U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Advanced Manufacturing, & Solid State Lighting Opportunities

January 28, 2015

SSL Program – Manufacturing Panel

San Francisco, CA

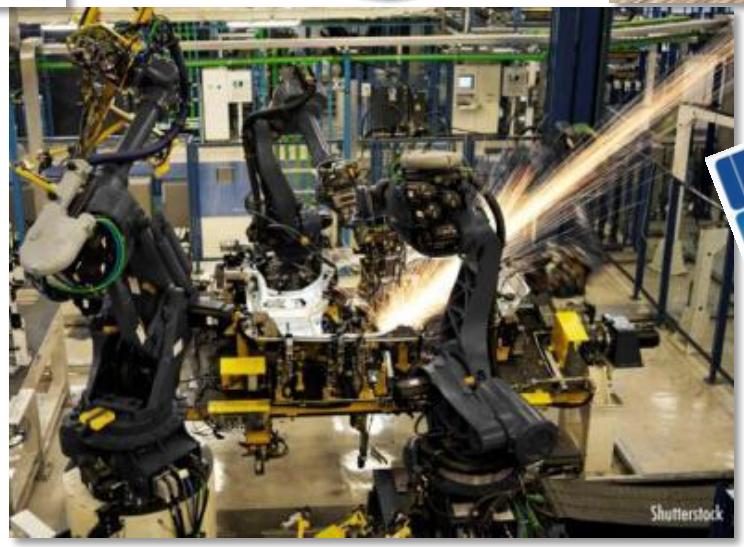
Mark Johnson

Director

Advanced Manufacturing Office

www.manufacturing.energy.gov

Status Quo: Products invented here, and made elsewhere

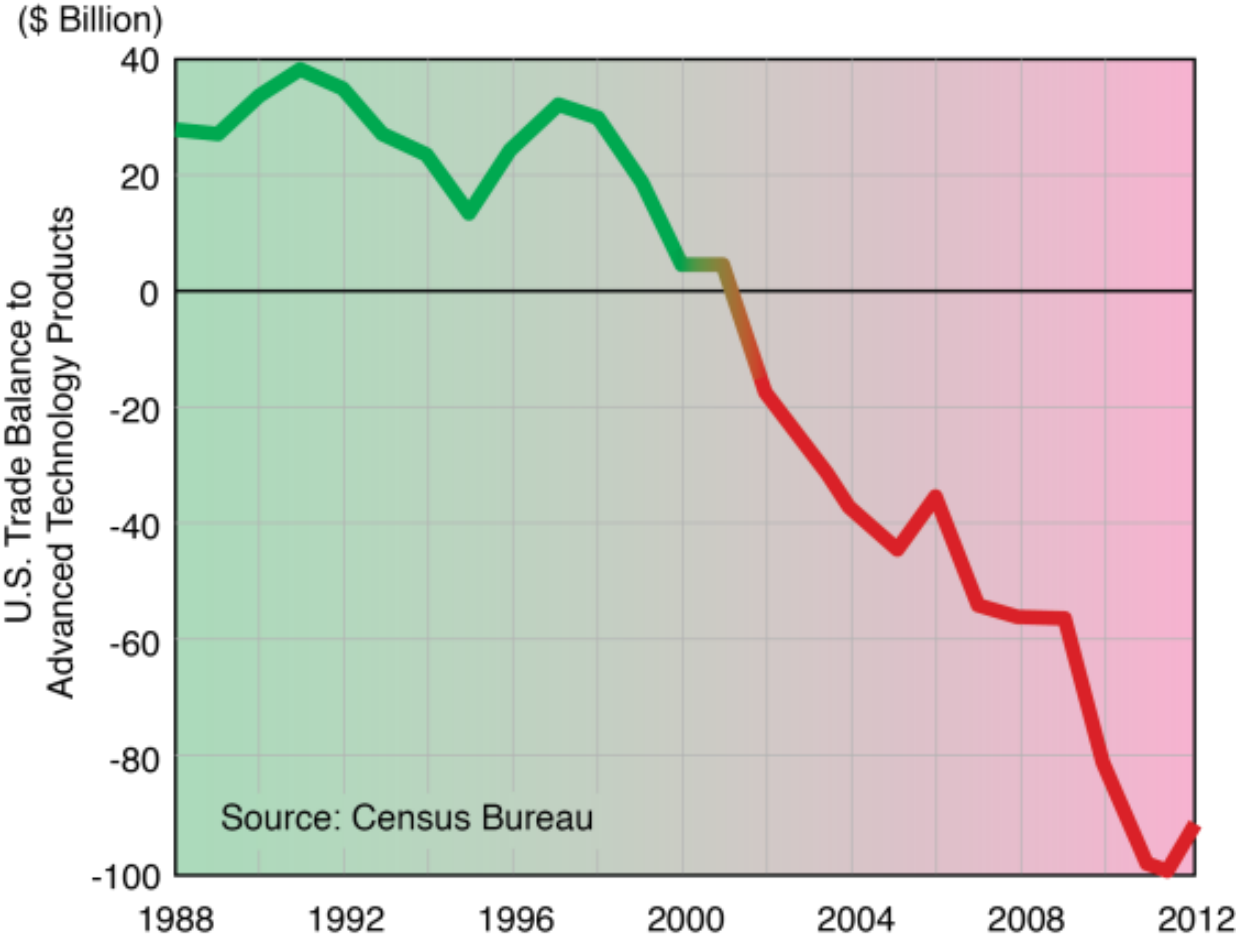


U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Significance of U.S. Manufacturing

11% of U.S. GDP, **12** million U.S. jobs, **60%** of U.S. Exports

U.S. Trade Balance of *Advanced Technology*



Swung to historic deficit, lost 1/3rd of workforce

Clean Energy: Nexus of Opportunities

- Energy self-reliance
- Stable, diverse energy supply

- Competitiveness in clean energy
- Domestic jobs

- Clean air
- Climate change
- Health

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Strategic Framework for Advanced Manufacturing

Climate Action Plan: Efficiency and Sustainability

National Economic Council: Manufacturing Competitiveness

Quadrennial Energy Plan: End-Use Sector Focus

Quadrennial Technology Plan: DOE Technology Area Focus

Clean Energy Manufacturing Tech-Team: Cross-Cutting Impact

Efficiency in Manufacturing Processes (Energy, CO_2)

