High Performance Computing for Manufacturing at the U.S. Department of Energy

HPC4Mfg Industry Day
San Diego, CA

March 3rd, 2017
Energy and Manufacturing Innovation

- **Security**
  - Energy independence
  - Stable, diverse energy supply

- **Advanced Manufacturing and Energy Innovation**

- **Economy**
  - Competitiveness in energy products
  - Domestic jobs

- **Environment**
  - Clean Air
  - Clean Water
A little history: The Start of a pair of Revolutions

Lexington & Concord
1775

Watt, Boulton & Co.
1775
(intelligence: steam regulation for external combustion engines)
“... 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
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
How will Manufacturing, Economy and Security of the Nation depend on Information, Computation, Actuation and Communication Technologies in the 21st Century?
Innovation, Talent and Jobs

Powerful multiplier effects mean every new advanced industry job supports more than two others.

<table>
<thead>
<tr>
<th>Advanced Industries</th>
<th>Jobs Supported by Each Additional Worker</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy</td>
<td>2.3</td>
</tr>
<tr>
<td>Manufacturing</td>
<td>1.8</td>
</tr>
<tr>
<td>Services</td>
<td>0.8</td>
</tr>
<tr>
<td>Total Sector</td>
<td>1.4</td>
</tr>
<tr>
<td>U.S. Economy</td>
<td>0.5</td>
</tr>
<tr>
<td>Non-Advanced Industries</td>
<td>0.4</td>
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</tbody>
</table>

Legend:
- Local
- Non-local domestic
Advanced Manufacturing are Great Jobs!

The chart shows the average wage (in thousands) for different levels of education in Advanced and Non-Advanced Industries.

- PhD: $153 (Advanced), $117 (Non-Advanced)
- Professional Degree: $130 (Advanced), $89 (Non-Advanced)
- Master’s Degree: $115 (Advanced), $69 (Non-Advanced)
- Bachelor’s Degree: $96 (Advanced), $56 (Non-Advanced)
- Associate’s Degree: $60 (Advanced), $56 (Non-Advanced)
- Some College: $44 (Advanced), $38 (Non-Advanced)
- Secondary Diploma: $34 (Advanced), $32 (Non-Advanced)
- No Secondary Diploma: $33 (Advanced), $20 (Non-Advanced)
US Workforce is Highly Productive

![Graph showing advanced industries GDP per worker and annualized growth in GDP per worker for various countries. The United States has the highest GDP per worker, followed by Norway. Growth in GDP per worker varies significantly across countries, with some experiencing positive growth and others negative.](image_url)
Manufacturing Innovation is Important to the Nation
AMO: Three complimentary strategies

Technical Assistance: Direct engagement with Industry

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

R&D Consortia: Public-Private Partnerships

Shared R&D Facilities offer affordable access to physical and virtual tools, and expertise, to foster innovation and adoption of promising technologies

R&D Projects: Bridging the innovation gap

Research and Development Projects to support innovative manufacturing processes and next-generation materials
R&D Projects: HPC for Manufacturing

- Program teams manufacturers with DOE’s network of National Labs
- Applying High Performance Computing to face critical manufacturing challenges
High Performance Computing for Manufacturing

Apply modeling and simulation capabilities to manufacturing challenges

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

A computer simulation of the virtual blast furnace. Image courtesy of Purdue University – Calumet.
HPC4Mfg leverages global leading HPC capabilities at the national labs to partner with industry and address critical technical challenges in manufacturing

- DOE labs possess 5 of the top 12 HPC systems worldwide and broad expertise in their application: 2 of top 3 in Top500

- Catalyzes Industry / National Lab partnerships

<table>
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<tr>
<th>Top500 / November 2016</th>
<th>Rmax (TF/s)</th>
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<tbody>
<tr>
<td>1. Sunway TaihuLight (China)</td>
<td>93,015</td>
</tr>
<tr>
<td>2. MilkyWay-2 (China)</td>
<td>33,863</td>
</tr>
<tr>
<td>3. Titan (Oak Ridge)</td>
<td>17,590</td>
</tr>
<tr>
<td>4. Sequoia (Livermore)</td>
<td>17,173</td>
</tr>
<tr>
<td>5. Cori (LBL)</td>
<td>14,015</td>
</tr>
<tr>
<td>6. Oakforest – JCAHPC (Japan)</td>
<td>13,555</td>
</tr>
<tr>
<td>7. K Computer – Riken (Japan)</td>
<td>10,510</td>
</tr>
<tr>
<td>8. Piz Daint - CSCS (Switzerland)</td>
<td>9,779</td>
</tr>
<tr>
<td>9. Mira (Argonne)</td>
<td>8,587</td>
</tr>
<tr>
<td>10. Trinity (Las Alamos)</td>
<td>8,101</td>
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HPC4Mfg Program: Advancing Innovation

Framework:
• Business-friendly terms and streamlined partnering process
• Leverage decades of investment in platforms, codes, and expertise
• Emphasis on open sharing of successes benefits entire sector

U.S. Manufacturers, Industry Partners, and Consortia
• Identify industry challenge
• Industry partners contribute 20% “in kind” funding
• Share success

National laboratories provide
• HPC capabilities and modeling/simulation expertise
• Assistance to industry to develop full proposal
• Develop standard CRADA to protect industry IP
• DOE funding < $300K
• Application opportunity every 6 months
• More information at www.hpc4mfg.org

Increase Energy Efficiency - Advance Clean Energy Technologies
What does Success Look Like?

Energy Products Invented Here...

...And Competitively Made Here!
Thank You

Questions?