |                                 |

# Results

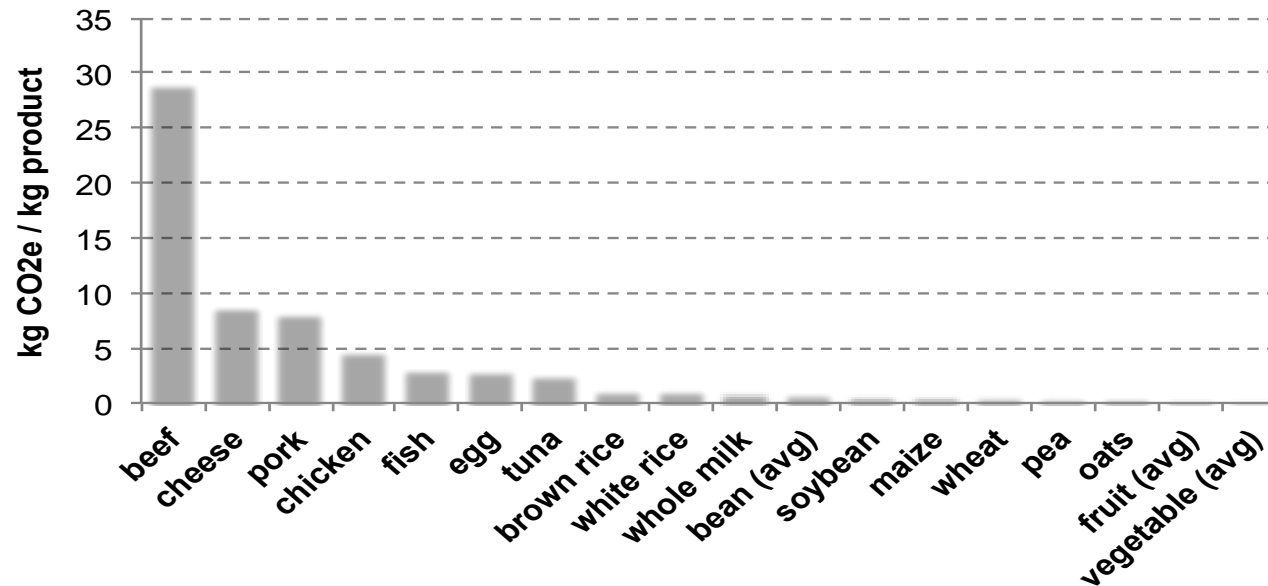
|                   | Customers served |                |                |                | Kg food served |                |               |                |
|-------------------|------------------|----------------|----------------|----------------|----------------|----------------|---------------|----------------|
|                   | Breakfast        | Lunch          | Dinner         | Total          | Breakfast      | Lunch          | Dinner        | Total          |
| <b>Rollins</b>    | 30,349           | 66,092         | 27,444         | <b>123,885</b> | 10,250         | 30,000         | 13,750        | <b>54,000</b>  |
| <b>Dobbs</b>      | 21,134           | 72,836         | 61,383         | <b>155,353</b> | 7,320          | 32,460         | 30,730        | <b>70,500</b>  |
| <b>Mark Twain</b> | 5,851            | 31,038         | 23,259         | <b>60,148</b>  | 2,350          | 8,840          | 7,500         | <b>18,700</b>  |
| <b>Plaza</b>      | 47,128           | 82,553         | 92,701         | <b>222,382</b> | 5,520          | 38,060         | 45,570        | <b>89,200</b>  |
| <b>TOTAL</b>      | <b>104,462</b>   | <b>252,519</b> | <b>204,787</b> | <b>561,768</b> | <b>25,450</b>  | <b>109,370</b> | <b>97,560</b> | <b>232,400</b> |

16.4% of food  
is lost or  
waste.  
12.7% is  
edible.



Costello, C., E. Birisci & R. McGarvey. (in press). 2015. Food Waste in Campus Dining Operations: Inventory of Pre- and Post-Consumer Mass by Food Category, and Estimation of Embodied Greenhouse Gas Emissions. *Renewable Agriculture and Food Systems*

