COUNTING CALORIES

BUILDING THE INTERNET OF ENERGY-SMART FOOD

2017 ARPA-E Energy Innovation Summit

February 28, 2017

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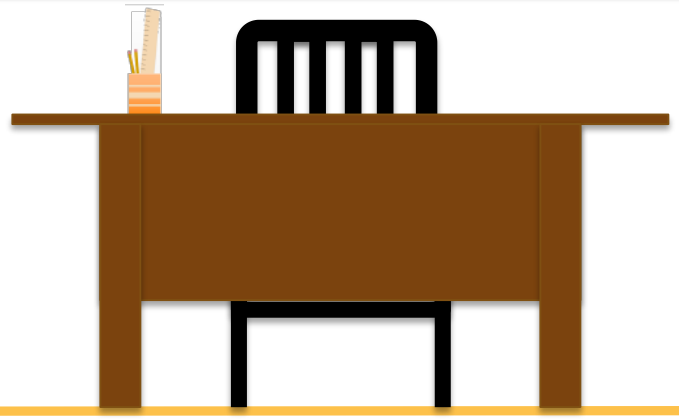
Advanced Research Projects Agency-Energy

For every 12 calories we put into the food system,

we only deliver 1 calorie for human nutrition

Input
Primary
Energy



Output
Food
Energy

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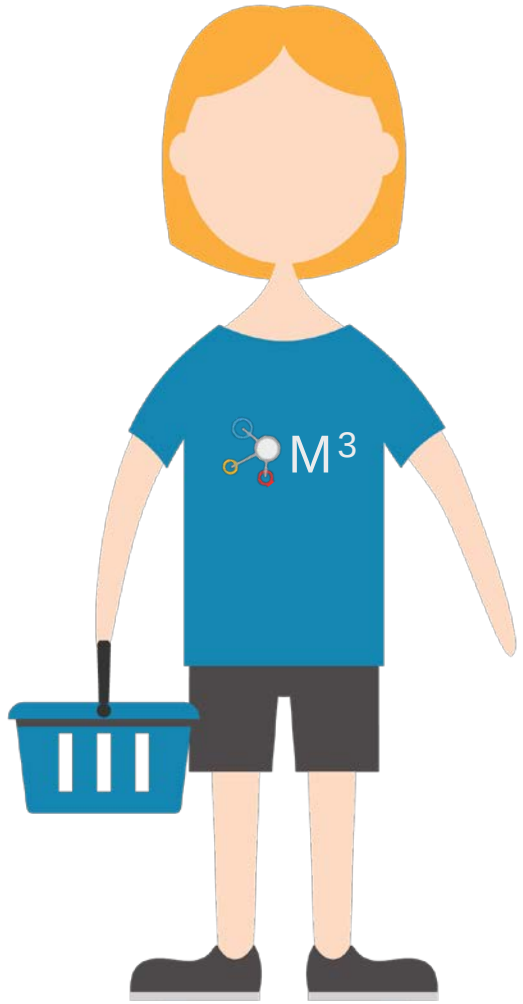
CHANGING WHAT'S POSSIBLE

Canning, Patrick, et al. "The Role of Fossil Fuels in the US Food System and the American Diet." (2017).
U.S. Department of Agriculture, Agricultural Research Service. 2016. Energy Intakes: Percentages of Energy from Protein, Carbohydrate, Fat, and Alcohol, by Gender and Age, *What We Eat in America,* NHANES 2013-2014.

On average, you consume ~800,000 kcal per year



As result you use:

~ 9.5 million kcal primary energy

~ 130,000 gallons of fresh water

And generate:

~ 3 metric tons CO_2eq emissions

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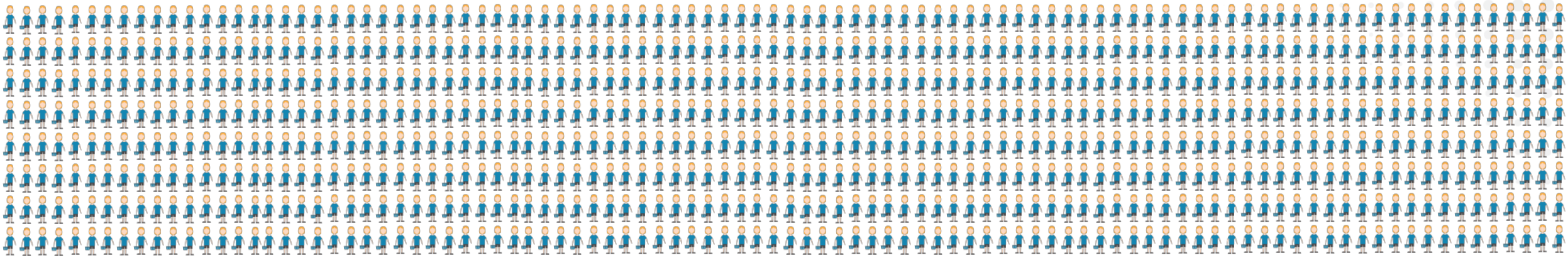
Maupin, Molly A., et al. Estimated use of water in the United States in 2010. No. 1405. US Geological Survey, 2014.
Weber, Christopher L., and H. Scott Matthews. "Food-miles and the relative climate impacts of food choices in the United States." (2008): 3508-3513.

