I am very pleased to summarize accomplishments and other activities of the Sustainable Futures Institute (SFI) faculty and students for the academic year 2011 - 2012. In the following pages you will find information on new and ongoing projects in the various thrust areas of the Institute as well as core education and outreach activities. Included also is a list of scholarly output from the faculty and students affiliated with the SFI. At the very end can be found information on the financial and other aspects of SFI operations. We continue to benefit from an active and engaged advisory board.

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. Financial support from the Richard and Bonnie Robbins endowment fund is much appreciated.

I invite your comments and continued interest and support in sustainability research, education, and outreach at Michigan Tech through the Sustainable Futures Institute.

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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 Institute Thrust Area Projects

1.1 SFI Highlight of the Year – Research Coordination Network for Pan American Bioenergy and Biofuels Sustainability

The goal of the RCN project is to link together biofuels/bioenergy researchers, industry, government and NGO practitioners concerned with the sustainability of biofuels and bioenergy development across the Americas. The project seeks to: i. Establish and sustain an international research coordination network with a focus on biofuels / bioenergy sustainability and with a geographic context of the Pan American region; ii. Develop coordinated research programs; and iii. Create new knowledge on social, environmental, and economic sustainability implications of large-scale biofuels/bioenergy production from biomass grown in this region. The sustainability themes that the network primarily focuses on include:

- Community Impacts;
- Water/Energy Nexus Issues;
- Biodiversity and Ecosystems;
- Energy Policy;
- Life Cycle Environmental Assessment;
- Food and other systems;
- Biogeochemical Cycles;
- Biomass Supply Transportation Logistics;

In addition to the creation of the network itself, the RCN has two main deliverables; 1. a research roadmap report on sustainability of biofuels and bioenergy in the Pan American region; and 2. a graduate course in sustainability of biofuels/bioenergy to be developed within the network and disseminated to the network through the internet. The members of the RCN connect through a comprehensive cyber-infrastructure to support real time dissemination of the RCN products, enable real time collaboration across the network, and provide for the growth of the proposed RCN.

Participants of this program come from a variety of academic disciplines, nationalities and organizational affiliations and participate in many ways. For example, a significant group (from the US, Brazil, Argentina and the host Mexico) recently attended a workshop in Merida, Mexico to discuss and develop strategies for guiding research into the Community Impacts, Biodiversity and Ecosystems, Water/Energy Nexus Issues and Biogeochemical Cycles (see details below). Other groups have been engaged in proposal development for broad based projects like the PIRE program (Dr. Kathy Halvorsen, PI) and more focused efforts such as the PEER program (Dr. Julio Sacramento [Universidad Autonoma de Yucatan], PI) described under the Sustainable Energy section below.

Year 1 Activities: Research Coordination Network

The 1st Workshop for the Pan American Biofuel and Bioenergy Sustainability RCN project was held in Merida, Yucatan, Mexico from May 29-31, 2012 at the UNAM-CEPHCIS campus. The main items in the agenda for this workshop were:

(1.) Introduce research and teaching interests of each participant;
(2.) Discuss overall projects goals;
(3.) Present and refine the education plan and make initial graduate course preparation assignments;
(4.) Present, discuss, and refine year 3 conference goals and objectives and identify lead coordinators for the preparation of review papers in each bioenergy sustainability dimension;
(5.) Review the approach for communication through a hub based cyber-infrastructure for the RCN; and
(6.) Participate in the pre and post evaluation sessions plus selected interviews.

Summaries of these activities are provided below.
(1.) Research and Teaching Interests

Each invited participant presented an oral summary of key research and teaching interests in bioenergy sustainability in the four focus areas of the workshop. These summaries have been posted to the sustainability hub (https://hubzero.admin.mtu.edu/) that has been developed under this project. Workshop participants also prepared and presented posters at the Piedre de Agua Hotel (where most of the participants stayed during the workshop) in order to provide more details on specific research projects. Overall, this was an effective way for workshop participants to learn of the wide scope of research expertise and projects within the RCN and to begin the process of research collaboration.

(2.) RCN Project Goals

This session at the Workshop started with an overview presentation by David Shonnard on the broad goals, objectives, milestones, and deliverables of the project. Jackie Huntoon presented on the project’s assessment plan followed by four breakout sessions addressing different aspects of the project: (a) Research Collaboration; (b) Expanding Topics in the RCN; (c) Increasing Participation; and (d) Diversity.

For increasing research collaborations across Pan American countries, it was noted that common research methods and protocols should be implemented to assure consistency and that there is a need to select a common set of sustainability metrics / indicators for case studies in different countries. Suggestions of possible sources of funding for interdisciplinary bioenergy research included: Canada (CIDA), Mexico (CONACYT), international sources (CYTED), US (USAID), and embassies. In order to increase participation it was suggested that we leverage existing international networks such as the Inter-American Institute of Agricultural Science (IICA and PROCISUR (part of IICA)), the Inter-American Institute (IAI), and the Latin American Organization of Energy (OLADEO).

