Responses for Public Release

This document contains the responses provided for public release by respondents to Category 2 of the U.S. Department of Energy Office of Energy Efficiency and Renewable Energy Request for Information (RFI) on Fiber Reinforced Polymer Composite Manufacturing – Part 2, DE-FOA-0001056.

CATEGORY 2: Public information for the composite manufacturing community.

In response to this category, please provide a half page marked as "for public release" summarizing your comments on this topic for the broader community and include contact information that you approve to be publically released. AMO intends to publish the responses to this category following the close of this RFI to better facilitate engagement throughout the composite manufacturing community.

The responses are provided in the table below – starting on page 2.

Organization, Point of Contact and Contact Information	Category 2 Response for Public Release
Arkema Inc. Robert Barsotti robert.barsotti@arkema.com 610.878.6028 King of Prussia, PA USA	In order to realize the proposed objectives, Arkema Inc. believes that a strong focus on all steps of composite fabrication and end of life must be considered together, including raw materials (both fiber and polymer matrix, including additives, initiators, pre-polymers, etc), design considerations, fabrication equipment, and process paths to reuse/recycle. As such, we look forward to collaborative teaming opportunities. Among several relevant technology areas at Arkema, a particular rich area for collaboration could be Arkema's Altuglas Composite Resin Solution technology. This material is a liquid acrylic thermoplastic resin that can be processed using traditional thermoset equipment/tools. Typical viscosities are between 100-500 cPS (Brookfield, 25C). The material uses a peroxide based initiator and results in a high molecular weight, acrylic thermoplastic polymer. The resin is styrene free and has the advantages of being recyclable, weldable, thermoformable, and repairable. As a result, multiple finishes are accessible, and the material can be processed using RTM, light RTM, VARTM and infusion at mold temperatures ranging from room temperature to 80C. The resin system produces parts with physical properties similar to or higher than UPR composites. Both aesthetic (10-15 GPa) and mechanical structural parts reinforced with glass fibers (20 to 45 GPa) are achievable.
E. I. du Pont de Nemours and Company Janet Sawgle Janet.M.Sawgle@dupont.com 248-684-8824 Troy, MI USA	In order to achieve a step change in the ability of industries like high volume automotive to reduce weight within the mandated time frames, it is essential that a multi-material approach be taken. A broad view of material solutions is essential to meet the vast array of part requirements. DuPont believes that glass reinforced thermoplastic composites will be a key enabling materials solution that will play a critical role in the adoption of composites on a large scale. Glass reinforced thermoplastic composites are already a cost effective route to significant weight reduction (30-50%). As with all materials, part selection is critical and one of the primary reasons to have a portfolio of solutions from which to choose. As mentioned in our response to this RFI, it is our opinion that an expanded scope of material solutions should be considered when future focus areas are selected for polymer composite funding. DuPont believes that common know-how we have acquired from the development of a commercial glass fiber material can be leveraged to support the development of carbon fiber materials. Furthermore, enabling technologies, such as advanced modeling and simulation to failure, effective techniques for joining dissimilar materials, and defect detection are needed to support this multi-material development approach.

Fibrtec Inc. Robert Davies Bob@Fibrtec.com 903-306-1069Atlanta, TX USA	Fibrtec Inc. is extremely pleased to see the Department of Energy addressing the critical need to take composite materials beyond high priced, high performance, low volume applications primarily revolving around aerospace. The requests for information that the DOE has issued express the desire to bridge the gap that presently exists between low cost, low volume composites and those seen of aircraft such as the F-35 and the Boeing 787. The first RFI identified key R&D areas that have to be addressed: high speed production, low cost production, energy efficient manufacturing, recycling/downcycling technologies, and innovative design concepts. All of these clearly have merit. Fibrtec has focused its composite materials work on thermoplastic matrix composites since they hold a great advantage over thermosets when it comes to meeting the goals of low cost, high volume, energy efficient manufacturing and recyclability. Fibrtec has identified the major shortcoming of the approaches that have been taken in the US as well as in Europe in thermoplastics, as the lack of a flexible feedstock, specifically a flexible thermoplastic prepreg. As a result of years of effort, Fibrtec has developed a flexible thermoplastic prepreg material, trade named FibrFlex™. It has been shown that this uniquely flexible material form, FibrFlex™, can be combined or input to off-the-shelf tailored fiber placement technology and result in the production of high quality, low cost performs, called Fibrprint™. Through alliances with resin, fiber, and tooling suppliers, Fibrtec has been able to establish an entire innovative development environment for thermoplastic matrix composites. Specifically, Fibrtec has linked innovative composite performing and rapid consolidation technologies with design processes that lead to the highly efficient composite manufacturing of complex, repeatable composite components. This approach establishes an open source, game changing, manufacturing framework that is critical to low cost, energy efficient, high volume, recyclable composite component manufacturing.
GE Power & Water Stephen Johnson stephen.b.johnson@ge.com 864-254-2164 Greenville, SC 29615	As a leading OEM of wind turbines, GE Power and Water has reviewed DOE's RFI and concluded that it reasonably represents the current landscape, challenges, and opportunities for glass fiber composites and carbon fiber composites in wind turbine blades. We welcome the initiative of the US Department of Energy in this area and agree with the RFI's statement that "innovative manufacturing techniques could further strengthen U.S. competitiveness in this market segment."

