M-TECH INTERNATIONAL LLC

"2014 NSF Nanotechnology Commercialization Study: Implications for Michigan's Manufacturers"

2015 Greenup Michigan, Ann Arbor, 11/4/2015

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2014 NSF Study of Nanotechnology in the U.S. Manufacturing Industry
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Dr. Bruce Kramer, Program Director, NSF

National Center for Manufacturing Sciences – Final Report

SURVEY DISSEMINATION PARTNERS

Center for High-rate Nanomanufacturing

Nanomanufacturing Weekly

NanoBusiness COMMERCIALIZATION ASSOCIATION

MRS Materials360 The Global View

NACFAM National Council for Advanced Manufacturing

ASM INTERNATIONAL

itecs INNOVATIVE technology market development

THE BATTERY SHOW The Expo for Advanced Batteries

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SOLID STATE TECHNOLOGY

Extension Media

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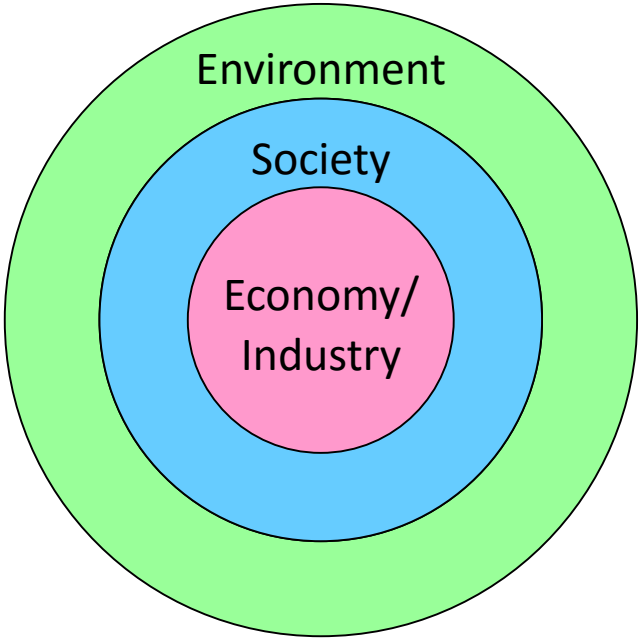
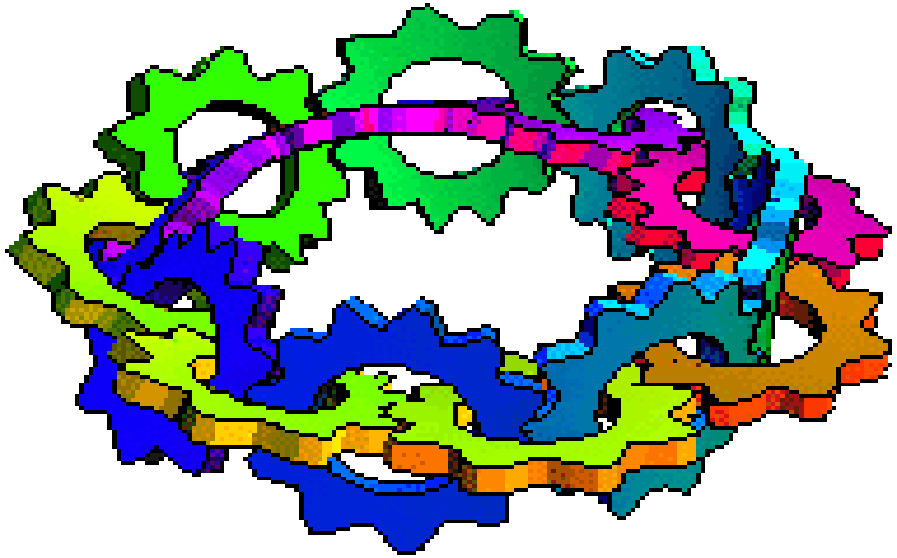
Interdependent, Interacting Eco-Systems

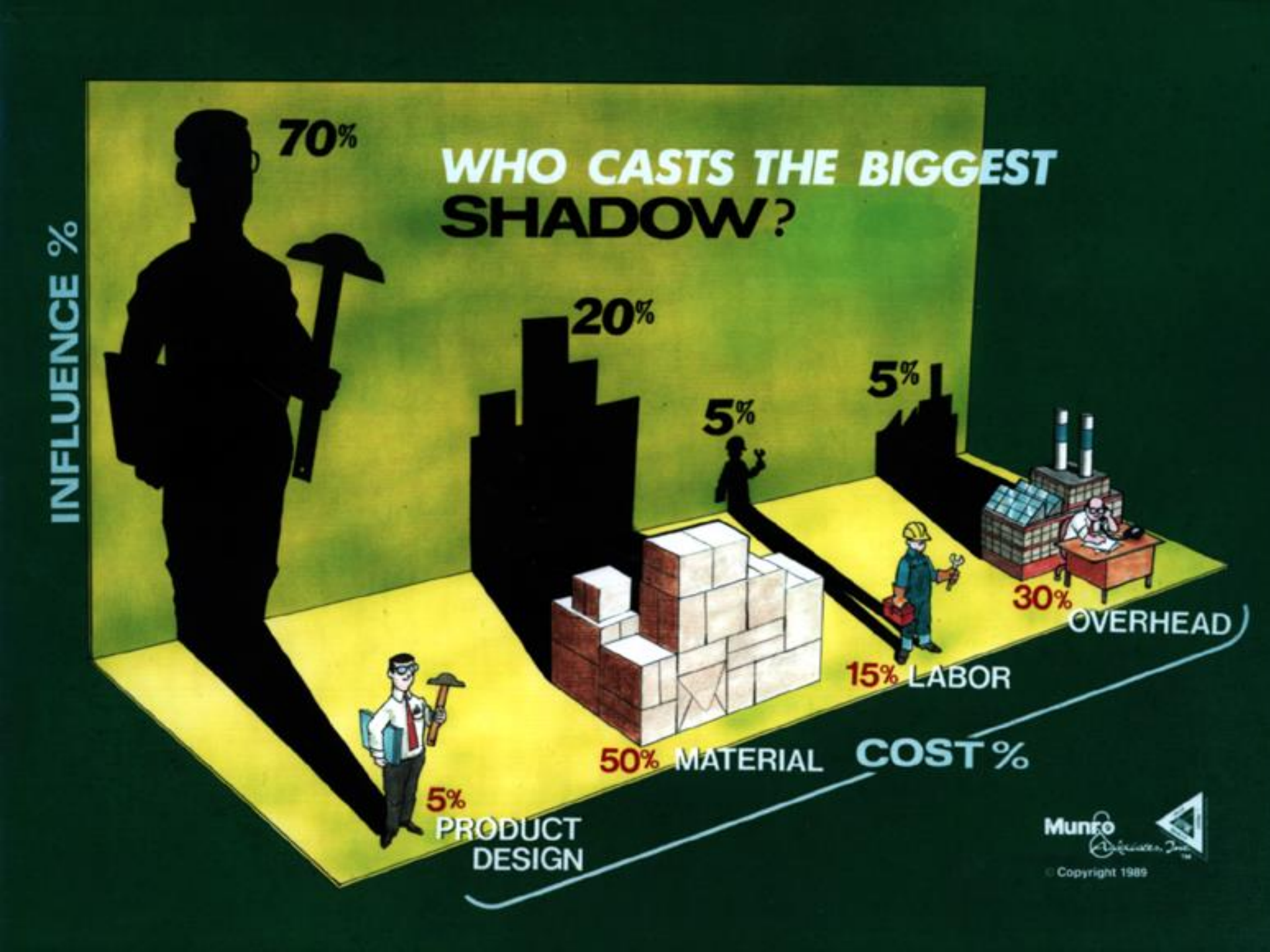




Source: HereNow4U.de, Eric Weisstein “Mobius Strip”

Need to simultaneously consider all three systems

The interaction between the economy and the environment, and complexity of socio-business problems connected with sustainability warrants collective action.

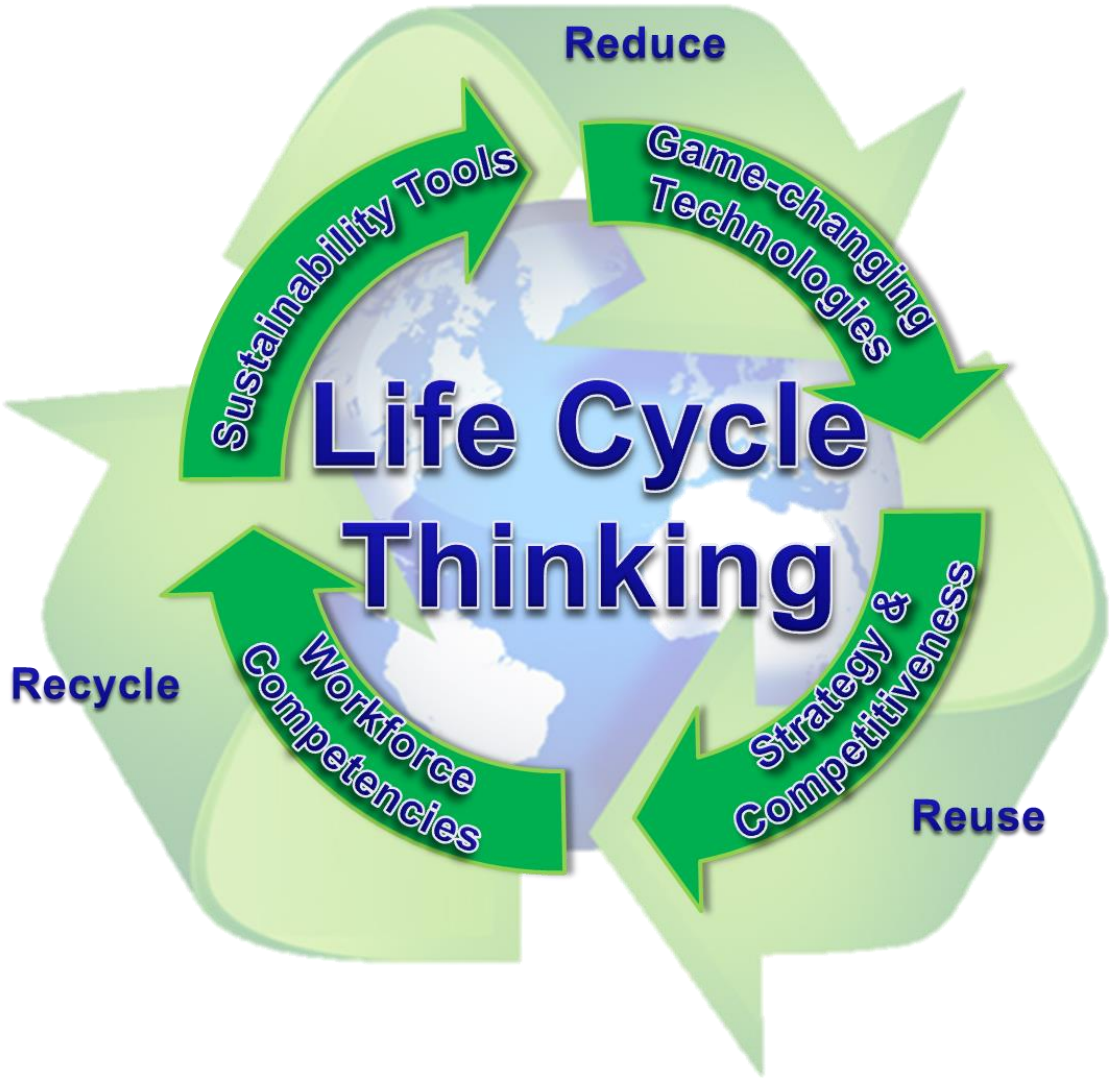

WHO CASTS THE BIGGEST SHADOW?
INFLUENCE %
70%
20%
5%
5%
30%
OVERHEAD
15% LABOR
50% MATERIAL
COST %
5%
PRODUCT DESIGN
Munro
Copyright 1989

The Graveyards of the World…


What does green mean?

