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

Grid Integration of Manufacturing Technology Workshop

February 10th, 2016

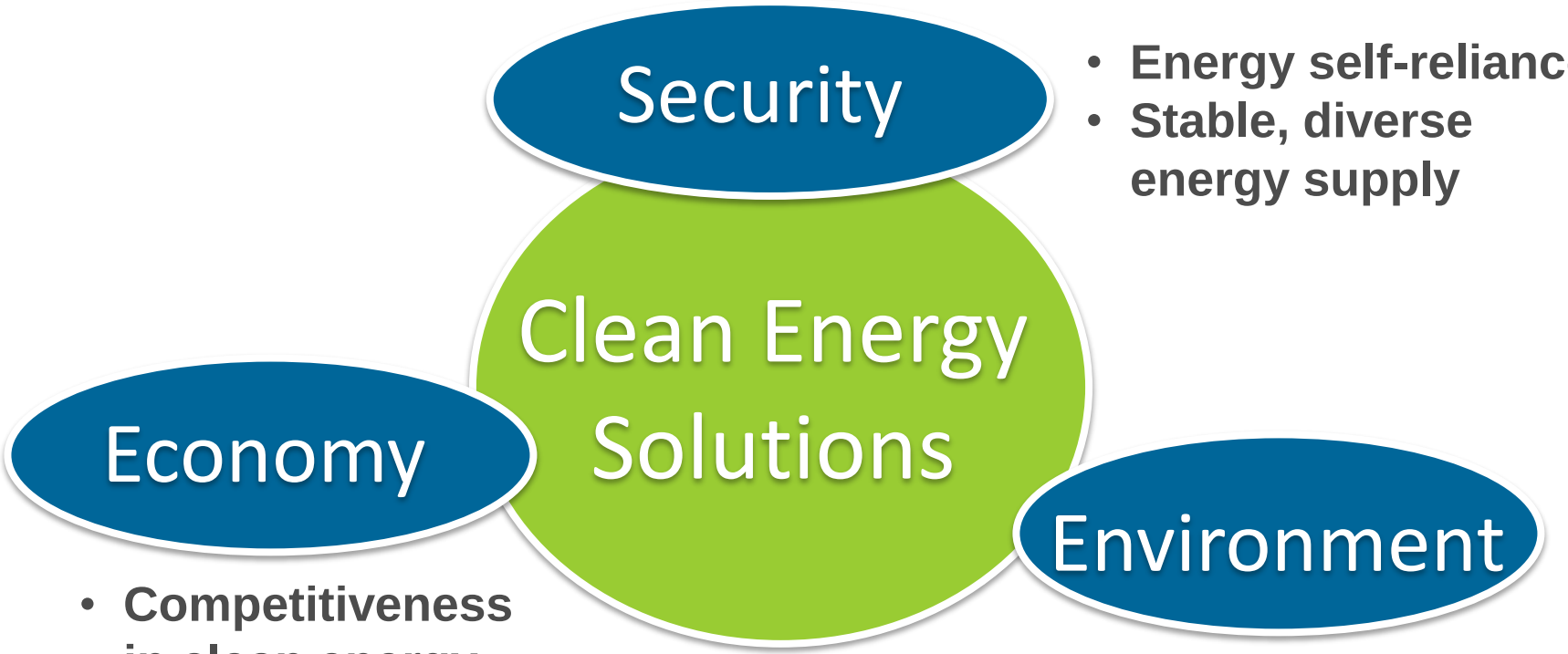
Mark Johnson

Director

Advanced Manufacturing Office

www.manufacturing.energy.gov

Clean Energy and Manufacturing: Nexus of Opportunities



- Energy self-reliance
- Stable, diverse energy supply

- Competitiveness in clean energy
- Domestic jobs

- Clean air
- Climate change
- Health

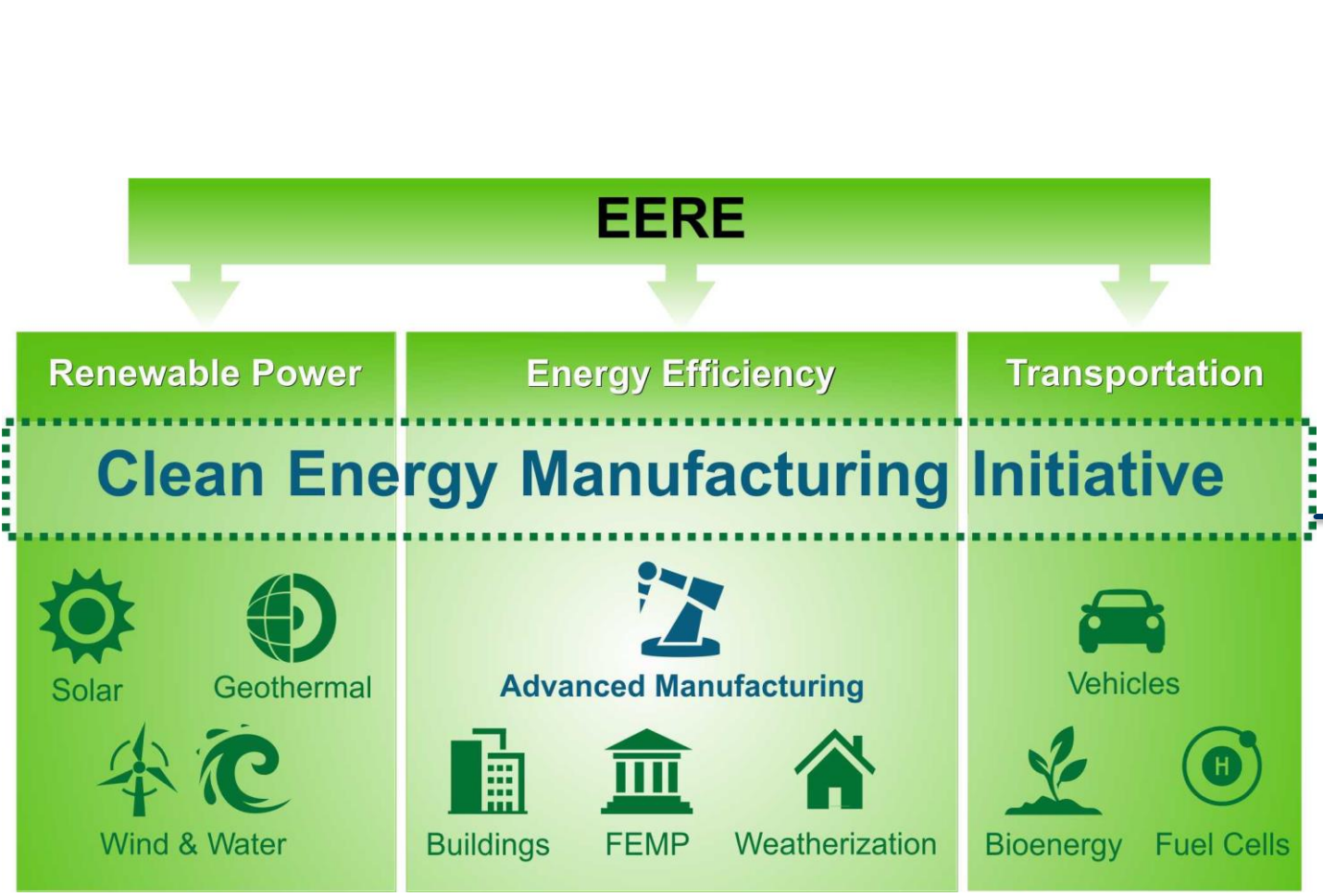
Clean Energy Manufacturing

Making Products which Reduce Impact on Environment

Advanced Manufacturing

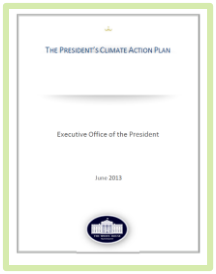
Making Products with Technology as Competitive Difference

Clean Energy Manufacturing Initiative – Across DOE

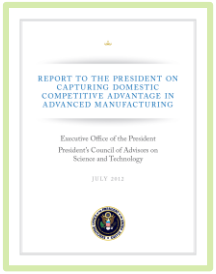


- Fossil Energy
  - O&G
  - CCS
- Nuclear Energy
- Electricity
- ARPA-E
- Science
- EM
- NNSA
- EPSA

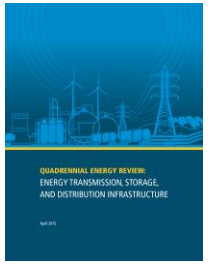
Advanced Manufacturing – Strategic Inputs



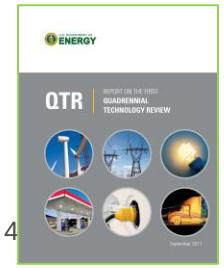
Climate Action Plan
(EOP / CEQ / OSTP 2014)



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



Quadrennial Energy Review
(DOE / EPSA 2015)



Quadrennial Technology Review
(DOE / Science and Technology 2015)

