



CLIMATE ACTION PLAN

OCTOBER 2011

Document prepared by the Montana State University Campus Sustainability Advisory Council (CSAC),
Andrew Sabalowsky, managing editor, with contributions from the CSAC members and MSU community.



BOZEMAN ▲ MONTANA

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GLOSSARY OF ABBREVIATIONS

AFRI	Agricultural and Food Research Initiative
ATA	Air Transportation Association
ACUPCC	American College and University President Climate Commitment
ASMSU	Associated Students of Montana State University
AASHE	Association for the Advancement of Sustainability in Higher Education
BSCSP	Big Sky Carbon Sequestration Partnership
BTC	Burns Technology Center
CSAC	Campus Sustainability Advisory Council
CBE	Center for Biofilm Engineering
CACP	Clean Air Cool Planet
CAP	Climate Action Plan
CLS	College of Letters and Sciences
CASMGS	Consortium for Agricultural Mitigation of Greenhouse Gases
DOD	Department of Defense
DOE	Department of Energy
DOE NREL	Department of Energy National Renewable Energy Laboratory
DEQ	Department of Environmental Quality
E3A	Exploring Energy Efficiency and Alternatives
EWB	Engineers Without Borders
EPA	Environmental Protection Agency
FTE	Full Time Equivalent
GIS	Geographic Information Systems
GWP	Global Warming Potential
GYE	Greater Yellowstone Ecosystem
GHG	Green House Gas
GDP	Gross Domestic Product
GRH	Guaranteed Ride Home
HVAC	Heating, Ventilation and Air Conditioning
ITC	Information Technology Consultant
IDL	Integrated Design Lab
IoE	proposed Montana Institute on Ecosystems
IPCC	Intergovernmental Panel on Climate Change
LRES	Land Resources and Environmental Sciences
LEED	Leadership in Energy and Environmental Design
MHK	Marine Hydrokinetic
MSDS	Material Safety Data Sheet
MT CO ₂ e	Metric Tons of Carbon Dioxide Equivalent
MSU	Montana State University
MUS	Montana University System
NRCS	Natural Resource Conservation Service
NECO	Network of Environmentally Conscious Organizations
PECASE	Presidential Early Career Awards for Scientists and Engineers
RFP	Request for Proposal
SOV	Single Occupancy Vehicle
SOFC	Solid Oxygen Fuel Cell
SFBS	Sustainable Food and Bioenergy Systems
TAGs	Triacylglycerides
USDA	United States Department of Agriculture
UFS	University Food Service
WARM	Waste Reduction Model
WTI	Western Transportation Institute
WAC	Wind Applications Center
WFS	Wind For Schools Program
ZERT	Zero Emissions Research and Technology

1. EXECUTIVE SUMMARY

In 2008, Montana State University (MSU) signed the American College and University Presidents Climate Commitment (ACUPCC): www.presidentsclimatecommitment.org. The ACUPCC acknowledges “the scientific consensus that global warming is real and is largely being caused by humans. We further recognize the need to reduce the global emission of greenhouse gases (GHGs) by 80 percent by mid-century at the latest in order to avert the worst impacts of global warming and to reestablish the more stable climatic conditions that have made human progress over the last 10,000 years possible.”

As part of the commitment, MSU’s Campus Sustainability Advisory Council (CSAC) was established (www.montana.edu/sustainability/csac.html) to advise MSU’s President on sustainability and meet ACUPCC obligations, which include the:

- periodic inventorying of GHG emissions;
- development and public reporting of the Climate Action Plan (CAP); and,
- strengthening of research, education, and civic engagement efforts to promote climate stabilization and progress toward sustainability.

The Elements of MSU’s Climate Action Plan (CAP)

MSU’s inaugural CAP describes current efforts to significantly reduce campus GHG emissions and outlines plans to integrate sustainability into all aspects of university operations, learning, discovery and service. Beginning with a baseline GHG inventory compiled in 2009, mitigation strategies and specific emissions reduction goals are presented. The CAP also presents ongoing and proposed activities that integrate sustainability and climate neutrality into operations, curriculum, research and civic engagement. Additionally, inspired by the uniqueness of place and cultures at MSU, we acknowledge and value the wisdom and traditional practices of native peoples associated with our place here in the Northern Plains and Northern Rockies. We therefore incorporate the Native American ideas of stewardship and community as prerequisites to sustainability, and include this perspective as an important element to the CAP. The CAP will be updated biannually to provide information on progress toward the above goals and new initiatives at MSU-Bozeman.

Baseline Greenhouse Gas Inventory

The 2009 annual baseline GHG inventory revealed that approximately 77,375 metric tons of

carbon dioxide-equivalent (MT CO₂e) were emitted from MSU-Bozeman campus operations, as defined by limits provided by the ACUPCC. Of this total, approximately one third are generated by direct fuel combustion on campus, one third from purchased electricity, and one third from indirect emission sources such as transportation and solid waste.

Mitigation Strategy and Benchmarking

MSU-Bozeman campus intends to implement a near-term emissions reduction strategy based on the following guidance from the University Council:

- continue and complete energy conservation projects presently funded;
- tackle additional cost-effective energy conservation projects as they become reasonable/attainable, contingent upon funding;
- leverage cost-effective technological advancements as they develop;
- comply with mandated energy efficiency requirements for new building projects;
- move resource conservation services in-house, and leverage these services into a Resource Conservation Culture Program; and,
- pursue renewable energy sources, offsets, and/or credits as cost-effective mechanisms become available and/or upon the State of Montana taking action to enable, support, and fund them.

Given the above direction, an ambitious, yet achievable GHG reduction strategy has been developed. An interim goal of 20 percent reduction from 2009 GHG emissions by 2025 has been established. Extensive planning and analysis is required to confidently establish further reduction milestones, and the ultimate goal of net-zero carbon emissions. Planning will continue concurrently with the implementation of early (Phase One and Two) projects during the next two to three years. Results and feedback from Phase One and Two efforts will contribute to CAP course corrections and milestone revisions, and be reported in the next (biannual) CAP release.

Climate Neutrality and Sustainability in Education, Research, and Outreach

MSU-Bozeman seeks to provide an environment that promotes the exploration, discovery, and dissemination of new knowledge, as well as serve the people and communities of Montana. This mission draws on the unique geographic setting and the ethnographic and cultural diversity of Montana, as well as our location in the Greater

1. EXECUTIVE SUMMARY

Yellowstone Ecosystem and adjacent Great Plains. We use our unique location to instill in students a sense of responsibility to sustain environmental integrity and function and to improve the quality of life for all. Research, education and outreach activities focused on sustainability range from clean energy and sustainable food production to climate change impacts and human health, and they are underway in various centers, colleges and departments at MSU. Many of these activities have historically occurred in isolation with little effort to bridge across departments and colleges. To coordinate and enhance communications, the MSU Institute on Ecosystems (IoE) is currently being launched.

The IoE is a faculty-designed and supported effort that builds on and transforms the existing Regents-approved Big Sky Institute (BSI). The IoE mission, to promote interdisciplinary discovery, education, and engagement focused on a sustainable future for Montana as well as mountain regions around the world, is a strategic alignment of ongoing and future efforts at MSU-Bozeman. The IoE will coordinate climate neutrality and sustainability education, outreach and research efforts amongst undergraduate and graduate students and staff/faculty across campus and within the community, providing:

- a new framework that will increase state and national visibility for Montana University System (MUS) environmental research and educational activities;
- a statewide community of scholars who share common interests in addressing complex environmental questions;
- new connections with partners from other universities, tribal colleges, state and federal agencies, NGOs, small businesses, and communities that will foster innovative opportunities for collaboration; and
- improved engagement with communities and stakeholders to support informed decision-making and development of solutions to environmental challenges.

Engagement and Partnerships

We seek engagement and partnerships in research, education, and service to ensure that objective science information with a practical human perspective is used to envision our future and the steps necessary to achieve it. MSU recently was awarded the Carnegie Foundation's Community Engagement classification, a designation which recognizes an institution's high level of outreach and collaboration with its surrounding community. MSU has a myriad of outstanding examples of environmental and community outreach, as evidenced later in the CAP. While these efforts are not coordinated and widely shared, the IoE will provide a point of contact for collaborations with other MUS institutions (including other MSU campuses, University of Montana, and tribal colleges), state and federal agencies (e.g., USGS Northern Rocky Mountain Science Center, Yellowstone National Park, Northern Region U.S. Forest Service, Bureau of Land Management), nongovernmental organizations (e.g., World Wildlife Foundation, Wildlife Conservation Society, Greater Yellowstone Coalition; Sonoran Institute), MSU Extension, communities, small businesses (e.g., Greater Yellowstone Business Partnership), corporations and foundations, and private citizens.

By setting a strong example through tangible progress toward net zero GHG operations, working with the IoE to effectively educate, train, and graduate students in interdisciplinary sustainability areas (including climate change), and successfully integrating with the surrounding community and region, MSU and the MUS is poised to become a leader in transforming the world toward understanding the science of climate change and seeking solutions that result in sustainable living, choices, and technologies that will ultimately mitigate climate change to the degree humanity has contributed to its causation.

2. BASELINE GREENHOUSE GAS (GHG) EMISSIONS

Baseline Inventory Summary

As a signatory to the ACUPCC, MSU has made an institutional commitment to reduce GHG emissions from campus operations, and ultimately achieve a carbon neutral footprint. The initial step in achieving this goal is to complete a comprehensive GHG emissions inventory. McKinstry Company was engaged by MSU to assist the CSAC in this process. McKinstry is a third-party engineering firm with demonstrated experience in GHG inventories. Working with an experienced third-party for GHG audits reduces overlooked emission sources, establishes consistent methods for subsequent audits, and lends an objective approach to audit processes. It was determined that the total emissions for the 2009 reporting period were 77,375 Metric Tons Carbon Dioxide Equivalent (MT CO₂e), taking into account Scope 1, 2, and 3 emissions (see Figure 2.1). This is a higher than average emissions value when compared to many ACUPCC institutions, but includes thorough data for Scope 3, emissions that are, at this time, omitted by many other institutions.

Introduction

GHG accounting and reporting was based on the principles set forth in the World Resource Institute GHG Protocol. These are:

- **Relevance** — Ensure the GHG Inventory appropriately reflects the GHG emissions of the university and serves the decision making needs of users — both internal and external to the university.
- **Completeness** — Account for and report on all GHG emission sources and activities within the chosen inventory boundary. Disclose and justify any specific exclusions.
- **Consistency** — Use consistent methodologies to allow for meaningful comparisons of emissions over time. Transparently document changes to the data, inventory boundary, methods, or any other relevant factors in the time series.
- **Transparency** — Address all relevant issues in a factual and coherent manner, based on a clear audit trail. Disclose any relevant assumptions and make appropriate references to the accounting and calculation methodologies and data sources used.
- **Accuracy** — Ensure that the quantification of GHG emissions is systematically neither over nor under actual emissions, as far as can be judged, and that uncertainties are re-

duced as far as practicable. Achieve sufficient accuracy to enable users to make decisions with reasonable assurance as to the integrity of the reported information.

MSU's 2009 GHG inventory was based on university data for the 2008–2009 fiscal year (July 2008–June 2009), and was calculated using the Clean Air Cool Planet Campus Carbon Calculator (CACCP) v6.4. Data was collected from a variety of sources, and some incomplete data was extrapolated to provide MSU with an estimate based on the best available data.

Reporting Boundaries

Through discussions with MSU, it was determined that the scope of this report would be limited to MSU activities at the Bozeman campus. Additionally, it was agreed that MSU would use the Operational Control Approach in determining organizational boundaries on the campus. Under this approach, MSU is accounting for GHG emissions from all operations under its operational control, which refers to the authority to introduce and implement operating policies, and is consistent with the ACUPCC reporting guidelines. The commitment requires that signatories report on and mitigate emissions from Scope 1 and 2 sources as well as commute and air travel from Scope 3. Comparing this inventory with peer institutions reveals that most inventories focus on required emissions sources. This inventory aims to document all MSU emissions, regardless of the required mitigation responsibilities.

It can be argued that many Scope 3 emissions are not under direct MSU control and should therefore be excluded. Holding the university accountable for personal commute choices and habits could be argued as outside the control of the reporting institution, and should not impact its footprint. MSU believes that it is important to accurately account for all emissions resulting from university existence, and this should not exclude emissions from choices of the campus population, and are therefore included in this report.

Description of Emission Sources

Throughout this report, emissions are grouped into three different Scope categories, as presented in Figure 2.1. Scope 1 emissions are direct GHG emissions occurring from sources that are owned or controlled by the institution. Scope 2 emissions account for indirect GHG emissions that are a consequence of activities that take place within the organizational boundaries but that

2. BASELINE GREENHOUSE GAS (GHG) EMISSIONS

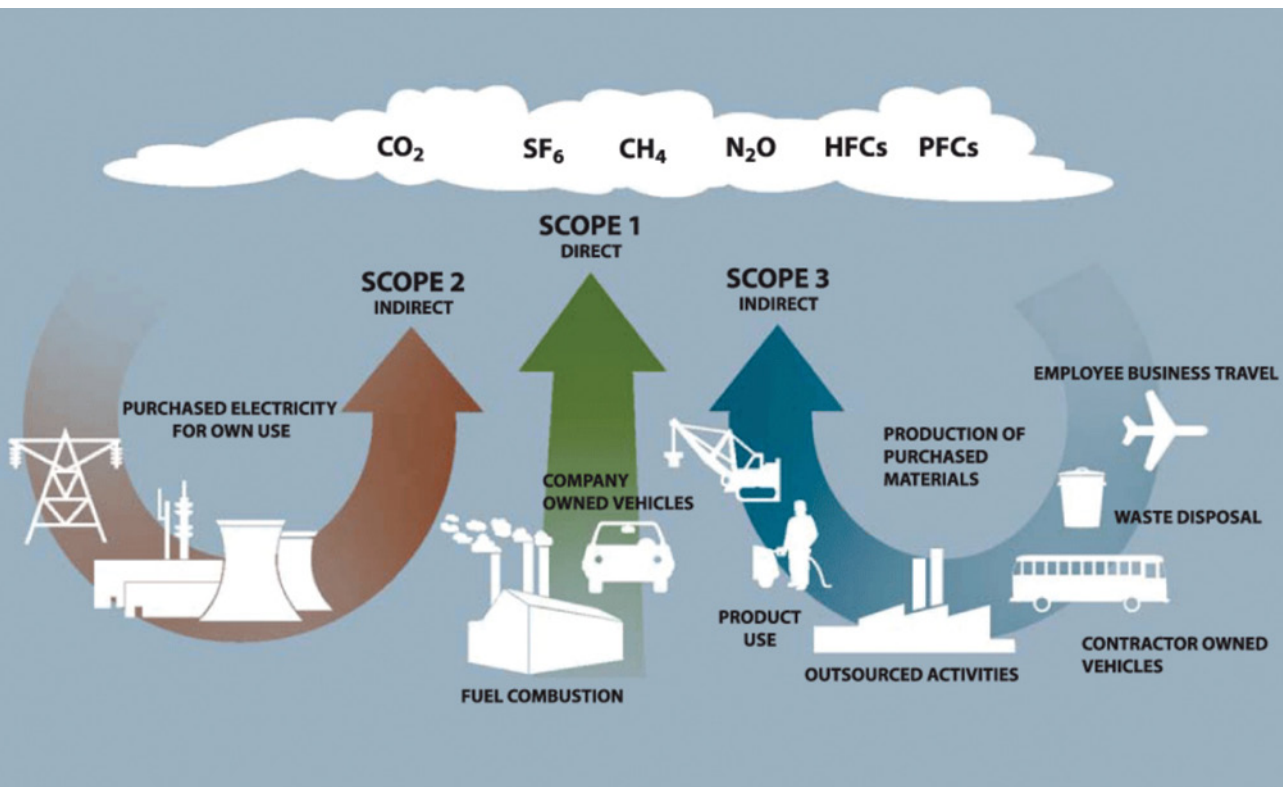


Figure 2.1 Summary of Operational Boundaries – ‘Scopes’ of GHG Emissions. (World Resources Institute)

occur at sources owned or controlled by another entity, such as purchased electricity. Scope 3 emissions are all indirect emissions not covered in Scope 2, and focus on cultural emissions associated with travel, waste, and commuting habits of the university. By understanding where university emissions are concentrated, MSU will be better prepared to strategically approach reduction to meet the ACUPCC requirements of achieving a carbon neutral campus.

