U.S. DEPARTMENT OF ENERGY

Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

Advanced Manufacturing Office

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manufacturing.energy.gov

Presentation for the Hydrogen and Fuel Cell Technologies Office Annual Merit Review
May 2020

EERE's Advanced Manufacturing Office (AMO)

U.S. DEPARTMENT OF ENERGY

Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

Advanced Manufacturing Office

BUDGET

$395M

FY20

WHAT WE DO

Partner with industry, academia, states, and National Laboratories **to catalyze R&D and the adoption of advanced manufacturing technologies and practices**

R&D Projects

FY20 = $151M

R&D Consortia

FY20 = $199M

Technical Assistance

FY20 = $45M

AMO Guiding Principles

AMO works to **increase energy and material efficiency in manufacturing** to drive energy productivity and economic growth.

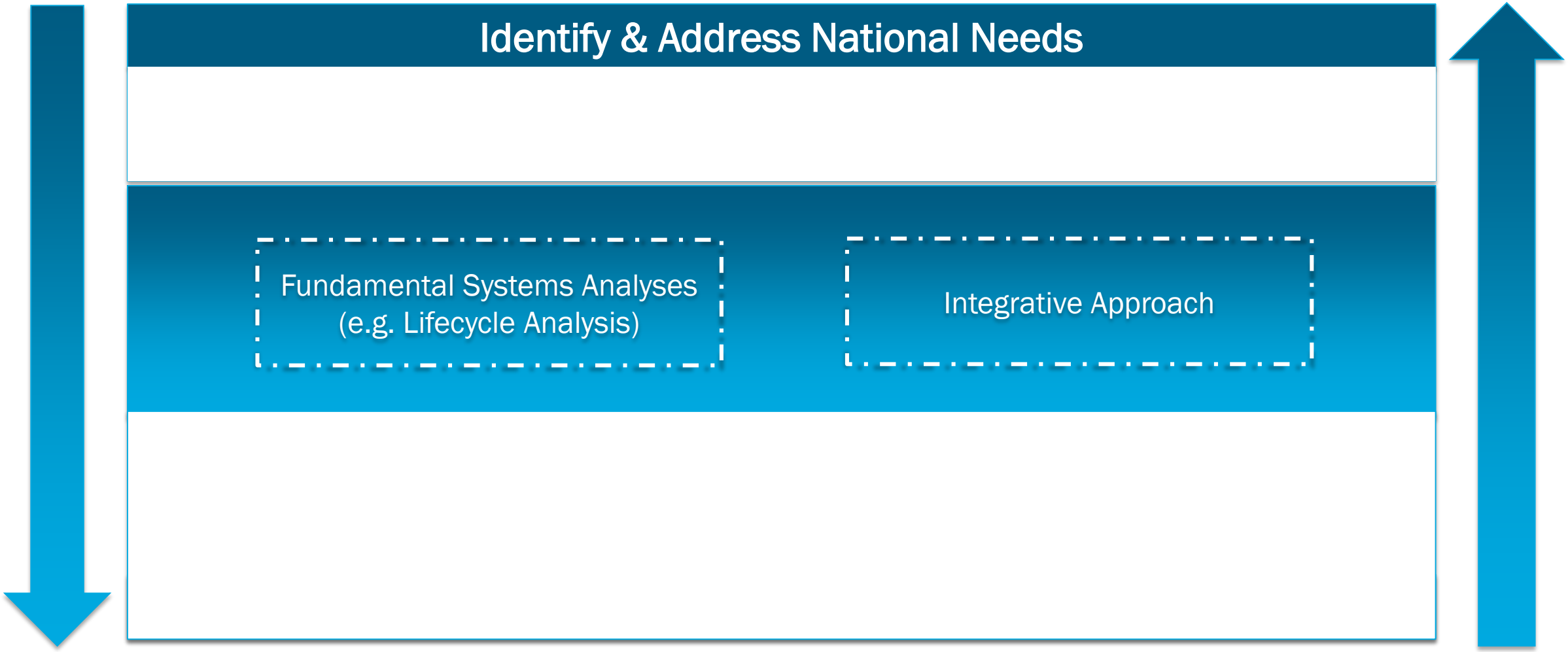
MANUFACTURING

- Uses roughly 25% of the nation's primary energy
- Represents nearly 80% of energy use in energy-intensive sectors
- Generates 11% of the U.S. GDP and 13 million jobs
- Incurs $200 billion in energy costs annually