(3.) RCN Education Plan and Assignments

Dr. Shonnard for Michigan Tech, Mr. Jorge Hilbert (Instituto Natiobnale de Argentina [INTA] for Universidad Tecnológica Nacional (UNT), and Dr. Rodrigo Medeiros for Universidade Federal Rural do Rio de Janeiro (UFRR) presented details regarding existing sustainability education programs. The Michigan Tech program is an interdisciplinary Graduate Certificate in Sustainability featuring two required courses and three elective courses, for 15 semester-credits total. The certificate appears on the students MS or PhD diploma. At UNT in Argentina, the program is a master’s degree in renewable energy, which includes a focus area on biomass based energy production. The program is 2 ½ years and including 650 hours of instruction, involves professors from Argentina and abroad, the possibility of research experiences in labs of international collaborators, and original investigations into thesis topics. At UFRR, the program involves a Global Masters of Development Practice (MDP) degree in sustainable development that is part of an international program organized out of the Earth Systems Institute at Columbia University (http://globalmdp.org/). The Global MDP is a 2-year program featuring a core curriculum in health sciences, natural sciences, social sciences, and management sciences; a global classroom, and field training experiences for 54 credits.

David Shonnard provided an overview presentation of the proposed 3-semester credit graduate course on Pan American Biofuels and Bioenergy Sustainability. It is anticipated that the course lectures and reading materials will be developed and identified by participants in the RCN and delivered by video conference between the collaborating
universities and institutions. Recording of lectures should take place for archiving and for posting on the RCN hub site for students to review if there are scheduling conflicts with the course period. Student-led teams will lead a presentation and in-class discussion of more advanced concepts, readings, and case studies. There will be interdisciplinary teams working on term projects where applications of concepts, methods, and analysis tools from the course is to be targeted at bioenergy case studies in different Pan American regions.

1.2 Sustainable Energy

Sustainable energy continues to be an important thrust for research and education initiatives and projects for the SFI, for its affiliated faculty and students, and for Michigan Tech. Many projects are focused on sustainability of biofuels and biofuel production systems, including feedstock supply chain analyses, life cycle environmental assessments, and the Wood to Wheels (W2W) forest-based biofuels projects.

Featured Projects in Development

National Science Foundation Partnerships for International Research and Education (PIRE), Kathy Halvorsen, PI

Science, Engineering and Education for Sustainability (SEES) researchers and practitioners grapple with one of our greatest challenges: Given enormous climate change-related uncertainty, how can we manage natural resources such that “Development … meets the needs of the present without compromising the ability of future generations to meet their own needs?” (Brundtland Commission 1987). Bioenergy will play a major role in meeting these challenges. This project concentrates on one form of bioenergy--liquid transportation fuels or “biofuels”--to investigate the impact of biofuel development on socio-ecological systems and associated ecosystem services, and how can those impacts best be measured, modeled, and mitigated? Project efforts focus on biodiesel from palm, soy, jatropha, and eucalyptus, and ethanol from sugarcane and woody biomass in four case studies across Brazil, Argentina, Mexico, and the United States (US). The project will integrate these case studies across the Americas to address the following questions:

- How will biofuel development affect socioeconomic systems?
- How will biofuel development affect ecological systems?
- What sustainability indicators and metrics best assess biofuel sustainability across highly variable Pan American socio-ecological systems? and
- How will policy address biofuel-related socio-ecological impacts?

Data collection and analyses will include: 1) biofuel- and ecosystem service-related cultural values, beliefs and norms, and economic and sociological impacts; 2) on-the-ground biofuel production-related ecosystem service impacts, including carbon storage, water quality and quantity, and biodiversity; 3) new sustainability science indicators and metrics using results from the socio-economic and ecosystem service studies; and 4) biofuel policy analysis tied to project ecosystem service and sustainability metrics.

National Science Foundation Sustainable Energy Pathways (SEP), Dr. David Shonnard, PI

The four-year Wood to Wheels (W2W) SEP project will conduct transformative, multidisciplinary, comprehensive, and integrated research in the area of forest-based infrastructure-compatible liquid biofuel for vehicular transportation. New knowledge generated will span the entire value chain, from forest biomass production to thermochemical processing, fuel combustion, and systems-level sustainability analyses. Project deliverables will help establish a new forest-based biofuels industry featuring high productivity forest energy crops, sustainable forest management practices, catalysts and process technologies, innovations in engine systems, sustainable decision-making databases, and analysis methods/software tools. Researchers from multiple disciplines will work at the cusp of emerging discoveries to develop new knowledge about complex coupled natural/industrial/societal systems. The project’s research will focus on the production of “infrastructure compatible green diesel” derived from a novel two-stage torrefaction / fast-pyrolysis treatment and catalytic conversion of bio-oil derived from woody feedstocks. The resulting fuel product will be a direct hydrocarbon replacement for fossil diesel. Fundamental combustion and emissions studies using both surrogate and synthesized green diesel will guide catalysis and pyrolysis research to achieve biofuel products with desired compositions and cost-effective engine emissions reduction. Similarly, fundamental research in torrefaction, pyrolysis and catalytic upgrading will inform studies to improve properties of
forest feedstocks. Through novel education and training programs, our students – postdoc, Ph.D.s, and undergraduates - will emerge as globally-aware, technically advanced, and innovation-focused engineering and science professionals.

