PRESIDENT'S COMMISSION ON CARBON NEUTRALITY

UNIVERSITY OF MICHIGAN

Final Report & Recommendations

March 2021

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Panoramic view of the City of Ann Arbor, Michigan, ca. 1880 | Courtesy of Library of Congress

LAND ACKNOWLEDGEMENT

The University of Michigan is located on the territory of the Anishinaabe people. In 1817, the Ojibwe, Odawa, and Bodéwadmi Nations made the largest single land transfer to the University of Michigan, ceded through the Treaty of Fort Meigs, so that their children could be educated. We recognize the history of displacement of Native communities that facilitated the founding of the University of Michigan. We acknowledge the sovereignty of tribal lands, and we reaffirm contemporary and ancestral Anishinaabek ties to this land as well as the profound contributions of Native Americans to this institution.[1]

1 This land acknowledgement was supplied by the University of Michigan's Office of Diversity, Equity and Inclusion (ODEI) and has been used previously by many units and groups across the university. This acknowledgement was developed with significant contribution from Indigenous-identified faculty, staff, and students and was reviewed by Native elders in the community. ODEI has since developed a committee led by five Native faculty to write a new land acknowledgement with the goal of having one land acknowledgement to be used across the university. The President's Commission on Carbon Neutrality wholeheartedly supports these efforts and strongly encourages U-M to engage deeply with Native communities throughout its carbon neutrality implementation efforts.

ENGAGEMENT BY **THE NUMBERS**

ACKNOWLEDGEMENTS

In presenting our final recommendations for the University of Michigan to achieve net-zero emissions, we, the President's Commission on Carbon Neutrality, owe a number of teams and individuals our collective gratitude.

First, we thank U-M President Mark Schlissel for committing the university to boldly confront the climate crisis, establishing this Commission to help address it, and entrusting us with the significant responsibility to recommend timelines, pathways, and approaches for the university to achieve carbon neutrality.

We thank the many U-M community members who continue to advocate for climate action by getting involved in on-the-ground campus sustainability activities, convening discussions, and making their voices heard at Regents' meetings and public gatherings. In addition, though fossil fuel investments and the U-M endowment are outside of the scope of the Commission's work, we recognize those community members who are elevating this important issue. Activism and advocacy were crucial in establishing the Commission and shaping this final report—and will be critical for ensuring that U-M reaches carbon neutrality in the years ahead.

We thank the members of our Student Advisory Panel and the Student Sustainability Coalition, who provided valuable guidance on what the U-M student community prioritizes. Carbon neutrality strategies must reflect realities on the ground to be successfully deployed and resonant within the U-M community and beyond.

We thank the 11 internal analysis teams and two external consultants (Integral Group and SmithGroup) for their robust research and engagement around a number of distinct issues, each critical in identifying ways to move U-M toward carbon neutrality and in shaping the Commission's recommendations.

We thank administrators and staff from UM-Ann Arbor Facilities and Operations (Architecture, Engineering and Construction; Grounds and Waste Management; Logistics, Transportation and Parking; the Office of Campus Sustainability; Real Estate Office; and Utilities), the Office of Diversity, Equity and Inclusion, the Office of the President, the Graham Sustainability Institute, Michigan Dining, Michigan Medicine, Michigan Publishing Services, the Office of the Vice President for Communications, UM-Dearborn Facilities and Operations, and UM-Flint Facilities and Operations, and the City of Ann Arbor for their assistance in knowledge and data-sharing.

Finally, we thank the more than 400 U-M students, staff, faculty members, alumni, and community members who contributed more than 700 comments to the Commission's public comment portal—including over 500 in response to our draft recommendations. Public input throughout the Commission's two-year process i.e., was integral to this final report being as inclusive, accessible, and comprehensive as we could make it and will continue to be essential as the university establishes priorities and pursues implementation efforts.

This map of Michigan shows locations where U-M has a significant presence in the state, most notably its three official campuses in Ann Arbor, Dearborn, and Flint. Other locations reflect a variety of properties, including natural areas, satellite locations for research and education, and health care facilities.

"Human influenced global climate change is the defining scientific and social problem of our age."

—University of Michigan President Mark Schlissel

PRESIDENT'S CHARGE TO THE COMMISSION

In October 2018, University of Michigan President Mark S. Schlissel declared his ambition for the university to achieve carbon neutrality, announcing his plan to appoint a presidential advisory commission tasked with analyzing options and developing recommendations to help set the university on this path. In February 2019, the President's Commission on Carbon Neutrality (PCCN) was launched, with the mission of contributing to a more sustainable and just world. President Schlissel charged the Commission with recommending timelines, pathways, and approaches for U-M (Ann Arbor, Dearborn, and Flint campuses) to achieve carbon neutrality that:

- Are environmentally sustainable;
- Involve the regional community;
- Create scalable and transferable models;
- Include the participation and accountability of all members of the university community; and
- Are financially responsible in the context of U-M's mission of education, research, health care, and service.

President Schlissel's full charge to the Commission can be found on the Office of the President's website.

TABLE OF CONTENTS

The Cube, Ann Arbor | By Michigan Photography

LETTER FROM THE COMMISSION

To the leaders of the University of Michigan, the broader community, and all who desire a sustainable and just future:

If there is one takeaway from the tumultuous events of 2020–2021, it is that our toughest challenges require extraordinary responses. As we fight back a global pandemic, grapple with resulting economic upheaval, and push our civic institutions to reckon with polarization, misinformation, violence, and systemic racism, another monumental crisis remains ever-present—climate change.

Glaciers and permafrost are melting at accelerating rates. Wildfires, extreme heat events, and hurricanes are becoming increasingly frequent and severe. Plant and animal biomes are shifting as long-held ranges become literally uninhabitable. But the effects are not limited to the natural environment. Climate change continues to be both cause and effect of social injustices, worsening existing humanitarian emergencies, and likely sparking one of the greatest migration crises in human history. It is intertwined with our most significant challenges in health, public policy, and social justice, and it demands an urgent, inclusive, and just response.

In 2018, the Intergovernmental Panel on Climate Change (IPCC) reported that global warming must be limited to 1.5 degrees Celsius (1.5˚C) above pre-industrial levels to mitigate even larger catastrophes for humanity and the natural environment.[2] The IPCC, a global network of scientists tasked by the United Nations to analyze trends in climate science, explained that reining in climate change to this extent would require reducing human-caused carbon emissions globally to 45 percent below 2010 levels by 2030, and to net-zero by 2050, assuming little or no overshoot of their model pathways. All greenhouse gas (GHG) emissions thereafter would need to be balanced by the removal of an equivalent amount of GHGs from the atmosphere.

2 IPCC. (2018). Summary for Policymakers. Global warming of 1.5˚C. An IPCC Special Report on the impacts of global warming of 1.5˚C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty. [V. Masson-Delmotte, P. Zhai, H. O. Pörtner, D. Roberts, J. Skea, P. R. Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J. B. R. Matthews, Y. Chen, X. Zhou, M. I. Gomis, E. Lonnoy, T. Maycock, M. Tignor, T. Waterfield (eds.)]. https://www.ipcc.ch/sr15/chapter/spm/

The IPCC warned, however, that achieving a 1.5˚C goal would require "rapid and far-reaching transitions in land, energy, industry, buildings, transport, and cities." Universities reach into all of these areas. Convening a large residential community, providing medical care, and spurring groundbreaking research across disciplines are all carbon-intensive processes that contribute to the climate crisis. At the same time, universities, in addition to being hubs for cross-sector research, endeavor to fulfill broader missions of serving the public and preparing the next generation of leaders in the science, policy, business, and social sectors. As training grounds for new approaches, universities have a unique opportunity to lead in confronting the most pressing issues facing society.

Recognizing that the United States has contributed approximately a quarter of the world's cumulative greenhouse gas emissions while outsourcing additional emissions to other countries, the United States has a responsibility to act more quickly than most other nations. Our responsibility is even greater because of the wealth disparities that exist between the United States and many of these nations. Climate change exacerbates these inequalities by creating a situation whereby historically oppressed and exploited communities disproportionately bear the harmful consequences. The IPCC explicitly calls out the unsustainable nature of racial, economic, and gender inequities, their historical contributions to climate change, and the consequential need to find climate solutions that center equity and justice.[3] Therefore, universities, and particularly those with the longest legacies of contributing to the climate crisis, have a responsibility to act urgently to achieve carbon neutrality in environmentally just ways.

In 1970, the University of Michigan (U-M) held the nation's first "Environmental Teach-In," which created a model for the events of the first Earth Day celebration, and in the 1980s, it helped to pioneer the environmental justice discipline. In the early 2000s, U-M began accounting for its greenhouse gas (GHG) emissions, and in 2011, U-M established its current GHG reduction goal (25 percent below 2006 levels by 2025) for the Ann Arbor campus. Now is time for U-M to step up and address the climate crisis in a bold and comprehensive manner.

The present climate emergency requires a transformation on a collective and institutional scale. And the scientific consensus demands that it be done with great urgency. Achieving a more sustainable and just world requires honest assessments of past missteps, the courage to challenge historical norms, and sustained action to bring about durable change.

3 IPCC. (2018). Summary for Policymakers. Global warming of 1.5˚C. An IPCC Special Report on the impacts of global warming of 1.5˚C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty. [V. Masson-Delmotte, P. Zhai, H. O. Pörtner, D. Roberts, J. Skea, P. R. Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J. B. R. Matthews, Y. Chen, X. Zhou, M. I. Gomis, E. Lonnoy, T. Maycock, M. Tignor, T. Waterfield (eds.)]. https://www.ipcc.ch/sr15/chapter/spm/

Since February 2019, the President's Commission on Carbon Neutrality has convened to leverage the resources and expertise of U-M to contribute to a more sustainable and just world by developing a plan for the university to reach net-zero (carbon neutral) emissions university-wide. Our analysis has gone beyond prior U-M efforts by accounting for Scope 1 emissions (resulting from on-campus sources); Scope 2 emissions (resulting from purchased electricity); and Scope 3 emissions (resulting from other indirect sources such as commuting, university-sponsored travel, and procurement). Though U-M's investment portfolio is beyond our charge, the Commission supports ongoing efforts by the administration and Regents to address, and demonstrate leadership on, this important issue.

Through the inclusion of the entire university in our scope of work—over 40 million building square feet across the Ann Arbor, Dearborn, and Flint campuses—we have developed an array of recommendations that can be effective in very different community and geographic settings. Though the UM-Ann Arbor campus constitutes the largest presence, comprising 388 buildings across 2,997 acres, U-M's footprint, and indeed its leadership on climate action, reverberates far beyond Ann Arbor. Our analyses cover emissions from the three campuses, which vary greatly in size, demographics, access to resources, and connectivity with their respective surrounding communities. Analyses also encompass emissions from Michigan Medicine, a leading regional health care system where patient care and cutting-edge research are paramount.

Throughout this report, we propose solutions that align with U-M's core missions of education, research, health care, and service and reflect the principles of diversity, equity, and inclusion. These recommendations, if adopted, will be implemented on active campuses where people live, learn, work, and heal. Essential functions like patient care, teaching, and research require the uninterrupted use of critical infrastructure, which cannot be shut down, to accelerate U-M's carbon neutrality push. Instead, we propose staging many of our recommendations to accommodate the living missions of the university.

Our recommendations are also designed to be scalable and transferable, so that they can be adopted by other institutions across sectors, near and far from Flint, Dearborn, and Ann Arbor. Encouragingly, municipalities around the region have already adopted ambitious goals. In June 2020, the City of Ann Arbor pledged to achieve "a just transition to carbon neutrality, community-wide, by 2030,"[4] and Washtenaw County established the same timeline a few months

4 City of Ann Arbor. (2020, April). A²Zero: Ann Arbor's Living Carbon Neutrality Plan. https://www.a2gov.org/departments/sustainability/Documents/A2Zero%20Climate%20Action%20Plan%20_3.0.pdf

later, in August.[5] Governor Gretchen Whitmer in September signed an executive order that "sets the goal of economic decarbonization in Michigan by 2050."[6] To ensure U-M climate actions have the greatest impact, the university must leverage existing collaborations and develop new ones—with local communities, the State of Michigan, and beyond—to achieve mutually shared goals.

We affirm that the climate crisis poses the most harm to communities that are historically and unfairly disadvantaged and disenfranchised. Each of our recommendations brings with it a different set of environmental justice considerations. Accordingly, environmental justice must be comprehensively interwoven throughout U-M's climate action plan, rather than being a supplementary step. U-M and its partners will have to conduct much more meaningful and intentional engagement on how to best address equity and justice issues at U-M's three campuses, around the region, and globally. Efforts to promote engagement around the plan must include opportunities for the identification and amelioration of environmental injustices, especially for the most impacted communities.

Though much of the path toward carbon neutrality requires technical solutions, we expect U-M's ultimate climate plan will emphasize opportunities to engage faculty, students, staff, alumni, donors, patients, and visitors. High-level and systemic institutional change is crucial for the cultural shift necessary to achieve these goals over the next several decades. So too is giving U-M community members the agency, responsibility, and resources to make their own significant contributions toward carbon emissions reductions both on and off campus. There must be engagement, support, and commitment at all levels, including the central administration, organizational units, and individuals throughout the university.

Consistent with this framing, the President's Commission on Carbon Neutrality is pleased to present its final report and recommendations. Suggested actions span many topics that are crucial to achieving net-zero emissions, including heating and cooling infrastructure, purchased electricity, transportation, energy consumption policies and pricing, campus culture, carbon offsets, and more.

5 MLive. (2020, August 6). Washtenaw County sets 2030 carbon-neutral goal, takes "biggest step" yet on climate change. https://www.mlive.com/news/ann-arbor/2020/08/washtenaw-county-sets-2030-carbon-neutral-goal-takes-biggest-step-yet-on-climate-change.html

6 The Office of Governor Gretchen Whitmer. (2020, September 23). Governor Whitmer announces bold action to protect public health and create clean energy jobs by making Michigan carbon-neutral by 2050. https:/ www.michigan.gov/whitmer/0,9309,7-387-90499_90640-540289--,00.html

Through the steps outlined in this report, the Commission recommends that U-M:

- Reach carbon neutrality for Scope 1 emissions across all three campuses by 2025 (inclusive of carbon offsets) and eliminate Scope 1 emissions entirely by 2040;
- Achieve carbon neutrality for Scope 2 emissions across all three campuses by 2025 or earlier;
- Establish, by 2025, carbon neutrality goal dates for Scope 3 emissions categories that are set for no later than 2040; and
- Deepen its commitment to environmental justice and strengthen its connections with local communities.

The climate crisis demands a swift, accountable, and just response. Going forward, we expect U-M to set bold goals, pursue the requisite emissions reduction strategies, continually assess and report progress, adapt strategies in response to technological advances and community input, and achieve carbon neutrality in a sustainable and just way.

With urgency and optimism,

The President's Commission on Carbon Neutrality

University of Michigan Biological Station | By Alexis Rankin

GUIDING PRINCIPLES

President Schlissel charged the Commission with recommending timelines, pathways, and approaches for U-M to achieve carbon neutrality in accordance with several criteria that are outlined on the following pages as guiding principles.

Each guiding principle includes a set of defining characteristics that were developed through Commission discussion. It is important to note that all of the recommendations in this report satisfy each of these criteria to a different degree.[7]

As the university formalizes a strategic roadmap to carbon neutrality, the Commission recommends evaluating all strategies in accordance with these guiding principles to ensure optimal outcomes.

7 Appendices at the end of this report provide detail on how each recommendation relates to each guiding principle. However, this guidance should be considered preliminary, and additional work will be required to flesh out and refine the details to inform implementation.

GUIDING PRINCIPLES

CARBON NEUTRAL

- Recognizes that the climate crisis demands urgent action
- Includes Scope 1, Scope 2, and Scope 3 categories that can be accurately measured and tracked
- Seeks a goal, trajectory, and set of strategies to accelerate emissions reductions and minimize cumulative greenhouse gas (GHG) emissions
- Ultimately eliminates all quantifiable carbon dioxide (CO_2) and other significant emissions or offsets them by investments in carbon credits or removal/sequestration projects

SUSTAINABLE

- Meets or exceeds IPCC 1.5 Celsius (˚C) global targets (carbon neutrality by 2050 and 45 percent below 2010 by 2030)
- Meets the needs of present generations without compromising the ability of future generations to meet their own needs
- Aligns with or enhances U-M's core missions of education, research, health care, and service and reflects its principles of diversity, equity, and inclusion

EQUITY & JUSTICE

- Addresses equity and justice issues among our three campuses, regionally, and globally
- Recognizes our privileged position within society and particularly within the State of Michigan
- Acknowledges that institutions in wealthier countries have significant legacy emissions and a greater responsibility for taking action to address the climate crisis

SCALABLE & TRANSFERABLE

- Seeks a range of solutions that collectively have broad applicability beyond U-M's three campuses, reaching organizations and communities of all sizes and sectors
- Prioritizes the sharing of relevant information in accessible and transparent ways

REGIONAL COMMUNITY INVOLVEMENT

- Collaborates with communities surrounding our campuses (Ann Arbor, Dearborn, and Flint) toward achieving mutually shared goals
- Engages more broadly in southeast Michigan and throughout the state
- Pathways, timelines, and strategies are responsive to, and reflective of, the regional communities with which we engage

U-M COMMUNITY PARTICIPATION & ACCOUNTABILITY

- Engages faculty, students, staff, alumni, donors, patients, and visitors in carbon neutrality efforts
- Pursues education and research to make a significant impact on carbon reductions
- Empowers U-M community members to take individual responsibility for helping achieve university goals and establishes mechanisms to facilitate that objective
- Provides a feasible plan with administrative and governance guidance, establishes mechanisms to track progress, and assures commitment and accountability throughout the university

FINANCIALLY RESPONSIBLE

- Supports the university's ability to carry out its core missions of education, research, health care, and service in the near and long term
- Limits capital and operating costs, pursues optimal return on investment, and considers full life cycle costs
- Recognizes physical, logistical, administrative, and financial constraints
- Considers changing market, regulatory, and policy conditions and an evolving landscape of funding and financing options

Left to right: UM-Flint Pavilion Building by Michael Barera, CC BY-SA | Burton Memorial Tower by Fatimah Bolhassan | UM-Dearborn by Michigan Photography

PROCESS OVERVIEW

This section provides an overview of the process elements that characterized the work of the President's Commission on Carbon Neutrality. It describes how the work was structured, the formal analyses that were completed, the timeline of activities, and the community engagement efforts that occurred throughout the two-year process.

The section also includes information on how the Commission approached several key topic areas that cut across all aspects of its work. These topics include environmental justice, financial analysis, and carbon accounting.

Commission Structure

The Commission included 17 members who collectively developed the recommendations in this report to transform U-M and achieve carbon neutrality in accordance with the President's charge.

In developing these recommendations, the Commission relied on analysis and input from many individuals and groups, as illustrated in the diagram below.

Beyond the Commission itself, the PCCN effort involved many coordinated activities, including internal and external analysis teams focused on specific topic areas; formal and informal advisors consisting of students, faculty, administrators, and external experts; and engagement efforts with the university community and broader public.

During the process, more than 1,000 people contributed to the Commission's work in various ways, including more than 700 people who shared their views through a public comment portal.

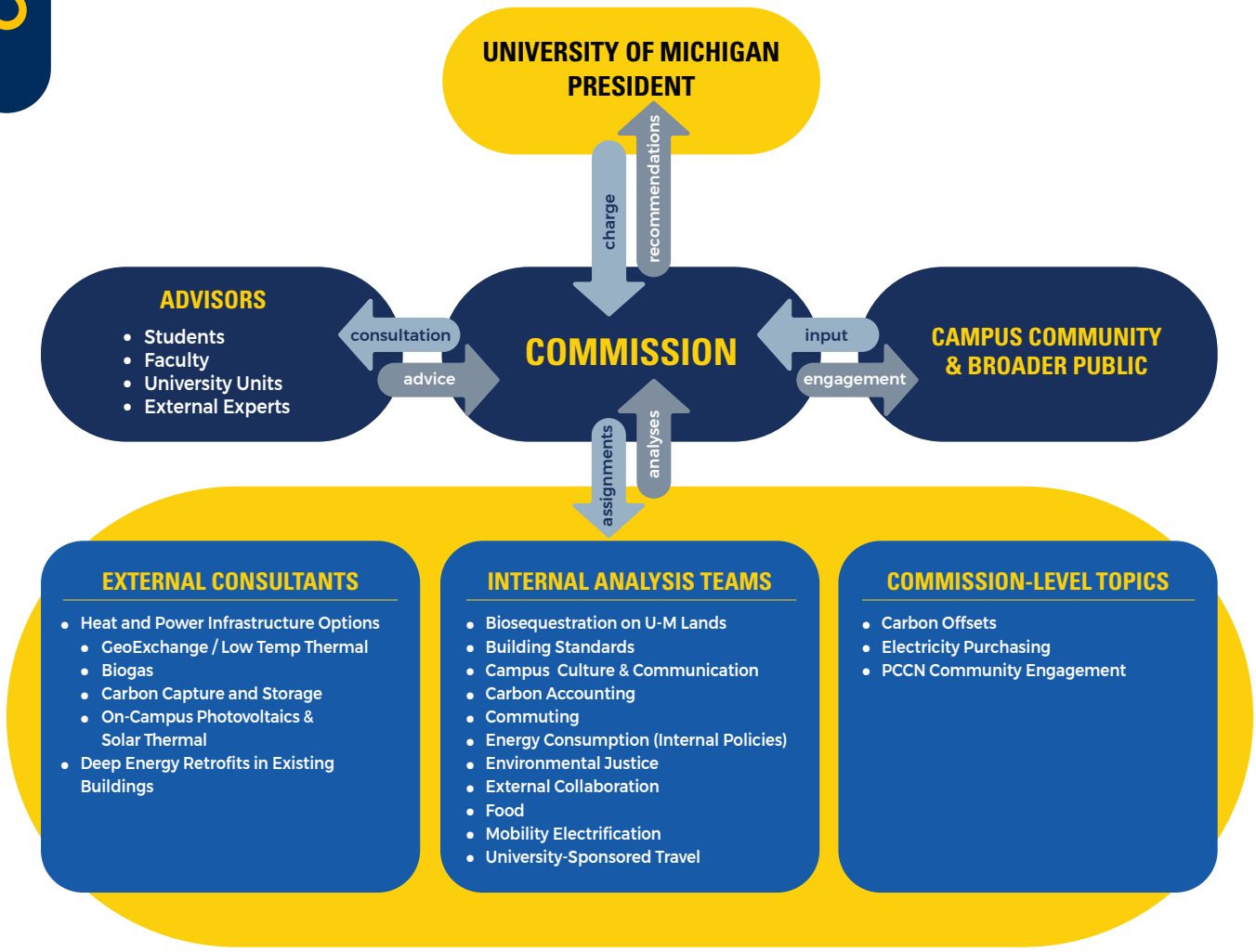


Diagram of the Commission's Structure

The Commission launched in February 2019 and concluded its work in March 2021. This section summarizes the three phases of work that were completed during that period.

Phase One focused on defining the dimensions of the challenge, developing a structure and workplan to effectively address them, securing the expertise needed to carry out robust analyses across multiple geographies and subject areas, and launching those analyses. For more information on Phase One work, refer to the Fall 2019 Interim Progress Report.

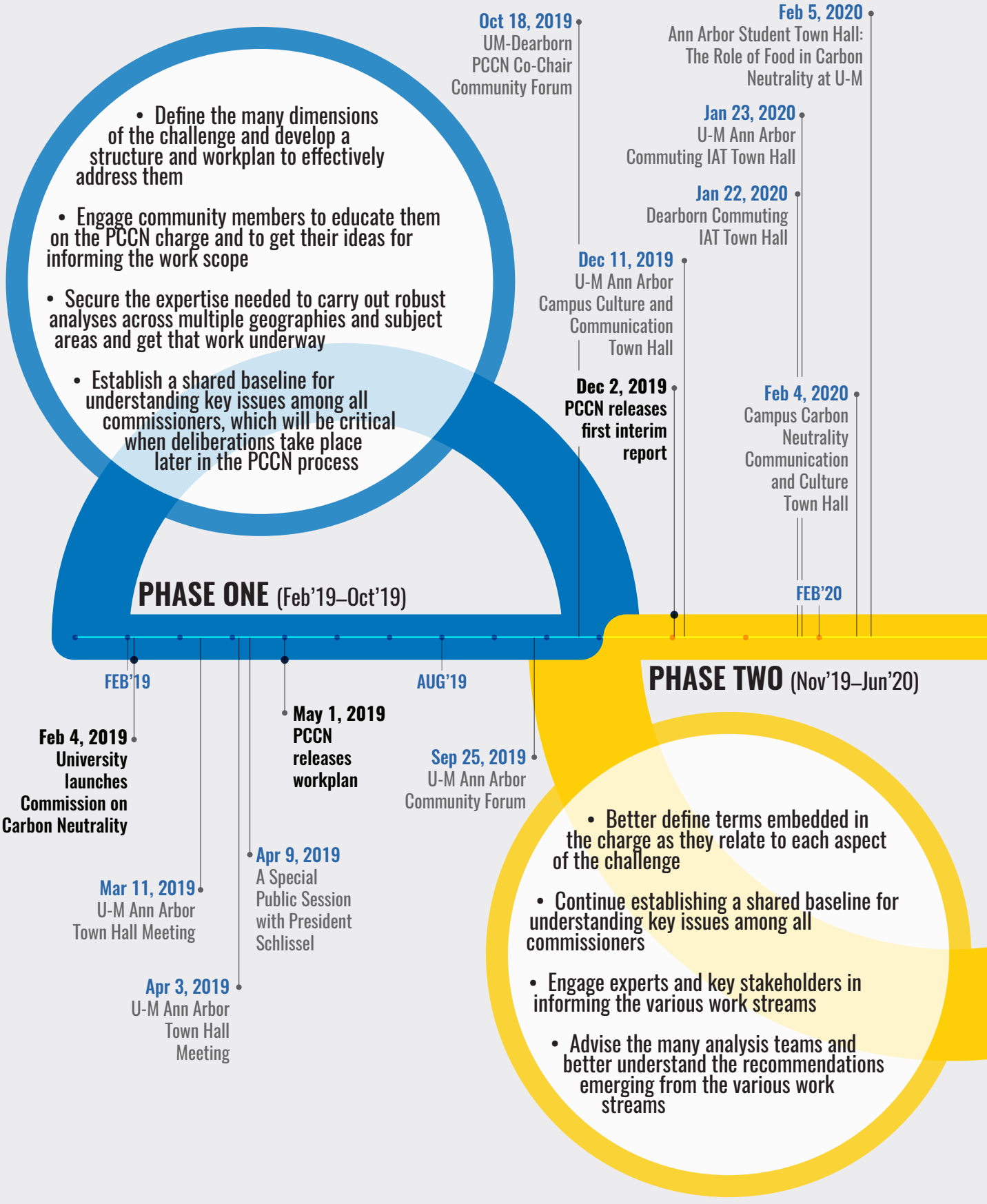
The second phase ran from November 2019 through June 2020 and focused on completing a wide range of analyses that informed the Commission's recommendations. During this period, Commission meetings focused on establishing a shared baseline for understanding key issues among all commissioners. This shared knowledge informed feedback to analysis teams and continued to be helpful for deliberations that took place during the PCCN's third and final phase of work. For more information on Phase Two work, refer to the Spring 2020 Interim Progress Report.

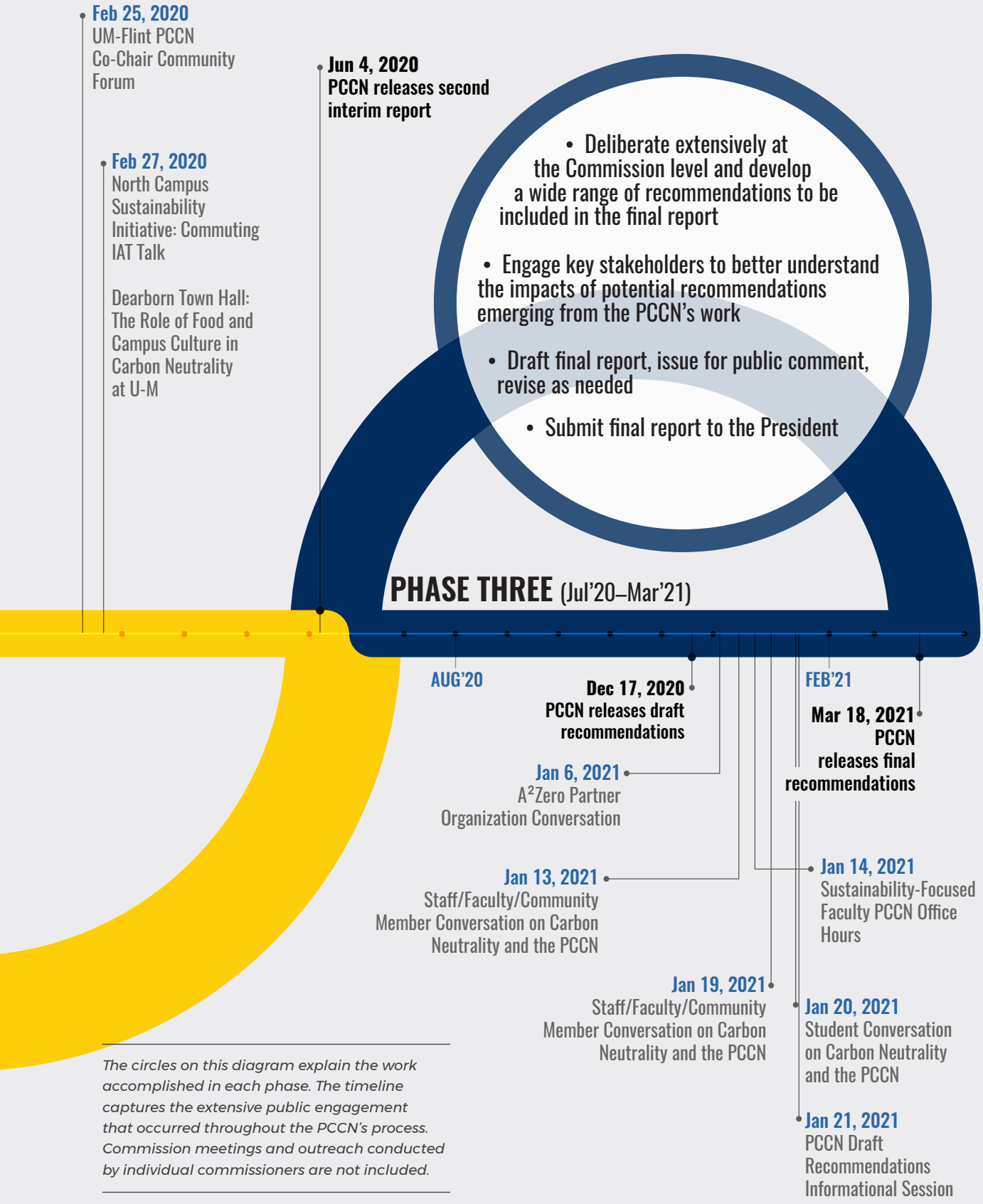
The final phase began in July 2020 and extended until the report was finalized and delivered to the President in March 2021. This period provided commissioners time to review the various analyses, engage in deep deliberations, and develop recommendations. The recommendations and their core messaging were decided on through weekly Commission meeting discussions, typically with general consensus being achieved. In cases where consensus could not be reached through discussion, proposed recommendations were brought to a vote, with a simple majority required for the recommendation to be adopted. Not all commissioners agreed with all recommendations, and in cases where a recommendation passed, but at least five commissioners voted against it, those in the minority could include a minority opinion in the report.

The Commission also used this final phase to write its draft report, which was released in mid-December 2020 and was open for public comments until late January 2021. During the comment period, Commission efforts focused primarily on stakeholder engagement, involving consultations with a wide range of advisors to explore potential ramifications associated with the various recommendations. After the comment period closed, the Commission reviewed, addressed, and reflected on the more than 500 comments received on the draft report, engaged in further deliberations, and made significant revisions prior to delivering this final report to President Schlissel in March 2021.[8]

8 Appendix C provides a link to a summary of each unique idea/perspective submitted through the comment process, along with an indication of how many people submitted that idea/perspective and a brief description of how it was addressed.

COMMISSION TIMELINE





The circles on this diagram explain the work accomplished in each phase. The timeline captures the extensive public engagement that occurred throughout the PCCN's process. Commission meetings and outreach conducted by individual commissioners are not included.

Formal Analyses

As requested by the Commission, formal analyses were completed by thirteen teams, including two external consulting firms and eleven internal analysis teams led by U-M faculty and staffed by U-M students and staff.

Across the Flint, Dearborn, and Ann Arbor campuses, more than 50 U-M undergraduate, graduate, and doctoral students, 17 faculty members, and dozens of staff members worked with the various analysis groups. Overall, the Commission's analyses included and engaged individuals from over 45 units across the three campuses.

After completing their work, each of the analysis teams engaged with the Commission to discuss their recommendations in more detail. These analyses were invaluable in informing the Commission's recommendations on carbon neutrality. While the Commission references analysis team reports throughout the document, the report, in large sections, includes direct language from the respective analyses.

In addition to these formal analyses, several other important topics were explored in detail through Commission-level discussions and subgroup activities. Notable topics include carbon offsets, electricity purchasing, and PCCN-related community engagement.

Carbon neutrality, at a global level, is balance between emitting carbon and absorbing carbon from the atmosphere in carbon sinks. At the level of an institution, carbon neutrality means that all quantifiable greenhouse gas emissions attributable to that institution's activities are eliminated or offset by investments in carbon credits or sequestration projects.

	ANALYSIS TOPIC	CATEGORY	SCOPE OF WORK
	Campus Culture	Organization and Culture	Structures and strategies to raise awareness, enhance personal investment, and change behaviors related to carbon neutrality.
	External Collaboration	Organization and Culture	Opportunities and strategies for collaborations focused on scaling and replicating high-impact solutions.
	Environmental Justice	Organization and Culture	Social equity impacts arising from potential recommendations and how these may be addressed.
	Heat & Power Infrastructure	Scope 1 Emissions	Pathways for evolving U-M's heating and power generation infrastructure, including natural gas, toward carbon neutrality across all three U-M campuses.
	Internal Energy Consumption Policies	Emission Scopes 1 & 2	Potential budget and finance mechanisms to decrease energy usage across U-M's campuses.
	Building Standards	Emission Scopes 1 & 2	Best practices regarding the adoption, implementation, and long-term efficacy of building codes to achieve carbon emissions reductions.
	High-Efficiency Building Retrofits	Emission Scopes 1 & 2	Deep-dive retrofit analyses of two distinct buildings on U-M's campus to inform what would be required to reduce building-level emissions as much as possible.
	Mobility Electrification	Emission Scopes 1 & 3	Strategies for converting internal combustion engine vehicles to battery electric vehicles (EV) and for encouraging EV commuting.
	Commuting	Scope 3 Emissions	Carbon impact of the commute to the U-M campuses and strategies to reduce the commute's footprint.
	University-Sponsored Travel	Scope 3 Emissions	GHG emissions associated with university-sponsored travel and approaches to reduce the carbon intensity.
	Food	Scope 3 Emissions	Approaches to decrease the GHG footprint associated with food consumption on U-M's three campuses.
	Carbon Accounting	Measurement	Model targets and timelines, energy demand reduction and supply decarbonization strategies, emission permits/ offsets, and implications of carbon prices.
	Biosequestration	Offsetting & Sinks	Approaches for potential large- and small-scale biosequestration projects on and off campus.

Community Engagement

The Commission, its internal analysis teams, and campus sustainability groups hosted many engagement activities to educate the community on the PCCN's work and to solicit input from participants.

These included:

- Three in-person community forums on the UM-Ann Arbor campus, featuring the Commission co-chairs and multiple commissioners;
- One in-person forum on the UM-Dearborn campus, featuring the Commission co-chairs;
- One in-person forum on the UM-Flint campus, featuring the co-chairs;
- Seven internal analysis team public engagement events, accompanied by four team surveys intended to reach those across all three U-M campuses who were unable to attend in-person events; and
- Multiple forums and webinars featuring internal analysis team members, campus sustainability groups, and the U-M community, each featuring question-and-answer or public comment sessions.

Throughout the process, Student Advisory Panel members provided feedback and ideas related to Commission activities. In addition, U-M's Student Sustainability Coalition helped organize and host public forums on the draft final report, and, with the Commission's encouragement, several student organizations mobilized their members to review and comment on the draft recommendations.

During its final phase of work, the Commission released analysis team reports for public comment, receiving feedback from key stakeholders and experts across the university, including from UM-Flint, UM-Dearborn, U-M Office of Architecture,

Dearborn campus | Courtesy of UM-Dearborn

Engineering and Construction, UM-Ann Arbor Facilities and Operations, and the Office of Campus Sustainability.

Communicators from the Office of the Vice President for Communications and the Graham Sustainability Institute regularly placed stories in U-M publications and channels, fielded media inquiries, and assisted in convening Commission events to better inform the public of the PCCN's progress.

Throughout its process, a public comment portal served as a primary avenue for U-M community members to share their ideas, suggestions, and concerns with the Commission. In total, community members contributed more than 700 public comments, including more than 500 during the Commission's draft recommendation comment period, which lasted from December 17, 2020 through January 26, 2021.

During the draft report public comment period, five public engagement events were held for the university community. The Planet Blue Ambassador program hosted two faculty, staff, and community member community conversations, and the Student Sustainability Coalition in partnership with Central Student Government hosted two student-focused community conversations. The Commission hosted an informational session intended for those who had not been closely following carbon neutrality efforts at U-M. In addition to these public events, the Commission co-chairs met with A²Zero (City of Ann Arbor) partner organizations, the PCCN's Student Advisory Panel, U-M's Student Sustainability Coalition, and sustainability-focused U-M faculty.

See Appendix B for a full list of PCCN public engagement events to date.

Environmental Justice

In pursuit of its mission to contribute to a more sustainable and just world, the Commission recognizes the intrinsic connection between carbon neutrality efforts and environmental justice and, accordingly, the need to pose solutions that address both.

In acknowledging environmental justice (EJ), we recognize the rights of individuals and communities to clean water, clean air, and a livable world, both now and in the future. Holding this true, the Commission acknowledges that as a renowned public university with legacy emissions, U-M has an increased responsibility to mitigate its own emissions while working collaboratively with others to do so as well. We include this brief introductory section, not to separate EJ from the rest of the report, but to acknowledge its overarching importance and to convey how EJ considerations are woven throughout.

Each issue outlined in this report—campus infrastructure, electricity sourcing, commuting, food systems, and carbon offsetting, to name a few—brings a unique set of EJ considerations. To begin identifying these considerations, the Commission directed each of the analysis teams that contributed to this work to identify key issues around environmental justice pertaining to their scope of work and specific recommendations.

In addition, a dedicated analysis team was established to research and provide perspective on EJ content in carbon neutrality plans from universities, cities, and countries and approaches to address social equity impacts arising from Commission recommendations. Drawing on all of this work, the Commission identified some specific EJ considerations associated with its recommendations, which are addressed to some extent within the body of the report and more explicitly in the appendices that correspond to each recommendation.

Despite these efforts, the Commission acknowledges our limited capacity to comprehensively integrate EJ throughout our recommendations and the final report's incomplete articulation of the complex and pressing justice issues. The EJ considerations outlined herein, and the recommendations for integrating EJ expertise into carbon neutrality implementation, are a starting point to help prepare U-M for conducting deeper exploration going forward. These efforts are needed, before and throughout implementation, as are the organizational structures to ensure accountability.

Environmental justice (EJ) is the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies.[9]

Procedural justice ensures that all people, regardless of race, ethnicity, income, national origin, gender identity, educational level, or other consideration, have meaningful involvement in environmental decision-making.

Distributive justice ensures an equitable distribution of environmental risks, impacts, and benefits, such as cleaner air, cheaper/more reliable energy, and healthier food.

Restorative justice repairs harm by engaging victims to reach a common understanding and agreement on how to achieve justice.

The Commission recognizes that the climate crisis poses the most harm to communities that are historically and unfairly disadvantaged and disenfranchised. Thus, adequately understanding and addressing EJ considerations is only possible through consistent engagement with environmental justice experts and frontline and fenceline communities.[10] Bearing the brunt of pollution and other negative impacts, these communities hold critical perspectives and direct experience of the impacts of climate change and must have a powerful voice in shaping how solutions are adopted and implemented. Going forward, U-M, along with its partners, must conduct meaningful engagement to address equity and justice issues at U-M's three campuses, around the region, and globally.

9 https://www.epa.gov/environmentaljustice/learn-about-environmental-justice

10 Those communities most impacted by fossil fuel pollution and climate change, which are largely low-income and Black, Indigenous, and People of Color communities.

The Commission tasked a group with developing a comprehensive carbon accounting model for all U-M campuses. The model integrates work completed by Commission analysis teams with additional analysis conducted by the modeling group.

The dynamic model characterizes and simulates GHG emissions for 29 carbon-reduction strategies. It includes more than 100,000 data points and more than 500 carbon-reduction strategy parameters (e.g., improving energy efficiency; replacing heating, ventilation, and air conditioning systems; electrifying vehicles; and shifting dietary habits).

Emission factors and 100-year global warming potential (GWP) values were sourced from Argonne National Lab's Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation (GREET) model. DTE Energy and Consumers Energy provided fuel mix projections and generation plans through 2050. Additional model parameters and technology forecasts were sourced from the U.S. Environmental Protection Agency and the Energy Information Administration of the U.S. Department of Energy.

The model estimates U-M's GHG emissions on an annual basis from 2018 to 2050. It includes carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O). It calculates emissions separately for Scope 1, 2, and 3 emissions for all three U-M campuses, plus several field and research stations. Upstream emissions include methane leakage and other emissions resulting from fuel processing, as characterized in GREET.[11]

The model compares U-M's progress against both neutrality and the IPCC 1.5˚C targets. It begins by calculating 2018 GHG emissions baselines by scope and plotting the business-as-usual (BAU) emissions trajectory from 2018 through 2050. The BAU trajectory illustrates annual GHG emissions absent any additional university action to reduce emissions.

Annual emissions reductions from BAU were calculated and plotted for three sets of emissions reduction strategies, resulting in three emissions trajectory cases. These trajectories reveal the gap remaining in each year to achieve neutrality. Emissions were monetized using recent Regional Greenhouse Gas Initiative permit prices to estimate the potential cost of offsetting the gaps.

As emissions tracking improves, the model will require annual updating and refinement. The lack of data in several areas, mostly related to Scope 3 activities, highlights the need for improved accounting systems. This pertains especially to purchased goods and services, which are not currently included in the model's Scope 3 calculation.

Additional work is required to make the model an operational tool for planning, tracking, reporting, and verification. Full details on model calculations, assumptions, and parameters are documented in the Carbon Accounting Modeling Report.

11 EDF estimates for leakage were used (https://www.edf.org/federalmethanemap/).

Pursuant to the financial responsibility criterion set forth in the President's charge, the Commission and its analysis teams sought to conduct financial analyses, to the extent possible, to inform cost projections for the various recommendations.

