Institute for ADVANCED
Composites Manufacturing
INNOVATION

IACMI Roadmapping Update

THE COMPOSITES iacmi INSTITUTE

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Roadmapping Goals

- Integrate the views and establish consensus of stakeholders from value chains in vehicles, wind, and CGS
- Identify other markets in which IACMI capabilities and expertise may be reasonably extended
- Identify & assess pathways for sustainability after year 5
- Develop and periodically revise a targeted technology roadmap
- Mission-critical, market-specific, and cross-market challenges, opportunities and technology solutions

IACMI Roadmapping Overview

Development Approach

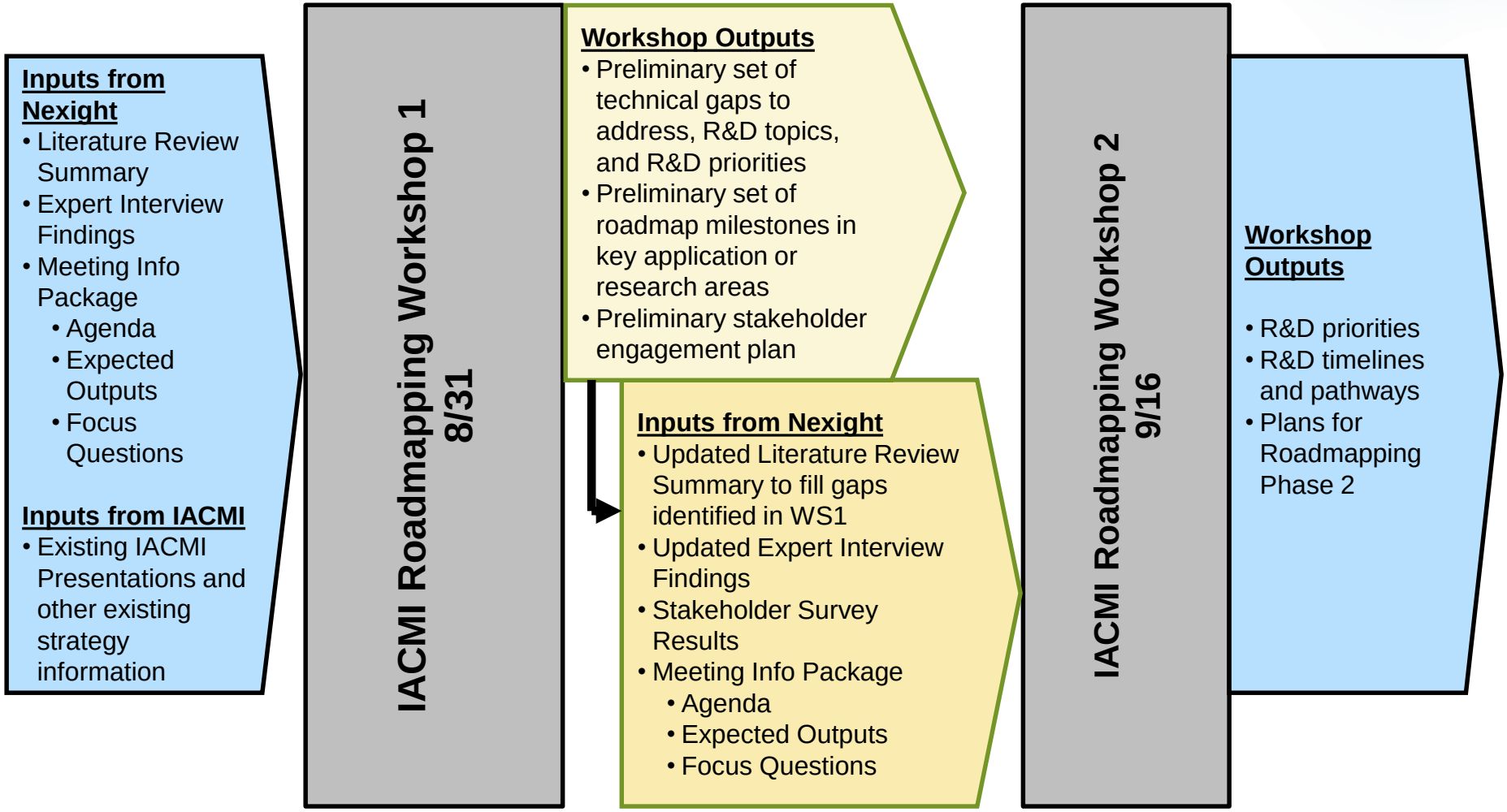
- ✓ **Phase 1**: Accelerated roadmap priority identification
- ➢ **Phase 2**: Full roadmap process development, stakeholder engagement, and roadmap development
- ❑ **Phase 3**: Roadmap monitoring and updating

IACMI Five-Year Objectives

- ↓**25%** CFRP **cost**
- ↓**50%** CFRP **embodied energy**
- ↑**80% recyclability** of fiber-reinforced composites

