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

AMO Overview:
Peer Review 2016
Opening / Welcome

June 14, 2016

Washington, DC

Mark Johnson

Director

Advanced Manufacturing Office

www.manufacturing.energy.gov

Manufacturing partnership goes back a bit…….

… the encouragement of manufactures is the interest of all parts of the Union.

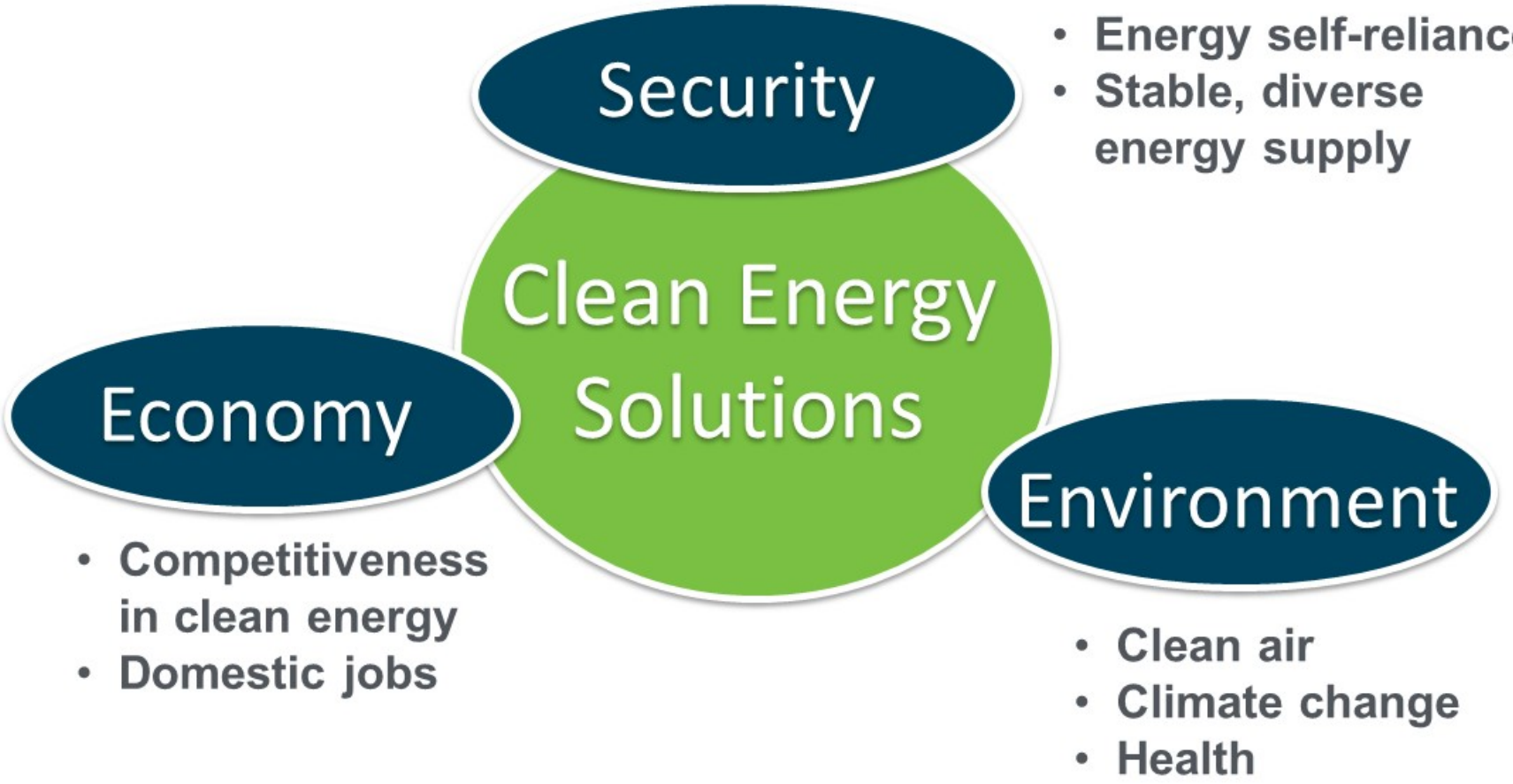
Not only the wealth; but the independence and security of a country, appear to be materially connected with the prosperity of manufactures.

… it is the interest of a community with a view to eventual and permanent economy, to encourage the growth of manufactures.

Alexander Hamilton, Treasury Secretary

Report to Congress, December 1791

Clean Energy and Manufacturing: A Mission for Innovation



Clean Energy Manufacturing

Making Products which Reduce Impact on Environment

Advanced Manufacturing

Making Products with Technology as Competitive Difference

Advanced Manufacturing and Mission Innovation

Mission Innovation Clean Energy R&D Focus Areas

	AUSTRALIA	BRAZIL	CANADA	CHILE	CHINA	DENMARK	EUROPEAN UNION	FRANCE	GERMANY	INDIA	INDONESIA	ITALY	JAPAN	KINGDOM OF SAUDI ARABIA	MEXICO	NORWAY	REPUBLIC OF KOREA	SWEDEN	UNITED ARAB EMIRATES	UNITED KINGDOM	UNITED STATES
INDUSTRY & BUILDINGS	●	●	●	●		●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
VEHICLES & OTHER TRANSPORTATION	●	●	●	●	●	●	●	●	●	●	●		●	●	●	●	●	●	●		●
BIO-BASED FUELS & ENERGY	●	●	●		●	●	●	●	●	●	●	●			●	●	●	●	●	●	●
SOLAR, WIND & OTHER RENEWABLES	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
NUCLEAR ENERGY	●	●	●		●												●		●	●	●
HYDROGEN & FUEL CELLS	●	●	●			●	●	●	●	●			●	●		●	●			●	●
CLEANER FOSSIL ENERGY		●	●		●	●			●	●	●			●			●				●
CO_2 CAPTURE, UTILIZATION & STORAGE	●	●	●		●	●	●	●	●				●	●	●	●	●		●	●	●
ELECTRICTY GRID	●	●	●	●	●	●	●	●	●	●	●	●	●		●	●	●	●	●	●	●
ENERGY STORAGE	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●		●	●	●
BASIC ENERGY RESEARCH	●		●			●	●	●	●	●	●	●	●	●		●		●	●		●

Indicators are for key areas of R&D investment, but do not imply a comprehensive representation of a country's full R&D portfolio.

- **Doubling Clean Energy R&D**
- **Framework for Clean Energy Targets**
- **Includes Advanced Technologies for Manufacturing of Clean Energy Products and Efficiency in Manufacturing**

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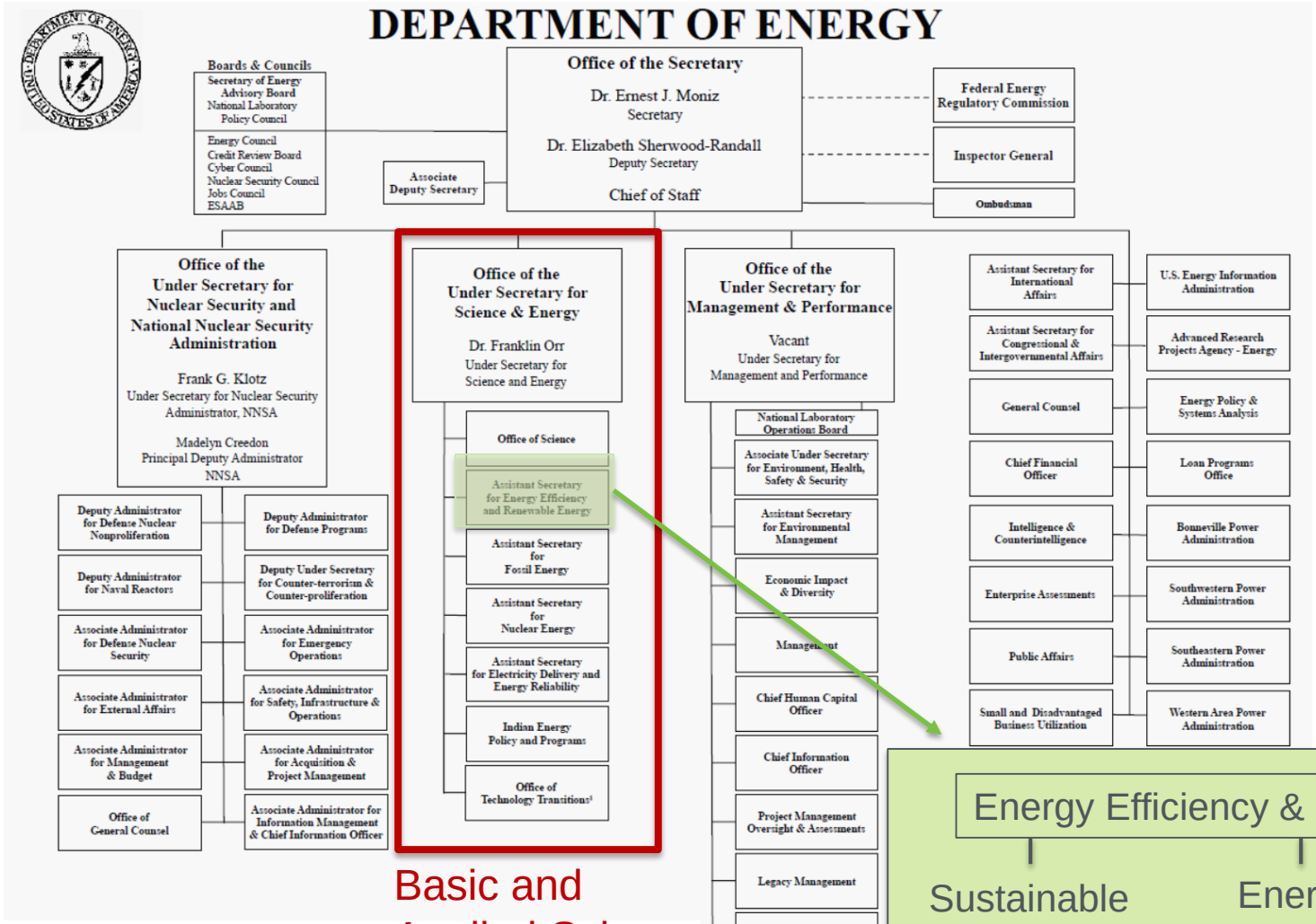
Advanced Manufacturing in the Department of Energy



