Director’s Letter

I am very pleased to summarize accomplishments and activities of the Sustainable Futures Institute (SFI) faculty, staff, and students for the year 2014–2015 (July 2014-June 2015). 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 status and other aspects of SFI operations.

The SFI continues to benefit from the dedication and talents of a number of notable individuals. Dr. Robert Handler continues to show steady leadership in the SFI as Operations Manager in a wide range of duties such as supervising the SFI staff (Dr. Jiqing Fan, postdoctoral engineer) and students, managing the institute budget, supporting sustainability research and education through distance technology, supervising MS and PhD students, and writing scholarly publications. He is doing an excellent job and I am very lucky to have Robert as Operations Manager! Professor Barry Solomon deserves recognition for helping SFI with managing aspects of the RCN project as co-editor of the special feature articles and conducting the project’s graduate course in Fall 2014. Professor Kathleen Halvorsen (Social Sciences) is providing great leadership on the PIRE grant, which is much appreciated. The SFI hosted two PhD exchange students this academic year; Kareen Encinas Soto from the Department of Chemical Engineering at the University of Sonora, Hermosillo and Fernanda Lares Orozco from the Technological Institute of Sonora in Mexico. Both conducted research based on life cycle assessment expertise and resources in SFI. We are managing a portfolio of sustainability research and education projects valued at approximately $10 million dollars from a range of funding sources; NSF, DOE, USDA, and several industry sponsors. Many of these projects involve international collaborations, which are raising the visibility of Michigan Tech and increasing our standing in the research and education community. During this reporting period, SFI scholars published 219 peer-reviewed research articles, book chapters, and proceedings papers. We look forward to an even more productive 2015-2016.

Financial support from the Richard and Bonnie Robbins endowment fund is much appreciated. Graduate student support of PhD candidates Suchada Ukaew and Ulises Gracida Alvarez from the Royal Thai Scholarship and from CONACYT in Mexico, respectively, are acknowledged. We continue to benefit from an active and engaged advisory board.

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

David Shonnard, SFI Director
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Michigan Technological University
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Email: drshonna@mtu.edu
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## List of Abbreviations

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<tr>
<th>Abbreviation</th>
<th>Full Form</th>
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<tbody>
<tr>
<td>ASEE</td>
<td>American Society for Engineering Education</td>
</tr>
<tr>
<td>AQIP</td>
<td>Academic Quality Improvement Program</td>
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<tr>
<td>BS</td>
<td>Department of Biological Sciences</td>
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<tr>
<td>CEBFM</td>
<td>Center for Environmentally Benign Functional Materials</td>
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<tr>
<td>CEE</td>
<td>Civil and Environmental Engineering Department</td>
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<tr>
<td>CFARNLIM</td>
<td>Center for Fundamental and Applied Research in Nanostructured and Lightweight Materials</td>
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<tr>
<td>CH</td>
<td>Department of Chemistry</td>
</tr>
<tr>
<td>ChE</td>
<td>Chemical Engineering Department</td>
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<tr>
<td>CLS</td>
<td>School for Cognitive Learning Sciences</td>
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<tr>
<td>CSEO</td>
<td>Center for Science and Environmental Outreach</td>
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<tr>
<td>DoE</td>
<td>Department of Energy</td>
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<tr>
<td>ECE</td>
<td>Electrical and Computer Engineering</td>
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<tr>
<td>ERC</td>
<td>Engineering Research Center, an NSF funding program</td>
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<tr>
<td>ESC</td>
<td>Ecosystem Science Center or Environmental Sustainability Committee</td>
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<tr>
<td>GMES</td>
<td>Geological Mining Engineering and Sciences</td>
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<tr>
<td>LCA</td>
<td>Life-cycle Analysis</td>
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<tr>
<td>MA</td>
<td>Department of Mathematical Sciences</td>
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<tr>
<td>MEDC</td>
<td>Michigan Economic Development Corporation</td>
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<tr>
<td>MDEQ</td>
<td>Michigan Department of Environmental Quality</td>
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<tr>
<td>MEEM</td>
<td>Department of Mechanical Engineering—Engineering Mechanical</td>
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<tr>
<td>MiSTI</td>
<td>Center for Materials in Sustainable Transportation Infrastructure</td>
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<tr>
<td>PCMI</td>
<td>Peace Corps Master’s International</td>
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<tr>
<td>MTCWS</td>
<td>Michigan Tech Center for Water and Society</td>
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<tr>
<td>NGO</td>
<td>Non-governmental Organization</td>
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<tr>
<td>NSF</td>
<td>National Science Foundation</td>
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<tr>
<td>PH</td>
<td>Department of Physics</td>
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<tr>
<td>Publ. Policy</td>
<td>Public Policy</td>
</tr>
<tr>
<td>SB&amp;E</td>
<td>School of Business and Economics</td>
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<tr>
<td>SFI</td>
<td>Sustainable Futures Institute</td>
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<tr>
<td>SFRES</td>
<td>School of Forest Resources and Environmental Sciences</td>
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<tr>
<td>SME</td>
<td>Society of Mechanical Engineers</td>
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<tr>
<td>SS</td>
<td>Department of Social Sciences</td>
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<tr>
<td>STEM</td>
<td>Science, Technology, Engineering, and Math</td>
</tr>
<tr>
<td>W2W</td>
<td>Wood-to-Wheels</td>
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1.0 Institute Thrust Area Projects

