



2015 Report from President Schlissel's Greenhouse Gas Reduction Committee

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Report of the President's Committee on Greenhouse Gas Reduction

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The University of Michigan strives to be a sustainability leader, not only in higher education, but in our society. As part of this commitment, U-M announced in 2011 six sustainability goals for 2025. This committee was tasked to evaluate and to make recommendations regarding U-M's stated greenhouse gas (GHG) reduction goal. The current goal is to reduce the University's scope 1 and 2 greenhouse gas emissions from FY2006 levels (680,000 metric tons of carbon dioxide equivalent (MTCO₂e) per year) by 25% by 2025. This equates to an absolute amount of GHG emissions of 510,000 MTCO₂e/year in 2025. (MTCO₂e/year is the prevailing metric for GHG emissions. It stands for metric tons -or 2,200 lbs - of carbon dioxide equivalent per year.)

Other universities have set more ambitious climate goals than U-M. Many have committed to carbon neutrality without a clear idea of how to achieve this. This report evaluates U-M's current goals and recommends future goals with rigorous assessment of current and potential future emissions.

While meeting the current goal will require continued effort, this goal lags those of many peer institutions, as well as the US climate commitment announced by President Obama to reduce US GHG emissions by 28% from 2005 levels. If U-M wishes to remain a leader in this area as a broad range of the University's stakeholders desire, a significantly more ambitious target is needed than was called for in 2011. The committee recommends a revised goal of at least 30% and planning for steps beyond 2025 to further reduce GHG emissions toward a goal of carbon neutrality.

It should be recognized that U-M's ability to reduce its absolute GHG emissions is constrained by several factors, some within its control, some not. These include:

1. *Climate:* Heating and cooling energy requirements are greater than those of many institutions in more temperate climates that have announced goals up to and including carbon neutrality.
2. *Carbon intensity of external electricity suppliers:* U-M relies on the local utility infrastructure for significant amounts of its electricity needs, and therefore "inherits" the GHG footprint associated with its fuel mix. This is one of the more carbon-intensive in the nation; 74% of the local electricity generation in 2013 was from coal. In addition, U-M is constrained from seeking other electricity suppliers, including those generating electricity from renewable sources, by the limits of Michigan's Electric Customer Choice law.
3. *Growth:* The University's acquisition of the North Campus Research Complex increased its energy consumption and emissions footprint. Although emissions estimates for NCRC were used to adjust the 2006 baseline before setting the 25% reduction target for 2025, that does not change the fact that, in the absence of other measures, growth of facilities puts upward pressure on emissions.
4. *Decentralization:* The decentralization of significant facilities decisions to both academic and non-academic units can lead to sub-optimal choices with respect to the realization of institutional goals, unless these are made a priority. For example, units may decline to make capital investments in energy efficiency or emissions improvements, even if these have a desirable payback and would further institutional goals. In addition, the energy conservation efforts under the University's Energy Management Program (EMP) include only General Fund buildings, and exclude the U-M Health System, Athletics, and Student Life.

In order to map possible pathways to set and to meet aggressive GHG reduction goals worthy of an institution such as the University of Michigan noted for its leadership, we have divided this report into three sets of actions as follows:

1. Steps to achieving the current goal
2. Reducing GHG emissions beyond the current goal
3. Opportunities recommended for further evaluation

Each of these contains possible actions related to reducing or offsetting the GHG footprint of the University's energy supplies and to reducing our energy consumption and associated emissions. Some may necessitate or stimulate greater levels of engagement by the campus community, and we have attempted to note these aspects as well.

As with any decadal projections, the costs and benefits of individual actions are based on certain assumptions. We have attempted to highlight uncertainties and vulnerabilities associated with these where significant.

Steps to achieving the current goal (25% reduction from FY2006 baseline to reach 510,000 MTCO_{2e}/year in 2025)

We project that in order to meet the current goal will require continuation of several existing measures, plus installation of the Central Power Plant Gas Turbine project, and including continuing increases in the renewables component of electricity produced by the local utility infrastructure and purchased by U-M. These projections are illustrated in Figure 1, which shows "wedges" for GHG reduction relative to a base case that assumes a 1% annual growth rate of U-M's GHG emissions from FY2014 levels without measures beyond continuation of the mitigation actions already implemented. (This base case is illustrated by the red line in Figure 1. The impact of continuing existing mitigation actions on what would be even higher emissions is represented by the red band above this line.)