Research is organized into three main thrusts plus a cross-cutting thrust integration activity; 1) **Sustainable Forest Systems** (forest productivity modeling, sustainability of ecosystem nutrition and productivity, genomics-guided feedstock improvement), 2) **Two-Stage Torrefaction/Pyrolysis-Based Conversion Processes** (pyrolytic production of bio-oil with catalytic upgrading to an *infrastructure-compatible green diesel*), 3) **Energy Utilization of Advanced Biofuels** (spray combustion kinetics, emissions characterization), and 4) **Integrated Sustainability Assessment and Decision Making** (decision support tools including indicator sets, process simulation and optimization, techno-economic analyses, life cycle assessment, greenhouse gas analyses and energy balances).

Hypothesis-driven research in the W2W SEP will be conducted in an interconnected fashion (*Figure 1*), with the goal of producing an infrastructure-compatible green diesel (GD) with system-wide benefits; such as clean combustion in engines (low particulates and NOx), reduced life-cycle greenhouse gas emissions compared to fossil fuel, low cost per gallon, rural job creation, increased energy independence, high productivity per acre of forest biomass, plant genotypes with favorable composition for conversion, and engines optimized to use the prescribed component make-up of the GD.

![Figure 1. W2W SEP: Overall Integrated Research Program](image)

**National Science Foundation/USAID Partnerships for Enhanced Engagement in Research (PEER), Dr. Julio Sacramento PI, Universidad Autonoma de Yucatan, Merida MX**

This PEER-PIRE proposal seeks complementary funding for Mexican collaborators of the PIRE proposal “Sustainability, Ecosystem Services, and Bioenergy Development across the Americas” The PIRE proposal addresses these themes by proposing answers to four main questions, including: “How is bioenergy development affecting social systems?” and “What sustainability indicators and metrics best assess biofuel sustainability across highly variable Pan American socio-ecological systems?” This PEER-PIRE proposal aims to provide answers to these two questions, in line with the LCA and community-impacts overarching themes. This work will be performed in the context of the jatropha-oil industry currently under development in the Yucatan state, Mexico. This case study is unique in that it presents evaluation of both universal and idiosyncratic aspects of sustainability. The research team will have strong input from international partners through the RCN and OISE-PIRE participants, through RCN workshops and conferences, and co-supervision of three graduate students. The expected project impacts are closely aligned with USAID’s interests on Environment, Agriculture, and Water, and more prominently on Global Partnerships with a focus on Sustainability. The main benefits of this research will be:

- Contributing to enhance the understanding of sustainability as a multicriteria problem including natural resource management, land and water use and availability, and socio-economic impacts on local communities;
- Elaborating new case studies on the application of sustainability-evaluation methodologies, for use in graduate education and policy decision-making;
Enhancing the understanding on how location, feedstock source, and sustainability indicators impact decisions about sustainability of biofuels/bioenergy systems; and
Increasing the research capacity of the Pan American partner institutions for graduate and postgraduate student education specialized in sustainability issues.

Pending Projects

Project: LCA and Evaluation of Techno-Economic Analyses of APB Expansion Project
Sponsor: American Process Inc, $27,632,
Investigator: Dr. David R. Shonnard

Project: Life Cycle Assessment of Hydropyrolysis Integrated with a Petroleum Refinery
Sponsor: Gas Technology Institute, $198,654
Investigator: Dr. David R. Shonnard

Project: OISE-PIRE: Sustainability, Ecosystem Services, and Bioenergy Development across the America's
Sponsor: National Science Foundation, $2 (pre-proposal)
Investigator: Dr. Kathy Halvorsen

Project: Section C Management and Life Cycle Assessments of the MSU BRDI
Sponsor: US Department of Agriculture, $322,825
Investigator: Dr. David Shonnard

Sponsor: US Department of Agriculture, $337,542
Investigator: Dr. David R Shonnard

Project: Life Cycle Assessments (LCAs) in Support of UOP-USDA BRDI Proposal 2011
Sponsor: US Department of Agriculture, $300,000
Investigator: Dr. David R. Shonnard

Project: SEP: Sustainable Forest-Based Biofuel Pathways to Hydrocarbon Transportation Fuels: Biomass Production, Torrefaction, Pyrolysis, Catalytic Upgrading, and Combustion
Sponsor: National Science Foundation, $1,996,585
Investigator: Dr. David R. Shonnard

Project: Collaborative Research: Electrochemical Reduction of CO2 to Small Organic Fuels on Encapsulated Metal Catalysts in Gas Diffusion Electrode Environment
Sponsor: National Science Foundation, $184,567
Investigator: Dr. Wenzhen Li

Project: High Power Density and Durability, Low Cost Hydroxide Exchange Membrane Fuel Cells (HEMFCs) Directly Fed with Biodiesel Residual Crude Glycerol
Sponsor: US Department of Energy, $-
Investigator: Dr. Wenzhen Li