IACMI Roadmap Development Plan: Phase 1

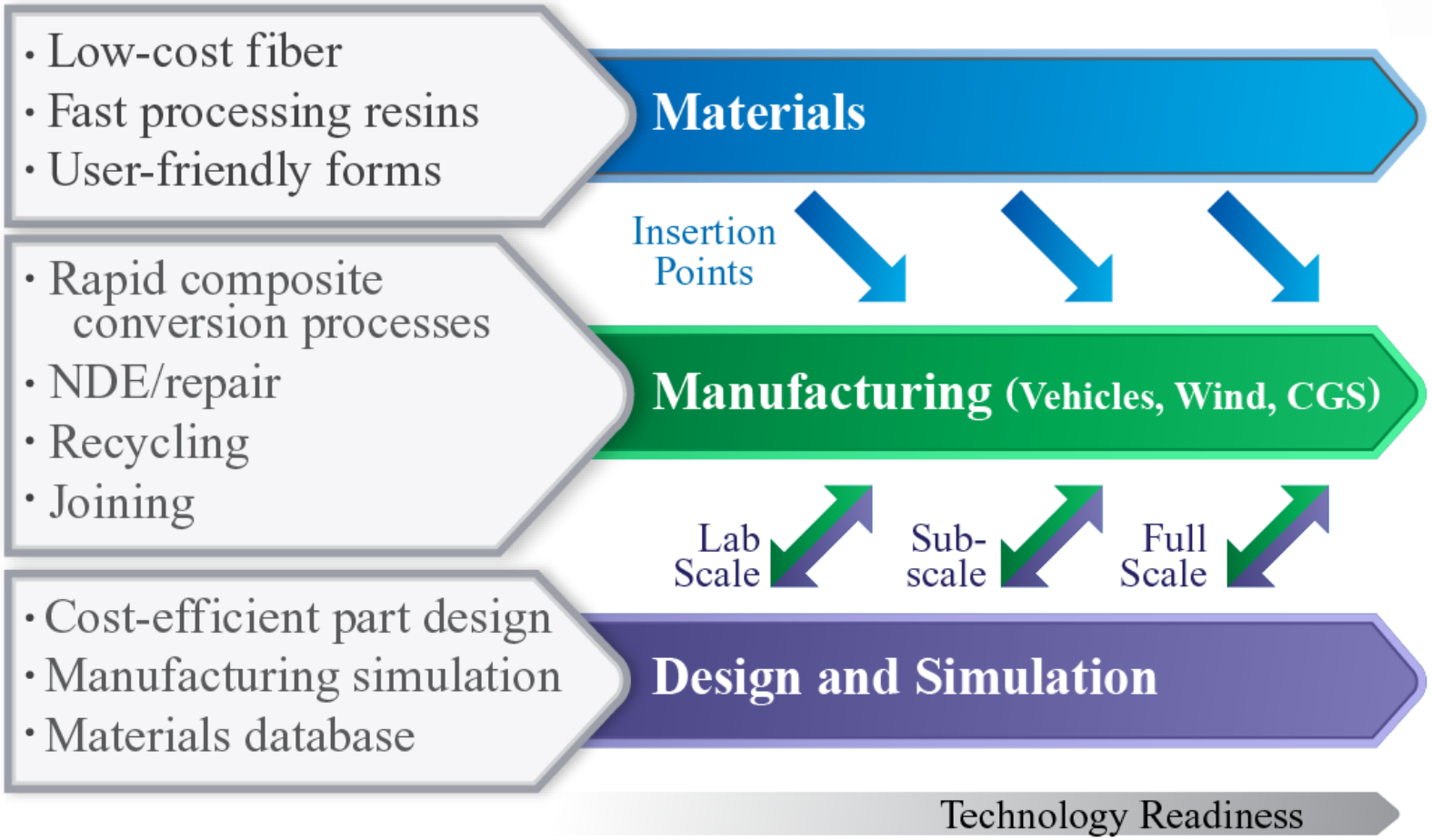
2015 Roadmapping Workshop Inputs and Outputs



Roadmapping Process

- **Literature Review -** Accelerated literature review, with emphasis on recently published roadmaps of relevance to IACMI's scope and focus
- **Expert Interviews -** One-on-one telephone interviews with select experts
- **Online Survey -** Online survey of IACMI members to solicit views on the relative priority of potential technical activities
- **In-Person Roadmapping Meetings -** Two in-person working meetings in Knoxville - define priorities and timelines for IACMI technical activities

An Integrated Approach to meet the DOE and IACMI goals



List of Roadmaps Analyzed

- ACC (American Chemistry Council). March 2014. *Plastics and Polymer Composites Technology Roadmap for Automotive Markets*.
- DOE EERE (U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy). 2013. *WORKSHOP REPORT: Trucks and Heavy-Duty Vehicles Technical Requirements and Gaps for Lightweight and Propulsion Materials*.
- DOE EERE (U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy). 2013. *WORKSHOP REPORT: Light-Duty Vehicles Technical Requirements and Gaps for Lightweight and Propulsion Materials*.
- DOE USCAR (U.S. Department of Energy, United States Council for Automotive Research). 2013. *U.S. DRIVE Materials Technical Team Roadmap*.
- DOE VTO (U.S. Department of Energy, Vehicle Technologies Office). 2014. *2014 Annual Merit Review*.
- DOE EERE (U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy). January 13, 2014. *Fiber Reinforced Polymer Composite Manufacturing Workshop: Summary Report*.
- NIST's Advanced Manufacturing Technology Consortia (AMTech) Program - *Facilitating Industry by Engineering, Roadmapping and Science (FIBERS)* for the Composites Industry, 2015.
- DOE (U.S. Department of Energy). 2008. *20% Wind Energy by 2030*.
- University of Massachusetts, Lowell. September 22-23, 2011. *Wind Energy Research Workshop Final Report: Identifying Research Gaps and Future Directions*.