Basic and Applied Science Coordinated Materials & Manufacturing

Energy Efficiency & Renewable Energy

Sustainable Transportation | Energy Efficiency | Renewable Power

Advanced Manufacturing Office

ENERGY | Renewable Energy

Advanced Manufacturing – Strategic Framing

Climate Action Plan
(EOP / CEQ / OSTP 2014)

Advanced Manufacturing Partnership (AMP2.0)
(NEC / PCAST / OSTP 2014)

Quadrennial Energy Review
(DOE / EPSA 2015)

Quadrennial Technology Review
(DOE / Science and Technology 2015)

1) Broadly Applicable Energy Efficiency Technologies for Energy Intensive and Energy Dependent Manufacturing

2) Platform Materials, Process and Information Technologies for Clean Energy Manufacturing with Sustainable Life-Cycle Impact

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Energy Intensive Industries

Primary Metals
1608 TBTU

Petroleum Refining
6137 TBTU

Chemicals
4995 TBTU

Wood Pulp & Paper
2109 TBTU

Glass & Cement
716 TBTU

Food Processing
1162 TBTU

Processes for Clean Energy Materials & Technologies

Energy Dependence: Energy Cost Considered in Competitive Manufacturing

Solar PV Cell

Carbon Fibers

Light Emitting Diodes

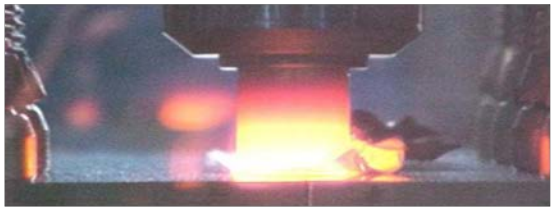
Electro-Chromic Coatings

Membranes

EV Batteries

Multi-Material Joining

Water Desalination



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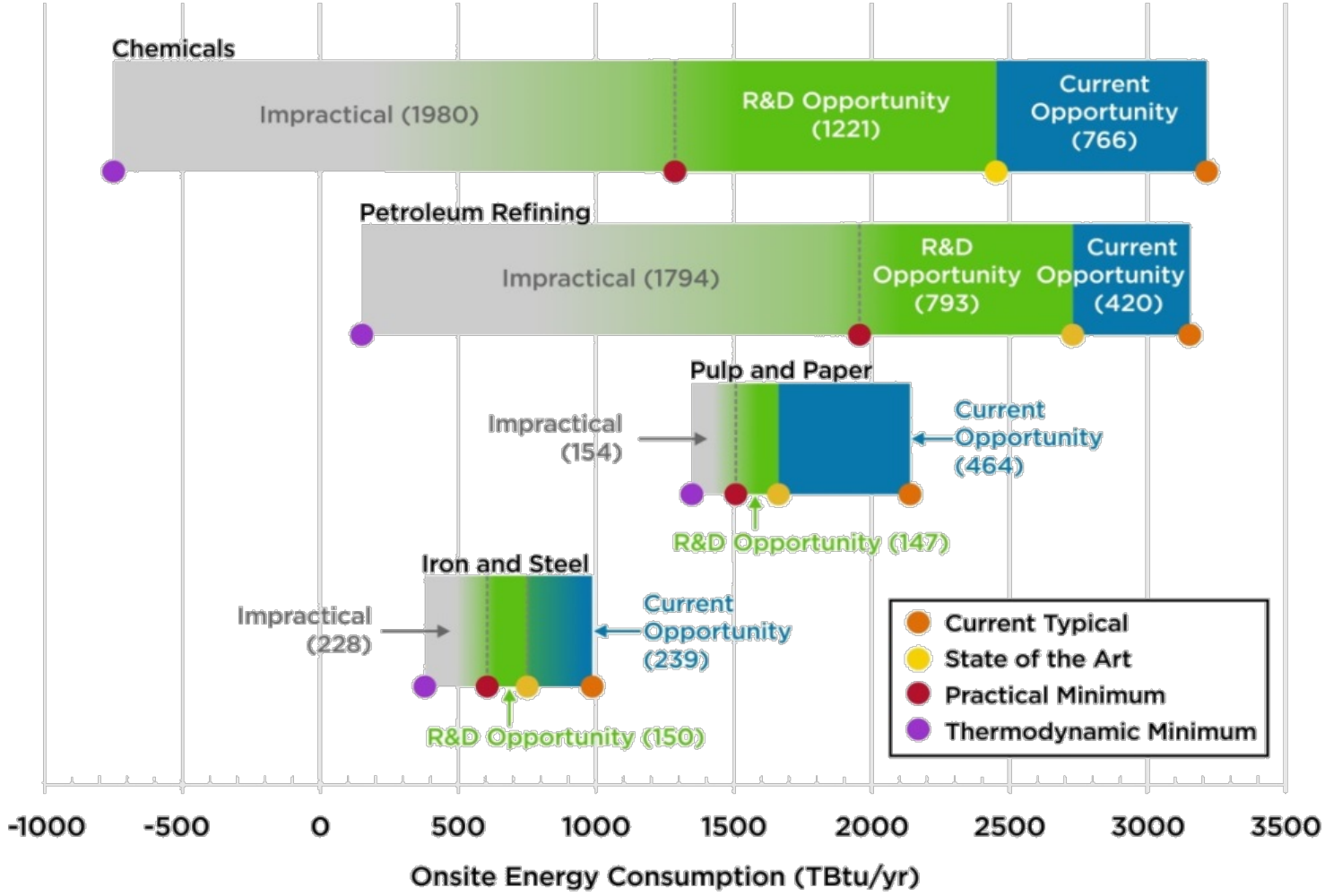
Manufacturing Bandwidth Studies: Energy Savings Potential



Current opportunities represent energy savings that could be achieved by deploying the most energy-efficient commercial technologies available worldwide. R&D opportunities represent potential savings that could be attained through successful deployment of applied R&D technologies under development worldwide

