

**ALCOA FOUNDATION'S CONSERVATION AND SUSTAINABILITY
FELLOWSHIP PROGRAM**

UNIVERSITY OF MICHIGAN PROJECT NARRATIVE:

**“ENABLING TECHNOLOGY FOR A SUSTAINABLE ENERGY FUTURE
THROUGH INTERDISCIPLINARY RESEARCH AND TRAINING”**

A Collaboration of

**School of Natural Resources and Environment
Stephen M. Ross School of Business
Gerald R. Ford School of Public Policy
College of Engineering**

Coordinated by

**Center for Sustainable Systems
Frederick A. and Barbara M. Erb Institute for Global Sustainable Enterprise**

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PROJECT BACKGROUND

The goal of the University of Michigan Alcoa Conservation and Sustainability Fellowship Program (ACSFP) is to develop an innovative interdisciplinary research initiative that addresses the link between technology and the economic, environmental, and social dimensions of sustainability. This Program brings together faculty expertise and leadership in sustainability from the School of Natural Resources and Environment, the Ross School of Business, the Ford School of Public Policy and the College of Engineering. The Center for Sustainable Systems and the Erb Institute for Global Sustainable Enterprise have over a decade of experience in leading interdisciplinary research and education on sustainability and will coordinate this unique postdoctoral fellowship program.

1. SUSTAINABILITY CABINET ORGANIZATION AND ACTIVITIES

1.1 Sustainability Cabinet Members and Expertise

The University of Michigan has tremendous faculty expertise across a range of disciplines contributing to the ACSFP. The following Cabinet members were selected given their commitment to interdisciplinary education and research. Five of the Cabinet have joint appointments between four Academic Units participating this Program; all of the holders of the University's four endowed chairs in sustainability are members of the Cabinet. These faculty bring expertise in energy analysis, sustainable enterprise, ecosystem modeling and management, environmental and natural resource economics, spatial analysis, industrial ecology, risk analysis, public policy, complex systems, and conflict resolution.

Daniel G. Brown

Associate Professor of Natural Resources & Environment
 Director, Environmental Spatial Analysis Laboratory (ESA Lab)
Geographical Information Science, Agent-Based Modeling, Remote Sensing, Landscape Ecology, Spatial Analysis, Spatial Decision Support Systems

Jonathan W. Bulkley

Peter M. Wege Professor of Sustainable Systems
 Professor of Natural Resources/Professor of Civil and Environmental Engineering
 Co-Director, Center for Sustainable Systems
 Co-Director, Certificate Program in Industrial Ecology
Risk Analysis; Resource Policy, Sustainable Water Resource Systems

William S. Currie

Assistant Professor of Natural Resources and Environment
Ecosystem Modeling, Terrestrial Ecology, Biogeochemistry, Ecosystem Responses To Environmental Change Related To Energy Production

Thomas N. Gladwin

Max McGraw Professor of Sustainable Enterprise
 Professor of Corporate Strategy and International Business/Professor of Natural Resources
 Co-Director, Erb Institute for Global Sustainable Enterprise
Business Impact on Biodiversity and Sustainable Mobility, Social Sustainability, Sustainability Metrics and Reporting

Andrew J. Hoffman

Holcim (US) Professor of Sustainable Enterprise
 Associate Professor of Management and Organizations/Associate Professor of Natural Resources
 Co-Director, Erb Institute for Global Sustainable Enterprise
Corporate Environmental Strategies, Organizational Behavior, Sustainability Strategies, Institutional and Cultural Change

Gregory A. Keoleian (ACSFP co-coordinator)

Associate Professor of Sustainable Systems
Co-Director, Center for Sustainable Systems
Co-Director, Certificate Program in Industrial Ecology
Life Cycle Design and Assessment; Life Cycle Optimization, Technology Assessment of Renewable Energy; Transportation and Building Sectors, Sustainability Metrics and Indicators

Thomas P. Lyon (ACSFP co-coordinator)

Dow Professor of Sustainable Science, Technology and Commerce
Professor of Business Economics and Public Policy/Professor of Natural Resources and Environment
Co-Director, Erb Institute for Global Sustainable Enterprise
Business/Government Relations, Corporate Environmental Strategy, Policy Analysis, Econometrics, Game Theory, Transaction Cost Economics, Political Economy of Regulation

Michael R. Moore

Associate Professor of Environmental Economics
Environmental Economics, Natural Resource Economics, Pollution Markets, Markets for Green Products, Conservation Policy

Barry G. Rabe

Professor of Environmental Policy/Professor of Public Policy
Director, Program in the Environment
Environmental Politics and Policy, Intergovernmental Relations and Policy Implementation in Multi-Level Government Systems, Subnational Climate Policy in the United States and Other Federated Systems

Steven J. Skerlos

Assistant Professor of Mechanical Engineering
Director, Environmental and Sustainable Technologies Laboratory
Eco-Design and Manufacturing, Environmental Systems Analysis, Recycling and Energy Recovery Technology Systems, Design Optimization for Life Cycle Energy Minimization

Julia M. Wondolleck

Associate Professor of Natural Resource
Environmental Dispute Resolution, Collaborative Ecosystem Management

Rosina M. Bierbaum (Cabinet advisor)

Dean of the School of Natural Resources and Environment
Professor of Environmental and Natural Resource Policy and Management
Former Acting Director of the White House Office of Science and Technology Policy (OSTP)

