Institute for ADVANCED
Composites Manufacturing
INNOVATION

DWEA SMART Wind Consortium Subgroup
Composite Materials and Process Opportunities

IACMI Overview and Potential Project Work

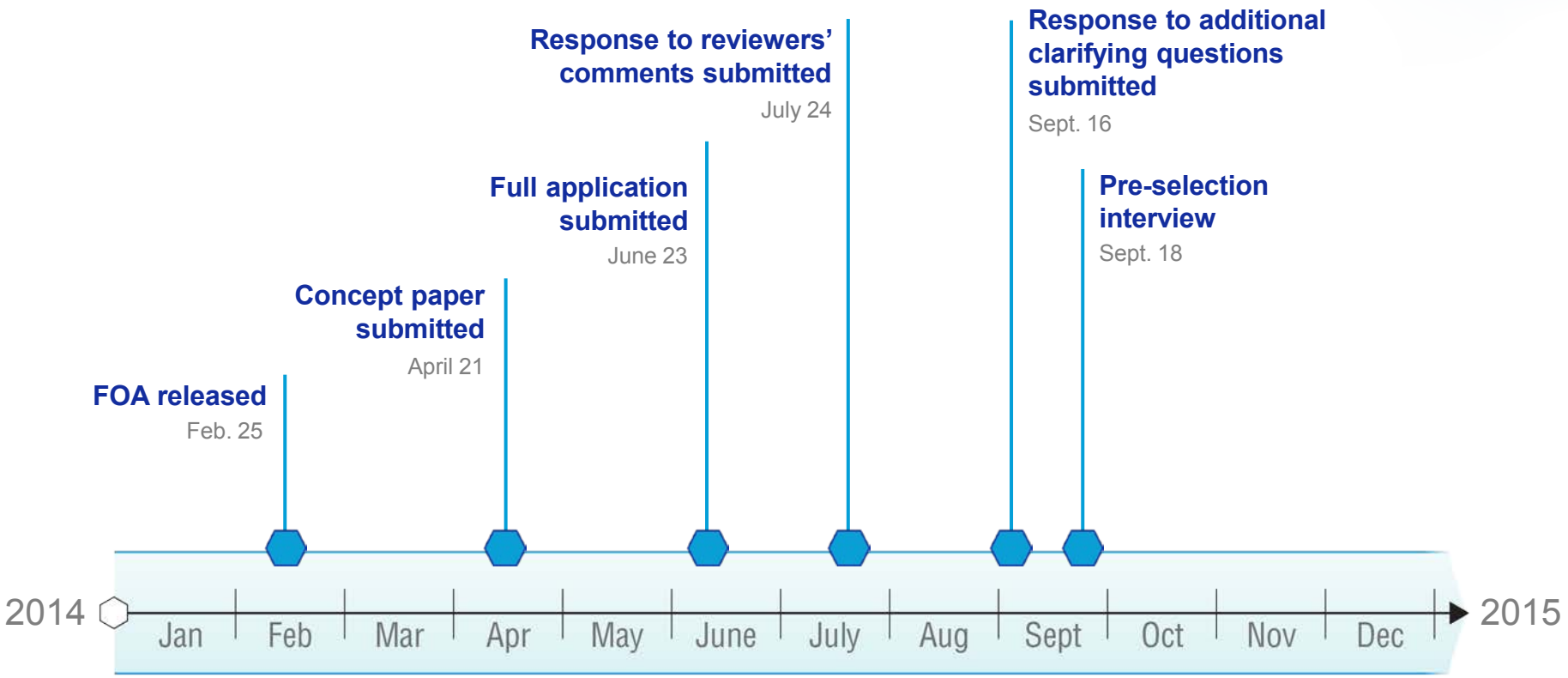
29 July, 2015

Derek Berry

IACMI Overview / Project Focus

1. IACMI history
2. IACMI structure
3. Technical project levels
4. IACMI goals and objectives
5. Wind industry challenges
6. Potential IACMI project topics

