NSF Workshop on Sustainable Manufacturing: Urgent Research Needs and Multidisciplinary Collaboration

Y. Huang, T. Edgar, M. El-Halwagi, M. Eden, and B. Bakshi

Sustainable Manufacturing Advances in Research and Technology (SMART) Coordination Network

Arlington, VA

August 20-21, 2015

Accelerating U.S. Advanced Manufacturing
- PCAST, Oct. 27, 2014

- **“The United States has been the leading producer of manufactured goods for more than 100 years.”**
- **“The United States has long thrived as a result of its ability to manufacture goods and sell them to global markets.”**
- **“U.S. strengths in manufacturing innovation and technologies that have sustained American leadership in manufacturing are under threat from new and growing competition abroad.”**

A renewed national effort has been made to secure U.S. leadership in emerging technologies that will create high-quality jobs and enhance America’s global competitiveness.

National Manufacturing Institutes

Established manufacturing institutes:

(1) Additive manufacturing (2012)
(2) Digital manufacturing (2014)
(3) Lightweight metals (2014)
(4) Wide bandgap semiconductors (2015)
(5) Polymer composites (2015)

Upcoming institutes (see manufacturing.gov):

(6) Energy focused smart manufacturing
(7) Photonics
(8) Hybrid electronics
(9) Fibers and textiles

Institute ideas discussed (at the DOE/DOD Manufacturing Innovation Topics Workshop, Oct. 9-10, 2014):

(10) High-efficiency modular chemical processes
(11) Advanced materials manufacturing
(12) Engineered nano-materials
(13) Roll-to-roll manufacturing

Manufacturing & Sustainability

- **Advanced manufacturing innovation could be not (sufficiently) sustainable.**

- **Sustainability issues start to be considered**

  <u>NSF-supported activity</u>:

  - **CMMI /CBET sponsored the Workshop on Environmental Implications of Additive Manufacturing, Oct. 14-15, 2014.**

    <u>Note</u>: The additive manufacturing institute is the first institute established in 2012.

