NNMI Industry Day: Smart Manufacturing AMO Overview

February 25, 2015
Atlanta, GA

Mark Johnson
Director
Advanced Manufacturing Office
www.manufacturing.energy.gov
Status Quo: Products invented here, and made elsewhere
Significance of U.S. Manufacturing

12% of U.S. GDP, 12 million U.S. jobs, 60% of U.S. Exports

U.S. Trade Balance of Advanced Technology

Swung to historic deficit, lost 1/3rd of workforce
Clean Energy: Nexus of Opportunities

- Energy self-reliance
- Stable, diverse energy supply

Security

Economy
- Competitiveness in clean energy
- Domestic jobs

Environment
- Clean air
- Climate change
- Health

Clean Energy Solutions
Strategic Framework for Advanced Manufacturing

Climate Action Plan: Efficiency and Sustainability
National Economic Council: Manufacturing Competitiveness
Quadrennial Energy Plan: End-Use Sector Focus
Quadrennial Technology Plan: DOE Technology Area Focus
Clean Energy Manufacturing Tech-Team: Cross-Cutting Impact

Efficiency in Manufacturing Processes (Energy, CO₂)
Enabling Materials and Technologies for Clean Energy

Modalities: Technology Assistance and Technology Development
Technology Development: R&D Projects and R&D Facilities
• DOE is active across the pillars of Advanced Manufacturing
• DOE is a leader in **advanced manufacturing innovation** and implementing the **National Network for Manufacturing Innovation (NNMI)**

**NNMI:**

[Image of logos for NASA, Department of Defense, Department of Commerce, Department of Energy, and NSF]
Clean Energy Manufacturing Initiative – Across DOE

Collaboration toward:
• Common goal to collectively *increase U.S. manufacturing competitiveness*

Coordination for:
• Comprehensive Strategy
• Collaborative Ideas
AMO’s Purpose is to Increase U.S. Manufacturing Competitiveness and Energy Efficiency through:

- **Broadly Applicable Efficiency Technologies for Energy Intensive and Energy Dependent Manufacturing**
  - examples: combined heat and power (CHP), efficient manufacturing process intensification, energy management and process controls

- **Platform Manufacturing Innovations for Advanced Energy Technologies**
  - examples: carbon fiber composites; critical materials; advanced materials manufacturing; high performance simulation, visualization and modelling, wide band gap semiconductors/power electronics
Energy Use in the Manufacturing Sector

Estimated 20%-30% Improvement in Systems Efficiency Through How Manufacturing Systems are Operated

Requires Improved Situational Awareness and Decision Support For Manufacturing Systems: Intelligence in Manufacturing
<table>
<thead>
<tr>
<th>Industry</th>
<th>Energy Consumption (TBTU)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary Metals</td>
<td>1608</td>
</tr>
<tr>
<td>Petroleum Refining</td>
<td>6137</td>
</tr>
<tr>
<td>Chemicals</td>
<td>4995</td>
</tr>
<tr>
<td>Wood Pulp &amp; Paper</td>
<td>2109</td>
</tr>
<tr>
<td>Glass &amp; Cement</td>
<td>716</td>
</tr>
<tr>
<td>Food Processing</td>
<td>1162</td>
</tr>
</tbody>
</table>
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

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 do we get innovation into manufacturing today?
Bridging the Gap to Manufacturing

AMO: Advanced Manufacturing Office

R&D Investment Level

Technology Maturity (TRL; MRL; etc.)