Several recommendations in this report, particularly those that are the most capital intensive, were informed by significant financial analysis to determine preliminary, high-level cost estimates. For example, Integral Group worked closely with U-M staff to develop a life cycle cost analysis (LCCA) comparing the financial outcomes of distinct future scenarios over the study's 30-year period (refer to Appendix J). The LCCA was driven by up-front capital costs; maintenance costs; energy costs; and financing costs, and compared a business-as-usual (BAU) case with a proposed project case. For the deep energy retrofits study, SmithGroup also conducted an LCCA to estimate the full costs of acquiring, owning, and disposing of building components and systems for the energy conservation management scenarios they evaluated (refer to Appendix P).

Many of the internal analysis teams also conducted financial analyses to inform their reports, with the most notable examples being the Energy Consumption Policies, Building Standards, and Mobility Electrification analyses. Other analysis teams provided cost estimates to the degree possible given the time and resources available to them.

More in-depth financial analysis and costing will be needed for all recommendations moving forward to accurately quantify costs and to help set priorities. In prioritizing various strategies for accomplishing the same objective, the administration should use dollars per metric ton of carbon dioxide equivalent ($/MTCO$_2$e) abated as a primary cost metric. In calculating payback periods for the various strategies, the Commission suggests that U-M do so in two ways: 1) using normal cash flows and 2) using normal cash flows plus a social cost of carbon (e.g., $50/MTCO$_2$e).

The Commission was not tasked to make recommendations regarding how U-M should finance recommended actions, and no such recommendations are provided. However, in pursuing carbon neutrality solutions, U-M should be attentive to the evolving landscape of policy and regulatory conditions, financial incentives (e.g., infrastructure grants) and financing options (e.g., public-private partnerships) that can be leveraged to get this work done. In the course of its decision making, U-M should investigate the full range of options for financing this important work, and pursue those that can accelerate carbon neutrality investments in the most financially responsible manner.

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ORGANIZATION AND CULTURE

This section provides recommendations on cultural and organizational approaches that will be critical in facilitating U-M's rapid and just transition to carbon neutrality.

A commitment to addressing climate change is essential at every level of the university—from the administrative leadership to the entire community of students, faculty, and staff.

The challenge at hand demands a bold university-wide commitment and new leadership structures to ensure success. It requires widespread engagement with internal and external stakeholders to inform planning and implementation. And it requires substantial investments in education and research programs to ensure that every community member is empowered to engage with this grand challenge and contribute to lasting solutions.

STRATEGY RECOMMENDATIONS SUMMARY

This table provides generalized comparisons of the recommendations in terms of the necessary financial investment and culture shift required at institutional, unit, and/or individual levels throughout the university community. These are subjective judgments based on the best available information and are for illustrative purposes only.

STRATEGY RECOMMENDATION	FINANCIAL INVESTMENT ($ – $$$$$)	CULTURE SHIFT (L–M–H)
LEADERSHIP STRUCTURES		
Commit to using environmental justice guiding principles and expertise, including community input, within all future deliberations, decision-making, and implementation efforts around U-M carbon neutrality.	$	High
Create an executive leadership (EL) position reporting directly to and advising the President, whose office and staff have responsibility for planning and coordinating university-wide carbon neutrality efforts; working across all three campuses to integrate implementation and accountability mechanisms at the unit level; engaging with stakeholders (particularly those most affected); receiving and incorporating feedback from the community; facilitating partnerships and otherwise promoting the scaling and transfer of U-M carbon neutrality solutions; and reporting on goal progress and shortfalls.	$$	High
Establish an institutional advisory committee to support the EL's office in developing, implementing, and communicating effective strategies for actuating U-M's carbon neutrality priorities, with a focus on leveraging and aligning university structures and resources to support U-M's carbon neutrality goals.	$	High
Establish a community advisory committee to support the EL's office in developing, implementing, and communicating effective strategies for actuating carbon neutrality priorities, with a focus on understanding external stakeholder perspectives, learning from their experiences, and partnering whenever possible for mutual benefit.	$	High

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STRATEGY RECOMMENDATION	FINANCIAL INVESTMENT ($ – $$$$$)	CULTURE SHIFT (L–M–H)
CAMPUS PLANNING		
Create and update campus- and district-level master plans to reflect that greenhouse gas emissions mitigation is one of the university's top priorities and update such plans at regular intervals with campus community input.	$	Med
Prioritize central locations for construction projects and expand affordable campus housing for students, faculty, and staff based on an evaluation of needs and demand, considering issues of equity and climate change resilience.	$	High
RESEARCH AND EDUCATION		
Make significant investments in research and its deployment on routes to achieving carbon neutrality.	$$	Med
Expand and prioritize carbon neutrality curriculum, training, and literacy programs to all members of the U-M community across all three campuses.	$	High
Invest in institutional structures to expand and support carbon neutrality-focused "living-learning labs" across all three U-M campuses.	$$	High
EXTERNAL COLLABORATION		
Conduct targeted network mapping related to all carbon neutrality strategies and pursue intentional engagement with key stakeholders to inform implementation.	$	Med
Tailor carbon neutrality communication and education and expand opportunities for stakeholder input.	$	Med

Achieving carbon neutrality will require coordinated action and accountability by all units and individuals throughout the university, and success requires that the structural and cultural architectures align with university goals and the associated work.

U-M's Diversity, Equity and Inclusion (DEI) initiative offers a model for how carbon neutrality efforts can be structured to become a core principle throughout the university. In addition, there are opportunities for coordination and collaboration between carbon neutrality and DEI efforts going forward, as environmental justice (EJ) should be a central organizing principle for all carbon neutrality efforts.

Strategy Recommendation: Commit to using environmental justice guiding principles and expertise, including community input, within all future deliberations, decision-making, and implementation efforts around U-M carbon neutrality.

To strive for a sustainable and just world, U-M must significantly improve its commitment to EJ within all carbon neutrality and university operations. To ensure success, U-M should set intentions, formal commitments, and institutional structures to incorporate EJ throughout its pursuit of carbon neutrality. To help accomplish this, the recommended carbon neutrality office (see recommendation below) should have embedded EJ expertise at a senior level and a commitment to weaving an EJ ethic throughout the organization. In addition, U-M should create a more comprehensive, university-wide framework to provide leadership, guidance, and coordination between the university and outside communities, stakeholders, and decision-makers. Establishing such structures will require hiring EJ specialists and integrating them across university efforts that are both inward looking and outward facing.

The goal of integrating EJ throughout the university would be to build durable frameworks of equitable engagement and relationships with community partners, specifically organizations, advocates, and scholars across Michigan and within the locations of university-driven projects. As recommended by the External Collaboration Analysis Report, such relationships should be developed and maintained with a commitment to meeting one another as equals and with the intentions to listen to, learn from, and collaborate with frontline and fenceline communities. Cultivating these relationships will ensure that broad-based community input informs U-M decision-making and facilitates a just implementation of carbon neutrality efforts. This is imperative to ensure that the university remains accountable to the communities it serves and impacts.

Strategy Recommendation: Act quickly to create an executive leadership (EL) position reporting directly to and advising the President, whose office and staff have responsibility for planning and coordinating university-wide carbon neutrality efforts; working across all three campuses to integrate implementation and accountability mechanisms at the unit level; engaging with stakeholders (particularly those most affected); receiving and incorporating feedback from the community; facilitating partnerships and otherwise promoting the scaling and transfer of U-M carbon neutrality solutions; and reporting on goal progress and shortfalls.

U-M's path toward carbon neutrality requires full presidential and regental commitment to making it a long-term priority and to ensure accountability at all levels of the organization. This commitment must be built to endure, regardless of who sit in leadership positions. Also unit leaders situated throughout the university must help set examples of this commitment through their actions. Similar to U-M's DEI efforts, the current and future Presidents and their senior leadership need to be consistently out front and visible on carbon neutrality and justice to help embed it within U-M's culture. Successful efforts around carbon neutrality require centralized leadership and coordination, decentralized commitments and strategies at the unit level, and robust advisory networks that are both internal and external to the university.

U-M must design its carbon neutrality effort in ways that leverage, invest in, and elevate those existing organizational structures and resources throughout the university that are essential to carrying out the work. U-M must avoid redundant efforts and unnecessary organizational growth and foster constructive collaboration across units. This will require that unit-level efforts and funding mechanisms are integrated to get the work done in productive and cost-effective ways. A key question from an organizational design perspective is whether U-M has sufficient knowledgeable and skilled people in the right positions necessary to execute its critical work. If not, then U-M has to build the requisite capabilities in current staff, hire additional qualified personnel, and strategically outsource specialized efforts as needed.

The governance structure for U-M's carbon neutrality efforts will be similar to other such large-scale initiatives at the university; that is, the President serves as the chief executive, and the Regents provide general oversight with regard to budget and policies. A successful carbon neutrality effort also requires an executive leader (EL) reporting directly to the President and whose office has broad responsibility for planning and organizing the overall carbon neutrality effort—spanning university operations, policies, culture, and stakeholder engagement—across all three campuses.

This role should be executed in consultation with a wide range of stakeholders (internal and external), working with U-M units as a consulting partner to build capabilities and tracking and reporting on progress in a scheduled, periodic manner to the entire university community. The EL and their staff would assist the President and other U-M leaders in understanding how all major university decisions are, or are not, compatible with institutional carbon neutrality goals. Clear guidance would need to be developed and communicated regarding how this role interfaces and collaborates with and influences units on all three campuses to ensure expectations are aligned throughout the university. The supporting staff should have sufficient skills to span across all aspects of this initiative, including knowledge of university operations, academic and research activities, community relations, and environmental justice.

Some of the key responsibilities for the EL and their office include:

- Review and prioritize all PCCN recommendations and assess their budgetary impacts and relationship to other U-M priorities.
- Plan, develop, coordinate, and communicate a detailed implementation plan for U-M carbon neutrality that builds on work completed by the PCCN, where goals meet SMART criteria (specific, measurable, achievable, relevant, and time-bound). This plan should include developing and publishing a strategic roadmap with explicit timelines and milestones to achieve carbon neutrality across all three campuses.
- Establish, for internal and external stakeholders, a clear point of contact that formally represents the U-M administration on university-wide carbon neutrality issues through an integrated lens of education, research, operations, and outreach.
- Provide the President with a primary advisor on carbon neutrality.
- Ensure that carbon neutrality considerations are represented in Executive Officer discussions and in making their appointments, which span all areas of the university.
- Regularly convene high-level internal and external carbon neutrality advisory bodies to ensure that widespread perspectives inform university strategy, decision-making, and accountability.
- Work across all U-M units in a consultative role to ensure mechanisms are implemented that cultivate and embed carbon neutrality culture and accountability at the unit and individual levels, recognizing that strategies may vary across unit types.
- Support and inform the development of campus- and district-level master plans and ensure that such planning emphasizes carbon neutrality as a core principle.
- Develop key performance indicators to assess progress toward carbon neutrality goals and communicate them in an accessible way to promote transparency and give the community insight into the process.

- Report semi-annually to the university leadership and broader communities on the rationale for choices made, as well as progress and shortfalls on the implementation plan's roadmap, timelines, and milestones.
- Regularly collaborate and engage with other cross-university efforts to identify synergies and accelerate one another's priorities.
- Demonstrate understanding of and ability to work toward environmental justice and ensure all EL office staff participate in EJ training.
- Build and accelerate partnership networks (internally and externally) to collaboratively design sustainable, just, and scalable strategies.
- Establish and maintain equitable relationships with all campuses.
- Partner with the Cities of Ann Arbor, Dearborn, Flint, and Detroit, and other jurisdictions to work toward shared carbon neutrality goals.
- Continue to solicit and review community feedback about priorities and recommendations via an online portal.
- Hold periodic sessions with stakeholders to hear their concerns, comments, and critiques regarding implementation and factor in their feedback in shaping future plans.
- Develop new priorities as needed and address new concerns and technological developments that arise.

Given the vast and distributed nature of carbon neutrality efforts, the EL would have limited authority or direct oversight over executing much of the critical work that is needed. Accountability for implementation and annual reporting mechanisms must become the norm in units throughout the university.

Strategy Recommendation: Establish an institutional advisory committee to support the EL's office in developing, implementing, and communicating effective strategies for actuating U-M's carbon neutrality priorities, with a focus on leveraging and aligning university structures and resources to support U-M's carbon neutrality goals.

Developing and implementing a strategic roadmap for carbon neutrality needs to be done in collaboration with senior leaders from across the university. The institutional advisory committee would:

- Inform and review carbon neutrality plans and strategies with a focus on assessing their budgetary impacts, implementation challenges, and relationship to other priorities pursued by U-M.
- Provide the EL's office with unique perspectives and insights from units spanning the university.
- Facilitate the establishment of a robust network across the university to more effectively implement carbon neutrality priorities.
- Identify opportunities for cross-unit partnership to facilitate collaboration and increase efficiency.

- Support the efforts of the EL's office to accelerate progress and accountability at the unit and individual levels.
- Inform strategies to ensure that every unit leader develops, pursues, and is evaluated on critical carbon neutrality-related tasks that they have the authority to prioritize, control, and execute.

The makeup of the institutional advisory committee should include:

- Approximately 12 members who have deep knowledge of and responsibilities for university administration.
- Senior-level representation from executive offices, including but not limited to the offices of the Provost, Chief Financial Officer, Research, Government Relations, Student Life, and Communications.
- Representation from the Dearborn, Flint, and Ann Arbor (including Michigan Medicine and Athletics) campuses, as well as other key U-M constituencies (e.g., Detroit Center).
- A few senior-level representatives from academic units of different sizes.

Strategy Recommendation: Establish a community advisory committee to support the EL's office in developing, implementing, and communicating effective strategies for actuating carbon neutrality priorities, with a focus on understanding external stakeholder perspectives, learning from their experiences, and partnering whenever possible for mutual benefit.

Developing and implementing a strategic roadmap for carbon neutrality must be done through collaboration with representatives from community groups who are active in areas of overlapping interest (e.g., unions, advocates of public transit and affordable housing, city governments, etc.) and carried out with appropriate transparency. Implementing U-M's plan will affect many Michigan communities, and thus collaboration with the community partners is critical.

A key purpose of a community advisory committee is to ensure that the perspectives of diverse stakeholders are well represented and fully considered as U-M develops and implements its carbon neutrality plan. Membership should include the following groups:

- At least one graduate and undergraduate student representing large student organizations or communities.
- Representatives from each of the affected civic communities (Flint, Detroit, Dearborn, and Ann Arbor).
- Representatives from frontline communities, including at least one Indigenous representative and individuals who identify as Black, People of Color, low-income, or people with disabilities.

- Faculty from several university units with expertise in sustainability and carbon neutrality, including at least one environmental justice expert.
- Leaders of nonprofit organizations, advocacy groups, organized labor, and the business community with deep expertise and connections in carbon neutrality and/or environmental justice matters. Key external stakeholder groups, as identified by U-M, should select their own designee to represent their interests.

Key roles of the community advisory committee include:

- Act as liaisons with various stakeholder communities to help inform the public of actions that U-M is undertaking or considering and bring any concerns to the EL for the university to address.
- Inform the EL and other U-M leaders about negative or positive impacts of adopting particular goals and/or timelines and how such actions may be experienced by various communities within and outside of U-M.
- Advise the EL regarding partnership opportunities in the region, including building strong connections with other bodies that are advising carbon neutrality efforts in the region.
- Inform and advise the EL regarding developments external to U-M that could help or hinder progress on the university's carbon neutrality goals, such as technological advances, community needs, potential regulatory or policy changes that may impact U-M's carbon neutrality plans, and opportunities to scale or transfer solutions to wider audiences.
- Provide the EL and university leadership with an annual report on their view of U-M's progress toward carbon neutrality and how it could be improved and accelerated.

Refer to Appendix F for evaluation criteria related to the leadership structures recommendations.

Campus Planning

The Commission's recommendations touch every aspect of the university's activities and will require changes across all three campuses, in every division, unit, and department. Their implementation will involve behavioral and culture changes by actors at every organizational level and throughout the campus community.

As described in the Heat and Power Infrastructure section of this report, achieving carbon neutrality for Scope 1 emissions will involve integrating decision-making related to buildings and land through district- and campus-level planning. For Scope 3 emissions—and in particular commuting—it is likewise crucial to implement decision-making that integrates an understanding of the way people interact with, and move through, places of various scales, thereby generating efficient and effective solutions that strategically address district and campus-scale problems.

U-M's Finance and Capital Projects Committee currently leads the production of annual reports on campus plans. These reports articulate a master plan for the university's large projects with a five-year time horizon and detail current and upcoming project requests that will be presented to the Board of Regents, with associated justifications. The university's planning staff possess significant expertise, but the planning process does not presently incorporate carbon neutrality as a key consideration. Although sustainability initiatives and projects are discussed, they are currently treated as supplemental aspects of existing projects or as opportunities to demonstrate leadership when they do not distract from existing priorities.

As the university moves forward with carbon neutrality commitments, its planning efforts must expand to include emissions mitigation and climate resilience as core considerations. Effective engagement must be central to these planning efforts, as U-M community members have indicated that it is currently difficult to engage with the planning process, hampering their ability to make decisions at the unit level.

To ensure that the solutions recommended in this report have the greatest possible impact, U-M must intentionally plan its land and space usage on each campus and apply targeted solutions to address campus-specific problems. In doing so, the university must include campus and local community voices in its planning processes while ensuring that clear expectations are developed for this engagement. To these ends, the Commission presents the following recommendation.

Strategy Recommendation: Create and update campus- and district-level master plans to reflect that emissions mitigation is one of the university's top priorities and update such plans at regular intervals with campus community input.

The university continues to invest billions of dollars in the construction of new clinical, classroom, research, and office buildings, and significant GHG emissions are attributable to these projects. The impacts include embodied emissions associated with the building materials, increased emissions associated with energy use in buildings, and increased emissions from commuting. Master planning is a critical tool to frame and address emissions and operations-related challenges as the university moves toward carbon neutrality.

Planning efforts at the district and campus levels can help U-M optimize the utilization of existing space and minimize emissions. For example, a master plan designed with community input can challenge assumptions around the need to grow and identify opportunities to solve space challenges in more efficient and environmentally conscious ways. Engaged planning can also help communicate why projects that expand infrastructure in the short term fit within a long-term vision for a carbon-neutral university. U-M should equip Facilities and Operations to elevate its planning work with a greater focus on engagement and provide tools and resources so that organizational units can better understand and pursue planning efforts with a focus on achieving carbon neutrality.

Resilience is the ability of a system and its component parts to anticipate, absorb, accommodate, or recover from the effects of a potentially hazardous event in a timely and efficient manner.[12]

Carbon-focused planning efforts also serve an important role in resolving decisions around "scope transfers," wherein a decision is made that results in Scope 1 or Scope 2 emissions becoming Scope 3 emissions, or vice versa. Effective planning to understand the impacts of scope transfer is especially important where the university is evaluating whether and when to move operations currently housed in leased spaces back on campus to be integrated with the low/no carbon systems and where the university is considering expanding on-campus housing to reduce Scope 3 commuting emissions.

12 Refer to page 34 of https://www.ipcc.ch/site/assets/uploads/2018/03/SREX-Chap1_FINAL-1.pdf.

To ensure that plans are well supported by experience and are useful to stakeholders in organizational units, the planning, creation, and auditing processes must be transparent, comprehensive, and inclusive, involving stakeholders who extend far beyond the leadership of departments and units. Staff, faculty, students, and members of local communities are all affected by the university's infrastructure decisions. Planning processes, therefore, provide an opportunity to engage these individuals, create buy-in to the university's plans, and resolve roadblocks to the university's long-term strategic vision. Such processes should be followed by regular reviews and updates, ideally continuing the current practice of updates on an annual basis.

Finally, the university's planning must reflect a goal of limiting additions to its current emissions. To this end, prior to the approval of new construction, the university should prioritize enhanced space utilization in existing facilities according to its district and campus plans. And where new construction is necessary, its master plans should dictate locations and strategies that seek to minimize Scope 3 commuting-related emissions.

Strategy Recommendation: Prioritize central locations for construction projects and expand affordable campus housing for students, faculty, and staff based on an evaluation of needs and demand and considering issues of equity and climate change resilience.

Prior to the approval of new construction, the university should prioritize enhanced space utilization in existing facilities to minimize new building footprints and their associated emissions (e.g., ongoing energy use and embedded carbon in materials). When new construction projects are unavoidable, the Commission recommends that U-M focus future campus construction in central locations and prioritize renovating and rebuilding, as opposed to converting green space. For example, once centrally located parking structures reach the end of their viability, the land on which they sit should be considered for expansion of academic or other functions. The Commuting Analysis Report provides examples of existing structures that could be converted.

Limited housing availability and associated high prices on and near U-M's campuses (particularly in Ann Arbor) cause significant numbers of students, staff, and faculty to rely on carbon-intensive long-distance commutes. Providing these community members with the opportunity to choose short-distance commutes can reduce the carbon impact of the commute by facilitating walking, cycling, transit use, and shorter automobile trips. To this end, the Commission recommends that each U-M campus undertake a study in the near future to evaluate faculty, staff, and student needs for, and interest in, affordable housing on its campus. While students generally live closer to campus and

have a lower commuting footprint, more on-campus housing could be beneficial from a carbon footprint perspective because students live in smaller spaces, which would increase density. This, in turn, would reduce demand for energy-inefficient off-campus student housing, which should have positive impacts on reducing students' overall energy demand. Providing opportunities for lower-income staff and faculty to live on or close to campus could facilitate a decrease in the carbon impact associated with commuting and energy-inefficient housing. Drawing on the results of the needs-based analysis, U-M should work to accommodate community needs across all three cohorts.

In conducting its evaluations, it will be essential for U-M to engage with the campus communities, especially low-income constituencies, to understand the need for, and interest in, housing on each of the campuses. It will also be important to engage with local planning officials in the surrounding communities and representatives of affordable housing organizations, giving careful consideration to the unique circumstances of each campus's commuting populations.

After identifying specific needs, U-M should consider the following in the process of addressing housing on and near campus:

- Prioritize the use of land U-M already owns to create new affordable, net-zero housing.
- Accompany any increase in student enrollment with creation of a proportionate number of new affordable, sustainable housing units.
- Maintain the affordability of the housing over time.
- Consult and collaborate with the surrounding communities of Flint, Dearborn, Ann Arbor, and Ypsilanti, and relevant local organizations, regarding their affordable housing programs and policies.

Additional on-campus housing would likely reduce U-M's Scope 3 emissions and address housing inequities. However, it would also increase emission Scopes 1 and 2 until a carbon neutral energy infrastructure is in place. If the university pursues additional on-campus housing for faculty, staff, and/or students, the Commission encourages U-M to use the Building Standards Analysis on net-zero housing to inform best practices for this expansion.

Refer to Appendix E for specific evaluation criteria related to the Campus Planning recommendations.

The University of Michigan's strength in research is second to none in the United States—and possibly the world. In particular, U-M has many world-leading research groups spanning a wide variety of topics related to achieving carbon neutrality.

Strategy Recommendation: Make significant investments in research and its deployment on routes to achieving carbon neutrality.

Notable research areas include renewable energy generation; biosequestration; carbon capture, utilization, and storage; energy efficiency; electricity grid design and management; waste-to-energy systems; mobility; life cycle analysis; carbon pricing policies; and the social impacts of climate change. It is thus imperative, and indeed U-M's responsibility, to engage the broad spectrum of research, scholarship, and educational opportunities in providing solutions to the institutional and global challenges leading to carbon neutrality.

U-M should accelerate efforts to make the institution a thought leader in the broad areas related to carbon neutrality. This requires a significant emphasis on integrating existing research efforts spanning the physical, natural, engineering, and social sciences, as well as public policy and the arts and humanities. Integrating sustainability research and education across disciplines should be prioritized and will lead to opportunities for the university to attract significant external funding to take this work even further.

To accomplish this task, the university should invest significantly in carbon neutrality research and education as broadly defined above. The Commission recommends that U-M at least double the current $5 million fund to $10 million to support proposals from the university research community. Proposals should be selected via conventional peer review mechanisms with preference given to proposals that cross interdisciplinary boundaries, given the fundamentally interdisciplinary nature of effective climate change solutions. Furthermore, active measures should be taken to rapidly move the most promising nnovations into the private sector for commercialization, where they have the largest opportunity to provide value to the global community. Effective research should promote unique educational opportunities for graduate and undergraduate students alike, so that U-M students will come to be recognized as the most knowledgeable and effective contributors to this emergent field of study. An excellent model for managing this initiative is the recent Carbon Neutrality Acceleration Program for faculty research administered by the Graham Sustainability Institute.[13]

13 Graham Sustainability Institute Carbon Neutrality Acceleration Program: http://graham.umich.edu/carbonneutrality.

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Funds should be disbursed in a manner that best accomplishes the following goals:

- Provide realistic, scalable, transferable, and socially just solutions consistent with the charge of PCCN.
- Establish U-M as a global leader in broadly conceived carbon neutrality research solutions.
- Provide unique educational experiences in both the classroom and research lab, to provide a breadth of training in all of the multi- and interdisciplinary aspects of carbon neutrality.
- Provide a platform from which large-scale external team funding can be attracted to U-M, such as National Science Foundation Engineering Research Centers, Materials Research Science and Engineering Centers, and Department of Energy Energy Frontier Research Centers.
- Provide internal and external visibility that emphasizes U-M's commitment to carbon neutrality, with research awards administered and tracked by an institute focused on carbon neutrality and energy.
- Provide a core activity that can attract external donor funding to sustain the initiative funding until the goal of carbon neutrality is achieved.

The initiative funds should be managed by an independent U-M entity that is best suited to this purpose and has strong backing and support from the central administration. For U-M to be successful in carrying out its carbon neutrality aspirations, it must invest significantly, and over the long haul, in assets necessary to organize and integrate the work, similar to what has been done around the biosciences.

To best ensure that research funds focus on developing innovations that lead to a reduction in carbon emissions, it is essential to ensure rapid translation into the private sector. For this reason, the Office of Technology Transfer should consider assigning a specialist with expertise in this area to focus on finding, licensing, and ultimately ensuring that innovations with technical, policy, and social impacts on reducing carbon footprints are made available for the public good in the most expeditious manner. With the support of its academic institutes and centers, U-M should endeavor to facilitate the widespread uptake of innovative policy and social research solutions beyond the university.

Strategy Recommendation: Expand and prioritize carbon neutrality curriculum, training, and literacy programs for all members of the U-M community across all three campuses.

A priority building block toward achieving carbon neutrality is ensuring that the U-M community is engaged and educated to make daily choices that reduce carbon emissions where they live, learn, work, and visit. It is also crucial that they take their learned experiences with them beyond the campus and throughout their lives. To educate and prepare the U-M community, the Commission recommends that the university prioritize baseline carbon neutrality educational modules that are used on all three U-M campuses. The university community is a diverse collection of individuals with varying priorities and levels of interaction with the institution. As U-M moves toward carbon neutrality, it will be essential that it develop educational opportunities for faculty, staff, students, community members, and visitors to contribute toward our carbon neutrality goals. The education, involvement, and accountability of U-M community members throughout their time at U-M is critically important for the university to achieve its carbon neutrality aspirations.

Student orientation | Courtesy of U-M Office of New Student Programs

Orientation programs

Orientation programs are a critical touchpoint for new students, faculty, and staff. In addition to building carbon neutrality content into in-person onboarding activities, all incoming community members should be required to complete an introductory training on U-M's sustainability programs and carbon neutrality goals, with an emphasis on why they are important and how community members can contribute in meaningful ways. The Planet Blue Ambassador program offers an established platform for educating the broad community and worked with U-M Student Life to develop and pilot an online orientation module during 2020. This module could be tailored to the specific student, faculty, and staff experience in the future. As U-M sets carbon neutrality goals, the Commission recommends that a training module be expanded to include Flint and Dearborn and updated to address new goals, information on the projects driving U-M toward carbon neutrality, and ways that members of the university community can participate. The Commission advises adapting the orientation programming with details specific to the Ann Arbor, Dearborn, and Flint campuses and for remote employees and students. Key topics for inclusion include environmentally friendly food choices, carbon-friendly travel alternatives, opportunities to reduce the carbon intensity of the commute, U-M workplace and classroom sustainability features, and environmental justice. Orientation programming should also publicize educational materials that are tailored for specific audiences, such as climate-friendly retirement investment options offered by U-M's retirement account providers (Fidelity and TIAA-CREF) in a readily available and accessible format. According to the Campus Culture and Communication Analysis Report, U-M's Human Resources office, which oversees retirement benefits, is able to identify specific funds that invest in low and no carbon options and would be willing to offer workshops for employees to make them aware of these investment options.

Curriculum

Curriculum is another major touchpoint for U-M students. The university is responsible for educating and preparing almost 65,000 undergraduate and graduate students across all three of its campuses each year, many of whom go on to pursue careers that create meaningful and lasting change in global society. As a result, U-M has a responsibility to ensure that each student, no matter their field of study, is prepared to engage with the global challenge of climate change and be part of a just solution in their industry or chosen field of endeavor.

Because different students and departments have varying needs and degree requirements, the Commission asserts that developing a single mandatory

course for all undergraduate and graduate students is unrealistic. Rather, every academic unit should be tasked with developing their own course on how climate intersects with their particular academic focus and/or build climate and carbon neutrality concepts into their core curricula for both undergraduate and graduate students. The university should establish planning grants or similar incentives to support these efforts (see Leadership Structures section). This would allow each U-M student to learn both how climate change affects their chosen field of study and how their chosen field of study can be a part of global solutions. It also provides academic units with opportunities to develop cutting-edge pedagogical approaches that can be replicated at other universities. This curriculum requirement should be integrated into the annual reporting and review process for each academic unit.

The university should also establish an ad hoc committee to document all existing courses that are relevant to climate and carbon neutrality and draw particular attention to those that approach the issue holistically where issues of ethics and environmental justice are integral. These courses should be highlighted in multiple formats (e.g., fact sheets, web pages) and in multiple forums at key points throughout the student experience as well as in locations that are visible to current and prospective U-M community members.

Widespread and frequent educational cues

Widespread and frequent educational cues will be critically important to remind the U-M community how their choices impact the environment and the university's carbon neutrality goals. Carbon neutrality is a community-wide endeavor that must be systematically communicated as faculty, staff, students, and visitors interact with the institution in their daily lives. Educational materials (e.g., information packages, signage, art installations) will provide community members the tools, inspiration, and encouragement necessary to make daily decisions in support of carbon neutrality. Some key subject areas to highlight include environmentally responsible food choices, carbon-friendly travel alternatives, and methods to reduce the carbon intensity of the commute. Avenues to reach the U-M community on a regular basis include general communication mechanisms, such as e-mail, social media, and signage, as well as more targeted materials for grant awards, scholarships, study abroad, office administration, housing, dining halls, labs, and parking passes. Cues to promote education and behavior change should also be integrated with building systems to the extent possible. For example, all campus buildings equipped with advanced metering should include transparent data readouts to easily understand the building's energy performance and how it compares to other, similar structures.

Strategy Recommendation: Invest in institutional structures to expand and support carbon neutrality-focused "living-learning labs" across all three U-M campuses.

Over the past ten years, the University of Michigan has created many "living-learning lab" programs and activities across campus that advance education and research and accelerate its sustainability goals. Some of the existing initiatives include the Campus Farm, the Sustainable Living Experience at Oxford Residence Hall, Michigan Dining sustainability programs, Planet Blue Student Leaders, and the Planet Blue Ambassador program.

In pursuing the carbon neutrality strategies recommended throughout this report, and in line with guidance from the Campus Culture and Communication Analysis Report, the Commission recommends that U-M invest in hands-on educational and research opportunities for students and faculty that highlight U-M's carbon neutrality efforts and support the university's core mission. A successful living-learning lab program requires investments in the organizational assets needed to incentivize and coordinate bottom-up and top-down collaborations between individual units and centralized organizational structures. Expansion of these efforts should be done in collaboration with external partners, including surrounding municipalities, local organizations, and corporations.

Participants in the student-driven U-M Campus Farm program on-site at the Matthaei Botanical Gardens | By Jeremy Moghtader

Solar picnic table | Courtesy of U-M Office of Campus Sustainability

Living-learning laboratory programs create a visible way for the U-M community to engage in the places where they live, work, learn, and visit. They establish a direct connection between transforming the campus operationally and integrating those efforts with research, education, and student life, making them excellent opportunities for donor-supported funding. Whenever possible, these efforts should include community partners to accomplish shared goals and extend learning to the broader communities surrounding U-M's campuses.

Some examples of such opportunities include:

- Cultivate the campus landscape to increase biosequestration while providing visible examples of U-M's commitment to carbon neutrality. Potential projects could involve increasing canopy cover through tree planting, replacing turfgrass with environmentally friendly alternatives, and establishing green infrastructure on campus (rain gardens, native gardens, bioswales, and green roofs). Find more information in the Biosequestration Analysis Report.
- Construct a sustainable and affordable net-zero residential building in U-M's cold climate region to demonstrate its feasibility.
- Ensure both larger-scale renewable energy installations (e.g., photovoltaic arrays, geo-exchange systems) and smaller demonstration projects (e.g., Solar Block M) are accessible for educational purposes (see Scope 1 Emissions Reduction Strategies section).
- Expand plant-forward diets across dining halls and food service locations on all three campuses (see University-Procured Food section).
- Expand waste reduction, composting, and recycling programs across all U-M campuses (see Solid Waste and Wastewater section).

- Explore the use of Positive Impact Points (PIPs) to encourage daily sustainable behaviors by U-M students.[14]
- Invest in carbon offset projects that support and expand education and research opportunities for the U-M community (see Carbon Offsets).
- Support student and faculty research projects focused on carbon neutrality challenges at an increased level from current investments (see Research and Education section).
- Establish student work-study positions and academic opportunities (e.g., U-M Law School's Problem Solving Initiative) to help evaluate and implement priorities.[15]

Widespread knowledge and awareness throughout the community will be essential for U-M to realize the Commission's vision for carbon neutrality, and these efforts can be enhanced by drawing on relevant faculty expertise. U-M must educate the community on why it is taking sustainable actions and what the positive impact of such changes will be with regard to carbon neutrality. The goal must be to capture the hearts and minds of the community to make these changes a permanent and shared cultural ethic.[16] These efforts will provide community members with tools, resources, and strategies that they can employ at home and in other areas of their lives. U-M's communication efforts around carbon neutrality must be consistently delivered across multiple channels (e.g., publications, e-mail, social media, signage, and more targeted materials) and originate from the highest levels of the administration to ensure resonance throughout the university and with external stakeholders.

Refer to Appendix F for more specific evaluation criteria related to the Research and Education recommendations.

14 For more on Positive Impact Points, refer to their website: https://www.pipsrewards.com/ourstory.
15 For more on the Law School's Problem Solving Initiative, refer to their website: https://problemsolving.law.umich.edu/.
16 Progress can be measured and tracked over time through the Sustainability Cultural Indicators Program.

External Collaboration

The climate crisis is a global issue that requires coordinated action to solve, and collaboration will be critically important to the success of U-M's carbon neutrality efforts.

For the university to have maximum impact, it must intentionally, deeply, and wisely engage with external stakeholders, partners, peers, and constituents. Engagement with a wide array of external stakeholders will provide U-M with valuable perspective, information, and support while moving forward to create scalable and transferable solutions that advance action on climate change beyond its three campuses.

External collaboration includes multi-directional and strategic partnerships that involve both engagement and communication with stakeholders. U-M must seize the opportunity to establish a model of effective external collaboration that other institutions will emulate as they pursue their own paths to carbon neutrality. With that ambition in mind, the key priorities of external collaboration for carbon neutrality, as suggested by the External Collaboration Analysis Report, are to:

- Ensure that proper skills, knowledge, and support are brought to the university so that it meets its carbon neutrality goals.
- Create an inclusive and equitable process that builds trust with affected frontline communities, ensuring that they have a powerful voice in implementation efforts.
- Identify collaboration opportunities and obstacles to overcome.
- Coordinate activities with external partners in pursuit of shared carbon neutrality objectives.
- Create an environment in which all relevant stakeholders' concerns are heard, addressed, and accounted for to ensure viable solutions.

To accomplish these priorities, the Commission recommends the following.

Strategy Recommendation: Conduct targeted network mapping related to all carbon neutrality strategies and pursue intentional engagement with key stakeholders to inform implementation.

As U-M begins implementing the recommendations set forth in this report, it must identify and characterize the interests of the U-M stakeholder community, including underrepresented communities and constituents linked to the Dearborn and Flint campuses. The unit tasked with leading U-M's carbon neutrality efforts must work with U-M's existing external relationship managers, such as the Office of Government Relations, the Business Engagement Center, and the Ginsberg Center, to help identify external stakeholders. Key stakeholders should also be identified through discussions with other constituencies,

such as student groups, community advocacy organizations, environmental justice experts, municipalities, and labor unions. It is critical that this mapping be done with both internal and external groups to guarantee that currently underrepresented groups are included. This will help U-M identify the different types of engagement strategies and approaches that will be required for success.

Once U-M establishes a high-level network map, collaborators and stakeholders specific to individual recommendations should be identified, prioritized, and engaged. This will be an ongoing and evolving process as U-M progresses toward its carbon neutrality goals. The proposed carbon neutrality office, with embedded environmental justice expertise, offers a space to build such infrastructure, networks, and partnerships.

U-M should also engage closely with comparable efforts being pursued throughout southeast Michigan. This includes identifying and facilitating interconnections with the carbon neutrality plans for Ann Arbor and Washtenaw County; GHG reduction plans in Detroit, Flint, and Dearborn; and the 2030 Districts for Ann Arbor and Detroit. Areas for possible partnership include working with local communities on collaborative approaches for transitioning off-campus student housing properties toward carbon neutrality, and jointly funding a center, such as the Vancouver City Studio, where city staff, faculty advisors, and key partners collaborate on long-term projects.[17]

U-M should also pursue a partnership network with other universities in southeast Michigan to share best practices and lessons learned. This type of collaborative network can accelerate progress at the institutional level and identify opportunities for collective action, including joint research projects and public policy advocacy for accelerating solutions. Along similar lines, Michigan Medicine should work with the Michigan Hospital Association and its members to share best practices and develop collaborations that help all Michigan health care organizations move toward carbon neutrality more quickly.

The university should consult all relevant stakeholders via outreach, with a particular focus on those who will be the most critical in helping U-M to achieve its carbon neutrality goals and communities that will be most impacted by its plans. While some constituents who work directly with the university may be relatively easy to identify, those from underrepresented and front-line communities in and around U-M may require proactive efforts to achieve meaningful engagement. Inclusivity and justice considerations should be prioritized alongside technical and commercial considerations.

17 For more on the Vancouver City Studio partnership, refer to their website: https://citystudiovancouver.com/.

Strategy Recommendation: Tailor carbon neutrality communication and education for specific audiences and expand opportunities for stakeholder input.

For external collaboration and partnerships to be successful, U-M must tailor its outreach and expand opportunities for stakeholder engagement. To do so, the university should develop specific communication and outreach programs for engaging various stakeholder groups that are identified through its stakeholder mapping exercise, while acknowledging the varying levels of sustainability and carbon neutrality literacy of each external community. U-M should meet each stakeholder group where they are; facilitate education when relevant; always employ cultural humility; be open, be ready, and expect to learn; and share decision-making. Doing so will lead to deeper and more sustained collaborations that center environmental justice. Additionally, these relationships will enhance the university's ability to scale and transfer solutions.

Special consideration should be given to engaging communities that may lack the resources or knowledge to engage effectively with the U-M campuses. To address this, U-M should create and adapt feedback channels that invite input from the external community in an inclusive manner. Existing feedback structures (e.g., vendor solicitations, surveys, Regents' meetings) should be adapted to intentionally solicit input on carbon neutrality efforts, and new channels should be established that are squarely focused on these issues. All feedback channels should be widely promoted and attentive to managing expectations, such as how stakeholder input will be handled by the university.

Refer to Appendix G for evaluation criteria related to the External Collaboration recommendations.

Clockwise from upper left: Michigan State Capitol by Brian Charles Watson via Wikimedia Commons | Voting on campus by Michigan Photography | Monument to Joe Louis by William Baule | Graham Scholars courtesy of Graham Institute | Across Difference: DEI Gratitude Symposium by Michigan Photography | U-M students and farmers at Asbury Farms, Flint, Michigan, by Jamie Lee

Wind turbines in Michigan | Courtesy of DTE Energy

NEUTRALITY GOALS AND EMISSIONS MITIGATION STRATEGIES

This section provides recommendations regarding carbon neutrality goals across all three greenhouse gas emission scopes and associated strategies for how those goals can be achieved. For emission Scopes 1 and 2, it addresses how U-M can transform its energy infrastructure, operate its buildings more efficiently, source 100 percent renewable electricity, and transition to a carbon-free vehicle fleet. It also describes numerous strategies to mitigate and improve accounting for various Scope 3 emissions, such as those related to commuting, university travel, food, waste, leased space, and building materials. Finally, it provides guidance on carbon offsetting strategies that can be employed until all emissions are fully eliminated.

Emission Scopes 1 and 2

This section provides information on U-M's greenhouse gas (GHG) emissions for Scopes 1 and 2 as well as recommended timelines, pathways, and strategies for achieving carbon neutrality.

CARBON NEUTRALITY GOAL SUMMARY

The following are recommendations for establishing carbon neutrality goals for emission Scopes 1 and 2.

SCOPE 1 EMISSIONS

Commit to carbon neutrality (inclusive of offsets) for Scope 1 emissions across all three campuses by 2025.[18,19]

Prioritize direct emissions reductions for Scope 1 by setting a goal of eliminating them across all three campuses by 2040 and exceeding global science-based targets via direct emissions reductions (i.e., without offsets) along the way.

SCOPE 2 EMISSIONS

Commit to carbon neutrality for Scope 2 emissions across all three campuses (i.e., Ann Arbor, Dearborn, and Flint) by 2025 or earlier.

Greenhouse gas emissions (GHGs) are gaseous compounds released into the atmosphere that absorb infrared radiation, trap heat, and contribute to the warming of the planet. Carbon dioxide and methane are two common GHGs.

18 Refer to Carbon Offsets and Sinks section for additional context.
19 When preceding a goal date within a recommendation, "by" means that the goal should be achieved before the end of that calendar year.

Boundaries and Baselines

Scope 1 emissions are generated from the combustion of natural gas in distributed boilers, the North Campus Research Complex power plant, the Central Power Plant (CPP), and the Hoover Heating Plant on the UM-Ann Arbor campus; the Central Steam Heating Plant on the UM-Dearborn campus; and the Central Energy Plant on the UM-Flint campus; as well as combustion of transportation fuels in fleet vehicles (buses and other U-M owned vehicles).

Scope 2 emissions are those associated with electricity purchased from DTE and Consumers Energy (and suppliers of smaller U-M facilities, such as Camp Davis). These emissions depend on the mix of fuels used by the electricity generators.