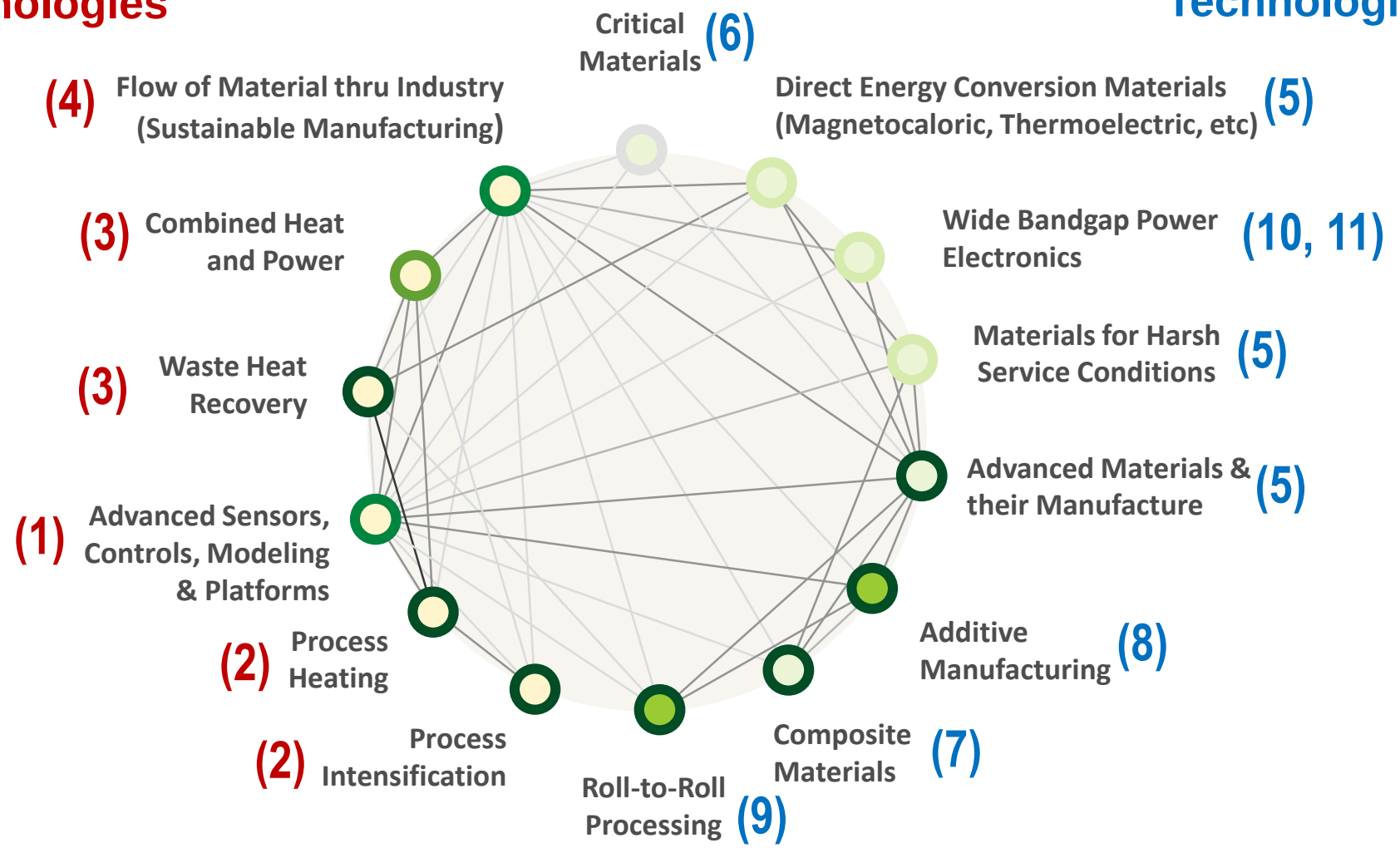
1) Broadly Applicable Efficiency Technologies for Energy Intensive and Energy Dependent Manufacturing

2) Platform Materials & Processes Technologies for Manufacturing Clean Energy Technologies

DOE QTR: Manufacturing Technology

Efficiency Technologies

Enabling Platform Technologies



Information & Data | **Processes** | **Materials**

Energy & Resource Management	**Advanced Manufacturing Processes**	Materials Development

Advanced Manufacturing Topical Priorities

Efficiency Technologies for Manufacturing Processes (Energy, CO_2)

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

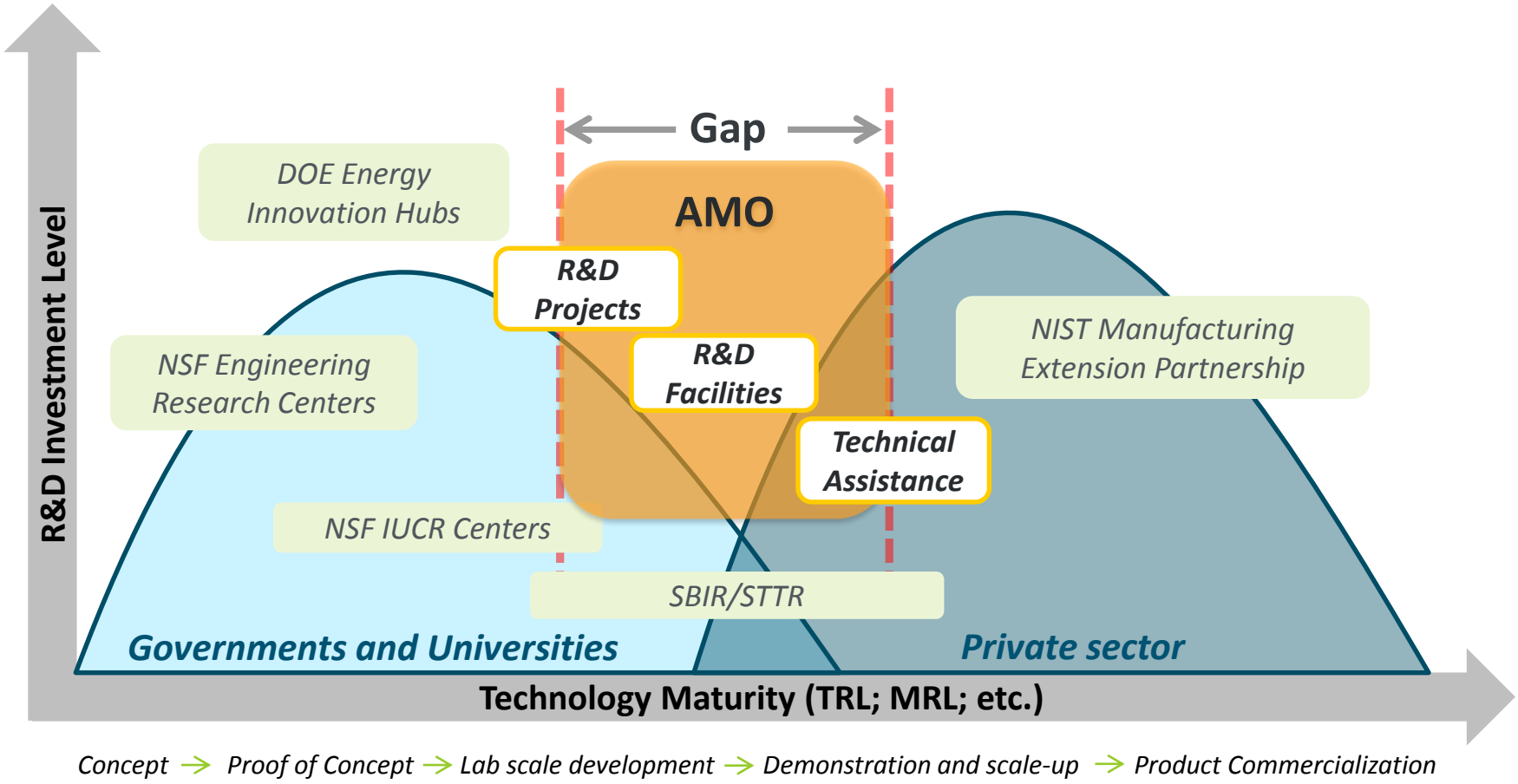
Platform Materials & Technologies for Clean Energy Applications

(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 Focus Areas Mapped to Advanced Manufacturing Topical Areas for Technology Development

Bridging the Gap to Manufacturing

AMO: Advanced Manufacturing Office



Modalities of Support

Technology Assistance: (Dissemination of Knowledge)

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

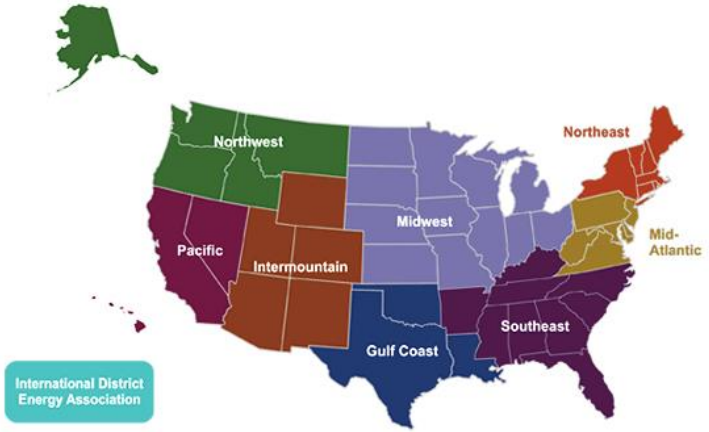
Technology Development Projects: (Individual R&D Projects)

