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

AMO Technical Resources Network Forum R&D Consortia

June 15, 2017

Valri Lightner

Senior Technical Manager

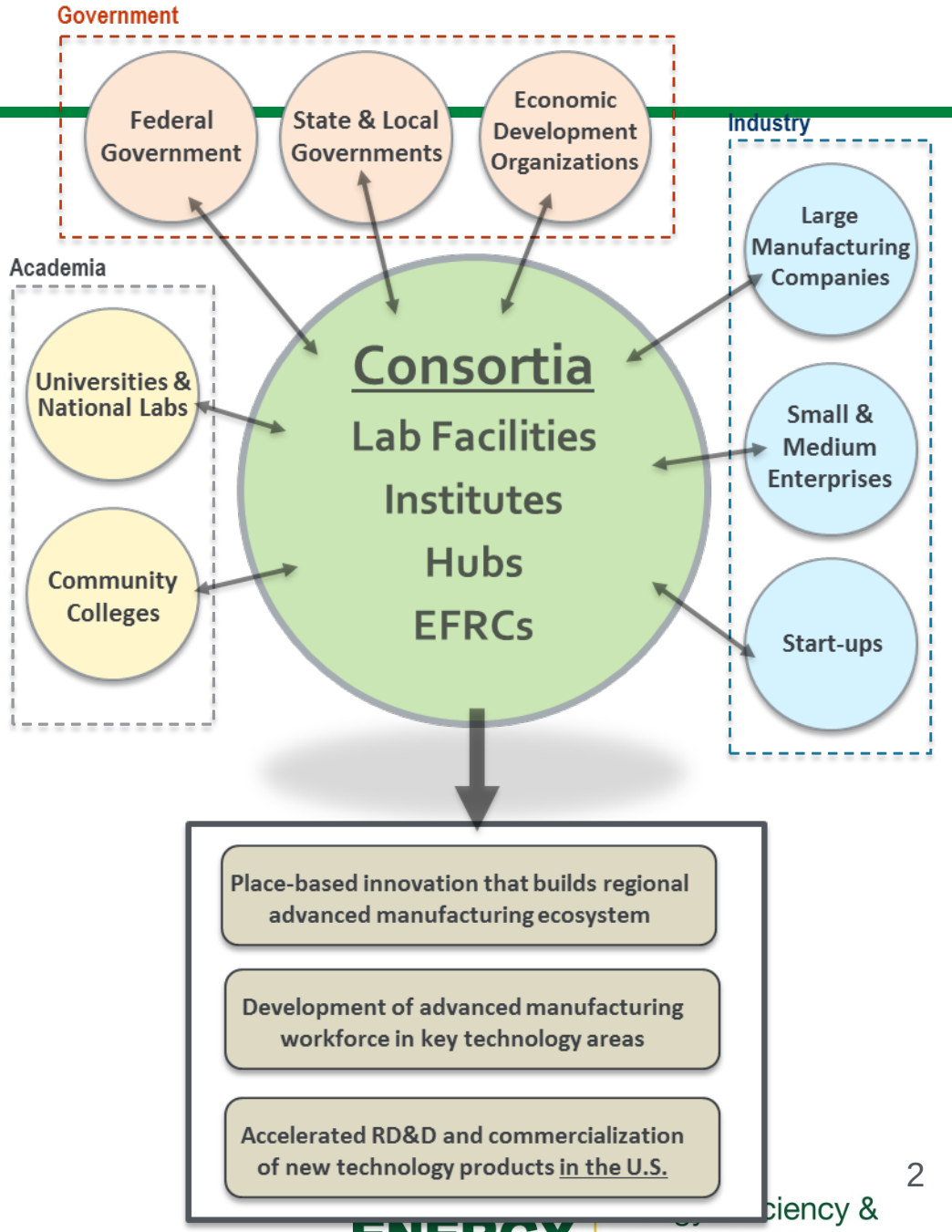
Advanced Manufacturing Office

www.manufacturing.energy.gov

Consortia Model

Each Consortia has:

- Clear technology focus
- TRL level suited to specific technology challenge
- Shared user facilities
- Ability to address critical challenges
- A balanced portfolio of projects



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R&D Consortia Network Opportunities

Panel Moderator, Valri Lightner, AMO Senior Technical Manager
Nick Justice, Executive Director **Victor Veliadis**, Chief Technical Officer Power America North Carolina State University
Alex King, Director Critical Materials Institute Ames Laboratory
Bryan Dods, Chief Executive Officer Institute for Advanced Composite Materials Innovation Collaborative Composite Solutions Corporation
Ray Collett, Chief Executive Officer **Mike Rinker**, VP Workforce Development Clean Energy Smart Manufacturing Innovation Institute Smart Manufacturing Leadership Coalition
Karen Fletcher, Chief Executive Officer Rapid Advancement in Process Intensification Deployment (RAPID) Institute American Institute for Chemical Engineers
Nabil Nasr, Chief Executive Officer Reducing Embodied-energy and Decreasing Emissions (REMADE) Institute Sustainable Manufacturing Innovation Alliance

2017 DOE Advanced Manufacturing Office Technical Resources and Networking Forum

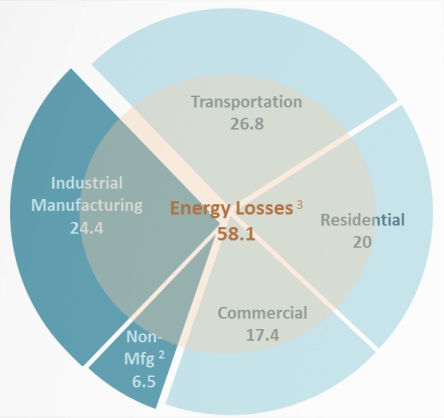
REMADE Institute Overview

Nabil Nasr

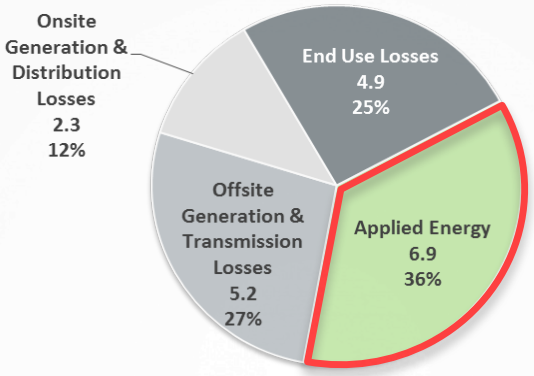
June 15, 2017
Washington, D.C

Current Manufacturing Landscape

U.S. Energy Consumption by Sector (2012) - 95.1 Quads[1]

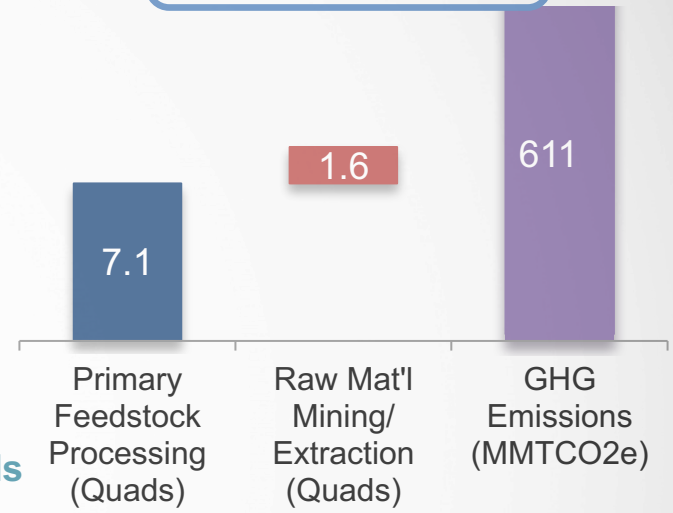


Mfg Energy Consumption (minus feedstocks) – 19.2 Quads



Energy Losses[4] – 12.4 Quads

Polymers, Metals, Fibers, & e-waste



Fibers (paper/composites)

Polymers (plastics)

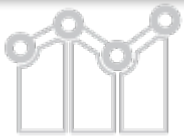
Electronics/e-waste

Metals

Four Material Classes Account for 37% of US Manufacturing Energy Consumption

Manufacturing Focus Areas

5 TECHNOLOGY FOCUS AREAS



SYSTEM ANALYSIS INTERGRATION

Data collection, standardization, metrics, and tools for understanding material flow

DESIGN FOR REUSE & DISASSEMBLY

Design tools for material utilization/reutilization, design for reman or disassembly

MANUFACTURING PROCESSES

Efficient use of materials, near net shaping, and use of secondary feedstock without loss of quality

REMANUFACTURING /EOL REUSE

Efficient and cost effective technologies for cleaning, component restoration, condition assessment, reverse

