



U.S. DEPARTMENT OF
ENERGY

Energy Efficiency &
Renewable Energy

Advanced Manufacturing Research & Development at the U.S. Department of Energy

*H2@Scale Workshop
Golden, CO*

November 17th, 2016

Mark Johnson

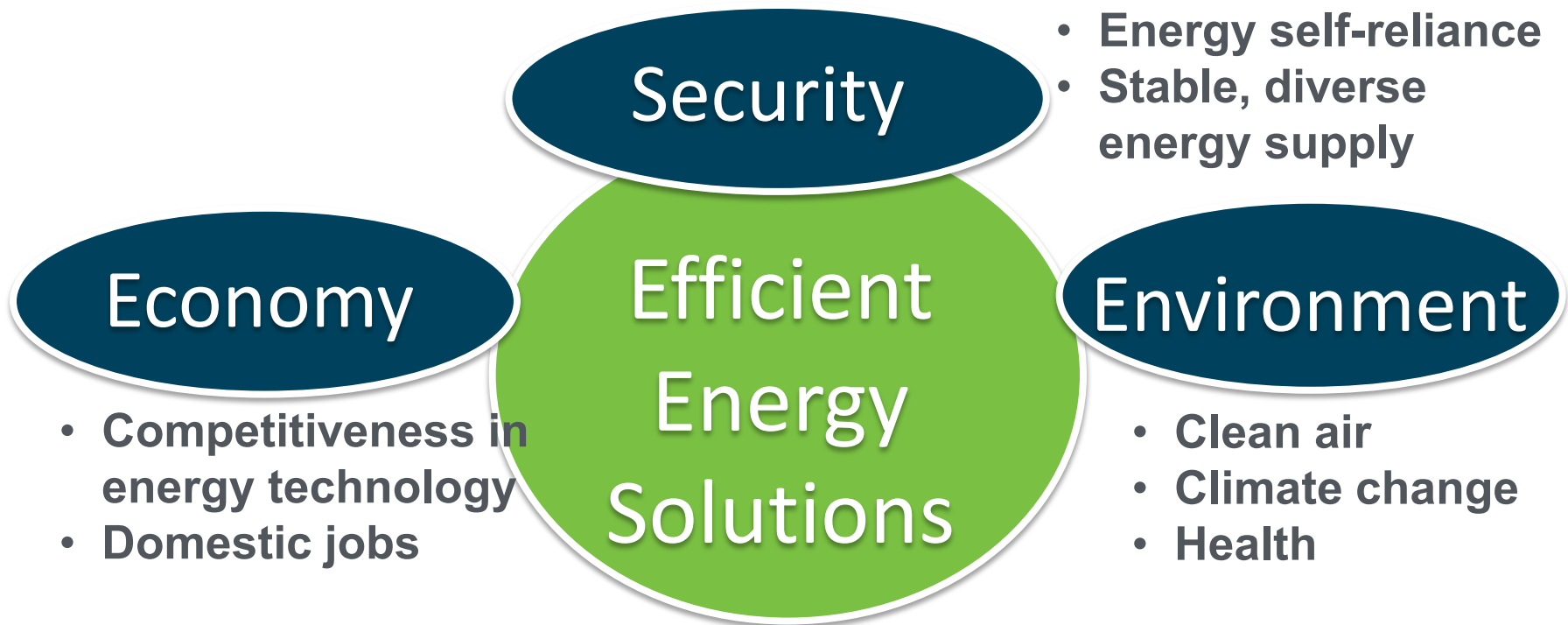
Director

Advanced Manufacturing Office

www.manufacturing.energy.gov

- **Overview of DOE Advanced Manufacturing Office**
- **Technology Assistance Programs**
- **Research and Development Projects**
- **Research and Development Consortia**

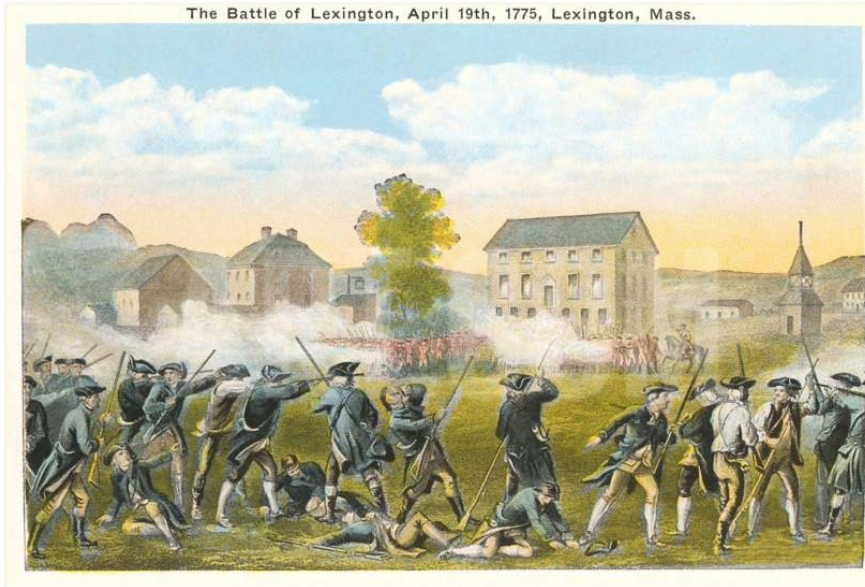
Energy and Manufacturing: Nexus of Opportunities



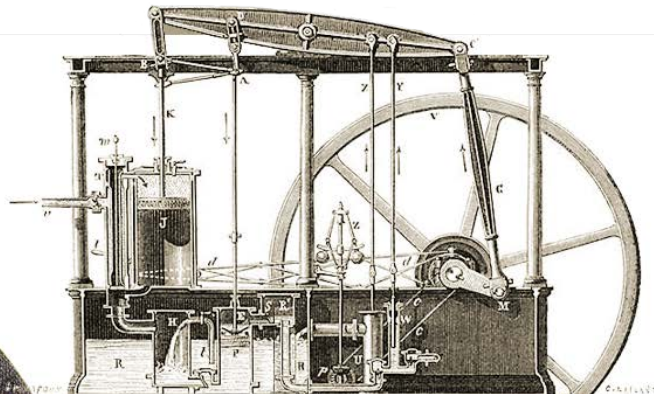
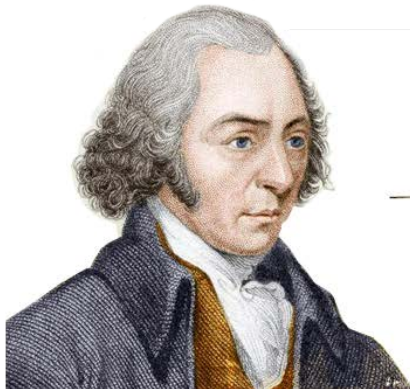
Goals