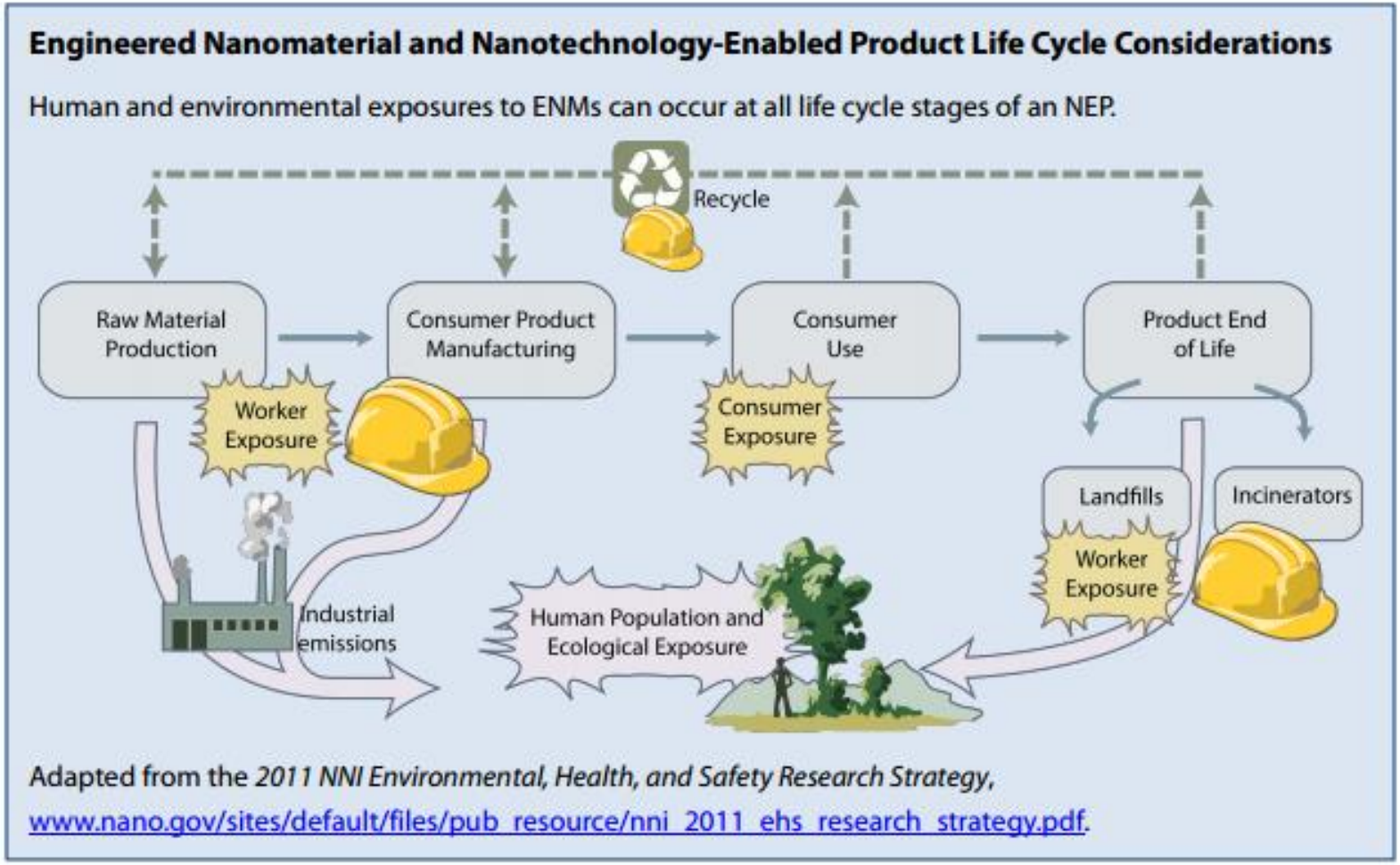
Sustainable = Technologies That…

- **Reduce** Impact on Life forms (human, animal, plant)
  - Toxic Effects
- **Reduce or Conserve** Finite Resources
  - Energy, Air, Water, Raw Materials, Fuel, Manpower
- **Reduce** Materials or Processing Required to Achieve Similar Function or Use
  - Lightweighting, Multifunctional, Nanotechnology
- **Reduce** Waste and Emissions
- **Ensure** Fairness to Stakeholders
- **Enhance** Safety to Operators and End users



Anticipate and document all stages of the product's life cycle and estimate the impacts, prior to taking key design-related decisions.

LIFE CYCLE CONSIDERATIONS OF NANOPARTICLES



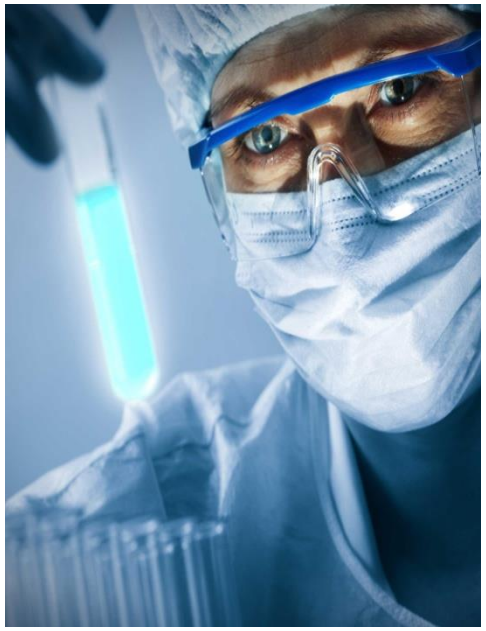
Referenced in NNI Strategic Plan, February 2014, p34.

Achieving Sustainable Nano-Products

4 NSF-Sponsored Studies Conducted by NCMS:

- 2003
- 2006
- 2009
- 2014

~1200 datasets on nano-organizations



Objectives:

- Assess NNI's Impact
- Industry Benchmarks
- Key Issues/Barriers
- Policy Feedback

Nanotechnology Is At the Heart of All Innovations!

LED Lighting

Precision Manufacturing

Green Chemistry

Water Treatment

CleanTech/Renewables

Biotechnology

Personalized Medicine

Electronics

Precision Agriculture

Aero/Auto/Defense Structures

Performance Coatings

Tools & Instrumentation

Food Processing

Biomimicry

Optics/Photonics

Smart Grid/Devices

Nano-scale Product Design, Engineering, Manufacturing, Characterization

NANOTECHNOLOGY PRODUCTS ARE EVERYWHERE

M. Mehta, M-Tech

NANOTECHNOLOGY IS EVERYONE'S BUSINESS…

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20 Nano-Commercialization Factors

1. Geographic Location/Clustering
2. Org Role in Nano-Value Chain
3. Respondent's Org Function
4. Nanotech Application Markets
5. Coping with Nano-Strategy
6. Corporate Priority for Nanotech
7. Organization Capacity
8. Available Infrastructure
9. Interactions with FFRDCs, NSERCs
10. Open-Innovation/Collaboration
11. Offshoring of Development
12. Direct Staffing
13. Commercialization Timelines
14. *Nano*-Product Type(s)
15. Technology/Manufacturing Readiness Levels
16. Sustainability/Eco-Labeling
17. Role of Government
18. Key Challenges & Barriers
19. US Leadership/Competitiveness
20. Externalities, Workforce, STEM

32-Question Online Survey = A Wellness Scorecard!

Global data portal at www.usnanosurvey.org

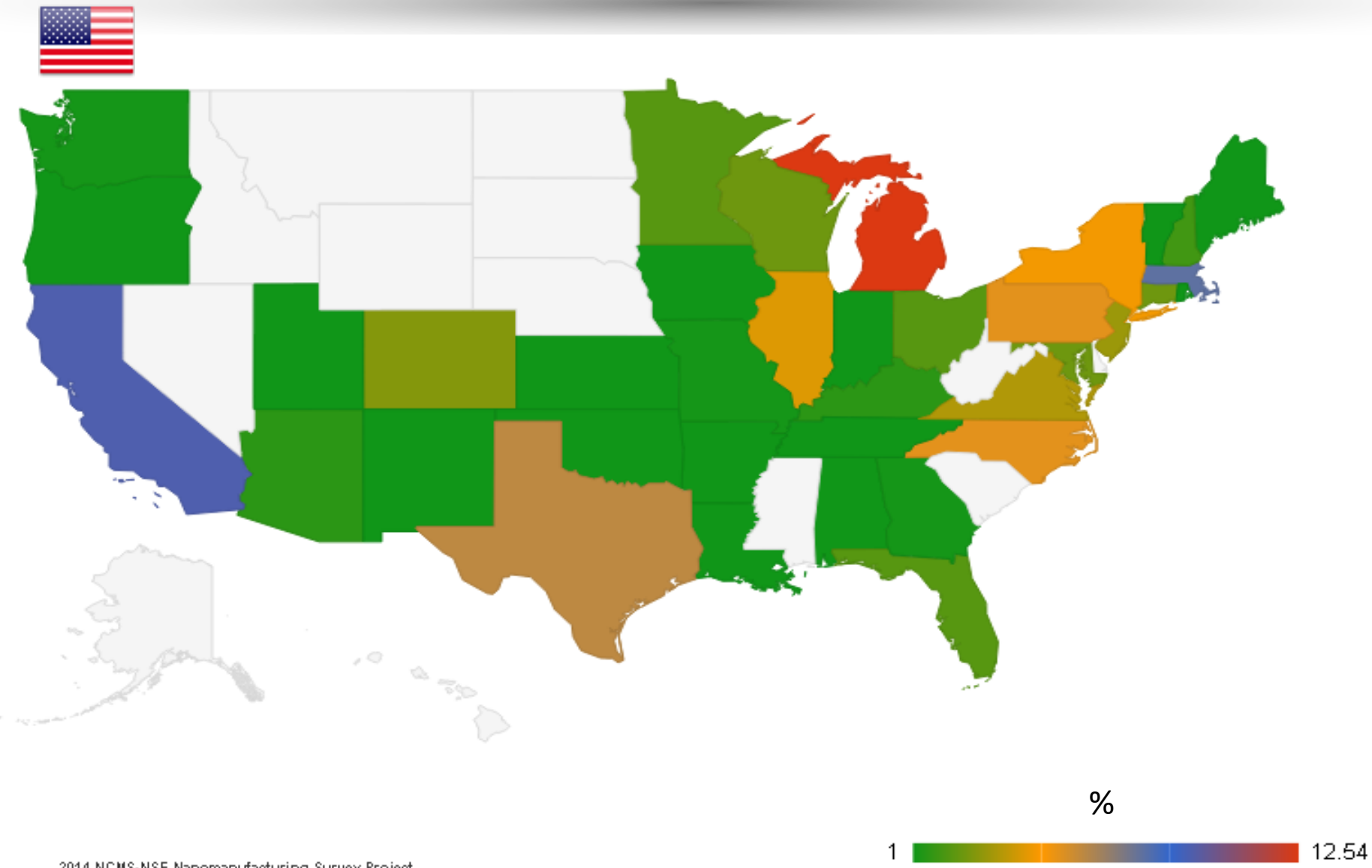
DISCLAIMER

While every effort has been made to verify the accuracy of the information presented herein, neither NCMS nor the sponsor of this report can accept any responsibility or liability for reliance by any person or entity solely on the contents of this report. Any opinions, findings, conclusions or recommendations expressed in this report are those of the author, and do not represent the views of the United States Government or any agency thereof.