RECYCLE & RECOVERY

Rapid gathering, identification, sorting, separation, contaminant removal reprocessing and disposal

INSTITUTE GOALS

Reducing Embodied Energy & Emissions in Manufacturing

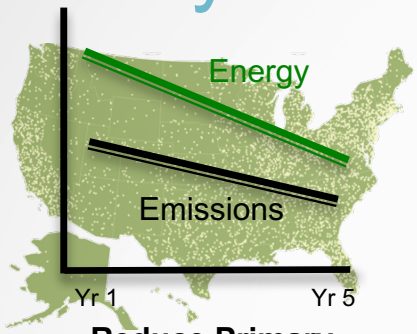
- Reduce primary feedstock consumption in manufacturing
- Achieve reduction in embodied energy of targeted materials
- Achieve cost parity for secondary materials
- Improve energy efficiency of secondary material processing
- Increase size of remanufacturing industry

4 MATERIAL CLASSES

Metals **Polymers** **E-waste** **Fibers**

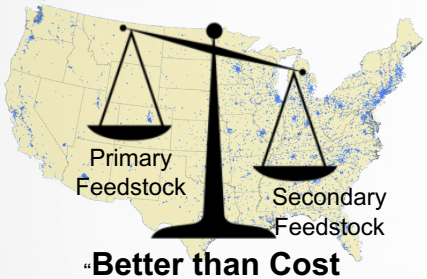
REMADE Institute Objectives

Why REMADE Should Interest You!



Reduce Primary Material Use

8,000 – 13,000 Domestic Remanufacturing Businesses



"Better than Cost and Energy Parity"

US Scrap Recovery Facilities, ISRI 2015

Widespread Application of New Technologies

14% of plastic packaging recycled globally.

manufacturing Indu

43B US Market. $12B Expor

omprised on 1

nly 2% intensity in prin

omestic Emplo

Mining/mat
manufac

Parts manufacurer

Produ
manuf

total revenues

Recycling and

- $80+ Billio
- Ecosyst
- Typical
- Domest

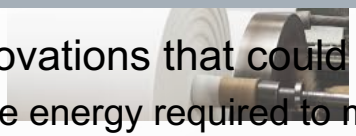
Million tons/yr.

oduct Suppliers

Electronic

etals

77% of domestic e-waste is imported



Directed towards innovations that could

- Dramatically reduce the energy required to manufacture key materials, and
- Improve overall manufacturing energy efficiency through increased material reuse, recycling and remanufacturing.

REMADE Institute Members

26 Leading Universities

R·I·T
Georgia Institute of Technology
Yale
School of Mines 1874 Colorado
Northwestern University
Washington State University
WPI
Virginia Tech
Clarkson University
Iowa State University
UCSB
UMass Lowell
MIT Massachusetts Institute of Technology
The University of Utah
Oklahoma State University
Wisconsin
Ohio State
University of New Hampshire
University of Pittsburgh
UWM University of Wisconsin Milwaukee
Texas Tech University
Carnegie Mellon University
University of California Irvine
Miami

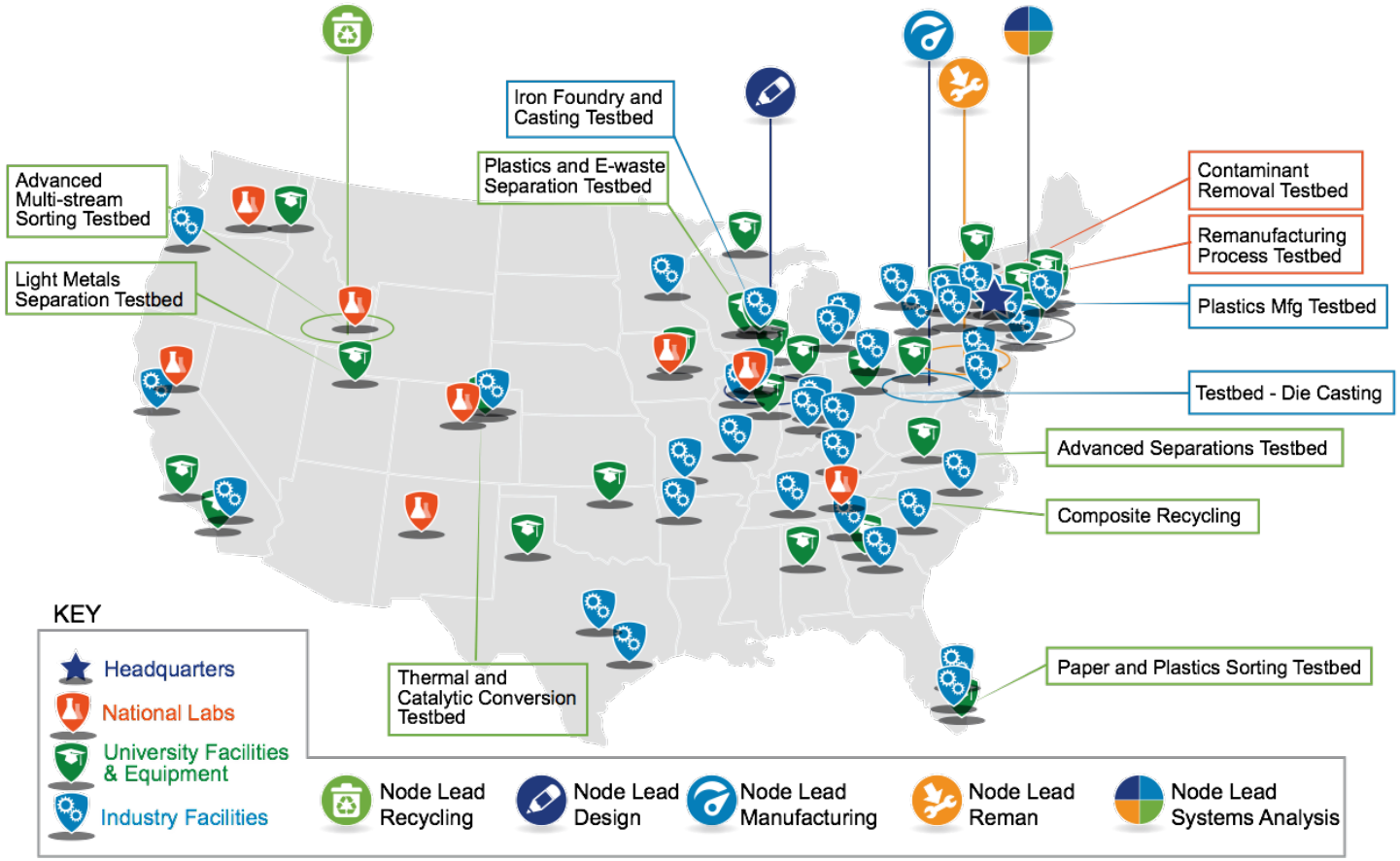
44 Industry Leaders & 26 Associations

CAT
Staples
Sealed Air
xerox
Cummins
Michelin
Celanese
Dell
Nike
Davies Office
Kohler
Delphi Automotive Systems
John Deere
umicore
Corning
Ellen MacArthur Foundation
Shaw Floors
SIMS Metal Management
Tessy Plastics
anteagroup
American Chemistry Council
Phinix
Remanufacturing Industries Council
American Forest & Paper Association
apra
ITC International Imaging Technology Council
ISRI Voice of the Recycling Industry
NCMS National Center for Manufacturing Sciences
iNEMI
sme
MERA

7 National Labs

INL
Argonne National Laboratory
Oak Ridge National Laboratory
NREL National Renewable Energy Laboratory
The Ames Laboratory Creating Materials & Energy Solutions U.S. Department of Energy
Sandia National Laboratories
Pacific Northwest National Laboratory

12 geographically distributed testbeds* provide mechanism to scale up early stage applied R&D



* Enable feasibility and validation in a relevant environment and are applicable to the four material classes and four material lifecycle stages targeted by REMADE.