Enabling Materials and Technologies for Clean Energy

Modalities: Technology Assistance and Technology Development

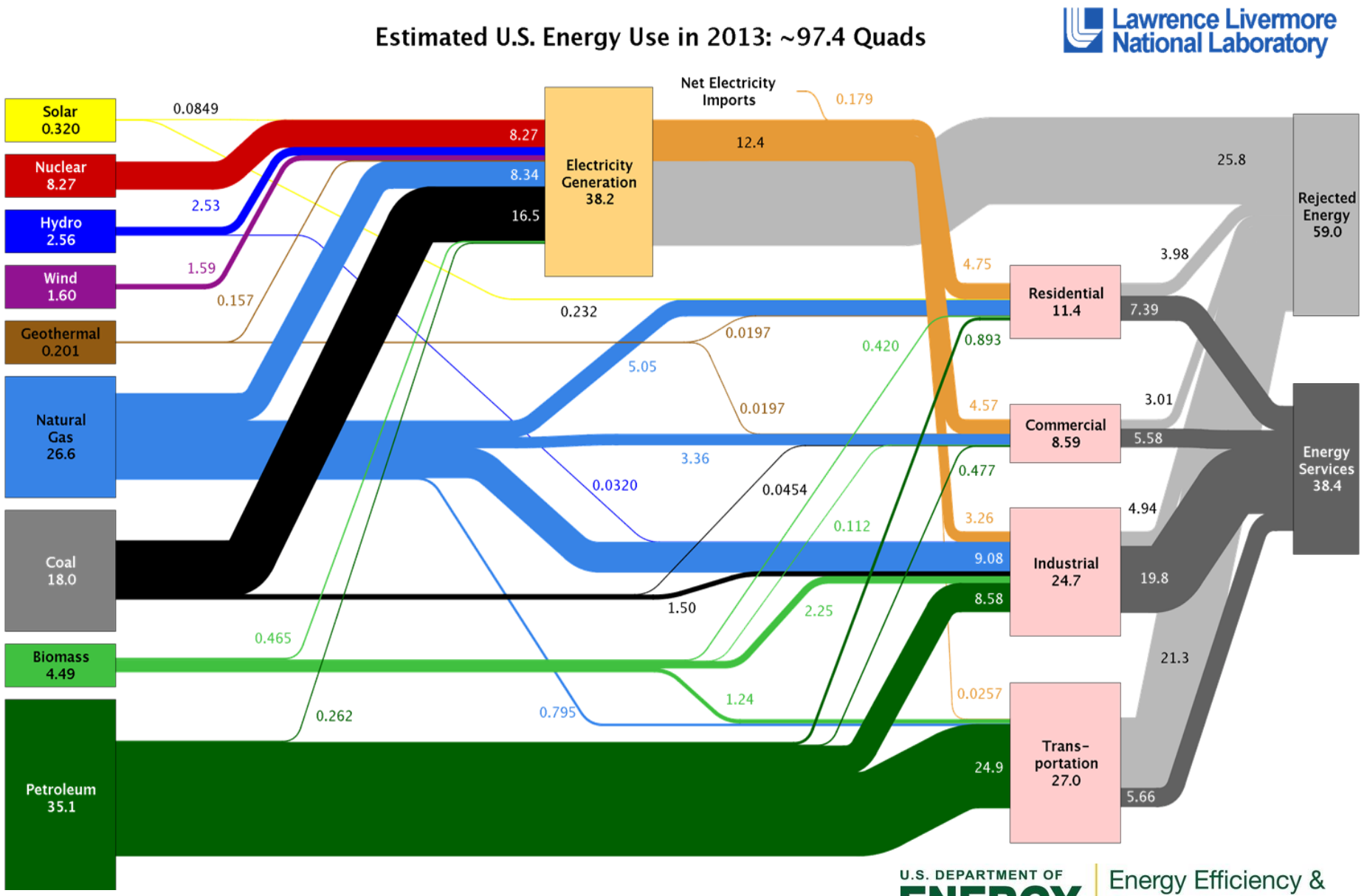
National Manufacturing Policy & DOE's Role

- DOE is active across the pillars of Advanced Manufacturing
- DOE is a leader in **advanced manufacturing innovation** and implementing the **National Network for Manufacturing Innovation (NNMI)**

NNMI:

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Energy Consumption by Sector



Energy Intensive Industries

- Primary Metals
- Petroleum Refining
- Chemicals
- Wood Pulp & Paper
- Glass & Cement
- Food Processing

