Letter from the Director

Dr. David Shonnard (ChE)

I am very pleased to summarize accomplishments and other activities of the Sustainable Futures Institute (SFI) faculty and students. Progress in all areas of SFI could not have been achieved without the efforts of Professor Ann Maclean, Deputy Director, and the SFI professional staff, Dr. Richard Donovan, Dr. Robert Handler, and Melanie Yang. This academic year 2009-2010 has been a very busy and productive period. We continue to develop sustainability courses and a Graduate Certificate in Sustainability and offer them to graduate and undergraduate students at Michigan Tech. Our ongoing partnership Southern University-Baton Rouge continues in support of one Certificate course. We have begun to offer some of these courses online for students who are either away from campus on coop or internships or are career professionals at major corporations who wish to gain additional knowledge of sustainability and skills in evaluating projects and technologies on sustainability. Enrollment in these courses remains strong and demand for the Certificate is high partly due to our first cohort of students from the MBA program in the School of Business and Economics. We continue our ongoing initiatives to influence sustainability education beyond the university by engaging high school teachers from across the U.S in a Summer Teacher Institute. Select teachers come to campus for a week-long lecture and laboratory experience in forest-based biofuels. Bus loads of high school students from across the UP visit campus for an afternoon of lectures and laboratory tours. Both of these programs are supported by a National Science Foundation grant led by Ann Maclean with participation by faculty in Engineering, School of Forest Resources and Environmental Science, and Social Sciences.

Research activity continues an upward trend in all technical areas of sustainability in the Institute, supported by the talent and efforts of 98 faculty members from nearly every academic college and school at Michigan Tech, 81 graduate SFI scholars, undergraduate researchers, and professional staff. Research efforts are led by both individual faculty investigators and also by the Directors of several SFI centers, including Dr. Alex Mayer (Michigan Tech Center for Water and Society), Dr. Michael Mullins (Center for Fundamental and Applied Research in Nanostructured and Lightweight Materials), Dr. Gerard Caneba (Center for Environmentally-Benign Functional Materials), Dr. Kurtis Paterson (D80 Center), Dr. John Gershensen (Materials, Design, and Manufacturing for Sustainability), Dr. David Shonnard (Wood-to-Wheels Initiative), and Dr. Neil Hutzler (Center for Science and Environmental Outreach). Total research and education projects stand at 55 with funding from government agencies, industry, foundations, and international aid organizations. Other important research statistics include 81 peer-reviewed research publications, 2 books, 16 book chapters, 7 reviews, 32 conference proceedings papers, and 158 presentations. Graphs and tables showing scholarly activity by SFI faculty and students appears at the end of this report.

This year we also engaged in a very large-scale multi-university proposal to the National Science Foundation to establish an Engineering Research Center on the theme of forest-based biofuels. This activity is described in the SFI Highlight of the Year section of this report.

This annual report for the year 2009-2010 contains a list of projects, publications, and other accomplishments in the key focus areas of the SFI: 1. Water Resources, 2. Energy, 3. Manufacturing and Materials, 4. Education, and 5. Outreach. I invite your comments and continued interest and support in sustainability research, education, and outreach at Michigan Tech.

David Shonnard, SFI Director
Richard and Bonnie Robbins Chair Professor in Sustainable Use of Materials
Department of Chemical Engineering

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List of Abbreviations

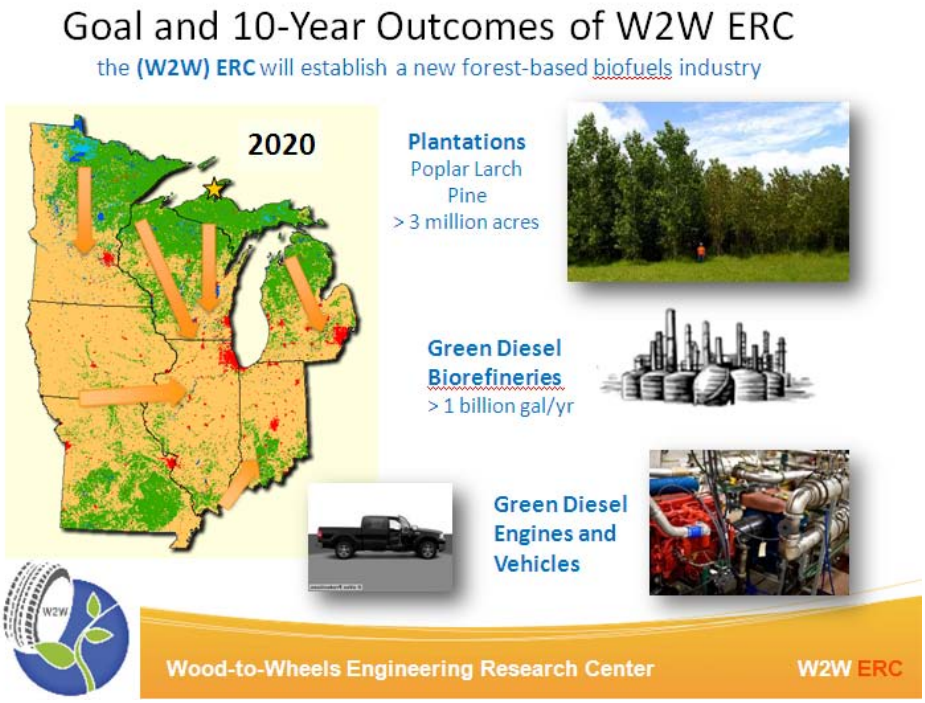
ASEE	American Society for Engineering Education
AQIP	Academic Quality Improvement Program
BS	Department of Biological Sciences
CEBFM	Center for Environmentally Benign Functional Materials
CEE	Civil and Department
CFARNLM	Center for Fundamental and Applied Research in Nanostructured and Lightweight Materials
CH	Department of Chemistry
ChE	Chemical Engineering Department
CLS	School for Cognitive Learning Sciences
CSEO	Center for Science and Environmental Outreach
DoE	Department of Energy
ECE	Electrical and Computer Engineering
ERC	Engineering Research Center, an NSF funding program
ESC	Ecosystem Science Center or Environmental Sustainability Committee
GMES	Geological Mining Engineering and Sciences
GOALI	Grant Opportunity for Academic Liaison with Industry (NSF)
IGERT	Integrative Graduate Education and Research Traineeship (NSF)
LCA	Life-cycle Analysis
MA	Department of Mathematical Sciences
MEDC	Michigan Economic Development Corporation
MDEQ	Michigan Department of Environmental Quality
MEEM	Department of Mechanical Engineering—Engineering Mechanical
MiSTI	Center for Materials in Sustainable Transportation Infrastructure
MI	Peace Corps Master's International
MTCWS	Michigan Tech Center for Water and Society
MUSES	Materials Use: Science, Engineering, and Society (NSF)
NGO	Non-governmental Organization
NSF	National Science Foundation
PH	Department of Physics
Publ. Policy	Public Policy
SB&E	School of Business and Economics
SFI	Sustainable Futures Institute
SFRES	School of Forest Resources and Environmental Sciences
SME	Society of Mechanical Engineers
SS	Department of Social Sciences
STEM	Science, Technology, Engineering, and Math
SUBR	Southern University A&M College at Baton Rouge
W2W	Wood-to-Wheels