Outcomes of the REMADE Institute

Early Stage R&D Projects
- Reducing cost/risk on commercializing new technology
- Solving pre-competitive industrial problems

Tech Integration
- Development of innovative methodologies and practices for supply chain integration

- **Small/Medium Enterprises** Engagement with small and medium-sized manufacturing enterprises

Workforce Development
- Education and training at all levels

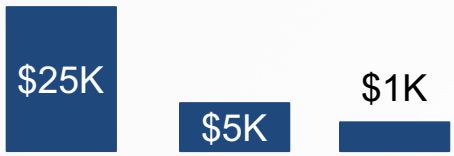
How Institutes Create Value for Members

Leveraged R&D	• A framework for multi-party collaboration to solve common problems and challenges • Potential for sharing R&D project costs/risk between project partners • Access to funds to support early stage R&D projects consistent with Institute investment plan
Project Outcomes	• Program management to assure timely and efficient execution • License to use all Institute-funded IP for business and R&D uses for Tier 1 Members • License to project-specific IP and other IP only for internal R&D uses for Tier 2 Members
Access to wide range of sources of innovation	• Broad and diverse membership • Members at the forefront of innovation in their industries • Broad set of academic and national lab partner expertise • New ecosystems to support innovation leading to growth, cost saving, and job creation

Engagement with the REMADE Institute

- Membership model responsive to SMEs

Annual Membership/Cost Share



- Respond to REMADE Project Calls

1-2 Project Calls/Year

- Collaborate on REMADE Projects

Typical Project Size - $300K – $1.5M
Typical Project Duration – 12-24 months

- Utilize a REMADE Institute Testbed

12 Geographically Dispersed Testbeds at National Lab & University Partner Sites

- Participate in Education & Workforce Development Activities

Career Pathways Developmental Framework applicable to all levels of workers

RAPID
Transforming Process Industries

RAPID Manufacturing Institute

DE-EE0007888

Karen Fletcher
CEO, RAPID

U.S. DOE Advanced Manufacturing Office Technical Resources & Networking Forum
Washington, D.C.
June 15, 2017

Vision

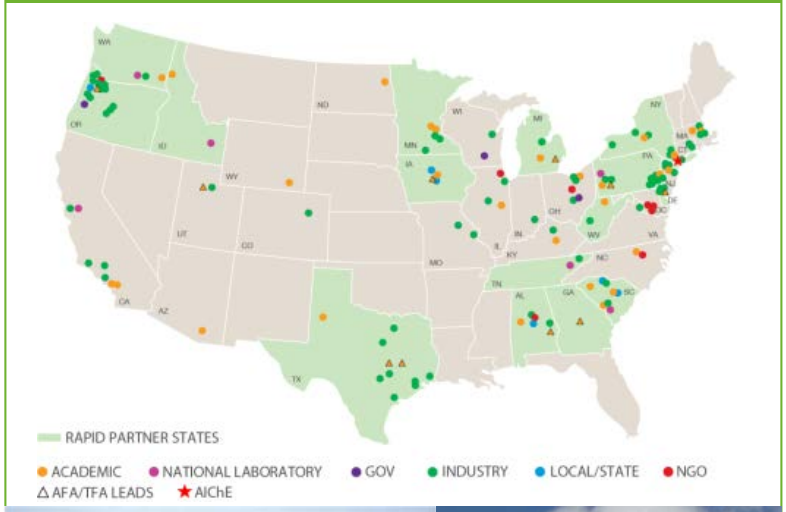
*A dynamic network of partners who collectively build a sustainable **ecosystem** that:*

… researches, develops and demonstrates innovative new technology for process intensification and modular process design

… delivers dramatic reductions in energy, waste, capital and operating cost

… makes U.S. Manufacturing and our workforce more competitive

RAPID's Ecosystem



Industry leaders, researchers, educators, engineers, operators and facilities

6 Technical Focus Areas

	Examples
1. Chemical & Commodity Processing	Chemical Manufacturing
	Oil & Gas Processing
	Pharmaceuticals & Specialty Chemicals
2. Natural Gas Upgrading	On-Site Natural Gas Upgrading
	Distributed Fuels & Chemicals production
	Light Gas separations
3. Renewable Bioproducts	Pulp & Paper
	Distributed Bio-refining
	Water Remediation

6 Technical Focus Areas

	Examples
4. Modeling & Simulation	Process Simulation
	Model based technology scale up
	Process Control
5. Intensified Process Fundamentals	Novel Energy Sources
	Alternative Separations
	Catalysis and Novel Chemistry
6. Module Manufacturing	Materials — Lighter and Less Expensive
	Modular Components Manufacturing
	Microchannel Reactors & Heat Exchangers

Initial Partners

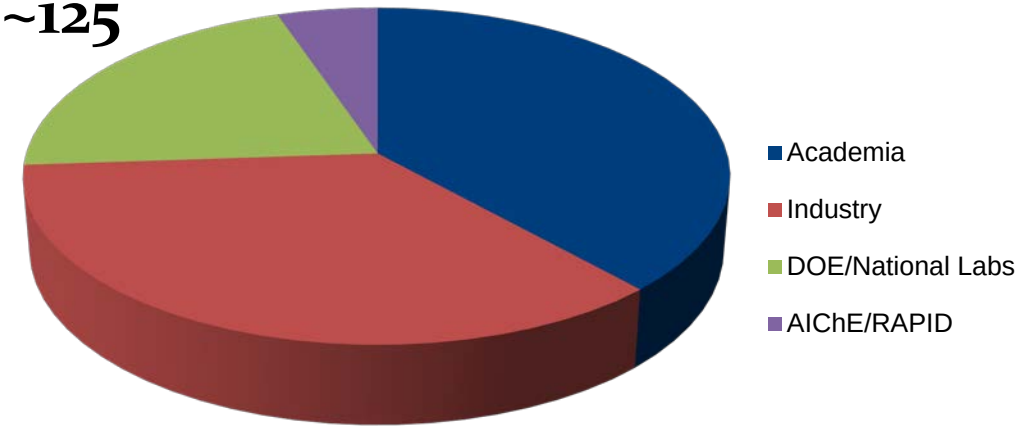
RAPID
Transforming Process Industries

This presentation does not contain any proprietary, confidential, or otherwise restricted information.

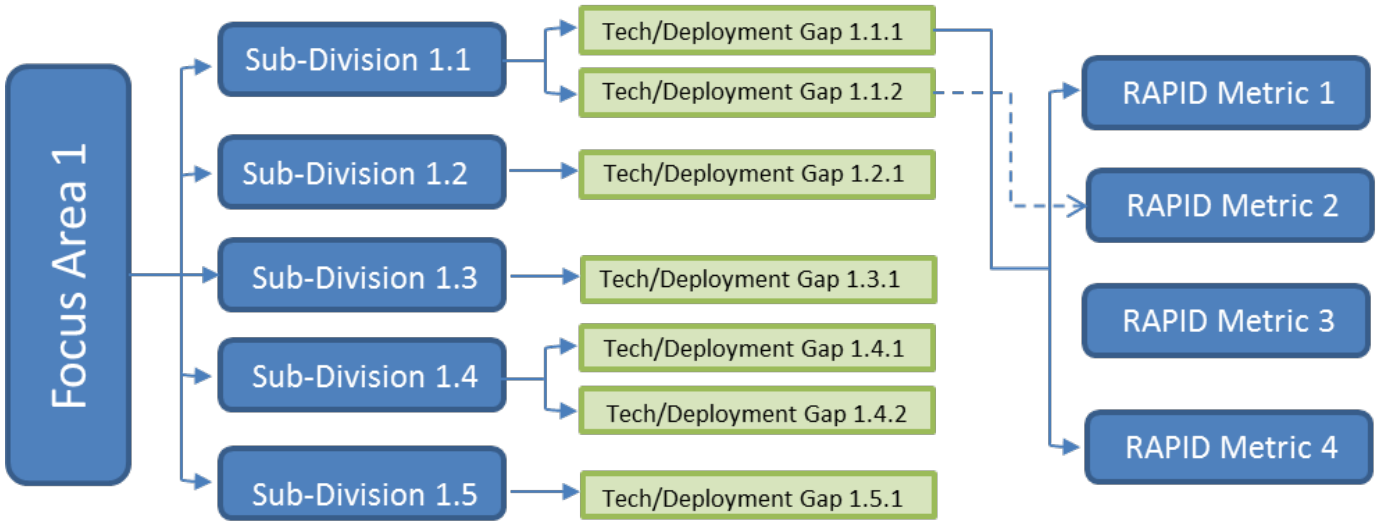
Roadmapping

Roadmapping participants ~125

- 28 companies
- 28 universities
- 12 Federal departments/labs



Roadmapping Process



Project Targets

- Demonstrate MCPI with >20% energy efficiency
- Develop tools to reduce the cost of deploying MCPI in existing processes by 50%
- Demonstrate 2x energy productivity by a combination of capital and operating cost related to improved feedstock and fuel efficiencies.
- Scale-out module manufacturing that reduce >20% cost/unit, with each doubling in module manufacturing production
- 10x reduced capacity cost, 20% improvement in energy efficiency and 20% lower waste relative to commercial state-of-the-art
- Establish comprehensive Body of Knowledge for MCPI

MCPI = Modular Chemical Process Intensification

Opportunities for Small Businesses

- Access to new process intensification technology and tools with the potential for:
  - Lower capital cost
  - Lower operating cost
  - Improved process efficiency
  - Improved energy efficiency
  - Reduced waste
  - Reduced environmental footprint
- Participation in roadmapping workshops with access to finished products
- Participation in R&D projects that directly address industry challenges
- Access to tools, models, and educational materials
- Collaborations with academia, national labs, supply chain partners
- Networking in the broader PI community through Institute meetings, conferences…

What's Happening Now?

