


U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Fiber Reinforced Polymer Composite Manufacturing RFI DE-FOA-0000980

Summary of Responses

December 11, 2013

The content presented on these slides is from responses DOE received to Request for Information DE-FOA-0000980. It is presented for information only and is not meant to represent DOE's position.

Advanced Manufacturing Office

www.manufacturing.energy.gov

RFI DE-FOA-0000980 - Overview

- AMO Released a Request for Information (RFI): Fiber Reinforced Polymer Composite Manufacturing DE-FOA-0000980 on 8/26/13
- Two topic areas
  - Topic Area 1: Fiber Reinforced Polymer Composite Manufacturing
  - Topic Area 2: Fiber Reinforced Polymer (FRP) Composite Supply Chain and Markets
- Initial close date 9/26/13; extended to 10/1/13
- 37 Responses representing 59+ respondents
  - Not all respondents answered every question.

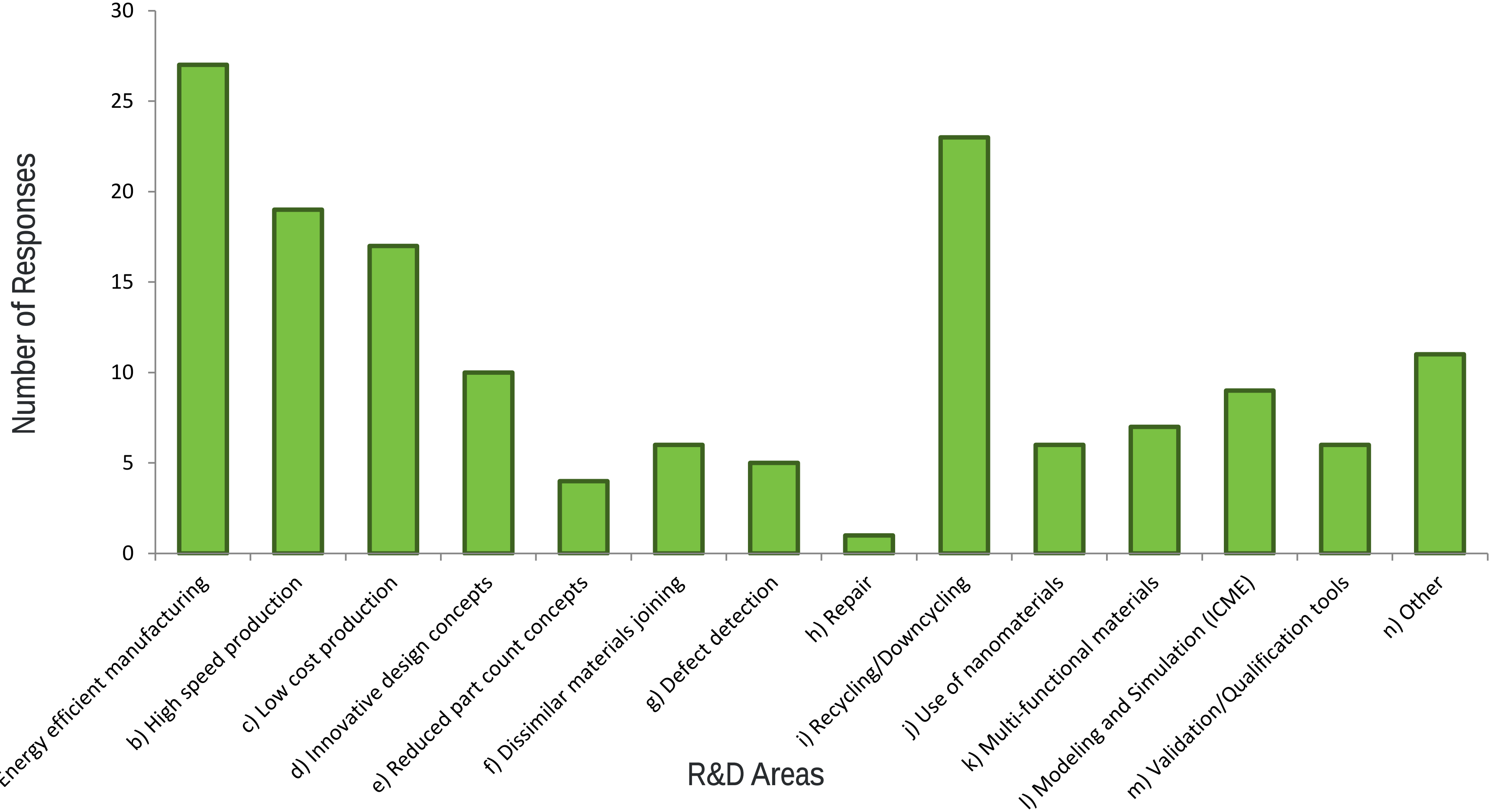
The content presented on these slides is from responses DOE received to Request for Information DE-FOA-0000980. It is presented for information only and is not meant to represent DOE's position.