1.0 Research

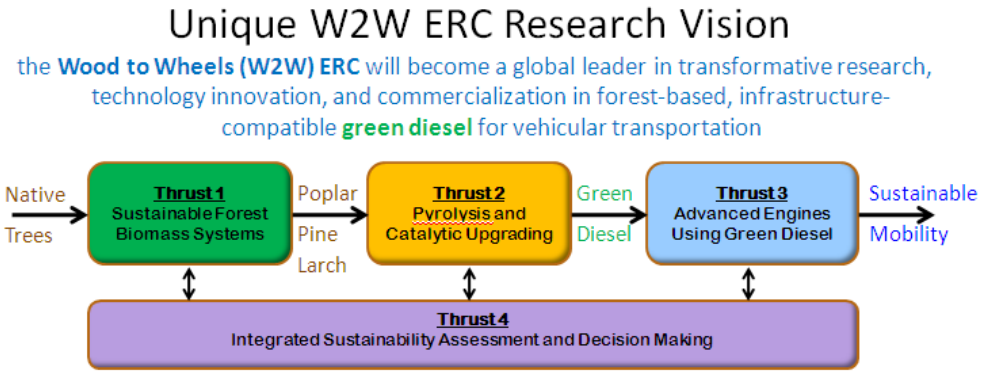
1.1 SFI Highlight of the Year – Wood-to-Wheels ERC

This past academic year was dominated by the large effort that the SFI staff and SFI-affiliated faculty have made in developing a large multi-university proposal on the Wood-to-Wheels initiative. On July 15 2009, Michigan Technological University submitted a pre-proposal to the National Science Foundation Engineering Research Center (ERC) program. The proposal, "NSF Engineering Research Center for Sustainable Forest-Based Biofuels Transportation Systems—Wood-to-Wheels (W2W)", was itself the result of several months of concerted effort and the culmination of years of planning by the Sustainable Futures Institute. In February of 2010 the Principal Investigator of the program, Dr. David Shonnard, was informed that the W2W ERC proposal was one of 29 proposals that had been invited to submit a full proposal.

The W2W ERC is an international partnership linking nearly 30 faculty at Michigan Tech with researchers at Iowa State University, Purdue University, Southern University-Baton Rouge and Luleå University of Technology (Sweden). Our overall goal is to lead the establishment of a commercial and sustainable forest-based biofuels industry producing infrastructure-compatible green diesel (GD). After 10 years, we envision several commercial-scale green diesel facilities producing greater than 1 billion gallons GD / yr supplied by over 3 million acres of high productivity plantations and with GD combusted in clean and energy efficient green diesel powered vehicles. The industry supported by the W2W ERC will supply sustainable and renewable transportation fuel to the major urban centers in the Upper Midwest region.



Affiliated universities also include Princeton University, the University of South Florida and the University of Wisconsin-Madison. In addition, the program includes 28 companies who have committed to become members of the W2W ERC Industrial partnership program. In total the program represents collaboration among nearly 50 universities, national labs, economic development agencies, private businesses and international institutions. The five year (with the potential for a five year renewal), $18.5 million program seeks to create a new forest based biofuels industry by conducting a research program across the entire value chain (from wood to wheels). The research program is organized into four thrusts: Sustainable Forest Systems, Pyrolysis-Based Conversion Processes, Energy Utilization of Advanced Biofuels and Integrated Sustainability Assessment/Decision Making.



The full proposal was submitted on May 5, 2010. In July of 2010, Dr. Shonnard was informed that the W2W ERC program was one of eleven that had been selected for a site visit by a National Science Foundation ERC review panel. On August 31 and September 1, 2010, Michigan Tech hosted the NSF Site Visit Team, university partners, and industry partners for a series of presentations to detail the expansive W2W program, respond to reviewer criticisms of the full proposal, and respond to Site Visit Team questions. The site visit was the culmination of months of effort by the Sustainable Futures Institute staff, ERC participants and the staff of many departments across the campus. Preparations included organizing / executing two virtual mock site visits, organizing /executing a full rehearsal, preparation of over two hundred presentation slides, preparation of printed material, coordination of travel accommodations for over 50 participants and preparation of facilities at the MUB and Lakeshore Center. The 26-page report from the NSF SVT outlined several areas for improvement that required a detailed response by the W2W ERC participants.

On October 15 2011, Dr. Shonnard and the W2W proposal team submitted a 66 page response to the SVT report in preparation for the required Reverse Site Visit to Washington DC. The SVT report response provided the ERC team with an opportunity to refine and expand upon the comprehensive effort. It required coordination of nearly twenty individual research faculty from four universities. On November 5, 2010, the long journey of the ERC proposal effort culminated in a one half hour summary presentation in Washington, DC to the NSF ERC Awards Recommendation Panel. This presentation was followed by another one half hour question and answer session. We have been informed by the ERC program manager that the NSF Engineering Research Center for Sustainable Forest-Based Biofuels Transportation Systems—Wood-to-Wheels (W2W) has been selected as one of six recommended for funding. We are now awaiting Congressional approval of federal agency budgets.

1.2 SFI Projects

New Projects

Project: The Nano-Interface between Material Science and Organometallic Chemistry
Sponsor: American Chemical Society, $100,000 (9/1/2010-8/31/2012)
Investigator: Dario J. Stacchiola

New Projects under Wood-to-Wheels Initiative
Leader: David Shonnard (ChE)

Project: Life Cycle Assessments of PyGasoline and PyDiesel From Different Regional Feedstocks: Corn Stover, Switchgrass, Sugar Corn Bagasse, Waste Wood and Forest Residues
Sponsor: UOP, LLC. , $125,002 (5/1/2010-7/31/2011)
Investigator: David Shonnard (ChE)

Project: Carbon Footprint Analysis of IH2 Biofuels: Proposed Detailed Analyses
Sponsor: Gas Technology Institute (GTI), $50,001 (6/1/2010-3/31/2011)

Investigator: David Shonnard (ChE)

Project: Working Bugs/MTU Center of Energy Excellence: Hydrolysis Research to Produce Sugars and Amino Acids from Defatted Dry Mill Syrup and other Renewable Resources
Sponsor: Working Bugs LLC, $119,999 (2/15/2009-2/14/2012)
Investigator: David Shonnard (ChE)