• Institute start-up; member sign-up	Now
• Roadmapping in 6 focus areas	Through Aug
• Call for "pre-proposals" & Call for proposals	Open til 6/30 August
• 4 "Jump Start" projects	Starting now
• Education survey – current state in PI curricula	In progress

Clean Energy Smart Manufacturing Innovation Institute (CESMII)

Mike Rinker, VP of CESMII Workforce Development

U.S. DOE Advanced Manufacturing Office Technical Resources & Networking Forum
Washington, D.C.
June 15, 2017

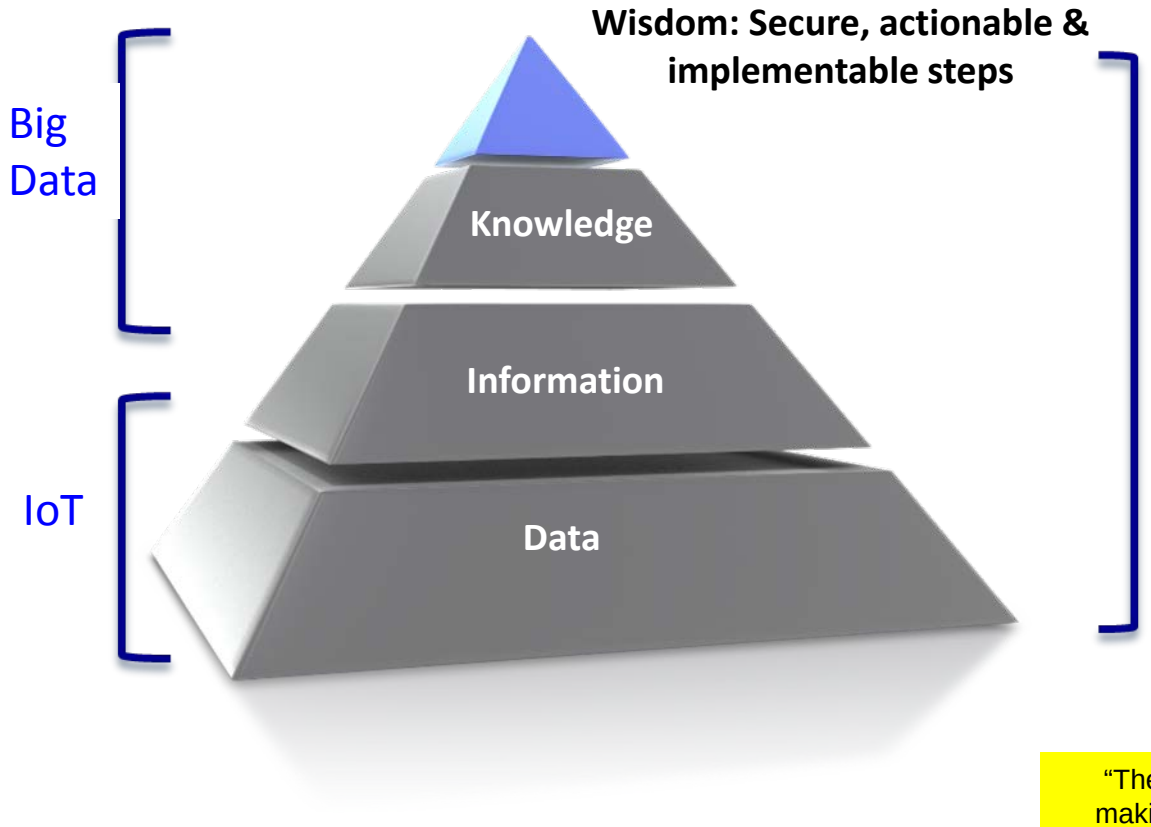
Discussion Outline

- The Smart Manufacturing Journey, and Value
- Challenges, Benefits, and Vision
- Successes
- Program Application Process/Business Engagement

Smart Manufacturing is a Journey

- Education – Optimize your MFG Process
- Understanding the VALUE you can achieve
- Trends, tools, workforce development
- Potential partners & mentors
- Setting an Integrated Vision
- Understanding where to start
- Being part of a community that shares knowledge

SMART Manufacturing



Smart Manufacturing

Accomplished through

- ***Open Architecture*** **– Multi-Vendor Compatible**
- ***Open Access*** **– low cost & easy to use**
- ***Open Market Place*** **– composable software libraries & data**
- **Open Market Place - Innovation**
- ***Trusted Data Broker***

"The collection of data is the start of digitization, making the systems smart is the journey" Bill Hill, CAMPS

Value Proposition…..Data as an asset

Manufacturing Process Optimization

- Improved quality, reduced scrap, uptime….
- Improved Margin, Profitability throughout the process:

ENERGY PRODUCTIVITY

ENERGY COST REDUCTION

- Develop a deep understanding of your Value Chain elements / partners / processes to understand the current problems you have OR want solved
- Untapped enterprise productivity and performance opportunities throughout small and medium companies
- Create new markets solutions and retrofit capabilities

Collaboration Benefits

Power of the CESMII Network

- Thought development circles: Vision, Exposure, Pull the Blinders off for what good looks like perspective
- Exposure to challenges at other organizations
- Make manufacturing “cool again” by engaging students earlier to testbeds, training, & skills
- Break the Paradigm of doing things the same way
- Low entry for SME’s for software integration: SW/HW integration, platform, high performance computing
- Certification of skills & resources; Workforce training at all levels for successful talent acquisition

Common Market/Sector Challenges

Multiple Industries

- Global Competitiveness
- Disruptive Technologies
- Siloed Information Systems & Management
- New Workforce skillsets & gaps
- Aging manufacturing infrastructure
- Security & Cyber-Security
- Identification of Energy as a key ingredient in the process

CESMII Vision

- *Enable and improve real-time decision making through the use of "data" as a key asset using platform solutions*
- *This is accomplished through collaborative testbeds to: "**Reduce Energy Cost & Improve Energy Productivity in US Manufacturing**"*
- *These tools allow businesses to identify & uncover opportunities in a faster, more effective, with a less costly approach then ever before impacting their productivity and profitability*
- *Create a sustainable ecosystem for users, providers to collaborate, test quickly & iterate with the best trained, certified workforce on the planet.*

Focused Efforts

Key Markets

People

Energy Intensive Markets

- Petroleum Refining
- Chemicals
- Plastics, Rubber
- Wood Pulp and Paper
- Primary Metals
- Food Processing
- Glass
- Cement

Energy Dependent Markets:

- Other Industries that have a significant cost of energy as part of the total cost of manufacturing

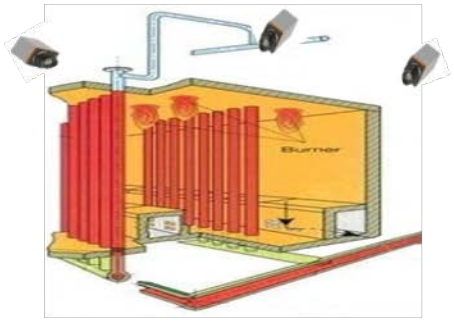
Setting the Bar High

US Department of Energy Goals for CESMII

- Double energy productivity in US manufacturing every 10 years
- Halve the cost of deploying SM systems relative to state of the art in 5 years
- Increase the SM workforce in US multi-fold in 10 years
- Double the SM supply chain adoption rate of increase in value and participation
- Reduce U.S. energy use in 10 years while increasing manufacturing competitiveness