"There are lies, damned lies, and statistics!"

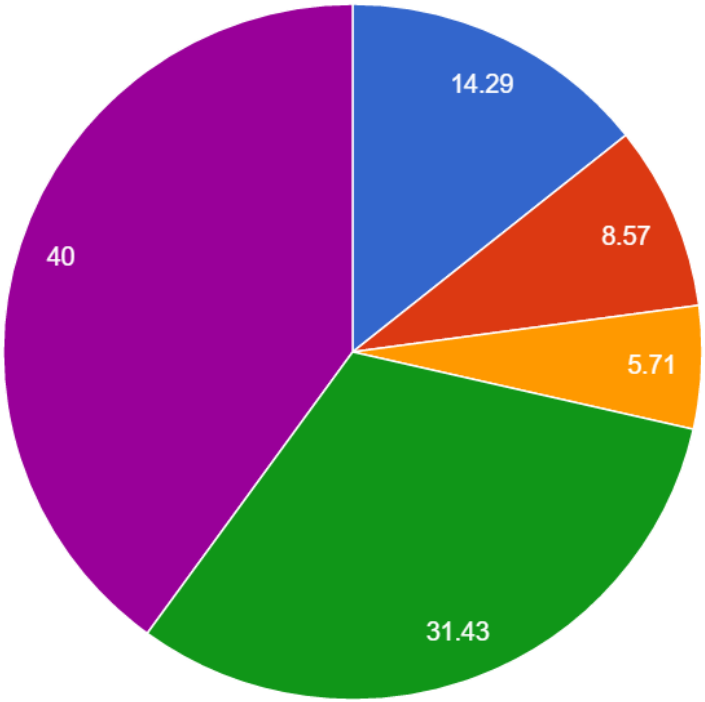
- Mark Twain

DISTRIBUTION OF ~300 SURVEY RESPONDENTS



COMMERCIALIZATION STAGE – MICHIGAN (35)

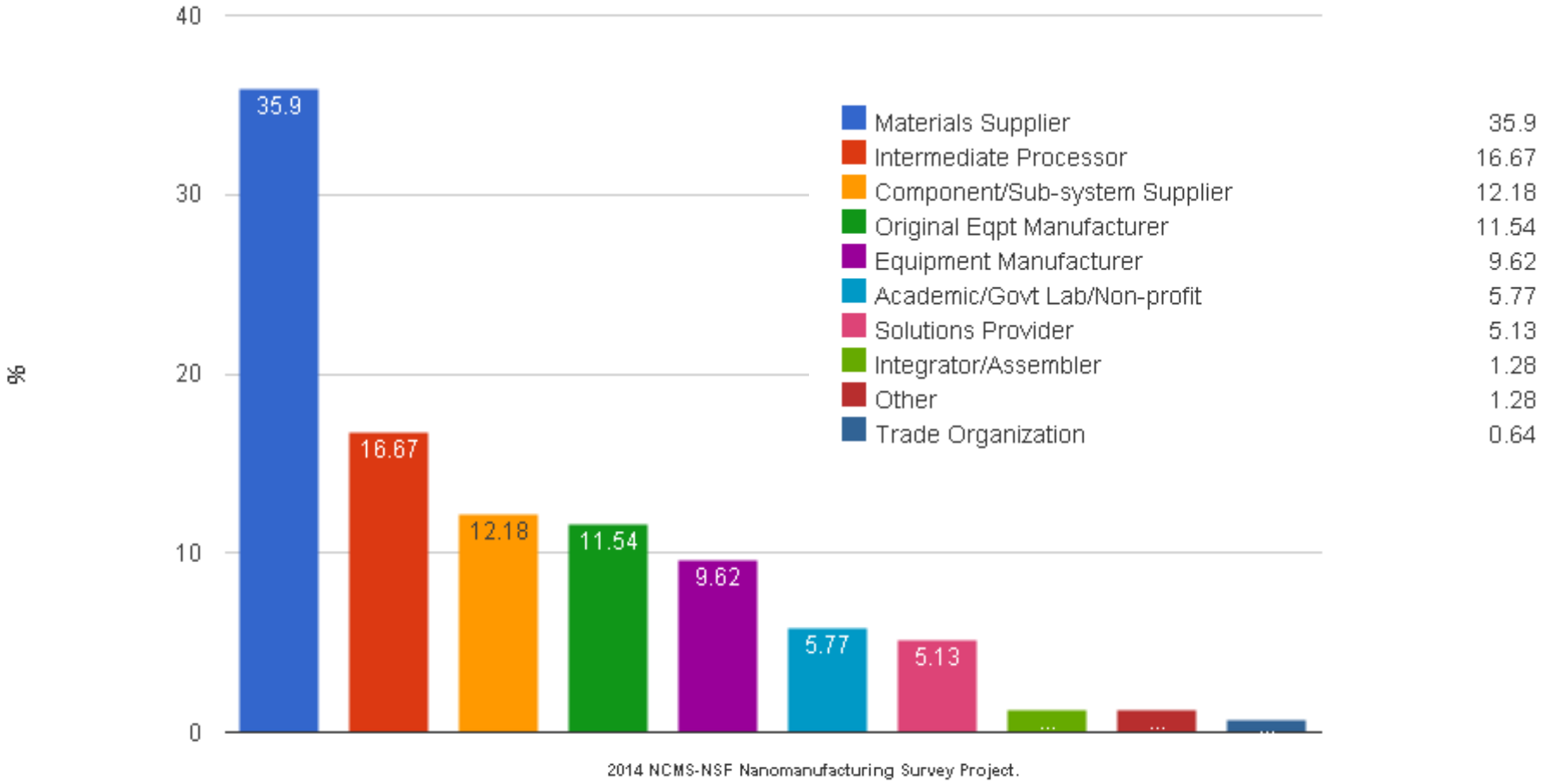
1 in 3 respondents were from established corporations,
1 in 5 from startups



Early Stage Startup	14.29
Late Stage Startup	8.57
Growth Phase Corp	5.71
Established or Diversified Corp	31.43
Not a manufacturer	40

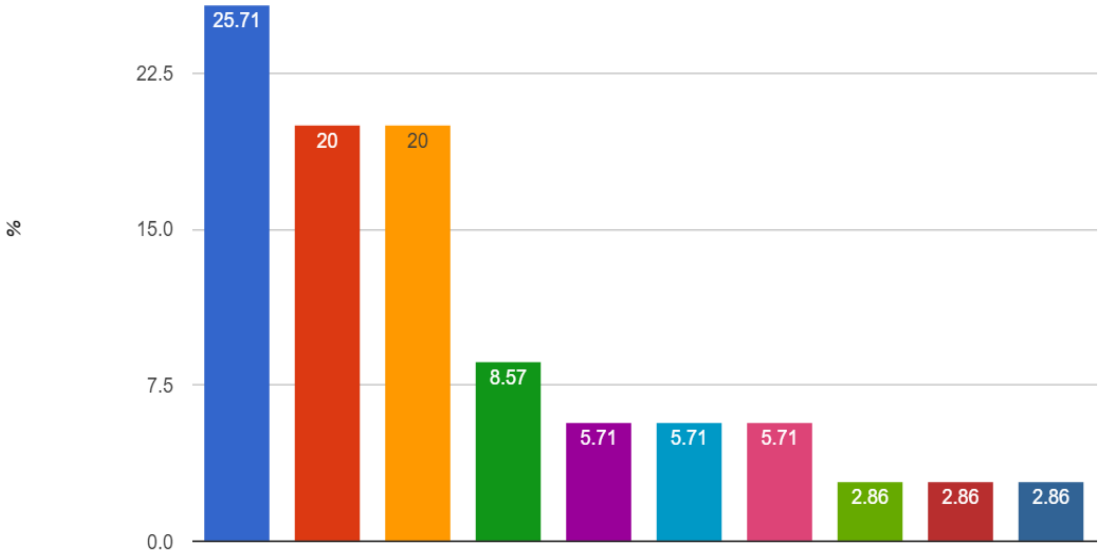
ORGANIZATION ROLE IN NANO-VALUE CHAIN - MANUFACTURERS

Suppliers of engineered nanomaterials and intermediate processors dominated the manufacturer list.



ORG ROLE IN NANO VALUE-CHAIN: MICHIGAN (35)

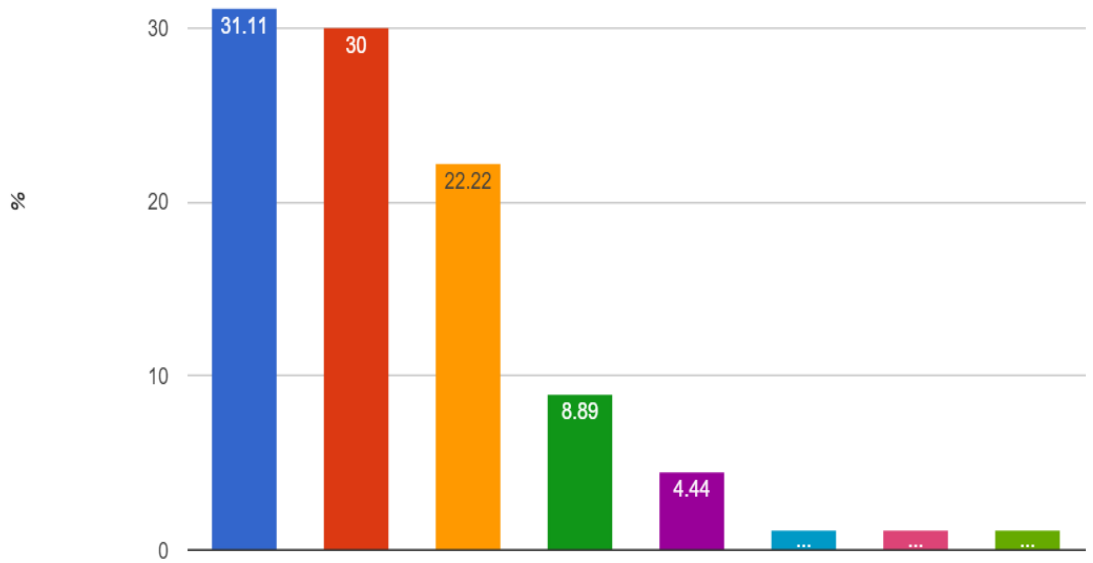
Academic Researchers, Materials Suppliers & Systems Integrators Dominate Michigan's Nano-space



2014 NCMS-NSF Nanomanufacturing Survey Project.

Academic/Govt Lab/Non-profit	25.71	Materials Supplier	20	Solutions Provider	20
Intermediate Processor	8.57	Integrator/Assembler	5.71	Trade Organization	5.71
Other	5.71	Component/Sub-system Supplier	2.86	Equipment Manufacturer	2.86
Original Eqpt Manufacturer	2.86				

