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

Update on DOE Advanced Manufacturing Office

HTAC Meeting
Washington, DC

May 4, 2017

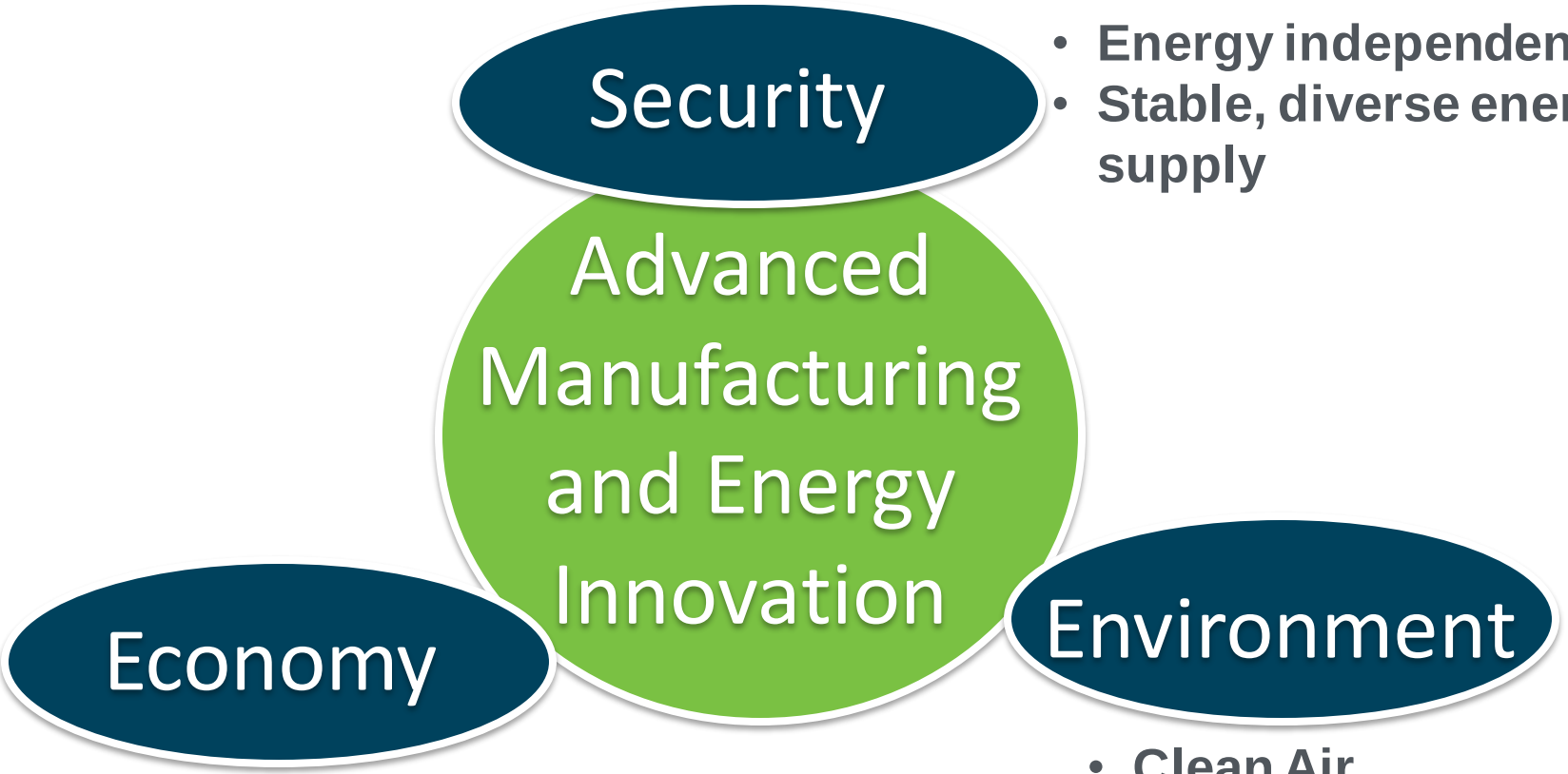
Robert Ivester

Deputy Director

Advanced Manufacturing Office

www.manufacturing.energy.gov

Impact of Energy and Manufacturing Innovation



- Energy independence
- Stable, diverse energy supply

- Competitiveness in energy products
- Domestic jobs

- Clean Air
- Clean Water

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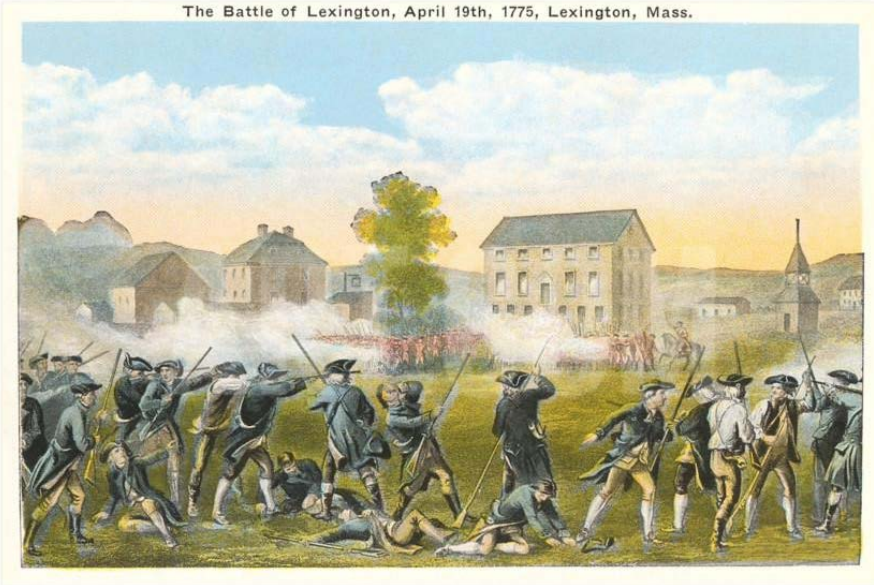
A little history: The Start of a pair of Revolutions



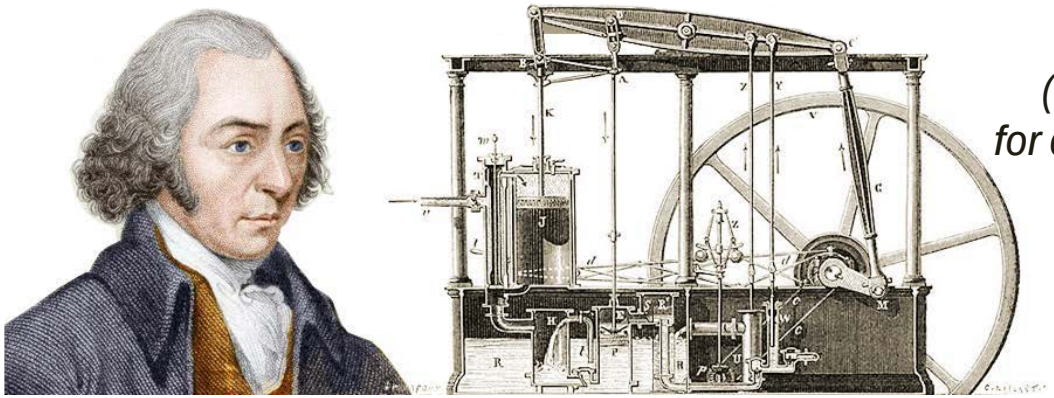
Lexington & Concord

1775

Watt, Boulton & Co.

1775

(intelligence: steam regulation for external combustion engines)



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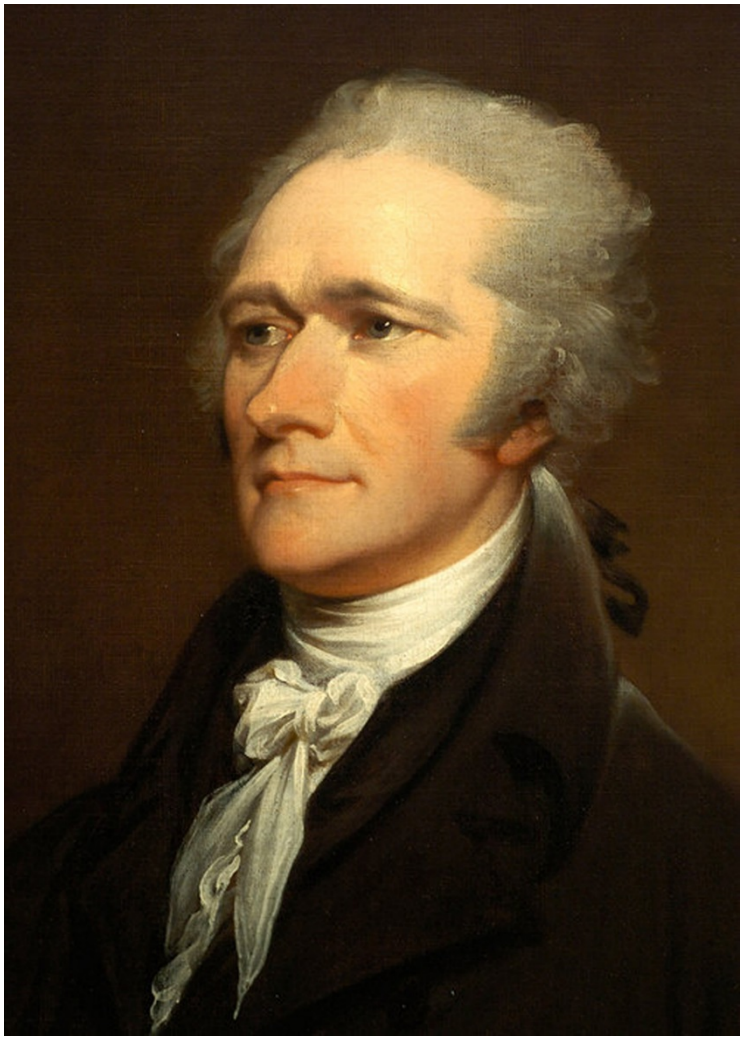
US Manufacturing Strategy for First Industrial Revolution



"... 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."

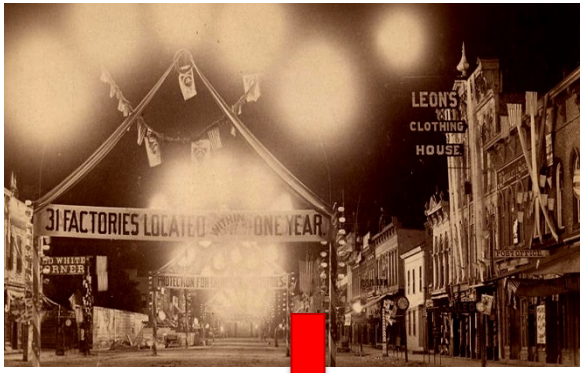
- Alexander Hamilton
US Treasury Secretary (1789-1795)

Reports to Congress

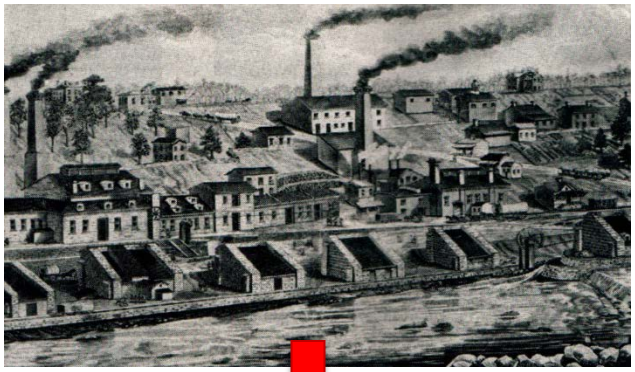
First Report on the Public Credit - 1790
Second Report on Public Credit - 1791
Report on the Subject of Manufactures - 1791

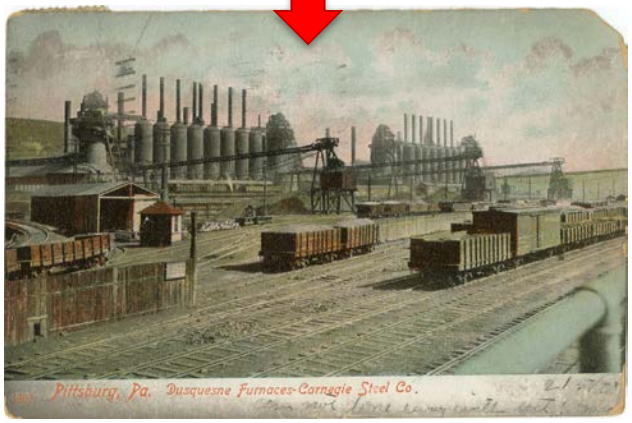
Second Industrial Revolution

Electrification

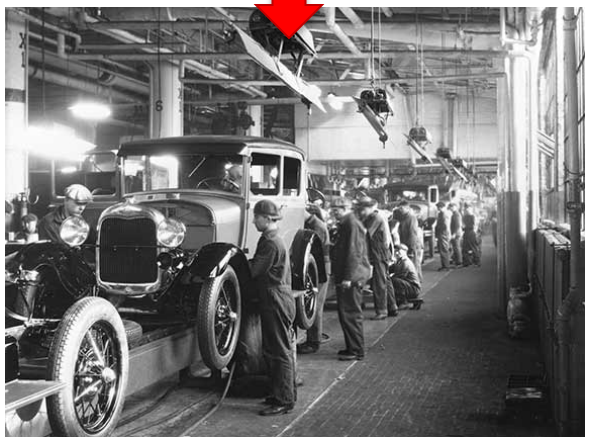


Process Scaling Energy & Materials





Standardization & Assembly Line



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Energy Intensive Industries -Today