Reducing Energy Intensity through Measurement & Operational Integration

First Steam Methane Reformer Furnace
Port Arthur, TX



- Already efficient
- Distributed sensing
- Distributed actuation (96 burners)
- High fidelity model & reduced order models

reduction wasted energy

reduction wasted energy

Simple Model

HPC Model

Reduce Cameras

Burner Controls

Halve capital cost

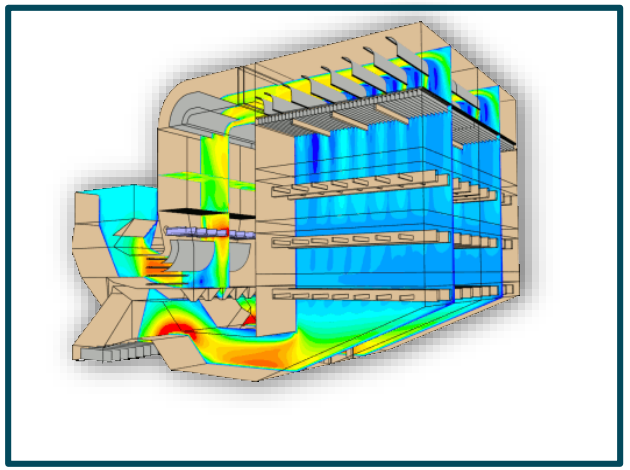
Dynamic energy management

Metrics

Praxair

Extend to 20 U.S. SMRs

Value Case: Steam Methane Reforming

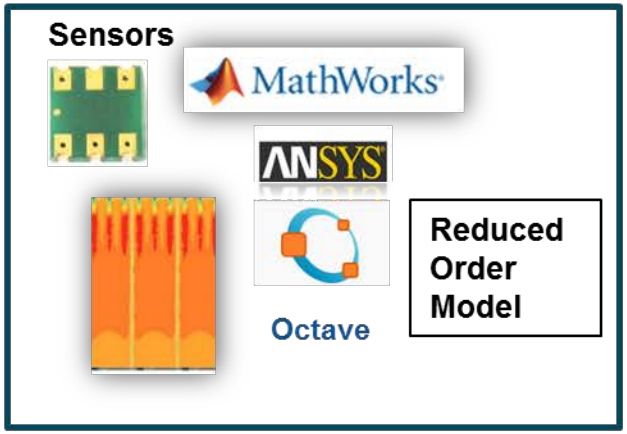


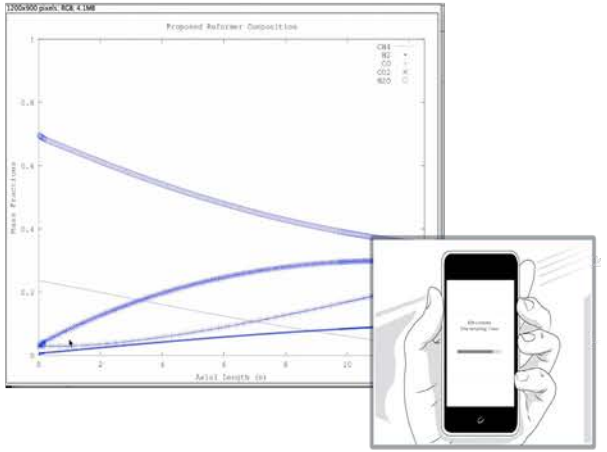
- **Bob is in engineering operations responsible for energy, product and customer demand productivity for several steam methane reformers (SMRs).**

- **Bob would like to check the performance of the reformers.**
- **Bob identifies an unfavorable high-temperature local regions on the surfaces of the tubes in the furnace**
- **Bob wants to evaluate new operating modes**

- **Bob evaluates the current operating modes via visualization tools and identifies that he needs to enter a new operating mode**

Value Case: Steam Methane Reforming





- Bob goes into the web portal to begin to evaluate different operating modes
- Bob specifies specific parameters

- Bob's systems have the proper sensors to collect data, provide input into sophisticated digital models for validation
- Bob enters new temperature conditions
- Bob submits the Smart Manufacturing enabled heterogeneous workflow toolkit that has been developed

- The workflow visualization tools display the result validating the new operating mode and estimated time to steady state with the new conditions
- Operations updates the set points on the furnace for the new operating conditions
- Bob can monitor performance on-site and off-site

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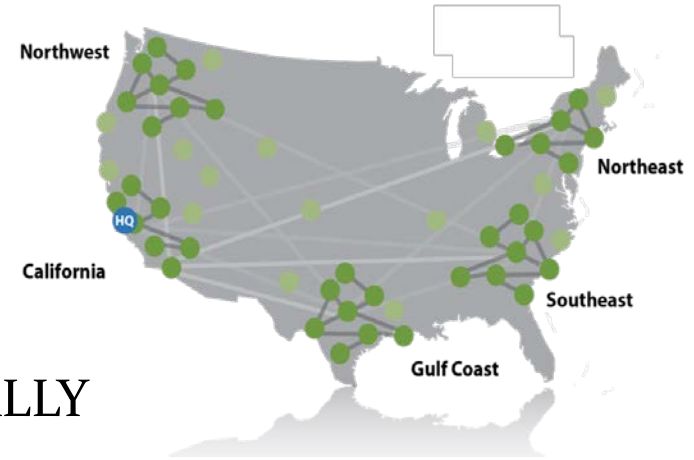
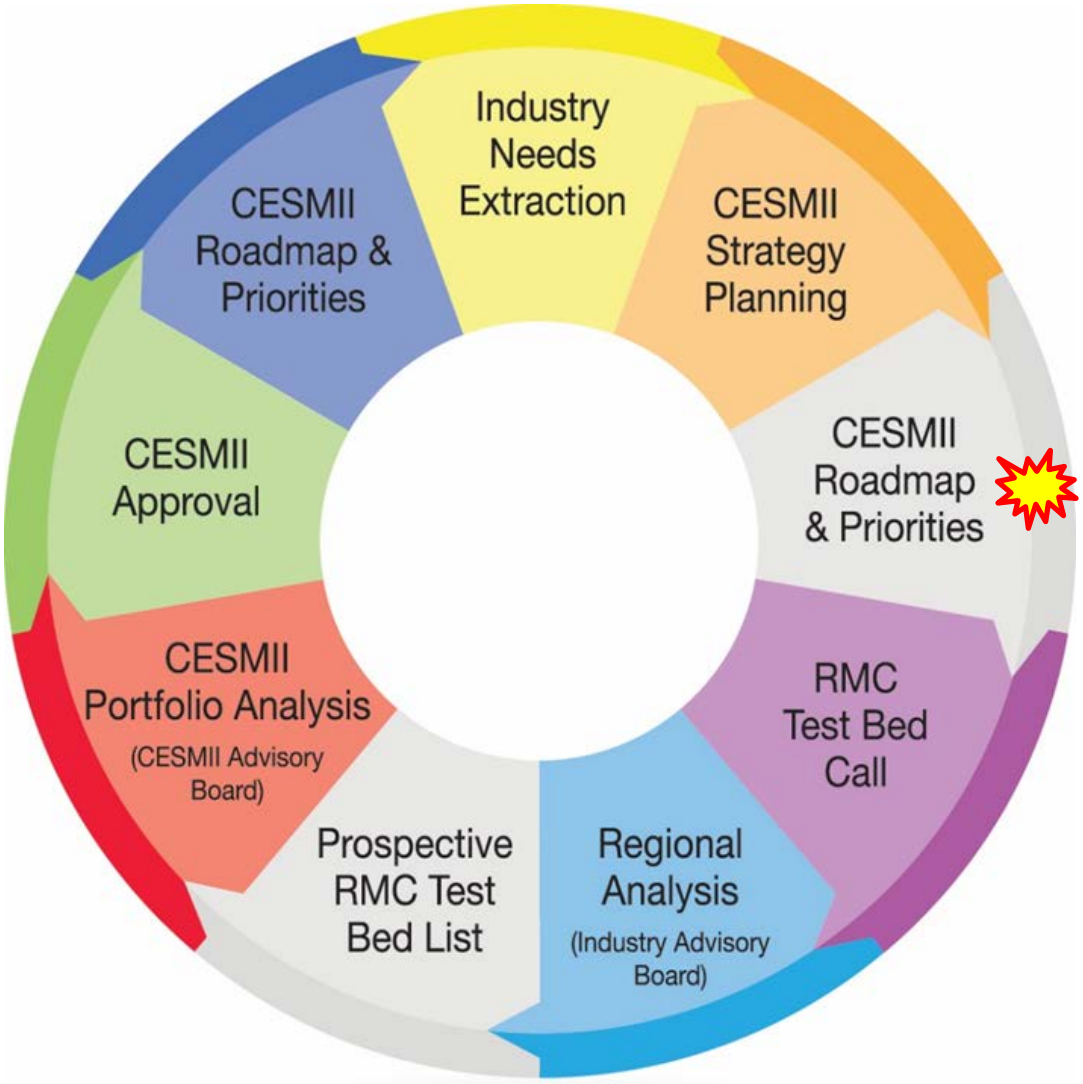
Regional Manufacturing Center's Across the USA

Power of your local to national network

- Key market and domain expertise
- Deep business, national lab, & academic relationships locally
- Connect you to CESMII resources NATIONALLY
- Manage Testbeds & Research programs
- Certified Local Training resources for your teams
- Identify industry needs across markets



Application Projects, Industry, RD&D Testbeds Programs



Engaging with CESMII

- Engage with the Local Regional Manufacturing Center (RMC) to access education and begin the journey
- Participate in workshops so you can learn & give us candid feedback & develop tools for your peers to use in their journey
- Join an affinity group around technology & marketplace challenges
- Identify the value of Smart Manufacturing for your Company through collaborative workshops and on-site visits to validate the impact
- Join the Institute
- Participate in Testbeds
- Set the Standard for the FUTURE, making USA Manufacturing the GLOBAL Standard!