Recent Scope 1 Emissions Profile

	FY2017	FY2018	FY2019	FY2020
Ann Arbor Campus Scope 1 Emissions ($MTCO_2$)				
Natural Gas	280,000	280,000	270,000	270,000
Transportation Fuel	7,300	7,300	7,300	6,200
	287,300	**287,300**	**277,300**	**276,200**
Dearborn Campus Scope 1 Emissions ($MTCO_2$)				
Natural Gas	7,000	7,200	5,900	5,500
Transportation Fuel	170	170	200	170
	7,170	**7,370**	**6,100**	**5,670**
Flint Campus Scope 1 Emissions ($MTCO_2$)				
Natural Gas	7,000	7,500	7,500	7,000
Transportation Fuel	240	230	210	180
	7,240	**7,730**	**7,710**	**7,180**
U-M Scope 1 Emission Total ($MTCO_2$)	**301,710**	**302.400**	**291,110**	**289,050**

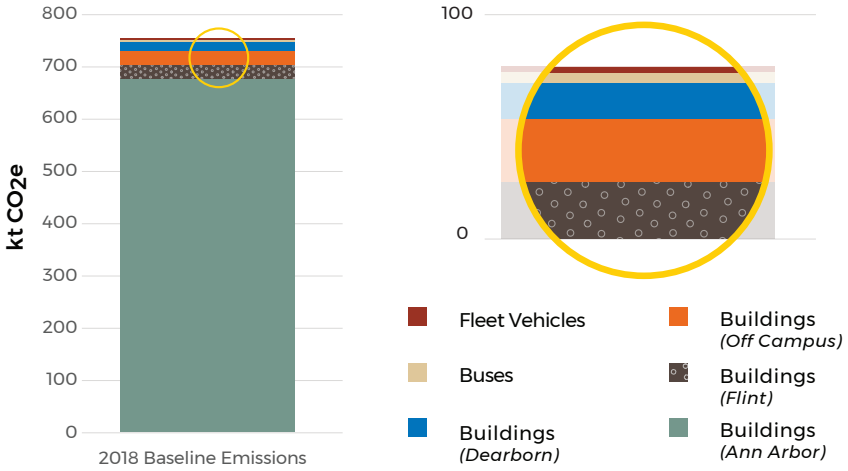
Recent Scope 2 Emissions Profile

	FY2017	FY2018	FY2019	FY2020
Ann Arbor Campus Scope 2 Emissions ($MTCO_2$)				
Purchased Electricity	360,000	340,000	370,000	320,000
Dearborn Campus Scope 2 Emissions ($MTCO_2$)				
Purchased Electricity	17,000	17,000	15,000	13,000
Flint Campus Scope 2 Emissions ($MTCO_2$)				
Purchased Electricity	21,000	22,000	20,000	17,000
U-M Scope 2 Emission Total ($MTCO_2$)	**398,000**	**379,000**	**405,000**	**350,000**

Baseline Emissions for Scopes 1 and 2

The Commission applied a 2018 baseline for its carbon neutrality goal recommendations—primarily because 2018 was the last full year preceding the Commission's launch and 2018 data were used for various analyses that informed the recommendations in this report. While the IPCC uses a 2010 baseline for emissions reduction guidance, using a 2018 baseline is slightly more aggressive because U-M's Scopes 1 and 2 emissions were 6 percent lower in 2018 than they were in 2010.[20]

Figure 1. Baseline GHG emissions for Scopes 1 and 2 (2018), including fleet vehicles, buses, and university-owned buildings.



Neutrality Goals

Goal Recommendation: Commit to carbon neutrality (inclusive of offsets) for Scope 1 emissions across all three campuses by 2025.

The urgency of the global climate crisis demands that U-M move quickly to achieve carbon neutrality because long-established institutions in wealthier nations have an outsized obligation to move more quickly than the IPCC advises for global emission reductions. Until an organization no longer produces direct emissions through its activities, it cannot achieve carbon neutrality without investing in verified carbon credits and/or carbon removal or sequestration projects equivalent to the emissions it still produces.

20 http://ocs.umich.edu/resources/sustainability-data/environmental-metrics/

Scope 1 GHG emissions come from sources controlled by U-M, such as the Central Power Plant, boilers in buildings, and buses.

As described in the recommendation below, eliminating direct reductions should be a university priority. However, transforming U-M's infrastructure to eliminate its Scope 1 emissions will be complex and costly and will take decades to complete. Therefore, the Commission recommends that, in order to demonstrate leadership in achieving neutrality, verified carbon credits and offset projects be a central strategy for U-M to achieve carbon neutrality in the near term. This recommendation is based on a set of assumptions around the quality of carbon credits and offset projects, which are outlined in the Carbon Offsets and Sinks section along with specific recommendations for the use of offsets.

An important assumption underlying this recommendation is that the use of offsets to help meet this goal is financially responsible. Expected carbon offsetting costs for U-M to achieve a Scope 1 carbon neutrality goal are relatively low compared to carbon reduction capital costs and the expected benefits from climate mitigation. Carbon accounting modeling shows that the cumulative Scope 1 emissions that need to be offset are 6.5 million $MTCO_2e$ between 2025 and 2050 (see Carbon Accounting Modeling Project report), assuming U-M implements the Commission's recommendations for transforming its energy infrastructure and other Scope 1 emissions reduction strategies. This translates to $65 million based on an offset cost of $10/$MTCO_2e$, which can be compared to the $3.5 billion capital cost estimate for transforming campus energy infrastructure to be emissions free. The two orders of magnitude between these costs also suggests that the purchase of offsets at current prices will not come at the expense of the potential acceleration of large-scale local emissions mitigation, especially when assumptions of technological advancement are taken into account. Using a social cost of carbon of $50/$MTCO_2e$, the societal benefits of this offset investment would be $325 million of avoided climate change damages. These benefits of mitigation are expected to be valued significantly higher when considering that more recent estimates of the social cost of carbon range from $100–$200/$MTCO_2e$.[21] More information regarding offset costs can be found in the Carbon Offsets and Sinks section.

21 Nuccitelli, D. (2020, July 30). The Trump EPA is vastly underestimating the cost of carbon dioxide pollution to society, new research finds. *Yale Climate Connections*. https://yaleclimateconnections.org/2020/07/trump-epa-vastly-underestimating-the-cost-of-carbon-dioxide-pollution-to-society-new-research-finds/

Significant co-benefits can result from investing in carbon offsets to achieve Scope 1 neutrality earlier than the technological and logistical barriers of achieving technical neutrality would otherwise permit. These benefits include providing a target that will engage the full U-M community to take early action, demonstrating U-M leadership in addressing the climate crisis, attracting alumni and private and public sector partners to collaborate and innovate, and taking advantage of incentives and opportunities that may emerge due to evolving policy landscapes at the state and federal levels. Early action could also result in utility cost and emissions savings through a community-wide effort to learn and adopt conservation and efficiency measures.

While a majority of commissioners supports a 2025 carbon neutrality goal for Scope 1 emissions that relies on carbon offsets, a minority of commissioners believes that a heavy reliance on offsets is not the optimal path to meeting earlier goal dates for achieving carbon neutrality for Scope 1 emissions. The rationale for this opinion stems from the limited financial and human resources available to the university and a belief in the urgency and importance of reducing on-campus emissions prior to using those same resources to pay a third-party to reduce global emissions via offset purchases. In their view, using funds otherwise invested in offsets to focus squarely on direct reductions in the near term will accelerate progress and more quickly reduce U-M emission levels, ultimately reducing the number of offsets that would be needed to achieve neutrality.

Refer to Appendix H to read the full opinion.

Goal Recommendation: Commit to carbon neutrality for Scope 2 emissions across all three campuses (i.e., Ann Arbor, Dearborn, and Flint) by 2025 or earlier.

U-M should set this aggressive and ambitious goal for Scope 2 emissions to address the urgent need to achieve global carbon neutrality. This goal would demonstrate U-M's commitment to addressing the local, regional, and global equity and justice challenges associated with greenhouse gas emissions and to engaging its campus communities, alumni, and public and private sector partners in that mission. The Commission recognizes that given the complexity and associated timeline for reducing direct emissions, achieving a 2025 neutrality goal for Scope 2 emissions will rely on purchased electricity that includes renewable energy certificates (RECs).

Scope 2 GHG emissions come from off-campus electricity generation plants and are associated with electricity sold to and used by U-M.

Goal Recommendation: Prioritize direct emissions reductions for Scope 1 by setting a goal of eliminating them across all three campuses by 2040 and exceeding global science-based targets via direct emissions reductions along the way.

The Science Based Targets Initiative (SBTi) holds that only direct emissions reductions should be counted as progress toward science-based targets (e.g., achieving a 45 percent reduction by 2030)[22] and that carbon credits and offsets should only be counted when going beyond science-based targets in pursuit of carbon neutrality. The Commission embraces this guidance and recommends U-M achieve direct reductions at a more aggressive pace than outlined by SBTi guidelines.

The Commission recommends that U-M eliminate direct emissions as soon as possible and no later than 2040. This is thought to be achievable based on the plans proposed by the Commission's external consultant (Integral Group), with modest additional assumptions about technological advancement in the coming decades. An offsets-based goal alone is insufficient to spur the transformation of technology, policy, markets, and behavior or to inspire research, education, and leadership on the technologies and solutions necessary to achieve global neutrality in environmentally just ways.

Science-based targets reflect the global GHG emission-reduction trajectory required to meet the IPCC guidance for holding global warming to 1.5°C above preindustrial levels.

22 Science Based Targets. (2020, April 1). SBTi Criteria and Recommendations. https://sciencebasedtargets.org/resources/files/SBTi-criteria.pdf

Timelines and Interim Targets

Figure 2 illustrates U-M emissions trajectories for Scopes 1 and 2 beginning with a 2018 baseline and continuing until 2050.[23] The dashed red line reflects a business-as-usual (BAU) scenario for Scope 1 and Scope 2 emissions, taking into account actions that U-M already has underway, including the Central Power Plant upgrade, the recent renewable power purchase agreement with DTE Energy, and energy conservation measures on campus. The BAU case, defined as continuing on our current course without taking extraordinary measures to reduce carbon emissions, includes changes to the electricity fuel mix at DTE and Consumers Energy that are projected to take place between now and 2050. The remaining trajectories include the same assumptions as the BAU case but reflect the Commission's recommended goals and strategies for mitigating emission Scopes 1 and 2 and achieving carbon neutrality across both scopes by 2025.

The area shaded in dark blue represents Scope 2 emissions, which are fully mitigated in 2025, in line with the Commission's recommendation that all of U-M's purchased electricity come from renewable sources.[24] The area shaded in hatched blue represents Scope 1 emissions, which decrease over time, mostly attributable to the strategies outlined in the Heat & Power Infrastructure section and additional technological advancement assumptions projected by the Commission. The area shaded in green below the net-zero line (x-axis) represents the projected emissions that would need to be offset to achieve carbon neutrality for Scope 1 emissions for all years between 2025 and 2040. As Scope 1 direct emissions decrease, fewer carbon offsets will be required over time to maintain carbon neutrality.[25] The total area shaded in dark and light blue represents cumulative emissions for Scopes 1 and 2 as estimated and reported by the Carbon Accounting subgroup, which could be considered a rough carbon budget for cumulative university emissions going forward. The sharp drop in 2040 reflects a Commission assumption that inevitable technological advancements will enable U-M to achieve zero emissions more quickly than the current carbon accounting model projects.[26]

23 These estimates are based on the Carbon Accounting group model and differ from emission values reported by OCS. The carbon cccounting model estimates, which include Integral's baseline assumptions, use different system boundaries, emission factors, and GWP values than OCS. Integral's baseline includes new buildings under construction (e.g., Clinical Inpatient Tower, Ford Robotics). Integral's work is also the basis for modeling the transition from the current heating and cooling systems on U-M campuses to GHX systems. This transition was a major component of Scopes 1, 2, and 3 emissions trajectories. The Carbon Accounting Modeling group used Argonne.

24 The procured electricity generates renewable energy certificates (RECs) that are retired by U-M or on its behalf.

25 Refer to the Carbon Offsets and Sinks section for more information on carbon offsets and associated costs.

26 The carbon accounting model applied timeline estimates provided by the Integral Group, which resulted in a more gradual decline to zero emissions between 2045 and 2050. Refer to the Carbon Accounting Modeling Project Report for additional information on the accounting model and emissions reduction scenarios.

Figure 2. Emissions trajectories for Scopes 1 and 2

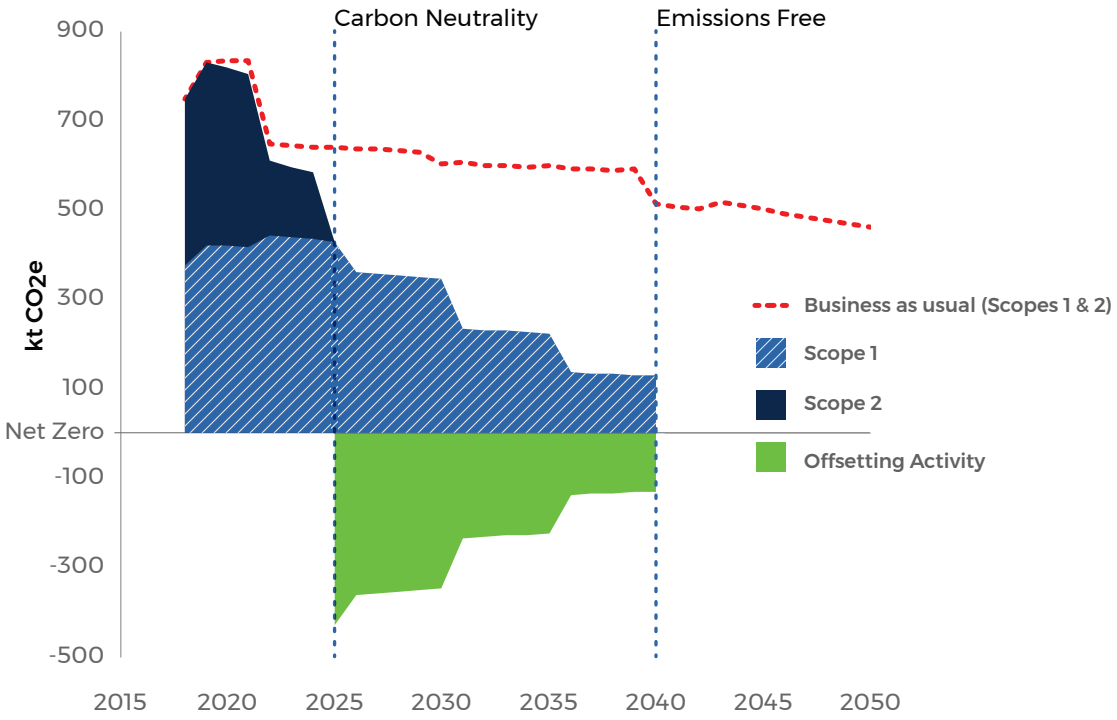


Figure 2 illustrates U-M emissions trajectories for Scopes 1 and 2 beginning with a 2018 baseline and continuing until 2050. The ***red line*** reflects a BAU scenario for total Scopes 1 and 2 emissions, taking into account actions that U-M already has underway. The ***dark blue section***, which represents Scope 2 emissions, drops off in 2025, when the Commission recommends that all of U-M's purchased electricity come from renewable sources. The ***hatched blue section*** represents Scope 1 emissions, and the ***green section*** under the net-zero line represents the projected emissions that need to be offset to achieve carbon neutrality for Scope 1 emissions for each year between 2025 and 2040. As Scope 1 direct emissions decrease, fewer carbon offsets will be required over time to maintain carbon neutrality.

Carbon offsetting occurs when an organization counterbalances its direct emissions by investing in, or purchasing credits associated with, verifiable emissions reduction or sequestration efforts somewhere on the planet.

STRATEGY RECOMMENDATIONS SUMMARY

The recommendations in this section represent what the Commission has determined to be the most impactful strategies for eliminating emissions for Scopes 1 and 2 across all U-M campuses based on demonstrated and proven technology. These recommendations are intentionally designed to be complementary, working together to fundamentally transform the university's approach to energy sourcing and conservation. This monumental transformation is centered on four key actions:

- Convert U-M's heating and cooling infrastructure from natural gas-fueled systems to medium temperature hot water systems that are powered by carbon-free sources (e.g., renewable electricity);
- Ensure that all electricity generated on campus and all electricity purchases clearly map to carbon-free generation sources;
- Implement university policies that reduce energy demand by fostering technological energy efficiency in campus buildings and conservation behaviors among campus community members; and
- Fully decarbonize the university's transit system, vehicle fleet (buses, trucks, van, and cars), and maintenance equipment.

All funded opportunities should be pursued in a manner that allows students and faculty across all three campuses to engage in this process to enhance research and co-curricular carbon neutrality programming.

Solar field in Detroit | Courtesy of DTE Energy

This table provides generalized comparisons of the recommendations in terms of the necessary financial investment and culture shift required at institutional, unit, and/or individual levels throughout the university community. These are subjective judgments based on the best available information and are for illustrative purposes only.

STRATEGY RECOMMENDATION	FINANCIAL INVESTMENT ($ — $$$$$)	GHG LEVELS ↓ — ↓↓↓↓↓	CULTURE SHIFT (L—M—H)
HEAT & POWER INFRASTRUCTURE			
Embark on a phased, district-level approach to converting U-M's heating and cooling infrastructure to be fossil fuel free, beginning with electrified systems centered on geo-exchange with heat recovery chiller technology and with the flexibility to pivot to other proven technological solutions as they emerge.	**$$$$$**	**↓↓↓↓↓**	**Low**
FLEET VEHICLES AND EQUIPMENT			
Fully decarbonize U-M's transit system, vehicle fleet (buses, trucks, and automobiles), and maintenance equipment.	**$**	**↓↓**	**Low**
PURCHASED ELECTRICITY			
Issue a request for proposal (RFP) to procure all purchased electricity for U-M's three campuses in a manner that generates renewable energy certificates that are retired by U-M or on its behalf, aligns with the principles outlined by the Commission, and seeks the desired co-benefits outlined for carbon offsets.	**$$**	**↓↓↓↓**	**Low**
Engage with the Cities of Ann Arbor, Dearborn, Detroit, and Flint and other entities that are, or could be, partners in advocating for renewable electricity policy changes in the State of Michigan to better understand their perspectives, conduct necessary due diligence, and potentially partner in advocacy efforts that reflect mutually shared objectives as well as actively explore ways to partner directly in pursuit of carbon neutrality goals.	**$**	**n/a**	**Med**
REVOLVING ENERGY FUND			
Create a Revolving Energy Fund on each of U-M's three campuses.	**$**	**↓↓↓**	**Med**
CARBON PRICING			
Establish a carbon pricing system at the organizational unit level across U-M where revenue flows to the REF for new energy conservation measures.	**$**	**↓**	**High**
BUILDING STANDARDS			
Establish best-in-class CO_2 emissions targets across nine building types for all new construction and major renovations.	**$$$**	**↓↓↓**	**Med**

Scope 1 Emissions Reduction Strategies

HEAT & POWER INFRASTRUCTURE

At the onset of its work, the Commission issued a request for proposal seeking an engineering firm with deep expertise in developing concept studies for large and complex institutions to evaluate potential pathways for evolving heat and power generation infrastructure toward carbon neutrality. After a competitive process, the Commission selected Integral Group to conduct this analysis. The consultants identified and evaluated multiple options and recommended optimal strategies for the various campus locations and facility types based on technical feasibility, greenhouse gas emissions reduction potential, capital and operating costs, disruptions to campus activities, and other risks and uncertainties. Review Integral Group's summary report for more information. A comparative summary of various technology options can be found in Appendix I.

Strategy Recommendation: Embark on a phased, district-level approach to converting U-M's heating and cooling infrastructure to be fossil fuel free, beginning with electrified systems centered on geo-exchange with heat recovery chiller technology and with the flexibility to pivot to other proven technological solutions as they emerge.

The Commission endorses the general conclusions reached by its external consultant, Integral Group, for U-M to electrify and decarbonize its heat and power infrastructure using a highly energy efficient geo-exchange (GHX) system and heat recovery chiller technology to support campus thermal needs, with the system being powered by renewable electricity (see Scope 2 recommendation below). This option, which was also endorsed by the Building Standards Analysis, requires an eventual campus-wide conversion from steam distribution to medium temperature hot water (MTHW) distribution as well as the construction of new cooling distribution networks. This also requires the conversion of high temperature hot water and steam building heating systems to accommodate MTHW, though some older buildings may have oversized radiators that could potentially deliver sufficient heat using MTHW without modification.

Geo-exchange (GHX) systems use the natural ambient temperature of the ground as a free energy source. The advantage of a GHX system is that it is extremely efficient compared to a traditional plant with boilers and chillers.

Geo-exchange is a process that leverages the Earth's constant subsurface temperature to improve the efficiency of thermal energy systems. According to the Integral Group report:

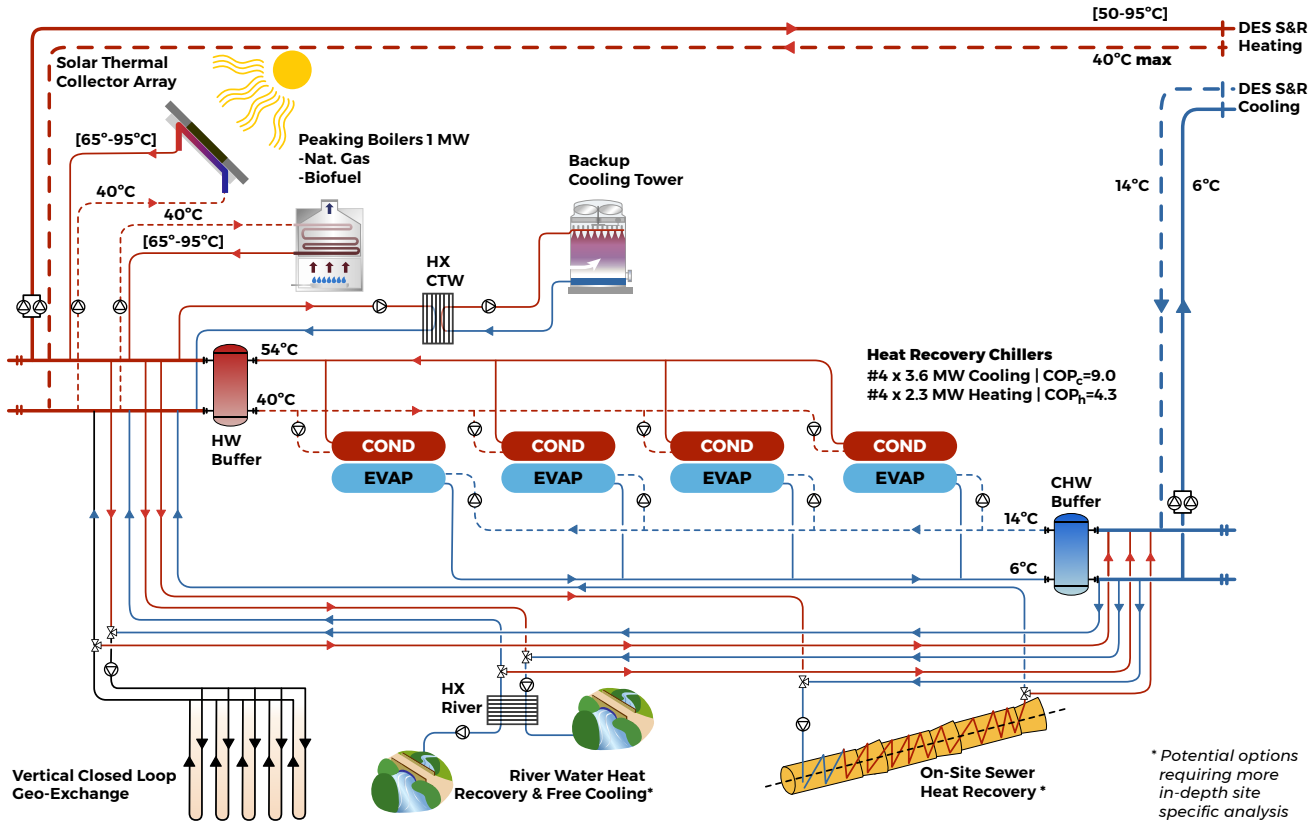
> *Geo-exchange (GHX) systems use the natural ambient temperature of the ground as a free low-grade energy source. The system is relatively low temperature and is normally equal to the annual average air temperature of the region, meaning it can be used as either a heat sink (for heat rejection), or as a low-grade heat source (for heat extraction). GHX systems consist of either "open-loop" wells using groundwater in a non-consumptive manner as a heat source or sink, or a "closed-loop" system typically constructed of a buried closed-loop high-density polyethylene (HDPE) piping network within an array of boreholes drilled hundreds of feet deep.*
>
> *The advantage of a GHX system is that it is extremely efficient compared to a traditional plant with boilers and chillers providing heating and cooling separately. Heat Recovery Chillers essentially move heat around the district from where it is being rejected to where it is being consumed, rather than running boilers and chillers simultaneously to both remove heat from the buildings and reject it via a cooling tower, while continuing to burn fossil fuels to generate more heat. This is particularly relevant for a district consisting of varied building typologies (i.e., science laboratory vs. residence) with diverse demand types. This means there are some buildings that need cooling at the same time as others need heating.*

Geo-exchange is a proven solution that is compatible with U-M's three campuses. The Integral Group report summarizes the benefits, limitations/risks, and long-term outlook for many decarbonization options to support their proposal in Appendix I. A phased, district-level approach will allow U-M to learn as it goes, and if other viable and acceptable technological alternatives emerge during the transition period, U-M will have the option to modify the design of future phases accordingly.

For each of the six campus districts (Central/Medical, Athletic, East Medical, North Campus, Dearborn, and Flint), the Commission recommends geothermal heat exchange with heat recovery chiller technology, in some cases paired with complementary technologies as described in the Integral Group report. This option requires an eventual campus-wide conversion from steam distribution to medium temperature hot water distribution networks, which requires the conversion of existing high temperature building heating systems. For all campus districts, the proposed strategy involves integrating, reusing, and extending the existing chilled water networks as part of the new systems. All campus buildings are currently heated by steam or hot water and

will require upgrades to their heating systems to be able to accept medium-temperature hot water. Each campus will also require a new centralized geothermal heat exchange and heat recovery chiller plant that ties in to a new and nearby geo-field. Each campus's size and thermal load will shape the scale of the geo-field boreholes and piping. In total, the consultant's analysis estimated nearly 20,000 boreholes, with most extending roughly 600 feet below ground.

Figure 3. District geo-exchange system

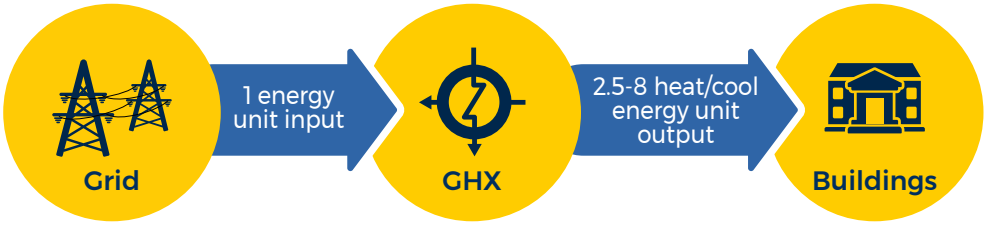


The vertical closed-loop geo-exchange system represents the most robust and well-established version of geothermal systems. All system installers must be certified and comply with all applicable state and federal regulations pertaining to groundwater protection. Immediately after each geo-exchange borehole is drilled, it is fitted with a closed-loop plastic high-density polyethylene (HDPE) pipe u-loop and fully grouted from the bottom up to the ground surface, with inert bentonite clay slurry that completely seals the borehole and protects any groundwater bearing layers from any possibility of introducing potential contaminants from the ground surface. The closed-loop HDPE u-loops are pressure tested before they are inserted into the geo-exchange borehole to eliminate leaks. The working fluid circulating through the u-loops for heating dominant applications is typically clean water with 15 percent to 25 percent propylene glycol mixture, which is a non-toxic food-grade additive. Once the u-loops are

installed and grouted inside the boreholes, they are fully protected, and their expected service life is 50 to 100+ years.

The transition to geothermal heat exchange with heat recovery chiller technology will increase the campuses' thermal efficiency for two main reasons. First, a heat recovery chiller can transfer three times the amount of heat per unit of energy input compared to combustion technology currently in use that transfers 0.8 units of heat per unit of energy input. Second, the geothermal heat exchange with a heat recovery chiller plant efficiently moves heat around a campus, thus optimizing the movement of thermal energy from where it is generated to where it is needed. As Figure 4 shows below, geo-exchange with medium temperature hot water results in highly efficient use of electricity.

Figure 4. Geo-exchange system efficiency



Air-source equipment (cooling towers or hybrid coolers) included in the proposed system configurations helps to minimize the size and cost of the geo-exchange system by providing a supplementary heat extraction/rejection function during warmer months of the year. Air-source heat pumps can be effective stand-alone systems for small, building-scale applications in warmer climates but are not an energy efficient or cost-effective solution for larger applications in colder climates. They also do not offer thermal storage capacity and cannot take advantage of energy recovery across multiple campus buildings.

In some GHX systems, wastewater/sewer heat recovery can represent additional low-grade thermal energy source/sink opportunity. However, it does not offer thermal storage capacity, and its technical and economical viability can only be determined by evaluating the specific project context complete with detailed technical and economic analyses. At the system scale considered for U-M's existing campuses, a large capacity municipal wastewater/sewer main would need to be available in close proximity to the proposed central heat recovery chiller plant locations. Annual wastewater flow and temperature variation at a specific location would also need to be analyzed before the appropriate wastewater heat extraction technology could be selected and sized and its performance analyzed and costs estimated with adequate accuracy.

The Commission recognizes the magnitude of this endeavor, which, if completed in its entirety, would be the largest university geo-exchange project

in the world. Ball State University currently has the largest operational geothermal district system in the United States with 3,600 boreholes, which took more than a decade to plan, design, fund, build, and operationalize.[27] For comparison, the proposed U-M project is five times larger, and the North Campus portion alone is approximately 27 percent larger, estimated to require 4,600 boreholes. With this in mind, the Commission recommends that U-M phase the implementation of the infrastructure improvements over the next two decades. This timeline is more aggressive than the preliminary guidance provided by the Commission's external consultant and reflects the Commission's belief that new, simpler to implement and less costly technological solutions will emerge in the coming decades. A phased approach will allow for modifications in response to these inevitable changes.

This infrastructure transformation will require substantial investments over multiple decades. As part of their analysis, Integral Group worked with U-M to develop a life cycle cost assessment (LCCA), reflecting both Integral's experience with projects of this type and U-M's experience with large capital project costs, which is detailed in Appendix J. Table 1 below summarizes high-level cost estimates for a project of this magnitude. Actual costs may vary greatly based on a wide range of factors and would not be known with greater certainty until detailed engineering studies are completed.

Table 1. High-level cost estimates for heat and power infrastructure recommendation. ***Note:*** *Electric infrastructure costs are not included in these estimates and could be substantial.*

(dollar figure in millions and in 2020 dollars)

CAMPUS	CENTRAL	ATHLETIC	EAST MED	NORTH	DEARBORN	FLINT	TOTAL
Thermal Systems	$1,101	$332	$50	$680	$99	$77	**$2,339**
Solar PV	$31	$41	$24	$102	$64	$35	**$297**
Bldg Conversion	$406	$61	n/a	$122	$21	$122	**$732**
TOTAL	**$1,538**	**$434**	**$74**	**$904**	**$184**	**$234**	**$3,368**

With regard to return on investment, the Integral Group report states:

> *While the proposed energy system transformation would result in lower utility costs for each campus, the up-front capital costs of the prospective transaction are massive. Seen through a traditional lens with standard assumptions, the payback is long.[28] Using traditional analysis, the nominal payback period would be 61 years; the 30-year NPV is ($2.01B).[29]*

27 Ball State University geothermal district system: https://www.bsu.edu/about/geothermal.
28 All payback estimates in this report were calculated using traditional analysis and do not include a social cost of carbon. The establishment of a government-imposed carbon price would accelerate payback periods.
29 The payback analysis accounts for all operating and maintenance costs as well as all equipment replacement within this timeframe.

Given the massive investment and the potential for new technological solutions to emerge, the Commission advises that the decarbonization of U-M's heat and power infrastructure be done in stages across the six campus districts. The Integral Group report provides guidance on a phasing approach.

However, the choices made for phasing should ultimately be governed by a clear set of principles that include such factors as the relative carbon intensity of current electricity sources (e.g., Central Power Plant vs. DTE), U-M's project management capacity, design/tendering/construction timelines, campus and community disruption, local impacts on the affected populations, visibility of the project, and existing equipment or building retrofit timelines. These principles and decisions around phasing must be developed with representation from each campus, accounting for the current differences in funding models, resources, and structures across each campus. U-M may want to prioritize a stand-alone campus option that could serve as a pilot for the rest of the project.

Table 2 provides guidance from Integral Group with regard to potential sequencing that seeks to minimize concurrent campus projects. As there is no interdependency between campuses related to thermal infrastructure, the campuses can be sequenced in any order. U-M should pursue a sequencing strategy that provides optimal alignment with the Commission's guiding principles, with particular attention being paid to mitigating the disruption of critical operations, such as health care and research facilities.

Table 2. Integral Group guidance on campus transformation sequencing

CAMPUS	TIMELINE	COMMENTS
North Campus	Years 1-15 (15 years)	Initial implementation project: North Campus Academic Core
UM-Dearborn	Years 1-10 (10 years)	Can achieve on-site net-zero emissions with parking lots and rooftop solar PV
Central Campus	Years 5-25 (20 years)	Gradual phase-out of CPP as new systems are built
Ross Athletic	Years 10-20 (10 years)	Quick timeline difficult, given sensitivity to on-site disruptions
East Medical	Years 15-20 (5 years)	Small campus, short timeline, starting in year 15 after North Campus is completed
UM-Flint	Years 15-25 (10 years)	10 yrs likely required because of demands from three concurrent projects from years 15-20

Implementing a project of this magnitude is an extraordinary endeavor. It will involve an urgent call to action and concurrent phasing of multiple campuses, requiring a significant amount of people power, management, organization, and funding across the 20-year timeframe. UM-Ann Arbor's Architecture Engineering and Construction (AEC) department possesses the in-house project management capability for a project of this magnitude, and it will be critical to engage and involve plant operations personnel on the Flint, Dearborn, and medical campuses throughout the system design and construction process. Doing so will ensure an effective transition with an educated staff and frontline buy-in to the new system. As this initiative moves forward, every effort should be made to provide the necessary training to ensure security for those whose jobs are currently tied to existing systems. To be effective, the university must plan and budget for this work immediately.

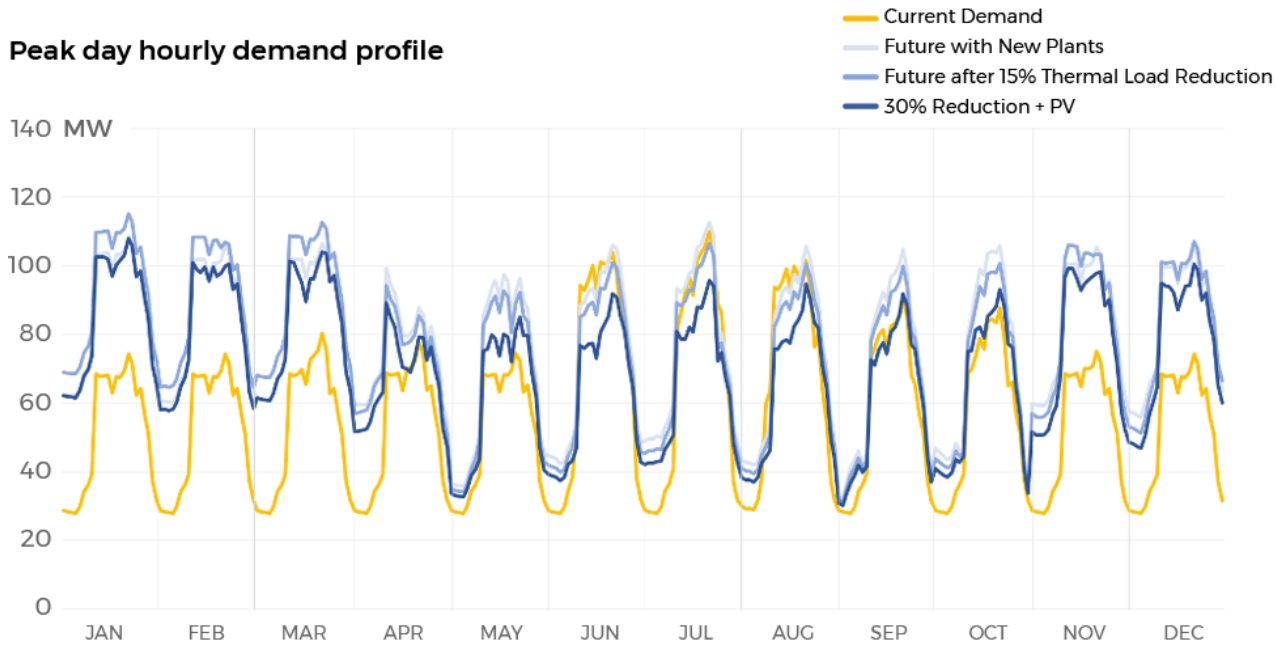
Given the unprecedented scale of this project, U-M will have an opportunity to acquire and develop in-house expertise in the implementation of a geo-exchange system that would be unparalleled in the nation. By developing this expertise in-house, U-M could potentially reduce external contractor fees that can constitute as much as 20 percent of project costs.

Availability and cost of capital will also be significant considerations that could accelerate or slow implementation. For example, if significant external sources of capital become available (e.g., government subsidies, philanthropic support), then the university should consider accelerating the timeline as much as possible. Furthermore, changes in government policy such as a carbon tax may increase the attractiveness of moving more quickly.

A phased approach to this project also provides the university flexibility to reassess strategies and technologies as alternative options evolve over time for heat and power infrastructure decarbonization. This way, the university is not tied to any one strategy if a more cost-effective solution materializes. The Commission recommends that U-M reassess the feasibility of other emerging technologies at least every five years throughout the multi-decade implementation timeframe to ensure that potential alternative, possibly less expensive and disruptive technologies are fully considered as they emerge.

Among the uncertainties with a project of this magnitude are additional costs attributable to upgrading and expanding the transmission and distribution (T&D) capacity of the local and regional electricity grid. While the Integral Group analysis suggests that the new system will demand significantly more electricity over the course of a year once it is fully operational, U-M's peak loads should not exceed current peaks. But the peaks would shift from summer to winter as shown in Figure 5, and at the time U-M retires its central plant, additional peak demand may potentially need to be met by the transmission and/or distribution utilities.

Figure 5. New proposed heat and power system: Central Campus electrical demand estimates



The Integral Group analysis did not evaluate the effects of U-M's increased electricity demand on the local transmission and/or distribution grid. However, a number of variables could determine whether incremental peak demand on the electric system will trigger upgrade costs. One critical variable will be the timeframe over which the change occurs—the longer the timeframe, the more options the utility will have to meet incremental loads. Another critical variable will be the interplay with incremental load for other customers served by the same substation.

If the new system substantially increases peak loads, then T&D expansion costs could be significant, and U-M would bear these costs if it were the only beneficiary of the upgrades. At the same time, overall load growth patterns in the surrounding areas could help offset some of these upgrade costs. U-M should work with its utility providers and regulators (e.g., the Michigan Public Service Commission) to identify campus districts that are the least stressed in terms of capacity constraints, to help inform a phased approach to building out the project. As emphasized in the Demand-Side Management section below, improving building standards and increasing the energy efficiency of existing buildings are extremely important. Taking these actions will lower electricity demand and peak loads in particular, which is a critical factor in keeping the physical footprint and associated costs of a geo-exchange system as low as possible.

Refer to Appendix K for specific evaluation criteria related to this recommendation.

UNIVERSITY-OWNED VEHICLES AND MAINTENANCE EQUIPMENT

Strategy Recommendation: Fully decarbonize U-M's transit system, vehicle fleet (buses, trucks, and automobiles), and maintenance equipment.

In addition to stationary sources throughout the campuses, U-M's Scope 1 emissions are produced by a variety of non-stationary sources, including the campus bus fleets; light- and medium-duty trucks and utility vehicles used for operations and maintenance; cars, vans, and other vehicles available to university units for rental; and non-vehicular maintenance equipment (e.g., lawn mowers and leaf blowers). As of FY2020, the UM-Ann Arbor fleet accounted for 2.2 percent of total Scope 1 emissions on the Ann Arbor campus.

While U-M's vehicle fleet and maintenance equipment account for only about 2 percent of the university's Scope 1 GHG emissions, the Commission considers decarbonizing the vehicle fleet and maintenance equipment to be an integral step to creating a culture of carbon neutrality across the institution and the surrounding communities. U-M's vehicle fleet—especially Blue Buses—and maintenance equipment are highly visible, mission-critical operations for the university that community members use and see every day, making them an effective avenue for culture change. Quickly decarbonizing the vehicle fleet will send a strong signal locally, regionally, and nationally that U-M is serious about its carbon neutrality goals.

Ann Arbor Campus

On the Ann Arbor campus, the Blue Bus fleet provides transportation for faculty, staff, and students seven days a week. The U-M Blue Bus fleet contributes the largest portion of fleet emissions for the Ann Arbor campus, making it an ideal point of focus for reducing emissions. In line with the Mobility Electrification Analysis Report, the Commission recommends U-M transition the Blue Bus fleet to all-electric buses by 2035. Establishing a plan for the supply, training, and infrastructure is needed, now that bus manufacturers are planning to transition their production toward battery electric buses.

Plans for optimal bus routes, the number of buses required, charging infrastructure, battery capacity, a more tailored fleet of smaller shuttles, and to electrify the truck and vehicle fleet across all three campuses need to be developed. U-M should work closely with the City of Ann Arbor and Washtenaw County in pursuit of design solutions that optimize the relationship between U-M's transit system and other local and/or regional systems.

In parallel with fleet decarbonization, U-M should proceed with the development of a high-capacity connector on the Ann Arbor campus while also analyzing the infrastructure's embodied carbon and whether a rapid-transit electric bus system might be an effective alternative to a rail system. A rapid

bus system or a connector would also alter the composition of U-M's overall bus fleet, since smaller electric shuttle buses would likely be needed for hub-to-spoke travel within the campus. The connector system would also facilitate additional emission reductions associated with less inter-campus personal vehicle travel (see Commuting section for more detail).

As it proceeds to electrify its fleet, U-M should evaluate the option of low-carbon fuel alternatives, such as hydrogen or synthetic fuels derived by wind and solar resources or sustainable biodiesel. Adapting a few of the current buses or shuttles to use such alternative fuels in pilot studies may, in the near term, enhance living-learning experiences and research collaborations.

Dearborn Campus

The UM-Dearborn campus shuttle service moves faculty, staff, and students and is much simpler than that of the Ann Arbor campus, with buses serving three routes from 7:40 am to 9:50 pm each weekday. The Commission recommends that U-M move quickly to initiate an electric bus replacement system on the UM-Dearborn campus with the goal of converting all shuttle buses to electric power by 2035.

Flint Campus

The Flint campus does not currently have a campus bus or shuttle service. If this were to change, electric vehicles should be pursued.

Inter-Campus Transit

U-M has discontinued the Detroit Connector, which was the shuttle bus service connecting the Detroit Center, Dearborn campus, and the UM-Ann Arbor Central Campus Transit Center. If U-M were to begin a new inter-campus bus service, U-M should utilize electric buses and replan the route to connect with the Ann Arbor Blake Transit Center and the Downtown Detroit areas near U-M's Detroit Center for Innovation. An improved intercity transit service connecting Detroit, Ann Arbor, Dearborn, and Flint, as well as outlying communities such as Brighton and Toledo, would better serve employees who live far from the Ann Arbor campus.

