

Proposal:

Carbon Management Initiative
DRAFT – DO NOT DISTRIBUTE
University of Michigan

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Abstract

Over the past few decades it has become increasingly evident that the global climate is changing. Much research and effort has been spent trying to understand climate change and the causes of it. Recently, studies by the Intergovernmental Panel on Climate Change (IPCC) have shown that it can be stated with confidence that a significant amount of this change is due to anthropogenic forces. The most recent IPCC study in 2007 provides evidence that the concentration of carbon dioxide, the most important anthropogenic greenhouse gas, in the atmosphere has increased by nearly 35% with respect to its pre-industrial value. This increase in carbon dioxide is primarily a result of the increase in human use of fossil fuels. It is now evident that if future generations truly want to solve the climate problem, they must look into controlling and reducing anthropogenic carbon dioxide emissions. It is proposed that the Carbon Management Initiative (CMI) be created at the University of Michigan to help tackle this trans-disciplinary issue. The University of Michigan is a world-renowned research institution with a strong representation of all sectors, including science, business, policy, engineering, social sciences, public health, and law, that are needed to provide a full investigation of the global carbon problem. It is believed that such an initiative is vital to the investigation of carbon and will provide the necessary solutions that not only benefit the university, but will also benefit the nation and worldwide community.

Mission

Generate opportunities and promote collaboration among the various disciplines at the University of Michigan in order to initiate trans-disciplinary learning and a strong foundation for the successful implementation of advancements in carbon management.

Executive Summary

It is proposed that the Carbon Management Initiative (CMI) be developed at the University of Michigan. The main goals of such an initiative will be to initiate and coordinate trans-disciplinary research and education throughout the University of Michigan and community. CMI will be headed by a director and an Executive Committee who will oversee the initiative, and an Advisory Committee will advise the director in the areas of research, education, and outreach and development. It is also proposed that there be an Coordinating Chair, that is in charge of making sure the committees and director stay in line with the trans-disciplinary goals of CMI.

The University of Michigan is a world re-known research institution with a broad range of outstanding programs. A few examples include the medical, law, business, and engineering schools as well as outstanding social science programs. This broad range of expertise makes the University of Michigan well positioned to develop the Carbon Management Initiative. Due to the cross-functional components involved in climate change and carbon management, this initiative will be focused on trans-disciplinary collaboration. Four schools and colleges are proposed to be pillars and head this trans-disciplinary collaboration. These include the School of Natural Resources and Environment, the Gerald R. Ford School of Public Policy, the Ross School of Business, and the College of Engineering. These four schools and colleges will address the four areas of rationale convergence: NGOs and public interests, politics and government, business, and science. In addition, they will introduce varying research areas and techniques along with the necessary skills for carbon management to truly be trans-disciplinary.

With the ever growing awareness that carbon dioxide emissions are increasing and that carbon dioxide is a major player in global warming and climate change, it is evident that there is a need for major changes in the energy production and transportation sectors. As a result, CMI proposes to help fund research that investigates possible carbon market solutions, the development of carbon neutral energy technologies for energy production and transportation, study of carbon sequestration and storage of emissions, and the examination of the health and societal impacts of climate change due to increased carbon emissions. It is planned that CMI would be able to fund such research through funding graduate student and faculty fellowships and small research grants that emphasize a trans-disciplinary approach.

Current and future leaders who are change agents actualizing carbon mitigation projects need to be prepared ex-ante for their entrance into the workforce. In response to this situation, the Graduate Certificate in Carbon Management at the University of Michigan may provide this education by developing carbon management specialists with the ability to leverage their skills in a trans-disciplinary project environment resulting in projects that mitigate carbon emissions. These graduates will study science, business, policy, and humanities while developing carbon management projects real time. These projects will be both self-designed by the trans-disciplinary teams and also will be solicited from the extensive University of Michigan network. The ideal candidate will

have a colloquial popular understanding of climate change and is seeking an intellectual deep dive into climate change and how to actualize trans-disciplinary projects to construct a carbon neutral economy. The candidate will also have had either significant professional experience in a related or unrelated field or have a strong scientific background. Upon graduation the ideal candidate would be able to communicate clearly, concisely, and proactively with business leaders, public sector, scientists, and NGOs / communities about the effects of climate change and how easily we can change what is happening. By emphasizing trans-disciplinary teamwork, students would be able take advantage of the profound intellectual capital at the University of Michigan while actualizing into change agents. Students will learn to focus on mitigating scientific debate, business misunderstanding, government inertia, and community / NGO distrust into positive teams that construct projects that actualize carbon positive projects.

Another important component of CMI is an outreach program that will sponsor events for the University of Michigan and public communities. Some possible programs are, public lectures, carbon management success fairs and newsletters, establishing alumni connections, and trans-disciplinary open source resources that will be available for the public.

Introduction

The Carbon Management Initiative (CMI) will be a collaboration among different departments throughout the University of Michigan that will be united in order to contribute to the trans-disciplinary study and research of carbon management. CMI through the foundation of components such as a graduate certificate program in carbon management, a program to fund research, and a community outreach program will establish the University of Michigan as a leader in carbon management.

Goals

CMI's main goals at the University of Michigan are:

- Initiate and coordinate trans-disciplinary carbon research and expertise throughout the entire University of Michigan.
- Serve as a center of carbon research and expertise at the University of Michigan.
- Encourage and support developing academic programs that contribute to carbon management education and promote collaboration and coordination within existing trans-disciplinary programs.
- Establish new faculty and fellowship research appointments that encourage trans-disciplinary collaboration focused on actionable carbon management solutions.
- Develop and promote outreach programs with and without alumni that are dedicated to educating and enlightening various communities on the benefits of carbon management on the local and global levels.