Processes for Clean Energy Materials & Technologies

Solar PV Cell

Carbon Fibers

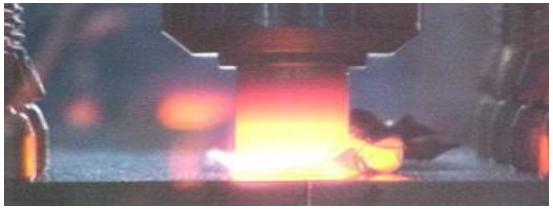
Light Emitting Diodes

Electro-Chromic Coatings

Membranes

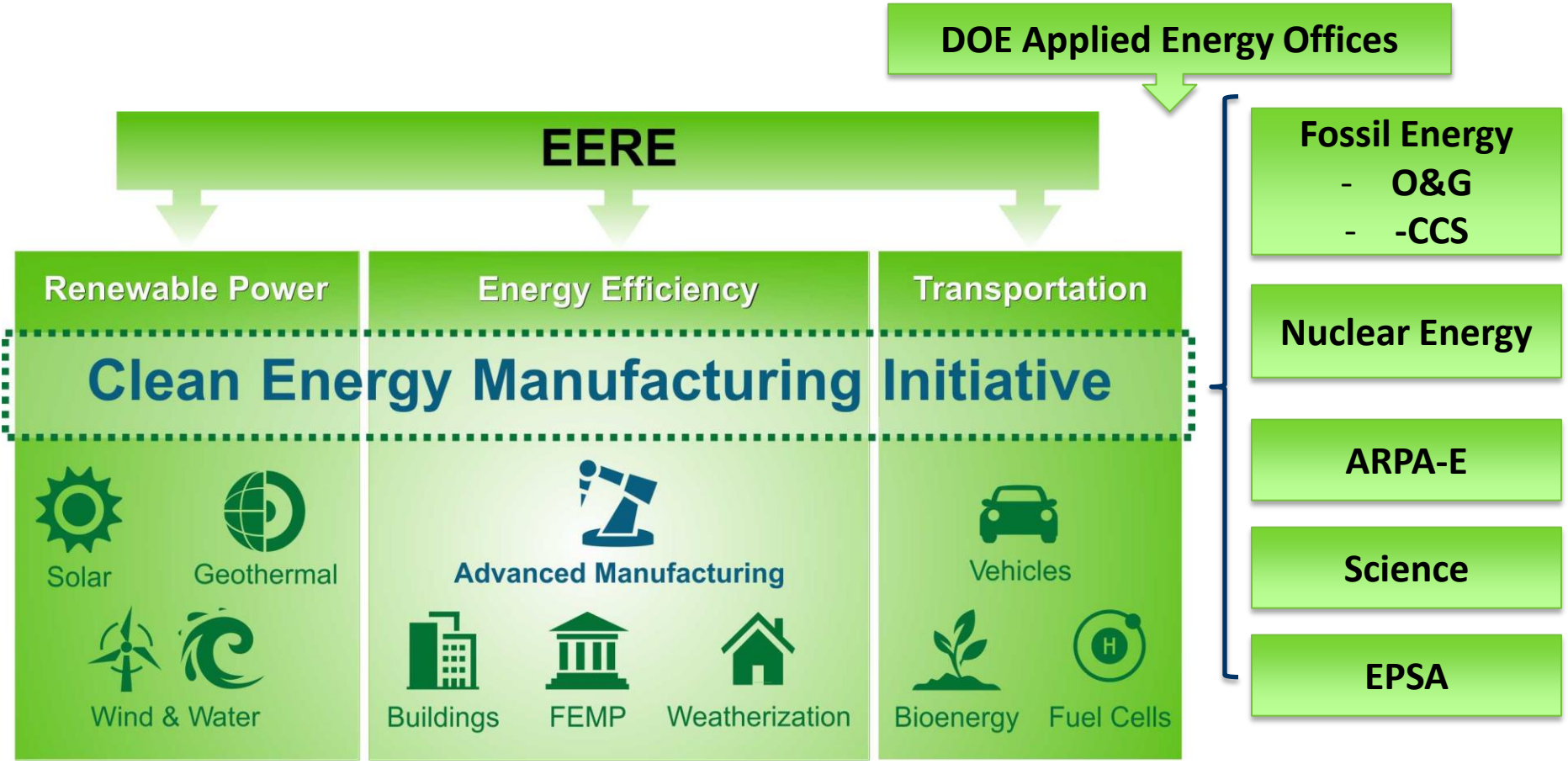
EV Batteries

Multi-Material Joining



U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Clean Energy Manufacturing Initiative – Across DOE



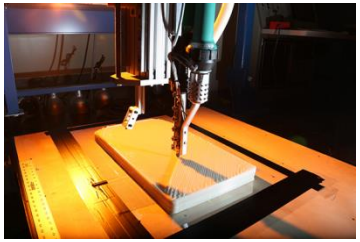
Collaboration toward:

- Common goal to collectively ***increase U.S. manufacturing competitiveness***

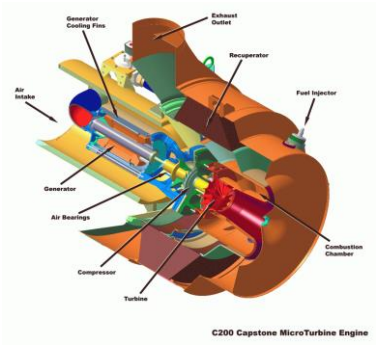
Coordination for:

- Comprehensive Strategy
- Collaborative Ideas

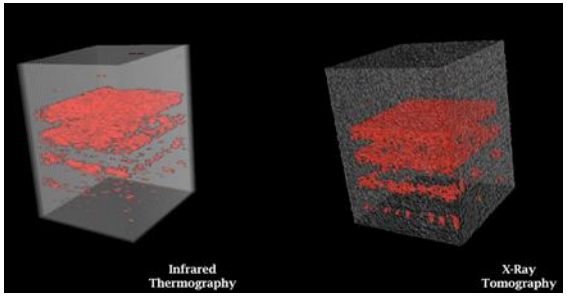
Advanced Manufacturing Office



Additive Manufacturing of Large Area Structures for Energy



Advanced Microturbine Systems for Distributed Generation and CHP



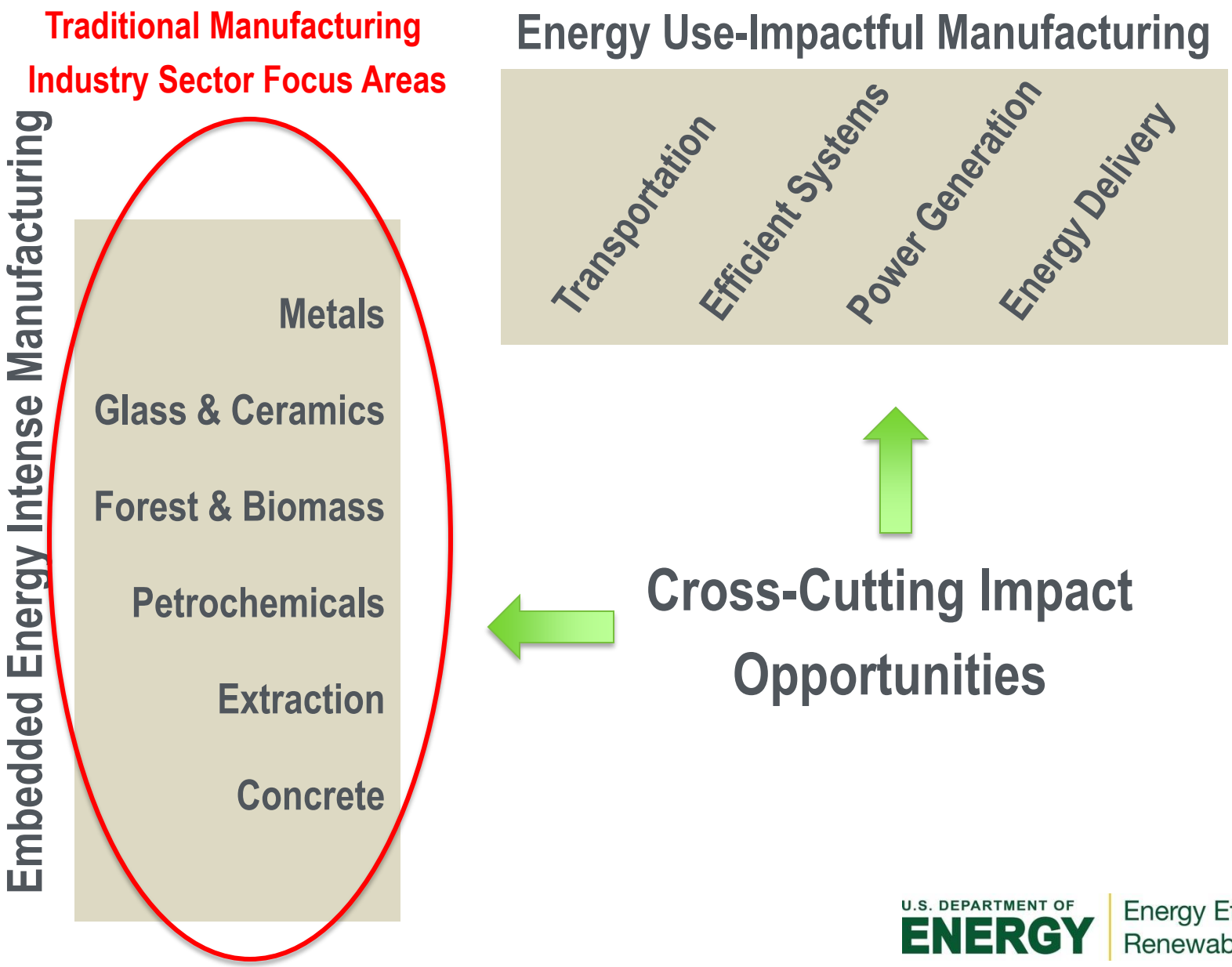
Computational Modelling, Infrared Detection and Tracking of Voids and Defects in High Performance Alloys