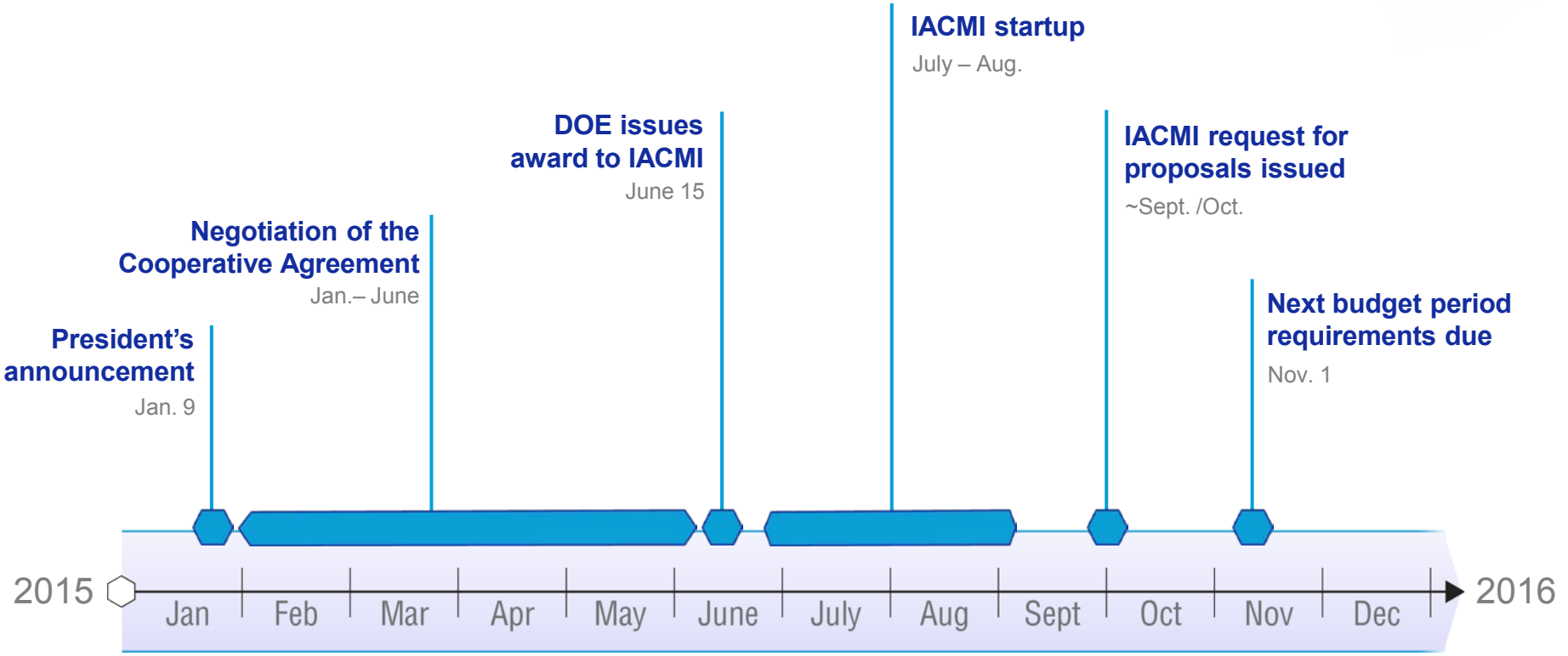
Prior to the President's Announcement



January 9, 2015: President Obama Announces New Composite Institute

"…and today, we're proud to announce our latest manufacturing hub, and it is right here in Tennessee. Led by the University of Tennessee–Knoxville, the hub will be home to 122 public and private partners who are teaming up to develop materials that are lighter and stronger than steel."