Topic Area 1: Fiber Reinforced Polymer Composite Manufacturing

1. What do you think are the three most important R&D areas with technology development needs in the Technology Readiness Level/ Manufacturing Readiness Level (TRL/MRL) 4-7 for fiber reinforced polymer composites to achieve the goals of reducing life-cycle energy consumption and greenhouse gas emissions by 50% over a ten year period?
2. What do you think are the three most important R&D areas with technology development needs in the TRL/MRL 4-7 for fiber reinforced polymer composites to achieve the goal of increasing U.S. manufacturing competitiveness?
3. For the technology areas you identified as the most important in your response for questions 1 and 2, which would be more effectively addressed through a shared R&D facility capable of precompetitive and protected work? Which would be more effectively addressed through individual, independent R&D projects?
4. What do you consider the most important training and workforce development needs (skills, certifications, etc.) to increase U.S. competitiveness in fiber reinforced composite manufacturing?

Q1-1: R&D Areas for Reducing Energy Consumption and GHG

What do you think are the **three** most important R&D areas with technology development needs in the Technology Readiness Level/ Manufacturing Readiness Level (TRL/MRL) 4-7 for fiber reinforced polymer composites to achieve **the goals of reducing life-cycle energy consumption and greenhouse gas emissions (GHG) by 50% over a ten year period?**