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

Industrial Technical Assistance

Combined Heat and Power

Technical Assistance Partnerships



Simplot
Bringing Earth's Resources to Life

SAINT-GOBAIN

NISSAN

legrand®

ALCOA

Energy-Saving Partnership

Better Buildings, Better Plants,
Industrial Strategic Energy Management

3M

Schneider Electric

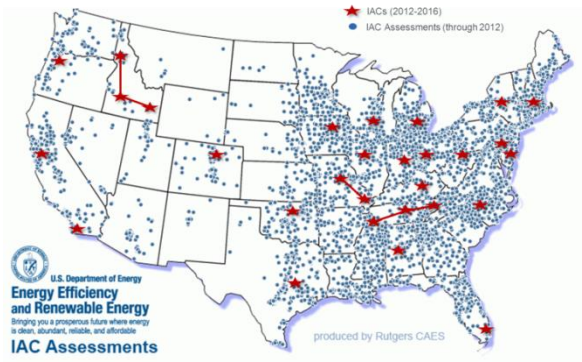
BRIGGS&STRATTON

Cummins

Johnson Controls

Student Training & Energy Assessments

University-based Industrial Assessment Centers



Better Plants
U.S. DEPARTMENT OF ENERGY

Shared R&D Facilities & Consortia

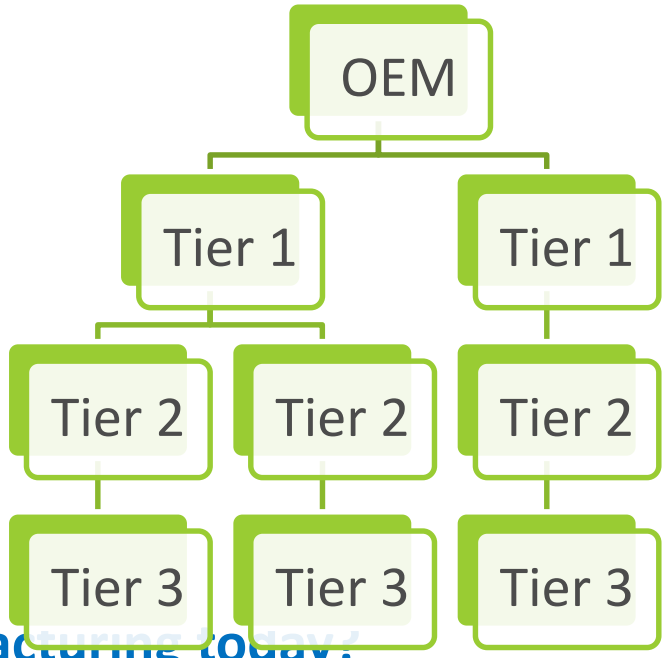
Address market disaggregation to rebuild the industrial commons

Then

Ford River Rouge Complex, 1920s

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

Now



How could we get innovation into manufacturing today?

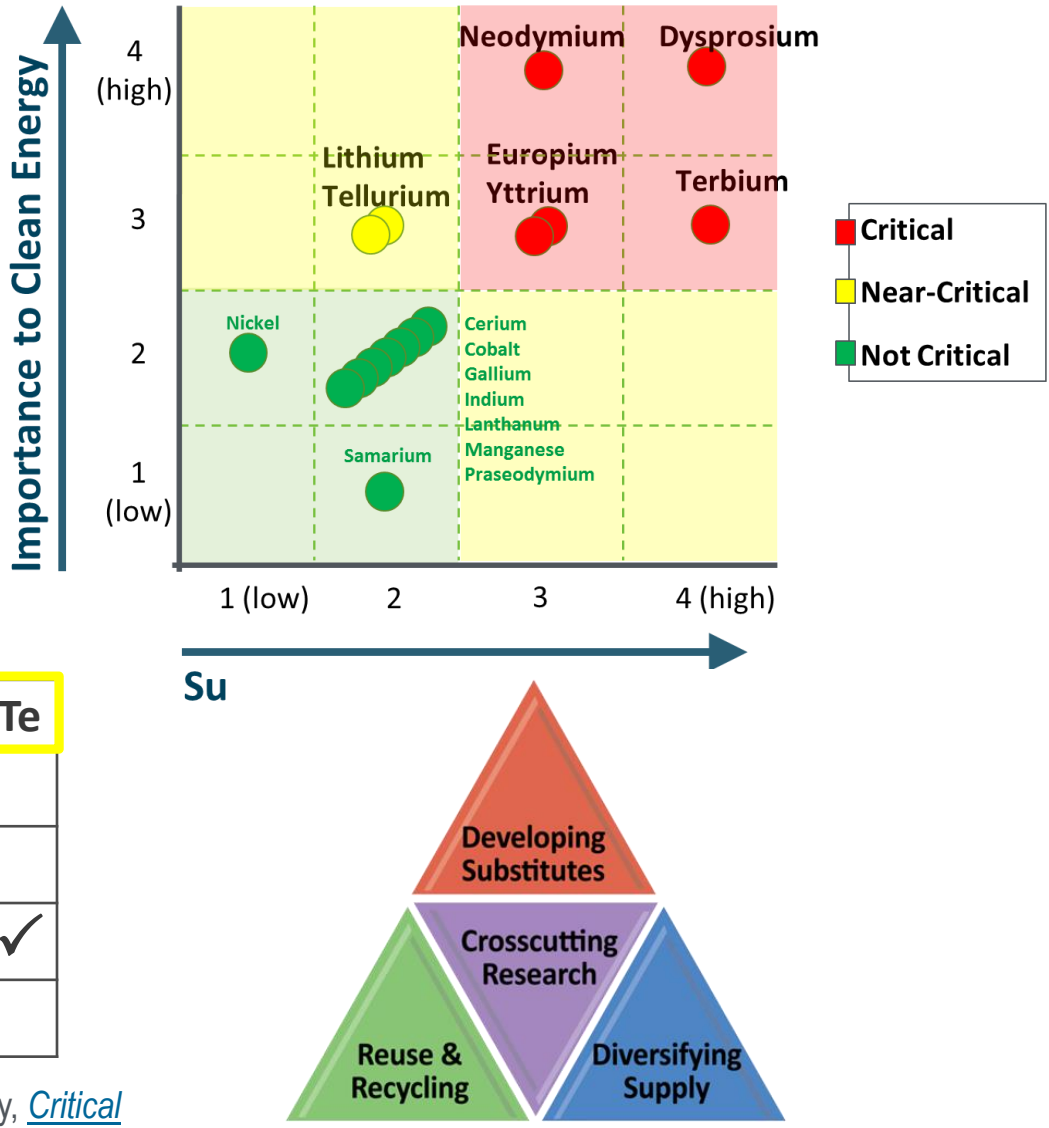
- RD&D Consortia based Eco-Systems

- Public-private partnership to scale

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	✓		✓				

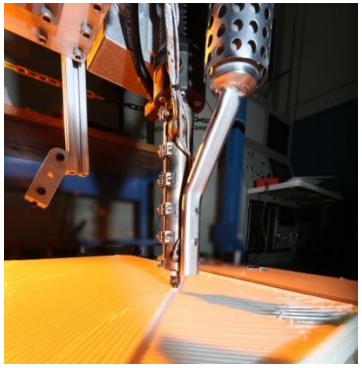
Critical Materials - as defined by U.S. Department of Energy, *Critical Materials Strategy*, 2011.