AMO: September 2015

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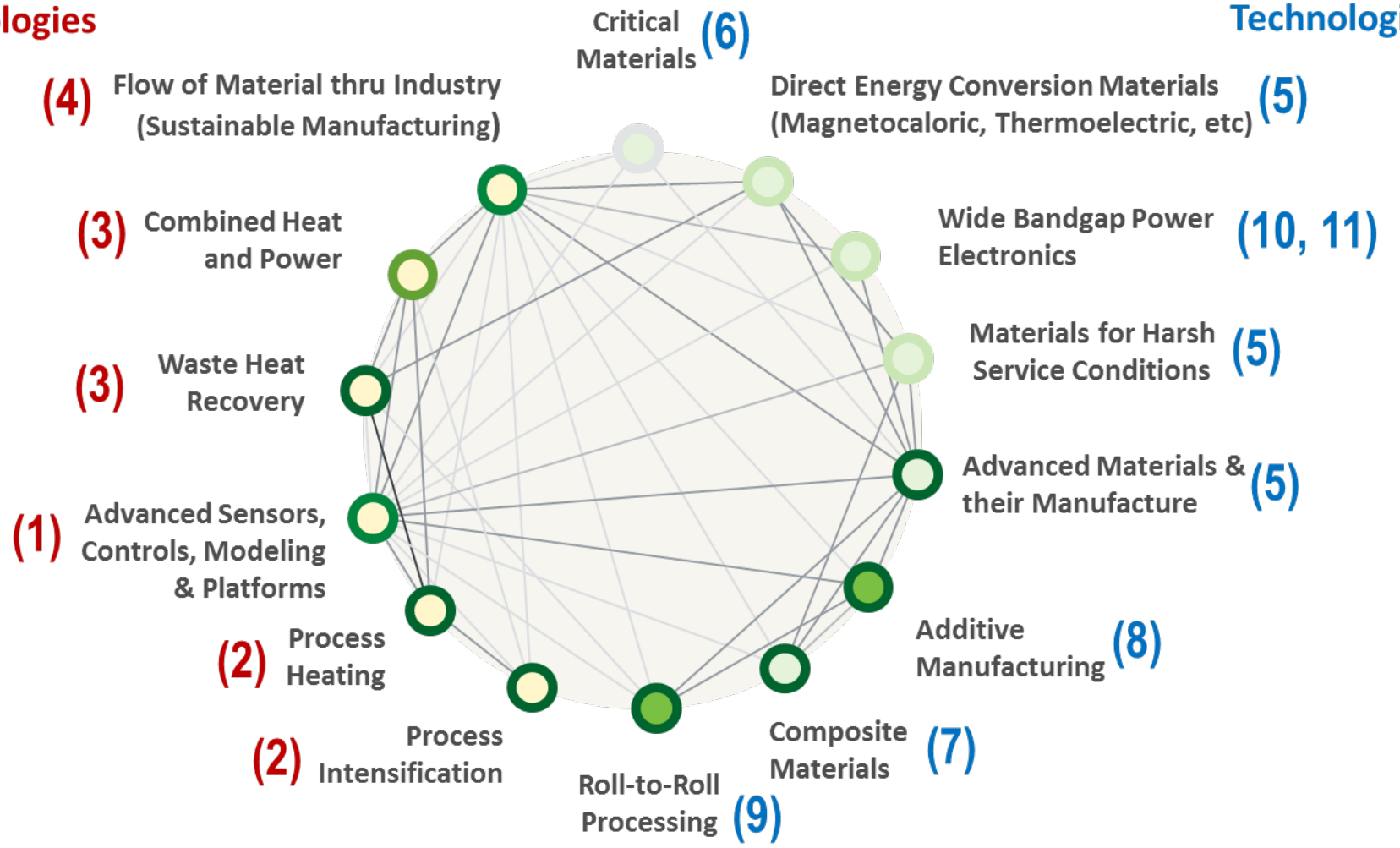
Quadrennial Technology Review: Manufacturing

Efficiency Technologies

Enabling Platform Technologies



Information	Process	Materials
Energy & Resource Management	Advanced Manufacturing Processes	Materials Development

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Advanced Manufacturing Topical Areas

Efficiency Technologies for Manufacturing Processes (Energy, CO_2)

(1) Advanced Sensors, Controls, Modeling and Platforms (HPC, Smart Manufacturing)
(2) Advanced Process Intensification
(3) Grid Integration of Manufacturing (CHP, DG and DR)
(4) Sustainable Manufacturing (Water-Energy, New Fuels & Reused Feedstocks)

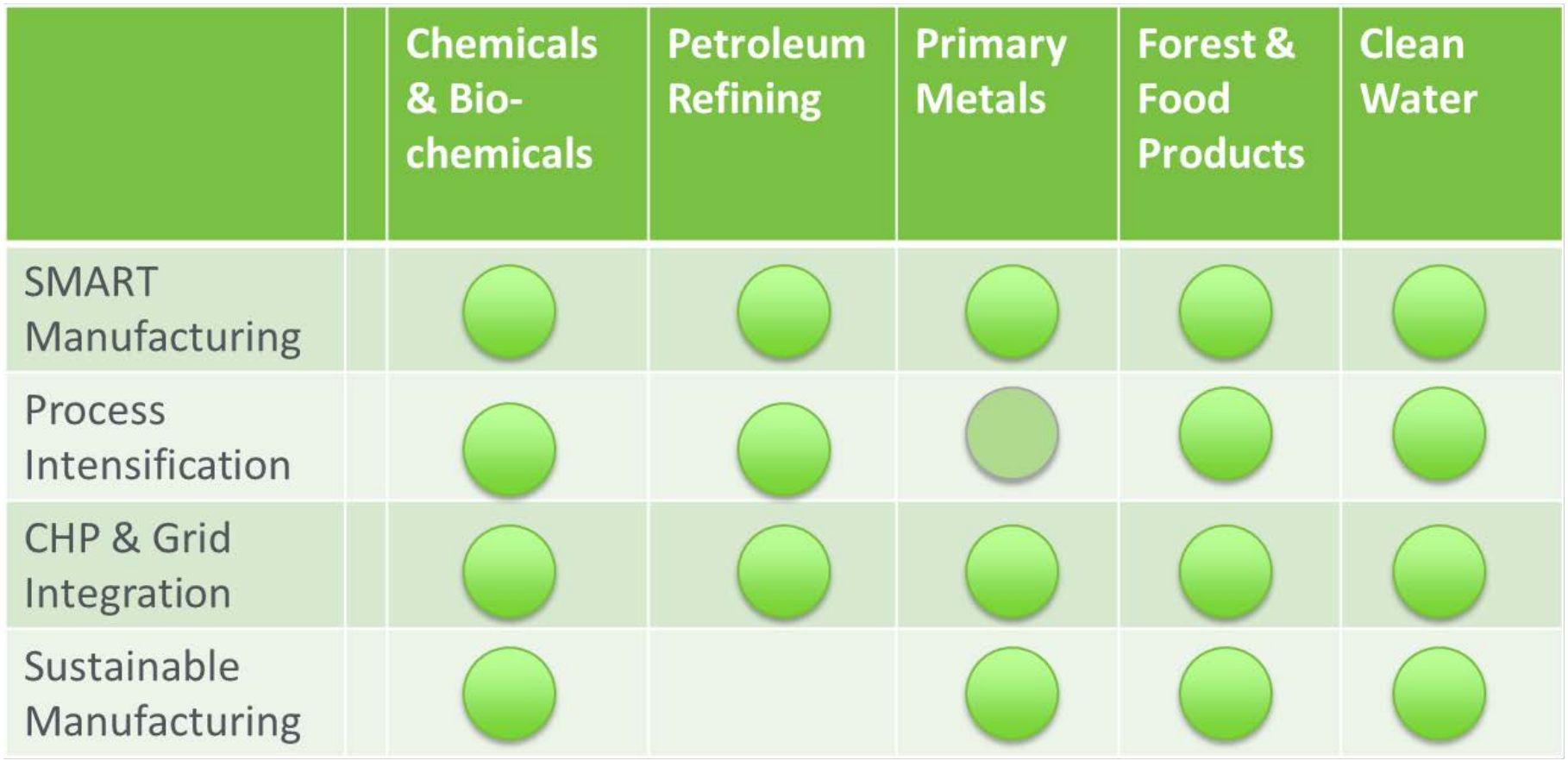
Platform Materials & Technologies for Clean Energy Applications

(5) Advanced Materials Manufacturing
(incl: Extreme Mat'l., Conversion Mat'l, etc.)
(6) Critical Materials
(7) Advanced Composites & Lightweight Materials
(8) 3D Printing / Additive Manufacturing
(9) 2D Manufacturing / Roll-to-Roll Processes
(10) Wide Bandgap Power Electronics
(11) Next Generation Electric Machines (NGEM)

Next Step:
Revise AMO Multi-Year Program Plan (MYPP) With Office Specific Approach in Each Technical Area

QTR Manufacturing (Ch.8) Focus Areas Mapped to Advanced Manufacturing Topical Areas for Technology Development

