

U.S. DOE IEDO Program Overview and Decarbonization Strategy for Food and Beverage Sector

Yaroslav Chudnovsky, Ph.D., MBA, FASME

Senior Technology Manager

Industrial Efficiency and Decarbonization Office (IEDO)

Joint IEDO-AMMTO Sustainable Food and Beverage Packaging Workshop , Rosemont, IL, September 24-25, 2024
IEDO Stakeholders Workshop Series “Decarbonization Challenges and Priorities in the Food and Beverage Industry”





U.S. DEPARTMENT OF
ENERGY

Office of
Policy

Investing in American Energy

Significant Impacts of the Inflation
Reduction Act and Bipartisan Infrastructure
Law on the U.S. Energy Economy and
Emissions Reductions



The Bipartisan Infrastructure Law of 2021 (BIL) and Inflation Reduction Act of 2022 (IRA) together represent a historic investment of over **\$430B** toward modernizing the American energy system to:

- Reduce GHG emissions 50% below 2005 levels in 2030
- Reach 100% carbon-free electricity by 2035
- Achieve net-zero emissions by 2050
- Deliver 40% of the benefits from federal climate and energy investments to disadvantaged communities

Building a Net-zero, Clean Energy Future

The U.S. industrial sector (manufacturing, agriculture, mining, and construction) accounts for:

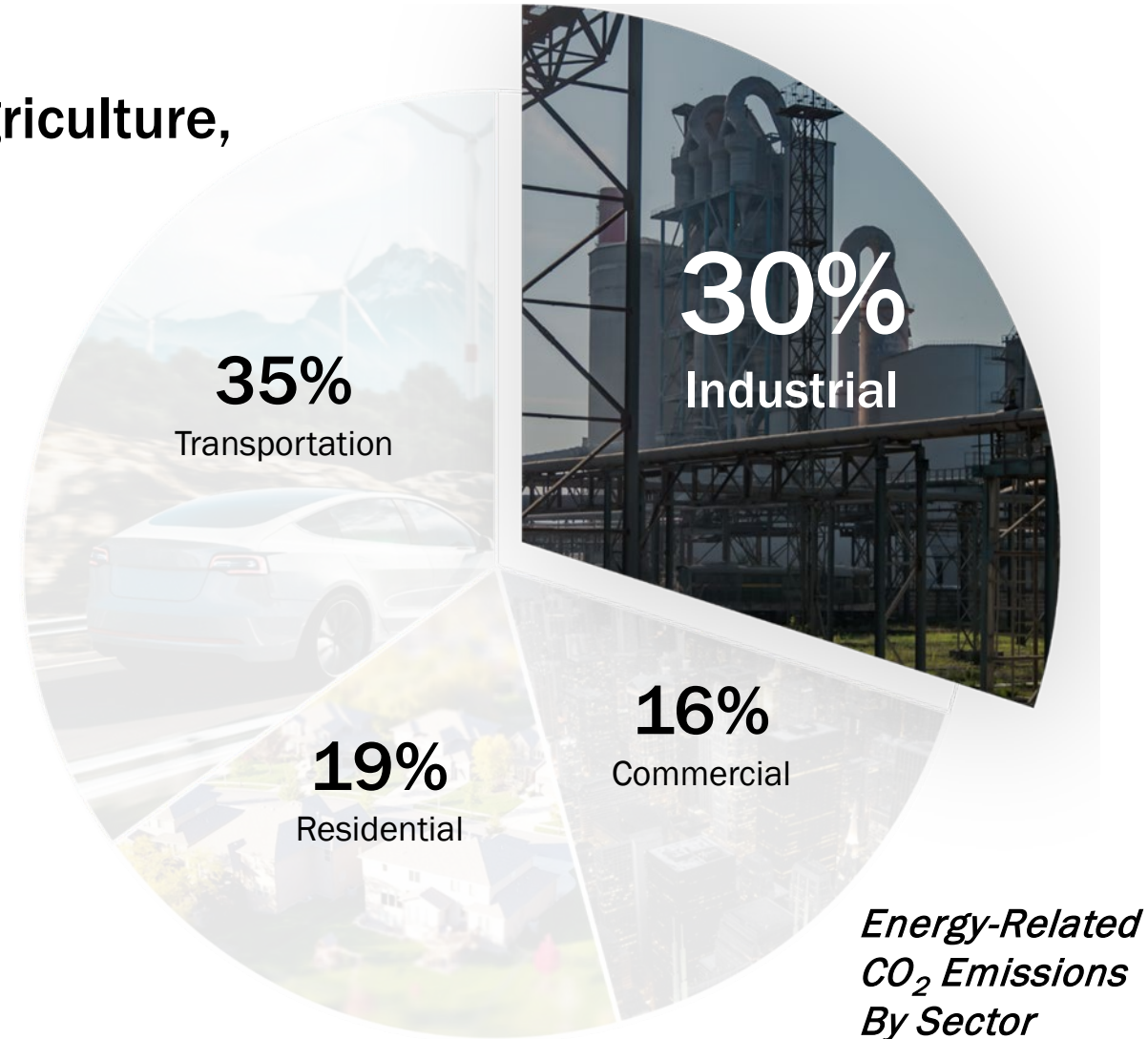
33% of the nation's primary energy use

30% of CO_{2e} emissions

Anticipated industrial sector energy demand growth of 30% by 2050 may result in a:

17% CO_{2e} emissions increase*

*EIA, Annual Energy Outlook 2021 with Projections to 2050.



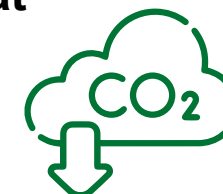
Systemic Barriers to Industrial Decarbonization

Investment scale → In the range of
\$700B – 1.1 Trillion

just for 8 industrial sector of focus in the IRA :

Estimated that

60%



by 2030 will come from technologies that are not net-positive decarbonization levers with existing IRA tax credits or require further R&D to address