Project: Alpena Prototype Biorefinery Center of Energy Excellence C5 Fermentation Improvement Project: Enzymatic Hydrolysis Testing Program
Sponsor: American Process Inc, $65,002 (3/15/2010-12/31/2010)
Investigator: David Shonnard (ChE)

Project: Planning Grant: I/UCRC for Joining the Center for Bioenergy Research and Develpment
Sponsor: National Science Foundation, $12,978 (5/15/2010-4/30/2011)
Investigator: David Shonnard (ChE)

Project: Life Cycle Assessments (LCAs) in Support of UOP and Envergent Renewable Energy and Chemicals Projects in 2010
Sponsor: UOP, LLC, $80,503 (5/1/2010-4/30/2011)
Investigator: David Shonnard (ChE)

Project: Life Cycle Assessments of Hydro-Renewable Jet from Jatropha Grown in Mexico: Greenhouse Gas Emissions and Cumulative Energy Demand
Sponsor: Desc Coporativo, S.A, $18,063 (9/6/2010-12/6/2010)
Investigator: David Shonnard (ChE)

Project: Life Cycle Assessments to Support Sustainable Algae-Based Biofuels Production for the National Alliance for Advanced Biofuels and Bioproducts
Sponsor: UOP, LLC, $44,995 (10/1/2010-9/30/2011)
Investigator: David Shonnard (ChE)

New Projects under Center for Science and Environmental Outreach

Director: Neil Hutzler (CEE), Joan Chadde (Coordinator)

Project: Great Lakes Maritime Transportation (GLMT) Education for K-12 Teachers
Sponsor: UW-Superior (Great Lakes Maritime Research Institute) and UW-Madison $40,000 (10/09-11/10)
Investigator: Joan Chadde

Project: Brining Environmental Education to Urban Teachers (Detroit & Pontiac)
Sponsor: Michigan Space Grant Consortium, $10,000 (05/2009-06/2010)
Investigator: Joan Chadde

Project: Funding for UP teachers to attend Michigan Alliance for Environmental & Outdoor Educa-tion (MAEOE) conference Oct.8-10, 2010
Sponsor: Upper Peninsula Environmental Coalition, $500 (2010)
Investigator: Joan Chadde

Project: Investigating Stream Health---Stream Monitoring Field Trip
Sponsor: Upper Peninsula Environmental Coalition, $494 (2010)
Investigator: Joan Chadde

Project: Lake Superior Stewardship Initiative Implementation Grant
Sponsor: Great Lakes Fishery Trust, $175,000 (07/01/2009-03/01/2011)
Investigator: Shawn Oppliger, Joan Chadde

Project: Conducting A Remotely-Operated Vehicle Workshop for Upper Peninsula Teachers

Sponsor: Michigan Space Grant Consortium, $10,000 (05/2010 - 04/2011)
Investigator: Joan Chadde

Project: Brining Environmental Education to Urban Teachers (Detroit)
Sponsor: Michigan Space Grant Consortium, $15,000 (2010-2011)
Investigator: Joan Chadde

New Projects under D80 Center – Engineering Development for Humanity

Project: International: Developing Global Engineers and Scientists through Collaborative Technology Innovation for Public Health Improvements in Tanzania
Sponsor: National Science Foundation, $145,467 (7/1/2009-6/30/2012)
Investigator: Kurt Paterson

Ongoing Projects

Project: BE/MUSES: Renewable Energy from Forest Resources: An Investigation into the Viability of Large-Scale Production of Sustainable Transportation Fuels from Lignocellulosic Biomass
Sponsor: National Science Foundation, $1,700,002 (9/1/2005-8/31/2011)
Investigator: Ann Maclean (PI)

Project: US-Egypt Cooperative Research: Preparation of Rice-Waste Reinforced Urea-Formaldehyde Composites with Improved Moisture Resistance
Sponsor: National Science Foundation, $30,000 (2/1/2007-1/31/2011)
Investigator: Patricia A. Heiden

Project: CPATH CDP: Integrating Sustainability Into Undergraduate Computing Education
Sponsor: National Science Foundation, $144,555 (7/1/2008-6/30/2011)
Investigator: Yu Cai

Project: Investigation into the Enhancement of Thermoplastic Polymers with Conductive Nano Materials
Sponsor: Boeing Co., $370,737 (5/1/2008-8/31/2012)
Investigator: Julia King

Project: US—Egypt Cooperative Research: Preparation of Rice-Waste Reinforced Urea-Formaldehyde Composites with Improved Moisture Resistance
Sponsor: National Science Foundation $41,053 (2/1/07 to 1/31/11)
Investigator: Patricia Heiden (CH)

Ongoing Projects under Wood-to-Wheels Initiative

COEE Project 1: Feedstock Supply Chain Model
Sponsor: State of Michigan $385,000 (1/1/09 – 4/11)
Principal Investigators: David Watkins (MTU) and Christopher Peterson (MSU)
MTU Investigators: Dana M. Johnson (SB&E), Bill Knudsen (ECE), James Pickens (SFRES), James Frendewey (SB&E), Barry D. Solomon (SS), Greg Graman (SB&E), .

COEE Project 2: Increasing Sustainable Biomass Feedstock Availability
Sponsor: State of Michigan $345,557 (1/1/09 – 1/11)
Principal Co-Investigators: Robert E. Froese, (MTU SFRES) and Karen Potter-Witter (MSU Forestry)
MTU Investigators: Kathleen E. Halvorsen (SS & SFRES) Ann L. Maclean and Linda M. Nagel (SFRES)

COEE Project 3: Improving Forest Feedstock Harvesting, Processing and Hauling Efficiencies

Sponsor: State of Michigan $549,674 (1/1/09 – 4/12)
Principal Co-leaders: Ajit Srivastava (MSU Dept of Biosystems & Ag Eng) and David Shonnard (MTU ChE)
MTU Investigators: Robert E. Froese (SFRES), Pasi Lautala and Terrence McNinch (Transportation Inst.)