Organization

For a trans-disciplinary initiative to be successful, it will require cooperation amongst many departments. We propose that the initiative be headed by the director of the Carbon Management Initiative. The director will lead CMI and handle its day to day functions. The role of the director will be to coordinate programs in carbon research, the graduate certificate program in Carbon Management, and the outreach programs. The director will act as the sponsor of the initiative and will also have a significant role in recruiting students and faculty and in fundraising. The director should be a self-driven individual knowledgeable in the area of carbon science and project management, as the director will oversee all of the research and education programs. The director should also possess effective communication and business skills, as the director will represent CMI publicly. The director will communicate with the Executive Committee that will serve as the overseeing voice responsible to the university. This committee will be comprised of professors from the various departments that comprise CMI, as explained in the next section. The Executive Committee will work to keep the goals of CMI in line with the interests of the participating departments and disciplines within the university and the interests of the university of as a whole. The Executive Committee will act as the governing body of CMI and will work in cooperation with the director of CMI.

One of the most important components of the initiative will be the Advisory Committee. The Advisory Committee will advise the director in all necessary areas of CMI, including research, education, the graduate certificate program, and outreach. The Advisory Committee will be comprised of three associate directors that will report directly to the director of CMI. The first associate director will be the Associate Director of Research. The Associate Director of Research will be in charge of managing all research that is funded or supported by CMI. They will play an important role of deciding upon whom to award CMI funded fellowships and small research grants within the university. The Associate Director of Research will also ensure that all research projects stay aligned with the goals and research thrusts of CMI, and be in charge of adapting these goals and research thrusts with the changing times and expectations. The next associate director will be the Associate Director of Education. The Associate Director of Education will oversee all CMI educational programs within the university. During the initial development of the initiative the majority of this commitment will be in overseeing the graduate certificate program in Carbon Management and the carbon related courses sponsored by CMI. The Associate Director of Education will be in charge of the application process for the graduate certificate program and adapting the curriculum to suit future needs of the carbon management degree and the students. The third associate director will be the Associate Director of Outreach and Development. The main objective for the Associate Director of Outreach and Development will be to oversee community outreach and education programs, alumni interaction, funding, and donor relationship management. This will include setting up outreach programs throughout the University of Michigan and community events that help educate and raise awareness of the carbon problem facing society today. The Associate Director of Outreach and Development will also work with the Director to organize fundraising activities to help support more grants, fellowship, and programs within CMI.

Working concurrently with the Advisory Committee will be the Coordinating Chair. The job of the Coordinating Chair will be to maintain collaboration amongst the participating departments and schools within the framework of the Advisory Committee. The Coordinating Chair will play an important role of making sure that all decisions of the Advisory Committee stay aligned with the trans-disciplinary approach of the initiative in order to maintain the strengths of such an initiative. It is believed that this organizational plan (see Figure 1) will allow for success within CMI, and its interaction with the University of Michigan, alumni, and the surrounding community.

Figure 1

Organization Chart Carbon Management Initiative

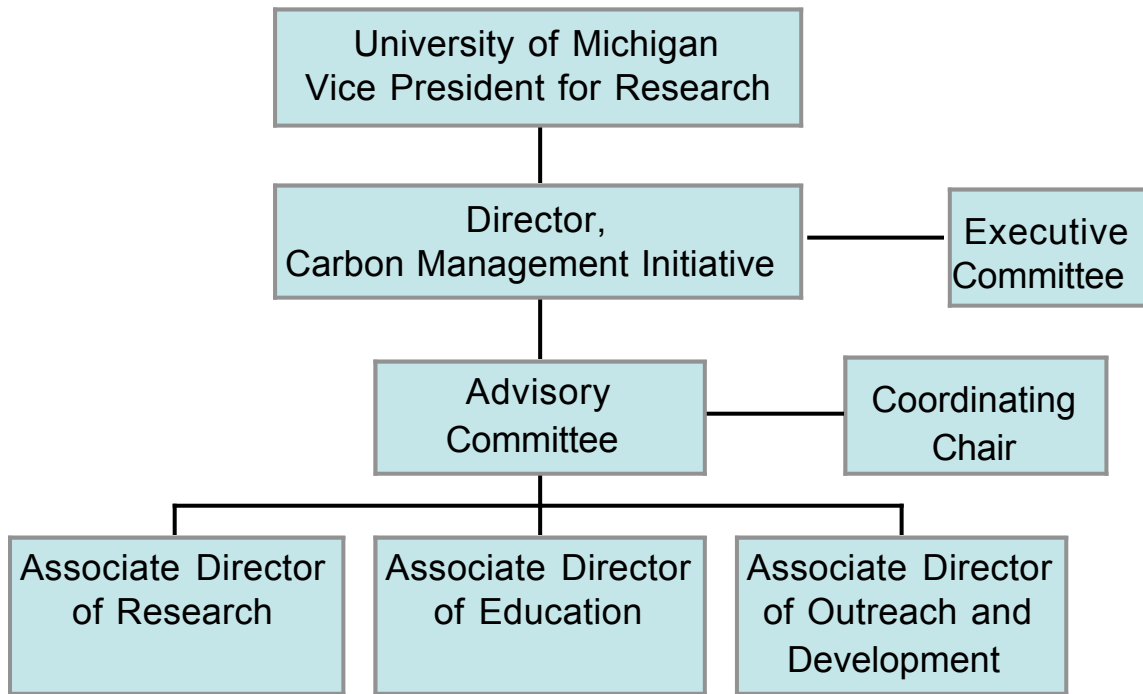


Figure 1: Organizational chart displaying the structure of the Carbon Management Initiative.

Trans-Disciplinary Collaboration

An initiative of this type will require the coordination and resources of many departments and disciplines throughout the University of Michigan community. One goal of this initiative is to enable trans-disciplinary collaboration and understanding. Specifically, this means training individuals how to interact with experts of a different discipline and gain an understanding of how these different aspects all impact carbon management. Carbon Management encompasses a multitude of topics including natural resources, the environment, energy, the climate, business, policy, law, public health, international relations, and many more. Therefore, we envision that the CMI will involve not only schools and departments, but also other initiatives and trans-disciplinary programs as well. Trans-disciplinary programs and potential fields of study are listed in Table 1 and 2 respectively.