Project: A Pan American Biofuels and Bioenergy Sustainability Research Network
Sponsor: National Science Foundation, $11,266,071
Investigator: Dr. David R. Shonnard

Project: Life Cycle Assessments to Support the Terrestrial Carbon Analytics (TCA) BRDI Preproposal
Sponsor: US Department of Agriculture, $-
Investigator: Dr. David Shonnard
Project: Life Cycle Assessment Research to Support MRIGlobal BRDI Preproposal  
Sponsor: US Department of Agriculture, $-  
Investigator: Dr. David Shonnard

Project: Life Cycle Assessments to Support the Avello BRDI Preproposal  
Sponsor: US Department of Agriculture, $-  
Investigator: Dr. David Shonnard

Project: Bimetallic Overlayer Catalysts for Sustainable Fuel Production From Lactose  
Sponsor: National Science Foundation, $299,998  
Investigator: Dr. Tony Rogers (Joe Holles)

Project: Environmental Life Cycle Assessments of PyGasoline and PyDiesel From Different Feedstocks: Hardwoods, Corn Stover, and Diseased Softwoods  
Sponsor: US Dept of Energy w/ UOP, $257,076  
Investigator: Dr. David Shonnard

Project: Life Cycle Assessments to Support LanzaTech: DOE FOA 0000467  
Sponsor: US Dept of Energy w/ LanzaTech, $149,960  
Investigator: Dr. David Shonnard

Project: LCA and Evaluation of Techno-Economic Analyses of APB Expansion Project  
Sponsor: American Process Inc., $27,632  
Investigator: Dr. David Shonnard

Project: Determinants of Citizen/Private Landowner Participation in Voluntary Land Management Programs  
Sponsor: National Science Foundation, $299,684  
Investigator: Dr. Audrey Mayer

Project: Roll-Printed, Nano-Architectured, Swiss-Roll Columns for Oil-Water Demulsification and Separation  
Sponsor: National Science Foundation, $850,000  
Investigator: Dr. Dennis Meng

Project: A Novel Two-Stage Torrefaction-Pyrolysis for the Production of High-Grade Bio-Oil  
Sponsor: National Science Foundation, $332,407  
Investigator: Dr. Ezra Bar Ziv

Project: Engaging Students & Families in Learning About Forests  
Sponsor: Michigan Dept of Natural Resources, $9,992  
Investigator: Joan Chadde

Project: Bioprocess Synthesis for Enhanced Cellulosic Biofuel Production  
Sponsor: National Science Foundation, $66,326  
Investigator: Dr. Wen Zhou

Project: EPA San Luis Basin Regional Sustainability Project  
Sponsor: Environmental Protection Agency, $199,580  
Investigator: Dr. Audrey Mayer

Project: Development of the New Forest-Based Biofuels Research Laboratory and Pilot Plant  
Sponsor: Herrick Foundation, $75,000  
Investigator: Dr. David Shonnard
New Projects

Project: RCN-SEES: A Research Coordination Network on Pan American Biofuels and Bioenergy Sustainability
Sponsor: National Science Foundation, $749,996, (1/1/2012-12/31/2015)
Investigator: Dr. David Shonnard

Project: RCN-SEES: A Research Coordination Network on Pan American Biofuels and Bioenergy Sustainability (Supplementals)
Sponsor: National Science Foundation, $20,000
Investigator: Dr. David Shonnard

Investigator: Dr. Wen Zhou

Sponsor: US Department of Transportation, $150,016, (4/1/2012-3/31/2013)
Investigator: Dr. David Shonnard

Project: A forest Based Biofuels Pilot Plant for Wood-to-Wheels at Michigan Tech
Sponsor: Gerstacker and Strosacker Foundations, $125,000, 1/01/2011-12/31/2014
Investigator: Dr. David Shonnard

Ongoing Projects

Project: Life Cycle Assessments to Support Sustainable Algae-Based Biofuels Production for the National Alliance for Advanced Biofuels & Bioproducts
Sponsor: UOP LLC/Honeywell, $89,995, (10/01/2010-06/30/2012)
Investigator: David Shonnard

Sponsor: Lanza Tech Limited, $75,300, (10/29/2010-05/01/2012)
Investigators: David Shonnard and Robert Handler

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/Honeywell, $125,002 (5/1/2010-7/31/2011)
Investigator: David Shonnard (ChE)

Project: Carbon Footprint Analysis of IH2 Biofuels: Proposed Detailed Analyses
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
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/Honeywell, $80,503 (5/1/2010-4/30/2011)
Investigator: David Shonnard (ChE)
Project: Planning Grant: I/UCRC for Joining the Center for Bioenergy Research and Development  
**Sponsor:** National Science Foundation, $12,978 (5/15/2010-8/31/2011)  
**Investigators:** David Shonnard (ChE) and Richard Donovan (SFI)

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

Project: COEE Project 3 - Improving Forest Feedstock Harvesting, Processing and Hauling Efficiencies  
**Sponsor:** State of Michigan $274,837 (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), Robert Handler (SFI), Pasi Lautala (CEE) and Terrence McNinch (Transportation Inst.)