# Life Cycle Greenhouse Gas Emissions by Food Type

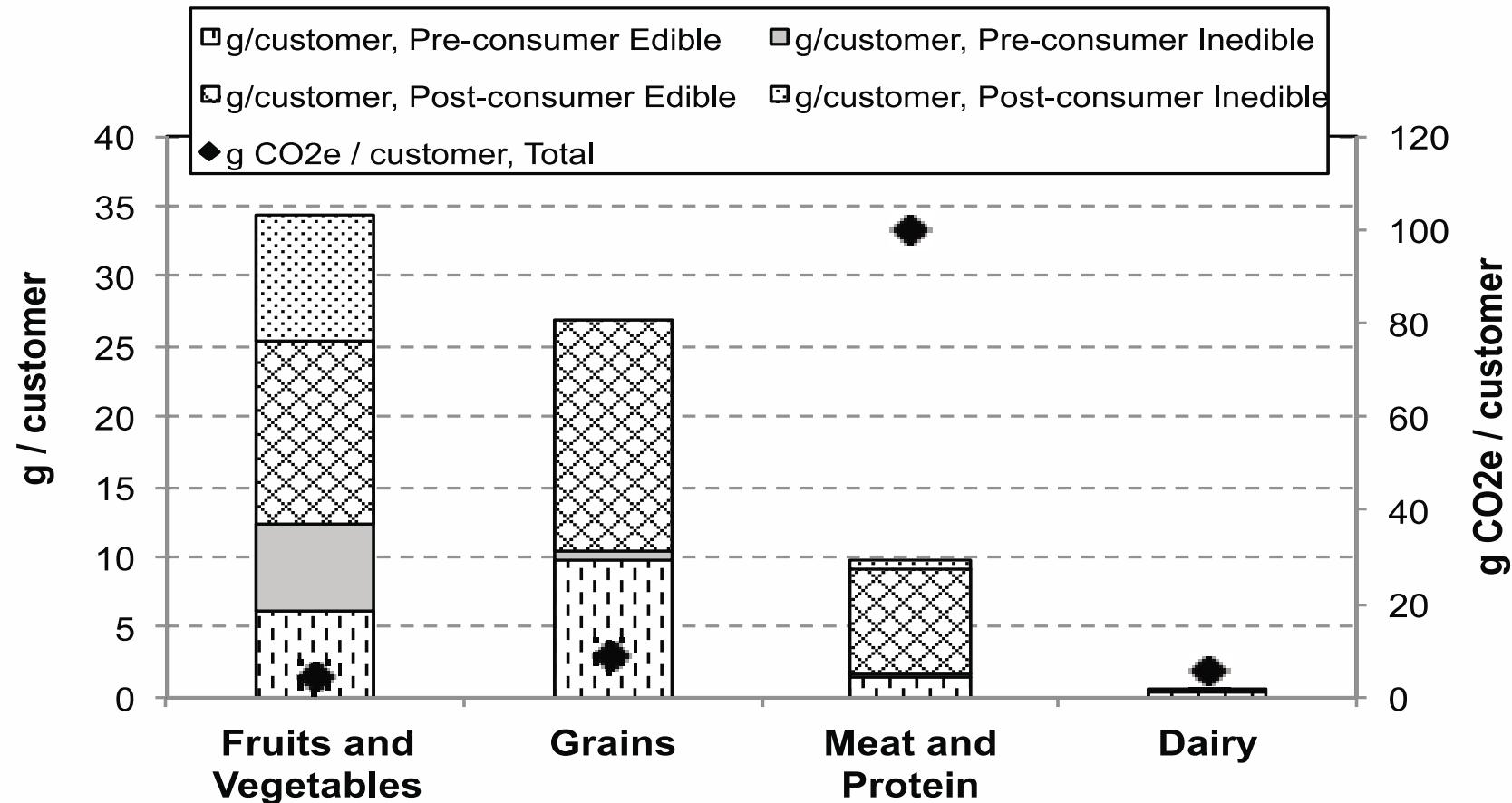


González, AD., B. Frostell and A. Carlsson-Kanyama. 2011. Protein efficiency per unit energy and per unit greenhouse gas emissions: Potential contribution of diet choices to climate change mitigation. *Food Policy*. 36:562-570.

GHG estimates include: farm operations, fertilizer manufacturing, and transport to a port.

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# Mass vs. embodied GHGs in Mizzou CDS food waste



**Focusing on weight versus full, life cycle GHG cost results in a different decision-making strategy.**

# Concluding thoughts

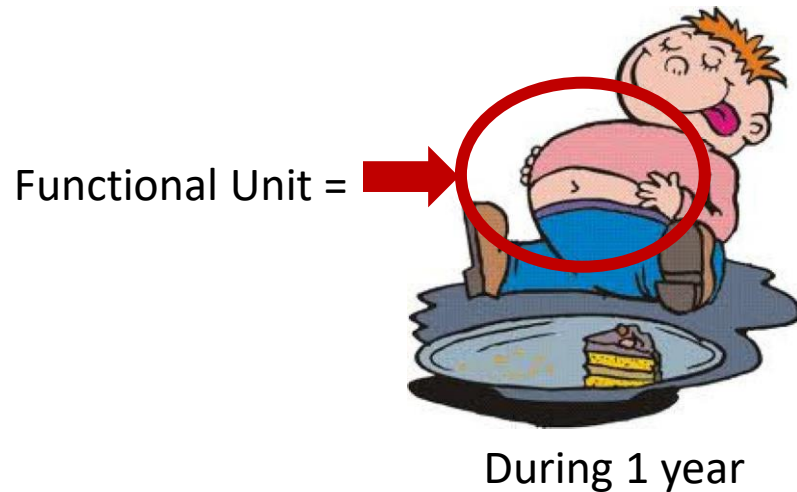
- If the concern is limited to the cost of disposal, then fruits, vegetable and grains are the target categories.
  - Keeping in mind that about 50% of the fruit and vegetable waste is likely to be irreducible as it is “inedible.”
- If the goal is to reduce overall environmental impact, where GHGs are the proxy, then managers should strategize to reduce plate waste from animal-based foods.
  - These are often behavior- or culturally-based solutions; which are more complex to implement than a waste management technology.

# Italian Cafeteria Study: Elementary School, Cento, Italy

L. García-Herrero, F. DeManna, M. Vittuari

# Goal and scope

To assess the environmental and economic impact of a meal eaten at school canteen. A mix of methods such as LCA, LCC and visual assessment was utilized.