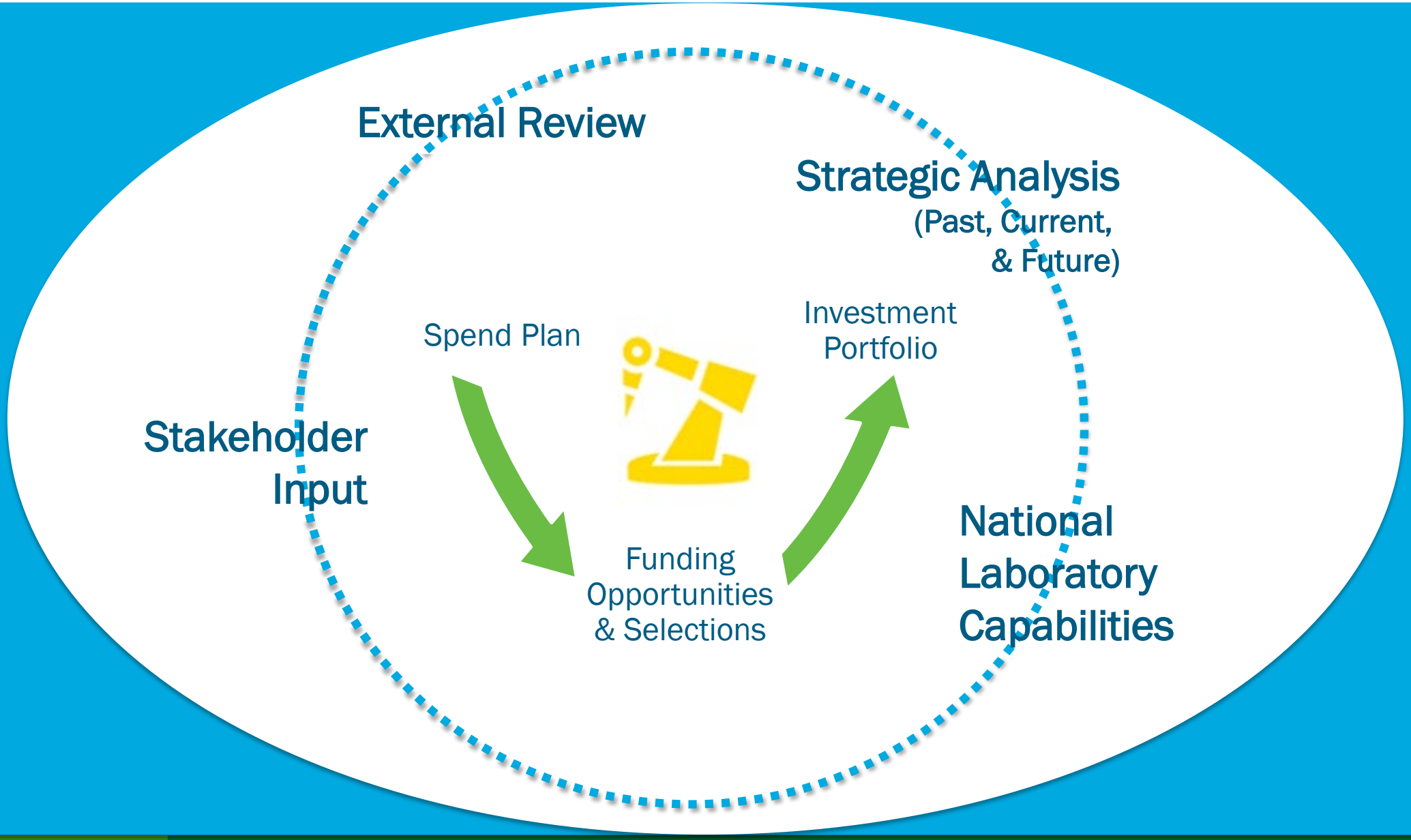
AMO GOALS

- Improve the **productivity, competitiveness, energy efficiency, and security** of U.S. manufacturing
- Reduce the **life cycle energy and resource impacts** of manufactured goods
- Leverage diverse **domestic energy resources and materials** in U.S. manufacturing, while strengthening environmental stewardship
- Transition DOE-supported innovative technologies and practices into **U.S. manufacturing capabilities**
- Strengthen and advance the **U.S. manufacturing workforce**