Project: 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 Susan Bagley (Biological Sciences)

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)  
**Investigators:** Ann Maclean (SFRES), David Flaspohler (SFRES), Christopher Webster (SFRES), David Shonnard (ChE), Barry Solomon (SS), John Sutherland (MEEM)

Project: Michigan Tech Research Year 1: Forestry Biofuel Statewide Collaboration Center  
**Sponsor:** Michigan Dept of Labor & Economic Growth, $646,850 (3/11/2009-12/31/2011)  
**Investigator:** Dr. David Shonnard

Project: Life Cycle Assessments to Support Sustainable Algae-Based Biofuels Production for the National Alliance for Advanced Biofuels and Bioproducts (NAABB): Year 3  
**Sponsor:** UOP, LLC, $47,999  
**Investigator:** Dr. David Shonnard

### 1.3 Sustainability Education

**Featured Projects in Development**

**National Science Foundation Transforming Undergraduate Education in Science, Technology, Engineering and Mathematics, Audrey Mayer, PI**

Because individual decisions have a profound effect on quality of life for current and future generations, a paramount educational objective for sustainability education is to empower students to become better decision-makers. To achieve this objective within the context of sustainable development, this course must present to students its historical context and its multiple interpretations, enabling students to analyze complex human/natural systems, and motivating students to explore more advanced sustainability topics in discipline-specific courses. The proposed course topics for accomplishing this sustainability education objective are:  

- **a.** sustainability concepts – origins of sustainable development and global challenges it addresses,  
- **b.** systems analysis – the ability to understand and assess interactions in complex human/natural systems,  
- **c.** environmental life cycle assessment – the ability to analyze and compare product systems from the standpoint of environmental impacts,  
- **d.** development theories – the knowledge of different approaches for development and their advantages and disadvantages,  
- **e.** economic sustainability – contrast ecological economics with traditional concepts,  
- **f.** social sustainability – policy and societal dimensions of sustainable development,  
- **g.** developing world issues, and  
- **h.** innovation for sustainable development.

These diverse topics will be explored using an active-learning approach where there will be an emphasis on
developing student skills, on engaging students in higher-order thinking (analysis, synthesis, evaluation), on participatory activities (case study presentations and leading discussions on readings), and in exploring their own attitudes and values. Students will use computer-aided software to apply methods of life cycle assessment to the analysis, to comparisons, and to decisions on the environmental compatibility of product systems in homework assignments and in a term project. Both formative and summative evaluations will address the project’s progress toward its overall goal by measuring its effectiveness at meeting specific objectives, as outlined in the proposal.

Pending Projects

**Project:** A Sustainability and Sustainable Development Program for all Undergraduate: Engaging Content Experts with Active Learning by Students  
**Sponsor:** National Science Foundation, $199,976  
**Investigator:** Audrey L Mayer

**Project:** Scholarships to Create Professionals for Engineering Community Resilience  
**Sponsor:** National Science Foundation, $619,488  
**Investigator:** Dr. Kurtis Patterson

**Project:** RET Site: "Wood-to-Wheels (W2W)" - Research Experiences for High School Teachers in Sustainable Transportation Technologies (Supplemental)  
**Sponsor:** National Science Foundation, $20,000  
**Investigator:** Dr. David R. Shonnard

New Projects

**Project:** Building Community Capacity to Manage Private/Public Forests and Develop Forest Stewards  
**Sponsor:** US Dept of Agriculture, $81,510, (9/8/2011-9/30/2013)  
**Investigator:** Joan Chadde

Ongoing Projects

**Project:** RET Site: Wood to Wheels-Research Experiences for High School Teachers in Sustainable Transportation Technologies  
**Sponsor:** National Science Foundation, $358,942, (01/15/2011-12/31/2013)  
**Investigators:** David R Shonnard (ChE), Brad Baltensperger (CLS), S. Joshi (SFRES), Jeffrey Naber (MEEM), K. Hungwe (CLS), Shawn Oppliger (CCISD), Christine Anderson

**Project:** Great Lakes Maritime Education for K-12 Teachers  
**Sponsor:** University of Wisconsin-Superior, $8750, (10/01/2010-09/30/2012)  
**Investigator:** Joan Schumaker Chadde

**Project:** Bringing Environmental Education to Urban Schools in Detroit  
**Sponsor:** US Dept of Agriculture, $13,999, (08/18/2010-09/20/2012)  
**Investigator:** Joan Schumaker Chadde

**Project:** Great Lakes Maritime Education for K-12 Teachers  
**Sponsor:** University of Wisconsin-Madison, $22,500, (10/01/2010-09/30/2012)  
**Investigator:** Joan Schumaker Chadde

**Project:** Family Engineering for Parents and Elementary-Aged Children  
**Sponsor:** National Science Foundation, $1,652,835, (5/15/2008-4/30/2012)  
**Investigators:** Neil Hutzler (CEE), Joan Schumaker Chadde