Inventory Results

Well-tracked data for Scope 1 and Scope 2 were typically available for MSU-Bozeman, but some Scope 3 data, specifically other directly-financed air and ground travel, were based upon best available data, recommended conversion factors, and supplemented by estimates from other ACUPCC universities. MSU’s emissions presented in this report reflect a higher than average value than comparable universities on the ACUPCC website. It is important to note that many of these institutions have not reported on air travel, and many

do not include comprehensive commute data. By omitting these Scope 3 emissions from the GHG reports, MSU-Bozeman total GHG emissions are approximately 43 percent lower than the 77,375 MT CO₂e reported for MSU in 2009. MSU and McKinstry chose to report on all data collected by MSU, and make assumptions for unknown parameters (study abroad air miles) in order to present the most comprehensive footprint information available. Although not all of these emissions are required reporting for ACUPCC, it is recommended that MSU continues to view their GHG inventory holistically and report on full emissions. MSU acknowledges that their reported emissions are likely to change as they evolve their data collection protocols, and are not required to report on all emissions stated in compliance with ACUPCC. Presented in Figures 2.2 and 2.3, 2009 GHG emission data by scope and source is reported in tabular and graphical forms, respectively.

2. BASELINE GREENHOUSE GAS (GHG) EMISSIONS

2009	MT CO ₂ e	% of Net Emissions	ACUPCC required?
Co-gen Electricity	0	0%	yes
Co-gen Steam	0	0%	yes
Other On-Campus Stationary	21,099	27%	yes
Direct Transportation	639	1%	yes
Refrigerants & Chemicals	1,585	2%	yes
Agriculture	92	0%	yes
Purchased Electricity	20,564	27%	yes
Purchased Steam / Chilled Water	0	0%	yes
Faculty / Staff Commuting	3,733	5%	yes
Student Commuting	4,073	5%	yes
Directly Financed Air Travel	12,335	16%	yes
Other Directly Financed Travel	2,403	3%	recommended
Study Abroad Air Travel	6,688	9%	yes
Solid Waste	2,132	3%	yes
Wastewater	0**	0%	recommended
Paper	0**	0%	recommended
Scope 2 T&D Losses	2,034	3%	recommended
Additional	0	0%	recommended
Non-Additional	0	0%	recommended
Scope 1	23,415	30%	
Scope 2	20,564	27%	
Scope 3	33,397	43%	
All Scopes	77,375	100%	
All Offsets	0		
TOTAL EMISSIONS	77,375		

Figure 2.2 2009 GHG Baseline Emissions at MSU-Bozeman

** Data not available

Data Collection Methodology

Below is a summary of how data for this report was collected, and any calculations or extrapolations used to generate the GHG inventory report. For a full list of assumptions and standard calculations, please reference the 2009 MSU-Bozeman GHG Inventory Report in Appendix 1.

General University Data

University Population — The MSU “Quick Facts 2008–2009” report was used for the university population. For faculty and staff, full time equivalent (FTE) employee numbers were used.

Scope One Emissions

- **Stationary Combustion** — This category accounts for the total direct emissions from stationary combustion on the MSU campus. Stationary combustion refers to the burning of fuels to produce electricity, steam, heat, or power using equipment in a fixed location such as boilers, burners, heaters, furnaces, incinerators, kilns, ovens, dryers, and engines. Any biogenic carbon dioxide emissions that result from the combustion of biomass or biomass-based fuel are not included in Scope 1.
- **Mobile Combustion from Direct Transportation** — Accounts for the total direct emissions from mobile combustion in MSU-owned fleet such as cars, trucks, tractors, and buses. These emissions were captured from MSU fuel records from motor pool and Gas Island fuel sales for campus fleet vehicles.

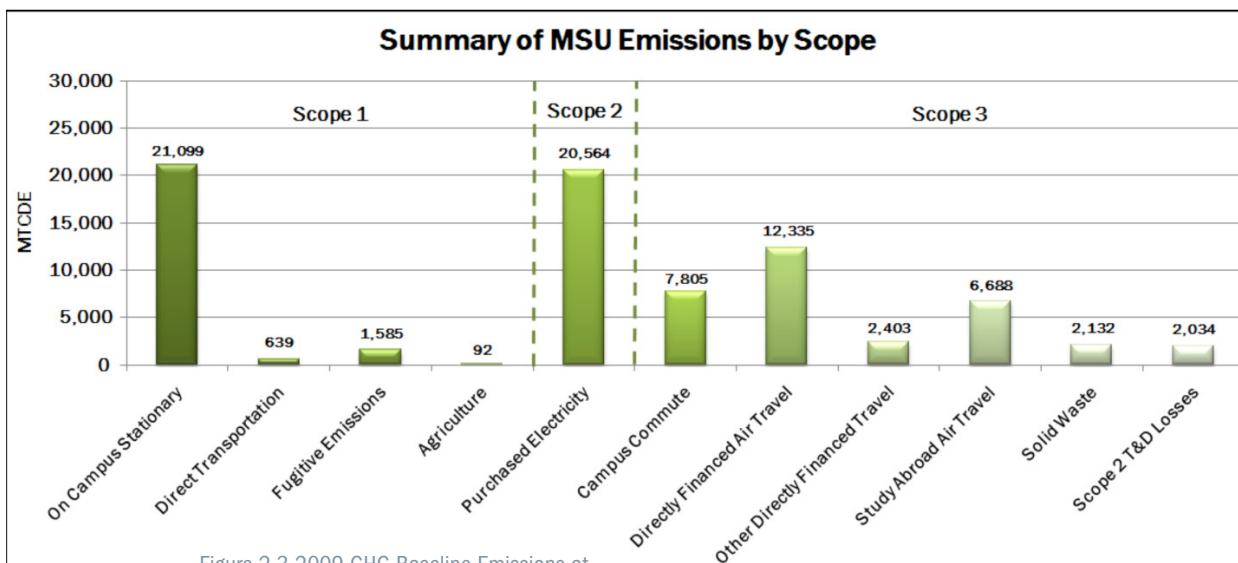


Figure 2.3 2009 GHG Baseline Emissions at MSU-Bozeman

2. BASELINE GREENHOUSE GAS (GHG) EMISSIONS

- Fugitive Emissions — Data for emissions due to the intentional or unintentional release of GHGs in the production, processing, transmission, storage, and use of fuels and other substances were acquired through MSU Facilities Services. This includes releases of hydro fluorocarbon during the use of refrigeration and air conditioning equipment and methane leakage from natural gas transport. The Clean Air Cool Planet (CACP) calculator identifies specific emissions factors for each type of refrigerant used on campus based on the Global Warming Potential (GWP) for the individual refrigerant. For refrigerants not in the CACP calculator, MSDS sheet values for GWP were used.
- Agricultural Emissions — This captures emissions from on-campus fertilizer production and application.

Scope 2 Emissions

- Purchased Electricity — This captures the total indirect GHG emissions resulting from the generation of electricity purchased and used by MSU. Default eGRID region and sub-region emissions coefficients for Bozeman, Montana (supplied in the Clean Air-Cool Planet Campus Carbon Calculator v6.4) were used for all electricity emissions calculations.
- Purchased Steam — MSU does not purchase any steam or chilled water.

Scope 3 Emissions

Commute Transportation — A commute survey was created and administered by ASMSU. This survey was distributed to faculty, staff and students on the MSU campus. Survey Questionnaire results are supplied in Appendix 2. Results from this survey were used to calculate emissions from student, faculty, and staff commuting. Extracting usable data required query sorting of the survey responses, and is explained below. A total of nine sorted reports were used to compile commute data for the GHG inventory.

CACP methodology for calculating commuting data bases calculations on FTE student population, giving part-time students equivalent of one-half a full-time student. This may not accurately capture the complex commute patterns of students going to and from campus, but until more accurate tracking is established, the CACP protocol will be used for MSU calculation.

- Commute Preferences — To determine

primary commute patterns for students, faculty and staff, each group was sorted individually. Responses to question four of the survey would then show the primary commute habits of each group (bus, SOV, carpool etc). Because the survey separated commute choices by season, averages were calculated for the GHG Inventory inputs. For faculty and staff, full-year averages were used because they are employed on a 12 month pattern. For student averages, spring/fall and winter response averages were used to determine percent utilizing each mode of transportation as their primary commute choice during the school year.

- Driving Distance — To determine the average trip distance for drive-alone commuters, each response group was filtered to sort by status (student, faculty or staff), and to those that selected “drive-alone” as their primary commute choice. The survey allowed respondents to specify distance they lived from campus. An average of these values was calculated for each group to enter into the CACP workbook. Any extreme outlier responses were omitted.
- Bus Distance — To determine the average trip distance for bus commuters, each response group was filtered to sort by status (student, faculty or staff), and to those that selected “bus” as their primary commute choice. The survey allowed respondents to specify distance they lived from campus. An average of these values was calculated for each group to enter into the CACP workbook.
- Weeks Worked/Trips Per Week — Values entered for the number of weeks commuting were assumed based on MSU data for employee benefits and academic calendars. It was assumed that all employees and students were commuting five days per week, to and from campus.

Air Travel — Air travel accounts for a large portion of most universities GHG emissions. Reported emissions from air travel for MSU are estimates based on best available data and extrapolations. The following bullets explain the methodology to calculate these Scope 3 emissions from MSU.

- Athletic Air Travel — Athletic air travel was tracked by MSU for the 2008–2009 academic year. This data was provided in dollars spent for each trip. The CACP input requires air miles, so to extrapolate air miles

2. BASELINE GREENHOUSE GAS (GHG) EMISSIONS

- from these dollar values, the recommended ATA conversion factor. It is entered into the CACP workbook as student air travel.
- Faculty and Staff Air Travel — MSU air travel spending is automatically tracked through the university purchasing card records and expense reports. The total spent on university air travel related to research and other travel was converted to air miles using the ATA conversion used throughout all MSU air travel calculations; this is equivalent to approximately 12,756,878 air passenger miles.
 - Study Abroad Air Travel — At this time, MSU does not track or record air miles associated with study abroad travel. Rather than leave this value at zero, the reporting team used estimated study abroad miles based on other reporting universities based on air miles per student. This estimate will be refined in future reports at MSU develops tracking protocol to capture study abroad travel.

Other Transportation — Reported emissions from air travel for MSU are estimates based on best available data and extrapolations. The following bullets explain the methodology to calculate these Scope 3 emissions from MSU research travel.

- Reimbursement for Mileage — Calculated from total dollar value reported by MSU using 2007–2008 standards reimbursement rates per mile.
- Fuel Costs — Calculated based on total reported fuel expenditures at \$2.50 per gallon.
- Bus Mileage — Bus data was only available specifically for athletic teams. For bus-only trips, MapQuest.com round trip distances between MSU and the opponent city were used for mileage. For trips where busses and airlines were used, it was assumed that each bus on the trip traveled 150 miles. Number of busses were based on number of participants (provided by MSU Athletic Department) and bus capacity of 49 passengers.
- Solid Waste — This captures the total indirect GHG emissions resulting from the incineration or decomposition of MSU's solid waste.
- Offsets — MSU does not currently purchase any offsets for their GHG emissions.

Report Omissions

Various inputs were omitted from this report due to a lack of data availability. MSU acknowledges these omissions impact the accuracy of this report, and are working to collect these data for future reports. The future inclusion of these inputs may or may not significantly change MSU's GHG footprint.

- Paper — MSU data not available.
- Wastewater — MSU data not available.

Recommended Inventory Improvements

Through the process of collecting, compiling, and reporting the 2009 GHG Inventory, gaps in current data collection processes were identified. The most critical improvements need to be addressed in accurate data collection for air travel miles and commute transportation patterns.

It is recommended that for future commute transportation surveys, MSU consider alternative methods that will reach more respondents. It is also recommended that the question “How many miles do you live from campus?” be rephrased “How many miles is your daily commute?” Because some campus members may not come in exactly 5 days per week, or may make multiple trips per day, “How many trips/miles per week do you drive?” is another suggested revision. For instance, it was found that some faculty not on campus responded with 100's of miles from campus (probably not their daily commute) which could skew averages if outliers had not been omitted. This change would more accurately capture what the emissions impact from daily commuting is for MSU employees and students.

The commuter survey did not account for commuting via light rail or commuter rail. If and when this becomes an option for campus commuters, it should be added to the response options.

For future accurate reporting, MSU should establish protocol for tracking air miles for faculty and staff travel, for-credit study abroad, and athletics. The most accurate reporting would come from direct collection of passenger miles (ground or air) rather than dollar amounts. In the current athletics tracking system, some recommended improvements would include miles driven on each bus and rental car. From the data provided, it is difficult to accurately convert dollars spent into miles driven. As MSU refines their data collection methods, future GHG Inventories will represent more accurate Scope 3 emissions.

[†]The ACUPCC Instructions for Submitting a Greenhouse Gas Report states that “for guidance on calculating air travel emissions, you may consult “Guidance on Scope 3 Emissions, pt 2: Air Travel” on the AASHE Blog. The AASHE Blog states that you can use statistics on the average price per passenger air mile from the Air Transportation Association of America to convert the total air travel expenditure into passenger air miles. Since the figures from the ATA exclude taxes, AASHE recommends adjusting the cost per passenger mile up by 20 percent to take taxes into account. The ATA data indicates that the nominal domestic yield in dollars per passenger mile was \$0.1384 in 2008. Adjusting this cost up by 20 percent per AASHE recommendations results in a cost of \$0.16608 per passenger mile.

3. EMISSIONS REDUCTION SCHEDULE, MILESTONES, AND CARBON REDUCTION GOAL

3.1 Identification of emissions trajectory and reduction potential

As part of MSU’s energy management program, detailed data regarding the use of energy in Campus buildings is tracked. For the purposes of this planning effort, the data has been restricted to electrical and natural gas energy consumption over the course of the last 22 years (1988–2009). Gross energy consumption for each utility has been tracked and compared to the gross building area increase. Electrical consumption has increased at an average rate of about 1.6 percent annually (Figure 3.1) over this time period while gross square footage has grown approximately 0.6 percent annually. Likewise, natural gas consumption has an annual average rate of 1.3 percent over the same time span (Figure 3.2). The disparity between a modest increase in the built environment and the more aggressive growth in

energy consumption is due to the proliferation of electrical equipment, mechanical loads, and MSU’s continued growth in areas of research requiring energy-intensive support systems.

In order to identify the relative energy efficiency of MSU’s buildings and potential energy conservation projects, campus was categorized into eight building types/functions. An energy index (annual energy use per unit area) was calculated for each category. In addition to benchmarking buildings by energy index, the energy magnitude was also considered in determining where mitigation focus should be applied. When energy magnitude is considered, 93 percent of all building energy is concentrated in five of the eight building sectors. These sectors include Research-Owned Buildings, Campus Core (State Owned academic and research buildings), Residence Halls, Family Housing, and Other Auxiliary Buildings, as presented in Figure 3.3.

Campus Electrical Consumption (1988-2009)