1.2 Sustainability Challenges and Research Activities

1.2.1 Global Sustainability Challenges and the Role of Technology

The sustainability challenges facing society in the 21st century include global climate change, declining fossil resources, persistent organic pollutants, freshwater scarcity, ecosystem degradation, biodiversity loss, overpopulation and limited access to basic human necessities in developing countries. Science and technology are central to both the origins of these sustainability challenges and to the prospects for effectively addressing them. The wise use of technology represents a necessary, but not a sufficient, prerequisite for sustainable human development. Technology represents a key lever for change, offering the means for radically improving resource productivity; reducing the environmental and social harm of production and consumption activity; reducing human vulnerability and empowering the poor; switching from nonrenewable to renewable energy; decoupling economic growth from environmental impact; enabling developing countries to leapfrog the burdens of the industrial revolution; and decarbonizing, dematerializing and detoxifying economic activity. For many analysts, technological progress represents the only real hope

for meeting the needs of a much larger human population in an equitable manner while simultaneously preserving the planet’s life-support systems and biodiversity.

In recent years the international scientific and technological community (e.g., Board on Sustainable Development of the U.S. National Research Council, U.S. National Science Foundation) has arrived at a consensus that urges a radical reorientation of science and technology supportive of the transition to sustainability with an approach that is more synthetic, dynamic, integrative, action-oriented, and collaborative. While the challenges associated with this new research orientation are extraordinary, we believe that the University of Michigan – with its long-standing emphases on interdisciplinarity, internationalism, complex systems, social change, industry collaboration and public service – is an ideal place to pursue this new paradigm of scholarship in search of a sustainable human future.

1.2.2 Research Area and Potential Topics

The University of Michigan Sustainability Cabinet will focus ACSFP research on sustainable energy technology. Energy technology plays a critical role in addressing many sustainability challenges including climate change, declining fossil fuel resources, acidification, smog formation, and energy security for both developed and developing nations. The ACSFP provides an exciting forum to bring together leading scholars in the field of sustainability to conduct interdisciplinary research on sustainable energy. The proposed theme for the ACSFP is “enabling technologies for achieving a sustainable energy future.” Figure 1 highlights sustainability challenges and opportunities for achieving this vision.

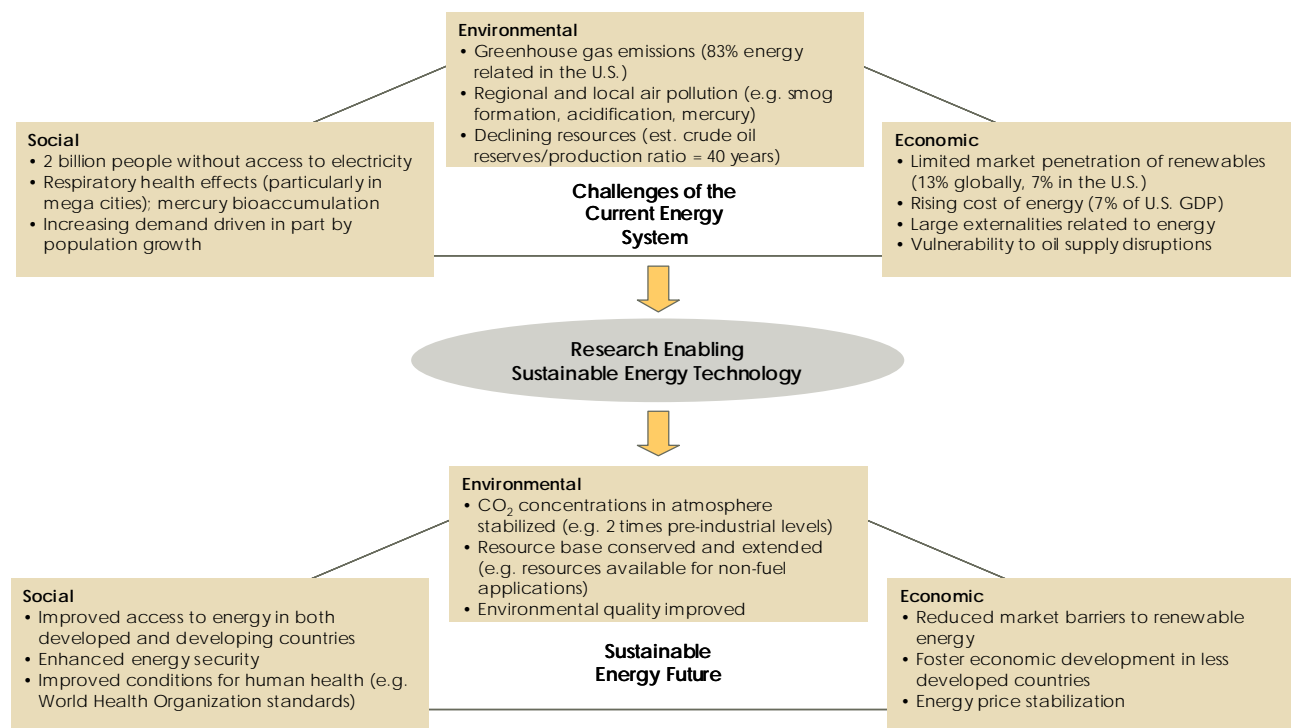


Figure 1. Environmental, Social and Economic Challenges and Opportunities for a Sustainable Energy Future

The faculty represented on the Sustainability Cabinet have an established record of research accomplishments related to the economic, social and environmental aspects of improving energy sustainability. The following are selected examples of this research:

- Life Cycle Design of Building Integrated Photovoltaics Systems (NSF)
- Life Cycle Assessment of a Willow Agriculture and Biomass Energy Conversion System (USDA)
- Systems Dynamics Modeling of Biofuels Substitution for Fossil Fuels in Land Transport in North America (British Petroleum)
- Agent-based and Systems Dynamics Modeling of Hybrid Vehicle Market Penetration in the U.S. Market (Ford Motor Company)
- State of Michigan Greenhouse Gas Inventory: Engagement of State Policymakers (Energy Foundation)
- Technology Assessment and Evaluation for the NextEnergy Zone Microgrid System (State of Michigan)
- Introducing Markets for Green Products: Product Demand, Environmental Quality, and Economic Welfare (U.S. EPA)
- The Information-Based Approach to Environmental Policy: An Analysis of Green Electricity Programs in Michigan (Michigan DEQ)
- Statehouse and Greenhouse: State-Level Policy Innovation in Greenhouse Gas Reduction (Pew Center)
- After Kyoto: Toward Implementation of Greenhouse Gas Reduction Policy in Canada (Canadian Studies Faculty Research Grant Program)

The Fellowship Program will build upon our research activities and expand the scope of our interdisciplinary research related to sustainable energy. Examples of possible research questions to pique the interest of Research Fellows are shown below.

- Which alternative renewable energy technologies for a given site provide the greatest environmental and economic benefits based on life cycle assessment and modeling?
- What is the potential for increasing the use of renewable energy in intensive manufacturing operations?
- In what amounts and at what levels could production tax credits and other economic instruments address economic barriers for renewable energy technologies?
- What impacts would carbon cap and trade regulations have on sustainable energy technology?
- Why have states emerged as the primary driving forces behind renewable energy policy formation in the past half-decade? Does this bottom-up approach lead to patterns of continued policy diffusion, regional clustering, or ultimate preemption by the federal government?
- How does the American climate change policy experience relate to other federated governmental systems, such as those of Canada, Australia, and the European Union?
- What are the market fundamentals that explain the market-clearing prices on the Chicago Climate Exchange? What are the gains from trade in the greenhouse gas market?
- Who will win and who will lose if international policy mechanisms are established for greenhouse gas reductions?
- How is climate change perceived by key market constituencies (customers, insurance companies, investors, etc.) and how do those perceptions help or hinder corporate greenhouse gas strategies?
- What is the appropriate role for corporate voluntary initiatives in promoting sustainable energy development in developing countries?
- What is the most effective way to implement a system of carbon emission permits that will encompass mobile sources such as automobiles?

- What institutional mechanisms are needed to make “green tags” a reliable way of meeting renewable energy portfolio standards?
- What are the sources of resistance to the siting of new forms of energy generation (such as wind energy in Nantucket Sound or aluminum smelting in Iceland)? What strategies might companies use to overcome them?
- Can ecosystem models be developed to explore tradeoffs among multiple societal goals such as energy production, food and fiber production, economic sustainability of resource-related industries, and protection of the ecological integrity of forests, lakes, and estuaries?
- What are the spatial land-use implications and demands of renewable energy use? How do social and spatial networks, and their interaction, support and shape the diffusion of sustainable energy innovations?

1.3 Interdisciplinary Framework and Collaboration

1.3.1 Framework

Figure 2 shows an integrative framework for organizing interdisciplinary research linking sustainable technology, policy, enterprise and sustainability science. Successful implementation of sustainable energy technology must address multiple and often competing objectives and constraints. This figure indicates the range of discipline-specific research methods and tools across various domains that will be integrated into a comprehensive research program.

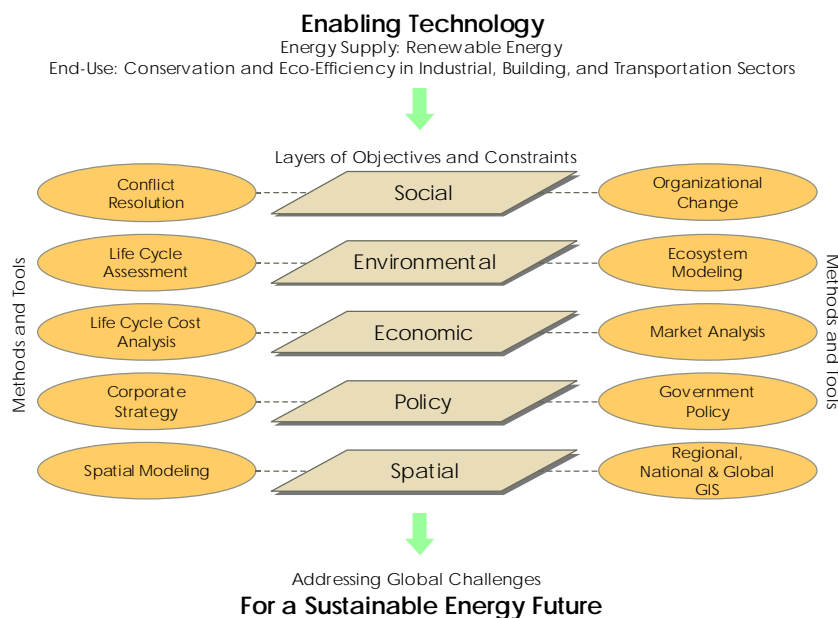


Figure 2. Framework for integration of multi-disciplinary research methods

1.3.2 Workshops

The ACSFP Cabinet and Fellows will convene ten research workshops, once per semester, as a mechanism for coordinating resources and encouraging interdisciplinary collaboration. These workshops will serve as opportunities for open discussion of research methods and progress between fellows and sustainability cabinet members. Team workshops have been effective in supporting interdisciplinary collaborations by Cabinet members on other large-scale projects.