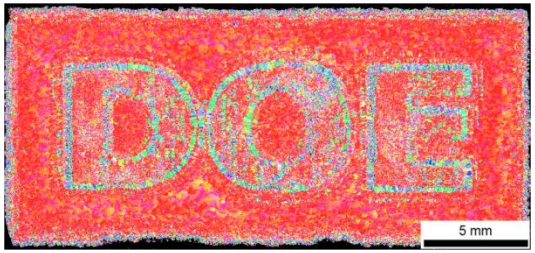
Manufacturing Demonstration Facility

Supercomputing Capabilities

Spallation Neutron Source

America Makes





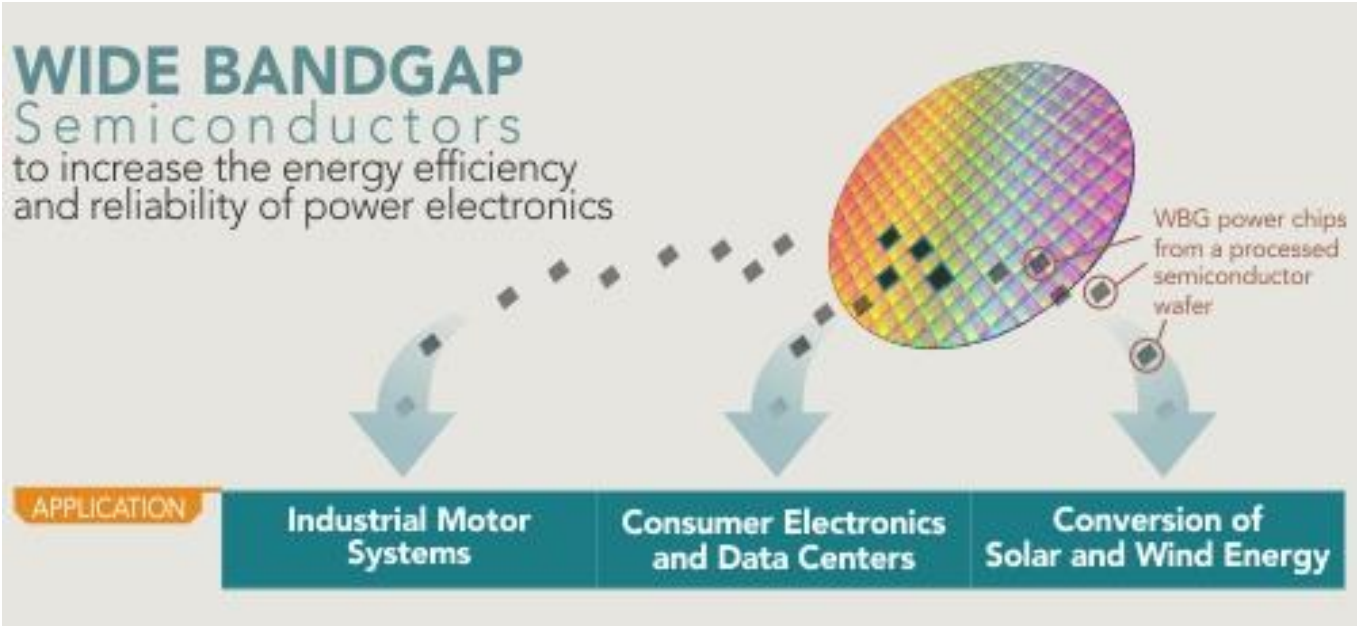
Additive Manufacturing

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.

PowerAmerica:
Next Generation Power Electronics Manufacturing Institute



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

- Higher temps, voltages, frequency, and power loads (compared to Silicon)
- Smaller, lighter, faster, and more reliable power electronic components

- $3.3 B market opportunity by 2020.[1]
- Opportunity to maintain U.S. technological lead in WBG

Poised to revolutionize the energy efficiency of electric power control and conversion

[1] Lux Research, 2012.

Institute for Advanced Composite Materials Innovation (IACMI)

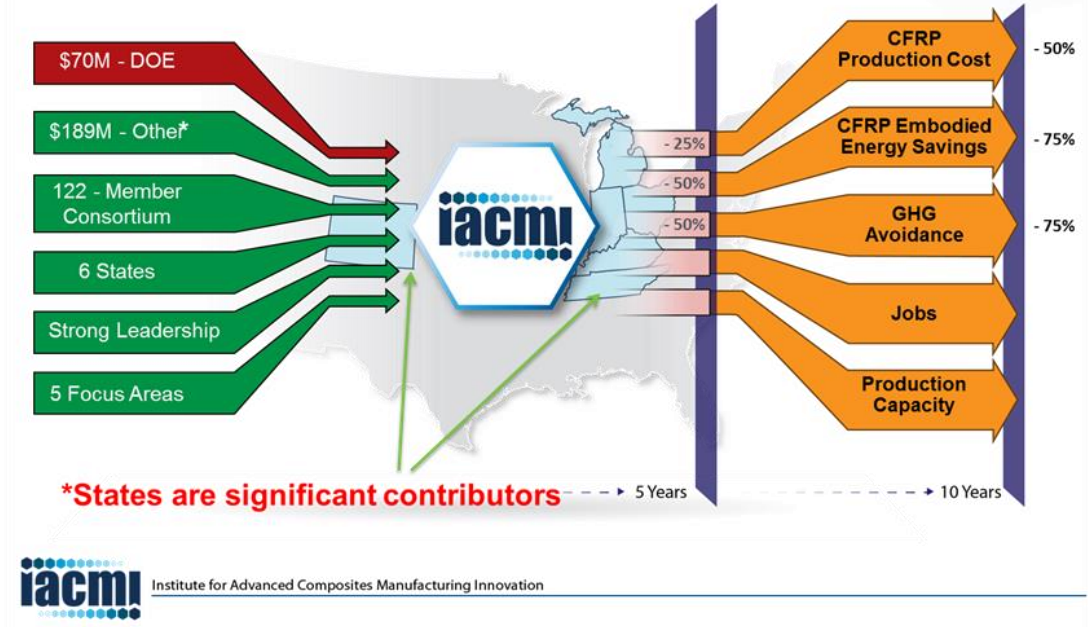
Objective

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

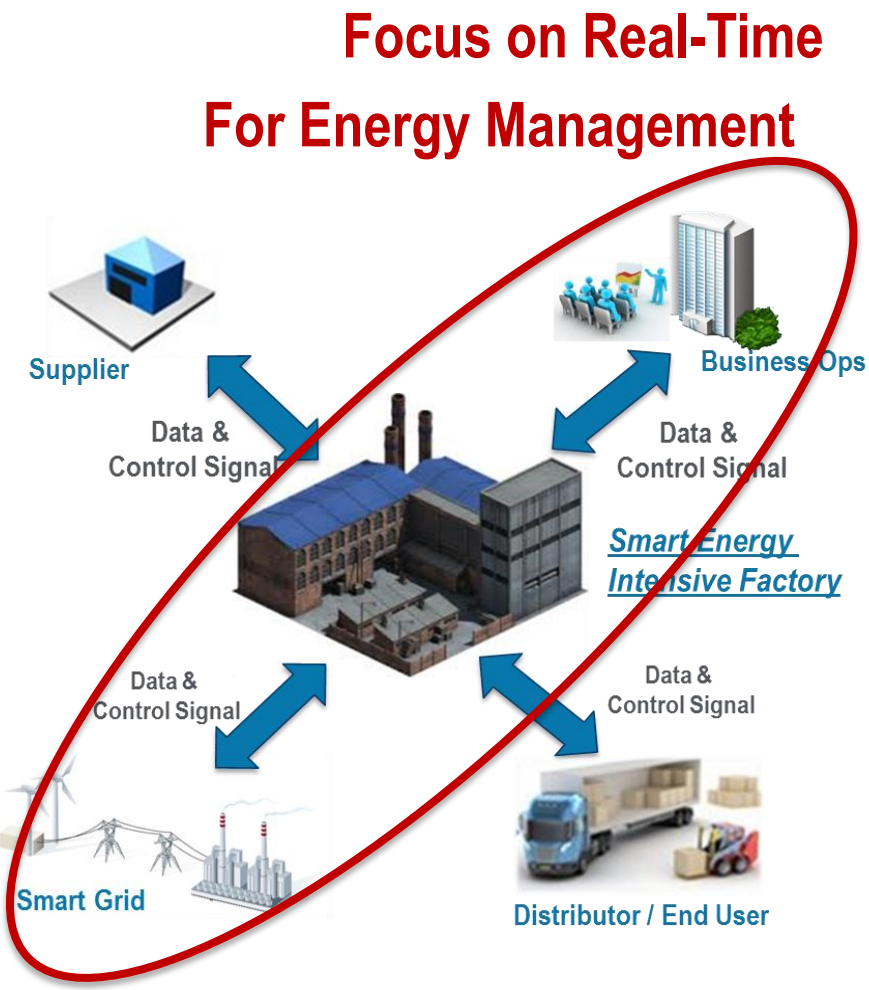
50% Lower Cost

Using 75% Less Energy

And reuse or recycle >95% of the material



SMART Manufacturing: Advanced Controls, Sensors, Models & Platforms for Energy Applications



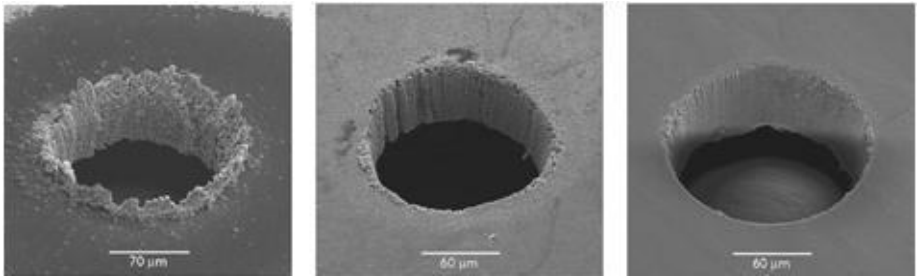
- Encompass machine-to-plant-to-enterprise real time sensing, instrumentation, monitoring, control, and optimization of energy **(>50% improvement in energy productivity)**
- Enable hardware, protocols and models for advanced industrial automation: requires a holistic view of data, information and models in manufacturing at Cost Parity (>**50% reduction in installation cost**)
- Significantly reduce energy consumption and GHG emissions & improve operating efficiency – (**15% Improvement in Energy Efficiency)**
- Increase productivity and competitiveness across all manufacturing sectors:
  - Special Focus on Energy Intensive & Energy Dependent Manufacturing Processes