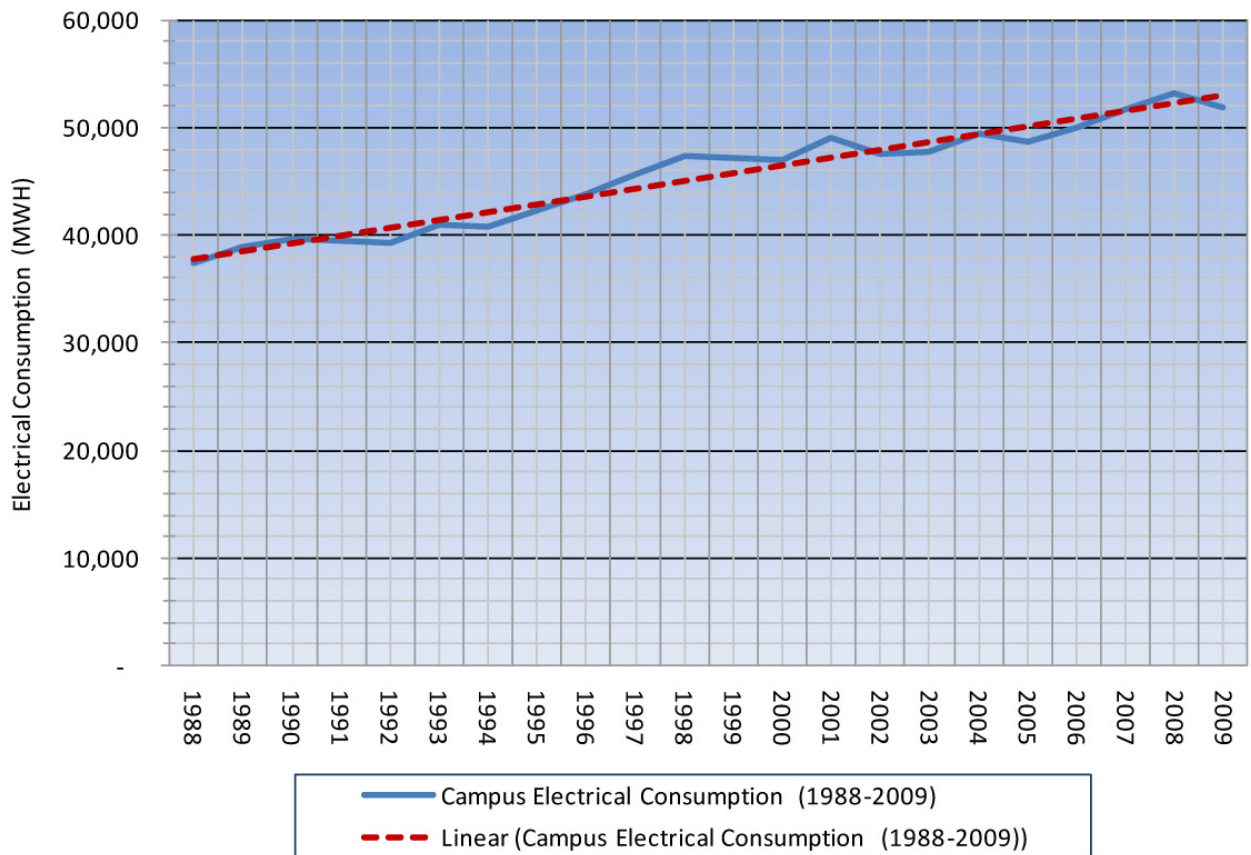


Figure 3.1 MSU-Bozeman Campus Electrical Consumption History

3. EMISSIONS REDUCTION SCHEDULE, MILESTONES, AND CARBON REDUCTION GOAL

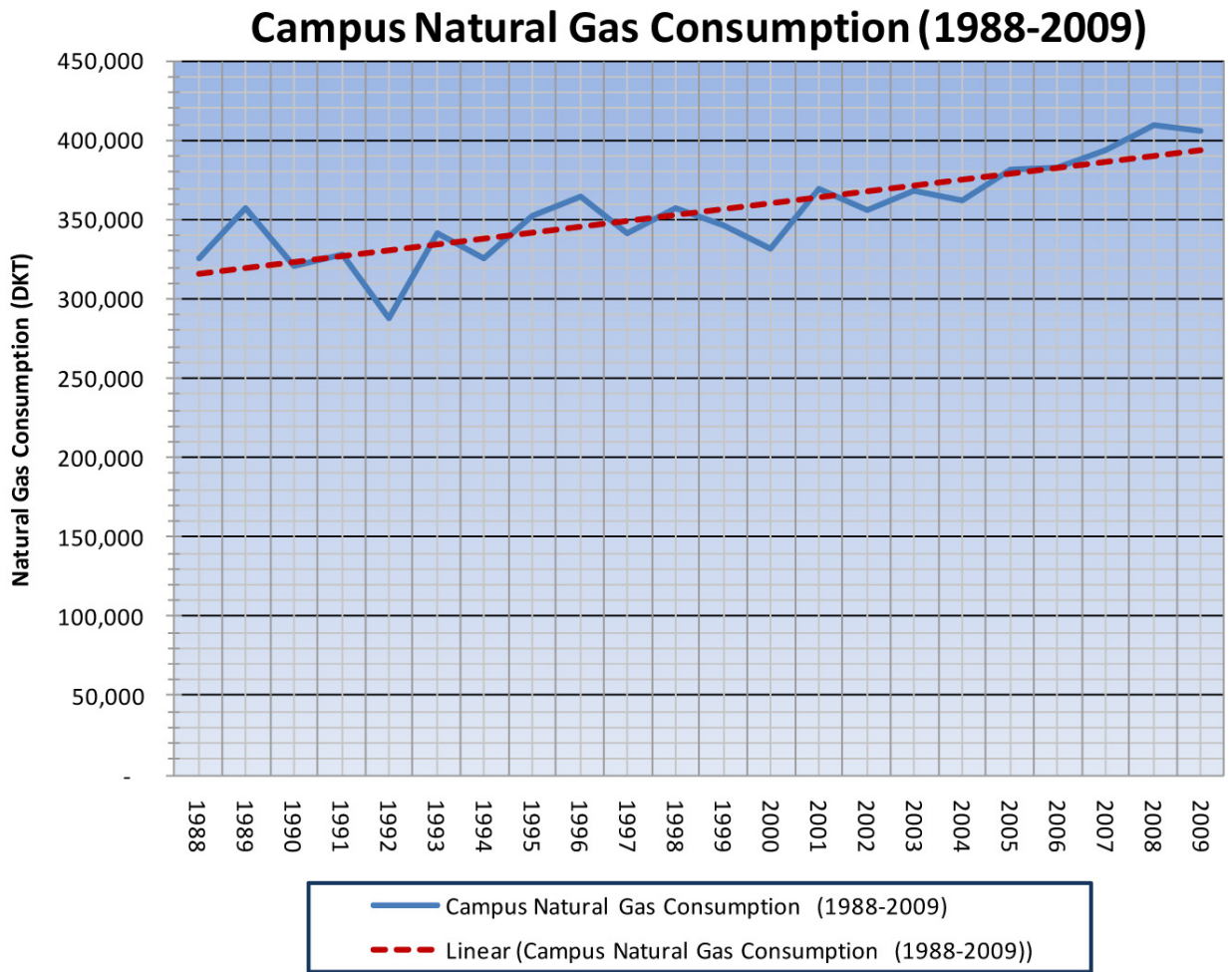


Figure 3.2 MSU-Bozeman Campus Natural Gas Consumption History

3. EMISSIONS REDUCTION SCHEDULE, MILESTONES, AND CARBON REDUCTION GOAL

Scope One and Two Energy per Facility Sector (Natural Gas and Electricity DKT)

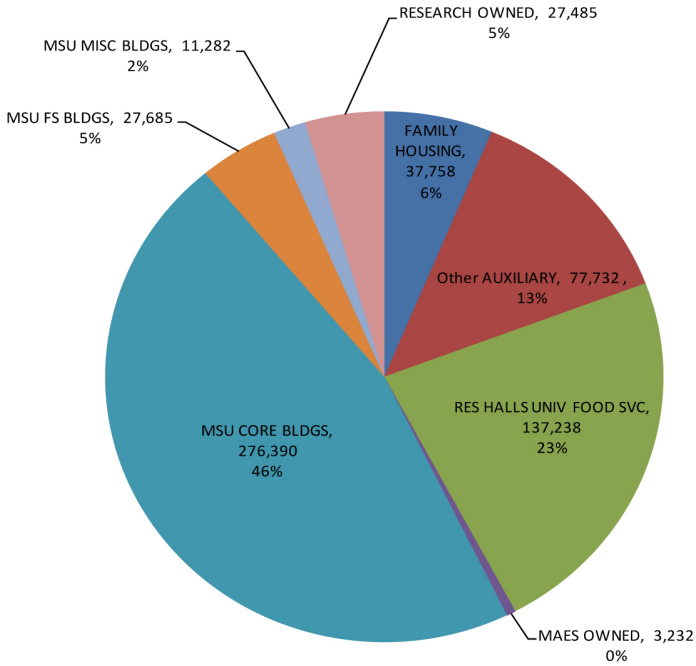


Figure 3.3 Energy Consumption / GHG Emissions Per Building Sectors

Climate Action Planning and Predictive Modeling

The baseline emission and mitigation strategy calculations were calculated using The Clean Air-Cool Planet Campus Carbon Calculator. This Excel workbook-based tool is designed to conduct greenhouse gas emissions inventories, project emissions into the future, and evaluate a portfolio of carbon reduction projects. The spreadsheets are based on workbooks provided by the Intergovernmental Panel on Climate Change (IPCC) for national-level inventories. The IPCC data has been adapted for institutional level assessment.

4. EMISSIONS REDUCTION STRATEGY

A strategy of phased projects and programs, focused on maximizing MSU's ability to reduce energy consumption and reclaim energy streams presently dissipated, is presented within this document. This strategy prepares systems for the eventual integration of renewable energy systems that compliment conservation and reclamation tactics. A multitude of Scope 3 reductions focused on reducing commuter travel emissions are discussed and an annual goal is projected.

Many of the mitigation tactics identified for Scopes 1 and 2 have been determined to interact and/or have mutual benefit. For this reason, both Scopes are considered for each of the following tactics. The preliminary assessment has been categorized in two phases based on implementation timeline, characteristics, and complexity. Phase One tactics are presently in design, construction, or implementation. The cost and economic performance of these projects are either known, or projected with a relatively high level of confidence. Phase Two tactics are identified as similar, conservation-based projects that can be implemented by applying readily available technology or that which is emerging, yet highly probable of cost effective success. Some of these tactics, such as the Leon Johnson Energy Retrofit, Northwest Campus Core District Energy Plant, and the Auxiliary Energy Performance project are presently being planned and developed. The costs, economic performance, and emissions reductions are more conceptual. The implementation of these tactics is further away and the accuracy of these key performance indicators is less than for Phase One. Continual reassessment of project scope and performance will promote the cost effectiveness of these efforts to meet the above guidelines. The Campus Lighting, Envelope, and HVAC Improvements are programmatic in nature. The indicated capital costs, economic performance, and emissions reductions are based strictly on benchmarks extrapolated from project historical performance, forecasted technology advances, and diminished "low hanging fruit" conventional conservation opportunities. These programs are intended to indicate mid-range planning goals, and do not indicate financial obligations to specific work.

Beyond these two phases are long range tactics that will require extensive study and development but levy significant impact on MSU-Bozeman's GHG emissions. These future phased tactics rely on advances in conservation based systems, substantial infrastructure innovation, and the

implementation of large-scale renewable energy strategies. Due to the extensive analysis required to assess the viability of these options, quantitative analysis has not been completed at this time.

Controlling Energy Usage Escalation

Development of a sustainability-oriented culture and strong stewardship are crucial to mitigating the historical energy escalation at MSU (1.3 percent natural gas and 1.6 percent electrical average annual growth for the last 20 years). In Phase One, an Energy Conservation Culture Program is proposed. Phase Two will focus on maintaining efficient operation of the physical plant through continuous commissioning and continuous improvement efforts. New facilities will be required to meet sustainability standards as determined by the State of Montana. By internalizing efforts to maintain or improve energy efficiency and implementing strict standards for the energy performance of MSU's building stock, the average escalation of campus energy usage is forecasted to be reduced by over 1 percent annually. This is reflected in this analysis by a reduction of the escalating business-as-usual energy trend to a 0.25 percent trend. MSU-Bozeman's efforts to control the energy usage escalation rate will be continuously adapted to achieve a maximum of 0.25 percent annual growth rate in total energy (including Scope 3) with an annual goal of holding a flat, or negative growth trend. Achieving this will let the technical and power procurement mitigation tactics achieve and retain maximum effectiveness.

4.1 Scope One and Two – Phase One Mitigation Tactics

In the course of energy planning, energy conservation through demand-side management is often considered the most cost effective means of managing energy costs. Energy conservation's potential is much higher. It also can be the lowest cost energy resource for the utility to acquire generation, transmission, and distribution capacity through load relief. In State governments, energy conservation savings can relieve utility budgets, allowing funds to be allocated to cash strapped programs. Many utilities, including Montana's Northwestern Energy realize this and are reinvesting in energy conservation through rebates, auditing services, and infusing capital to improve the energy strategies on projects.

Phase One tactics identified are focused on the implementation of energy conservation projects

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Phase One Mitigation Tactics (Completed Projects)						
Project/Program Identifier	Status	Capital Cost	Average Discounted Annual Cash Flow	Discounted Payback Time (years)	Annual Reductions (MTCO ₂ e)	
Resource Conservation Culture Program	Contracted program to be internalized 2011					
Student Union Building Lighting & HVAC Retrofit	Constructed	\$ (232,497)	\$ 23,795	9.8	(179)	
Engineering/Phys. Science Lighting & HVAC Retrofit	Constructed	\$ (260,000)	\$ 33,716	5.3	(306)	
Wilson HVAC Retrofit	Completion Spring 2011	\$ (1,161,347)	\$ 20,301	24.0	(287)	
Cobleigh HVAC Retrofit	Completion Spring 2011	\$ (1,591,250)	\$ 26,533	23.0	(433)	
Exterior Pole Mount Lighting Retrofit	First round of deployment Summer 2011	\$ (660,000)	\$ 25,836	15.0	(186)	
Exterior Building Lighting Retrofit	First round of deployment Summer 2011	\$ (150,000)	\$ 20,468	7.3	(141)	
Phase One Lighting Retrofits	Eight completed in 2010, seven to be completed in 2011	\$ (797,749)	\$ 53,301	13.5	(446)	

Figure 4.1 Phase One GHG Emission Mitigation Tactics

Phase Two Mitigation Tactics (Projects in Process)					
Project/Program Identifier	Status	Capital Cost	Average Discounted Annual Cash Flow	Discounted Payback Time (years)	Annual Reductions (MTCO ₂ e)
Leon Johnson Energy Retrofit	Completion scheduled for Fall 2012.	\$ (2,500,000)	\$ 40,000	13	-558
NW District Energy Plant	Pending Concept Assessment	\$ (2,200,000)	\$ 44,490	19	-1400
Auxiliary Services Energy Performance Contract (Phase One)	Investment Grade Audit	\$ (9,000,000)	\$ 561,000	15	-5150

Figure 4.2 Phase Two GHG Emission Mitigation Tactics

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on a variety of State owned facilities and limited work on Auxiliary facilities. The projects that are included in the Phase One implementation are listed in Figure 4.1. Many of these projects are presently being designed, constructed, or otherwise initiated.

This phase of work consists of lighting and HVAC improvement projects and the initiation of a Resource Conservation Culture Program. A Resource Conservation Specialist will be hired to further develop the interface with the campus community, establish benchmarks and measurement techniques, and act as liaison to the more technical energy conservation efforts.

These projects were initiated before the climate action planning process began, and in some cases, the primary project driver was not energy conservation, rather; deferred maintenance, safety, or system performance improvement. This group of projects is indicative of future phases of work that can be completed with conventional approaches and available technology.

While these projects are necessary and some perform well overall financially, they result in less than a 4 percent reduction of overall 2009 GHG emissions. At this stage of climate planning, it becomes apparent that we are not going to conserve our way out of a carbon intensive operation. Rather a dramatic evolution in the way that MSU's campus is heated, cooled, and powered is needed. It is imperative that a successful plan considers this from the inception of the effort to coordinate the phases and numerous tactics stretched out over several decades that will be required to achieve the set goals.

4.2 Scope One and Two – Phase Two Mitigation Tactics

The conventional technologies that enabled the conservation based projects of Phase One are coupled with near-term emerging technologies to define the scope of Phase Two. Several Phase Two efforts such as the Leon Johnson Energy Retrofit, Northwest Campus Core District Energy Plant, and Auxiliary Performance Contract, have significant momentum and definition. Other projected areas are defined programmatically only. These future programs include future lighting, envelope, and HVAC upgrades that have been conceptually defined with budget estimates and potential savings/reductions by applying forecasts for advanced conservation-based projects. Economic

and energy benchmarks were applied to arrive at planning goals. Figure 4.2 provides an estimate of Phase Two tactics.

The need to address deteriorating existing systems coupled with the advancement of energy technologies will continue to present opportunities for Phase Two project development. Systems such as lighting will continue to evolve with lower energy consumption and longer life. Control technology continues to present conservation opportunities while HVAC systems will continue to require extensive upgrade to address deferred maintenance and to improve energy. It will be crucial that all HVAC retrofits implemented in the near and mid-term be complementary to long term energy strategies described in Phase Three.

MSU is presently engaged in the early stages of an Energy Performance Contract with McKinstry focused on the Auxiliary Services portions of Campus. This unique project delivery method employs increasingly detailed audit analysis to identify and aggregate high performing energy savings measures. Presently, the energy performance contractor is in the process of developing an investment grade audit of between 300 and 400 Facility Improvement Measures. This analysis will identify those projects with the highest energy, operational, and economic effectiveness. Pending Board of Regents authority, this single effort may result in several million dollars of investment in energy savings, precipitating the single largest GHG reduction in the present CAP. Figure 4.3 presents GHG emissions projections at MSU-Bozeman with Phase One and Two mitigation tactics, focusing on the 20 percent reduction by 2025.

4.3 Scope One and Two – Phase Three Mitigation Tactics

While Phases One and Two combined are forecast to generate about a 20 percent reduction in MSU's 2009 baseline greenhouse gas emissions (Figure 4.3), cost and technical barriers will dramatically impede the ability to achieve significant additional savings with the same tactics.