Primary Metals
1608 TBTU

Petroleum Refining
6137 TBTU

Chemicals
4995 TBTU

Wood Pulp & Paper
2109 TBTU

Glass & Cement
716 TBTU

Food Processing
1162 TBTU

Other Manufacturing
~1600 TBTU

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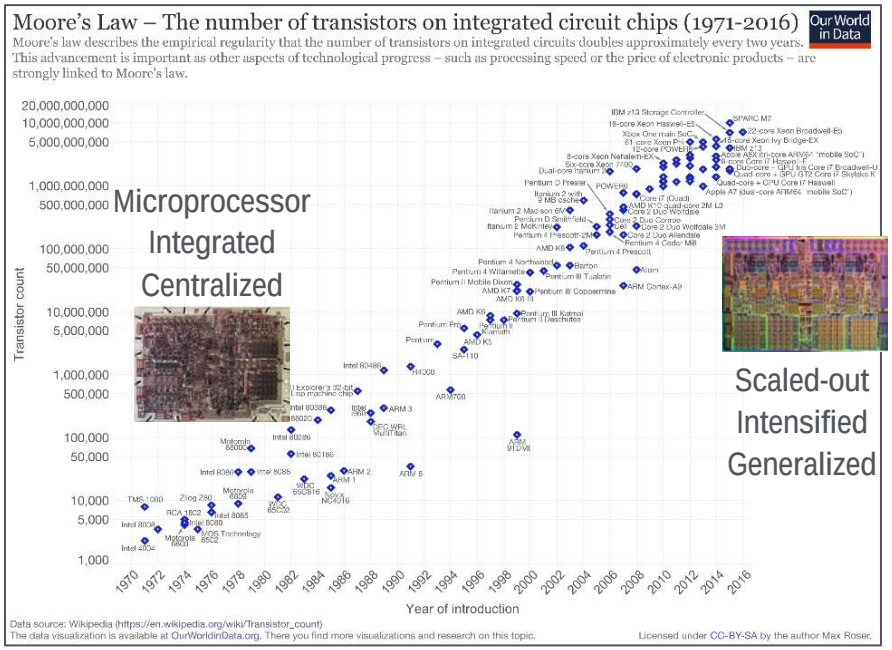
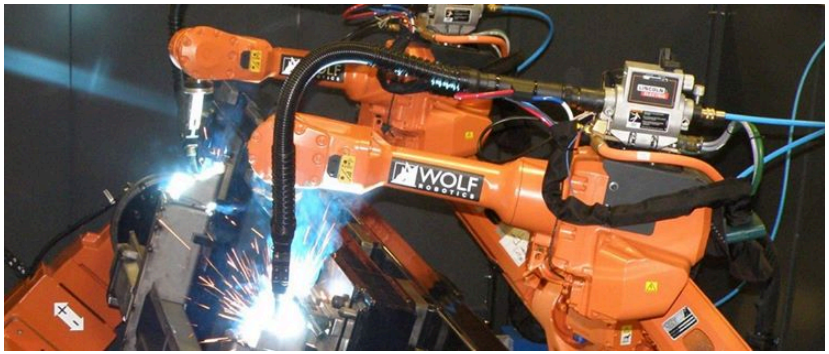
Third Industrial Revolution - Today





How will Manufacturing, Economy and Security of the Nation depend on Information, Computation, Actuation and Communication Technologies in the 21st Century?

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Processes for Energy Materials & Technologies

Energy Dependence: Energy Cost Considered in Competitive Manufacturing

Solar PV Cell

Carbon Fibers

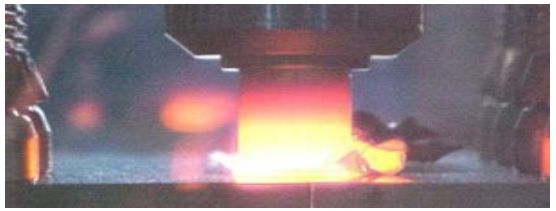
Light Emitting Diodes

Electro-Chromic Coatings

Membranes

EV Batteries

Multi-Material Joining



Water Desalination

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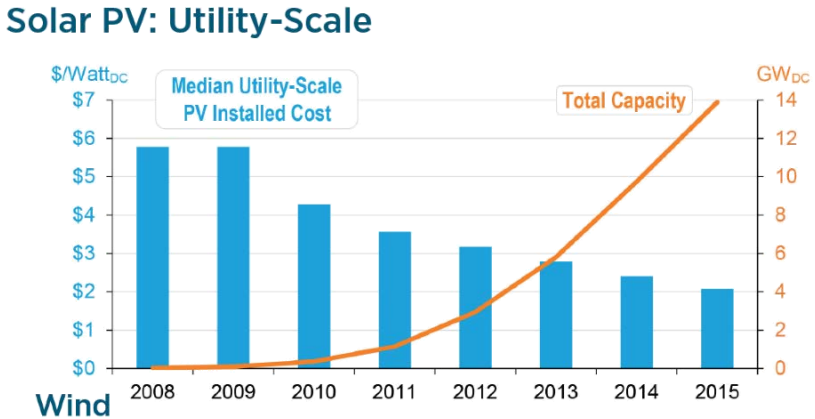
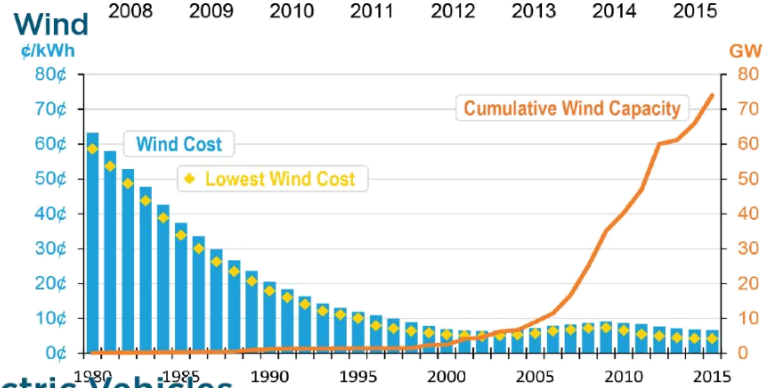
Manufacturing Innovation and Technology Learning Curves

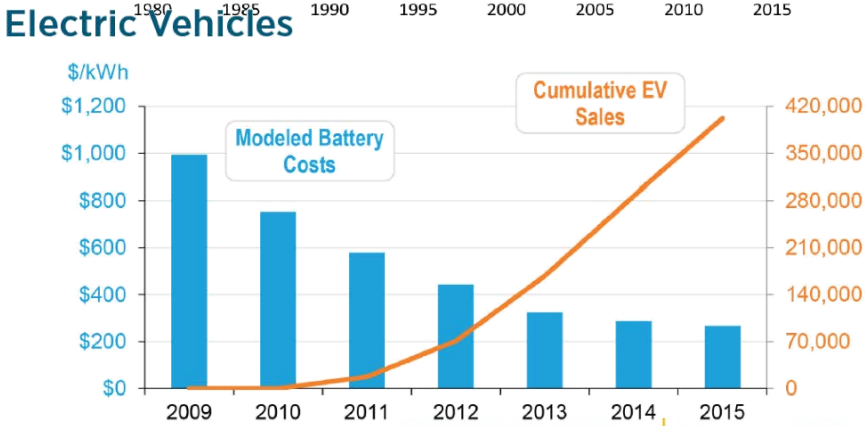
Solar Power:



Wind Power:



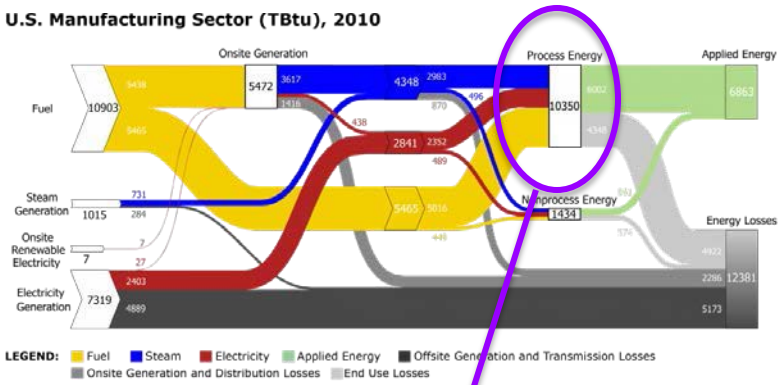
EV Batteries:



Source: EERE Revolution Now!

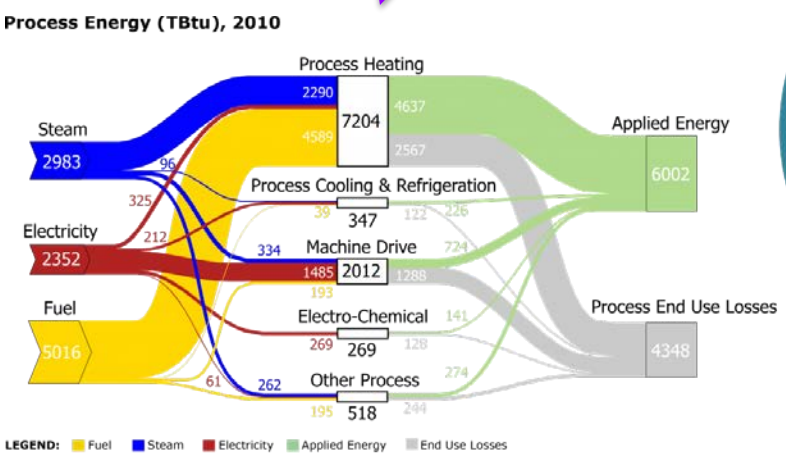
Advanced Manufacturing -- Opportunity

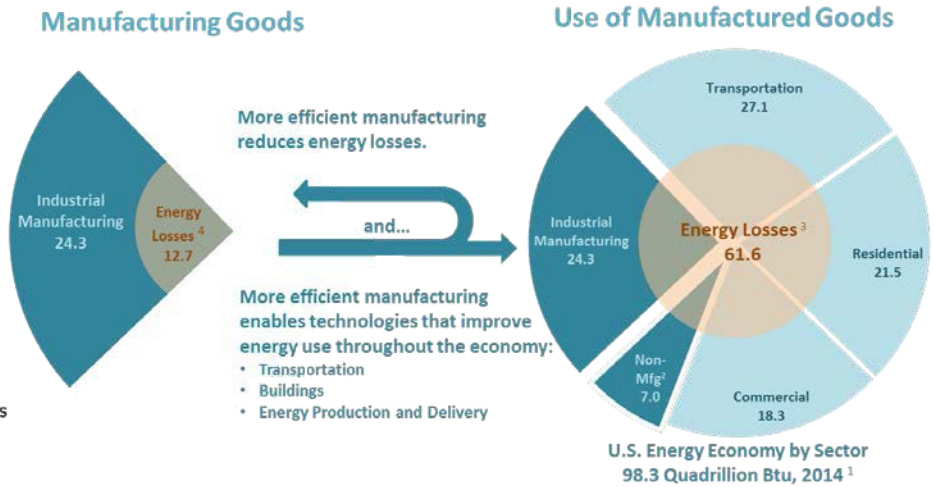
Technology Innovation through Applied Research and Development in Advanced Manufacturing and Energy is a Foundation for Economic Growth and Jobs in the US



$2T Manufacturing GDP
12.4M Manufacturing Direct Employment Jobs
0.8 / 1.0 – Indirect / Direct Jobs - All Manufacturing
2.2 / 1.0 – Indirect / Direct Jobs - Advanced Sub-Sectors