2. FELLOW RECRUITMENT, SELECTION AND SUPPORT

2.1 Recruitment and Selection

The University of Michigan has an established track record of recruiting outstanding students, faculty and research staff. As a result, the University is consistently regarded as one of the leading research universities in the United States. These high expectations for outstanding research capabilities will be applied to the recruitment of Sustainability Fellows.

2.2 Support

2.2.1 *Financial*

To recruit top candidates in the field we offer an annual stipend of \$46,000 for each Academic Fellow. This stipend is in the range offered by other distinguished fellowship programs at the University of Michigan. The Fellows will receive appointments within relevant Academic Units at the University of Michigan and associated benefits.

2.2.2 *Mentorship*

Each Academic Fellow will be mentored by two faculty members from the Sustainability Cabinet who will meet regularly with the Fellows, monitor their research progress, and provide guidance on future career opportunities. Fellows will receive office space and other research support (including a laptop computer).

3. CONVENINGS

The University of Michigan will organize a conference for the Academic Partners and Academic Fellows. The Center for Sustainable Systems and the Erb Institute have hosted a wide range of lectures, conferences, seminars, and workshops that address sustainability. Examples include:

- 2nd International Conference of the International Society for Industrial Ecology, July 2003
- Organizational Transformation for a Sustainable Future Conference, co-sponsored with the HRH The Prince of Wales's Business and the Environment Programme, July 2004
- Business, Environment, Learning and Leadership (BELL) Conference, co-sponsored with the World Resources Institute, July 1999.

To facilitate the development of a productive international community of Sustainability Academic Partners, Academic Fellows, and Signature Partners we propose the following:

- Academic Fellows prepare extended abstracts describing their research and distribute these to Academic Partners and other participants in advance of Convenings.
- Panels comprising Academic Partners and representatives from industry, government, and non-governmental organizations will be organized to provide constructive feedback and stimulate discussion for each Academic Fellow presentation.
- The Convening should also be designed to encourage comparative studies (e.g., cross cultural), exchange of data and research findings, and joint publications by participants.
- Organizers can also help prepare a press release and summary report for each Convening that highlights key research findings derived from the Alcoa Conservation and Sustainability Fellowship Program.

4. LINKAGES AND LEADERSHIP IN SUSTAINABILITY WITHIN THE UNIVERSITY OF MICHIGAN

Sustainability Cabinet members were selected to provide maximum linkages between established research centers on campus. Cabinet members represent the Center for Sustainable Systems, the Erb Environmental Management Institute, the Environmental Spatial Analysis Lab, Ecosystem Management Initiative, and the Environmental and Sustainable Technologies Lab and have appointments in the School of Natural Resources and Environment, the Ross School of Business, the College of Engineering, and the Ford School of Public Policy.

The Alcoa Conservation and Sustainability Fellowship Program will be coordinated at the University of Michigan by the Center for Sustainable Systems (CSS) and the Erb Environmental Management Institute. These organizations have an established network of faculty and administrative resources to lead the program. A brief description of CSS, Erb and other participating organizations follows, including examples of interdisciplinary project experience.

The **Center for Sustainable Systems (CSS)** is an interdisciplinary research and education center in the University of Michigan's School of Natural Resources and Environment. The Center brings together faculty and students from natural resources, engineering, business, physics, public health and other disciplines to address the critical issues of sustainability in the 21st Century. CSS collaborates with diverse stakeholders to develop and apply life cycle based models and sustainability metrics for systems that meet societal needs. CSS promotes tools and knowledge that support the design, evaluation, and improvement of complex systems. Twenty-eight University faculty members have collaborated with CSS on one or more research and education activities.

The Center has completed more than 50 research projects on topics such as renewable energy, hydrogen infrastructure, transportation, green buildings, consumer products and packaging. Methods and tools employed in these research endeavors include life cycle assessment, life cycle design, life cycle costing and life cycle optimization.

- CSS collaborated with SUNY Syracuse College of Environmental Science and Forestry and the National Renewable Energy Lab to study the energy and environmental performance of willow biomass energy. An NSF sponsored interdisciplinary team of faculty from industrial ecology, environmental economics, energy policy and architecture modeled and evaluated amorphous silicon building integrated photovoltaics.
- A cross-campus team led by CSS, in conjunction with the U.S. EPA and General Motors, integrated life cycle assessment and dynamic programming to investigate optimal vehicle service life based on economic and environmental impacts. This project was funded by the NSF Technology for Sustainable Environment Program and involved faculty from industrial ecology, industrial engineering, risk analysis and physics.
- In partnership with Chrysler, Ford, GM, the Aluminum Association, American Iron and Steel Institute and the American Plastics Council, CSS and Ecobalance conducted one of the most complex and complete Life Cycle Inventories (LCI) of its kind – an LCI of a midsize automobile.
- CSS is currently leading a five-year project bringing together seven U-M faculty from Material Science and Engineering, Civil Engineering, Environmental Health Sciences, Environmental Economics, Resource Policy and Geology to guide the design and implementation of more sustainable infrastructure

materials and systems. This project is sponsored by the NSF MUSES (Materials Use: Science, Engineering, and Society), Biocomplexity Program.

The **Frederick A. and Barbara M. Erb Institute for Global Sustainable Enterprise** was created to study and understand the roles and relationships among businesses, governments and not-for-profit organizations as they interact and affect the environment. The Erb Institute is jointly administered by the Ross School of Business and the School of Natural Resources and Environment. Central to the Institute's mission are the activities of the Erb dual degree program that was launched in 1992 as a joint venture between the two schools. The Erb program has been consistently rated as one of the best programs of its kind according to the bi-annual "Grey Pinstripes" Survey conducted by the World Resources Institute and Aspen Institute.