Crosswalk of IACMI Technical Plan R&D Needs and Other Relevant Roadmaps

IACMI Technology Area and Innovation	ACC Roadmap	DOE VTO Trucks and Heavy Duty	DOE VTO Light Duty	DOE MTT Roadmap	DOE VTO Annual Report	DOE FRPC Workshop Report	[WIND] DOE: 20% BY 2030	[WIND] UMASS: Wind
Vehicles Technology Area								
Generate fast-processing resins with internal mold release for RTM and stamping						x		x
Develop low scrap, automated composite preforming fabrication techniques to match molding times						x		x
Develop low scrap, automated tape layup prepreg fabrication techniques to match molding times								
Reduce part-molding cycles of RTM fabrication methods from 8 minutes to 3 minutes	x					x		
Reduce processing cycles of thermoset prepreg stamping fabrication techniques from 10 minutes to 3 minutes	x					x		
Reduce processing cycles of thermoplastic prepreg stamping fabrication techniques from 7 minutes to 3 minutes	x					x		
Reduce processing cycles of injection overmolding fabrication techniques for engineered thermoplastics from 3 minutes to 90 seconds	x				x	x		
Demonstrate low cost carbon fibers in automotive part applications	x		x	x				
Increase the in-plant reuse rate of carbon fiber process scrap in high quality parts	x			x				
Advance high speed, high strength joining techniques for dissimilar materials (e.g., metal and composite vehicle parts)	x	x	x	x		x		
Enhance robotics capabilities to enable high speed handling of materials, preforms and molded parts			x			x		
Implement low cost tooling (e.g., via additive manufacturing) for molding of automotive vehicle parts			x					
Increase recovery and reuse rates of end-of-life carbon fiber parts	x	x		x				
Develop discontinuous carbon fiber reinforced thermoset/thermoplastic processing	x							
Develop NDE validation techniques for fiber-based architectures (vehicles, wind, CGS)	x			x				x
Implement in-situ process controls to monitor the degree of curing in composite parts (vehicles, wind, CGS)								
Enable rapid detection of void levels in molded parts (vehicles, wind, CGS)								x
Enhance NDE validation techniques for bonded joints (vehicles, wind)	x	x	x	x		x		x

Interview with Subject Matter Experts

- Industry experts with strong track record in the composites technologies
- Charter, Premium, Resource and Consortium members
- Representatives from SMEs, small and large OEMs, Tier 1-2-3, material suppliers, supply chain, end-users, fabricators
- DOE and Government representatives
- Composites organizations with global representation
- Interviews with authors of relevant road maps
- Interviewees included IACMI and non-IACMI experts

General Interview Findings (thus far)

Interviewees (thus far) are in agreement that IACMI Is-

- Focused on the right technical gaps and R&D activities needed to achieve its five-year technical targets
- Serving a critical role in building a U.S.-based network and supply chain of companies
- Playing an important role of education and workforce training