AMO's Purpose is to Increase U.S. Manufacturing Competitiveness and Energy Efficiency through:

- **Broadly Applicable Efficiency Technologies for Energy Intensive and Energy Dependent**
- **Manufacturing**
  - examples: combined heat and power (CHP), efficient manufacturing process intensification, energy management and process controls

- **Platform Manufacturing Innovations for Advanced Energy Technologies**
  - examples: carbon fiber composites; critical materials; advanced materials manufacturing; high performance simulation, visualization and modelling, wide band gap semiconductors/power electronics

Manufacturing Sector Whitespace



Broad Topical Areas

- **Platform Materials and Technologies for Energy Applications**
  - Advanced Materials Manufacturing (Mat'l Genome, Nanomaterials, etc.)
  - Critical Materials
  - Advanced Composites & Lightweight Materials
  - 3D Printing / Additive Manufacturing
  - 2D Manufacturing / Roll-to-Roll Processes
  - Wide Bandgap Power Electronics
  - Next Generation Electric Machines
- **Efficiency in Manufacturing Processes (Energy, CO_2)**
  - Advanced Sensors, Controls, Modeling and Platforms (ie. Smart Manf.)
  - Advanced Chemical Process Intensification
  - Grid Integration of Manufacturing (CHP and DR)
  - Sustainable Manufacturing (Water, New Fuels & Energy)
- **Emergent Topics in Manufacturing**

1. Technical Assistance

2. R & D Projects

3. Manufacturing R & D Facilities

AMO-supported R&D Facilities

1. **Manufacturing Demonstration Facility:** at Oak Ridge National Lab

2. **America Makes**: The National Additive Manufacturing Innovation Institute

3. **Critical Materials Institute**: *A DOE Energy Innovation Hub* at Ames National Lab

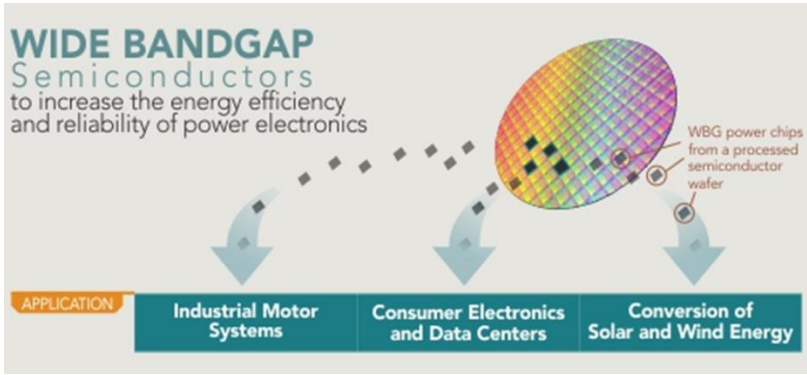
4. **Next Generation Power Electronics Manufacturing Innovation Institute:** *Power America* at NC State University