Tables 1 and 2

| |
|--|
| Trans-Disciplinary Programs |
| Science, Technology, and Public Policy |
| Science, Technology, and Society |
| Energy Systems Engineering |
| Industrial Ecology |
| Global Health |
| CMI |

Table 1: Trans-disciplinary programs that may be involved with the CMI.

| |
|---|
| Potential Fields of Study |
| Business School |
| School of Public Policy |
| School of Public Health |
| The Law School |
| The College of Engineering |
| The School of Natural Resources and Environment |

Table 2: Potential fields of study that may align with the interests of CMI.

While many departments and disciplines across the University of Michigan will be required to successfully implement such an initiative, we believe that carbon management has four main areas that require attention. These areas include non-governmental organizations (NGOs) and public interests, politics and government, science, and business. In the context of carbon management these areas correspond to sustainable living, policy of emission restrictions, research funding, and environmental laws, the science of climate impacts and technology development, and business management and markets. Figure 2 shown below indicates how these areas are interconnected. In addition, the school or department that most directly correlates to each topic is listed below the focus area.

Figure 2

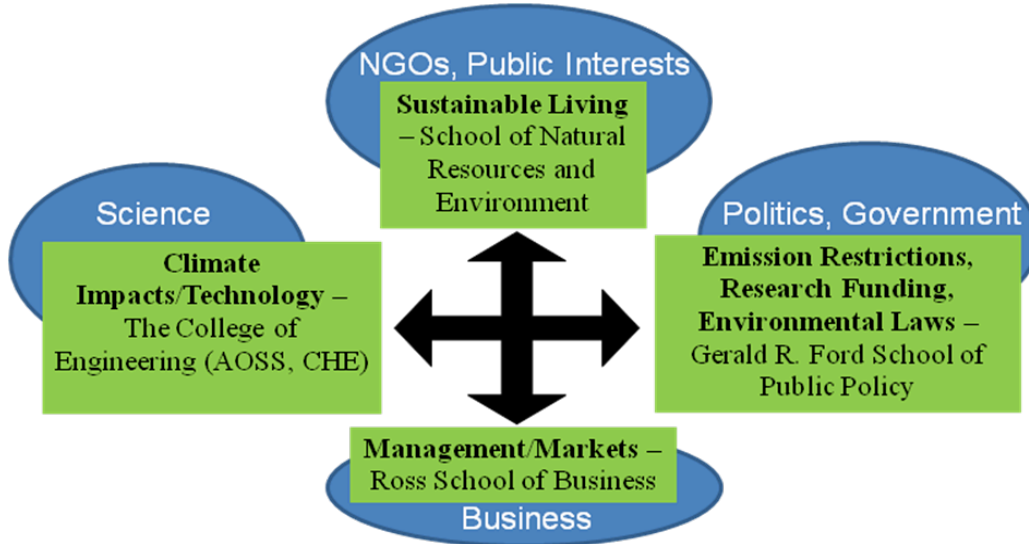


Figure 2: An illustration of the four interconnected areas of focus and the programs across the university that will support CMI.

As is seen above in Figure 2, the focus areas of science, NGOs and public interests, business, and politics and government align with the research and interests of specific colleges and schools throughout the university. As a result, we propose that the following four schools and departments work together to facilitate and direct the carbon management certificate. These four schools are:

- The School of Natural Resources and Environment
- The Ross School of Business
- The Gerald R. Ford School of Public Policy
- The College of Engineering

Collaboration and involvement from these four programs is vital to the success of the Carbon Management Initiative. As is depicted in Figure 2, this specific combination of involved players will bring sustainable living, environmental considerations, public interests, policy/politics, management, business, and scientific climate understanding to the program. Additionally, their involvement will enhance the opportunities that are available to their students. Table 3 below lists these programs and how they will contribute to the Carbon Management Initiative.

Table 3

| Program | Role | Areas of Contribution |
|---|---------------------------------|--|
| School of Natural Resources and Environment | NGO and Public Interests Pillar | Sustainability Planning, Environment Leadership |
| The Ross School of Business | Business Pillar | Management, Markets, Strategies |
| The Gerald R. Ford School of Public Policy | Politics and Government Pillar | Policy, Strategies, Funding |
| The College of Engineering | Science and Technology Pillar | Climate Science/Modeling, Climate Impacts, Engineering, Technology |

Table 3: The four pillars of CMI and their areas of contribution.

Each program listed in Table 3 will contribute specific research, knowledge, and skills to the Carbon Management Initiative. In addition to having different focus areas, each program will contribute different perspectives and different approaches to research. Coordinating all of these approaches will truly yield successful results when implementing carbon management. These programs and their contributions are described in detail in the following sections.

School of Natural Resources and Environment

The Carbon Management Initiative is focused on facilitating and successfully implementing carbon management. This is directly related to the well being of the environment and creating sustainable living. The School of Natural Resources and Environment is focused on doing just that, protecting the Earth's resources and creating a sustainable economy. In addition, the School of Natural Resources and Environment is highly involved with nongovernmental organizations and public interests. As a result, we believe that the School of Natural Resources and Environment should be a pillar of the Carbon Management Initiative. This recommendation is based on the goals of the school, the faculty expertise and interest, and the interest of the students. Relevant research areas currently being pursued by faculty include ecology and geospatial modeling, the relationship between humans and ecological systems, understanding the interaction between machines and climate to create sustainable energy, and understanding the impacts of climate change on the Great Lakes. These research areas are unique in that they incorporate human living into the understanding of science. These current research projects indicate that a program such as CMI may be supported and of interest to the faculty. In addition, many students in the School of Natural Resources and Environment may contain interests related to such a certificate program due to the degrees offered by the school.

