Carbon Fiber Technology Facility

Dave Warren, PI

Lee McGetrick
Director, Carbon Fiber Technology Facility
Oak Ridge National Laboratory

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OAK RIDGE NATIONAL LABORATORY
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Carbon Fiber Technology Facility (CFTF) Transition to Operations in 2014

Timeline

- Capital project completed March 2013 (ARRA funded)
- Operations from March 2013 to present

Barriers addressed

- Cost of carbon fiber
- Technology scaling
- Market development
- Workforce development

Budget

- $6.2M in FY 2014
  - $4M AMO
  - $1.5M VTP
  - Remainder covered by carry-over and ARRA project contingency

Partners and Collaborators

- Oak Ridge Carbon Fiber Composites Consortium
- Technical Collaboration Projects & CRADA's
  - 13 active projects underway or pending AMO approval
  - Open call for proposals at http://www.ornl.gov/user-facilities/cftf/working-with-cftf

ORNL carbon fiber research is focused mainly on low cost carbon fiber

$10 - $15/pound

Major Cost Elements
(industrial grade carbon fiber):

Precursor	~ 50%
Conversion	~ 40%
Other	~10%

Automotive targets:

- $5 - $7/lb,
- Minimum tensile 250 ksi, 25 Msi, 1% ultimate strain

Relevance

Potential automotive market alone is huge for low-cost carbon fiber

Carbon fiber potential in 2017 at 50% of current price

Global Automotive Production by Car Type in 2017	Expected Vehicle Production in 2017	Expected use of CF in Cars	Carbon Fiber Demand (M lbs) @ 0.50 X current price	Carbon Fiber Demand ($ M) @ 0.50 X current price
Super Cars	6K	100% of cars	1.3 M lbs	$7 M
Super Luxury Cars	600K	10%	101.2 M lbs	$506 M
Luxury Cars	4 Million			
Other/Regular Cars	92 Million	1%	202.4 M lbs	$1,012 M
Global Automotive Production in 2017	97 Million		305 M lbs	$1,525 M

Source: Lucintel, ACMA Composites 2012

~ 3X current global CF demand for ALL APPLICATIONS

In August of 2009 DOE EERE awarded $34.7M to ORNL to construct and start-up the Carbon Fiber Technology Facility

- Demonstrate low-cost carbon fiber (LCCF) technology scalability
- Produce quantities of LCCF for large-scale process evaluations and prototyping
- Partner with educational institutions to develop a skilled workforce

CFTF is intended to be the bridge from R&D to deployment and commercialization of low-cost carbon fiber

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Approach

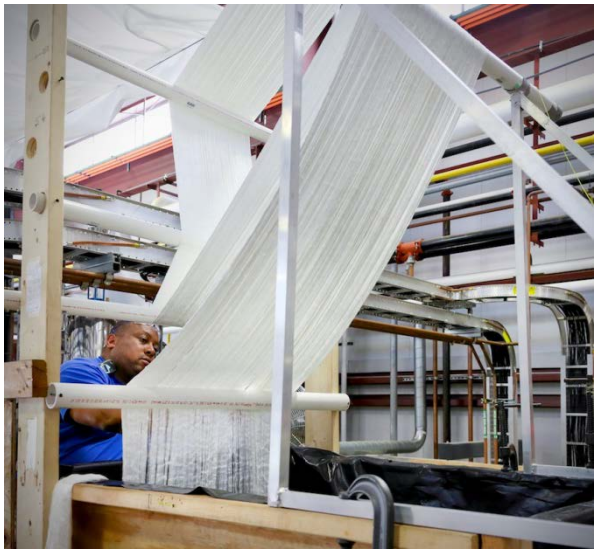
CFTF is the world's most capable open-access carbon fiber manufacturing facility

The CFTF serves as a national resource to assist industry in overcoming the barriers of carbon fiber cost, technology scaling, and product and market development