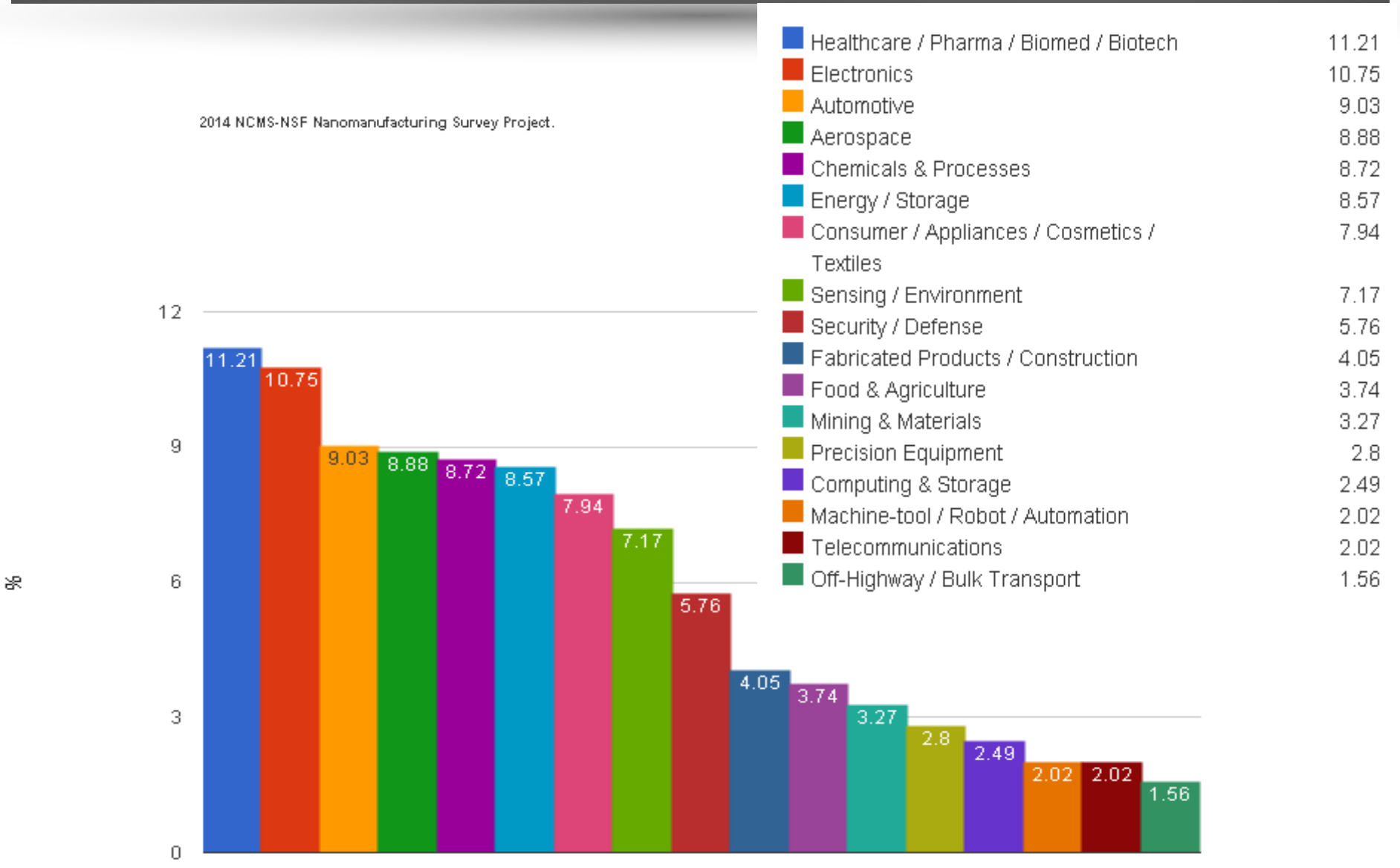
NANOTECH DRIVERS – MICHIGAN (35)



2014 NCMS-NSF Nanomanufacturing Survey Project.

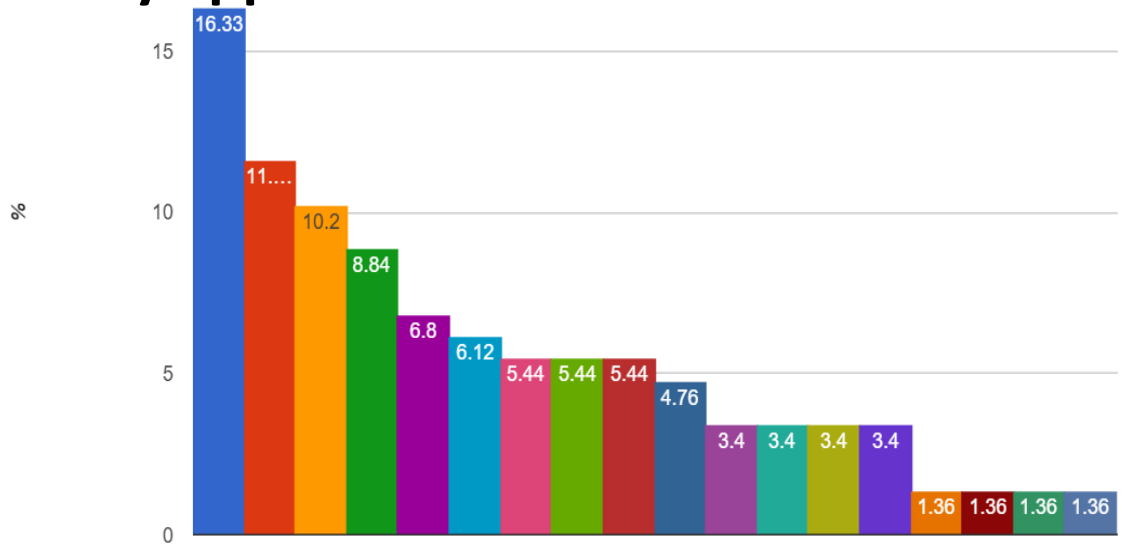
New product or service	31.11	Superior performance	30	Improve manufacturing	22.22
Enhance competitiveness	8.89	Reduce EH&S footprint	4.44	Compliance to regulations	1.11
Conserve resources	1.11	Other	1.11		

APPLICATION MARKETS – MANUFACTURERS



APPLICATION MARKETS – MICHIGAN (35)

Automotive, Aerospace, Energy/Storage and Healthcare are the primary application markets for nanotechnology in Michigan



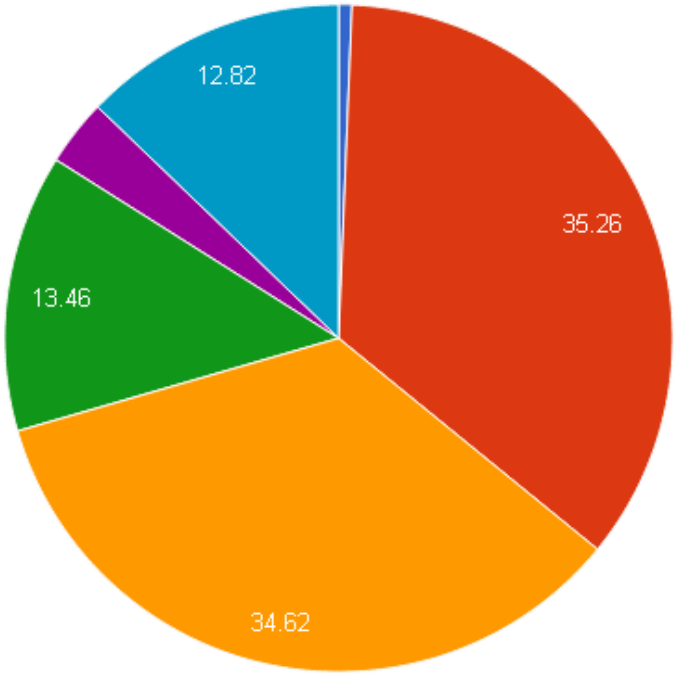
2014 NCMS-NSF Nanomanufacturing Survey Project.

Automotive	16.33	Aerospace	11.56	Energy / Storage	10.2
Healthcare / Pharma / Biomed / Biotech	8.84	Consumer / Appliances / Cosmetics / Textiles	6.8	Sensing / Environment	6.12
Chemicals & Processes	5.44	Security / Defense	5.44	Electronics	5.44
Machine-tool / Robot / Automation	4.76	Off-Highway / Bulk Transport	3.4	Precision Equipment	3.4
Mining & Materials	3.4	Fabricated Products / Construction	3.4	Food & Agriculture	1.36
Other	1.36	Computing & Storage	1.36	Telecommunications	1.36

OPEN INNOVATION - MANUFACTURERS

About 50% manufacturers are involved in Open Innovation.

47% indicated no involvement in Open Innovation for nanotechnology, or Don't know.



Other	0.64
Not involved with OI in nanotech	35.26
Occasionally participate in OI	34.62
Routinely participates/invests in OI	13.46
Proven OI record with nano-product(s)	3.21
Don't know	12.82

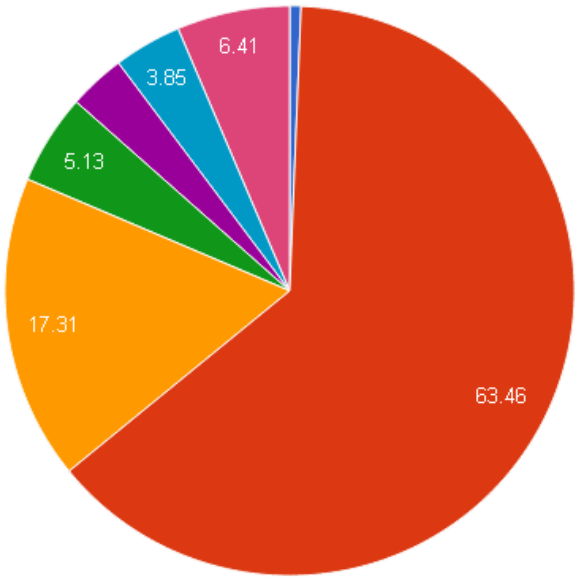
Types of O-I Practices	(%)
Seek specialized resources	**25**
Leverage subject matter expertise	**20.33**
Seek co-development partners	**21.67**
Technology-scouting / investment	**11.33**
Fund / pursue challenge awards	**5.0**
Don't know	**15.33**

2014 NCMS-NSF Nanomanufacturing Survey Project.

OFFSHORE DEVELOPMENT – MANUFACTURERS

63% manufacturing respondents indicated nanotechnology is entirely developed in the U.S.

25% indicated offshore nanotechnology developments.