Feeding the U.S. population comes at a high price…



3 quadrillion
kcal of energy

12% of U.S. Total

1 billion
metric tons CO_2eq

15% of U.S. Total

43 trillion
gallons of water

80% of U.S. Total

Annual cost of feeding the United States

Canning, Patrick, et al. "The Role of Fossil Fuels in the US Food System and the American Diet." (2017).
Maupin, Molly A., et al. Estimated use of water in the United States in 2010. No. 1405. US Geological Survey, 2014.
Schaible, Glenn, and Marcel Aillery. "Water conservation in irrigated agriculture: Trends and challenges in the face of emerging demands." (2012).
Weber, Christopher L., and H. Scott Matthews. "Food-miles and the relative climate impacts of food choices in the United States." (2008): 3508-3513
EPA, February. "Draft Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2015." Environmental Protection Agency (2017): 1-28.

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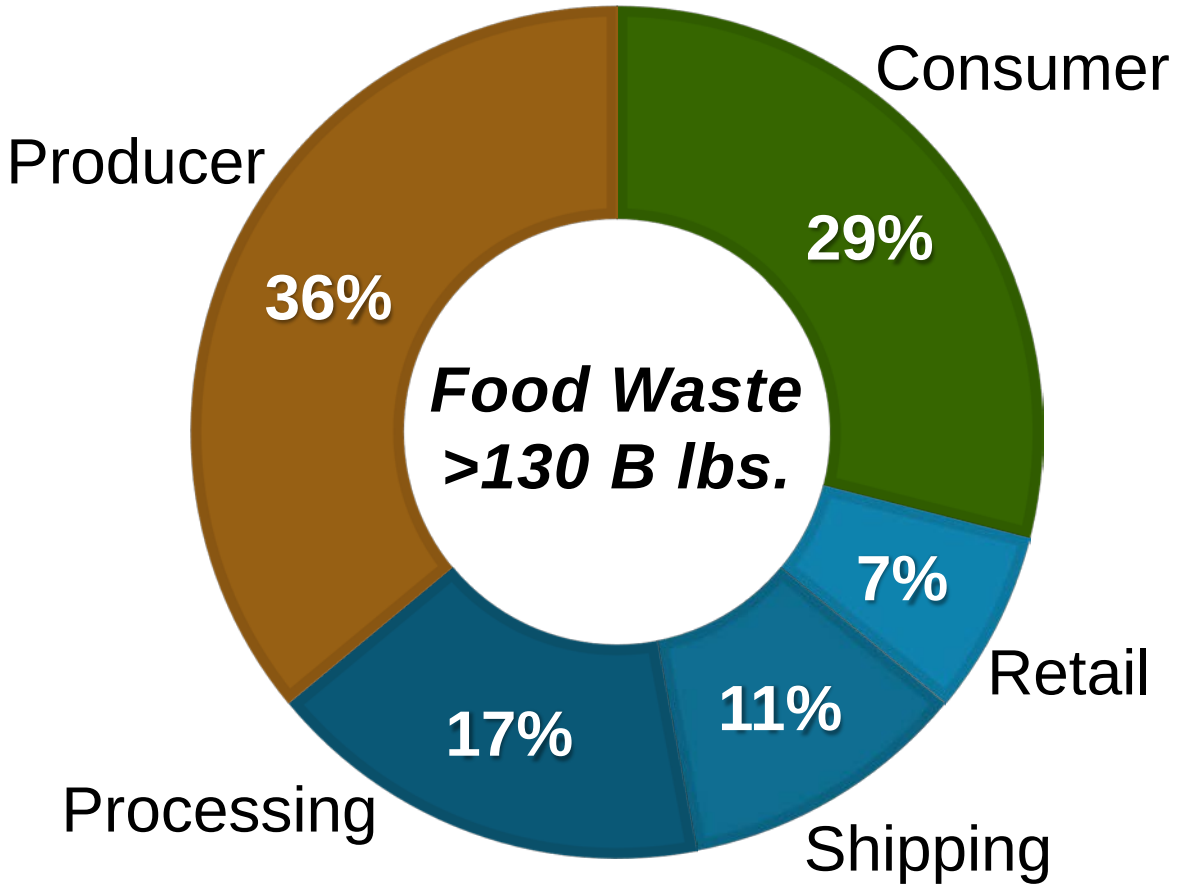
40% of the food we produce is wasted each year