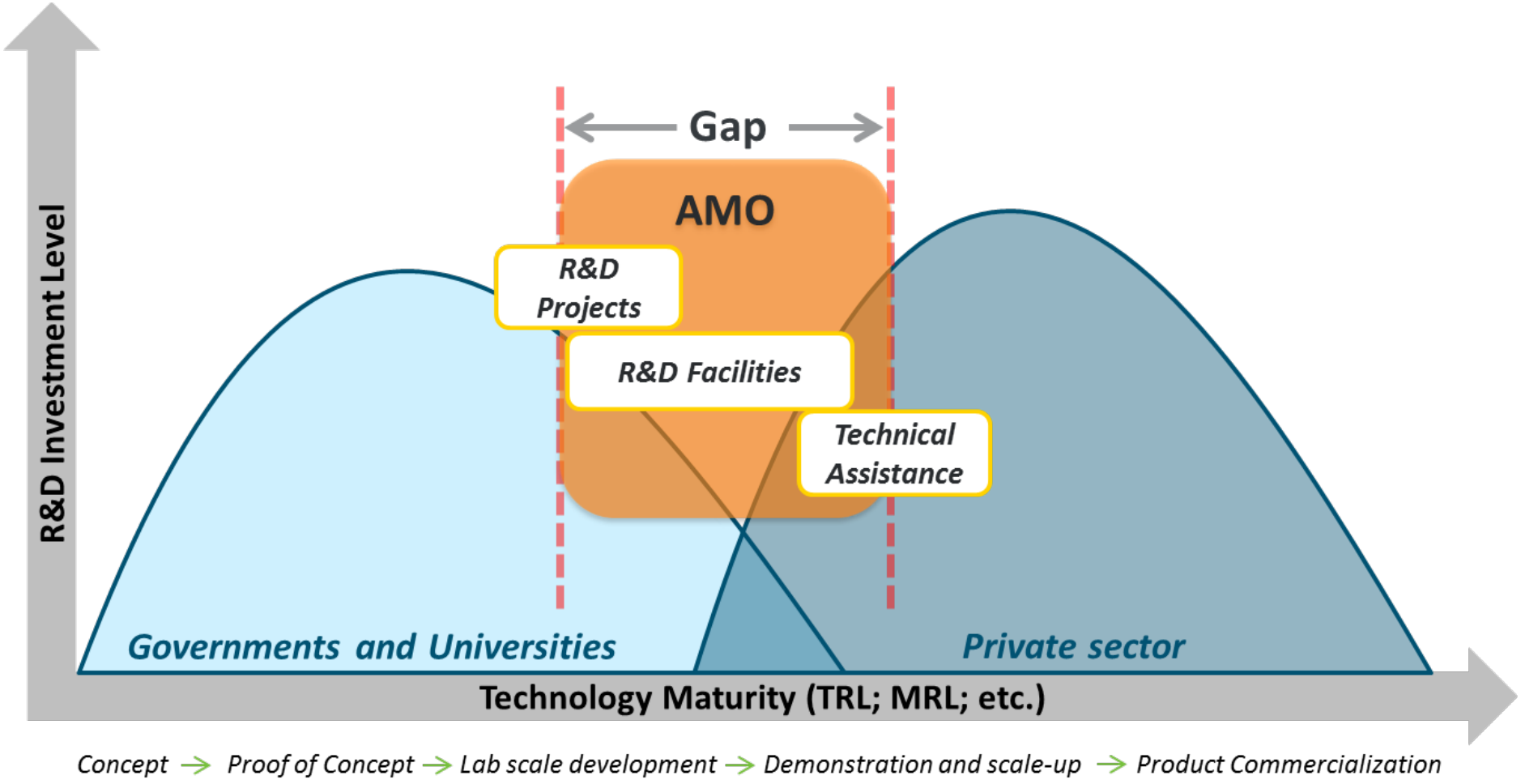
Possible Impact Areas of Cross-Cutting Technology for Energy Intensive Industry Sectors



Many Sector Specific Roadmaps Being Revised through Complementary Program Supported by NIST / AmTech

Bridging the Gap from Discovery to Manufacturing

AMO: Advanced Manufacturing Office



Modalities of Support

Technology Assistance: (Dissemination of Knowledge Gaps)

Better Plants, ISO-50001 / SEP, Industrial Assessment Centers, Combined Heat and Power Tech Assistance Centers, Energy Management Tools & Training

Technology Development Facilities: (Innovation Consortia)

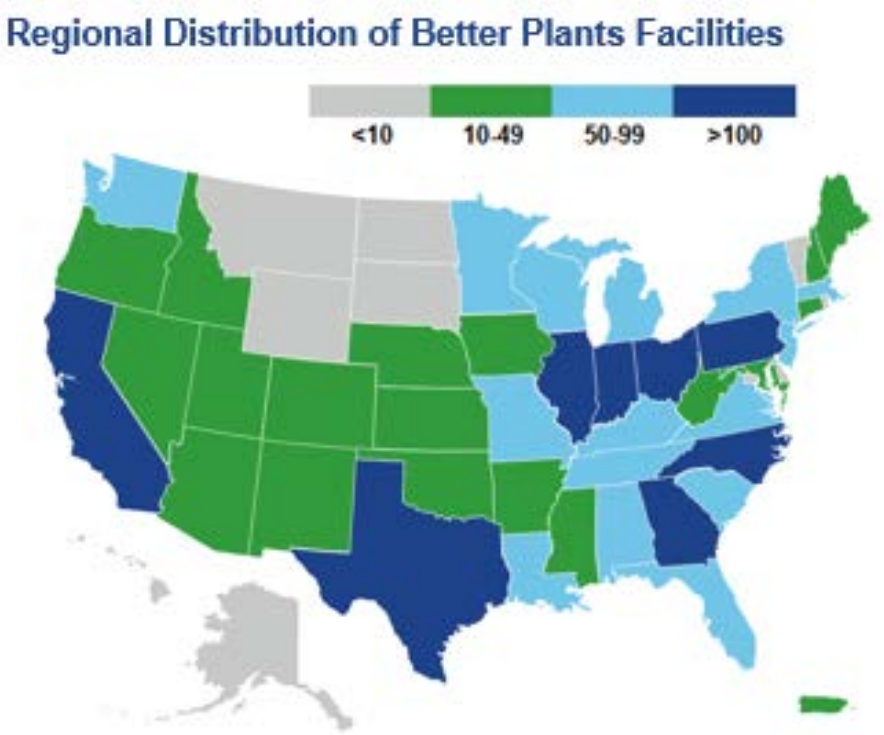
Critical Materials Hub, Manufacturing Demonstration Facility (Additive), Power America NNMI, IACMI NNMI, CyclotronRoad, HPC4Manufacturing

Technology Development Projects: (Individual R&D Projects)

Individual Projects Spanning AMO R&D Space - University, Small Business, Large Business and National Labs. Each a Project Partnership (Cooperative Agreement).

Technical Assistance: Better Plants Program

- Key component of President's Better Buildings Initiative to improve energy efficiency of commercial and industrial buildings by 20% by 2020.
- Voluntary pledge by leading manufacturers and industrial-scale energy users to reduce energy intensity
- DOE provides technical assistance to meet goals



Better Plants Snapshot

Partnership Size	Total
Number of Partner Companies	157
Approximate Number of Facilities	2,400
Percent of U.S. Manufacturing Energy Footprint	11.4%
Reported Savings through 2014	
Cumulative Energy Savings (TBtu)	457
Cumulative Cost Savings (Billions)	$2.4
Cumulative Avoided CO_2 Emissions (Million Metric Tons)	26.6
Average Annual Energy-Intensity Improvement Rate	2.1%

- To date, Better Plants Partners have saved **$2.4 billion in cumulative energy costs** (more than 0.45 Quads of energy)