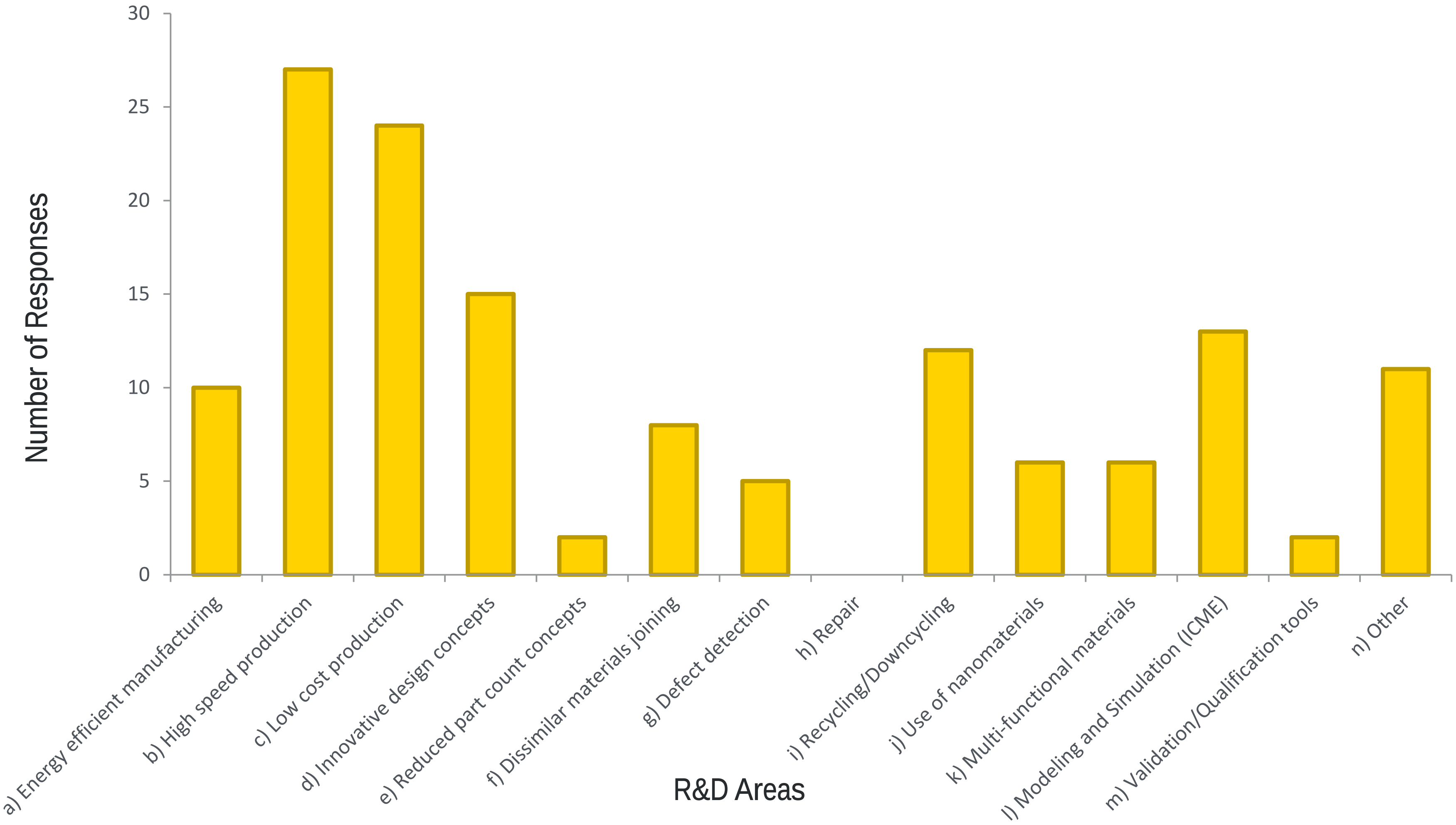


The content presented on these slides is from responses DOE received to Request for Information DE-FOA-0000980. It is presented for information only and is not meant to represent DOE's position.

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Q1-2: R&D Areas for Manufacturing Competitiveness

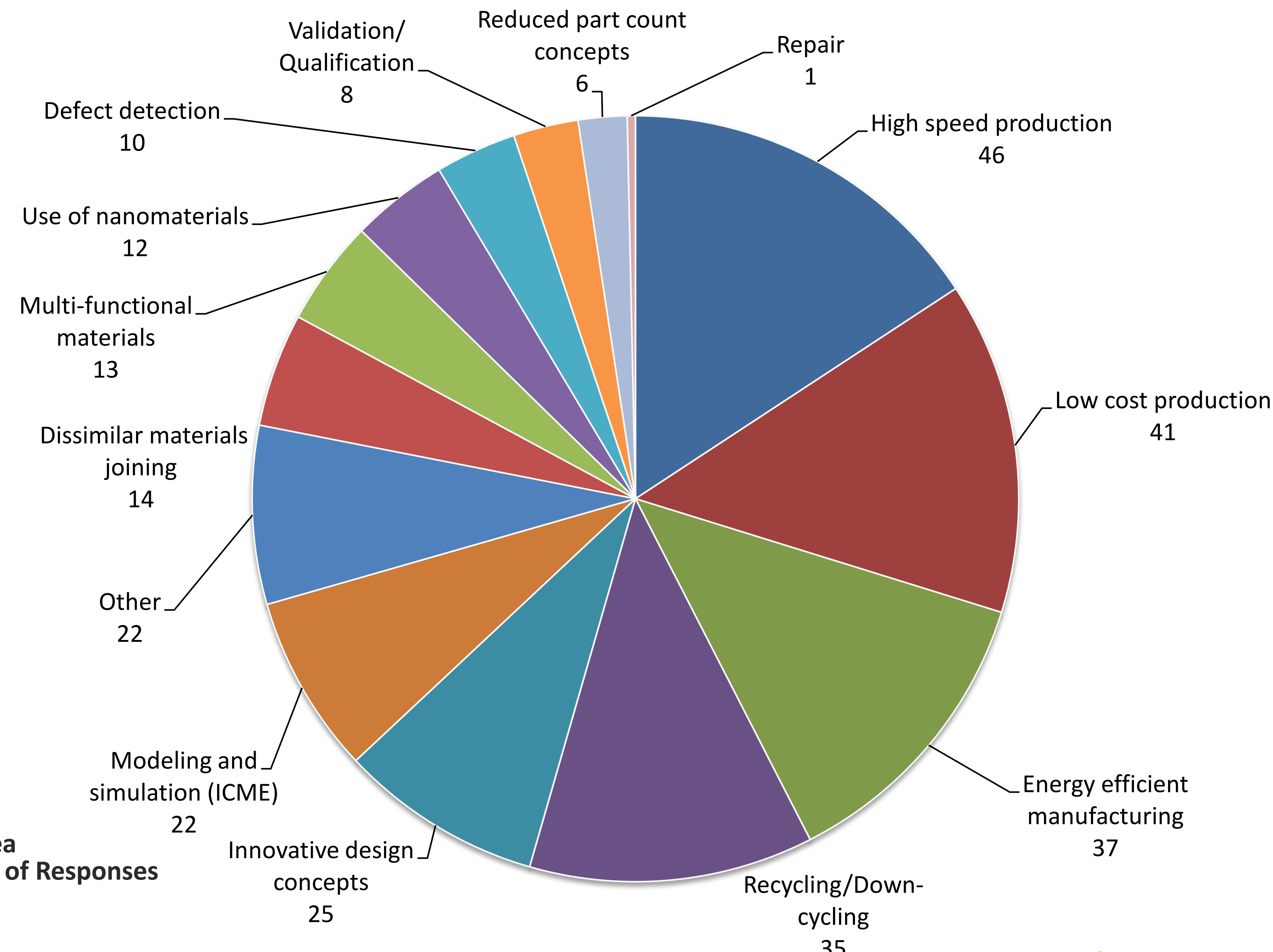
What do you think are the **three** most important R&D areas with technology development needs in the TRL/MRL 4-7 for fiber reinforced polymer composites to achieve the **goal of increasing U.S. manufacturing competitiveness**?