FY 2014 Milestones

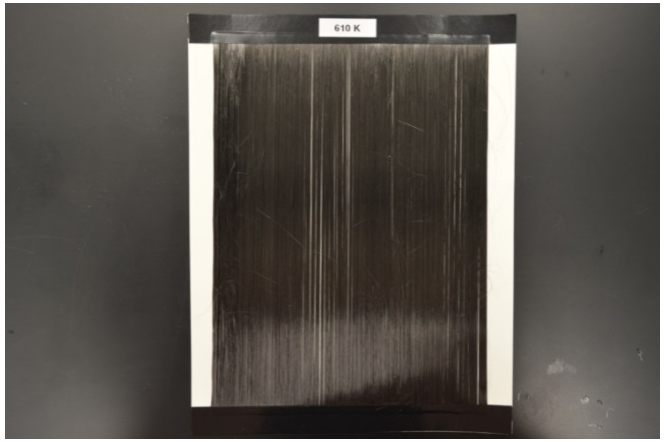
Number	Description
1	Transfer at least 51% of oxidized fibers and carbon fibers produced at the CFTF to industry partners, academia, or research institutes for use in downstream projects or applications that further DOE EERE clean energy mission and goals.
2	Environmental Compliance. Demonstrate 100% accurate and on-time reporting against reporting criteria detailed in the CFTF Title 5 Air Permit
3	Personnel safety. Maintain a strong safety culture focusing on accident and injury prevention.
4	Plant reliability. Operate with at least 80% reliability during planned production runs.
5	Implement the preventive maintenance, inspection, and testing (PM) program and demonstrate at least 95% compliance to PM schedules during each quarterly reporting period.
6	Participate in and host industry tours, workshops, and meetings in order to market the CFTF capabilities and garner support for operations funding.

Early low-cost carbon fiber production at CFTF using a textile acrylic fiber

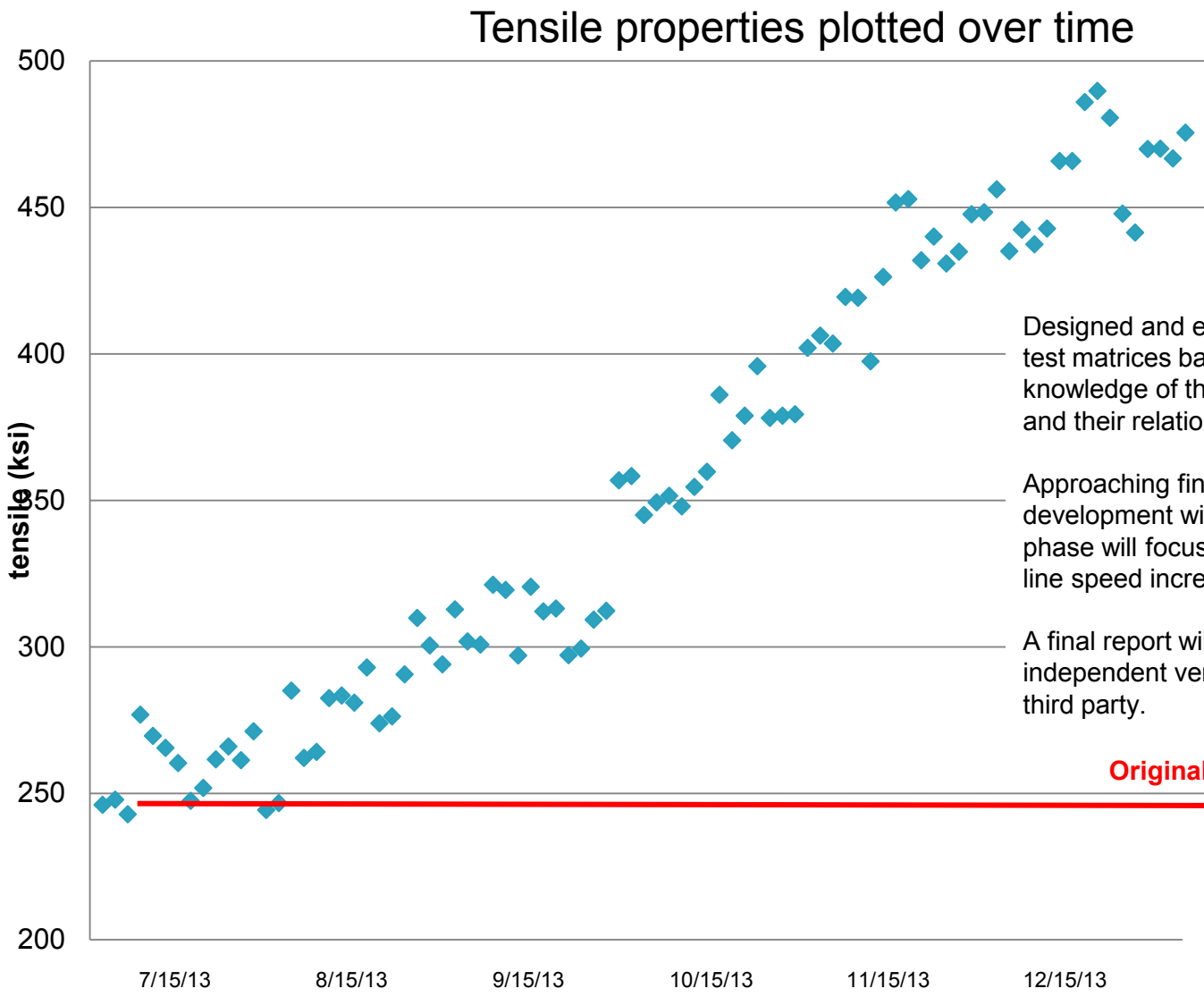


Carbon fiber is produced in a very large tow form (610K Tow)