After the President's Announcement



IACMI Kick-off Meeting / Agreement Signing

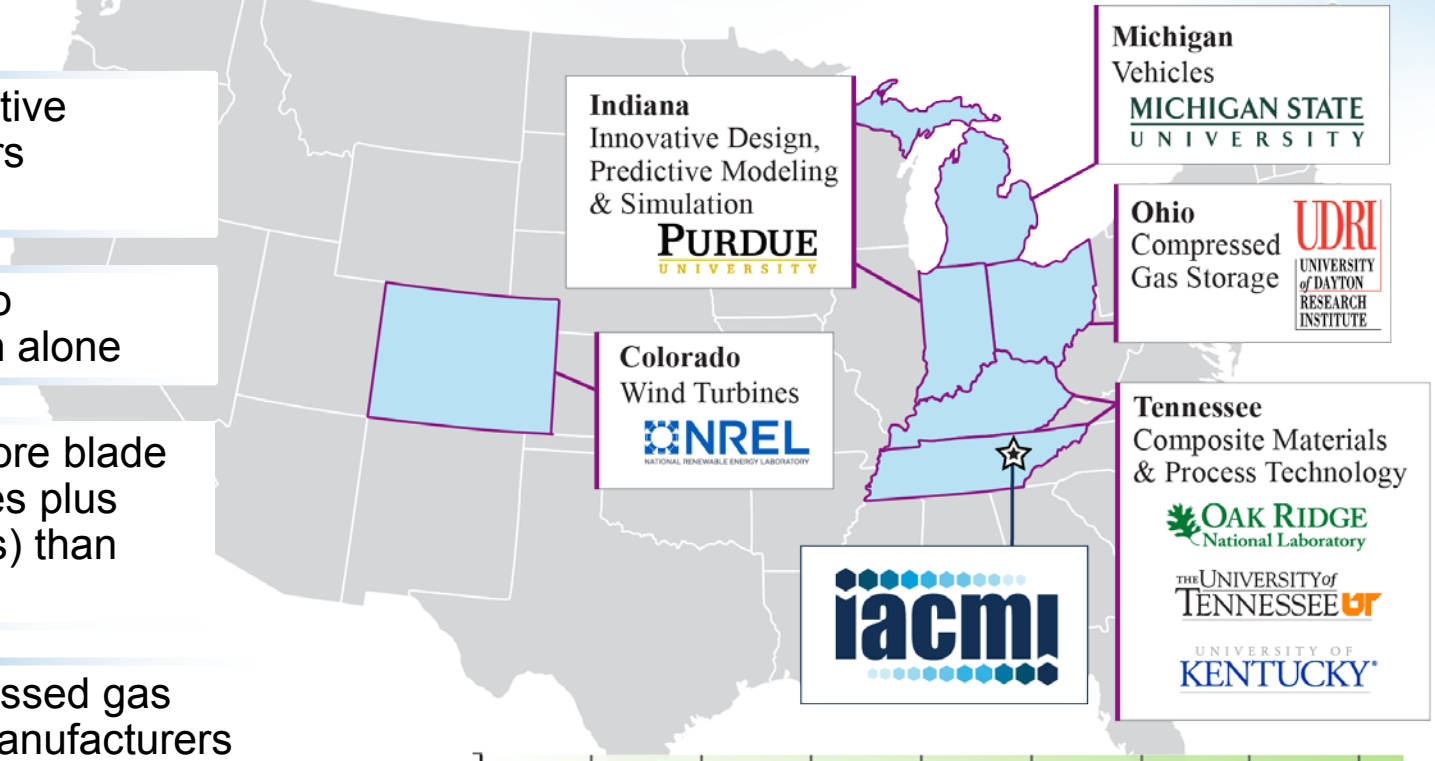
(l-r) Craig Blue, IACMI CEO; David Danielson, US Department of Energy; and David Millhorn, University of Tennessee.