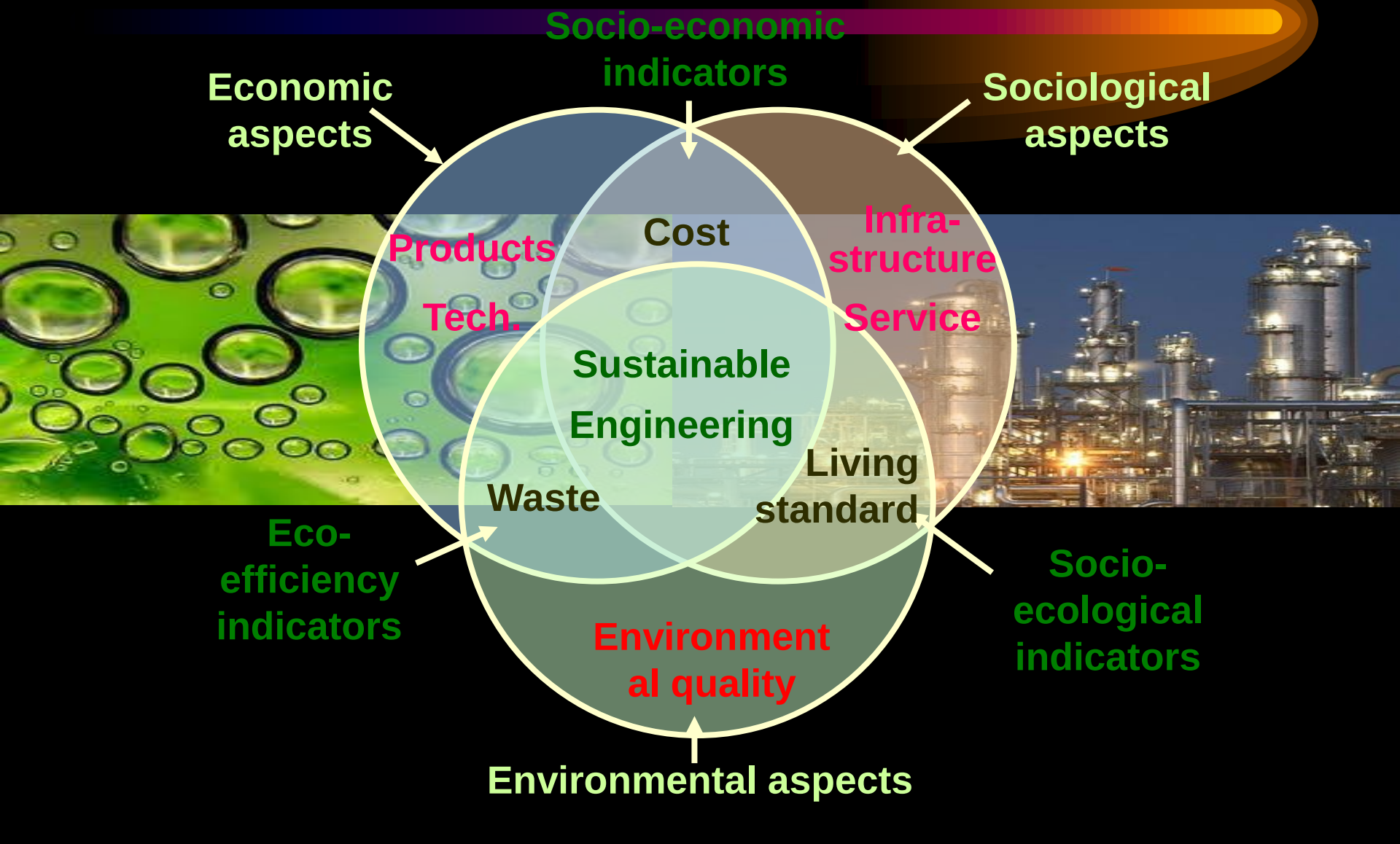
Sustainable Manufacturing

- **DOC and EPA Definition:**

  Sustainable manufacturing is "the creation of manufactured products through economically-sound processes that minimize negative environmental impacts while conserving energy and natural resources".

  Sustainable manufacturing also "enhances employee, community, and product safety, which are all social issues."

Manufacturing Sustainability: A Need to Re-evaluate and Re-engineer Engineering Systems



Multi-institutional Collaboration Effort

- **Creation of Sustainable Manufacturing Advances in Research and Technology Collaboration Network (SMART CN) in 2012, sponsored by U.S. NSF (RCN SEES)**
- **Project Objective**
  - **To bridge the gap between academic knowledge discovery and industrial technology innovation for sustainable manufacturing**
  - **To foster interactions that create new research directions and help advance manufacturing sustainability.**

SMART CN – Leadership Team

Principal Investigators/Executive Committee

Y. Huang
Wayne State U

T. Edgar
U Texas

M. El-Halwagi
Texas A&M U

C. Davidson
Syracuse U

M. Eden
Auburn U

Steering Committee

L. Achenie
Virginia Tech.

D. Allen
U Texas

B. Bakshi
Ohio State U

B. English
U Tennessee

D. Fasenfast
Wayne State U

I. Grossmann
Carnegie Mellon U

K. High
Oklahoma State U

I. Jawahir
U Kentucky

C. Maravelias
U Wisconsin

K. Ogden
U Arizona

M. Rezac
Kansas State U

F. Shadman
U Arizona

SMART CN – Group Expertise

- Economics
- Energy and renewable energy
- Environmental engineering (air, water, land)
- Industrial ecology and LCA
- Manufacturing science and engineering
- PSE (product and process design and integration, process control, process optimization, supply chain and enterprise management)
- Resource engineering (agriculture, water, energy)
- Sociology
- Sustainability education
- Sustainability science and engineering