Phase Three focuses on the strategic integration of renewable energy systems, and possibly carbon sequestration tactics, with the conservation driven work of Phases One and Two. The key to a successfully integrated approach to carbon management at MSU is continual systems thinking. The building level retrofits of the earlier

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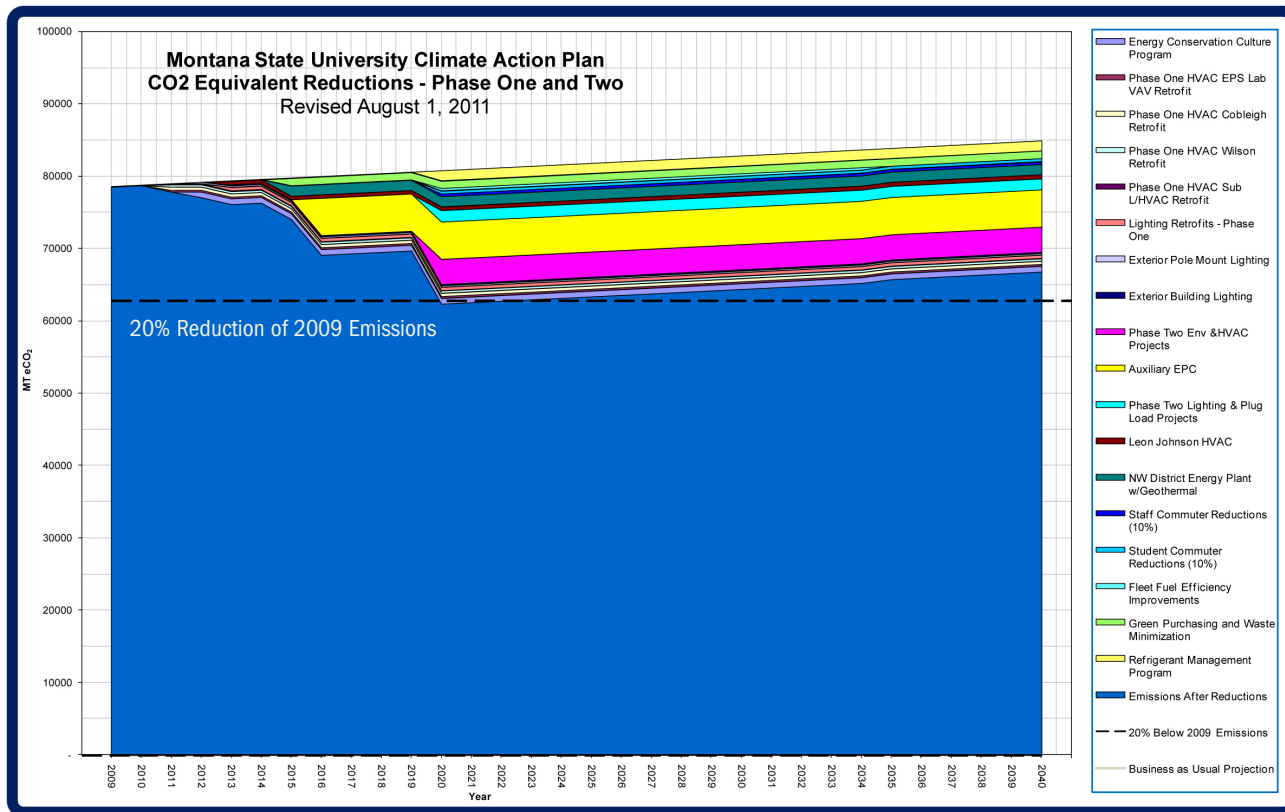


Figure 4.3

phases must be completed in a manner that allows a district approach to building power, heat, and cooling to be achieved. The district systems need to be arranged to facilitate the acquisition of low carbon power sources that may be provided at the utility level. Flexibility of the developed on sight resources is critical to allow the off-site electrical generation to be sources from a range of possibilities. Strategic alignment of the tactics described in Phase Three will minimize dependence upon carbon intensive sources of Scope One and Two energy streams.

The first two phases of this plan set the scene for implementation of on-site renewably based energy systems. HVAC retrofits will have been designed and constructed with distribution systems capable of accepting energy from low temperature heat sources such as heat recovery, geothermal, and solar thermal. The primary task of Phase Three is to re-power these HVAC systems with a portfolio of reclaimed and renewable energy sources. The system concept will be inherently flexible.

The future energy system at MSU will be a decentralized model developed around a core water loop designed to transport energy from building to building while having the capability

of accepting energy from, or depositing energy to, a variety of sources. Initially this core water loop would be established and likely provided heating energy via heat injection from the central heating system (existing). As buildings are retrofit, in a range of ways discuss below, they are then connected to this district system to allow energy to be exchanged with it only after the building's energy balance has been met. Additional core water systems may be established in outlying areas of campus, including Family Housing.

Building Retrofits

The recovery and transportation of otherwise waste heat must be intrinsic to systems selected for all building retrofits that will interface with the future core water system at MSU. Specific building types are discussed below. System types that may apply include, but are not limited to:

1. Unitary water source heat pump,
2. Central, or sector defined, heat pump energy plants simultaneously producing heating and cooling energy streams,
3. Variable refrigerant volume with water cooled condensers,
4. Direct use of core water in system condensers/coolers (refrigeration)

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Historical Classroom and Office Buildings

The diverse building set at MSU will require innovative approaches to retrofit depending on the particular buildings characteristics. Many of the older buildings are presently directly heated with steam and cooled only with natural ventilation with the exception of split systems or once-through water systems both of which are resource inefficient and provide no opportunity for heat reclamation. These buildings will require a great deal of creativity by the design team to maintain historical integrity while implementing system design that will properly condition the space at an optimal energy efficiency and enable heat removed from the building to be reclaimed into the core water system for use elsewhere in the system. This retrofit may occur through the integration of a unitary water source heat pump design, variable refrigerant volume with water cooled condenser, or possibly through central heat pump design for either the entire building or sectors.

Laboratories

The more complex buildings on campus, such as laboratory and research facilities, present the challenge of optimizing the heat recovery of laboratory exhaust volumes. Presently, run-around loop heat recovery systems are common at MSU, but the effectiveness of these systems on an annual basis is quite low as they are driven to work best under the highest temperature differences. Most of the year, the mild conditions in Bozeman do not allow these systems to operate efficiently so the heat goes unrecovered. Due to the inappropriate application of unitary (recirculation) equipment in some labs, the most likely retrofit for this building set may be centralized heat pumps that would simultaneously generate chilled water and heating water rather than treating the opposite energy stream as a waste byproduct, as is conventionally done. This system type would allow low temperature water, from the chilled water/heat recovery side of the process, to maximize the heat recovery from laboratory exhaust streams.

Residence Halls

The high domestic hot water loads, space heat requirements, and, in some cases, collocated kitchen/dining service loads make residence halls an intriguing opportunity for integration into the core water system. Substantial heat streams from

kitchens, such as refrigeration and space cooling complement the need for large quantities of domestic hot water. A unitary approach to a water source heat pump conversion would allow each zone to be conditioned with the resulting heat (cooling) being made available for other uses. A residence hall with an efficient HVAC/envelope design should be in a net cooling mode to low ambient temperatures (about 10-20° F). The excess heat can be injected into process and domestic loads.

Establishing the Core Water Loop

The true power of a district-wide heat recovery and transportation system is in the ability to maximize the reuse of all the energy entering all of the buildings interconnected. Not only the energy introduced by building mechanical systems, but also the heat that results from light, people, plug loads, and passive solar. The ability to collect this heat, move it into a transport medium (water), and share it with other buildings establishes a base load energy source for all buildings that can minimize the net energy input to that required by the entire system. Since this core water loop would operate at about room temperature, it can be established in a non-insulated piping system that would be installed in the existing tunnel system. The tunnel system, which was established in the 1990's, is an incredibly vital component of the system (Figure 4.4). Approximately 1.6 miles of underground tunnel, with room for piping expansion exist around the perimeter of the core campus. Without the visionary planning that resulted in this valuable infrastructure, the concept of central core water would be impractical.

Developing the initial resources required to provide energy to the core water loop would preferably occur concurrently with core water loop development.

While sporadic geothermal resources exist in close proximity to MSU, e.g., Bozeman Hot Springs and Fish Hatchery at Bridger Canyon, the conceptual implementation of geothermal on campus does not depend on developing active resources. Rather it is based on the more conservative approach of establishing extensive well fields on campus of closed loop wells, manifolded together. These "daisy chained" closed-loop wells would not draw water from the earth, rather the heat transfer fluid would circulate through the U-shaped heat exchanger and back to the core water

SECTION

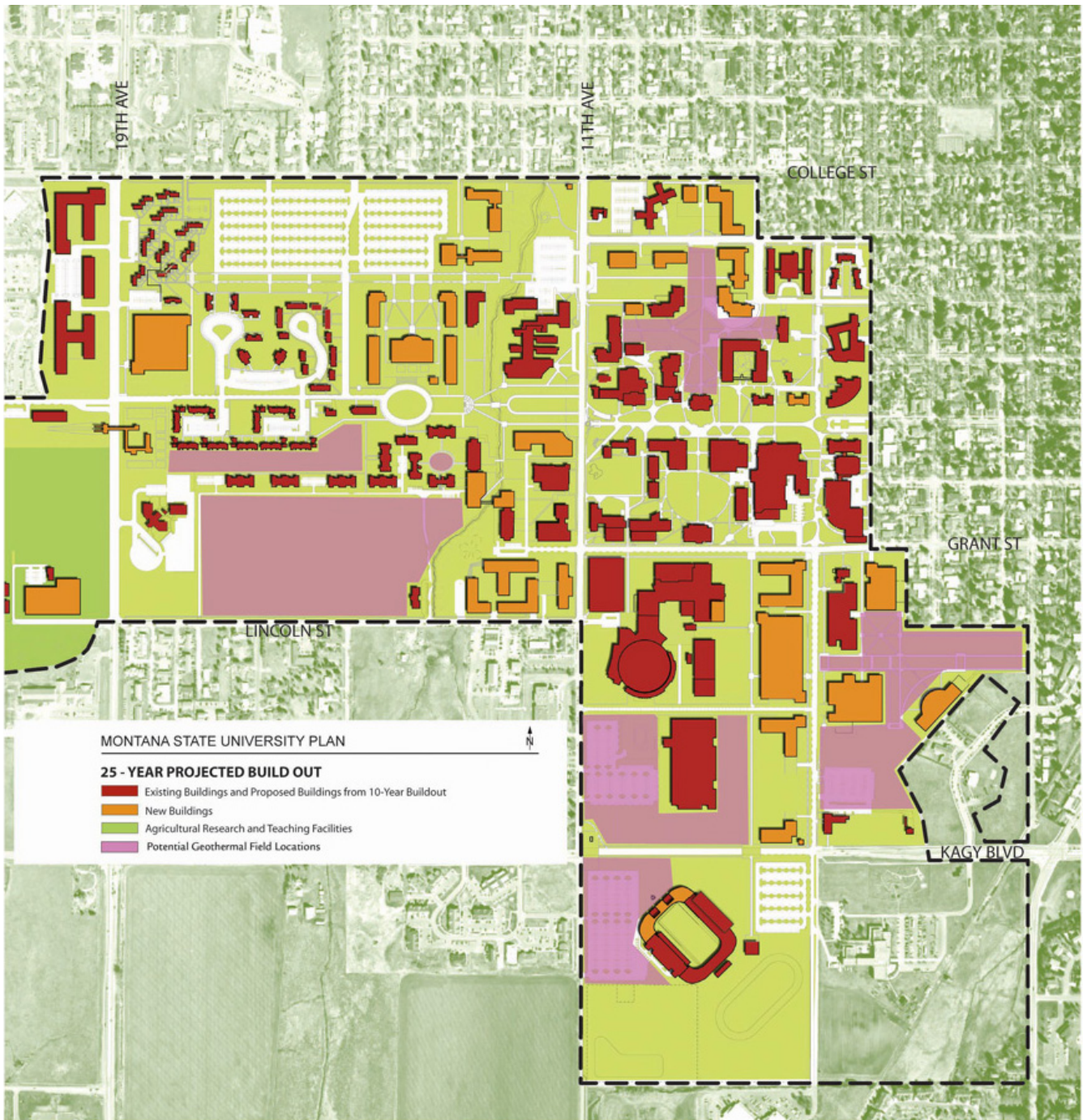


Figure 4.4 Implementing Renewable Heat Sources

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loop at ground temperature. Well field locations would need to be identified and coordinated with the long range master plan.

The analysis of this concept is at the very earliest stages and extensive study and testing needs to be completed to test technical, economic, and environmental feasibility. Early indications of the systems spatial requirements and technical feasibility are positive. The economics of this project are complex as the project, while quite capital-intensive, may be timed to address substantial deferred maintenance at the time of implementation.

Conceptual Results – All Scope All Phases

The following GHG projections, or ‘wedge’ diagram (Figure 4.5) provides a conceptual view of the results of implementing the Phases Discussed above, as well as Scope 3 mitigation tactics discussed in that section. The long range tactics of Phase Three are conceptual and no commitment will be made to continue their development until extensive analysis is completed and funding is secured. With inclusion of these concepts, it is possible that MSU may be able to approach, and possibly surpass 50 percent reduction of 2009

GHG emissions. Rather than assigning this milestone to a date, it may be more appropriate to focus on technical and economic feasibility triggers. Later versions of this process will begin to solidify an approach and timelines can be more accurately considered then.

4.4 Scope Three Mitigation Tactics

Strategies to implement GHG reductions for transportation are more difficult than modifying a building (i.e., installing energy efficient windows, new heating/cooling systems, etc.), as transportation choices are based on individual choices/behaviors. Several strategies for reducing commuter emissions, including increasing online course offerings, incentivizing the use of low emission transportation choices, promoting on-, or near-campus living, and increased education and outreach. The transportation section of the Climate Action Plan looks at possible actions, including these, to reduce transportation impacts of MSU while integrating MSU transportation strategies into the broader community. With 69 percent of MSU’s students, faculty and staff

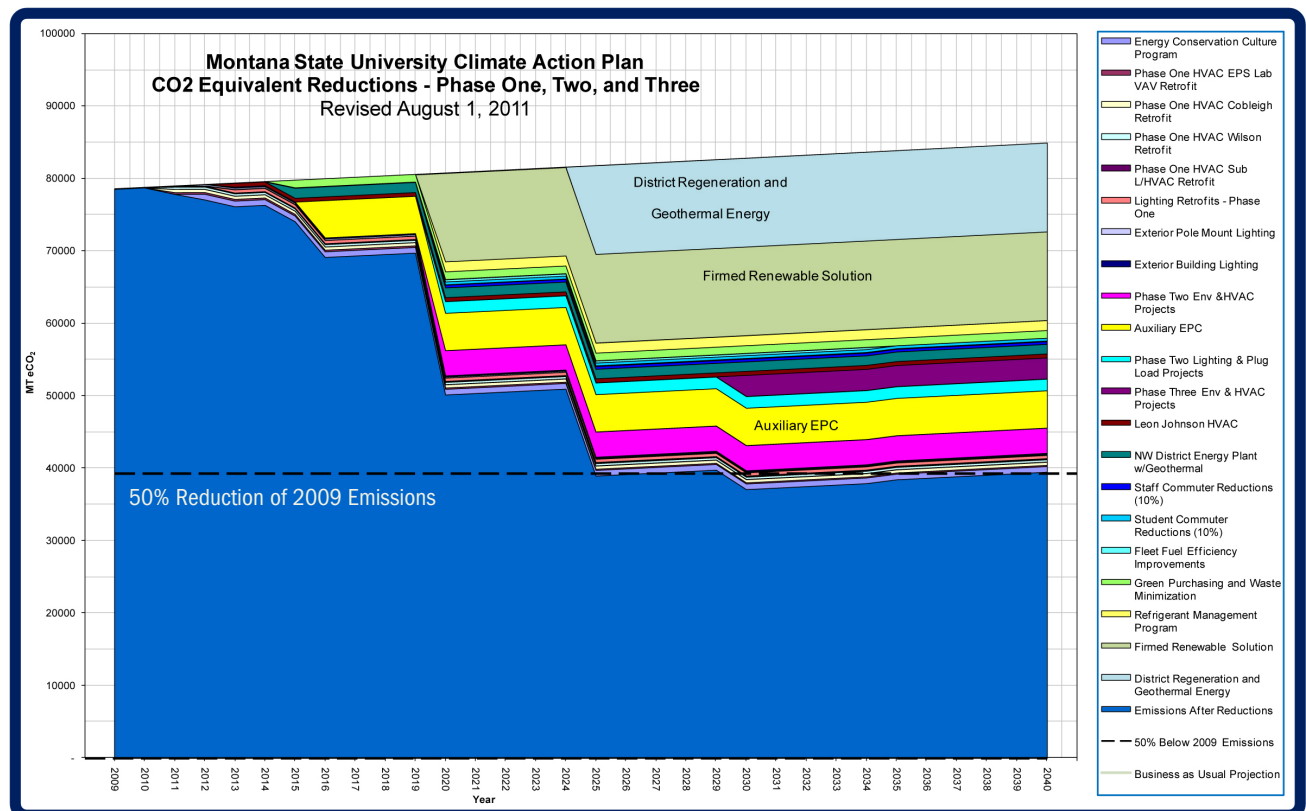


Figure 4.5

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living within five miles of campus, it is important that MSU work with the City of Bozeman to implement transportation options. Further, 31 percent of students, faculty and staff live more than five miles from campus, therefore, the University must work with other partners, including Gallatin County, as well.

4.4.1 Transportation

Introduction

Transportation, in the form of the campus vehicle fleets, commuting and air travel, are relevant to the climate action plan because these activities produce a significant amount (38 percent) of MSU's net emissions. These Green House Gas (GHG) emissions are based on travel to and from, or on behalf of the University. However, it should be noted that the inventory used as a foundation for this Climate Action Plan does not include student travel beyond their daily commute to MSU. Therefore, student trips for employment, shopping purposes, or activities are not captured. These trips by students may create as much, or more, GHG emissions than their commutes to MSU, and should be calculated in the future.