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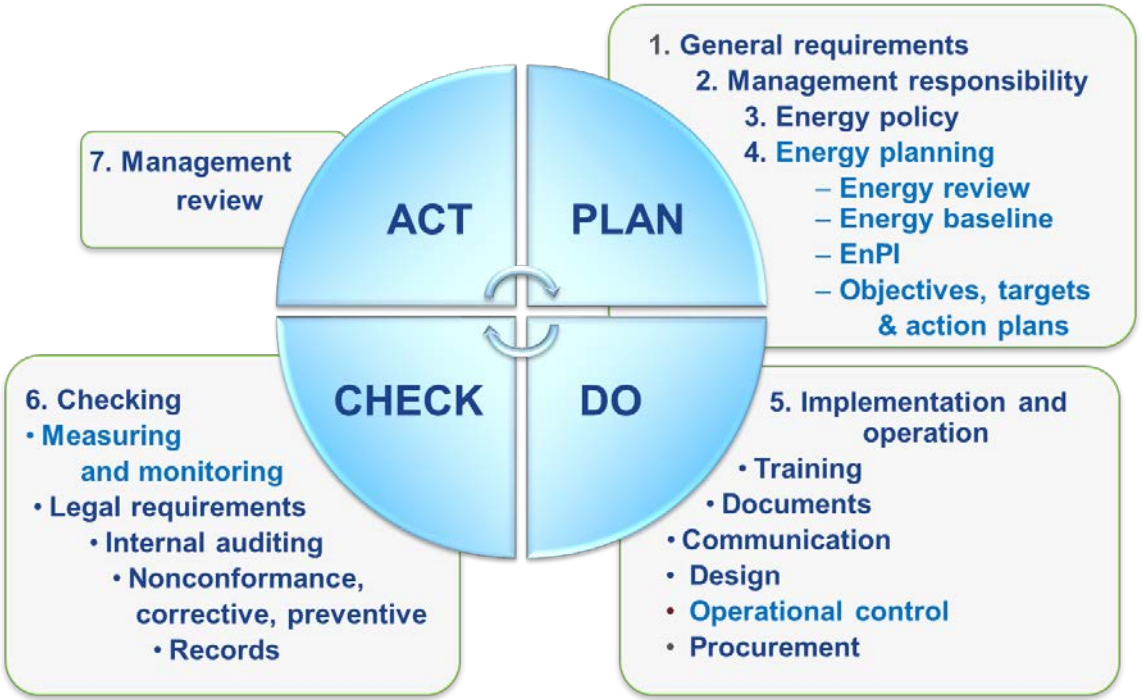
ISO 50001–Energy Management Systems (EnMS)

International standard that draws from **best practices around the world**. Developed with input from 56 countries, many countries now adopting it as a national standard.

ISO 50001 specifies requirements for establishing, implementing, maintaining and improving an EnMS.

ISO 50001 is a Framework

It does not prescribe specific energy performance improvement criteria.

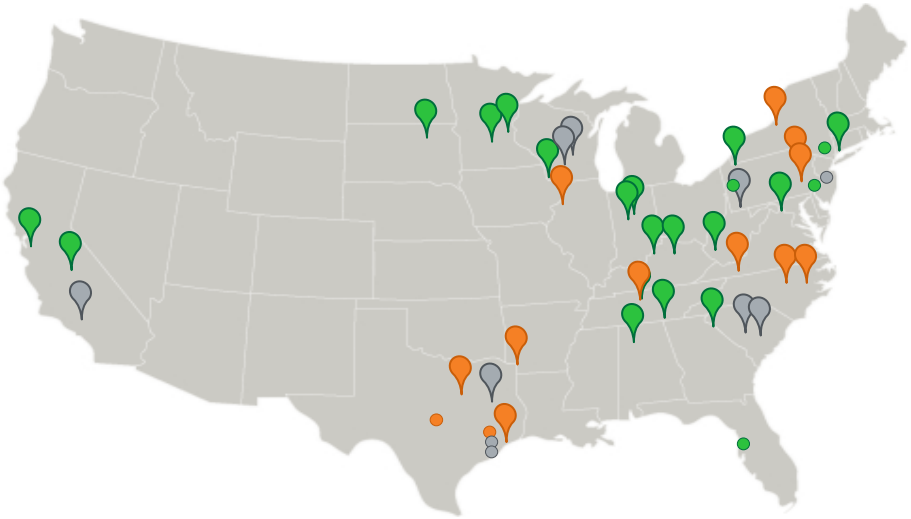


Light blue text represents new data-driven sections in ISO 50001 that are not in ISO 9001 & ISO 14001

Superior Energy Performance™

Superior Energy Performance
U.S. DEPARTMENT OF ENERGY

- SEP is a certification program that helps facilities meet the ISO 50001 energy management standard and verify the savings they achieve
- 28 plants have been certified so far. Nine improved energy performance by an average of 10% and saved over $500,000 per year



ISO 50001 is a foundational tool that any organization can use to manage energy

ISO 50001

Components in place:
- Top Management
- Energy Team
- Policy
- Planning
- Baseline
- Performance Metrics

Superior Energy Performance

ISO 50001

Single facility ISO 50001 conformance with verified energy performance improvement

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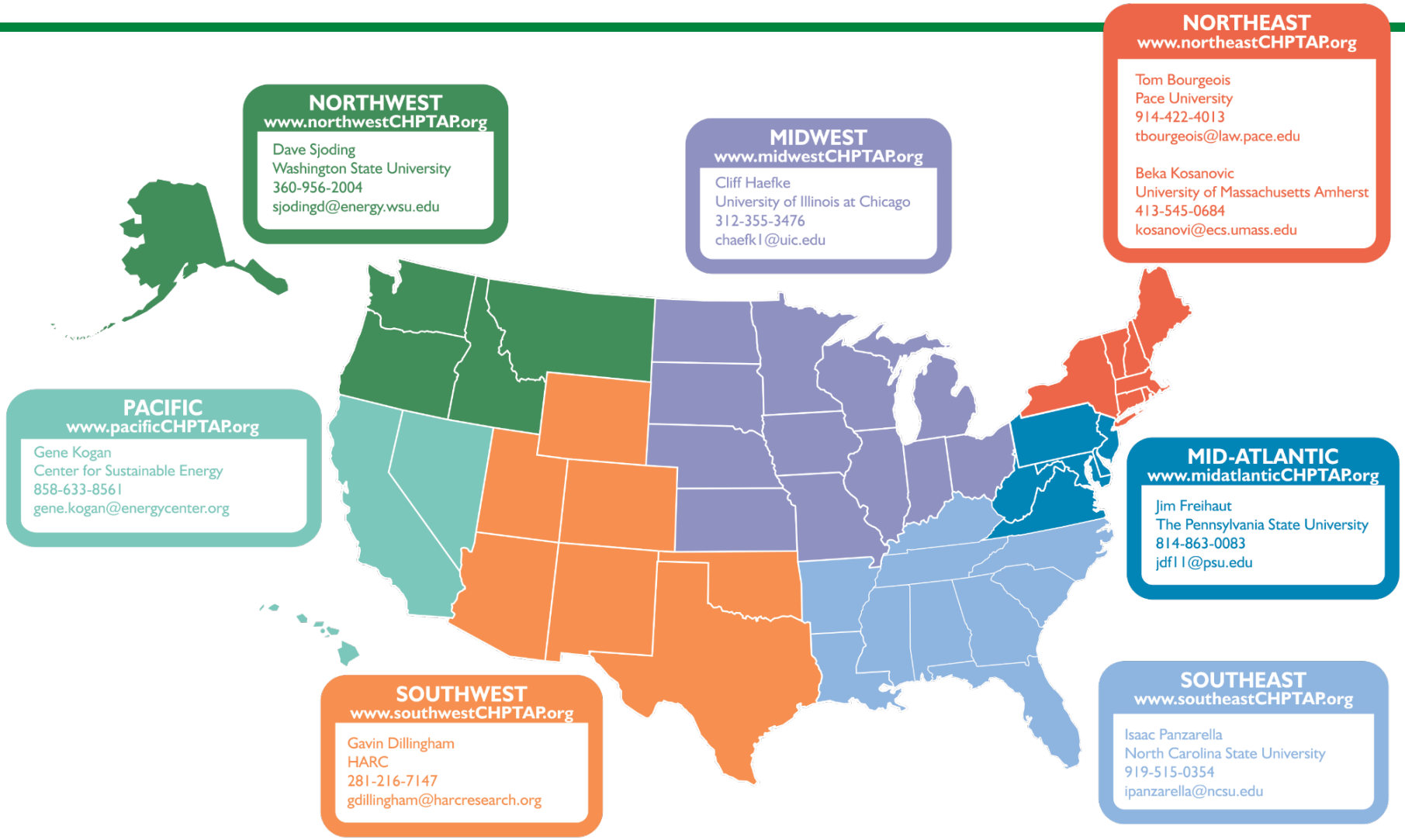
Technical Assistance: Combined Heat and Power

- **Education and Outreach**
  Providing information on the energy and non-energy benefits and applications of CHP
- **Technical Assistance**
  Providing technical assistance to end-users and stakeholders to help them consider CHP, waste heat to power, and/or district energy with CHP in their facility
- **Market Opportunity Analysis**
  Supporting analyses of CHP market opportunities in diverse markets including industrial, federal, institutional, and commercial sectors

Technical Assistance: Combined Heat and Power



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Highlights over Past 12 Month