The content presented on these slides is from responses DOE received to Request for Information DE-FOA-0000980. It is presented for information only and is not meant to represent DOE's position.

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Most Important R&D Areas (Combined Q1-1 and Q1-2)

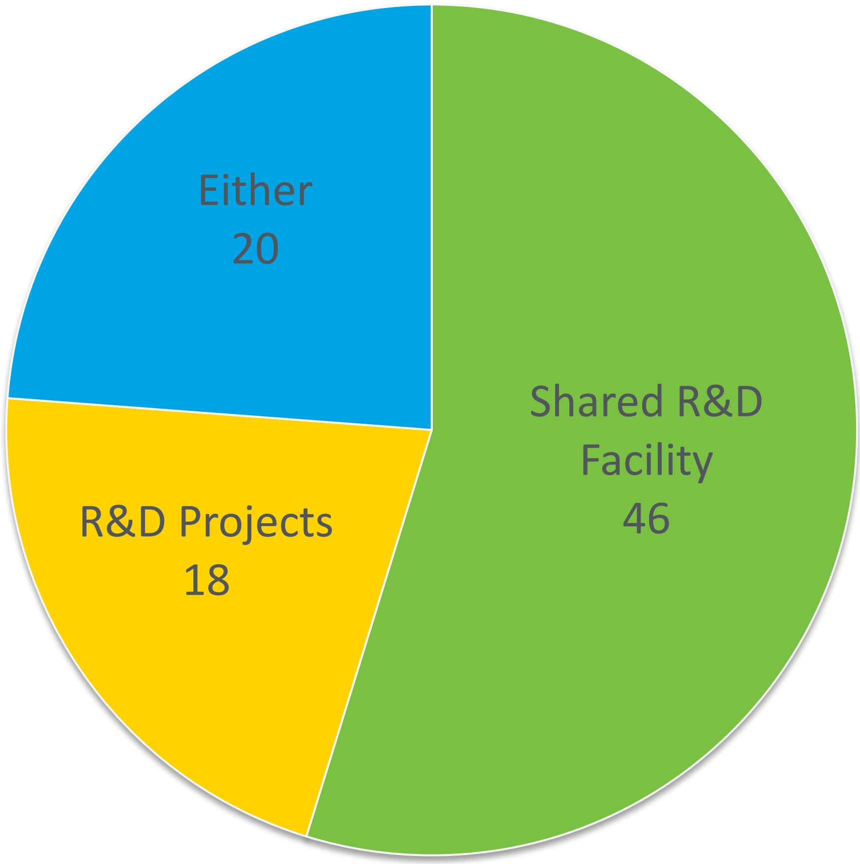


Legend:
R&D Area
Number of Responses

The content presented on these slides is from responses DOE received to Request for Information DE-FOA-0000980. It is presented for information only and is not meant to represent DOE's position.