Framework to Shape AMO's Portfolio



AMO Strategic Process



Stakeholder Input

National Laboratory Listening Sessions

Forward-looking conversations to collaborate on **new R&D opportunities** and investigate **future manufacturing needs and trends**

WHAT WE HEARD

- The National Laboratory complex is well-positioned to address national needs in manufacturing.
  EX: CRITICAL MATERIALS | ENERGY STORAGE | CIRCULAR ECONOMY
- Each National Laboratory brings unique domain expertise to solve key U.S. manufacturing challenges.
- National Laboratories offer specialized equipment, expert staff, infrastructure, and platforms for industry collaboration.
- Sessions underscored the need for advances in computation and materials science to transform U.S. manufacturing.

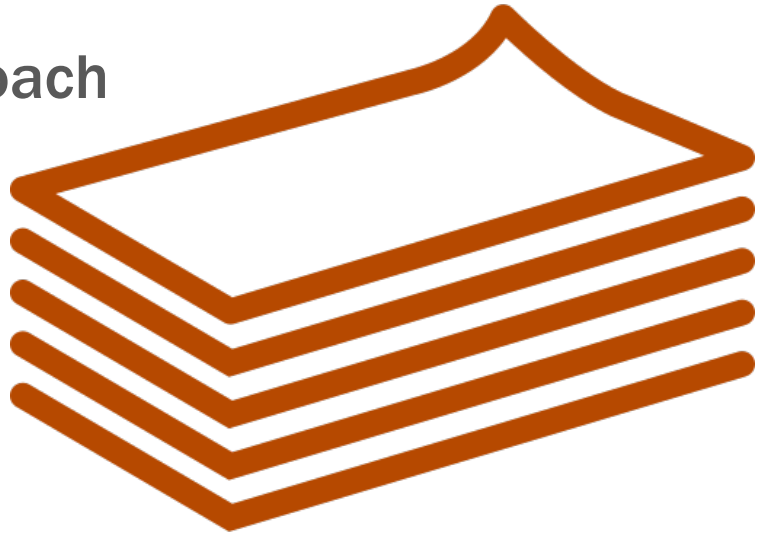
KEY STRATEGIC CAPABILITIES

- High Performance Computing
- Machine Learning
- Manufacturing Demonstration
- Chemical Separations
- Testing and Validation (for materials, devices)
- Fundamental Systems Methods

AMO will harness the individual National Laboratories' capabilities and the strength of the complex to inspire discovery and secure U.S. leadership in the future of manufacturing.

Strategic Analysis: Technical White Papers

- Draw on collaborative office knowledge on a topic area
- Frame and refine ideas using a bottom-up / top-down approach
- Clarify opportunity areas and uncover linkages
- Lay out the current state of the field, the challenges and barriers that exist, the opportunity to address the challenge, and a potential strategy for a path forward for 2021 and beyond



Sample Topics

NATIONAL NEEDS

- Critical minerals
- Water security
- Energy storage

FUNDAMENTAL SYSTEMS METHODS

- Carbon capture
- Electrification
- Circular economy

FUNDAMENTAL AND APPLIED SCIENCE

- Chemical processes
- Additive manufacturing
- Power electronics

Funding Opportunities and Investment Portfolio

AMO's funding opportunities and selected projects:

- **Address national needs**
- **Fund congressionally directed efforts**
- **Support the manufacturing enterprise of the future**

FUNDING OPPORTUNITIES

FOAs | PRIZES | LAB CALLS

- AMO's strategic framework guides development of new funding topics through:
  - Strategic Analysis
  - Stakeholder Workshops
  - National Laboratory Listening Sessions

INVESTMENT PORTFOLIO

R&D PROJECTS | CONSORTIA | PRIZE WINNERS

- AMO actively manages a diverse portfolio, evaluating projects regularly for technical merit, energy impact, and progress against office goals through:
  - Peer Review
  - Introspective Portfolio Analysis
  - Verification & Validation; Field Validation

FY20 Funding Opportunities

AMO FY20 MULTI-TOPIC FOA: ≤ $67M

- Next-generation manufacturing processes that improve energy efficiency in energy-intensive and energy-dependent industries, including steel manufacturing
- Modular, hybrid, or catalytic processes to improve energy efficiency in chemical manufacturing
- Connected, flexible, and efficient manufacturing facilities, products, and energy systems

WATER SECURITY

Water Resource Recovery Prize: ≤ $1M

- Two-phased competition for novel, systems-based solutions for resource recovery at small-to-medium-sized water resource recovery facilities