One program in particular, the Environmental Policy and Planning Degree Program, is highly aligned with the goals of the Carbon Management Certificate. This

program focuses on teaching the students the ability to create decision-making processes that are scientifically credible, consider varied interests, and lead to the development of organizations that support sustainable living. In addition, students develop skills to design and implement effective policies and plans in concert with human behaviors. Such goals fully support the Carbon Management Initiative and represent NGOs and public interests. Consequently, we propose this as a pillar of the initiative.

Ross School of Business

The economy and business are some of the largest areas that climate change will affect and are a portion of the driving forces in determining whether or not policy is passed to combat climate change. For example, investment in new technologies, enforcement of a carbon tax, and the implementation of a cap and trade system are primarily driven by their effects on the economy and business success. Therefore, it is imperative that the business school is one of the pillars of this program. It will allow students to gain a full understanding of how the pursuit of technology and policy impact the business sector. In addition, understanding business strategies will allow students to formulate projects that achieve their climate goals without negatively impacting business development and success. Efficient and successful management skills will also be crucial skills to be developed in the program.

The Ross School of Business will profit from this partnership by gaining additional passionate students with varying backgrounds that will bring unique perspectives to the table. In addition, such a partnership will improve relations between The Ross School of Business and environmentally conscious businesses. The involvement of The Ross School of Business will build upon focus areas already available in specific departments. For example, the Business, Economics, and Public Policy Department relates how business decisions impact public policy, one large consideration in understanding how to combat climate change and manage carbon. Research in this department primarily focuses on the study of markets and firm behavior, with a focus on relevant public policies. The Law, History, and Communication Department focuses on how law impacts business decisions, of particular interest to this certificate are the impacts of environmental law. Research in this department focuses on the role of law in making business decisions and also the role of law in promoting ethical conduct within organizations and meeting societal expectations of responsible behavior. Additional research areas include developing instruments that contribute to communication decision-making and improvement in the global workplace. These are just a couple of examples of how the business school has existing programs that can easily transition into partnering and being involved with this certificate program. An added advantage of involving the business school in CMI is the approach of performing research on carbon management with a focus on the business outcome and impact.

Gerald R. Ford School of Public Policy

Another important facet of combating climate change involves understanding, influencing, and implementing policy. This entails understanding how politics and the government impact policy. Consequently, the Gerald R. Ford School of Public Policy should be a pillar of the Carbon Management Initiative. In doing so, students will learn what considerations and factors influence policy and will gain an understanding of how to implement policy. This crosses a broad swath of applications including policy that will impact carbon markets, funding for scientific research, and emission standards to name just a few examples. The curriculum in the school of public policy emphasizes developing analytical, management, and ethical methods. The faculty also has a broad range of research areas. A couple of research areas include bureaucracy and the role of the mass media in the political system and sub-national governmental capacity to develop policies to address global warming. Such research brings an understanding of governmental and political considerations to light.

Science, Technology, and Public Policy Certificate Program

The School of Public Policy will benefit from the Carbon Management Program because it will enhance the already existing Science, Technology, and Public Policy certificate program. This multidisciplinary certificate program, which can be used as an example for the Carbon Management Certificate Program, focuses on working to understand how science and technology are influenced by policy and vice versa, as well as developing the ability to perform science and technology policy analysis. Such skills are envisioned to be a portion of the curriculum for the Carbon Management Certificate Program. This alignment of goals makes the School of Public Policy a natural fit as a pillar for this certificate program. If done, students involved will bring new issues to light involving the climate and the environment that are main players in public policy, therefore, expanding and enriching the existing Science, Technology, and Public Policy Program.

College of Engineering

We recommend that the fourth pillar of the Carbon Management Initiative be the College of Engineering. By doing so, a mathematical, scientific, and engineering approach will be brought to the program. This is particularly important because not only is it important to understand how to model and understand scientific impacts to the climate, it is also important to understand what technology exists and from there understand how and what technology needs to be developed to enact carbon management. In addition, research in the College of Engineering is approached differently than in the three other schools. Engineering research is based on science and is set up to either prove or disprove that something works or is valid. At the same time this research overall is focused on problem solving, going from understanding the problem to creating ways to address the problem. This type of research completes the carbon

management picture when used in coordination with the three other kinds of research in the pillars previously mentioned.

Two departments in the College of Engineering specifically align with the needs and goals of the Carbon Management Initiative. These departments are the Department of Atmospheric, Oceanic, and Space Sciences and the Chemical Engineering Department. The importance and extent of their involvement is described in the following sections.

Department of Atmospheric, Oceanic, and Space Sciences

The perception of climate change is largely influenced and advanced by science and scientists. As a result, we propose that the department of Atmospheric, Oceanic, and Space Sciences (AOSS) in the College of Engineering contribute to the final pillar of the Carbon Management Initiative. Doing so will bring climate and space modeling scientists, engineers, and their knowledge to the program. This is vital because such knowledge is required for the issue of climate change and carbon management to be discussed in full. The department and its students are clearly interested in such topics with programs like the Climate Change Consortium available for membership. In addition, this department has a great deal of faculty that is directly involved with science policy, including climate and research policy, on a federal level. Such involvement will render top-end contacts for discussion and first hand knowledge of policy barriers and development.

It will be advantageous for the department to become part of the Carbon Management Initiative because doing so will not only cater to the interest of many of its students, but will also allow the faculty to be involved with students and university wide personnel that are passionate about the climate and human impact on it. In addition, being part of the Carbon Management Initiative may open the possibility for research areas relating climate observations and climate change.