Strategies to implement GHG reductions for transportation are more difficult than modifying a building, as transportation choices are based on individual choices/behaviors. Montana State University, the City of Bozeman, and surrounding area have made progress on alternative transportation modes that give individuals options other than driving their own vehicle (single-occupancy vehicle or SOV).

In its Greenhouse Gas Inventory Report (04-21-10) on Montana State University, McKinstry noted several strategies for reducing commuter emissions, including:

- Offer more online courses
- Increase parking fees
- Subsidize public transportation passes
- Carpool parking priority
- Restrict student cars and/or parking to upper classmen
- Installation of more bike racks and bike paths
- Subsidize on-campus housing to minimize off-campus living
- Education to campus about carbon footprint goals and the impact of individual commuter choices
- Convert parking lots to green spaces

The following sections discuss possibilities,

including these, to reduce transportation impacts of MSU while integrating MSU transportation strategies into the broader community. It is important in discussing transportation plans that MSU not be viewed as an "island." Unless someone is living on campus, a person is traveling in and through Bozeman, and perhaps even one or two counties, to get to class or employment at MSU. Therefore, it is important that the transportation component of MSU's Climate Action Plan integrate with the City's and other transportation plans/climate action plans.

As of the adoption of this Climate Action Plan, the City of Bozeman was finalizing its Climate Action Plan. The following seven transportation recommendations were included in the City's plan:

1. Support policies for long-term integrated transportation and land use planning for a 20–30 year horizon
2. Promote a bike friendly community
3. Promote an electric car friendly community
4. Promote and provide incentives for clean fuels
5. Develop educational resources for the community on transportation options
6. Reduce vehicle miles traveled and fuel emissions
7. Air travel (examine emissions from Gallatin Field and its effects)

As noted in the following sections, MSU's Climate Action Plan includes similar transportation recommendations. As MSU and the City of Bozeman adopt and implement their Climate Action Plans, the two entities should work together as closely as possible to take advantage of funding opportunities and other synergies that may exist. A full analysis of transportation emissions, with comprehensive recommendations is supplied in Appendix 3 of this CAP. A shortened summary of findings and recommendations is supplied below.

While the majority of transportation cost and savings is based on the individual, not the University, if enough individuals stop driving to campus, there would be potential to reduce the number of parking spaces/lots that the University maintains. Financial savings to the University by reducing parking lot and University street maintenance would be somewhat offset by a reduction in the number of parking permits sold. However, there would be a reduction in green house gas emissions. Trees could be planted in parking lots that are no longer needed, which would also help to obtain a credit for Green House Gas emissions.

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Campus Fleet (MSU Vehicles)

Montana State University owns 372 motor vehicles that are used by various departments for various purposes. There are three basic strategies to reduce GHG emissions from these vehicles. These strategies are modernizing the fleet, using electric vehicles, and using human powered vehicles.

As the fleet ages, MSU must update vehicles with more modern, fuel efficient and cleaner vehicles. In addition to purchasing more efficient vehicles, MSU must analyze the purpose for each vehicle, so that the proper size vehicle can be purchased. For example, heavy or light gasoline or diesel powered trucks may not be necessary if an electric or human-powered vehicle can accomplish the same task. For the short distances within the campus, electric vehicles could be used for many of the tasks that require some sort of vehicle, and should be strongly considered. However, to reduce the campus carbon footprint, the source of the electricity to power the vehicles needs to be considered as well. MSU already supplies bicycles for campus employees traveling short distances in and around campus. Utilitarian tricycles with trailers to haul tools and other equipment are used for campus landscaping. MSU should continue to maximize the use of these human powered vehicles in the future.

Campus Commuting

Objectives to reduce the Green House Gas emissions related to faculty, staff and students commuting to campus include eliminating or shortening the commute, or allowing a more efficient (less GHG emissions) commute. Policies should provide incentives or alternatives to SOVs, and disincentives to SOV enablers (like convenient and inexpensive parking). Strategies to achieve these objectives are discussed below, and in greater detail in Appendix 3.

Eliminating the Commute

More housing near campus

Similar to the City of Bozeman's recommendation for integrated transportation and land use planning, this strategy would provide more housing opportunities near campus, to reduce the need to drive to campus. Housing within close proximity to campus would allow the vast majority of people to be able to walk or bike to campus.

Online classes, meetings and training

With options for students to take classes online, the need to commute to campus may be greatly reduced. This would take an investment by MSU to have the technologies in place so that as many classes as possible are delivered via the Internet, or other electronic means. While it is recognized that numerous classes require hands-on (on campus) learning, commuting GHG emissions could be reduced by maximizing the number of online classes. Faculty, staff and students also commute to campus for meetings and/or trainings. If these meetings and trainings could be supported online, these commutes could also be eliminated.

Walking

The City of Bozeman, the Montana Department of Transportation and others have been working to provide pedestrian connections to MSU. The Greater Bozeman Area Transportation Plan (2007 update) places a strong emphasis on integrating pedestrian facilities into the transportation network. It identifies gaps in the pedestrian networks and recommends improvements.

The existing number of MSU students and employees who walk to campus is not well documented, though two recent studies provide insight. A 2007 study evaluation used employee and student addresses from the 2005 fall semester, showing approximately 3,900 individuals lived within one mile of campus and about 7,400 lived within three miles (MSU, 2007). Assuming MSU has 12,500 students and 3,500 employees, approximately 46 percent of MSU employees and students live within three miles of campus. While the geographic distribution of students and employees will vary from year to year, the geographic concentration should not change considerably without significant housing additions in close proximity to MSU.

An online transportation survey of MSU students and employees conducted in 2010 identified a random sample of 1500 MSU employees and students and had approximately 500 respondents. Approximately 53 percent of respondents reported living within three miles of campus, which is similar to the 46 percent estimated from the 2007 evaluation. The 2010 transportation survey indicated:

- 22.9 percent (112 people) reported walking as their primary travel mode to campus in the spring and fall (September, October, March, April and May).

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- 27.6 percent (135 people) reported walking as their primary mode from November through February.
- Approximately 27 percent of respondents reported living within one mile of campus.

Specific strategies and recommendations for increasing walking are supplied in Appendix 3. Proposed solutions include raising awareness of walking access, and the financial and health benefits, with widely disseminated maps and targeted advertising. MSU's wellness program already gives points for employees who walk or bike to campus.

Bicycling

Bicycle facilities vary significantly and may include items such as wayfinding signs, separated paved pathways, covered bike parking, or end-of-trip facilities such as showers. Consistent with pedestrian facilities, the City of Bozeman and others have been working to provide bicycling connections to MSU. The City rebuilt West Babcock Street in 2005, adding bicycle lanes and sidewalks, which resulted in an increase of 256 percent in bicycle and pedestrian users (City of Bozeman, 2007). The Greater Bozeman Area Transportation Plan (2007 update) places a strong emphasis on integrating bicycle facilities into the transportation network. It recommends specific locations for bike lanes, bike routes, expanded shoulders and shared-use paths. Further bicycle-friendly infrastructure improvements are recommended.

There is significant interest at MSU in increasing bicycle commuting. MSU recently removed its ban on bikes on campus and installed a significant number of new bike racks in convenient locations around campus. The ASMSU sustainability center is researching options for a commuter/cruiser bike share/rental program in partnership with ASMSU Outdoor Recreation Center. Some campus buildings have end of trip facilities for bicycle commuters such as showers, lockers and changing rooms. The transportation survey of MSU students and employees conducted in 2010 indicates:

- 18.2 percent (89 people) reported bicycling as their primary travel mode to campus in the spring and fall (September, October, March, April and May).
- 3.5 percent (17 people) reported bicycling as their primary mode from November through February.
- Approximately 53 percent of respondents reported living within three miles of campus.

Specific strategies and recommendations related to increasing bicycle commuting are supplied in Appendix 3.

Transit (commuter and fixed route)

Transit refers to public transportation options within the community and college campus. A year-round transit system, Streamline, was introduced to the greater Bozeman area in August 2006. One added benefit of transit is that it can extend the trip length of other modes such as walking and biking. All Streamline buses are fitted with racks to accommodate up to 3 bicycles to facilitate this.

Funding for this service comes from a number of sources, including ASMSU and MSU. The service operates year-round, Monday-Friday, with limited service on Saturdays. The current Streamline service, and the paratransit service, GALAVAN, cost approximately \$1.3 million to operate. Ridership on the Streamline system has continued to grow, with daily ridership averaging 750-800 rides per day, with over 1,000 rides per day in the winter months. This ridership is significantly higher than the initial estimates of 286 rides per day.

Given that transit fares are typically less than the cost of operating a car, and that Streamline is currently fare-free, individuals who use Streamline can save a significant amount of money. While MSU would receive little, if any, financial savings, MSU does accrue the reduction in GHG emissions by promoting its students, faculty and staff to utilize public transportation to commute to campus.

Adding additional routes and/or greater route frequency may be a way to increase ridership and reduce MSU's Scope 3 emissions. Beginning in August 2011, Streamline will provide half-hour frequency on its main Bozeman routes during peak morning and afternoon commute periods (7-9 am and 4-6 pm). Funds from the Federal Transit Administration, which are administered by the Montana Department of Transportation, help support Streamline, and reduce the amount of local funding necessary to operate the system. Typically, local funds pay for approximately half of the cost of adding another route, or to add more frequency to existing routes.

Car pooling

Montana State University made the ability to car pool easier when it switched its parking permits from a "sticker" to a "hang tag." Multiple vehicles can be registered to a single hang tag/parking

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permit. This allows multiple individuals to act as the “driver” of a car pool, using a single hang tag/parking permit. The University does not actively promote car pooling, however. There is no formal process (software, etc.) for individuals who are interested in car pooling to find a “match” for a ride. Any car pools that exist are based on personal relationships, and people knowing other faculty/staff who live near them. As with transit, the cost savings accrued through car pooling are primarily to the individuals involved.

There are several programs to increase the use of car pooling. Most of them focus on using software to allow for students, faculty and staff to find other people interested in car pooling.

- www.memphis.edu/greencampus/carpooling.php
- www.campuslifetimeservices.ucsf.edu/transportation/rideshare/carpool
- www.zimride.com
- www.greenride.com/Solutions/Connect/Description

If Montana State University were to actively promote car pooling, marketing could be accomplished through the MSU News email, campus newspaper, and providing links from various MSU websites to a car pool software. Also, priority parking close to campus for car pool vehicles would be an incentive.

Implementing and promoting car pooling is estimated to cost between \$10,000 and \$20,000 per year. MSU may be able to work with the City of Bozeman and/or other large employers in the area to help pay for the car pooling software and incentives, and to increase the number of people participating in car pools. Based on a partnership between the Western Transportation Institute and the Human Resource Development Council District IX, Inc., with support from the Montana Department of Transportation and Montana Department of Public Health and Human Services, a statewide ridesharing software program should be implemented by October 2011.

Van pooling

There are no existing van pools (or van pool programs) in the Bozeman area. Van pools are similar to car pools, but are more formalized arrangements, typically with the vehicle (van) supplied by an employer or other entity, and a set cost for those who participate in the van pool. Monthly prices for participants can range from \$80-\$150/month depending upon several factors, including the distance traveled and how many

people are participating in the van pool. Like a car pool, participants utilize a van pool to reduce the cost of commuting (alone).

Supporting/other strategies

In order to transition students, faculty and staff from a single occupancy vehicle (SOV) to another mode, supporting strategies are needed, which can be thought of as incentives and disincentives.

Incentives

A Guaranteed Ride Home (GRH) provides commuters who regularly vanpool, carpool, bike, walk, or take transit with a reliable ride home when unexpected emergencies arise. Many large employers with transportation programs offer commuters a GRH for personal emergencies and unscheduled overtime. In Bozeman, the GRH would take the form of a voucher that a commuter could use at a local taxi service to get home if something unexpected occurred (say a child getting sick at school). The employee could use a GRH voucher to pay for the trip, and the University would only have to pay for the GRH vouchers that get used. Employers using GRH typically provide two to four vouchers per year. GRH is designed for commuters who worry about how they'll get home when an emergency arises. Knowing there's a guaranteed ride home allows one to use commute with peace of mind and confidence.

Raise awareness of the financial and health benefits of commuting rather than SOV driving. Some promotion and encouragement activities could include:

- Incentives/giveaways in exchange for choosing a transportation alternative (e.g. discounts at local businesses)
- Discounts at local businesses to people who don't drive to campus
- Discounts at the MSU Bookstore or MSU Food Services to people who don't drive to campus
- A “pay not to park” incentive

Disincentives

Disincentives (or policies) can be put in place to make it less desirable to drive an SOV, and can lead people to look for alternative modes of transportation. Disincentives should be used in conjunction with incentives to make driving an SOV more expensive, or take more time than an alternative mode. Given the fact that the

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University primarily controls parking on campus, disincentives could include:

- Increased parking costs (for all parking spaces/permits)
- Distance based parking fees (so those who live closer to campus have to pay more for a parking permit, since they have more alternatives available)
- Parking meters on campus so people have to pay each time they park.

Parking meter disincentive is based on the concept that the first time a person purchases a semester or year-long parking permit, a cost is incurred, but after that, parking is “free.” Placing parking meters at all spots on campus changes the paradigm, so that it costs money every time one parks on campus.

Air Travel

Directly financed air travel, study abroad air travel, and other directly financed travel accounted for 16, 9, and 3 percent of MSU’s net emissions, respectively. Note that faculty, staff and student commuting only accounted for 10 percent of MSU’s net emissions. While the alternatives for the student travel abroad are to not travel, or purchase offsets, there is another alternative related to other directly financed air travel.

As a major research university, many faculty, staff and students are traveling to be part of conferences to learn of research, or to present research findings. Until many of these conferences embrace video-conferencing, or holding virtual conferences, there will still be a tremendous need to travel by air to these meetings/conferences. In that situation, MSU will be able to purchase offsets to compensate for this travel.

In instances where air travel is taking place for meetings, project updates, or other instances when a conference call, webinar, or video conference is adequate, MSU should have policies and procedures in place so that faculty, staff and students can determine when air travel is justified, and when an alternative should be selected.

Emission Reductions

The shorter the distance someone commutes to campus, the more alternatives are available. For example, if someone lives within one mile of the MSU campus, alternatives such as walking and biking are viable options. However, if someone lives ten miles from campus, it is unreasonable to expect that they would walk or bike. The survey

that was used to develop the baseline inventory indicated that the majority of faculty, staff and students live within a relatively close proximity to campus (Table 1).

Distance from Campus	Percentage of Respondents	Cumulative Percentage
Less than 1 mile	27.4%	27.4%
1.1-3 miles	25.4%	52.8%
3.1-5 miles	16.2%	69.0%
5.1 to 10 miles	14.7%	83.7%
10.1-15 miles	8.5%	92.2%
15.1-20 miles	3.3%	95.5%
20.1-30 miles	3.3%	98.8%
30.1-40 miles	0.5%	99.3%
40.1-50 miles	0.5%	99.8%
50.1 miles or more	0.3%	100.1%

Figure 4.6: Faculty, staff and student commute distances

The data indicates that roughly half of the campus population lives within a distance (three miles or less) where non-motorized options could be utilized. Further, only 4.5 percent of faculty, staff and students live more than 20 miles from campus, a distance which tends to add to the cost of options such as van pools and transit.

Figure 4 shows that a majority of housing in Bozeman is within three miles (the blue line) of campus. Driving from Belgrade to campus is approximately twelve miles.

The GHG inventory based its calculations on 9,124,603 automobile miles and 189,376 bus miles of commuting by faculty and staff, and 9,826,713 automobile miles and 411,168 bus miles of commuting by students. The GHG inventory did not capture student travel for other purposes (working, shopping, etc.).

While an analysis has not been completed to the level of detail that would allow for a decision that implementing van pooling, for instance, would reduce commuter traffic by 10 percent, Figure 4.7 provided data on the GHG emission savings based on the reduction of commuter mileage.

It should be noted that if MSU faculty, staff and students ride the bus (Streamline) it does not increase GHG emissions, as the buses are operating anyhow. However, to get a reduction of commuter mileage beyond 10 percent, an additional bus route, or more frequent bus service, may be required. The reduction table above does

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	Car miles	Bus miles	Energy Use MMBtu	CO2 kg	CH4 kg	N2O kg	eCO2 Metric Tonnes
2009 Baseline							
faculty/staff	9,124,603	189,376	51,924.5	3,642,451.6	721.8	248.7	3,732.7
students	9,826,713	411,168	56,640.7	3,974,894.2	780.3	269.2	4,072.5
5% reduction							
faculty/staff	8,668,373	189,376	49,381.1	3,464,032.0	686.4	236.5	3,549.9
students	9,335,377	411,168	53,922.4	3,784,131.4	742.9	256.3	3,877.1
10% reduction							
faculty/staff	8,212,143	189,376	46,837.6	3,285,612.4	651.1	224.3	3,367.0
students	8,844,042	411,168	51,204.1	3,593,368.5	705.4	243.4	3,681.6
15% reduction							
faculty/staff	7,755,913	246,189	44,610.9	3,129,410.8	620.1	213.7	3,206.9
students	8,352,706	534,518	49,168.2	3,450,496.9	677.4	233.7	3,535.2
20% reduction							
faculty/staff	7,299,682	246,189	42,067.5	2,950,991.3	584.8	201.5	3,024.1
students	7,861,370	534,518	46,449.9	3,259,734.1	639.9	220.8	3,339.8

Figure 4.7: Potential GHG savings for commuter reductions

reflect an increase in bus miles, but that may not necessarily reflect the true picture.