Chemicals



Refining



Iron &
Steel



Food &
Beverage



Cement



Pulp &
Paper



Aluminum

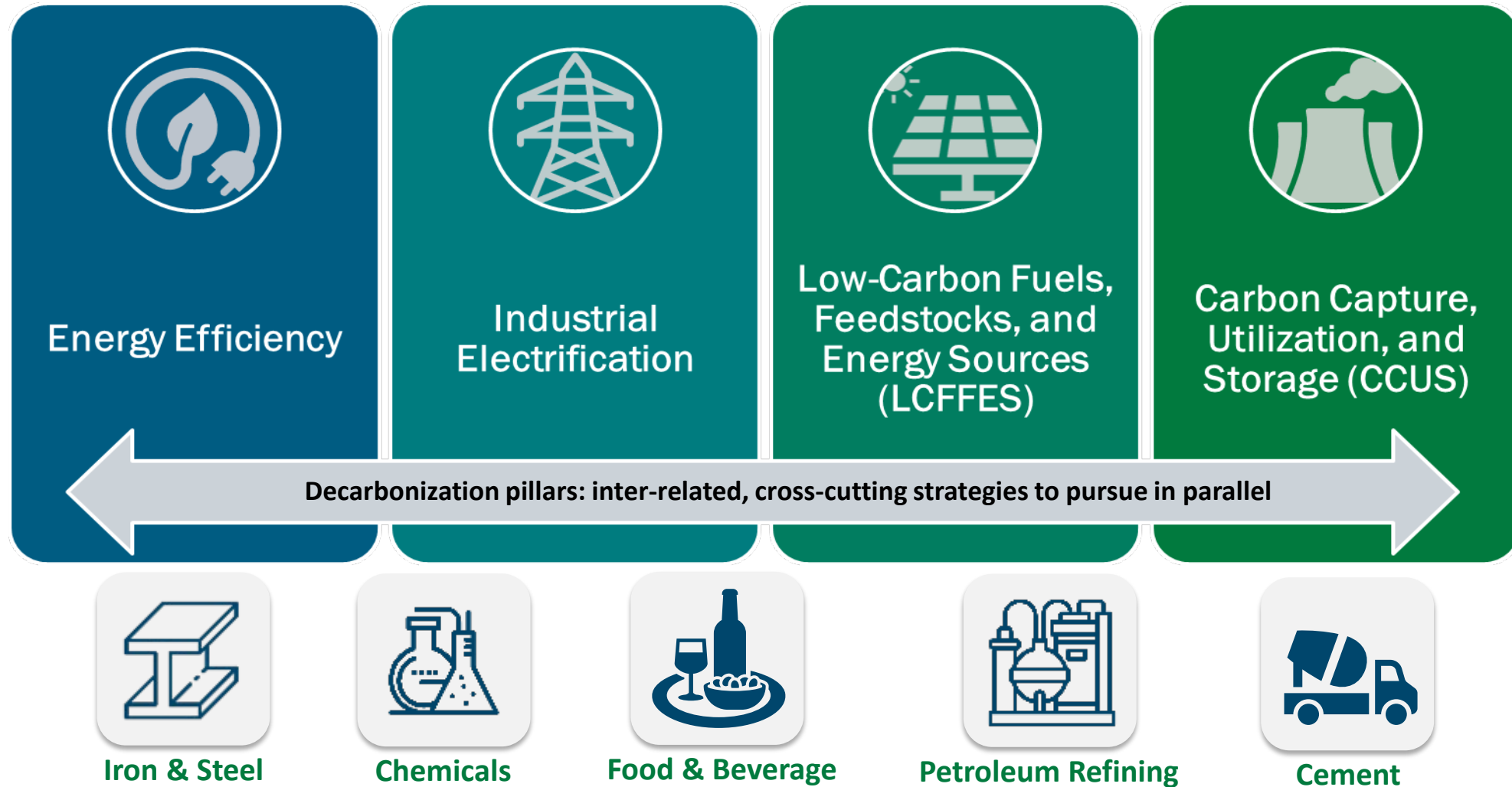


Glass

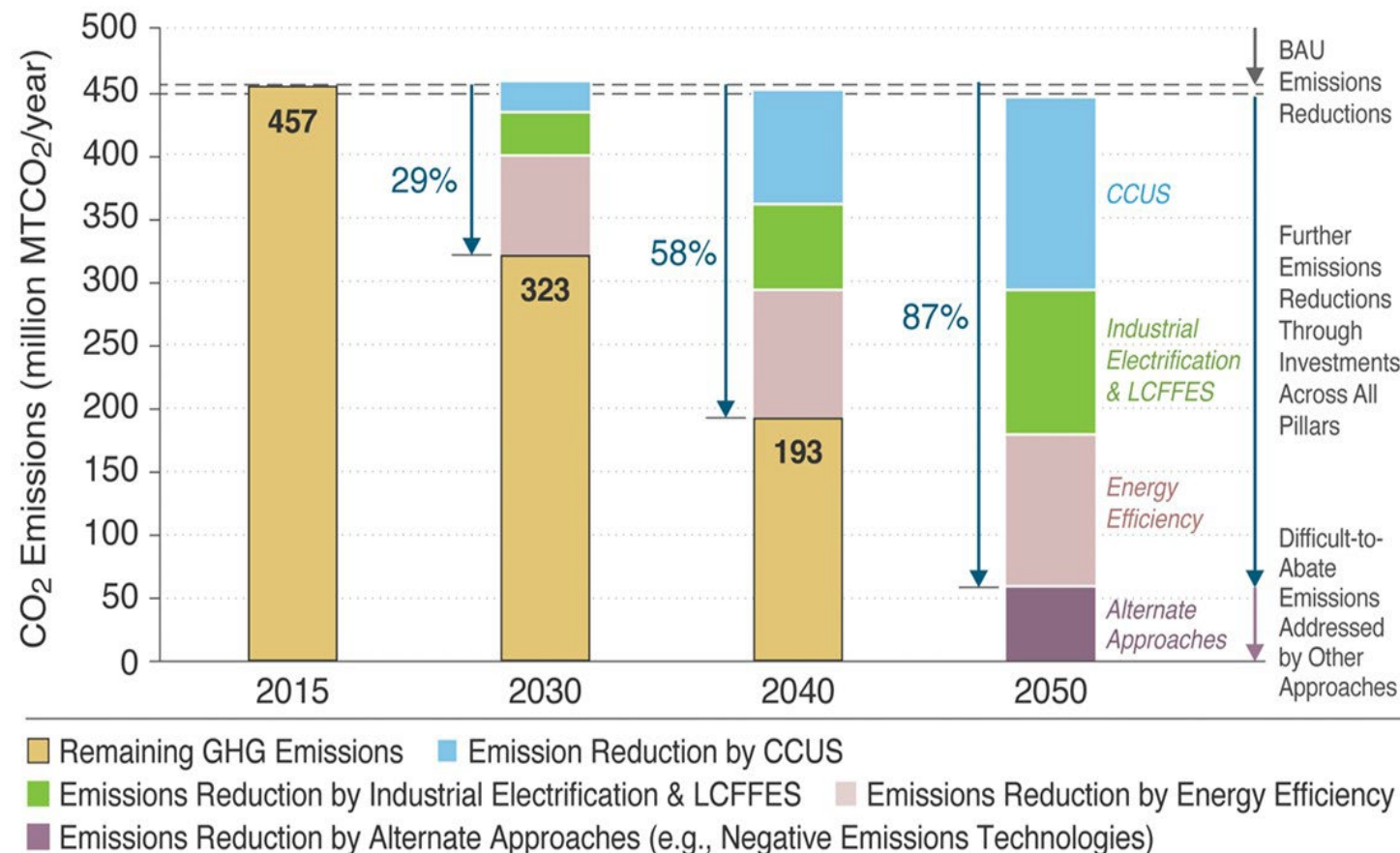
Targeted investment for research, development, and pilot-scale demonstrations is a need and opportunity for U.S. industrial manufacturing

U.S. DOE Industrial Decarbonization Roadmap

Industrial Decarbonization Pillars



Path to Near-Zero Industrial GHG Emissions by 2050



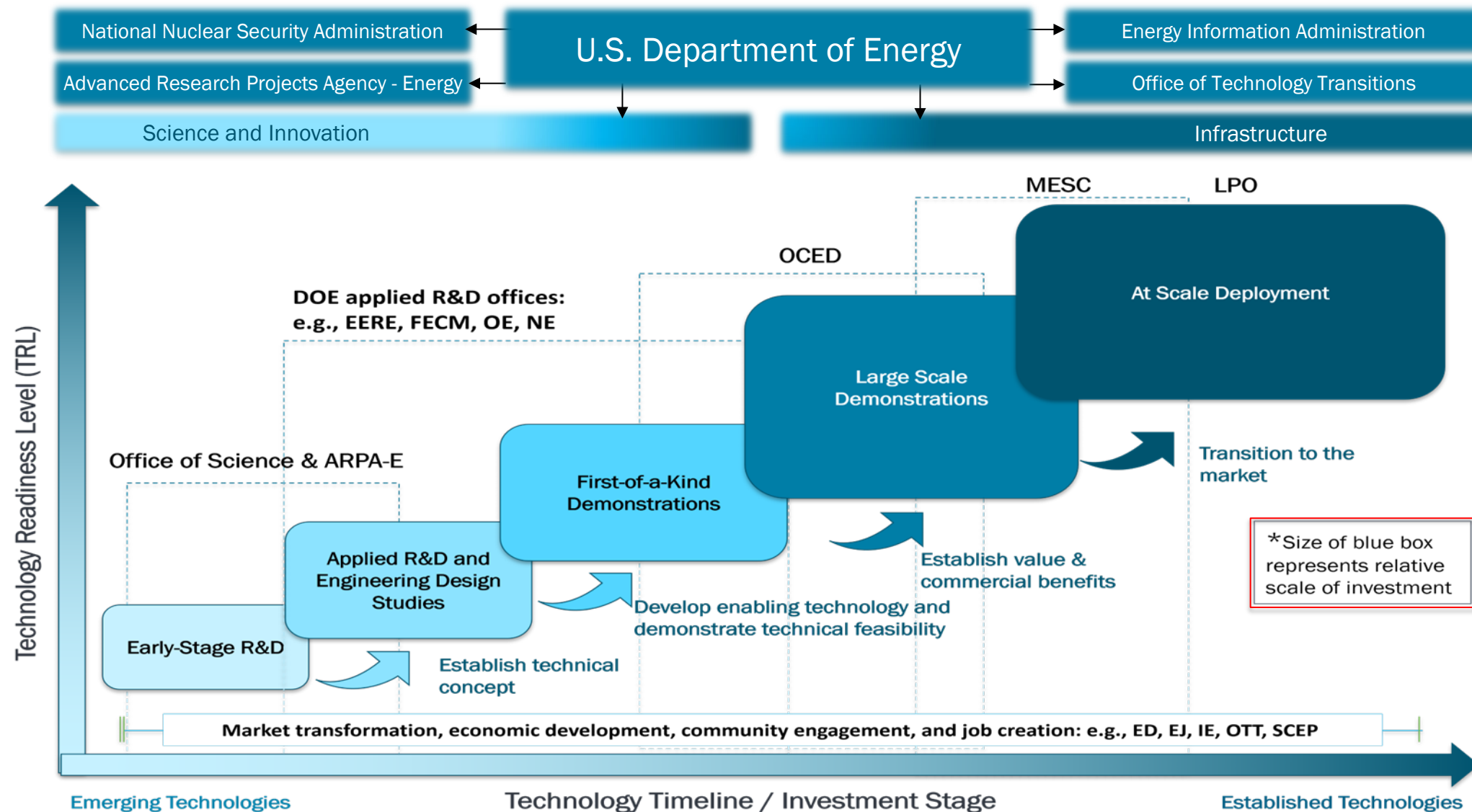
Roadmap Recommendations

- Advance Early-Stage RD&D
- Invest in Multiple Process Strategies
- Scale through Demonstrations
- Address Process Heating
- Decarbonize Electricity Sources
- Integrate Solutions
- Conduct Modeling and System Analyses
- Engage Communities, Develop a Thriving Workforce

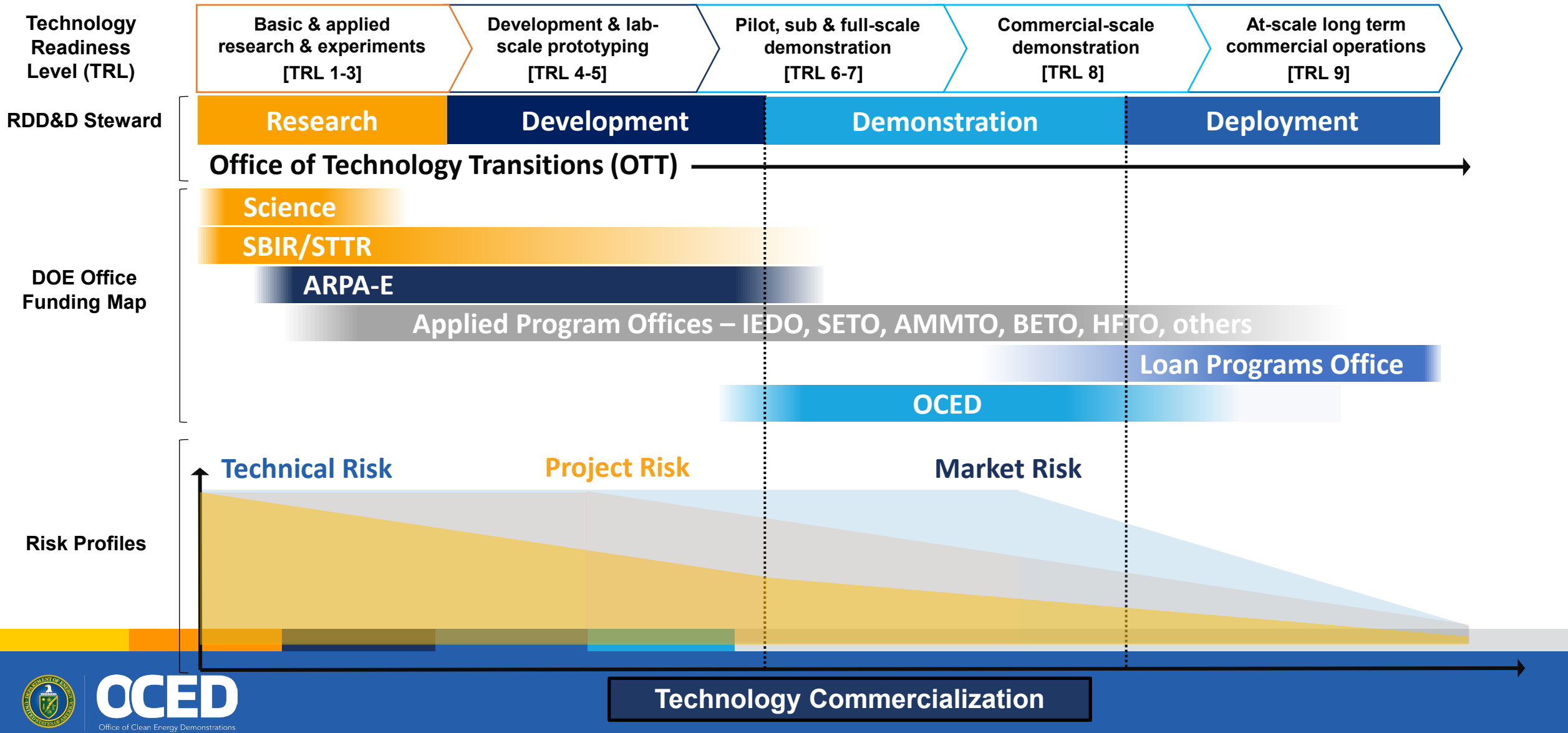
More in-depth sector assessment is coming soon