Annual Food Loss And Waste



Annual Food Waste Footprint

1.2 Quadrillion kcal

6 Trillion Gallons

400 MMT CO_2eq

Buzby, Jean C., Hodan Farah-Wells, and Jeffrey Hyman. "The estimated amount, value, and calories of postharvest food losses at the retail and consumer levels in the United States." (2014).
Gustavsson, Jenny, et al. "Global food losses and food waste." Food and Agriculture Organization of the United Nations, Rom (2011).
Canning, Patrick, et al. "The Role of Fossil Fuels in the US Food System and the American Diet." (2017).
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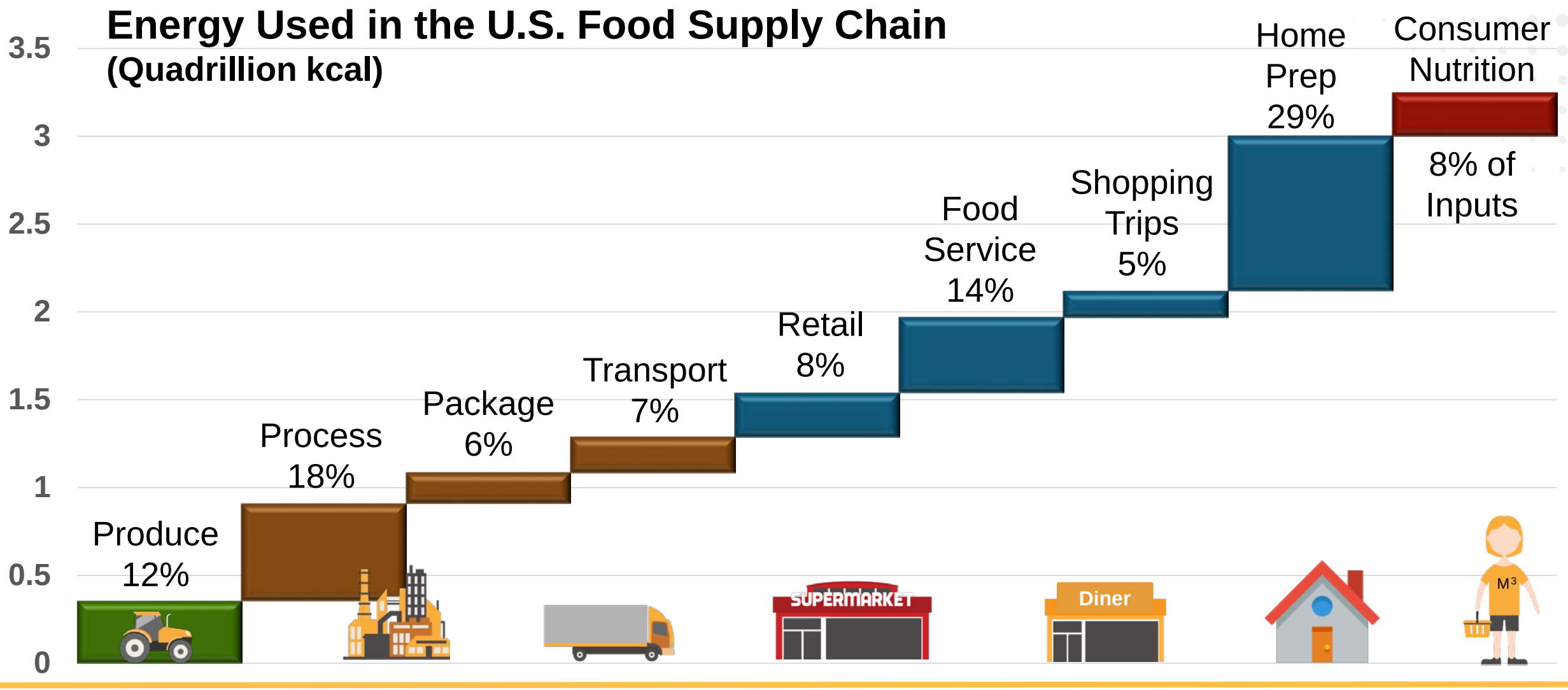
Where does all this energy go?