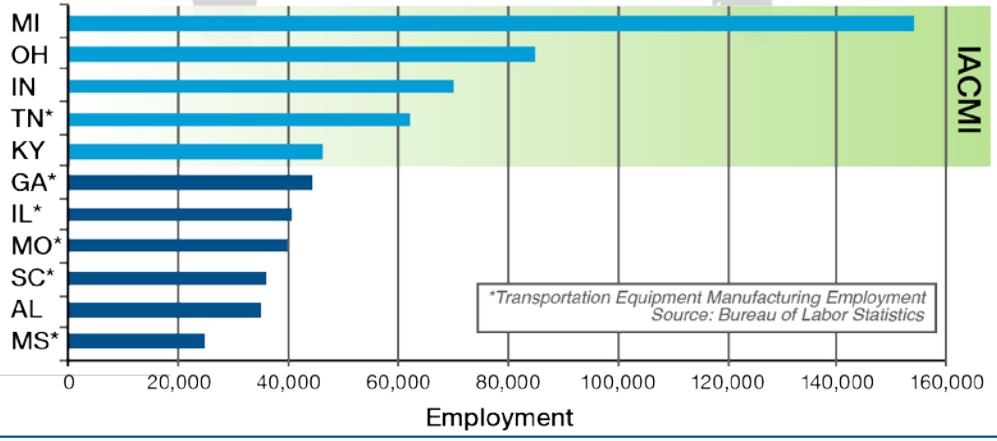
Wednesday, June 17th, 2015

Shared RD&D facilities will support industry

Core partners are capable and strategically located

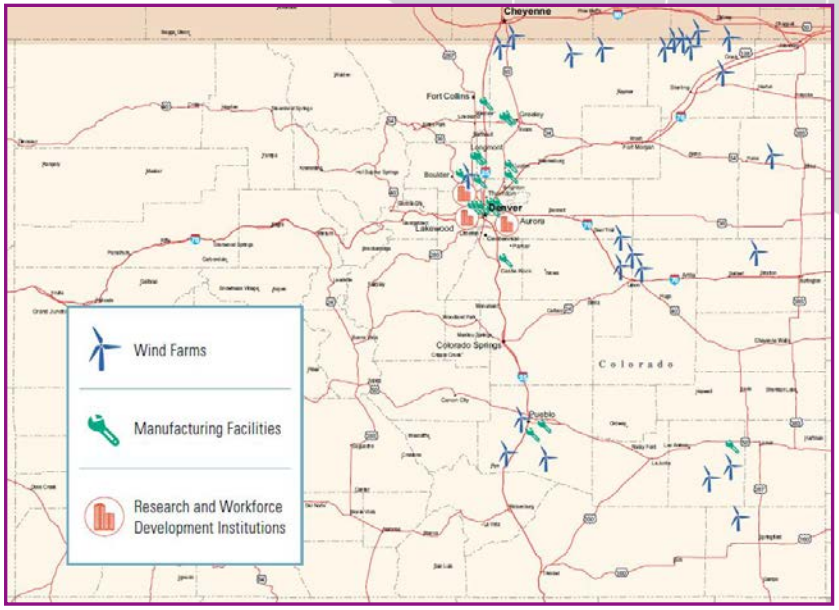
- >70% of automotive production occurs in IACMI states
- >70% of US auto R&D in Michigan alone
- Colorado has more blade facilities (factories plus technical centers) than any other state
- >60% of compressed gas fueled vehicle manufacturers with in half-day drive from IACMI Focus Areas





Core partners are capable and strategically located

Colorado has more blade facilities (factories plus technical centers) than any other state



Source: Winds of Change, E2 Environmental Entrepreneurs

Indiana
Innovative Design, Predictive Modeling & Simulation
PURDUE UNIVERSITY

Michigan
Vehicles
MICHIGAN STATE UNIVERSITY

Ohio
Compressed Gas Storage
UDRI UNIVERSITY of DAYTON RESEARCH INSTITUTE

Colorado
Wind Turbines
NREL NATIONAL RENEWABLE ENERGY LABORATORY

Tennessee
Composite Materials & Process Technology
OAK RIDGE National Laboratory
THE UNIVERSITY of TENNESSEE
UNIVERSITY OF KENTUCKY

iacmi

The State of Colorado has

- 22 wind industry manufacturing plants
- 29 operating wind farms
- 3 wind research and workforce development institutions

Wind Technology Area

- 30 year history of collaboration with every major wind turbine OEM and US blade manufacturer
- Extensive university-based composite material and manufacturing research at Colorado School of Mines, Colorado State University, and University of Colorado-Boulder
- Largest US university-based turbine blade manufacturing prototyping facility at Iowa State University
- Wind composite manufacturing scale−up facility

Wind turbine manufacturing

MI

Automation (Viper)
- Fast resin infusion and curing

IN

Models for
- Preforming
  - Infusion
- Cure kinetics
- Performance

OH

Automation
- Fast resin infusion and curing

TN

Low-cost carbon fiber
- Pultrusion
  - Nondestructive Evaluation
- Blade recyclability

IACMI members lead their markets

Vehicles

Global #1, 3, 5, 7; mainstream OEM's with >30% global and >45% US production share

TOYOTA

of America

Ford

HONDA

Wind

Top 3 US OEM's with >70% share of installed US wind generation capacity, US #1 blade manufacturer

Vestas

SIEMENS
Siemens Wind Power

tpi DELIVERING COMPOSITE SOLUTIONS

CGS

US #1 composite tank fabricator; 2 innovative new entrants; truck and auto OEM's

HEXAGON
LINCOLN

xperion

3M

OSHKOSH

Members

Charter:
11 members

DOW · Ford · Volkswagen · Dassault Systemes · Lockheed Martin · DowAksa

Premium:
18 members

American Chemistry Council · BASF The Chemical Company · Continental Structural Plastics · Cytec · DuPont · fives · Evonik Industries · GE · Heil Trailer · Honda · Huntsman · Local Motors · Boeing · PolyOne · PPG · sabic · xperion