In addition to furthering the objectives of its academic program, the Erb Institute aims to address the interdisciplinary issues involved in solving environmental problems, including pursuit of the following objectives: to attract high-quality University of Michigan faculty and environmental practitioners to collaborate and focus on realistic environmental problems and opportunities; to work directly with leaders in government, business and not-for-profit organizations having a stake in and responsibility for environmental matters; to support experiential education through on-site internships and team projects in the business and nonprofit sectors; to provide academic enrichment through seminars, executive education, lectures and special conferences; and to support multidisciplinary research on business and the environment.

- The Erb Institute is leading a campus-wide initiative on Sustainable Mobility and Accessibility Research and Transformation (SMART) in collaboration with the Center for the Study of Complex Systems, Ford Motor Company and the Taubman College of Architecture and Urban Planning. SMART has initiated a series of agent-based and systems dynamics modeling projects focused on the evolutionary dynamics of the hydrogen infrastructure, biofuels substitution and hybrid vehicle market penetration.

The goals of SNRE's **Environmental Spatial Analysis (ESA)** Program are to demonstrate and test methods for environmental spatial analysis in the context of problems of scientific and social significance; to apply spatial data analysis methods to real environmental problems; to train a new generation of spatially enabled resource managers and policy analysts; and to transfer the best spatial analysis technologies to users and managers. The ESA Lab, equipped with state of the art hardware and software, provides a home for researchers and students conducting interdisciplinary research in which environmental spatial analysis is a key component. Project examples include studies of hydrogeology and watersheds, forest ecology, public health, land use and land cover change, with varied geographic focus ranging from Michigan to North and South America, the Middle East, Russia, and Southeast Asia.

- Project SLUCE (Spatial Land Use Change and Ecological Effects at the Rural-Urban Interface) seeks to understand the individual decision-making that drives land use decisions and to formulate and test alternative policies and interventions that could reduce environmental costs and enhance environmental benefits. Models and tools resulting from this project can be used in studying issues related to the siting of renewable energy technologies.

The **Ecosystem Management Initiative (EMI)** was launched in 2001 to promote sustainable natural resource management through ecosystem-based teaching, research, and outreach. Natural resource management is at a crossroad. Serious problems – ecological, economic, and social – demand new scientific understanding, updated management strategies, and better ways for people to interact to address and solve these problems.

The **Environmental and Sustainable Technologies (EAST) Laboratory** in the College of Engineering was founded in 2000 to develop and communicate knowledge regarding the environmental impact of design and manufacturing decisions (identify environmental problems), and develop appropriate technologies to mitigate the environmental impacts of design and manufacturing activities (identify economic solutions). The EAST Lab is active in the fields of sustainable engineering design, life cycle assessment and remanufacturing, and has developed a framework to evaluate environmental policy options from the engineering design perspective for their economic and environmental impacts.

One of the ACSFP co-coordinators serves on two campus-wide committees directly related to the proposed Sustainable Energy theme. The recently revised mission of the **Michigan Memorial Phoenix Project** approved by the Regents is to conduct research on the development of energy sources and energy policies that will promote world peace, the responsible use of the environment, and economic prosperity. The proposed role of the Phoenix Project is “coordinating the research activities from a variety of disciplines that are presently dispersed among multiple schools and colleges, including research on energy generation from sources such as nuclear, hydrogen, solar, wind, and geothermal, as well as energy storage, energy management, and energy policy.” Former University of Michigan President James Duderstadt chairs the Executive Committee for this Project as well as the **Hydrogen Committee**.

5. INSTITUTIONAL INFORMATION AND UNIVERSITY OF MICHIGAN COMMITMENT

The University of Michigan is a public state-assisted institution, created in 1817, with its main campus located in Ann Arbor, a lively and diverse city (population: 110,000). The Ann Arbor campus enrolls about 40,000 students. The University’s instructional staff numbers about 4,800, with a non-instructional staff of 26,000, for a total employment of 30,800. In 2001-2002, 9,950 degrees were awarded.

Throughout its history the University of Michigan has been a recognized leader in the field of sustainability through research, education and outreach programs. Beginning with the establishment of the nation’s first course in forestry in 1881, planning the nation’s first Earth Day celebration, establishing one of the first business-environment dual degree programs, and creating four named professorships in sustainability, the University of Michigan continues to demonstrate leadership and excellence in sustainability research and education.

A recent survey of 200 faculty in seven Schools by the Provost’s Office indicated that environment and sustainability grants account for about 10% of the total non-Medical School grants at the University of Michigan on an annual basis (\$33 million). Another recent survey by the College of Engineering estimated that present energy technology grant awards total \$27 million.

The **School of Natural Resources and Environment (SNRE)** will have an integral role in the Alcoa Conservation and Sustainability Fellowship Program at the University of Michigan. The School's overarching objective is to contribute to the protection of the earth's resources and the achievement of a sustainable society. Through research, teaching, and outreach, SNRE's faculty, staff, and students are devoted to generating knowledge and developing policies, techniques and skills to help practitioners manage and conserve natural and environmental resources to meet the full range of human needs on a sustainable basis. The U-M Department of Forestry was established in 1903 and in 1927, the Department grew into the School of Forestry and Conservation to become the first of its kind in the country. The School established another academic first when, in 1950, it became the School of Natural Resources. In 1992, "Environment" was added to the name to better reflect its range of activities. Over 7,000 people have earned degrees from the School of Natural Resources & Environment. The School is a focal point for interdisciplinary research and education on sustainability. There are 18 joint faculty appointments between SNRE and seven other Schools and Colleges.