**Project:** Outdoor Science Investigations Field Trip Program
**1.4 Complex Systems Analysis**

**Featured Projects in Development**

**National Science Foundation Partnership for Innovation (PFI), Dr. Richard P. Donovan, PI**

The Building Innovation Capacity in Science, Engineering and Education for Sustainability Assessment (SEES-A) project is designed to bridge the gap between academic research and application development for bioenergy and biofuel sustainability. The proposed project seeks to establish an integrated sustainability analysis/assessment testbed to serve as a platform that pushes the extensive sustainability research activities of the Sustainable Futures Institute (SFI) at Michigan Technological University out to appropriate stakeholders, and pulls information from the stakeholders back into the SFI research programs. The logic model for SEES-A, illustrated below, shows three interrelated activities: (i) Development of a Knowledge Enhancement Partnership (KEP) Program consisting of small businesses and other stakeholders who will co-develop applications for their markets; (ii) Establishment of a Sustainability Assessment Extension Center; and (iii) Creation of a Graduate Enterprise for Sustainability Assessment. Overall, the program will create field-tested sustainability assessment tools to position our KEPs to take advantage of the results of sustainability science research while providing outreach and formative evaluation for the sustainability research efforts at partner organizations. The program is designed to prepare students, researchers and practitioners for careers in sustainability science by providing opportunities to professionally interact with stakeholders such as landowners, community leaders and government policy makers.
Pending Projects

Project: EPA San Luis Basin Regional Sustainability Project  
Sponsor: Environmental Protection Agency, $199,580  
Investigator: Dr. Audrey Mayer

Project: Building Innovation Capacity in Science, Engineering and Education for Sustainability Assessment  
Sponsor: National Science Foundation, $599,899  
Investigator: Dr. Richard P. Donovan

New Projects

Project: Planning Visit for US-Australia Collaborative Research on Climate-Related Infrastructure Adaptation for Natural Hazards  
Investigator: Dr. Yue Li

Project: Integration of Mainshock-Aftershock into Performance-Based Engineering using Publicly Available NEEShub Data  
Sponsor: National Science Foundation, $286,000, (5/1/2011-4/30/2014)  
Investigator: Dr. Yue Li

Project: US-Vietnam Workshop on Multiple Natural Hazards Assessment and Mitigation under the Impact of Climate Change  
Sponsor: National Science Foundation, $39,450, (5/15/2012-4/30/2013)  
Investigator: Dr. Yue Li

Ongoing Projects

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

Project: Bioavailability and Phosphorus Management for Onondaga Lake  
Investigator: Martin T. Auer (CEE)

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 (CEE)

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: 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: Evaluating Riparian Timber Harvesting Guidelines: Phase 3, Result 2 Evaluate Aquatic Habitat Impacts  
Investigator: Casey Huckins (BL)

Sponsor: National Science Foundation, $317,390, (09/15/2010-08/31/2013)  
Investigator: Alex Mayer (CEE)

Project: Predicting Ecosystem Changes in Lake Superior  
Investigator: Nancy Auer (BL)

1.5 Developing World Sustainability  

Pending Projects

Project: Sustainable Bioenergy for the Americas: Research and Development through Peace Corps Masters International Engagement for Pan American Bioenergy Sustainability  
Sponsor: US Department of State, $1,491,434  
Investigator: Dr. Richard P. Donovan

Ongoing Projects

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: 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

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 (CEE), Alex Mayer (CEE), Kurtis Paterson, (CEE) and Jacqueline Huntoon, Graduate School

Project: Graduate Student Scholarships to Advance a Global Outlook of Economic and Social Prosperity that Protects the Environment  
Investigator: Judith A Perlinger

Project: Enhancing the Capacity for Sustainable Forest Management in Chiapas and Oaxaca  
Sponsor: Higher Education for Development, $459,562 , (02/16/2009-09/30/2012)  
Investigator: Alex Mayer
**Pending Projects**

**Project:** Selective Electrocatalytic Oxidation of Biorenewable Polyols over Bimetal Catalysts  
**Sponsor:** National Science Foundation, $299,999  
**Investigator:** Dr. Wenzhen Li

**Project:** Life Cycle Assessments to Support LanzaTech: Department of Energy Innovative Manufacturing Initiative  
**Sponsor:** Department of Energy, $145,319  
**Investigator:** Dr. David R. Shonnard

**Project:** Environmentally Responsible Treatment and Generation of Useful Products from Aluminum Extraction Waste Materials  
**Sponsor:** US Environmental Protection Agency, $14,711  
**Investigator:** Dr. Gerard T. Caneba

**Project:** Biomediated Geomechanical Processes for Dust Mitigation and Monitoring at Mine Tailings Impoundments  
**Sponsor:** National Science Foundation, $210,287  
**Investigator:** Dr. Eric Seagren

**Project:** Collaborative Research: Nexus of Simulation, Sensing and Control for Aerodynamic Loads Reduction of Wind Turbine Blades  
**Sponsor:** National Science Foundation, $270,200  
**Investigator:** Dr. Qingli Dai

**Project:** Oil Dispersion Studies and Dispersants from FRRPP-based Surfactants  
**Sponsor:** University of Alabama at Birmingham, $449,998  
**Investigator:** Dr. Gerard Caneba