- Develop a robust U.S. energy systems economy where products are developed here and manufactured here
- Make the entire U.S. manufacturing sector more competitive by making it more energy productive

The Start of the Manufacturing Revolution



Lexington & Concord
1775



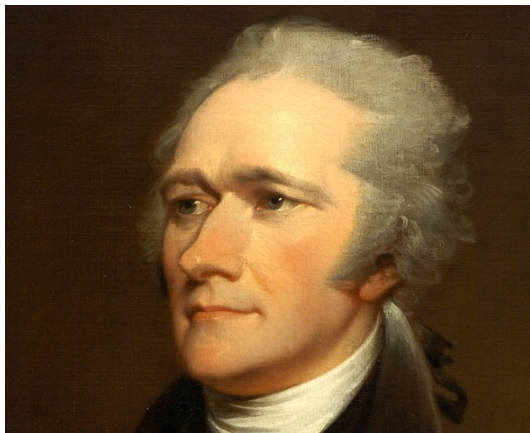
Watt, Boulton & Co.
1775

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

Today's Goal: Energy products invented here and made here



Focus on:

- Energy efficient manufacturing
- Competitive manufacturing of energy technologies
- Technology + Talent (People)

This Decade:

Wind Power:

70GW+

3x increase

30% cost reduction

This Decade:

Solar Power:

25GW+

20x increase

60% cost reduction

This Decade

Batteries & EVs:

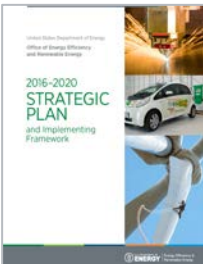
420,000+ EV's

70% battery cost reduction

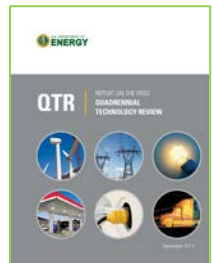
Advanced Manufacturing – Strategic Framing



Advanced Manufacturing Partnership (AMP2.0)
(NEC / PCAST / OSTP 2013 & 2014)



Strategic Plans
(DOE 2014 & EERE 2016)

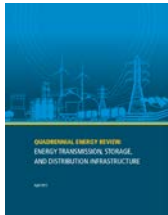


Quadrennial Technology Review
(DOE / Science and Technology 2015)

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

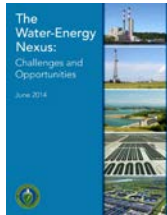
2) Platform Materials, Process and Information Technologies for Clean Energy Manufacturing with Sustainable Life-Cycle Impact