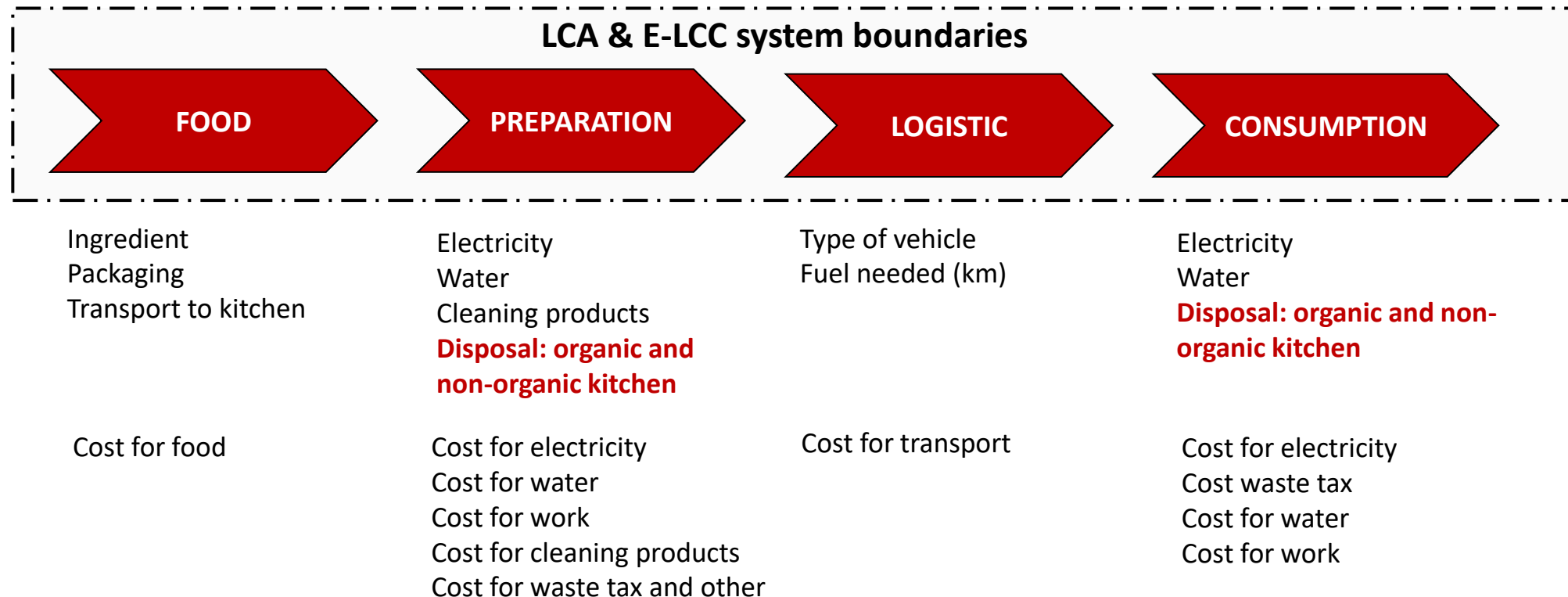


(\*) Weighted average based on frequency of daily winter and summer menu and amount of students.

# Goal and scope

## School canteen description and system boundaries:









- 18 public school canteens of Cento (Italy) in 2017-2018. Nursery and elementary school (3-10 years old).
- Catering service preparing more than 1270 meals per day, considering for this research the **233836** meals per year: specific composition, origin, and weight.



# Food waste – visual assessment

Preparation waste – catering service

Plate and serving waste – field work to schools

|  |   |   |   |   |  |   |   |   |  |  |  |                      |  |                      |  |                      |  |
|--|---|---|---|---|--|---|---|---|--|--|--|----------------------|--|----------------------|--|----------------------|--|
| Select the day   |   | Number of students  |   | Room number   |  | Turn  |   |   |  |  |  |                      |  |                      |  |                      |  |
| <table border="1"> <tr> <td>M</td><td>T</td><td>W</td><td>T</td><td>F</td> </tr> <tr> <td></td><td></td><td></td><td></td><td></td> </tr> </table> |   | M   | T   | W   | T  | F   |   |   |  |  |  | <input type="text"/> |  | <input type="text"/> |  | <input type="text"/> |  |
| M  | T   | W   | T   | F   |  |   |   |   |  |  |  |                      |  |                      |  |                      |  |
|  |   |   |   |   |  |   |   |   |  |  |  |                      |  |                      |  |                      |  |
|  | CLEAN DISH  | ALMOST CLEAN DISH   | ATE $\frac{3}{4}$   | ATE $\frac{1}{2}$   | ATE $\frac{1}{4}$  | JUST A BITE   | NO TASTE  | TRAY  |  |  |  |                      |  |                      |  |                      |  |
|  |  |  |  |  |  |  |  |  |  |  |  |                      |  |                      |  |                      |  |
| FIRST COURSE   | <input type="text"/>  | <input type="text"/>  | <input type="text"/>  | <input type="text"/>  | <input type="text"/>   | <input type="text"/>  | <input type="text"/>  | <input type="text"/>  |  |  |  |                      |  |                      |  |                      |  |
| SECOND COURSE  | <input type="text"/>  | <input type="text"/>  | <input type="text"/>  | <input type="text"/>  | <input type="text"/>   | <input type="text"/>  | <input type="text"/>  | <input type="text"/>  |  |  |  |                      |  |                      |  |                      |  |
| SIDE DISH  | <input type="text"/>  | <input type="text"/>  | <input type="text"/>  | <input type="text"/>  | <input type="text"/>   | <input type="text"/>  | <input type="text"/>  | <input type="text"/>  |  |  |  |                      |  |                      |  |                      |  |
| BREAD WASTED (Num. portion student's size)   |   | <input type="text"/>  |   |   |  |   |   |   |  |  |  |                      |  |                      |  |                      |  |
| ADDITIONAL RELEVANT INFORMATION  |   |   |   |   |  |   |   |   |  |  |  |                      |  |                      |  |                      |  |
| <div style="border: 1px solid black; height: 80px;"></div>   |   |   |   |   |  |   |   |   |  |  |  |                      |  |                      |  |                      |  |



One week data collection at the school canteen: winter menu and summer menu. Two different nursery and elementary schools. About 200 pupils addressed in each data collection, per day.

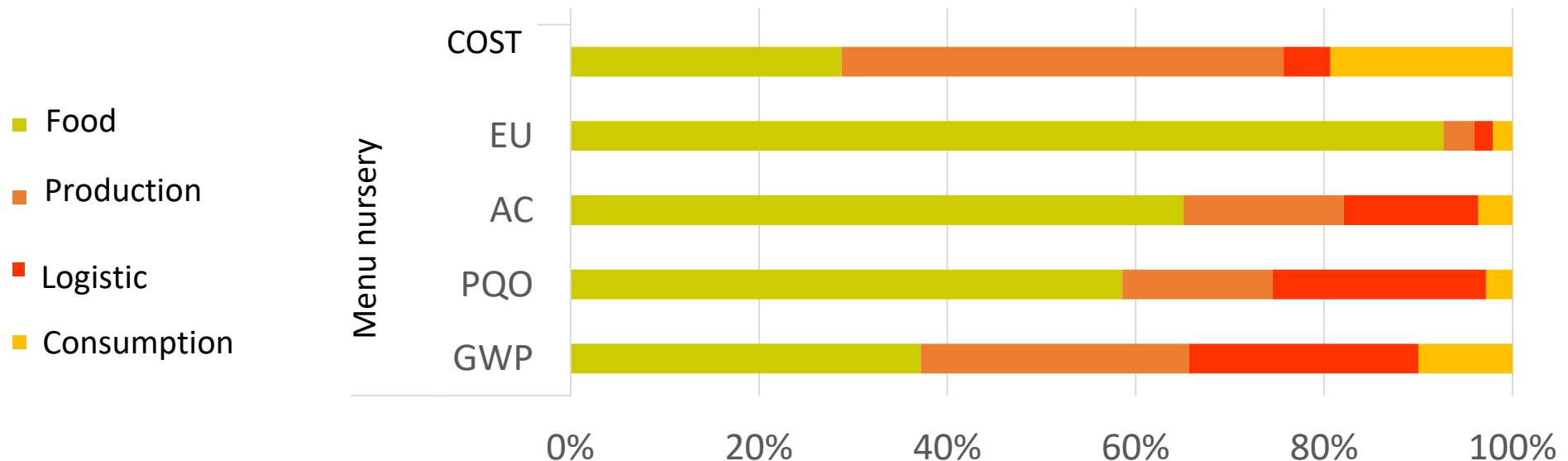
# LC impact assessment – results winter menu nursery school canteens