>40 Resource Members

Project Types

Project Type	Project Total Budget	Cost Share Requirement	Duration	Other Requirements	Intent
Enterprise	>$600K	Minimum 1:1 with 50% being cash	Up to 5 years	• A small number of value-chain members can jointly submit • Must involve team collaboration and potential large economic and commercial impact	Bigger projects with multiple partners that significantly contributes to achieving IACMI goals.
Technical Collaborations	$20K-$600K	Minimum 1:1 (large entities: 50% being cash)	Up to 2 years	Awarded in 2 phases: • Phase 1 is <6 months and $150K total costs • Optional Phase 2 is <18 months and $450K total costs	Smaller investigatory efforts that can be started up quickly.
Topic Specific	>$20K	Minimum 1:1	Up to 1 year	Only accept white papers that address specific IACMI-issued topics	Address topics of interest to our Members

Initial IACMI Projects Launched in BP1

- Vehicles
  - Focus on overcoming the barriers to high speed, low cost fabrication of carbon fiber composites
  - Will develop automotive-specific carbon fiber, fast curing resins, and target high volume vehicle platforms
  - Industrial partners: Ford, Dow Chemical, DowAksa, Harper

- Wind Turbines
  - Exploration of reactive infusion thermoplastic resins for improved cycle time, durability, recyclability
  - Overcome concerns with fiber-matrix adhesion, high temperature processing and characterization
  - Industrial partners: Johns Manville, TPI Composites

- Compressed Gas Storage
  - Innovative method to rapidly fabricate impact resistant, medium and large CNG Type-IV pressure vessels using braided fabric
  - Reduce cycle time, improve damage tolerance and meet pressure requirements
  - Industrial partners: xperion E&E USA, A&P Technologies

IACMI Goals As Stated in the Funding Opportunity Announcement

Focus Areas

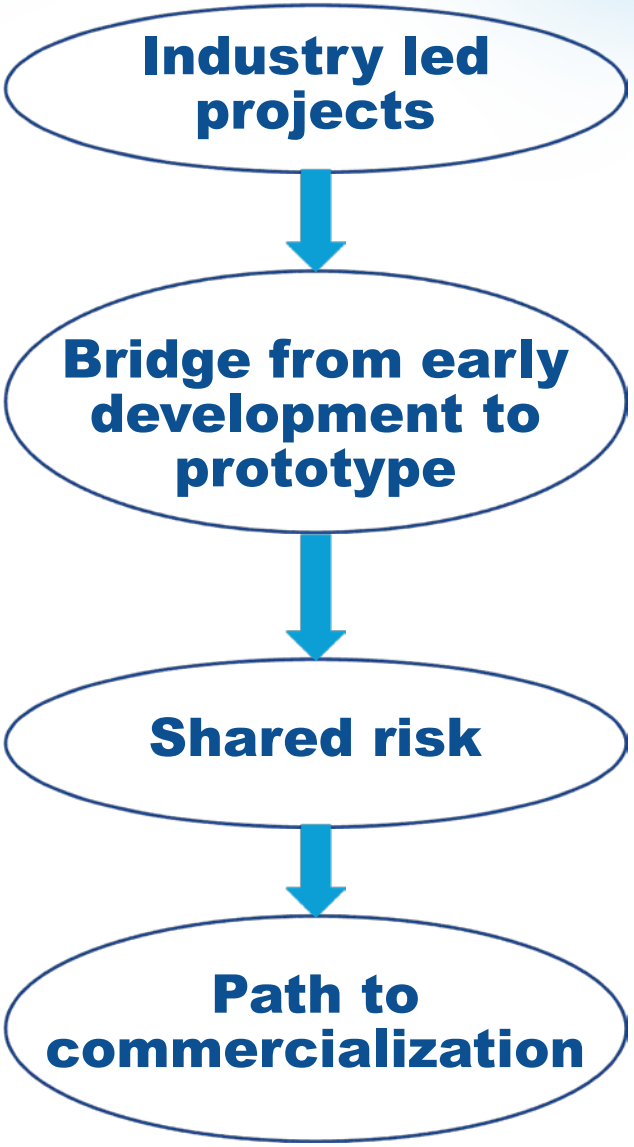
- Vehicles
- Wind turbine blades
- Compressed gas storage