Mitigation actions already taken, to be continued:

1. *Continued purchase of Renewable Energy Credits (RECs).* U-M currently purchases the RECs associated with 100% of the output from two 2.5MW wind turbines in Michigan operated by Heritage Sustainable Energy. This represents an offset of our GHG emissions of about **10,000 MTCO_{2e}/yr** at a cost of \$25/MT (or \$20/MWh as actually purchased.) Note that since RECs are assigned in terms of MWh of renewable energy, not avoided emissions, the GHG reduction assigned to these was calculated on the basis of the mix of fuels currently used by the local utility infrastructure to generate electricity purchased by U-M. The value of these RECs is also subject to change as the carbon intensity of electricity produced by utility system changes, thus the cost per MT offset may vary somewhat from the value above.
2. *Restored operation of the NCRC gas turbine.* This turbine was put back in operation in 2013 and is projected to reduce U-M's GHG emissions by **10,000 MTCO_{2e}/yr** relative to the base case in which an equivalent amount of electricity (24,000MWh/yr) is purchased from DTE. The difference results from the lower emissions from natural gas fired generation relative to a coal-heavy resource mix.

3. *Continued investment in the Energy Management Program (EMP) for General Fund buildings.* This program reduces campus energy consumption and thereby the associated GHG footprint. The level of investment is \$3.4 million/yr of recurring funds, of which \$1 million/yr is devoted to Energy Conservation Measures – projects requiring small capital investments. There is currently an additional \$9,000,000 of one-time funds available for major, large capital project investments. Examples of past and ongoing ECM projects include occupancy sensor controls for lighting and HVAC systems, lighting retrofits, building system controls upgrades, lab air change reductions and fume hood retirements. We estimate that the EMP is currently producing emissions reductions of **20,000 MTCO₂e/yr**, and that this contribution could be increased by 8 to 10% each year, if the existing program is funded at its current level to implement additional projects. Note that the energy and emissions savings of these projects are recurring over the life of the project. Historically, these projects have helped offset the continued growth of campus facilities, and are an important means to do so in the future. If funding is increased, the program could realize additional savings beyond simply offsetting growth.

Central Power Plant Gas Turbine Project: (Contribution to GHG reduction represented by the difference between the red and gray lines in Fig. 1)

4. *Construction of this 15MW natural gas combined cycle project* would reduce the University's total emissions by **145,000 MTCO₂e/yr**. This amount results from the much lower footprint of this facility relative to that of equivalent utility power purchases. The capital cost of this project is \$75,000,000 with an approximate 10 year payback and loan economics based on a 20 year life. Additionally, the project provides for enhanced reliability of electric and steam supplies to the University Campus.

Reduced GHG footprint of purchased electricity: (Contribution to GHG reduction represented by the difference between the gray and salmon lines in Fig. 1)

5. The University currently purchases >60% of its electricity needs from DTE. In 2013 DTE reported that 4.76% of its electricity generation was from renewable sources, and has stated that they will meet Michigan's Renewable Portfolio Standard (RPS) requirement of 10% in 2015. If this fraction increases to 20% by 2020 and by 1% per year thereafter, it would contribute sufficient GHG reductions for U-M to meet its 25% reduction target and reach approximately 28% reduction from the FY 2006 base by 2025, illustrated by Figure 1.

This scenario has a number of actual and perceptual limitations. Some of these are described below.

1. The CPP project is the single largest U-M contributor to meeting the 2025 target. While effective in this regard, it ties us to fossil fuels for at least two decades and likely more. Emissions from this project could be offset by the purchase of RECs; the annual cost would be about \$1,250,000/yr. This is unlikely to be viewed as the action of a climate leader or to engage the campus community in the vision and implementation of GHG reduction. Ultimately it will be important to reduce the level of fossil fuel use, even natural gas, between 2025 and 2050 if national goals such as an 80% reduction of carbon emissions from stationary sources are to be met. It is important in the view of the committee to establish concrete plans for alternate fuels for this facility in the longer term, and/or ways to offset its emissions. It will also be important

for the university to be clear that this investment is part of a transition toward carbon-free alternatives.