The University of Michigan community is committed to providing exceptional postdoctoral fellowship opportunities and this program has the full support of both the Dean of the School of Natural Resources and Environment (Rosina M. Bierbaum), and the University Provost and Executive Vice President for Academic Affairs (Paul N. Courant).

5.1 Education Programs in Sustainability at the University of Michigan

The University of Michigan offers many exciting dual and joint degree programs across the nineteen academic schools and colleges. There are over fifty dual degree programs offered through the Rackham Graduate School. The following interdisciplinary education programs address sustainability and involve seven Academic Schools and Colleges. Over the past two years, over 1400 graduate students have received degrees in two or more fields – 42 from SNRE related to sustainability.

The **Erb Dual Degree Program** is a sustainability-focused educational program of the Erb Environmental Management Institute. Students in the three-year program earn two Masters degrees – a Master of Business Administration (MBA) from the Stephen M. Ross School of Business and a Master of Science from the School of Natural Resources & Environment. The Erb program is the largest and most integrated program of its kind worldwide. The current community includes 46 close-knit, dual-degree students who are engaged in a challenging blend of coursework, projects and research related to business, the environment and sustainability. The *Wall Street Journal* named the Ross School of Business the No. 1 business school in the nation in September 2004 and acknowledged the contributions of Erb and SNRE in achieving this position.

The **Graduate Certificate Program in Industrial Ecology (PIE)** enables University of Michigan graduate students to explore the nexus of technology, sustainability and enterprise and the environment in greater depth. PIE's certificate complements any field of study by providing specialization in technological and industrial innovation, consumer behavior and consumption patterns, policy and regulatory issues, and

economic factors and market forces to achieve more sustainable systems. Participating students will be better prepared to design and manage natural and industrial systems to meet human needs in an environmentally, economically, and socially sustainable manner.

The **Sustainable Systems Plan** is a new graduate curriculum offered through the School of Natural Resources and Environment to guide the development and transformation of technologies, enterprise, and systems for meeting basic human needs in a sustainable manner. This curriculum is designed to provide interdisciplinary education and professional development for students in SNRE and those in current and future dual degree programs (e.g., Business and Engineering).

A group of faculty in the College of Engineering and SNRE are developing a new joint MS/MSE degree program in **Sustainable Systems Engineering**. This program will be complementary to the Corporate Environmental Management Program but focus on the intersection between technology and sustainability.

The School of Natural Resources and Environment encourages interdisciplinary education and training in other areas through dual degree programs in Law, Public Policy, Architecture and Urban Planning, Economics, Engineering, and Russian & East European Studies.

5.2 Related Fellowship Programs

The University of Michigan has organized and participated in a wide range of interdisciplinary fellowship programs. Three examples are provided here which serve as models for shaping the Alcoa Conservation and Sustainability Fellowship Program.

The University of Michigan was the recipient of two **AT&T Industrial Ecology Faculty Fellowship** awards. The first award supported the Industrial Ecology of the Automobile seminar series and the development of the first university course in Industrial Ecology in 1994. The seminar series brought together key stakeholders from the automotive industry, government, environmental organizations, and academia to examine vehicle environmental impacts, alternative technologies, and government and industry policy shaping life cycle design and management of the automobile. As a result of this program the Society of Automotive Engineers published the book *Industrial Ecology of the Automobile*.

The **Michigan Society of Fellows**, under the auspices of the Rackham Graduate School, was established in 1970 with endowment grants from the Ford Foundation and the Horace H. and Mary Rackham Funds. The most distinctive aspect of the Society is a multidisciplinary emphasis, which gives the Fellows an opportunity to interact across disciplines and to expand their horizons and knowledge. While their own scholarship is enriched, the Fellows also enrich the University of Michigan through teaching during their residency and bringing new insights to other faculty members. Each year the Society selects four outstanding applicants for appointment to three-year fellowships in the arts and humanities, in the social, physical and life sciences, and in the professional schools. The newly appointed Postdoctoral Fellows join a unique interdisciplinary community composed of their peers as well as Senior Fellows.

Established in 1993, the **Population and Environment Fellowship Program** is the only program of its kind providing applied learning experiences to emerging Population and Environment (PE) professionals. The Program aims to develop a cadre of future PE leaders, while at the same time supporting the field's pioneering organizations and methods. The Program works by placing fellows on two-year assignments with organizations working to link family planning and environmental programming in the developing world. The assignments are structured so that the fellow gains experience designing, implementing, and evaluating PE programs; the host organization gains a professional who is prepared to help it develop sustainable PE activities; and the field gains new methods for linking these sectors and evaluating the results. Since the Program's inception, some 50 Population-Environment Fellows have worked toward greater balance between people and the environments that sustain them.

5.3 Select Peer Reviewed Sustainability Research Publications

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- Rabe, B. *Statehouse And Greenhouse: The Emerging Politics Of American Climate Change Policy* (Brookings Institution Press, 2004).
- Rabe, B. "Power to the States: The Promise and Pitfalls of Decentralization," in Vig and Kraft eds., *Environmental Policy: New Directions For The Twenty-First Century* (Congressional Quarterly Press, 2005)

Hula A., Jalali, K., Hazma, K., Skerlos, S.J., Saitou, K. 2003, "Multi-Criteria Decision Making for Optimization of Product Disassembly Under Multiple Situations," *Environmental Science and Technology*, Vol. 37, No. 23, pp. 5303-5313

Wondolleck, J. M., B. Gray, and T. Bryan, "Us versus Them: How Identities and Characterizations Influence Conflict," *Environmental Practice* 5(3): September 2003.