Chemical Engineering Department

Many departments within the College of Engineering will be an asset to the initiative. However, we recommend that along with AOSS the Chemical Engineering Department (CHE) be highly involved in contributing to this final pillar of CMI. This department is of particular interest due to its research in energy and the environment. This research group focuses on combating the negative effects of increased energy usage by developing more efficient methods to convert chemical energy into electrical energy, destroying exhaust emissions and toxic pollutants in an environmentally friendly manner, developing sustainable methods of synthesis, inventing more efficient gas separation, and by fabricating micro-machined power sources to replace batteries. These research areas align with carbon management and incorporate the engineering aspect to creating technologies and a solution to achieving sustainable living.

Research Program in Carbon Management

With the ever growing awareness that the increasing emissions of carbon dioxide into the atmosphere is a major player in global warming and climate change, it is evident that there is a need for major changes in energy production and transportation. Over the past decade there have been various proposals that aim to reduce or eliminate carbon emissions over the next 100 years in order to curb the consequences of climate change. Some notable proposals include the implementation of renewable energy, the sequestration of carbon from traditional fossil fuel based energy plants, and the introduction of a carbon market into the regional and world market. As expected there are advantages and consequences for each proposal. One of the main objectives of the Carbon Management Initiative is to look into this trans-disciplinary problem and to analyze and develop possible solutions.

Main Research Targets

The proposed research topics of the Carbon Management Initiative are:

- Investigate possible carbon market solutions via an trans-disciplinary approach. Research in this area is necessary in recognizing the need and likely implementation of carbon markets in the foreseeable future. This approach will be able to combine the universities strengths of policy, economics, business, and science disciplines to look into the political, economical, and societal feasibility of such proposals.
- The research and development of carbon neutral energy technologies to provide alternatives to fossil fuel energy technologies that are known to be major players in climate change. The University of Michigan provides highly ranked Nuclear Engineering and Chemical Engineering departments and increasing activity in the development of other renewable energy sources as a solid background for this area of research. This research should include in-depth analysis of economical feasibility of such technologies and their societal impacts.
- The examination and development of carbon sequestration and storage of emissions from preexisting fossil fuels technologies. This research should also look into developing more efficient technologies to improve on the existing fossil fuel technologies. This area could provide a cost-effective quick solution to the existing infrastructure to help abate carbon emissions within the next decades.
- Specific interest in research and development of the transportation sector is important due to its fraction of carbon emissions and the University of Michigan's close proximity and relationship with the automobile industry. An in-depth investigation will require the combined efforts of highly ranked engineering, policy, and business disciplines at the University of Michigan to understand the possibilities of such advancements in this area.

- Research focused on the examination and understanding of the health and societal impacts of climate change due to increased carbon emissions. This research will focus on the impacts of climate change and also the societal impacts of carbon management.

These main research targets are motivated by the stabilization wedges introduced by Pacala and Socolow in 2004.

Graduate Student Fellowships

The Carbon Management Initiative proposes to support on average three outstanding Ph.D. students at the University of Michigan in support of the CMI mission. These students will be selected on a basis that their research is aligned with the research targets of CMI, including but not limited to the analysis of economic, policy, and societal impacts of/and the development of carbon neutral energy and transportation technologies and of carbon markets. Students from all related departments including, engineering, physical sciences, business, economics, and social sciences will be encouraged to apply. Special consideration will be given to students who demonstrate that their research is trans-disciplinary and reaches across departments and schools at the university. It is important that students who receive the CMI fellowships work closely with faculty advisors to stimulate carbon research. These graduate student fellowships will be given for two years, but the student must supply a follow-up after the first year to show the progress that has been made in order to receive funding in the second year. Graduate students are expected to apply after they have completed the first two years of their Ph.D. program, or they have reached candidacy, as to allow most of their time to be devoted to research. It is expected that graduate students who receive the fellowship are interested in pursuing careers in the field of carbon research or closely related fields.

Faculty Fellowships

In addition to graduate student fellowships, the Carbon Management Initiative proposes to support outstanding faculty candidates at the university. Under this program CMI would support highly qualified candidates to faculty appointments within one of the four main initiative departments/schools. These faculty would be placed into one of these departments but would be considered to be in trans-disciplinary positions. The fellowship faculty would be expected to carry out research in an area parallel to CMI research targets, including but not limited to analysis of economic, policy, and societal impacts and development of carbon neutral energy and transportation technologies and of carbon markets. It would also be expected that the fellowship faculty teach one course that is aligned with the Graduate Certificate Program in Carbon Management mentioned in the next section. In addition to the research and teaching requirement, the faculty would also need to carry out other duties that are required by all faculty of their respective department/school, including chairing committees and serving on dissertation committees. Due to the special situation it would be ideal if the faculty served as the

dissertation committee member from a cognate department for students participating in the graduate certificate program in Carbon Management or who have received the CMI graduate student fellowship. Also, it would be expected that the fellowship faculty apply actively for research grants that align closely to the trans-disciplinary approach of CMI. In addition, these faculty would be encouraged to advise and support graduate students who have interests related to CMI research, in attempt to support the trans-disciplinary education promoted by CMI.

Small Research Grants

Not only will the Carbon Management Initiative support fellowships for graduate students and faculty, the initiative will also support small research projects within the university. These small research grants will be available to research groups of all departments and schools at the University of Michigan. The grants will be awarded to groups that promote trans-disciplinary research in carbon management. These grants are meant to encourage groups that are typically not accustomed to working in a trans-disciplinary approach to do so. Also, the small research grants are meant to support, just as the name suggests, small projects and are not expected to support Ph.D. research or a typical faculty research proposal. They are intended to be small secondary projects, not a research group's primary research. Special consideration will be given to projects that incorporate undergraduate or masters students into the investigations, as aligned with the CMI mission. The small research grants are intended to encourage cooperation and collaboration of the entire university community in solving a worldwide problem, such as carbon management. The program will provide a unique experience for faculty and students not typically allowed for when confined to specific research within their own discipline.