Technical Accomplishments and Progress



Mechanical properties achieved with T-PAN have steadily improved over time



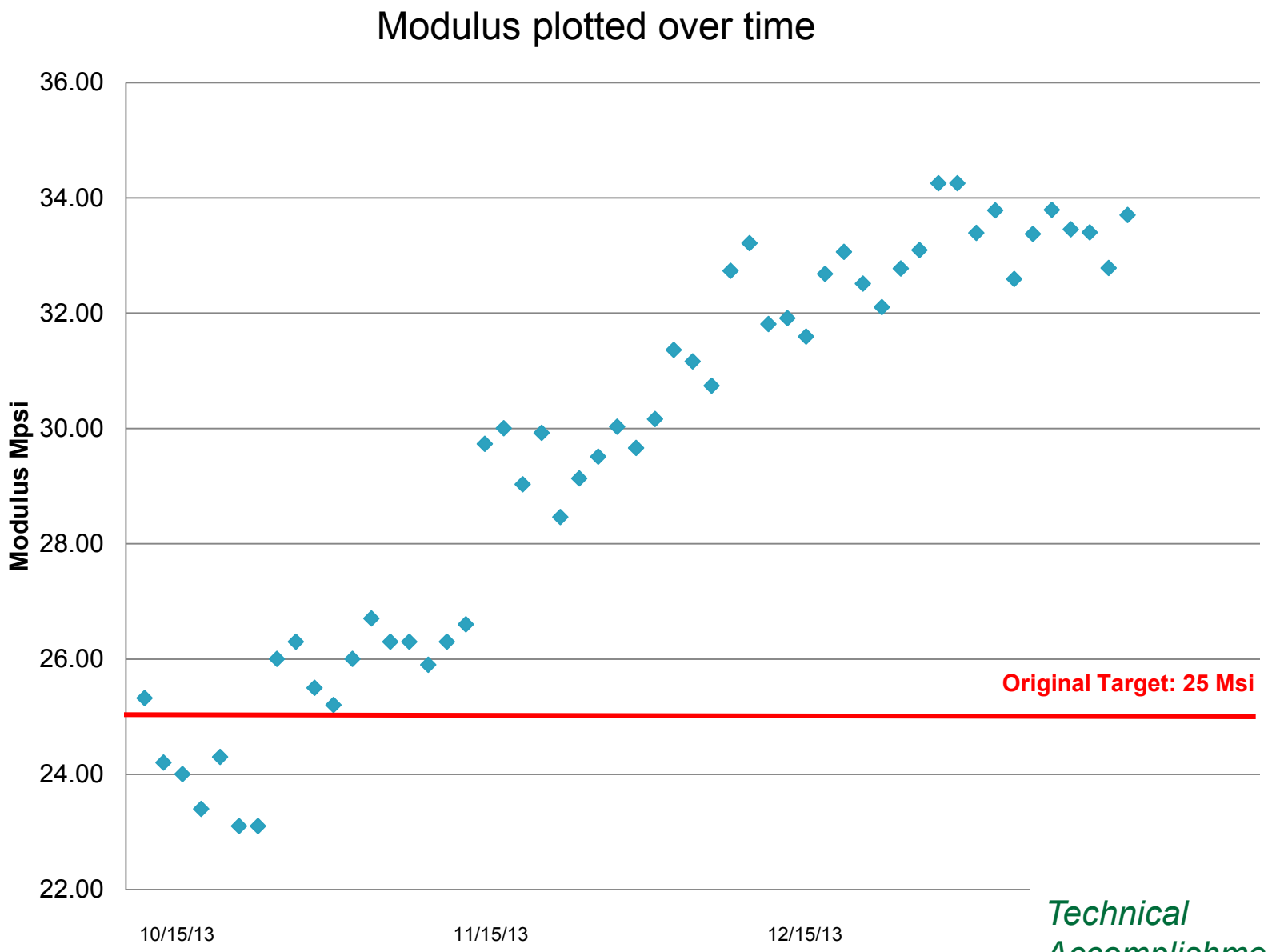
Designed and executed a series of test matrices based on technical knowledge of the process conditions and their relationship to the polymer.