COMING SOON – Water security-specific FOA: ≤ $20M

CRITICAL MATERIALS FOA: ≤ $30M

R&D for:

- Field validation and demonstration
- Next-generation extraction, separation, and processing technologies

BATTERY MANUFACTURING LAB CALL ≤ $12M*

- Collaborate with industry on battery technology scale-up

*Joint with the Vehicle Technologies Office

BOTTLE FOA: ≤ $25M*

- Highly recyclable or biodegradable plastics
- Novel methods for deconstructing and upcycling existing plastics
- BOTTLE Consortium collaborations

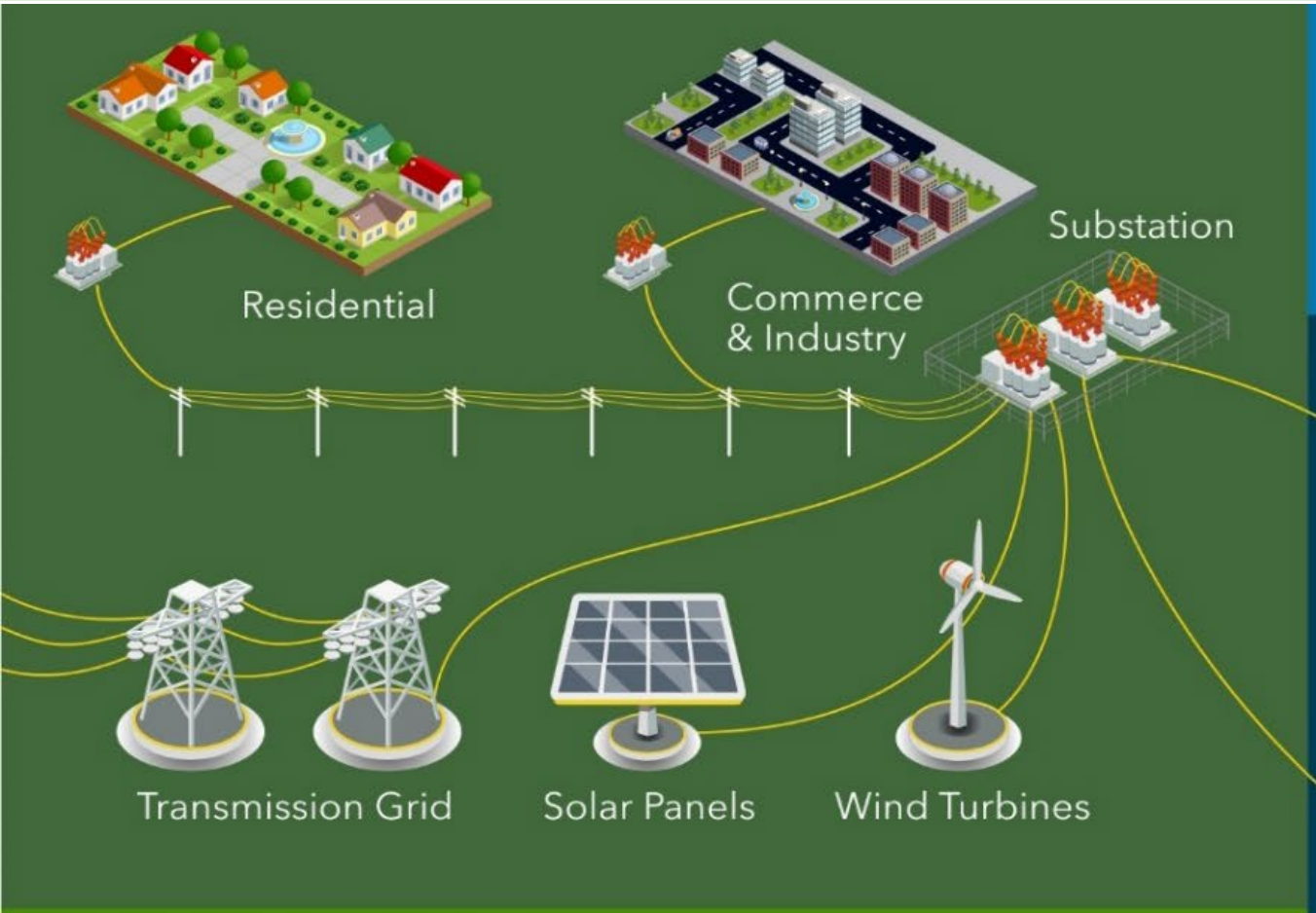
*Joint with the Bioenergy Technologies Office