Five Year Technical Goals

- 25% lower carbon fiber-reinforced polymer cost
- 50% reduction in CFRP embodied energy
- 80% composite recyclability into useful products

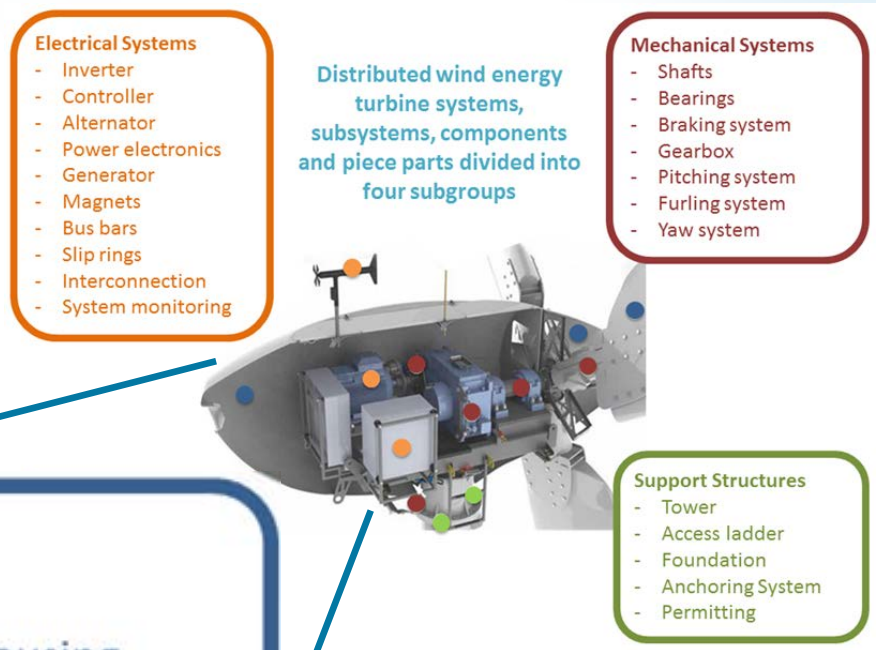
Impact Goals

- Enhanced energy productivity
- Reduced life cycle energy consumption
- Increased domestic production capacity
- Job growth and economic development



Partnering Opportunities Between DWEA SMART Wind Consortium and IACMI

Sustainable Manufacturing, Advanced Research and Technology



Composites
- Blades
- Nacelle housing
- Nosecone
- Tower

Institute for Advance Composites Manufacturing Innovation

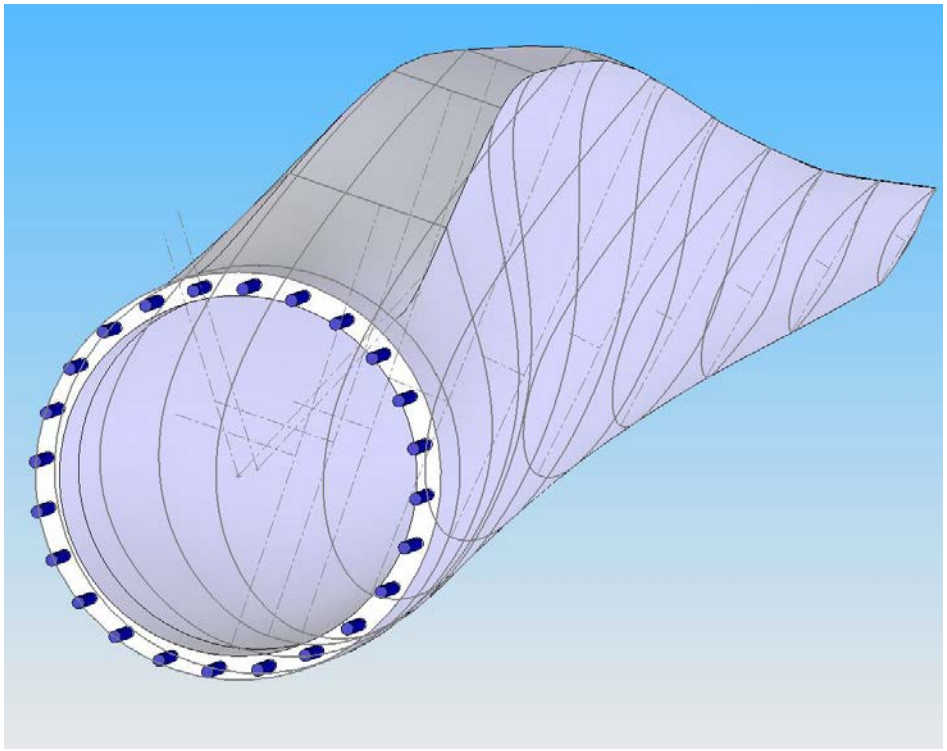
Drivers for Composites in the Wind Industry