COEE Project #4: Outreach, Extension and Technology Transfer for the Feedstock Supply Chain
Sponsor: State of Michigan $79,336 (5/09 to 12/2010)
Principal Co-leaders: Karen Potter-Witter (MSU Forestry) and Kristin Schmitt (Northern Institute of Applied Carbon Science, SFRES)

Project: C5 Fermentation Improvement Project: An MTU Subcontract to Alpina Prototype Biorefinery Center of Energy Excellence.
Sponsor: American Process Inc., $321,138 (2/1/09 to 8/20/11)
Investigators: David Shonnard (ChE) and Sue Bagley (BS)

Project: Expanded Life Cycle Assessments of Biofuels, Petroleum Diesel, and Synthetic Diesel: Screening and Detailed Assessments
Sponsor: United Oil Products, $79,448 (1/1/08 to 8/31/09)
Investigator: David Shonnard (ChE)

Project: A Systems Approach to Improve Processing Efficiency of Biomass for Co-Production of Biofuels and Biopolymers
Sponsor: General Motors $275,027 (1/1/08 – 1/31/10)
Investigators: David Shonnard (ChE), Sue Bagley (BS), and Patricia Heiden (CH)

Ongoing Projects under Center for Science and Environmental Outreach

Project : Bringing Environmental Education to Urban Schools in Michigan Initiative
Sponsor: Michigan Space Grant Consortium: $9,552 (5/2008-4/2009)
Investigator: Joan Chadde (CSEO)

Project: Family Engineering for Parents and Elementary-Aged Children
Sponsor: National Science Foundation, $663,474 (5/15/08 to 4/30/09)
Investigators: Neil Hutzler (CEE) & Joan Chadde (CSEO)

Project: Lake Superior Stewardship Initiative
Sponsor: Great Lakes Fishery Trust, $175,000 to CCISD (subcontract to MTU: $55,540) 8/2009 to 2/2011
Great Lakes Fishery Trust, $200,000 to CCISD (subcontract to MTU: $70,000) 1/2008 to 6/2009
Investigator: Joan Chadde and Lloyd Wescoat (CSEO) Shawn Oppliger (CCISD)

Project: Outdoor Science Investigations Field Trip Program
Sponsor: Kinship Foundation, $125,000 (07/2007-06/2012)
Investigator: Joan Chadde

1.3 Michigan Tech Center for Water and Society

Director: Alex Mayer (GMES)

New Projects

Project: Enhancing the Capacity for Sustainable Forest Management in Chiapas and Oaxaca
Sponsor: Higher Education for Development, $250,000 (2/16/2009-9/30/2010)
Investigator: Alex Mayer

Project: New GK12 Global Watershed: Integrating Rural and Global Perspectives with Research and Technological Advances
Sponsor: National Science Foundation, $2,499,352 (9/1/2009-8/31/2014)
Investigator: Alex Mayer

Project: Monitoring Zebra Mussel Phosphorus Excretion
Sponsor: Michigan Dept of Environmental Quality, $61,103 (9/1/2009-8/31/2011)
Investigator: Martin T. Auer

Project: Bioavailability and Phosphorus Management for Onondaga Lake
Sponsor: Upstate Freshwater Institute Inc, $85,555 (1/1/2010-8/31/2011)
Investigator: Martin T. Auer

Project: Integrated Modeling and Experimental Evaluation of Hydrodynamic and Microbial Controls on DNAPL Dissolution and Detoxification
Sponsor: National Science Foundation, $376,192 (12/28/2009-8/31/2012)
Investigator: Jennifer G. Becker

Project: Analysis of Hydrogeochemistry of Upland-Peatland Waterlands Using Isotopic Tracers
Sponsor: Department of Agriculture, $7,826 (5/20/2010-4/30/2011)
Investigator: Alex Mayer

Project: A Linked Sediment-Water Column Model for Onondaga Lake
Sponsor: Upstate Freshwater Institute Inc, $54,474 (1/1/2010-5/31/2011)
Investigator: Martin T. Auer

Ongoing Projects

Project: Erosion Reduction by Air Entrainment, Phase 2
Sponsor: South Florida Water Management District, $44,999 (4/1/09 to 10/1/09)
Investigators: Brian Barkdoll (CEE) and Mohan Rao (MEEM)

Project: Component 3, Compile and Analyze Regional Data Sets: Work Plan FY2009, Water Quality Management Program, United States EPA Clean Water Act sect. 106
Sponsor: United States EPA, $19,999 (1/1/09 to 12/31/09)
Investigator: Casey Hutchens (BS) in collaboration with Little River Band of Ottawa Indians

Project: Sustainable Development for Rural Communities: Social, Health, Economic, and Environmental Advances
Sponsor: US Department of Education $180,000 (9/1/2008 - 8/31/2012)
Investigators: Alex Mayer (CEE/GMES), Carol MacLennan (SS), and Blair Orr (SFRES)

Project: Enhancing the Capacity for Sustainable Forest Management in Chiapas and Oaxaca
Sponsor: Higher Education in Development/USAID $250,000 (1/1/2009 - 12/31/2011)
Investigators: Alex Mayer (CEE/GMES), Kathleen Halvorsen (SFRES/SS)

Project: Streamside Lake Sturgeon Culture for the Ontonagon River
Sponsor: Michigan DNR $ 33,846 (10/1/07 to 9/30/2011)
Investigators: Nancy Auer (BS) and Edward Baker (DNR)

Project: Collaborative Research: The Carbon Balance of Lake Superior: Modeling Lake Processes and Understanding Impacts on the Regional Carbon Budget
Sponsor: National Science Foundation $242,199 (8/1/06 - 7/31/10)
Investigators: Galen A. McKinley, Chin Wu, and Ankur Desai of University of Wisconsin - Madison
Noel Urban (CEE) of Michigan Technological University

Project: Modeling and Analyzing the Use, Efficiency, Value and Governance of Water as a Material in the Great Lakes Region through an Integrated Approach
Sponsor: National Science Foundation MUSES program $1,078,322 (9/1/07 to 8/31/2012)
Investigators: Alex Mayer (GMES), David Watkins (CEE), Qiong Zhang (SFI), James Mihelcic (USF), Julie Zimmerman (Yale), and Sheila Olmstead (Yale)

Project: Characterizing Lessons Learned from Federal Biomass Removal Projects
Sponsor: US Forest Service $35,603 (9/19/07 to 12/31/10)
Investigator: Kathleen Halvorsen (SFRES/SS)

Project: S-STEM Program: Graduate Student Scholarships to Advance a Global Outlook of Economic and Social Prosperity that Protects the Environment
Director: Judith A. Perlinger (CEE)
Sponsor: National Science Foundation, $599,978 (6/2008 to 9/2012)
Faculty: Veronica Griffis, Alex Mayer, Kurtis Paterson, (CEE) and Jacqueline Huntoon, Graduate School
Administrative Staff: Marie A. Ryding, Madeline Mercado Voelker, Kirsten L. Holles

1.4 Center for Fundamental and Applied Research in Nanostructured and Lightweight Materials

Director: Michael E. Mullins (ChE)

Project: SFI/Center for Fund & App Res in Nanostructured and Lightweight Materials (CNLM)
Sponsor: U.S. DOE $1,230,001 (8/1/08 to 1/31/10)
Investigator: Michael E. Mullins

Research in the following seven areas is funded by the above mentioned US DOE grant:

1.) Project: Development of Lightweight, Thermally Conductive Bipolar Plates for Improved Thermal Management in Fuel Cells
Investigators: Julia King and Jason Keith (ChE)

2.) Project: Exploration of pseudomorphic overlayer bimetallic catalysts for CO removal following fuel reforming to minimize electrode poisoning
Investigator: Joseph Holles (ChE)

3.) Project: Development of Hybrid Nanocomposites
Investigator: Michael Mullins (ChE)

4.) Project: Development of Oriented Polymeric Materials for Membrane Applications
Investigator: Ryan J. Gilbert (ChE)

5.) Project: 5. Preparation of graphitic carbon foam current collectors
Investigators: MTU: Tony Rogers (ChE); Clemson University: O. Mefford

6.) Project: Development of lightweight carbon electrodes using graphitic carbon foams for battery and fuel cell applications
Investigators: Tony Rogers, Bahne Cornilsen with students Matthew Chye and Wen Nee Yeo (ChE)

7.) Project: Movement of Water in Fuel Cell Electrodes
Investigator: Jeffrey Allen

Other Nanostructured and Lightweight Materials Projects Projects

Project: Investigation into the Enhancement of Thermoplastic Polymers with Conductive Nano Materials
Sponsor: Boeing $420,391 (5/1/08 to 8/31/12)
Investigator: Julia King (ChE)

1.5 Center for Environmentally Benign Functional Materials

Directors: Gerard Caneba (ChE)
The mission of the CEBFM is to increase and then sustain research activities into the synthesis, characterization, and analysis of materials that are capable of performing multiple functions in a wide variety of applications. CEBFM researchers from traditional departmental and disciplinary boundaries gather to create a knowledge-base that can assist in further development of technologies for challenging applications critical to the growing technological needs of the US and the world.

1.6 Materials, Design, and Manufacturing for Sustainability

Project: Collaborative Research: Institute/University Cooperative Research Center (I/UCRC) on Assembly Research
Sponsor: National Science Foundation, $10,000 (11/10/08 to 10/20/10)
Investigators: Jamie Camelio (MEEM), and John Gershenson (MEEM)
The I/UCRC on Assembly Research is composed of faculty, graduate students, and laboratory facilities from the University of Michigan and Michigan Tech, and at least ten industry and/or government organizations that collectively fund and direct research activities. This grant enables participants to plan travel to various industries to recruit them for the Center and explain the goal, mission and technology transfer potential of the various industries of the Assembly Design and Manufacturing program. The rationale for forming this collaborative center is that innovative assembly and design manufacturing practices will play critical roles in U.S. industry's ability to compete on the global market. Members directly participate in graduate student education and training, producing a workforce knowledgeable in industrially relevant research and providing access to those students as they prepare for industry employment.

2.0 Education

SFI's education programs cover a variety of interdisciplinary activities, including an NSF Integrative Graduate Education and Research Traineeship project (IGERT), seminars, and courses, as well as ongoing curriculum development efforts. In addition to the programs listed in this section, many other projects throughout this report also contain vital educational components.

Education Project

Project: SF IGERT (Integrative Graduate Education and Research Traineeship)
Sponsor: National Science Foundation (2/1/04 to 7/31/11)
Director: David Shonnard (Chemical Engineering)

The following students have been supported by IGERT in the past 6 years:

Student Name	Department	Advisor	Graduation Date	Current Position
Rodwick Barton Carter	ChemEng	Drs. Jason Keith and Julie King	08/2008	Working at Boeing, Washington State
Abigail Clarke-Sather	MEEM	Drs. John Sutherland and Qiong Zhang	09/2009	Visiting Young Scientist at the Chinese Academy of Sciences (CAS)

Josh Cowden	CEE	Dr. James Mihelcic	01/2009	MWH in Sacramental, CA
Lauren Fry	CEE	Dr. James Mihelcic	08/2010	Post Doc at MTU
Valerie Fuchs	CEE	Drs. James Mihelcic and John Gierke	08/2010	Post Doc at Yale University
Karl Haapala	MEEM	Dr. John Sutherland	12/2008	Assistant Professor at Oregon State University
Deborah Huntzinger	GEO	Dr. John Gierke	12/2006	Post Doc at University of Michigan
Margot Hutchins	MEEM	Drs. John Sutherland and John Gierke	08/2010	working as a consultant in sustainability
Michelle Jarvie	CEE	Dr. David Hand	08/2007	Environmental Engineer at Cleveland Cliffs
Jill Jensen	ChemEng	Dr. Dave Shonnard	12/2009	Post Doc at Idaho National Lab
Cory McDonald	CEE	Dr. Noel Urban	12/2010	USGS in Colorado
Christopher Polonowski	MEEM	Dr. Jeff Naber	08/2009	Post Doc at Sandia national laboratories
Meredith Ballard	CEE	Dr. David Watkins		Student at MTU
Michael Brodeur-Campbell	ChemEng	Dr. Dave Shonnard		Student at MTU
Justin Carlson	ChemEng	Dr. Komar Kawatra		Student at MTU
Benjamin Ciavola	MEEM	Dr. John Gershenson		Student at MTU
Melanie Kueber	CEE	Dr. Larry Sutter		Student at MTU
Kristina Lawyer	MEEM	Dr. Jeff Nabor		Student at MTU
Julio Rivera	MEEM	Drs. Donna Michalek and John Sutherland		Student at MTU

Courses

SFI has developed the following sustainability related courses in order to meet the requirement of IGERT and support sustainability education on campus as well as off campus.

ENG 5510 - Sustainable Futures I (3 credits)
Instructor: Dr. David Shonnard
Students registered during Fall 2009: 28 (including 9 online students)
Covers introductory and intermediate concepts of Sustainable Development. Explores methods/tools for assessing sustainability from economic, environmental, societal perspectives for current and emerging industrial technologies. Explores applications of Life Cycle Assessment in the public policy arena and in the private sector. Industrial applications of sustainable development are further explored through case studies and guest lectures.

ENG 5520 - Sustainable Futures II (3 credits)
Instructors: Dr. Richard Donovan and Dr. Robert Handler
Students registered during Spring 2010: 12 at MTU and 4 at SUBR

Covers sustainability in developed and developing countries. Topics include policy analysis, regulatory impact & cost benefit analyses, trade & markets, laws & regulations, international disasters, GIS applications, green manufacturing, and evolution of environmental policy in U.S. and other countries.

ENG 5530 – Graduate Colloquium in Sustainability (1 credit)
Instructor: Dr. Richard Donovan and Dr. Robert Handler
This course introduces students to general and specific issues related to sustainability. The colloquium discusses historical readings that define the movement towards sustainability, international issues related to sustainable development, corporate leadership, consumption, and societal issues. A recent representative discussion centered on a document from the Commission of the European Communities about the Biomass Action Plan.