TRANSPORTATION FOAs

- **≤ $15M*:** Polymer Composites for Vehicle Applications
  - *Joint with the Vehicle Technologies Office)
- **≤ $15M**:** Electrolyzer Manufacturing R&D
  ≤ $15M:** Advanced Carbon Fiber for Compressed Gas Storage Tanks
  - **Joint with the Hydrogen and Fuel Cell Technologies Office

AMO Technical Areas

Flexible Combined Heat and Power Systems

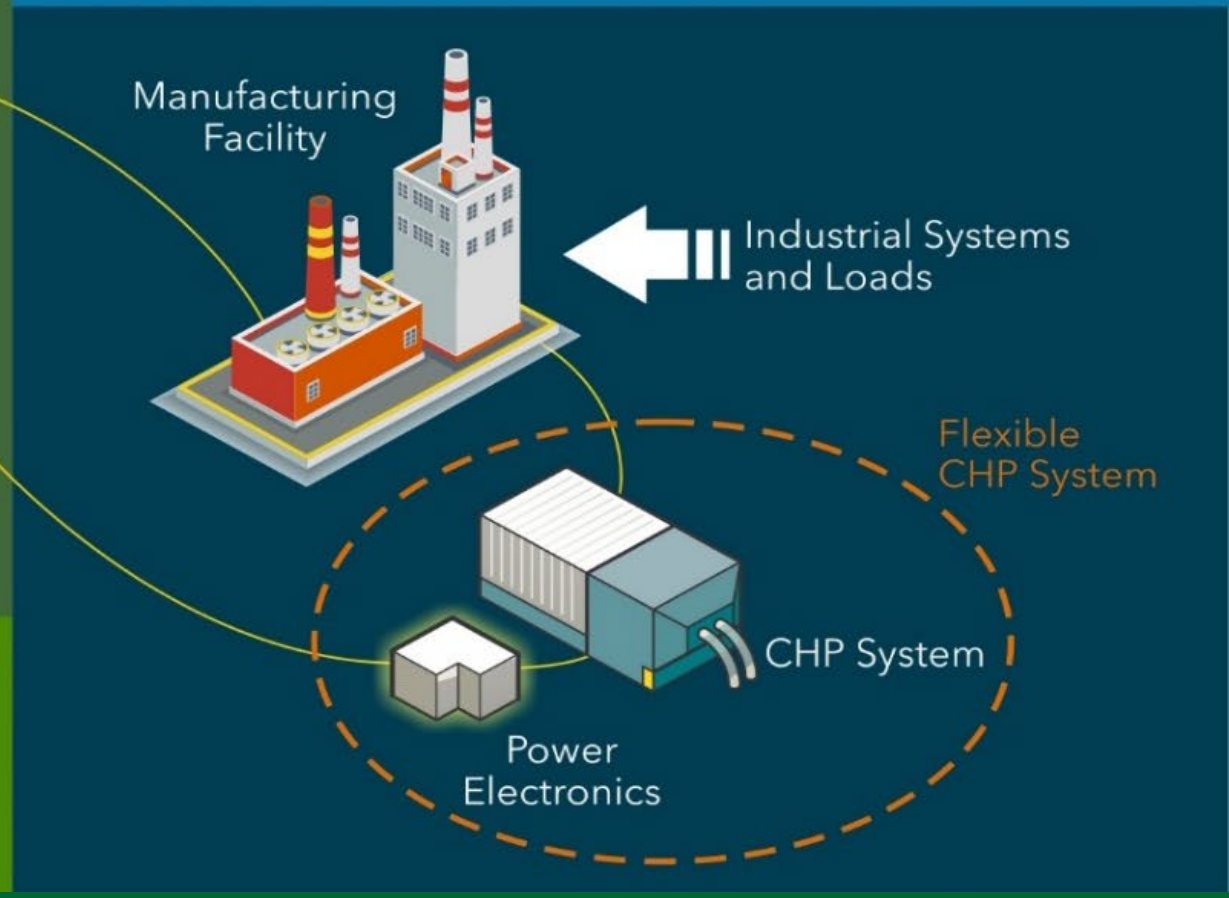


TODAY'S ELECTRIC GRID

- Power system serves residential, commercial, and industrial loads, and interconnects with a growing number of intermittent renewable energy resources