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North Carolina A&T State University Kunigal Shivakumar kunigal@ncat.edu 336-285-3203 Greensboro, NC USA	North Carolina A&T State University (A&T) is a leader in polymer reinforced composite materials through the activities in the Center for Composite Materials Research (CCMR). The center has proven record of excellence in processing and fabricating, microstructural characterization, testing and modeling of fiber reinforced polymer composite materials and structures. The faculty and staff of CCMR have a combined experience of over 100 years in the above areas. The center has well equipped laboratories and facilities to train and educate B.S. to Ph.D. students as well as offering short courses. Technician trainings are offered through collaborations with community colleges. The Department of Energy's proposed objectives of low cost and mass production, with least life cycle energy consumption and recyclability of fiber reinforced polymer composite products for clean energy applications is timely and necessary to support the domestic manufacturing competitiveness in key industries. While doing this, timely preparation of domestic workforce is also equally important. In this direction the center extends its support to DOE in development of technology and preparation of workforce for mass production of fiber reinforced polymer composite products for clean energy applications.
Plastics Research Corporation Robert Black robert.black@prccal.com 909-391-2006 Ontario, CA USA	Technology & Manufacturing Summary: At Plastics Research Corporation (PRC) we design and manufacture Fiber Reinforced Plastic (FRP) products for commercial and military applications. The Company occupies a 100,000 square foot facility situated on approximately eight acres of land with over 10,000 square feet of lamination/grinding booths plus 10,000 square feet for compression molding operations and now specializes in high volume, low cost compression molded products. Summary: Plastics Research Corporation is uniquely qualified for internal and externally funded R&D because we are a firm with MS, CM and OEM capability. In addition, we have 40 years of experience in fiber reinforced thermoset resin-based lamination by most production methods. We understand the economics of fiber reinforced materials and production methods because that is our business.
Quickstep Composites LLC DaleBrosius dbrosius@quickstepcomposites.com 586-530-3372 Dayton, OH USA	The topic of how to proliferate the use of fiber reinforced polymer composites beyond aerospace is both complex, as well as diverse in how it should be addressed. The DOE Advanced Manufacturing Office has done an admirable job in capturing the input from the first RFI and condensing it into a starting point for further discussion and action. Recognition that future vehicles will be multi-material solutions (i.e., metal/composite jointed structures), and that hybrids of glass and carbon can provide cost effective solutions to composite structural panels need to be more emphasized. Production rates for both glass fiber and carbon fiber composites need to be below 3 minutes for vehicle rates approaching 100,000 units. The proliferation of polymer composites in automotive/heavy truck and wind energy needs to be addressed from multiple perspectives – materials cost, design/simulation, manufacturing speed/cost, and end-of life treatment – all need to be considered and attacked simultaneously. This may be done via consortia or other private partnerships, but in all cases can be accelerated via cost-sharing or other funding mechanisms administered by DOE.