Approaching final stages of development with this polymer. Next phase will focus on repeatability and line speed increases.

A final report will be issued following independent verification of results by a third party.

Technical Accomplishments and Progress

Mechanical properties - continued



Technical Accomplishments and Progress

Technical collaboration projects

Company	Industry Type	Application	Status	Material Type	Tow
Composites Application	End-User	Lightweighting of dry bulk tank	CF Shipped	Carbon Fiber	610k
United Technologies	End-User	Non-structural composites for	CF Shipped	Carbon Fiber	24k
AvCarb Material Solutions	Producer/ End-User	Carbon fabrics for automotive	Approved, ready to	Oxidized PAN	610k
Green Dynamics	End-User	Production of carbon fabrics	CF Shipped	Carbon Fiber	610k
Graftech International	Producer	Development of Continuous	In-Review	Cellulose Paper	
Cytec	Producer/ End-User			Carbon Fiber	610k
Chomarat North America	End-User	Evaluation in A-surface	Awaiting DOE	Carbon Fiber	610k
Faurecia	End-User	Low-Cost Carbon Fiber	Awaiting DOE	Carbon Fiber	610k
North Carolina State	End-User	Super-capacitors for military	CF Shipped	Carbon Fiber	610k
Goodrich Wheels & Brakes	End-User	Friction applications with OPF	Proposal pending	Oxidized PAN	610k
Epsilon	End-User	Wind blade applications	Proposal pending	Carbon Fiber	610k

- **Proposals submitted via Fed Biz Ops (search solicitation# ORNL-MDF-2013-1)**
- **Cost share by industry partners**
- **Early feedback from several projects indicate good results – final results will be published**

Response to Previous Year Reviewers' Comments

"A well-spent $35 million of taxpayer dollars."

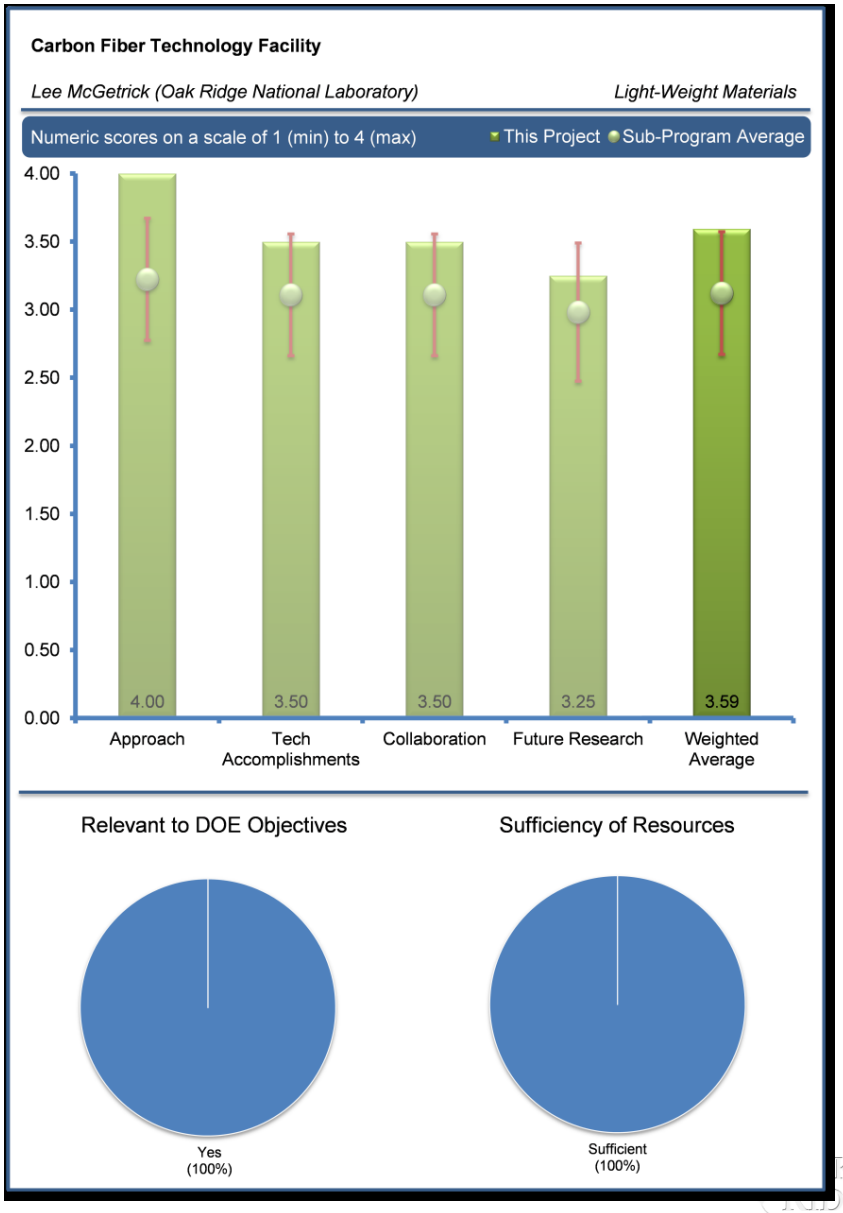
"Press on with the progress, as it is 110% relevant."