Centers and Labs

The following is a list of centers and labs at the University of Michigan that have interests' in line with those of the Carbon Management Initiative.

- **Center for Advanced Computing:** The Center for Advanced Computing provides computing resources and knowledge in the purchasing, sustaining, and using parallel computers for the University of Michigan.
- **Center for Sustainable Systems:** The Center for Sustainable Systems is an interdisciplinary education and research center in the University of Michigan's School of Natural Resources and Environment aimed to advance concepts that support the design, evaluation, and improvement of complex systems.
- **Automotive Research Center:** The Automotive Research Center a U.S. Army RDECOM Center of Excellence that is University of Michigan led to advance the modeling and simulation of military and civilian vehicles.

- Transportation Energy Center: As a university based trans-disciplinary research center, the Transportation Energy Center provides basic and applied research knowledge for the National Automotive Center in Warren, Michigan.
- Michigan Memorial Phoenix Energy Institute: The Michigan Memorial Phoenix Energy Institute is a university center aimed at providing the path to secure and sustainable energy future by making use of the university strengths in public policy, economics, business, and social science as the foundation for implementation of scientific and technological advancements.
- Erb Institute for Global Sustainable Enterprise: At the University of Michigan the Erb Institute for Global Sustainable Enterprise encourages global sustainable enterprise through interdisciplinary research and education initiatives, including their MBA / MS Program.
- Graham Environmental Sustainability Institute: The Graham Environmental Sustainability Institute is jointly funded by the University of Michigan and the Graham Foundation to promote multidisciplinary research and education in environmental sustainability.
- Institute of Social Research: Among the world's oldest survey research organizations, the Institute for Social Research is a world leader in the advancement and application of social science methodology.
- University of Michigan Transportation Institute: The University of Michigan Transportation Institute encourages interdisciplinary research to increase driving safety and advance transportation systems expertise.
- Atmospheric Chemistry and Climate Modeling Group: The Air Pollution Modeling and Monitoring Laboratory is involved in field studies of atmospheric pollution and responsible for the development and analysis of urban and regional air quality modeling techniques. The group receives significant support from the U.S. Environmental Protection Agency.
- Laboratory for Atmospheric Science and Environmental Research: The Laboratory for Atmospheric Science and Environmental Research provides a research and educational environment to study a wide range of concerns in atmospheric science.
- Environmental and Sustainable Technology Laboratory: Committed to technology, knowledge and policy innovations the Environmental and Sustainable Technology Laboratory works reduces the impact of engineering design and manufacturing decisions on the environment.

- General Motors/University of Michigan Collaborative Research Laboratory: The General Motors/University of Michigan Collaborative Research Laboratory performs research and development activities in areas that are of critical importance to General Motors.
- Hydrogen Energy Technology Laboratory: The Hydrogen Energy Technology Laboratory supports efforts to the discovery and development of materials, processes, and systems that are significant to hydrogen energy research.
- Optimal Design Laboratory: The Optimal Design Laboratory is devoted to the interdisciplinary study of design methods and tools that advance the design process and the quality of designed artifacts.

It is proposed that CMI work closely with these labs and centers when engaging in the research targets aligned with the CMI mission. It is important that CMI promote collaboration amongst these centers and labs and other such centers and labs not listed above (used MMPEI website as the initiator of these centers and labs).

Graduate Certificate Program in Carbon Management

A Rackham certificate of graduate studies is a non-degree credential, less extensive than a master's program, which is designed to provide students with a specialized set of courses that supplement a primary field of study. A student must be formally admitted to a certificate program. Between 15 and 19 graduate credit hours of coursework are required to earn a certificate. Students complete at least one term in a Rackham or non-Rackham graduate degree program before [applying](#). Some certificate programs, however, are free standing, and persons who have earned a Bachelor's degree or higher may apply directly through standard admissions procedures.

The following general rules apply to certificate of graduate studies programs:

- Only Rackham courses may be used to meet certificate requirements; no transfer credit or undergraduate courses may be applied.
- The student must have at least a cumulative grade point average of B (5.00 on a 9 point scale) in courses for the certificate program.
- Not more than one-sixth of the credits required for any given master's degree may be double-counted between a certificate and that master's. Double-counted courses may not exceed one-half of the certificate requirement. Such double-counted credit may not be used to fulfill requirements of other degrees or certificates ([section 2.3.2](#)). No double-counting is permitted for free-standing certificate programs.
- Students have a maximum of four years, from the date of first enrollment in the program, in which to complete the certificate.
- A student who has completed all work must use Wolverine Access to formally apply for graduation (degree). Deadlines for each term are published by [Rackham OARD](#).

Specific information about admissions and certificate requirements is available on the [Programs of Study](#) site.

Coursework

Individuals who enter this field will need to have the following skills:

- Scientific understanding of climate change and ecology
- Business understanding of project management
- Policy understanding of interacting with the intention to create interrelated decisions between various political actors
- NGO understanding of dealing with activists and communities
- The ideal candidate will have a colloquial popular understanding of climate change and is seeking an intellectual deep dive into climate change and how to actualize trans-disciplinary projects to construct a carbon neutral economy. The candidate will also have had either significant professional experience in a related or unrelated field or have a strong scientific background. Upon graduation the

- ideal candidate would be able to communicate clearly, concisely, and proactively with business leaders, public sector, scientists, and NGOs / communities about the effects of climate change and how easily we can change what is happening.
- By emphasizing trans-disciplinary teamwork, students would be able take advantage of the profound intellectual capital at the University of Michigan while actualizing into change agents. Students will learn to focus on mitigating scientific debate, business misunderstanding, government inertia, and community / NGO distrust into positive teams that construct projects that actualize carbon positive projects.
 - These projects will be both self-designed by the trans-disciplinary teams and also will be solicited from the extensive Go Blue alumni network. For example, a business manager or chief scientist who is an alumni from the University of Michigan could suggest possible projects to the student teams and then student teams could list desired projects. Final approval for the students to work on a project would be at the discretion of the firm.
 - Trans-disciplinary refers to how individuals with specific knowledge can communicate from their expertise engaging others while actualizing carbon positive change.