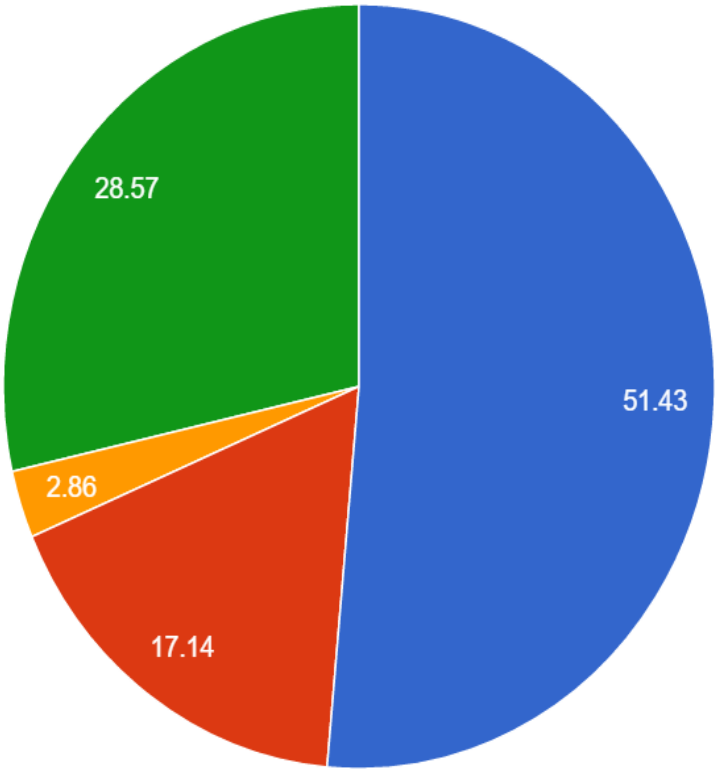


Other	0.64
Entirely developed in the U.S.	63.46
Some offshore development/trials	17.31
Significant offshore development/trials	5.13
Substantial offshore development/trials	3.21
Entirely developed/trialed/deployed offshore	3.85
Don't know/Not Applicable	6.41

2014 NCMS-NSF Nanomanufacturing Survey Project.

OFFSHORE R&D - MICHIGAN

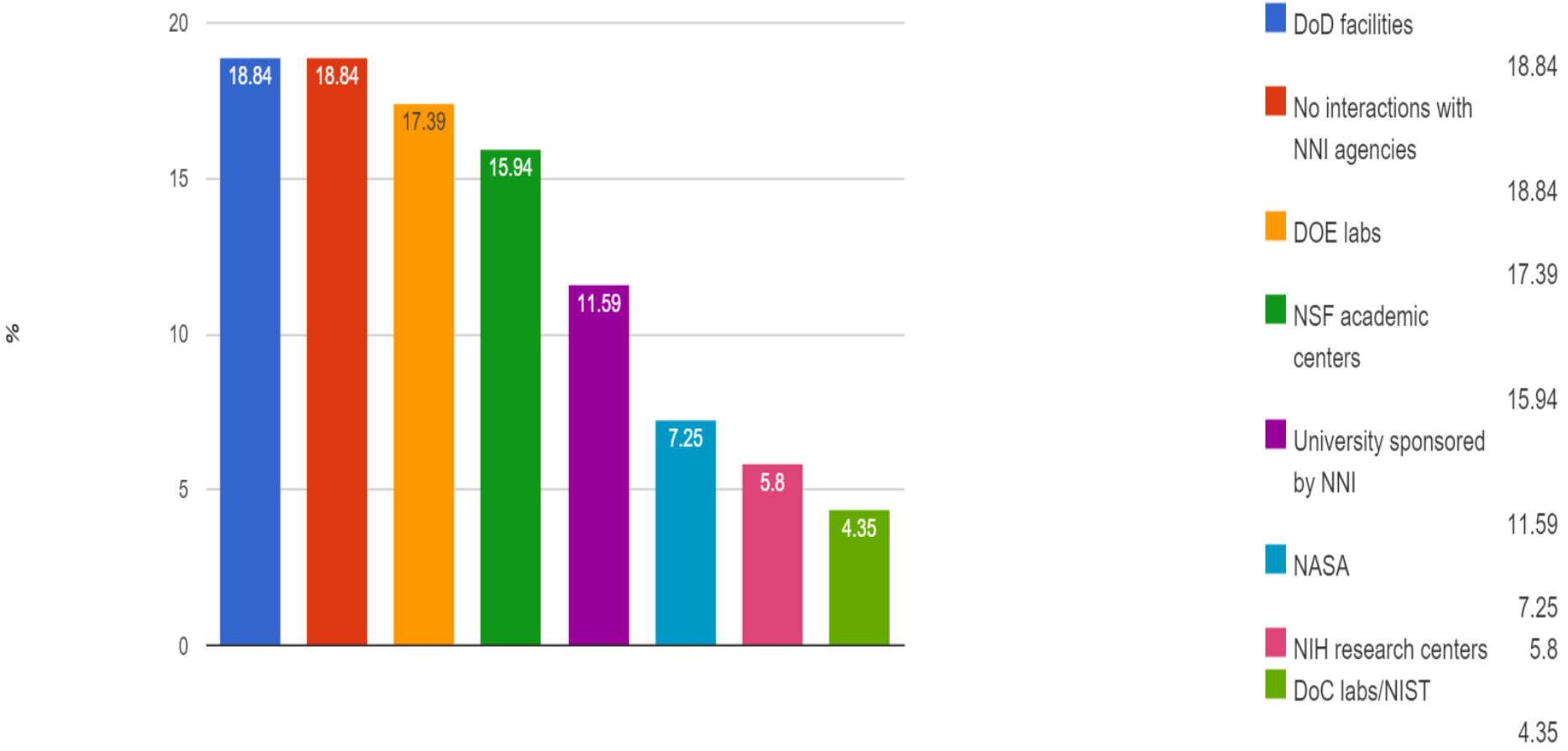
Fewer Michigan corporations involved in offshore nanotechnology R&D compared to National aggregate.



Entirely developed in the U.S.	51.43
Some offshore development/trials	17.14
Significant offshore development/trials	2.86
Don't know/Not Applicable	28.57

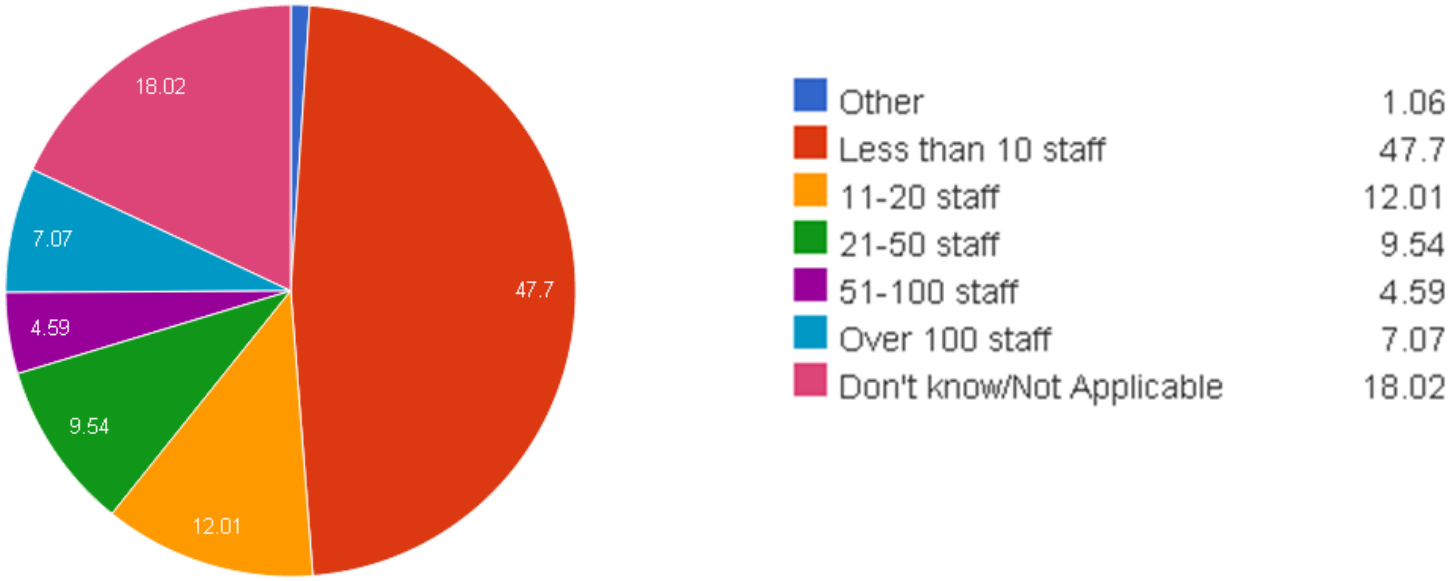
NNI COLLABORATIONS - MICHIGAN

Michigan organizations are more likely to collaborate with DOD, DOE and NSF in nano-R&D



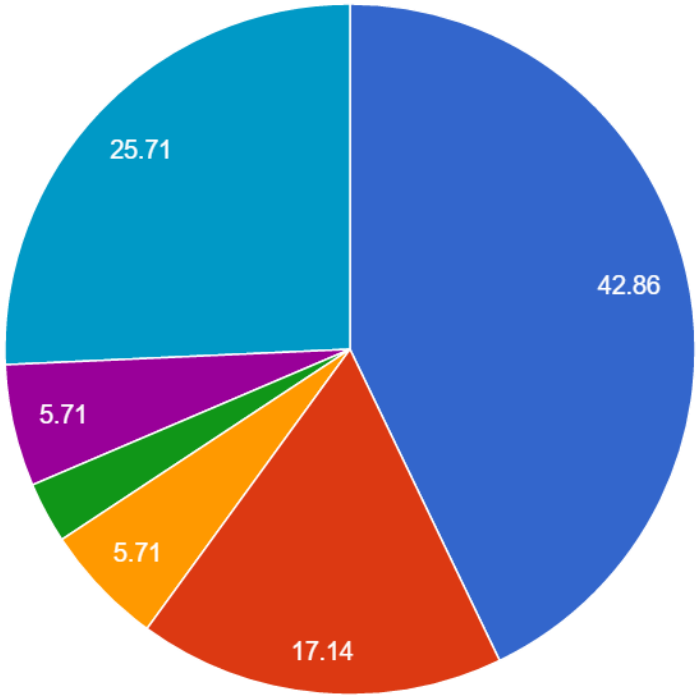
DIRECT STAFFING IN NANOMANUFACTURING

- Start-ups (<10 staff) are still the norm in nanotechnology development, but larger organizations are also engaged in commercial developments with nano-enabled products.
- Consolidation and vertical integration trend continues.
- 18% respondents did not disclose staffing levels.