SMART CN – Collaboration Organizations

Domestic

- AIChE - Institute for Sustainability (IfS)
- CACHE Corporation
- Center for Advanced Process Decision-Making, Carnegie Mellon U.
- Center for Sustainable Engineering, Syracuse U.
- Industrial and Urban Sustainability Group (I&US), Wayne State U.
- Institute for Sustainable Manufacturing (ISM), U. of Kentucky
- National Alliance for Advanced Biofuels and Bioproducts (NAABB)
- National Center for Manufacturing Sciences (NCMS)
- National Council for Advanced Manufacturing (NCFAM)
- NSF ISRC Engineering Center for Environmentally Benign Semiconductor Manufacturing, U. of Arizona
- Smart Manufacturing Leadership Coalition
- Texas-Wisconsin-California Control Consortium, Austin, TX
- The Industrial Sustainability Group, Wayne State U.

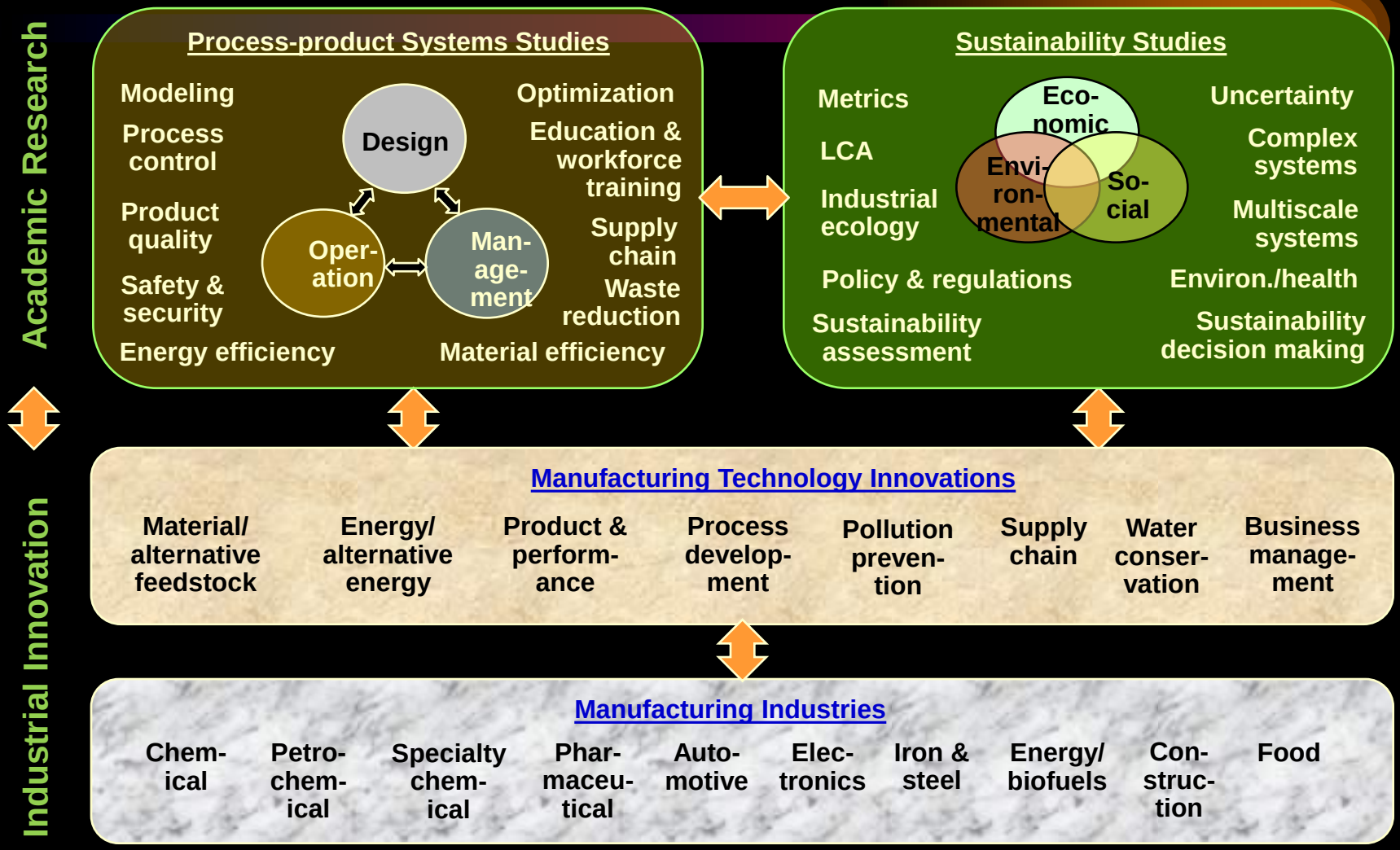
International

- Denmark, Germany, China, Norway, Singapore, Japan, India

Project Tasks

1. To conduct comprehensive and in-depth review of the frontier research and technological development for sustainable manufacturing
2. To define roadmaps for manufacturing sustainability and identify bottlenecks in a number of focused research areas via workshops
3. To coordinate research through sharing knowledge, resources, software, and results
4. To establish partnerships with industrial groups to expedite technology innovation
5. To conduct education and outreach to a wide range of stakeholders