DOE Industrial Decarbonization Roadmap, September 2022. <https://www.energy.gov/eere/doe-industrial-decarbonization-roadmap>

U.S. Department of Energy's RD&D Landscape



Roles Across RDD&D Continuum



OCED: \$6.3 Billion Federal Investment in Industrial Demonstration

\$20+ billion investment

for transformational, advanced industrial facilities to

Solidify a first-mover advantage for U.S. industry in low- and net-zero carbon manufacturing

Substantiate the market for clean products through high-impact, replicable solutions

Build broadly shared prosperity for American workers and communities

Across **hard-to-abate sectors** including:



Aluminum
& Metals



Cement &
Concrete



Chemicals &
Refining



Process
Heat



Food &
Beverage



Glass &
Ceramics



Iron &
Steel



Pulp &
Paper

OCED: 33 Awards (including 3 for Food and Beverage Sector)

HEAT

3 GLASS |
3 FOOD & BEVERAGE |
2 PROCESS HEAT

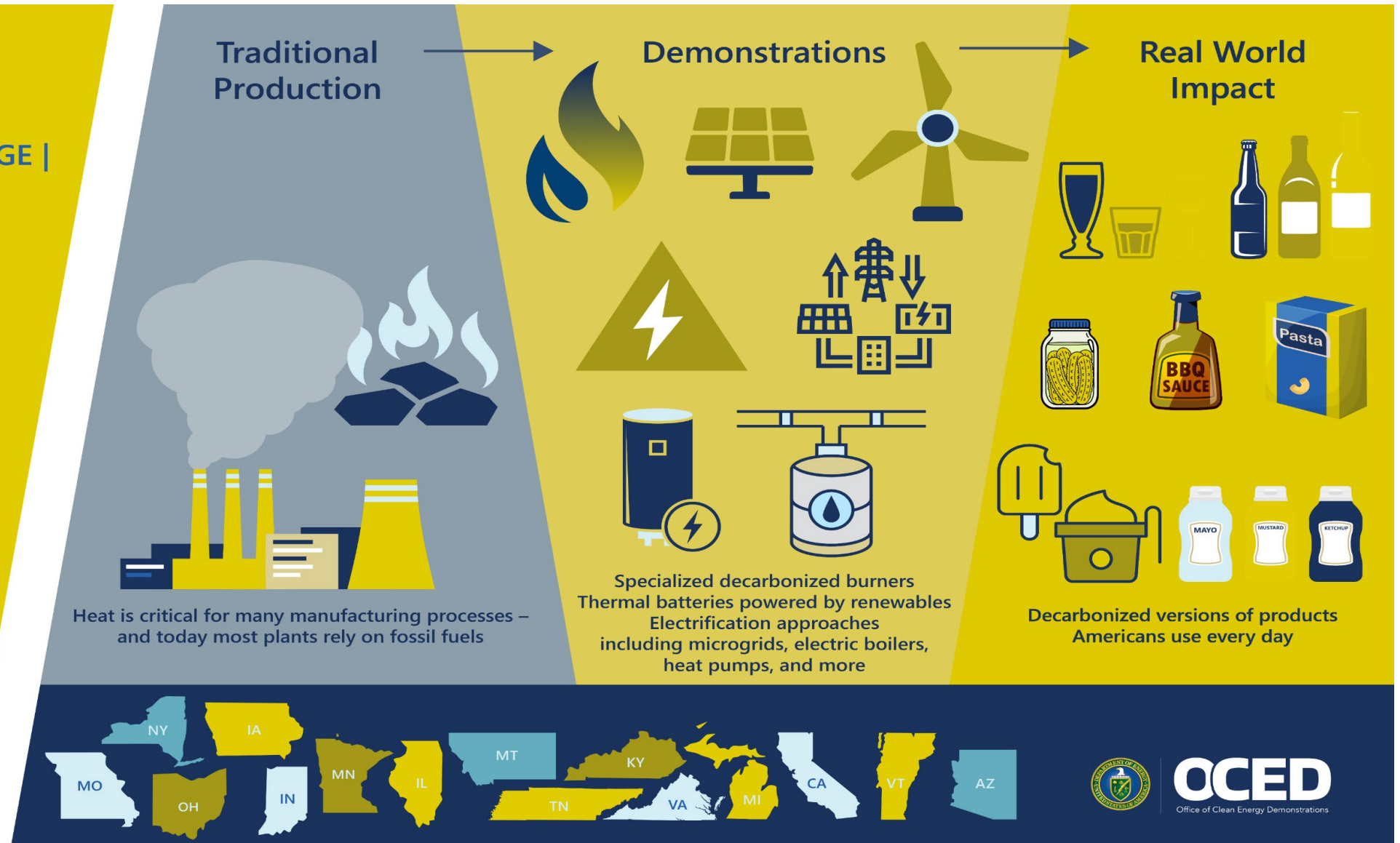
8

projects

\$700M+
federal investment

1.5M
metric tons CO₂
avoided annually

Note: Anticipated based on information provided to the Department of Energy as of March 2024



IEDO's Research & Development Strategy

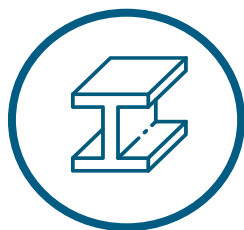
Mission: IEDO leads the development and accelerates the adoption of sustainable technologies that increase efficiency and eliminate industrial GHG emissions

IEDO invests in both **sector-specific** technology solutions and **cross-cutting** technologies that can be applied across the industrial sector.



- Cross-Sector Technologies
- Energy and Emissions Intensive Industries
- Technical Assistance and Workforce Development

The **Energy and Emission Intensive Industries (EII)** subprogram accelerates the readiness of emerging, sector-specific technologies to decarbonize the most energy- and emissions- intensive industrial subsectors



IRON & STEEL
1,469 TBtu
100 MMT CO₂e



CHEMICALS
4,842 Tbtu
332 MMT CO₂e



FOOD & BEVERAGE
1,935 TBtu
96 MMT CO₂e



FOREST PRODUCTS
2,883 TBtu
80 MMT CO₂e



CEMENT & CONCRETE
367 TBtu
66 MMT CO₂e



The **Cross-Sector Technologies (CST)** subprogram accelerates the readiness of energy- and emissions- reducing components, systems, and operational technologies, across a broad range of industries



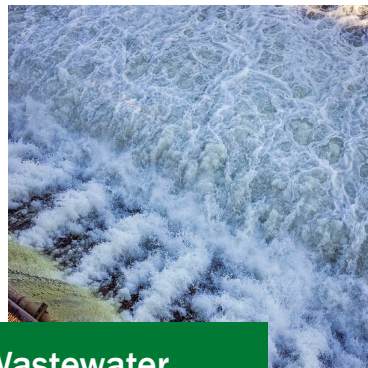
Thermal Processes



Low-Carbon Fuels,
Feedstocks, Energy Sources



Energy
Efficiency



Wastewater
Treatment

Chemicals and Refining Priorities

Crosscutting



- Carbon capture integration



- Low-carbon fuels
- Low-carbon & electrified process heating



- Waste heat recovery

Sector-Specific



- Sustainable feedstocks
- Electrochemical reactors
- High-efficiency thermal reactors
- Advanced separations
- Material reuse

Iron and Steel Priorities

Crosscutting



- Low-carbon fuels and electrification for heating



- Waste heat recovery

Sector-Specific



- Alternative reductants – hydrogen, ammonia for DRI/HBI; biomass for solid pig iron
- Molten ore processing – molten oxide electrolysis; hydrogen plasma direct smelting
- Carbon capture and storage on existing BF/BOF facilities

Cement and Concrete Priorities

Crosscutting



- Carbon capture from limestone decarbonation



- Electrification and low-carbon fuels



- Waste heat recovery

Sector-Specific



- Alternative binders and process routes
- Clinker substitutes
- CO₂ mineralization
- Alternative building materials

Forest Products Priorities

Crosscutting



- Carbon capture integration with boilers

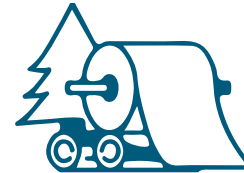


- Low-carbon fuels for lime kilns and boiler
- Process electrification



- Drying and dewatering innovations

Sector-Specific



- Increase biomass utilization
- Energy efficient separations for concentrating liquor
- Increase fiber yield of pulping
- Increasing solids content in paper forming

Food and Beverage Priorities

Crosscutting



- Low-carbon fuels or electrification for process heating

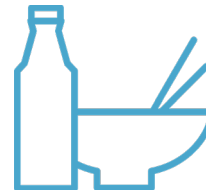


- Low-temperature waste heat recovery from process exhausts



- Drying and dewatering innovations, wastewater recovery and reuse

Sector-Specific



- Alternative protein production
- Waste management and reduction
- Innovative refrigeration solutions
- Sustainable food and beverage packaging
- Post-harvest and post-processing

IEDO Technical Assistance and Workforce Development



Public /private partnerships to help manufacturers and industrial organizations set and achieve long-term energy intensity reduction goals



Education and training for the current and future manufacturing workforce



No-cost tools and resources for manufacturers to reduce GHG emissions and improve energy efficiency and competitiveness



End-user support, stakeholder engagement, and technical services for the industrial sector

TAWD PRODUCTS INCLUDE:

ENERGY
ASSESSMENTS

PEER-TO-PEER
NETWORKING

TOOLS &
TRAINING

TECHNOLOGY
SCREENING

PROJECT
PROFILES

IEDO Technical Assistance & Workforce Development

Direct engagement with industry to drive the widespread adoption of proven technologies and practices to improve energy performance and reduce GHG emissions



Support the deployment of energy efficiency and decarbonization technologies and practices



Foster feedback from stakeholders on critical technology challenges that may be addressed through RD&D



- Expert technical assistance and training on energy efficiency
- Access to innovation and instruments
- National recognition for achievements



- Energy efficiency plus decarbonization technical assistance and training
- Facilitated peer-to-peer knowledge sharing
- National recognition for achievements



- Tools, guidance and recognition for facilities that implement an ISO 50001-based energy management system
- No-cost, self-paced, audit-free



- Regional network of Onsite Energy Tech Assistance Partnerships (TAPs)
- Site screenings for multi-technology solutions and advanced analysis
- Market analysis, outreach, and stakeholder engagement

NO-COST TOOLS AND SOFTWARE



MEASUR Software Suite



50001 Ready Navigator Tool



REopt Web Tool



Financing Navigator



Low Carbon Action Plan Tool



Carbon Inventory Calculator



Electrification Impact Calculator

Better Plants and Better Climate Challenge Impact



2.2 QBTU
of energy saved



\$10.6 billion
saved



1.8%
average annual
energy intensity
improvement rate



131 million
metric tons of CO₂ saved



14%
of the U.S.
manufacturing footprint

IEDO Funding Announcements



FY22 Industrial Efficiency and Decarbonization:

- \$135M for 40 projects to decarbonize the **five highest-emitting industrial subsectors**

FY23 IEDO Multi-Topic:

- \$171M for 49 projects to advance **high-impact applied RD&D** projects to decarbonize the U.S. industrial sector. Includes **sector-specific and cross-sector approaches**

FY24 IEDO CST and EEI Multi-Topic:

- \$121M funding opportunities for Applied Research and Development Projects to Advance Cross-Sector Technologies(\$38M) and Decarbonize the Energy- and Emissions-Intensive Industrial Subsectors (\$83M)

Decarbonization of Water Resource Recovery Facilities:

- \$27.8M for 10 projects to **decarbonize the entire life cycle of Water Resource Recovery Facilities**

Electrified Processes for Industry without Carbon (EPIXC) Institute

- \$70M over 5 years to bridge the gap between research and commercialization for novel electrification processes; and mobilize an **innovation ecosystem** of private companies, National Labs, universities, labor unions and community partners

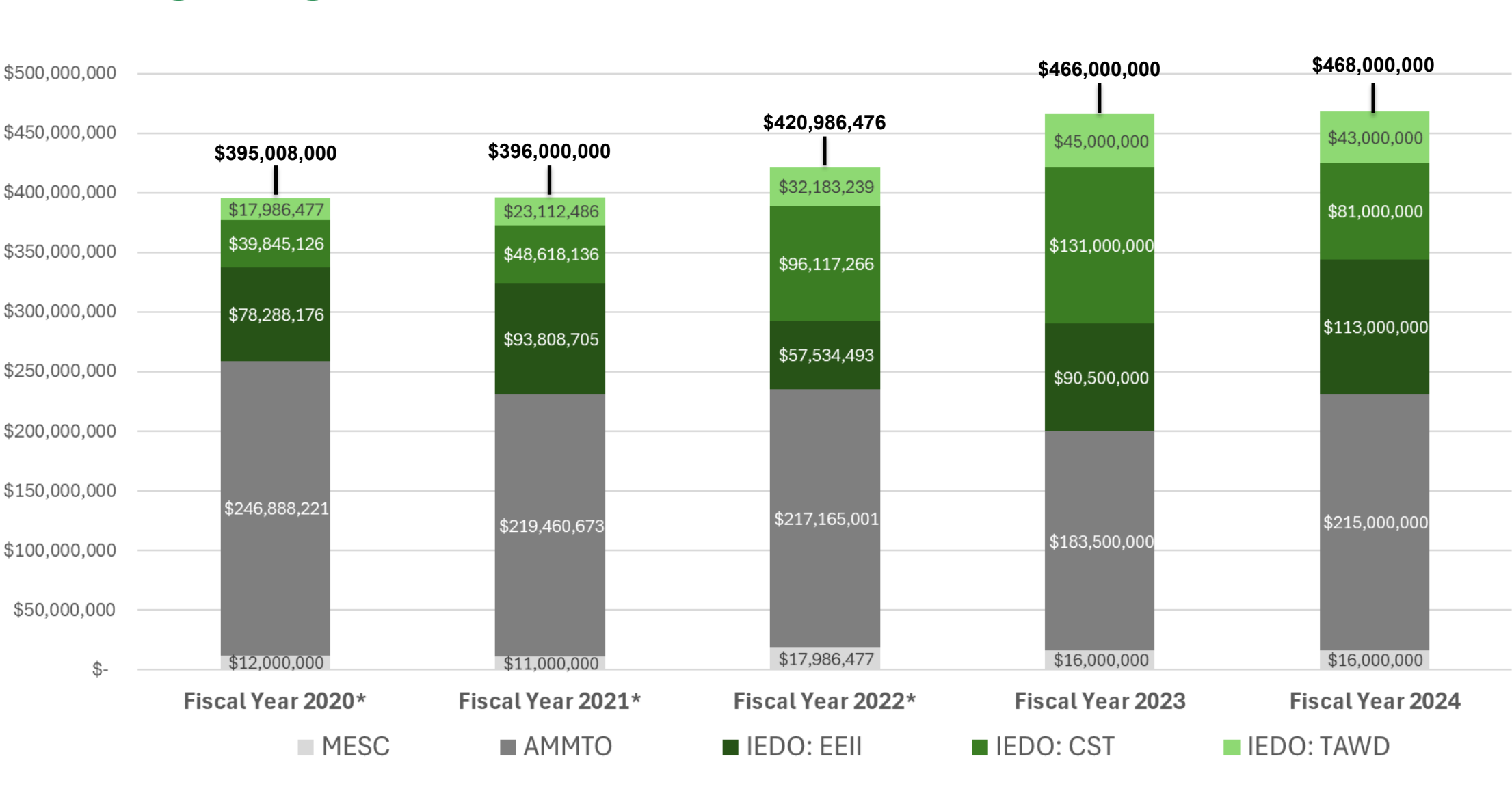
Rapid Advancement in Process Intensification Deployment (RAPID) Institute:

- \$40M for a second 5-year phase to drive more resilient, lower cost, and reduced energy and carbon footprint manufacturing in the **chemical process industries**

National Alliance for Water Innovation (NAWI) Hub

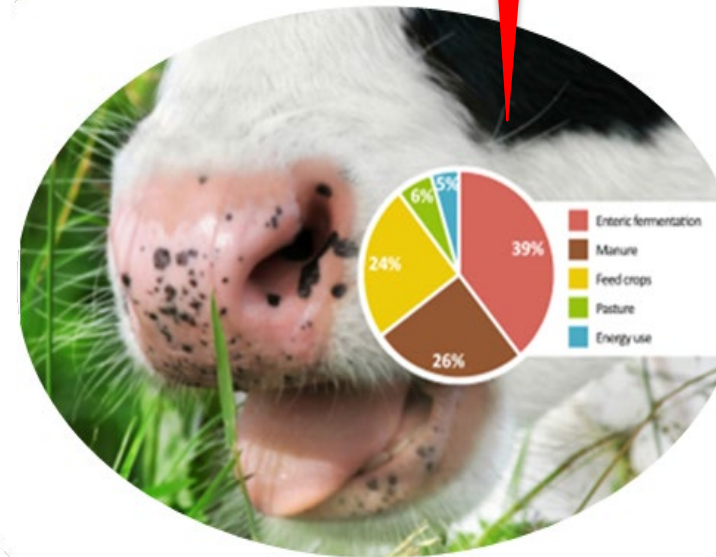
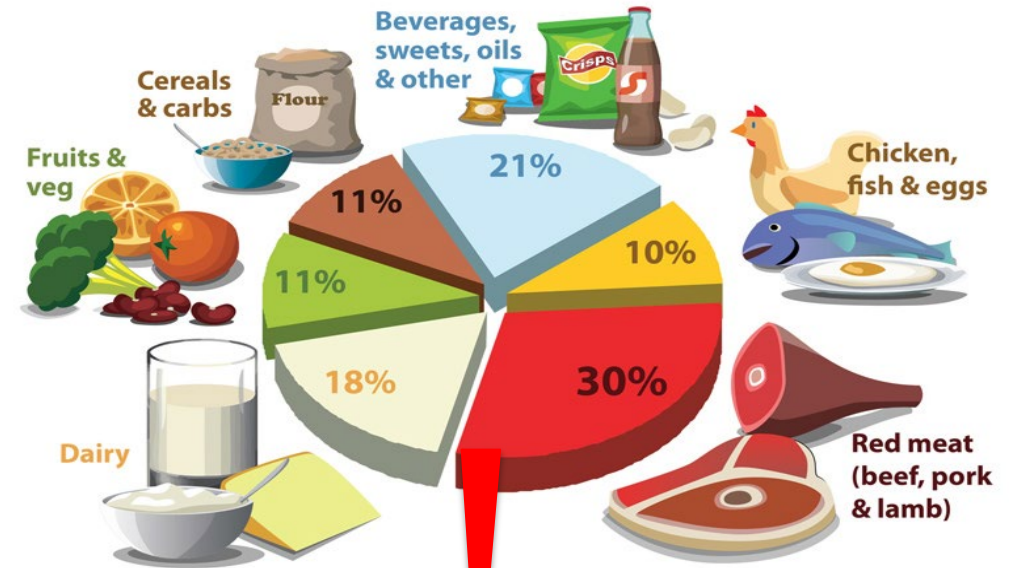
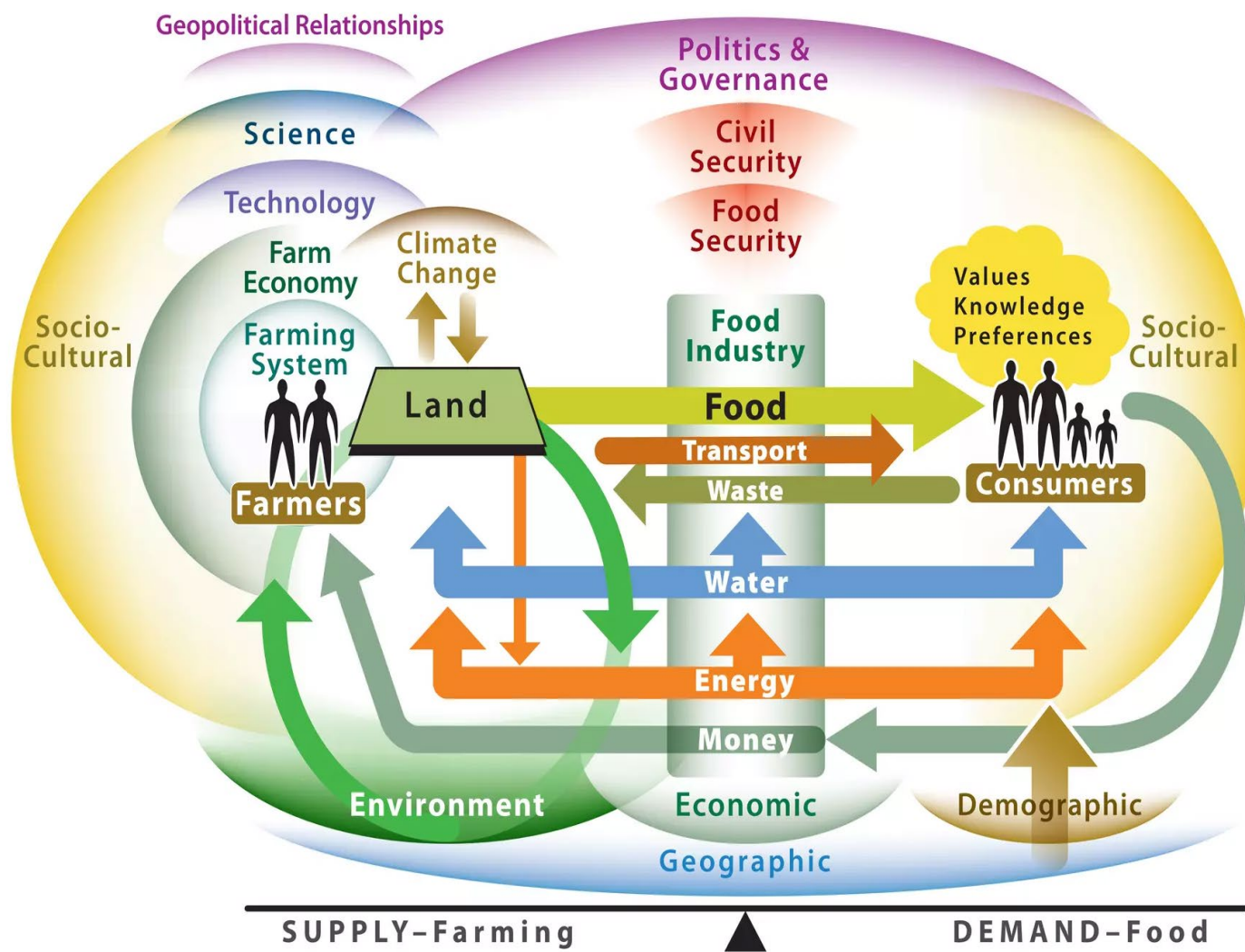
- \$75M for a 5-year renewal of DOE's Energy-Water Hub **focused on desalination and water-treatment technologies** to secure affordable and energy efficient water supplies from nontraditional water sources