Some Additional Manufacturing Related Issues



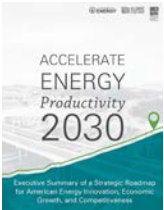
Quadrennial Energy Review (QER): 2015

- Manufacturing for Infrastructure and the Grid



Water-Energy Nexus: 2014

- Water for Energy & Energy for Water



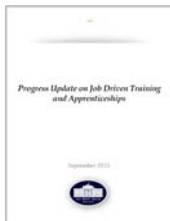
Energy Productivity 2030: 2015

- Double GDP/kJ Economy from Energy



Innovation Strategy: 2015

- Technology, Workforce & Capabilities



Job Training and Apprenticeship: 2015

- Advanced Manufacturing Skills and Opportunities



Revolution Now: 2015

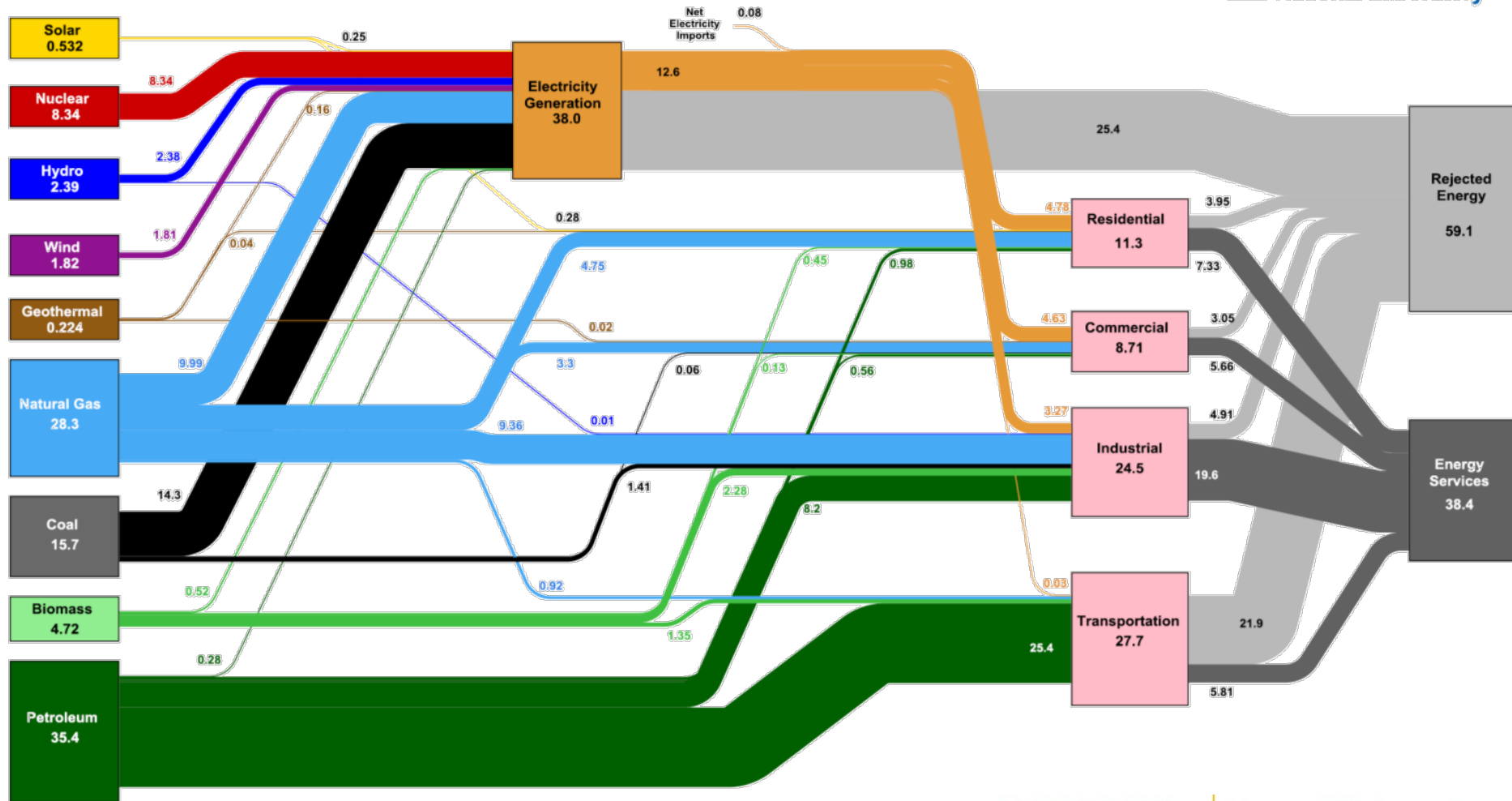
- Cost Effective New Technologies

3) Promotion of Innovation Partnerships

4) Tools, Training & Human Capital Development

Energy Use in the US Economy

Estimated U.S. Energy Consumption in 2015: 97.5 Quads



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



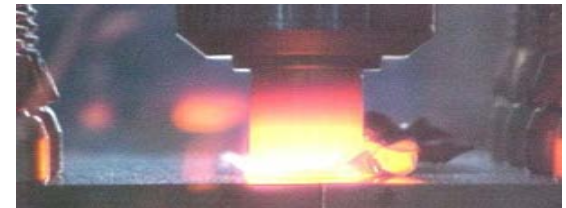
Membranes



EV Batteries



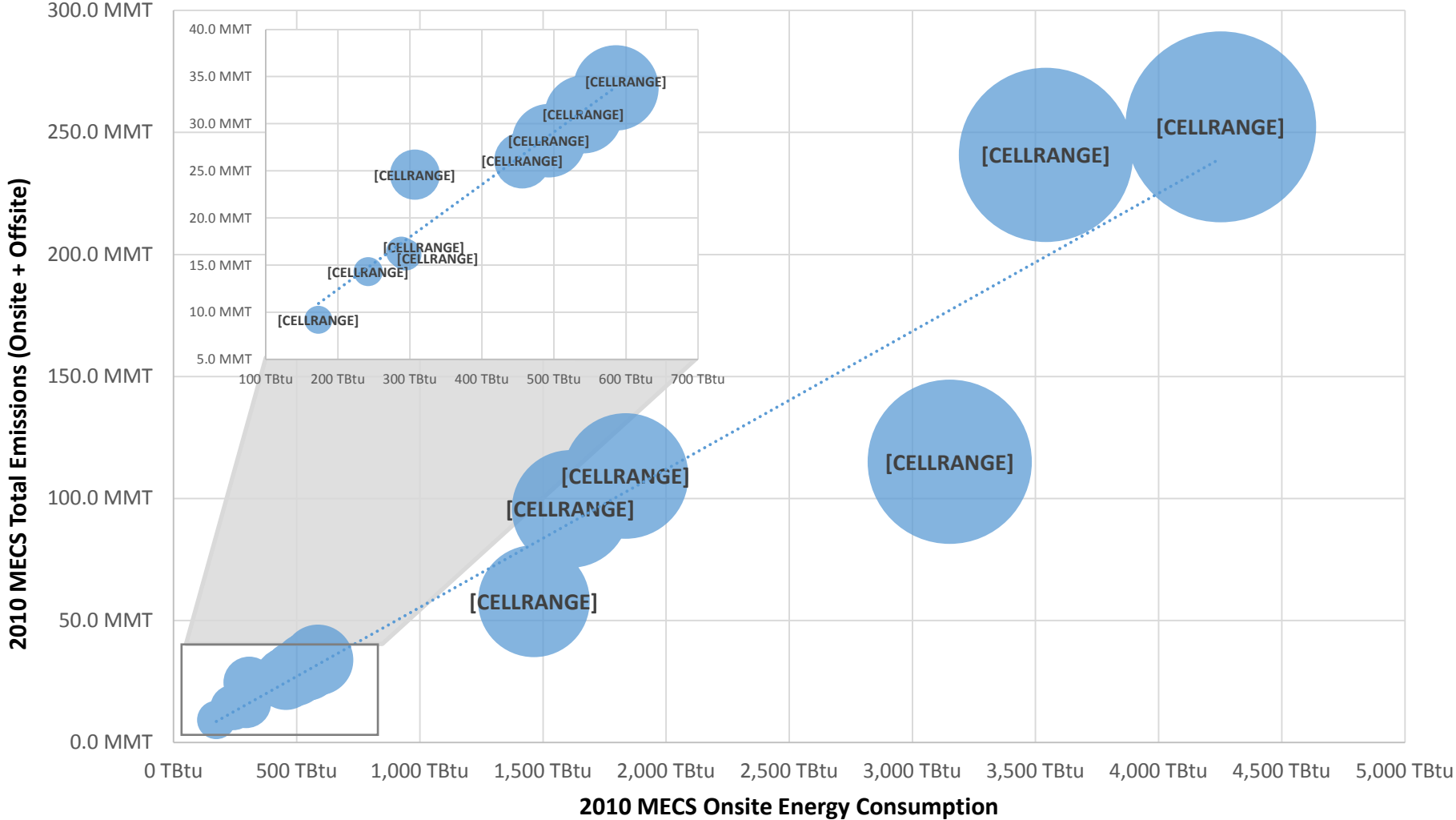