2014 NCMS-NSF Nanomanufacturing Survey Project.

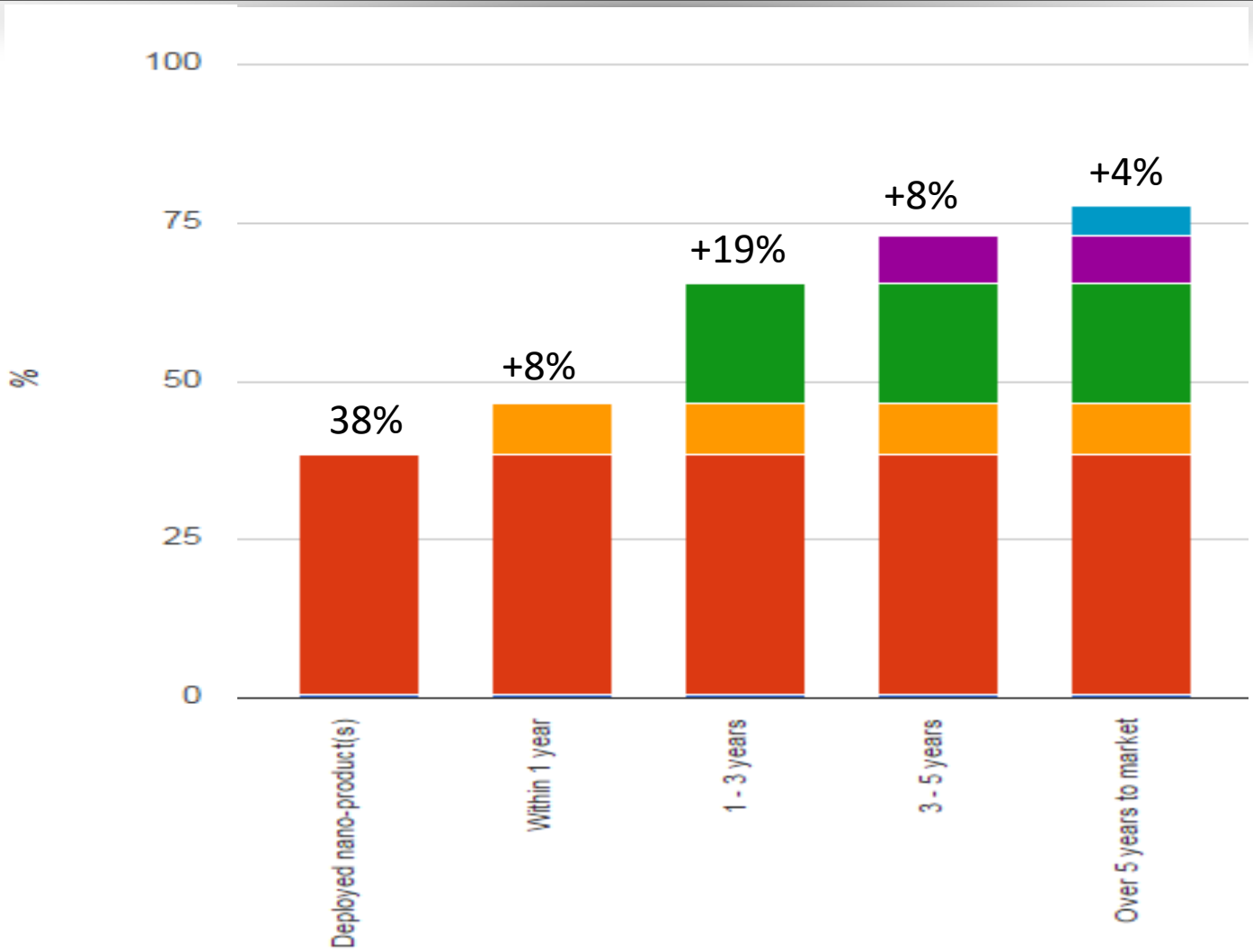
DIRECT STAFFING - MICHIGAN



Less than 10 staff	42.86
11-20 staff	17.14
21-50 staff	5.71
51-100 staff	2.86
Over 100 staff	5.71
Don't know/Not Applicable	25.71

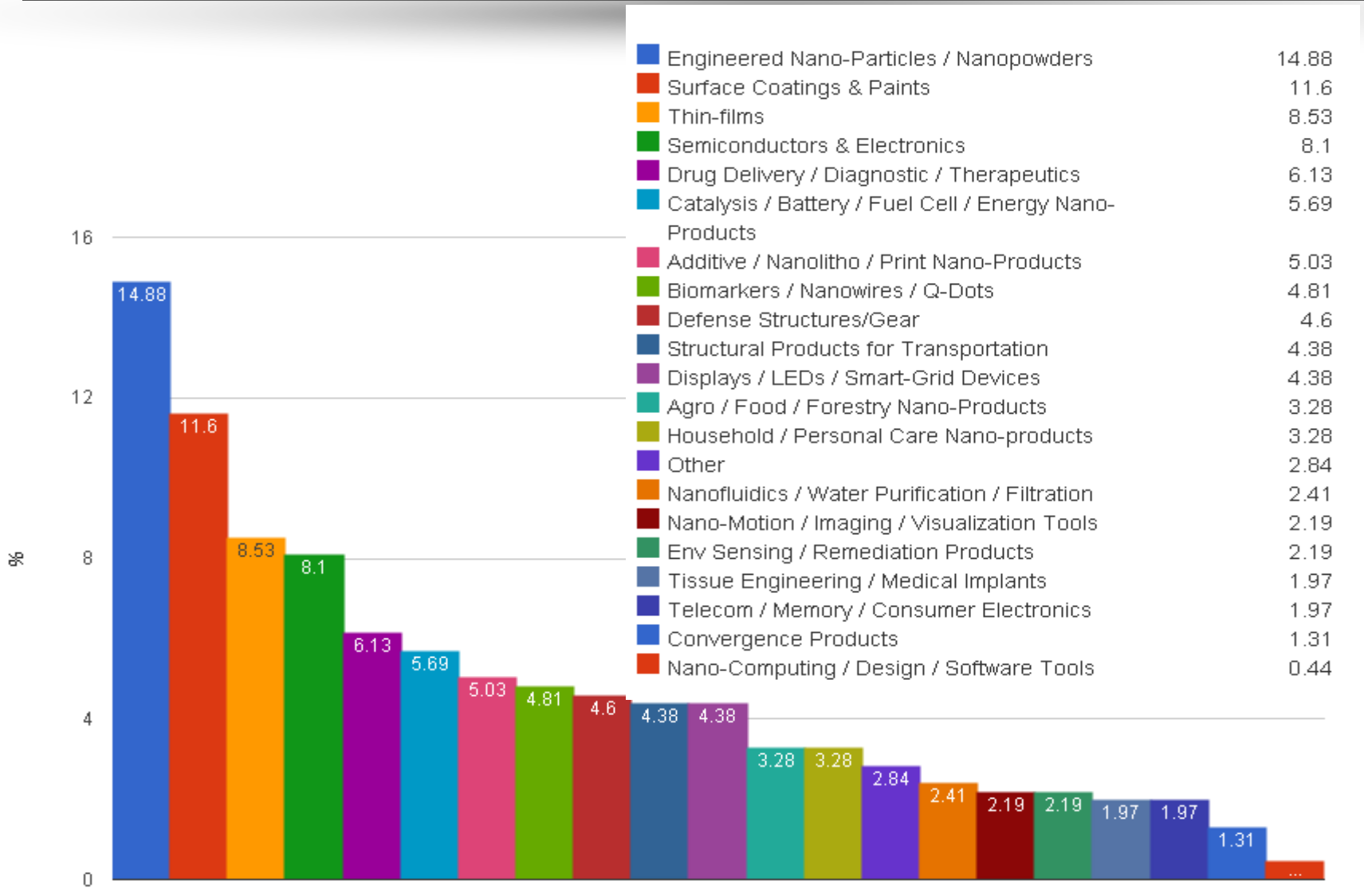
2014 NCMS-NSF Nanomanufacturing Survey Project.

COMPRESSED INDUSTRY R&D TIMELINES- 77% WILL DEPLOY NANO-PRODUCTS BY 2020



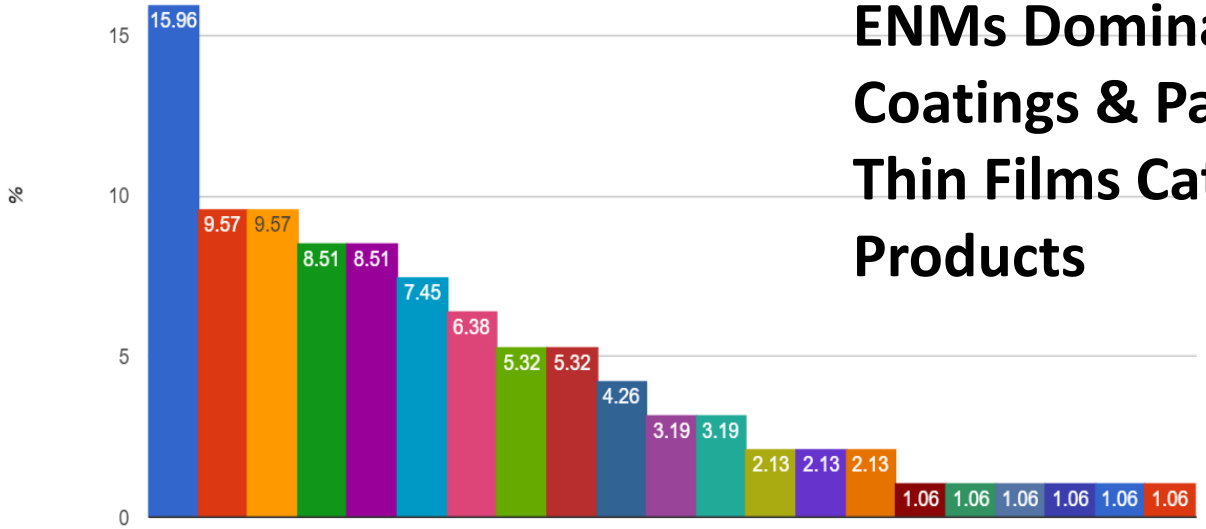
2014 NCMS-NSF Nanomanufacturing Survey Project.

NANOPRODUCT TYPES – MANUFACTURERS



2014 NCMS-NSF Nanomanufacturing Survey Project.

NANOPRODUCTS - MICHIGAN



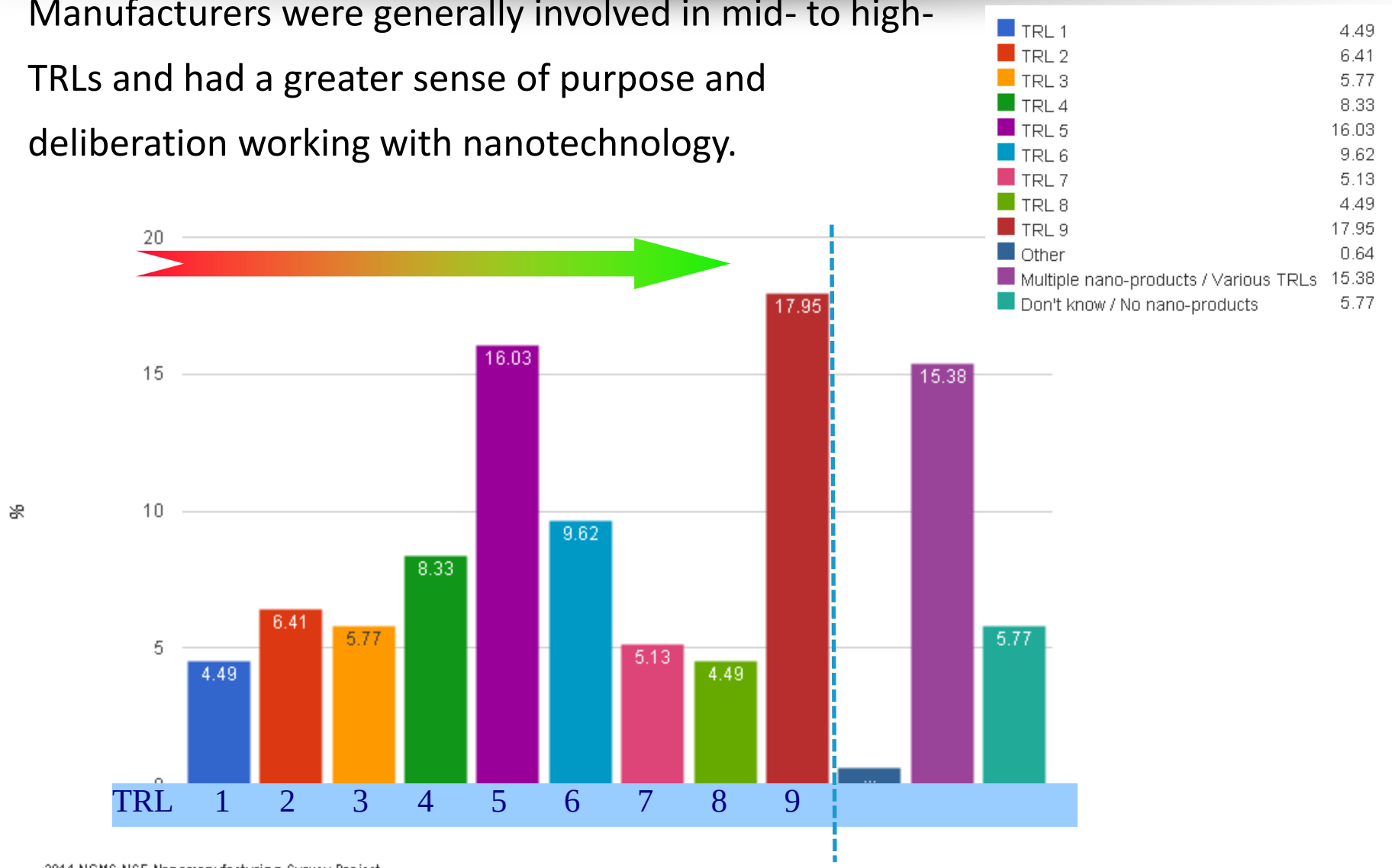
ENMs Dominate!
Coatings & Paints,
Thin Films Catalysts/Battery Products