## Environmental impacts:

- Global warming
- Photochemical oxidation
- Acidification
- Eutrophication

| Environmental and costing impact |           |             |            |               |      |
|----------------------------------|-----------|-------------|------------|---------------|------|
|                                  | GWP       | PQO         | AC         | EU            | Cost |
|                                  | kg CO2 eq | kg C2H4 eq. | kg SO2 eq. | kg PO4 3- eq. | €    |
| Menu Nursery                     | 1,651     | 0,001       | 0,013      | 0,015         | 6,28 |

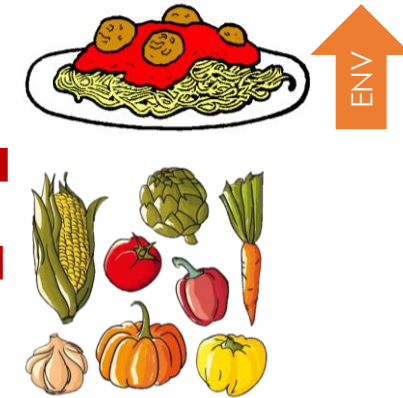
Results of each impact category in % from a meal eaten at the nursery school



# Food waste assessment results

Percentage of food waste per course in the school canteen

| Course    | Food waste per course (%) |
|-----------|---------------------------|
| First     | 11.65                     |
| Second    | 37.23                     |
| Side dish | 79.56                     |
| Bread     | 22.02                     |
| Fruit     | 28.08                     |



Global environmental and cost impact of the menu eaten and food waste

|               | GWP kg CO <sub>2</sub> eq | Cost (€) menu paid |
|---------------|---------------------------|--------------------|
| Food eaten    | 1.10                      | 4.17               |
| Food wasted   | 0.54                      | 2.10               |
| % waste/total | 32.86                     | 33.58              |

# Interpretation

Food: this phase has the biggest GWP, PQO, EU and AC impact.

Logistic: considering that schools are in about 5 km distance from the kitchen, the environmental impact is remarkable (more than 20% GWP).

- Timing
- Empty transportation

Preparation: it has the highest costing impact due to workforce involved, followed by the cost of energy consumption.

Consumption: food waste accounts for ap. 30% of GWP and 33% cost menu.

- Side dish: most wasted
- Second dish: biggest environmental and costing impact

# Plans for Columbia Public Schools

- Quantify and understand the environmental and economic impact of food waste at school canteens: Replicate and adapt the Italian case.
- Identify measures to reduce food waste.
- Identify policy interventions which can stimulate a better school canteen performance.
- Exchange best practices between COMO and Cento (Italy).

# Questions, Comments?

- Chris Costello [costelloc@missouri.edu](mailto:costelloc@missouri.edu)
- Laura García-Herrero [laura.garciaherrero@unibo.it](mailto:laura.garciaherrero@unibo.it)

# Memorial Stadium – Columbia, MO

71,168 seating capacity

West Stadium.  
Premium boxes.

Premium box trash  
chute.

East Stadium.  
Premium boxes.

Hearnes roll-offs (2)

Premium box  
trash chute.

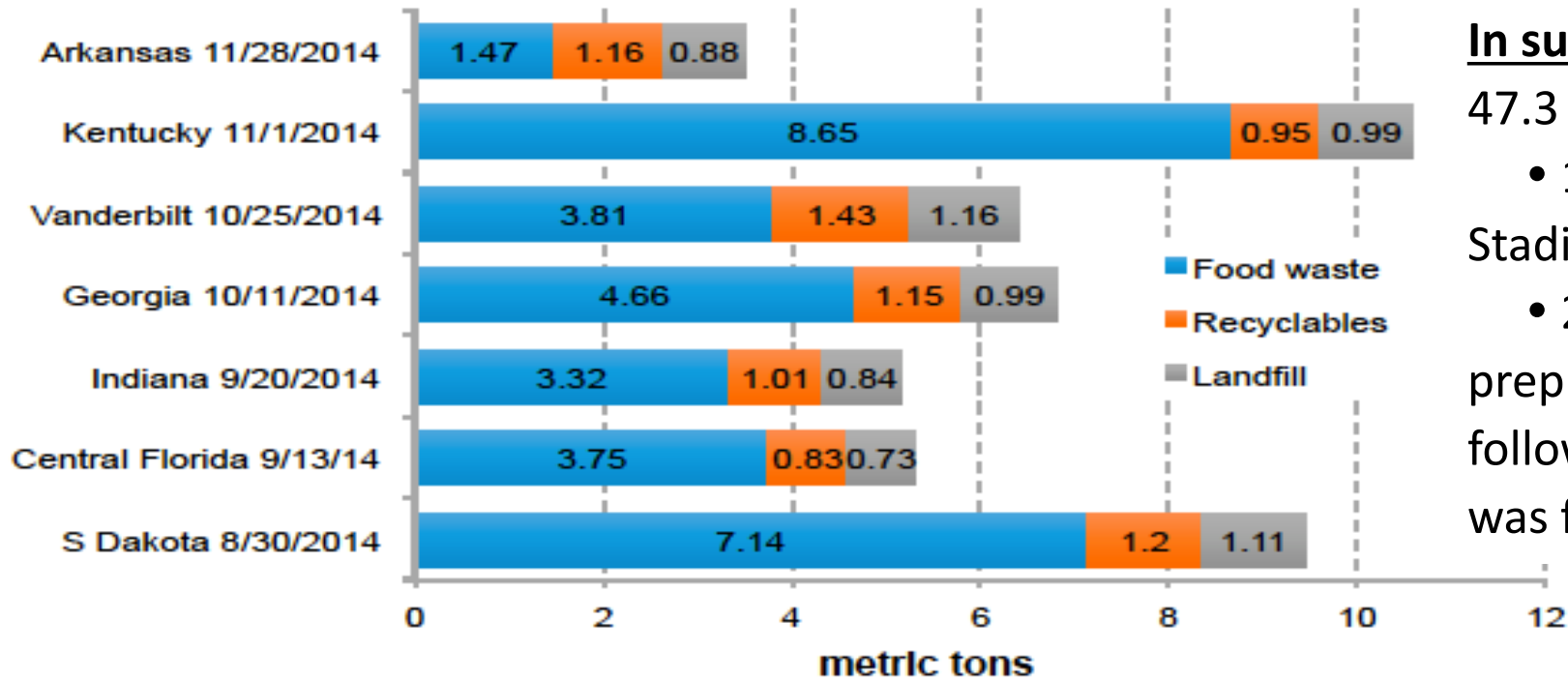
South Stadium,  
student tickets

Main roll-offs (4)