Multi-Material Joining



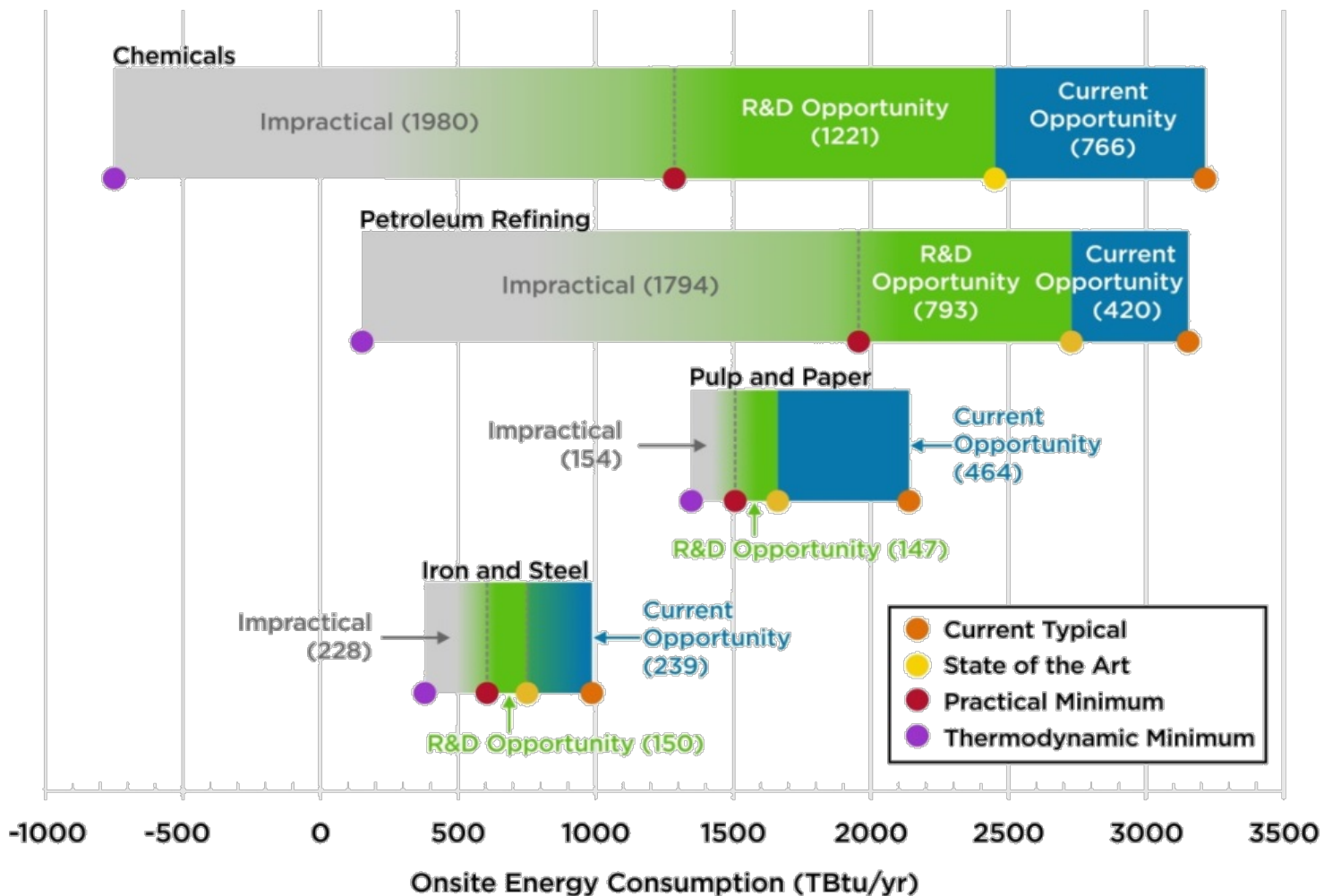
Water Desalination



Primary Energy & Energy-related Emissions by Sector

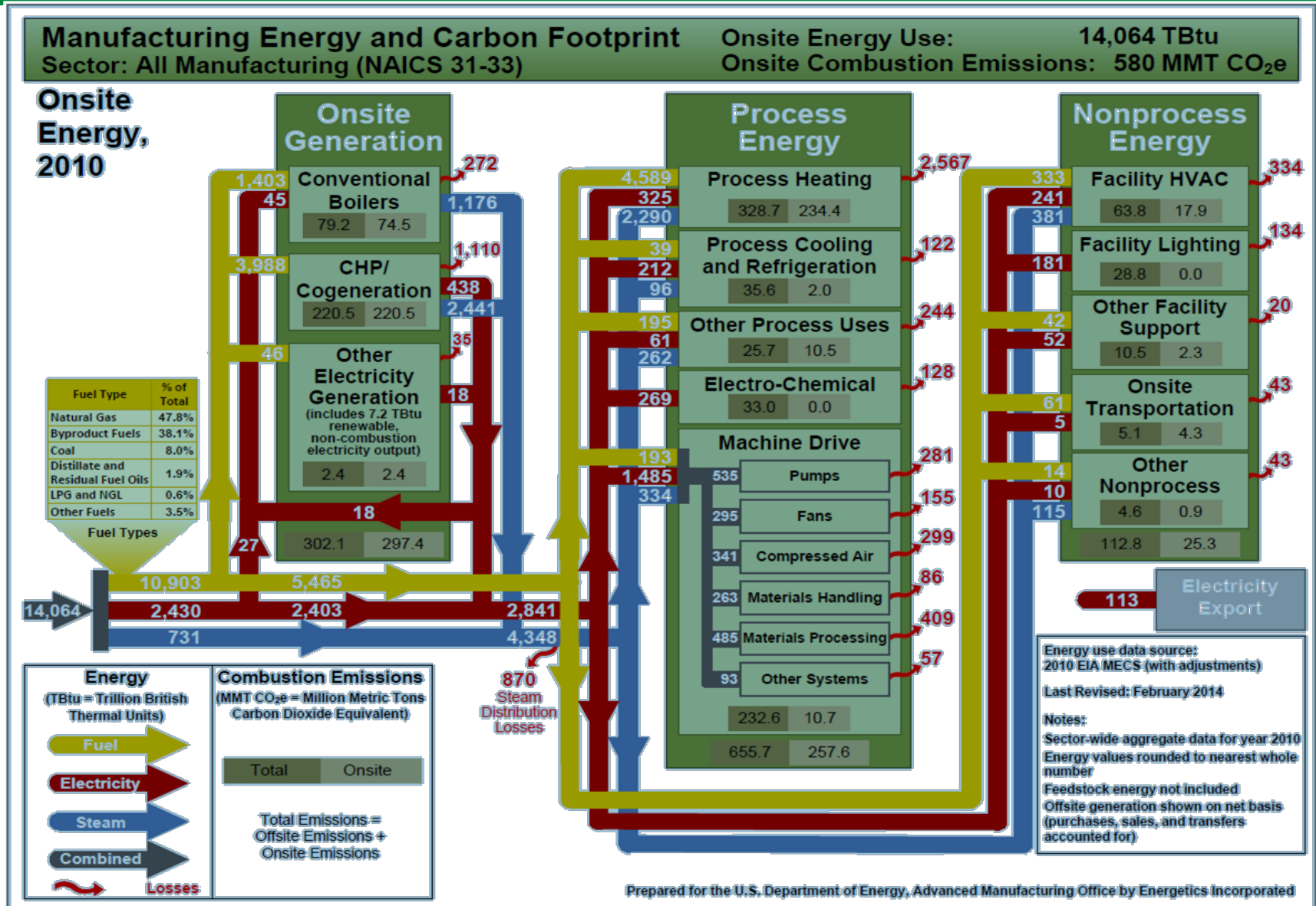


Manufacturing Bandwidth Studies: Energy Savings Potential



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

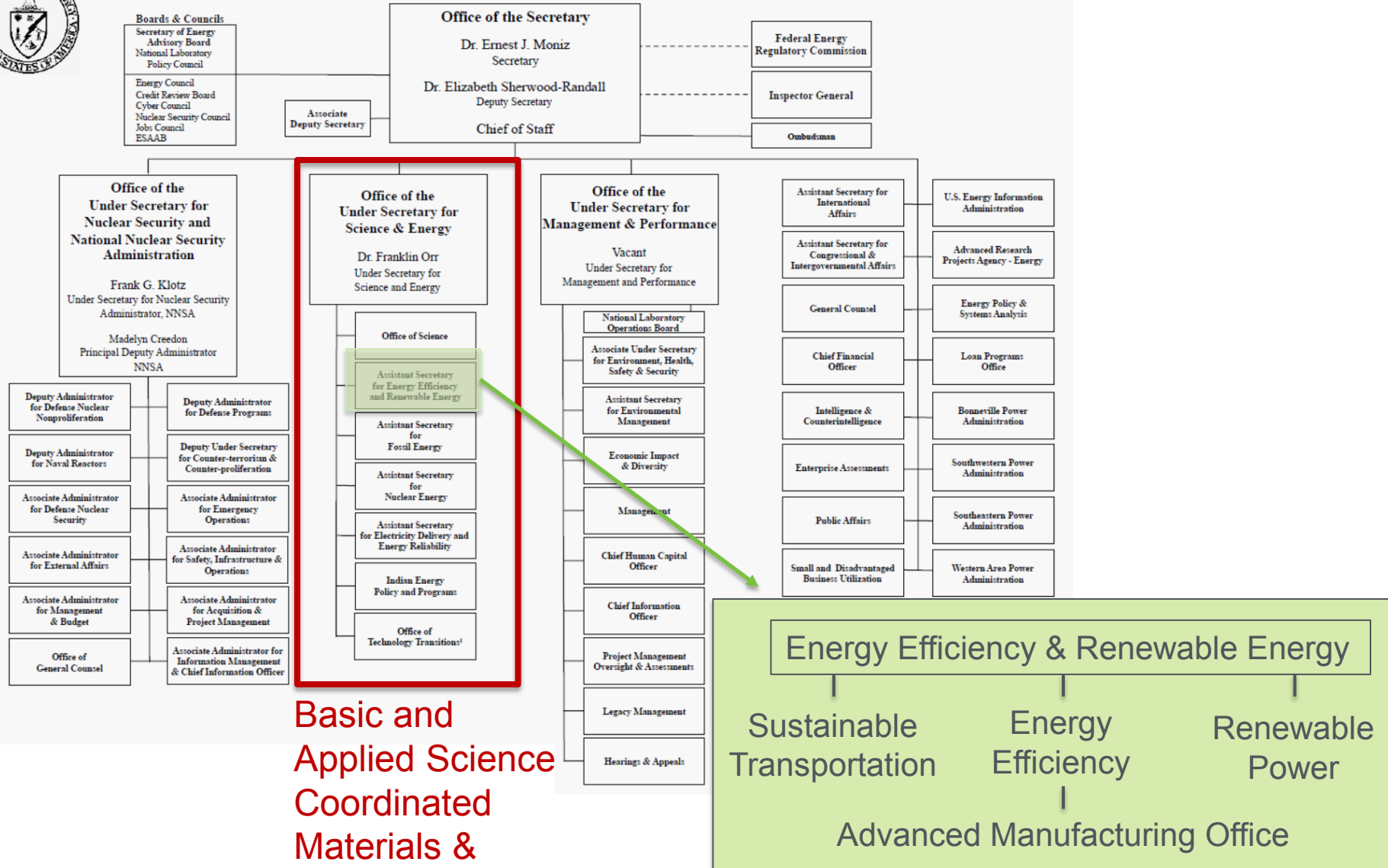
Deeper Look at Energy in Manufacturing



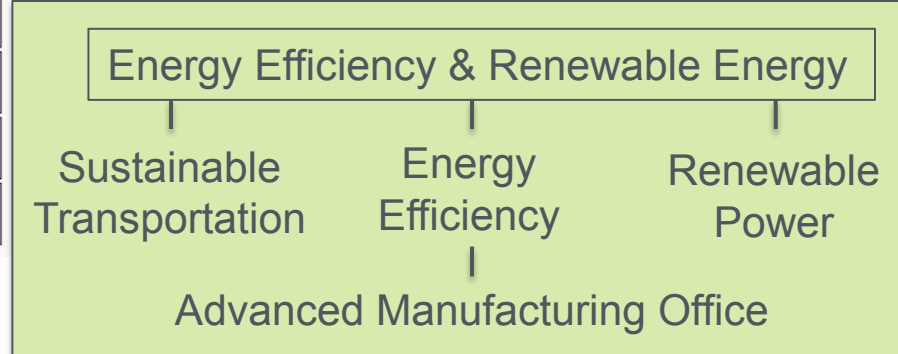
Advanced Manufacturing in the Department of Energy