Leverage AMP 2.0 and QTR

Topical Engagement with Industry

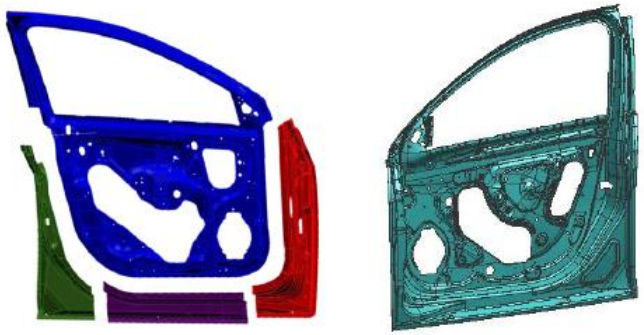
Workshops inform BOTH potential institute topics AND broader R&D portfolio

R&D Projects: Manufacturing Processes



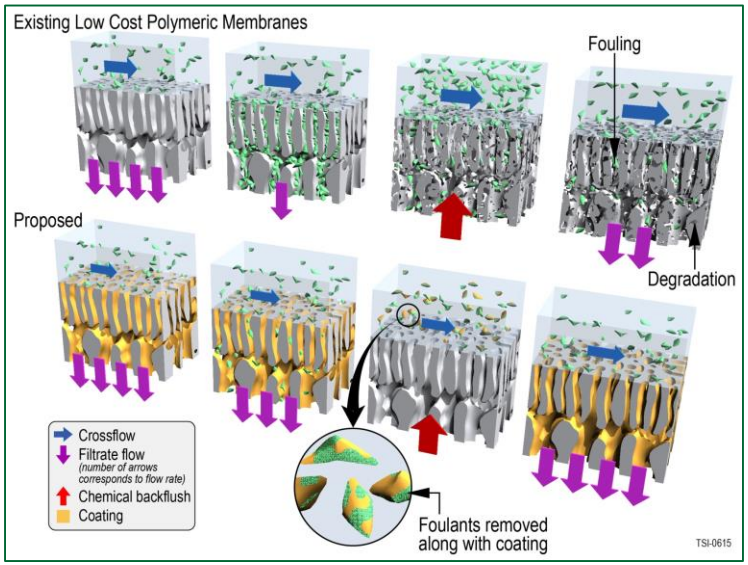
Ultrafast, femtosecond pulse lasers (right) will eliminate machining defects in fuel injectors.

Image courtesy of Raydiance.



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

Graphic image provided by General Motors.

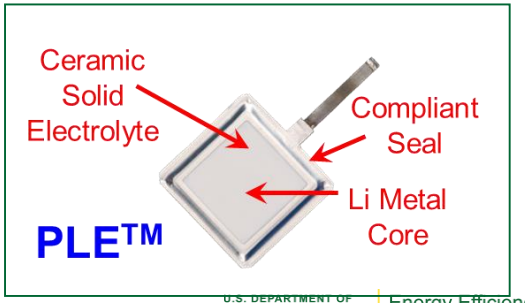


Protective coating materials for high-performance membranes, for pulp and paper industry.

Image courtesy of Teledyne

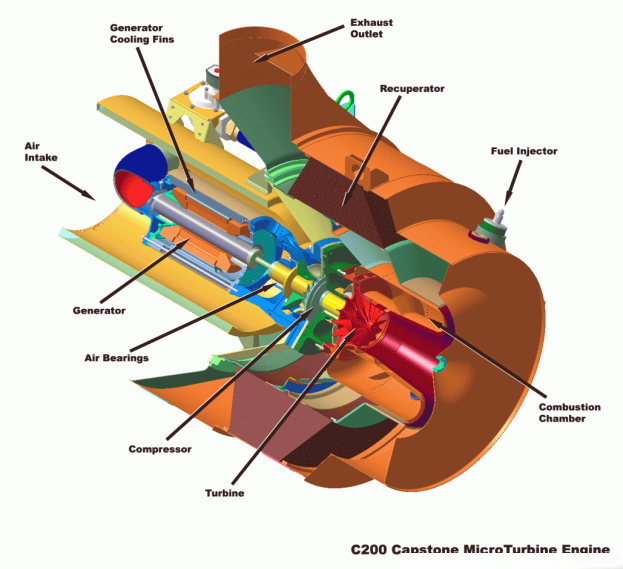
A water-stable protected lithium electrode.

Courtesy of PolyPlus



R&D Projects: Combined Heat and Power(CHP)

Advanced MicroTurbine System (AMTS) R&D Program

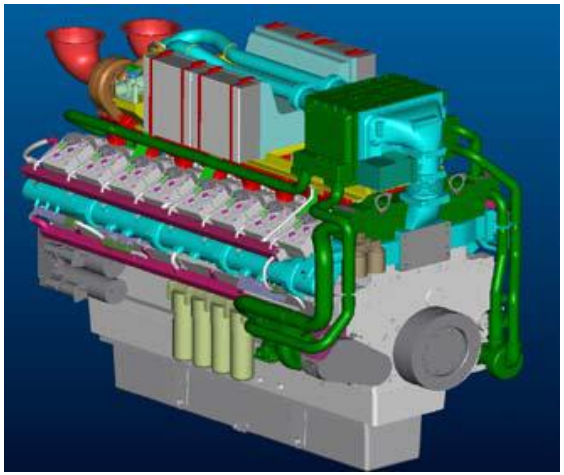


C200 Capstone MicroTurbine Engine

C200 MicroTurbine Engine

Capstone photos source: capstoneturbines.com

Advanced Reciprocating Engine Systems (ARES) R&D Program

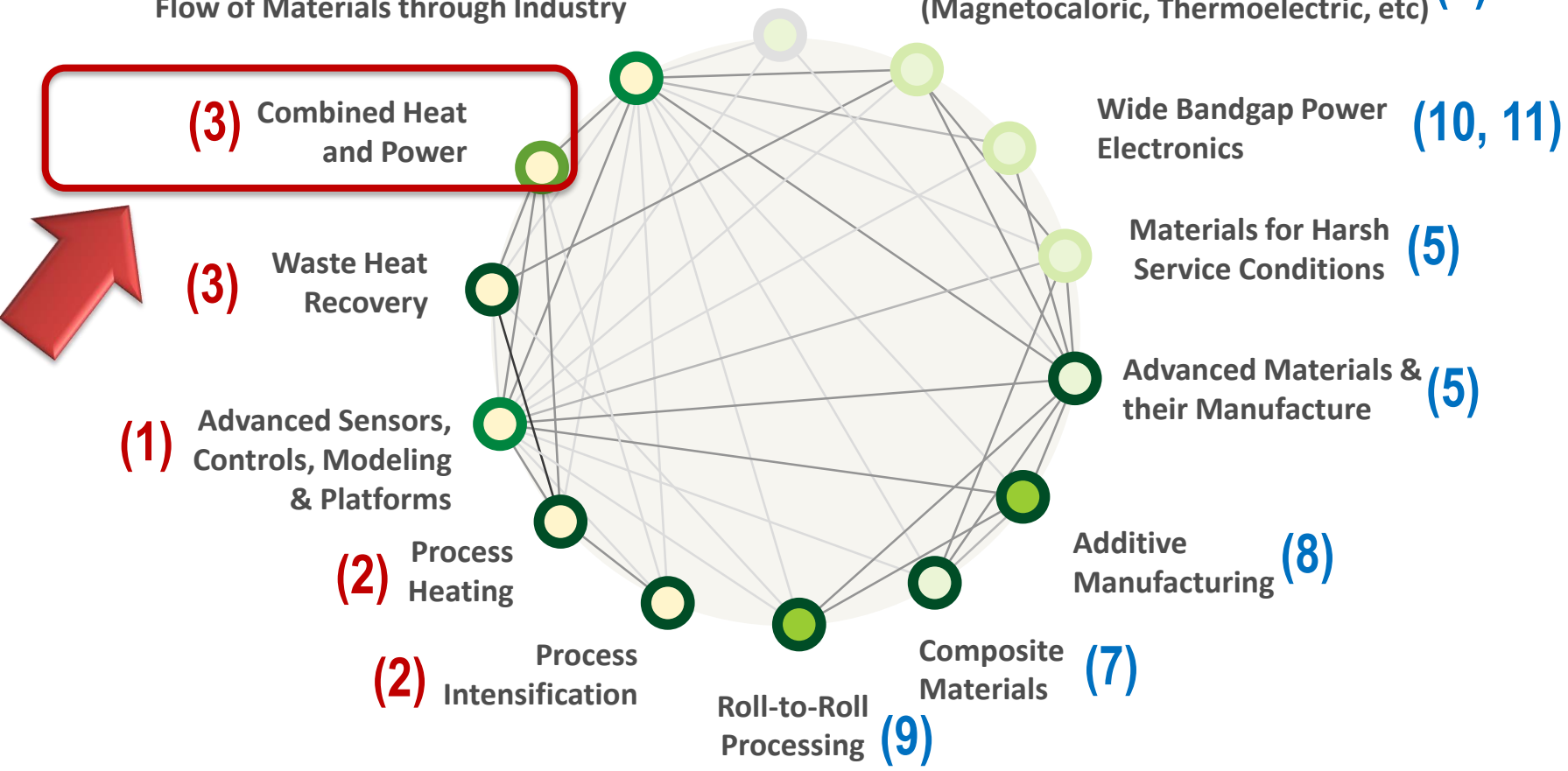


QSK60G engine

DOE QTR: Manufacturing Technology

Efficiency Technologies

Enabling Platform Technologies



Information & Data | **Processes** | **Materials**

Energy & Resource Management | **Advanced Manufacturing Processes** | Materials Development