1.1 SFI Highlight of the Year

2015 Research Coordination Network (RCN) Workshop on Pan-American Biofuels and Bioenergy Sustainability
June 3-5, 2015, Houghton, MI USA – Michigan Tech. University

This workshop was the final event in the 4-year NSF Research Coordination Network (RCN) on Pan-American Biofuels and Bioenergy Sustainability, which began in January of 2012 and ends on December 31, 2015. The ~40 workshop attendees involved not only the core organizing group in the RCN but also a good number of new invitees to the network. The purpose for this final workshop was to review progress on proposed tasks and to plan for future sustainability research and education activities beyond the end of the project. Specifically, objectives for this final workshop were to review the status of the Special Issue Articles (SIA), to review the graduate course, to discuss plans for publishing a Research Roadmap Report (RRR), and discuss future of the RCN on Pan-American Biofuels and Bioenergy Sustainability beyond the end of the NSF project. The Special Issue Articles were published in Fall of 2015 in the journal *Environmental Management* with Professors David Shonnard and Barry Solomon (Michigan Tech, Social Sciences) as guest editors. The RRR is the capstone activity in the RCN in which the major findings from the Special Issue Articles are summarized along with lists of recommendations for closing knowledge gaps through research and education. The graduate course was conducted in Fall 2014 by lead instructor Professor Barry Solomon with Dr. Robert Handler taking charge of the enabling distance learning technology issues. Students taking this course were from numerous institutions throughout the Pan-American region and with support from faculty participants in the RCN at their home institutions. Discussions on future funding of the RCN centered on mechanisms to support coordinated research among international research teams representing several Pan-American countries.

The workshop agenda is shown next showing the sequence of topics and other activities.
**RCN Workshop Program Overview**

<table>
<thead>
<tr>
<th>Wednesday, June 3</th>
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<tbody>
<tr>
<td>Hotel Check-in, Franklin Square Inn</td>
<td>12:00 pm – 5:00 pm</td>
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<tr>
<td><strong>Welcome Reception Dinner</strong></td>
<td>7:00 pm</td>
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<tr>
<td>Shelden Grill, 7th Floor of Franklin Square Inn</td>
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</tbody>
</table>

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<thead>
<tr>
<th>Thursday, June 4 (Day 1)</th>
<th>MTU Memorial Union Building (Ballroom B)</th>
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</thead>
<tbody>
<tr>
<td><strong>Welcome by Max Seel (Provost and Vice President)</strong></td>
<td>8:30 - 9:00 am</td>
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<tr>
<td>Assessment Introduction (J. Huntoon or C. Wojick)</td>
<td></td>
</tr>
<tr>
<td>Reports on Status of Special Feature Articles</td>
<td>9:00 – 10:30 am</td>
</tr>
<tr>
<td>Coffee Break</td>
<td>10:30 -11:00 am</td>
</tr>
<tr>
<td><strong>RCN Course / Education – Outcomes and Future Plans</strong></td>
<td>11:00 – 12:00</td>
</tr>
<tr>
<td>Lunch, at Memorial Union</td>
<td>12:00 – 1:00 pm</td>
</tr>
<tr>
<td><strong>Intro to RCN Research Roadmap Report (RRR)</strong></td>
<td>1:00 – 1:30 pm</td>
</tr>
<tr>
<td><strong>Breakouts – How to integrate Articles / Conference / other information into RRR</strong></td>
<td>1:30 – 2:30 pm</td>
</tr>
<tr>
<td>Coffee Break</td>
<td>2:30 pm – 3:00 pm</td>
</tr>
<tr>
<td><strong>Group Discussion, RRR timelines and needs</strong></td>
<td>3:00 – 4:30 pm</td>
</tr>
<tr>
<td>Dinner, Pilgrim River Steakhouse</td>
<td>Pickup from Hotel at 6:45 pm</td>
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<tr>
<th>Friday, June 5 (Day 2)</th>
<th>MTU Great Lakes Research Center (202)</th>
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<tbody>
<tr>
<td><strong>Kick-off and Intro on Future Directions for RCN</strong></td>
<td>8:30 - 9:00 am</td>
</tr>
<tr>
<td>Breakouts and feedback, future goals for RCN</td>
<td>9:00 – 10:30 am</td>
</tr>
<tr>
<td>Coffee Break</td>
<td>10:30 -11:00 am</td>
</tr>
<tr>
<td><strong>Intro, funding strategies for RCN</strong></td>
<td>11:00 – 11:30 am</td>
</tr>
<tr>
<td><strong>Breakouts – by country? Discuss funding targets/timelines</strong></td>
<td>11:30 – 12:30</td>
</tr>
<tr>
<td>Lunch, at Great Lakes Research Center</td>
<td>12:30 – 1:30 pm</td>
</tr>
<tr>
<td><strong>Group Discussion, How to integrate/coordinate future funding plans</strong></td>
<td>1:30 – 2:30 pm</td>
</tr>
<tr>
<td>Closing remarks and Assessment (C. Wojick)</td>
<td>2:30 – 3:00 pm</td>
</tr>
<tr>
<td><strong>Vans to Copper Harbor (TBD)</strong></td>
<td>Pickup from Hotel at 4:00 pm</td>
</tr>
<tr>
<td><strong>Dinner, Keweenaw Mountain Lodge</strong></td>
<td>7PM</td>
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</tbody>
</table>