Growing Budget for Industrial Decarbonization RD&D



* FY20–FY22 was the Advanced Manufacturing Office (AMO)

Food and Beverage Ecosystem



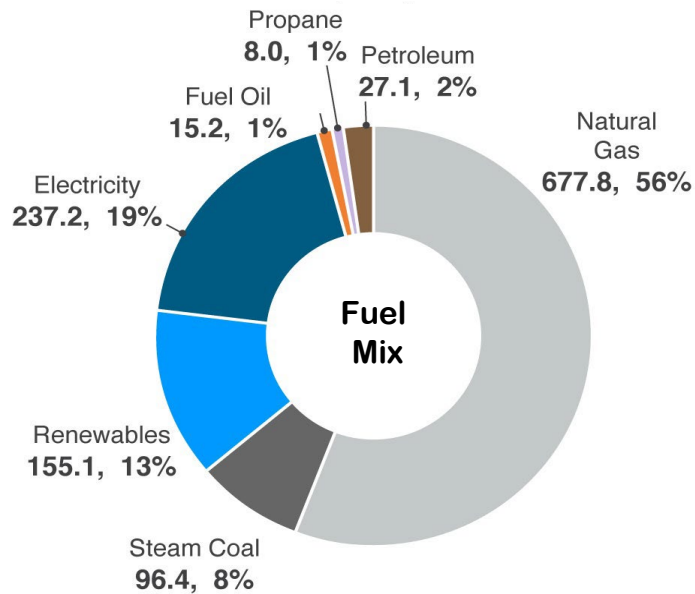
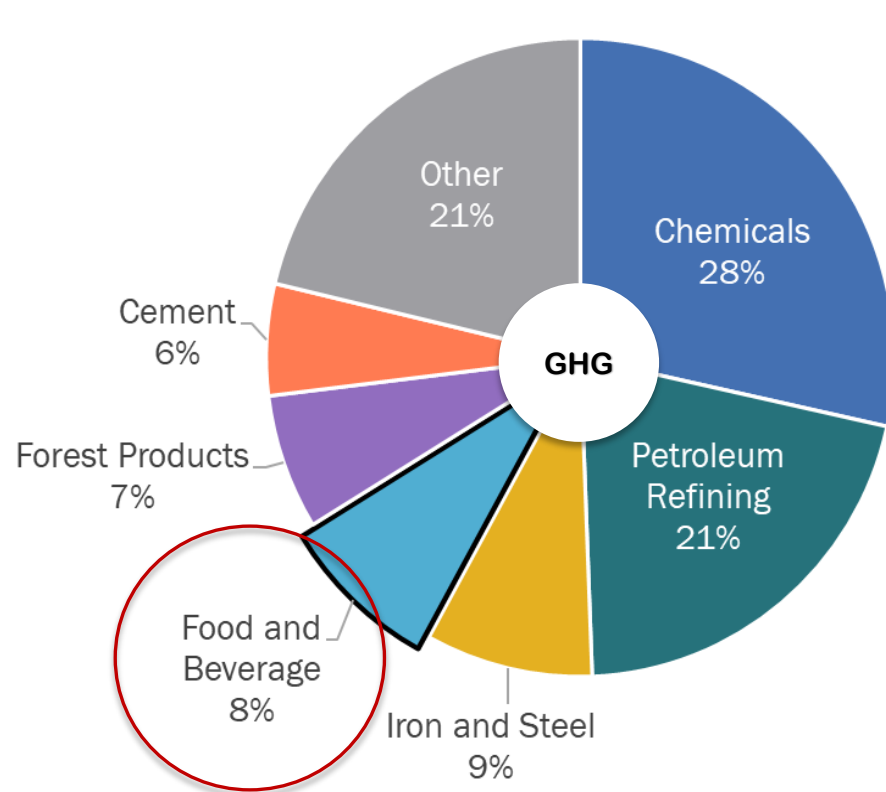
314 MMT CO2e/year
 US animal products industry + livestock agricultural emissions
 =
 CO2e to power to all US homes
 🐮 🥛 = 🏠

Resource: UK Government Office for Science (2011)

U.S. Food and Beverage Sector Overview

Food and Beverage Sector is a critical component of the U.S. economy:

- Over 58,000 establishments involved in food and beverage manufacturing [U.S. Bureau of Labor Statistics, 2024]
- Produced and shipped over \$1.2 trillion products and employed over 2 million workers [U.S. Census Bureau, 2024]
- Directly consumed ~ 2 quads of energy and accounted for ~ 96 MMT of GHG emissions [MECS 2018]



Sources:

DOE [Industrial Decarbonization Roadmap](#), September 2022

AMO [Thermal Process Intensification report](#), May 2022

USCB [Annual Survey of Manufacturers](#), 2019

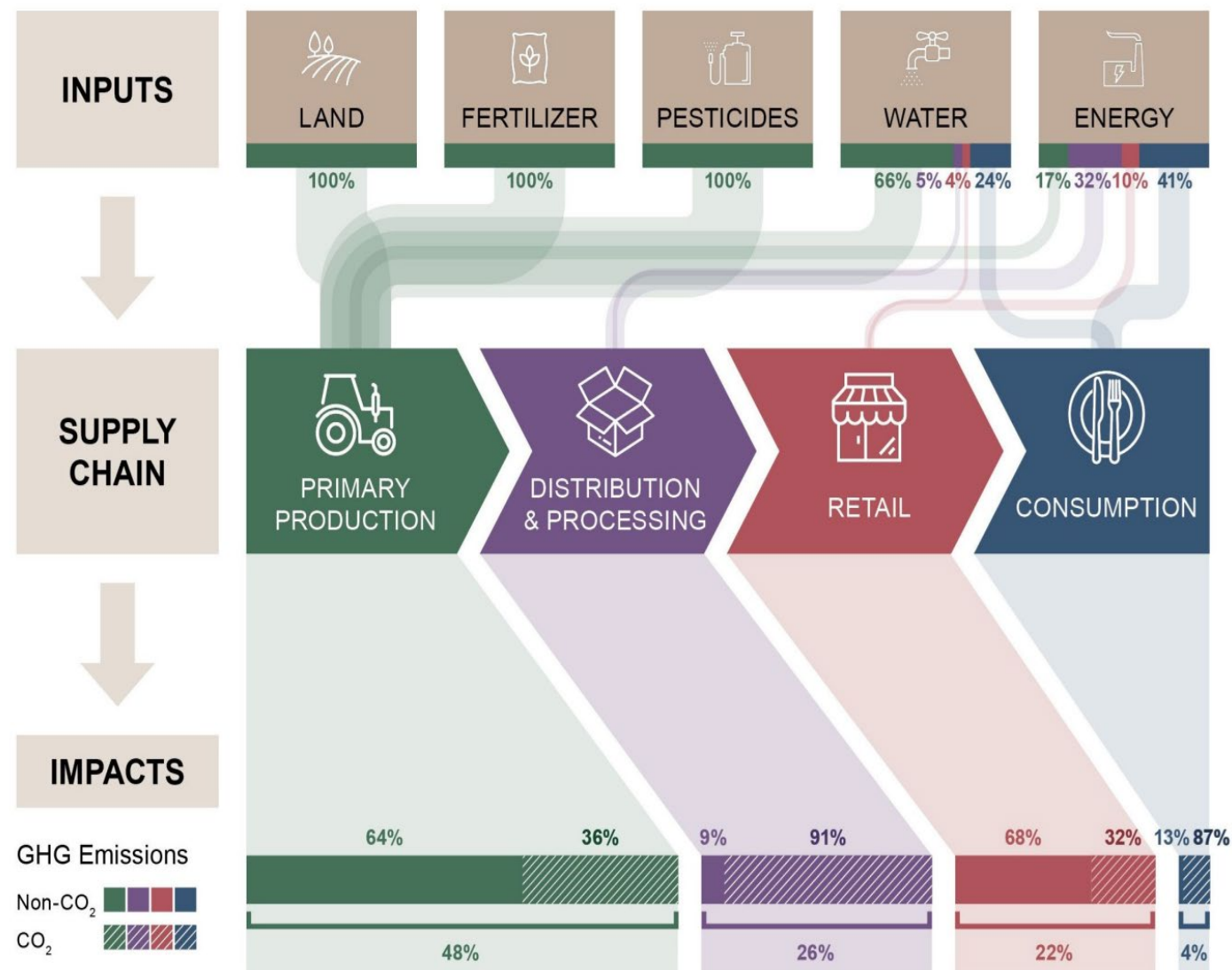
USDA ["Manufacturing: Food and Beverage Manufacturing"](#), 2021