**Project:** MTU Support of "Circular Manufacturing for Improved Material Efficiency (CMIME)"  
**Sponsor:** Purdue University (re: National Science Foundation), $23,999  
**Investigator:** Dr. David R. Shonnard

**Project:** Hyphenated SEC-IR Instrumentation for Studies of Water-based Gel Propellants  
**Sponsor:** US Department of Defense, $305,961  
**Investigator:** Dr. Gerard Caneba

**New Projects**
**Project:** REF-TC: Benchmark Performance Testing of Michigan Tech Rechargeable Carbon Foam Supported by Nickel Asymmetric Capacitors  
**Sponsor:** Internal, (7/1/2011-8/31/2012)  
**Investigator:** Bahne C. Cornilsen

**Project:** Novel Techniques for Stabilization and Conservation of Ferrous Metals in Industrial Heritage  
**Sponsor:** US Department of the Interior, $25,000, (5/1/2012-6/30/2013)  
**Investigator:** Dr. Timothy Scarlett

### Ongoing Projects

**Project:** Collaborative Research: Institute/University Cooperative Research Center (I/UCRC) on Assembly Research  
**Sponsor:** National Science Foundation, $10,000 (11/1/08 to 10/31/2012)  
**Investigators:** Jamie Camelio (MEEM), and John Gershenson (MEEM)

**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

**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)

## 2.0 SFI Core Education Activities

### Courses

SFI has developed the following sustainability related courses in order to 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)  
This course covers introductory and intermediate concepts of Sustainable Development. The course explores methods/tools for assessing sustainability from economic, environmental, societal perspectives for current and emerging industrial technologies. It also 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  
This course 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.
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.

- OSM4100 (or OSM5100) Operations Strategy
- BA5610 Business Process Management
- BA5780 Managing in the Global Environment
- CE5408 Public Transit
- CE5993 Engineering with Developing Countries
- EC5640 Natural Resource Economics
- EC5650 Environmental Economics
- HU4625 Risk Communication
- CE/CSE 5710 Modeling and Simulation Applications for Decision-Making in Complex Dynamic Systems
- SS3800 Energy Technology and Policy
- SS 4390 Seminar in Sustainability Issues
- SS3820-Ethical, Legal and Societal Implications (ELSI) of Nanotechnology
- EC4620/EC5620 Energy Economics

**Environment and Society (requires minimum of one course – 3 credits)**
Courses in the Environment and Society section bridge the gap between these two pillars.

- BL4120 Environmental Remediation and Toxicology---note prerequisites
- EC5650 Environmental Economics
- FW3110 Natural Resource Policy
- FW3410 Conservation Biology
- FW3760/SS3760 Human Dimensions of Nat. Resources
- FW 5150 Institutions and Natural Resource Management
- FW5180 Conservation Ethics
- SS3620 International Environmental Technology Policy
- SS5300 Environmental Policy and Politics
- SS 5313 Sustainability Science, Policy and Assessment
Industry and Environment (requires minimum of one course – 3 credits)
Courses in the Industry and Environment section bridge the gap between these two pillars.
BL4220 Applied and Industrial Microbiology
ENVE4504 Air Quality Eng. and Science
ENVE 4508 Water and Wastewater Treatment
CE4050/CE5050 Green Building Design
CE 5666 Water Resources Planning and Mgmt
ENVE5511 Air Quality/Built Environment
CE5920 Civil Engineering Independent Study (TBD)
CE5930 Environmental Engineering Independent Study (TBD)
CE 5710- Modeling and Simulation Applications for Decision-Making in Complex Dynamic Systems
CM4550 Industrial Chemical Production
CM4710 Biochemical Processes
CMG 4800- Sustainable Construction
EE5260 Wind Power
FW 5413 Sustainable Biomass
FW5550 GIS for Resource Mgmt.
GE4630 Mineral Industry Economics
MEEM/ENVE 5453 and 5454 See Think Design Delight
MEEM5685 Environmentally Responsible Design & Mfg.

Since 2004, the following 89 students from throughout Michigan Tech and the SF IGERT program have received Graduate Certificates of Sustainability:

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3.0 Outreach
Members of the SFI were engaged in numerous outreach activities throughout the year. Highlighted activities are described below.

Aquaponics Laboratory
Aquaponics is a term to describe the integration of aquaculture (fish farming) with hydroponics (growing plants without soil) in a closed-loop, mutually-supporting system (see Figure 1). Fish wastes provide fertilizer for plant growth, while the plants filter and clean water to maintain a healthy environment for the fish. Several important bacterial species are involved to convert ammonia present in fish waste to nitrate, a form of nitrogen that is non-toxic to fish, and mediate other important reactions in the system. Improved technology and a resurgence of interest in the field has spawned a new wave of engineered systems in recent years, focusing on optimizing the interactions of fish and plants through improved aeration, efficient water movement, feed management, and nutrient cycling. In areas where good soil is not in abundance or in urban settings, aquaponics has been investigated as a means of locally-grown sustenance for a community, and community-based aquaponics projects have been spreading throughout the country, even in the colder Great Lakes region (e.g., Sweetwater Organics and Growing Power in Milwaukee, WI).