Other Campus Vehicles

In addition to electrifying university buses and shuttles, U-M should transition light- and medium-duty trucks; utility vehicles; and cars, vans, and other vehicles available to university units for rental to 100 percent carbon-free vehicles as soon as possible. This can be done in a variety of ways, including fuel-cell hybrid vehicles, electric vehicles, and utilization of sustainable biofuels, and is applicable across all three U-M campuses. The timeline for transitioning smaller vehicles on all campuses can be accelerated by leveraging various

expected incentives for campus charging infrastructure and for replacing older and less efficient vehicles. The university rental vehicles are often used for long-distance travel by students, faculty, and staff, and thus their transition to 100 percent electric vehicles should be informed by the state and national EV charging infrastructure deployment. This shift will require adequate education around the use of electric vehicles and helping users identify off-site charging stations to minimize range anxiety. The university should also consider investing in short-haul transportation options (e.g., bicycles, e-bikes).

U-M should make this transition as quickly as possible, recognizing that engineering studies will need to be completed to determine infrastructure needs. To transition to a carbon-free vehicle fleet and maintenance equipment, all campuses will require adequate support throughout the transition. Early actions by U-M could accelerate broader uptake of these technologies in the region, and the speed of U-M's transition will be influenced by a variety of factors, including:

- Partnerships with other key stakeholders in the region (e.g., cities, utilities, industry) to optimize transit solutions at the local and regional level;
- On-campus and local utility infrastructure capacity;
- The timeline for decarbonizing the university's purchased electricity;
- Opportunities to advance new technologies through living-learning lab research projects;
- The political landscape and associated incentives; and
- Opportunities to partner in deploying charging infrastructure with electric utilities, local communities, and charging station companies.

U-M can track progress on this recommendation by monitoring the number of electric buses acquired, annual GHG reduction, annual electricity usage and diesel fuel savings, up-front costs of the electric buses and chargers, servicing and maintenance infrastructure investments, and the achieved cost savings relative to the diesel bus costs.

Refer to Appendix L for more specific evaluation criteria related to this recommendation.

Scope 2 Emissions Reduction Strategies

PURCHASED ELECTRICITY

Strategy Recommendation: Issue a request for proposal (RFP) to procure all purchased electricity for U-M's three campuses in a manner that generates renewable energy certificates that are retired by U-M or on its behalf, aligns with the principles outlined by the Commission, and seeks the desired co-benefits outlined for carbon offsets.

The Commission has concluded that sourcing 100 percent renewable electricity from the grid is among the least complex and lowest cost near-term options for U-M to significantly reduce its greenhouse gas emissions. DTE Energy (DTE) and Consumers Energy—the electric utilities serving U-M's campuses—have established public goals to make their electricity supplies carbon neutral by 2050 and 2040, respectively. However, the Commission recommends that U-M accelerate that timeline in accordance with the goal stated above.[30] As a point of reference, the Science-Based Targets Initiative (SBTi) outlines an 80 percent decarbonization by 2025 and a 100 percent decarbonization by 2030 for purchased electricity.

Electricity derived from renewable sources has historically made up a very small percentage of U-M's electricity purchases. However, that is on schedule to change in 2021 as a result of UM-Ann Arbor's power purchase agreement for 75 megawatts (MW) of wind energy through DTE's large customer MIGreenPower program, which supplies renewable energy from designated facilities in the State of Michigan. Under this regulated tariff, U-M will pay a price premium of approximately 1.5 cents per kWh above its standard rate and the associated renewable energy certificates (RECs) will be retired on its behalf. This agreement will supply approximately 200,000 megawatt hours of renewable electricity annually, or approximately 40 percent of the Ann Arbor campus's current annual electricity buy. This will represent more than 50 percent of the Ann Arbor campus's purchased electricity once the expansion to the university Central Power Plant is complete in 2021. With the current DTE fuel mix, this would result in an annual GHG reduction of nearly 110,000 metric tons of carbon dioxide ($MTCO_2e$).

According to the International Renewable Energy Agency,[31] the costs of generating electricity from renewable sources are falling steadily and are already

30 DTE Energy. (2020, January 1). DTE Clean Energy. https://dtecleanenergy.com/; Consumers Energy. (2020, February 24). MI Clean Energy Plan. https://micleanenergyplan.com/

31 More on electricity generation costs from renewables here: https://www.irena.org/publications/2020/Jun/Renewable-Power-Costs-in-2019

less expensive than those associated with building new fossil fuel plants when compared on a levelized cost of energy basis.[32] Specifically, solar photovoltaics (PV) show the sharpest cost decline over the past decade (82 percent), while onshore wind costs decreased by 40 percent, and offshore wind costs fell by 29 percent. Given these trends, the Commission believes that electricity from renewables will continue to become increasingly cost-effective in the years to come. In addition, other electricity generation and storage technologies are likely to emerge as alternatives in the coming decades (e.g., hydrogen fuel generation via solar water splitting, concentrated solar power, heat scavenging thermal photovoltaics, and advanced flow batteries), and U-M should evaluate and consider these options over the longer term.

Mitigating the remaining emissions associated with electricity purchases for U-M's three campuses will require additional investments in sourcing renewable electricity. There are various ways to accomplish this, each with potentially different levels of attractiveness across the three campuses. Options currently permissible under State of Michigan law include utility rate programs, virtual power purchase agreements, behind-the-meter installations, and power purchase agreements.

Utility Rate Programs

One option is to increase existing subscription levels to regulated renewable electricity options like DTE's MIGreenPower program. With this subscription, U-M would pay a levelized subscription fee for the assets supporting the enrollment and would receive a partial credit reflecting the value of the energy and capacity from these assets. The subscription fee cannot increase over the life of the contract, while the credits will reflect market rates, which are expected to increase over time. DTE's incremental renewable projects, which would most likely be solar, will be constructed in Michigan. DTE would retire the renewable energy credits (RECs) on behalf of U-M, and DTE would not count them toward their own goals.

32 Levelized cost of energy analysis does not take into account the intermittent nature of renewables and thus is insufficient when evaluating different energy resources for long-term utility planning purposes.

Wind turbines in Michigan | Courtesy of DTE Energy

Virtual Power Purchase Agreements

A second option is to enter into a virtual power purchase agreement (VPPA), which is a financial contract by which U-M could purchase electricity output from a new utility-scale renewable energy project located anywhere in the world from a third-party project developer at a pre-agreed price. The project developer would sell this electricity into the grid for the market price at the time the electricity is sold. If the market price is greater than the fixed VPPA price, U-M would receive the benefit. If the market price is less, U-M would pay the project developer to make up the difference. Under a VPPA, U-M would continue to source its actual electricity from its utility partners (DTE and Consumers) at their contractual rate. VPPAs have some similarities to programs like DTE's MIGreenPower, in that the electricity flows into the grid and not directly to the customer, yet there can be differences in how RECs are handled. For example, within the MIGreenPower program, the RECs are retired by DTE on behalf of the customer, whereas in a VPPA, the customer typically takes ownership of the RECs, though an RFP could require that RECs be retired on behalf of the customer. While U-M could enter into a VPPA linked to an out-of-state or out-of-country project, the Commission recognizes that there are reasons why in-state projects may be preferred, such as supporting Michigan's economy.

Behind-the-Meter Installations

A third option is to install U-M owned and operated, behind-the-meter, renewable energy projects on various structures and lands within U-M's campuses to reduce the amount of electricity that would need to be purchased from the electric utilities. Integral Group modeled rooftop solar potential for buildings

and parking lots across all campuses and concluded that such installations could displace approximately 18 percent of U-M's current demand for purchased electricity. Projects could also be constructed on greenspace within the campus boundary. For example, a 150-acre parcel between Green Road and Huron Parkway could likely accommodate a 50 MW photovoltaic installation, which could potentially cover 10-15 percent of UM-Ann Arbor's current demand for purchased electricity.[33] While such options may yield renewable energy at advantageous prices, these options were not modeled as part of the Commission's work. DTE has other tariff and contracting options that would allow for larger sized

NCRC solar array | By Graham Sustainability Institute

installations but with different economics (i.e., credits for outflows into the grid). The Commission expects such decisions will depend on a variety of factors, including project phase-in timelines on the three campuses, life cycle costs, availability of capital, land availability, and staffing capacity, which may change over time. With regard to on-campus behind-the-meter projects, U-M should consider whether energy storage should be included in the plan, given the variable nature of renewables. The benefits of on-site storage continue to increase as battery costs fall and additional benefits are possible from enhanced reliability and resilience during emergencies. Techno-economic analyses of behind-the-meter storage can be pursued with available tools.[34] While university structures are already in place to facilitate electricity purchasing options from energy providers, investments in U-M owned and operated photovoltaic systems may require additional staffing capacity and a more extensive exploration of partnership potential with surrounding communities.

33 This estimate is based on data from the National Renewable Energy Laboratory's PVWatts calculator.
34 REopt Lite | REopt Energy Integration & Optimization Tool | NREL.

Power Purchase Agreements

A fourth option is to enter into a power purchase agreement (PPA) with an electricity provider to develop behind-the-meter renewable energy projects on campus where the project would be owned and operated by the project developer, but both the electricity and associated RECs would flow to the university. The City of Ann Arbor is exploring a version of this in which the developer would own the asset up front, and the city would have the option to buy it back at a reduced rate in the future. Grid-connected PPA projects in front of the meter are not currently available under State of Michigan law. Behind-the-meter generation requires an interconnection agreement with the connected utility provider. The regulated utilities levy a "standby" charge on electrical power generated behind the meter, as approved by the Michigan Public Service Commission.

U-M should actively explore all current and potential strategies to determine which strategy, or combination of strategies, will best serve the goal of sourcing 100 percent renewable electricity by 2025 in a manner that optimizes university priorities, in alignment with the Commission's Guiding Principles. The Commission also recognizes that other options for sourcing renewable electricity could emerge in the years ahead and that U-M could play an active role in helping to shape those options. Given the accelerating pace of clean energy technology innovation and corresponding decreases in generation and storage costs, the university should carefully consider the appropriate term length of any new electricity procurement agreements, with the understanding that all future electricity procurement strategies would need to be carbon neutral. The university's procurement of renewable energy systems should attempt to account for sustainability of the production of these systems, such as considering the embedded carbon dioxide in the systems and ensuring the systems were manufactured consistent with the university's values on labor standards and human rights.

> **Strategy Recommendation:** Engage with the Cities of Ann Arbor, Dearborn, Detroit, and Flint and other entities that are, or could be, partners in advocating for renewable electricity policy changes in the State of Michigan to better understand their perspectives, conduct necessary due diligence, and potentially partner in advocacy efforts that reflect mutually shared objectives as well as actively explore ways to partner directly in pursuit of carbon neutrality goals.

As U-M pursues a goal of sourcing 100 percent renewable electricity, it should consider currently available options and potential policy changes if they align with U-M's carbon neutrality goals. Some options that are currently being advocated for, which many believe are important to address concerns regarding

accessibility and equity, include microgrids, community solar, solar gardens, and Community Choice Aggregation (CCA). The City of Ann Arbor's A²Zero plan seeks to enact CCA legislation in the State of Michigan,[35] which would enable a local government to pool the electricity demand of customers within its jurisdiction to procure power from an alternative supplier at a competitive price, with the electric utility continuing to provide transmission, distribution, and billing services. Moving forward, the university should engage with current and potential partners and stakeholders and conduct due diligence with regard to renewable electricity options in the State of Michigan to determine whether, and how, it wants to advocate for additional options through potential policy changes.

35 City of Ann Arbor. (2020, April 1). Sustainability and Innovations. https://www.a2gov.org/departments/sustainability/Pages/default.aspx

Francis Willson Thompson Library at UM-Flint | By Tricia Borcherding

For all options pursued, the university should seek to pair investments in renewable electricity with research and education opportunities for U-M faculty and students. In addition, the university should allocate ongoing funding to support advanced systems research related to energy generation from photovoltaics, solar thermal, waste heat, and wind power, as well as energy storage, grid architecture and management, and other carbon neutral solutions (see Research and Education section). U-M should actively seek funds from government agencies, particularly the Department of Energy, the Department of Defense, the National Science Foundation, and donors to help support investments in these projects.

Refer to Appendix M for more specific evaluation criteria related to Purchased Electricity recommendations.

Demand-Side Management Strategies

This section focuses on strategies the university can pursue to reduce energy demand in its buildings, thus reducing emissions for Scopes 1 and 2. Demand-side management can include a wide range of strategies such as building envelope design, technological energy efficiency measures, and policy mechanisms to incentivize conservation-oriented behavior change. Demand-side management and reduction strategies should be prioritized in the near term because doing so will reduce the amount of renewable energy the university needs to generate and procure. Reducing peak demand for heating and cooling through demand-side management efforts will also reduce the number of geo-exchange boreholes required to transform U-M's heat and power infrastructure, thus lowering the overall project costs.

Demand-side management is the modification of consumer demand for energy through various methods such as technological improvements, financial incentives, and behavior change.

REVOLVING ENERGY FUND

A revolving energy fund (REF) is a well-established financial instrument for funding energy conservation and carbon reduction projects, which has been adopted by many universities across the United States.[36] The goal of the REF is to support carbon neutrality as quickly as possible by prioritizing energy conservation projects with the lowest cost of emissions reductions.

Strategy Recommendation: Create a revolving energy fund (REF) on each of U-M's three campuses.

Investments in energy conservation measures (ECMs), such as light emitting diode (LED) lighting and equipment upgrades, are cost-effective ways to reduce the energy consumption and associated emissions of individual buildings. For example, the PCCN's Energy Consumption Policies (ECP) Analysis team found that over the past 13 years, ECMs in U-M General Fund buildings (i.e., units primarily

36 The Billion Dollar Green Challenge encourages institutions to participate in a revolving energy fund. For a full list of the participating institutions, see http://greenbillion.org/participants/.

supported by tuition, state appropriations, and indirect costs of research) had a median return on investment (ROI) of 22.7 percent. The ECMs that realized greater than 20 percent ROI did not involve renovation or construction to complete. More involved and complex ECM projects that require building renovation and construction have much higher capital costs and subsequently longer payback periods. These results show that greenhouse gas reductions from certain types of ECMs make good business sense for U-M. Moreover, based on the analysis team's data, there is no sign that U-M has picked all of the low-hanging fruit, as the ROI of projects over the past 13 years shows no sign of decreasing over time, suggesting that U-M is currently underinvesting in ECMs.

While the ECP Analysis Report suggests that there are many ECMs yet to pursue with simple paybacks of 4 or fewer years, additional ECM work with paybacks of 10 or more years will be required to achieve a 25 percent reduction in baseline carbon emissions. The Office of Campus Sustainability (OCS) estimates that an average ECM payback of 8 or fewer years is only achievable for projects that do not require construction or renovation activity, such as lighting retrofits. More intensive energy reduction ECMs require construction, renovation, and/or retro-commissioning work, which add significant capital costs to the project and much longer payback periods. Refer to Appendix B of the ECP Analysis Report for the details of the data and financial calculations.

Following the recommendation of the ECP Analysis, the Commission recommends accelerating ECM work at U-M by establishing an REF on each of U-M's three campuses (Ann Arbor, Dearborn, and Flint). The REF policy will empower the leaders and staff of individual units to foster emissions reductions at the building level through ECMs. Due to different budget models across different campuses and divisions, U-M should also consider whether to create multiple REFs within each campus to account for different budget models (e.g., general vs. auxiliary funded buildings). Doing so would foster greater buy-in at

An energy conservation measure (ECM) is an intervention undertaken to reduce the energy consumption of a particular piece of equipment or a certain aspect of essential building services. A combination of several ECMs can be used to reduce energy consumption across an entire facility or building.

the unit level and prevent unintended consequences, such as academic units subsidizing athletics. Additionally, because U-M's energy management team has been performing ECMs in general fund buildings since the mid-1990s, there may be more low-hanging fruit in auxiliary unit buildings. Coordination across all REF efforts is essential to enhance information sharing and learning opportunities across divisions and campuses.

With an REF in place, U-M units would submit project proposals with quantified energy and financial savings estimates. If approved, the REF would provide the unit with a loan to cover the up-front capital expense. The loan would be repaid to the fund through utility bill savings from the resulting reduction in energy consumption. Managing the mechanics of the REF program would require additional staff effort, which could be significant, depending on the process involved to promote the program and solicit, review, and select projects. A key role for these staff will be ensuring that the selection process is transparent, fair, and easy for organizational units to navigate.

A significant benefit of an REF is that it provides a long-term and stable mechanism for consistently funding ECM work, which is not affected by changes in short-term policy and budget priorities. The REF model provides the opportunity to seek additional funds from alternative sources, such as federal subsidies and utility energy efficiency programs. If a project were to receive funds from both the REF and an external source, the external funds would offset a portion of the loan from the REF. The university should also develop opportunities for students, faculty, and staff to engage with the development, evaluation, and implementation of ECM projects whenever possible, to bring valuable perspective to the process and to foster learning among the community.

Ann Arbor Campus

The ECP Analysis estimates that ECMs implemented through an REF on the UM-Ann Arbor campus could reduce total emissions (Scopes 1 and 2) by 25 percent over 10 years. After 10 years of operation, annual emissions are projected to be 104,727 $MTCO_2e$ less than they were at the start of the 10-year period, although OCS estimates that it would likely take longer due to the complexity of individual projects and the challenge of project sequencing. U-M would need to provide the UM-Ann Arbor campus with at least $25 million in seed funding for the REF. The ECP's sensitivity analysis suggests that this level of funding would facilitate the most cost-effective project investments and that project paybacks would gradually decline at higher funding levels. In other words, higher funding levels would not necessarily result in a concomitant level of efficiency gains, because efficiency improvements are limited by the remaining opportunities available in the facilities being renovated and retrofitted.

The current energy management team has successfully implemented impactful ECMs over the past 25 years, but expansion and application of this expertise to the entire Ann Arbor campus is needed to fully utilize the REF and achieve the desired emissions reductions. There are multiple approaches to doing so, including increasing the size of the current energy management team, providing resources to enhance partnerships between embedded sustainability staff and the ECM team, and engaging in external partnerships and contracts on energy conservation projects. Implementing one or more of these approaches will be particularly important for auxiliary units that may not have sufficient staffing levels or expertise to carry out this work.

An implementation challenge for the REF on the Ann Arbor campus is the decentralized nature of the university, which extends to budgets and budget models. Therefore, U-M should implement REFs throughout the university, including auxiliary units such as Michigan Medicine, Athletics, and Student Life (University Unions and Housing).

The Thumbprint at Frances Wilson Thompson Library | Courtesy of UM-Flint

Dearborn and Flint Campuses

The Dearborn and Flint campuses do not currently track carbon emissions by building, and unlike the Ann Arbor campus, utility bills are paid centrally on those campuses. These characteristics make the decentralized REF policies proposed for the Ann Arbor campus unsuitable for Dearborn and Flint as they are presently structured. Even so, dedicated REFs should be established by the central administration for the Dearborn and Flint campuses. Consistent with the ECP Analysis recommendations, U-M should actively engage with the Dearborn and Flint campuses to determine if $2.5 million in seed funding is appropriate for their REFs. It is anticipated that at least one energy management staff member will be required to assist with identifying and executing energy efficiency projects on each of these two campuses. Similar staffing and

expertise approaches to those for the Ann Arbor campus may be necessary for implementation of a REF on the Dearborn and Flint campuses. With adequate funding in place, UM-Flint Facilities and Operations staff would be eager to implement an REF system, which they think would be a game changer to bolster the campus's energy efficiency and carbon reduction efforts.

If REFs were implemented at UM-Flint and UM-Dearborn, it is estimated that they would result in a 25 percent emissions reduction over 10 years. Due to incomplete data, U-M should begin by expanding the data collection capabilities at these campuses.

The Commission agrees with the ECP Analysis recommendations that the following priority actions are needed to catalyze the implementation of an REF on all three U-M campuses:

- Perform additional analysis and consultation with relevant auxiliary units and campus leaders to determine the logical way to integrate the REF on the Ann Arbor campus.
- Adjust and upgrade emissions accounting to support the REF.
- Hire the energy management staff necessary to meet the program goals.
- Allocate funds and create new REF business accounts for all campuses.

In line with the ECP Analysis Report's suggested implementation timeline, the following timeline should be adopted to implement REFs across the three campuses:

- First year—Determine the seed funding sources and create a new business account for the REF. Conduct broad engagement and information sharing on the upcoming opportunities.
- Second year—Hire and train regional energy managers. Inform units of the opportunity and provide necessary education.

To assess progress made on this recommendation, U-M must track emissions reductions from the ECMs, the annual cost savings, and the number of ECMs completed with the REF. Current metrics and verification practices must be significantly expanded for the REF to function effectively and sustainably. Proposed alternative practices are available in the ECP Analysis Report.

Refer to Appendix N for more specific evaluation criteria related to this recommendation

CARBON PRICING

A carbon price is a cost that is linked to fossil fuel usage and reflects the associated climate damage it causes. A carbon price increases the overall cost of energy and thereby creates a financial incentive to reduce both the production and use of fossil fuels. The idea of a carbon tax, or carbon pricing equivalent via cap-and-trade, has been embraced by a large and diverse set of economists in the United States and around the world, including Yale University's William Nordhaus, who earned the 2018 Nobel Prize in Economics.[37]

The World Bank reported in 2020 that more than 60 nations employ some form of a carbon price, with leading models including those from the European Union, Canada, and a growing number of Asian nations.[38] In the United States, 12 states have adopted some version of a carbon price, the most recent being Virginia in 2020, while Michigan has yet to do so.[39] Carbon pricing can be complementary with a range of other policies, creating strong incentives to reduce fossil fuel usage and support efforts to expand the availability of energy alternatives or promote greater energy efficiency.

A growing global trend has been to use revenue from a carbon price to finance the transition to a low-carbon economy. This is perhaps most evident in the United States in the 11-state Regional Greenhouse Gas Reduction Initiative,[40] which generates substantial revenue to support related programs, and the emerging Green Deal initiative in the European Union. In the absence of federal or state carbon pricing mechanisms, individual institutions are experimenting with putting a price on carbon within their organizations. In higher education, for example, carbon pricing has emerged as a central component in carbon neutrality strategies adopted at such institutions as Yale University, Cornell University, Smith College, and Swarthmore College.

The **social cost** of carbon is the dollar value ascribed to the societal damage caused by one ton of carbon dioxide emissions in a given year.

37 Metcalf, G. E. (2018). *Paying for pollution: Why a carbon tax is good for America*. Oxford University Press.
38 World Bank. (2020). State and trends of carbon pricing 2020. © World Bank. https://openknowledge.worldbank.org/handle/10986/33809. License: CC BY 3.0 IGO.
39 https://priceoncarbon.org/business-society/state-actions/
40 Regional Greenhouse Gas Reduction Initiative: https://www.rggi.org/

Strategy Recommendation: Establish a carbon pricing system at the organizational unit level across U-M where revenue flows to the REF for new energy conservation measures.

Following the recommendation of the ECP Analysis Report, the Commission recommends that U-M establish a centrally administered carbon pricing system that charges each organizational unit according to its carbon footprint. Carbon pricing aligns incentives by internalizing the impact of emissions into financial decisions through a price on greenhouse gases. Linking a carbon pricing system with an REF to fund ECMs presents an opportunity to show leadership among universities while driving down emissions and sending a clear signal to organizational units about U-M's priorities.

As stated by the ECP Analysis, in the absence of external emissions pricing systems, internal pricing provides an opportunity to:

- Demonstrate meaningful environmental commitment and leadership;
- Cost-effectively reduce energy use and emissions; and
- Implement a customized pricing system to match organizational structure and goals.

The proposed pricing system is designed to capitalize on each of these categories while fitting smoothly into the existing organizational structures and maintaining the university's core mission.

Revenue generated by the carbon price should be divided so that 30 percent returns directly to the contributing unit, earmarked for energy efficiency upgrades, and the remaining 70 percent contributes to the REF, or goes to U-M's energy management team if an REF is not created. In general, the revenue should be invested in the lowest cost (i.e., $/MTCO$_2$e reduction) opportunity to mitigate emissions.

The REF and carbon pricing system play synergistic roles in providing the incentives and means for reducing emissions through energy conservation projects. The two policies work well together because they promote increased use of each mechanism more than if only one were implemented alone. Without the carbon price, the use of the REF for energy efficiency projects is less urgent to units. Without the REF, the carbon price places a larger financial burden on units before centralized revenues grow large enough to begin funding energy efficiency projects for all units to reduce their emissions. The two policies, when paired, give leaders and staff of university units the agency and responsibility to reduce their units' carbon emissions through both technological and behavioral energy conservation measures.

The Commission acknowledges that unit-level resistance to this recommendation is likely and that U-M needs to directly engage unit leaders in developing the program to make it work. To ensure the effectiveness and integrity of the system, U-M should be clear about how the carbon pricing revenue will be spent and should develop mechanisms to ensure that all units will benefit directly from associated energy conservation investments in the long run.

U-M should begin by implementing a proxy carbon price across all three campuses for emission Scopes 1 and 2. A proxy price will assist the university in assessing the feasibility of applying a carbon price across all three campuses. Based on the findings, U-M should adopt a phased approach to implementing a carbon price in line with the recommendations put forth by the ECP Analysis team. U-M should begin with a carbon price of $50/MTCO$_2$e—which is currently a generally accepted social cost of carbon[41]—and escalate the price at 2.5 percent per year, as recommended by the ECP Analysis team. To further incentivize action by units, the top two units by percentage emissions reductions each year would receive an additional 10 percent of their carbon charge revenue. The desire for a competitive component was a clear lesson from Yale's Carbon Charge program with different pricing systems.[42]

Once carbon emissions accounting and tracking is standardized across units, the carbon price should be expanded to Scope 3 emissions included in carbon neutrality goals that are quantifiable and within U-M's ability to reduce.

To catalyze progress on this recommendation, an initial step is to form a committee comprising unit leaders and university budget officials to develop the details in a way that will make it workable within U-M budget structures and their likely evolution in the coming years. As the proposed carbon pricing system is phased in, organizational structure and budget-model considerations will need to be evaluated and changes made in accordance with lessons learned. The university will need to work closely with the Dearborn and Flint campuses to design customized carbon pricing infrastructures and to identify emissions reduction strategies to address existing inequalities in resource allocations. Before a price is implemented at Flint, submetering infrastructure and more robust accounting programs will need to be put in place.

After these steps are taken during the first year, and depending on the findings from the proxy pricing study, U-M should implement the pricing system incorporating lessons learned during the preliminary phase. This entails collecting the first revenue, continuing to collaboratively build energy management capacity, and reviewing the first cohort of projects for the

41 President Biden's Executive Order on Protecting Public Health and the Environment and Restoring Science to Tackle the Climate Crisis, Section 5, establishes a working group to calculate a new U.S. social cost of carbon by January 22, 2022. For more, review the Executive Order.

42 Yale University. (2020, January 1). Yale Carbon Charge. Yale Carbon. https://carbon.yale.edu/

efficiency investment fund. The carbon price should then be incrementally increased so that it aligns with the most current thinking on an appropriate social cost of carbon in Year 5 and continues to do so each year thereafter.

To measure progress on this recommendation, U-M needs to track emissions reductions from the energy conservation measures, the annual cost savings, and the number of energy conservation measures completed with the REF. Current U-M metric and verification practices are inadequate and must be substantially revised for the carbon price to function both effectively and sustainably. The Commission suggests that one unit be identified to oversee and manage both the REF and the carbon pricing program.

Refer to Appendix N for more specific evaluation criteria related to this recommendation.

BUILDING STANDARDS

As noted in the Building Standards Analysis, most approaches to the design and evaluation of high-performance buildings to date focus on energy demand calculations, such as energy use intensity. Increasing the energy efficiency of U-M buildings is extremely important going forward, because reducing energy demand across campuses (particularly peak demand) will decrease the size and cost of projects to transform U-M's heat and power infrastructure. However, a singular focus on energy demand can be misleading because energy demand and consumption have a relationship to GHG emissions that is contingent on several other factors, such as the fuel mix associated with the energy being supplied to the building.

As of 2019, buildings on the UM-Ann Arbor campus consumed 98.5 percent of the total measured energy and contributed 97.3 percent to measured Scope 1 and Scope 2 GHG emissions. In the past 10 years, the Ann Arbor campus has grown in building area by approximately 6.5 million gross square feet.[43] In contrast, the Flint and Dearborn campuses have seen much smaller rates of growth and are also significantly smaller in total building gross area. If growth trends continue, the rate at which new construction contributes to future GHG emissions will be strongly influenced by the types of buildings constructed.

43 University of Michigan Office of Campus Sustainability. University of Michigan, Environmental Metrics FY19. https://ocs.umich.edu/wp-content/uploads/2020/04/FY2019-Env-metrics.pdf

Strategy Recommendation: Establish best-in-class CO_2 emissions targets across nine building types for all new construction and major renovations.

In line with the Building Standards Analysis Report, the Commission recommends that U-M move rapidly to adopt strict emissions targets for all new construction projects, including major renovations on the Ann Arbor, Dearborn, and Flint campuses. The emissions target should be specific to nine building types found on U-M's campuses, as Table 3 shows. This shift would prioritize evaluating buildings based on their CO_2 emissions while recognizing that energy performance considerations are also important. Prioritizing CO_2 emissions into the new construction building standards requires the consideration of both the individual performance of a structure and the impact of its energy intensity on total campus emissions, both of which align with the Commission's heat and power infrastructure recommendation. This approach represents a shift from U-M's current energy/cost building code, and because there are no existing codes for a carbon per square foot approach, it is something that U-M would need to develop.[44]

Table 3. Proposed building types compared with major building codes and standards

Based on University of Michigan Ann Arbor Campus
Recommended Maximum Emissions Targets by Building Type

U-M Buildings									
Classification	Educational Building (no lab)	Educational Building (low load lab)	Educational Building (high load lab)	Library	Clinical	Residential (dormitory)	Residential (low rise, duplex, single family)	Administrative	Athletic (excluding natatoria)
ASHRAE 90.1 2013									
Kg CO_2/sq ft	14.0	21.0	28.0	7.5	19.0	7.9	4.5	15.0	7.0
Recommended Goal									
Kg CO_2/sq ft	**10.0**	**16.0**	**21.0**	**6.0**	**15.0**	**5.2**	**1.0**	**10.0**	**5.0**
% reduction from ASHRAE 90.1 2013	28.6%	23.8%	25.0%	20.0%	21.1%	34.2%	77.8%	33.3%	28.6%

Also in alignment with the heat and power infrastructure recommendation, all new and renovated buildings at U-M should be designed and constructed to be easily converted to a medium-temperature hot water system, which is already underway with new campus construction. In addition, advanced metering will need to be installed to measure hourly consumption of electricity, natural gas, steam, and water input and outflow.

44 University of Michigan Architecture, Engineering and Construction. (2020, January 1). Design Guidelines. https://umaec.umich.edu/for-vendors/design-guidelines/

With the university's large and varied portfolio of buildings ranging in purpose—whether residential, academic, utility, heavy research, or medical—U-M has the ability to implement aggressive building standards that would have significant impacts across multiple building types while demonstrating statewide and nationwide leadership. Such diverse building standards would be especially scalable and transferable to peer institutions, industry, hospitals, and like-minded institutions with carbon neutrality aspirations.

U-M's Architecture, Engineering and Construction (AEC) currently oversees all building renovation and new construction projects over $3 million on the Ann Arbor, Dearborn, and Flint campuses. AEC has developed and implemented extensive design standards that meet or exceed building standards required at the state level. Therefore, AEC will play a pivotal role in the successful implementation of the proposed new building standards, along with other units such as the Facilities Operations departments at UM-Dearborn and UM-Flint and Michigan Medicine Facilities Planning & Development.

While paving the way toward long-term energy savings, strict standards will likely add significant up-front costs to new construction projects. Success requires engagement with deans and other unit leaders to understand their perspectives and address potential concerns prior to implementing the new standards. Once new construction standards are implemented, U-M will likely need to train skilled tradespeople and develop educational efforts for all building occupants to increase their understanding of how to optimize building performance.

U-M should utilize dynamic modeling technology to track the proposed building standards throughout the design phase. Models should include dynamic efficiency values of heating, ventilation, and air conditioning (HVAC) systems, as well as locally specific values for the impact of the building's energy mix over time. U-M should also verify design targets with actual building performance over time. Verification will require ubiquitous metering per building across all input and output types.

When designing new construction projects, U-M should compare costs and conduct feasibility studies for energy efficiency and renewable energy options that can be building integrated and complement district-level systems. When calculating the cost/benefit impact of these standards for a particular building type, studies must also account for the interlocking impacts of other recommendations for Scopes 1 and 2. AEC should also work with the Dearborn and Flint campuses to determine the best way to scale the recommended construction building standards to meet their particular needs. The Revolving Energy Fund can serve as one mechanism to support energy conservation measures in major renovation projects.

University Hospital | By Michigan Photography

U-M should immediately begin to pursue the following next steps to catalyze progress:

- Expand the analysis of new construction building standards on all three campuses and finalize a set of criteria and costs needed to ensure standards accelerate progress toward U-M carbon neutrality goals.
- Prior to permitting construction, mandate that all new buildings follow the guidelines to accelerate progress toward carbon neutrality.
- Review all ongoing construction projects and assess the costs and practicality of having these projects fully or partially conform to the standards.
- Expand research on net-zero emissions buildings standards and systems to accelerate impacts on campus and to scale and transfer them beyond the university.
- Improve the ability to measure embodied carbon in building materials to inform strategies for mitigating these impacts as described in the Building Materials section.

Refer to Appendix O for more specific evaluation criteria related to this recommendation.

DEEP ENERGY RETROFITS IN EXISTING BUILDINGS

Complementing the work conducted by the Building Standards Analysis team, the Commission hired an external consultant (SmithGroup) to identify and provide cost estimates on strategies to significantly minimize energy use and carbon impacts in existing campus buildings. A goal of this work was to identify energy conservation measures (ECMs) that can be repeated across similar building types and used to reduce energy use and carbon emissions. The initial desire was to conduct these analyses for five specific building types (i.e., administrative/classroom, research, clinical, athletic, residential) across campus, but due to time and budget constraints, only two studies were initiated on two very distinct buildings—the Art and Architecture (A&A) Building (administrative/classroom) and Couzens Residential Hall (residential).[45]

Constructed in 1971 and with a significant addition built in 2017, the A&A Building has a variety of space types, including studios, workshops, labs, classrooms, and administrative offices. The multi-dimensional ECM strategies evaluated by SmithGroup included mechanical and electrical building systems, the building enclosure, walls, and roof, as well as various combinations of these same systems. The analysis concluded that the A&A Building is a prime candidate for significant renovations. However, the costs of deep retrofits to drive significant carbon reductions would be very high in terms of dollars spent per $MTCO_2e$ reduced. Specifically, the retrofit scenario resulting in the largest GHG reduction (77 percent) is projected to cost $114 million with a simple payback of 492 years.

Art & Architecture Building | By Michigan Photography

45 For more on the SmithGroup building energy efficiency studies, refer to the full report: http://doi.org/10.3998/mpub.12106747

Couzens Hall | By Michigan Photography

Couzens Hall is an undergraduate residence hall that was constructed in 1926, with a significant addition built in 2011. The SmithGroup team analyzed several approaches for Couzens that could be applied to similar building types that may not have had a recent renovation. The ECM strategies evaluated included mechanical and electrical building systems, the building enclosure itself, and various combinations of individual ECMs. As with the A&A study conclusions, the costs of deep retrofits at Couzens would be very high relative to the associated GHG reductions. The retrofit scenario resulting in the largest GHG reduction (58 percent) is projected to cost $63 million with a simple payback of 803 years.

Based on these initial studies, the Commission determined that Integral Group's district-level approach to decarbonizing U-M's heating and cooling infrastructure as described in detail above, while also costly, is preferable to a distributed approach to decarbonizing building heating and cooling. U-M should continue to conduct studies of different building types (e.g., classroom, research, clinical, and athletic) to clarify which ECM strategies are most cost-effective in reducing energy consumption. ECMs with more attractive returns on investment should be aggressively pursued through the REF program.

Refer to Appendix P for more information on SmithGroup's studies of the Art and Architecture Building and Couzens Hall.

This section provides information on U-M's GHG emissions for Scope 3 as well as pathways and strategies for achieving carbon neutrality.

CARBON NEUTRALITY GOAL SUMMARY

The Commission recommends that U-M set carbon neutrality goals for Scope 3 emissions in the following manner.

SCOPE 3 EMISSIONS

By no later than 2025, set carbon neutrality goal dates for each of the Scope 3 categories recommended for inclusion by the Commission, recognizing that goal dates may vary by category based on U-M's ability to measure and influence the associated emissions categories. The Commission also recommends that, in yearly intervals up until 2025 and beyond, U-M actively consider including additional Scope 3 categories in its goals.

In setting carbon neutrality goal dates for Scope 3 emissions categories, establish targets (inclusive of offsets as needed) that are more aggressive than science-based targets and reach neutrality no later than 2040.

Boundaries and Baselines

Scope 3 emissions result from upstream (pre-combustion) fuel extraction and processing, commuting, university travel, food (upstream and downstream), water treatment (upstream and downstream), land use, and upstream (production) embodied carbon in purchased goods and services.[46] Figure 6 estimates the Scope 3 baseline emissions for U-M.[47] Due to significant accounting uncertainty at this time, purchased goods are not included in these estimates but are likely larger than any of the other categories. The Carbon Accounting team estimated upper and lower bounds for emissions associated with purchased goods to be from 300,000 to 1.4 million $MTCO_2e$. This range is based on total dollars spent on purchased goods using low and high carbon emission factors per dollar spent. The degree of uncertainty in U-M estimates of Scope 3 emissions are characterized in the Carbon Accounting Modeling Project Report.

Scope 3 GHG emissions are all of the upstream and downstream GHGs related to U-M activities excluding Scope 2 emissions, such as commuting, university travel, and purchased goods.

46 Refer to the Greenhouse Gas Protocol Corporate Value Chain (Scope 3) Accounting and Reporting Standard for details regarding upstream and downstream Scope 3 emissions categories.
47 Refer to the Carbon Accounting Modeling Project Report for delineation of these categories as well as data and information on additional Scope 3 categories that have less significant GHG impacts.

Figure 6. Scope 3 baseline emissions (not including purchased goods and services). The upstream emissions category (beige) includes upstream emissions from buildings, commuting, fleet vehicles, university travel, Blue Bus, and other mitigation activities. Negative Scope 3 emissions occur for activities that pull GHGs out of the atmosphere.[48, 49]

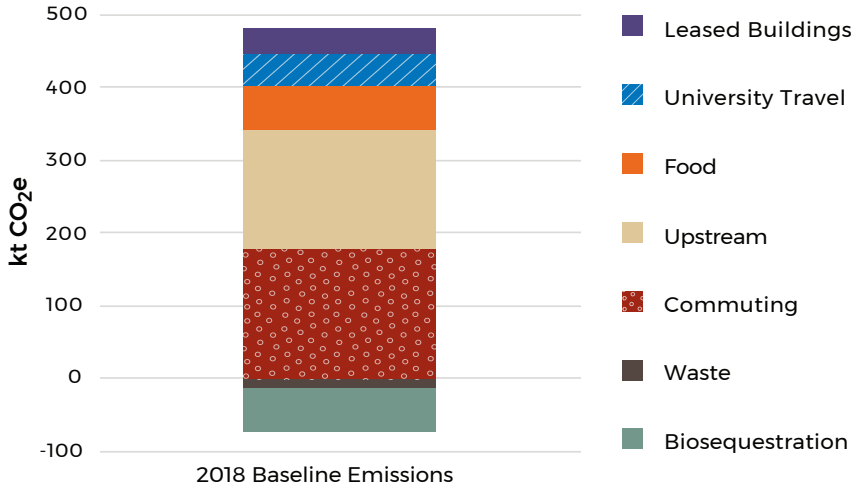
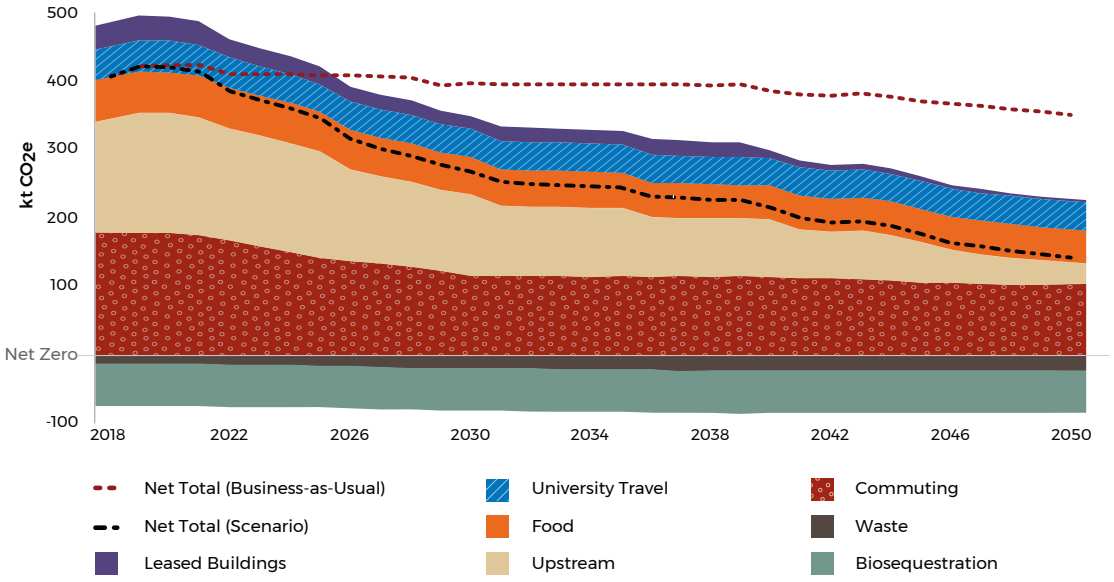


Figure 7. Trajectories for U-M Scope 3 emissions from 2018 through 2050. The red line reflects net total emissions in a business-as-usual (BAU) scenario, including projected changes to the electricity fuel mix. The black line projects net total emissions (excluding purchased goods), reflecting the Commission's recommended mitigation strategies.[50] Technological innovations and faster decarbonization of future energy supply would cause Scope 3 emissions to fall more rapidly than depicted.[51]



48 Biosequestration is the extraction of carbon from the atmosphere by living things (e.g., plants) and is categorized as a Scope 3 activity using the scope definitions provided by the GHG Protocol.

49 Carbon sequestered from composting and mulching and avoided emissions from recycling and food donations exceed emissions from landfill waste, resulting in a net carbon sink.

50 Purchased goods is a significant Scope 3 category that is not included in Figure 7 due to current limitations in estimating associated emissions levels. U-M needs to improve its ability to account for these emissions, and specific recommendations are provided in the Purchased Goods section.

51 In addition to the categories shown, several small categories are included in the emissions total.

Goals and Timelines

Goal Recommendation: By no later than 2025, set carbon neutrality goal dates for each of the Scope 3 categories recommended for inclusion by the Commission, recognizing that goal dates may vary by category based on U-M's ability to measure and influence the associated emissions categories. The Commission also recommends that, in yearly intervals up until 2025 and beyond, U-M actively consider including additional Scope 3 categories in its goals.