U.S. Bureau of Labor Statistics, www.bls.gov, 2024

U.S. Census Bureau, <https://data.census.gov>, 2024

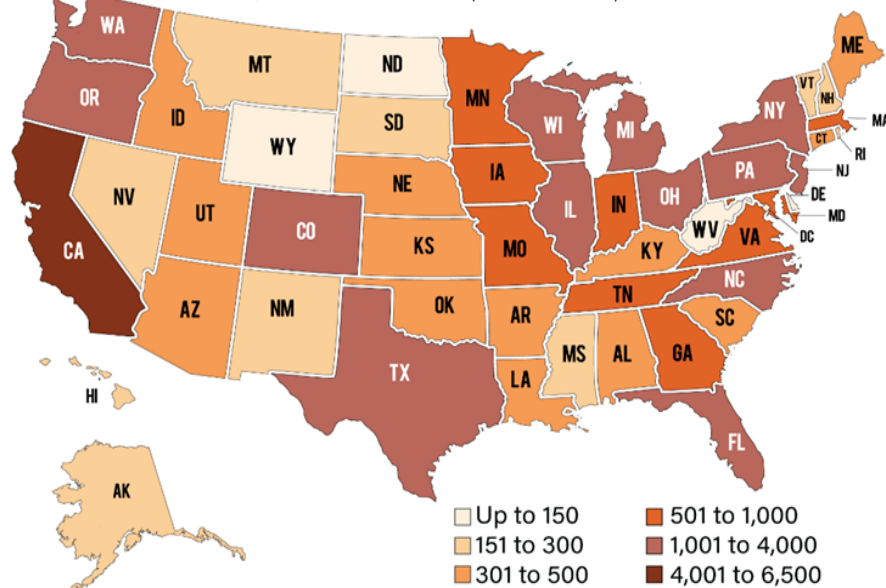


Environmental Impact Nationwide

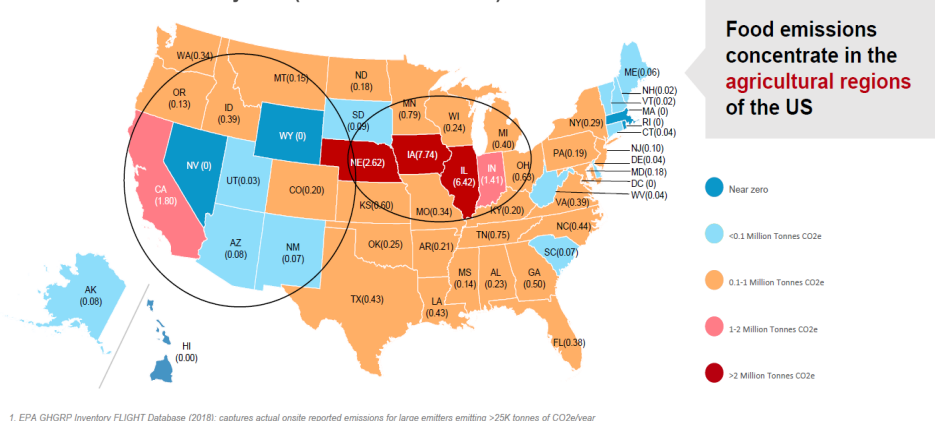


Food and beverage manufacturing establishments, 2020

Source: USDA, Economic Research Service (2020 US DOC data)

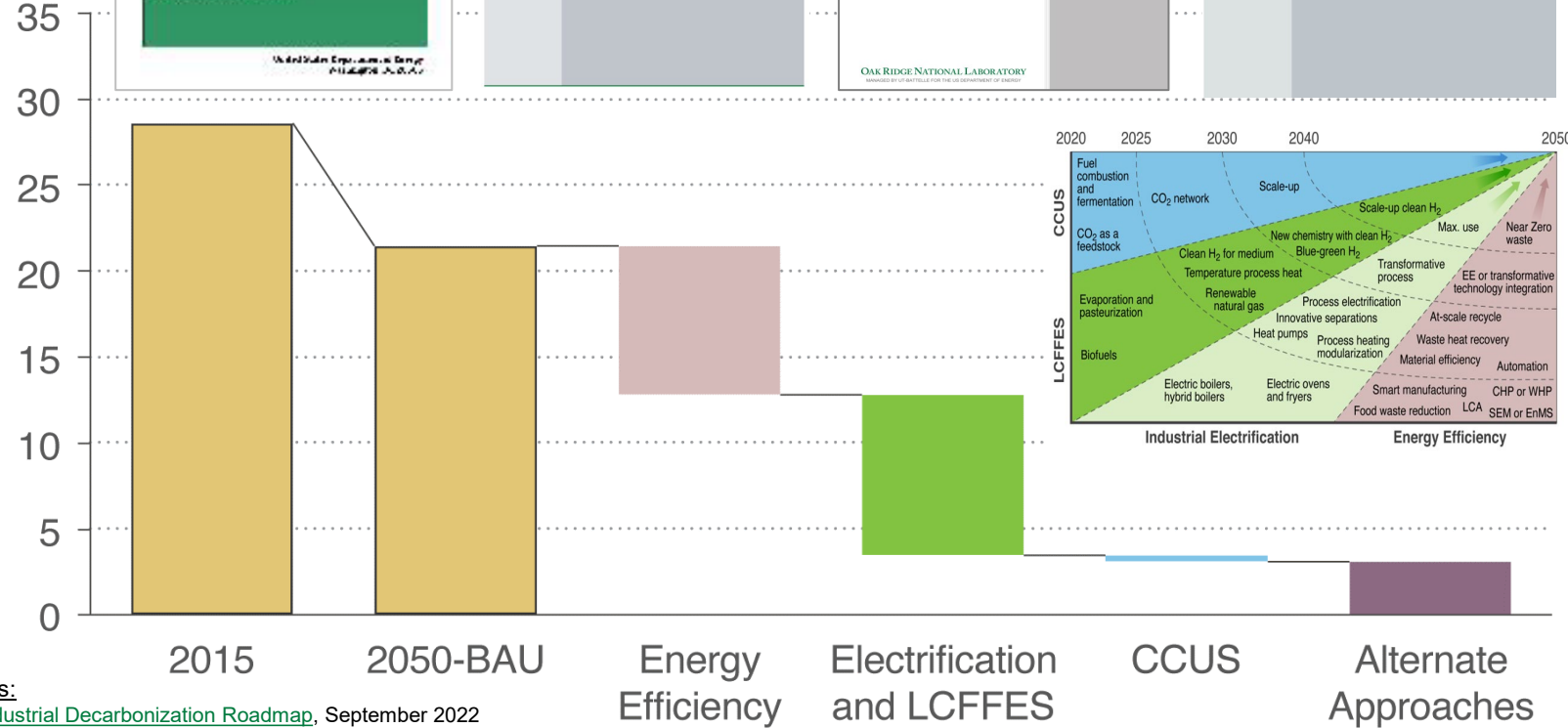


Food thermal emissions by state (Million Tonnes of CO₂e)¹

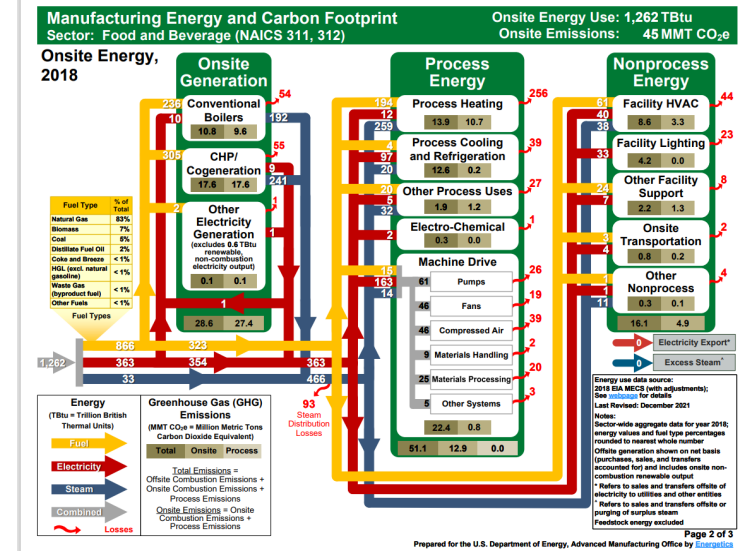
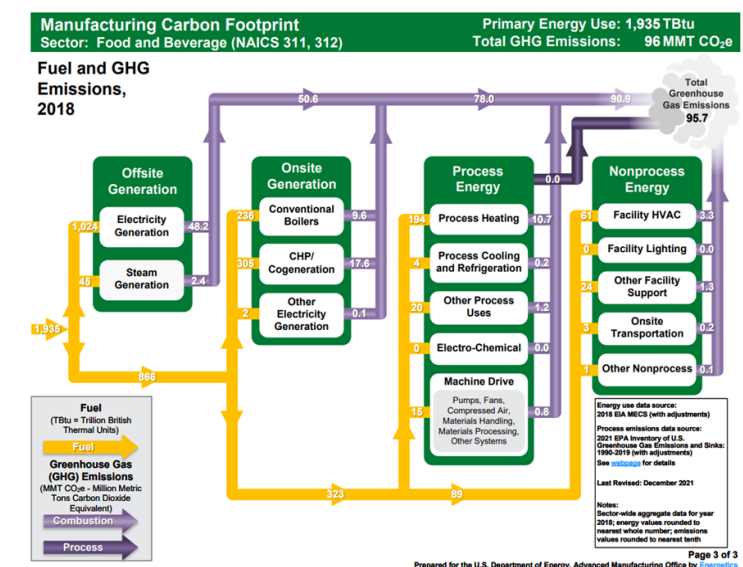
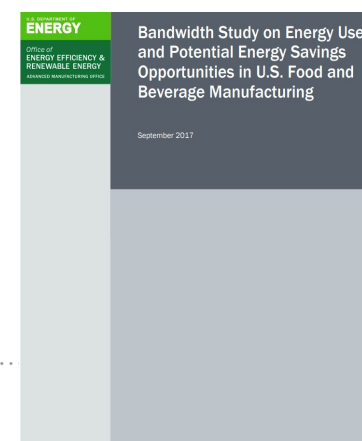
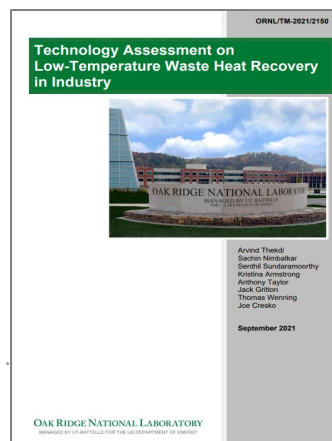
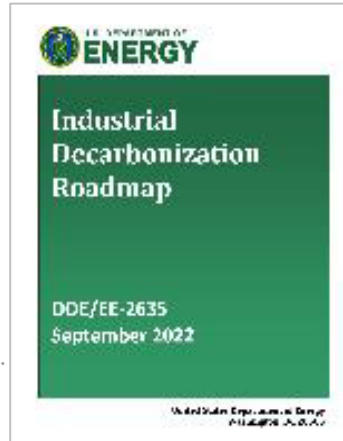