2014 NCMS-NSF Nanomanufacturing Survey Project.

Engineered Nano-Particles / Nanopowders	15.96	Surface Coatings & Paints	9.57	Thin-films	9.57
Other	8.51	Catalysis / Battery / Fuel Cell / Energy Nano-Products	8.51	Structural Products for Transportation	7.45
Drug Delivery / Diagnostic / Therapeutics	6.38	Additive / Nanolitho / Print Nano-Products	5.32	Semiconductors & Electronics	5.32
Biomarkers / Nanowires / Q-Dots	4.26	Env Sensing / Remediation Products	3.19	Nanofluidics / Water Purification / Filtration	3.19

NANO-PRODUCT READINESS – MFRERS

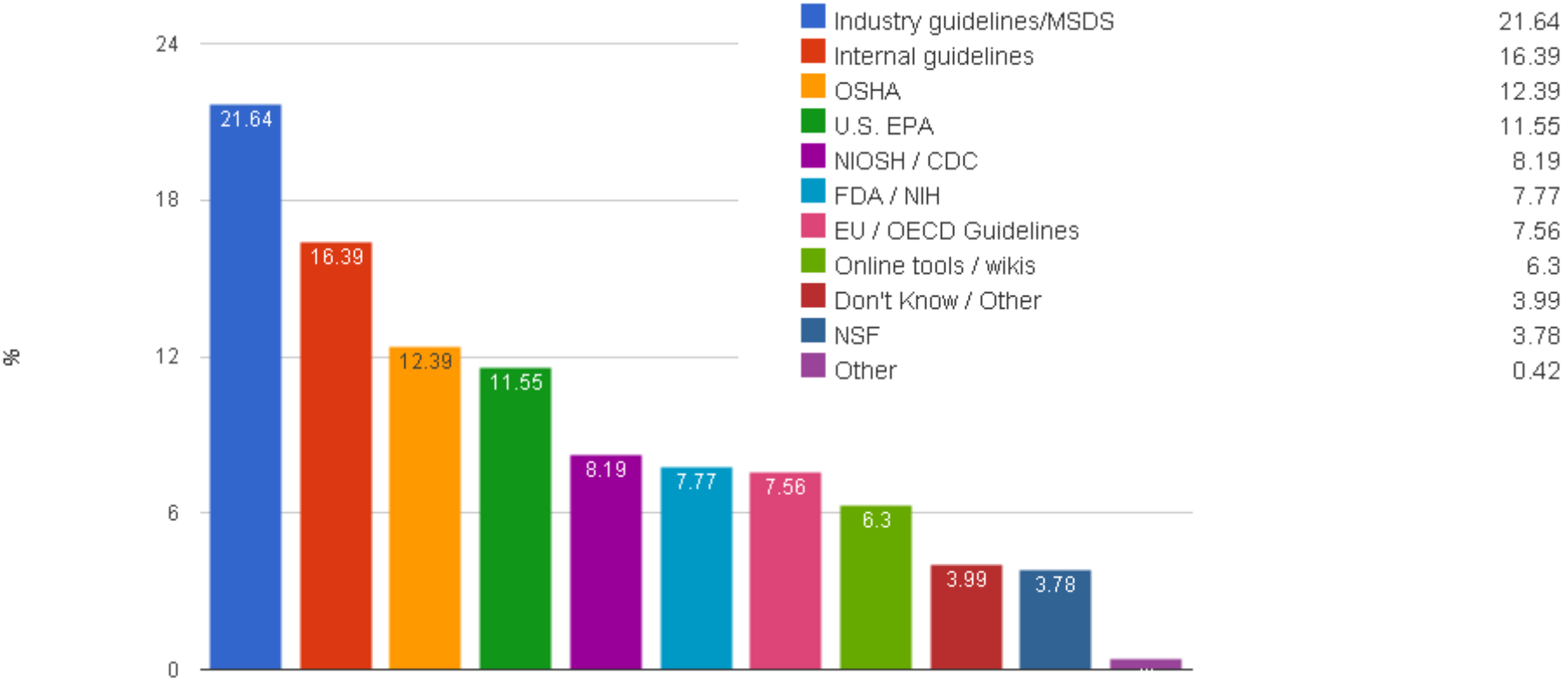
Manufacturers were generally involved in mid- to high-TRLs and had a greater sense of purpose and deliberation working with nanotechnology.



2014 NCMS-NSF Nanomanufacturing Survey Project.

EH&S RESOURCES – MFRERS

Little difference observed in trends for aggregate respondents versus manufacturers - the top 5 EHS resources accessed are:
Industry guidelines/MSDS, Internal guidelines, OSHA, EPA and NIOSH/CDC



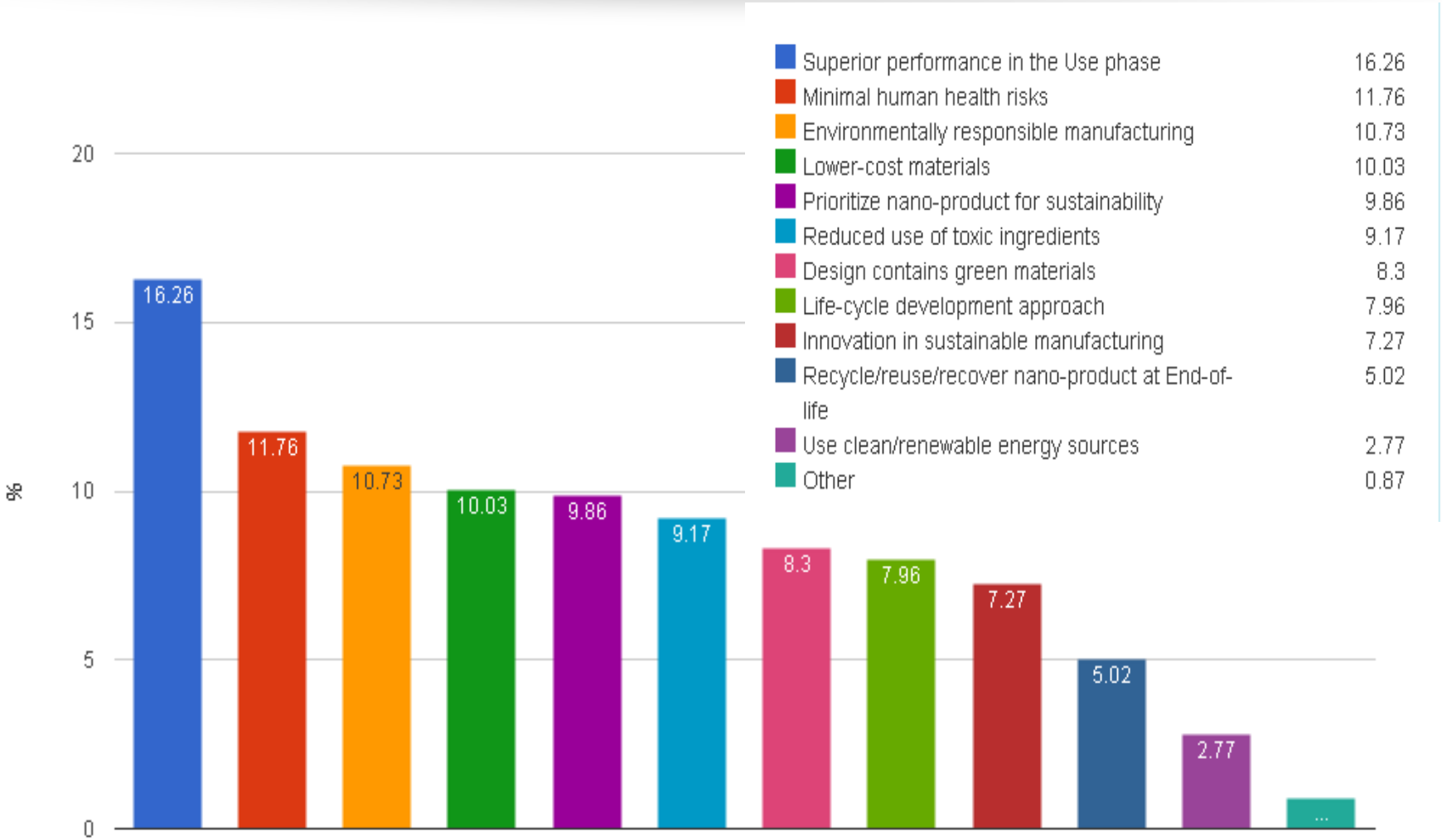
2014 NCMS-NSF Nanomanufacturing Survey Project.

TOP BARRIERS TO NANOMANUFACTURING

High	Medium	Low
Insufficient Capital	Robust Supply-chains	Government Policy Issues
Long Pathway	Uncertain Benefits of Nanotech	Foreign Competition
High Processing Cost	IP Challenges	Lack Management Skills
Process Scalability	Material/Product Variability	Unattractive Market
Regulatory Uncertainty	Lack Standards/Measurement	Robust Supply-chains
EH&S Concerns	EH&S Concerns	Critical Materials
IP Challenges	Government Policy Issues	Multi-disciplinary Complexity
Lack Manufacturing Resources	Lack Manufacturing Resources	Lack Nanomaterial Databases
Multi-disciplinary Complexity	Process Scalability	Lack Design Tools
Lack Standards/Measurement	Multi-disciplinary Complexity	Lack Tech Manpower
Uncertain Benefits of Nanotech	High Processing Cost	Lack Manufacturing Resources
Material/Product Variability	Lack Nanomaterial Databases	IP Challenges
Lack Tech Manpower	Critical Materials	Material/Product Variability
Foreign Competition	Foreign Competition	Lack Standards/Measurement
Lack Design Tools	Regulatory Uncertainty	Uncertain Benefits of Nanotech
Lack Nanomaterial Databases	Lack Design Tools	High Processing Cost
Lack Management Skills	Lack Management Skills	Regulatory Uncertainty
Robust Supply-chains	Unattractive Market	EH&S Concerns
Government Policy Issues	Insufficient Capital	Process Scalability
Unattractive Market	Long Pathway	Long Pathway
Critical Materials	Lack Tech Manpower	Insufficient Capital