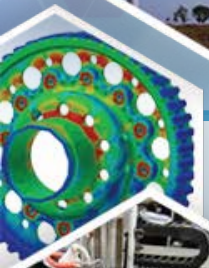
Membership Models

Basic annual membership to CESMII by size and type

Member Types
Large Companies (500+ employees/members)
Medium Companies (>100 and <500 employees/members)
Small Companies (<100 employees/members)
K-12 Educational
Academics, Govt. Labs, and Non-profits

Membership Types

1. National
2. Regional
3. Resource
4. Consortium


Institute for Advanced Composite Manufacturing Innovation

Contract No. DE-EE0006926
Project Team: Collaborative Composite Solutions Corporation
Project Period: June 2015 - May 2020

Bryan G. Dods
CEO, Collaborative Composite Solutions Corporation

U.S. DOE Advanced Manufacturing Office Technical Resources & Networking Meeting
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Program Objective

- The technical topic area for IACMI is low cost, energy efficient manufacturing of fiber reinforced polymer composites.
- The Composite Institute targets continuous or discontinuous, primarily carbon and glass fiber systems, with thermoset or thermoplastic resin materials.
- These types of composites are foundational technologies that are broadly applicable and pervasive in multiple industries and markets with potentially transformational technical and economic impact.

Overview

TIMELINE & BUDGET

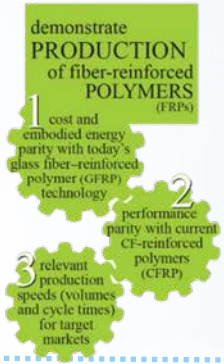
START
June 2015

END
May 2020

Total Budget: **$175M**

- Total cost share: **$105M**
- Total federal share: **$70M**
- Total DOE funds spent: **$19M**

TECHNICAL PROJECT GOALS



TECHNICAL AREAS

WIND ENERGY
Derek Berry, NREL

VEHICLES
Lawrence Drzal, MSU

COMPRESSED GAS STORAGE
Brian Rice, UDRI

CROSS-CUTTING AREAS

MATERIALS & PROCESSING
Cliff Eberle, ORNL

MODELING & SIMULATION
Byron Pipes, Purdue University

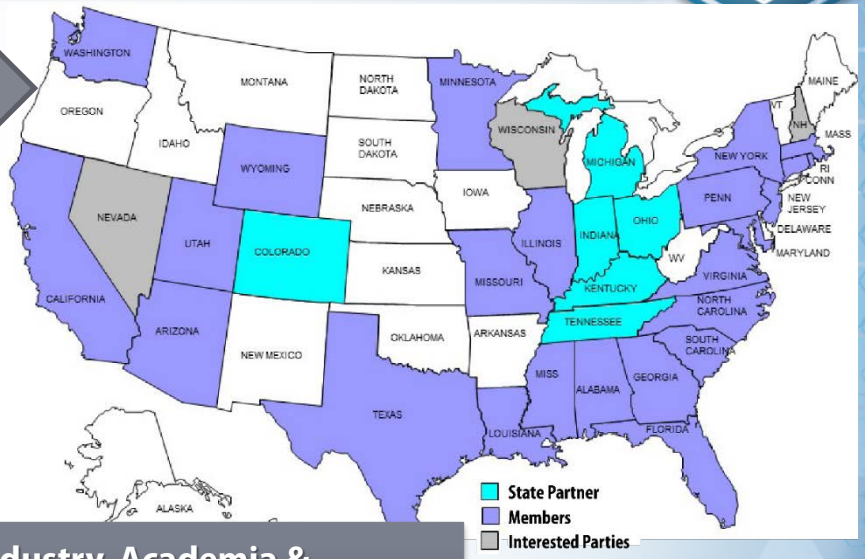
Transition and Deployment: Membership

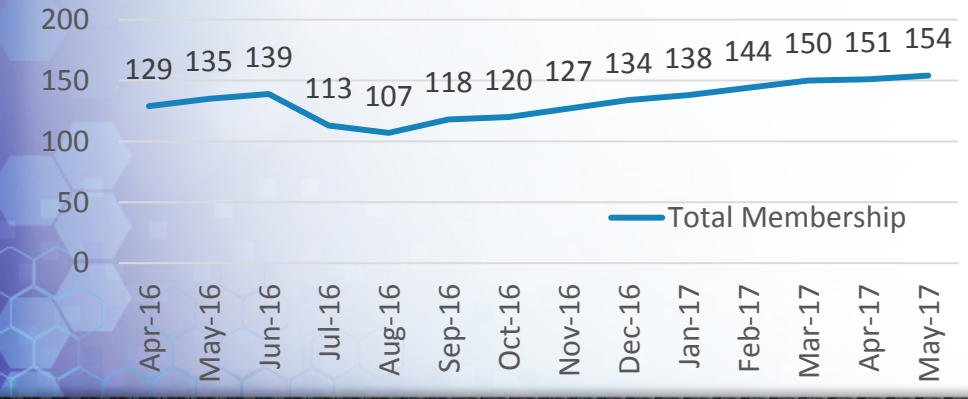
154 Members

9 Charter
13 Premium
8 Resource
122 Consortium
1 associate
1 community college

Representing 34 States

Note: This information includes members in good standing (dues paid). There are approximately 6 additional members in progress.





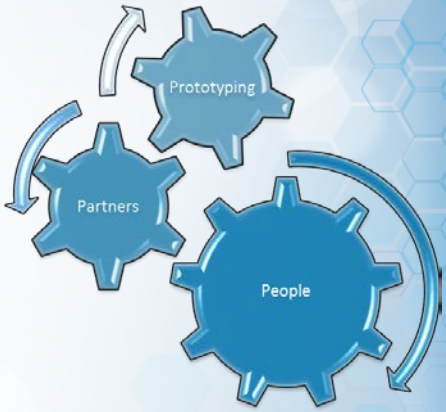
Industry, Academia & Government Stakeholders

Academia: 13
Association: 6
Government: 9
Large Enterprises: 48
Small to Medium-Sized Enterprises: 81

*Updated 5/24/17

Technical Approach

Create Industrial Innovation Collaboration Centers proximity of manufacturing hubs



Application Areas

Vehicles • Compressed Gas Storage • Wind

Focus Areas

Energy • Speed • Recycling

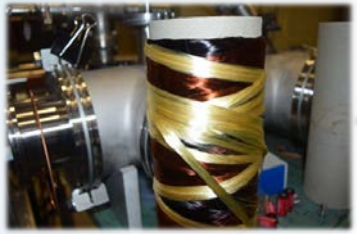
Enabling Technology Areas

Design • Simulation • Joining

Nondestructive Evaluation • Materials

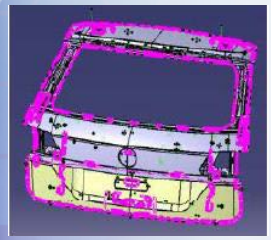
Shared spaces catalyzing ideas, expediting R&D

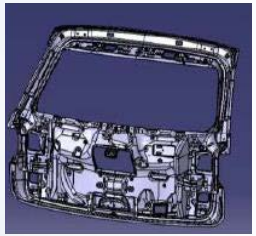
Technology Innovation



Low Cost
Carbon Fiber /
Recycled Fiber

Dry Fabric, Prepreg,
Chopped Fiber, Tow,
SMC, Pultrusion,



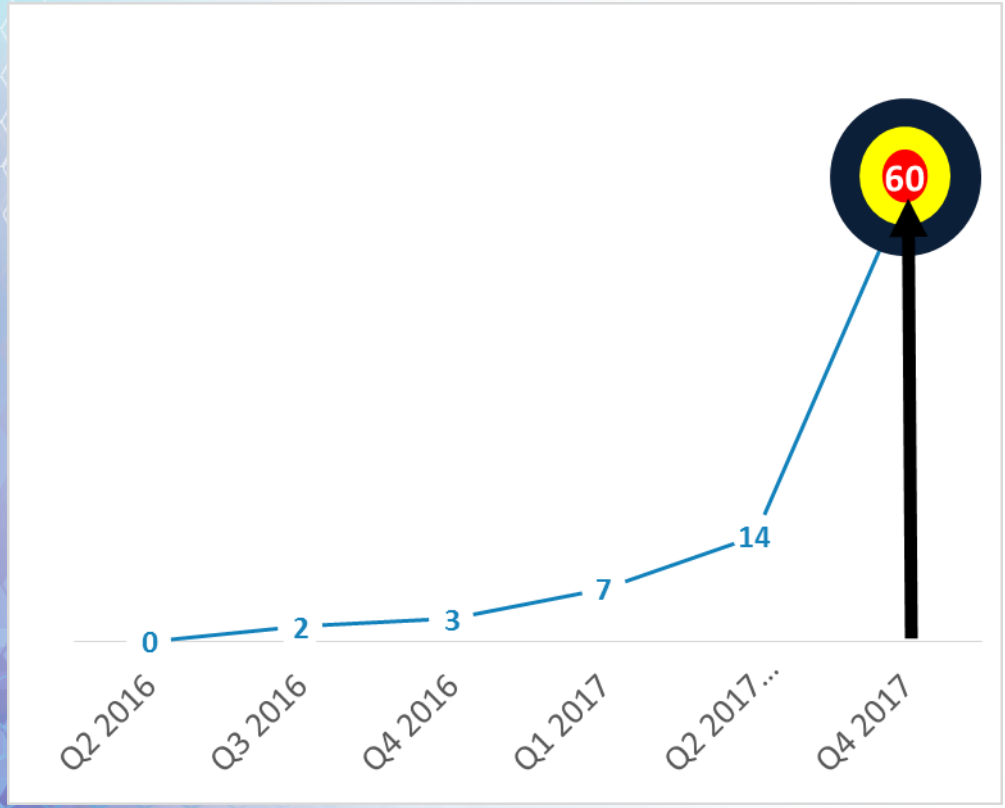


New Designs – 50% faster,
90% part count reduction

Integrated modeling & simulation suite running on
high performance computing platform