Graduate Certificates in Sustainability

SFI has developed the Graduate Certificate in Sustainability to recognize curricular breadth in the following three areas: 1) Policy, societal, and economic systems; 2) Environmental systems; and 3) Industrial systems. The Sustainable Futures Model takes a systems approach that combines information and insight from a meta-disciplinary perspective to help students understand how disciplinary information connects to larger systems. To students seeking employment or further education in this field, the SFI Graduate Certificate provides a competitive edge - through the study of current, accurate information and research surrounding the impact of society's ecological footprint. The systems approach provides a platform for critical and responsive analysis of the interdependence of each structure. As the need for sustainable development and management becomes more important in an increasingly interdependent world, a well-trained problem-solver is a valuable asset to the global environmental system. A graduate student can integrate the certificate into a specialized education in engineering, forestry, science, social sciences, humanities, business, and economics. To achieve the Graduate Certificate in Sustainability, students need to have earned a total of 15 credits, including SF 1 and SF 2 as described above. Graduate students can integrate the certificate into a specialized education in engineering, forestry, science, social sciences, humanities, business, and economics.

The remaining 9 credits are to be divided equally among the three pillars of sustainability, listed below:

Industry and Society (requires minimum of one course – 3 credits)
Courses in the Industry and Society section bridge the gap between these two pillars.
BA5760 Corporate Social Resp. and Business Ethics
CE5993 Field Engineering in the Developing World
HU4625 Risk Communication
MEEM4990 Adv. Service Systems Dynamics and Design
SS3700 Industry and Society
SS3800 Energy Technology and Policy
SS3890 Industry and the World Economy

Environment and Society (requires minimum of one course – 3 credits)
Courses in the Environment and Society section bridge the gap between these two pillars.
BL3850 Environmental Toxicology and Society
FW3110 Natural Resource Policy
FW3410 Conservation Biology
FW3760/SS3760 Human Dimensions of Nat. Resources
FW5180 Phil. and Ethics of Conservation and Ecology
SS3620 International Environmental Technology Policy
SS3630 Environmental Policy and Politics
SS5300 Environmental Policy and Politics
(PPOL750 transfer equivalent)
SS5350 Environmental Policy Analysis
(PPOL714 transfer equivalent)
SS5400 Sociology of the Environment

Industry and Environment (requires minimum of one course – 3 credits)

Courses in the Industry and Environment section bridge the gap between these two pillars.
BA4790 Ecological Sustainability and Organizations
BL4220 Applied and Industrial Microbiology
CE4504 Air Quality Eng. and Science
CE4508 Water and Wastewater Treatment
CE4990 Green Building Design
CE5405 Environmental Impacts of Transportation
CM4550 Industrial Chemical Production
CM4710 Biochemical Processes
EC4600/EC5600 Nat. Resource and Environmental Economics
EC4620/EC5620 Energy Economics
EE5260 Wind Power Grid Integration
FW5550 GIS for Resource Mgmt.
(PPOL786 transfer equivalent)
GE4630 Mineral Industry Economics
MEEM4240 Combustion and Air Pollution
MEEM5653 Life-cycle Engineering
MEEM4685/5685 Environ. Responsible Design and Manufacturing
SS5100 Global Environmental Systems

Since 2004, the following **58** students from throughout Michigan Tech and the SF IGERT program have received Graduate Certificates of Sustainability:

Student Name	**Completion Date**
Barkley, Matthew D	01-May-2010
Lawyer, Kristina M	01-May-2010
Nesbitt, Jaclyn E	01-May-2010
Manser, Nathan D	19-Dec-2009
Satchell, Erin M	19-Dec-2009
Casey, Colin M	15-Aug-2009
Green, Kaitlin E	15-Aug-2009
Mo, Weiwei	15-Aug-2009
Tarte, Andres B	15-Aug-2009
Fry, Lauren M	02-May-2009
Pawelzik, Paul	02-May-2009
Robles Morua, Agustin	02-May-2009
Rowe, Mark D	02-May-2009
Sothirajah, Jayanthi	02-May-2009
Cowden, Joshua R	20-Dec-2008
Jenkins, Timothy L	20-Dec-2008
Wright Wendel, Heather E	20-Dec-2008
Anderson, Mark J	16-Aug-2008
Barton Carter, Rodwick L	16-Aug-2008
Kersten, Linda D	16-Aug-2008
Dumpert, James W	03-May-2008
Jensen, Jill R	03-May-2008
Yao, Meng	03-May-2008
Chow, Jack T	22-Dec-2007
Fuchs, Valerie J	22-Dec-2007
Garcilaso Vejar, Luis R	22-Dec-2007
Kucharski, Matthew J	22-Dec-2007
Liermann, Theresa A	22-Dec-2007
Ocwieja, Sarah M	22-Dec-2007

Pettit, Brendon L	22-Dec-2007
Ghimire, Santosh R	18-Aug-2007
Christophe, Antoinette S	05-May-2007
Clarke-Sather, Abigail R	05-May-2007
Rivera, Julio L	05-May-2007
Womack-Richardson, Edith V	05-May-2007
Muga, Helen E	12-Aug-2006
Suzuki, Ryu	12-Aug-2006
Ye, Xiaoli	12-Aug-2006
Daily, Brian N	29-Apr-2006
Eatmon, Thomas D	29-Apr-2006
Haapala, Karl R	29-Apr-2006
Huntzinger, Deborah N	29-Apr-2006
Hutchins, Margot J	29-Apr-2006
Ilija Ojeda, Monica	29-Apr-2006
Mehl, Jessica A	29-Apr-2006
Schweitzer, Ryan W	29-Apr-2006
Seifert, Christian W	29-Apr-2006
Shaw, Ryan P	29-Apr-2006
Shonsey, Cara W	29-Apr-2006
Welling, Lisa C	29-Apr-2006
Chen, Rui	17-Dec-2005
Shapiro, Jesse S	17-Dec-2005
Henry, Brian P	30-Apr-2005

3.0 Outreach

SFI Banquet and Poster Session

The Sustainable Futures Institute held its **Fifth Annual Poster Session and Banquet** in the Rozsa Lobby on October16th, 2009. About five hundred faculty and students attended the poster session and one hundred of them stayed for the banquet. The event offered SFI students, staff, and faculty an opportunity to review some of its many successes throughout the year, view posters related to its many projects, and learn about some of the sustainability issues still facing us. **Dr. Alex Mayer** and **Dr. Michael Mullins** were introduced as the 2009 Distinguished Fellows of SFI and **17 graduate students** were awarded certificate as SFI Scholars during the event. Keynote speaker for the event was **Dr. Charles Kerfoot**, Director of the Lake Superior Ecosystem Research Center. Dr. Kerfoot spoke about the new $25 Million Great Lakes Research Lab soon to be built at Michigan Tech on the Houghton Canal. Kerfoot pointed out that this new building will facilitate further research and education about pressing issues in the Upper Great Lakes issues, such as the effects of Global Climate Change on Lake Superior water levels, the development of realistic coastal models, impacts of non-indigenous nuisance species; and restoration of native fish stocks, among several other issues.