Figure 3

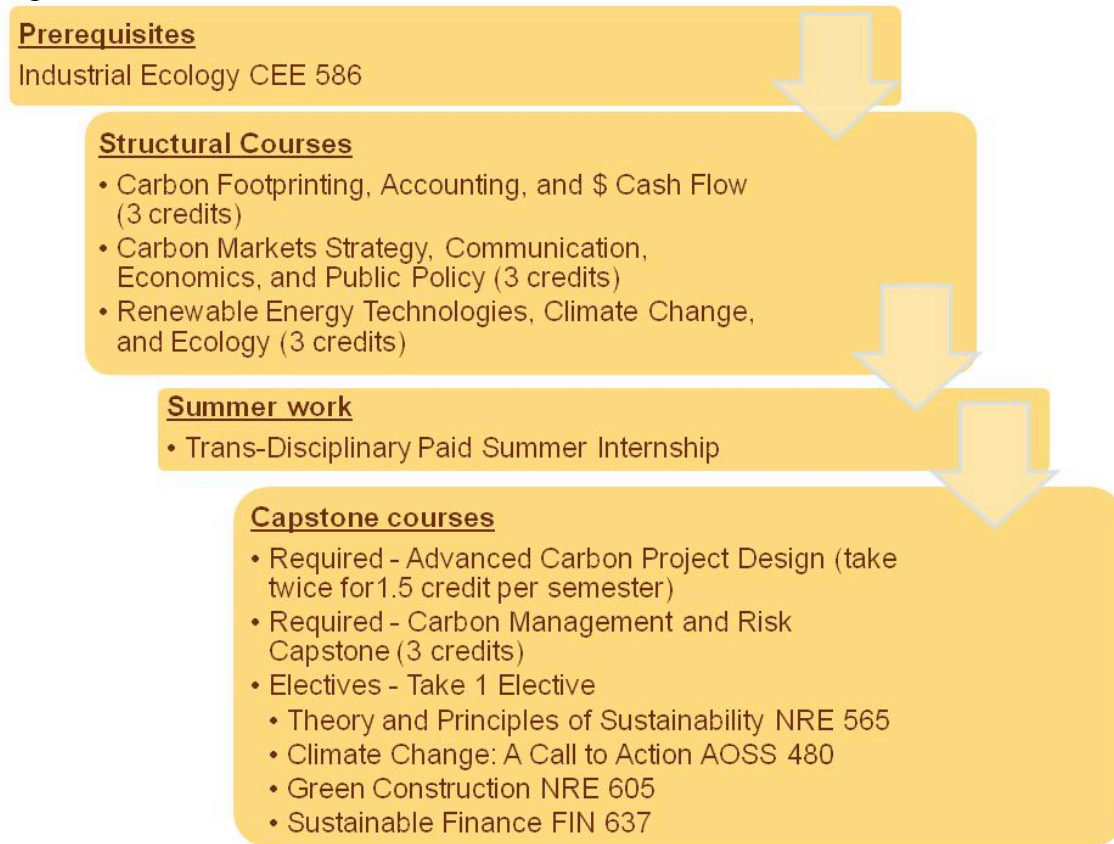


Figure 3: Course Schedule

Prerequisite Course – (3 credits)

- CEE 586 Industrial Ecology
 - This course is taken in the first year of the program.
 - It allows students to gain an introduction to the material before applying to the CMI program.
 - This course, taught by Dr. Keoleian, provides an analysis of material and energy flows in industrial and ecological systems to enhance eco-efficiency and sustainability in meeting human needs. Methods: life cycle assessment quantifies energy, wastes and emissions for materials production, manufacturing, product use, and recovery/disposition; life cycle design integrates environmental, performance, economic, and policy/regulatory objectives.
 - This course is required as a prerequisite because with this class students can become accustomed to triple bottom line footprinting and begin to understand trans-disciplinary communication situations and the strategies to develop success in such environments.

Required Courses – (15 credits)

- *New Course*: Carbon footprinting, accounting, and cash flow accounting related to

carbon projects (3 credits)

- This course is taken in the 2nd year of the program.
 - Advanced footprint calculation
 - Greenhouse gas accounting
 - Cash flow accounting for carbon projects
 - Accounting for tradable credits
 - This course builds upon the intellectual gap in our understanding on what constitutes a good-info carbon accounting basis for a firm. Firms do not need exact figures yet scientists wish to provide exact figures. This dilemma will be elaborated on so that students have a strong understanding of how to communicate effectively with each group so as to actualize projects. Also, this course will explain the gap in our applied understanding of how to construct risk adverse cash flow accounting standards to manage each project's cash flows. Currently, this is a hole in the understanding of how projects are constructed. A strong project manager will know the accounting rules that should be applied so as to minimize project risk. This includes how projects are accounted for at each stage of a project's development from project developer, project aggregator, project broker and trader, and project credits purchaser. In this manner, students will develop a better understanding of all three interactions that a strong project depends upon – developing diverse risk adverse supply, provide value-added project sales so as to develop demand, and the regulatory function between supply and demand both on the carbon accounting basis, the community development basis, and on the cash flow accounting basis because this is the essence of managing a triple bottom line project.
- *New Course: Carbon markets strategy, communication, environmental economics, and public policy (3 credits)*
 - This course is taken in the 2nd year of the program.
 - Compliance markets in the EU
 - Global voluntary markets
 - New game business model relationships with carbon business strategies
 - Implements community-led bottom-up project design
 - Enables local community sustainability enterprise capacity building
 - Creates first-mover advantage
 - Sets benchmark for private-sector / public-private sector led climate change mitigation
 - Decreases climate change through regional value creation
 - “Rational Convergence” communication between
 - Scientists
 - Government
 - Business leaders
 - Policy makers, NGOs, and communities
 - This means that since each of the above four actors communicate very differently, they are unable to communicate usually

effectively between each other. This inhibits value creation and project development. Students will engage in role-playing exercises to discover the nuances of how these different actors engage each other. Furthermore, students will discuss with climate change mitigation leaders how they successfully communicate with each of the above four actors and how this successful communication leads to their project's success.