24 QBTU (25% of National Total) – Manufacturing
2/3 Manufacturing Energy is in Intensive Sectors





QTR, 2015

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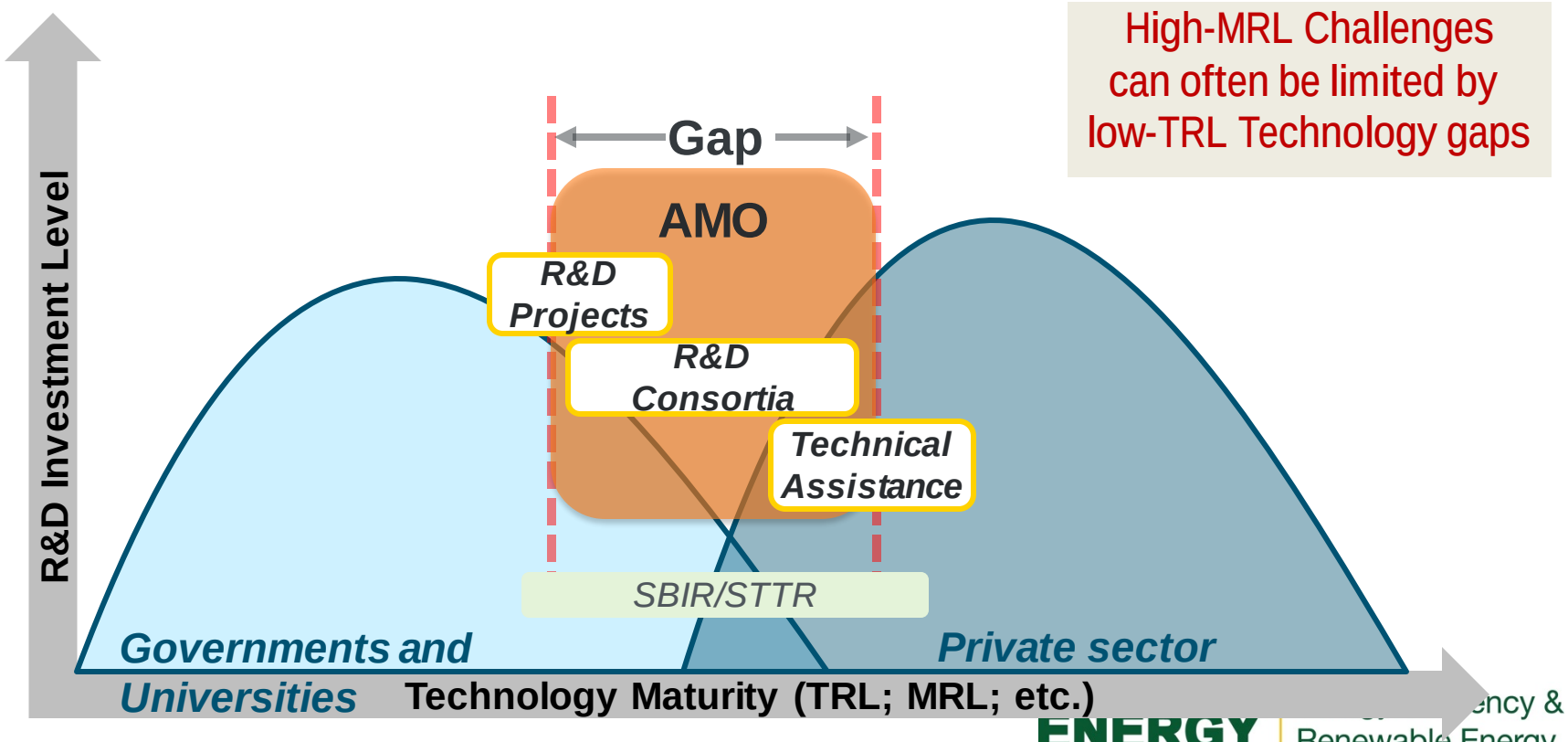
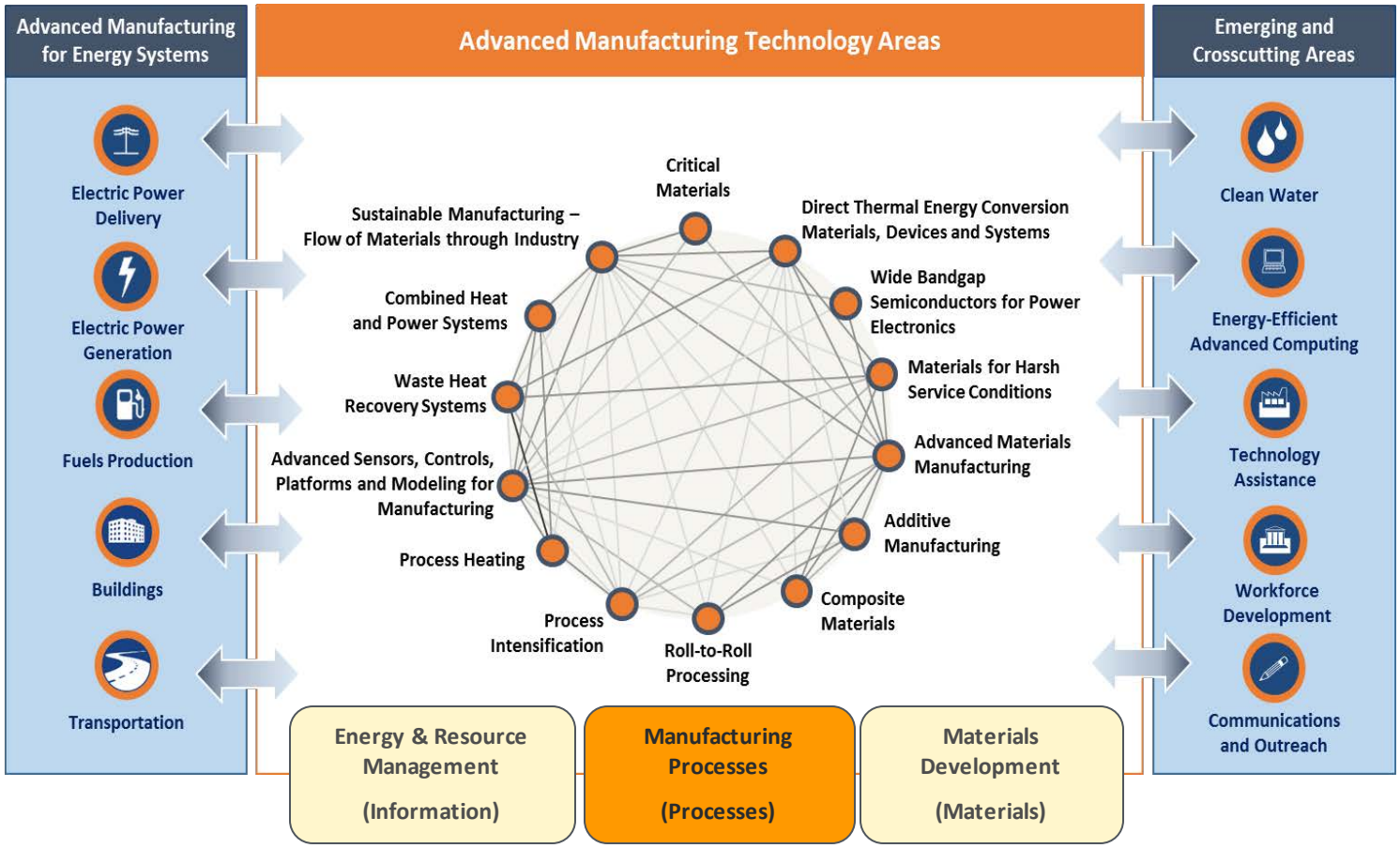
AMO: Advanced Manufacturing Office

- Improve the productivity and energy efficiency of U.S. manufacturing
- Reduce life cycle energy and resource impacts of manufactured goods
- Leverage diverse domestic energy resources for U.S. manufacturing, while strengthening environmental stewardship
- Lower barriers for moving innovative technologies / practices into U.S. manufacturing capabilities
- Strengthen and advance the U.S. manufacturing workforce



QTR and Multiyear Program Plan (draft) Technologies



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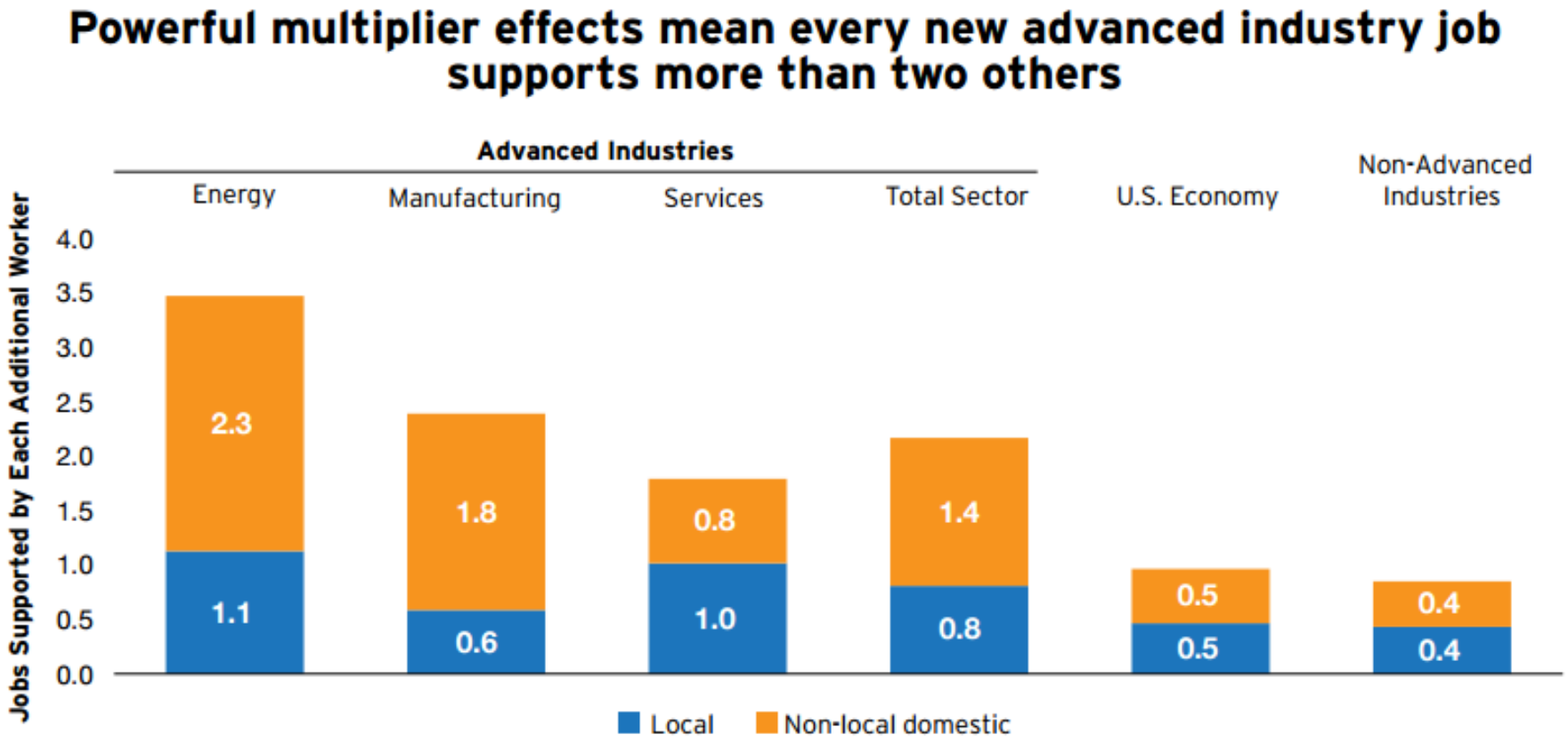
Innovation, Talent and Jobs



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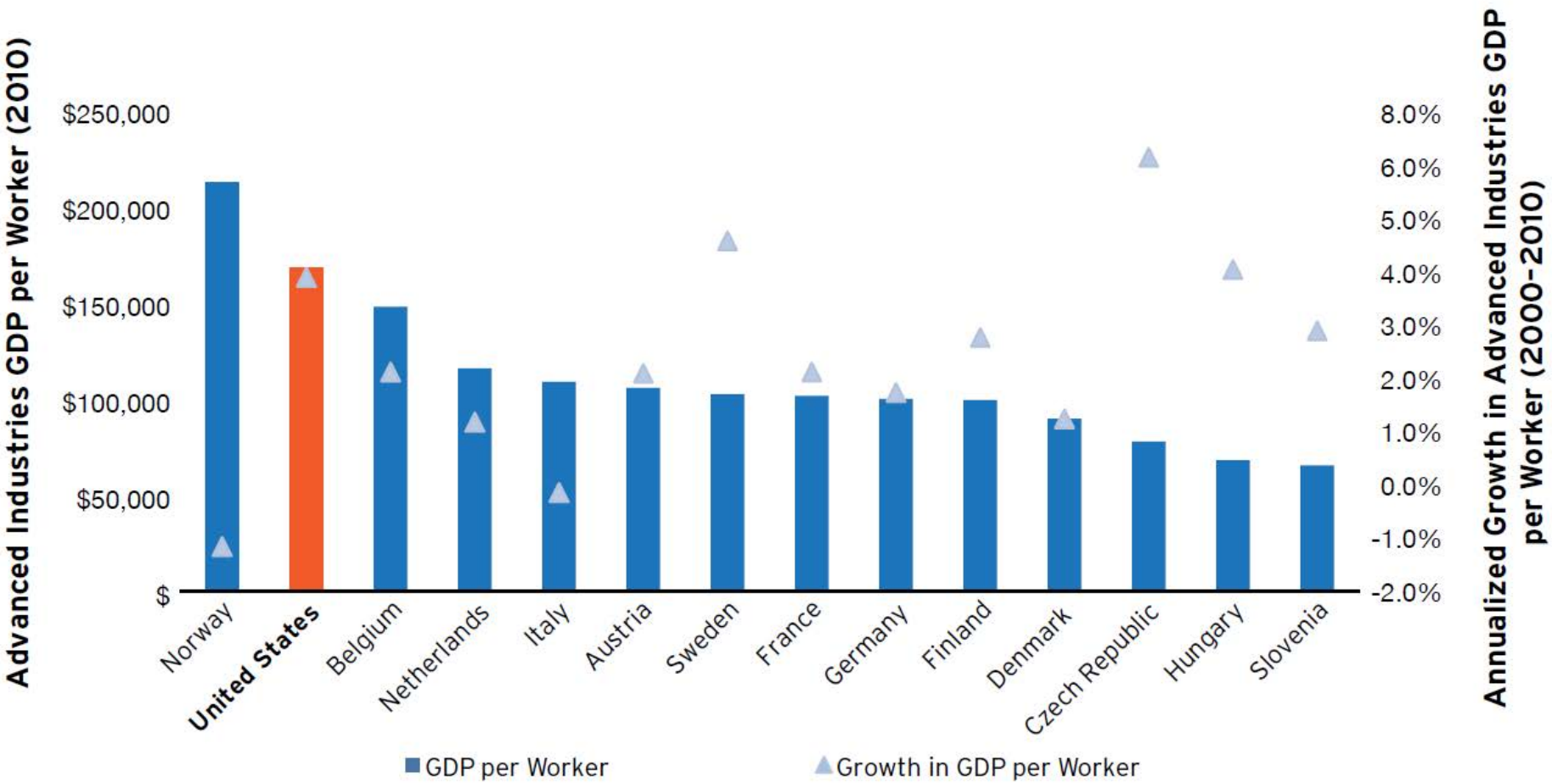
US Workforce is Highly Productive