1) Peter Flynn, P. Eng., Ph.D., Professor and Poole Chair in Management for Engineers - Emeritus
Department of Mechanical Engineering University of Alberta, Edmonton, Alberta Canada
Time and Location: October 5, 2009, 3:00 p.m. Rekhi Hall G 006
Title: Biomass Energy: A Criterion for Picking the Right Technology

Biomass is a carbon neutral potential fuel source for electrical power generation or transportation fuels, each by two routes. This raises the question: what is the object of renewable energy and how does one select the "best technology?" We propose that for all countries focused on greenhouse gas mitigation, the minimum incremental cost per unit of greenhouse gas (GHG) reduction, in essence the carbon credit required to economically sustain a renewable energy plant, is the most appropriate social criterion for choosing from a myriad of alternatives. Key steps in evaluating the required carbon credit include determining the appropriate scale for a given technology, the avoided carbon per unit of useful energy output, and the carbon credit required to provide an adequate return on investment for each technology. The application of this criterion is illustrated for four processing alternatives for straw/corn stover in central and western North America: production of power by direction combustion and biomass integrated gasification and combined cycle (BIGCC), and production of transportation fuel via lignocellulosic ethanol and Fischer Tropsch (FT) syndiesel. The methodology is suitable for other forms of renewable energy including woody biomass. The social policy implications of this approach are reviewed.

Peter Flynn received a Ph. D. from the University of Alberta in Chemical Engineering in 1974, and then spent 25 years in engineering, management and executive roles in Canada's energy industry. From 1984 to 1988 he served as President of CNG Fuel Systems, North America's largest supplier of equipment to let vehicles use compressed natural gas as a vehicle fuel. In 1999 he returned to the University of Alberta to oversee the Engineering Management graduate program. He has authored a textbook, Financial Management for Engineers, and did research in greenhouse gas mitigation, mainly biomass economics, and in power price patterns in deregulated markets and its implications for pumped storage.

2) Dan P. Davison, CEO, Double Helix Management Services Ltd
Time and Location: November 3, 2009, 2:00 p.m. Rekhi Hall GO6
Title: The Millennium Model Research Foundation: Socio-Economic Model for a Sustainable Future

The slogan of the Millennium Model Research Foundation is “Building 1000 Self-Sustainable Communities on Principles that last for 1000 Years”. The presentation will quickly lead the audience through the need to embrace philosophies of The Moral Explosion, which describes the philosophy for sustaining the human community, and then describes the practical enterprise model to support the community. Together, these will form the social-economic base for 1000 Self-Sustainable Communities as given in the business description of Double Helix Management Services Ltd. The talk will describe the immediate implementation of 10 Self-Sustainable Communities and how those communities are expected to develop 10 more with an additional round of development through the leadership and education arm of The Millennium Model Research Foundation.

Dan Davison has held international corporate executive and management positions in the industries of energy; food, farm and facilities; transportation and communications; currency and banking; health and wellness; education and training. He has most recently started a new company called Double Helix Management Systems Ltd. as the financial arm of his non-profit foundation called “The Millennium Model Research Foundation”. The monetization and capitalization are based on gold bullion and 6 infra-structure industries reflecting absolute values for everyone involved with global impact, and will be launched in late 2009. The foundation and investment management firm were formed as part of a unique monetization and capitalization system devised by Davison which are themselves designed to support the implementation and construction of 1000 self-sustainable communities. The communities are to be established on different continents and each community will accommodate at least 10,000 persons.

3) Yu Cai, Assistant Professor, MTU School of Technology
Time and Location: February 9, 2010, 3:00 p.m. Rekhi Hall GO6
Title: Green Computing

Yu Cai's research studies the promotion of green computing without sacrificing performance and security in computing systems to build a sustainable future. His educational plan is to advocate and integrate sustainability into

computing education. Green computing represents a dramatic change in the priority of the IT industry from its traditional economic cost/benefit model to the new sustainable model.

4) Rikard Gebart, Managing Director ETC - Pitea, Sweden
Time and Location: March 25, 2010, 11:00 a.m. Rekhi Hall GO6
Title: Forest Biorefinery in Sweden - Research and Commercial Introduction

Sweden is one of Europe's leading producers of traditional forest products, e.g. pulp, paper and sawn goods. In recent years, rising oil prices and tough international competition in the area of forest products has led industry to evaluate the possibility of making additional new products, e.g. synthetic motor fuels. Estimates have shown that the cash flow at a typical pulp mill can increase by almost 50% if the mill introduces gasification-based production of motor fuels and that the payback time for the investment is attractively short.
In this presentation, some of the on-going developments in the area of forest-based biorefining in Sweden is reviewed. Already commercial is the conversion of tall oil (a by-product from chemical pulp mills) into FAME diesel done by the company SunPine in Pitea, Sweden. Close to commercial is the production of DME via black liquor (another by-product from chemical pulp mills) gasification developed by Chemrec. DME is a synthetic diesel fuel that burns without soot production and this has motivated Volvo Truck to develop a new diesel engine for heavy trucks that will be field tested in ten trucks with DME from a pilot plant in Pitea, Sweden.
Another technology that is under development is direct gasification of biomass in an entrained flow configuration developed by IVAB. This technology is being tested in a pilot gasifier in Pitea, Sweden. In addition to the review of on-going industrial developments some recent results from experiments in an industrial size black liquor gasifier will be presented and compared with predictions from a CFD based gasifier model.

4.0 Other University Sustainability Partners

The SFI is one of several entities at Michigan Tech with a focus or thrust directed at sustainability. Some of these organizations, centers, and institutes have formal relationships with SFI as have been described. Other entities have a less structured linkage with SFI – a brief summary of several of these units are provided below. Together, all of these Michigan Tech groups contribute their ideas and insights to advancing the goal of sustainability.