Whereas U-M's current GHG reduction goal includes only emission Scopes 1 and 2, the Commission recommends that U-M establish carbon neutrality goals inclusive of Scope 3 emissions. This recommendation is intended to put U-M on that path while acknowledging that, compared to emission Scopes 1 and 2, it is usually more difficult to measure Scope 3 emissions with a high degree of accuracy and challenging to influence their trajectory (see Figure 7). The Commission recognizes the importance of providing U-M with time to implement accounting systems to better track and establish baselines for these emissions categories and to better assess the degree to which U-M can influence them. For each of the Scope 3 categories identified below, the Commission recommends setting goals as soon as effective accounting systems are in place, recognizing that some categories will take longer than others. At the same time, the Commission strongly believes that U-M should not wait to act to reduce these emissions until goal dates have been set. Most of the following section is devoted to recommendations for reducing Scope 3 emissions that can and should be undertaken as soon as possible.

Compared to emission Scopes 1 and 2, it is usually more difficult to measure Scope 3 emissions with a high degree of accuracy and more challenging to influence their trajectory, as seen in Figure 8. This is because U-M's Scope 3 emissions are someone else's Scope 1 and Scope 2 emissions, so eliminating these emissions requires concurrent action by many individuals and organizations. With awareness of the mounting urgency for reducing carbon emissions reaching all governments, institutions, and enterprises, it is reasonable to expect that Scope 3 emissions will decrease at an accelerating rate, thus making U-M's efforts to measure and reduce them less onerous with time.

Figure 8. U-M's ability to influence and estimate emissions levels for Scopes 1, 2, and 3.

U-M's Ability to Confidently Estimate Emission Levels

	High	Medium	Low
High	◆ Central Power Plant ◆ Boilers & Other Stationary ◆ UM Vehicle Fleet ◆ Maintenance Equipment	◆ Purchased Electricity ◆ Waste Disposal	
Med		◆ Commuting ◆ UM-Sponsored Travel	◆ Upstream (Electricity and Fuels)
Low			◆ Food Purchasing ◆ General Purchasing

Color key: Scope 1 | Scope 2 | Scope 3

Among peer institutions that have already established carbon neutrality goals, there is a wide variance with regard to tracking Scope 3 emissions and setting goals for them. As illustrated in Table 4 below, many of these peer institutions are actively working to better measure Scope 3 emissions for purposes of eventually including them in carbon neutrality goals.

Table 4. Scope 3 tracking and goal dates for sample peer institutions with carbon neutrality commitments, excluding all peers without Scope 3 goals.

EMMISION CATEGORY	BERKELEY	CORNELL	DUKE	HARVARD	ILLINOIS	OHIO STATE	UCLA	VIRGINIA	YALE
COMMUTING		2035			2050	2050	2050		
FOOD									
PURCHASED GOODS									
SOLID WASTE						2050			
UNIVERSITY TRAVEL		2035			2050	2050	2050		
UPSTREAM METHANE LOSSES (NG)									
UPSTREAM T&D LOSSES (ELECTRICITY)						2050			
WASTEWATER						2050			

Tracked and included in carbon neutrality goal

Tracked / not yet included in carbon neutrality goal

NOT tracked / not yet included in carbon neutrality goal

Goal Recommendation: In setting carbon neutrality goal dates for Scope 3 emissions categories, U-M should establish targets (inclusive of offsets as needed) that are more aggressive than science-based targets and reach neutrality no later than 2040.

With this recommendation the Commission emphasizes the urgency of moving toward carbon neutrality across all emissions categories and acknowledges the fact that eliminating these emissions is complex and requires concurrent action by many individuals and organizations that are largely beyond U-M's control. In response to IPCC guidance and in the interest of global climate justice, it is important that U-M move quickly to work with others to do the same. The Commission acknowledges that achieving carbon neutrality with respect to Scope 3 emissions may need to involve verified carbon credits and offset projects. As with the use of offsets to help meet Scope 1 emissions goals, this recommendation is based on a set of assumptions around the quality of carbon credits and offset projects, which are outlined in the Carbon Offsets and Sinks section along with specific recommendations for the use of offsets.

STRATEGY RECOMMENDATIONS SUMMARY

This table provides generalized comparisons of the recommendations in terms of the necessary financial investment and culture shift required at institutional, unit, and/or individual levels throughout the university community. These are subjective judgments based on the best available information and are for illustrative purposes only.

STRATEGY RECOMMENDATION	FINANCIAL INVESTMENT ($ — $$$$$)	GHG LEVELS ↓ — ↓↓↓↓↓	CULTURE SHIFT (L—M—H)
COMMUTING			
Proceed with the design and development of the Ann Arbor campus connector and integrate it with local/regional transit systems.	$$$$	↓↓	Med
Reform the parking policy on each of U-M's three campuses by shifting to a daily fee system and establishing an equitable, income-based fee structure while eliminating parking subsidies on the Ann Arbor campus.	$$	↓↓	High
Expand the availability of electric vehicle charging stations across all three U-M campuses.	$$	↓	Med
Invest in affordable and accessible alternatives to the personal vehicle commute, including rideshare, cycling, and free bus access on the Flint and Dearborn campuses.	$$	↓↓	Med
Embrace and incentivize flexible telecommuting options for employees whose job roles can be performed remotely.	$	↓↓	Med

STRATEGY RECOMMENDATION	FINANCIAL INVESTMENT ($ — $$$$$)	GHG LEVELS ↓ — ↓↓↓↓↓	CULTURE SHIFT (L—M—H)
UNIVERSITY TRAVEL			
Provide and incentivize low-carbon ground transport options (e.g., trains, hybrid/electric buses and passenger vehicles) for university-sponsored travel.	$$	↓↓	Med
Promote video conferencing as an alternative to in-person meetings and travel.	$	↓↓	High
Implement a carbon price for faculty, staff, and students who travel on university business, with the revenue being used to support the reduction or offsetting of U-M emissions.	$	↓	High
FOOD			
Pursue plant-forward food procurement and consumer diets across all three U-M campuses.	$	↓↓	High
SOLID WASTE AND WASTEWATER			
Scale up food waste diversions and reductions, increase capacity for composting on U-M's campuses, and launch a campus-wide composting program at UM-Dearborn and UM-Flint.	$$	↓	High
Explore improved water efficiency and site design standards for all new construction to reduce both upstream and downstream emissions from water treatment.	$	↓	Low
LEASED BUILDINGS			
Strive to meet additional space needs through better utilization of permanent space (including co-working spaces) and leased space that are intentionally designed as flexible co-working facilities for staff across multiple units who, for example, telecommute three or more days per week.	$	↓↓	High
Prioritize leasing arrangements that allow the university to pay electric and gas utility bills directly.	$	↓	Low
Develop and implement language in all leasing policy documents that requires high energy efficiency and a low GHG footprint, ideally in alignment with U-M building standards, and require property owners/managers to provide detailed information on their efforts to implement energy efficiency and emissions reductions and how this ethic is woven into their overarching operating principles.	$	↓	Med

Strategy and Accounting Recommendations

The following recommendations reflect strategies that the Commission believes will be most impactful in improving measurement and influencing the trajectory of Scope 3 emissions. After embarking on these efforts, U-M should re-evaluate these strategies on a regular basis, consistent with guidance provided in the Leadership Structure section of this report.

To view a summary table of all accounting recommendations, please refer to Appendix Q.

COMMUTING

The university does not have direct control over faculty, staff, and student commuting. However, U-M's policies and practices—parking, public transit, housing, land-use planning, and telecommuting—all shape community member decisions regarding how far and how frequently they commute and which transportation modes they use to do so.

Informed by the Commuting Analysis Report, the Commission recommends the following strategies with the goal of creating a commuting system that equitably serves all members of the campus community while reducing its carbon intensity. These strategies are designed to be complementary and allow community members to utilize whichever commute mechanisms best serve their needs on a daily basis.

In addition to these recommendations, U-M should explore faculty, staff, and student needs for affordable housing on its campuses to facilitate lower carbon intensity commuting and address equity considerations around local housing costs. Refer to the housing recommendation in the Organization and Culture section for more detail.

> **Strategy Recommendation:** Proceed with the design and development of the Ann Arbor campus connector and integrate it with local/regional transit systems.

The Commission recommends that U-M proceed with developing the proposed high-capacity Ann Arbor campus connector. Development of the campus connector as light rail would result in the removal of 25 U-M buses from the fleet, which would reduce GHG emissions by approximately 1,400 $MTCO_2e$ annually and lower U-M's overall demand for electrified replacement buses. Emissions would be further reduced by less inter-campus personal vehicle travel, though the estimated magnitude of these reductions is not quantified at this time.

In developing the connector, U-M should take additional steps to integrate it with municipal and regional transit systems to ensure that it supports transit movements to and from campus, in addition to serving as an inter-campus shuttle. Toward this end, U-M should develop this project in collaboration with the City of Ann Arbor, the City of Ypsilanti, Ann Arbor Township, Washtenaw County, and the Michigan Department of Transportation. In line with the Commuting Analysis Report recommendations, the system should be extended east to US-23 and west to the Blake Transit Center. The system should also link with the potential rail station at Fuller Road adjacent to the medical campus. The system's capacity should be designed under the assumption that the UM-Ann Arbor campus connector will ultimately be a major node in a larger municipal system.

The Commuting Analysis Report recommended that U-M consider designing the system as bus rapid transit as opposed to high-speed rail, to accommodate the buses of the Ann Arbor Area Transportation Authority (AAATA) as well as those of the university. Such integration could accelerate transit service between the town and a range of campus destinations. Regardless of system technology and configuration, the Commission strongly supports the development of an electrified rapid transit system to interconnect the Ann Arbor campuses. The carbon footprint of the infrastructure required for various options should be a major consideration in designing the system. As a shared community benefit, this proposal could form the basis of a funding application to the Federal Transit Administration. New federal and state funding opportunities are likely to become available under the Biden Administration and as a consequence of Gov. Whitmer's September 2020 executive order on carbon neutrality, respectively.

The Ride Ann Arbor / Courtesy of Graham Sustainability Institute

U-M Lot M5, Ann Arbor | By Dwight Burdette, CC BY 3.0, via Wikimedia Commons

Strategy Recommendation: Reform the parking policy on each of U-M's three campuses by shifting to a daily fee system and establishing an equitable, income-based fee structure while eliminating parking subsidies on the Ann Arbor campus.

The most effective tool the university has to reduce emissions from the commute in the immediate term is its parking policy. The Commission recommends that U-M:

- Replace annual and monthly parking permits with a daily parking payment structure that incentivizes individual commuters to seek alternatives (e.g., telecommuting, public transit, rideshare programs, cycling) to driving personal vehicles to campus every day. A daily pass system should be designed to accommodate all faculty/staff work schedules across the university, as is currently the case with daily fee passes.
- Link parking rates to employee salary levels to create an equitable system that is based on their ability to pay. This policy is in place at Rutgers University, Rochester Institute of Technology, and Indiana University.

Implementation should include robust community engagement across all three campuses to gain buy-in and inform the final design of the new parking policies. Parking policy and pricing is an issue that affects the daily life of all faculty, staff, and students and therefore requires extensive engagement and buy-in to ensure community understanding and acceptance.

Ann Arbor Campus

The Commission recommends that the Ann Arbor campus eliminate the $172 per-year university contribution to the parking passes of faculty and staff and account for this current benefit when setting the income-adjusted pricing structure recommended above. This university contribution represents a direct subsidy to carbon emissions in the commute and one from which commuters who make the lowest-carbon choices are unable to benefit.

The UM-Ann Arbor campus should set parking charges with the goal of utilizing available parking throughout the campus. During peak periods, central parking locations are at or beyond capacity, while approximately 1,300 spots in peripheral locations remain vacant (refer to Appendix D of the Commuting Analysis Report). This inefficient utilization of existing parking leads to pressure for expanding close-in parking capacity, with its inevitable carbon impacts. Adopting this recommendation might require adjusting public transit resources to accommodate higher ridership from the peripheral locations. The UM-Ann Arbor Logistics, Transportation and Parking (LTP) Office will be responsible for implementing parking policy reform on the Ann Arbor campus.

Dearborn and Flint Campuses

On the Dearborn and Flint campuses, the Commission recommends parking charges currently incorporated into mandatory per-term registration fees be disaggregated and made optional to offer cost savings to students who opt to reach campus by different modes. Unlike the Ann Arbor campus where lower carbon modes of transport are more available to community members, the Dearborn and Flint campuses are primarily commuter campuses. The campus communities commute by personal vehicle and park on campus out of necessity. This means that other transportation options must be developed and available to get the community to and from campus before parking disincentives are applied on the Dearborn and Flint campuses. The reformed parking policies must also align with a compelling communications plan so the campus community can access and understand the policy reforms. The UM-Flint Parking Office and UM-Dearborn Facilities and Operations Office will be responsible for implementing parking policy recommendations.

To maintain progress on this recommendation, U-M should create a system to track the number of parking system participants and the automated counting of daily parkers.

Refer to Appendix R for more specific evaluation criteria related to this recommendation.

Strategy Recommendation: Expand the availability of electric vehicle charging stations across all three U-M campuses.

Commuter vehicle choices directly impact the carbon intensity of the commute. Each commuter who shifts to an electric vehicle (EV) will incrementally reduce the carbon intensity of the university commute. Although the university does not have direct control over which vehicles the U-M community chooses to use, U-M can encourage EV adoption among faculty, staff, and students, including by providing adequate EV charging infrastructure at their workplaces. With this in mind, the Commission recommends U-M expand EV charging infrastructure across all three U-M campuses with the goal of supporting 20 percent EV adoption of long-distance (20+ miles) faculty and staff commuters by 2030, which aligns with goals articulated by the City of Ann Arbor. According to the Mobility Electrification Analysis Report, there are currently 14 Level 2 charging stations available on the Ann Arbor campus, eight charging stations on the UM-Dearborn campus, and one charging station on the UM-Flint campus. Providing ample charging stations across U-M's campuses will enable community members who already own, or are considering ownership of, an EV the ability to use the EV for travel to and from campus, thus reducing the carbon intensity of their commute. Premium access to workplace charging at convenient parking locations will also be an incentive for more car- or vanpooling as those vehicles transition to electric power. The Commission recognizes that increasing the number of charge stations will ultimately put increasing demands on the electricity grid. Hence, these changes must be made in collaboration with the campus electricity providers.

In addition to expanding workplace and visitor EV charging capacity on campus, U-M should vigorously explore partnerships with the regional utility companies and other entities to increase the awareness of the U-M community members of the benefits of EVs and the various incentives for installing home charging systems for their EVs. Home charging systems will allow U-M community members to charge their vehicles at off-peak hours, in addition to on-campus charging. Recent studies show that workplace charging from networked chargers and in the middle of the day will provide a much needed load-balance when commuters select managed charging while parked (deferred or other smart management of EV charging to avoid peak power) and may create behind-the-meter storage for on-site renewables and facilitate higher penetration of renewables to the grid.[52]

52 https://www.michigan.gov/documents/energy/Energy_Storage_Session_5-Storage_as_a_Grid_Resource_Jester_652345_7.pdf

U-M Lot M5, Ann Arbor / Courtesy of U-M Office of Campus Sustainability

By both increasing EV charger availability on campus and partnering with utilities and others to increase the awareness of the availability of home charging system incentives and assistance, U-M will encourage its community members that have to drive their personal vehicle to make decisions that help reduce commuting emissions in pursuit of carbon neutrality goals. U-M should also consider other incentives to increase EV adoption, such as provision of some premium parking spaces to EV owners that commute a long distance and do not have other commuting options.

To maintain progress on this recommendation, U-M should create a system to track the following metrics:

- The number of EV chargers installed on each campus;
- EV charger utilization data including electricity consumption and charging session durations; and
- GHG emissions reductions and fuel cost savings as well as the actual costs of the charging equipment, their maintenance, and electricity use.

Additional study is needed on the Dearborn and Flint campuses to determine the best placement and quantity of EV chargers. A techno-economic study that includes potential benefits of solar carports to provide shelter and feed the charging stations should be developed for the Dearborn and Flint campuses. The Commission stresses the importance of significant community engagement through the formation and implementation of these policies, since they impact the daily lives of the U-M community.

To implement the EV charging infrastructure, U-M AEC, the UM-Ann Arbor LTP Office, the UM-Flint Parking Office, UM-Dearborn Facilities and Operations, and the OCS should partner to develop a detailed implementation timeline. Such a timeline should be informed by EV adoption rates associated with climate change mitigation strategies and by environmental justice considerations. It should include aspirational goals that will position U-M as a regional, national, and even an international leader and be updated and adjusted periodically. In addition, the implementation planning team should develop policy around rates to be paid by users of the charging stations. Pricing should seek to encourage the use of EVs but not cause unintended consequences, such as discouraging at-home charging.

In pursuing this recommendation, U-M should acknowledge the limitations in the adoption of electric vehicles in the short term due to economic barriers for lower-income populations and consider such obstacles when prioritizing commuting solutions or programs designed to support EV adoption.

Refer to Appendix R for more specific evaluation criteria related to this recommendation.

Strategy Recommendation: Invest in affordable and accessible alternatives to the personal vehicle commute, including rideshare, cycling, and free bus access on the Flint and Dearborn campuses.

Rideshare

Currently, rideshare programs (e.g., vanpools and carpools) are supported on the Ann Arbor campus but not on the UM-Dearborn and UM-Flint campuses. According to the Commuting Analysis Report's estimates, fewer than 1 percent of university affiliates currently commute by rideshare to the Ann Arbor campus. Rideshare is particularly relevant for longer-distance commutes, which account for an outsized fraction of the carbon impact of the commute as a whole. The current program on the Ann Arbor campus should be enhanced to increase use by helping interested community members to easily find one another and increasing incentives (e.g., discounted parking fees, convenient parking locations, and workplace charging so that EVs can be used) for commuters who choose to participate in rideshare programs. On the Dearborn and Flint campuses, the university should pursue additional engagement to determine if this is a desirable program for their faculty, staff, and students. The UM-Ann Arbor LTP Office, UM-Dearborn Facilities, and UM-Flint Parking Office should be responsible for implementing this recommendation. Rideshare usage is already tracked on the UM-Ann Arbor campus. Tracking should be implemented on the UM-Dearborn and UM-Flint campuses.

Cycling

The Commission views cycling as an increasingly relevant and integral part of campus transit and encourages the university to pursue a multi-modal transportation system by incorporating accessible and safe cycling paths. Additionally, U-M should create a workable and safe Central-to-North Campus bike route; provide dry, accessible, and secure bike storage spaces across campus; and establish an on-campus bike-service facility. In developing cycling pathways, U-M campuses should work with their respective cities to ensure they interconnect with other local cycling pathways. Similar efforts should be pursued to ensure walkability to all campus locations and their interconnections with local walking infrastructure.

Ann Arbor campus | By Michigan Photography

Dearborn and Flint Campuses

As previously stated, the Dearborn and Flint campus populations commute by automobile largely out of necessity. To reduce the personal vehicle commute, the university will need to provide accessible and affordable alternative modes of transportation.

The university currently provides free access to AAATA buses for all students, faculty, and staff. Universal access transit agreements should be extended to all students, faculty, and staff on the Dearborn and Flint campuses. The transit agreements should be cooperative agreements with the Suburban Mobility Authority for Regional Transportation on the Dearborn campus and the Mass Transportation Authority for the Flint campus. Increased bus service to campus, including a higher number of accessible and protected bus stops and campus-based routes, should be included in the agreements for both the Dearborn and Flint campuses.

U-M should also work with the City of Dearborn to fund and complete the bikeways to the Dearborn campus currently proposed in the City of Dearborn's Multimodal Plan.[53] There are also a variety of cycling improvements that should be explored on the Flint and Dearborn campuses, including secure and maintained bike racks, road markings, signage, traffic signal timing, and shower facilities.

Before implementation begins, issues related to alternative transportation need to be better understood in the contexts of the Dearborn and Flint campuses to ensure that the proposed policies and alternatives create the desired change. This process could be initiated by implementing a transportation survey on both campuses to collect the necessary data.

Progress on these recommendations should be tracked by measuring the number of cyclists and bike path usage and the number of farebox swipes on the Flint and Dearborn campuses.

Refer to Appendix R for more specific evaluation criteria related to this recommendation.

Strategy Recommendation: Embrace and incentivize flexible telecommuting options for employees whose job roles can be performed remotely.

While current data on the net emissions impacts of telecommuting are inconclusive, the Commission intuits that the net benefits should be favorable due to fewer vehicle trips from homes to campuses and longer-term opportunities for U-M to more effectively utilize campus space and decrease the need for new construction. As evidenced by the COVID-19 pandemic, telecommuting provides a viable option for many employees to conduct their work effectively without the need for daily trips to and from campus. As U-M continues with current task force efforts focused on the future of telecommuting policies, and as soon as in-person work is deemed safe to resume, the university should implement flexible telecommuting policies and incentives across all three campuses that facilitate the opportunity to work remotely on a regular basis. The Commission also recognizes that face-to-face interactions with colleagues and students are important for individual well-being and a thriving community and thus strongly supports telecommuting policies with a high degree of flexibility and that best meet the needs of individuals and the broader community. The Commission also recognizes that many U-M community members must be on campus to perform their duties and that any telecommuting incentives adopted by the university should not adversely affect these individuals.

53 City of Dearborn. (2019, June 6). City of Dearborn Multimodal Plan. https://walkbike.info/Dearborn/plan/

UNIVERSITY-SPONSORED TRAVEL

The Commission defines university-sponsored travel as travel by faculty, students, staff, and visitors that is paid for with university-administered funds across all three campuses. This does not include business trips paid for by other institutions, personal trips, or daily commuting by faculty, staff, or students.

Reducing U-M's travel carbon footprint will be a challenge that requires both cultural and behavioral shifts to separate university travel from academic life. U-M will need to empower the university community to reduce their own travel by encouraging individuals to:

- Evaluate whether a particular trip is necessary;
- Substitute ground for air travel;
- Substitute a virtual meeting for a trip; or
- Mitigate air travel by means of a travel carbon offset.

At an institutional level, the Commission recommends that U-M incentivize low-carbon ground transport; provide viable alternatives to travel, such as video conferencing; and implement a carbon price on travel once appropriate carbon accounting measures are in place. The proposed changes to the university's current university-sponsored travel programs will require significant culture and behavior changes, and educational programming will be integral to the success of these programs. See the Organization and Culture section of the report for the educational program recommendations.

Amtrak | By Aris via Unsplash

Strategy Recommendation: Provide and incentivize low-carbon ground transport options (e.g., trains, hybrid/electric buses, and passenger vehicles) for university-sponsored travel.

The Commission recommends that U-M promote and incentivize transportation options that have the lowest carbon emissions per passenger mile. This includes the use of low-carbon ground transportation options (e.g., trains, electric/hybrid buses, electric/hybrid vans) as an alternative to air travel for trips under 300 miles. According to a survey administered by the University-Sponsored Travel Analysis team, 81 percent of the 2,300 survey respondents are willing to use ground transportation for distances under 300 miles to reduce greenhouse gas emissions. These distances would cover locations as far as Chicago, Indianapolis, Pittsburgh, and Toronto. Disincentives for air travel under 300 miles should also be established. When air travel is unavoidable, U-M should create incentives for students, faculty, and staff to use low-carbon ground transportation options to and from the airport. For more on the survey and analysis, see Appendices I and J of the University-Sponsored Travel Analysis Report.

Strategy Recommendation: Promote video conferencing as an alternative to in-person meetings and travel.

The Commission agrees with the University-Sponsored Travel Analysis team's assumption that a significant portion of university travel could be replaced with video conferencing. Video conferencing platforms have steadily improved over the past decade, and during the COVID-19 pandemic, their use has surged due to technology improvements and increased familiarity. The Commission recommends that U-M promote video conferencing via several methods: The university should establish and staff state-of-the-art video conferencing facilities in easily accessible locations across all three campuses to facilitate best-in-class hybrid meetings. U-M should also establish a standard of live streaming and archiving all public lectures and seminars so that community members have multiple options for interaction.

The Commission recognizes that the primary downside to virtual meetings is that connections are easier made in person. However, considerable university travel can readily be replaced by virtual meetings. In the University-Sponsored Travel Analysis team's survey, participants were open to video conferencing for several forms of travel, including grant review panels, society committee meetings, and networking events.

Video conferencing should be strongly promoted and encouraged for cross-campus meetings to minimize unnecessary travel and inefficient use of time moving from one campus to another.

Strategy Recommendation: Implement a carbon price for faculty, staff, and students who travel on university business, with the revenue being used to support the reduction or offsetting of U-M emissions.[54]

The Commission recommends that once appropriate and accurate carbon accounting systems are in place, U-M pursue additional engagement and analysis to determine the best way to implement a carbon price on university-sponsored travel. Such a price could be incorporated into the Commission's broader carbon pricing recommendation for emission Scopes 1 and 2.

In designing such a system, special attention must be given to the various funding sources used to support university travel and what types of expenses are allowable. For example, some grant funds may not permit such an expense directly, but it could perhaps be covered with indirect cost rebates, departmental/unit contributions, or unrestricted funds.

Attention must be given to designing the system with clear guidelines as to how the revenue will be collected and used. Potential options for using the revenue include direct investments in U-M's carbon reduction infrastructure projects, increasing funding levels for the Revolving Energy Fund, or purchasing carbon credits that align with the Commission's carbon offsets guidance. Additional thought should be given to equity considerations and whether there may be ways for the revenue to directly benefit carbon reduction efforts within the unit.

Airplane | By Tom Barrett via Unsplash

54 The University-Sponsored Travel Analysis team surveyed 2,300 individuals who traveled for U-M business during fiscal year 2019. The survey data showed that the majority of those surveyed (more than 65 percent) would support the travel fee dependent on implementation conditions.

Accounting Recommendation: Standardize travel data collection to facilitate carbon footprint calculations and provide feedback to community members on the impacts of their university-sponsored travel.

As suggested in the University-Sponsored Travel Analysis Report, U-M should develop a centralized system to collect necessary information on all university-sponsored travel to establish a baseline of miles traveled, number of travel segments, and the travel carbon footprint to monitor the reduction progress. Since Concur already hosts most of U-M's travel data at all three campuses, the Commission recommends that all other sources of travel data be integrated with Concur.

The system should also be configured to provide automatic carbon footprint information to the traveler to facilitate behavior changes to reduce the university-sponsored travel carbon footprint. It should require information such as travel data, departure and arrival locations, and mode of travel (air, train, car, or bus). The metrics used to track travel should be the amount of greenhouse gas emissions per trip measured in $MTCO_2e$, determined using an internal calculator embedded in the Concur system.

To catalyze progress on this recommendation, U-M should establish a group assigned to oversee the development of a standardized travel data collection system across all three U-M campuses. Such a group should include individuals from each U-M campus. Establishing a standardized accounting system for the university-sponsored travel carbon footprint is integral to reducing emissions and measuring the success of the employee travel emissions reduction strategies. As part of this effort, U-M should track and report the number of air travel trips averted by use of ground transportation or video conferencing each year.

Refer to Appendix S for more specific evaluation criteria related to the university-sponsored travel recommendations.

MDining | Photo courtesy of Planet Blue

UNIVERSITY-PROCURED FOOD

The U-M food system is a complex and decentralized network of both self-operated units and contracts to external operators. The Ann Arbor campus has separate food services through Michigan Athletics, Michigan Dining (MDining), Michigan Medicine patient and retail operations, the Ross School of Business, the University Unions, the North Campus Research Complex, and the U-M Law School, in addition to strategic catering and vending services. There are also separate food operations at UM-Dearborn and UM-Flint. Based on FY19 data obtained from the various units by the Food Analysis team, MDining constitutes nearly half (42.1 percent) of the annual food expenditures across U-M's three campuses. For a comprehensive overview of food operations across the university, see Appendix H of the Food Analysis Report.

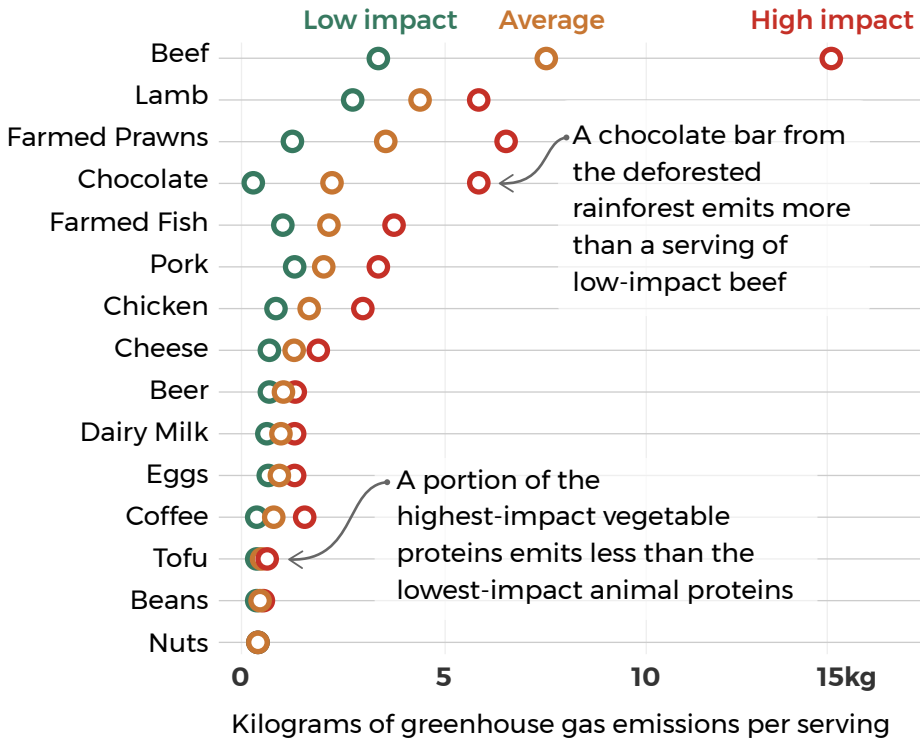
Strategy Recommendation: Pursue plant-forward food procurement and consumer diets across all three U-M campuses.

U-M currently has a goal to procure 20 percent of its food from sustainable sources by 2025, as defined by Sustainable Food Guidelines that were developed in 2011.[55] While progressive at the time, these guidelines do not account for the fact that different diets have vastly different carbon footprints and that locally sourced or third-party certified foods are not consistently associated

55 University of Michigan Office of Campus Sustainability. (2020, January 1). Sustainable Food. https://ocs.umich.edu/sustainability-goals/sustainable-food/; University of Michigan Office of Campus Sustainability. (2014, November 1). University of Michigan—Ann Arbor, Sustainable Food Guidelines. Google document. https://docs.google.com/document/d/1kmofOkOQ8gIzCUVFjgIBUXseoS2VInEgFWyC18Hu05M/edit

with lower carbon emissions.[56] The carbon footprint differences between diets are largely driven by the relative proportion of animal-source foods in diets, specifically ruminant meat, which is responsible for the greatest amount of greenhouse gas emissions. Replacing ruminant meat in diets with plant-based foods, and to a lesser extent fish and poultry, can lead to considerable emissions reductions. Figure 10 provides examples of the kilograms of greenhouse gas emissions per serving of various food items.[57] Plant-forward diets are one culinary strategy to implement such substitutions.

Figure 10. Kilograms of greenhouse gas emissions per serving



Source: Poore & Nemecek (2018), Science

Plant-forward eating is "a style of cooking and eating that emphasizes and celebrates, but is not limited to, plant-based foods" (e.g., fruits, vegetables, whole grains, legumes).[58] Importantly, plant-forward diets can include animal-source foods, such as meat, dairy, and eggs, although these foods are de-emphasized relative to plant-based foods. Among animal-based proteins, fish and poultry are prioritized, dairy and eggs play a supporting role, and red meats are limited.

56 Weber, C. L., & Matthews, H. S. (2008). Food-miles and the relative climate impacts of food choices in the United States. *Environmental Science and Technology, 42*(10), 3508–3513. The Culinary Institute of America and the Harvard T.H. Chan School of Public Health, Department of Nutrition. (2019). 2019 menus of change annual report. https://doi.org/10.1021/es702969f

57 Stylianou, N., Guibourg, C., & Briggs, H. (2019, August 9). Climate change food calculator: What's your diet's carbon footprint? BBC News. https://www.bbc.com/news/science-environment-46459714

58 The Culinary Institute of America and the Harvard T.H. Chan School of Public Health, Department of Nutrition. (2019). 2019 menus of change annual report. https://www.menusofchange.org/images/uploads/pdf/2019MOC_AnnualReport.pdf

It is important to expend considerable effort in making plant-forward menus attractive to avoid the unintended consequence of having U-M community members reject the choices and opt for more carbon intensive food options off campus. MDining has demonstrated leadership in offering and promoting healthy and flavorful plant-forward options in its dining halls that should serve as a model to be emulated in other dining establishments throughout the university.

The following actions should be taken to reduce emissions from food procurement across all three U-M campuses and all food operations:

- Increase the availability of plant-based dishes and food options;
- Restructure choice architecture within dining halls and retail outlets by reducing counter space devoted to serving animal protein, ensuring that the protein option is an "opt in" choice or is added last to plates, and controlling protein portions at all-you-care-to-eat facilities;
- Employ taste-focused labeling to re-brand dishes through use of fresh ingredients, complementary seasonings, and the combination of two or more fruits and vegetables to build flavor;
- Emphasize plating and the visual appeal of plant-based foods with a focus on rebalancing plates such that vegetables serve as entrees and protein is an accent on the plate;
- Use products that incorporate blended plant and animal protein;
- Use less carbon-intensive animal proteins;
- Ensure that sufficient meal options respecting religious and cultural traditions, as well as dietary restrictions, are maintained;
- Engage in campus-wide educational programs to provide rationale (e.g., carbon footprint, nutritional benefits) for moving to a plant-based diet, and partner with MHealthy to amplify the message; and
- Distinguish the goal of decarbonizing food purchasing from the existing 2025 sustainable food goal.

The Commission concurs with the Food Analysis team's recommendation that U-M should establish a university-wide Sustainable Purchasing Policy for all procured products with a section focused on low-carbon food procurement best practices and policies (e.g., plant-based proteins, low-carbon meats sourced from regenerative farms). As a part of this policy, all requests for proposal for new food contracts should require suppliers to demonstrate how they will conform to U-M's sustainability and carbon neutrality goals. The decision-making criteria for awarding contracts must explicitly include a vendor's commitment to reducing carbon emissions, and all food providers should be held accountable to U-M's goals. See Appendix J of the Food Analysis Report for more details on this recommendation.

To track progress on advancing plant-forward diets throughout the university's food system, the following metrics must be tracked and analyzed: expenditures on animal versus plant-based proteins; food-related greenhouse gas emissions by unit and academic year; number of staff and units trained in plant-forward menus across the university; and the number of research collaborators with the new plant-forward diet programs.

The following priority actions should be taken to catalyze progress on this recommendation:

- Build on the work of the Food Analysis team to develop robust carbon accounting for all food operations across the three U-M campuses;
- Expand educational programming for students, faculty, and staff around attractive, delicious, and nutritious plant-forward food options in line with the organization and culture recommendations; and
- Hire culinary trainers to assist food operations across the Ann Arbor, Dearborn, and Flint campuses.

Refer to Appendix T for more specific evaluation criteria related to this recommendation.

Accounting Recommendation: Establish and standardize food purchasing data collection to facilitate carbon footprint calculations and provide feedback to community members on the impacts of their food procurement and consumption.

To develop a carbon emissions reduction goal for on-campus food, accurate greenhouse gas emissions baselines for units other than MDining will need to be determined. The university food service and retail outlets on U-M's three campuses are diverse and present challenges in monitoring and accessing the supply chain data required to determine the GHG emissions footprint. Consistent data that lists the weight and cost of food being procured by each university unit are essential to assess the cost and carbon footprint implications of menu changes, to track U-M's annual food-related GHG emissions footprint, and to assess progress on the goals.

In line with the Food Analysis team's recommendation to improve tracking, U-M Procurement Services needs to work with current vendors to collect and track detailed food item purchase lists for each year. As new contracts are established, new vendors should be required to submit detailed food item purchase lists, and their ability to do so should be among the criteria for awarding contracts, particularly for larger vendors with the capacity to do so. The detailed lists could then be linked to a food life cycle database to calculate food-related emissions. MDining has nearly completed the process of linking

all food items they procure to an emissions database. Adjustments to this database may be needed for smaller food operations versus those with large-scale food contracts.

The proposed actions will require coordination through Procurement Services with vendors, engagement across all food service operations on the three U-M campuses, and the use of the General Fund to support the implementation of these actions. Consideration should also be given to not making the reporting requirements an undue burden for smaller, local vendors who may have less capacity to provide the desired data.

PURCHASED GOODS

The university has significant purchasing power to influence the supply chains for purchased goods and reduce the associated Scope 3 emissions, particularly if U-M partners with peer institutions in efforts to do so. Presently, production emissions data for purchased goods are only available on a very limited basis. The Commission makes two recommendations related to the accounting of purchased goods: 1) use existing U-M expenditure data to estimate an emissions baseline for this category, and 2) seek to improve the production emissions data available for decision-making and tracking emissions reduction into the future.

> **Accounting Recommendation:** Implement an accounting system for GHG emissions associated with purchased goods that disaggregates expenditures into sector categories and uses an economic input-output approach to estimate an emissions baseline and inform targets by category.

The Commission recommends that U-M implement a carbon accounting system to more precisely quantify carbon emissions from U-M purchased goods and services across all three campuses. U-M should disaggregate purchased goods expenditures into sector categories (e.g., office furniture, medical supplies, computers, chemicals, vehicles, food, natural gas) to refine estimates and reduce double counting of emissions included elsewhere in the Commission's GHG accounting model.

Once purchasing data are disaggregated, U-M should use an economic input-output (EIO) approach to estimate an emissions baseline for U-M purchased goods and to set targets by purchasing category. An EIO approach traces economic transactions through the supply chain of a product system and evaluates resource requirements and environmental emissions using a commodity input-output model coupled with key environmental impact datasets.

MEquip | By Michigan Photography

Limitations to the EIO approach include a high level of aggregation in industry or commodity classifications and a basis in monetary value that can distort physical relations between industries due to price inhomogeneity. For this reason, EIO estimates of emissions are not generally useful for differentiating and selecting vendors within product categories. As part of its work for the Commission, the Carbon Accounting Modeling group used EIO data to estimate the potential range of values for emissions based on U-M spending on purchased goods.[59]

> **Accounting Recommendation:** Request production emissions data and information on labor and growing practices from vendors to strengthen guidance for low-carbon and environmentally just procurement at U-M. These data can be used in making purchasing decisions, in setting cost and performance criteria, and in emissions reduction tracking.

U-M has an opportunity to use its buying power to reduce emissions and encourage just labor and growing practices through procurement of university goods and services. This positive change could be amplified through engagement with peer institutions, including through existing consortiums of peer institutions.

59 Refer to the Carbon Accounting Modeling Project Report for more information on these estimates.

BUILDING MATERIALS

These recommendations concern GHG emissions associated with the resource extraction, production, transport, installation, and disposal of building materials.

Accounting Recommendation: Explore accounting methods for estimating embodied emissions associated with building materials and products, as described in the Building Standards Analysis Report. Accounting methods should accommodate and reflect the purchasing processes for materials and products used in campus construction projects. This recommendation should apply to all retrofits as well as new construction.

Accounting Recommendation: Consider requesting emissions data from building material and product vendors to strengthen guidance for low-carbon procurement at U-M. Any policy on providing embodied emissions data should not result in inequity or bias in vendor selection. These data can be used in material and product selection decisions in addition to cost and performance criteria, as well as in emissions reduction tracking.

A master's project at the U-M School for Environment and Sustainability has been launched by the Center for Sustainable Systems and U-M's Office of Campus Sustainability (OCS) to develop an accounting system to realistically estimate carbon emissions from the production of purchased goods. This project could explore the use of EIO methods to estimate embodied carbon in recently approved new U-M buildings, evaluate the magnitude of this category, and guide further quantification efforts.

SOLID WASTE AND WASTEWATER

OCS tracks the volume of solid waste, including food and non-food waste, disposal to landfill, recycling, and composting, as well as the volume of water used and wastewater dispersal from the Ann Arbor campus. However, OCS does not currently track the GHG emissions associated with solid waste and wastewater disposal within its accounting system. Reducing solid waste is an important strategy for decreasing downstream emissions associated with solid waste management and is directly relevant to U-M's current goal to reduce landfill waste by 40 percent below 2006 levels by 2025.[60] Water conservation is also an important strategy to decrease energy usage in wastewater treatment facilities and on campus for heating water.

60 University of Michigan Office of Campus Sustainability. (2020, January 1). Waste Reduction. https://ocs.umich.edu/sustainability-goals/waste-reduction-goal/

Ann Arbor campus composting | Photo courtesy of U-M Office of Campus Sustainability

The Commission supports widespread university efforts to decrease solid and liquid waste in all of its forms and strongly encourages the university to continue pursuing its ambitious solid waste reduction goal. As originally proposed by the PCCN's Food Analysis team, the Commission offers the following food-related recommendation with regard to waste reduction.

Strategy Recommendation: Scale up food waste diversions and reductions, increase capacity for composting on U-M's campuses, and launch a campus-wide composting program at UM-Dearborn and UM-Flint.

To meet the objectives of this recommendation, U-M should adopt or expand the following key strategies across all dining, retail, catering, and contract food services on U-M's three campuses, many of which are already standard practice at MDining:

- Cut post-consumer waste through trayless dining, smaller portions and plates, customized portion sizes and "try a taste" stations, room service and menu choices for patients, and messaging on the environmental harm of food waste;
- Further reduce pre-consumer waste and reinforce such strategies with new kitchen staff (e.g., efficient food storage, preparation, menu planning, food repurposing/upcycling);
- Adopt creative options for increasing food donations to area food banks and student food pantries on all three campuses and pilot innovative methods to address food insecurity while also cutting food waste;
- When washable dishes and utensils are not an option, offer incentives, cost-sharing, and infrastructure required to prioritize reusable products, reduce single-use plastics, and standardize the use of compostable materials across all three campuses in U-M owned/operated food operations and on-campus vendors and caterers;

- Develop compostable material standards and require that all third-party food service providers (e.g., Sodexo, Aramark, caterers, on-campus restaurants) comply with U-M composting and Zero Waste standards;
- Expand the capacity to recycle and compost on the Ann Arbor campus. Already near capacity, U-M's Waste Management Services will not be able to meet the demand if U-M expands composting and recycling. Based on staff estimates, another truck would be needed ($340,000) along with two drivers ($100,000);
- Launch a composting program at Dearborn and Flint. With no municipal composting, the financial and emissions cost of hauling would need to be explored in comparison with on-campus systems;
- In all buildings on all three campuses, increase composting and recycling bins through pilots to identify the best placement and provide visible and clearly understandable signage and education to ensure proper and increased use;
- Explore opportunities to expand composting efforts into other areas of the medical/hospital system (currently composting prep-waste from patient and cafeteria kitchens and post-consumer compost originating from patient kitchens). Staff kitchens and smaller food service/vendor areas may be a feasible next step, although the challenges of dock space limitations will need to be addressed; and
- Require on-campus food vendors/companies to compost pre-consumer food waste from their own production and operations.