In December 2011, SFI postdoctoral researcher Robert Handler and Biological Sciences faculty Nancy Auer received funding from the internal Michigan Tech Century II Campaign Endowed Equipment (C2E2) Fund to purchase an aquaponics system to be operated in the Dow building greenhouse. C2E2 is a program aimed at providing equipment money to improve the lives of faculty, students, and staff campus-wide. After the system was ordered, delivered, and constructed, plants and bacteria were introduced in April 2012 (Figure 2a). Tilapia was the initial fish species chosen for the system, and 72 tilapia fingerlings were added to the system in May 2012. The fish...
have grown well since then, as have the variety of plants and herbs grown in the 6 months of operation (Figure 2b). In the first four months alone, nearly 18 kg of basil was grown in only 20 ft² of growing space!

Figure 2 – One of the two aquaponics systems after installation in the Dow 905 greenhouse (A) and after 3 months of operation (B) in summer 2012.

Dr. Handler and Dr. Auer propose to use the aquaponics system as a tool to illustrate a variety of science, technology, engineering, and mathematics (STEM) concepts. Properly functioning aquaponics systems seem simple, but a great deal of biological and chemical activity is occurring in a thoughtfully-engineered system, resulting in many teachable moments and illustrative scenarios for students in a variety of disciplines. In the 6 months of system operation, we have used the system for teaching modules in 4 Michigan Tech classes. Several undergraduate student groups have toured the system, two students have completed independent study projects related to the project, and the Consumer Product Manufacturing (CPM) Enterprise group has a team of engineering students dedicated to devising process improvements for the system. We hosted roughly 100 5th-7th graders as part of the Lake Superior Water festival held in October 2012 (Figure 3), and have proposed to include an aquaponics module in a Summer Teacher Institute organized by the Western UP Center for Science, Math, and Environmental Education. Three students in the Michigan Tech Entrepreneurship Club have also formed a project team focused on the commercial feasibility of aquaponics, and with guidance from Dr. Handler and Michele Loughead (Business & Economics) they have performed well in two business plan competitions in 2012. They look forward to continuing their current collaboration with a variety of Michigan Tech groups on various aspects of the aquaponics system, and leveraging this successful experience into larger opportunities in the future.

Figure 3 – Students learning about the aquaponics system during the first annual Lake Superior Water Festival in October 2012.

IN2WOOD International Conference. May 3-4, 2012

IN2WOOD is an EU-funded program to foster collaboration among 13 participating organizations representing wood and forest products cluster in Slovakiam Ukraine, Italy, Switzerland, Germany and Austria. Operations Manger, Senior Engineer and Scientists of the SFI, Dr. Richrard P. Donovan, was invited to participate in the conference through podium presentations (“Sustainable Futures Institute: Wood-to-Wheels and Sustainable Bioenergy Pathways”) as well as panel discussions. The podium presentation provided an overview of on-going and
proposed work at SFI. This activity was the direct result of SFI partnering with the MEDC in sponsoring a related European group’s (BIOCLUS) tour of the UP last year.

**Association of Consulting Foresters National Convention, Grand Rapids MI June 23-26 2012**

The Association of Consulting Foresters was founded to advance the professionalism, ethics and interests of consulting foresters throughout the country. Bioenergy represents a new and potentially transformative market for forest products throughout the US. Operations Manager, Senior Engineer and Scientist of SFI, Dr. Richard P. Donovan, was invited to present at the National Convention held June 23-24 2012. The presentation, (“Sustainable Futures Institute: Wood-to-Wheels and Sustainable Bioenergy Pathways”, provided an overview of SFI bioenergy projects that have the potential to impact the work of consulting foresters throughout the US.

### 4.0 Other University Sustainability Partners

The SFI is one of several entities at Michigan Tech with a focus or thrust directed at sustainability. As the only center/institute on campus with a campus wide mission of developing large inter-disciplinary projects, SFI has partnered with these campus centers as well as sustainability related centers across the US. Together, all of these Michigan Tech groups contribute their ideas and insights to advancing the goal of sustainability.

**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/](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](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/](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. [http://ecosystem.mtu.edu/](http://ecosystem.mtu.edu/)

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/](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**


, 2011, "Sediment Dynamics upon Dam Removal", American society of Civil Engineers (ASCE), Reston, VA, *Published.*


**Book Chapters**


Journal Articles


Dawdy, David R., Griffis, Veronica W., Gupta, Vijay K., 2012, "Regional flood frequency analysis: how we got here and where we are going", Journal of Hydrologic Engineering, *Accepted*. 


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Acknowledgement of Advisory Board

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.

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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.

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**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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Sustainable Futures Institute Operations

The graphs below contain data on numbers of proposals, new awards, ongoing active projects, as well as financial indicators of SFI operations.
Other Income includes direct support of SFI staff from ongoing funded projects, as opposed to staff support from internal research and development (IRAD) funds, also known as Inventive Income. IRAD represent funds from the Michigan Tech general account and is based on the Facilities and Administrative (F&A) costs on external grants to the university through the SFI.