Impact Analysis and 2015-2050 Decarbonization Forecast*

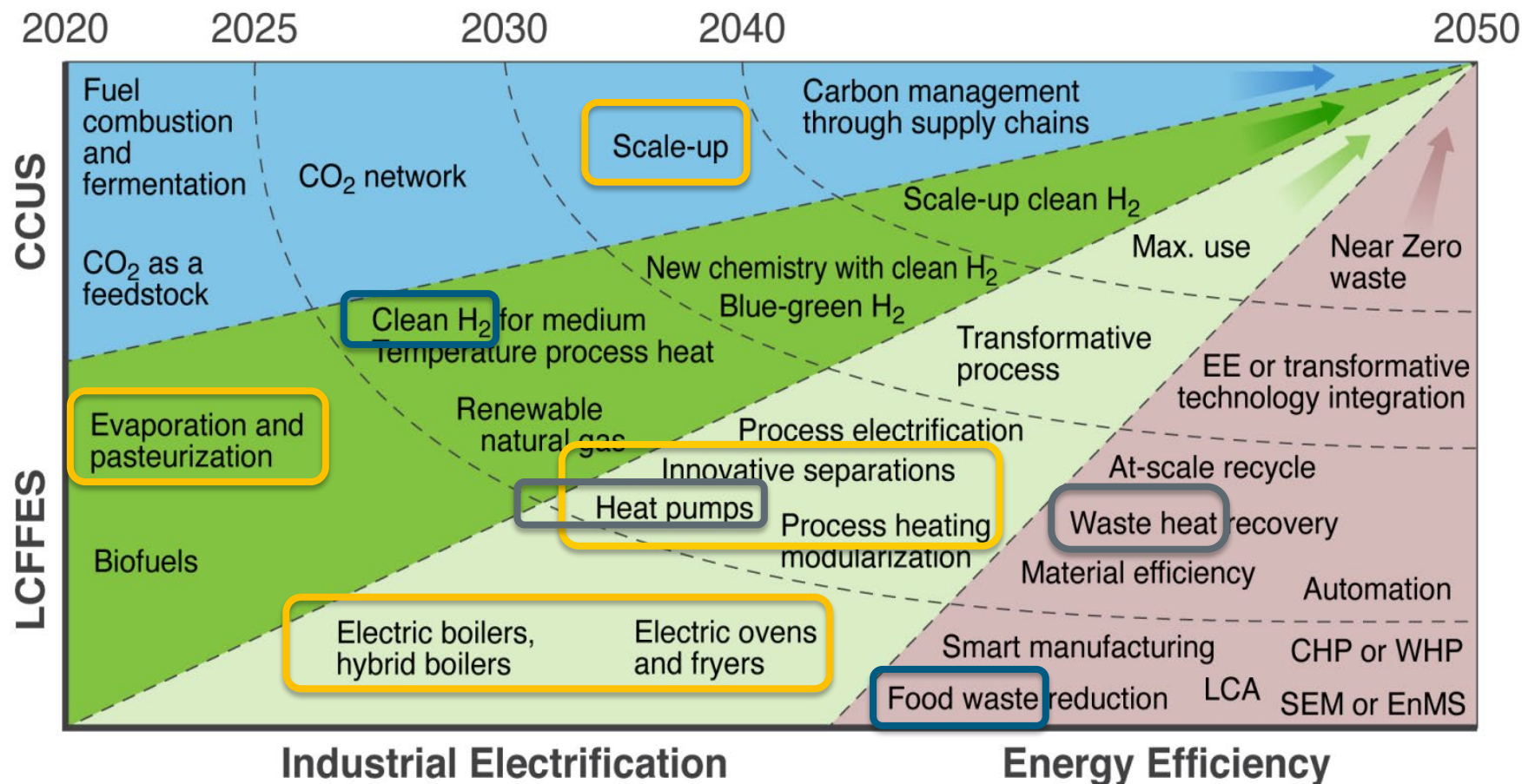
CO₂ Emissions (million MTCO₂)



Sources:
DOE [Industrial Decarbonization Roadmap](#), September 2022
AMO [Thermal Process Intensification report](#), May 2022
AMO [Bandwidth Study U.S. Food and Beverage Manufacturing](#), December 2017
ORNL [Technology Assessment on Low-Temperature Waste Heat Recovery in Industry](#), September 2021



Landscape of Needed RD&D Investment



Industrial GHGs require approaches at multiple levels:

Core process

Facility

Beyond plant bounds

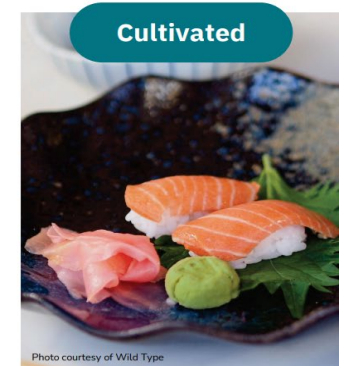
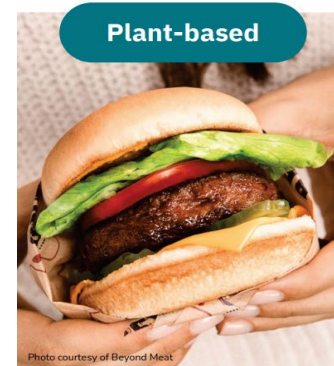
Landscape of major RD&D investment opportunities for industrial decarbonization between now and 2050

LCFFES = Low Cost Fuels, Feedstocks, and Energy Sources; CCUS = Carbon Capture Utilization and Storage

Source: [Industrial Decarbonization Roadmap](#)

Trends Affecting the Future of Food System

- U.S. Population Growth
 - 16% projected increase through 2050¹
- FDA Proposed Revisions of “Healthy” Claim on Packaging²
 - Aim to reduce diet-related diseases by 2030
 - 80% of population not eating enough vegetables and fruits
- Consumers Preferences³
 - Rethinking the Value Equation**: increased interest in nutritious foods
 - Private Label**: trading down brands for more affordable private labels
 - Consuming Consciously**: sustainability-focused products
 - Plant-Based Products**: significant growth in sales
 - Foods for Health**: functional foods in addressing health issues
- Global Food Traceability
- Local Changes in Fuel Mix
- Energy and Water Demand and Availability
- Environmental Policies and Compliance Rules
- Urban Expansions
- Sector is expected to grow by ~ 70%⁴



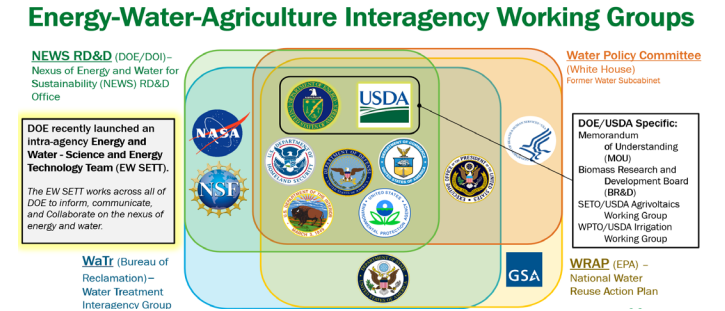
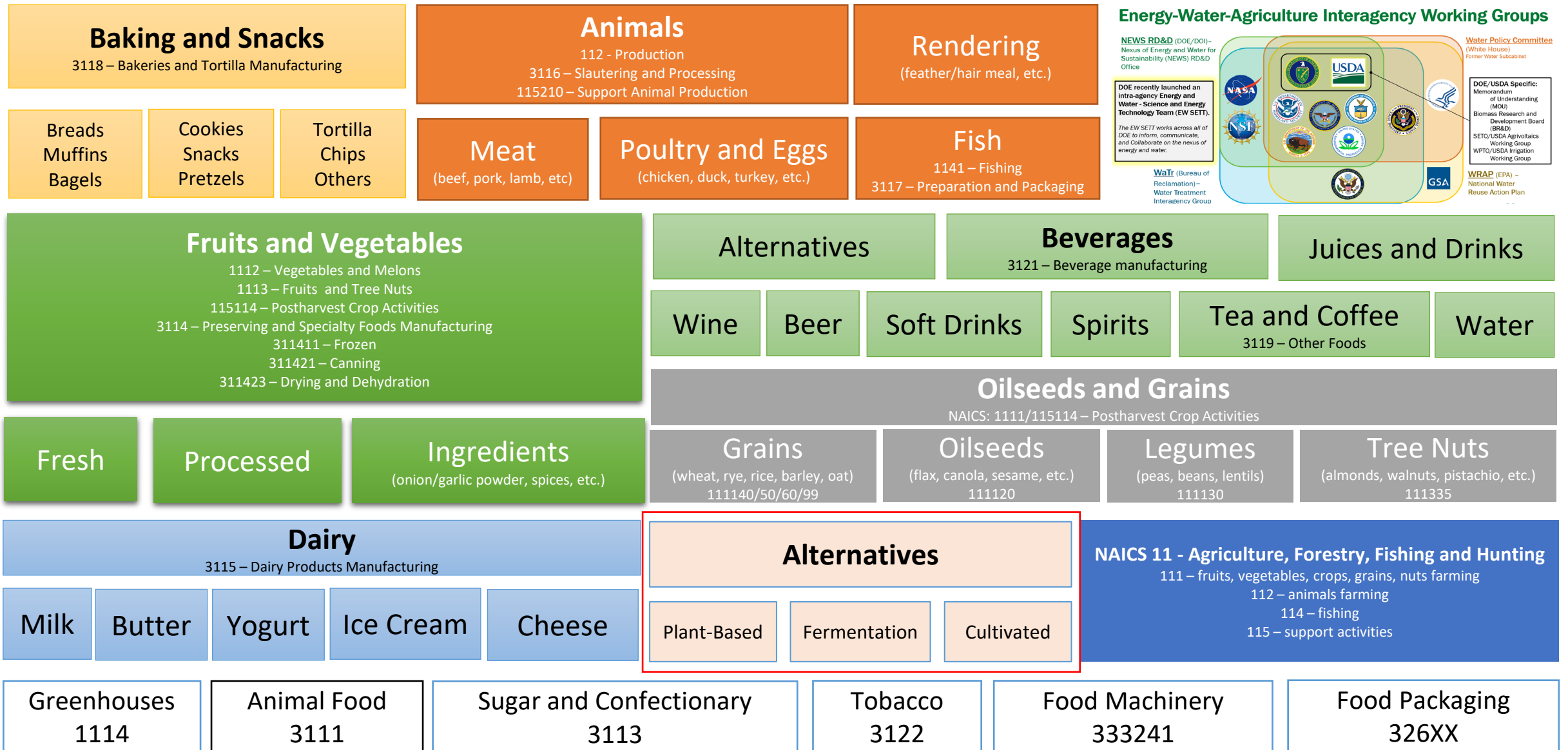
(1) U.S. Census Bureau, Population Projections for the U.S. 2017-2060

(2) FDA News Release, Updated Definition of “Healthy Claim”. 2022

(3) Institute of Food Technologists (IFT), Outlook 2023: Consumer Trends

(4) American Energy Outlook, 2021

There is no one stakeholder representing the entire U.S. Food and Beverage Industry



EEL Food and Beverage Portfolio and Budget

INHERENTLY THE PORTFOLIO WAS FOCUSED ON FOOD AND BEVERAGE MANUFACTURING: NAICS 311-312

FOA-0002804 (FY22)