A survey of attendees indicated that most participants were faculty and were from the United States, however wide representation from other institutions and Pan-American countries was evident.
The pictures to follow were taken from the workshop on Friday June 5 at the Great Lakes Research Center at Michigan Tech. The workshop ended with plans to complete all outstanding tasks involving the SIA, RRR, and future support of the RCN. The final event was a tour of the Keweenaw Peninsula by vans from Michigan Tech and dinner near Copper Harbor, MI at the Keweenaw Mountain Lodge. Many thanks to the graduate students who helped as van drivers; Bethany Klemetsrud, Michelle Cisz-Brill, and Brad Barnett. After the tour, we heard many positive comments from our domestic and international guests about the magnificent beauty of the surroundings near Michigan Tech.
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 Collaboration – LanzaTech, Inc.**

LanzaTech is a renewable energy company that is focused on making productive use of low-value or waste carbon sources. They have developed a series of novel *Clostridium* microorganisms that can directly ferment carbon-containing gas feedstocks into ethanol and a variety of co-products, including acetic acid, butanediol, and other commodity chemicals. Ethanol can also be upgraded into jet fuel and other drop-in hydrocarbon fuels. Their initial research and development initiatives have focused on making productive use of steel mill exhaust gases, which are often simply flared and emitted to the atmosphere. LanzaTech has initiated several partnerships with steel mills in India, China, and Belgium. They have also investigated other carbon-containing feedstocks, including stranded natural gas, municipal solid waste, and terrestrial biomass feedstocks like corn stover. LanzaTech is a respected leader in the renewable fuels industry and have a short but distinguished record of awards for sustainability and green chemistry advances.
Michigan Tech researchers within the Sustainable Futures Institute have collaborated with LanzaTech to evaluate the life-cycle environmental footprint of many different potential LanzaTech process scenarios since 2010. LanzaTech was aware of Michigan Tech’s leading reputation in this area from prior work between the SFI and UOP (a Honeywell Company), where several LanzaTech employees had previously worked. The SFI has partnered with LanzaTech on several funded proposals from different agencies of the U.S. federal government, including the DOE, FAA, DOE DARPA, and DOE ARPA-E, and have current projects with LanzaTech that will stretch into 2017. We have enjoyed the working relationship with have cultivated with this innovative company, and look forward to pursuing new projects together that lead to new knowledge in this important field.

Pending Projects

**Project:** CAREER: An Integrated Research and Educational Plan for Multiscale Modeling and Design of Microbial Biochemical Processes  
**Sponsor:** National Science Foundation $500,407  
**Investigator:** Wen Zhou (ChE, SFI)

**Project:** Molten Salts Impregnated with Composite Nanoparticles for High Energy-Density Thermal Storage  
**Sponsor:** University of Texas at Arlington $299,852  
**Investigator:** Dr. David Shonnard (ChE, SFI)

**Project:** Cooperative-Based Diverse Feedstock Bioenergy Project in Ontonagon County, Michigan  
**Sponsor:** US Dept of Energy $4,284,292  
**Investigator:** Dr. Audrey Mayer (SFRES, SFI)

**Project:** Pyrolysis of Scrap Tires to Generate High-Value Chemicals and Fuels  
**Sponsor:** Michigan Dept of Environmental Quality $110,002  
**Investigator:** Robert M. Handler (ChE, SFI)

**Project:** Assessment of the L’Anse Warden Electric Company  
**Sponsor:** Keweenaw Bay Indian Community $540,095  
**Investigator:** Robert M. Handler (ChE, SFI)

**Project:** Life Cycle Assessments to Support GTI: Direct Catalytic Synthesis of Acetic Acid from CO$_2$ and CH$_4$  
**Sponsor:** Gas Technology Institute (GTI) $47,602  
**Investigator:** Robert M. Handler (ChE, SFI)

**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 (ChE, SFI)

**Project:** Environmental Life Cycle Assessments of Drop in Hydrocarbon Fuels and Chemicals using Methane/Hydropsyrolisis-Hydroconversion (DE-FOA-0000974)  
**Sponsor:** Gas Technology Institute (GTI) $165,845  
**Investigator:** Dr. David Shonnard (ChE, SFI)
New Projects

Project: Spatial Patterns of Forest Values for Bioenergy Production in the Western Upper Peninsula of Michigan  
Sponsor: Us Dept Of Agriculture $2,233  
Investigator: Dr. Audrey Mayer (SFRES, SFI)

Project: Characterization of Products from Fast Pyrolysis of Municipal Solid Waste: Preliminary Analyses Using Micro-Pyrolysis  
Sponsor: Battelle Energy Alliance LLC / Idaho National Laboratory $24,482  
Investigator: Dr. David Shonnard (ChE, SFI)

Ongoing Projects

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, (09/01/2012 – 08/31/2015)  
Investigator: Dr. Wenzhen Li (ChE)