- *New Course: Renewable energy technologies, climate change, and ecology (3 credits)*
 - This course is taken in the 2nd year of the program.
 - Analyze carbon sinks (natural environment). This refers explicitly to avoided deforestation, biodiversity management and biodiversity banking, wetlands credit development and trading, and plantation forests.
 - Analyze mitigation. This refers explicitly to energy efficiency, aviation, electric power generation, marine bunker fuels, and power grid efficiency.
 - Analyze adaptation. This refers explicitly to management and improvement of actionable items so as to protect our cultural, financial, and ecological resources such as cities, communities, and biodiversity in the face of unmitigated climate change.
 - Analyze built environment. This refers explicitly to the regional and urban planning, architecture, transportation, and energy infrastructure.
 - This course analyzes the built environment, the natural environment, and their interactions for carbon management opportunities. This course will add students in understanding how each of their disciplines, from literature to climate science to business, can have a profound and career enriching role in mitigating climate change. Students will spend time analyzing actual projects for the pros and cons of how the project is constructed. Optimally, students will analyze a carbon sink project such as an avoided deforestation project, a carbon mitigation project such as an industrial gas or landfill methane gas project, and an energy efficiency project such housing energy efficiency. Students in this class will gain a strong understanding of the various compliance and voluntary carbon markets and the pros and cons of each. Finally the class will end by summarizing how these activities in the built environment in regional and urban planning, energy efficiency and generation, and natural sinks are related to the triple bottom line and ecological sustainability.
- *New Course: Carbon management and risk capstone (3 credits)*
 - This course is taken in the 3rd year of the program.
 - This course requires a triple bottom line analysis applying modern portfolio theory and risk management to projects while analyzing each projects ecological, community, and profit / carbon components from a risk / return matrix point of view.
- *New Course: Advanced carbon project design (repeated twice 1.5 credit per semester)*
 - This course is taken in the 3rd year of the program.
 - Trans-disciplinary team focused on actionable project during Fall / Winter

semester.

- This course will be the follow-up course from the summer course. Students can either continue working on the project from the summer or elect to work on another project. If the student graduates in April, the student is required to take this course both Fall and Winter semesters.

Summer Internship – required

- Carbon project design
 - This is conducting between the 2nd and the 3rd year of the program.
 - Trans-disciplinary team focused on an actionable summer project. This paid internship will focus on actualizing a carbon management project. Students will need to coalesce diverse teams and bring them together to develop a carbon positive project that is actionable within a professional business, science, and / or policy organization.
 - CMI will reach out to the University of Michigan alumni network to find internships that will provide group trans-disciplinary carbon management environments.

Optional courses – (1 required)

- This course is taken in the 3rd year of the program.
 - Theory and principles of sustainability by Dr. Princen (NRE 565 3 credits)
 - Climate Change: A Call to Action by Dr. Rood (AOSS 480 3 credits)
 - Green Construction by Dr. Hoffman (NRE 605 3 credits)
 - Sustainable finance by Dr. Kaul (FIN 637 2.25)

Outreach Program in Carbon Management

One important component of the Carbon Management Initiative will be its outreach programs. In accordance with the CMI mission, the initiative will sponsor not only the University of Michigan but also public events. These sponsored events will range from public seminars in which experts in the area of Carbon Management will discuss their research and developments in lectures to educate the general university body and public on current advancements and what the implications are. It is important to integrate CMI into the University of Michigan and community as the very research that the initiative is setup to support is vital to everyone. The carbon problem will affect everyone and it is essential that all people understand its consequences.

In this line of thinking, the Carbon Management Institute may develop the following:

- An annual CMI graduate student carbon management success fair.
- Quarterly newsletters that discuss carbon management solutions developed by the University of Michigan.
- Alumni connections with current graduate students in a formal and informal network developing role so as to facilitate future opportunities.
- Trans-disciplinary open source resources that will be available for the public.

References

- IPCC, Climate Change 2007: The Physical Science Basis, Summary for Policymakers, available at <http://www.ipcc.ch/>.
- MMPEI, Michigan Memorial Phoenix Energy Institute website, <http://mmpei.umich.edu/>.
- Pacala, S. and R. Socolow, 2004, Stabilization Wedges: Solving the Climate Problem for the Next 50 Years with Current Technologies, *Science*, 305, 968-972.
- University of Michigan, Ross School of Business website – Academic Departments, <http://www.bus.umich.edu/Academics/Departments/>.
- University of Michigan, School of Natural Resources and Environment website, <http://www.snre.umich.edu/>.
- University of Michigan, Ford School of Public Policy website, <http://www.fordschool.umich.edu/>.
- University of Michigan, College of Engineering website, <http://www.engin.umich.edu/>.
- University of Michigan, Atmospheric, Oceanic, and Space Sciences Department website, <http://aoss.engin.umich.edu/>.
- University of Michigan, Department of Chemical Engineering website, <http://www.engin.umich.edu/dept/cheme/>.
- University of Michigan, Science, Technology, and Society website, <http://www.umich.edu/~umsts/>.
- University of Michigan, Energy Systems Engineering website, <http://interpro.engin.umich.edu/website/igpcat.htm?id=8>.
- University of Michigan, School of Public Health website, <http://www.sph.umich.edu/>.
- University of Michigan, Rackham Graduate School website, https://secure.rackham.umich.edu/academic_information/programs/#certificate.