To track progress on reducing emissions from university waste, U-M should continue to track tons of waste to landfill and tons of waste diverted. Additionally, U-M should strive to track food waste to landfill, compost and the amount of food donated, and the amount of reduced contamination in food waste audits. Improved data collection is necessary to establish a realistic baseline and to more accurately track university-wide progress. Food waste tracking also provides chefs and consumers feedback on progress, which helps to further reduce waste.[61] Specific recommendations on food waste audits and tracking are available in the Food Analysis Report.

An accurate diversion and reduction baseline founded on the actual makeup of current landfill waste is necessary across all three U-M campuses. Additional work is required to create a composting program and accounting system on the UM-Dearborn and UM-Flint campuses.

Refer to Appendix U for more specific evaluation criteria related to this recommendation.

61 Ragab, Y. (2018). Dining services reduce food waste through donation and tracking system. *The Daily Illini*. https://dailyillini.com/news/2018/04/23/dining-services-reduce-food-waste-through-donation-and-tracking-system/; ReFed. (2018). Foodservice Food Waste Action Guide. https://www.refed.com/downloads/Foodservice_Guide_Web.pdf

Accounting Recommendation: Generate data on emissions intensity of local water and wastewater treatment for all U-M campuses and implement an accounting system for tracking and reporting GHG emissions from water and wastewater treatment.

Water and wastewater treatment services are energy and carbon intensive.[62] Cities, on average, use 3,300-3,600 kWh/million gallons of water delivered and treated. In 2013, energy-related emissions resulting from wastewater treatment operations in the United States, excluding organic sludge degradation, amounted to 15.5 million $MTCO_2e$. These services are likely included in U-M's purchased supplies and services expenditure as U-M relies on municipal water utilities for these services. Once emissions from wastewater are incorporated into the accounting, the Commission recommends that these emissions be included in a Scope 3 emissions reduction goal.

Dearborn and Flint Campuses

The UM-Dearborn and UM-Flint campuses do not currently track quantities of waste and wastewater on their campuses. The Commission recommends that U-M implement a tracking system for quantity of and carbon emissions from waste and wastewater disposal on both campuses. Once such a system is implemented, the emissions from waste and wastewater disposal should be incorporated into a Scope 3 emissions reduction goal with an accompanying plan to reduce the emissions.

Strategy Recommendation: Explore improved water efficiency and site design standards for all new construction to reduce both upstream and downstream emissions from water treatment.

Water management within urban contexts is undergoing a significant transformation toward approaches favoring integration and resource recovery. This shift has come to be recognized as the "One Water" approach that promotes geographically contextual water management as a single resource to be managed holistically, viably, and sustainably. The One Water approach works from a watershed perspective to consider the interrelationships between all waters running through it, including drinking water, wastewater, stormwater, recycled water, aquifers, and rivers. This approach makes a more explicit connection between energy and water and hence carbon reduction potential. High performance buildings typically focus on reducing a building's operational energy demand through improvements to a building's envelope and HVAC systems.

62 Center for Sustainable Systems, University of Michigan. (2020). U.S. Wastewater Treatment Factsheet. Pub. No. CSS04-14; Center for Sustainable Systems, University of Michigan. (2020). U.S. Water Supply and Distribution Factsheet. Pub. No. CSS05-17.

Water delivery and treatment systems also consume energy and therefore contribute to a building's emissions footprint.

U-M should convene a group of experts to analyze the emissions reduction impacts of improved water efficiency in new construction and major renovation projects. If the findings are significant, U-M should pursue additional construction standards and site design standards to attain emissions reductions in this area. See Appendix E in the Building Standards Analysis Report for additional information.

Refer to Appendix U for more specific evaluation criteria related to this recommendation.

UM-Dearborn Observatory, Science Learning Research Center | By Michigan Photography

ELECTRICITY AND FUELS UPSTREAM

Upstream impacts occur prior to fuel combustion and are included in Scope 3. They include emissions from resource extraction, flaring, leakage, refining, and transportation of fuels. Transmission and distribution losses in electricity systems are also included in Scope 3. Emissions resulting from construction of infrastructure (pipelines, refineries, transmission lines) are not included.

Upstream emissions associated with electricity depend on the mix of fuels used for electricity generation. Reducing upstream emissions requires reducing the use of petroleum-based liquid fuels, natural gas, and electricity generated from fossil sources, either by lowering demand or by switching to renewable sources.

According to the analysis completed by the Commission's Carbon Accounting Modeling group, for every $MTCO_2e$ emitted from the combustion of natural gas at U-M, methane emissions and other upstream emissions in the natural gas production process result in an additional 0.39 tons $MTCO_2e$ emitted (using GWP_{100}=30 and Alvarez estimates),[63,64] with methane leakage alone contributing 0.15 tons of that amount. Based on this analysis, U-M estimated that expanding its Central Power Plant (CPP) will result in a cumulative reduction of more than 400,000 $MTCO_2e$ within the first 10 years of operation.

At the CPP, the use of renewable natural gas (an anaerobically generated biogas) could reduce upstream impacts, but fugitive emissions are still likely to exist and have the same atmospheric impact as conventional natural gas. For this reason and others—including supply chain limitations that inhibit scalability and transferability—the Commission does not view renewable natural gas as a viable long-term alternative to its recommended Scope 1 solutions until these underlying concerns can be resolved.

Accounting Recommendation: Estimate upstream electricity and fuel emissions using Argonne National Laboratory's Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation (GREET) model.

The Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation (GREET) model is a tool that examines the life cycle impacts of vehicle technologies, fuels, products, and energy systems. The Carbon Accounting model uses GREET data to estimate the upstream emissions associated with Scopes 1 and 2 and some Scope 3 activities. The model allows for the use of different methane leakage estimates in calculating upstream emissions.

63 https://doi.org/10.3998/mpub.12245679
64 Using EPA estimates or GWP_{20}=85 results in different estimates of the upstream emissions.

LEASED BUILDINGS

To meet short-term space needs and to accommodate growth, U-M leases space in buildings that it does not own. Most emissions associated with leased buildings are related to energy and water usage. U-M has accurate utility data on most of its leased properties, which in general are less efficient than U-M buildings. In cases where property management companies do not provide U-M with reliable utility cost data, it complicates emissions estimation and tracking.

Strategy Recommendation: Strive to meet additional space needs through better utilization of permanent space (including co-working spaces) and leased space that are intentionally designed as flexible co-working facilities for staff across multiple units who, for example, telecommute three or more days per week.

Strategy Recommendation: Prioritize leasing arrangements that allow the university to pay electric and gas utility bills directly, as is already in place for most leased properties.

This approach simplifies accounting for GHG emissions and creates an incentive for U-M units to reduce their energy usage and to include these emissions in a carbon price, per the carbon price recommendation. In cases where this model is not feasible, U-M should include a provision in lease agreements to supply monthly utility use data for UM-occupied space (including electricity, heating fuel(s), and water).

Strategy Recommendation: Develop and implement language in all leasing policy documents that requires high energy efficiency and a low GHG footprint, ideally in alignment with U-M building standards, and require property owners/managers to provide detailed information on their efforts to implement energy efficiency and emissions reductions and how this ethic is woven into their overarching operating principles.

Accounting Recommendation: Develop and implement an accounting system for emission Scopes 1 and 2 associated with all leased space and integrate it with U-M's GHG accounting system.

Refer to Appendix V for more specific evaluation criteria related to the leased building recommendations.

As seen in the preceding recommendations, the Commission envisions U-M using carbon offsetting strategies as a component of meeting its neutrality goals for emission Scopes 1 and 3.

Carbon offsets are defined in many ways. For example, the nonprofit organization that manages the Presidents' Climate Leadership Commitments defines a carbon offset as "a reduction or removal of carbon dioxide equivalent greenhouse gas emissions that is used to counterbalance or compensate for emissions from other activities."[65] Alternatively, the World Wildlife Fund defines a carbon credit as "an electronic and serialized unit that represents one $MTCO_2e$ that is reduced, avoided, or sequestered from projects applying an approved carbon credit methodology."[66]

The recommendations presented here are intended to guide the university to an offsets program that ensures high quality, provides significant co-benefits, and is consistent with environmental justice principles.

Recommendations Summary

The following table summarizes the Commission's recommendations with regard to carbon offsets and sinks, which are based on the following assumptions:

- Purchasing offsets should not delay progress in meeting direct emissions reduction targets.
- Taking a lead role in developing new offset projects makes it easier to build in desired co-benefits (e.g., locality, community involvement, education/research opportunities) but would also likely have higher costs, take more time to develop, and be in tension with acting urgently.
- An expert committee that includes diverse expertise (e.g., carbon credit markets, environmental justice, financial) will be able to identify high-quality, low-cost carbon credit and offset project options for U-M to purchase in the near term.
- Investments in carbon credits and offset projects will not adversely impact mission-critical priorities.
- The offsets market is evolving quickly due to increased attention and global demand, which should foster more uniform standards and greater transparency over time.

65 Second Nature report on Carbon Markets and Offsets Guidance
66 World Wildlife Fund guidance on voluntary purchases of carbon credits

CARBON OFFSETTING RECOMMENDATIONS

CRITERIA

As a minimum threshold of consideration, all carbon offset investments made by U-M should be real, measurable, additional, permanent, leakage avoidant, verified, enforceable, and compliant with social and environmental safeguards.

CO-BENEFITS

Clearly define and prioritize desired co-benefits criteria associated with carbon offsetting, and prioritize offset investment opportunities accordingly.

U-M PROJECTS

Identify opportunities for biosequestration projects on U-M lands that have significant carbon sequestration potential and meaningful achievements across prioritized co-benefit categories.

ADVISORY COMMITTEE

Establish a standing committee with diverse expertise and perspectives to review the offset guidance recommended by the Commission; ensure environmental justice expertise is represented; routinely solicit input and validation from reputable external experts and stakeholders to establish minimum requirements for offsetting Scope 1 and Scope 3 emissions; develop clear guidance on desired co-benefits criteria; ensure engagement with impacted communities when U-M is involved in project development; and periodically issue broad calls for proposals that meet all threshold requirements and address desired co-benefits criteria. This committee will advise U-M leadership annually on its ability to use offsets to meet or surpass existing carbon neutrality goals. It will also monitor developments in this rapidly evolving field and advise of emerging opportunities for U-M to lead regionally and nationally in this area.

Context and Recommendations

Until an organization eliminates all GHG emissions associated with its activities, it cannot achieve carbon neutrality without using carbon offsets and sinks to counterbalance its remaining emissions. In addition, the Science Based Targets Initiative (SBTi) holds that offsets should not be counted as progress toward science-based targets; instead, they should be counted only in addition to meeting these targets through direct mitigation efforts.

Carbon offsetting activities can be implemented at locations throughout the world, and the credits associated with these offsetting activities can be acquired by individuals and institutions worldwide. Some strategies that organizations employ to counterbalance their direct GHG emissions include investments in renewable energy, technological sequestration projects, reforestation, other forms of biosequestration, and credits from cap-and-trade systems.

The Commission recognizes that there have been significant performance problems in many early offset programs—both those adopted under international auspices and those developed for the voluntary carbon market—and that offset projects can vary widely in terms of price and quality. At the same time, many national and subnational governments, as well as both public and private universities and colleges around the world, see a constructive role for offsets to play in the far-reaching transition toward decarbonization.

Some governmental entities that have incorporated the use of offsets into their climate compliance regimes include the following:

The 10 Northeastern and Atlantic states' Regional Greenhouse Gas Initiative (RGGI), a cap-and-trade compliance program for the electric utilities in participating states, allows utilities to meet up to 3.3 percent of their emission reduction obligations through purchasing offsets. In this formal albeit limited part of the RGGI process, offsets serve as an alternative compliance path and a way to contain overall compliance costs for participating utilities. RGGI offset investments pursued to date have focused on such areas as end-use energy efficiency, afforestation strategies to sequester carbon, and non-carbon greenhouse gases, such as methane.[67]

Similarly, the State of California's cap-and-trade program allows regulated entities to help satisfy their emission reduction obligations through purchasing a limited number of eligible offsets. The California Air Resources Board controls quality by developing protocols that define the types of projects that are eligible

67 Raymond, L. (2016). *Reclaiming the atmospheric commons: The Regional Greenhouse Gas Initiative and a new model of emissions trading.* MIT Press; Rabe, B. (2018). *Can we price carbon?* (chap. 4). MIT Press.

Saginaw Forest | Photo by Dave Brenner

and how their emissions reductions should be estimated. Approved project areas include, among others, forestry, livestock production, rice cultivation, and coal mining. Recent state legislation has led to the creation of a Compliance Offsets Protocol Task Force to review all dimensions of the California offsets program and guide the California Air Resources Board in prioritizing disadvantaged communities, Native American or tribal lands, and rural and agricultural regions within the state in the development of future offset protocols.[68]

At the international level, the United Nations International Civil Aviation Organization (ICAO) member countries agreed in 2016 to require airlines operating international routes to begin offsetting their GHG emissions above a 2020 baseline. To implement this agreement, ICAO developed a set of quality criteria and an approved list of offset certification programs that the airlines need to use in sourcing their offsets.[69]

Universities and colleges, too, have incorporated offsets into their climate goal strategies through a variety of approaches. Some purchase offsets via the carbon market. Others, such as Duke University, have brought the programs in-house to develop and administer the offset projects themselves, which can provide educational opportunities and co-benefits to the local community and help in consideration of environmental justice dimensions. Institutions can also employ a mix of such approaches.

Refer to Appendix W for a list of notable examples of other institutions' approaches to using carbon offsets to counterbalance their GHG emissions.

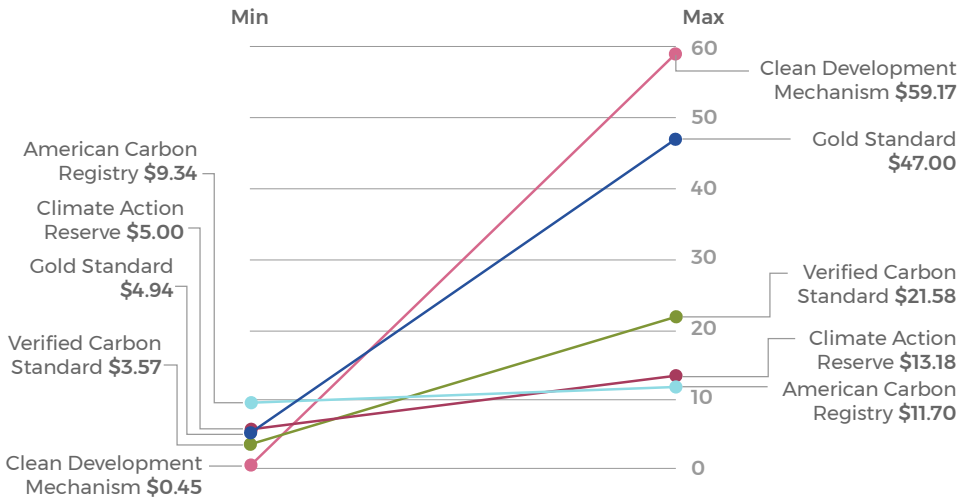
68 California Air Resources Board: https://ww2.arb.ca.gov/our-work/programs/compliance-offset-program

69 ICAO CORSIA: https://www.icao.int/environmental-protection/CORSIA/Pages/implementation-elements.aspx

One important distinction is the difference between carbon offsets and renewable energy certificates (RECs). Specifically, carbon offsets can be used to counterbalance Scope 1 and Scope 3 emissions if they meet "additionality" and other requirements. However, according to the Center for Resource Solutions (CRS), there are no additionality requirements associated with RECs (see Scope 2 Recommendations section).[70] In addition, CRS and several other reputable experts on offsetting, including EPA Green Power Partnership, The International REC Standard, Second Nature, and Edison Energy, advise that RECs can only be used to counterbalance Scope 2 emissions and that RECs cannot be applied to emission Scopes 1 and 3.

The Commission recognizes that offset projects vary widely in price and quality. Figure 11 shows a cost range, with the same *Financial Times* article reporting voluntary offset project average costs ranging from \$1.40/$MTCO_2e$ for renewable energy projects to \$4.30/$MTCO_2e$ for forestry and land-use projects. These projects are of unknown quality, however, and \$10/$MTCO_2e$ is therefore the more reasonable basis for estimating rough offset costs. The BGC Carbon Market Daily reported in January 2021 high quality California Carbon Offset prices ranging from \$12-\$13/$MTCO_2e$ and RGGI at slightly below \$8/$MTCO_2e$. The costs to institutions that develop their own offset projects can run significantly higher than those purchased from offset project developers or from the secondary carbon market. Given that the carbon offset market is expected to grow dramatically in coming years, U-M can play an important role in shaping policy and markets by participating in these markets. Figure 11 below illustrates the wide variability in offset prices.

Figure 11. Price ranges (\$) per $MTCO_2e$ on selected carbon registries in 2018, including the Clean Development Mechanism, the Verified Carbon Standard, the Gold Standard, the Climate Action Reserve, and the American Carbon Registry.[71]



70 Center for Resource Solutions. (2016, March 1). Additionality and Renewable Energy Certificates. https://resource-solutions.org/wp-content/uploads/2016/03/RECs-and-Additionality.pdf

71 Gross, A. (2020, September 28). Carbon offset market progresses during coronavirus. *Financial Times*. https://www.ft.com/content/e946e3bd-99ac-49a8-82c9-e372a510e87c

As described below, a carbon offset committee should guide investments in the offset market. This committee is intended to set best practices for carbon offset investments and ensure that offset criteria are principled and appropriate for U-M.

As noted above, carbon offsets and other offsite mechanisms are widely used by business and industry; local, state, and national governments; academic institutions; and NGOs. While offset markets and investments are imperfect mechanisms, they are nevertheless playing a significant role in helping institutions meet their carbon neutrality goals. The Commission recommends that U-M prioritize direct reductions whenever possible and acknowledges that carbon offsets will be required to achieve the carbon neutrality recommendations in this report, with decreased reliance on them over time.

Given the variable quality of carbon offsets available on the market, credibility is of the utmost importance when using them as part of a carbon neutrality strategy, and certain threshold criteria must be met. In addition, different offsetting opportunities present a range of potential co-benefits that warrant consideration in selecting among the various options. Finally, to address both urgency and equity considerations, processes around carbon offsets must be executed with deep consideration of environmental justice and with collaboration of the communities in which they are placed. These key considerations inform the Commission's first recommendation on the topic.

Strategy Recommendation: As a minimum threshold of consideration, all carbon offset investments made by U-M should be real, measurable, additional, permanent, leakage avoidant, verified, enforceable, and compliant with social and environmental safeguards.

- Real—The reduction must have actually occurred and not as a result of flawed accounting (e.g., overstated impacts, double counting).
- Measurable—Carbon credits must be calculated based on robust scientific data using accurate quantification methods and must be expressed in quantitative terms using standardized GHG metrics.
- Additional—The reduction would not have occurred in the absence of a market for offset credits or without U-M initiating and supporting the project directly for the purpose of offsetting its emissions.
- Permanent/durable—The reduction must last in perpetuity or for as long as the credit is being claimed. Permanence is particularly relevant to bio-sequestration projects (i.e., nature's ability to permanently store carbon without releasing it at some point in the future).
- Leakage avoidant—The generation of carbon credits should not lead to an increase in emissions elsewhere, or safeguards must be in place to monitor and mitigate any increase that does occur.

- **Verified**—The reduction must have been monitored and confirmed to have occurred by a reputable, unbiased, third-party verification organization to ensure that the credibility of the claim is beyond reproach.
- **Enforceable**—The reduction must be counted only once and then retired.
- **Compliant with social and environmental safeguards**—The generation of carbon credits should not violate laws, regulations, or treaties or result in social or environmental grievances and should meet international best practice standards for social and environmental safeguards.

Beyond meeting the basic requirements described in the first recommendation, the Commission recommends that U-M consider various socio-economic and environmental co-benefits when evaluating which carbon offset strategies to pursue.

Strategy Recommendation: Clearly define and prioritize desired co-benefits criteria associated with carbon offsetting, and prioritize offset investment opportunities accordingly.

Co-benefits are desirable elements associated with various offset strategies that are above and beyond threshold requirements. There are many possible co-benefit categories, and they may be prioritized differently depending on the organization's unique circumstances. The Commission recommends that key co-benefits include:

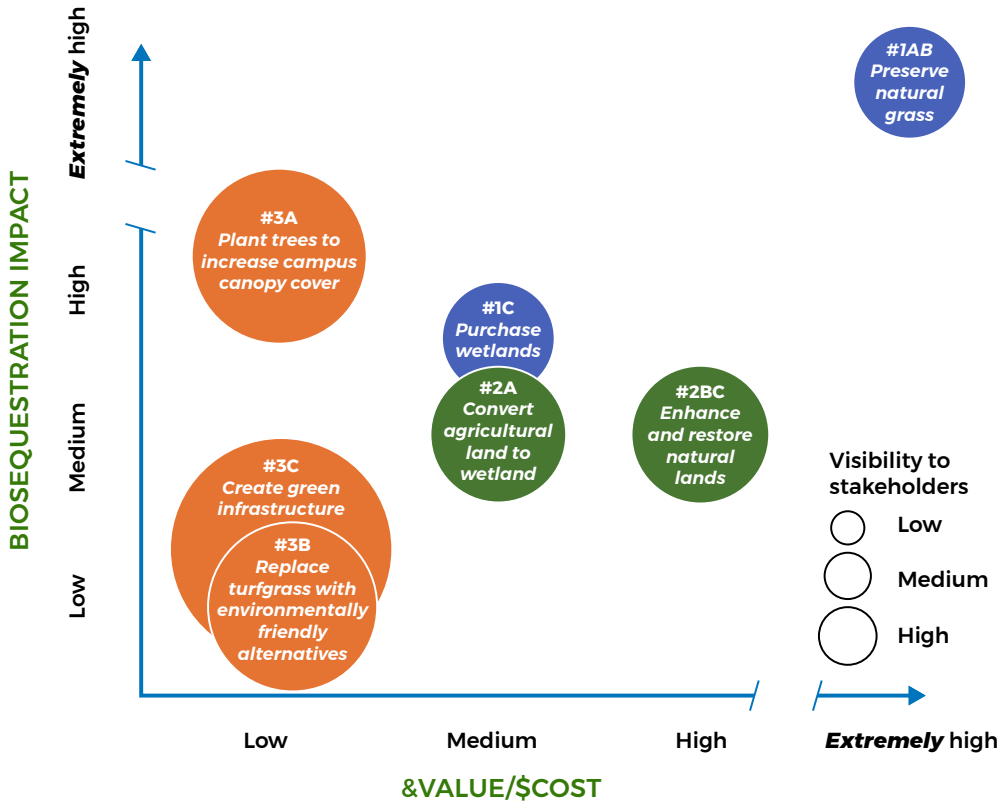
- Providing education and research opportunities for students and faculty;
- Being located within the State of Michigan with positive multiplier effects for Michigan communities;
- Having clearly attributable social equity and justice benefits;
- Promoting environmental health, conservation, and restoration;
- Reducing emissions of potent short-lived climate pollutants such as methane and nitrous oxide;
- Offering opportunities to develop and advance partnerships in the local/regional community; and
- Having significant potential for scalability, transferability, and replicability.

In addition to considering carbon offset opportunities beyond the campus, the Commission also established an internal analysis team focused on the biosequestration potential of U-M lands, which can serve as carbon sinks to counterbalance university GHG emissions.

Strategy Recommendation: Identify opportunities for biosequestration projects on U-M lands that have significant carbon sequestration potential and seek meaningful achievements across prioritized co-benefit categories as well as higher-visibility, smaller-scale projects that offer educational opportunities for the university community.

According to the Biosequestration Analysis Report, biosequestration is "the ability of plants to collect carbon from the air (via photosynthesis) and store carbon structurally via growth (e.g., in wood, photosynthetic tissues, roots, etc.)" and "currently plays a large role in mitigating carbon emissions on local and global scales."

Figure 12. A high-level summary of biosequestration project options. "$Value/$Cost" represents the level of carbon sequestration potential per dollar spent. The colors of the bubbles, and the numbers within them, correspond to specific recommendations within the Biosequestration Analysis Report.



The analysis team recommended that to maintain existing levels of sequestration and ecosystem services, U-M owned natural lands should be protected, expanded, and enhanced by the university. In doing so, the changing climate in Michigan should be considered. Potential benefits of biosequestration projects on U-M owned lands include direct control and ownership of projects and the ability to weave in other co-benefits. However, the Commission

recognizes that many considerations go into land-use planning and that multiple factors will guide such decisions. In pursuing the development of biosequestration projects, U-M should seek to collaborate with community organizations that have common interests (e.g., watershed councils, land conservancies). Such collaborations could include projects on current or future U-M lands as well as projects on properties not owned by the university.

If land-use modifications reduce the amount of carbon stored in its natural lands, then this should be reflected as an increase in U-M's carbon footprint. Alternatively, if the university increases the amount of carbon stored in its natural lands, then this should be reflected as a decrease in the U-M's carbon footprint. These biosequestration changes should be assigned to the organizational unit responsible for the change for purposes of calculating the appropriate net emissions level for the carbon pricing program. U-M should also pursue smaller-scale biosequestration projects to use the campus as a living lab. Small-scale biosequestration projects described in the Research and Education section also have potential as living-learning lab projects.

Refer to Appendix X for specific evaluation criteria related to this recommendation.

While the Commission spent a significant amount of time reviewing and discussing various approaches to offsetting carbon, the complex and rapidly changing offsets landscape requires sustained attention for as long as offsetting strategies are used. This informs the Commission's final recommendation with regard to carbon offsetting.

Strategy Recommendation: Establish a standing committee with diverse expertise and perspectives to review the offset guidance recommended by the Commission; ensure environmental justice expertise is represented; routinely solicit input and validation from reputable external experts and stakeholders to establish minimum requirements for offsetting Scope 1 and Scope 3 emissions; develop clear guidance on desired co-benefits criteria; ensure engagement with impacted communities when U-M is involved in project development; and periodically issue broad calls for proposals that meet all threshold requirements and address desired co-benefits criteria. This committee will advise U-M leadership annually on its ability to use offsets to meet or surpass existing carbon neutrality goals. It will also monitor developments in this rapidly evolving field and advise of emerging opportunities for U-M to lead regionally and nationally in this area.

NEXT STEPS

This report marks the culmination of the President's Commission on Carbon Neutrality's formal process, analyses, deliberations, and recommendations. Encompassing two years of work, it provides President Schlissel and the Regents with a proposed roadmap to carbon neutrality. It describes, in great detail, how certain cultural and institutional practices could spur a more sustainable university community and how various technical approaches across emissions categories could move U-M toward a carbon-free future.

Now that the Commission's report is in their hands, President Mark Schlissel and the U-M Regents will need to review it and begin the process of determining which recommendations are put into practice and the associated timelines for their implementation. The ultimate U-M climate plan adopted by the President will have to address these key facets related to implementation: a) which actions U-M will take; b) the scopes and timelines for its actions; and c) how U-M will implement the various technological, institutional, and cultural steps. Urgency, accountability, inclusivity, and justice will be paramount.

The Commission expects that next steps will not only entail community input and fruitful discussions on the part of university leadership but will also allow the university to step fully into a leadership position among its peer institutions as the U-M community works collectively and collaboratively to address the climate crisis. Independent of U-M's particular path forward, the Commission also offers this report as a resource to other institutions and communities seeking to reduce their own respective greenhouse gas emissions or otherwise take climate action.

Finally, the Commission thanks this report's readers, whether they are U-M students, staff, faculty, alumni, or community members; peers in academia; or just otherwise interested. The climate crisis threatens us all. Acting together, we can and must address it and seize our opportunity to help foster a more promising future.

Appendix A: Abbreviations Glossary

A&A	Art and Architecture Building
AAATA	Ann Arbor Area Transportation Authority
AEC	Architecture, Engineering and Construction
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
BAU	Business-as-Usual
˚C	Degrees Celsius
CCA	Community Choice Aggregation
CH_4	Methane
CO_2	Carbon Dioxide
COVID-19	Coronavirus Disease 2019
CPP	Central Power Plant
CRS	Center for Resource Solutions
DEI	Diversity, Equity and Inclusion
DTE	DTE Energy
ECM	Energy Conservation Measure
ECP	Energy Consumption Policies
EIO	Economic Input-Output
EJ	Environmental Justice
EL	Executive Leadership
EV	Electric Vehicle
FY	Fiscal Year
GHG	Greenhouse Gas Emissions
GHX	Geo-exchange
GREET	Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation
GWP	Global Warming Potential
HDPE	High-Density Polyethylene
HVAC	Heating, Ventilation, and Air Conditioning
ICAO	International Civil Aviation Organization
IPCC	Intergovernmental Panel on Climate Change
kWh	Kilowatt Hour
LCCA	Life Cycle Cost Assessment
LDAR	Leak Detection and Repair
LED	Light Emitting Diode
LTP	Logistics, Transportation and Parking Office
$MTCO_2e$	Metric Tons of Carbon Dioxide Equivalent
MTHW	Medium Temperature Hot Water
MW	Megawatt
N_2O	Nitrous Oxide
NPV	Net Present Value
OCS	Office of Campus Sustainability
ODEI	Office of Diversity, Equity and Inclusion
PCCN	President's Commission on Carbon Neutrality
PPA	Power Purchase Agreement
PV	Photovoltaics
REC	Renewable Energy Certificate
REF	Revolving Energy Fund
RFP	Request for Proposal
RGGI	Regional Greenhouse Gas Initiative
ROI	Return on Investment
SBTi	Science-Based Targets Initiative
SMART	Specific, Measurable, Achievable, Relevant, and Time-Bound
T&D	Transmission and Distribution
U-M	University of Michigan
UM-Ann Arbor	University of Michigan Ann Arbor Campus
UM-Dearborn	University of Michigan Dearborn Campus
UM-Flint	University of Michigan Flint Campus
U.S.	United States of America
VPPA	Virtual Power Purchase Agreement

Appendix B: Public Engagement Event Summary

- **January 21, 2021** — PCCN Draft Recommendations Information Session; Recording
- **January 14 & 20, 2021** — Student Conversation on Carbon Neutrality and the PCCN hosted by the Student Sustainability Coalition
- **January 13 & 19, 2021** — Community Conversation on Carbon Neutrality and the PCCN hosted by the Planet Blue Ambassador program
- **October 29, 2020** — Webinar: Distinct Analyses, One Sustainable Direction: Students and Faculty Share Insights from U-M's Carbon Neutrality Push; Recording
- **March 18, 2020** — CANCELLED—The Role of Climate Justice in Carbon Neutrality at the University of Michigan
- **March 16, 2020** — CANCELLED—UM-Flint Town Hall: The Role of Food and Campus Culture in Carbon Neutrality at the University of Michigan
- **February 27, 2020** — UM-Dearborn Town Hall: The Role of Food and Campus Culture in Carbon Neutrality at the University of Michigan
- **February 27, 2020** — North Campus Sustainability Initiative: Commuting Analysis Team Lunchtime Talk
- **February 25, 2020** — UM-Flint: Charting U-M's Path to Carbon Neutrality
- **February 5, 2020** — Ann Arbor Student Town Hall: The Role of Food in Carbon Neutrality at U-M
- **February 4, 2020** — UM-Ann Arbor Campus Culture and Communication Town Hall
- **January 23, 2020** — UM-Ann Arbor Commuting Internal Analysis Team Town Hall
- **January 22, 2020** — UM-Dearborn Commuting Internal Analysis Team Town Hall
- **December 11, 2019** — UM-Ann Arbor Campus Culture and Communication Town Hall
- **December 10, 2019** — Business and Carbon Neutrality: A Panel Discussion on Becoming a Carbon-Free Campus
- **October 21 & 22, 2019** — Ross School (Zell-Lurie Institute) Business Pitch Competition
- **October 18, 2019** — Charting Our University's Path to Carbon Neutrality, University of Michigan-Dearborn's Strategic Planning Thought Leader Series
- **September 25, 2019** — PCCN Community Forum; Recording
- **April 16, 2019** — Open Forum: President's Community on Carbon Neutrality
- **April 9, 2019** — A Special Public Session with President Schlissel; Recording
- **April 3, 2019** — Town Hall Meeting #2; Recording
- **March 11, 2019** — Town Hall Meeting #1; Recording

Appendix C: Draft Report Public Comment Process

The PCCN released a draft of its report on December 17, 2020, for public comment through January 26, 2021. During this time, the PCCN received a total of 521 comment submissions.

All comment submissions were reviewed by PCCN staff and shared with commissioners. A general description of each unique idea or perspective, along with an indication of the number of submissions that included the corresponding idea or perspective, was logged onto a Comment Summary sheet. The Comment Summary sheet also briefly indicates how each comment was addressed or clarified in the final report.

In sum, 565 unique ideas or perspectives were offered across the 521 comments submitted on the PCCN's draft report. The Draft Report Public Comment Summary sheet is available here.

A compilation of the unedited and unattributed public comments is also available here. Any comments submitted anonymously or by commenters who opted out of publishing their comments are not included in this compilation; however, those commenters' views are still represented in the Comment Summary sheet.

Appendix D: Leadership Structures Recommendations Evaluation Criteria

Strategy Recommendation: Commit to using environmental justice guiding principles and expertise, including community input, within all future deliberations, decision-making, and implementation efforts around U-M carbon neutrality.

Strategy Recommendation: Act quickly to create an executive leadership (EL) position reporting directly to and advising the President, whose office and staff have responsibility for planning and coordinating university-wide carbon neutrality efforts; working across all three campuses to integrate implementation and accountability mechanisms at the unit level; engaging with stakeholders (particularly those most affected); receiving and incorporating feedback from the community; facilitating partnerships and otherwise promoting the scaling and transfer of U-M carbon neutrality solutions; and reporting on goal progress and shortfalls.

Strategy Recommendation: Establish an institutional advisory committee to support the EL's office in developing, implementing, and communicating effective strategies for actuating U-M's carbon neutrality priorities, with a focus on leveraging and aligning university structures and resources to support U-M's carbon neutrality goals.

Strategy Recommendation: Establish a community advisory committee to support the EL's office in developing, implementing, and communicating effective strategies for actuating carbon neutrality priorities, with a focus on understanding external stakeholder perspectives, learning from their experiences, and partnering whenever possible and mutually beneficial.

Carbon Neutrality Impacts

For all carbon reduction efforts to be successful and sustainable, U-M's commitment must be woven into all levels of its organizational structure. The leadership structures recommendations seek to do this.

Equity and Justice Considerations

The Commission's first recommendation urges the university to commit to using environmental justice (EJ) principles and expertise within all future deliberations, decision-making, and implementation around U-M carbon neutrality.

Additionally, throughout the established leadership structure, there will need to be regular collaboration and engagement with the university Diversity, Equity and Inclusion (DEI) Office as well as integrated and thoughtful consideration of EJ issues as the university begins decarbonization of its three campuses.

Regional Community Involvement

A key responsibility of an executive leader reporting directly to the President is to be a clear point of contact that formally represents the U-M administration on university-wide carbon neutrality issues for external stakeholders. This recommendation is integral to the success of all other recommendations to partner and collaborate with the local and regional community. The community advisory committee put in place must also include and partner with the Cities of Ann Arbor, Dearborn, Flint, and Detroit to work toward carbon neutrality goals.

Scalable and Transferable

The direct report and leadership structure will be charged with building and accelerating partnership networks, internally and externally, to collaboratively design and implement scalable strategies. Engagement with the regional community and peer institutions will also be integral to ensuring proper sharing of knowledge, best practices, and lessons learned. The community advisory committee could be an avenue to further scale and transfer U-M's carbon neutrality strategies.

U-M Community Participation and Accountability

This recommendation prioritizes both centralized leadership and decentralized commitments and strategies at the unit level. This leadership structure is meant to empower and support faculty, staff, and students engaging in carbon neutrality work to effect positive change in their areas of influence and responsibility. The institutional advisory committee will also advance U-M community participation and accountability as it seeks to leverage and align university structures and resources to support U-M's carbon neutrality goals.

Financial Considerations

Implementing and sustaining robust leadership structures will require investments in personnel and support systems to propel U-M on its carbon neutrality path. Fortunately, U-M has many organizational pieces already in place to facilitate the transformation, and these resources should be leveraged to keep additional costs to a minimum.

Appendix E: Campus Planning Recommendations Evaluation Criteria

Strategy Recommendation: Create and update campus- and district-level master plans to reflect that emissions mitigation is one of the university's top priorities and update such plans at regular intervals with campus community input.

Carbon Neutrality Impacts

The solutions articulated in the PCCN's recommendations offer significant GHG emissions reduction opportunities across emission Scopes 1, 2, and 3. Campus- and district-level master plans that reflect emissions mitigation as a university priority will bolster and accelerate the university's carbon neutrality efforts and emissions reductions.

Equity and Justice Considerations

U-M must ensure its planning creation, auditing processes, and campus plans align with the principle of equity and justice outlined by the Commission.

Regional Community Involvement

The planning creation and auditing processes, should involve members of the local and regional communities who are affected by the university's infrastructure decisions.

Scalable and Transferable

A transparent, comprehensive, and inclusive planning process would likely enhance U-M's ability to scale and transfer its carbon neutrality strategies to local and regional communities.

U-M Community Participation and Accountability

The planning creation and auditing processes must be transparent, comprehensive, and inclusive, involving stakeholder input. Stakeholders in campus planning must include staff, faculty, students, and members of the local communities who are deeply affected by the university's infrastructure decisions, in addition to department and unit leadership. Thoughtful engagement with stakeholders during the planning process engages the community, creates buy-in to the university's plans, and resolves roadblocks to the university's long-term strategic vision.

Financial Considerations

Increased levels of engagement in the planning process could require additional staffing and resources to manage.

> **Strategy Recommendation:** Prioritize central locations for construction projects and expand affordable campus housing for students, faculty, and staff based on an evaluation of needs and demand and considering issues of equity and climate change resilience.

Carbon Neutrality Impacts

Estimates of the direct effects of housing development on the carbon impact of the commute range from 7,000 to 26,000 $MTCO_2e$ depending on the quantity and type of housing developed on the Ann Arbor campus, according to the Commuting Analysis Report. On the UM-Dearborn and UM-Flint campuses, the direct effects of housing development on the carbon impact of the commute range from 200 to 600 $MTCO_2e$ depending on the quantity and type of housing developed. It should be noted that any decisions to build additional on-campus housing capacity would, while contributing to reductions in U-M's Scope 3 emissions, increase its Scope 1 and Scope 2 emissions until carbon neutral energy infrastructure is in place.

Equity and Justice Considerations

Housing programs promote equity differently on the three U-M campuses. Housing expansion in Ann Arbor could help expand affordable housing options locally. In Dearborn, policies to encourage nearby residence could significantly lower the cost of living for employees and students through reduced commute costs. And in Flint, policies to encourage local residence could be a force for urban revitalization. Some housing units could be set aside for leasing or renting at affordable rates. For example, University of California, Santa Cruz groups employees based on income and ensures each group receives a certain percentage of on-campus housing.

Regional Community Involvement

In the process of addressing housing on and near campus, U-M should consult and collaborate with the surrounding communities of Flint, Dearborn, Ann Arbor, and Ypsilanti and relevant local organizations.

Scalable and Transferable

Enhanced and creative construction and housing policies have the potential to scale and transfer to U-M's peer institutions. Affordable housing close to university campuses can be a challenge at many major universities.

U-M Community Participation and Accountability

Expansion of on-campus housing will naturally engage and involve more community members in the places they live on campus. Currently, on-campus student housing is a major touchpoint to engage and involve first-year students in sustainability.

Financial Considerations

As housing need and demand are assessed on each campus, U-M will also need to study the financial considerations related to providing additional on-campus housing.

Appendix F: Research and Education Recommendations Evaluation Criteria

Strategy Recommendation: Make significant investments in research and its deployment on routes to achieving carbon neutrality.

Strategy Recommendation: Expand and prioritize sustainability curriculum, training, and literacy programs to all members of the U-M community across all three campuses.

Strategy Recommendation: Invest in institutional structures to expand and support carbon neutrality focused "living-learning labs" across all three U-M campuses.

The following evaluation criteria relate to the above three recommendations.

Carbon Neutrality Impacts

n/a

Equity and Justice Considerations

Research projects should focus on solutions that are socially equitable. Educational programming should focus on carbon neutrality citizenship skills required to analyze and problem solve sustainability challenges in an equitable way. The U-M community should also understand the basics of climate change, climate justice, and environmental justice.

Regional Community Involvement

All three of the research and education recommendations are internal to the university; however, visible educational cues will likely positively affect members of the surrounding community, particularly those who frequently engage with the university through its health services, athletics, and arts programs. Additionally, living-learning laboratory programming is an opportunity to partner with the surrounding communities.

Scalable and Transferable

The carbon reduction multiplier effect is relevant here. This effect includes the immediate and long-term emissions reductions as thousands of students, faculty, staff, and visitors gain a deep understanding of sustainability while at U-M, leading to a self-sustaining culture that will carry forward once they leave campus. Rather than simply pushing habits onto the community, educational programming will foster intellectual capacities.

U-M Community Participation and Accountability

Such research programs and funding will empower the university community to dive into the issue of climate change and develop decarbonization solutions. This is a direct way to engage the university in carbon neutrality work through U-M's core missions of education, research, health care, and service. Furthermore, expanded carbon neutrality educational programming and accessible living-learning labs will ensure that the U-M community is interacting with and learning about carbon neutrality and the solutions U-M is employing throughout their time on the university's three campuses. Such programming will empower the university community to make educated and informed choices each day while on and off campus.

Financial Considerations

The Commission recommends that the university scale up their current $5 million research fund to $10 million to support proposals from the university research community. Educational programming will need to be equitably supported on all three U-M campuses.

Appendix G: External Collaboration Recommendations Evaluation Criteria

Strategy Recommendation: Conduct targeted network mapping related to all carbon neutrality strategies and pursue intentional engagement with key stakeholders to inform implementation.

Strategy Recommendation: Tailor carbon neutrality communication and education for specific audiences and expand opportunities for stakeholder input.

The following evaluation criteria relate to the above two recommendations.

Carbon Neutrality Impacts

n/a

Equity and Justice Considerations

As the university implements this recommendation, it should be certain to identify missing groups from its stakeholder community, such as under-represented communities and constituencies related to the Dearborn and Flint campuses. U-M will need to engage significantly with its stakeholder community at each stage of implementation to ensure that its actions toward carbon neutrality are equitable and just, specifically to historically marginalized groups. Inclusivity considerations should be prioritized alongside technical and commercial considerations.

Regional Community Involvement

These two recommendations focus on how to effectively and thoughtfully engage with the regional community to form sustainable and mutually beneficial partnerships.

Scalable and Transferable

If external collaboration is done well, U-M's carbon neutrality strategies and solutions will stretch much further than U-M's geographic scope.

U-M Community Participation and Accountability

n/a

Financial Considerations

A robust external collaboration model will take additional time and resources to execute, but U-M has many quality organizational engagement resources already in place that should be leveraged to keep additional costs to a minimum.

Appendix H: Use of Offsets for Scope 1 Emissions: A Second Opinion

The Commission recommended a 2025 carbon neutrality goal to be achieved primarily by the purchase of offsets. A minority of commissioners, however, believe that a heavy reliance on offsets is not the optimal path to meeting these earlier goal dates for achieving carbon neutrality for Scope 1 emissions. The rationale for this opinion stems from the limited financial and human resources available to the university and a belief in the urgency and importance of reducing on-campus (technological) emissions prior to using those same resources to pay a third-party to reduce global emissions via offset purchases.