NEW CONCEPT

- Flexible CHP system provides electricity and thermal energy for plant processes and operations
- Flexible CHP system provides additional generating capacity when grid demand increases and/or renewable resources are not available. Flexible CHP also can provide other services, such as frequency regulation, to keep the grid stable



Carbon Fibers and Composite Materials

The Carbon Fiber Technology Facility CFTF

- Only **Open Access** State-of-the-Art Facility in the U.S
- 42,000 ft^2 facility with production capacity of 25 tons/year of fiber from multiple precursors in various forms

The Carbon Fiber Technology Facility (CFTF) serves as a national resource to assist industry in overcoming the barriers of carbon fiber cost, technology scaling, and product and market development. CFTF is intended to be the bridge from R&D to deployment and commercialization of low-cost carbon fiber

- Demonstrate carbon fiber production using lower-cost precursors and reduced energy
- Enable development of domestic commercial sources for production of low-cost fiber or high-volume composites applications
- Formulate a Workforce Development program for carbon fiber and advance composites workforce

Key Thrusts

- Establish and perform collaborative R&D projects to reduce technical uncertainties of CF manufacturing process
- Investigate potential alternative carbon fiber precursors
- Investigate CF intermediate forms and technical challenges in composite applications
- Establish artificial intelligence-based framework and correlate process data to product characteristics
- Investigate and develop process measurement, sensing, and control methods

Up to **70% reduction** in carbon fiber manufacturing process **embodied energy**