DEPARTMENT OF ENERGY



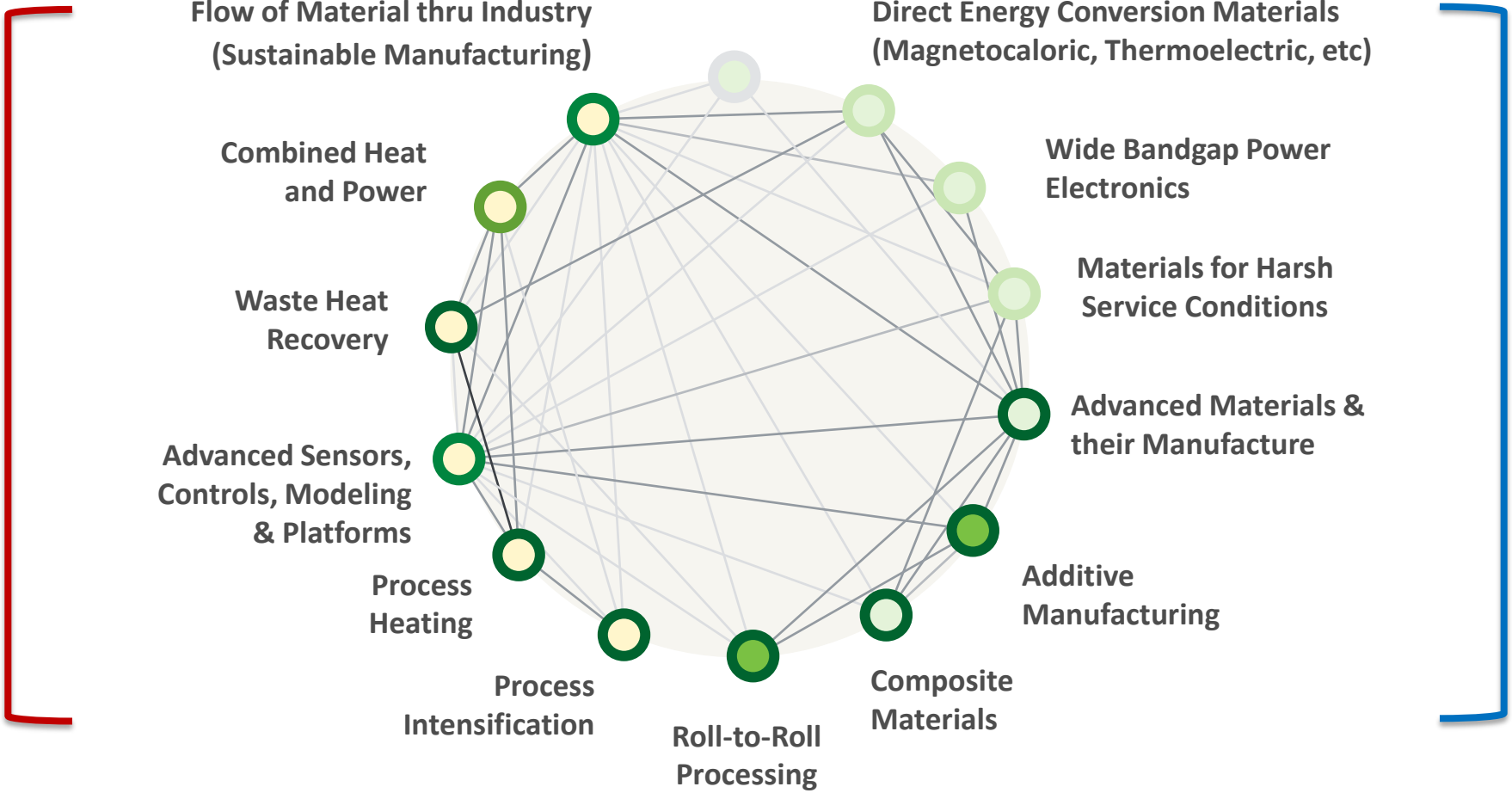
Basic and Applied Science
Coordinated Materials & Manufacturing



Quadrennial Technology Review: Manufacturing

Efficiency Technologies

Enabling Platform Technologies



Information

Processes

Materials

Energy & Resource Management

Advanced Manufacturing Processes

Materials Development

U.S. DEPARTMENT OF **ENERGY**

Energy Efficiency & Renewable Energy

Advanced Manufacturing Technology Areas

Efficiency Technologies for Manufacturing Processes (Energy, CO₂)




















- (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)

QTR Manufacturing (Ch.6) Focus Areas Mapped to Advanced Manufacturing Research & Development Areas

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

	Chemicals & Bio-chemicals	Petroleum Refining	Primary Metals	Forest & Food Products	Clean Water
SMART Manufacturing					
Process Intensification					
CHP & Grid Integration					
Sustainable Manufacturing					

**Sector Specific Roadmaps through
Complementary Program Supported by NIST / AmTech**

AMO: Three complementary strategies

Technical Assistance: Engagement with Industry

Driving a corporate culture of continuous improvement and wide scale adoption of proven technologies, such as CHP, to reduce energy use in the industrial sector

R&D Consortia: Public-Private R&D Partnerships

Shared R&D Facilities offer affordable access to physical and virtual tools, and expertise, to foster innovation and adoption of promising technologies

R&D Projects: Bridging technology innovation gaps

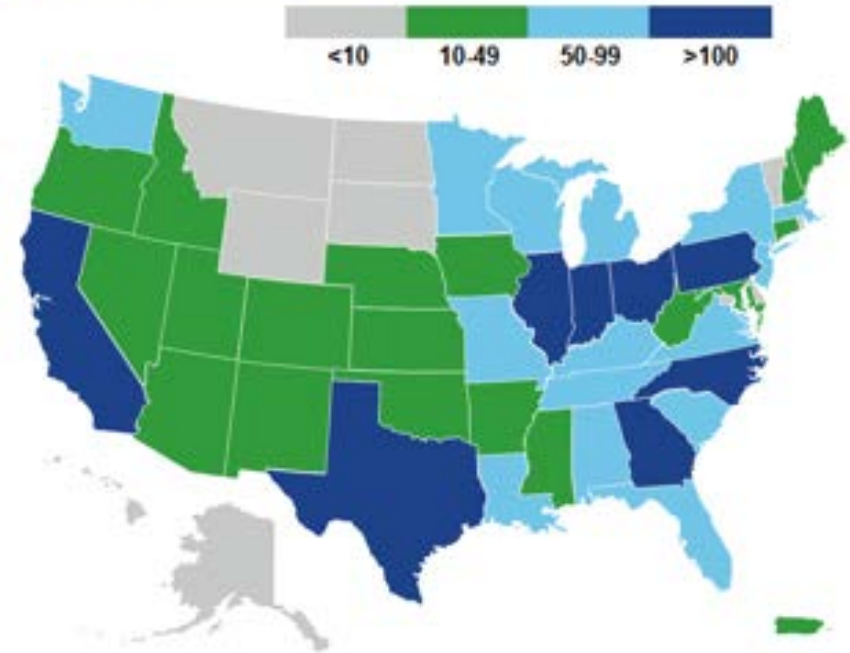
Research and Development Projects to support innovative manufacturing processes and next-generation materials

-
- **Overview of DOE Advanced Manufacturing Office**
 - **Technology Assistance Programs**
 - **Research and Development Projects**
 - **Research and Development Consortia**

Technical Assistance: Better Plants Program

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

Regional Distribution of Better Plants Facilities



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 reported **\$2.4 billion in cumulative energy costs** (more than 0.45 Quads of energy)

Partners benefit from...

- National recognition
- In-Plant Trainings
- Networking opportunities
- Access to an expert Technical Account Manager
- Enhanced access to DOE resources and opportunities

For more info go to www.energy.gov/BetterPlants

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.