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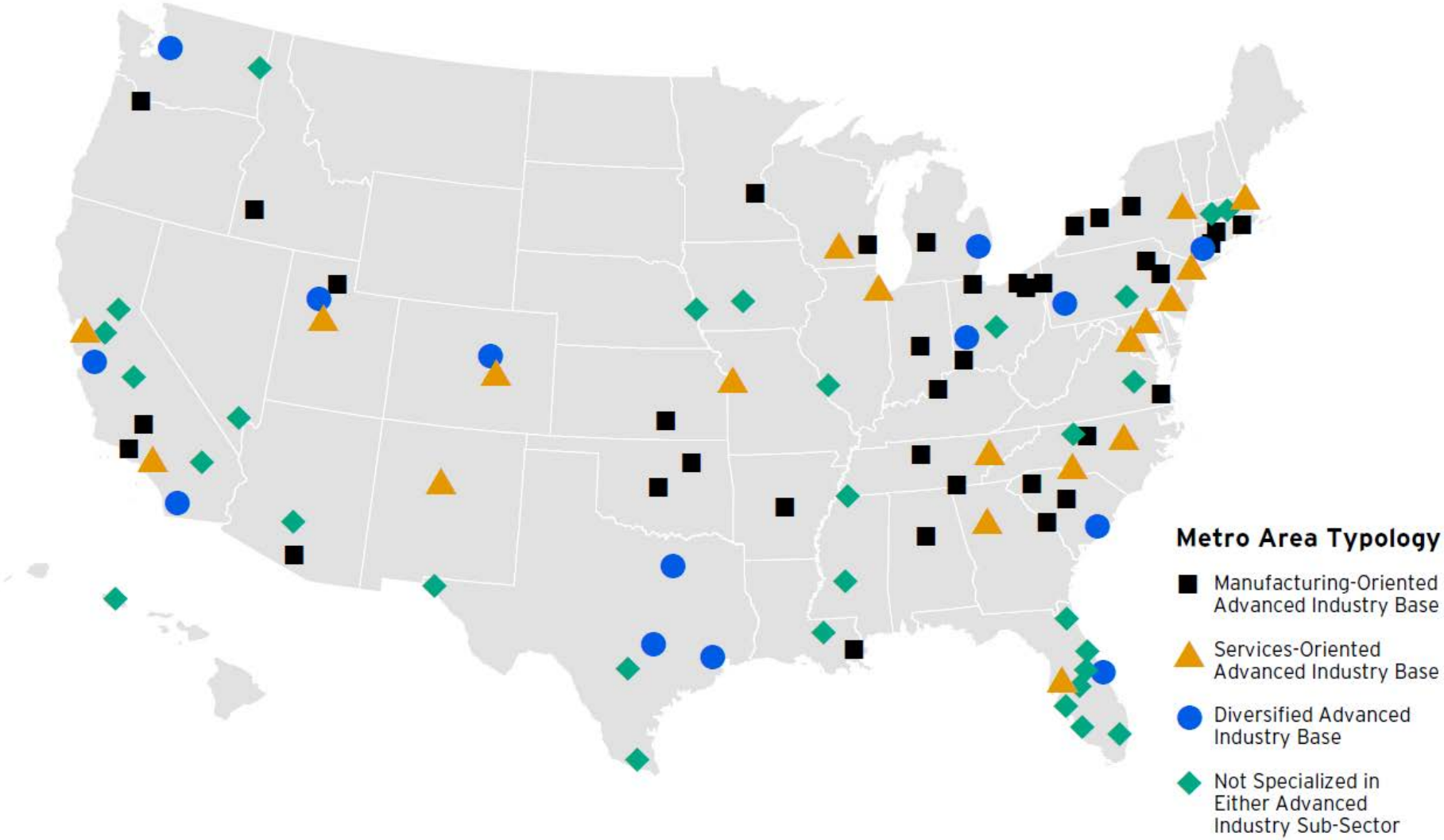
Manufacturing Innovation is Important to the Nation



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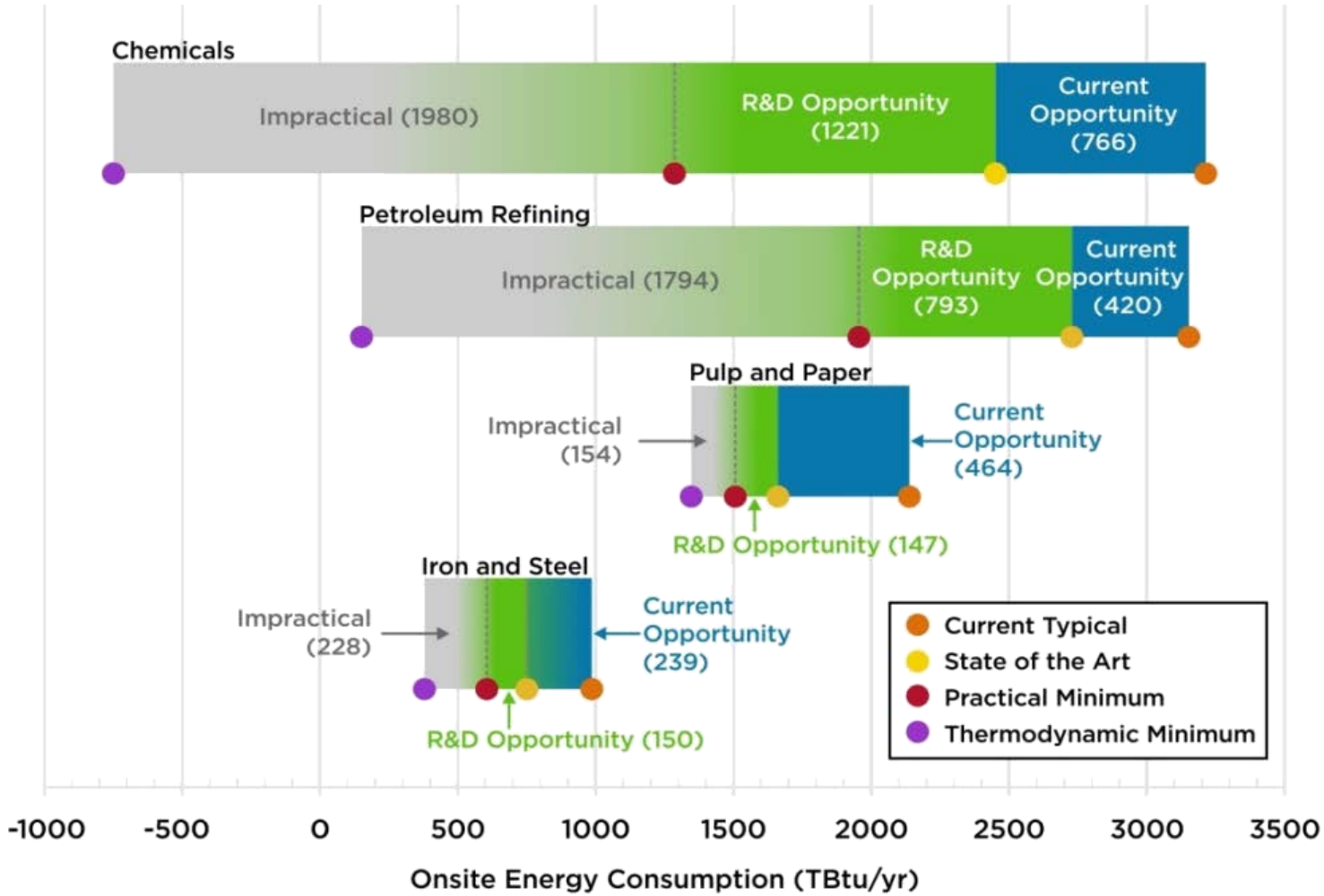
Manufacturing Bandwidth Studies: Energy Savings Potential



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

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Impact Areas of Cross-Cutting Efficiency Technology R&D 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

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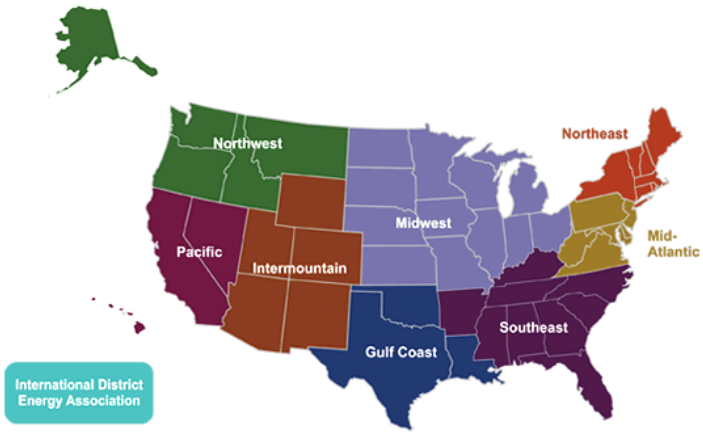
- Technology Partnership Programs
- Research and Development Projects
- Research and Development Consortia

Technology Partnerships Programs

Efficient On-Site Energy

CHP Technical Assistance Partnerships

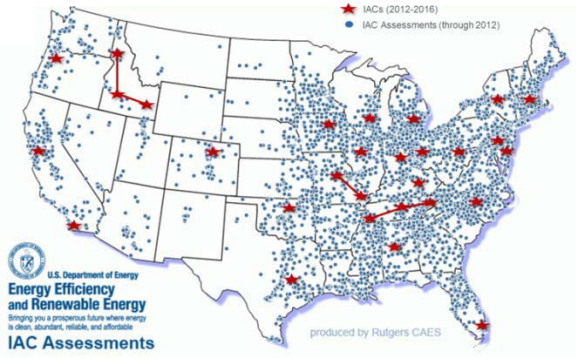


Energy-Saving Partnership

Better Buildings, Better Plants,
Industrial Strategic Energy Management

Student Training & Energy Assessments

University-based Industrial Assessment Centers



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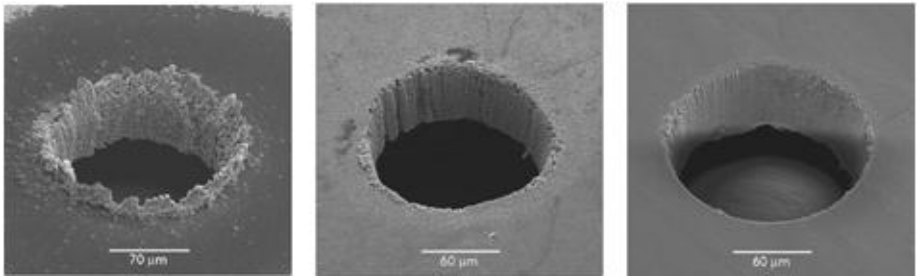
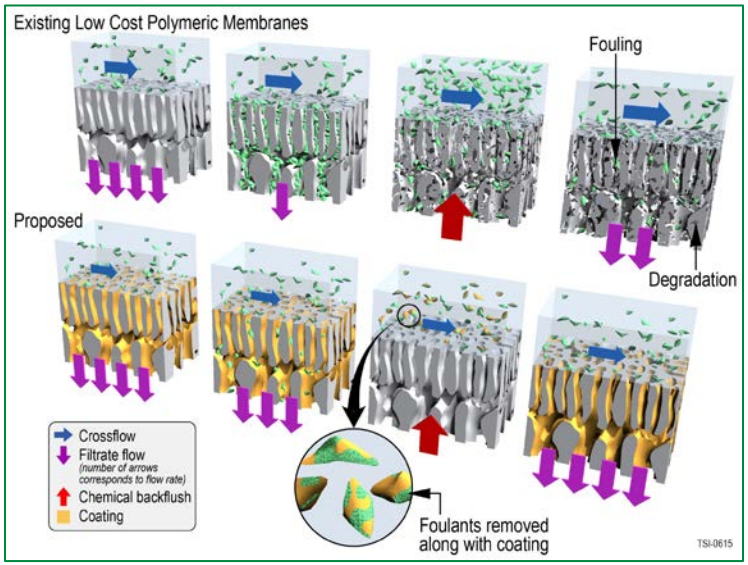
- Technology Partnership Programs
- Research and Development Projects
- Research and Development Consortia

R&D Projects: Manufacturing Processes



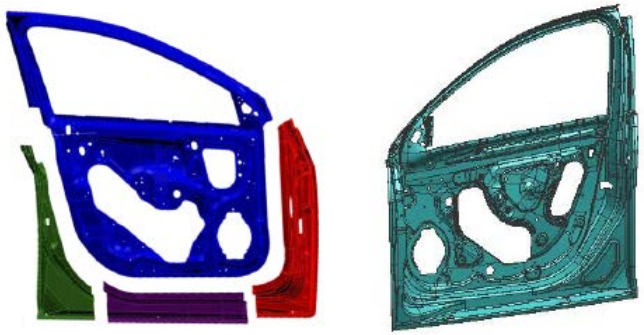
Ultrafast, femtosecond pulse lasers (right) will eliminate machining defects in fuel injectors.