Q1-3: Type of R&D Activity

For the technology areas you identified as the most important in your response for questions 1 and 2, which would be more effectively addressed through a shared R&D facility capable of precompetitive and protected work? Which would be more effectively addressed through individual, independent R&D projects?



Legend:
Response
Number of Responses

The content presented on these slides is from responses DOE received to Request for Information DE-FOA-0000980. It is presented for information only and is not meant to represent DOE's position.

Q1-4: Training and Workforce Development

What do you consider the most important training and workforce development needs (skills, certifications, etc.) to increase U.S. competitiveness in fiber reinforced composite manufacturing?

- Most common responses are grouped and summarized as the need for:
  - Certified manufacturing/technical workforce
    - Professional level, re-education of designers and engineers
    - Community college and trade schools for technicians for manufacturing with hands on training
  - Increased focus at universities – undergraduate and graduate levels
    - Identified knowledge areas: materials science courses in general focused on composites (rather than metals), design and simulation for composites, robotics, automation, industrial controls, textiles, interfacial and surface science, nanomaterials

- Multiple responses also indicated a more general need to supporting K-12 STEM education and engagement with students at a young age to interest them in science and technical fields

The content presented on these slides is from responses DOE received to Request for Information DE-FOA-0000980. It is presented for information only and is not meant to represent DOE's position.

Q1-4: Continued (Example Comments from Responses)

- “The combination of automation and information technology is the next wave of productivity…The acceleration of this trend in carbon fiber manufacturing will impact three workforce development trends. First is the need for more skilled technicians (with associate degrees from technical colleges) to build and maintain the IT-driven machinery. Second is the need for more engineers (with bachelor’s degrees in engineering and computer science) to design and develop these IT-driven factories. Third is the need for big data analytics experts to use high performance computing centers with advanced modeling and simulation programs to optimize IT-driven smart manufacturing (with master’s or doctoral degrees or IT entrepreneurs).”
- “#1: certification of hands-on skills, not just ‘book learning,’ including for shop personnel, technicians, and entry level professionals.”
- “The most important training and workforce development needs (skills, certifications, etc.) to increase U.S. competitiveness in fiber reinforced composite manufacturing are professional training for workers, technical training at high school level and high technology training at community college and college levels.”
- “There are comparatively fewer trained engineers and other technical experts in composites engineering versus more mature material industries. This fact reinforces the need for multilevel curriculum and certification program for future composites workforce needs as reinforced composites technology becomes more widespread.”
- “There are very few university level programs in the U.S. that educate engineers in the latest technologies in the field of composites, especially carbon fiber composites and design/simulation/CAE. Increased emphasis in this area is essential to increasing U.S. competitiveness for composites manufacturing. There is also a need for training in the areas of robotization and industrial controls, as evolving high speed processes for composites will increasingly rely on machinery to transform fibers into textiles, textiles into shaped preforms and preforms and resins into composites. These activities need to be automated to achieve high throughput and lower costs.”
- “There is an important and essential need for plastic and composite university degree programs. There are very few such programs in the country currently. In addition, currently available engineering programs tend to focus, even today, on traditional material solutions. More options need to be available and encouraged now in order to meet the needs of the future workforce. A skills gap also exists in the current workforce. Trades and skilled workers should be required to have additional certification related to advanced materials, such as plastics and composites. This would not only serve to educate the skilled workforce, but also help demonstrate how to work with advanced materials within a current operational setting.”

The content presented on these slides is from responses DOE received to Request for Information DE-FOA-0000980. It is presented for information only and is not meant to represent DOE’s position.

Topic Area 2: FRP Composites Supply Chain and Markets

1. Please identify the role of your institution or business in the supply chain: a) a material supplier (MS), b) component manufacturer (CM) includes tiered suppliers, c) original equipment manufacturer (OEM), d) end user or e) other (please identify)?
2. What composite material systems classes (i.e. continuous carbon fiber/epoxy resin) are most important to your business now? What composite material systems (i.e. discontinuous carbon fiber/thermoplastic resin) do you anticipate to be most important to your business 10 years from now?
3. What are the relevant targets for fiber reinforced polymer composites with respect to your industry for: (CM, OEM, End Users)
   - production volume (units per year)
   - process cycle time (time per unit)
   - percent cost reduction (relative to current)
   - percent weight reduction (relative to current) and
   - other important performance metrics?
4. What do you consider the three most significant obstacles you face to increase investment and/or adoption of this technology: a) high capital cost, b) high material cost, c) material supply chain insecurity, d) lack of customer demand, e) technical limitations, f) lack of knowledge, g) insufficient tools or h) other (please identify)?
5. Please describe how the value of high performance materials is reflected in the cost of the final product or value proposition for a new technology in your market.
6. What are the most significant opportunities for increased use of fiber reinforced polymer composites in industrial equipment (heat exchangers, membranes, piping, etc.)?