"Having a center of excellence like this can help the technical community focus on the science of LCCF, and research projects, like microwave-assisted or plasma-assisted oxidation."

"This project is a national asset and one of the best investments. ..the investigator should continue to focus on the next R&D body of work required to replicate this project, and develop the knowledge to scale this project to a full production operation."

"For composites to grow and compete against other technologies, it becomes key to educate current and future engineers on the capabilities of CF composite. ..this national asset could play a part in this type of education. This goes beyond the workforce training outlined in the presentation."

Thank you for your support. During the last year we have strived to make the best use of this national resource by reaching out to industry and establishing a number of collaboration projects. These projects, which are taking the low-cost materials produced at the CFTF and putting it into composite applications, are intended to create the industry pull needed to drive full scale commercialization of this technology. And this is only the first low-cost precursor material to be scaled – we hope to repeat this process several times over in the future.



Proposed Future Activities

Improve Efficiency, Throughput and Commercialization of Textile Acrylic Fiber:

- Band splicing with very large tow
- Fiber layering through furnaces to reduce nitrogen and energy consumption per pound of fiber
- Large tow splitting with precise yields
- In-situ measurements for process control (e.g., fiber color, density, modulus, sheen)

Expand industry partnerships through Work for Others projects for scale-up of alternative low-cost precursors

Expand industry partnerships in Work for Others projects for scale-up of alternative manufacturing technologies:

- Plasma surface treatment
- Cellulosic fiber compounding through vented extruders

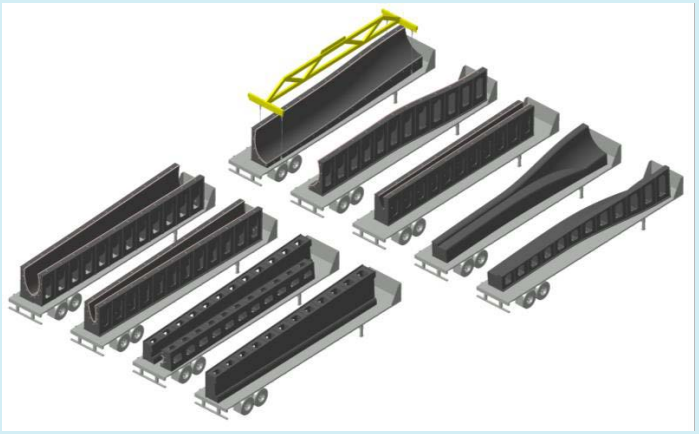
Summary

- The Carbon Fiber Technology Facility is relevant in proving the scale-up of low-cost carbon fiber precursor materials and advanced manufacturing technologies
- Significant accomplishments during FY-2014:
  - Demonstrated a full year of operations with zero accidents or environmental non-compliances
  - Deployed several systems that will serve on-going operations very well
    - Training and qualification (tablet-based)
    - Preventive Maintenance, Testing, and Calibration system
    - Automated Inventory Tracking System
- Excellent results over time in the development of conversion recipes to optimize properties of carbon fiber produced from textile-grade acrylic fiber
- Established several technical collaboration projects with industry designed to help create market pull for low-cost, industrial grade carbon fiber

Technical Back-up Slides

Technical collaboration project example

Green Dynamics Solution for On-site Construction of Large Wind Turbine Blades



A set of modular infusion tools made up of 12m (40ft) sections that can be shipped to a remote wind farm site on flat bed trailers.

Green Dynamics has developed a blade, tools, and a manufacturing methodology that will allow continuous blades of 60 to 100 meters or more to be produced onsite at wind farms.

Low-cost carbon fiber made at the CFTF was turned into a unidirectional fabric which was then lightly stitched to a glass mat structural spar.

Ability to produce a demonstration laminate was key goal for this first phase of the project.

Results:

- Infused vertically over 6 feet
- Infuse thicker mixed carbon/glass laminates
- Demonstrated tool seal concept