Image courtesy of Raydiance.



Protective coating materials for high-performance membranes, for pulp and paper industry.

Image courtesy of Teledyne

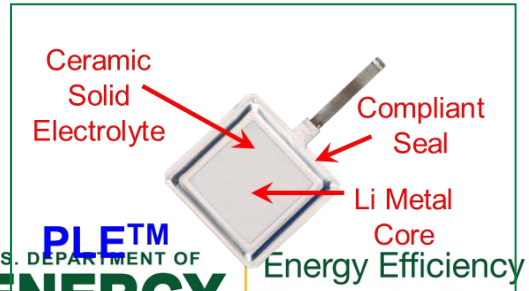


Energy-efficient large thin-walled magnesium die casting, for 60% lighter car doors.

Graphic image provided by General Motors.

A water-stable protected lithium electrode.

Courtesy of PolyPlus



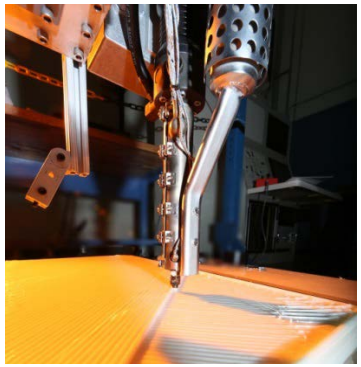
Manufacturing Demonstration Facility

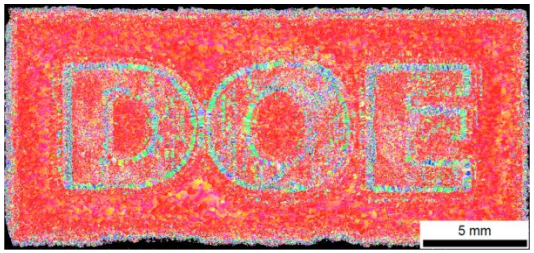
Supercomputing Capabilities

Spallation Neutron Source

MDF Manufacturing Demonstration Facility

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.

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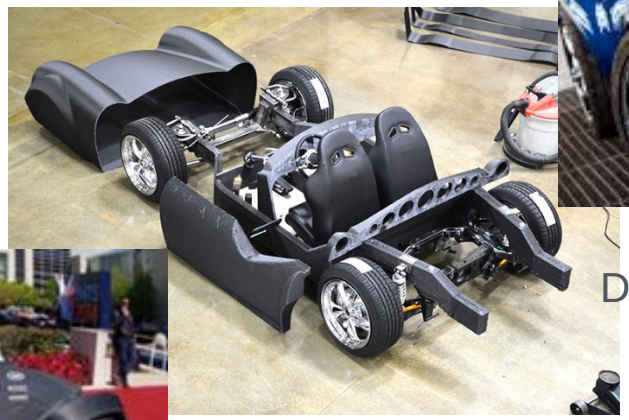
Additive – Rapidly Developing Technology – Big-Area Additive Manufacturing (BAAM)

Printed Cobra Project: Design to Prototype
Six (6) people in six (6) weeks.



Designed & Printed Car Prototype
(with Shelby Inc.)

Developed Surface Process
(with Tru-Design Inc.)

Crowdsource Design &
Build EV
(with Local Motors

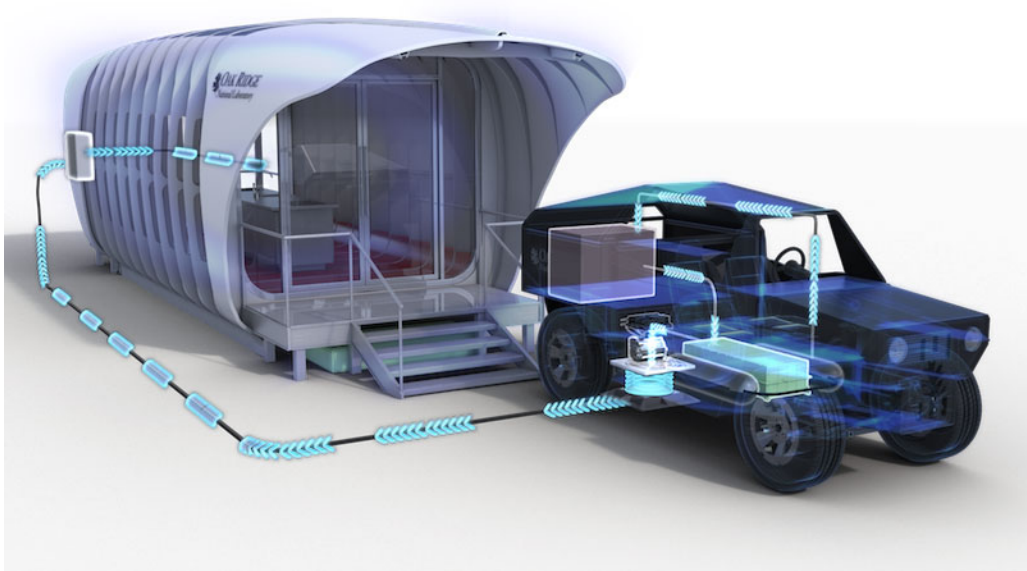
Developed blended polymer / fiber
(with Sabic & Techmer Inc.)

Developed Unique 3D Printing Tool
(with Cincinnati Inc.)

Partnerships with Vehicles and Buildings R&D

3D Printing of Large Area Structures

Partnership with Designers, Manufacturers, Universities, Laboratories and Suppliers



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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
- Potential copper metal casting projects

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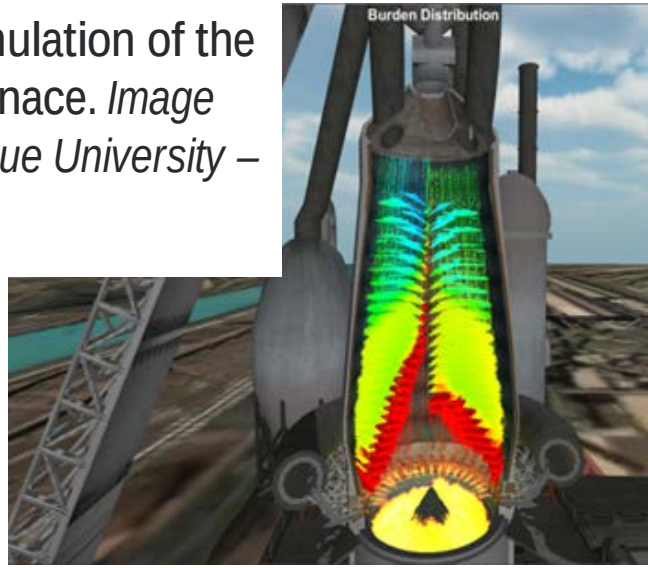
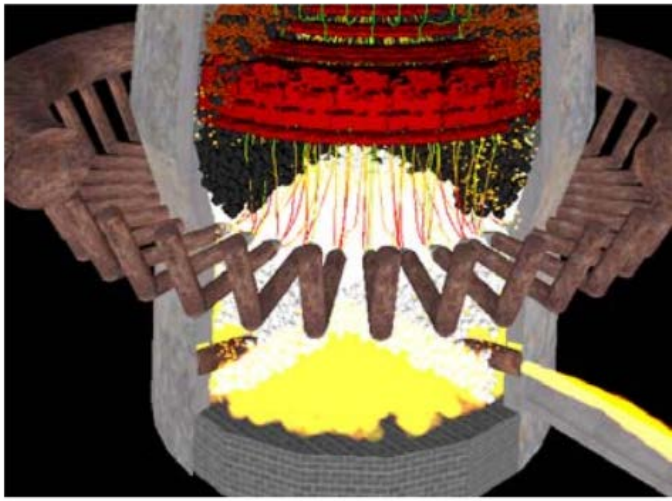
High Performance Computing for Manufacturing

Apply modeling and simulation capabilities to manufacturing challenges

A computer simulation of the virtual blast furnace. *Image courtesy of Purdue University – Calumet.*



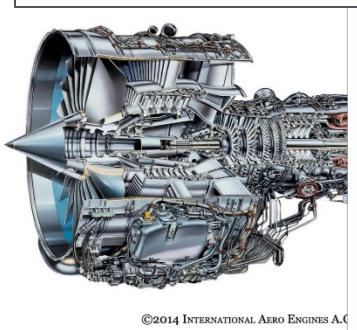


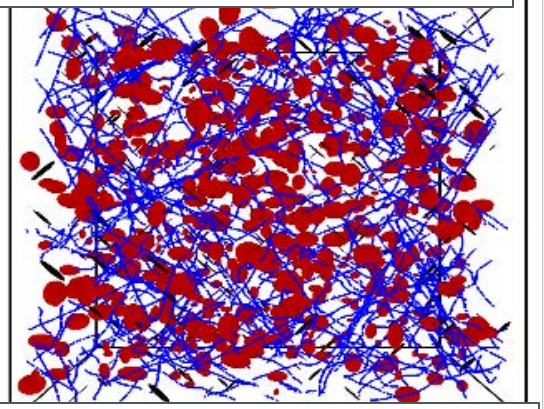
- Industry defined challenges
- Businesses Partner with National labs
- Business-friendly terms and streamlined partnering process

HPC4Mfg is extending scientific knowledge in different industrial sectors.

Creating new lightweight alloys

Goal: Predict the strength of lightweight aluminum-lithium alloys produced under different process conditions; could save millions of fuels costs if used in aircraft design



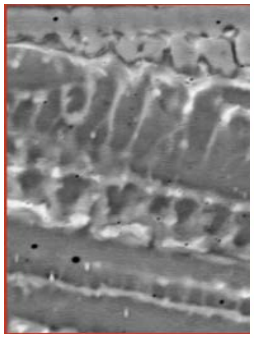


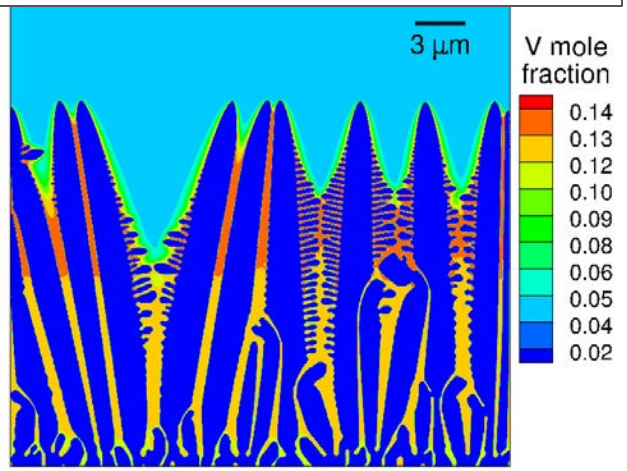
Results to date: Developed new dislocation mobility laws for Al-Li alloys; examining influence of different precipitate density; predicting yield strength for differing particle sizes

Team: LIFT with LLNL

Dendritic Growth in AM Parts

Goal: Use HPC to multi-scale morphology of solidification microstructure of Nickel base 718





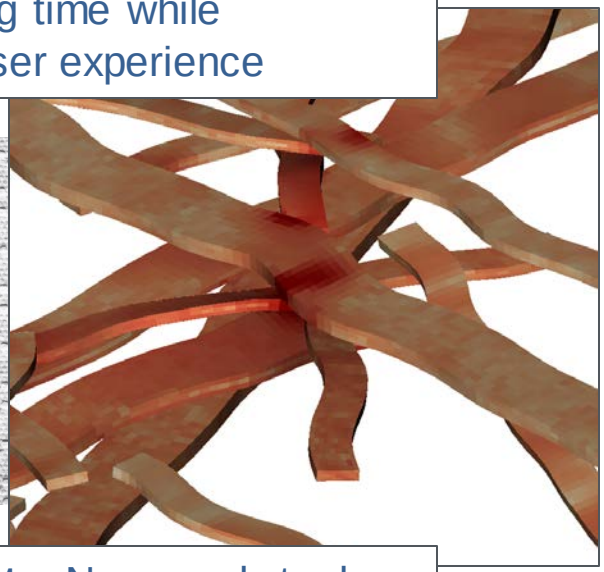
Results to date: Predicting crystal growth over large domains from multi-component alloys using the Caliphad approach; moving to new alloy systems

Team: UTRC with ORNL/LLNL

HPC has been used to design better processes in a variety of industries

Paper Towel Manufacturing

Goal: Use HPC to evaluate different microfiber configurations to optimize drying time while maintaining user experience

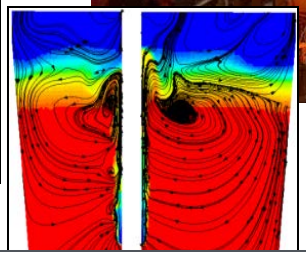


Results to date: New mesh tool reduces product design cycle by 2X cycle; additional cores by another 8X; largest non benchmark run of Paradyn code at LLNL