The content presented on these slides is from responses DOE received to Request for Information DE-FOA-0000980. It is presented for information only and is not meant to represent DOE's position.

Q2-1: Role in the Supply Chain

Please identify the role of your institution or business in the supply chain: a) a material supplier (MS), b) component manufacturer (CM) includes tiered suppliers, c) original equipment manufacturer (OEM), d) end user or e) other (please identify)?

Role in the supply chain	Number of Responses
Material Supplier	16
Component Manufacturer	9
Original Equipment Manufacturer	2
End User	2
Other	14

"Other" identified as: Industry/Trade Association (3), University (7), Technical consulting firm (1), National laboratory (1), Major academic research institute (1), Private R&D company (1) and Non-profit consortium (1)

The content presented on these slides is from responses DOE received to Request for Information DE-FOA-0000980. It is presented for information only and is not meant to represent DOE's position.

Q2-2: Important Material Systems Now and Future

What composite material systems classes (i.e. continuous carbon fiber/epoxy resin) are most important to your business now? What composite material systems (i.e. discontinuous carbon fiber/thermoplastic resin) do you anticipate to be most important to your business 10 years from now? (MS, CM, OEM, End Users)

- Common answers to the question for the composite material systems most important to business now include: glass (weaves, tape, continuous, chopped, pellet)/thermoplastics; carbon (continuous)/thermoset (epoxy, phenolic) and carbon (prepreg, woven)/thermoplastic.
- Common answers to composite materials systems anticipated to be most important 10 years from now include: bio-based/renewable materials, carbon (continuous/chopped)/thermoplastics and epoxy/thermoset resins.
- Additional comments about future materials include characteristics like: higher temperature, faster cure, multi-material systems/hybrids, and novel fibers.

Q2-3: Relevant Targets

- What are the relevant targets for fiber reinforced polymer composites with respect to your industry for: (CM, OEM, End Users)
  - production volume (units per year)
  - process cycle time (time per unit)
  - percent cost reduction (relative to current)
  - percent weight reduction (relative to current) and
  - other important performance metrics?

- Responses are grouped by associated market segment in the charts that follow.
- One response for Aerospace –provided only data on cost listed here:
  - Aerospace - cost equivalence to aluminum components for secondary structural components and >25% cost reduction relative to today's composite components

Q2-3: Automotive

Production Volume (units per year)	Process cycle time	% cost reduction (relative to current)	% weight reduction	Other important Properties
minimum 50,000 parts/year to be consider for use, more likely even100,000 – 300,000 parts per year per model would be required before converting to composites.	1-2 minute per unit, more likely less 1 minute	cost neutral would be sufficient for the conversion to a composite part given a reduction in weight	50-75%	Mechanically suitable performance and relevant application making use of a composite system's advantages, such as lighter weight or corrosion resistance.
15,000 to 75,000 per annum	5 minutes to 30 minutes, depending on volumes	greater than 50%	10% weight reduction compared to current carbon fiber parts, over 60% reduction versus steel and 40% versus aluminum	Class A surface finish straight from the mold without labor intensive rework
>250,000	<1 Min/part	$3-10/lb maximum value of weight savings. Cost of Carbon fiber $5-7/lb	>50 reduction relative to steel	
>100,000 units/line/yr	< 2 min/unit	>60% relative to current niche vehicle production	>40% vs steel	$2-3 cost premium/lb weight saved for mass market
100,000 or more parts per year	5 minutes or less	10-15%	30-40%	

The content presented on these slides is from responses DOE received to Request for Information DE-FOA-0000980. It is presented for information only and is not meant to represent DOE's position.