<http://www.dakdillonphotography.com/2012/an-overhead-view-of-mizzous-sec-kickoff/>

## High-level breakout of overall waste by major waste category.



### In summary:

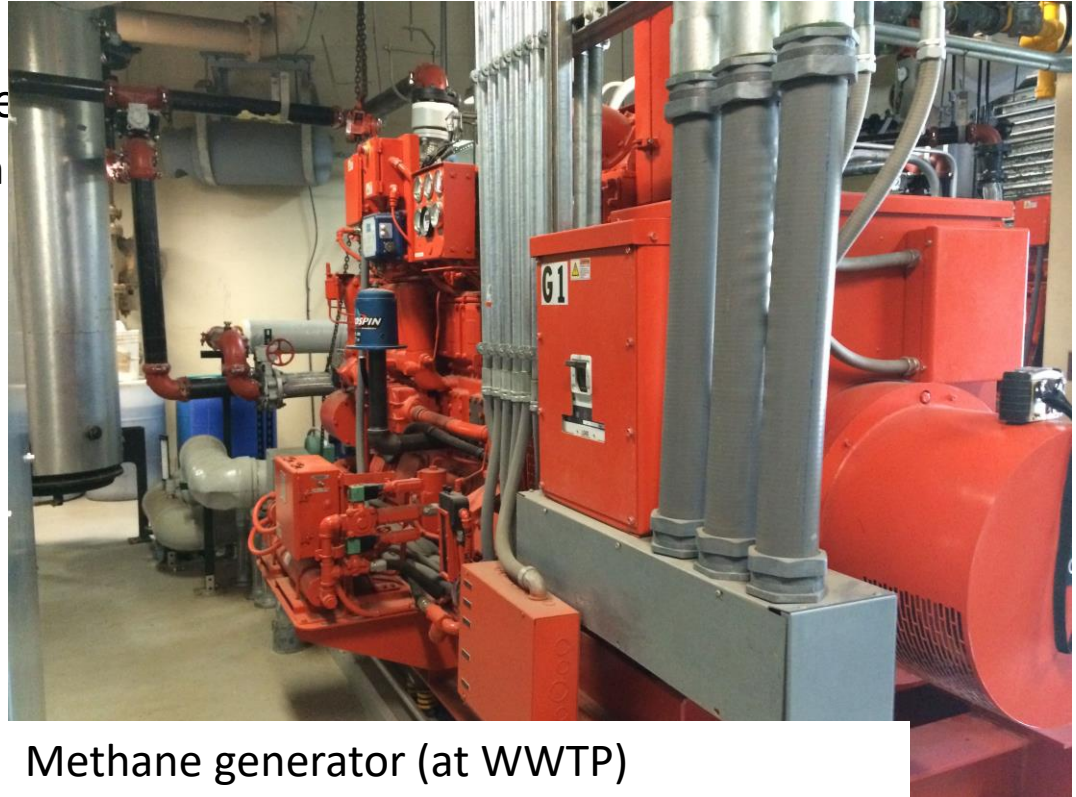
47.3 mt of waste to landfill

- 17.7 mt generated within the Stadium on game day.
- 29.6 mt generated during prep for game day or unsold items following game day. 96% of this was food.

**Figure 4.** Approximate weights by major category of pre-consumer, un-sold and post-consumer food waste.

The Environmental Protection Agency's Waste Reduction Model (WARM) was used to estimate the life cycle carbon dioxide (CO<sub>2</sub>), methane (CH<sub>4</sub>), and nitrous oxide (N<sub>2</sub>O) emissions and energy use impacts of waste management options for materials found in the waste audit.

- Waste reduction options:
  - Landfill, with options to customize landfill type
    - Note: Columbia has a bioreactor landfill which is designed to capture methane and generate electricity
  - Recycling
  - Composting
  - Incineration
  - Source Reduction, aka, waste avoidance



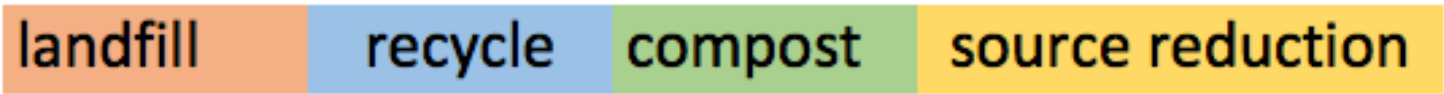
Methane generator (at WWTP)

Realistic options for waste disposal in Columbia were explored for the waste stream generated over the 2014 season to estimate the relative life cycle GHGs & energy use of each.

| Material              | 1     |
|-----------------------|-------|
| Aluminum Cans         | 1.2%  |
| Glass                 | 2.8%  |
| LDPE                  | 4.0%  |
| PP                    | 4.0%  |
| PS                    | 4.0%  |
| Corrugated Containers | 7.9%  |
| Food Waste (non-meat) | 5.1%  |
| Beef                  | 5.7%  |
| Poultry/Pork          | 10.3% |
| Bread                 | 13.4% |
| Fruits and Vegetables | 30.7% |
| Dairy Products        | 4.2%  |
| Mixed Paper (general) | 4.3%  |
| Mixed Plastics        | 2.4%  |
| Mixed Organic         |       |
| PLA                   |       |

Scenario 1, perfect recycling.

Percentages indicate weight of each material contribution to the 47.3 mt generated.