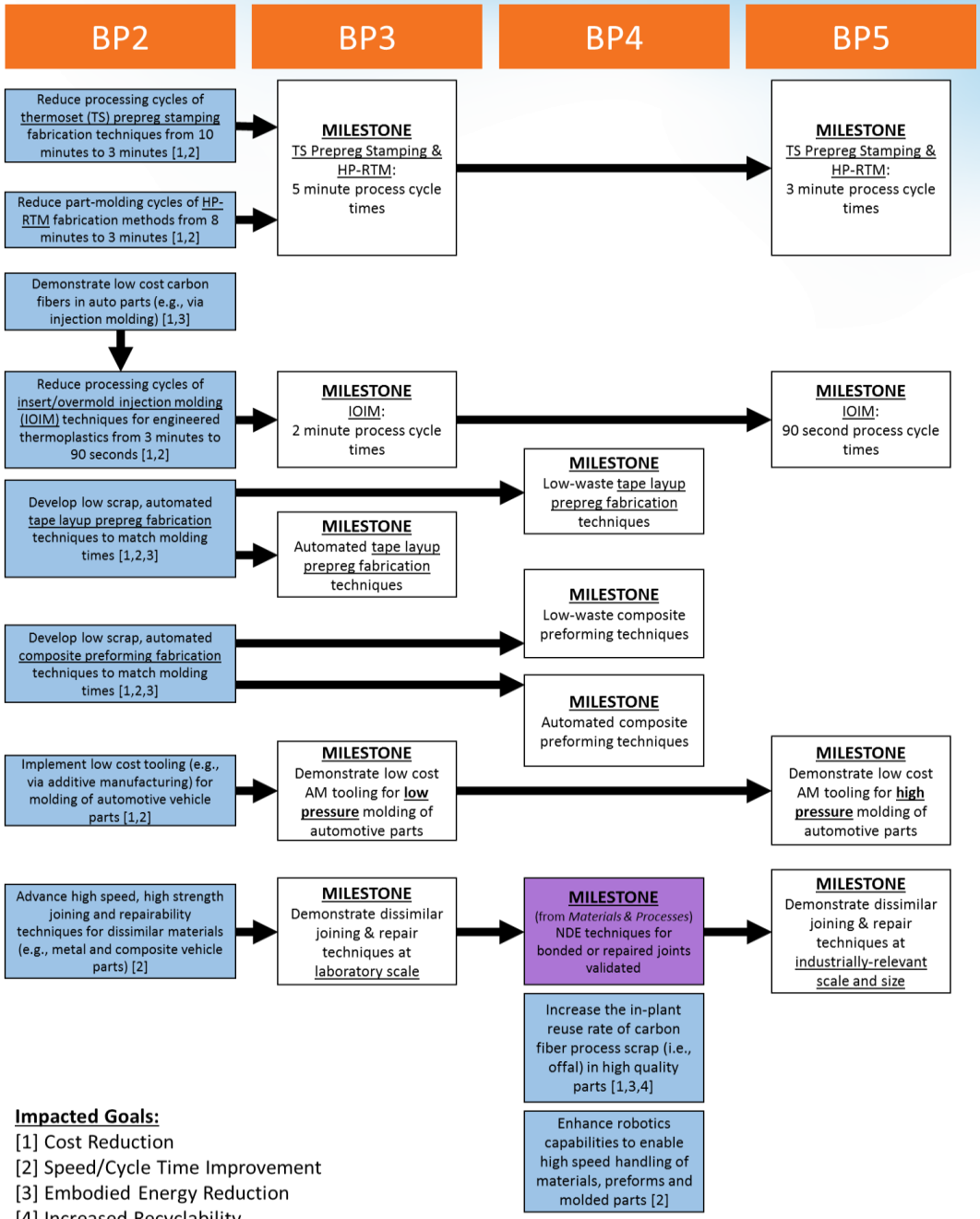
Summary of IACMI Survey Respondents (as of Dec 2015)

	Respondents by Area of Work
Vehicles	48%
Wind Turbines	24%
Compressed Gas Storage	25%
Materials and Processes	89%
Modeling and Simulation	37%
Total Respondents	102

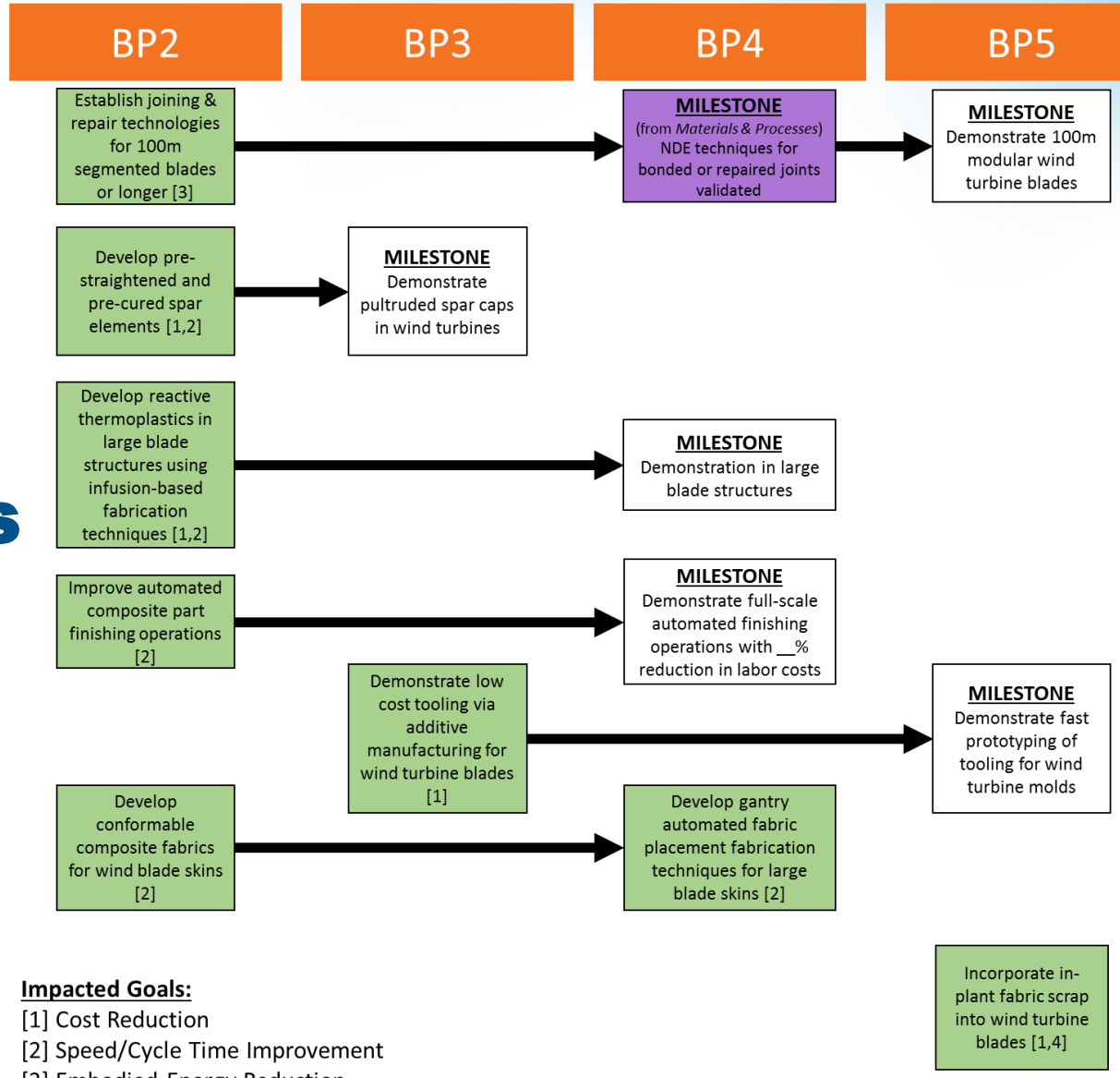
Impact Ratings of Activities on IACMI Goals: Vehicles