2. While continued improvement of DTE's resource mix and its GHG footprint are likely, these may not meet the assumptions above. At present the Michigan Legislature is deliberating whether to alter the current RPS, much less increase it. Also, the ability of the local utilities to meet their reduction goals is predicated on the current proposed EPA regulations on the reduction of use of coal fired electric production. If these regulations are not implemented or are reduced in expectation, it could adversely impact U-M's ability to reach its current 2025 goal, much less surpass it. Thus the contribution of "greener" electricity purchases may not be as large as that projected in Figure 1. Further, to the extent that the footprint of purchased electricity is reduced, the relative advantage of increasing clean generation on campus is also reduced. The total impact of replacing electricity purchased externally with that generated internally is difficult to determine, as internal generation also has the benefit of producing significant amounts of steam that are used for heating of campus buildings. Never the less, it is fair to say that the greener purchased power becomes, the smaller the benefits of generating more power ourselves instead of purchasing it from the public utility system.

The measures listed above are projected to be sufficient to achieve a 20% reduction of U-M's GHG emissions from FY2006 baseline. This falls short of the current goal of a 25% reduction in GHG emissions in 2025 relative to the baseline. This shortfall could also be met by approximately doubling the contributions to GHG reduction from REC purchases and the EMP program. GHG emissions could be reduced even further by purchase of additional certified RECS. Costs of these are uncertain, but the current effective value of \$25/MT per year for RECs purchased from DTE's Green Currents program may be used as a guide. (A brief description of REC prices and "quality" appears in Appendix 1.)

This course of action may be unsatisfying to much of the campus community. It continues current efforts to promote engagement and education, but it relies to a significant extent on plans for natural gas use that many would regard as unsustainable. One should realize, however, that many plans, including to some extent the EPA's Clean Power Plan, do include the elimination of high carbon-content fossil fuel sources in favor of lower content fossil fuels such as natural gas as step toward reduced GHG emissions. For real and perceived reasons it is essential that we consider viable pathways to achieving greater reductions, especially those that can motivate individual and collective behavior changes, leverage engagement and enrich education opportunities. We outline below steps to further reduce campus GHG emissions, with consideration of the capacity, costs, and benefits of each.

Reducing GHG emissions beyond the current goal

The committee has identified two major investment opportunities which, when combined with participation in REC or RIN (biofuel Renewable Identification Number) markets, could potentially offset U-M's entire GHG emissions. There is, not surprisingly, a greater level of uncertainty with these, as we describe below. They offer the advantage of large scale impact on U-M's GHG footprint, but suffer from the disadvantage of being off-campus. Therefore we also consider smaller scale opportunities for on-campus projects that would be more visible and could provide living-learning opportunities for students.

Significant off-campus projects

1. *Landfill gas.* The University is currently considering a proposal for a purchase agreement for landfill gas. This landfill gas is currently being flared, so its consumption for energy generation would not increase overall GHG emissions. This gas could be utilized in different ways, depending on markets and other considerations. If consumed to fuel the U-M Central Power Plant 15MW turbine, we estimate that it could reduce net GHG emissions by approximately **54,000 MTCO₂e/yr** at a likely cost premium relative to natural gas at current market prices. When added to the portfolio of emissions reductions discussed above this would bring U-M's net reduction from FY2006 levels to approximately 28%, as illustrated by the blue line in Figure 1. One advantage of the landfill gas purchase is that the remaining GHG footprint of the CPP turbine project could be negated directly by use of an *identifiable*, in-state renewable resource.

If U-M decides to participate as a seller in renewables instruments, there is a potentially lucrative play. Conversion of landfill gas into compressed natural gas or liquid natural gas for transportation fuel (by a third party) would allow us to sell Renewable Identification Number (RINs) rather than RECs. RINs are used to track renewable transportation fuels. The RIN system allows the EPA to monitor compliance with the Renewable Fuel Standard (RFS2), a federal program that requires transportation fuels sold in the United States to contain minimum volumes of renewable fuels. Unlike RECs, RINS represent a federally regulated commodity, and therefore are most often more valuable than RECs. There are 13 RINs/MMBTU and while the value of RINS can fluctuate, each RIN is worth approximately \$1. Sale of the RINs associated with U-M's potential landfill gas at current prices could generate \$10,000,000/yr year. This would be sufficient to purchase RECs at an equivalent price of \$25/MT to offset about 80% of U-M's GHG emissions. If high quality RECS could be purchased at \$20/MT (\$16/MWh), the revenue from RIN sales would be sufficient to purchase sufficient RECs to make U-M carbon neutral. Lower REC prices could actually lead to revenue generation after achieving carbon-neutrality; such funds could be invested in other energy and sustainability projects, or saved in a fund to offset losses if the RIN market turns downward in the future.