Q2-3: Other Markets

Market	Production Volume (units per year)	Process cycle time (time per unit)	% cost reduction (relative to current)	% weight reduction	Other important Properties
Wind	>10K blades/yr at >60m length	<2 days/blade	>25% cost reduction		
Compressed Gas Storage Tanks	10 to 50 times our current production capabilities	1/10 to 1/40 of the time per current production capabilities	6% reduction in material cost; 30% reduction in total product cost	2%	Increased safety of high pressure composite storage vessels; Increased composite toughness; Increased ability to vent and relieve internal pressure during a fire situation; Increase the use of recyclable materials; Increased pressure vessel storage capacity; Eliminate and reduce the use of solvents and toxic materials
Oil and Gas	10K tonnes/yr	1m/min	>25% cost reduction		
Nanocellulose fibers	10 million tons per year	10 tons per hour	30 % cost reduction	50%	Life-cycle assessments – lower GHG emissions, made from sustainable renewable resource
Unspecified	Continuous fiber/resin tape volumes: 21,600,000 sq. ft. (2016); Laminated tape product volumes: 19,300,000 sq. ft. (2016)	Continuous fiber/resin tape: 4.3 seconds/sq. ft. (2016); Laminated tape products: .5 seconds/sq. ft. (2016)	Continuous fiber/resin tape: 33% (2016); Laminated tape products: 28% (2016)	Continuous fiber/resin tape: 15% (2016); Laminated tape products: 10% (2016)	Renewable source raw material conversion: 30% of annual volume (2020); Recycling/Downcycling/Recovery: 15% of annual volume (2018)

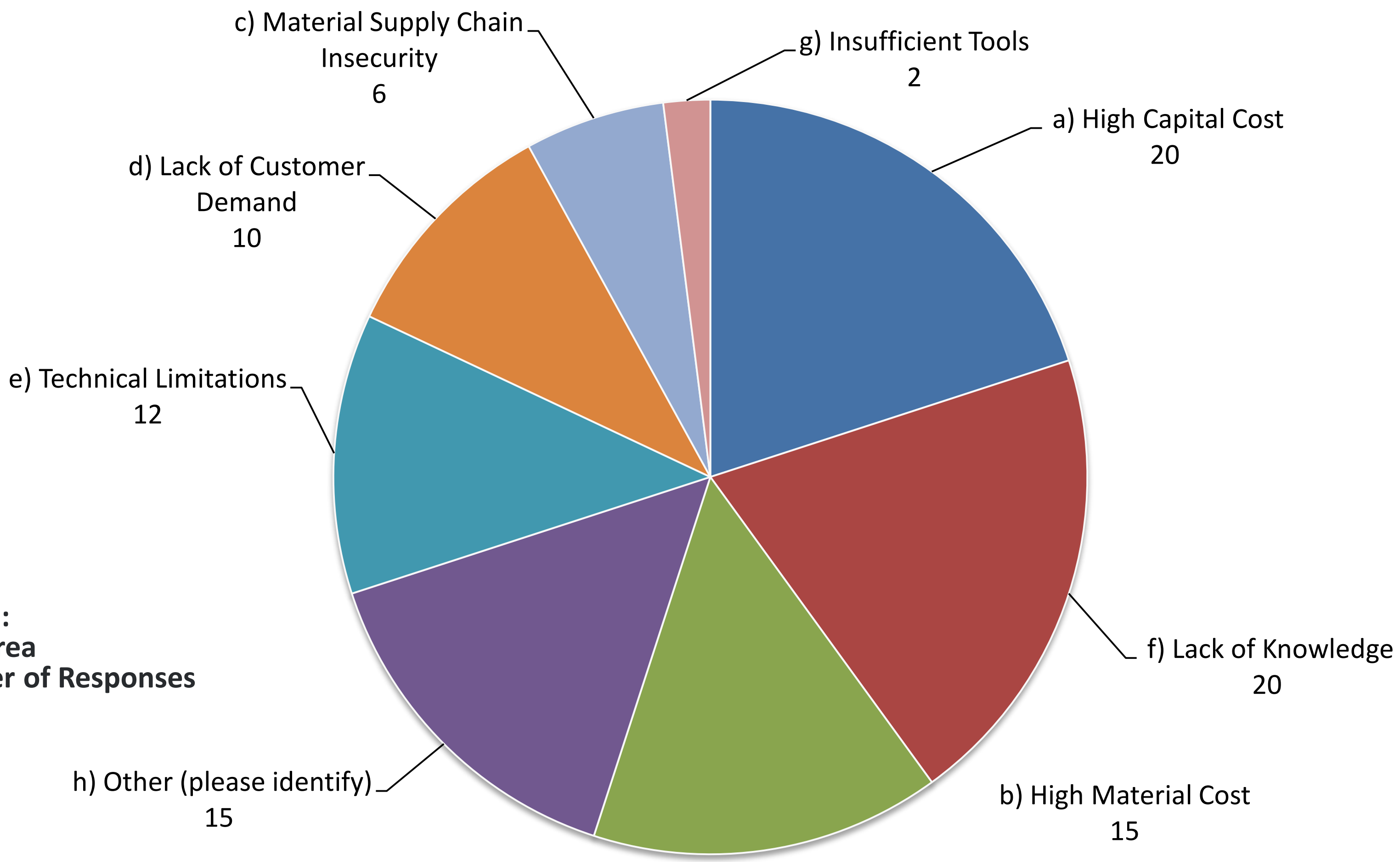
The content presented on these slides is from responses DOE received to Request for Information DE-FOA-0000980. It is presented for information only and is not meant to represent DOE's position.