Realistic options for waste disposal in Columbia were explored for the waste stream generated over the 2014 season to estimate the relative life cycle GHGs & energy use of each.

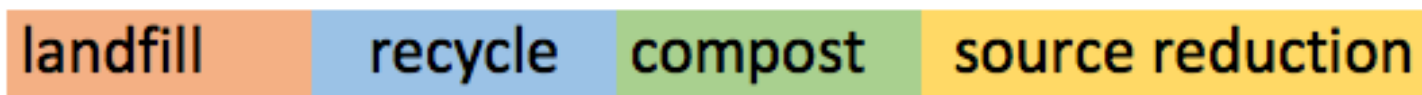
| Material              | 1     | 2a    | 2b    |
|-----------------------|-------|-------|-------|
| Aluminum Cans         | 1.2%  | 1.2%  | 1.2%  |
| Glass                 | 2.8%  | 2.8%  | 2.8%  |
| LDPE                  | 4.0%  | 4.0%  | 4.0%  |
| PP                    | 4.0%  | 4.0%  | 4.0%  |
| PS                    | 4.0%  | 4.0%  | 4.0%  |
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| Poultry/Pork          | 10.3% | 10.3% | 10.3% |
| Bread                 | 13.4% | 13.4% | 13.4% |
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| Mixed Paper (general) | 4.3%  | 4.3%  |       |
| Mixed Plastics        | 2.4%  | 2.4%  | 2.4%  |
| Mixed Organic         |       |       | 12.1% |
| PLA                   |       |       |       |

Scenario 1, perfect recycling

Scenario 2a, perfect recycling, compost food waste

Scenario 2b, perfect recycling– except paper and cardboard, compost food waste, paper and cardboard

Percentages indicate weight of each material contribution to the 47.3 mt generated.



Realistic options for waste disposal in Columbia were explored for the waste stream generated over the 2014 season to estimate the relative life cycle GHGs & energy use of each.

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|-----------------------|-------|-------|-------|-------|
| Aluminum Cans         | 1.2%  | 1.2%  | 1.2%  | 1.2%  |
| Glass                 | 2.8%  | 2.8%  | 2.8%  | 2.8%  |
| LDPE                  | 4.0%  | 4.0%  | 4.0%  |       |
| PP                    | 4.0%  | 4.0%  | 4.0%  |       |
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| Beef                  | 5.7%  | 5.7%  | 5.7%  | 5.7%  |
| Poultry/Pork          | 10.3% | 10.3% | 10.3% | 10.3% |
| Bread                 | 13.4% | 13.4% | 13.4% | 13.4% |
| Fruits and Vegetables | 30.7% | 30.7% | 30.7% | 30.7% |
| Dairy Products        | 4.2%  | 4.2%  | 4.2%  | 4.2%  |
| Mixed Paper (general) | 4.3%  | 4.3%  |       | 4.3%  |
| Mixed Plastics        | 2.4%  | 2.4%  | 2.4%  | 2.4%  |
| Mixed Organic         |       |       | 12.1% |       |
| PLA                   |       |       |       | 12.0% |

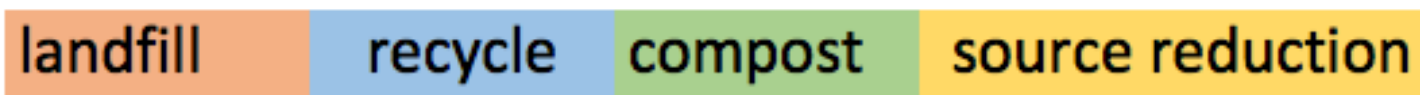
Scenario 1, perfect recycling

Scenario 2a, perfect recycling, compost food waste

Scenario 2b, perfect recycling– except paper and cardboard, compost food waste, paper and cardboard.

Scenario 3\*, replace some plastics with “biodegradable” plastic, compost food waste and PLA, recycle everything else

Percentages indicate weight of each material contribution to the 47.3 mt generated.



Realistic options for waste disposal in Columbia were explored for the waste stream generated over the 2014 season to estimate the relative life cycle GHGs & energy use of each.

| Material              | 1     | 2a    | 2b    | 3*    | 4*    |
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| Aluminum Cans         | 1.2%  | 1.2%  | 1.2%  | 1.2%  |       |
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| Mixed Paper (general) | 4.3%  | 4.3%  |       | 4.3%  |       |
| Mixed Plastics        | 2.4%  | 2.4%  | 2.4%  | 2.4%  |       |
| Mixed Organic         |       |       | 12.1% |       | 12.1% |
| PLA                   |       |       |       | 12.0% | 18.4% |

Scenario 1 – perfect recycling

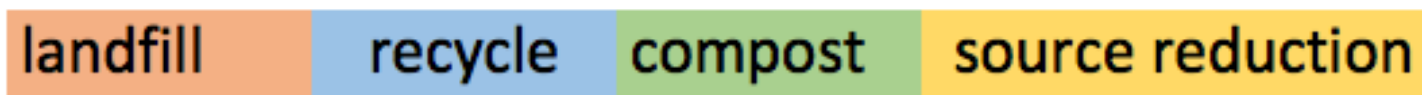
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Scenario 2b, perfect recycling– except paper and cardboard, compost food waste, paper and cardboard

Scenario 3\*, replace some plastics with “biodegradable” plastic, compost food waste and PLA, recycle everything else

Scenario 4\* – replace all packaging with “biodegradable” plastic & compost everything

Percentages indicate weight of each material contribution to the 47.3 mt generated.