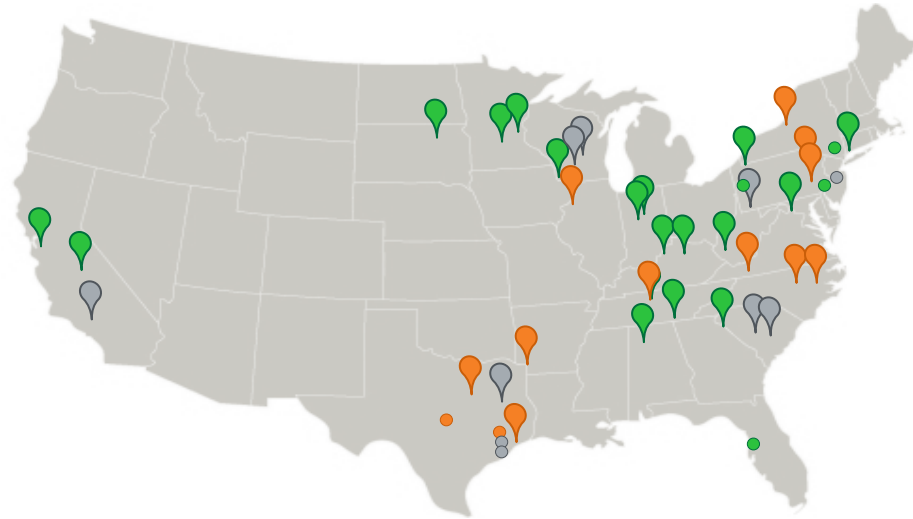
ISO 50001 specifies requirements for establishing, implementing, maintaining and improving an EnMS.

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

- 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

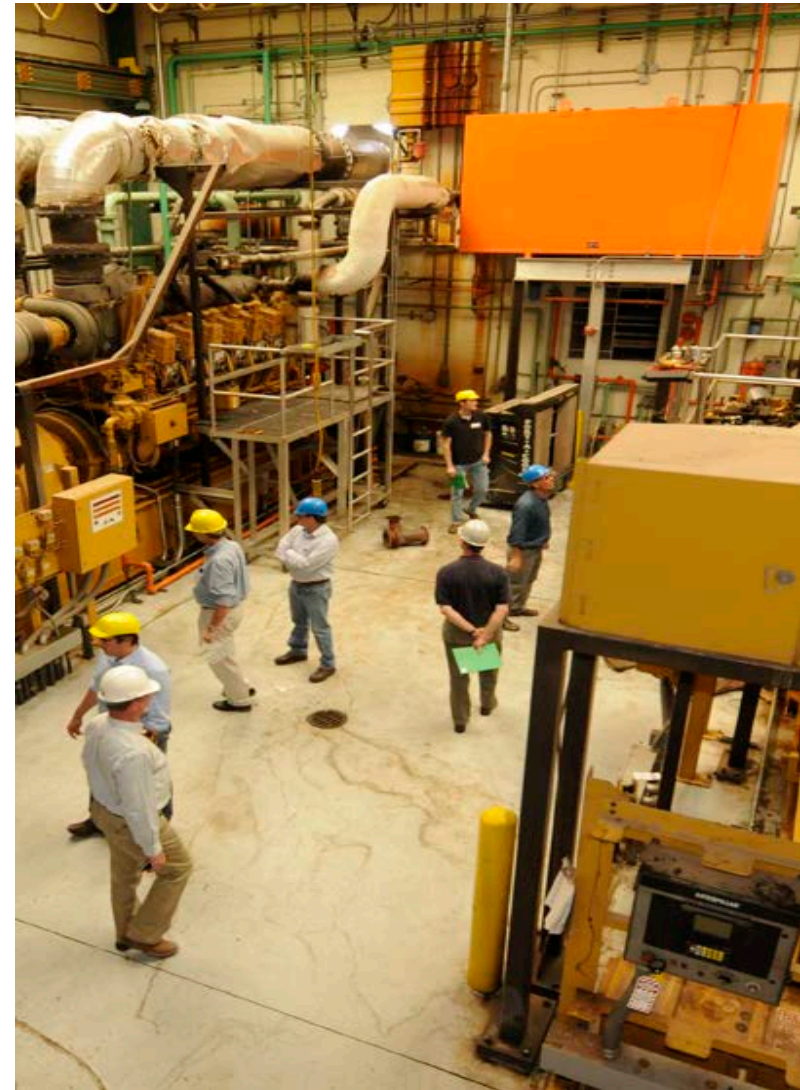
ISO 50001



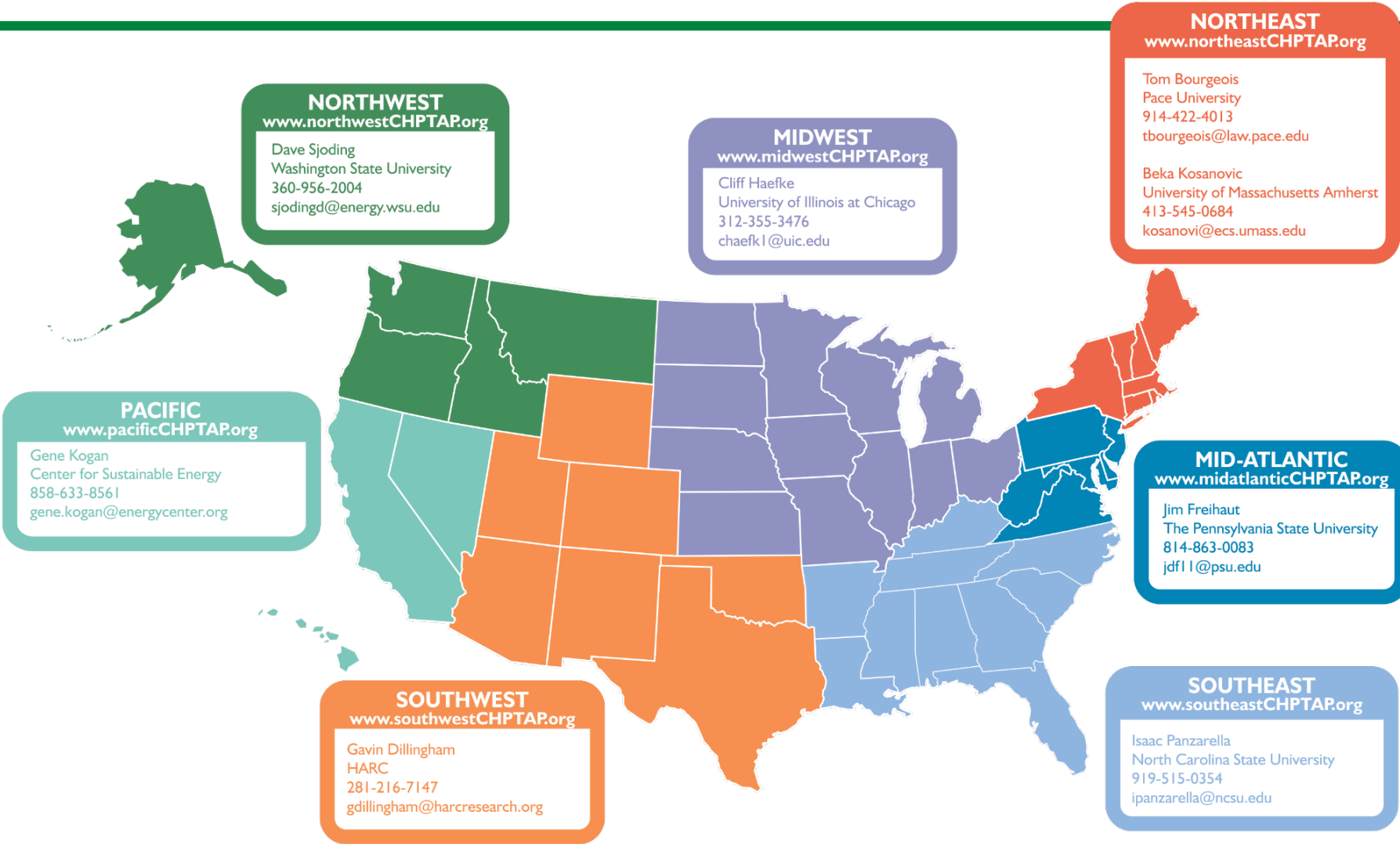
Single facility ISO 50001 conformance with verified energy performance improvement