13 UNIVERSITY PARTNERS

3 NATIONAL LABORATORIES

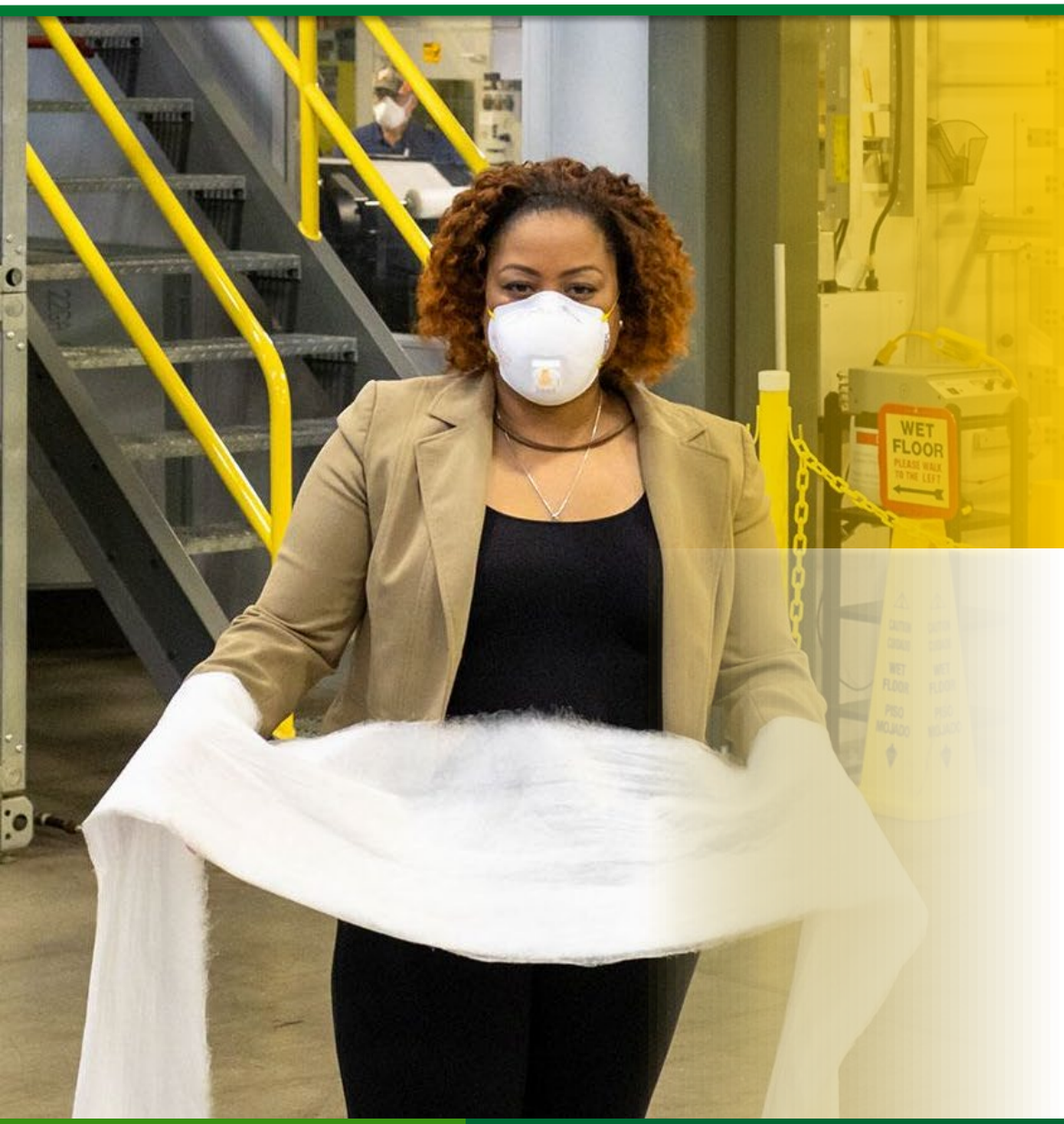
25 TONS ANNUAL CAPACITY

78 INDUSTRY PARTNERS

4 LICENSED TECHNOLOGIES

3,500+ VISITORS SINCE 2013

Carbon Fiber Technology Facility – N95 Filter Production



CAPABILITY

ADVANCED EQUIPMENT AND EXPERTISE

- AMO's investment in the CFTF created conditions for the team to react nimbly to develop new, scalable methods to meet demand for N95 filter material.
- Experts de-risked a specific and reproducible set of parameters, making them adoptable by the manufacturing industry.

SUCCESS

AGILE RESPONSE TO N95 DEMAND

- Work with N95 inventor Dr. Peter Tsai to tackle real-time challenges with conversion
- Partner with engine, filtration, and power generation manufacturer Cummins to convert their commercial melt blowing lines to potentially produce millions of pounds of N95 material
- Open source the process parameters for industry, enabling textile and filter manufacturers with melt blown machines to start making N95 filters

Advanced Roll-to-Roll (R2R) Manufacturing

R2R Objectives

- Develop technologies to reduce the cost per manufactured throughput of continuous R2R manufacturing processes.
- Develop in-line instrumentation tools that will evaluate the quality of single and multi-layer materials in-process

R2R Manufacturing Collaborations

nel · GM · PLUG POWER

OAK RIDGE National Laboratory

Colloidal chemistry & surfactant research
Slurry processing and coating scale-up
Deposition parameters, drying and curing

SOLAR WINDOW TECHNOLOGIES, INC. · nel · FISKER · NAVITAS SYSTEMS

Argonne NATIONAL LABORATORY

Novel deposition via electrospinning
In-situ characterization via X-ray scattering
Advanced testing capabilities

NREL NATIONAL RENEWABLE ENERGY LABORATORY

Physics & methods for coatings/deposition
Fabrication/in-situ testing
Novel NDE, QC and metrology

Industry

BERKELEY LAB

Macroscopic mathematical modeling of colloids
Coating parameter measurement & quantification
X-ray tomography of dried coatings

Sandia National Laboratories

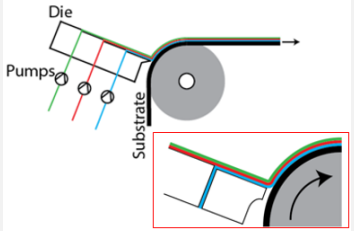
Validation of continuum-scale models
Acceleration of coating designs & scale-up processes
Prediction of optimum coating/deposition windows

Ink Dispersion Characterization

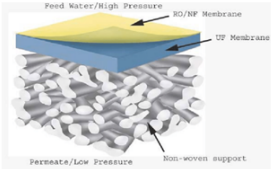
- Understanding how ink composition and interactions to determine ink structure as well as device performance
- Optimize ink stability and processing (e.g. coatability and interactions with substrate)

Multilayer Coating

- Develop in-line multilayer coating on thin films (<10 μm) with high yield (>95%)
- Increased throughput, decreased energy intensity, decreased footprint, decreased CapEx



