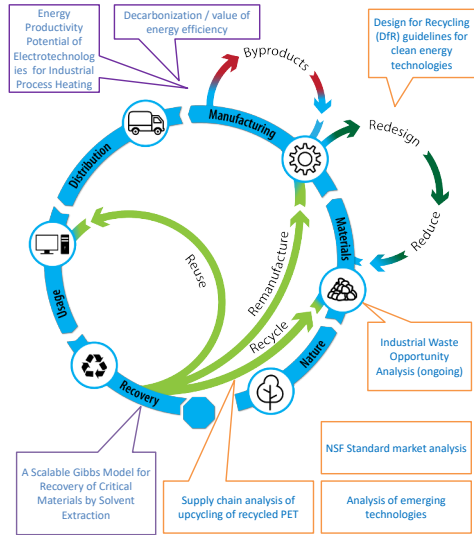




Summary



The **Circular Economy** is an aspirational goal where the U.S. (and global) economy fully utilizes all materials in the most efficient way possible and has zero waste to landfills. The figure above represents this aspirational goal and indicates where the team's research projects are contributing to this goal.

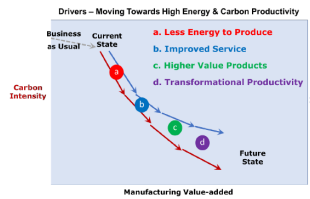
Past and current activities for sustainable manufacturing target **reducing energy and material use** in the manufacturing sector and developing the baseline knowledge. We are addressing the challenge of how to evaluate the potential for different strategies by developing general approaches to evaluate them and establishing a baseline to use a reference point.

AMO Strategic Analysis Team

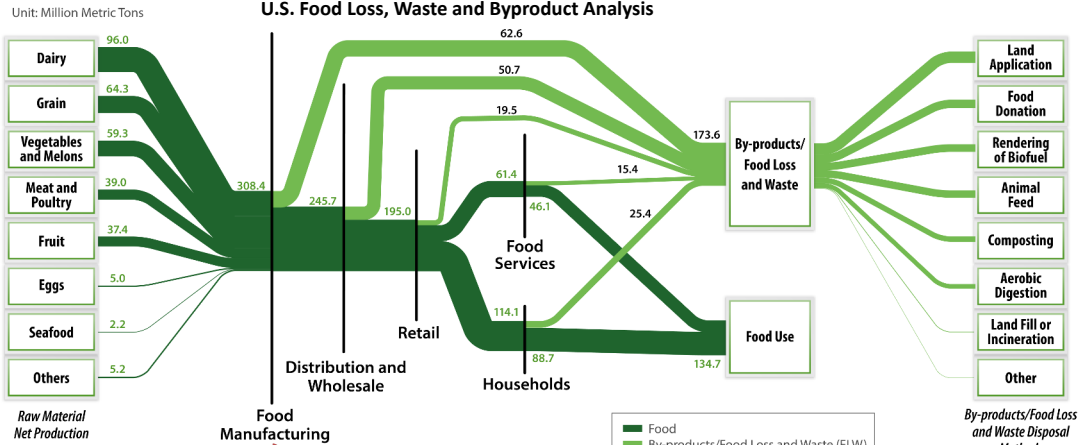
The multi-laboratory **AMO Strategic Analysis Team** provides independent, objective, and credible information to inform decision-making. To gain insights on manufacturing supply chains, the team conducts **techno-economics, value chain, trade, patent, and global manufacturing competitiveness analysis** relevant to advanced manufacturing technologies.

Sustainable manufacturing encompasses a wide range of systems issues, including energy intensity, carbon intensity, and use intensity. Manufacturing systems have traditionally been designed based on a linear model, starting with raw materials extracted from nature and ending at disposal in a landfill at the end of the product's useful life. A circular economy redirects this approach by providing opportunities to re-manufacture and reuse end-of-life consumer products, leading to more efficient use of materials. Analyzing the supply chain and material flows through a product's entire lifecycle can help to identify energy, material, and water savings opportunities throughout the greater U.S. economy, including the production and delivery of energy and energy use within the industrial, transportation, and buildings sectors.

AMO aims to improve the **energy productivity** of the U.S. manufacturing sector while reducing lifecycle energy and resource impacts of manufactured goods.



Industrial Waste Analysis



Analysis of the Entire Food Supply Chain:

- Raw material net production includes the raw material produced in U.S., the stock change, raw material imported and exported
- Raw materials for non-human-consumption and alcohol production are excluded
- All the raw materials and food products are calculated based on farm-weight
- Data for disposed by-products/food waste for each disposal method will be determined

Analysis for Yogurt Manufacturing:

- Four major types of yogurt products in U.S. are studied
- Acid whey and cream are the major by-products/waste from yogurt manufacturing processes



Potential Market Impact of Voluntary Sustainability Leadership Standards – PV Case Study



Motivation

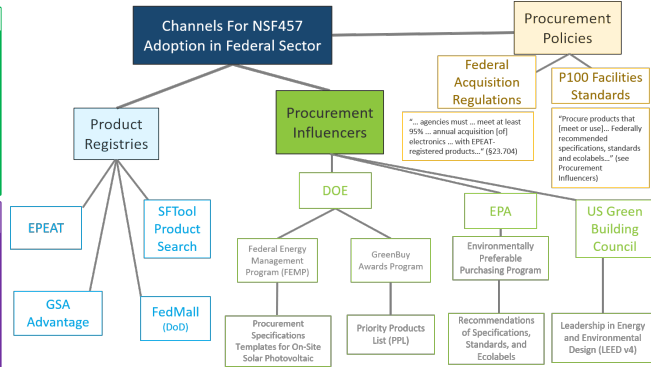
- For many clean energy products, there is no clear, objective, verifiable, consensus-based criteria for sustainability attributes.
- Sustainability Leadership Standard for PV Modules (NSF457) was approved in December 2017 as a new ANSI standard to meet this need for PV.
- By end of 2019, a new EPEAT registry (Electronic Products Environmental Assessment Tool) will be created based on NSF457 to make it easier for purchasers to specify PV modules for sustainability attributes and identify modules in the marketplace meeting those criteria.

Methodology

- Conducted a market assessment, interviewing nearly 50 stakeholders, to understand the motivations, pathways and potential for purchase of sustainability-certified PV modules in three market segments: federal, corporate and utility. Results for federal market assessment are shown in results in bottom right figure.
- Explored channels for adoption of NSF457 in Federal sector (mapped in figure in upper right).
- Currently NSF457 is being expanded to include PV inverters, expected to be formally added by Fall 2019.
- Scope of standard is illustrated in figure below



Source: GEC, 2018



Results: Summary of federal market assessment

Market Penetration Estimate: Federal Sector Example

The wedges collectively amount to 7 MW per year to 37 MW per year of NSF457 demand as low- and high-end estimates (based on expert judgement in the market)

For context, annual federal PV procurement has been on the order of 80 MW/year for the past five years; (Perea et al. 2018).