The charge to the commission is to be financially responsible while developing a path to neutrality that is scalable, transferable, just, and sustainable. In our view, leadership is best demonstrated by doing all we can to begin reducing emissions on campus first. While all Commissioners share an appreciation for the urgency of U-M to be a leader in solving the climate crisis, we believe that prioritizing offsets has the potential to distract the university's attention and resources away from investments in direct emissions reduction projects. Instead, we support focusing squarely on direct reductions in the near term, which will accelerate progress and more quickly reduce U-M emission levels, ultimately reducing the number of offsets that would be needed to achieve neutrality. This approach will also accelerate U-M's ability to share successful strategies with other institutions.

How we view the concepts of both leadership and financial responsibility is core to this opinion. The university balances numerous priorities in maintaining its leadership in education (and educational access for students of limited means), research (some of which is directed at finding innovative solutions to achieving carbon neutrality), health care, and service. Now added to this is the extremely important commitment to achieving carbon neutrality. In an environment where resources are limited, it becomes increasingly difficult to meet all of the priorities of a world-class educational institution; thus, trade-offs will inevitably need to be made. In balancing priorities, therefore, we advise that pursuing the ambitious goals and impactful strategies set forth in the recommendations of the Commission to achieve direct emissions reductions should take precedence over the purchase of offsets, even at the risk of delaying the achievement of a neutrality date recommended elsewhere in this document. We assert, therefore, that U-M can most clearly demonstrate leadership by a dedicated and early focus on eliminating emissions on our own campuses.

We note that several comments offered in response to the draft recommendations report also support this position.

To reach global neutrality by 2050, reliance on offsets must steadily give way to direct reductions and removals of remaining GHG emissions. Moreover, as more companies and institutions set carbon neutrality goals reliant on offsets, growing demand could soon create a shortage of high-quality offsets, leading to significant price increases. Given this large and rapidly growing interest in offsets by institutions worldwide, we do not believe U-M would demonstrate leadership through becoming yet another member of this cohort.

A potentially more impactful alternative to purchasing offsets would be to set aside funds that would otherwise be used in the near term on offsets to create an internal carbon neutrality fund that would be used to accelerate U-M's own projects for achieving decarbonization even sooner than 2040 as recommended for Scope 1 emissions.

In summary, therefore, this opinion holds that the administration should carefully examine its use of offsets for their quantity, quality, and purpose to ensure that it is prioritizing the elimination of direct emissions with the utmost speed.

Appendix I: Integral Group's Infrastructure Decarbonization Solutions Matrix

OPTION	BENEFITS	LIMITATIONS / RISKS	LONG-TERM OUTLOOK
Electrification	◆ Mature technologies (e.g., solar, wind) can produce zero-carbon and increasingly cost-effective electricity ◆ Most climate scientists, including those involved with the Intergovernmental Panel on Climate Change (IPCC), believe electrification of the building sector is a vital component of a pathway to <2˚ global warming	◆ Intermittency of renewable power poses a big challenge: wind doesn't always blow and sun doesn't always shine when buildings need power ◆ While energy storage holds promise, batteries remain expensive ◆ Reliance on the centralized electric grid, with its bulk power generation and long transmission lines, can be less reliable than on-site combined heat and power (CHP)	◆ While still the source of significant debate, an increasing number of energy modelers find credible pathways to 80%+ renewable energy ◆ Battery storage costs are falling; costs may drop below $100/kWh by 2024 (from $1,100/kWh in 2010) ◆ A breakthrough in electricity generation, such as hydrogen or nuclear, would help catapult the penetration of zero-carbon resources
Biofuels / Biomass / "Renewable Natural Gas" (RNG)	◆ Transition from natural gas to biofuels—such as RNG generated from landfills and farms—can leverage existing infrastructure; a "fuel switch" can achieve quick carbon reductions ◆ Biofuels often provide improved reliability relative to solar or wind generation	◆ Biofuel feedstock, including landfill gas and wood, is relatively limited; experts predict biofuels could only scale so far, satisfying just 10%-15% of U.S. thermal demand ◆ Biofuels face criticism about whether they are "zero carbon" in practice (e.g., wood "waste" has at times included forest clear-cutting)	◆ Because of inherently limited supply, increased demand in the biofuels market could work against itself: increased demand for biofuels would, almost by definition, increase prices ◆ Biofuels suppliers, particularly those involving wood "waste," may continue to seek loopholes in market requirements, minimizing carbon impact
Carbon Offsets	◆ Carbon offsets, such as tree planting and wetland restoration, provide a quick and often cheap path to decarbonization	◆ Real-world experience with carbon offsets is poor, often falling well short of decarbonization goals ◆ Many widely accepted carbon accounting practices devalue or reject the use of offsets	◆ While directly reducing emissions—i.e., reducing on-site building emissions—will be a superior option, offsets could play a meaningful role in carbon mitigation if accounting standards tighten
Geo-exchange (GHX)	◆ Leveraging the Earth's constant temperature vastly improves efficiency of electric HVAC equipment (e.g., heat pumps)	◆ Land constraints can limit viability ◆ Increased first-cost relative to other all-electric solutions (e.g., air-source heat pumps)	◆ Reduction in total life cycle costs will continue to make geo-exchange attractive when land constraints not an issue
On-site Solar PV	◆ Mature technology ◆ Costs have fallen dramatically over the last decade ($10/W to below $2/W for commercial sector)	◆ On-site solar is limited in its ability to generate high % of demand; even if every U-M roof and parking lot were covered with solar, unlikely to generate more than 20% of electric needs	◆ Increased panel efficiency may be as important as cost reductions—as efficiency improves, on-site solar can provide greater portion of energy demand
Solar Thermal	◆ Tech, which heats water, has better efficiency than solar PV ◆ Improves GHX efficiency by reheating ground in winter	◆ Solar thermal is unable to meet significant portion of thermal demands on its own	◆ While more of a complementary (rather than primary) solution, solar thermal can play a meaningful role in key applications
Carbon Capture	◆ On-site carbon capture (e.g., using flue gas from on-site CHP) can provide carbon mitigation with minimal disruption to business-as-usual	◆ The carbon capture industry has seen little more than pilot projects thus far; critics argue carbon capture has long over-promised and under-delivered	◆ While an infusion of government R&D could change the dynamics, the carbon capture industry is far from proving commercial viability
Nuclear (Modular)	◆ In theory, modular nuclear could provide extremely reliable on-site power generation	◆ Even at utility scale, nuclear remains very expensive; at modular scale, it's even more expensive at present ◆ Concerns remain about nuclear waste and safety	◆ While industry has a budget-busting history, it continues to see very significant R&D—with some investors confident costs will come down
Hydrogen	◆ Hydrogen can be stored and transported, a big advantage over traditional renewables ◆ Converting hydrogen to heat and electricity produces no GHGs	◆ At present, most hydrogen production is natural-gas driven ◆ Costs remain very expensive relative to alternatives	◆ Some observers see a future in which hydrogen is generated at scale by solar (vs. natural gas) ◆ While industry needs breakthroughs, may hold most promise of "long shot" tech including carbon capture and nuclear

Appendix J: Integral Group Life Cycle Cost Assessment

The Life Cycle Cost Analysis (LCCA) for this project is a tool to compare the financial outcomes of distinct future scenarios over the study's 30-year period for:

- Business-as-usual (BAU): baseline costs to maintain (and replace when necessary) existing energy infrastructure and purchase fuel (e.g., electricity, natural gas) vs.
- Proposed project (PP): costs to build / maintain new energy infrastructure and purchase fuel

The LCCA is driven by four key components: up-front capital costs, maintenance costs, energy costs, and financing costs.

Construction Costs (for BAU and PP)

These costs are largely derived from market intelligence, gained from Integral Group's past projects and discussions with vendors, and in some instances from U-M's cost estimates for recent or present projects. The LCCA assumes a 30 percent contingency, per U-M's feedback. This is roughly equivalent to the contingency level that Integral Group typically uses.

Maintenance Costs (for BAU)

Maintenance costs, which include system replacement when necessary, are central to the BAU case. Integral Group and U-M worked diligently to develop an accounting of major existing systems, date installed, expected lifetime, planned replacement (in select instances when replacement is already planned), and associated costs.

Financing Costs / Discount Rate (for BAU and PP)

The LCCA's discount rate accounts for opportunity costs, borrowing costs, and the time value of money. It is anticipated that this figure will be refined with further feedback from the university.

Energy Costs (for BAU and PP)

The LCCA's current forecasted rate escalations for electricity and natural gas are derived from the *Annual Energy Outlook 2020* of the U.S. Department of Energy's Energy Information Administration (EIA). The analysis includes base case; high-rate escalation scenario (attributed to high future oil and gas prices); and low-rate escalation scenario (attributed to low economic growth). At present, the analysis uses a very rough approximation for the price and escalation of renewable natural gas (RNG): a simple multiple of natural gas prices.

CENTRAL CAMPUS	**CAPITAL COST - CARBON NEUTRAL INFRA**	**$**	**1,638,641,052**
	Business-as-Usual (BAU): Existing System Replacement (30-yr)	$	252,603,011
	BAU: Utility Costs (30-yr)	$	1,607,696,641
	Carbon Neutral Infra (CN): Utility Costs (30-yr)	$	1,110,372,869
	BAU: Life Cycle Cost (30-yr)	$	1,860,299,651
	CN: Life Cycle Cost (30-yr)	$	2,685,989,265
	Net Present Value (NPV): Δ CN - BAU	$	(825,689,614)
NORTH CAMPUS	**CAPITAL COST - CARBON NEUTRAL INFRA**	**$**	**904,455,068**
	BAU: Existing System Replacement	$	163,178,529
	BAU: Utility Costs	$	653,890,585
	CN: Utility Costs	$	445,837,703
	BAU: Life Cycle Cost	$	817,069,114
	CN: Life Cycle Cost	$	1,315,506,038
	NPV: Δ CN - BAU	$	(498,436,923)
ATHLETIC CAMPUS	**CAPITAL COST - CARBON NEUTRAL INFRA**	**$**	**432,595,878**
	BAU: Existing System Replacement	$	6,271,869
	BAU: Utility Costs	$	102,238,091
	CN: Utility Costs	$	58,165,675
	BAU: Life Cycle Cost	$	108,509,960
	CN: Life Cycle Cost	$	474,123,250
	NPV: Δ CN - BAU	$	(365,613,289)
FLINT CAMPUS	**CAPITAL COST - CARBON NEUTRAL INFRA**	**$**	**233,113,540**
	BAU: Existing System Replacement	$	6,716,891
	BAU: Utility Costs	$	63,144,149
	CN: Utility Costs	$	37,137,198
	BAU: Life Cycle Cost	$	69,861,040
	CN: Life Cycle Cost	$	261,284,833
	NPV: Δ CN - BAU	$	(191,423,793)
DEARBORN CAMPUS	**CAPITAL COST - CARBON NEUTRAL INFRA**	**$**	**184,323,984**
	BAU: Existing System Replacement	$	870,984
	BAU: Utility Costs	$	41,570,741
	CN: Utility Costs	$	2,336,047
	BAU: Life Cycle Cost	$	42,441,725
	CN: Life Cycle Cost	$	179,570,647
	NPV: Δ CN - BAU	$	(137,128,922)
EAST MED CAMPUS	**CAPITAL COST - CARBON NEUTRAL INFRA**	**$**	**73,804,744**
	BAU: Existing System Replacement	$	870,984
	BAU: Utility Costs	$	53,532,867
	CN: Utility Costs	$	35,690,634
	BAU: Life Cycle Cost	$	54,403,851
	CN: Life Cycle Cost	$	106,656,734
	NPV: Δ CN - BAU	$	(52,252,883)

LCCA Output Summary

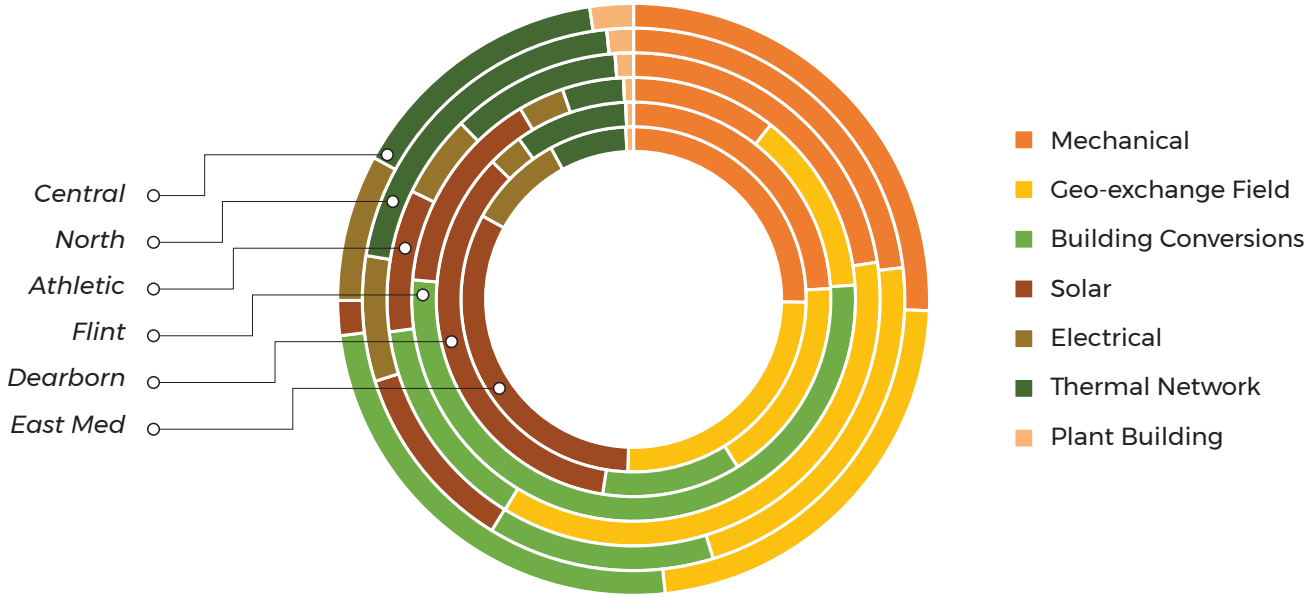
TOTAL CAPITAL COST	**$**	**3,466,934,267**	
TOTAL NPV	$	(2,070,545,425)	
Discount rate		4.0%	*<-- user can adjust this figure*

			Simple payback (yrs)
Total Utility Savings (nom)	**$**	**1,696,892,582**	61
Total Utility Savings (dis)	$	832,532,948	
Utility Savings - w carbon tax (nom)	$	3,394,954,681	31
Carbon tax (hypothetical)	$	200	*<-- user can adjust this figure*

Cost Category Breakdown

$ shown in millions	Central	North	Athletic	Flint	Dearborn	East Med	TOTAL
Low-Carbon Plants	**$ 478**	**$ 303**	**$ 129**	**$ 53**	**$ 89**	**$ 38**	**$ 1,090**
Mechanical	$ 323	$ 161	$ 75	$ 19	$ 34	$ 14	**$ 626**
Electrical	$ 101	$ 52	$ 18	$ 6	$ 4	$ 5	**$ 186**
Solar	$ 24	$ 79	$ 31	$ 27	$ 49	$ 18	**$ 228**
Plant Building	$ 30	$ 11	$ 4	$ 1.3	$ 0.9	$ 0.4	**$ 48**
Geo-exchange Field	**$ 286**	**$ 154**	**$ 120**	**$ 24**	**$ 24**	**$ 14**	**$ 622**
Thermal Infrastructure Network	**$ 185**	**$ 145**	**$ 37**	**$ 8**	**$ 13**	**$ 4**	**$ 392**
Building Conversions	**$ 312**	**$ 94**	**$ 47**	**$ 94**	**$ 16**	**$ -**	**$ 563**
Subtotal before Contingencies	$ 1,261	$ 696	$ 332	$ 179	$ 141	$ 55	**$ 2,665**
TOTAL PROJECT COST	**$ 1,639**	**$ 904**	**$ 433**	**$ 233**	**$ 184**	**$ 74**	**$ 3,467**

Capital Cost Breakdown by Major Line Item



Appendix K: Heat and Power Infrastructure Strategies Evaluation Criteria

HEAT AND POWER INFRASTRUCTURE

Strategy Recommendation: Embark on a phased, district-level approach to converting U-M's heating and cooling infrastructure to be fossil fuel free, beginning with electrified systems centered on geo-exchange with heat recovery chiller technology and with the flexibility to pivot to other proven technological solutions as they emerge.

Carbon Neutrality Impacts

GHG emissions projections are highly dependent on the grid electricity emissions factor, which in turn depends on the size, type, and operating schedules of different generating facilities. U-M's current grid emissions factor is relatively high compared to the national average and very high compared to areas of the country with abundant renewable energy. However, U-M's grid emissions factor will decline over the coming decades as DTE and Consumers Energy move toward supplying fully carbon neutral electricity. The PCCN's emission trajectory model factors in how the grid emissions factor is projected to evolve going forward. The choices made for phasing should consider the relative carbon intensity of current electricity sources (e.g., Central Power Plant [CPP] vs. DTE grid) over time.

The proposed new systems scenario includes reductions from on-site photovoltaic generation, though it should be noted that the same level of emissions reduction could be achieved if the university decided not to install on-site photovoltaic generation and instead purchased an equivalent amount of renewable electricity from the grid. If the university decided against installing on-site photovoltaic generation or purchasing an equivalent amount of renewable electricity from the grid, the total GHG emissions with the proposed new geo-exchange systems would still be lower than the university's business-as-usual GHG emissions.

Equity and Justice Considerations

The Commission has identified three primary equity and justice considerations for this recommendation:

1. Locally generated electricity and thermal energy (including renewables) could benefit the local economy by creating construction jobs in the short term.

2. This proposal will reduce the amount of natural gas and fuel oil burned in Ann Arbor, Dearborn, and Flint and will replace that energy with clean electricity. This will result in local health benefits from cleaner air.

3. Funding sources and mechanisms are not equivalent for the three campuses. To maintain an equitable share of burden, centralized planning and resource allocation should be instituted with representation from all campuses.

Regional Community Involvement

This is an extraordinary endeavor that will require cooperation with the surrounding communities. U-M will need to work with its utility providers, regulators, and surrounding communities to ensure that the campus transformation does not have adverse effects on the surrounding areas.

Scalable and Transferable

Geo-exchange technology is a feasible solution to decarbonize U-M's heat and power infrastructure. Although geo-exchange has been demonstrated at scales similar to that of one of the smaller of U-M's campuses, a project the scale of all the U-M campuses does not exist. If U-M were to undertake this project, it would be a leader and model to other institutions and communities. The campus-level approach of this recommendation is scalable and transferable as it allows institutions of various sizes and building types to find a comparable model to their situation in one of U-M's campuses, though land constraints can limit viability.

U-M Community Participation and Accountability

The required construction would result in a significant amount of disruption of roads, buildings, fields, lawns, and parking lots across all of U-M's campuses. Much of the proposed infrastructure improvements, including geo-exchange technology, is not visible to the eye once installed. However, signage and other communications tools throughout the campus could draw attention to the geo-exchange system and educate the community about its benefits. Including other renewable technologies in the implementation plan, such as photovoltaics, would communicate U-M's commitment to carbon neutrality.

Financial Considerations

The Commission's consultants provided high-level estimated projected cost for the proposed project. Actual costs would need to be determined over time through detailed engineering studies and contractor bids. Uncertainties exist that could affect the cost of the project, including availability of governmental subsidies for clean energy projects, variable construction costs, and electric infrastructure. Using traditional analysis, the nominal payback period based on these high-level estimates would be 61 years; the 30-year NPV is $2.01 billion.

Appendix L: University Vehicles and Maintenance Equipment Strategies Evaluation Criteria

UNIVERSITY-OWNED VEHICLES AND MAINTENANCE EQUIPMENT

Strategy Recommendation: Fully decarbonize U-M's transit system, vehicle fleet (buses, trucks, and automobiles), and maintenance equipment.

Carbon Neutrality Impacts

Replacing a single Blue Bus with an electric bus on the Ann Arbor campus would reduce combined Scope 1 and Scope 2 emissions by 60 percent relative to the current average emissions from a diesel bus. Emissions reductions from bus electrification will start small but accelerate as the electric grid transitions to carbon neutrality, offering a cumulative abatement of about 44,000 $MTCO_2e$ by 2040. Further reductions could be realized through grid decarbonization at a rate faster than currently planned in DTE's and Consumers Energy's articulated goals for reducing emissions.

On the Dearborn campus, the emissions reduction potential of replacing the UM-Dearborn shuttles with electric shuttles would be 0.65 $MTCO_2e$/day.

Equity and Justice Considerations

Campus buses serve individuals from all U-M demographic groups and are relied on by individuals who lack access to automobiles. Replacing diesel buses with electric buses will maintain the equity and social justice features of U-M's mass transit services. Furthermore, because electric buses do not cause the local air pollution and direct individual exposure to toxic exhaust that the existing diesel buses do, the electric buses will enhance the welfare of those that rely on U-M bus services.

Electrifying other campus vehicles will require a commitment to ensuring adequate education around the use of electric vehicles and helping users identify off-site charging stations to minimize range anxiety.

Regional Community Involvement

The timing and scale of these transitions may also be affected by the political landscape and associated incentives. Efforts to transform U-M's transit system should be done in partnership with other key stakeholders in the region (e.g., cities, utilities) to optimize transit solutions at the local and regional level. Early movement by U-M could accelerate broader uptake of these technologies in the region. Furthermore, as the university considers the conversion to electric buses, opportunities to partner in the deployment of charging infrastructure should be explored with DTE, Consumers Energy, and third-party charging station companies.

Scalable and Transferable

Electrifying the U-M bus fleet and shuttle buses will help to increase the already growing scale of electric transit bus use in the United States. It would also position U-M as a leader in the region, providing operational experience that can be transferred to the AAATA and other regional transit agencies.

U-M Community Participation and Accountability

The Commission foresees no particular issues related to campus culture beyond those customary for the operation and use of the Blue Bus and shuttle bus services. The bus systems are widely used and highly visible to the community and would be a strong signal of U-M's commitment to carbon neutrality. Should en route fast-charging be considered in the future, there may be impacts to scheduling due to needs to recharge en route, a matter that would require some communication with the campus community.

To encourage EV use and minimize range anxiety, the university will need to educate its community members and help them identify off-site EV charging sites.

Financial Considerations

An earlier analysis concluded that an electric bus and its depot charger currently exceeded the cost of a conventional diesel bus by $375,000. However, the estimated operations and maintenance savings were at least $30,000 per year for an average bus route. Additional analysis is also necessary to determine the financial savings associated with replacing the UM-Dearborn campus shuttle buses and the U-M connector buses. The Commission is certain that electric bus and vehicle prices will fall over time but uncertain of the rate at which they will fall.

Appendix M: Purchased Electricity Strategies Evaluation Criteria

PURCHASED ELECTRICITY

Strategy Recommendation: Issue a request for proposal (RFP) to procure all purchased electricity for U-M's three campuses in a manner that generates renewable energy certificates that are retired by U-M or on its behalf, aligns with the principles outlined by the Commission, and seeks desired co-benefits outlined for carbon offsets.

Strategy Recommendation: Engage with the Cities of Ann Arbor, Dearborn, Detroit, and Flint and other entities that are, or could be, partners in advocating for renewable electricity policy changes in the State of Michigan to better understand their perspectives, conduct necessary due diligence, and potentially partner in advocacy efforts that reflect mutually shared objectives as well as actively explore ways to partner directly in pursuit of carbon neutrality goals.

The following evaluation criteria relate to the above two recommendations.

Carbon Neutrality Impacts

If U-M sources all purchased electricity from renewable sources, this would result in a 405,000 $MTCO_2e$ reduction below FY19 levels.

Equity and Justice Considerations

Early moves by U-M and other large institutions across the state will demonstrate that significant demand exists for renewable electricity solutions, which should help to accelerate the retirement of coal plants in Michigan. Such an effect should decrease associated health risks, primarily for lower-income and disadvantaged populations who live close to coal-fired power plants.

Regional Community Involvement

Efforts to source 100 percent of U-M purchased electricity from renewable sources could be done in a variety of ways. Depending on the selected option(s), U-M should partner with other key stakeholders in the region (e.g., cities, utilities) to optimize renewable energy solutions at the local and regional level. Swift movement by U-M could accelerate broader renewables uptake in the region. U-M should also engage with the Cities of Ann Arbor, Dearborn, Detroit, and Flint and other entities that are, or could be, partners in advocating for renewable electricity policy changes in the State of Michigan.

Scalable and Transferable

Renewable energy generation (particularly solar photovoltaics) is the fastest growing segment of the energy mix in the United States. U-M's purchasing power and size could help to accelerate both DTE's and Consumer Energy's plans to transition their generation to renewable electricity sources. If replicated at significant scale, these large investments in utility-scale solar should also further reduce costs, making other applications like rooftop solar more affordable for commercial facilities and residences across the state and nation. Additionally, policy changes related to renewable electricity in the State of Michigan could expand the ability for municipalities to reduce their GHG footprint through renewable electricity procurement.

U-M Community Participation and Accountability

In general, purchased electricity has low visibility and thus has minimal implications for campus culture. Therefore, to the extent possible, investments in renewable electricity should be paired with research and education opportunities for U-M faculty and students and the broader communities surrounding U-M's campuses. Additional campus culture benefits could be realized through visible projects on U-M structures and lands. The community can be made aware of the impact of renewable energy generation on campus by mounting displays in buildings that give quantitative data of the amount of electricity being locally generated (see, for example, the display in Pierpont Commons relating to the DTE solar field on North Campus).

Financial Considerations

Despite the rapidly declining costs of renewable electricity in recent years, current programs such as MIGreenPower and SolarGardens still have a significant price premium over U-M's standard electricity tariff, which includes a diverse mix of fuels (e.g., nuclear, coal, natural gas). The timing and structure of investments in renewable electricity will need to take into consideration projected future cost trends. It should also be noted that transformation of U-M's heat and power infrastructure (Scope 1 recommendation) will nearly eliminate our reliance on combusting natural gas. This, however, will also have the effect of significantly increasing the need for electricity required to power U-M's campuses. Purchased electricity demand can be reduced by generating renewable electricity on campus or on nearby properties acquired for that purpose. However, economies of scale make larger solar installations more cost-effective than smaller projects. Further investigation is required to determine the cost/benefit of the installation of renewables on our three campuses.

Appendix N: Demand-Side Management Strategies Evaluation Criteria

REVOLVING ENERGY FUND

Strategy Recommendation: Create a revolving energy fund (REF) on each of U-M's three campuses.

Carbon Neutrality Impacts

Based on the Energy Consumption Policies (ECP) Analysis team's estimates, an REF with $25 million of seed funding on the Ann Arbor campus is expected to reduce UM-Ann Arbor Scope 1 and Scope 2 emissions by 25 percent through energy conservation projects over 10 years. After 10 years of operation, annual emissions are projected to be 104,727 $MTCO_2e$ less than they were at the start of the 10-year period.

It is estimated that REF programs will result in 25 percent emissions reduction over 10 years at the Dearborn and Flint campuses. Due to incomplete data from the Dearborn and Flint campuses, the Commission recommends U-M begin by expanding the data collection capabilities at these campuses.

Equity and Justice Considerations

All units will receive equal support from their regional energy manager to identify energy efficiency projects. This means that all units will have an equal opportunity for receiving funds from the REF based on the need of their building(s) and the merits of their proposals. Units with buildings that have not been recently renovated will have a greater need for project funds than units with newly renovated buildings. There may also be opportunities to extend this approach to support external projects in low-income communities, perhaps supported with donor funding, where there are explicit research and learning components that contribute to the mission of the university.

Regional Community Involvement

As stated above, there may be opportunities to extend REF funds to support external projects in low-income communities where there are explicit research and learning components. The university should seek to partner with the surrounding community on such projects.

Scalable and Transferable

The ECP Analysis team noted that 20 institutions have implemented REFs, although the specific details of each REF was difficult to acquire. U-M could scale and transfer their REF program by making their operational details available online. For this purpose, a single point of contact should be listed to answer relevant questions. Beyond that, the REF is a concept that can be applied to institutions and communities at any scale and hence is readily transferable. The REF also offers potential partnership opportunities with U-M's electricity providers. For example, DTE has expressed that they may be willing to: 1) sponsor a second level study to go deeper into programmatic designs and financial implications for all parties; 2) establish a special energy efficiency incentive design offering as a motivation for early adopters in the REF initiative; 3) provide additional technical support and/or leverage of the Michigan Saves energy efficiency loan financing program (already in place and active with DTE's commercial and industrial energy efficiency program); and/or 4) support funding to the REF via a new vehicle working in conjunction with DTE's energy efficiency programs (and subject to regulatory approval).

U-M Community Participation and Accountability

The REF will empower university units to take ownership of their buildings' energy efficiency through identifying and creating their own energy conservation measure project proposals. This provides local control and benefits for the most active units. The REF and the ECM projects that result also present research and learning opportunities for faculty and students.

Financial Considerations

Consistent with the ECP Analysis team, the Commission recommends $2.2 million in seed funding for the Dearborn REF and $2.4 million in seed funding for the Flint campus. The Commission proposes an Ann Arbor campus REF of at least $25 million in seed funding. It is important to note here that approximately 90 percent of U-M's energy consumption is attributable to the Ann Arbor campus, with Flint and Dearborn accounting for about 5 percent each.

CARBON PRICING

Strategy Recommendation: Establish a carbon pricing system at the organizational unit level across U-M where revenue flows to the REF for new energy conservation measures.

Carbon Neutrality Impacts

The Energy Consumption Policies (ECP) Analysis team estimates a 51 percent baseline reduction in Scope 1 and Scope 2 carbon emissions over 10 years once the full carbon price is established, with a cumulative abatement of approximately 943,000 $MTCO_2e$ over 10 years of implementation on the Ann Arbor campus.

Equity and Justice Considerations

The proposed carbon pricing system seeks to address equity issues head on by having entities bear the social costs of carbon that are attributable to their activities. However, consideration needs to be given to interdepartmental differences among the various campuses and their units. Initially, more efficient buildings will have the advantage of paying less. However, less efficient buildings will receive a larger amount of direct return funds and will have more competitive projects for consideration if the REF is implemented. In addition, there are equity considerations to address with respect to different types of units (e.g., high- vs. low-energy intensity operations). Special attention must also be paid to the system's implementation at Dearborn and Flint given their different budget allocation models. For example, all utility and building budgets at UM-Flint are centralized, and hence what works at U-M Ann Arbor must be modified to provide correct incentives to these two campuses.

Regional Community Involvement

As this would be an internal budgetary mechanism, there would be limited need for broader engagement around implementation of a carbon price. However, there would be opportunities to discuss the approach with other organizations in the region with an eye toward education and potential replicability.

Scalable and Transferable

Through analysis of various carbon pricing tools, the ECP analysis found that earmarking Direct Return funds for energy efficiency projects provides a novel and equitable incentive structure. U-M could pilot this feature so that peer institutions could learn about the transferability of a carbon price to a large-scale public institution. Implementing this recommendation would be a major contribution to the existing body of knowledge on carbon pricing and a step toward leadership in higher education climate action. When implemented across all three campuses, U-M has a unique opportunity to provide models transferable to other organizations and campuses of widely differing sizes and budgets.

U-M Community Participation and Accountability

A carbon price offers a special opportunity to engage all U-M units in the carbon neutrality trajectory. A carbon pricing program will empower individual units and unit leaders to see and understand the implications of their unit's energy consumption and take necessary action to reduce the unit's consumption. Strong leadership from the President and other campus administrators is required for the success of a sustainable program for carbon pricing. Resistance from U-M units with higher levels of energy intensity is to be expected, but the proposed proxy price will help to solve this problem by providing a multi-year pilot that normalizes the concept prior to full implementation with budget implications. To be most effective, a carbon pricing system needs to be highly visible at the unit level to incentivize actions focused on carbon neutrality.

Financial Considerations

A fully implemented carbon price of \$50/MTCO_2e would equate to 0.66 percent of the overall U-M budget, though that percentage would vary across units. In general, budget impacts are well below 1 percent for each unit, with only three units above 1 percent. Those units are the Medical School, the Provost & Executive Vice President for Academic Affairs, and the Vice President for Student Life. For specific information on the estimated budget impact per Ann Arbor Budgeting Unit, see Appendix E.2 of the ECP Analysis Report. Staffing will be required to manage the carbon pricing program and its integration with the REF mechanism.

Appendix O: Building Standards Strategies Evaluation Criteria

BUILDING STANDARDS

Strategy Recommendation: Establish best-in-class CO_2 emissions targets across nine building types for all new construction and major renovations.

Carbon Neutrality Impact

Adopting the recommended emissions targets for new construction projects would result in a range of emissions reductions between 20 percent and 78 percent per building depending on the building type (Appendix I, table). More details on the emissions targets for new construction can be found in the Building Standards Analysis Report, Appendix C. Ultimately, the carbon footprint of a building is directly tied to the carbon footprint of U-M's energy sources and district-level systems that supply the building. The university needs to prioritize decarbonizing its purchased electricity and existing heat and power infrastructure, as called for in the Scope 1 & Scope 2 Emissions Mitigation Strategies recommendations.

Based on University of Michigan Ann Arbor Campus
Recommended Maximum Emissions Targets by Building Type

U-M Buildings									
Classification	Educational Building (no lab)	Educational Building (low load lab)	Educational Building (high load lab)	Library	Clinical	Residential (dormitory)	Residential (low rise, duplex, single family)	Administrative	Athletic (excluding natatoria)
ASHRAE 90.1 2013									
Kg CO_2/sq ft	14.0	21.0	28.0	7.5	19.0	7.9	4.5	15.0	7.0
Recommended Goal									
Kg CO_2/sq ft	**10.0**	**16.0**	**21.0**	**6.0**	**15.0**	**5.2**	**1.0**	**10.0**	**5.0**
% reduction from ASHRAE 90.1 2013	28.6%	23.8%	25.0%	20.0%	21.1%	34.2%	77.8%	33.3%	28.6%

Equity and Justice Considerations

The current budget model of the university places most of the economic responsibility for major renovations at the level of its 19 schools and colleges and on the three individual campuses. The finances of the various schools, colleges, units, and campuses differ significantly and would limit or prevent many from embarking on construction projects that implement carbon minimization strategies. To ensure equity across schools, colleges, units, and campuses and, by extension, the academic communities, U-M should develop mechanisms

to overcome these inherent economic discrepancies through a centralized implementation process and equitable funding.

Regional Community Involvement

As these would be internal building standards, there would be limited need for broader engagement to implement and apply the standards to university buildings. However, if the standards are implemented, there will be an opportunity to share best practices with other like-minded institutions. Additionally, the State of Michigan building standards are currently set at ASHRAE 90.1 2013. The ASHRAE 90.1 standards have steadily issued revisions to improve energy efficiency standards yet are still a decade away from issuing net-zero energy building standards according to the Building Standards analysis. U-M has the opportunity to engage with the local and regional communities to advocate for improved building standards at the state level to drive significant carbon reductions beyond the scope of the university.

Scalable and Transferable

The nine established building types are representative of most of the built environment. The proposed dynamic modeling methods have strong promise for transferability. The modeling methods will enable peer institutions to implement and apply similar emissions-focused building standards to their new construction and major renovations projects. External engagement related to issues of thermal comfort, the emerging aesthetics of low-emissions buildings, and the visibility of these efforts on all three U-M campuses will be an important part of implementation.

U-M Community Participation and Accountability

Individual preferences and broader cultural expectations of thermal comfort can significantly influence building performance and energy consumption. Appendix H of the Building Standards Analysis Report offers information on the potential impacts of occupant behavior on building performance.

Financial Considerations

There is no cost to implement the new standard. However, there is a cost to apply the standard to new construction and renovations. Costs are dependent on the size and type of project, with administrative buildings being the least costly to apply the standard to and lab and clinical buildings being the most costly. These costs should be met by embedding them in the fundraising for the new constructions, in the same manner as all energy saving and operating costs are now included before a building is permitted to be constructed. More details are available in Appendix C of the Building Standards Analysis Report.

Appendix P: Art and Architecture and Couzens Hall Building Energy Efficiency Studies

ART AND ARCHITECTURE BUILDING ENERGY EFFICIENCY STUDY SUMMARY

Introduction and Scope

This building efficiency study focused on the original Art and Architecture (A&A) Building, circa 1971. The focus of the study was to develop strategies to significantly reduce energy use and maximize the reduction of carbon emissions. The building was evaluated for energy conservation measures (ECMs) that were applicable to this type of structure and building use. Please note the recent 2017 addition was not included within this study. The design team started by visiting the building, collecting existing utility data, and reviewing the existing drawings. Their initial task was to determine how the current building was performing, to set a benchmark for comparison.

Then the team developed 11 individual ECMs and three combined ECMs that were evaluated and cost-estimated. The ECM strategies included mechanical and electrical building systems, the building enclosure itself, and various combinations of the individual ECMs. A summary of the ECMs is contained on pages 4-13 of the SmithGroup Art and Architecture and Couzens Hall Building Energy Efficiency Studies Report. More in-depth descriptions of each of the ECMs can be found on pages 25-40 of the SmithGroup report, including explanatory graphics. The combined ECMs were as follows:

- ECM Scenario A: This ECM reflects a combination of ECMs that the team estimated would typically be done under current U-M Design Guidelines during a building renovation.
- ECM Scenario B: This ECM reflects a combination of ECMs selected to produce the maximum reduction in carbon.
- ECM Scenario C: This ECM combination is the same as ECM-B but with no photovoltaics (PV).

To be judicious with the budget and schedule allocated for the study, shoebox (simplified) energy modeling was employed to compare the original building energy performance with the proposed ECM energy performance.

Project Costs

To determine the estimated project costs of the various scenarios, the team worked with a construction manager to develop high-level construction cost estimates. Although the OPCs could be perceived as high when comparing specific ECMs to various benchmarks, it's important to consider that these estimates take into account the specific existing conditions at the A&A Building and include the full scope of associated work in the A&A Building to implement the ECMs. The full scope of this associated work is detailed in the report and appendix and provides a comprehensive understanding of all the associated construction work that is required to implement each ECM. The total estimated project costs for the scenarios include the estimated construction costs, related construction costs (such as hazardous materials abatement and city utilities costs), contingencies, and professional fees and therefore represents the total costs anticipated to implement the various ECMs and bundled ECM scenarios.

Analysis of the ECMs

As noted, the study looked at the simple payback for each of the ECMs. The study calculated simple payback in years as the difference between the project cost divided by the annual energy cost savings. The simple paybacks assumed the existing system(s) did not need to be replaced. This assumption produces long simple paybacks. A comparative example would be replacing your home's windows solely for the purpose of gaining the benefit of improved energy efficiency. The energy use intensity (energy use per square foot per year) was calculated for each of the ECMs. The most promising and compatible discipline ECMs were combined and then analyzed via a very high-level life cycle cost (LCC) analysis for comparative purposes (see pages 41 and 42 of the report). LCC is a method for assessing the total cost of ownership in present value terms, which takes into account all costs of acquiring, owning, and disposing of a building or building system. The following tables summarize the results of the simple payback and life cycle cost analysis for each of the ECM scenarios.

Table A. Individual ECM Strategies

ART & ARCHITECTURE INDIVIDUAL ECM STRATEGIES										
	Energy Conversation Measure	EUI (kBtu/sf)	% Energy Savings	CO_2 (tons/year)	% CO_2 Savings	Annual Energy Cost	Annual Energy Cost/SF	% Cost Savings	Project Cost*	Simple Payback (years)
Existing Conditions	NA	175	-	3,251	-	$ 338,377	$ 1.46	-	-	-
HVAC Systems	**HVAC-1** DOAS, Chilled Beams	136	22%	2,566	21%	$ 270,858	$ 1.17	20%	$ 55,566,000	823
	HVAC-2 DOAS, Chilled Boxes & Chilled Beams	129	26%	2,478	24%	$ 264,866	$ 1.14	22%	$ 54,831,600	746
	HVAC-3 DOAS, Chilled Sails, Destratification Fans	98	44%	2,019	38%	$ 225,756	$ 0.98	33%	$ 58,378,050	518
	HVAC-4 DOAS, Water-Source VRF (high-lift transfer)	49	72%	1,910	41%	$ 275,688	$ 1.19	19%	$ 61,956,900	988
ELECT Systems	**ELECT -1** PV	153	13%	2,381	27%	$ 212,726	$ 0.92	37%	$ 16,152,750	129
	ELECT -2 LED	173	1%	3,128	4%	$ 319,115	$ 1.38	6%	$ 17,346,150	901
ARCH Systems	**ARCH-1** New Curtain Wall	168	4%	3,070	6%	$ 316,423	$ 1.37	6%	$ 18,835,200	858
	ARCH-2 High-Performance Curtain Wall	164	6%	3,012	7%	$ 310,565	$ 1.34	8%	$ 22,512,600	809
	ARCH-3 High-Performance Skylights	173	1%	3,191	2%	$ 331,494	$ 1.43	2%	$ 4,126,950	600
	ARCH-4 10% Existing Glazing Reduction	170	3%	3,137	4%	$ 325,487	$ 1.41	4%	$ 1,482,300	115
	ARCH-5 Alt 1 Brick Reskin, High-Performance Curtain Wall & Skylights, 10% Glazing Reduction	141	19%	2,595	20%	$ 269,151	$ 1.16	20%	$ 40,729,500	588
	ARCH-5 Alt 2 Rainscreen Reskin, High-Performance Curtain Wall & Skylights, 10% Glazing Reduction	141	19%	2,595	20%	$ 269,151	$ 1.16	20%	$ 39,756,150	574
	ARCH-5 Alt 3 Metal Panel over Existing Brick, High-Performance Curtain Wall & Skylights, 10% Glazing Reduction	141	19%	2,595	20%	$ 269,151	$ 1.16	20%	$ 38,568,150	557

Natural Gas Rate: $3.40/Mcf
Electricity Rate: $0.086/kWh
*Project cost based on Walbridge Cost Estimate V2 dated 6/2/2020

Table B. Combined ECM Strategies

ART & ARCHITECTURE COMBINED ECM STRATEGIES										
Energy Conversation Measure	Description	EUI (kBtu/sf)	% Energy Savings	CO2 (tons/year)	% CO2 Savings	Annual Energy Cost	Annual Energy Cost/SF	% Cost Savings	Project Cost*	Simple Payback (years)
Existing Conditions	Dual Duct AHU, Cooling Towers, Steam Boilers, Lighting at 0.8 W/sf, Original Envelope at 0.75 CFM/sf leakage factor	175	-	3,251	-	$ 338,377	$ 1.46	-	-	-
Combined ECM-A HVAC-2, ARCH-2, ELEC-2	DOAS, Chilled Boxes, High-Performance (HP), Curtain Wall, LED	115	34%	2,266	30%	$ 246,305	$ 1.06	27%	$ 87,879,600	954
Combined ECM-B HVAC-4, ARCH-5, ELEC-1, ELEC-2	VRF (high-lift), HP Wall/Sky, 10% Glazing, Brick, LED, PV	19	89%	735	77%	$ 105,981	$ 0.46	69%	$ 114,238,350	492
Combined ECM-C HVAC-4, ARCH-5	VRF (high-lift), HP Wall/Sky, 10% Glazing, Brick, LED, PV	41	77%	1,605	51%	$ 231,632	$ 1.00	32%	$ 107,558,550	1,008

Natural Gas Rate: $3.40/Mcf
Electricity Rate: $0.086/kWh
*Project cost based on Walbridge Cost Estimate V2 dated 6/2/2020

Table C. Life Cycle Cost Summary (1)

LIFE CYCLE COST SUMMARY (1)			
Energy Conservation Measure	Project Cost	Life Cycle Cost	Total CO_2 (3)
Existing Building Condition	-	(2)	97,530
ECM-A	$87,879,600	$95,848,168	67,980
ECM-B	$114,238,350	$120,530,681	22,050
ECM-C	$107,558,550	$115,744,291	48,150

1. 30-year life cycle.
2. Not provided as not comparable to ECM-A, B, C.
3. 30-year total CO_2 emissions in tons (lower values are better). An approximation provided for comparative purposes only; does not adjust for reductions in CO_2 emissions associated with DTE electricity production anticipated to occur over 30-year period.