5. **Composites Materials and Structures Manufacturing Innovation Institute:** *Institute for Advanced Composite Materials Innovation* at Knoxville, TN

America Makes

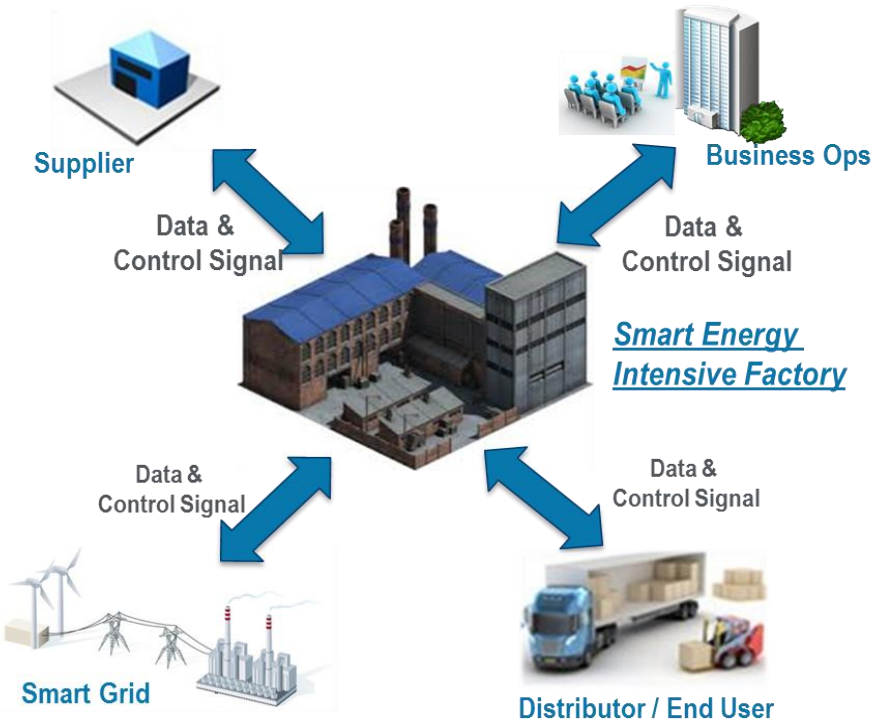
CMI Accelerating Energy Innovations

Critical Materials Institute



U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Advanced Controls, Sensors, Models & Platforms for Energy Intensive Process & Clean Energy Productivity



Smart factories will be interconnected with supply chain, distribution, and business systems.

- Encompass machine-to-plant-to-enterprise-to-supply-chain aspects of sensing, instrumentation, monitoring, control, and optimization
- Enable hardware, protocols and models for advanced industrial automation: requires a holistic view of data, information and models in manufacturing
- Leverage High Performance Computing for High Fidelity Process Models
- Significantly reduce energy consumption and GHG emissions & improve operating efficiency – **20% to 30% potential**
- Increase productivity and competitiveness across all manufacturing sectors: Special Focus on Energy Intensive Manufacturing Processes

Leverages AMP 2.0

Advanced Materials Manufacturing

leveraging unique capabilities for fast-tracking materials to market, while expanding and enhancing the tools & methods in the core

Core Effort for Advanced Materials

unique set of in-house capabilities in accelerated energy-materials development

Advanced Modeling, Computing, and Simulation Capabilities

leveraging and expanding on the current MGI multi-physics, multi-scale computational base