5.4 International Programs on Sustainability at the University of Michigan

HRH The Prince of Wales' Business & the Environment Programme, developed and run by the University of Cambridge Programme for Industry, is the largest and longest-running executive learning program on sustainable business in the world. Held annually in four locations (U.K., Austria, U.S. and South Africa), the Programme's Senior Executive Seminars have introduced over 1,000 international executives and thought leaders to the sustainability debate and provided the insight and support necessary for them to champion sustainable development profitably in their organizations. Professor Gladwin has been a core faculty member of the Programme since its start in 1994 and serves as Faculty Director of the U.S. seminars. Annual alumni reunions of the U.S. seminars are held at the University of Michigan Ross School of Business.

The Center for Sustainable Systems participated in the **Alliance for Environmental Systems Analysis and Management**, which included the Royal Institute of Technology (Sweden), Swiss Federal Institute of Technology, Technical University of Vienna, University of California, Berkeley, and the University of Michigan. The Alliance hosted annual workshops and student and faculty exchanges for a four-year period.

The Erb Institute has recently joined with Cornell, Virginia and MIT to collaborate with the new **Center for Eco-Intelligent Management at the Instituto de Empresa** in Madrid. The Center will disseminate sustainable enterprise research and mount executive programs for the Spanish-speaking world.

Through **International Multidisciplinary Action Projects (IMAP)**, the University of Michigan Ross School of Business offers graduate students an opportunity to benefit from exposure to international business challenges. The largest program of its kind in the nation, IMAP students work full-time with corporations and nonprofit organizations on projects that test students' skills, produce valuable information for sponsors, and stimulate exchanges that benefit scholars and business practitioners alike. The successful combination of critical thinking, multidisciplinary connections and real-world applications has led to solid recommendations and innovative solutions for businesses throughout the world. Erb students have been active participants in sustainability-oriented projects.

The **International Institute** is responsible for coordination of research and training in area, comparative, and international studies as well as promotion of innovative collaborations in international affairs across the University's schools and colleges. It comprises one of the nation's broadest assemblages of interdisciplinary centers and initiatives, including the University's U.S. Department of Education-supported National Resource Centers in area studies and international business; other area studies, comparative, and thematic programs and initiatives; publications; and the Office of International Programs (organizing undergraduate study abroad and exchange programs). Dr. Jimin Zhao, Research Investigator at the Center

for Sustainable Systems is currently collaborating with the International Institute and Tsinghua University to study concrete infrastructure sustainability in China as part of a five year NSF sponsored grant.

5.5 University of Michigan Research Infrastructure

Research is central to the University's mission and its nineteen academic schools and colleges. The University of Michigan's research expenditures of \$749 Million in 2002-03 are the second largest of any university in the U.S. Excellence in research is a crucial element in the University's high ranking among educational institutions. National surveys consistently rank the University's professional schools among the top 10, reflecting a research record of important publications and other contributions to the advancement of the disciplines involved.

The University's research draws upon a comprehensive library system that includes three main libraries, 19 divisional libraries, 7 departmental and area collections, and additional special libraries. The University of Michigan collection is one of great breadth and depth. The University of Michigan has the sixth largest academic research library in the country; total holdings number over 7,000,000 volumes. Furthermore, the University is a leader in building digital collections, converting approximately 5,000 volumes a year. This rate of digitization exceeds that of any other academic library. Google and the University of Michigan recently announced a joint agreement that will add the 7 million volumes in the University library to the Google search engine and open the way to universal access to information.

6. OUTCOMES AND EVALUATION

The University of Michigan ACSFP is designed to achieve the six objectives indicated below and bring recognition to Alcoa and the Alcoa Foundation for its leadership in establishing this progressive program. Success will be measured using the following qualitative and quantitative indicators identified with bullets.

- 1) Establish an internationally recognized postdoctoral fellowship program carrying the Alcoa name that attracts top young scientists and engineers from around the world to participate in interdisciplinary sustainability research.
 - Number and quality of applicants
- 2) Provide outstanding interdisciplinary training to prepare postdoctoral fellows for productive careers in the private sector or public sector including academia.
 - Each postdoctoral fellow is expected to achieve the following: minimum two peer reviewed publications, contribute to the preparation of at least one research proposal, present their research at University of Michigan Workshops and International Convenings, and guest lecture in multiple courses.
 - Positions of Postdoctoral Fellows completing the program
- 3) Develop, demonstrate, and disseminate new interdisciplinary models, tools, and knowledge that integrate science, technology, corporate and public policy for solving sustainability challenges of the 21st century.
 - Number of peer reviewed publications

- Citations to these publications by other researchers
 - Number of presentations at national and international conferences and professional society meetings
 - Research impact in public and private sectors
 - Direct feedback from CSS and Erb External Advisory Boards, Alcoa, and Signature Practitioners
- 4) Contribute to the creation of a new intellectual community and network among Academic Partners, Academic Fellows, Signature Practitioners, and Alcoa focusing on sustainability.
- Comparative studies, data exchange between partner institutions
 - Joint publications among partner institutions
- 5) Leverage the resources of this program with existing research and education activities at the University of Michigan and expand our capabilities through new research grants and educational programs.
- Level of additional research funding from NSF and other funding agencies related to this program
 - Contribute to the development and implementation of a new Graduate Program in Sustainable Systems Engineering at the University of Michigan
- 6) Inform and guide future Alcoa Foundation grantmaking and engagement strategies.
- Number and quality of topics recommended for next-generation sustainability grantmaking