It should be noted that the larger the amounts involved, the greater the uncertainty. If RIN markets were to collapse, the "worst case scenario" associated with paying a premium for landfill gas would be the use of this gas in our own power plant (blue line in Figure 1.) That would still reduce our GHG footprint. If the RIN market were to collapse due to changes in the federal RFS, we would potentially still be able to participate in the REC market, with important but lesser financial and GHG advantages as shown in the figure. Therefore the committee recommends aggressive exploration of this landfill gas opportunity. We are also mindful that landfill stewardship is often a contentious issue for immediately surrounding neighborhoods and communities. Any pursuit of this landfill gas opportunity would require early and far-reaching community engagement through a transparent and deliberative set of decision-making processes.

2. *Wind Farm Development.* As a recent University of Michigan Energy Institute analysis has shown, the percentage of Michigan's electricity generated from wind could be increased from

its current level, approximately 5%, to more than 20% at fairly competitive prices. Utility-scale solar is unlikely to be cost competitive with onshore wind in Michigan unless significantly higher penetrations of renewables are achieved. However, in the absence of action by the Michigan Legislature to increase the RPS, development of such resources will lose an important regulatory driver, and is likely to be slowed owing to uncertainty about and variations in natural gas prices. There is a need and an opportunity for large investors committed to renewable energy to continue the advances made thus far. The University of Michigan could set an important example, either alone or in partnership with other Michigan institutions of higher education, by investing in development of additional wind-based energy generation.

Currently U-M purchases 100% of the RECs from two 2.5MW turbines. As future projects would likely involve similar turbines, we can use values for turbines of this size for purposes of assessment. Each turbine costs approximately \$3,000,000, and results in an annual reduction of about 3,500 MTCO₂e/yr compared to current utility emissions. Cast in terms of a capital investment to reduce U-M's GHG emissions, this equates to an investment of approximately \$5.8million for each additional 1% reduction in our GHG emissions from the FY2006 base, and that lasts for the 20+ year lifetime of the wind turbines. A further advantage is that operating costs for wind turbines are much lower than those for natural gas plants, as there are no fuel costs.

The likely location for such a project would be the Thumb region of the state, as that is the location of Michigan's best wind resource. (The wind resource in Ann Arbor is much less, too low for cost-effective power generation.) Therefore U-M would not be able to utilize directly the power generated from a wind farm in which it had an equity stake, and would have to sell this into the electricity market. The remoteness of the site does not directly engage the UM community, but the ecological, energy and GHG benefits are cost-effective. Further, this option could be incrementally scaled up with each installation of a wind turbine, whether initially or over time.

Both of these options would require significant financial commitments by the University. They, along with the other actions considered in this report, can be benchmarked against the cost of REC purchases to offset our GHG emissions. At a REC price equivalent to \$25/MT, UM could meet its 2025 emissions target at an annual cost of \$6 million/yr by purchasing RECs and offset its entire emissions at a cost of about \$23 million per year at maximum projected levels in the absence of other mitigation actions. Note that these are *annual* costs – these amounts would need to be spent year after year. Also, the cost per MT could rise in unpredictable ways. Many in the campus community would regard this path as “simply buying our way out.” For that reason, *the committee strongly favors investments, even if less economical today, to both green our energy supplies and to reduce our consumption.* If our GHG reduction goals turn out to be high relative to the outcomes of such investments, then REC purchases may be considered to cover shortfalls. We do not recommend them as the *principal* tool for reducing the University's GHG footprint.

On-campus projects

The committee has identified several additional projects that could be carried out on campus or nearby. These generally have lesser capacity for impacting U-M's GHG footprint and/or less favorable

economics, but they represent an important set of opportunities for visible, on-campus investment, engagement, and education. They should therefore be included as options for investment of University resources, especially if other projects, e.g., landfill gas, become significant revenue generators.

3. *On-campus solar photovoltaic (PV) array.* The two solar arrays installed by DTE on the U-M North Campus provide a good benchmark for assessing the potential for an investment in PV. As a base case we consider a 1 MW installation (twice the size of the DTE installation on Plymouth Road) which might be sited on University property. Such an installation would have a capital cost of about \$1.8 million and cover about 5 acres. This 1 MW installation would be expected to generate about 1200 kWh per year, resulting in electricity cost savings of approximately \$100,000 per year, i.e., a roughly 22-year payback. GHG reduction would be about 1000 MTCO₂e/yr, or about 0.15% of the FY 2006 base.

