Grid Integration of Manufacturing Technology Workshop

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Clean Energy and Manufacturing: Nexus of Opportunities

Clean Energy Solutions

- Competitiveness in clean energy
- Domestic jobs
- Energy self-reliance
- Stable, diverse energy supply
- 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

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

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)

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
Bridging the Gap to Manufacturing

AMO: Advanced Manufacturing Office

Government and Universities

Private sector

Concept → Proof of Concept → Lab scale development → Demonstration and scale-up → Product Commercialization
Modalities of Support

**Technology Assistance**: (Dissemination of Knowledge)

**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

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

**Student Training & Energy Assessments**
University-based Industrial Assessment Centers
Shared R&D Facilities & Consortia

Address market disaggregation to rebuild the industrial commons

Then

Now

Ford River Rouge Complex, 1920s

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

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

¹Lux 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 (>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

Advanced Materials
- Materials in Extreme Conditions
- Sustainable Materials in Manufacturing

Process Intensification
- Process Intensification (Chemical)
- Process Intensification (Thermal)

Roll-to-Roll Processing
- Functional Membrane Structures

Advanced Sensors, Controls, Models, Platforms
- Smart Manufacturing

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.

A water-stable protected lithium electrode. Courtesy of PolyPlus

Protective coating materials for high-performance membranes, for pulp and paper industry. Image courtesy of Teledyne.
R&D Projects: Combined Heat and Power (CHP)

**Advanced MicroTurbine System (AMTS) R&D Program**

- C200 MicroTurbine Engine
- Capstone photos source: capstoneturbines.com

**Advanced Reciprocating Engine Systems (ARES) R&D Program**

- QSK60G engine
Advanced Manufacturing Topical Priorities

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QTR Manufacturing Focus Areas Mapped to Advanced Manufacturing Topical Areas for Technology Development
OverGeneration and Intermittent Generation Resources
Deeper Look at Energy in Manufacturing
Grid Integration and CHP

connections to other QTR chapters and technology assessments

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

Annual Capacity Additions (MW)

Sources: DOE/ICF CHP Installation Database (U.S. installations as of December 31, 2014)
ICF Internal Estimates
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

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 Science
MRL 1-3: Foundational Lab Facilities
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

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Ford River Rouge Complex, 1920s
Photo: Library of Congress, Prints & Photographs Division, Detroit Publishing Company Collection, det 4a25915.

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MRL 3/4: Enabling Components Made in Laboratory

TRL 1-3: End-Use Adoption
MRL 1-3: Foundational Science

Applied Research
Development Demonstration
Deployment
Industry Partnerships
Technology Needs and Requirements
Technology Capabilities and Opportunities
Lab Facilities