Rocky Mountain Institute (RMI) Greg Rucks grucks@rmi.org 970-927-7312 Snowmass, CO 81654	Manufacturing speed is less of a barrier than it seems. The reason only low production runs exist today is less due to insufficient manufacturing technology than to market dynamics. Carbon fiber composite parts are expensive due primarily to high material costs. Only niche (i.e. low-volume) customer segments are willing to pay the price premium for carbon fiber composite, so the part-producing supply chain provides manufacturing technology only sufficient to meet those volumes. Several Tier 1 producers are today tech ready to move to at least 50,000 units per year if there is a business case to do so. The key to that business case is to pursue those part applications with a high enough value-add to offset material costs for the mainstream market and to harmonize the supply chain around the material systems and manufacturing processes—already available today—to produce those parts.
Sandia National Laboratories Brian Naughton bnaught@sandia.gov 505-844-4033 Albuquerque, NM USA	Utility-scale wind turbine blades have continued to get longer as the industry attempts to capture more wind energy per turbine. With increased length comes increased cost in the materials, manufacturing, transportation and maintenance of wind turbine blades which pose a continual challenge for the industry. Sandia National Laboratories partners with companies, universities and other organizations to conduct research addressing the technical and economic issues facing the wind industry in blade material design and manufacturing through multi-scale material testing, modeling, and full-blade design and field-testing. Sandia along with its partners has conducted a variety of projects related to composite materials for wind turbine blades over the years. Among these projects is the public Composite Materials Database representing over 12,000 composite specimen test results and produced annually since 1988 in partnership with Montana State University. Another current project, the Blade Reliability Collaborative, has brought together a broad range of industry, lab, and university partners to identify key reliability problems and potential solutions in the design, manufacture, and operation of composite wind turbine blades. The objective of these efforts is to provide data, tools and independent validation of technology solutions to increase the quality, reliability, and cost-effectiveness of next-generation composite blade designs.

Stanford University Fu-Kuo Chang fkchang@stanford.edu 650-723-3466 Stanford, CA USA	Composite materials are desirable because of their relative lighter weight, high strength and stiffness when compared to legacy metal materials. Their use could lead to more energy-efficient manufacturing and products, as well as overall more efficient and lightweight structures. However, the hurdles to regular use of composite materials in industry are not yet met. Production of composite components needs to be at high quality and speed, but low cost in order to be cost-efficient for use by industry. In addition, manufacturing techniques need to be energy efficient and enable recycling of materials to reduce waste. The manufacture of composite parts must be reliable and repeatable, with the resultant components defect-free, manufactured as designed (i.e. material properties as expected), and repairable. In order to overcome these obstacles, manufacturing should include monitoring of materials during and after cure, in order to ensure integrity of components. Multifunctional composite materials along with corresponding enabling technologies are capable of providing a way to efficiently manufacture, monitor, and maintain composite structures throughout their life cycle. By utilizing an embedded sensor network during and after cure, the continuous state of a component can be monitored. Appropriate modeling, signal processing, and diagnostic and prognostic techniques can be used to determine the current state of a structure and predict future behaviors. The Structures and Composites Laboratory at Stanford University is leading research related to innovative and robust manufacturing techniques to fabricate low-cost, but high performance composites with self life-cycle health management capabilities. This research includes development of sensor systems that can be embedded in a composite material during layup and associated techniques to use these sensors to monitor curing of the material, determine properties of the resulting component, and monitor structural integrity throughout the service life of the system. The resulting systems may enable high-energy efficiency manufacturing, improved structural capabilities, and reduced maintenance down time.

University of Denver Dr. M. Kumosa mkumosa@du.edu 303-871-3807 Denver, CO USA	To expand and accelerate the ongoing HV conductor research and other projects related to the applications of polymer matrix composites on transmission lines and not covered by the appendix of the RFI, the University of Denver in collaboration with the University of Illinois Urbana-Champaign and the Michigan Technological University have proposed to the National Science Foundation to establish an Industry University Cooperative Research Center (I/UCRC) named "Collaborative Research: I/UCRC for Novel High Voltage/Temperature (HV/T) Materials and Structures." The Center is in the final stages of negotiations. The final decision will be made by NSF by the middle of January. Based on the ongoing discussions with NSF, we expect the Center to be awarded. The proposed projects for this brand new Center include: 1. Nanotechnology for Novel HV/T Materials and Structures 2. HTLS Polymer Core Composite Conductors 3. Life Prediction of Polymer Based HV/T Structures and Materials 4. General Electro-Thermo-Mechanical Multiscale Modeling of HV/T Materials and Structures 5. Development of New HV/T Metallic Materials and Structures for a Variety of Space, Aerospace, HV Transmission and Other Applications 6. In - Service Monitoring of HV/T Structures