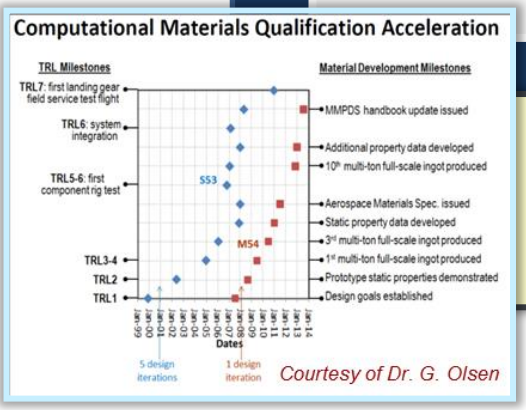
feedback pathways

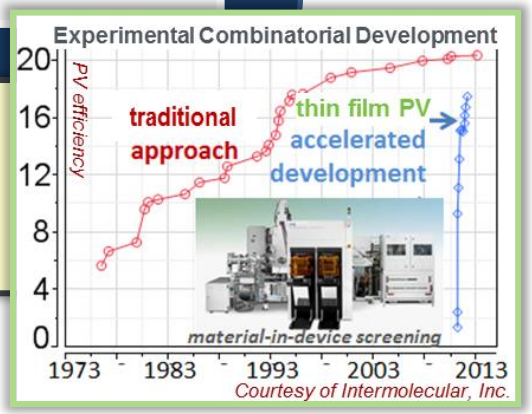
High Throughput Synthesis, Characterization & Analysis Capabilities

high productivity combinatorial discovery & development tailored to specific energy end uses

linkages in methods / data / intellectual property

Combines multi-physics, multi-scale computation with high-throughput synthesis and characterization for intelligent, focused RD&D in numerous energy technology thrusts, managed, e.g., in cross-cutting Materials Manufacturing Centers of Excellence (MMCOEs)





Leverages AMP 2.0

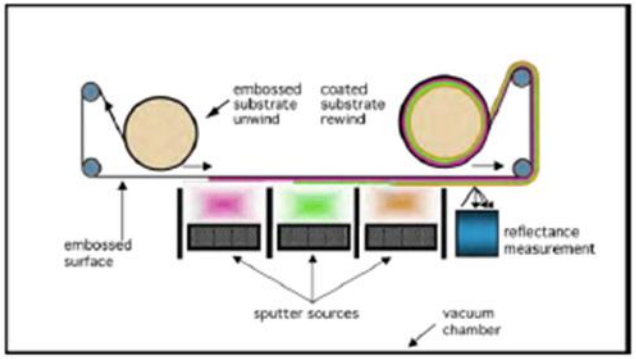
U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

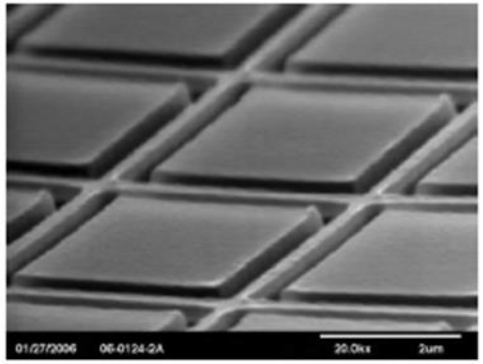
2D Fabrication / Advanced Roll-to-Roll Manufacturing

- **Technology development for the electronic manufacturing service (EMS) sectors to move from plate-to-plate standard lithography to continuous R2R processing.**
- **Miniaturization of critical feature sizes to the nanoscale**
- **Advancing tools and methods for process control, defect sensing, and real-time feedback**

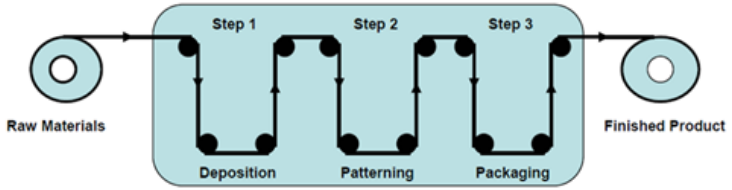
- **<u>Potential Energy Applications</u>:**

  Solar, Batteries, Fuel Cell MEAs, Separation Membranes, Solid State Lighting, Building Envelopes, etc.





Prototype "Nano-Fab" using R2R at CAMM, Binghamton University (SUNY)



Idealized R2R Process Methodology

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

What does Success Look Like?

Energy Products Invented Here…

…And Competitively Made Here!

Thank You

Questions?