- Quadrennial Technology Review
- Bandwidth Reports
- Multi-year Program Plan (MYPP) – Initial Framing: Built on QTR

  Valri Lightner to present this morning
- 3 New NNMI Institutes–Smart Manufacturing near selection, 2 new topic areas announced with workshops from >5 topics.
- HPC4MFG – 1st round launch, 2nd round full-proposals
- Technologist-in-Residence -1st round launch, 2nd solicitation open
- Small Business Vouchers - 1st round launch, 2nd round in review
- Lab-Based Entrepreneurial Partnerships – Launch of 2nd cohort at LBL (Cyclotron Road); expansion announced at Argonne (Chain Reaction)
- Industrial Assessment Program – Program Refresh and R&D Linkage
- Inter-Office Partnerships – Platform Technology Collaboration

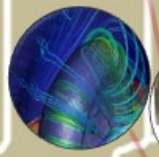
DOE NNMI Institute #2 – Carbon Fiber Composites (Oak Ridge, TN)

- Established regional centers of excellence across a number of fiber composite applications

Colorado
Wind Turbines
NREL
NATIONAL RENEWABLE ENERGY LABORATORY

Michigan
Vehicles
MICHIGAN STATE UNIVERSITY

Indiana
Innovative Design, Predictive Modeling & Simulation
PURDUE UNIVERSITY



Ohio
Compressed Gas Storage
UDRI
UNIVERSITY of DAYTON RESEARCH INSTITUTE

Tennessee
Composite Materials & Process Technology
OAK RIDGE National Laboratory
THE UNIVERSITY of TENNESSEE
UNIVERSITY OF KENTUCKY

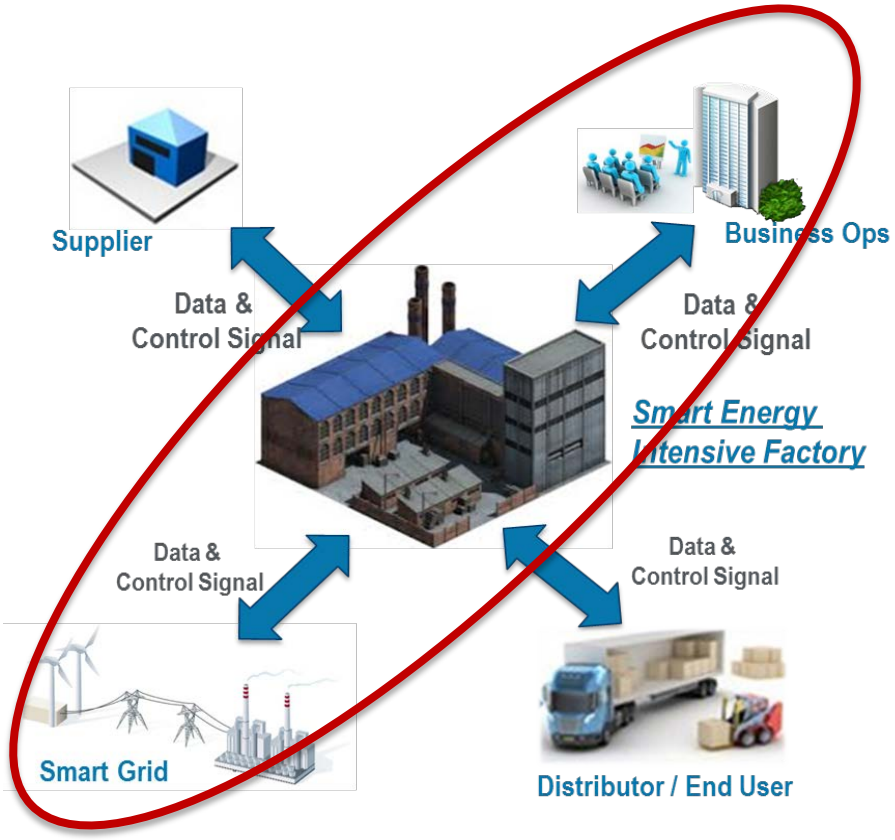
50% Lower Cost

Using 75% Less Energy

And reuse or recycle >95% of the material

DOE NNMI Institute #3 – Smart Manufacturing (TBA June 2016)

- Advanced sensors and controls for real-time process management



Focus on Real-Time

For Energy Management

Institute Goals

- >50% improvement in energy productivity
- >50% reduction in installation cost of Smart Manufacturing hardware and software
- 15% Improvement in Energy Efficiency at systems level
- Increase productivity and competitiveness across all manufacturing sectors

Two upcoming AMO / DOE-led NNMI Institutes

Up to $70 million in Federal cost share for each:

Modular Chemical Process Intensification: Focus on breakthrough technologies to dramatically improve energy efficiency of novel chemical manufacturing processes.

→ Funding Opportunity and Teaming Lists can be found at https://eere-exchange.energy.gov/

REMADE: Dramatically reduce life-cycle energy consumption through the development of technologies for reuse, recycling, and remanufacturing of materials.

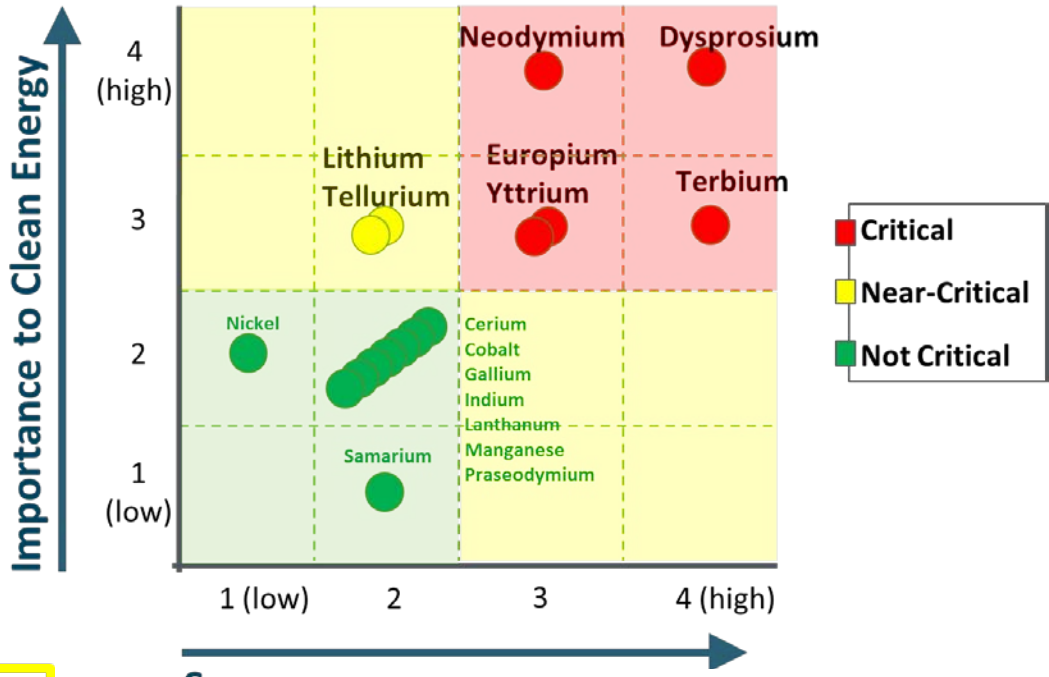
→ Funding Opportunity to be released in June

CMI Accelerating Energy Innovations

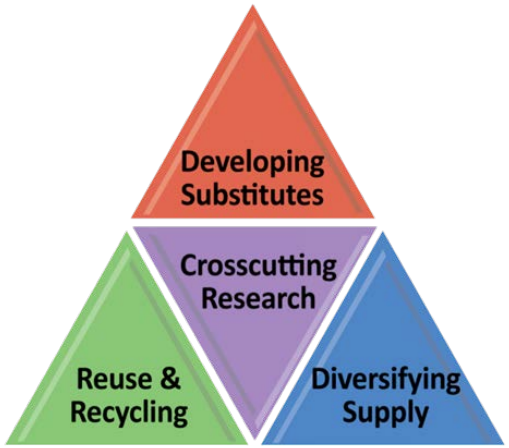
Critical Materials Institute

A DOE Energy Innovation Hub

- Consortium of 7 companies, 6 universities, and 4 national laboratories
- Led by Ames National Laboratory



	Dy	Eu	Nd	Tb	Y	Li	Te
Lighting		✓		✓	✓		
Vehicles	✓		✓			✓	
Solar PV							✓
Wind	✓		✓				



Critical Materials - as defined by U.S. Department of Energy, *Critical Materials Strategy*, 2011.