2014 NCMS-NSF Nanomanufacturing Survey Project.

SUSTAINABILITY ATTRIBUTES – MFRERS



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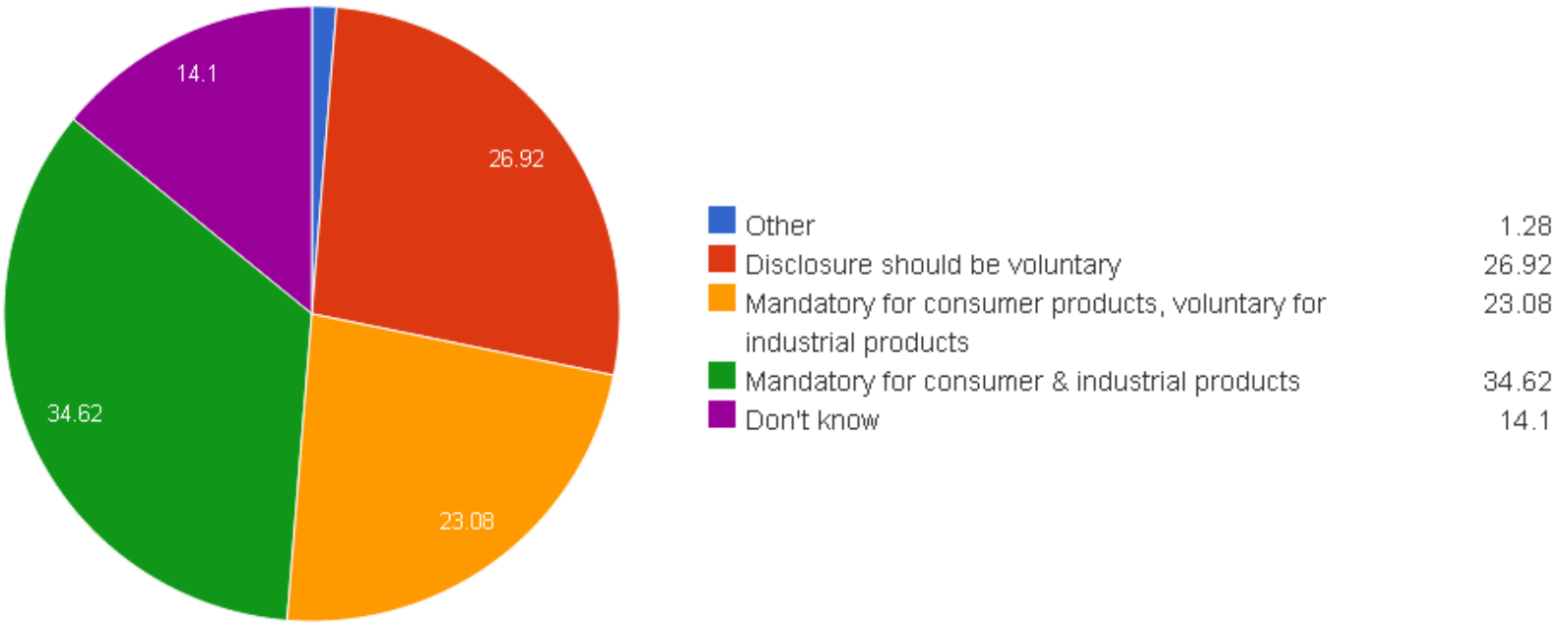
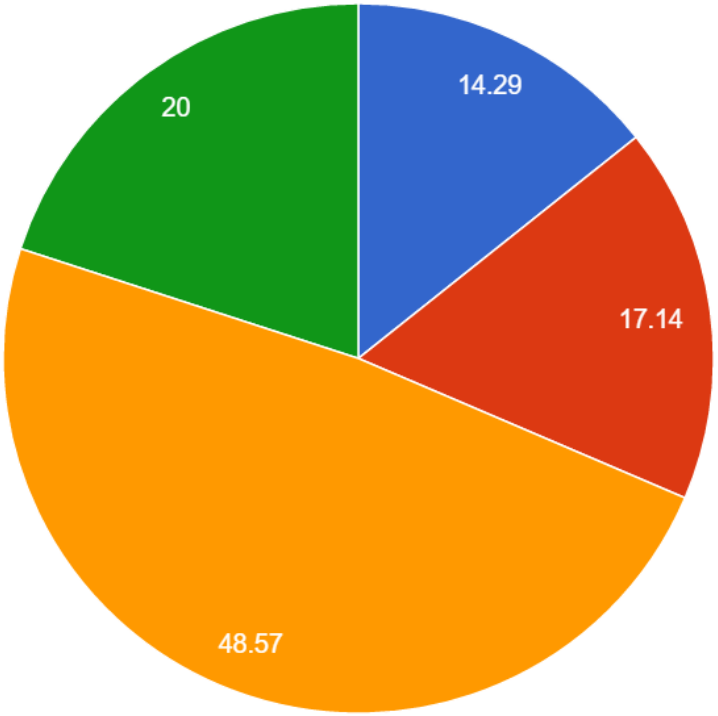
ECO-LABELS & DISCLOSURE– MANUFACTURERS

The statistical trends for 185 manufacturers were similar to the aggregate 300 respondents.



ECO-LABELS & DISCLOSURE - MICHIGAN

1 in 2 Michigan corporations feel Eco-labels should be mandatory for all products

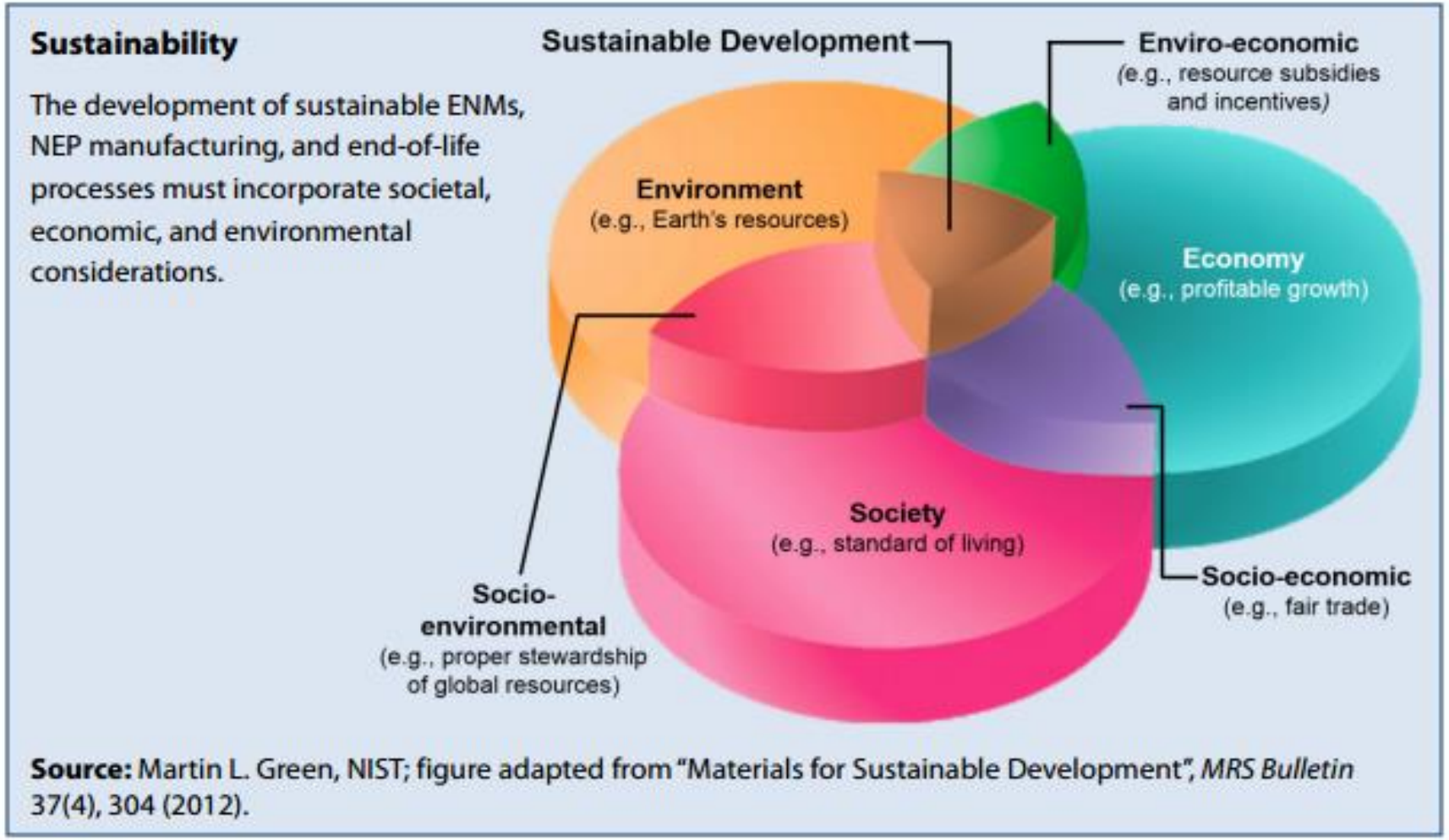


Disclosure should be voluntary	14.29
Mandatory for consumer products, voluntary for industrial products	17.14
Mandatory for consumer & industrial products	48.57
Don't know	20

MEGA-TRENDS DRIVING NANO-ENABLED PRODUCTS

- Smart, Connected Devices & Vehicles, Internet of Things (IoT/IoE)
- Mobile Computing Platforms (Smart telecom, Wearables, Sensors)
- Personalized Nanomedicine (Diagnostics, Therapeutics)
- Multi-functional Coatings, 3-D Printing, Additive Manufacturing
- Energy and Storage (Solar PV, Battery, Fuel Cell Chemistry)

TRIPLE BOTTOMLINE SUSTAINABILITY IS IMPERATIVE…



Referenced in NNI Strategic Plan, February 2014, p36-37

Life Cycle Thinking…

Sustainability Tools

- Energy/Emissions/Water Impacts, Footprints
- Financial Link with Tools & Models
- Data Standards & Reporting
- Iterative P-D-C-A Processes to Launch/Monitor/Revise Products & Processes

Trust But Also Verify!

Game-Changing Technologies

- Nanotechnology/Nanomanufacturing
- Additive Manufacturing
- Virtual Prototyping Across Scales
- Lightweighting & Green Manufacturing

Unintended Consequences of Novel Technologies

Workforce Competencies

- Nurture Workforce on Basics, STEM
- Long-Term US Talent Availability
- Risk of Doing Less While Knowing Less!
- Competition from BRIC Nations

Strategy (At All Levels)

- Early Engagement of End-Users
- Apply Multiple Perspectives & Disciplines
- Collaboration & Trust Across Supply Chains
- Decouple Regulation from Politics

Address System-Level Solutions

The Payoffs: Safe, C**Lean**, Efficient **Systems**

WHAT'S NEEDED?

Nano-scale Product Decisions Cannot Be Made in Isolation!

- Non-dilutive capital and Govt. investment/R&D incentives by both, federal and state agencies for sustained leadership, entrepreneurial growth and retention of innovation in the U.S.
- New collaboration models (e.g., O-I) are key for accelerated product realization, EHS risk mitigation, faster product launches, competitiveness and accelerating market-adoption of safely designed nano-enabled products.
- Translational R&D workforce is critical to stimulate future economic development/job growth – the skills gap is a major weakness for U.S. manufacturers.

Thank You!

"Sustainability is not a problem to be solved. It is a future to be created. True leadership is about cultivating the collective capacity so that people shape futures they truly desire."

- Peter Senge

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