Team: Proctor and Gamble with LLNL

Reducing Coke Usage in Steel

Goal: Use models of complex reacting flows HPC to optimize blast furnace processes to reduce carbon loads and coke usage; savings up to $80M/yr if successful



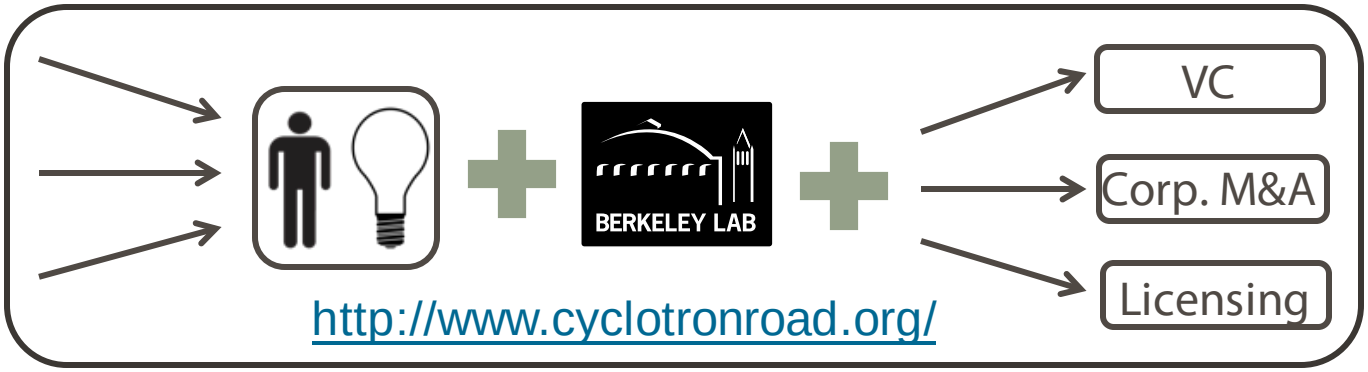
Results to date: 1000X improvement in computational speed of parametric studies to examine factors such as CO2 enrichment, wind rate. Scaling code up to 2000 cores

Team: Purdue Calumet with LLNL

Cyclotron Rd and Innovation Accelerators

Lab Embedded Accelerator Model:

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



cyclotronroad

CHAIN REACTION INNOVATIONS

INNOVATION CROSSROADS

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

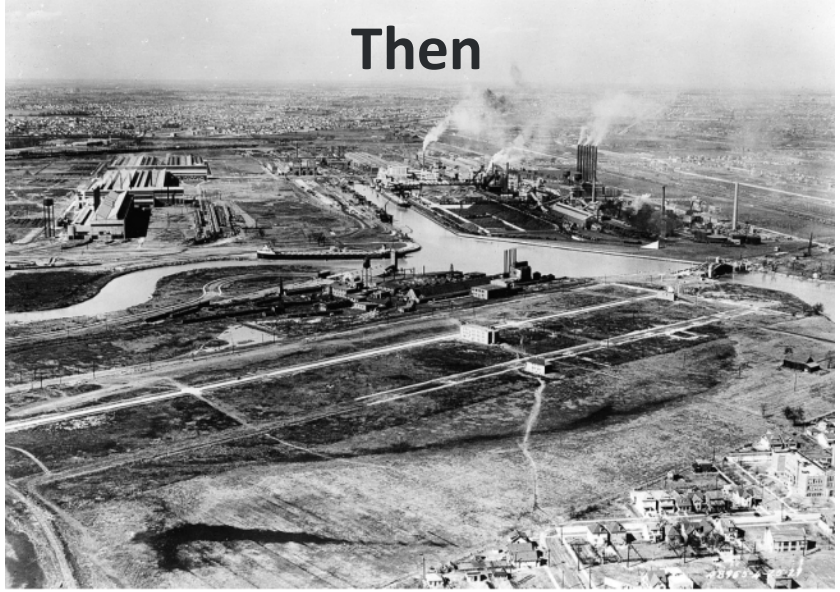
…First pilot phase spurred **$10 million in follow-on funding** and launched **privately-funded startups**

FY17: expand to support up to more labs & projects

- Technology Partnership Programs
- Research and Development Projects
- Research and Development Consortia

R&D Facilities & Consortia

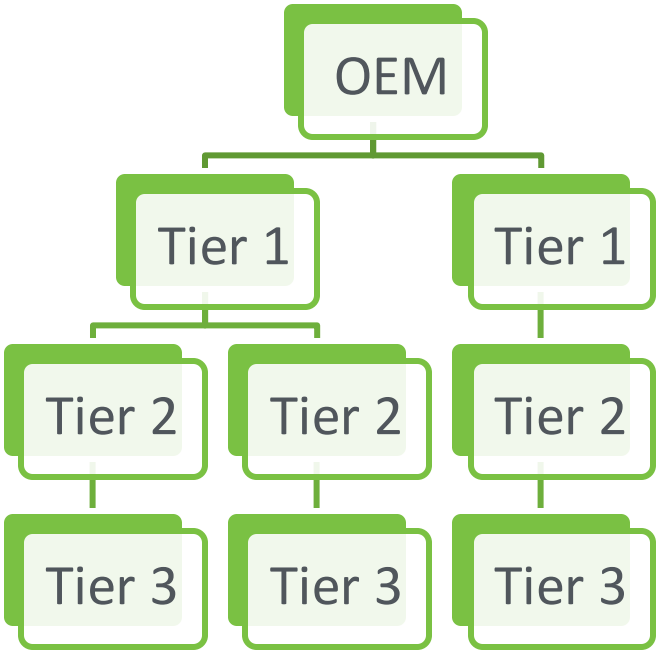
Address market disaggregation challenge to the industrial commons



Ford River Rouge Complex, 1920s

Photo: Library of Congress, Prints & Photographs Division, Detroit Publishing Company Collection, det 4a25915.

Now



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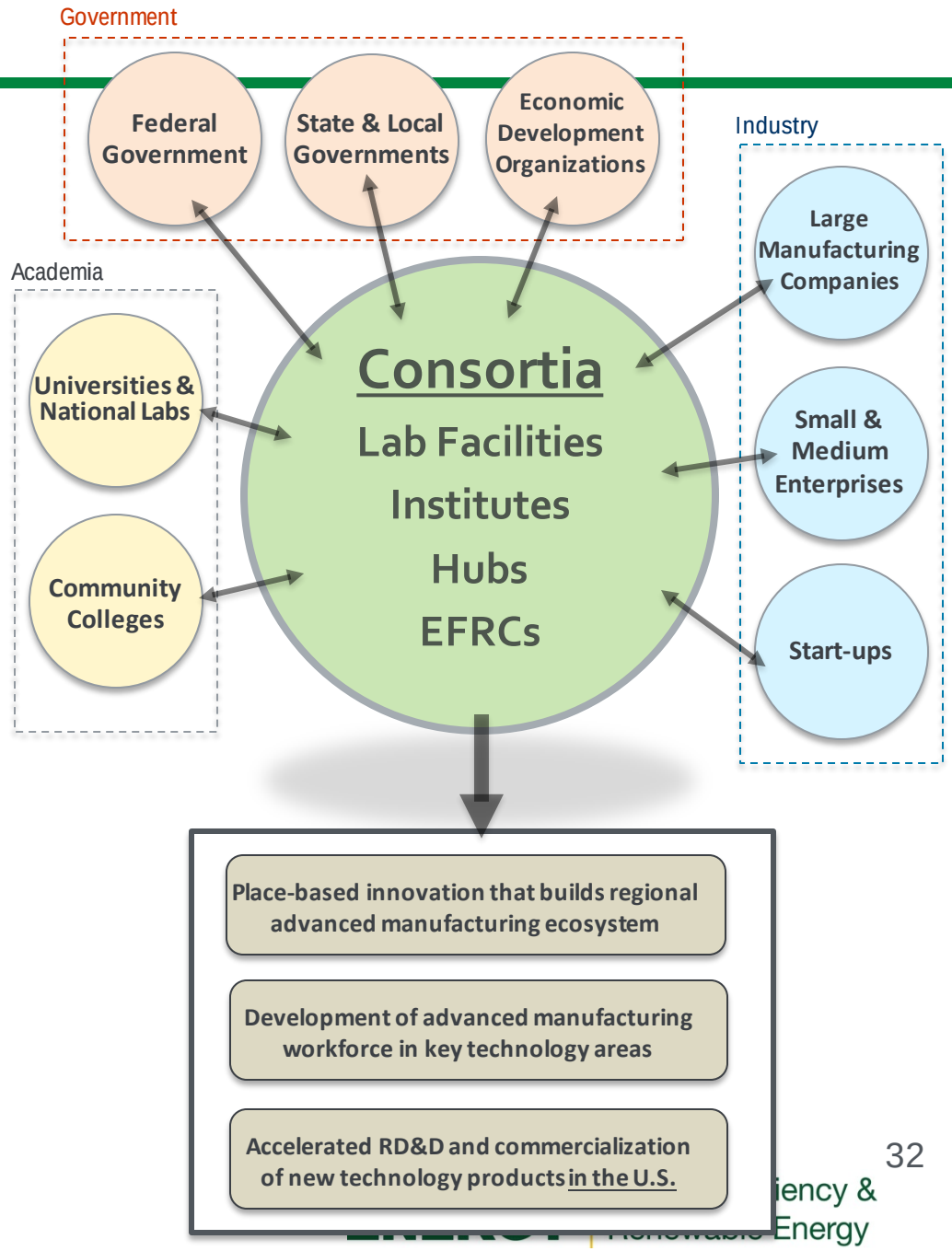
Consortia Model

Each Consortia has:

- Clear technology focus
- TRL level suited to specific technology challenge
- Shared user facilities
- Ability to address critical challenges
- A balanced portfolio of projects



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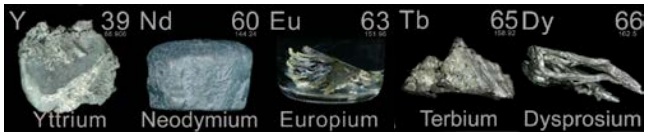
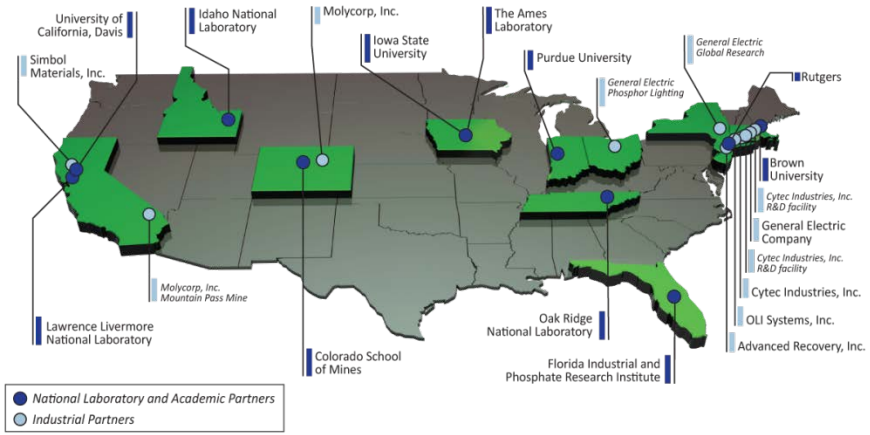
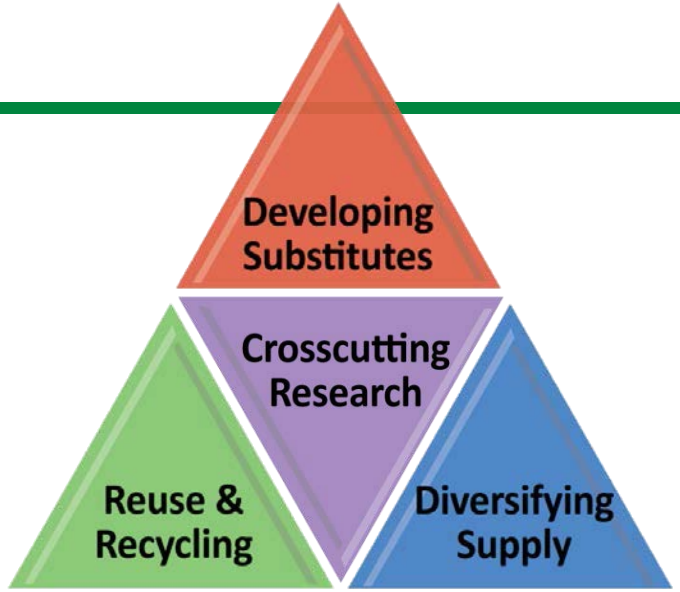
CMI Accelerating Energy Innovations

Critical Materials Institute

Eliminate materials criticality as an impediment to the commercialization of clean energy technologies for today and tomorrow.