COUZENS HALL BUILDING ENERGY EFFICIENCY STUDY SUMMARY

Introduction

This study was commissioned by the President's Commission on Carbon Neutrality (PCCN) to evaluate the existing Couzens Residential Hall (Couzens), circa 1926, with a major renovation in 2011, and identify energy conservation measure (ECM) strategies to reduce energy demand and associated carbon emissions as much as possible. The design team started by visiting the building, collecting existing utility data, and reviewing the existing drawings. Their initial task was to determine how the current building was performing, to set a benchmark for comparison. Due to the major renovation in 2011 and potential future renovations to the site utilities, the team analyzed several approaches for Couzens that could be applied to similar building types that may not have had a recent renovation.

Then the team developed 19 individual ECMs and six combined ECMs that were evaluated and cost estimated. The ECM strategies included mechanical and electrical building systems, the building enclosure itself, and various combinations of the individual ECMs. All ECMs are within the Couzens building and not adjacent sites or buildings. A summary of the ECMs is contained in Table D (individual) and Table E (combined). More in-depth descriptions of each of the ECMs can be found on pages 48-68 of the full report, including explanatory graphics. The combined ECMs were as follows:

- ECM Scenario A: This ECM reflects a combination of ECMs that the team estimated would typically be done under current U-M Design Guidelines during a building renovation.
- ECM Scenario B: This ECM reflects a combination of ECMs selected to produce the maximum reduction in carbon.
- ECM Scenario C: This ECM combination is the same as ECM-B but with no renewable energy, photovoltaics (PV).
- ECM Scenario D: This ECM combination aims to reduce project costs and still achieve a healthy carbon reduction result. This combination includes the same HVAC ECMs as B and C but only PV for electrical and solar shading for architectural.
- ECM Scenario E: This ECM combination aims to reduce project costs and still achieve a healthy carbon reduction result without PV or solar shading.
- ECM Scenario F: This ECM combination aims to produce the maximum reduction in carbon utilizing the existing campus infrastructure without any renewable energy (PV).

To be judicious with the budget and schedule allocated for the study, shoebox (simplified) energy modeling was employed to compare the original building energy performance with the proposed ECM energy performance.

Project Costs

To determine the estimated project costs of the various scenarios, the team worked with a construction manager to develop high-level construction cost estimates. Although the OPCs could be perceived as high when comparing specific ECMs to various benchmarks, it is important to note that these estimates consider the specific existing conditions at Couzens and include the full scope of associated work in Couzens to implement the ECMs. The full scope of this associated work is detailed in the report and appendix and provides a comprehensive understanding of all the associated construction work that is required to implement each ECM. The total estimated project costs for the scenarios include the estimated construction costs, related construction costs (such as hazardous materials abatement and city utilities costs), contingencies, and professional fees and therefore represents the total costs anticipated to implement the various ECMs and bundled ECM scenarios.

Analysis of the ECMs

As noted, the study looked at the simple payback for each of the ECMs. The study calculated simple payback in years as the difference between the project cost divided by the annual energy cost savings. The simple paybacks assumed the existing system(s) did not need to be replaced, which is reasonable given that the building recently underwent a major renovation. This assumption produces long simple paybacks. A comparative example would be replacing your home's windows solely for the purpose of gaining the benefit of improved energy efficiency. The EUI (energy use per square foot per year) was calculated for each of the ECMs. The most promising and compatible discipline ECMs were combined and then analyzed via a very high-level life cycle cost (LCC) analysis for comparative purposes, see pages 82-84 of the report. LCC is a method for assessing the total cost of ownership in present value terms, which considers all costs of acquiring, owning, and disposing of a building or building system. The following tables summarize the results of the simple payback and life cycle cost analysis for each of the ECM scenarios.

Table D. Individual ECM Strategies

COUZENS INDIVIDUAL ECM STRATEGIES											
	Energy Conversation Measure	EUI (kBtu/sf)	% Energy Savings	CO_2 (tons/ year)	% CO_2 Savings	Annual Energy Cost	Annual Energy Cost/SF	% Cost Savings	Project Cost*	Simple Payback (years)	CO_2 Avoided (cost/ton)
Existing Conditions	NA	98.4	-	1,420	-	$ 151,956	$ 0.66	-	-	-	-
HVAC Systems	**HVAC-1A-1-Existing** Centralized Water-Source Heat Pump	61.8	37%	1,364	4%	$ 180,671	$ 0.78	-19%	$ 2,971,350	103	$ 53,060
	HVAC-1A-2-Future [1] Centralized Water-Source Heat Pump	61.6	37%	1,364	4%	$ 180,901	$ 0.78	-19%	$ 3,285,900	114	$ 58,677
	HVAC-1B-1-Existing De-centralized Water-Source VRF Fan Coils	54.4	45%	1,152	19%	$ 150,314	$ 0.65	1%	$ 30,863,700	18,796	$ 115,163
	HVAC-1B-2-Future [2] De-centralized Air-Source VRF Fan Coils	53.6	46%	1,130	20%	$ 147,113	$ 0.64	3%	$ 31,178,250	6,438	$ 107,511
	HVAC-1C-Existing/ Future De-centralized Air-Source VRF Fan Coils (supplement heat)	61.3	38%	1,355	5%	$ 179,585	$ 0.78	-18%	$ 32,186,700	1,165	$ 495,180
	HVAC-1D-Existing/ Future De-centralized Air-Source VRF Fan Coils	61.3	38%	1,356	5%	$ 179,724	$ 0.78	-18%	$ 32,680,800	1,177	$ 510,638
	HVAC-2 OA Preheat Using CHW	96.2	2%	1,400	1%	$ 150,730	$ 0.65	1%	$ 785,700	641	$ 39,285
	HVAC-3 Preheat Domestic Hot Water with Sanitary Flow	94	4%	1,381	3%	$ 149,547	$ 0.65	2%	$ 533,250	221	$ 13,673
	HVAC-4 De-centralized Ground-Source Heat Pumps	75.8	23%	1,330	6%	$ 159,686	$ 0.69	-5%	$ 13,009,950	1,683	$ 144,555
	HVAC-6 Residential Room Space Temp Set-Back	96.8	2%	1,421	0%	$ 158,830	$ 0.69	-5%	$ $645,300	94	$ 645,300
ELECT Systems	**ELECT -1** PV	93.8	5%	1,285	10%	$ 132,462	$ 0.57	13%	$ 4,708,800	242	$ 34,880
	ELECT -2 Lighting Efficiency Upgrade	97.3	1%	1,342	5%	$ 138,971	$ 0.60	9%	$ 6,623,100	510	$ 84,912
	ELECT -3 Submetering	97.3	1%	1,360	4%	$ 142,273	$ 0.61	6%	$ 2,601,450	269	$ 43,358

COUZENS INDIVIDUAL ECM STRATEGIES											
	Energy Conversation Measure	EUI (kBtu/sf)	% Energy Savings	CO_2 (tons/ year)	% CO_2 Savings	Annual Energy Cost	Annual Energy Cost/SF	% Cost Savings	Project Cost*	Simple Payback (years)	CO_2 Avoided (cost/ton)
ARCH Systems	**ARCH-1** High-Performance Windows	94.4	4%	1,371	3%	$ 147,365	$ 0.64	3%	$ 9,936,000	2,164	$ 202,776
	ARCH-2 Solar Shading	98.6	0%	1,421	0%	$ 151,867	$ 0.66	0%	$ 1,814,400	20,387	$ 1,814,400
	ARCH-3 Flat Roof Insulation	96.4	2%	1,398	2%	$ 150,211	$ 0.65	1%	$ 2,743,200	1,572	$ 124,691
	ARCH-4 Reinsulate from the Interior	87.4	11%	1,305	8%	$ 142,893	$ 0.62	6%	$ 21,176,100	2,337	$ 184,140
	ARCH-5 Alt 1 Remove Interior Insulation and Reskin Block	77.6	21%	1,203	15%	$ 134,948	$ 0.58	11%	$ 51,232,500	3,012	$ 236,094

Natural Gas Rate: $3.40/Mcf
Electricity Rate: $0.086/kWh
*Project cost based on Walbridge Cost Estimate dated 12/14/2020
HVAC-5 Not used
Mechanical ECMs: **Existing** utilizes the current central campus plant to provide heating and cooling of water. **Future** assumes utilizing chilled water from a future campus geo-exchange district.
1. From Walbridge Estimate include cost of HVAC ECM 1A-2 + HVAC ECM 1A-1
2. From Walbridge Estimate include cost of HVAC ECM 1B-2 + HVAC ECM 1B-1

Table E. Combined ECM Strategies

COUZENS COMBINED ECM STRATEGIES											
Energy Conversation Measure	Description	EUI (kBtu/ sf)	% Energy Savings	CO_2 (tons/ year)	% CO_2 Savings	Annual Energy Cost	Annual Energy Cost/SF	% Cost Savings	Project Cost*	Simple Payback (years)	CO_2 Avoided (cost/ ton)
Existing Conditions		98.4	-	1,420	-	$ 151,956	$ 0.66	-	-	-	-
Combined ECM-A HVAC-1A-2 , ELEC-2	"Typical" U-M approach to a renovation project	58.8	40%	1,283	10%	$ 169,276	$ 0.73	-11%	$ 10,152,000	586	$ 74,102
Combined ECM-B HVAC-1A-2, HVAC-2, HVAC-3, HVAC-6, ELEC-1, ELEC-2, ELEC-3, ARCH-5	Maximize carbon reduction and provide renewable energy	32.5	67%	597	58%	$ 73,429	$ 0.32	52%	$ 63,082,800	803	$ 76,650
Combined ECM-C HVAC-1A-2, HVAC-2, HVAC-3, HVAC-6, ELEC-2, ELEC-3, ARCH-5	Maximize carbon reduction	37.0	62%	732	48%	$ 92,922	$ 0.40	39%	$ 60,825,600	1,030	$ 88,409
Combined ECM-D HVAC-1A-2 , HVAC-2, HVAC-3, HVAC-6, ELEC-1, ARCH-2	Balanced approach to achieve healthy carbon reduction while minimizing costs including renewable energy	45.4	54%	978	31%	$ 128,372	$ 0.55	16%	$ 9,213,750	391	$ 20,846

COUZENS COMBINED ECM STRATEGIES											
Energy Conversation Measure	Description	EUI (kBtu/sf)	% Energy Savings	CO2 (tons/year)	% CO2 Savings	Annual Energy Cost	Annual Energy Cost/SF	% Cost Savings	Project Cost*	Simple Payback (years)	CO2 Avoided (cost/ton)
Combined ECM-E HVAC-1A-2, HVAC-2, HVAC-3, HVAC-6	Balanced approach to achieve healthy carbon reduction while minimizing costs	50.1	49%	1,115	21%	$ 148,222	$ 0.64	2%	$ 4,684,500	1,255	$ 15,359
Combined ECM-F HVAC-1B-1, HVAC-2, HVAC-3, HVAC-6, ELEC-2, ELEC-3, ARCH-1, ARCH-2, ARCH-3, ARCH-4, ARCH-5	"Maximize carbon reduction utilizing existing campus infrastructure without renewable energy"	32.9	67%	611	57%	$ 75,383	$ 0.33	50%	$ 99,812,250	1,303	$ 123,377

Natural Gas Rate: $3.40/Mcf
Electricity Rate: $0.086/kWh
*Project cost based on Walbridge Cost Estimate V2 dated 12/14/2020

Table F. Life Cycle Cost Summary (1)

LIFE CYCLE COST SUMMARY (1)			
Energy Conservation Measure	Project Cost	Life Cycle Cost	Total CO_2 (3)
Existing Building Condition	-	(2)	42,598
ECM-A	$10,152,000	$13,517,722	38,499
ECM-B	$63,082,800	$66,863,258	17,924
ECM-C	$63,825,600	$64,852,582	21,973
ECM-D	$9,213,750	$11,828,049	29,335
ECM-E	$4,684,500	$7,462,359	33,458
ECM-F	$99,812,250	$105,065,305	18,330

1. 30-year life cycle.
2. Not provided as not comparable to ECM-A, B, C, D, E, F.
3. 30-year total CO_2 emissions in tons (lower values are better). An approximation provided for comparative purposes only; does not adjust for reductions in CO_2 emissions associated with DTE electricity production anticipated to occur over the 30-year period.

Conclusion

There are opportunities to significantly reduce the carbon emissions of Couzens.

This study looked at options using the existing campus infrastructure and a new potential campus infrastructure. The central plant is a big undefined context to reduce energy and carbon. This study addressed some of the existing and future options under consideration for the central plant transformation. However, the timing and commitment of the transformation is still evolving. Clarity of a single compelling strategy that can be applied to other buildings has not emerged, in part because Couzens is a newly renovated building that contributed to some energy improvements that older buildings would not have as a baseline. The most opportune time to include efficient systems is when replacement is required. The marginal costs of improvement can have a reasonable payback period. The fact that Couzens had been recently renovated to a level comparable to meeting current U-M guidelines for energy and sustainability increases the payback timeline.

The combined scenarios were largely impacted by the HVAC ECM options. Scenario B that uses a centralized water-source heat pump and renewable energy shows results similar to scenario F that uses decentralized water-source VRF fan coils and nonrenewable energy. Both of these options provided the most energy and carbon reductions.

Appendix Q: Accounting Recommendation Summary

The following are recommendations for Scope 3 emissions accounting.

ACCOUNTING RECOMMENDATIONS
UNIVERSITY-SPONSORED TRAVEL
Standardize travel data collection to facilitate carbon footprint calculations and provide feedback to community members on the impacts of their university-sponsored travel.
FOOD
Establish and standardize food purchasing data collection to facilitate carbon footprint calculations and provide feedback to community members on the impacts of their food procurement and consumption.
PURCHASED GOODS
Implement an accounting system for GHG emissions associated with purchased goods, which disaggregates expenditures into sector categories and uses an economic input-output approach to estimate an emissions baseline and inform targets by category.
Request production emissions data and information on labor and growing practices from vendors to strengthen guidance for low-carbon and environmentally just procurement at U-M. These data can be used in making purchasing decisions and in setting cost and performance criteria and in emissions reduction tracking.
LEASED BUILDINGS
Develop and implement an accounting system for emission Scopes 1 and 2 associated with all leased space and integrate it with U-M's GHG accounting system.
BUILDING MATERIALS
The university should explore accounting methods for estimating embodied emissions associated with building materials and products, as described in the Building Standards Analysis Report. Accounting methods should accommodate and reflect the purchasing processes for materials and products used in campus construction projects. This recommendation should apply to all retrofits as well as new construction.
The university should consider requesting emissions data from building material and product vendors to strengthen guidance for low-carbon procurement at U-M. Any policy on providing embodied emissions data should not result in inequity or bias in vendor selection. These data can be used in material and product selection decisions in addition to cost and performance criteria, as well as in emissions reduction tracking.
WATER
Generate data on emissions intensity of local water and wastewater treatment for all U-M campuses and implement an accounting system for tracking and reporting GHG emissions from water and wastewater treatment.
ELECTRICITY AND FUELS UPSTREAM
Estimate upstream electricity and fuels emissions using Argonne National Laboratory's Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation (GREET) model.

Appendix R: Commuting Strategies Evaluation Criteria

COMMUTING

Strategy Recommendation: Proceed with the design and development of the Ann Arbor campus connector and integrate it with local/regional transit systems.

Carbon Neutrality Impact

Development of the campus connector as light rail would result in the removal of 25 U-M buses from the fleet, which would reduce GHG emissions by approximately 1,400 $MTCO_2e$ annually and lower U-M's overall demand for electrified replacement buses. There would also be additional emission reductions associated with less inter-campus personal vehicle travel, which are not quantified at this time.

Equity and Justice Considerations

The connector should be ADA accessible for the community. The exact route should be thoughtfully constructed to be the most accessible to the greatest number of community members.

Regional Community Involvement

In developing the connector, U-M should take additional steps to integrate it with the municipal and regional transit systems to ensure that it aids in transit movements to campus in addition to serving as an inter-campus shuttle. Toward this end, U-M should develop this project in close collaboration with the City of Ann Arbor, the City of Ypsilanti, Ann Arbor Township, Washtenaw County, and the Michigan Department of Transportation. The system's capacity should be designed under the assumption that the UM-Ann Arbor campus connector will ultimately be a major node in a larger municipal system.

Scalable and Transferable

An effective high-speed transit system on campus that is integrated with the surrounding communities will be one of the first in the region. This project could act as a model for other communities of similar size.

U-M Community Participation and Accountability

U-M will need to ensure the planned connector addresses the campus community's transportation needs.

Financial Considerations

This proposal could form the basis of a funding application to the Federal Transit Administration. Federal and state funding opportunities are likely to become more available under the Biden administration and as a consequence of Gov. Whitmer's September 2020 executive order on carbon neutrality, respectively.

> **Strategy Recommendation:** Reform the parking policy on each of U-M's three campuses by shifting to a daily fee system and establishing an equitable, income-based fee structure while eliminating parking subsidies on the Ann Arbor campus.

Carbon Neutrality Impact

A conservative estimate of the Ann Arbor component of the parking policy reform could result in a carbon reduction of 6,300 $MTCO_2e$/year, or 6 percent of the carbon impact of the faculty and staff commute to the Ann Arbor campus.

Equity and Justice Considerations

Linking parking charges to the commuter's income ensures that the impacts of the proposed parking policy changes do not fall on those least able to afford them. Low-income staff are challenged by Ann Arbor's high cost of living. Many live in outlying communities and have a relatively long-distance commute, which should be a consideration when reforming the parking policy structure. The university should seek to provide accessible and affordable alternatives to the personal vehicle commute.

Regional Community Involvement

As this recommendation is for internal parking policy reform, there would be limited need for broader engagement around implementation. However, there would be opportunities to discuss U-M's parking policy reform with other organizations with an eye toward education and potential replicability. Also, the university should seek to understand the impact this recommendation may have on surrounding public transit systems. A significant number of commuters switching from personal vehicles to public transit could increase public transit demand. This would require collaboration with the surrounding communities to ensure adequate public transit options and capacity.

Scalable and Transferable

No single institution has combined all of the recommended parking reform policies, making this an opportunity for U-M to lead by employing all of the proposed parking policies for optimal carbon emissions reductions. The Commission also encourages U-M to coordinate with the City of Ann Arbor on complementary and mutually reinforcing EV charging infrastructure plans. Additionally, U-M should share knowledge gained with other communities in the region. Transforming the parking system could also provide research opportunities to generate findings that could inform improvements and promote potential replicability at other institutions.

U-M Community Participation and Accountability

Faculty, staff, and students frequently expect available parking within an easy walk of campus, an expectation that pushes parking system expansion. This recommendation represents a shift toward alternatives to the personal vehicle commute and parking and toward efficient parking system management. Such a shift will require education of and engagement with the U-M community around the proposed parking system changes and alternatives to the personal vehicle commute.

Financial Considerations

The suggested changes to the parking program will have revenue impacts to the U-M parking system, which is self-funded. Parking revenue is essential for paying the debt service on parking structures and lots, capital maintenance, and daily operating costs. These revenues are also used to fund current alternative transportation programs such as MRide, which provides free access to AAATA's bus system for U-M community members, vanpools, and studies for alternative transportation programs. The university also directs parking revenue to support other U-M initiatives, such as recreational sports. $30 million annually is generated from the parking program that supports the above programs and functions.

Strategy Recommendation: Expand the availability of electric vehicle charging stations across all three U-M campuses.

Carbon Neutrality Impact

EV adoption by 20 percent of long-distance faculty and staff commuters would result in a reduction of 9,200 $MTCO_2e$/year in 2030. This is equivalent to approximately 10 percent of current commuting emissions.

Equity and Justice Considerations

Any university action regarding EV incentives must take into account that some community members cannot presently afford EVs. To ensure charging access for all employees, the Commission recommends charging stations be evenly distributed across permit types and that 4 percent of charging spaces be ADA accessible. In pursuing this recommendation, U-M should acknowledge the limitations in the adoption of electric vehicles in the short term due to economic barriers for lower-income populations and consider such obstacles when prioritizing commuting solutions or programs designed to support EV adoption.

Regional Community Involvement

U-M should explore partnerships with the local utilities that assist U-M community members with investing in home charging systems for the EVs. These charging stations will allow the U-M community to charge their vehicles at off-peak hours, thus reducing the need for incremental electricity infrastructure to meet electric vehicle demand during peak times.

Scalable and Transferable

EV readiness is a key area in which U-M can constructively engage with the broader community and business partners in the automotive, electric utility, and related industries. The Commission recommends U-M continue to pursue these partnerships to assist in scaling EV readiness across the state and region.

U-M Community Participation and Accountability

EV chargers will be visible to the broader community and will signal U-M's commitment to carbon neutrality.

Financial Considerations

Supporting a 20 percent EV adoption rate by long-distance commuters by 2030 would require an initial investment of approximately $4 million. On-campus EV chargers would require approximately $73,000 per year in maintenance costs. The Commission advises against offering free EV charging for U-M community members because it provides an incentive for people to take personal transportation over mass transit and human-powered options. For charging stations that are powered by the grid, charging fees should vary based on the time of day and overall electricity demand. In other words, the charging fees should be highest during peak load periods and lowest when grid demand is at its lowest level.

Strategy Recommendation: Invest in affordable and accessible alternatives to the personal vehicle commute, including rideshare, cycling, and free bus access on the Flint and Dearborn campuses.

Strategy Recommendation: Embrace and incentivize flexible telecommuting options for employees whose job roles can be performed remotely.

The following evaluation criteria relate to the above two recommendations.

Carbon Neutrality Impact

The Commuting Analysis team estimated emissions reduction of 8,200 $MTCO_2e$/year for expanding rideshare programming across all three U-M campuses and 50 $MTCO_2e$/year for universal transit access at UM-Dearborn and UM-Flint. The commuting team also estimated 1,500 $MTCO_2e$/year reduction from improvements to cycling infrastructure on the Ann Arbor and Dearborn campuses. For the full carbon accounting methodology, see Appendix B of the Commuting Analysis Report.

Equity and Justice Considerations

Increased opportunities for alternatives to driving alone will help save commuting costs, particularly for lower-salaried commuters from farther away. The universal access program will give the U-M community visible and viable commute alternatives. Additionally, cycling infrastructure will improve campus access and safety. A bike service center will offer students and employees easy access to maintenance and cycling information.

The Commission recognizes there are many physical accessibility limitations around alternative commute options. Those who commute long distance may not have adequate public transit options. There are also limitations around rideshare programs for those who may have to travel frequently between class and their residence or have an unexpected need to attend to. U-M should consider and seek to alleviate these limitations where possible when implementing the alternatives.

Regional Community Involvement

There are significant opportunities to engage the local and regional community around alternatives to the personal vehicle commute. On the Ann Arbor campus, the university will need to engage significantly with the City of Ann Arbor, Ann Arbor Township, and the Michigan Department of Transportation to ensure that the U-M connector system aids in transit movements to campus in addition to serving as an inter-campus shuttle. U-M should also seek to engage with the City of Ann Arbor as it expands its cycling infrastructure.

On the Dearborn campus, the university should work closely with the City of Dearborn to explore opportunities for partnership around the City of Dearborn's Multimodal Plan.[72]

On the Flint campus, the university should work closely with the City of Flint to understand the community's needs and priorities and identify areas for partnership relating to public transportation.

Scalable and Transferable

The value of the proposed universal access agreements could grow over time if U-M pursues the development of park-and-ride services that specifically serve hubs where students, faculty, and staff live. Integration of the U-M connector with the broader public-transit environment can occur in phases, with the U-M connector potentially beginning on U-M land as an exclusively university project. The proposed cycling policies will help to build a strong working relationship between U-M and the Cities of Ann Arbor and Dearborn around transportation. This relationship could be mobilized for further improvements, such as a bikeway between Ann Arbor and Ypsilanti. Further development/refinement of the above recommendations would benefit from increased engagement with the communities surrounding U-M's three campuses.

U-M Community Participation and Accountability

A focus group and survey in Dearborn found that 1) there is a prevalent campus culture of driving to work; 2) there is also an interest in using the bus; and 3) there are significant barriers to riding the bus. Ongoing engagement and marketing campaigns are needed to help overcome these barriers.

Financial Considerations

Costs range significantly, with the lowest cost proposal being the rideshare programming and highest cost proposal being the U-M connector.

72 City of Dearborn. (2019, June 6). City of Dearborn Multimodal Plan. https://walkbike.info/Dearborn/plan/

Appendix S: University-Sponsored Travel Strategies Evaluation Criteria

UNIVERSITY-SPONSORED TRAVEL

Strategy Recommendation: Provide and incentivize low-carbon ground transport options (e.g., trains, hybrid/electric buses, and passenger vehicles) for university-sponsored travel.

Strategy Recommendation: Promote video conferencing as an alternative to in-person meetings and travel.

Strategy Recommendation: Implement a carbon price for faculty, staff, and students who travel on university business, with the revenue being used to support the reduction or offsetting of U-M emissions.

The following evaluation criteria pertain to the three recommendations above.

Carbon Neutrality Impact

Key to the university-sponsored travel recommendations is the creation of a centralized system to provide baseline data, evaluate emissions reduction potential, and provide the capability to track emissions reduction progress. With this system in place and the above strategies to reduce and provide alternatives to university travel, the University-Sponsored Travel Analysis team estimates a reduction in overall air travel by 20 percent over 5 years with 10 percent abstaining from or switching to ground travel and 10 percent replacing travel with video conferencing. Given U-M's current travel carbon footprint of approximately 45,000 $MTCO_2e$/year, this would result in a reduction of 9,000 $MTCO_2e$/year. Further reduction may be possible depending on the level of behavior change and should be actively pursued. Additional reductions would occur with the implementation of a travel offset program.

Equity and Justice Considerations

No individual should be asked to pay for the use of video conferencing. Similarly, it will be necessary for U-M to make exceptions for ground transportation for those who may be unable to use alternative modes of travel for accessibility reasons. As virtual meetings and conferences become more mainstream, attention will need to be paid to ameloriating potentially negative impacts on meeting support and food services staff.

Regional Community Involvement

As these recommendations are for internal university travel policies, there would be limited need for broader engagement around implementation. However, there would be opportunities to discuss U-M's university travel programs and incentives with other organizations with an eye toward education and potential replicability. Additionally, should U-M expand its offerings of low-carbon ground transport, there will be opportunities to partner with alternative transit operators, such as the Michigan Flyer, Amtrak, regional bus system, and suppliers of low-carbon vehicles for U-M rental.

Scalable and Transferable

U-M could become a leader in the space of video conferencing and low-carbon transit. Few universities both quantify and aggressively address the Scope 3 emissions from university-sponsored travel. Following this recommendation, U-M would be a model for peer institutions in how to effectively address emissions from university-sponsored travel.

U-M Community Participation and Accountability

It may be challenging to transition units that use an alternate travel tracking system to adopt Concur to track all university-sponsored travel. Individual accountability will be enhanced through the centralized tracking system by providing each traveler access to carbon footprint information. This will bring the environmental impact of travel to bear on those making travel decisions.

To gain acceptance for a reduction of air travel among the campus community, a shift in culture will need to occur. A culture change could be bolstered by strategic news articles and presentations to individual units/departments. A broader culture shift within academia will also need to occur in order for expectations within units and among faculty members to change, at risk of disadvantaging faculty due to limited travel. The success of these initiatives depends on behavior change at the individual level. U-M will need to work hard to educate and empower its faculty, staff, and students to make educated and carbon-friendly decisions. More on educational programming can be found in the Organization and Culture section.

Financial Considerations

The financial costs of implementing a centralized tracking system will depend on several factors, including Concur's pricing; the structural aspects of the system, which would affect how many people oversee the creation and maintenance of the system; and the availability of departments or groups to undertake the project. The savings such a system would bring are likely to be large, as not having a standardized procedure to quantify greenhouse gas emissions has contributed to travel unfettered by environmental impact considerations.

Initial investments in video technology upgrades will be needed to support high-quality remote meetings and conferences. The ongoing cost associated with the proposed reduction strategies are minimal. Potential costs include educational programming, low-carbon vehicles, and maintaining video conferencing hubs. Individual units and travelers could incur additional costs due to the university-sponsored travel carbon price recommendation. There is also the potential for lost revenue in units such as University Unions, for which hosting meetings is a primary source of revenue.

Appendix T: University-Procured Food Strategies Evaluation Criteria

UNIVERSITY-PROCURED FOOD

Strategy Recommendation: Pursue plant-forward food procurement and consumer diets across all three U-M campuses.

Carbon Neutrality Impact

The Food Analysis team estimates that achieving a 25 percent reduction in greenhouse gas emissions associated with food is possible with appropriate changes to menus and procurement practices. See Appendices B and C of the Food Analysis Report for the full carbon emissions calculations.

Equity and Justice Considerations

Menu changes must be responsive to the needs and capacities of the diverse food operations across the university on all three campuses as well as the preferences and cultures of individuals. The university should prioritize and maintain affordable food options on campus for students, faculty, and staff.

Regional Community Involvement

Any changes that the university makes to its food procurement will undoubtedly impact its vendors and their supply chains. The university could expand its potential to positively change major food vendors through partnerships with regional institutions that procure food from the same vendors. Such requirements enacted broadly across multiple institutions have the potential to effect significant change across the industry.

Scalable and Transferable

Of the 33 U.S. universities surveyed by the Food Analysis team, only two have established a goal for greenhouse gas emissions reductions related to food procurement. If U-M were to develop a robust accounting system and establish a carbon emission reduction goal for its food system, it would be a leader among peer institutions.

U-M Community Participation and Accountability

The proposed changes will require consumer acceptance and behavior change to be successful. These changes need to be implemented over a reasonable timeline to ensure that consumer demand aligns with the alternative food options. This process can be accelerated through courses, online training, and orientation activities to develop knowledge and awareness among students. On-boarding and ongoing training for faculty and staff should include modules on the impact of food systems and diets on climate change and specific actions that can be carried out to reduce food-related emissions.

Financial Considerations

A majority of the actions recommended above will require a relatively low investment at the university level. The recommendation will require an investment in cultural change, educational programming, and institutional capacity building. Shifting to a plant-forward menu has the potential to either reduce or increase costs depending on the alternatives selected for each food service operation.

Appendix U: Solid Waste and Wastewater Recommendations Evaluation Criteria

SOLID WASTE AND WASTEWATER

Strategy Recommendation: Scale up food waste diversions and reductions, increase capacity for composting on U-M's campuses, and launch a campus-wide composting program at UM-Dearborn and UM-Flint.

Carbon Neutrality Impact

Current practices on the Ann Arbor campus in FY19 avoided 13,010 $MTCO_2e$. The proposed actions would result in an improved diversion rate that would avoid more carbon emissions.

Equity and Justice Considerations

Unfunded mandates would inequitably affect smaller and underresourced units (e.g., Dearborn and Flint). Efforts to scale up diversion and reduction must be responsive to the needs, capacities, and advances already made within different units and buildings on campus; significantly increasing food donations could improve regional and student food security.

Regional Community Involvement

The university could partner with local food banks and student food pantries to increase food donations. Food that cannot be donated could be provided to local and regional livestock farmers to collect food scraps for their operations.

Scalable and Transferable

Peer institutions are adopting ambitious goals, some pledging to become "Zero Waste campuses" by striving for more than 90 percent diversion rates. If U-M achieved diversion rates between 59 percent to 62 percent, it would be one of the top two institutions among large-scale universities doing so. U-M could act as a model and leader in this space for other institutions. To approach such levels would require disaggregating food waste from other streams, particularly clinical care waste, for accounting purposes. Approximately 50 percent of non-regulated waste generated on the Ann Arbor campus is generated from clinical care activity, and progress in diverting this waste remains challenging due to a lack of recycling markets for this unique waste stream.

U-M Community Participation and Accountability

The proposed changes will require effective and comprehensive education of staff, faculty, and students, as well as willingness of staff, faculty, and students to divert food waste and avoid contamination.

Financial Considerations

This recommendation will require an up-front investment in culture change and institutional capacity building efforts. Additionally, funding will be required to create a composting program on the Dearborn and Flint campuses.

> **Strategy Recommendation:** Explore improved water efficiency and site design standards for all new construction to reduce both upstream and downstream emissions from water treatment.

Carbon Neutrality Impacts

As of FY19, the UM-Ann Arbor campus consumed approximately 1.2 billion gallons of potable water, which equates to 1,784 $MTCO_2e$ emissions. Currently, emissions associated with water are not included in U-M's carbon accounting. Occupant behavior is a large factor in actual water use, so it is difficult to project a direct correlation between fixture efficiency and emissions reductions. Changes related to rainwater harvesting and greywater reuse offer potential reductions in wastewater discharge quantities coupled with heat recovery opportunities. Specific water volumes were not calculated given the unknown nature of the relationship of building footprint to parcel for future consideration.

Equity and Justice Considerations

Affordability and access to water is an issue of environmental equity and social justice in our region and globally. This is playing out as a public health crisis in Flint with lead contamination and in Detroit with increased COVID-19 spread rates due to lack of access to water for handwashing. Efforts made to conserve water and rethink distribution and treatment infrastructure have the potential for meaningful equity impacts.

Regional Community Involvement

There are significant opportunities for U-M to partner with the communities surrounding the three U-M campuses to improve water quality and distribution and treatment infrastructure. The Flint campus currently engages with the broader Flint community to build solutions to and bring the community together around the Flint water crisis.[73] The Dearborn campus receives its water

73 University of Michigan-Flint. (2020, January 1). Campus and Community Engagement. UM-Flint Campus Water. https://www.umflint.edu/campus-water/campus-community-engagement

from and sends its wastewater to the City of Detroit water treatment facilities. The Ann Arbor campus receives its water from and sends its wastewater to the City of Ann Arbor's water treatment facilities. As U-M explores water efficiency standards across all three campuses, engagement with the Flint community, the Dearborn and broader Detroit community, and the City of Ann Arbor should be expanded to improve water quality, distribution, and treatment infrastructure.

Scalable and Transferable

U-M currently has many researchers invested in issues of water conservation, water quality, and water infrastructure. Work from the research realm could more directly impact the implementation of new approaches to One Water on the U-M campuses.

U-M Community Participation and Accountability

Water is a highly visible natural resource that has a strong and established campus culture that cuts across research, teaching, and campus life. While the metrics of emissions reductions in water conservation efforts are not as significant as those related to building energy operations recommendations, the visibility and cultural impact can be more direct and visible.

Financial Considerations

As stated in the Building Standards Analysis Report, low-flow, high-efficiency fixtures can have higher initial costs than less efficient alternatives. However, this cost is compensated for by savings in water bills. Rainwater harvesting and greywater reuse strategies have initial up-front cost driven by the complexity of a building's plumbing infrastructure and the target capture volumes. Water storage tanks have been demonstrated to account for approximately 50 percent of additional up-front costs but can also play an important visual role by displaying the systems at play in low-emissions buildings.

Appendix V: Leased Buildings Recommendations Evaluation Criteria

LEASED BUILDINGS

Strategy Recommendation: Strive to meet additional space needs through better utilization of permanent space (including co-working spaces) and leased space that are intentionally designed as flexible co-working facilities for staff across multiple units who, for example, tele-commute three or more days per week.

Strategy Recommendation: Prioritize leasing arrangements that allow the university to pay electric and gas utility bills directly, as is already in place for most leased properties.

Strategy Recommendation: Develop and implement language in all leasing policy documents that requires high energy efficiency and a low GHG footprint, ideally in alignment with U-M building standards, and require property owners/managers to provide detailed information on their efforts to implement energy efficiency and emissions reductions and how this ethic is woven into their overarching operating principles.

The following evaluation criteria pertain to the above three recommendations.

Carbon Neutrality Impacts

Although leased buildings have a smaller carbon footprint relative to the other Scope 3 emissions categories, the above recommendations will have a positive impact on U-M's carbon footprint. Exact carbon reduction potential is unclear at this point.

Equity and Justice Considerations

Aggressive standards could have unintended consequences, such as increasing rates and making leased space cost prohibitive for small organizations.

Regional Community Involvement

As part of its external collaboration efforts, the university should work closely with local partners in efforts to develop and implement standards to improve energy efficiency and carbon impact for all leased properties.

Scalable and Transferable

Leasing policy document language regarding high energy efficiency and low GHG footprint should be publicly available for other institutions, organizations, and municipalities to draw on in developing their own leasing documents. Such language is largely transferable and should be a resource for all.

U-M Community Participation and Accountability

Prioritizing leasing agreements that allow the university to pay the electric and gas utility bills directly empowers individual units to reduce their electric and gas bills. It also will enable the university to include these emissions in a carbon price, which further incentivizes individual units to reduce their electric and gas consumption.

Financial Considerations

Implementing these recommendations should be relatively low cost, but their implications on overall space costs are uncertain. Facility upgrades associated with stricter standards may increase lease rates but should also result in lower operating expenses. Units will need to understand that it may cost them more to ensure their leased space is in line with GHG reducing measures implemented by the university. Better space utilization across the university and limiting leased space overall should save the university money, though there are many uncertainties in this regard since the emergence of COVID-19. For example, future space needs may be somewhat mitigated by telecommuting, but social distancing requirements may also require more square feet per person.

Appendix W: Carbon Offsets—Peer Institution Examples

Organizations can adopt a wide range of philosophies to guide their use of carbon offsets. For example, a "neutrality-first approach" contends that an organization has a moral responsibility to become immediately carbon neutral and that offsetting is a credible means of achieving that result. Alternatively, a "least-cost approach" compares the cost of offsets alongside the marginal cost of abatement for internal mitigation projects and favors the option that is less costly. Organizations may also adopt a "scope-specific approach," wherein different characteristics across emission scopes lead to prioritizing direct mitigation activity in one scope and offsetting activity in another.

Notable examples of other universities' approaches to using offsets include:

- The University of California (UC) system's draft carbon offsets policy acknowledges the urgency of near-term reductions but seeks to prioritize direct reductions and use offsets as a transitional strategy.[74] Its draft policy advocates for using high-quality, scalable offsets that will advance research and student education, have health and justice benefits for the UC community, and consider health and social impacts on low-income communities and communities of color.
- Duke University's Carbon Offsets Initiative prioritizes carbon offsets projects that provide educational opportunities; provide environmental, economic, and societal co-benefits to their local, state, and regional communities; and serve as a resource for other institutions.[75] For example, Duke recently acquired the rights to a 10,000-acre "carbon farm" that, once fully operational, will store enough carbon to help the university meet its carbon neutrality goals.[76]
- Massachusetts Institute of Technology (MIT) partnered with the Boston Medical Center and Post Office Square Redevelopment Corporate on a 25-year solar virtual purchase power agreement (VPPA) in North Carolina.[77] The renewable energy certificates associated with this purchase counterbalance 40 percent of MIT's Scope 2 emissions associated with its electricity use—similar to the expected result from U-M's participation in DTE's MIGreenPower program.
- Under The Ohio State University's (OSU) hierarchy of greenhouse gas emissions reduction strategies, using carbon offsets is an effort of last resort.[78]

74 University of California, Office of the President. Energy Services. https://www.ucop.edu/energy-services/carbon-offsets/index.html

75 Duke Carbon Offsets Initiative. Guide to Carbon Offsets and Co-benefits. Duke Office of Sustainability. https://sustainability.duke.edu/sites/default/files/cobenefitsguide.pdf

76 Duke University, Nicholas School of the Environment. (2018, October 11). Duke University begins work on 10,000-acre "carbon farm" in Eastern N.C. https://nicholas.duke.edu/news/duke-university-begins-work-10000-acre-carbon-farm-eastern-nc

77 Massachusetts Institute of Technology. (2016, October 1). Summit Farms: Investing in off-site renewable energy. Massachusetts Institute of Technology Sustainability.

78 The Ohio State University. (2020, April 8). Path to carbon neutrality: Ohio State Climate Action Plan. OSU Climate Action. https://si.osu.edu/sites/default/files/CAP_Final_04082020.pdf

Appendix X: Biosequestration Recommendation Evaluation Criteria

BIOSEQUESTRATION

Strategy Recommendation: Identify opportunities for biosequestration projects on U-M lands that have significant carbon sequestration potential and seek meaningful achievements across prioritized co-benefit categories as well as higher-visibility, smaller-scale projects that offer educational opportunities for the university community.

Carbon Neutrality Impacts

U-M owned natural lands currently sequester at a rate of 41,000-78,500 $MTCO_2e$ per year. There is potential for increased sequestration through the purchasing and protection of contiguous undeveloped sites. On-campus smaller-scale projects provide limited carbon sequestration potential.

Equity and Justice Considerations

The university should explicitly consider women- and minority-owned businesses to provide services for the biosequestration projects. The access to natural lands and green spaces is correlated with socioeconomic standing, but natural lands also provide cultural benefits, and accessibility is important. On-campus demonstration projects should be accessible to the community.

Regional Community Involvement

If the university chooses to pursue biosequestration projects on U-M lands in a way that achieves the prioritized co-benefits, there are many opportunities for collaboration with the regional community. Such projects should be accessible to organizations and other institutions for research and educational programming. The university should partner with the surrounding community to engage with the local municipalities, tribal leadership, and nonprofits/organizations that advocate for and accelerate the preservation of natural lands. Smaller-scale and highly visible biosequestration projects could be an area for partnership with the surrounding communities. Projects could be located on campus or nearby in the local community.

Scalable and Transferable

The university should share the outcomes, best practices, and lessons learned from such projects with peer institutions to advance the scalability and transferability of this recommendation. Existing peer consortiums may be a good avenue to do so.

U-M Community Participation and Accountability

To ensure the university community is aware of such projects, because they are mostly off campus, U-M must implement effective signage and communication, experiential learning opportunities for students, and research opportunities. Smaller-scale and highly visible projects close to or on campus could be used to demonstrate the large-scale biosequestration projects taking place off campus for educational purposes. The on-campus projects are a way to bring U-M's off-campus sustainability projects to life for the community.

Financial Considerations

Sustainable management practices to optimize ecosystem service outcomes will incur additional costs and/or reallocation of funds or person hours. The increased biosequestration occurring from proper management of lands could be used as a counterbalance against emissions in other arenas. Purchasing and protecting additional lands will create up-front and increase ongoing costs.

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Published in the United States of America by Michigan Publishing

Designed by Graham Sustainability Institute Marketing and Communications

DOI: https://doi.org/10.3998/mpub.12230588

ISBN 978-1-60785-727-3 (paper)
ISBN 978-1-60785-724-2 (open access)

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