For comparison with the Wind Farm Development option above, large scale solar would have a capital cost of about \$12.2 million per 1% of GHG reduction and would require an array area of about 35 acres. While the latter number sounds large, it is less likely to be a limitation than is capital cost. U-M has approximately 9,600,000 square feet (220 acres) of surface parking lots. If one assumes that half of this space could be covered by solar canopies, nameplate capacity would be about 22MW and the resulting power output would reduce U-M's GHG emissions by about 3.3% from the FY 2006 base, at a capital cost approaching \$40 million.

While the economics, whether of a 1 MW array or 20 MW of solar parking lot canopies, may not be competitive with other options, demonstration projects within this size range could be highly visible and could provide development or partnership opportunities for individual or corporate advocates of solar technologies. Smaller scale projects, e.g. solar or wind on campus buildings, are likely to have even less favorable economics, but may present learning or development opportunities that make them worthwhile to consider. Location of such projects on the North Campus, the hub of much of U-M's energy research, could be especially valuable in providing educational and research opportunities.

4. *North Campus geothermal.* Since the North Campus is powered exclusively by energy purchased from DTE, it offers an attractive venue for alternative energy projects. One that might be well suited is a North Campus geothermal installation to reduce heating and cooling loads of the buildings. Current estimates are that this could reduce U-M's GHG footprint by as much as **20,000 MTCO₂e/yr**, or 3% of the FY 2006 base, at a capital cost of \$22M. Thus the capital cost per 1% of GHG reduction is comparable to that of the Wind Farm Development option described above, but the ultimate capacity is limited by the area of the North Campus. Cost, GHG emissions benefits and scope require further analysis beyond the rough estimates here. While this project would be less visible than an above-ground PV array, it could still include useful educational opportunities through transparent and accessible design of the associated utility plant.
5. *On-campus wind turbines.* The wind resource in Ann Arbor is insufficient to justify investment in large, utility scale (MW) turbines. However, for purposes of visibility and learning, it may be worthwhile to consider installation of smaller scale turbines. Costs of 10 to 15 kW units are about \$50,000 and up. Such units would not have a significant impact on U-M's GHG footprint

and are unlikely to have viable payback times, but may provide useful demonstrations of carbon-free electricity generation on campus. Moreover, there are multiple designs for units of this scale (including various types of horizontal and vertical axis designs) and an on-campus demonstration project could be used to “race” and compare different designs. Partnerships with manufacturers could further reduce institutional costs.

6. *Competitive demonstration projects.* We are privileged to be part of a highly talented, creative, and energized campus community. We should make the most of that, particularly in the pursuit of visible, on-campus, demonstration and education projects. The on-campus projects that this committee has described tend to be small in GHG impact and have relatively unfavorable paybacks, but if we are willing to consider such investments, we should engage the creativity of our entire community. Therefore we recommend making available funds for competitive proposals for demonstration projects that have impact on-campus in demonstrating and educating students about paths to GHG reduction through generation alternatives and reduced consumption/efficiency improvements. The scope the program at U-M requires further development, but we note that other universities have successfully implemented such programs.

Opportunities recommended for further evaluation

The options described above to meet and to exceed our current 2025 GHG reduction goal are focused almost entirely on reducing the GHG footprint of the energy we use. Supply-side impacts tend to have the larger impacts and more easily quantifiable costs and benefits. It is critical, however, to include actions that also reduce consumption. Indeed, energy conservation – the “negawatt” in the case of electricity – is often the lowest hanging fruit, with the lowest capital costs and shortest paybacks. These can have an important cumulative impact and are more likely to serve as focal points to energize campus engagement. The University has an active program of energy conservation that provides a foundation for expanded efforts. This and other opportunities that should be explored further are described below.

1. *Expand the Energy Management Program (EMP), in the existing covered buildings (General Fund) as well as to non-GF buildings.* U-M’s energy conservation efforts date back to the early 1980s. These efforts have helped to minimize the growth of the University’s energy consumption and GHG emissions even as building space on campus has grown over 22% since 2000. Projects such as occupancy sensor controls for lighting and HVAC systems, lighting retrofits, building system controls upgrades, and lab air change reductions have been important contributors to reducing consumption. The current budget for ECM projects is \$3,400,000/yr. However, this program is restricted to General Fund buildings, which constitute about 45% of U-M’s total space in Ann Arbor.