Q2-3: Fiberglass Specific Responses

Production Volume (units per year)	Process cycle time (time per unit)	% cost reduction (relative to current)	% weight reduction	Other important Properties
Increase Sales; there is enough manufacturing capacity	Increase line speed by 20 %	3% per year	Not considered	Grow Sales 10% per year
N/A	N/A	5%	10%	N/A
750 million pounds of pultruded profiles	Totally varies based on part thickness	20%	10-15%	Scrap reduction of 10-15%
5000/yr	120hrs	15%	N/A	

Q2-4) Significant Obstacles

What do you consider the **three** most significant obstacles you face to increase investment and/or adoption of this technology: a) high capital cost, b) high material cost, c) material supply chain insecurity, d) lack of customer demand, e) technical limitations, f) lack of knowledge, g) insufficient tools or h) other (please identify)?



Legend:
R&D Area
Number of Responses

The content presented on these slides is from responses DOE received to Request for Information DE-FOA-0000980. It is presented for information only and is not meant to represent DOE's position.

Q2-5: Value Proposition

Please describe how the value of high performance materials is reflected in the cost of the final product or value proposition for a new technology in your market.

Comments from respondents are summarized below:

- Lightweighting
- Performance – Strength
- Cost/Performance basis
- Support meeting Government regulations i.e. CAFÉ standards
- If it can't be done, a composite may be able to do it.
- Quality must continue to rise to draw in new customers to the advantages of composite materials.

The content presented on these slides is from responses DOE received to Request for Information DE-FOA-0000980. It is presented for information only and is not meant to represent DOE's position.

Q2-6: Industrial Equipment Opportunities

What are the most significant opportunities for increased use of fiber reinforced polymer composites in industrial equipment (heat exchangers, membranes, piping, etc.)?

- The FRPs such as glass/vinyl ester and glass/polyesters, SMCs, BMCs have high potential in piping as FRP for corrosion protection.
- Growth in corrosion applications in the chemical and power generation industries, fire resistant opportunities, and thermal break profiles to replace steel.
- Opportunities in chemical tanks and pipes will emerge as higher temperature resistant and more corrosion resistant composites are developed
- Modifying the infrastructure within the facilities would represent the best opportunities. Increasing the lifetime and durability of piping and enhancing its chemical resistance
- High pressure piping and structural load bearing components would be the top targeted areas replacing conventional monolithic materials.
- Deep sea risers, Pump impellers, Spoolable pipe & deep sea umbilicals, Gas Cylinders, Hydraulic pump components, Platform structural parts
- Cryogenic vessels and nano-tube reinforced "pre-pregs“
- Composite pressure vessels are the key enabling technology to alternate transportation fuels, reduced carbon gas emissions, and lowering the environmental impact of transportation
- Automotive, aviation, tractor trailers, ship structures
- Housing/construction also mentioned by several respondents
- New features offered by new products, materials and processes such as higher temperature/corrosion resistant composites. Predictability of composites will also increase use.
- Anywhere where corrosion resistance, high strength/stiffness to weight, and design flexibility is required. If durability of FRP materials was more known, I think the materials would be seen in several industrial equipment applications.