Vehicles	Average Rating	Total Responses
Demonstrate low cost carbon fibers in automotive part applications	4.49	70
Advance high speed, high strength joining techniques for dissimilar materials (e.g., metal and composite vehicle parts)	4.10	73
Develop low scrap, automated composite preforming fabrication techniques to match molding times	4.04	70
Reduce part-molding cycles of RTM fabrication methods from 8 minutes to 3 minutes	3.91	64
Reduce processing cycles of thermoplastic prepreg stamping fabrication techniques from 7 minutes to 3 minutes	3.88	66
Develop discontinuous carbon fiber reinforced thermoset/thermoplastic processing	3.84	68
Generate fast-processing resins with internal mold release for RTM and stamping	3.83	66
Reduce processing cycles of thermoset prepreg stamping fabrication techniques from 10 minutes to 3 minutes	3.78	65
Reduce processing cycles of injection overmolding fabrication techniques for engineered thermoplastics from 3 minutes to 90 seconds	3.76	66
Increase the in-plant reuse rate of carbon fiber process scrap in high quality parts	3.64	69
Develop low scrap, automated tape layup prepreg fabrication techniques to match molding times	3.62	71
Develop NDE validation techniques for fiber-based architectures	3.52	67
Enhance NDE validation techniques for bonded joints	3.51	68
Increase recovery and reuse rates of end-of-life carbon fiber parts	3.47	73
Enable rapid detection of void levels in molded parts	3.42	69
Enhance robotics capabilities to enable high speed handling of materials, preforms and molded parts	3.41	70
Implement low cost tooling (e.g., via additive manufacturing) for molding of automotive vehicle parts	3.37	71
Implement in-situ process controls to monitor the degree of curing in composite parts	3.21	67