Project: Life Cycle Assessments to Support LanzaTech: DOE FOA 0000467  
Sponsor: LanzaTech, $149,960, (10/01/2012-06/30/2016)  
Investigator: Dr. David Shonnard (ChE, SFI)

Project: Life Cycle Assessments (LCAs) in Support of UOP-USDA BRDI Proposal 2011  
Sponsor: US Department of Agriculture, $300,000, (01/01/2013 – 06/30/2016)  
Investigator: Dr. David Shonnard (ChE, SFI)

Sponsor: UOP LLC/Honeywell, $43,707, (1/1/2013-12/31/2014)  
Investigator: Dr. David Shonnard (ChE, SFI)

Project: RCN-SEES: A Research Coordination Network on Pan American Biofuels and Bioenergy Sustainability  
Sponsor: National Science Foundation , $769,996, (01/01/2012 – 12/31/2015)  
Investigator: Dr. David Shonnard (ChE, SFI)

Project: SEP: Sustainable Forest-Based Biofuel Pathways to Hydrocarbon Transportation Fuels: Biomass Production, Torrefaction, Pyrolysis, Catalytic Upgrading, and Combustion  
Sponsor: National Science Foundation, $1,800,000, (09/01/2012 – 08/31/2016)  
Investigator: Dr. David Shonnard (ChE, SFI)

Project: OISE-PIRE: Sustainability, Ecosystem Services, and Bioenergy Development across the Americas  
Sponsor: National Science Foundation, $4.8 million (10/01/2012 – 09/30/2017)  
Investigator: Kathleen E. Halvorsen (SFRES)
Investigator: Dr. David Shonnard (ChE, SFI)

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 (ChE, SFI)

Project: Life Cycle Assessment of Hydropyrolysis Integrated with a Petroleum Refinery  
Investigator: Dr. David Shonnard (ChE, SFI)

1.3 Sustainability Education

Featured New Project

Michigan Science Teaching and Assessment Reform (MiSTAR), Dr. Jacqueline Huntoon PI

MiSTAR is made possible by the generous support received from the Herbert H. and Grace A. Dow Foundation which was established by Mrs. Grace A. Dow in 1936 in memory of her husband Dr. Herbert H. Dow. This ambitious three-year project seeks to transform the way science is taught at the middle school level in the State of Michigan. The Sustainable Futures Institute staff are helping with project management and curriculum development during this project. A large, interdisciplinary team of MiSTAR investigators are developing and testing the effectiveness of three initiatives:

- A new integrated science curriculum for grades 6-8 that is aligned with state and national science standards and assessments, uses a Michigan-centric, problem-based approach to stimulate students’ interest, and demonstrates how science and engineering are used to develop new knowledge and innovative solutions to contemporary problems.

- A new model for teacher education in integrated science that prepares pre-service middle grades teachers to engage students in science and engineering practice and emphasizes core ideas and cross-cutting concepts.

- An in-service professional development program in integrated science that prepares teachers to integrate science and engineering in the middle grades and augments their science and engineering content-area knowledge and pedagogical skills.

Project: Michigan Science Teaching and Assessment Reform (MiSTAR)  
Sponsor: Herbert H. and Grace A. Dow Foundation, $4.8 million (07/01/2014-11/15/2017)  
Principal Investigator: Dr. Jacqueline Huntoon (Provost and Vice President for Academic Affairs)
Ongoing Projects

**Project:** RET Site: Wood to Wheels-Research Experiences for High School Teachers in Sustainable Transportation Technologies  
**Sponsor:** National Science Foundation, $378,942, (01/15/2011-12/31/2014)  
**Investigators:** Drs. David Shonnard (ChE), Brad Baltensperger (CLS), Chandrashekhar Joshi (SFRES), Jeffrey Naber (MEEM), Kedmon Hungwe (CLS), Shawn Oppliger (CCISD), Christine Anderson

**Project:** New GK12 GlobalWatershed: Integrating Rural and Global Perspectives with Research and Technological Advances  
**Sponsor:** National Science Foundation, $2,499,352, (09/01/2009-08/31/2014)  
**Investigator:** Dr. Alex Mayer (CEE)

**Project:** Building Community Capacity to Manage Private/Public Forests and Develop Forest Stewards  
**Sponsor:** US Dept of Agriculture, $81,510, (09/01/2011-09/30/2014)  
**Investigator:** Joan Chadde (CEE)

1.4 Complex Systems Analysis

Dr. Audrey Mayer has taken on the role of SFI Associate Director in this focus area, and she is working diligently to develop a cohort of Michigan Tech faculty with expertise in a variety of methods for modeling the networks and metrics associated with a comprehensive assessment of systems for sustainability. One example of this work is featured below with a submission to the DOE Landscape Design for Sustainable Energy program

Featured Project in Development

**Department of Energy Landscape Design for Sustainable Energy,**  
**Cooperative-Based Diverse Feedstock Bioenergy Project in Ontonagon County, Michigan**  
**PI Dr. Audrey Mayer (SFRES / SS)**

In this proposed project, we will demonstrate how a small-scale, diverse, locally-owned bioenergy production system can be sustainable and improve community resilience; we propose that this should be the new “state-of-the-art” in bioenergy production. Our objectives are to 1) Increase adoption of hybrid poplar and switchgrass feedstocks; 2) Establish a self-supporting bioenergy cooperative with operational bioenergy production facilities that are vertically integrated and locally owned; and 3) Initiate and maintain an enhanced environmental sustainability monitoring system relative to existing agricultural and forest land uses. While this project will be producing important innovations in research and development of cellulosic ethanol products, an equally important component of this project is education and outreach to the community.