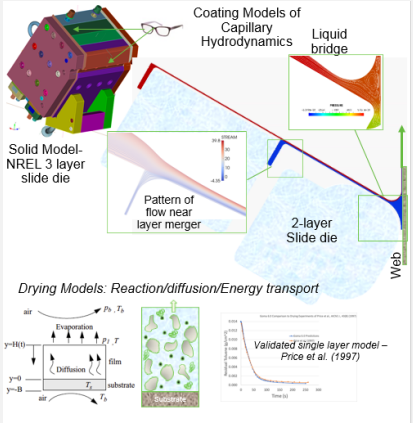
Technology example: Multi-layer slide die coating



Application example: Water purification membrane

Modeling and Simulation

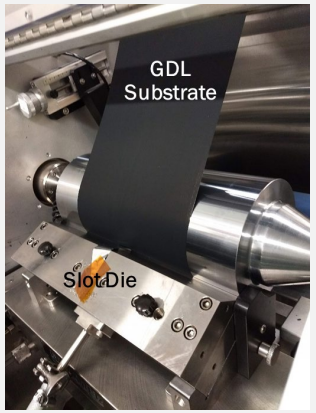
- Continuum scale models for process design and scale-up
- Deposition models
- Drying models
- User-interface and training



Accomplishment

Eliminated Need for PEMFC Cathode Overlayer

- PEMFC single-layer and multi-layer electrode performance based on ink characterization studies
- Property Models
- Characterization
- Fabrication



Manufacturing's Role in Energy Storage Grand Challenge

GOAL

U.S. global leadership in energy storage utilization and exports with a **secure domestic manufacturing supply chain independent of foreign sources of critical materials**

DOE FOCUS

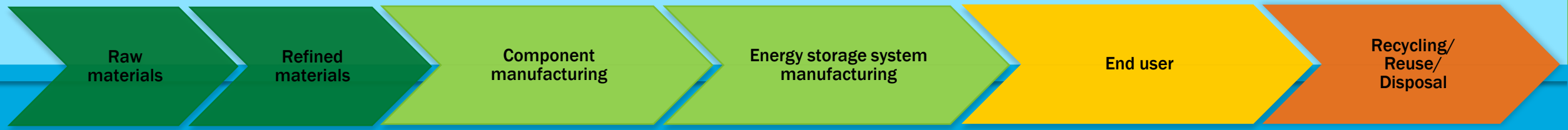
Accelerate scale-up of **emerging manufacturing processes**

Improve **critical materials supply chain** resilience

Address **technical barriers** in production and manufacturing

Technologies and Supply Chains

Meeting the Energy Storage Grand Challenge goal will require a combination of research and technology development across the manufacturing supply chain.



R&D AREAS

- Manufacturing process intensification
- Critical materials use & sourcing
- Roll-to-roll manufacturing capabilities
- Membrane manufacturing processes
- New materials & manufacturing processes for harsh service environments
- Water desalination & purification
- Combined Heat & Power systems

POTENTIAL TECHNOLOGIES

- Flow batteries
- Thermal energy storage
- Lithium-based batteries
- Non-lithium-based solid state batteries
- Hydrogen generation & storage
- Compressed air energy storage
- Pumped hydro
- Synthetic fuels (e.g. synbiogas)
- And others

DOE Education & Workforce Initiatives

HIGH SCHOOL

- National Science Bowl® competitions

UNDERGRAD

- Community College Internships Program
- Science Undergraduate Laboratory Internships Program

GRADUATE

- Graduate Student Research Program
- Interdisciplinary and industrially-relevant traineeships

Energy Storage Internship Program

FACULTY

- Visiting Faculty Program for under-represented institutions
- Curriculum development for degree programs

WORKFORCE

- Lab-Embedded Entrepreneurship Program
- Industrial Assessment Centers undergraduate training *(31 universities)*
- Community college hands-on training

Lab-Embedded Entrepreneurship Programs

1. **Recruit** the best energy technology innovators
2. **Leverage** expert mentorship and world-class facilities at the national labs on a win-win basis
3. **Position** people and technology for market

Spin the nation's top innovators "in" to the National Labs

Technical Assistance

CAPABILITY

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

- Technical assistance and in-plant training
- Access to National Laboratory resources, software, and instrumentation
- Networking opportunities
- National recognition through awards, case studies, and success profiles

SUCCESS

230+ partners

3,200+ plants

54 energy & water goal achievers

>$6B cumulative energy cost savings

>1 quadrillion TBtu saved

Better Plants® U.S. DEPARTMENT OF ENERGY

Thank You

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and to subscribe for updates:

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