- Wind blade molding cycle time
- Labor content
- Material costs
- Light-weighting of wind turbine components
- Recyclability
- Quality/reliability of structural components

Courtesy of TPI Composites

Shared Goals for Turbine Composite Structures

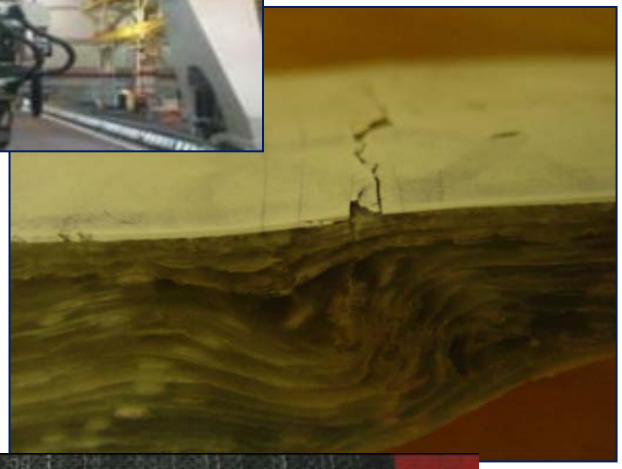
- Improve the manufacturing quality of structural composite components
- Decrease the cost of composite raw materials
- Increase the recyclability of composite wind turbine components at the end of life
- Decrease the embodied energy of the manufacturing process for blades, towers, nacelles, and nose cones
- Reduce the production cycle time of turbine composite components
- Enhance the lifetime reliability of composite parts



Sandia/TPI BSDS 9 m blade

Wind Blade Challenges and Opportunities

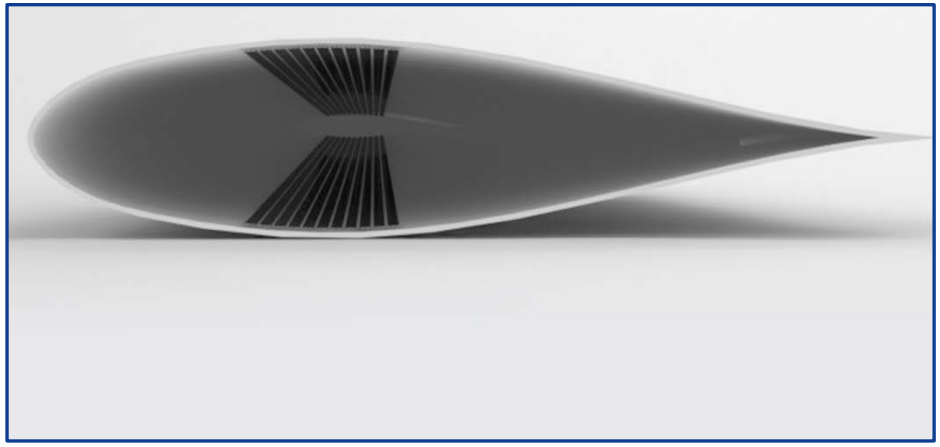
- Reduction in hands-on labor
  - Automated fabric laying
  - Automated tape laying
- Transportation logistics
  - Segmented blades
- Recyclability
  - Thermoplastics
- Field reliability of blades
  - In-process nondestructive evaluation
  - Structural testing
- Blade structural properties
  - Pultruded spar caps
- Time to market
  - Additive manufacturing—molds