Environmental Sustainability Committee
Chair: Shalini Suryanarayana (Educ. Oppor.)
The ESC supports environmental initiatives and serves as a resource for campus environmental sustainability improvements. The ESC helps monitor utility use, sponsors environmental speakers and Earth Day activities, and provides leadership on other campus green opportunities to make the campus community aware of the importance of sustainability. http://www.esc.mtu.edu/

Advanced Power Systems Research Center (APSRC)
Director: Jeffrey Naber (MEEM)
The purpose of the Advanced Power System Research Center is to create a multidisciplinary organization that will foster large, collaborative, research efforts in the areas of clean, efficient, and sustainable Power Systems technologies. http://www.me.mtu.edu/research/power/

Advanced Sustainable Iron and Steel Center (ASISC)
Directors: S. Komar Kawatra (ChE)
This Center's mission is to investigate and develop novel, advanced methods for producing the 130 million tons of iron and steel needed annually by the U.S. in a sustainable, environmentally-acceptable manner.
http://www.chem.mtu.edu/chem_eng/news/2008/kawatra2_2008.html

Biotechnology Research Center (BRC)
Director: Chandrashekhar P. Joshi, (SFRES)
The mission of the Biotechnology Research Center (BRC) at MTU is to promote education and research in the areas of molecular biology, biochemistry, genetics, genomics, bioinformatics and biotechnology at both the graduate and undergraduate levels for the benefit of society and the environment. http://biotech.mtu.edu/

Ecosystem Science Center (ESC)
Director: Andrew Burton, School of Forest Resources & Environmental Science

The Biotech Research Center fosters interdisciplinary research at Michigan Tech. Biotechnology encompasses the applications of various science and engineering disciplines for industrial utilization of living organisms or their products. The mission of the Biotechnology Research Center (BRC) at Michigan Tech is to promote education and research in the areas of molecular biology, biochemistry, genetics, genomics, bioinformatics, and biotechnology at both the graduate and undergraduate levels for the benefit of society and the environment. The multidisciplinary nature of the BRC is reflected in the diverse expertise of the BRC faculty. Participation includes faculty from the Biology, Chemistry, Mathematics, Biomedical Engineering, Mechanical Engineering and Engineering Mechanics, and Forest Resources and Environmental Science departments. Faculty, staff and students are open to collaborating on research projects and joining together for research symposiums, seminars and conferences. Working together helps to achieve their common goal: the advancement of biotechnology. http://ecosystem.mtu.edu/

Power & Energy Research Center (PERC)
Director: Bruce Mork (ECE)
Increased focus on alternate and renewable energy, development of new energy technologies, and deregulation of the utility industry are redefining the role of the Power Engineer and creating a wealth of technical and educational challenges. This Center is focused on addressing those challenges. http://www.ece.mtu.edu/perc/

University Transportation Center for Materials in Sustainable Transportation Infrastructure (MiSTI)
Director: Larry Sutter
MiSTI focuses on the identification and use of naturally occurring, industrial byproducts, and/or recycled materials in the design/construction of a more sustainable transportation infrastructure. http://www.misti.mtu.edu/index.php

Center of Excellence for Transportation Materials
Director: Zhanping You (CEE) This Center partners with the Michigan Department of Transportation and Michigan Tech to maintain highly qualified technical staff and certified labs. The specific focus includes the behavior, performance, and sustainability of portland cement-based materials, asphalt-based materials, unbound granular materials, and soils.

5.0 SFI Publications

Books

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Book Chapters

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The SFI Advisory Board is an indispensable means of seeing that we are abiding by our mission and vision. This board meets semi-annually to consult on ideas and strategies for continued success. The board also offers invaluable resources and connections to possible partners. We would like to thank the following people for their willingness to serve on this board:

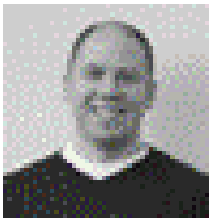
Joseph W. Allen, Director of Sustainable Development and Lifecycle Products for Caterpillar's global Remanufacturing business and a member of Caterpillar's corporate Sustainable Development Team. Mr. Allen is working to increase awareness of the positive impact remanufacturing has on reuse, recycling, and sustainable development.

Christina Behr-Andres is a 1992 Civil Engineering graduate of Michigan Tech and is currently a Deputy Division Leader at Los Alamos National Laboratory (LANL) for the International, Space, and Response Division. She served in management positions in the Earth and Environmental Sciences Division and the Water Stewardship Program at LANL.

A. Harvey Bell IV is former Executive Director of General Motors North American Advance Vehicle Development, responsible for the Vehicle Integration Center, Performance Managers, Harmony & Human Factors, Vehicle Architecture & Design Check/Integration, Energy, Drive Quality & Environment, Noise & Vibration, HVI Innovation Program, Aero/Thermal/Sealing Integration Center, Vehicle Dynamics & Control Systems and Vehicle Concept Engineering.

Damien Ejigiri is Dean and Director of the Nelson Mandela School of Public Policy and Urban Affairs, Southern University and A&M College (SUBR) in Baton Rouge, LA. SUBR partners with Michigan Tech in the direction of SFI's IGERT program. Dr. Ejigiri's research is primarily in Urban and Regional Planning. He has won several awards of excellence for his teaching

Mike Hales is the Director of the Corporate Environmental Compatibility Program at Dow Corning Corporation. He leads the initiative to integrate a design for the environment approach into Dow Corning's business and decision-making processes. He is a member of Dow Corning's Corporate EHS and Global Issue Management Councils. He represents Dow Corning on the State of Michigan's Green Chemistry Roundtable.



Kevin Kuske General Manager, Turnstone and Wood, divisions of Steelcase North America, is dedicated to helping "create great experiences wherever work happens." All solutions are designed with Cradle to CradleTM and lean thinking to create sustainable products and processes.

Clare Mendelsohn is the Director of the Air Force's Western Regional Environmental Office in San Francisco. She also serves as the Department of Defense Regional Environmental Coordinator for the Pacific Northwest. In those capacities, she is responsible for stakeholder outreach and advocacy on environmental and mission sustainment matters, as well as in-house consulting and analysis.

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Bill Olson is Director of the Office of Sustainability and Stewardship for Motorola Mobile Devices. In his role, Bill leads the ECOMOTO program and is responsible for driving go-to-market strategy for green mobile device products like the Motorola W233 RENEW. Bill graduated from the University of Wisconsin-Madison with a Ph.D. in Inorganic Chemistry. Bill has 23 US patents and more than 40 technical publications.

Victoria Pebbles has served with Great Lakes Commission since 1993. She has been working on Great Lakes policy for 15 years and on national environmental policy for 25 years. Ms. Pebbles currently directs the Commission's program on Economy and Society, which addresses clean energy, coastal management, ports and navigation, and tourism and recreation.

Chris Swanston is Director of the Northern Institute of Applied Carbon Science (NIACS), and a Research Ecologist in the USDA Forest Service Northern Research Station. Swanston studies carbon biogeochemistry and cycling in terrestrial ecosystems, and NIACS develops synthesis products, fosters communication, and pursues science in carbon management, climate change, and bioenergy.

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We also like thank SFI's external collaborators that include numerous corporations, government agencies, educational institutions, and other organizations. All of these entities deserve recognition for their continuing support for and interaction with the SFI.

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