It is recommended that Montana State University work with the City of Bozeman to promote currently available alternative modes to reduce commuting miles. These existing alternatives include walking, biking, car pooling and utilizing public transportation. Alternatives such as car pooling could be enhanced through the use of software for ride matching, and by MSU implementing incentives, such as preferential parking for car pool vehicles. In addition, incentives, such as giveaways or other promotions, could increase the use of transit. MSU could use additional surveys to gauge the interest in new options such as van pools, to see if those options are worthy of future investment.

4.4.2 Waste Minimization

Greenhouse gas emissions are associated with the production and disposal of each product used at MSU. Emissions associated with landfilled solid waste accounted for 2,132 MT CO₂e in MSU's inaugural GHG inventory. Emissions from production (mining, manufacture, shipping, etc.) were not included in inventory. Nevertheless, it should be acknowledged that the university holds some responsibility in this area because university purchasing decisions impact upstream production. As such, landfill diversion, source reduction, and purchasing practices must all be considered

as part of a holistic strategy of sustainability and resource conservation at MSU.

Furthermore, the Montana Integrated Waste Management Act of 1991 stipulates that all State agencies and the university system shall prepare, implement, and maintain a source reduction and recycling plan that includes at minimum, "provisions for composting yard wastes and recycling office paper, cardboard, used motor oil and other materials for which recycling markets exist or may be developed."

4.4.2.1 Landfill Diversion

As their contents decompose under anaerobic conditions, landfills emit CO₂ as well as methane, an even more potent greenhouse gas. According to the EPA, municipal solid waste landfills were the second largest source of human-related methane emissions in the US in 2006.

In FY10 MSU disposed of 1,866 tons of material at the Logan Landfill. A waste stream analysis performed by Facilities Services in 1990 indicated that recyclable materials made up at least 45 percent of the waste stream from MSU's academic buildings and between 15-25 percent of waste from auxiliaries sources. Organic (compostable) materials made up 20 percent of waste from residential and food service areas. While these figures are 20 years old, they suggest a baseline of what can be done to reduce MSU's waste and divert reclaimable material.

An effective program to divert all reclaimable materials from landfill-bound trash will reduce

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MSU's GHG emissions as well as demonstrate the University's commitment as a steward of Montana's environment and public resources.

Current Diversion Activities:

- Recycling - Operated by ASMSU and funded by student fees, recycling activities in FY10 diverted 118 tons of aluminum, steel, plastics, paper and cardboard, or about 6 percent of MSU's waste that year. Utilizing the EPA's WARM calculator the diversion of this material from landfill accounted for a net prevention of 424 MT CO₂e in combined downstream and upstream emissions. With adequate funding and resources the proportion of recyclables diverted from MSU's trash could be increased dramatically.
- E-scrap - Safety & Risk Management operates an E-scrap program (implemented Jan 2009) that is funded by a fee charged on all university computer purchases (2.5 percent of the purchase price). For this reason the program currently accepts only MSU-owned property, however electronics left behind at year end from dorms and family housing is also taken care of through the E-scrap program. Reusable equipment is either redistributed within the university or another educational facility, or donated to non-profit organizations. Over 500 units have been redistributed. Data is destroyed from Unusable computers then shipped to E.C.S. recycling facility. E.C.S. Headquarters is located in Santa Clara. This company also has 3 refineries located in the U.S. To date the E-Scrap program has shipped 32 tons of electronic material to recycling.
- Composting - University Food Services is in the process of researching the feasibility of composting food residuals in the dining halls. In Fall 2010 a one-semester pilot project was conducted, which separated compostable waste at one UFS kitchen and took it to a commercial composter in Amsterdam, Mont. Data from this pilot will be used to inform plans to expand the program. A Bokashi-based cold composting pilot project for both the salad bar and for Harrison dining hall is presently being set up to start beginning the Fall semester of 2011. Diversion of up to 26,000 lbs/yr with the closed loop system is anticipated.
- Property Surplus - University Business Services' Surplus Property program collects unwanted

furnishings and equipment from campus departments and offices and makes those items available to other university entities.

- Various - Facilities Services has historically recycled/reused: crankcase oil, batteries, anti-freeze, parts cleaners, used tires, scrap metals, light tubes, refrigerants, concrete, asphalt, road sand, and yard waste. Further research needs to be done to quantify these activities and their GHG and waste diversion benefits.

Strategies to Increase Landfill Diversion:

- Conduct an updated waste stream analysis to determine goals and benchmarks for increasing MSU's recycling and material diversion rates.
 - Expand and promote recycling campus-wide. Increase access to and convenience of recycling in all buildings and at all university events. Make recycling as easy — or easier — than throwing something away.
 - Establish an on-campus recycling facility to allow more efficient material handling and operations. A facility with a baler for cardboard and office paper might increase cost efficiency of the program and the volume it could handle.
 - Explore ways for the various campus waste management programs/services to coordinate, collaborate, and share resources (i.e. trash, recycling, composting, and e-waste programs, which are currently operated separately).
 - Reconsider how costs for trash services are budgeted and assessed campus wide and evaluate whether mechanisms can be developed to incentivize recycling/waste reduction. (For example, some campuses have increased fees for trash removal while providing recycling services free of charge, thus encouraging occupants to maximize recycling efforts.)
 - Fund the E-scrap program so that it may accept e-waste from students and on-campus residences as well as MSU departments. Consider opportunities to partner with the City/County to collect e-scrap from the community at large as well.
 - Expand the composting pilot program to all University eating establishments. Explore possibilities for partnering with off campus entities (City of Bozeman, County, or local businesses) to achieve economies of scale.
- The holistic goal is 80 percent diversion from the landfill by 2050. This will be accomplished

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by achieving a series of lesser but sequential goals – 25 percent reduction by 2020, 50 percent reduction by 2030, 65 percent reduction by 2040. The tools and strategies of waste minimization, diversion, source reduction and responsible purchasing can be used to attain these interim and long-term goals, and will require further research and stakeholder input as they evolve.

4.4.2.2 Source Reduction and Responsible Purchasing:

Source reduction is generally accomplished by focusing on systems and behaviors, identifying where waste-intensive practices can be changed. Reducing unnecessary waste at the source will allow MSU to mitigate the inefficient use of resources and decrease disposal costs (both trash and recycling). By reducing total trash generated, source reduction will also reduce some of the GHG emissions associated with solid waste.

Responsible purchasing is an approach to procurement of goods and services that prioritizes choices which minimize negative social and environmental impacts throughout the product lifecycle, including production, distribution, use, and disposal. Responsible purchasing can be a tool for source reduction, for example selecting products or services that generate less waste (i.e. packaging). It is also a means by which the university can utilize its purchasing power to support production practices that have a lower environmental impact. For example when MSU buys goods made with recycled content this not only reduces waste, but also helps to ensure a continued market for the recyclable materials we sell through our recycling program.

The bulk of GHG emissions benefits associated with source reduction and responsible purchasing will be “upstream,” corresponding to reduced demand on traditional manufacturing, mining, etc. Upstream emissions are not included in MSU’s GHG Inventory, however this does not diminish the value of these actions as part of an overall sustainability strategy. In promoting and implementing source reduction and responsible purchasing practices, MSU will demonstrate its leadership in resource conservation and the creation of an environmentally sound production system.

Current Source Reduction and Responsible Purchasing Activities:

- University Food Service offers 20 percent discount on certain beverages when a reusable cup is used.

- University Food Service eliminated trays from all dining halls, reducing consumption, food waste, and resources used to wash trays.
- All ITC Global Student Computer Labs are automatically set to print double sided (duplex) to conserve paper.
- ITC offers refilled/remanufactured toner cartridges and collects spent cartridges for reuse.
- The Montana Department of Environmental Quality currently requires all State departments to purchase recycled content paper. It is a goal of the Montana Integrated Waste Management Act that 95 percent of all state paper purchases will be recycled content. Data for paper purchasing was not available at the time of MSU’s inaugural GHG Inventory, and it is recommended that this be monitored in the future.
- Corporate Express, an online interface for ordering office supplies per State contract prices, automatically suggests “green” product alternatives to buyers. Efficacy and participation will need to be evaluated to optimize future participation.
- Some large contracts between MSU and outside vendors contain sustainability clauses or related requirements. MSU will continue to encourage such negotiations with large purchasing contracts.
- The Montana Made program spends 12 percent of University Food Service’s budget on food products that are grown/processed in Montana. This supports the vitality of the local food economy and provides meals with a lower carbon footprint.

Strategies to Increase Source Reduction and Responsible Purchasing:

The following suggestions have been successfully implemented at other campuses in America, and it is recommended MSU integrate as many of them as is feasible, based upon further research and stakeholder input.

- Extend the reusable mug discount to all beverages. Provide refillable beverage containers to all employees/students and create a highly visible campaign/incentive program to reduce drink container waste. Programs like these integrate environmental practices into campus culture and have been shown to reduce disposable cup waste by 30 percent.
- Eliminate the sale of bottled water on campus and instead provide refill stations at water fountains and in dining halls. Remove

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- MSU branding from bottled water (MSU's endorsement sends a conflicting message).
- Eliminate the use of non-recyclable neon/deep-dyed (astrobright) paper in campus communications and Printing Services because it is not recyclable, contaminates the recycling stream, and has been linked to health effects from heavy metals used in its production.
 - Change practices from one campus communication document per faculty/staff mailbox, to one announcement per department, and email notification.
 - Discontinue printing of annual campus telephone directories in favor of the online searchable directory. If necessary, make directories available via an on-demand print option (for a fee), to accommodate those who strongly prefer a printed directory.
 - Take steps to monitor and reduce excess print overruns of course catalogs, admissions materials, athletics schedules and similar campus publications.
 - Reduce number of Bozeman Daily Chronicle, Exponent, and Local Advertising issues delivered to dining halls. (Many are not even read before they are recycled.)
 - Maximize opportunities to digitize university processes and services, reducing reliance on paper records and communications.
 - Create a comprehensive program to publicize and encourage responsible purchasing strategies and provide information and guidelines (preferred products, etc.) to department procurement officers. Note: Because procurement is decentralized at MSU (except for contracts and purchases over \$5000), campus-wide purchasing policies will be difficult to enforce. These practices could instead be encouraged through education and by developing and offering cost-effective opportunities for department administrators to make responsible purchasing decisions.
 - Establish requirements and/or guidelines to ensure MSU is meeting the DEQ mandate for purchasing recycled content paper.
 - Develop boilerplate criteria for all competitive bids/contracts that address campus sustainability concerns and goals and require bidders to disclose their environmental practices/impacts for consideration. Include environmental and waste impacts in comparative cost assessments of bids.

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The ACUPCC requires signatories to demonstrate and articulate plans for “actions to make climate neutrality and sustainability a part of the curriculum and other educational experience for all students.” This requirement is well-aligned with MSU-Bozeman’s land-grant institutional mission, and will continue to be integral to future education and civic engagement activities.

Developing an interdisciplinary undergraduate program focused on sustainability

At MSU-Bozeman, the high level of research activity underway in environmental areas complements a growing interest in climate change, adaptation, and sustainability among our students and faculty. MSU is therefore building upon the research and education activities already underway at MSU (including the new EPSCoR Track 1 infrastructure grant) by developing an interdisciplinary undergraduate program in sustainability. This program will draw on our diverse strengths in research and education; our unique network of partners in government, non-profit organizations, and business; and our inspiring location in the Greater Yellowstone Ecosystem.

We envision a cross-college program, leading to an undergraduate certificate. The program will provide support for sustainability educational initiatives in all colleges; facilitate relevant training and in-service experiences, and offer critical mentoring, career advising, and job placement to students in this interdisciplinary area. Our goal is to instill in students a sense of wonder about Montana’s wildlands and managed lands, while at the same time inviting them seek solutions to pressing environmental challenges and join efforts to build sustainable communities and ecosystems. This interdisciplinary program will draw on the strengths of our faculty and external partners by focusing on topics ranging from clean energy, water, and air; sustainable food production; climate change impacts; rural human health; community sustainability; clean energy development, and sustainable business practices.

Sustainability education is already underway in various centers, colleges and departments at MSU. However, we need better coordination and facilitation if we are to inspire and train Montana’s and the nation’s brightest students and help them pursue meaningful careers. The proposed Montana University System Institute on Ecosystems (IoE) would seem to be a logical home for this interdisciplinary education initiative. As a statewide consortium, the Institute will lever-

age existing capacity across the entire Montana University System, through focal administrative hubs at MSU-Bozeman and the University of Montana-Missoula.

The IoE will provide (1) a new framework that will increase state and national visibility for Montana University System environmental research and educational activities; (2) increased capacity to recruit and retain nationally competitive faculty and graduate and undergraduate students in interdisciplinary environmental and sustainability areas; (3) new opportunities for Montana University System students through support and coordination for education programs focused on the environment and sustainability; (4) a statewide community of scholars who share common interests in addressing complex environmental questions and supporting development of solutions for sustainable human and ecosystem well being; (5) access to services and facilities through the two-hubs comprising the Institute; (6) coordination of strategically allocated funding, including but not limited to the current EPSCoR RII Track 1 grant; (6) new connections with partners from other universities, tribal colleges, state and federal agencies, NGOs, small businesses, and communities that will foster innovative opportunities for collaboration; and (7) improved engagement with communities and stakeholders to support informed decision-making and development of solutions to environmental challenges.

5.1 Undergraduate and Graduate Education

MSU-Bozeman offers a wide-variety of CAP-related curricula and individual courses across campus. While every academic college, school and outreach entity at MSU is in some way integrating sustainability and climate neutrality into their operations, extensive inventorying and structuring is presently in progress. Current flagship programs include the College of Business, and the Sustainable Food and Bioenergy Systems (SFBS) interdisciplinary degree program. The College of Business presently offers a sustainable business course and is developing other courses to foster leaders and change agents in the area of corporate sustainability. In 2009, the first cross-college, interdisciplinary degree program focused wholly on sustainability, the Sustainable Food and Bioenergy Systems Program, was established. This two-college, four-departmental program currently has over 80 student majors. The program explores sustainable food and bioenergy from production through consumption, linking eco-

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logical, economic and social aspects of these systems. A student run farm serves as an experiential classroom for students in the program as well as for students from other programs and majors.

Sustainability and climate neutrality are also being integrated into all MSU curricula as evidenced by new courses and new content within existing courses. In the spring of 2010, over 150 faculty from across the MSU-Bozeman campus came together to explore their common interest and desire to improve the integration of sustainability and climate-change science across the university curriculum. As a result, inventorying current courses in sustainability (including CAP-related courses) is presently in progress, and will be available through the IoE, and in the next MSU CAP. The newly funded IoE is chartered to serve as a campus hub for undergraduate education focused on sustainability, facilitating improved integration of perspectives from many disciplines. **The IoE will coordinate climate neutrality and sustainability education, outreach and research efforts amongst undergraduate and graduate students and staff/faculty across campus and within the community.**

Sustainability and climate neutrality are increasingly being integrated into all MSU curricula as evidenced by new courses and new content within existing courses. For example:

- The Creative Research Lab in the College of Arts and Architecture is focused on environmental and human sustainability in architectural design through several collaborative projects including its “EcoSmart House Project.”
- The College of Business is expanding its course offerings relative to sustainable business practices.
- A cross-college Water Resources Minor is in development, enhancing undergraduate exposure to science, engineering and policy topics related to sustaining water resources.

5.2 MSU Native Community

“As natives, we are part of the world’s longest longitudinal study and climate change research project. The findings of this project are only now entering the academic world and Native scientists/students are critical to the appropriate sharing, use, translation and perpetuation of this work.”—Lisa Lone Fight, Mandan, Hidatsa, Arikara, Graduate Researcher in LRES.

American Indians have long been celebrated as conservationists throughout the last century and into this one. This image became popularized by the Crying Indian commercial for the “Keep America Beautiful” campaign in 1971. Also in 1971, former Secretary of the Interior Stewart Udall published *The Indians: First Americans, First Ecologists*. While the label First Ecologists has been debated, the sentiment remains inescapably Native.

Native people of the Americas have long believed that it was a sacred duty to be good stewards of the environment. Wilma Mankiller, former Chief of the Cherokee Nation, observed: “In Iroquois society, leaders are encouraged to remember seven generations in the past and consider seven generations in the future when making decisions that affect the people.”