Potential Project Areas for Wind Technology Composite Components

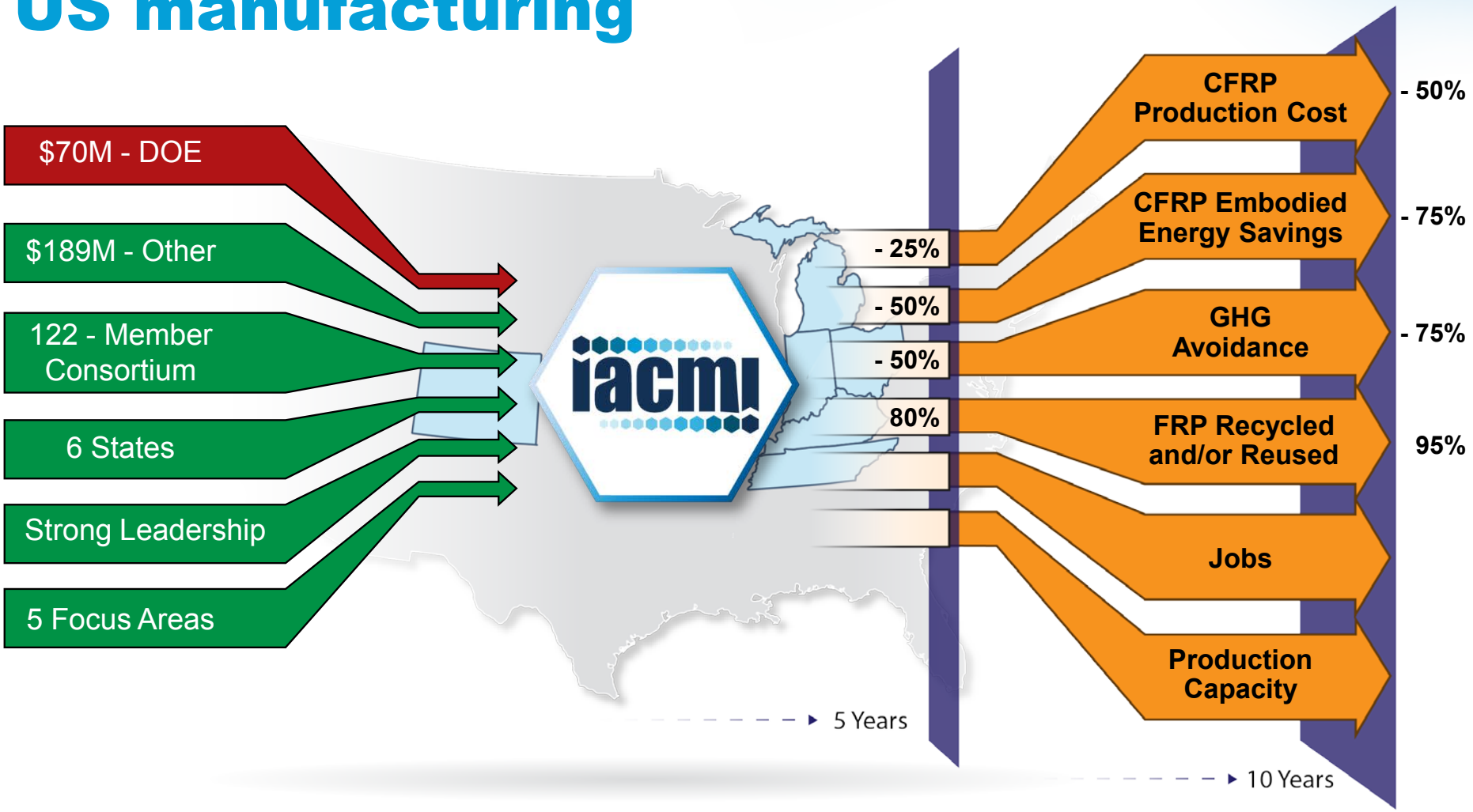
- Thermoset/thermoplastic matrix development
- Automated fabric placement during laminate layup
- Automated nondestructive evaluation during the composite production process
- Pultruded blade and tower sections
- Pultruded structural spar caps
- Segmented blades
- Additive manufacturing of composite tooling and components
- Possible overlap with the automotive technology area of IACMI in the area of compression molding, resin transfer molding, and injection molding

TPI/Sandia CX-100 Blade Infusion



Fiberline Composites

Federal investment will catalyze a composites ecosystem in the heart of US manufacturing



Questions

- Contact Derek Berry:

  derek.berry@nrel.gov

- Visit **IACMI.org** to sign up for updates