Our project is organized into three tasks: cooperative establishment and community outcomes (Task 1); environmental monitoring (Task 2); and logistics, LCA and TEA (Task 3). Task 1 activities include surveys of landowners (potential cooperative members), and businesses and residents (potential end users of energy products), the development of business and management plans for the cooperative, and facilitated peer-to-peer workshops for landowners and residents to increase awareness and adoption of
cellulosic energy products. Informal focus groups with area farmers will collect information on how the energy production system is impacting (positively or negatively) local agriculture. Information gathered from landowners and customers on desirable feedstocks and end products will drive the types and placement of feedstock sources in Task 2. Task 2 activities primarily focus on the identification of existing feedstocks and establishment of new feedstocks, and environmental monitoring of feedstock production on biodiversity, water, soils, and greenhouse gases emissions. This information will feed into Task 3, which uses modeling and simulation to investigate the potential efficiency, profitability, and environmental impacts of each feedstock-to-energy-product pathway, using Life Cycle Assessment and Techno-Economic Analysis models.

This project will dramatically reduce the region’s dependence upon imported energy sources, and will showcase how regions can deploy innovative renewable energy technologies while keeping profits local and building local economies. Our cooperative-based approach uses multiple stakeholders to identify preferred feedstocks and energy products, and partnered with local rural development agencies and farmers, we can ensure that the energy system does not negatively impact other industries in the region. The final results of this project will include a self-sustaining bioenergy cooperative, a systematic review of advantages and disadvantages of feedstock-to-energy product streams, an ongoing environmental and social assessment program, established feedstock plantations for long-term research, a landowner information program run by the cooperative (including periodic facilitated peer-to-peer workshops), and an educational outreach program on bioenergy production for landowners and residents.

Project: Cooperative-Based Diverse Feedstock Bioenergy Project in Ontonagon County, Michigan
Sponsor: US Dept of Energy $4,284,292
Investigator: Dr. Audrey Mayer (SFRES, SFI)

New Project

Project: Collaborative Research: Nexus of Simulation, Sensing and Acuation for Aerodynamic Reduction of Wind Turbine Blades
Sponsor: National Science Foundation, $10,000 (05/15/2013 - 04/30/2016)
Investigator: Dr. Qingli Dai (CEE)
Ongoing Projects

**Project:** Integration of Mainshock-Aftershock into Performance-Based Engineering using Publicly Available NEEShub Data  
**Sponsor:** National Science Foundation, $286,000, (05/01/2011 - 04/30/2016)  
**Investigator:** Dr. Yue Li (CEE)

**Project:** Virtual Water Accounting: A New Paradigm for the Adaptive Management of Great Lakes Water  
**Sponsor:** Great Lakes Protection Fund, $399,999, (02/03/2011 – 4/30/2015)  
**Investigator:** Dr. Alex Mayer (CEE)

**Project:** Integrated Modeling and Experimental Evaluation of Hydrodynamic and Microbial Controls on DNAPL Dissolution and Detoxification  
**Sponsor:** National Science Foundation, $376,192 (12/28/2009-2/28/2015)  
**Investigator:** Dr. Jennifer G. Becker (CEE)

**Project:** IDR: Collaborative Research: Sustainable Water Resources for Communities Under Climate Change: Can State-of-the-Art Forecasting Inform Decision-Making in data Sparse Regions?  
**Sponsor:** National Science Foundation, $317,390, (09/15/2010-08/31/2016)  
**Investigator:** Dr. Alex Mayer (CEE)

**Project:** Collaborative Research: Nexus of Simulation, Sensing and Acuation for Aerodynamic Reduction of Wind Turbine Blades  
**Sponsor:** National Science Foundation, $278,812 (05/15/2013 - 04/30/2016)  
**Investigator:** Dr. Qingli Dai (CEE)

1.5 International Development

Although he has been instrumental in several International Development projects in the past, Dr. David Watkins (CEE) has taken on a more integral role within the SFI as the Associate Director in this focus area. His experience within this area while serving Michigan Tech as head of the D80 Center and coordinating the variety of internationally-focused programs will serve as valuable experience as we work to develop externally-funded projects in this area.

**Featured Project in Development-**
**Global Alliance for Clean Cookstoves, AFI and CPM**

The Michigan Tech Consumer Product Manufacturing (CPM) Enterprise has partnered with the Agri-Forestry Investment (AFI) company led by Marc Blanchard. AFI is working to develop the supply chain that will lead to greater adoption of clean cookstoves in West African countries, and most of their work is located in Benin currently. They have identified a few important aspects of the supply chain that could be improved:

- Using agriculture and forestry residues as raw materials,
- Introducing engineering for the carbonization process in order to reach a rapid and semi-continuous process, and
• Adding a briquetting module to the supply chain in order to facilitate the handling of the final product and to obtain a longer burning time in the family kitchen.