Automation and Material Systems
with < 3 minute cycle times

Industry's Research and Development Partner: Projects



- ***Project Team*** assembled with specific functions to guide you through the entire process
- ***White Paper Proposal Process*** streamlined from concept to proposal to award with less duplication of effort
- ***Member Portal*** designed for members to easily interact and pioneer new project ideas
- ***Shift*** to proactive project development

Results: Collaborative Manufacturing Innovation: 9M Wind Blade
January 2017, 11 Industry Partners

DOWAKSA

CHOMARAT

COMPOSITES ONE

Johns Manville

CREATIVE FOAM CORPORATION

OAK RIDGE National Laboratory

STRONGWELL

Chem Trend

ARKEMA INNOVATIVE CHEMISTRY

tpi COMPOSITES

Axson

BUILDING TRUST

Sika

HUNTSMAN

Results: Outcomes, Dupont Project

Thermoplastic composite parts manufacturing enabling high volumes, low cost, reduced weight with design flexibility

DUPONT®

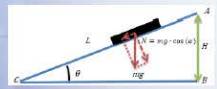
FIBRTEC composite materials made simple for advanced applications

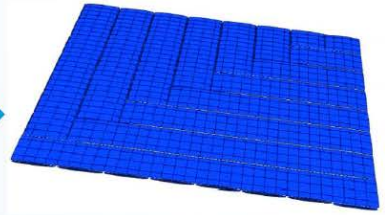
PURDUE UNIVERSITY

COMPOSITES DESIGN & MANUFACTURING HUB

Tow Modulus

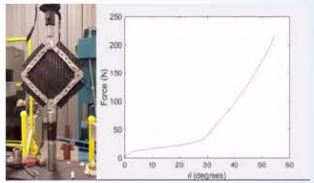
Tow Friction





Unconsolidated RFF Unit Cell Model

Picture Frame Test



Results: Recent Announcements = Economic Impact

TORAY
500 jobs
$1B investment
South Carolina

1,000 jobs
$6.2M investment
Tennessee
LEISURE POOLS
SWIMMING IN QUALITY AND STYLE

TEIJIN
242 jobs
$600M investment
South Carolina

2015 2016 2017

LIFETIME

115 jobs
$115M investment
Tennessee

70 jobs
$12M investment
Tennessee
MVP
MAGNUM VENUS PRODUCTS

Results: Composite Workforce Training

Two-day training workshops held at IACMI facilities in partnership with Composites One and the Closed Mold Alliance

Workforce 2017:
480+ Workshop Participants, representing 35+ states and companies such as Tesla and GM

Our team at Siemens Wind Power sent sixteen new employees to the 2017 workshop to gain experience and insight as part of their on-boarding program."
– Jacques Nader

- **LIVE DEMONSTRATIONS** of the latest technology and equipment
- Sessions including **DRONE INSPECTIONS, BLADE REPAIR and more…**

Built2Last

Vanderbilt University
February 2017

Composites in Wind

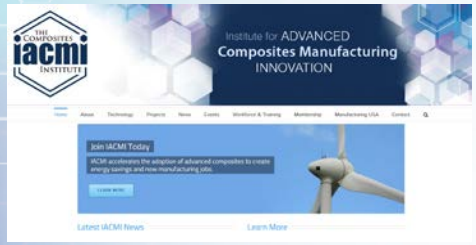
National Wind Technology Center
April 2017

Road2Composites

Michigan State University
May 2017

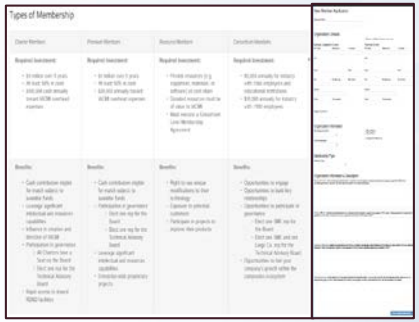
The fourth workshop this year will be held in Indiana November 7-8th

Preparing an IACMI Project



1. Visit www.iacmi.org

2. Read the RFP



3. Become an IACMI member

4. Form a team – there are 150+ members to choose from

5. Submit White Paper

Critical Materials Institute

11 Corporations, 7 Universities, 4 National Labs
Led by the Ames Laboratory

Alex King, The Ames Laboratory
CMI Director

Advanced Manufacturing Office Technical Resources & Networking Forum
Arlington, VA
June 15, 2017

You can’t make it without materials

H																	He
Li	Be											B	C	N	O	F	Ne
Na	Mg											Al	Si	P	S	Cl	Ar
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
Cs	Ba	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
Fr	Ra	Ac	Rf	Db	Sg	Bh	Hs	Mt	Ds	Rg	Cp		Fl		Lv		

Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu
Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr

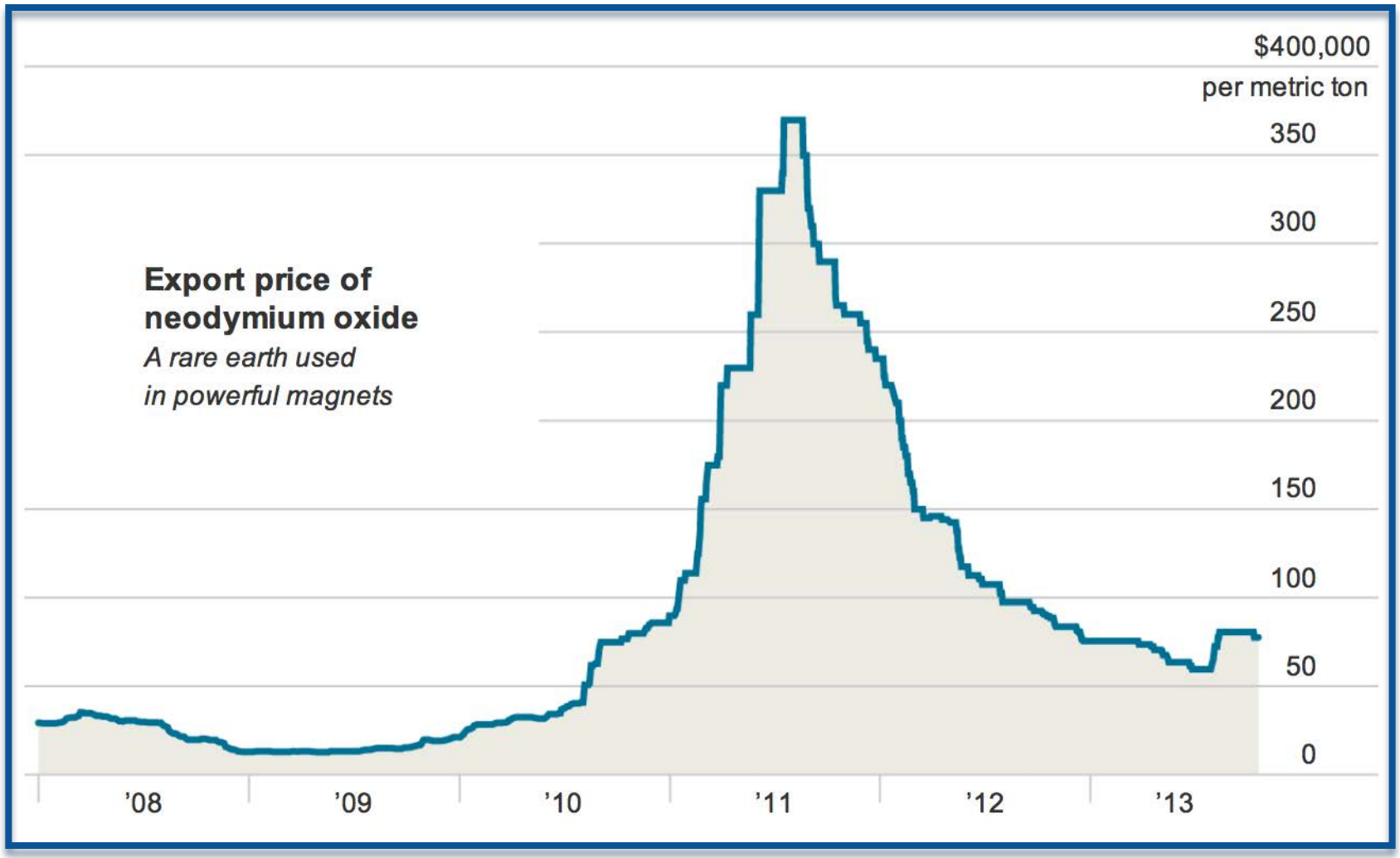
~30 elements

H																	He
Li	Be											B	C	N	O	F	Ne
Na	Mg											Al	Si	P	S	Cl	Ar
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
Cs	Ba	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
Fr	Ra	Ac	Rf	Db	Sg	Bh	Hs	Mt	Ds	Rg	Cp		Fl		Lv		

Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu
Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr

~75 elements

We work on ***critical*** materials



Price Graphic: *New York Times*, 10-22-2013

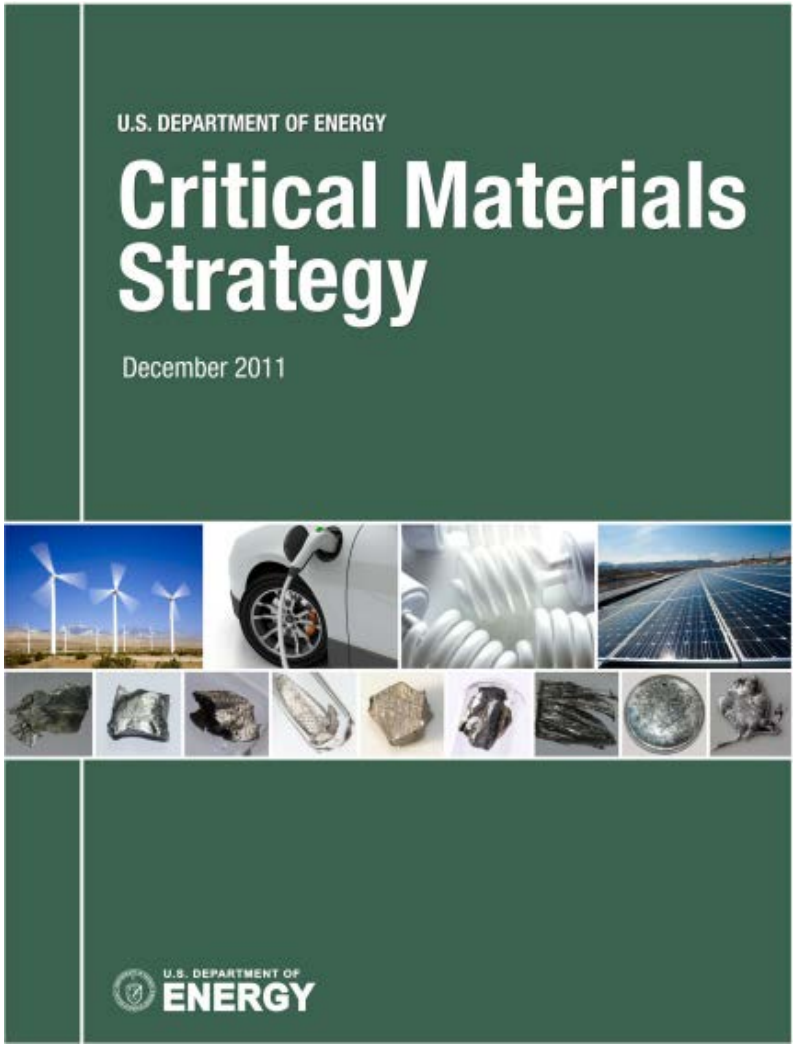
This presentation does not contain any proprietary, confidential, or otherwise restricted information.

Who do we work with?

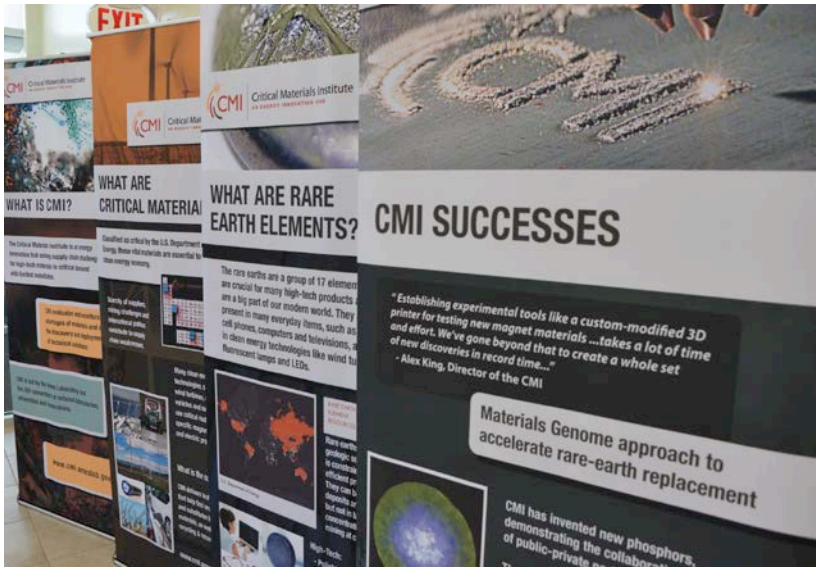
- Companies that need materials
- Companies that help to provide materials

Technical Approach

- Diversify sources;
- Provide alternatives to the existing materials;
- Make better use of the existing supplies through efficient manufacturing, recycling and re-use.



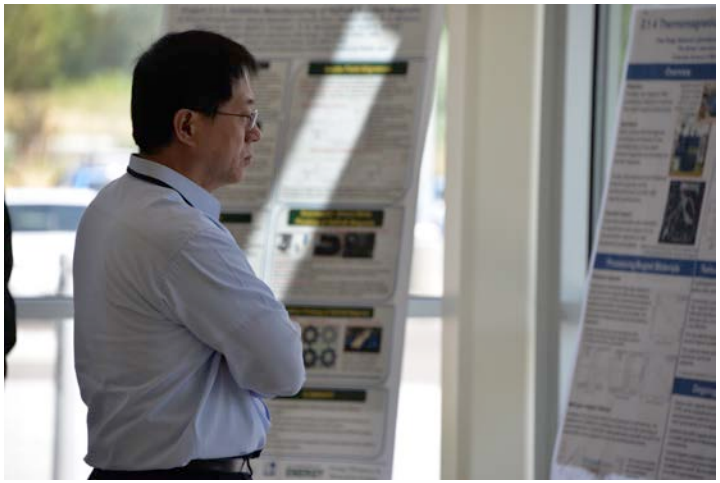
Industrial Engagement Programs



- Team Members
  - Participate in CMI research projects
  - Share in the research costs
  - Participate in the IP management plan
- Associates
  - Sponsor research using CMI's assets
  - May wholly own the resulting IP, subject to DOE rules & regulations
- Affiliates
  - Participate in CMI meetings and information streams
  - Pay an annual membership fee
  - Get an "early look" at CMI intellectual property

This presentation does not contain any proprietary, confidential, or otherwise restricted information.

Who can join the CMI Affiliates Program?



- U.S. Corporations, Associations, Academic Institutions and Government Agencies…
  - …that are involved in some significant fashion in the materials supply chain for clean energy technologies.
- Foreign entities of the same kinds…
  - …with the approval of the U.S. Department of Energy.

What are the principal benefits to the Affiliates?

- CMI bi-weekly newsletters and CMI monthly webinars
- Priority notification of inventions available for licensing, to the extent allowed by Fairness of Opportunity requirements
- CMI Annual Meetings and Topical Workshops
- Opportunities to interact with (and potentially recruit) CMI graduate students, postdocs
- Partnering for new funding opportunities
- Opportunities to expand engagement under appropriate contractual terms

What is the annual cost to be an Affiliate?

- ***$500 per year*** for start-up companies*, universities, not-for-profits, and FFRDCs.
- ***$2,500 per year*** for entities not defined above.
- ***No fee*** for federal agencies, providing member benefits to staff who are government employees.

*Less than 5 years old and/or not having completed an IPO

Technology Adoption

- 60+ invention disclosures
- 35+ patent applications
- 2 patents awarded
- 5 technology licenses issued