Table 1 compares the space growth and energy consumption change from FY04 to FY14 for six budget units, ranked in order of consumption. Excluding NCRC, for which a baseline cannot be established for this period, it is apparent that General Fund buildings, Student Life, and Auxiliary units have decreased consumption as space has grown. In contrast, Athletics and the University

Hospital have seen dramatic growth of consumption, in one case with and in the other without significant growth of space.

Because the nature, use and vintage of the facilities within each of these units vary significantly, it is not possible to identify the magnitude and cost of an expanded EMP in each without more detailed analysis. Actual and apparent impacts may also be quite different. For example, while Athletics represents only about 3% of the total, its activities tend to be highly visible. The University Hospital is the second largest consumer, but with many operations that cannot be put at risk. Never the less, we believe that there exists a very timely and important opportunity to extend U-M’s Energy Management Program and ECMs to all units, and to expand it within General Fund Buildings as well. The experience of the EMP program to date is that capital investments of about \$1,100 achieve 1 MTCO₂e per year reduction for the duration of the project life. These projects have all had paybacks of 8 years or less, making them net revenue generators. While much low-hanging fruit has already been picked, this provides a benchmark for assessing impact and cost of energy conservation investments vs. other options for reducing GHG emissions.

Table 1. Comparison of energy consumption, consumption growth and space growth by budget unit

Budget Unit	FY 14 energy consumption (billion BTUs)	% Change in energy consumption, FY04 to FY14	% Change in space, FY04 to FY14
General Fund	3230	-3.5	+22.2
University Hospital	1200	+45.0	+81.0
NCRC	800	+9.5 (FY10-FY14)	n/a
Student Life	415	-5.8	+1.2
Auxiliary units/others	270	-15.6	+35.7
Athletics	200	+93.6	+56.0

An expanded Energy Conservation Program also provides an important opportunity for more direct and meaningful engagement of individuals and units in working toward a common goal. Student Life has been effective in using competitions between residence halls to decrease energy consumption, increase recycling etc. Similar competitions within other units might be implemented or expanded. Modifications to energy charges and rebates to units to incentivize ECM should also be considered.

A more aggressive position with respect to ECM would be to revise the payback requirements. As noted above, currently the expected payback for ECM investments is no more than 9 years. This essentially places no value on carbon. By including the cost of carbon, at least at the level required to purchase offsetting RECs, a greater range of ECM projects would become economically viable. Extending this approach further, units could be required to offset energy consumption due to space or activities growth, either through ECM projects or REC purchases or a combination of the two.

2. *Improve building design practices and standards.* The current U-M standards for design and construction of new buildings use LEED silver certification and the American Association of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE) 90.1-2007 energy code requirements +30% for all projects with a construction budget of \$10,000,000 or greater as the principal sustainability and energy criteria. LEED is a broad-based green building standard that includes, but does not focus exclusively on, energy consumption and GHG emissions reduction, whereas ASHRAE is focused exclusively on energy. To increase the energy efficiency of U-M's building stock, we recommend that the University adopt ASHRAE 90.1-2007 +50% as its energy standard and consider even more aggressive approaches, such as ASHRAE 90.1-2013, or the American Institute of Architects AIA 2030 Commitment, which also focuses directly on energy and GHG reduction. Both of these alternatives have lower upfront administrative and certification costs (which can be substantial in the case of LEED.)
3. *Expand partnerships with the City of Ann Arbor.* Partnerships with the City provide excellent opportunities for reducing U-Ms footprint while increasing community engagement and visibility. Expansion of cooperative efforts with recycling, composting, and a bio-digester to generate energy from waste should be considered, as well as transit, shared bikes and other shared vehicles (recognizing that some of the latter would only affect Scope 3 emissions.) Other capital projects such as solar, wind and biogas facilities may represent additional partnership opportunities.
4. Expand internal university policy on the purchase and use of energy using equipment. This can refer to small devices in offices to large HVAC or research equipment in our labs and other facilities. Saving from Policy can be expected to add first cost but can be expected to dramatically reduce energy use and associated GHG emissions. This is the lowest first cost per ton of GHG removal and could impact university GHG emissions by 5 to 20 %. Some actions could be as simple as requiring coffee makers to have thermoses instead of hot plates, or shortening the duration of motion- and light-activated switches. There are also likely savings to be had from laboratories and research equipment. Additional purchasing requirements or process steps are unlikely to be acceptable to researchers. However an incentive program to retire older, inefficient or duplicative laboratory equipment could be effective.