Because the CPM enterprise has prior experience investigating biomass carbonization methods through a D80 project in Panama, AFI has sought out a partnership with the CPM for technical advancement of the proposed biomass carbonization process. The CPM enterprise has been studying the air flow within the current biomass carbonization chamber design, and how to turn the process into a semi-continuous system instead of a batch process through more advanced feedstock handling. The D80 has been facilitating the relationship between the Michigan Tech CPM and AFI, and hopes to further this relationship for more technical study and in-country visits to Benin in support of this project.

Pending Projects

**Project:** Restoring the Environmental through Prosperity, Livelihoods, and Conserving Ecosystems (REPLACE)
**Sponsor:** US Agency for International Development / Cloudburst Consulting Group, (01/01/2013 - 08/01/2017)
**Investigator:** Dr. Blair Orr (SFRES)

1.6 Materials, Design, and Manufacturing for Sustainability

Dr. John Gershenson is the SFI Associate Director in this project area, and we have made plans for re-invigorating this thematic area of research and education within the Michigan Tech community with a series of small, concrete projects that draw on our expertise in environmental life-cycle assessment, as a gateway to explore different manufacturing processes and materials systems. We have heard from several employers of Michigan Tech students that current graduates often lack this background in sustainability and systems thinking, and we will work to re-introduce this mindset into the research and education programs within ME-EM and associated departments.

**Featured Project in Development:**
**Kohler Manufacturing Sustainability Partnership**

The SFI is developing a relationship with Kohler, Inc in an effort to help the company understand and improve its operations in regards to its environmental footprint and larger sustainability goals. This year, the SFI was approached by a few Kohler employees who are Michigan Tech alums. They work in the small but active Kohler group that is charged with documenting Kohler sustainability initiatives, and are interested in recruiting more Michigan Tech students that have a holistic view of product life cycles and sustainability thinking. Kohler is a large company that makes a surprisingly diverse array of products, with increasingly global supply chains. In order to make improvements in the environmental impacts of Kohler products, it is first necessary to understand the full life cycles of these products, including raw materials acquisition, materials processing, product use, product disposal/recycle, and all of the interconnected transportation steps along the way. This is a daunting challenge, but Kohler has made impressive strides in this area and should be able to move more quickly by partnering with the SFI. During the past year, we have had several productive meetings with Kohler, where we have outlined several potential areas for collaboration between Michigan Tech and Kohler, including using real-world
Kohler problems as term projects in SFI-led classes, involving Michigan Tech graduate students in Kohler-sponsored research, and pursuing more advanced research about adapting novel sustainability metrics and indicators to the Kohler company. This appears to be a fruitful collaboration that can be beneficial for both partners, and the SFI is excited to deepen the relationship with Kohler in the coming years.

Pending Projects

Project: Sustainable Biomaterials from By-Products Generated in Agriculture and Food Systems  
Sponsor: US Dept. of Agriculture, $79,954  
Investigator: Dr. Patricia A. Heiden (CH)

Project: Environmental Sustainability Analysis of Hydrotreated Palm Oil from the eni Venice Refinery  
Sponsor: Eni SpA $4,085  
Investigator: Dr. David R. Shonnard (ChE)

Project: Life Cycle Assessment of Canned and Fresh Produce: Greenhouse Gases and Energy Balances  
Sponsor: Foodminds LLC $30,609  
Investigator: Dr. David R. Shonnard (ChE)

Project: "High-tech analysis of low-tech methods for sustainable Class A biosolids production"  
Sponsor: Water Environmental Research Foundation $154,909  
Investigator: Dr. Jennifer G. Becker (CEE)

New Projects

Project: Economic Feasibility of a Hydroponic Green House in the Upper Peninsula of Michigan Utilizing Waste Heat or Cogeneration  
Sponsor: Verso Paper, $30,000, (02/01/2015 – 06/1/2016)  
Investigator: Dr. David Shonnard (ChE)

Ongoing Projects

Project: Selective Electrocatalytic Oxidation of Biorenewable Polyols over Bimetal Catalysts  
Sponsor: National Science Foundation, $259,998, (09/01/2012 – 08/31/2015)  
Investigator: Dr. Wenzhen Li (ChE)

Project: Biomediated Geomechanical Processes for Dust Mitigation and Monitoring at Mine Tailings Impoundments  
Sponsor: National Science Foundation, $208,913, (09/01/2012 – 08/31/2015)  
Investigator: Dr. Eric Seagren (CEE)

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 (SS)
**Project:** REF-TC: Performance Testing of Michigan Tech Rechargeable Asymmetric Capacitor with a Carbon Foam Supported by Nickel Hydroxide Electrode  
**Sponsor:** Internal, (7/1/2012 - 8/31/2013)  
**Investigator:** Dr. Bahne Cornilsen (CH)
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 2014: 21 including 5 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. David Shonnard, Dr. Joshua Pearce, Dr. David Watkins, Dr. Audrey Mayer, Dr. Latha Poonamallee, Dr. Amlan Mukherjee, and Dr. Robert Handler
Students registered during Spring 2015: 10
This course covers additional sustainability themes in developed and developing countries. Topics include policy analysis, sustainability indicators, innovation, laws & regulations, international disasters, GIS applications, green manufacturing, and evolution of environmental policy in U.S. and other countries.