PROGRAM TIMELINE

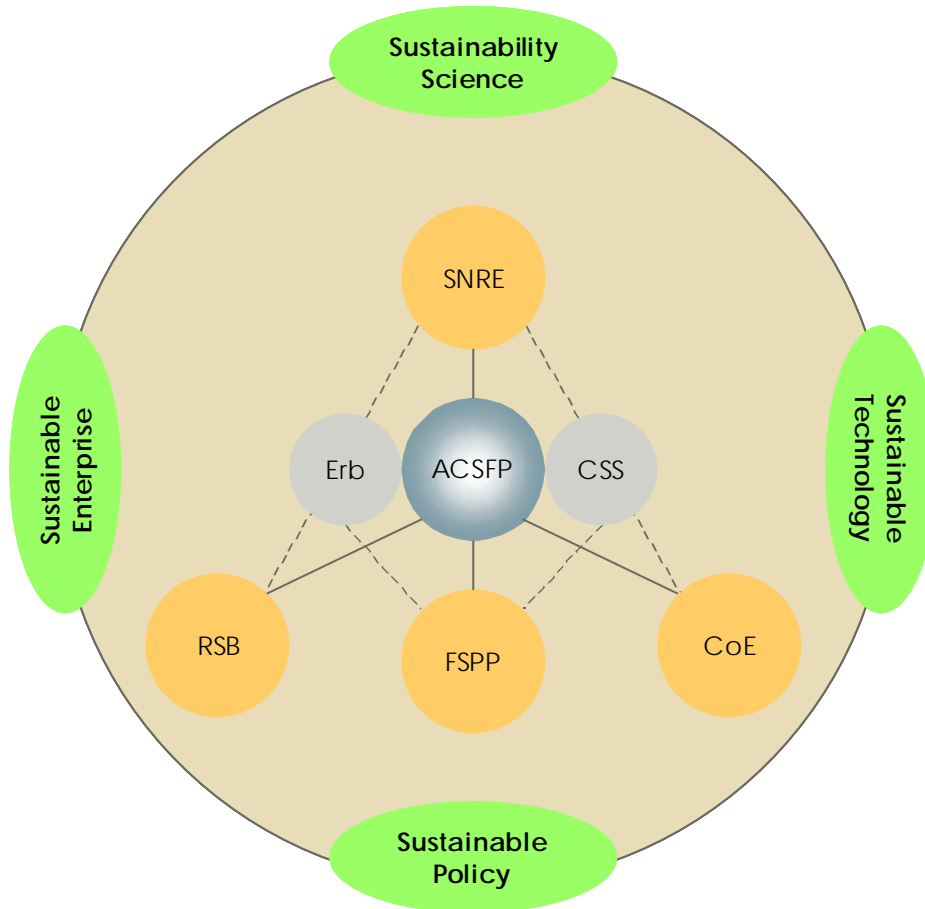
The timeline for the Conservation and Sustainability Fellowship Program at the University of Michigan is indicated in the figure below. The five-year Program began planning in Spring Term 2005 and will end Winter Term 2010. Fellows recruited are generally expected to begin research work and reside on campus full-time no later than the term following their recruitment. The total number of Fellows in residence are two in 2005-6, four in 2006-7, four in 2007-8, two in 2008-9, and none in 2009-2010. All six Fellows would be able to participate in one Academic Convening and one Signature Convening.

As indicated in section 1.3.2 of this narrative, the Cabinet and Academic Fellows will organize two University of Michigan Workshops each year to facilitate collaboration and exchange. Not shown on the timeline are regular meetings between the Cabinet and Fellows.

We expect at least sixteen publications to result from the ACSFP at the University of Michigan. Academic Fellows are expected to coauthor with the Cabinet at least two scholarly publications during their appointment. In addition, we expect at least four other publications over the course of the Program. The University of Michigan Cabinet will provide an annual report of activities and accomplishments to IIE and Alcoa Foundation. The University of Michigan Cabinet will make an annual Press Release about the program and its accomplishments.

PROGRAM TIMELINE Program Activity/Event	2005		2006			2007			2008			2009			2010
	S/S	F	W	S/S	F	W	S/S	F	W	S/S	F	W	S/S	F	W
<i>Recruiting</i>	■	■		■			■								
<i>Appointments</i>															
Fellow 1			■	■	■	■	■	■							
Fellow 2			■	■	■	■	■	■							
Fellow 3									■	■	■				
Fellow 4									■	■	■	■	■		
Fellow 5									■	■	■	■	■	■	
Fellow 6									■	■	■	■	■	■	
<i>U-M Workshops</i>		•	•		•	•		•	•		•	•		•	•
<i>Convenings</i>															
Academic					•			•							
Signature Program					•							•			
<i>Publications</i>															
Peer-Review Publications					2		4			4			4		2
Press Releases	■			■	■		■	■		■	■		■	■	
Annual Reports			■			■			■			■			

ATTACHMENT: PARTICIPATING ORGANIZATIONS AT THE UNIVERSITY OF MICHIGAN



- ACSFP Alcoa Conservation and Sustainability Fellowship Program
- CoE College of Engineering
- CSS Center for Sustainable Systems
- EAST Environmental and Sustainable Technologies Lab, CoE (not shown)
- EMI Ecosystem Management Initiative, SNRE (not shown)
- Erb Erb Institute for Global Sustainable Enterprise
- ESA Environmental Spatial Analysis Lab, SNRE (not shown)
- FSP Ford School of Public Policy
- RSB Ross School of Business
- SNRE School of Natural Resources and Environment