From GHG reduction to Carbon neutrality: Setting the target at zero

We have outlined above a pathway for meeting the University's 2025 target for GHG emissions, and options for reducing emissions beyond this target. Some of these are not directly comparable, but Table 2 below attempts to summarize costs and capacity limits for each for reductions beyond the 2025 target.

Table 2. Costs and capacities for actions to reduce GHG emissions from the FY2006 baseline.

Action	Recurring cost for 1% GHG reduction	Capital cost for 1% GHG reduction	Capacity limit (as a % of FY 2006 baseline of 680,000 MT/yr)
REC purchases	\$170,000		
Landfill gas burned in CPP	\$930,000	NA	8%
Landfill gas converted to RINS	Generates revenue	NA	Potentially >100%, depending on RIN and REC prices
Wind farm	NA	\$5,800,000	Off-site
On-Campus PV	NA	\$12,200,000	3% (parking lot canopies)
North Campus Geothermal	NA	\$7,300,000	3%
ECM		\$5,600,000	20%?
Campus Policy	NA	1 to 5% of equipment cost	20%

As noted at the beginning of this report, many other institutions have set more ambitious climate goals than U-M and many have committed to carbon neutrality. While the path may not be entirely clear (or indeed represent a unique solution) we hope that the analysis here clarifies some of the actions and associated costs that could move us toward carbon neutrality. There is need for ongoing work to chart our course as these options evolve, as well as to generate the necessary funds to pursue them.

Therefore we make 3 additional recommendations for serious consideration.

1. *Develop plans for and implement an internal carbon tax.* There is a need to incentivize individuals and units to reduce their energy consumption and carbon footprints, as well as to generate resources for the institutional investments required. Various academic institutions have begun to discuss ways to price carbon internally, and Yale is in the process of piloting one. This builds on the substantial academic literature that endorses a direct carbon pricing mechanism, such as a tax, as the best way to drive long-term energy transition and could draw from global best practices in North America and beyond. The committee strongly supports the development of an internal carbon price at the University of Michigan. This could place U-M in the leadership vanguard, if pursued quickly.

We are well aware that despite the simplicity of its appeal, development and implementation will be challenging. Issues range from compliance with federal regulations regarding allowable charges, to robust methods of quantifying carbon emissions contributions at the unit level, to setting the price to determine the use of funds generated – e.g., should such a tax be revenue neutral, or used in some part to build up a climate-friendly investment pool? We therefore enthusiastically recommend that a task force be established to develop a plan for an internal carbon tax, with the goal of making Michigan the nation’s first public university to take such a step. This has the potential to be the initiative that most raises GHG consciousness and rallies behavioral changes at both the individual and unit level.

2. *Develop a plan to address Scope 3 emissions.* Although outside the purview of this committee, we recommend that a parallel exercise be carried out to develop a plan and target for reduction of U-M's Scope 3 (transportation related) emissions. This committee should consider ways to reduce emissions associated with commuting to and from campus, as well as business travel by University personnel. Such an effort could be done in partnership with U-M's Sustainability Cultural Indicators survey, which already assesses the commuting behavior of faculty, staff, and students, and plans to add questions regarding university-related air travel. Air travel is a large, highly masked GHG producer that especially warrants actions to quantify and reduce. Data to assess the magnitude of university-related air travel could be extracted from the Concur system as a first step.
3. *Establish a standing committee to evaluate progress regularly and to assess future opportunities.* The activities of the present ad hoc committee have revealed to its members the need for continuing assessments of both progress and opportunities to reduce the University's GHG emissions. We recommend that a standing committee be formed that will carry out this work on an ongoing basis in the future, and that faculty, staff, and students are represented on the committee.

Appendix 1

Summary of REC types and prices

Renewable Energy Credits (RECs) take several forms, which can greatly impact their cost and environmental value. Compliance RECs (i.e., those required to meet state-level Renewable Portfolio Standards), are typically the most valuable. These RECs must meet the requirements of the state's RPS, including such factors as technology type and plant vintage. Main tier compliance RECs can exceed \$60/MWh, but lose considerable value in saturated markets (<http://apps3.eere.energy.gov/greenpower/markets/certificates.shtml?page=5>).