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Demands on global food systems are growing…

FARMERS WILL NEED TO PRODUCE MORE FOOD IN THE NEXT 50 YEARS

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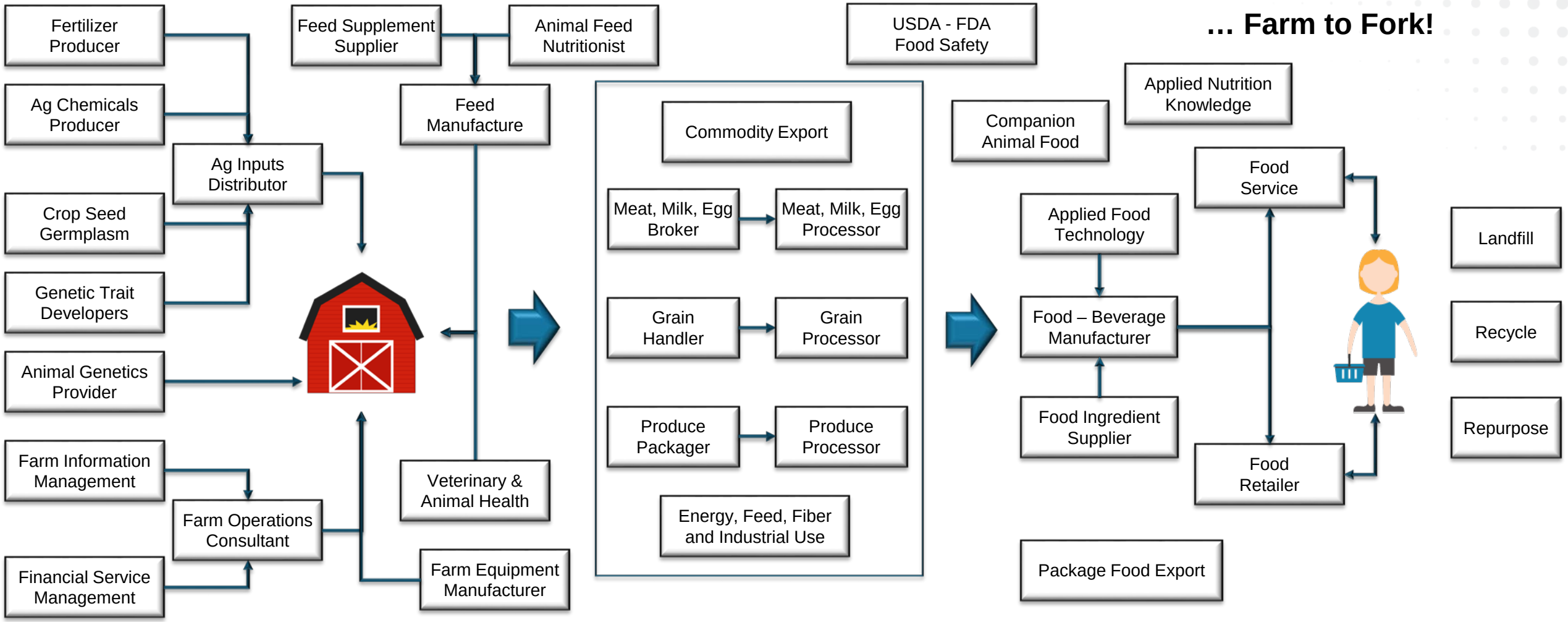
THAN WAS PRODUCED IN THE PREVIOUS 10,000

COMBINED

Source: "Working to Maximize Yields." Improving Agriculture. Monsanto.

