Enabling Materials and Processes for Clean Energy and Electric Power

August 26, 2015
OE / DOE Workshop on Materials for Grid
Oak Ridge, TN

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Director
Advanced Manufacturing Office
www.manufacturing.energy.gov
Clean Energy and Manufacturing: Nexus of Opportunities

Security
- Energy self-reliance
- Stable, diverse energy supply

Economy
- Competitiveness in clean energy
- Domestic jobs

Environment
- Clean air
- Climate change
- Health

Clean Energy Solutions

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

EERE

Renewable Power
- Solar
- Geothermal
- Wind & Water

Energy Efficiency
- Buildings
- FEMP
- Weatherization
- Advanced Manufacturing

Transportation
- Vehicles
- Bioenergy
- Fuel Cells

Clean Energy Manufacturing Initiative

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
Advanced Manufacturing Topical Priorities

**Efficiency Technologies for Manufacturing Processes (Energy, CO₂)**
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**
Energy Consumption by Sector

Estimated U.S. Energy Use in 2013: ~97.4 Quads

- Solar 0.320
- Nuclear 8.27
- Hydro 2.56
- Wind 1.60
- Geothermal 0.201
- Natural Gas 26.6
- Coal 18.0
- Biomass 4.46
- Petroleum 35.1

Electricity Generation 38.2
- Net Electricity Imports 12.4
- Electricity Imports 0.179

Transportation 27.0
- Residential 11.4
- Commercial 8.59
- Industrial 24.7
- Energy Services 38.4

Energy Efficiency & Renewable Energy

U.S. DEPARTMENT OF ENERGY
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 and Energy in Sustainable Manufacturing


Water for Energy

Energy for Water

Water Energy Uses

Energy reported in Quads/year. Water reported in Billion Gallons/day.
## Possible Impact Areas of Cross-Cutting Technology for Energy Intensive Industry Sectors

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<th>Chemicals &amp; Bio-chemicals</th>
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Bridging the Gap to Manufacturing

AMO: Advanced Manufacturing Office

Concept → Proof of Concept → Lab scale development → Demonstration and scale-up → Product Commercialization
AMO Elements

Three partnership-based approaches to engage industry, academia, national labs, and state & local government:

1. **Technical Assistance** – 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

2. Research and Development Projects

3. Shared R&D Facilities
Industrial Technical Assistance

**Efficient On-Site Energy**
Clean Energy Application Centers
(to be called Technical Assistance Partnerships since in FY14)

![Map of Efficient On-Site Energy](image)

**Energy-Saving Partnership**
Better Buildings, Better Plants,
Industrial Strategic Energy Management

**Student Training & Energy Assessments**
University-based Industrial Assessment Centers

![Map of Student Training & Energy Assessments](image)
AMO Elements

Three partnership-based approaches to engage industry, academia, national labs, and state & local government:

1. Technical Assistance

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

3. Shared R&D Facilities
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

Advanced Reciprocating Engine Systems (ARES) R&D Program

C200 MicroTurbine Engine

QSK60G engine

Capstone photos source: capstoneturbines.com
AMO Elements

Three partnership-based approaches to engage industry, academia, national labs, and state & local government:

1. Technical Assistance
2. Research and Development Projects
3. **Shared R&D Facilities** - affordable access to physical and virtual tools, and expertise, to foster innovation and adoption of promising technologies
Shared R&D Facilities

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

OEM

Tier 1

Tier 2

Tier 3

Tier 1

Tier 2

Tier 3

Tier 2

Tier 3

Tier 3

How do we get innovation into manufacturing today?
Manufacturing Technology Maturation

TRL 3/4: Enabling Technology Tested in Laboratory
MRL 3/4: Enabling Components Made in Laboratory

TRL 4/5: System Technology Tested in Laboratory
MRL 4/5: Investigate Pilot Environment to Make Components

TRL 5/6: Hardware-in-Loop System Testing in Laboratory
MRL 5/6: Investigate Pilot Environment to Make Systems

TRL 6/7: System Testing in Production Relevant Environment
MRL 6/7: System Components made in Pilot Environment

End-Use Adoption

TRL 1-3: Foundational
MRL 1-3: Science

Industry Partnerships

Technology Needs and Requirements

Energy Efficiency & Renewable Energy
Critical Materials Institute

A DOE Energy Innovation Hub

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

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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.
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

Focus on Real-Time
For Energy Management

- Encompass machine-to-plant-to-enterprise real time sensing, instrumentation, monitoring, control, and optimization of energy
- 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 & Energy Dependent Manufacturing Processes

Leverages AMP 2.0
What does Success Look Like?

Energy Products Invented Here...

...And Competitively Made Here!
Thank You

Questions?