Governments and Universities

Private sector

Concept → Proof of Concept → Lab scale development → Demonstration and scale-up → Product Commercialization
Manufacturing Technology Maturation

- **TRL 6/7**: System Testing in Production Relevant Environment
  - **MRL 6/7**: System Components made in Pilot Environment
- **TRL 5/6**: Hardware-in-Loop System Testing in Laboratory
  - **MRL 5/6**: Investigate Pilot Environment to Make Systems
- **TRL 4/5**: System Technology Tested in Laboratory
  - **MRL 4/5**: Investigate Pilot Environment to Make Components
- **TRL 3/4**: Enabling Technology Tested in Laboratory
  - **MRL 3/4**: Enabling Components Made in Laboratory
- **TRL 1-3**: Enabling Technology Tested in Laboratory
  - **MRL 1-3**: Enabling Components Made in Laboratory

**Foundational Science**

**End-Use Adoption**
Critical Materials Institute
A DOE Energy Innovation Hub

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

Program goal is to accelerate the manufacturing capability of a multitude of AM technologies utilizing various materials from metals to polymers to composites.
Lead: North Carolina State University


Mission: Develop advanced manufacturing processes that will enable large-scale production of wide bandgap semiconductors, which allow power electronics components to be smaller, faster and more efficient than silicon.

Poised to revolutionize the energy efficiency of power control and conversion
Institute for Advanced Composite Materials Innovation

**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

*States are significant contributors*
Getting to the Topic: Pathway To Date

Open RFIs, Regional Dialogs, White Papers, & Reviews

Topical Workshops, & Focused RFIs

Competitive Solicitation & Teaming Board

Preliminary Topic Identification

Subject Expert FOA Topical RFI Review Panels

Topic Development

Solicitation

Execution

Spring 2014

Summer 2014

Fall/Winter 2014

Spring/Summer 2015

Cross-cutting Technology Opportunities

Additive Manufacturing
Critical Materials
Wide E_g Power Electronics
Advanced Composites

Sensors, Control, Platforms & Models
Advanced Materials Manufacturing
Chemical Process Intensification
2D / Roll-to-Roll Manufacturing

CHP/DG & Grid Integration
Sustainable Manufacturing
Electric Machines
Manufacturing Sector Whitespace

Energy Intensive Sector Focus Areas

- Metals
- Glass & Ceramics
- Forest & Biomass
- Petrochemicals
- Extraction
- Concrete

Clean Energy Applications

- Transportation
- Efficient Systems
- Power Generation
- Energy Delivery

Cross-Cutting Impact Opportunities
Broad Topical Areas

• **Platform Materials and Technologies for Energy Applications**
  - Advanced Materials Manufacturing (Mat’l Genome, Nanomaterials, etc.)
  - Critical Materials
  - Advanced Composites & Lightweight Materials
  - 3D Printing / Additive Manufacturing
  - 2D Manufacturing / Roll-to-Roll Processes
  - Wide Bandgap Power Electronics
  - Next Generation Electric Machines

• **Efficiency in Manufacturing Processes (Energy, CO₂)**
  - Advanced Sensors, Controls, Modeling and Platforms (ie. Smart Manf.)
  - Advanced Chemical Process Intensification
  - Grid Integration of Manufacturing (CHP and DR)
  - Sustainable Manufacturing (Water, New Fuels & Energy)

• **Emergent Topics in Manufacturing**
## Questions We Asked: RFIs and Workshops

<table>
<thead>
<tr>
<th>Core Questions</th>
<th>Application to NNMI Topic Selection</th>
</tr>
</thead>
</table>
| **High Impact:**                | • What is manufacturing challenge to be solved?  
• If solved, how does this impact clean energy goals?  
• If solved, who will care and why specifically?                                                                                                               |
| **Additionality:**              | • Who is supporting the fundamental low-TRL research & why wouldn’t they support mid-TRL development?  
• Who else might fund this mid-TRL development & how might EERE/AMO support catalyze this co-investment?                                                  |
| **Openness:**                   | • Has this mid-TRL manufacturing challenge been stated broadly?  
• Is there fertile low-TRL scientific base to address the challenge?  
• Has a broad set of stakeholders been engaged in dialog?                                                                                                       |
| **Enduring Economic Benefit:**  | • Would this manufacturing challenge impact more than one clean energy technology application?  
• Is industry currently trying to identify solutions?                                                                                                           |
| **Proper Role of Government:**  | • What is the national interest? What is the market failure? (Why would industry not solve this by itself?)  
• Is there a pathway for Federal funding to end & what are the metrics for this transition?  
• Is there large potential for follow-on funding, & what are the stage gates to follow-on support?                                                                |
| **+ Appropriate Mechanism**     | • Why is this specific mid-TRL problem best addressed through a 5-Year, multi-participant, industry-oriented institute (NNMI) now?         |
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
Costs in Deploying Smart Information Systems
Possible Barriers to Adoption & Possible Path to Cost Parity