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



DOE CHP Technical Assistance Partnerships (CHP TAPs): Program Contacts
chp@ee.doe.gov

Claudia Tighe
CHP Deployment Program Manager
Office of Energy Efficiency and Renewable Energy (EERE)
U.S. Department of Energy
E-mail: claudia.tighe@ee.doe.gov

Jamey Evans
Project Officer, Golden Field Office
EERE
U.S. Department of Energy
E-mail: jamey.evans@go.doe.gov

Patti Welesko Garland
Enterprise Account POC
CHP Deployment Program
EERE, U.S. Department of Energy
E-mail: Patricia.Garland@ee.doe.gov

Ted Bronson
DOE CHP TAP Coordinator
Power Equipment Associates
Supporting EERE
U.S. Department of Energy
E-mail: tbronson@peaonline.com


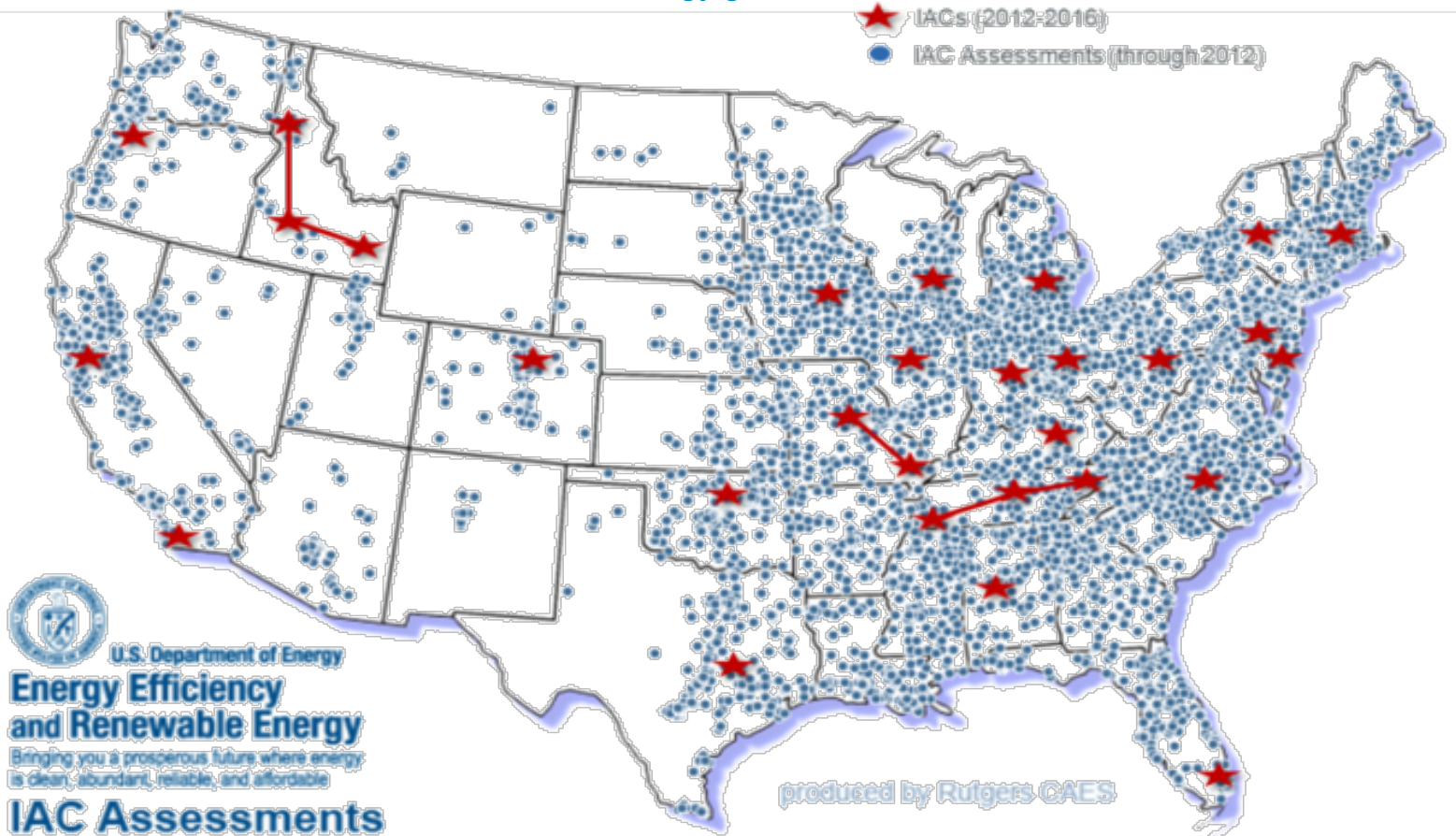
Technical Assistance: Industrial Assessment Centers

Energy Assessments & Student Training

University-based Industrial Assessment Centers

Support for small/medium sized manufacturing

Energy.gov/IAC



U.S. Department of Energy
**Energy Efficiency
and Renewable Energy**
Bringing you a prosperous future where energy
is clean, abundant, reliable, and affordable
IAC Assessments

produced by Rutgers CAES