Welcome!

Fiber Reinforced Polymer Composite Manufacturing Workshop

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Breakout Instructions

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Let’s dig deeper:

- **Manufacturing Process Technologies - Blue Teams A and B** (e.g. lay-up techniques, out of the autoclave, novel cure techniques, resin infusion, pultrusion, SMC, tooling, machining)

- **Enabling Technologies and Approaches - Red Team** (e.g. design methods and databases, analytical tools, nondestructive evaluation, damage tolerance, joints, repair, other)

- **Recycled and Emerging Materials - Green Team** (e.g. recycling carbon fiber, renewable precursor materials, advanced glasses, nanomaterials)
EERE 5 Core Questions

• **Impact:** Is this a high impact problem?
• **Additionality:** How will EERE make a significant difference relative to what other entities are doing?
• **Openness:** Are we focusing on the broad problem we are trying to solve and open to new ideas, new approaches and new performers?
• **Enduring Economic Benefit:** Will this result in enduring economic benefit to the United States?
• **Proper Role of Government:** Why is what we are doing a proper high impact role of government versus something best left to the private sector to address on its own?
Main R&D Areas for Low-Cost Composites

- **Manufacturing throughput** without degrading performance
- **Energy use** for composite materials and structures fabrication
- **Recyclability** for both in-process scrap and end-of-use.
- **Enabling technologies and approaches** to support improvements to composite manufacturing.
Proposed Objectives for Composites

• **Cost:**
  – Reduction of the production cost of carbon fiber composites for targeted applications (vehicles, wind, high-pressure gas storage) by >25% in five years, on a pathway to a reduction of cost >50% over 10 years;*

• **Energy:**
  – Reduction of life cycle energy and greenhouse gas emissions by more than 50% for fiber reinforced polymer composite applications over a ten year time frame;*
  – **Reduction of the embodied energy** and associated greenhouse gas emissions of carbon fiber composites by 50% compared to today’s commercial thermoplastic technology and 75% to today’s commercial thermoset technology in five years; and

• **Recyclability:**
  – Demonstration of innovative technologies at sufficient scale for 80% recyclability of both glass and carbon fiber reinforced polymer composites in five years, and >95% in ten years into useful components with projected cost, quality and production volumes at commercial scale competitive with virgin materials.
# Application Areas and CFC Targets

<table>
<thead>
<tr>
<th>Application</th>
<th>Current CFC Cost</th>
<th>CFC Cost Reduction (2018)$^1$</th>
<th>CFC Ultimate Cost$^{a,b}$</th>
<th>CFC Tensile Strength$^c$</th>
<th>CFC Stiffness$^c$</th>
<th>Production Range/Cycle Time</th>
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<tbody>
<tr>
<td>Vehicles (Body Structures)</td>
<td>$26-33/kg</td>
<td>35%</td>
<td>&lt;$11/kg by 2025$^{63}$~60%</td>
<td>0.85GPa$^d$ (123ksi)</td>
<td>96GPa$^d$ (14Msi)</td>
<td>100,000 units/yr &lt;3min cycle time (carbon) &lt;5min cycle time (glass)$^{63,64}$</td>
</tr>
<tr>
<td>Wind (Blades)</td>
<td>$26/kg</td>
<td>&gt;25%$^{64}$</td>
<td>$17/kg ~35%$</td>
<td>1.903 GPA (276ksi)</td>
<td>134GPa$^d$ (19.4Msi)$^6$</td>
<td>10,000 units/yr (at &gt;60m length blades using carbon fiber)$^{64}$</td>
</tr>
<tr>
<td>Compressed Gas Storage (700 bar – Type IV)</td>
<td>$20-25/kg</td>
<td>30%$^{64}$</td>
<td>$10-15/kg ~50%$$^{68}$</td>
<td>2.55 Gpa (370ksi)</td>
<td>135 Gpa (20Msi)$^{69}$</td>
<td>500,000 units/yr (carbon fiber)$^{64}$</td>
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Key Questions

• Identify a **specific key technology** that has the potential to help achieve these objectives and the **target application areas** or whether the technology is cross-cutting.

• What is the **state of the art** for this technology? Notional Technology Readiness Level/Manufacturing Readiness Level (TRL/MRL) - basic research, applied, pilot scale, commercial?

• What are the **current limitations/challenges** to this technology, in particular …for use in clean energy and industrial applications? …that prevents industry from doing this on their own?
<table>
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<th>Identified Technology</th>
<th>Application Area</th>
<th>State of the Art</th>
<th>Limitations/Challenges</th>
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| ICME - Integrated Computational Materials Engineering The integration of materials information, captured in computational tools, with engineering product performance analysis and manufacturing process simulation. | Cross Cutting | Generally TRL 3-4, with selected (few) examples at TRL 7 and beyond | • Need for open demonstrations of the integrated approach  
• Democratizing tools and especially integration approaches  
• Developing open datasets, data management approaches and standards  
• Growing the small community of specialists trained in ICME techniques |
“Don’t you need to be like, making something in order to create jobs”

- Neil DeGrasse Tyson