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Platform Materials & Technologies for Clean Energy Applications

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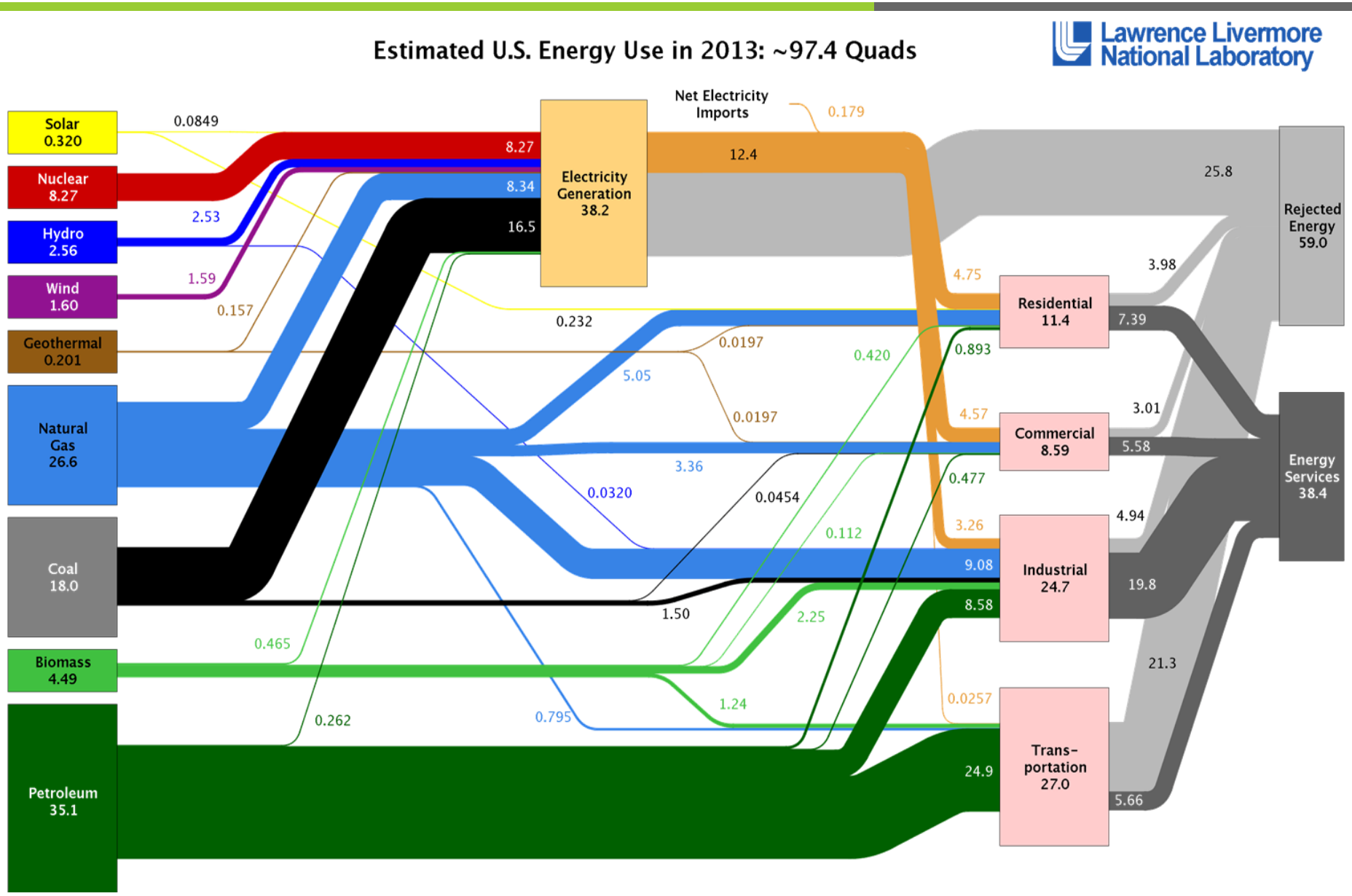
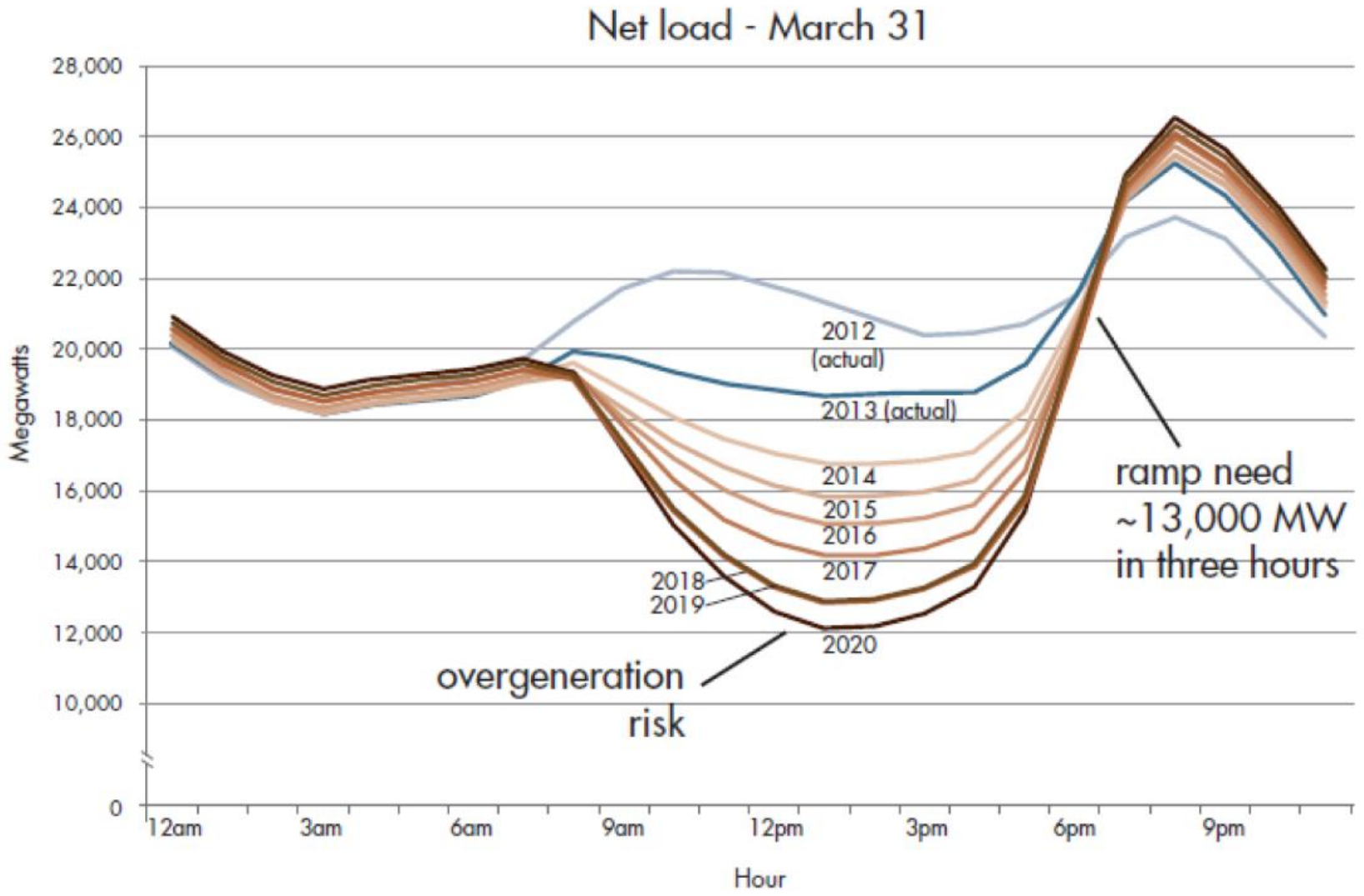
QTR Manufacturing Focus Areas Mapped to Advanced Manufacturing Topical Areas for Technology Development