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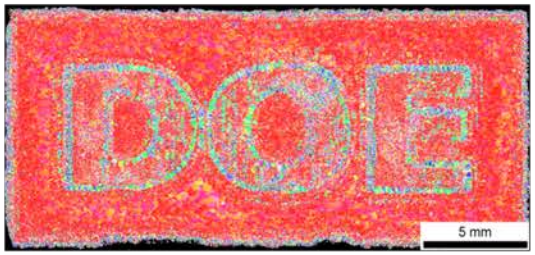
Manufacturing Demonstration Facility

Supercomputing Capabilities

Spallation Neutron Source

America Makes



Additive Manufacturing

Arcam electron beam processing AM equipment

POM laser processing AM equipment

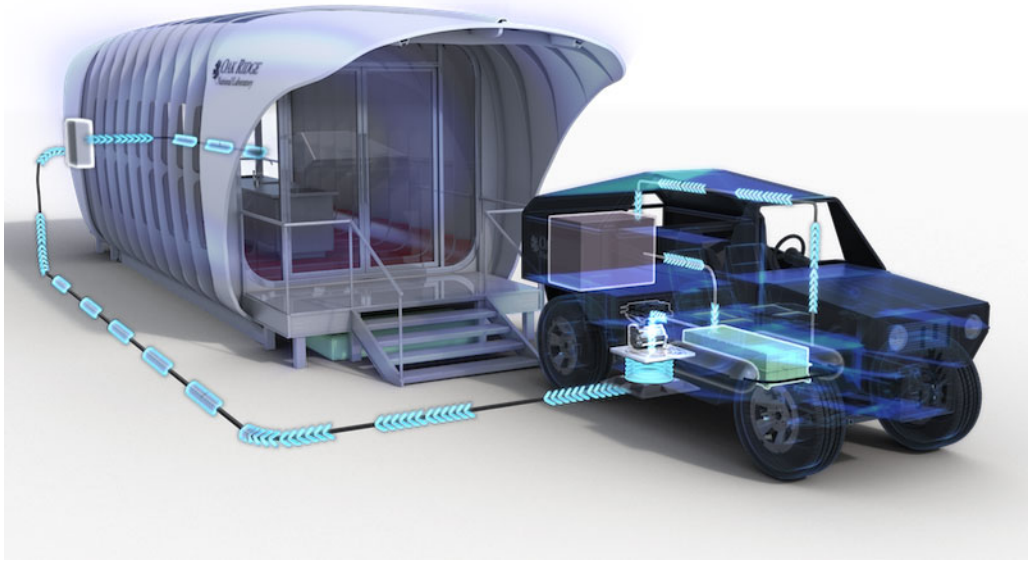
Program goal is to accelerate the manufacturing capability of a multitude of AM technologies utilizing various materials from metals to polymers to composites.

ENERGY | Energy Efficiency & Renewable Energy

Partnerships with Vehicles and Buildings R&D

3D Printing of Large Area Structures

Partnership with Designers, Manufacturers, Universities, Laboratories and Suppliers

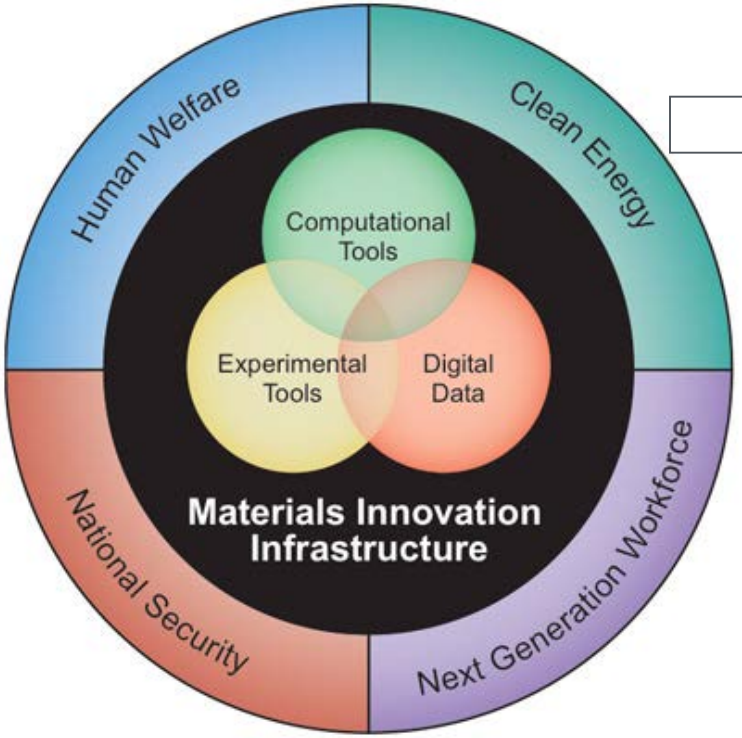


MDF: 3D Printing Wind Blade Molds

Bringing Manufacturing Innovation to the Renewable Energy Space

- Enable innovative blade designs
- Achieve lower overall costs and higher efficiencies
- Collaboration with Oak Ridge, Sandia, and TPI Composites

In Support of the Materials Genome Initiative (MGI)



MGI - Framework

Energy Materials Network
U.S. Department of Energy

Coordinated resource network with a suite of capabilities for advanced materials R&D

Predictive Simulation Across Scales	Synthesis & Characterization	Rapid Screening	End Use Performance
Process Scalability	Process Control	Real-time Characterization	Reliability Validation

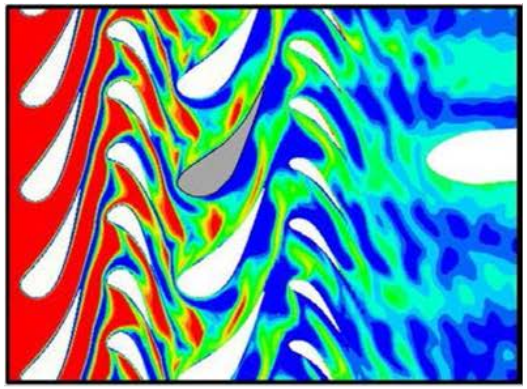
Data Management & Informatics

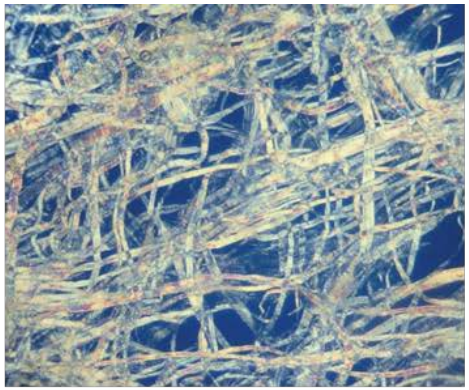
Materials Design & Synthesis → **Functional Design** → **Process Scale-Up & Qualification**

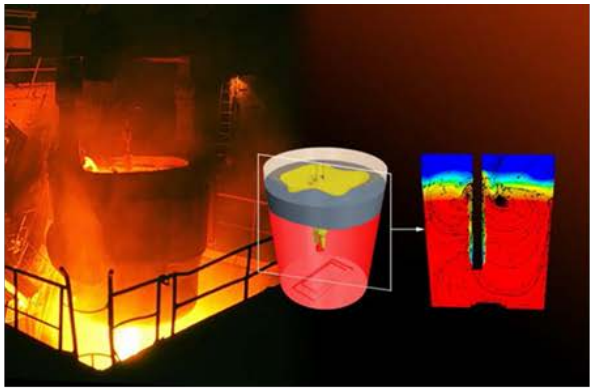
New Material Innovations for Clean Energy 2X Faster and 2X Cheaper