The MSU-Bozeman campus is host to a diversity of people and cultures, internationally as well as from within Montana. MSU Native American and Native Alaskan students, staff and faculty represent numerous tribes from all seven reservations in Montana, in addition to elsewhere across North America. In Montana, the Native American (American Indian) population is estimated at 68,000. This constitutes approximately 7 percent of the general population in the state. The twelve tribes of Montana have a long history of living on, and with the land.

MSU-Bozeman strives to partner in cross-cultural education to promote sustainability and climate neutrality. Coordinated by the Native American Studies (NAS) program, numerous programs integrate sustainability, and ultimately climate neutrality, as can be learned from and taught to the Native American perspective.

Indigenous Science and Traditional Native Knowledge Resources

MSU-Bozeman lies within the traditional bioregion, or ecoregion, of a number of Native American Nations. These nations have developed a sophisticated yet seldom externally accessed body of knowledge regarding methods of living sustainably in this environment. While this plan currently deals primarily with “technical” solutions, indigenous people have long stated that there are not only technical and practical but also “conceptual” solutions to climate change embedded in indigenous science, traditional knowledge and world view. The incorporation of these conceptual tools includes, but is not limited to: seven generation planning; indigenous architec-

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tural and landscape ecology models; indigenous conceptions of the nature of human/environment interfaces and interactions; traditional ecological knowledge, and indigenous science. Such tools offered by indigenous peoples are unique resources from which MSU is well positioned to benefit.

MSU's CAP also benefits from indigenous scientists/students/staff performing primary work in these areas and can be at the forefront of such research and application. These sources of knowledge, resources, and tools must be actively sought and deliberately included as components of MSU's CAP. From this perspective, the CAP embraces an expansive view that conceives of MSU not as an island or fixed point but as an intersection of multiple corridors extending actively and reciprocally into indigenous communities and systems throughout the region.

The Department of Native American Studies (NAS)

The NAS Department is an academic department that offers a non-teaching undergraduate minor, a graduate certificate and a Masters in Native American Studies. The Department offers courses that conform to the Diversity criteria in the University Core Curriculum.

One of the areas of focus and interest in the Core courses is contemporary issues in Indian Country. Students study land tenure, coal gasification on and near reservations, and the impact of development (of many sorts) on the culture and sustainability of reservation life.

In the Masters program, graduate students can focus their studies on a diverse number of topics related to Native American Studies. One of the strong emphases of study is natural resource development and conservation on reservations. In support of that area, students often take NASX 525, Indigenous Philosophies of Sacred Ecologies, a course available, too, to any graduate student. The course description follows:

Examination of indigenous philosophies of sacred ecologies, contrasting Native views with those held by Europeans regarding the natural world. The course also traces the impact of historical colonialism in the environment up to contemporary conflicts over sacred sites and environmental resources.

Native American Student Center

Montana State University has been granted approval to begin raising funds to build a Native American Student Center to house programs and

services to enhance and improve Native student academic performance, retention and graduation. This building will feature an architectural design that reflects Native cultures of the state as a visible reminder of the importance of Native peoples to the uniqueness of this region.

In recognition of the importance of preserving resources for the future, the proposed Native American Student Center will be constructed as a "green" building. The building will seek an appropriate LEED rating and will foster the sustainability goals of our campus. The Center will include substantial natural light, cutting down on energy used in the facility for lighting and will include mechanically-assisted natural ventilation. The Center will be constructed with certified sustainable wood products and local stone and brick. The building will be designed to maximize solar energy of its location.

American Indian Council

Montana State University has a Native student population of approximately 400. The major student organization for Native students, and non-Indian students interested in American Indians, is the American Indian Council (AIC). Their major mission is to encourage healthy choices and promote Native culture. As a student organization, AIC attempts to engage in activities related to environmental awareness including recycling, highway clean-ups, and participating in campus-wide sustainability actions.

American Indian Research Opportunities

American Indian Research Opportunities (AIRO, www.montana.edu/wwwai) is a consortium of Montana's seven Tribal Colleges (Blackfeet Community College, Chief Dull Knife College, Fort Belknap College, Fort Peck Community College, Little Big Horn College, Salish Kootenai College, and Stone Child College) and Montana State University-Bozeman, dedicated to providing opportunities for American Indian students in career fields where they are significantly under-represented. The advisory board to the AIRO consortium consists of representatives from each of the seven tribal colleges and Montana State University-Bozeman. Specific goals of AIRO include recruiting, retaining and graduating American Indians (and other minorities/disadvantaged students) with associate, baccalaureate, master's and doctoral degrees in Science, Engineering and Mathematics (SEM), as well as promoting SEM fields to American Indian students, par-

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ents, teachers, and the Indian community. These goals integrate the American Indian perspective and culture of conservation, with scientific understanding of human impacts on ecology and global climate change, which is carried back to American Indian communities at all levels from children to elders.

Designing Our Community

Designing Our Community (DOC, www.coe.montana.edu/doc) was founded with a multi-year grant from the William and Flora Hewlett Foundation — Engineering Schools of the West Initiative. The vision of DOC is to become firmly established as the premier institution of choice for Native American students in engineering, engineering technology, and computer science, and to be a successful partner with Native American communities in developing the future workforce. As with AIRO, improving access to the Native American communities in the sciences and engineering, results in greater science literacy relevant to understanding global climate change and engineering solutions in these underrepresented communities.

5.3 MSU Extension Services

The MSU Extension Service is an educational resource dedicated to improving the quality of people's lives by providing research-based knowledge to strengthen the social, economic and environmental well-being of families, communities and agriculture enterprises throughout Montana.

MSU Extension Services supplies various outreach and training opportunities to Montana residents and businesses relevant to climate change. At the MSU/Montana Weatherization Training Center (www.msuextension.org/category.cfm?Cid=14), training and certification is supplied to Montana and regional contractors dealing with home energy auditing/diagnostics, and cost effective installation of weatherization and home energy management systems. The Exploring Energy Efficiency and Alternatives — E3A program is a comprehensive training program for educators and contractors dealing with all aspects of home, farm, and ranch energy alternatives and building efficiency practices. E3A training covers wind, solar, weatherization, bio-fuels, methane digesters, hydro-power, geo-thermal, energy alternatives. The WxTV Training Network (www.wxtvonline.org) is a free, publically available online weath-

erization training platform for the nation's 900 weatherization agencies. Other clean energy subjects, such as solar and wind home usage are also covered, with the creation of up to 40 episodes annually. Additionally, MSU Extension Services operates the Montana Materials Exchange (www.montana.edu/mme). This is an online reuse platform for reuse of commercial and industrial materials to substantially reduce GHGs associated with transportation of waste, importation of excess new materials, and landfill operations.

An associate's degree program is being developed by MSU extension services in "Residential Building Performance," scheduled to start in the Fall of 2012. This will supply more comprehensive training than the above training programs for improving energy efficiency and designing/constructing clean energy solutions regionally compatible with residential buildings.

5.4 Other Outreach and Civic Engagement Activities

As a land-grant university, MSU-Bozeman is especially focused on community outreach and education. Various outreach endeavors at MSU are particularly relevant to climate education and greenhouse gas reduction, as listed below:

Student Organizations

Numerous student-led initiatives and academic programs already exist at MSU and the demand for such opportunities is growing among students and faculty. Some current and successful activities are listed below.

Network of Environmentally Conscious Organizations (NECO): NECO is a student-run organization focused on outreach, education and student initiated projects that promote sustainability on campus and in the community. Recent projects have included: establishing recycling in the residence halls, instituting composting at MSU, promoting conscientious sustainable behavior, and lobbying for PV solar panel retrofits on campus. NECO also advertises and sponsors lectures, films, and events that promote sustainable practices on campus and in the surrounding community, in addition to direct public outreach. Interested persons can learn more about NECO at the following website: www.bozoneco.com/get-involved

ASMSU Sustainability Center: Through self-initiated student fees, ASMSU established and

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operates the Sustainability Center. The ASMSU Sustainability Center is a student-funded program of the Associated Students of MSU (www.montana.edu/greenasmsu). ASMSU operates a student-run Recycling program, plans programs and events, coordinates campus recycling, waste and water-use reduction programs, hands-on student community projects, and collaborates with various campus partners to develop initiatives that enhance sustainability at MSU and engage students in the process. Programs run by the ASMSU Sustainability Center include:

- ASMSU Recycling: a student-funded program with services performed by student employees.
- Sustainability Luncheons: held twice each semester, the Sustainability Luncheon series brings the campus community together for a presentation or conversation on a sustainability topic with free refreshments featuring local Montana Made products.
- Take Back the Tap: The Sustainability Center has partnered with the City of Bozeman and University Food Service in joining this nationwide campaign to raise awareness of the environmental and health concerns related to bottled water.
- Gallatin Earth Celebration: The Sustainability Center is a co-sponsor of this annual Earth Week series of events hosted by MSU and the City of Bozeman each year.
- MSU Climate Action Plan: The Sustainability Center will facilitate continuing student involvement in the development of subsequent editions of this campus Climate Action Plan (CAP).
- Independent Research Project Opportunities: The Sustainability Center welcomes independent student research projects (for stipend, or credit, or simply volunteer) in areas consistent with its mission. An updated list of past and current research is maintained at www.montana.edu/greenasmsu/Research.html

Engineers Without Borders (EWB): MSU-Bozeman has a student chapter of EWB, a nationwide non-profit organization with over 180 student chapters. The mission of EWB-USA and its chapters is: “EWB-USA supports community-driven development programs worldwide by collaborating with local partners to design and implement sustainable engineering projects, while creating transformative experiences and responsible leaders.” (www.ewb-usa.org/mission.php). EWB-

USA encourages a strong sense of stewardship, outreach, and sustainable (environmentally and culturally) engineering solutions for communities in need, both in the USA and around the world.

Faculty/Staff-run Organizations

Burns Technology Center (BTC, <http://eu.montana.edu/btc>): The BTC was created in 1993 by MSU and the Montana Board of Regents to develop and demonstrate cost-effective telecommunications applications and distant learning strategies. The BTC successfully incorporates technology into traditional teaching and learning, as well as extends the university into the homes and communities of every Montanan. In addition, the center’s distance learning programs reach people and communities across the United States and beyond. The BTC satisfies several goals of the CAP by increasing science literacy throughout Montana and beyond, and allowing distance education learning to decrease travel-related energy costs. Additionally, the BTC has made publicly available the free, downloadable unit: Hydrogen and the Environment: The quest for alternative fuels (<http://hydrogen.montana.edu>). Other materials will continue to develop through the BTC in the future.

Wind for Schools (WfS, www.coe.montana.edu/wind/skystream/locations.html): Wind for Schools is a parallel program with a primary objective to engage rural American in wind-related projects. By facilitating installation of small wind turbines at rural K-12 schools, the WfS program provides a knowledge base for alternative energy. The amount of supplemental power delivered to the primarily rural school facilities is relatively small, but the educational benefits are great.

The Integrated Design Lab | Bozeman (www.idlbozeman.com): The Integrated Design Lab is funded by the Northwest Energy Efficiency Alliance. Services include energy and lighting analysis for Montana architects and engineers who wish to become more aware of the environmental impacts of energy consumption. IDL serves as a Montana contact for energy and daylighting information, education, and tools for assessing integrated design decisions. MSU Faculty Director: Thomas Wood

Big Sky Carbon Sequestration Partnership (BSCSP, www.bigskyco2.org): The BSCSP is one of the U.S. Department of Energy’s seven regional carbon sequestration partnerships. The partnerships engage key stakeholders to create a nationwide network that will help determine the best approaches for

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capturing and permanently storing greenhouse gases that contribute to climate change. The BSCSP region extends beyond Montana, encompassing Wyoming, Idaho, South Dakota, eastern Washington and Oregon as well. Its membership includes universities, national laboratories, private companies, state agencies and Native American tribes. The BSCSP relies on existing technologies from the fields of engineering, geology, chemistry,

biology, geographic information systems (GIS) and economics to develop novel approaches for both geologic and terrestrial carbon storage in our region. The BSCSP engages in cutting-edge carbon sequestration research and development; economic and regulatory analyses; public education and outreach; and regional demonstration projects to deploy new technologies.

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In support of the MSU-Bozeman 2011 climate action plan, this section details ongoing and developing research activities related to energy and climate change (both on and off campus). First discussed is an overview of MSU's research mission and infrastructure. This is followed by an inventory of CAP-related research activities and plans to expand same.

6.1 Research Mission and Infrastructure

The integration of learning and discovery is a hallmark of the undergraduate experience at Montana State University, which offers every student a hands-on research or creative project in his or her sophomore year. MSU has become a model university for combining these two critical aspects of higher education. With outdoor laboratories as close as Yellowstone National Park, MSU students have ample opportunities to pursue exciting projects throughout their college careers. Not limited to the sciences, those projects also include such artistic endeavors as original musical compositions, paintings and architectural designs.

Those hands-on opportunities make MSU a leader in the number of prestigious Goldwater Scholarships for undergraduate excellence in science and math. MSU is among the nation's top tier of research universities, as recognized by the Carnegie Foundation for the Advancement of Teaching. The Foundation recently ranked MSU as one of 96 research universities with "very high research activity."

MSU faculty are recipients of National Science Career Awards, Presidential Early Career Awards for Scientists and Engineers (PECASE), a Technology Review magazine "young innovator" award and a McArthur Foundation Award. Faculty and student take advantage of the ability to conduct pioneering research in a unique learning environment. MSU's expenditures from sponsored research programs reached \$109.5 million in fiscal year 2010 and continued growth is expected.

MSU-Bozeman is committed to reducing energy needs and greenhouse gas emissions through its continually expanding research. Present greenhouse gas reduction research areas include fuel cells, wind energy, harvesting transportation fuel from algae, microorganisms with biofuel-producing capabilities, biofuel from seed crops, and the storage of carbon dioxide deep underground, known as carbon sequestration. In envi-

ronmental research, MSU covers everything from invasive weeds that threaten livestock grazing, to how climate change will change the frequency of wildfires, to lower GHG producing agricultural practices. Contributions through research will continue to benefit not only the current student body and surrounding region, but ultimately result in products and strategies to ameliorate greenhouse gas emissions on a global level as developed technologies are implemented.

6.2 CAP-Related Research Inventory

Discovery and Creativity

Interdisciplinary discovery creates solutions for societal issues related to the environment and sustainability. In contrast to the disciplinary organizational structure within most universities, environmental research on topics, such as climate change, requires interdisciplinary solutions that engage natural and social scientists, engineers, applied mathematicians, land managers, policy makers and communities. The IoE will increase visibility and provide a collective voice in environmental sciences and sustainability to help us succeed in new interdisciplinary research areas. Currently, over 65 faculty have research focused on sustainability and the environment, and nearly one-third of current research grants target environmental themes and continued growth is expected. The university has made significant investments in faculty and resources in energy, natural resources, ecology, earth sciences, environmental sciences, environmental engineering, and computational sciences.

Recent hires bring new strengths in energy, climate change science, snow science, watershed modeling, biogeochemistry, land-atmosphere interactions, aquatic ecology, plant ecology, optical sensors, ecological and environmental statistics, environmental microbiology, and environmental education. Current research in environmental sciences accounts for about one third of MSU's annual research funding, and faculty have received national awards for excellence in environmental research and education. Research at MSU takes advantage of the unique opportunities and natural laboratories available in Montana and the Greater Yellowstone Ecosystem (e.g., we have more research in Yellowstone National Park than any university in the country), but our focus on the environment, energy, and sustainability extends to all continents. Current research centers and institutes focused on sustainability-related

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research (described in more detail below) include the Energy Research Institute; Zero Emissions Research and Technology (ZERT); Big Sky Carbon Capture and Sequestration; Center for Biofilm Engineering; Thermal Biology Institute; Creative Design Laboratory; Jobs Center for Entrepreneurship for the New West; Center for Bioinspired Nanomaterials; Western Transportation Institute, the Wind Applications Center, Center for Invasive Plant Management, and the REHAU Montana EcoSmart House.

6.2.1 Research Centers Inventory

There are several umbrella research centers at MSU, many of which include outreach, education, and research components relevant to the subjects of sustainability and greenhouse gas reduction. Below, are listed the research centers that most directly address issues surrounding greenhouse gas reduction:

Center for Biofilm Engineering (CBE, www.biofilm.montana.edu): At the Center for Biofilm Engineering (CBE), multidisciplinary research teams develop beneficial uses for microbial biofilms and find solutions to industrially relevant biofilm problems. The CBE was established at Montana State University, Bozeman, in 1990 as a National Science Foundation Engineering Research Center. As part of the MSU College of Engineering, the CBE gives students a chance to get a head start on their careers by working on research teams led by world-recognized leaders in the biofilm field. Biofuel production and CO₂ sequestration are but two of the CBE's present and ongoing research areas that contribute to greenhouse gas reduction strategies (www.biofilm.montana.edu/research-program.html).

Energy Research Institute (www.montana.edu/energy): The Montana State University Energy Research Institute is an umbrella for MSU's energy research and education programs, which account for roughly \$15 million in research each year. The institute encompasses more than 170 faculty, staff and students spread across 11 university departments who are working in fields such as clean-coal technology, fuel cells, wind, coal-bed methane, biofuels, as well as carbon sequestration and climate change. Over the past several years, MSU has developed a number of programs focused on energy, making the university a significant contributor to national and international energy research and development.