- Low Carbon Process Heating and Cooling Solutions
- 3 awards **[\$11.6M]**

FOA-0002997 (FY23)

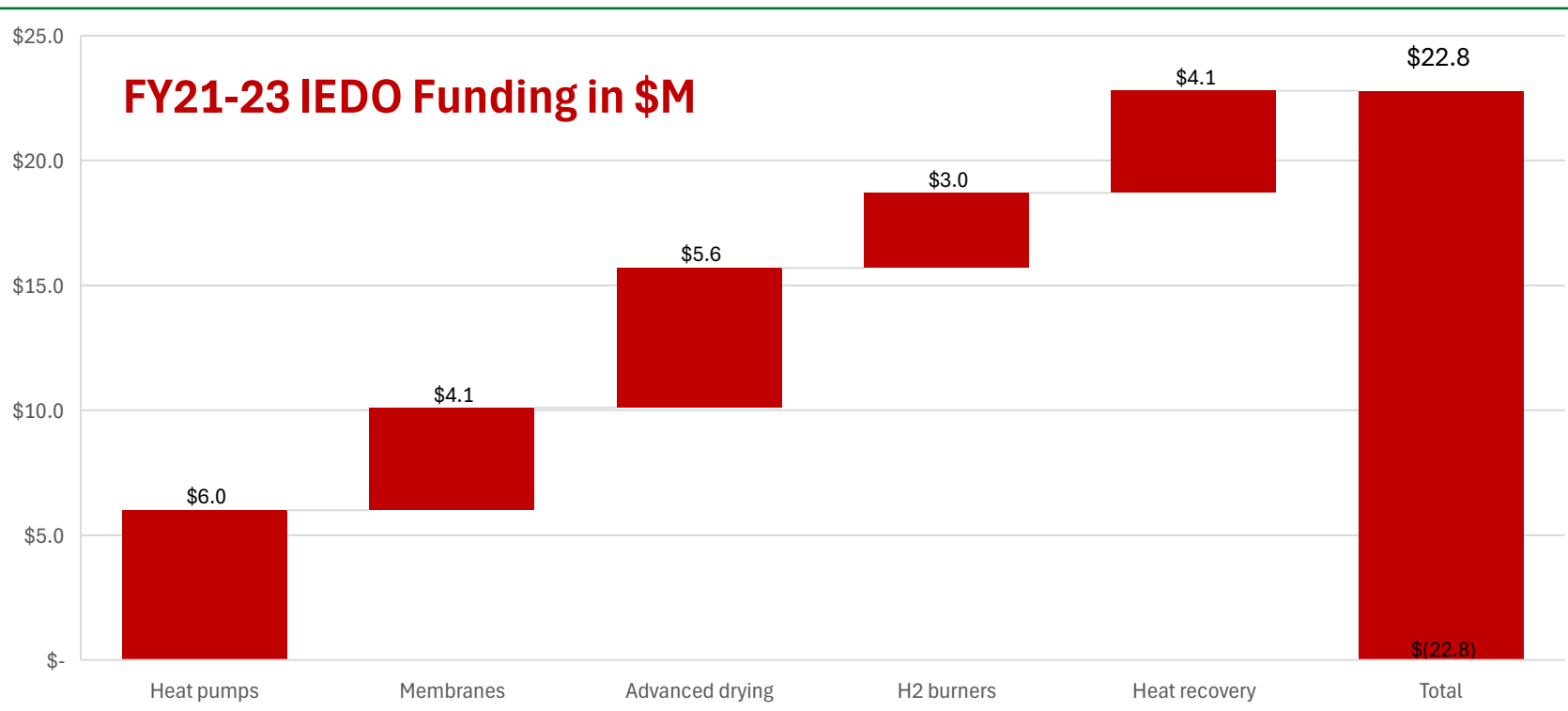
- Low- and Zero-Carbon Solutions for Food and Beverage Process Heating, Cooling and Refrigeration
- 4 awards **[\$11.2M]**

FOA-0003219 (FY24)

- Sustainable food packaging
- Alternative proteins and foodservice
- Energy use optimization **[TBD]**

FY25 Tentative Priorities

- Sustainable food packaging
 - ✓ Materials and designs
 - ✓ Shelf-life extension
 - ✓ Food waste reduction
- Alternative proteins
 - ✓ Scope 1-2 reduction
 - ✓ Bioreactors, NPD
- Advanced refrigeration
 - ✓ Refrigeration efficiency
 - ✓ Energy recovery
- Post-harvest and post-processing
 - ✓ Washing, drying, sorting
 - ✓ Warehousing
- Energy use optimization
 - ✓ Primary input redistribution
 - ✓ Heat and water recovery

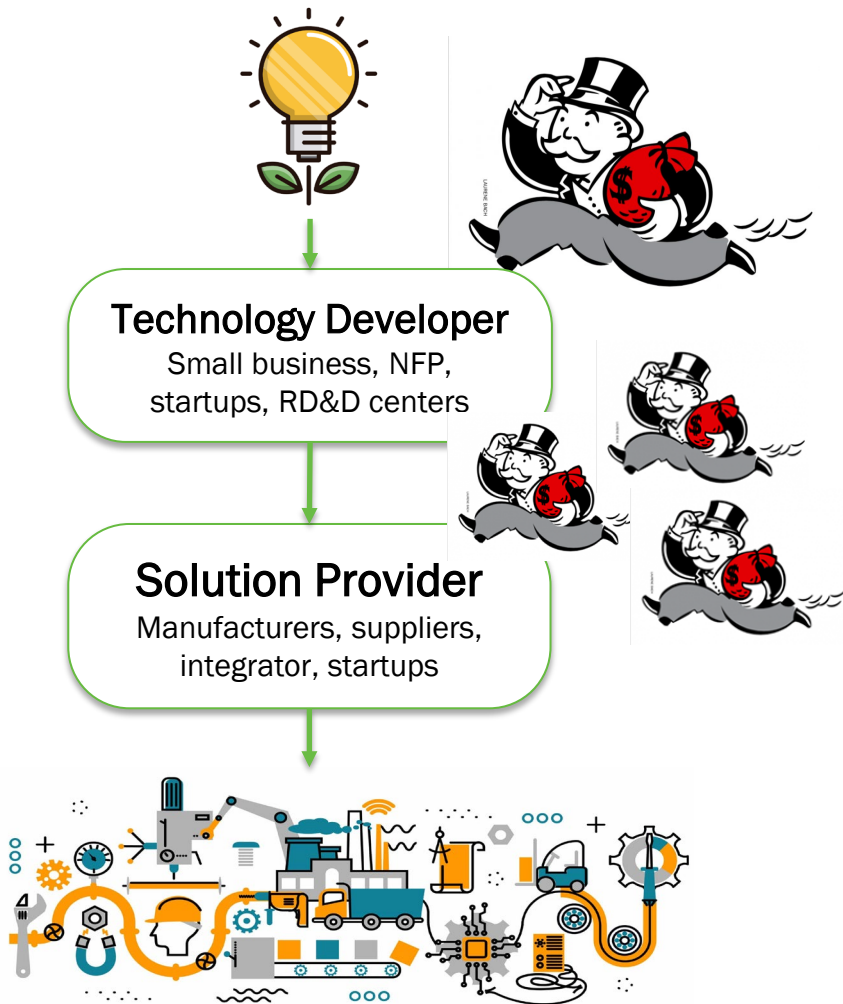


Food and Beverage RD&D Portfolio – Planning



- Focus on innovative and transformational concepts
 - TRL3 through TRL7 along with compelling TEA and lifecycle analysis
 - Multi-scale spectrum of technology demonstrations (laboratory, pilot, field)
 - Target commercialization across the prioritized areas by 2030
 - Proven decarbonization impact (> 85% GHG reduction)
- Continue stakeholder engagement activities
 - Site visits, workshops, roundtables to refine the challenges and priorities
 - Accelerate adoption of decarbonization technologies
- Active collaboration on industrial decarbonization agenda
 - U.S. DOE offices: AMMTO, SETO, FECM, HFTO, BETO, OCED, ARPA-E
 - National laboratories and strategic analysis teams (ongoing Roadmap Extension)
 - Interagency programming: USDA, DOD, NASA, FDA, EPA, NIH, DOI, others
 - USDA: Climate-Smart Partnership \$1B+, CEA, Post-harvest, Alternative proteins
 - State Energy Offices: CEC (IAW Program, FPIP \$100M+), NYSERDA, others

Idea to Market Pathway



EERE Funding Opportunities

<https://www.energy.gov/eere/funding/eere-funding-opportunities>

SBIR/STTR Funding Opportunities

<https://science.osti.gov/sbir/Funding-Opportunities>

IEDO Funding Opportunities

<https://www.energy.gov/eere/iedo/iedo-funding-opportunities>

OCED Funding Opportunities

<https://www.energy.gov/oced/oced-funding-information>

FECM Funding Opportunities

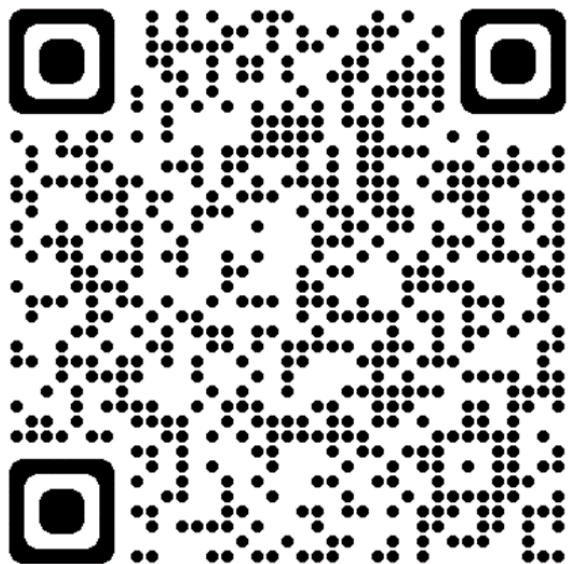
<https://www.energy.gov/fecm/solicitations-and-business-opportunities>

OTT Funding Opportunities

<https://www.energy.gov/technologytransitions/technology-commercialization-fund>

Teaming Partner List via EERE eXCHANGE

IEDO is Hiring – Join Our Team!



www.energy.gov/eere/iedo/iedo-careers

Email: IEDOJobs@ee.doe.gov

We seek to create a workforce that reflects the diversity of Americans and ensures that all Americans benefit from a decarbonized industrial sector



Increasing **Diversity** in Partnerships, Applicant FOA pool, and FOA Reviewers



Identifying **Equity**-related barriers that impact communities



Using **Inclusive** Language to welcome broader participation in funding opportunities



Expanding **Accessibility** for Disadvantaged Communities (DACs), including through community-based stakeholder engagement

IEDO is committed to empowering diverse communities and amplifying best practices for DEIA internally and externally





**Comments?
Questions?
Concerns?**