Selected Goals

- Materials supply chains assured for clean energy manufacturing in the US
- Commercialize at least one technology in each of its three technical focus areas
- Develop updated criticality assessments to ensure relevance of CMI research and identify potential critical materials for clean energy

Initial Support

- $120M for R&D June 2013-June 2018

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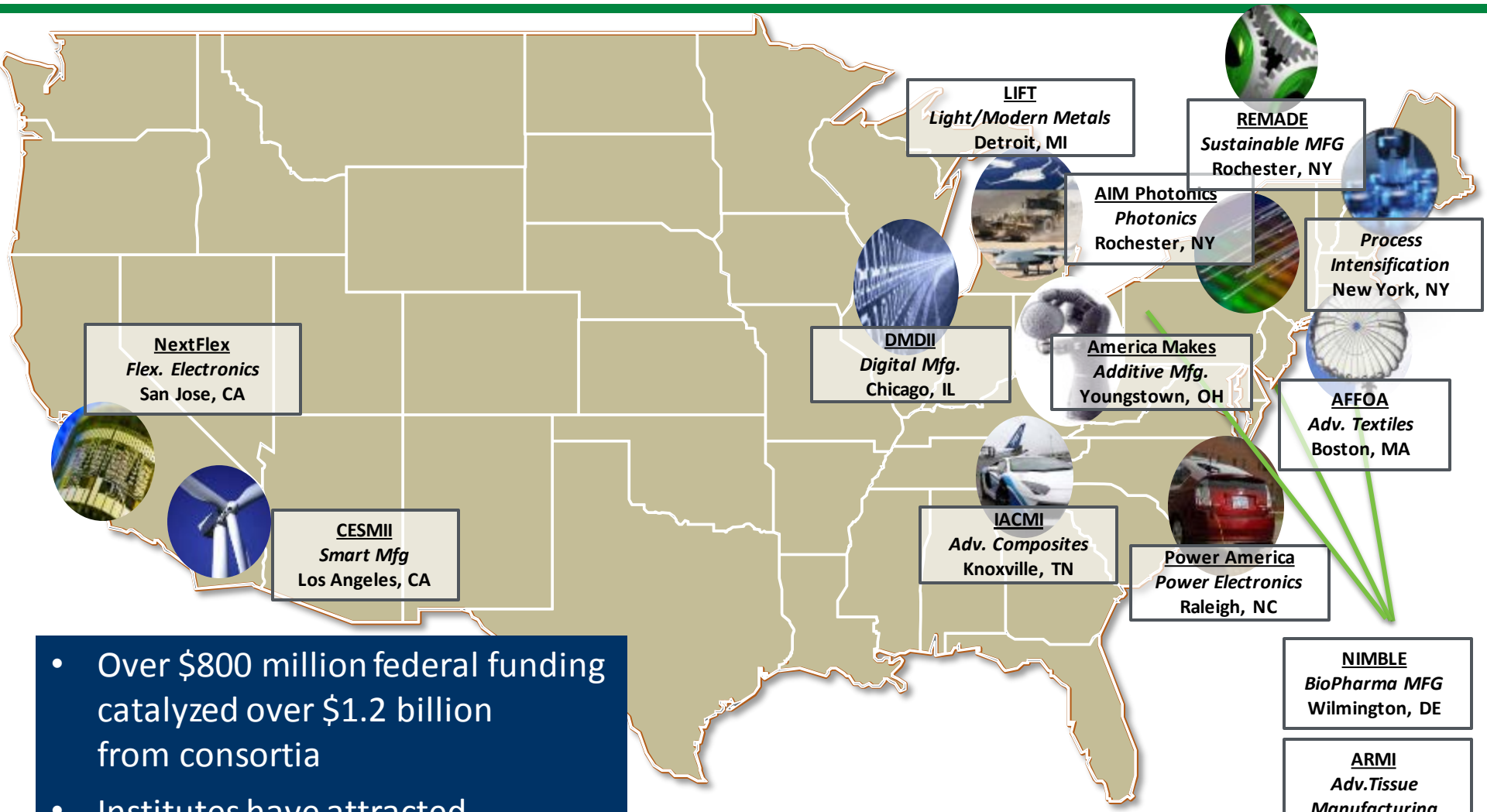
14 Manufacturing Innovation Institutes launched to date



- Over $800 million federal funding catalyzed over $1.2 billion from consortia
- Institutes have attracted hundreds of companies and universities as active partners from across the country

Manufacturing USA

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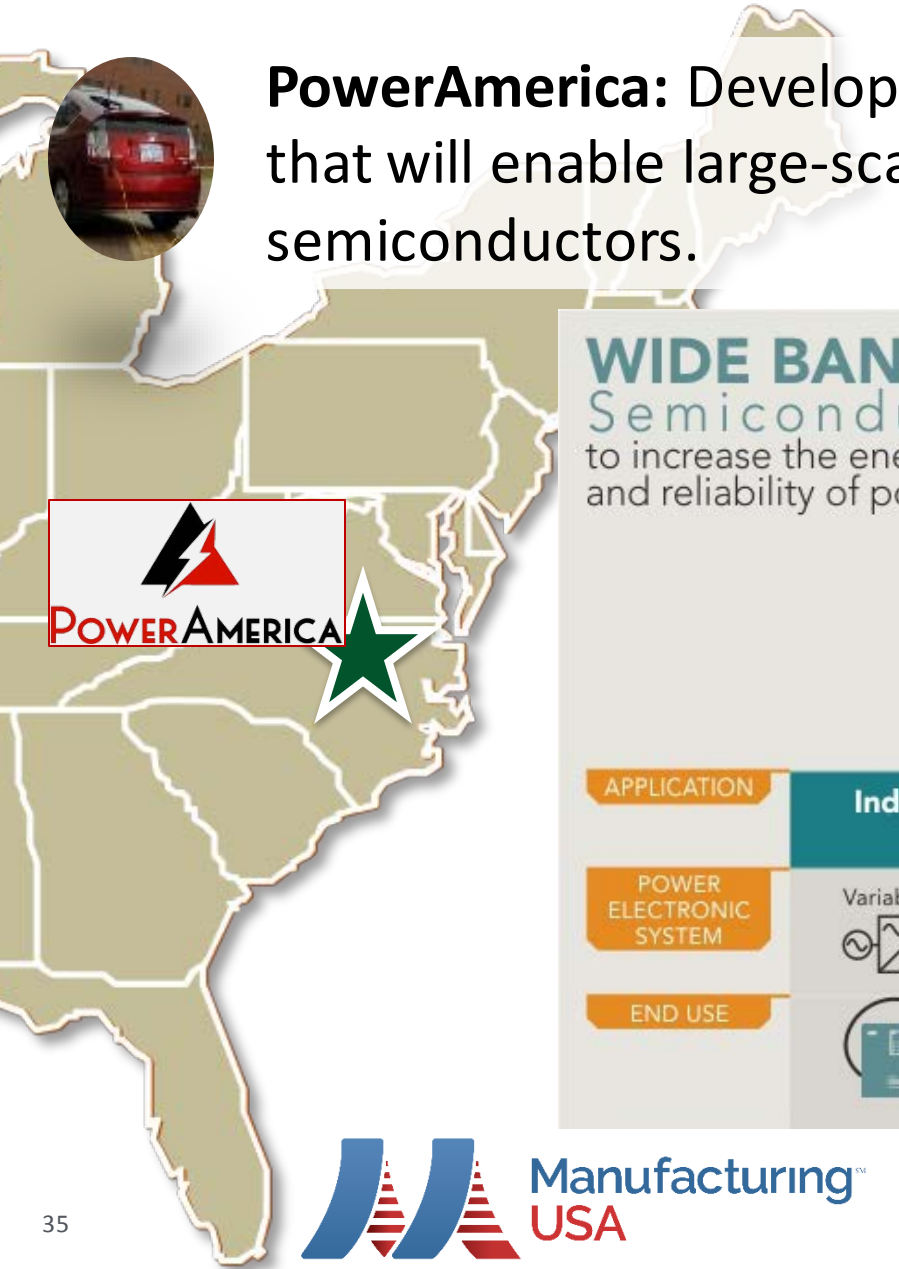
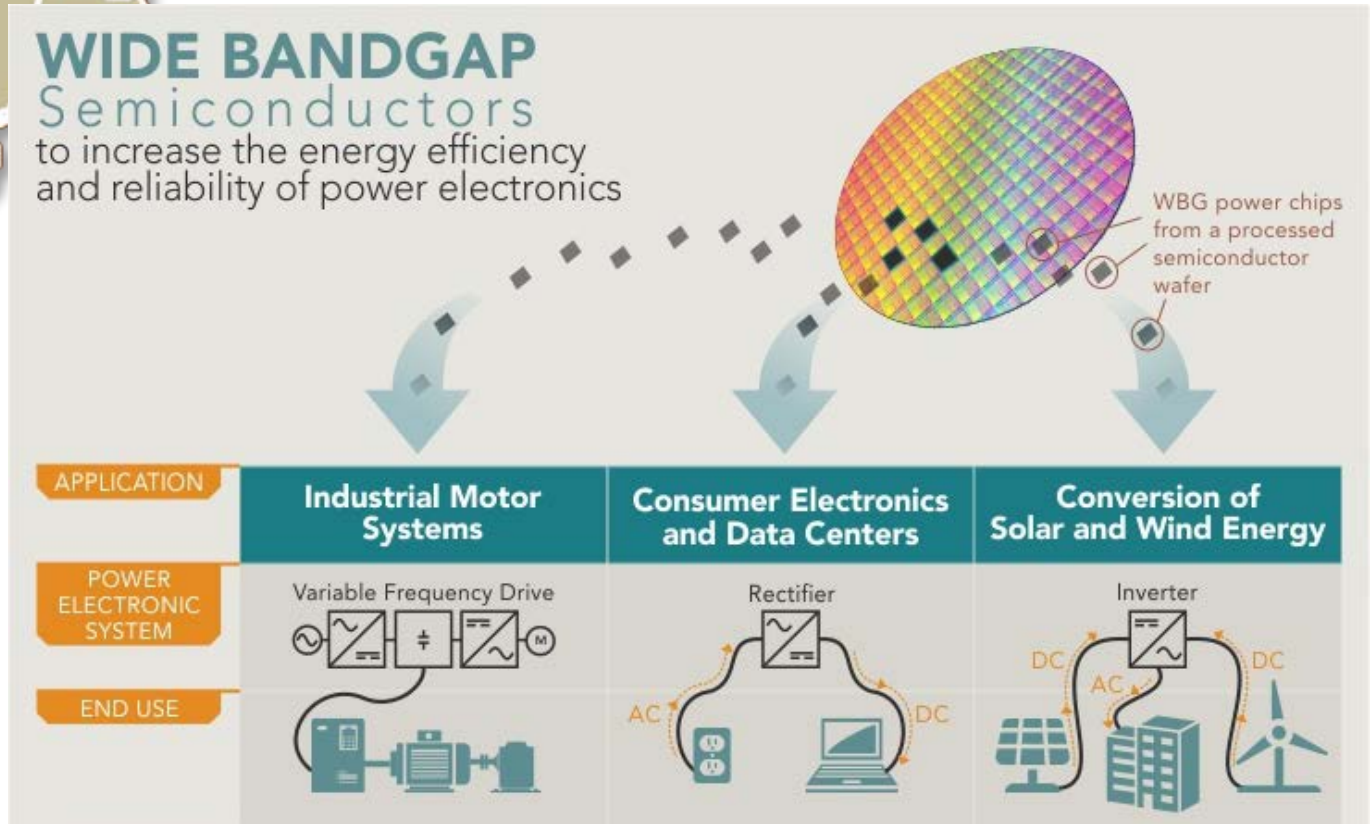
DOE Manufacturing USA Institute #1: PowerAmerica (Raleigh, NC)



PowerAmerica: Develop advanced manufacturing processes that will enable large-scale production of wide bandgap semiconductors.



Manufacturing USA

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Highlights: X-Fab Texas launches SiC Merchant Foundry

X-Fab Texas

- Using existing Si fab line, launched first available "merchant" SiC line
- Will dramatically reduce cost of SiC wafers for global power electronics market
- Supports 400 jobs in Lubbock, TX and will produce first device fall 2016

Read More at: https://www.whitehouse.gov/blog/2016/04/04/depth-look-how-manufacturing-hubs-helped-business-innovate

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

Institute for Advanced Composite Material Manufacturing (IACMI): Develop and demonstrate technologies to produce carbon fiber composites at 50% the cost and 75% less energy.