Notional Barriers to Widespread Adoption

Deployment Cost of Energy
Productivity Improvement

Platform Costs: Zeroth of Kind Deployment

NRE Costs: First of Kind Deployment

NRE Costs: Nth of Kind Deployment

Hardware & Installation

O&M Costs

Energy Cost Parity
Cost Parity For Investment Recovery ($/MBTU, ¢/kWh)

Today Future

est. 2x–5x Above Parity

Cost Parity For
Energy Efficiency & Renewable Energy

26
## Technical Issues and Adoption Challenges

<table>
<thead>
<tr>
<th>Platform Challenges</th>
<th>1\textsuperscript{st} of Kind Demonstration</th>
<th>N\textsuperscript{th} of Kind Demonstration</th>
<th>Hardware &amp; Deployment</th>
<th>O&amp;M</th>
</tr>
</thead>
<tbody>
<tr>
<td>High Fidelity Modelling</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Data Architecture &amp; Platform</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Sensor Development &amp; Qualification</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Algorithms, Controls and Data</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Demonstration Testbeds (1\textsuperscript{st} of Kind)</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
</tbody>
</table>

### Notional Technical Issues Related to Adoption Challenges
## Smart Manufacturing & Digital Manufacturing

<table>
<thead>
<tr>
<th></th>
<th>Digital Manufacturing</th>
<th>Smart Manufacturing</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Emphasis</strong></td>
<td>Information technology focus for highly integrated design and manufacturing of products and processes</td>
<td>Advanced Sensors, Controls, Platforms and Modeling for Manufacturing including Process Simulation and Control</td>
</tr>
<tr>
<td><strong>Description</strong></td>
<td>“digital thread” allowing all manufacturing to pass design and process information up and down the supply chain</td>
<td>Unprecedented real-time control of energy, productivity, and costs across factories and companies</td>
</tr>
<tr>
<td><strong>Core Technical &amp; Process Areas</strong></td>
<td>Intelligent machines with integrated IT machine to machine communication, across platforms and companies; computer simulation, 3D models, Model Based Enterprise, interoperable systems, design of advanced materials and processes, &amp; analytics</td>
<td>Advanced sensing, instrumentation, monitoring, control, and process optimization using both advanced hardware and software platforms, as well as modeling and simulation technologies</td>
</tr>
<tr>
<td><strong>Key Benefit</strong></td>
<td>Reduced cost and time; faster marketplace penetration of new products</td>
<td>Save money, conserve energy, greater efficiency, real-time control of manufacturing processes and supply</td>
</tr>
<tr>
<td><strong>Applicable Industries</strong></td>
<td>All manufacturing</td>
<td>Energy-intensive and Energy-dependent</td>
</tr>
<tr>
<td><strong>Potential Savings</strong></td>
<td>Accuracy - &quot;First part correct,&quot; correct by design, correct by construction, and automatic verification and correction</td>
<td>10-20% reduction in the cost of production, largely by optimization of energy use and energy productivity</td>
</tr>
<tr>
<td><strong>Cyber Security</strong></td>
<td>Life-Cycle (entire digital thread)</td>
<td>Real Time (sensors and controls)</td>
</tr>
</tbody>
</table>

What does Success Look Like?

Energy Products Invented Here...

...And Competitively Made Here!
Thank You

Questions?