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 three areas of interconnection between the pillars of sustainability: Industry – Society, Environment-Society, and Industry-Environment. The full listing of allowable course for the Graduate Certificate can be seen on the SFI website: [http://www.sfi.mtu.edu/Certificates-IGCS-F2014-1.pdf](http://www.sfi.mtu.edu/Certificates-IGCS-F2014-1.pdf). Since 2004, 96 students from throughout Michigan Tech and the SFI IGERT program have received Graduate Certificates of Sustainability. In the most recent fiscal year, 2 students were awarded the certificate. If a healthy number of students are still enrolling in ENG 5510 and 5520, this means that we need to redouble our communication efforts about the Graduate Certificate in Sustainability in many of the academic departments on campus. Students may be completing all of the required coursework without filling out the paperwork required by the Graduate School to qualify for the certificate.
3.0 Outreach

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

**Houghton Energy Efficiency Team (HEET)**

SFI has been supportive of the Houghton Energy Efficiency Team (HEET) and Houghton County’s current bid to win the Georgetown University Energy Prize, which will be awarded to one of 50 competing communities at the end of 2016. Communities that demonstrate measured decreases in utility consumption, along with a plan to involve the community in energy reduction efforts and increase awareness of energy issues, will fare well in the competition. The SFI participated in the development of the HEET proposal for entry into the Georgetown prize, and now the SFI is supporting the HEET group through fundraising efforts, participating in energy awareness activities, and community outreach.

**CleanTech Open – Midwest Sustainability Guidance**

SFI Operations Manager Robert Handler became associated with the leadership team behind the CleanTech Open through our connections with the Next Energy group within the State of Michigan. The CleanTech Open is a national accelerator program for cleantech businesses, mostly at the startup stage but encompassing many company scales. Dr. Handler is a member of the CleanTech Open Midwest Sustainability Committee, a group that tries to provide consistent guidance to companies participating in the accelerator program concerning internal sustainability assessments and communicating that information to stakeholders. Dr. Handler assisted one company in particular, SurClean, with an environmental life-cycle assessment of their laser-based paint removal system versus conventional paint stripping operations, and SurClean was awarded a Regional Finalist position at the Midwest Innovation summit and will be competing at the national level later this year.

**Summer Visiting Researcher Scholars**

In FY 15, the SFI hosted 3 summer research scholars from Mexico (2) and Brazil. The Brazilian student, Natalia Teixeira, identified Michigan Tech and the Sustainable Futures Institute through her participation in the Brazilian Scientific Mobility Program (BSMP) as an ideal place to spend her mandatory summer
Academic Training internship, learning about life-cycle assessment and applying it to her main undergraduate research interest in pesticides. Under guidance from SFI staff, she developed a life-cycle assessment study that compared two different types of neonicotinoid pesticides, which is a class of compounds that has come under increasing scrutiny lately for their harmful impacts on bees. Kareen Encinas Soto came from Hermosillo, Mexico to learn life-cycle assessment techniques from SFI researchers and develop a life-cycle assessment study of buffel grass, a native grass to her region that is currently being studied for ethanol production. Fernanda Lares Orozco came from Sonora, Mexico to learn about life-cycle assessment and further develop an environmental impacts study about wheat cultivation in the Yaqui valley, a major area of intensive agricultural production in Mexico. These students were all a pleasure to work with, and taught us at least as much as we were able to teach them during their stays here. The SFI is excited to continue the recent trend of hosting summer visiting research scholars, through the BSMP program or through connections developed from our various international research efforts.
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/

**Advanced Sustainable Iron and Steel Center (ASISC)**
**Director:** 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.

**Biotechnology Research Center (BRC)**
**Director:** Michael Gretz, (BL)
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://biotech.mtu.edu/

**Center for Water and Society (CWS)**
**Director:** Noel Urban (CEE)
The mission of the CWS is to promote research, education, and outreach in all disciplines at Michigan Tech related to water issues, and the purpose is to enhance the ability and the visibility of MTU personnel to solve water-related problems of local, regional, and international interest.
http://www.mtcws.mtu.edu/

**Ecosystem Science Center (ESC)**
**Director:** Andrew Burton, (SFRES)
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/
Great Lakes Research Center (GLRC)
Director: Guy Meadows
The mission of the Great Lakes Research Center (GLRC) is to be a leader in interdisciplinary aquatic science and engineering, focused on the Laurentian Great Lakes Basin in its entirety through excellence in research, education, and outreach. GLRC is a Michigan Tech research institute, and the Center for Water and Society (CWS) has chosen to become affiliated with the GLRC. CWS brings a broader scope of research to the GLRC, which fosters more interdisciplinary and collaborative research among all members.
http://www.mtu.edu/greatlakes

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 challenge.
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

Transportation Materials Research Center
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.
http://www.tmrc.mtu.edu

Rail Transportation Program (RTP)
Director: Pasi Lautala (CEE) The RTP provides the foundation for all the activities in the field and has become a permanent part of university curriculum and research. The RTP has three integrated components: events & extracurricular activities, projects & research, and education.
5.0 SFI Publications

Books


Book Chapters


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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:

Daniel P. Alder is a MS graduate of Michigan Tech in the Department of Mechanical Engineering – Engineering Mechanics. He is a senior engineer at Caterpillar in Peoria, IL. His expertise is in design and manufacturing with applications to component recycle and waste reduction.