Consortium for the Agricultural Soils Mitigation of Greenhouse Gases (CASMGs, www.montana.edu/sustainability/curriculum.html): The CASMGs is a consortium of nine universities and one national laboratory assembled to investigate the potential of agricultural soils to mitigate greenhouse gases.

Economics of Climate Change and Greenhouse Gas Mitigation (www.montana.edu/sustainability/curriculum.html): This research program investigates issues facing the agricultural sector due to climate change, including the impact of climate change on U.S. cropping systems, and focuses on how to design programs to sequester carbon in agricultural soils.

6.2.2 Specific CAP-related Research Subjects

Agricultural management research

Research programs by faculty in the Department of Land Resources and Environmental Sciences (LRES) are targeting energy use reduction in agricultural and focusing on cropping systems that sequester carbon. Research under a current USDA AFRI grant focuses on energetic, economic and environmental benefits of using legume green manures as a nitrogen fertilizer replacement strategy. Faculty: Perry Miller (PI), Clain Jones, Rick Engel.

Current research is also investigating Camelina as a low input crop with added value from its byproducts. Camelina oil can be used for production of insulation foams and as a component of carpets. Camelina meal can be used for fertilization or remediation of phenolic contaminants. Additionally, Camelina meal can be used to reduce soil borne diseases and insects as an alternative to chemical pesticides. Camelina can also be used for its oils in biofuels, or for solid biomass pellets. Faculty: David Sands, Department of Plant Sciences and Plant Pathology. Dr. Sands is also presently researching composting microbes to degrade bioplastics. (http://mbprogram.montana.edu/faculty.asp?per_id=16&in_id=12)

In addition to the above mentioned green manure research as an alternative to energetically expensive nitrogenous fertilizers, Perry Miller is presently conducting studies with various alternative crops aimed at finding economical ways of sustainable soil management (<http://scarab.msu.montana.edu/CropSystems/>). Geoffrey C. Poole, of the LRES Department is presently studying land management approaches to limit N₂O emissions from streams.

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Department of Agricultural Economics and Economics:

Research within the department spans a wide array of topics. Subjects relevant to the goals of the MSU CAP include: climate change, resource and environmental economics, and public choice. The Department of Agricultural Economics and Economics also houses the CASMGS and the Economics of Climate Change and Greenhouse Gas Mitigation research centers described above.

Carbon Sequestration Biological

Rick Lawrence: The Spatial Sciences Center remote sensing lab is engaged in two major research efforts related to carbon sequestration. The first effort is developing monitoring and validation methods for cropping practices that increase soil carbon and are eligible for carbon credits traded on the Chicago Carbon Exchange. The second effort relates to geologic carbon sequestration in coordination with Dr. Kevin Repasky and Dr. Joe Shaw in the Electrical Engineering Department to develop methods using remote sensing to monitor geologic sequestration sites for leakage.

Perry Miller: Dr. Miller is presently conducting two long-term cropping systems studies at MSU. The A.H. Post Research Farm address carbon sequestration, reduced N₂O emissions, and energy use efficiency. A long-term out-of-state project on 6 farms is specifically addressing carbon sequestration in agricultural soils.

Geological

Zero Emissions Research and Technology (ZERT, www.montana.edu/zert)

DOE partnership investigating geochemical CO₂ sequestration: The Zero Emission Research and Technology Center (ZERT) is a research collaborative focused on understanding the basic science of underground (geologic) carbon dioxide storage to mitigate greenhouse gasses from fossil fuel use and to develop technologies that can ensure the safety and reliability of that storage. ZERT is a partnership involving DOE laboratories (Los Alamos National Laboratory, Lawrence Berkeley National Laboratory, National Energy Technology Laboratory, Lawrence Livermore National Laboratory, and Pacific Northwest National Laboratory) as well as universities (Montana State and West Virginia University).

Research Goals are to: 1) develop sophisti-

cated, comprehensive computer modeling suites which predict the underground behavior of carbon dioxide; 2) investigate the fundamental geochemical and hydrological issues related to underground carbon dioxide storage; 3) develop measurement techniques to verify storage and investigate leakage; and 4) develop mitigation techniques and determination of best practices for reservoir management. Faculty: David W. Bowen (Modeling and Mapping), Kevin Repasky and John L. Carlsten (Monitoring and remote sensing), Al Cunningham, Robin Gerlach, Dr. Andrew Mitchell and Mark Skidmore (Mitigation: Subsurface Biofilm Barriers).

Multi-spectral imaging of vegetation to detect CO₂ leaking from underground carbon sequestration storage facilities. This is part of the Lasers and Lidar Group (www.physics.montana.edu/optics/jlc/index.html) within the ZERT research program. Faculty: Joe Shaw, Rick Lawrence, Kevin Repasky, J.L. Carlsten (www.coe.montana.edu/ee/jshaw/index.htm)

Climate Change Impacts

NSF-funded research investigating C, N and S cycling in coastal plain wetlands to understand population dynamics. Predicting the likely ecosystem carbon and nutrient cycling of coastal plain freshwaters into a saltier and increasingly uncertain hydrologic future requires significant improvements to the current understanding of freshwater ecosystems. Incorporating sulfur (from sea salt) dynamics into our understanding of how microbes alter carbon and nutrient cycling and utilizing simulation modeling to mesh dynamic hydrology together with microbial biogeochemistry is important to formalize the emerging conceptual understanding of wetland biogeochemistry into a flexible, easily adjusted modeling framework. Developing software models will test various hypotheses and understand how sulfate intrusion in wetlands impacts greenhouse gases released to the atmosphere.

The field site is representative of large areas of SE coastal plain agricultural landscapes that are being actively restored or abandoned. The economic and ecological 'success' of this project is closely watched by regulators and practitioners throughout the region. This research program will directly affect the potential for site owners to sell validated carbon and nutrient credits in emerging ecosystem service markets. Resulting research findings (together with their economic implications) will influence future patterns of

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mitigation and conservation investment throughout the southeastern coastal plain and will provide critical information that will facilitate climate adaptation planning throughout the region.

Faculty: E.S. Bernhardt, G.C. Poole, A.J. Burgin, and C.I. Izurieta

Biofuels

Algal BioFuels Group:

The Algal BioFuels Group at Montana State University (MSU) has a unique combination of expertise for the development and application of algal technologies for production of biofuels and renewable chemicals. Current projects encompass \$2.3M in funding from DOE, DOD and State sources. Unique algal strains have been isolated and characterized from a variety of different environments. In-house analytical capabilities are being developed to characterize algal triacylglycerides (TAGs), hydrocarbons, as well as fuel potential (hydrocarbons and fatty acid methyl ester analysis) for screening new isolates and optimizing fuel output of algal cultures. Faculty: Ross Carlson, Barbara Cooksey, Keith Cooksey, Matthew Fields, Robin Gerlach, Brent Peyton (Algal biodiesel and Mycodiesel).

Biohydrogen

Robust Phototrophic Microorganisms for Biological Hydrogen Production: Optimization of light driven or mediated hydrogen production for alternative energy. MSU researchers are exploring hydrogen production in either algae or Cyanobacteria for optimal hydrogen production and attempting to identify the organisms with the highest hydrogen production potential, thus laying the groundwork for metabolic engineering to create organisms with enhanced hydrogen production capabilities. PI: John Peters (www.chemistry.montana.edu/john.peters/research.html)

Fuel Cells

Biomimetic Systems for Light Driven Hydrogen Production: In work supported by the Department of Energy, researchers are applying enzymes and enzyme mimics (with Trevor Douglas) to the production of hydrogen-producing materials for alternative energy solutions. The project involves novel patented solar to hydrogen materials strategies that can be potentially applied in a number of different ways. Since durability is one of the key aspects of enzymes that limit their effective use in many industrial processes, enzyme stability, thermal adaptation, and immobilization as

mechanisms to promote the use of enzymes as materials is under investigation. PI: John Peters (www.chemistry.montana.edu/john.peters/research.html)

Solid Oxide Fuel Cells (SOFCs):

Operation of solid-oxide fuel cells (SOFCs) are being researched in combined-heat and power (CHP) mode for improved energy efficiency to ultimately avoid the use of power generated by steam power plants. Hybrid operation of SOFC-microturbines are also being researched for improved energy efficiency. PI: M. Hashem Nehrir (www.coe.montana.edu/ee/hnehrir)

Current research is also investigating the stability and corrosion of various fuel cell components in the humid environment of Solid Oxide Fuel Cells (SOFCs). Specifically, in steel current collectors of SOFC stacks, chromia is volatilized from these plates. Insulation and fuel feed tubes used in SOFCs can also release silica in the moist SOFC environment. Both of these volatile species, chromia and silica, can enter the gas stream and poison the cell. Improved techniques for making these volatility measurements are also being developed. More stable anode materials for SOFCs running at higher operation temperatures (> 800°C) in a reversible mode are also being developed. These would be used on NASA missions to Mars, and could lead to improved SOFCs for earth operation as well. A reversible cell would use solar energy during the day to generate hydrogen fuel. The hydrogen would be used at night to generate electrical energy. PI: Richard J. Smith (www.physics.montana.edu/people/facview.asp?id_PersonDetails=4)

Wind

MSU faculty Doug Cairns is currently working on manufacturing and testing new materials for wind turbine blade structures.

Composite material testing is presently being conducted in coordination with twelve industry partners for wind turbine blades to increase reliability and reduce the cost of wind energy. Research is on the durability of composite materials in a salt water environment is also being conducted for Marine Hydrokinetic (MHK) devices for water power generation such as tidal or ocean/river currents. Faculty: John Mandell, Prof. Emeritus (www.coe.montana.edu/composites/People/Faculty%20and%20Staff/John%20Mandel.htm)

Additionally, the Montana Wind Applications Center (WAC) is in place to offer wind energy

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educational opportunities to students at Montana State University, to support wind-related outreach efforts throughout Montana, and to assist the companion Montana Wind for Schools program. The WAC (www.coe.montana.edu/wind) was created in 2008 with startup funding provided by the U.S. Department of Energy National Renewable Energy Laboratory (DOE NERL). Faculty: Robb Larson.

Solar

Current research at MSU is focusing on methods for characterizing the temporal and spatial distribution of solar radiation across Montana. The placement and sizing of solar technologies is dependent on knowledge of the availability of solar radiation. The project aims to better understand the controls on solar radiation variability, to develop methods for representing the solar radiation characteristics, and to provide information useful for the efficacy of solar radiation technologies across Montana. The project will develop a system for communicating the availability and dependability of solar radiation across the state of Montana. The system will provide spatial maps of variables of importance to solar collector technologies, including: solar radiation means and extremes, frequency and duration of low radiation values, and runs of high radiation values. Faculty: Lucy Marshall.

Green Architecture and Construction:

REHAU MONTANA ecosmart house: Project research will specifically focus on sustainability, low energy usage, and disability design. A key objective of the research is to determine how the various building systems can best be integrated to optimize energy consumption, comfort, and life-cycle costs. (www.montanaecosmart.com/index.php)

Fly Ash Cement: Relative to sources of greenhouse gases, the United States and the rest of the world use a lot of concrete, and the production of the traditional Portland cement that goes into this concrete accounts for 7 percent of worldwide greenhouse gas emissions. Therefore, finding substitutes for Portland cement as the binding agent in concrete could have a significant impact on greenhouse gas emissions. In this regard, an innovative green concrete that uses no Portland cement is being researched. The solid constituents in this concrete are nearly 100 percent recycled or industrial by-products. Instead of Portland cement as the binding agent, fly ash, a

by-product of burning coal to generate electricity is being used, and post consumer crushed glass, instead of sand and gravel for the filler material, is being used. Faculty: Michael Berry (member of Western Transportation Institute)

Other alternative energy research

Dr. M. Hashem Nehrir (www.coe.montana.edu/ee/hnehrir/) has multiple research endeavors relevant to the goals of MSU's CAP. He presently is researching near optimal operation of a hybrid wind-microturbine power generation system to minimize fuel (natural gas) consumption. He additionally is focusing on using residential electric thermal storage loads, such as electric water heaters, to store excess wind energy that may be available in a given area during high wind periods. Additional research includes control of electric loads to reduce the need for spinning reserve generation, hence reducing emission of undesired gases. Spinning reserve generators are often steam-based power generating units which are used in emergency cases. Additionally, Dr. Hehrir is researching power management of microgrids with hybrid alternative energy power generation sources. One objective in this work is the maximum use of renewable power generation resulting in minimum emission of undesired gases.

6.3 Future Research Directions

Separate from the Burns Technology Center, MSU-Bozeman is calling for proposals in order to expand access to MSU learning through development of online classes. President Cruzado noted that in the coming months and years, Montana State University will be expanding online distance education, a vehicle that enables us to reach out and meet the diverse educational needs of students in every corner of this state. In doing so, she proposed the designation of funds to give motivated faculty the time and support to develop online courses or transform existing ones into online programs reaching previously un-served or under-served learners. Faculty may request funds for time for program planning and course development and/or conversion. Priority will be given to programs able to launch in Fall 2011 or Spring 2012. Programs that require longer planning and approval time will also be considered, and there will be additional Requests for Proposals (RFPs) in future years. (eu.montana.edu/online/faculty/grow)

In addition, MSU is well positioned to coordinate and support primary research on

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Native Communities, Indigenous Science and traditional knowledge related to climate change. The resources previously mentioned provide a foundation for this type of innovative, cross disciplinary endeavor.

7. FINANCIAL CONSIDERATIONS

Financial investment resulting in GHG emissions reductions will be prioritized according to the ability of options to cost effectively achieve multiple goals. For example, efforts that reduce emissions may also reduce deferred maintenance, address system deficiencies, interface with education and research, and/or achieve operational cost reductions. No funding is presently identified for implementation of mitigation tactics. All infrastructure investments made will consider these criteria and capitalize on funding opportunities by:

- 1) leveraging existing programs, such as the IoE for

- 2) pursuing curricular and staffing opportunities;
- 2) pursuing the establishment of a Sustainability Endowment through the MSU Foundation funding structure;
- and 3) investigating external funding, through government and private grants, for CAP-related activities, including curriculum development, public outreach and partnering, infrastructure improvements, and research opportunities. To the extent possible, investments will be planned to complement the overall strategy of energy conservation and preparation of building systems for the integration of renewable energy sources.

8. COMMUNICATIONS AND ACTION ITEMS

This MSU CAP is a living document approved by the President and University Council, submitted to the American College and University Presidents Climate Commitment for posting on their website (www.presidentsclimatecommitment.org). It will be revised and resubmitted every two years. Suggested revisions for the 2013 submission can be made through the MSU Campus Sustainability Advisory Council.

A simple checklist can help guide decision-making at MSU to be in accordance with both its new Mission Statement (www.montana.edu/accreditation/MSU_Mission_and_Core_Themes_2011.pdf; accessed Nov 10, 2011) and the CAP.

Does the proposed action:

- 1) Decrease or hold neutral per capita greenhouse gas emissions?
- 2) Move towards use of renewable energy and material supplies?
- 3) Decrease or hold neutral per capita use of materials?
- 4) Decrease or hold neutral per capita waste stream?
- 5) Contribute to or provide knowledge and/or application dealing with sustainable practices for environment, society, and short and long term economics?
- 6) Contribute to the knowledge and experience base for students interested in sustainability?
- 7) Build towards more sustainable operations for MSU employees?
- 8) Push the envelope of sustainability for communities and organizations across Montana?
- 9) Acknowledge and honor the sense of place of Montana State University within the natural and human worlds?

To make concrete progress toward the goals of this CAP, immediate and near-term actions are recommended. The first such action taken toward satisfying the goals upon signing onto the ACUPCC was the establishment of CSAC at MSU. As the official advising council for MSU, regarding sustainable practices and meeting the signed objective of ultimate net-zero Carbon emissions, CSAC recommends the following:

- 1) Continued participation in the Uncommon Sense Business Leadership for a Sustainable Future program, which establishes methodologies for tracking, reporting, and improving practices in waste management, responsible purchasing, social and community investment, inventorying GHG emissions, and improving energy, water, and transportation efficiencies;
- 2) Creation of an Office of Sustainability. Such an office, with at least one FTE hire and physical office would supply a direct liaison between students, the IoE, advising on curricular choices toward the foreseen Sustainability Certificate, pairing students with identified research opportunities, and MSU Extension Services. This is a separate function from the ASMSU Sustainability center (described earlier), and would therefore require separate staff to perform these tasks.
- 3) Begin immediate changes in travel data acquisition in order to accurately track/audit air transportation mileage, commuter driving, and waste tracking. Specific changes in data acquisition are supplied in previous chapters of this CAP, and improved methods will be developed in the coming biennium through participation in the Uncommon Sense workshops.

Communications for the MSU CAP will be governed by MSU Communications via the CSAC website: www.montana.edu/sustainability.