Timeline of Technical Activities and Milestones – Vehicles



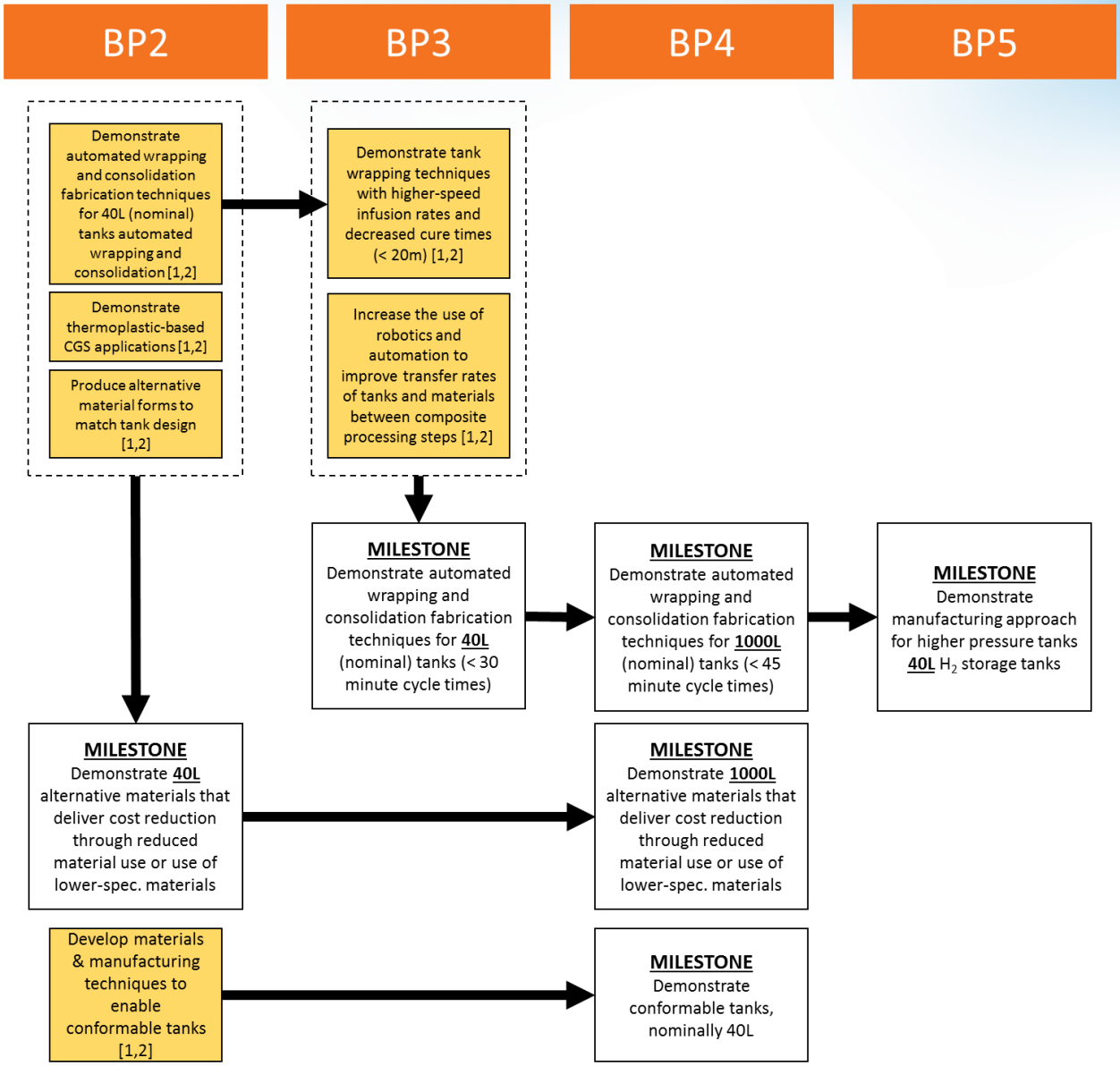
Wind Turbines



Impacted Goals:

[1] Cost Reduction
[2] Speed/Cycle Time Improvement
[3] Embodied Energy Reduction
[4] Increased Recyclability

Compressed Gas Storage



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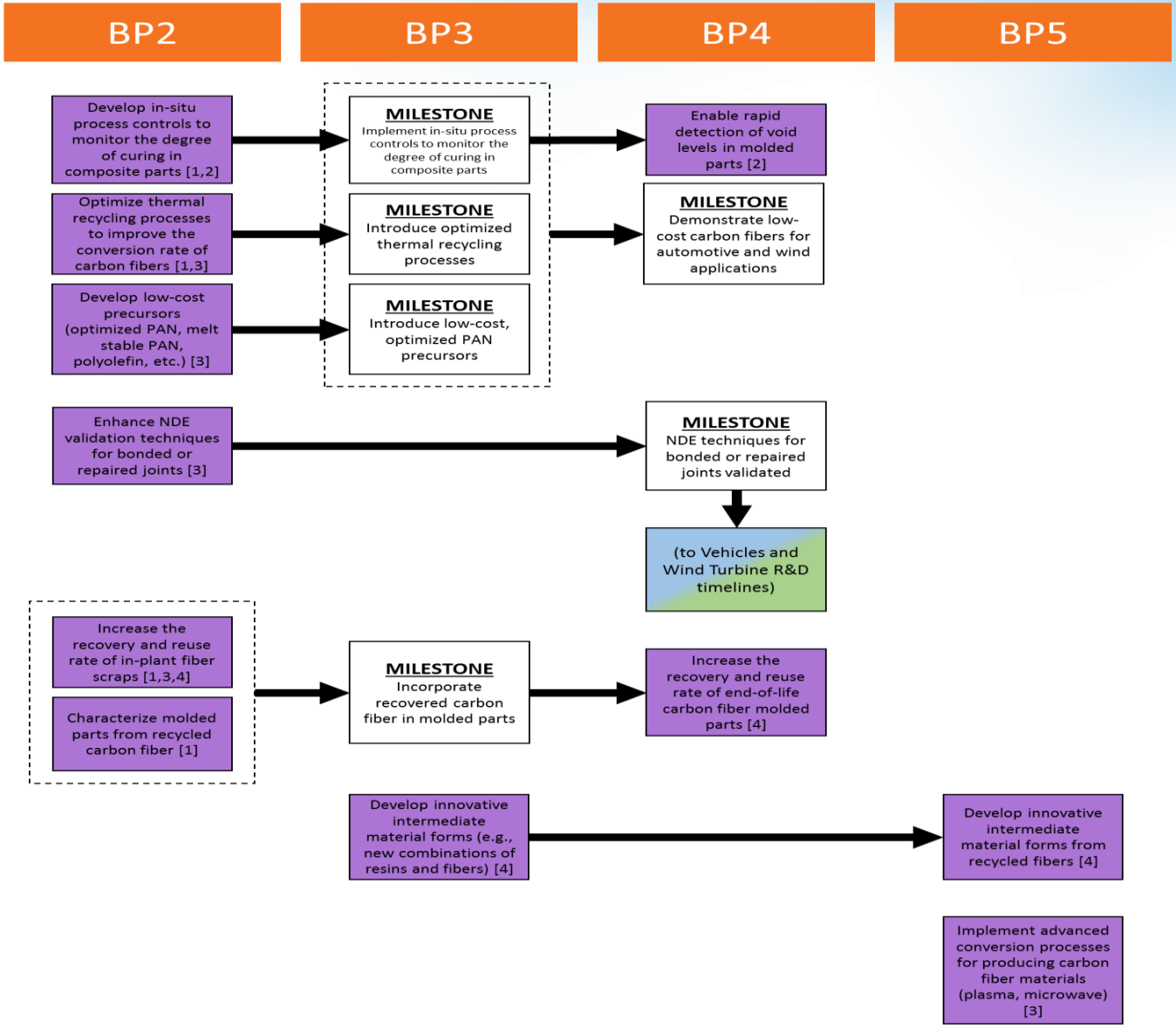
Materials & Processes