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.


Stephen Kamin is a manufacturing consultant for Dow Corning Corporation.

Kevin Kuske is the President and CEO of izzy+, an office furniture and seating company based in Spring Lake, MI. He is dedicated to helping “create great experiences wherever work happens.” izzy+ brings together great design, advanced engineering, and lean manufacturing capabilities.

Clare Mendelsohn is a 1987 Chemical Engineering graduate of Michigan Tech and a 2002 graduate of the Sloan School of Management. She is the Public Service Team Leader for the Hiawatha National Forest, based in Gladstone, Michigan, and a division of the U.S. Forest Service.

Mark Mleziva, a 1992 Chemical Engineering graduate of Michigan Tech, is Research Manager at Kimberly-Clark Corporation in its' Corporate Research & Engineering Department in Neenah, WI. His responsibilities include longer range sustainable and environmental technology exploration and development focused towards solutions for Kimberly-Clark's global branded consumer and B-B products.

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.

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.

The SFI thanks all SFAB members for their guidance, advice, and collaboration.

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.

List of 2015 SFI Members

SFI Fellows
Ann Maclean, School of Forest Resources and Environmental Science, MTU
Chandrashekhar P. Joshi, School of Forest Resources and Environmental Science, MTU
Neil Hutzler, Civil and Environmental Engineering, MTU
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Michigan Tech Administration Members
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Christa Walck, Associate Provost

Sustainable Futures Institute Staff Members
Robert Handler, Operations Manager/Researcher
Jiqing Fan, Post-doctoral Research Associate
Jack Babcock, Undergraduate Research Assistant
Kareen Encinas Soto, PhD candidate, University of Sonora, Hermosillo, Mexico (visiting scholar)
Fernando Laires, MS candidate, Technological Institute of Sonora, Mexico (visiting scholar)
Natalia Teixeira, undergraduate chemical engineer, (visiting scholar – BSMP program)

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William Predebon, Chair, MEEM  
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William I. Rose, GMES  
Eric A. Seagren, CEE  
David R. Shonnard, SFI Director, ChE  
Sheryl A. Sorby, CEE  
Lawrence L. Sutter, (CEE) Dir. of Trans. Center  
Noel Urban, CEE, Dir CWS  
David W. Watkins, CEE  
Jeremy J. Worm, Research Eng., MEEM  
Song-Lin Yang, MEEM  
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Wen Zhou, ChE  

Center for Science and Environmental Outreach

Joan Schumaker Chadde, Educational Coordinator

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Bahne Cornilsen, CH
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Hugh S. Gorman, SS
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Christopher

Webster

School of Technology

Lynn A. Artman
Jim Frendewey
Yu Cai

Sunil Mehendale
Sustainable Futures Institute Metrics

The graphs below contain data on numbers of proposals, new awards, ongoing active projects, as well as financial indicators of SFI operations. In the period up to FY09, most proposals submitted were for smaller single discipline research and education. After FY10, more of a focus on large multi-disciplinary proposals is much more common than before, resulting in a small number of submitted proposals, new awards and active projects. However, the total value of all projects managed currently and in the past by the SFI is increasing and now is just over $30 million.
SFI Operations Funds are shown above, reflecting the changing nature of SFI support in recent years. 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 Incentive 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.
The summary of expenses from the SFI IRAD account in FY15, totaling $110,750, provides an interesting look into how the SFI manages its funds while supporting research and education efforts at Michigan Tech. 60% of IRAD funding was used to pay the Operations Manager, with the rest of Operations Manager funding coming from externally funded research projects. IRAD support accounted for roughly 2/3 of the funding for the Operations Manager position in FY 15, which is a large increase from the roughly 8% support in FY 14. Over the long term we would like to keep the Operations Manager supported at least 50% from IRAD funds as opposed to direct support from research projects, to ensure the Operations Manager has enough time to work on developing new research and education projects with faculty and students at Michigan Tech. Employing undergraduate and graduate students accounted for 3% of IRAD expenses, while 3% also was spent on travel for SFI personnel on SFI-related assignments. A significant amount of SFI IRAD expenses, nearly 20%, were for monetary returns to other Centers and Institutes on campus as a result of memorandums of understanding (MOUs) developed with those organizations when developing large, multidisciplinary proposals. This obviously affects the funding structure of the SFI, but these MOUs were required by collaborating Centers and Institutes and may represent the future realities of proposal development within the SFI. These MOUs are for large projects that have been developed since 2012. 14% of SFI IRAD funds are used for supporting research projects, which includes providing conference calling and project management services to large projects under the SFI, life cycle assessment software licenses for classroom and research use, and stipends to teachers who co-taught ENG 5520. Just 1% of SFI IRAD funds were used for office expenses such as office supplies, normal MTU IT/phone charges, and the like.