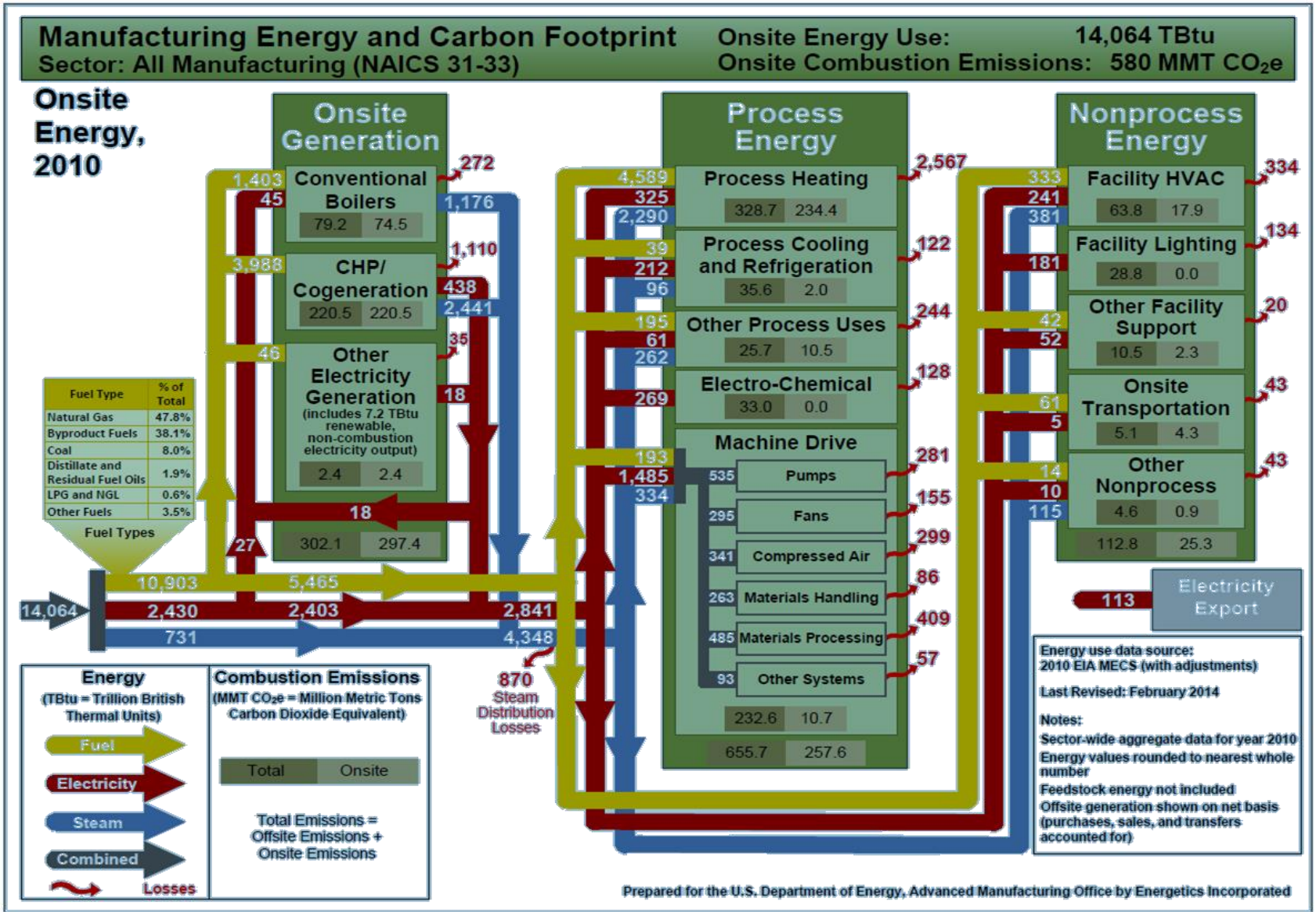
Energy Consumption by Sector



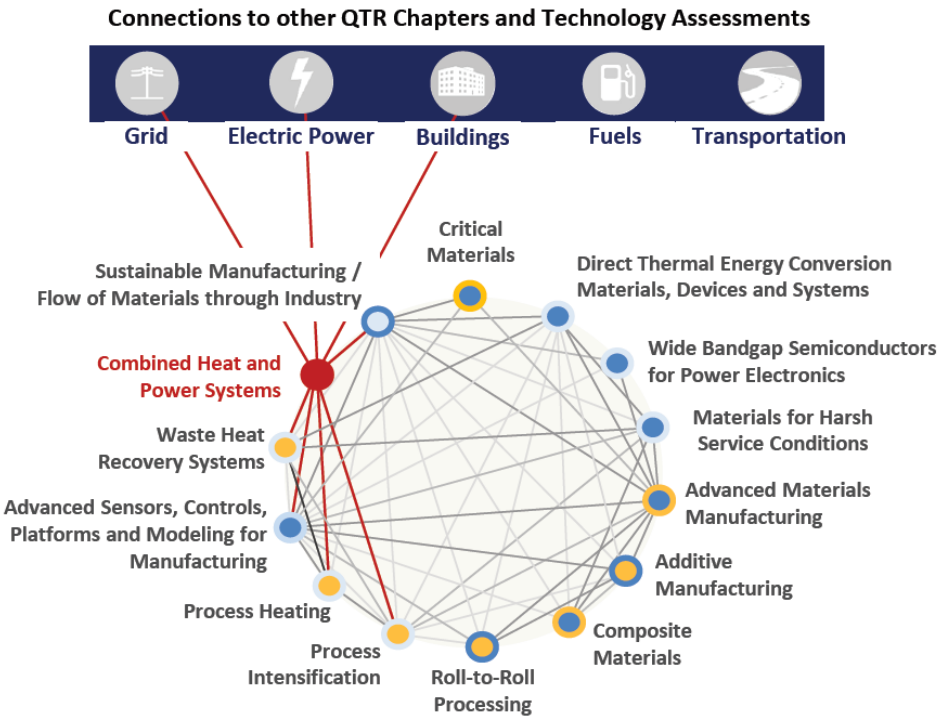
OverGeneration and Intermittent Generation Resources

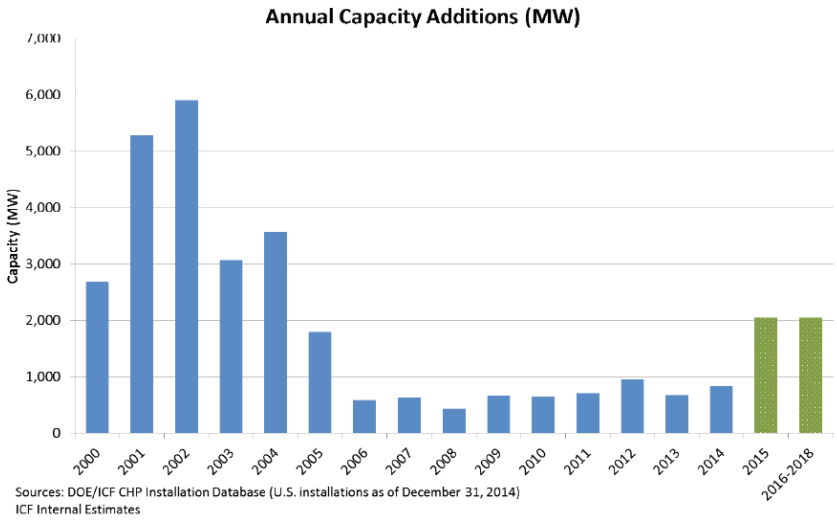


Deeper Look at Energy in Manufacturing



Grid Integration and CHP





Representative Intra-Chapter Connections

- **Sustainable Manufacturing / Advanced Materials Manufacturing:** modular design of CHP systems for easier reconfiguration, upgrade and repair
- **Waste Heat Recovery:** heat recovery for CHP systems
- **Process Heating:** integration of CHP with manufacturing process heating equipment
- **Advanced Sensors, Controls, Platforms and Modeling for Manufacturing:** models to support development of high-efficiency CHP configurations; improved controls for grid integration

Representative Extra-Chapter Connections

- **Grid:** CHP for distributed generation
- **Electric Power:** CHP for distributed generation
- **Buildings:** CHP for commercial, institutional, and multi-family residential buildings, and data centers

Questions Regarding Grid Integration of Manufacturing

- **Cost Effective and Agile Conversion of Heat (Exergy) to Power**
  - Small Scale / Cost Effective System
  - Utilization of Multiple Wastes
  - Rampable and Reliable System Resources