- Launched in January 2015
- $70 million Federal support matched by $180 million non-Federal
- 94 Total members including 72 industry members, 14 universities, and 2 national labs
- 46 Small and medium-sized industry partners

Institute for Advanced Composite Materials Innovation (IACMI)

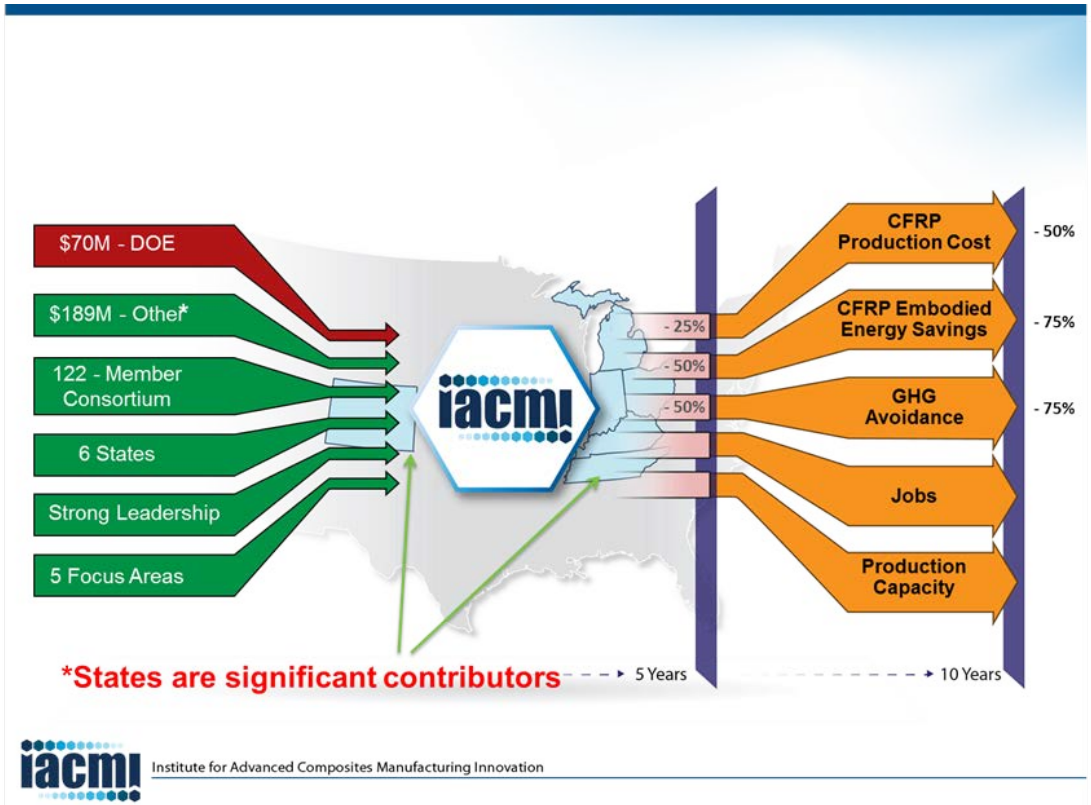
Objective

Develop and demonstrate innovative technologies that will, within 10 years, make advanced fiber-reinforced polymer composites at…

50% Lower Cost

Using 75% Less Energy

And reuse or recycle >95% of the material



Manufacturing USA

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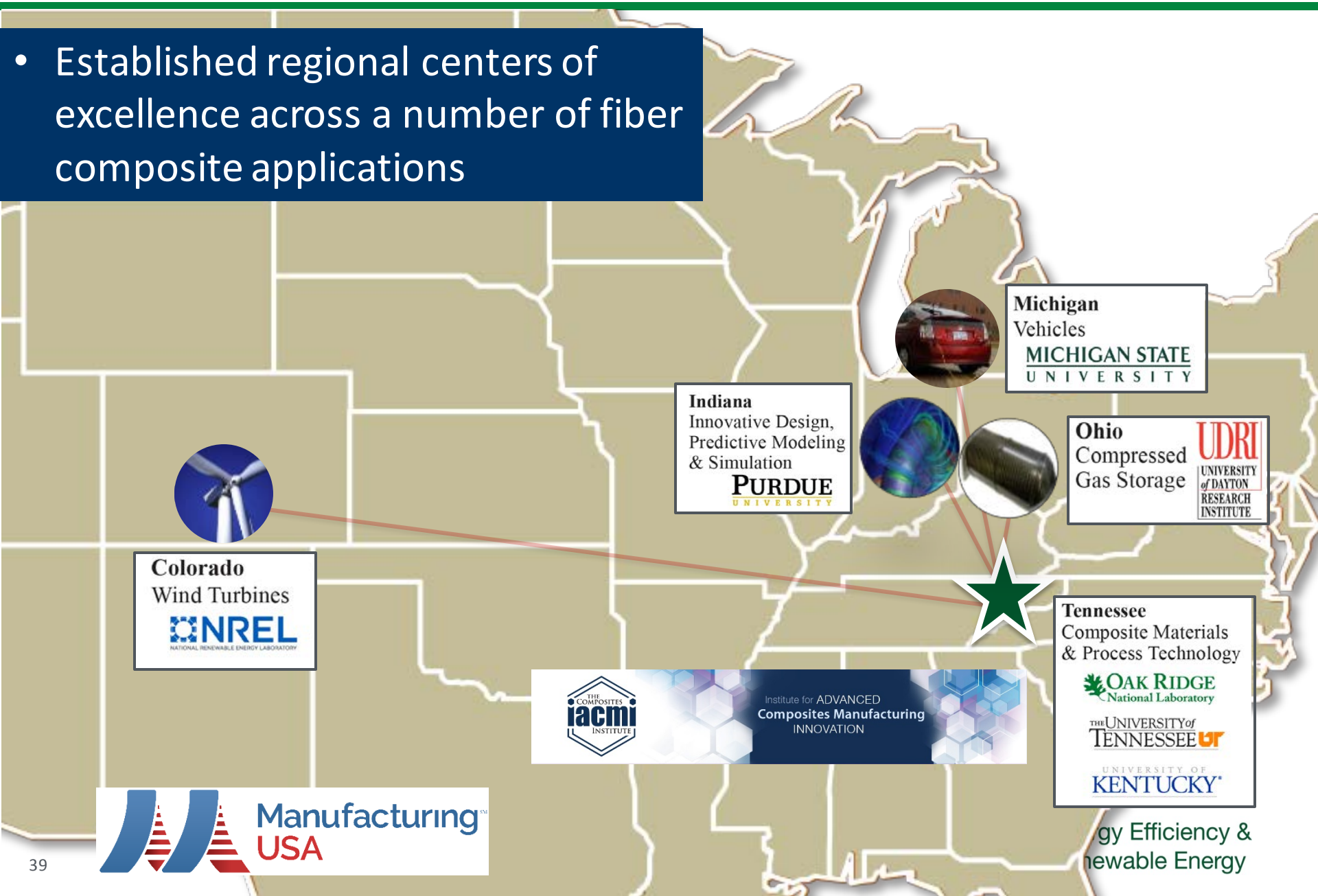
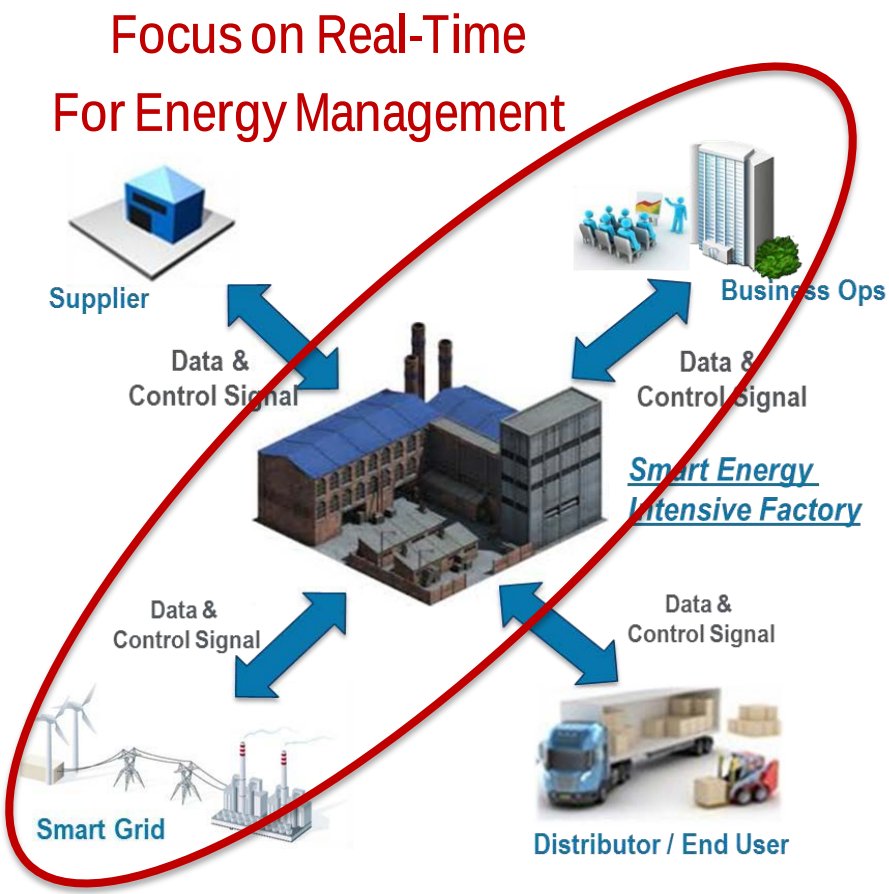
Institute for Advanced Composite Materials Innovation (IACMI)

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



DOE NNMI Institute #3 – Smart Manufacturing (Los Angeles, CA)

- Advanced sensors and controls for real-time process 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

Manufacturing USA

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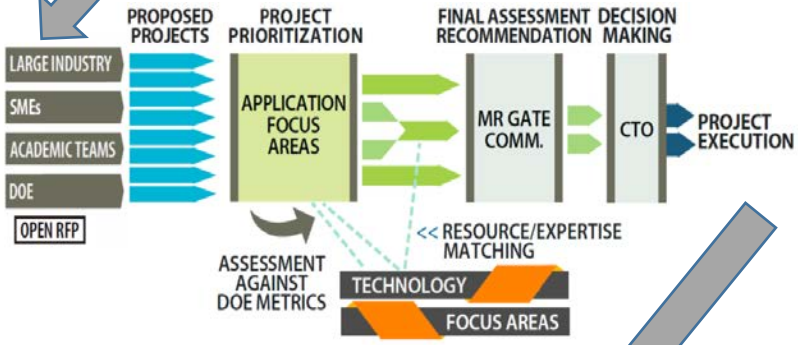
DOE NNMI Institute #4 – RAPID (New York, NY)

Objective: Develop a set of technologies that bring significant reduction in equipment size, process complexity, cost or risk reduction that will result in…

Test Bed Challenges

- Modeling/Simulation/ Optimization & Control for Existing PI Processes
- Low Energy Separations for Existing Processes
- Material & Chemistry Intensification for Existing Processes
- Module Manufacturing for PI and MCPI
- Modular Decentralized Scale Out Processing



- 2x Improved energy efficiency - 20% Improved energy productivity

- 50% Decreased deployment cost

- Technology Solutions
- Standards/ Design Tools/ Design Specs Available
- Work Force Trained

Capital Investment/ Commercial Deployment

IMPACT

800,000 Jobs Created

1100 TBtu Energy

82 MT CO_2

1900 Trained/Yr

Design Tools

>120 Industry Partners

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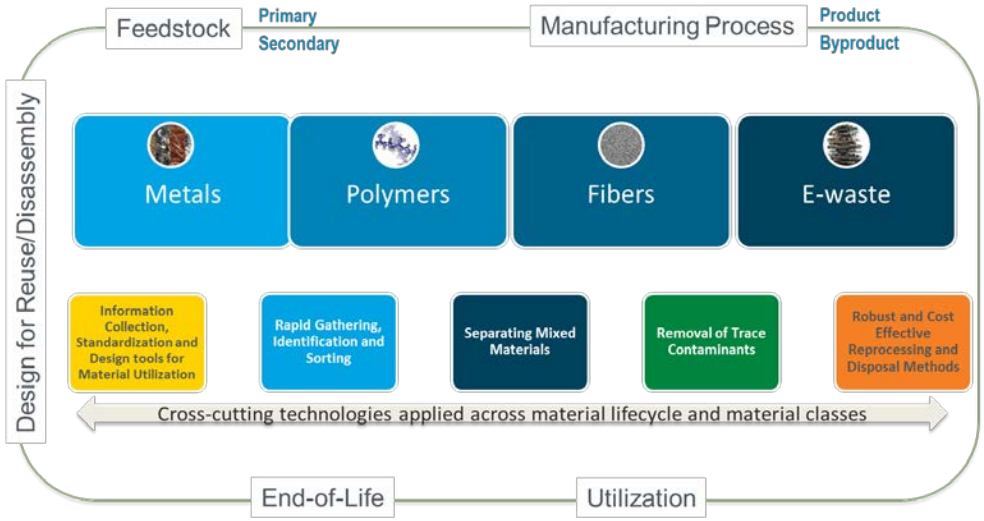
DOE NNMI Institute #5 – REMADE (Rochester, NY)

REMADE: Reducing EMbodied-energy And Decreasing Emissions



Key Technical Goals:

- **Reduce energy and emissions** through reduction of primary material use
- **Achieve secondary (e.g. scrap, reused, recycled) feedstock** "better than cost and energy parity" for key materials, and
- **Widespread application of new platform technologies** across energy intensive industries and at key stages in the manufacturing process

Technology Focus Areas

SYSTEM ANALYSIS & INTEGRATION

Data collection, standardization, metrics, and tools for understanding material flow.

DESIGN FOR REUSE & DISASSEMBLY

Design tools for material utilization/reutilization, and design for reman or disassembly.

MANUFACTURING PROCESSES

Efficient use of materials, near net shaping, and use of secondary feedstock without loss of quality.

REMANUFACTURING / EOL REUSE

Efficient and cost effective technologies for cleaning, component restoration, condition assessment, and reverse logistics.

RECYCLING & RECOVERY

Rapid gathering, identification, sorting, separation, and contaminant removal reprocessing and disposal.

Lead: Sustainable Manufacturing Innovation Alliance (SMIA)
$70M public investment, $70M match
26 universities,
44 companies,
7 national labs,
26 industry trade associations and foundations

What does Success Look Like?

Energy Technologies Invented Here…

…And Productively Manufactured Here!

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Thank You