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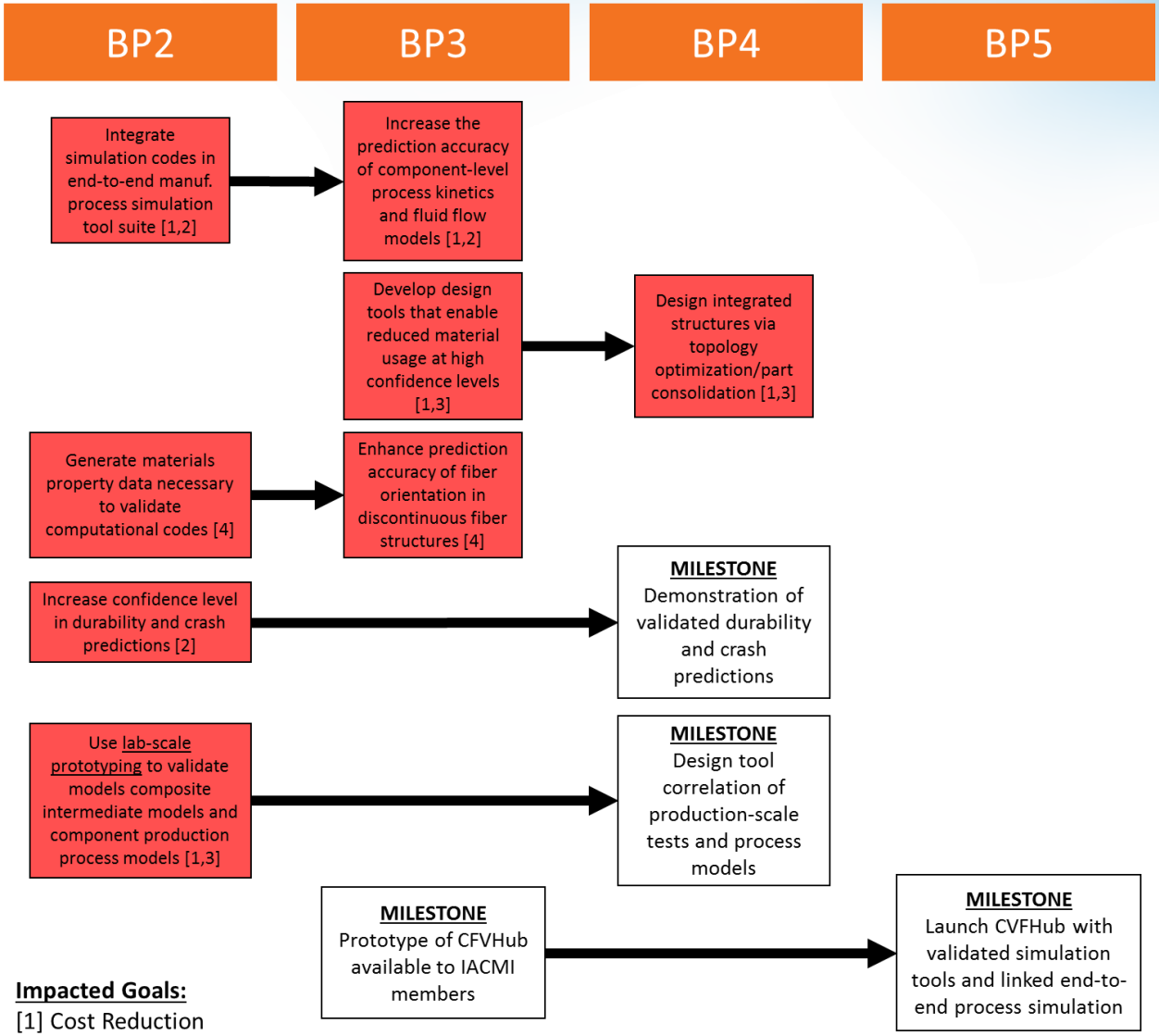
Modeling & Simulation



Impacted Goals:

[1] Cost Reduction
[2] Speed/Cycle Time Improvement
[3] Embodied Energy Reduction
[4] Increased Recyclability