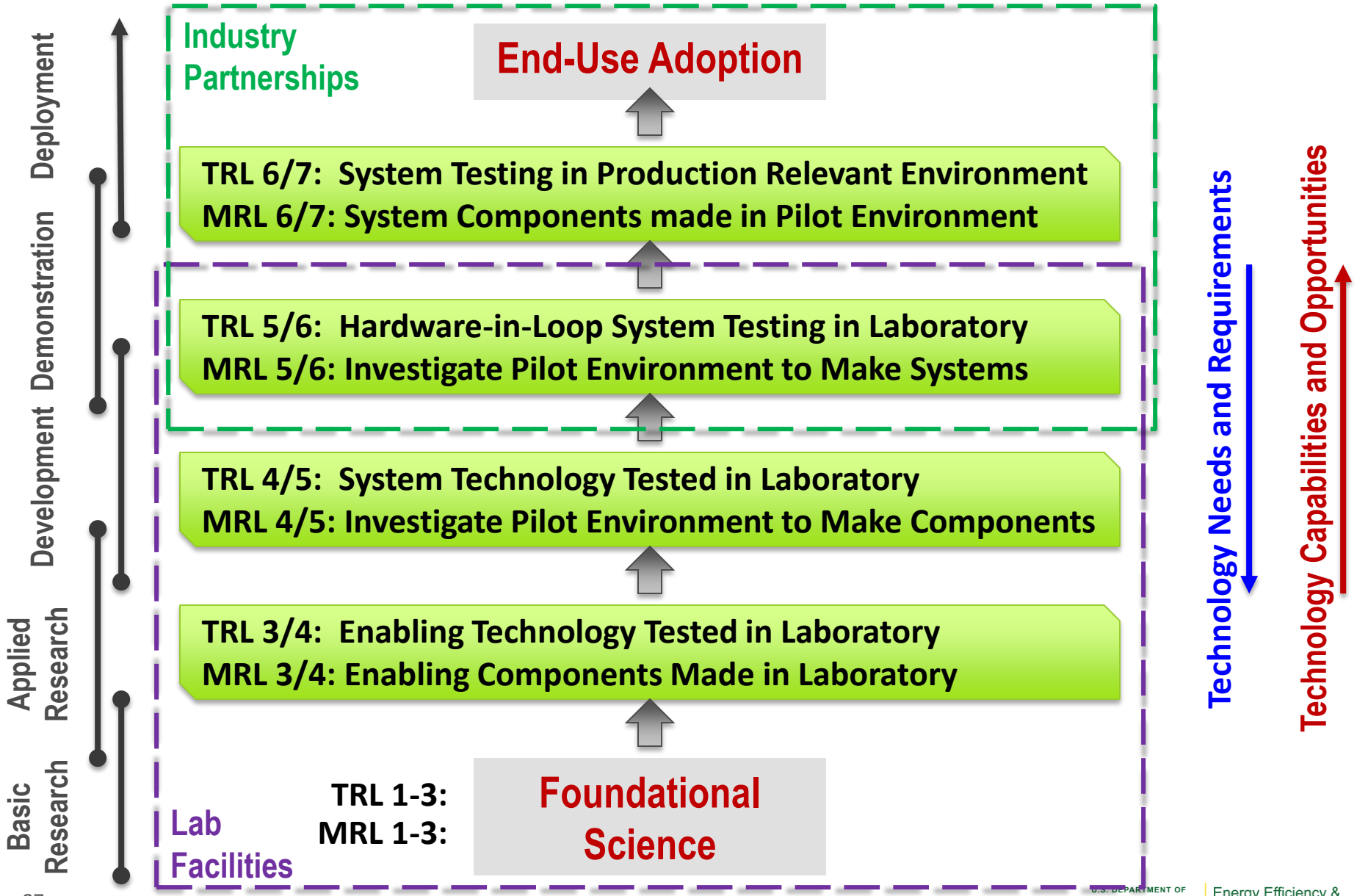
- **Cost Effective, Agile and Economical Demand Response**
  - Intelligence Throughout Manufacturing
  - Decision Making and Control Technologies

- **Cost Effective Use of Manufacturing for Power Stability**
  - Higher Heat Rates
  - Technology Challenges
  - Cost-Performance Trade-Offs: Technologies to Bend Cost Curves

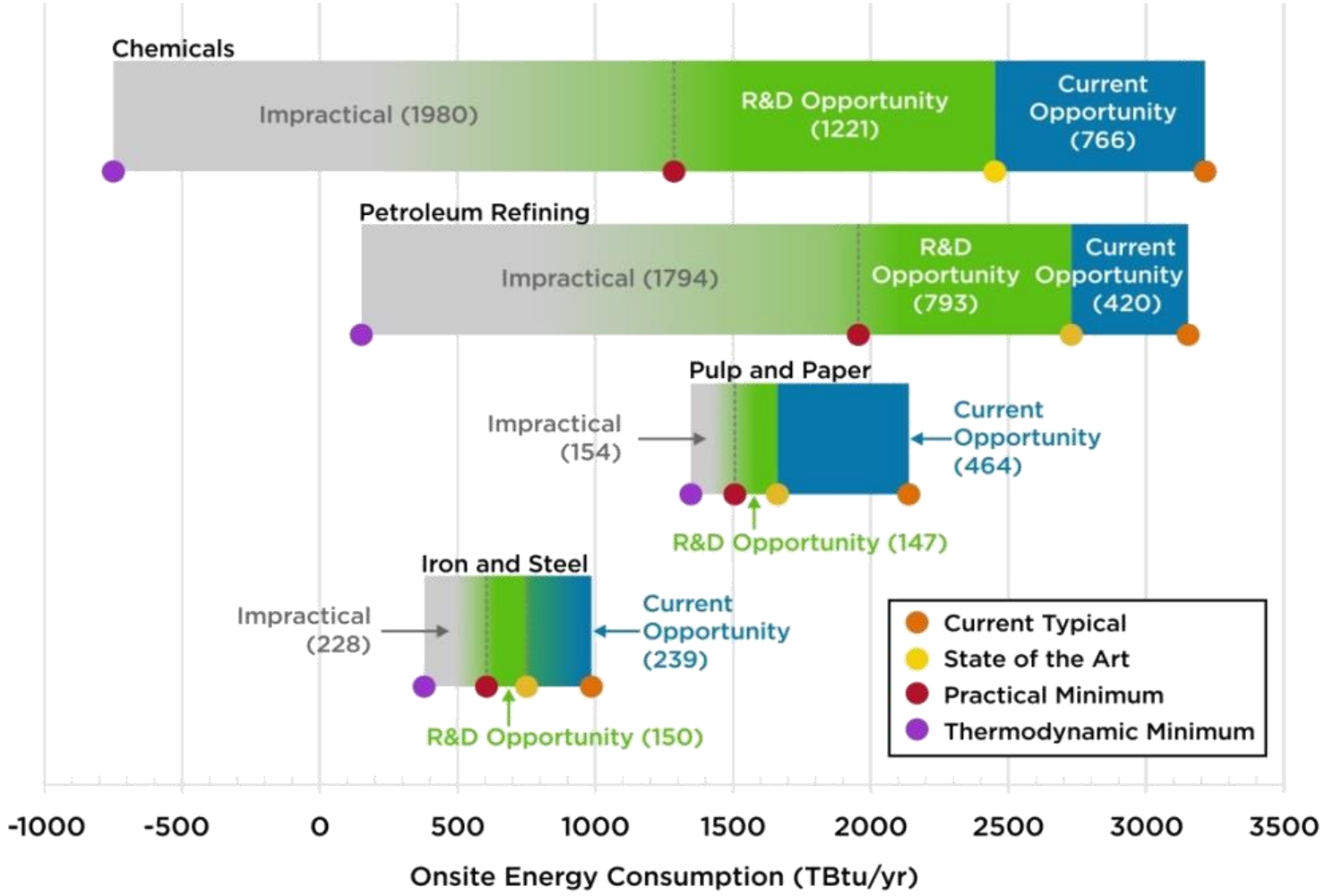
Focus on Technology Challenges

Thank You!

Manufacturing Technology Maturation



Bandwidth Studies: Energy Savings Potentials



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

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

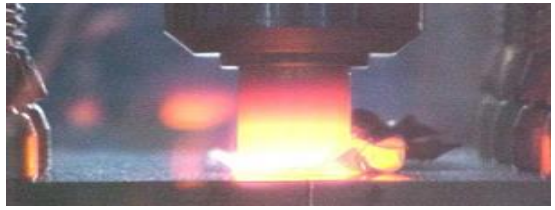
Light Emitting Diodes

Electro-Chromic Coatings

Membranes

EV Batteries

Multi-Material Joining



Shared R&D Facilities & Consortia

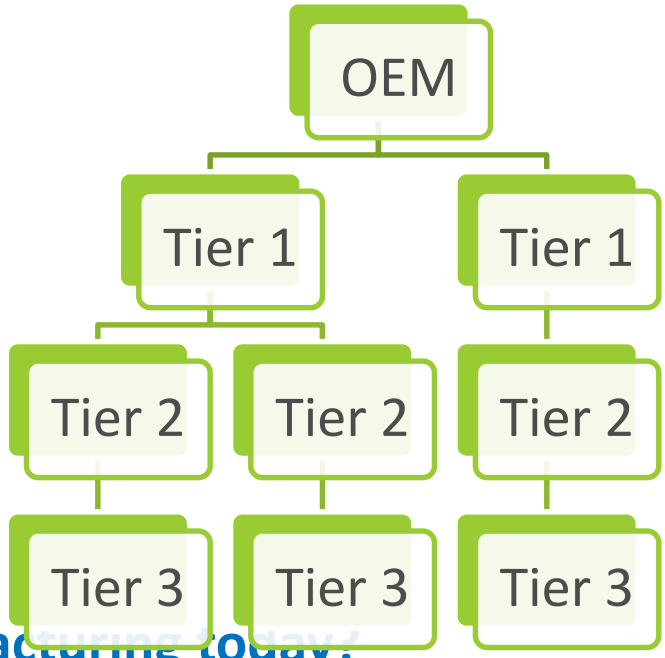
Address market disaggregation to rebuild the industrial commons

Then

Ford River Rouge Complex, 1920s

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

Now



How could we get innovation into manufacturing today?

- RD&D Consortia based Eco-Systems

- Public-private partnership to scale

Manufacturing Technology Maturation