# Realistic options for waste disposal in Columbia were explored for the 14 season to estimate the relative life

waste str  
cycle GH(

Scenario 1, perfect recycling  
Scenario 2a, perfect recycling, compost food  
Scenario 2b, recycle, compost food waste,  
paper and cardboard  
Scenario 3\*, replace some plastics with PLA  
& compost, recycle  
Scenario 4\*, replace all packaging with PLA  
& compost everything

| Material              |
|-----------------------|
| Aluminum Cans         |
| Glass                 |
| LDPE                  |
| PP                    |
| PS                    |
| Corrugated Containers |
| Food Waste (non-meat) |
| Beef                  |
| Poultry/Pork          |
| Bread                 |
| Fruits and Vegetables |
| Dairy Products        |
| Mixed Paper (general) |
| Mixed Plastics        |
| Mixed Organic         |
| PLA                   |

In all "5" Scenarios, edible food waste is avoided

Scenario 5a, avoid all edible food waste  
Scenario 5b, perfect recycling, compost  
inedible FW  
Scenario 5c, perfect recycling, compost  
inedible FW and paper  
Scenario 5d\*, replace some plastics with PLA,  
compost inedible FW  
Scenario 5e\*, replace all packaging with PLA,  
compost all PLA & compost

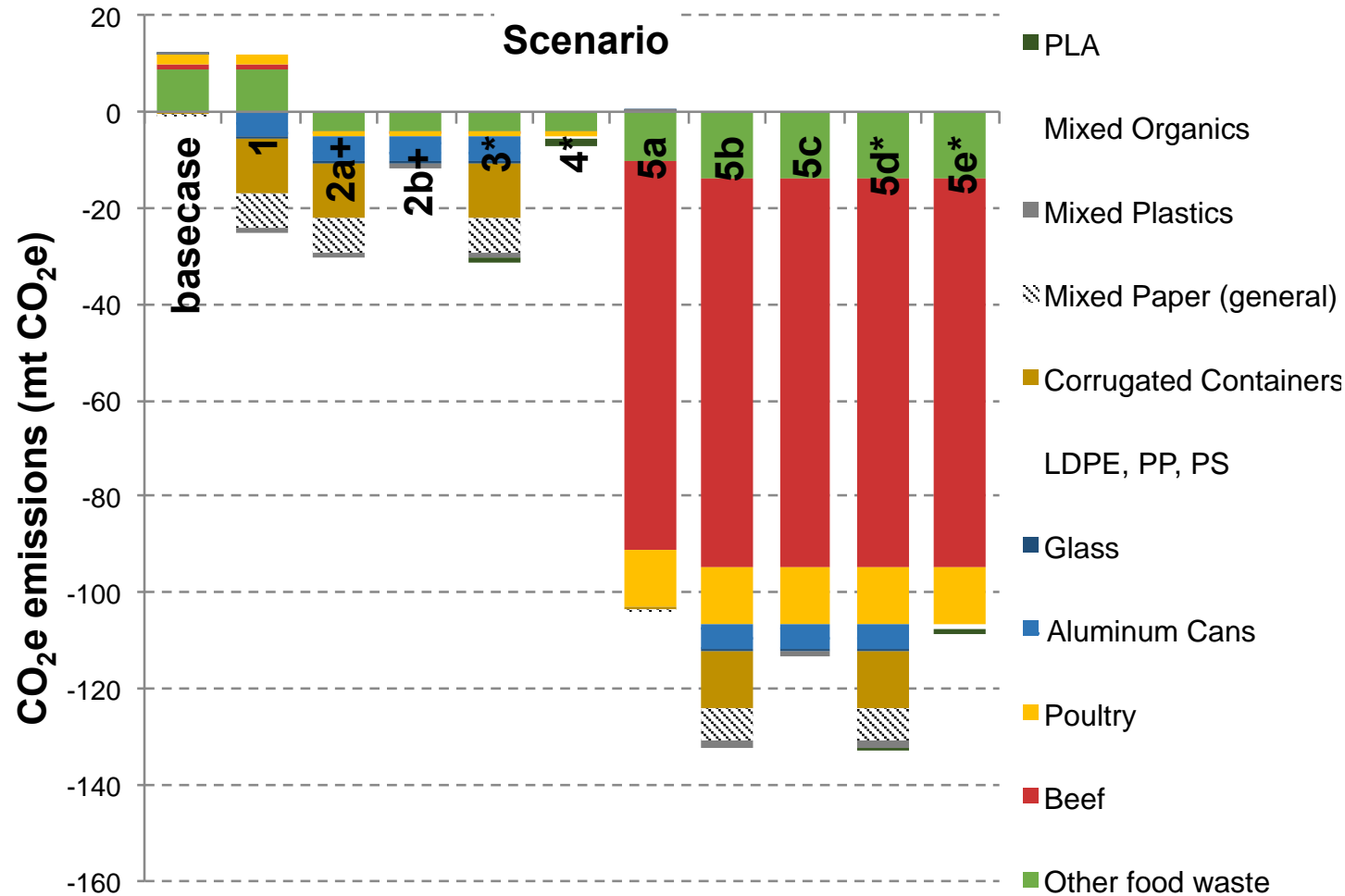
| 5a    |       | 5b    |       | 5c    |       | 5d*   |       | 5e*   |       |
|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| E     | I     | E     | I     | E     | I     | E     | I     | E     | I     |
| 1.2%  |       | 1.2%  |       | 1.2%  |       | 1.2%  |       |       |       |
| 2.8%  |       | 2.8%  |       | 2.8%  |       | 2.8%  |       |       |       |
| 4.0%  |       | 4.0%  |       | 4.0%  |       |       |       |       |       |
| 4.0%  |       | 4.0%  |       | 4.0%  |       |       |       |       |       |
| 4.0%  |       | 4.0%  |       | 4.0%  |       |       |       |       |       |
| 7.9%  |       | 7.9%  |       |       |       | 7.9%  |       |       |       |
| 5.1%  |       | 5.1%  |       | 5.1%  |       | 5.1%  |       | 5.1%  |       |
| 5.7%  |       | 5.7%  |       | 5.7%  |       | 5.7%  |       | 5.7%  |       |
| 10.3% |       | 10.3% |       | 10.3% |       | 10.3% |       | 10.3% |       |
| 13.4% |       | 13.4% |       | 13.4% |       | 13.4% |       | 13.4% |       |
| 15.5% | 15.1% | 15.5% | 15.1% | 15.5% | 15.1% | 15.5% | 15.1% | 15.5% | 15.1% |
| 4.2%  |       | 4.2%  |       | 4.2%  |       | 4.2%  |       | 4.2%  |       |
| 4.3%  |       | 4.3%  |       |       |       | 4.3%  |       |       |       |
| 2.4%  |       | 2.4%  |       | 2.4%  |       | 2.4%  |       |       |       |
|       |       |       |       | 12.1% |       |       |       | 12.1% |       |
|       |       |       |       |       |       | 12.0% |       | 18.4% |       |

landfill recycle compost source reduction

Costello, C., R. McGarvey, E. Birisci. Achieving Sustainability beyond Zero Waste: A Case Study from a College Football Stadium. *Sustainability*. **2017**, 9, 1236; doi:10.3390/su9071236

Percentages indicate weight of each material contribution to the 47.3 mt generated.