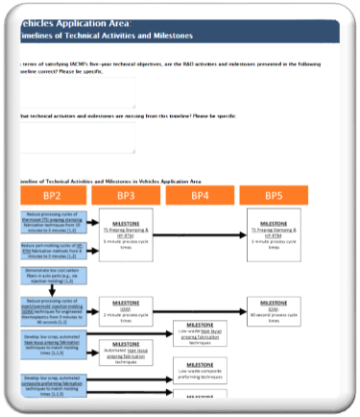
Continuous stakeholder engagement…

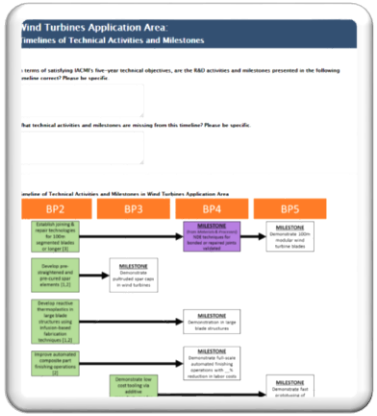
- Completion of all Charter and Premium member phone interviews
- 2nd survey will go out within the next few weeks
- Phone interviews ….
- Workshops in March and May 2016 for further targeted discussions within the technology areas

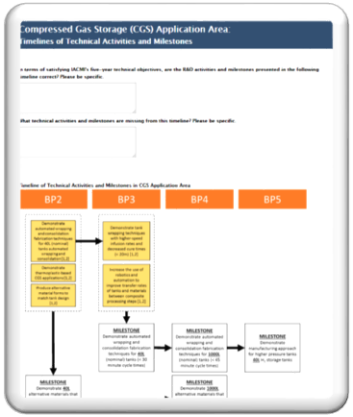
Phase 2 Stakeholder Survey: Input Request from IACMI Membership

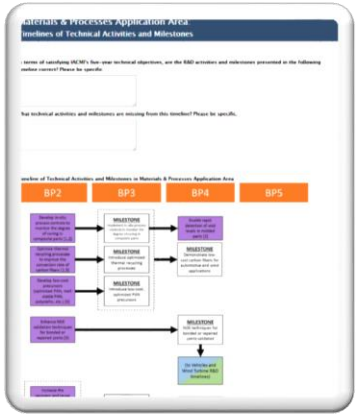
Please provide feedback on Phase 1 IACMI Technology Roadmap.

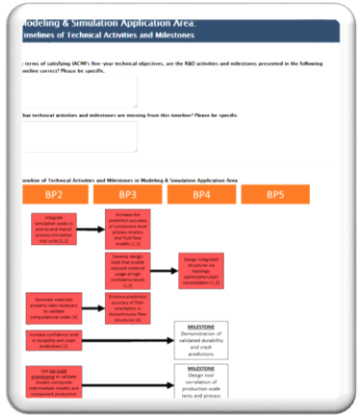
http:/// link will be provided











Institute for Advanced Composites Manufacturing Innovation (IACMI)

Preliminary Technology Roadmap: Timelines of Technical Activities and Milestones

This survey is being conducted on behalf of the Institute for Advanced Composites Manufacturing Innovation (IACMI). We are seeking your input on the timelines of technical activities and milestones in IACMI's Preliminary Technology Roadmap.

Given IACMI's budgeting cycles, IACMI required preliminary roadmap results in an accelerated timeframe, to be followed by more thorough stakeholder consultation and roadmap development in FY16 and ongoing roadmap monitoring and updating thereafter. Accordingly, the roadmap development approach has been described in three Phases:

- **Phase 1: Accelerated roadmap priority identification**
- **Phase 2: Full roadmap process development, stakeholder engagement, and roadmap development**
- **Phase 3: Roadmap monitoring and updating**

About this Survey

The Phase 1 preliminary technology roadmap presents timelines that depict how the technical R&D activities that were deemed to be high priorities for budget period 2 (BP2) will develop over the next five years. The timelines are organized around IACMI's major research focus areas: vehicles, wind energy, compressed gas storage, materials development, and modeling and simulation. These timelines can guide near-term IACMI decisions regarding technology-specific R&D activities by identifying the highest-priority activities that require action in BP2. Further, these timelines also show how BP2 investments will lead to milestones and, ultimately, the five-year IACMI technical objectives:

- **Reduce production cost of carbon-fiber reinforced composites by >25% in 5 years on a path to >50% in 10 years.**
- **Demonstrate technologies that reduce embodied energy and GHG emissions of carbon fiber by 50% in 5 years on a path to 75% reduction in 10 years.**
- **Demonstrate technologies for >80% recyclability or reuse of fiber-reinforced composites in 5 years on a path to >95% in 10 years.**

Summary and Next Steps

- IACMI road map - a consensus view of the technology and business landscape for composites manufacturing in clean energy applications
- The roadmap is helping to prioritize investments in IACMI's technology development pathways, RFPs and shared infrastructure
- A public version (Version 1) of the roadmap will be available on the IACMI website by February 2016
- Detailed Phase 2 roadmapping workshops planned for March and May 2016
- Continual monitoring and updating of Roadmap to maximize IACMI impact to stakeholders, technology advances and implementation