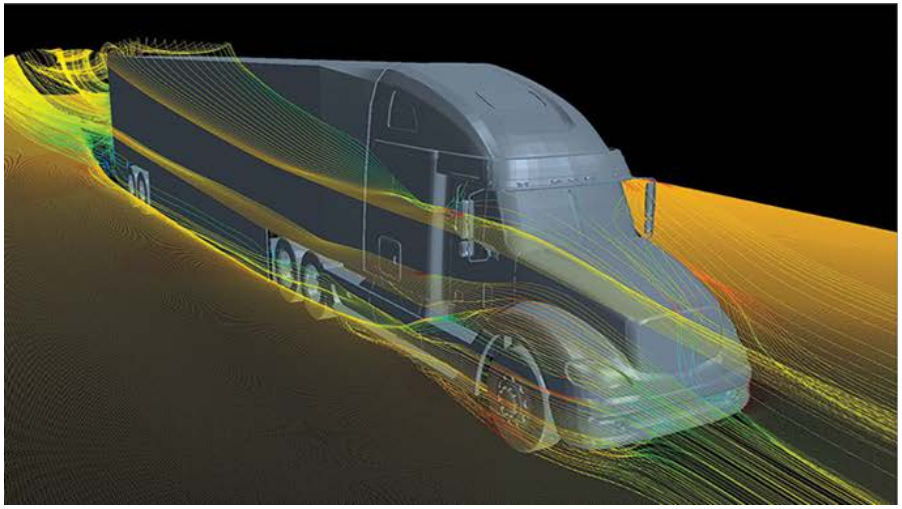
High Performance Computing for Manufacturing (HPC4Mfg)

- Program teams manufacturers with DOE's network of National Labs
- Applying High Performance Computing to face critical manufacturing challenges









Lawrence Livermore National Laboratory

BERKELEY LAB
Bringing Science Solutions to the World

OAK RIDGE National Laboratory

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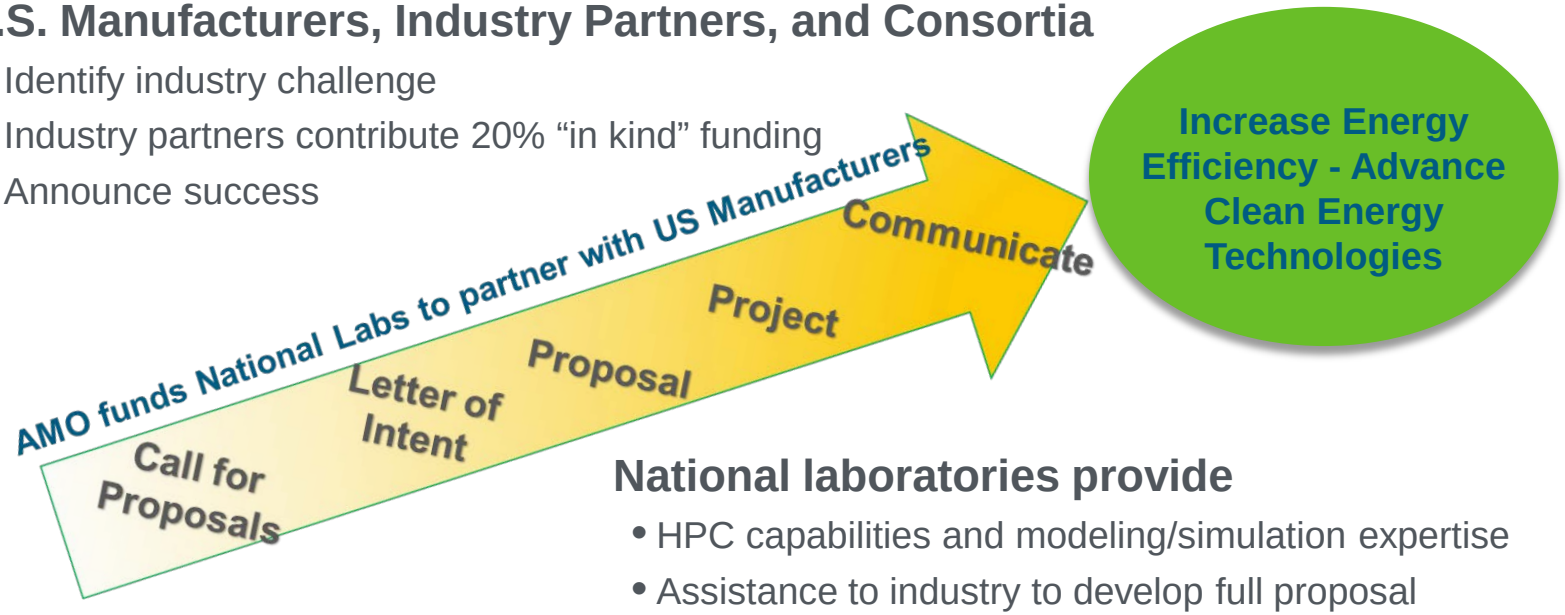
HPC4Mfg Program: Advancing Innovation

Purpose: National Laboratory-company partnerships apply modeling and simulation capabilities to manufacturing challenges in order to inform manufacturing design decisions, modify operations procedures, or guide long-term investment strategies to increase U.S. competitiveness. Key tenets include:

- Business-friendly terms and streamlined partnering process
- Leverage decades of investment in platforms, codes, and expertise
- Emphasis on open sharing of successes benefits entire sector

U.S. Manufacturers, Industry Partners, and Consortia

- Identify industry challenge
- Industry partners contribute 20% “in kind” funding
- Announce success



National laboratories provide

- HPC capabilities and modeling/simulation expertise
- Assistance to industry to develop full proposal
- Develop standard CRADA sympathetic to protection of industry IP
- DOE funding < $300K

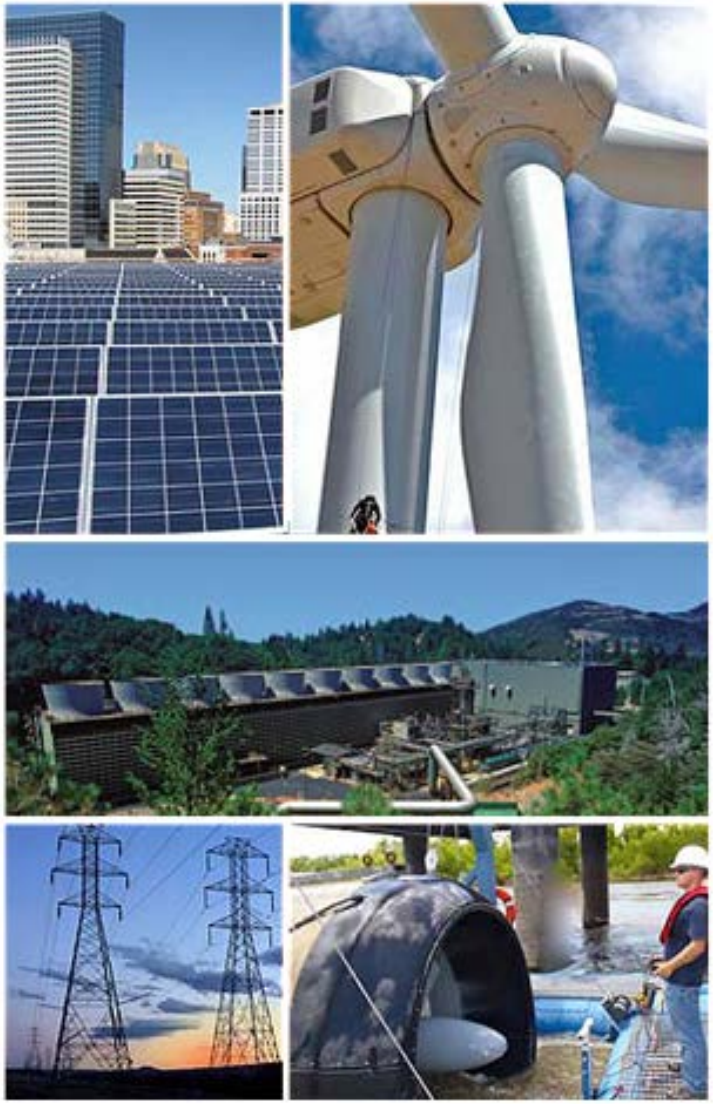
R&D: Next Generation Electric Machines (NGEM)

- Focus on developing energy efficient, high power density, integrated medium voltage drive systems.

Current efforts:

- Manufacturing of high performance thermal and electrical conductors
- Manufacturing of low-loss silicon steel
- High temperature superconducting wire manufacturing
- Manufacturing of other enabling technologies to increase performance.

Potential to save 1.6% of total U.S. electricity consumption each year



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Mission Innovation: Cyclotron Rd and Innovation Accelerators

Lab Embedded Accelerator Model:

Let the nation's best energy innovators "spin in" to our national labs

① **Recruit** the world's best energy technology innovators

② **Leverage** experts and facilities at a world-class R&D institute

③ **Deploy** people, IP, and technology to the marketplace

…First pilot phase spurred **$5 million in follow-on funding** and launched a **privately-funded startup** (Mosaic Materials)

FY17: expand to support up to 5 labs and 50 projects

What does Success Look Like?

Energy Products Invented Here…

…And Competitively made here for 21st Century