The Food Supply Chain … is Massive and Complex

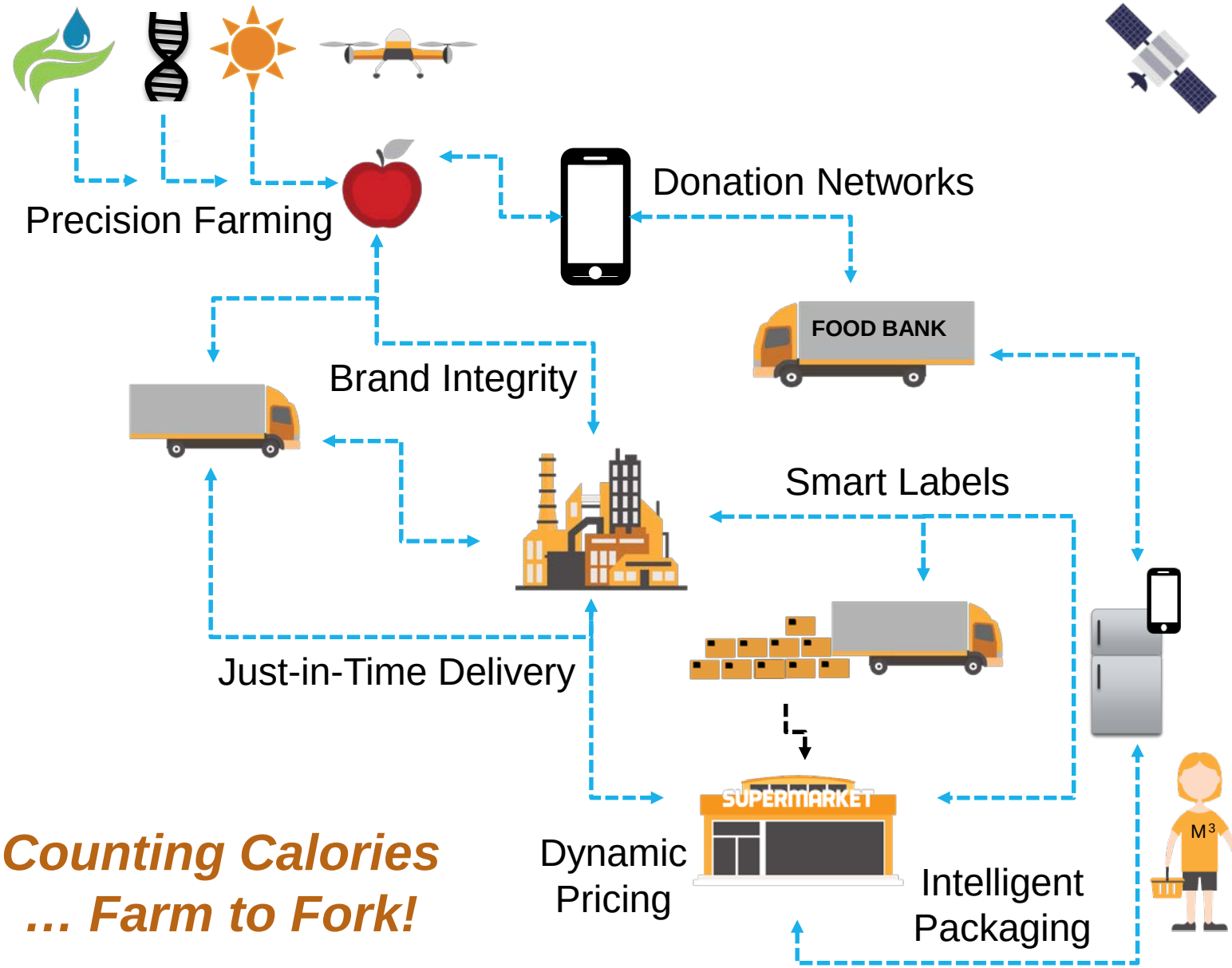
We Need to Re-Connect … Farm to Fork!



Imagine: An Integrated Energy-Smart Food Network

Energy-Smart Food Dashboard

- **Reliable Supply & Forecast**
- **Product Quality & Identity**
- **Real-Time Market Demand**
- **Product Personalization**
- **Resource Optimization**



Counting Calories … Farm to Fork!

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ARPA-E: Reimagining an Energy-Smart Food Network

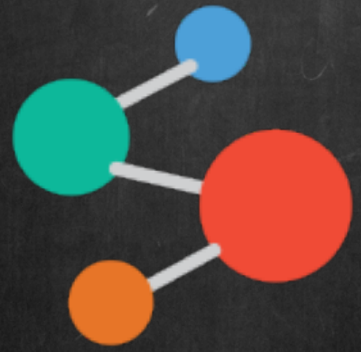
Key Areas of Opportunity

M x M x M = M³

Models
Analytics & Machine Learning

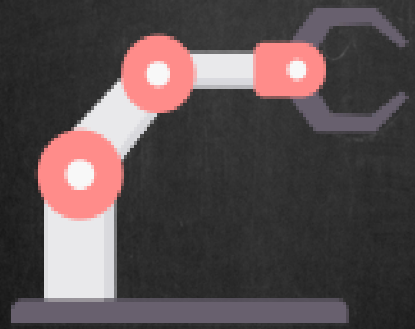
x

Materials
Preservation & Conservation



x

Machines
Sensors & Robotics



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To Develop and Integrate New Technologies

Welcome to the World of Energy-Smart Food

Tell Us Your Ideas!

joe.cornelius@hq.doe.gov