Academic and Industrial Collaboration on Sustainable Manufacturing



Sustainable Manufacturing Roadmap Development Workshop

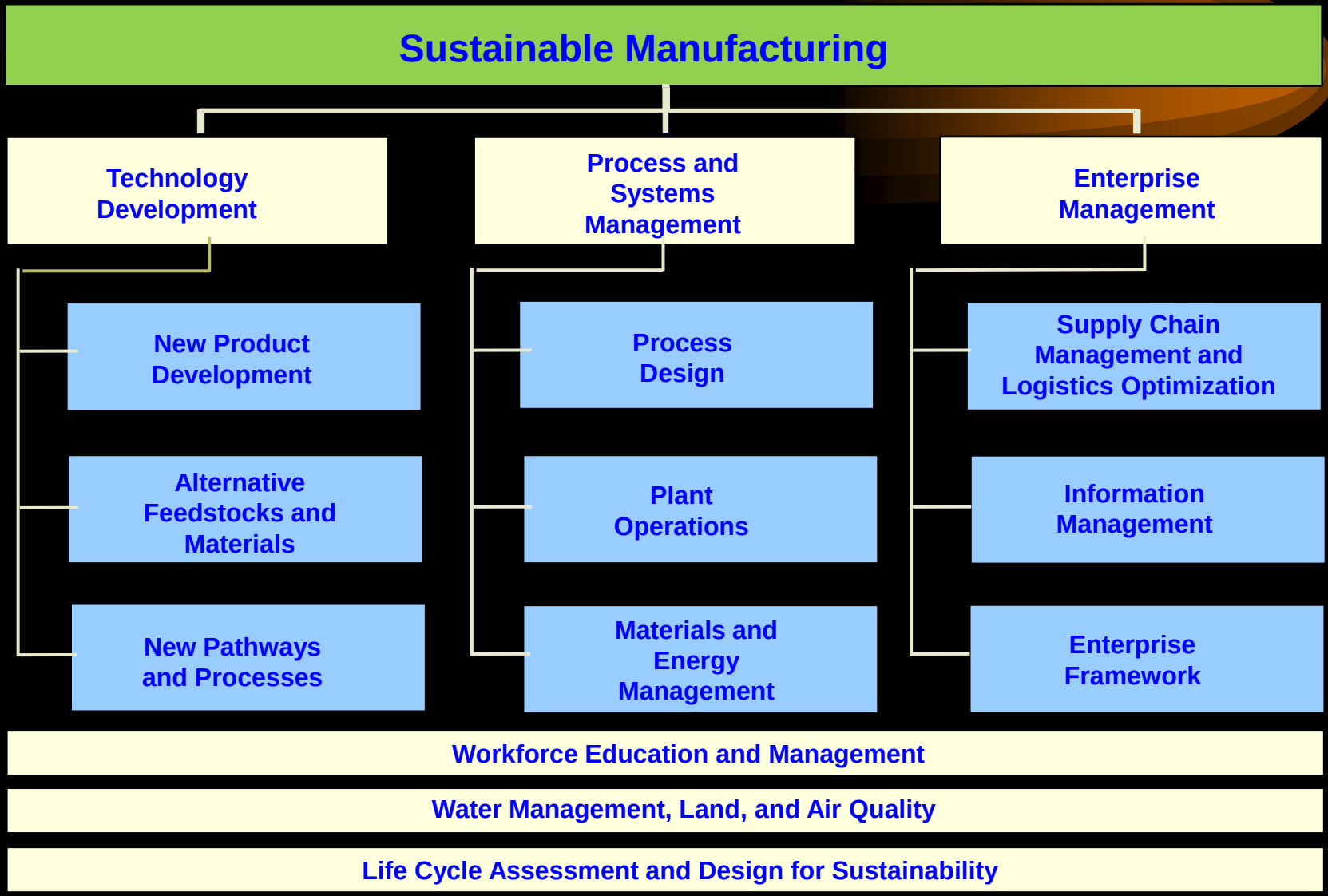
Cincinnati, OH, Aug. 15-16, 2013

- **Workshop Goal**
  - To explore the topics of sustainable manufacturing
  - To capture the key needs and solutions that point to an R&D agenda
  - To flesh out some key ideas into project slates
  - To facilitate a meaningful dialogue
  - To develop a roadmap
- **Roadmap Report**

  Huang, Y., T. Edgar, M. El-Halwagi, C. Davidson, and M. Eden, "Report on Sustainable Manufacturing Roadmap Development Workshop, 2013"

  http://www.research.che.utexas.edu/susman/documents/workshop

Functional Model for SM Roadmap Development



10 Key Themes

1) Standards and platforms for information exchange
2) Clear definition and semantic understanding
3) Pervasive adoption of sustainability practices
4) Comprehensive characterization and quantification of manufacturing processes
5) Comprehensive life-cycle assessment
6) Sustainable manufacturing education
7) Model-based assessment and control for sustainability
8) Data and model access for sustainability
9) Optimized design for sustainability
10) Systematic sustainability achievement

- Huang, Y., T. Edgar, M. El-Halwagi, C. Davidson, and M. Eden, Report on Sustainable Manufacturing Roadmap Development Workshop, 2013 (http://www.research.che.utexas.edu/susman/documents/workshop/SMART%20CN_SM%20Roadmap%20Workshop_Final%20Report%20_041514.pdf)

This Workshop

Objective:

- To identify and prioritize urgent, specific needs in the field of sustainable manufacturing
- To suggest the best strategies for achieving the research goals in order to make a long-term impact on advanced manufacturing

Format:

- Keynotes + breakout discussion & report + panel discussion + NSF talks

Breakout Session Design

Session 1 – Sustainability Implications in Manufacturing

- Group 1.1 - Tech. Management
- Group 1.2 - Product/process Development
- Group 1.3 - Enterprise Management

Session 2 – Research and Education Need Specifics

- Group 2.1 - System Design for Sustainability
- Group 2.2 - Sustainable Manufacturing
- Group 2.3 - Sustainable Industrial Networks

Session 3 – Major Collaboration Needs and Platforms

- Group 3.1 - Multidisciplinary Collaboration
- Group 3.2 - Academic and Industrial Collaboration

General Questions for Group Discussion

Q1: What are the significant sustainability implications in advanced manufacturing and how can sustainability principles be fully applied in advanced manufacturing innovations?

Q2: What are the key fundamental research areas critical to the progress of sustainable advanced manufacturing technologies and how should they be prioritized?

Q3: What are the effective approaches for multidisciplinary collaboration among sustainability communities and advanced manufacturing communities, and between academic institutions and industries to achieve the priority research areas?

Q4: What kind of major platform could be created to promote national research and educational collaboration in the field of sustainable advanced manufacturing?