# Life cycle GHGs for Waste Management Scenarios



Scenario 1, perfect recycling

Scenario 2a+, perfect recycling, compost food

Scenario 2b+, recycle, compost food

waste, paper and cardboard

Scenario 3\*, replace some plastics with PLA & compost, recycle

Scenario 4\*, replace all packaging with PLA & compost everything

**In all "5" Scenarios, edible food waste is avoided**

Scenario 5a, avoid all edible food waste

Scenario 5b, perfect recycling, compost inedible FW

Scenario 5c, perfect recycling, compost inedible FW and paper

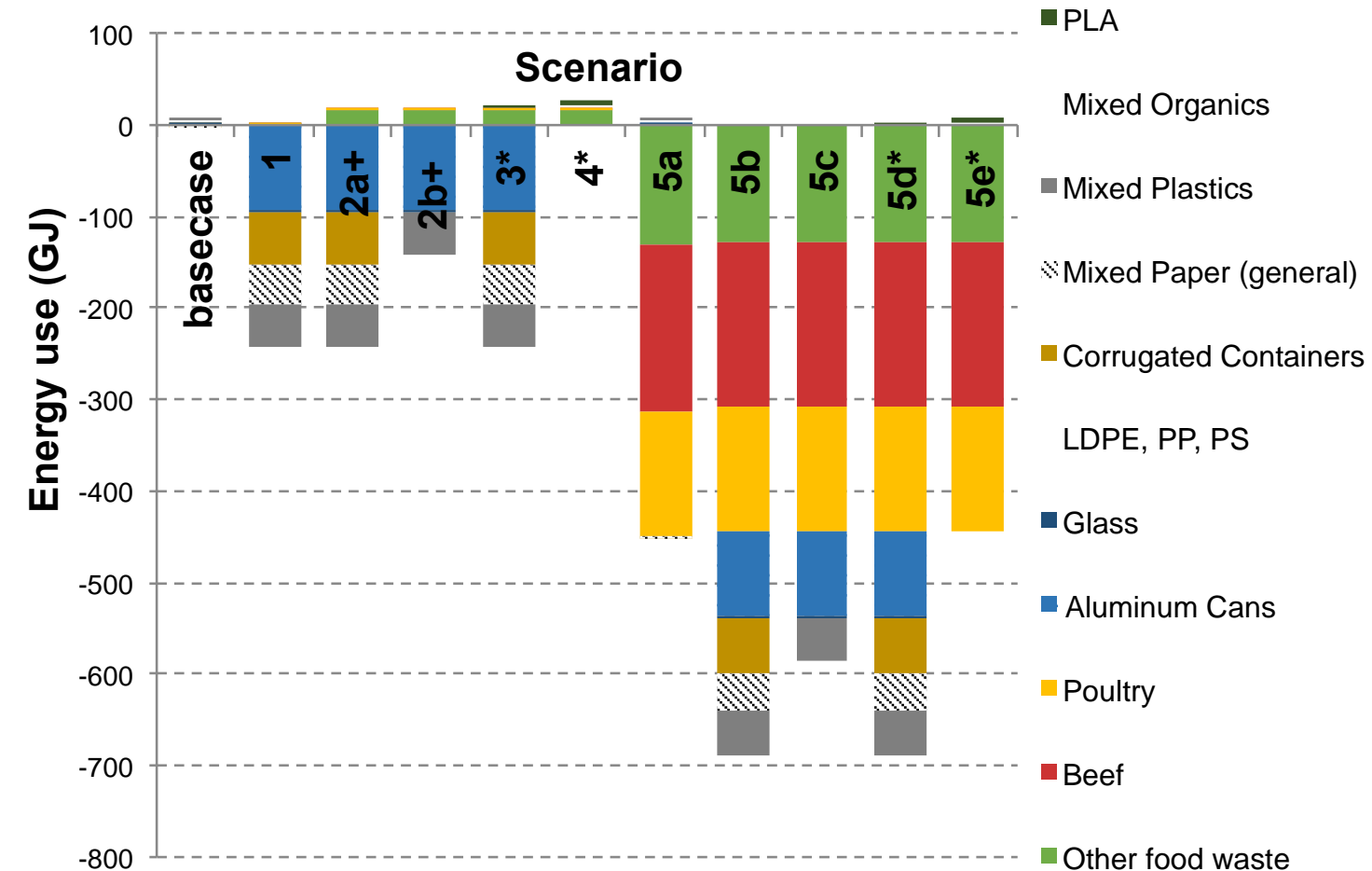
Scenario 5d\*, replace some plastics with PLA, compost inedible FW

Scenario 5e\*, replace all packaging with PLA, compost all PLA & compost

\* 100% waste diverted from landfill

+ 88% waste diverted from landfill

# Life cycle Energy Use for Waste Management Scenarios



Scenario 1, perfect recycling

Scenario 2a+, perfect recycling, compost food

Scenario 2b+, recycle, compost food waste, paper and cardboard

Scenario 3\*, replace some plastics with PLA & compost, recycle

Scenario 4\*, replace all packaging with PLA & compost everything

**In all "5" Scenarios, edible food waste is avoided**

Scenario 5a, avoid all edible food waste

Scenario 5b, perfect recycling, compost inedible FW

Scenario 5c, perfect recycling, compost inedible FW and paper

Scenario 5d\*, replace some plastics with PLA, compost inedible FW

Scenario 5e\*, replace all packaging with PLA, compost all PLA & compost

\* 100% waste diverted from landfill

+ 88% waste diverted from landfill

# Take homes and Challenges

- Defining Zero Waste in terms of waste diversion may not always lead to the most environmentally preferable outcome.
  - It is important to think systematically.
- Improve fan sorting of recycling
- Improve management of food production to reduce waste.
  - Reduce production...but this is very complex and challenging.
  - Donate food that meets health and safety requirements...still challenging, but more attainable.
  - Consider reducing production of high-GHG and energy use foods and replacing with lower impact foods.