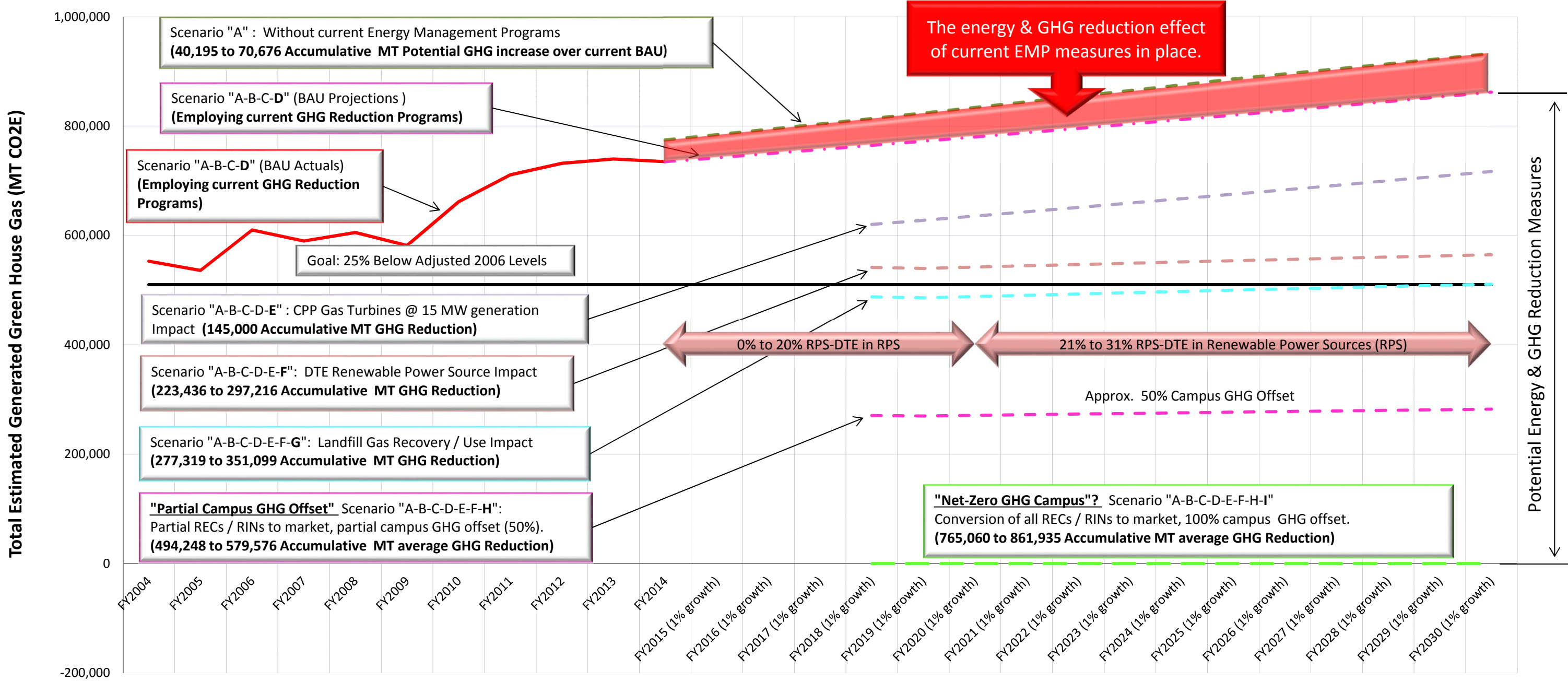
Voluntary RECs are not driven by RPS compliance, but instead by the desire of a company or individual to purchase renewable energy credits to offset the impact of their electricity consumption. U-M currently purchases REC through DTE Energy's voluntary REC program at a rate of \$20/MWh. The quality and cost of voluntary RECs can vary greatly. Voluntary RECs of any quality can be obtained for as little as \$1/MWh (<http://apps3.eere.energy.gov/greenpower/markets/certificates.shtml?page=5>), but the environmental value and the *additionality* of such products are often challenged.

- For compliance-quality RECs, without the benefit of the PTC (production tax credit), costs would be higher (>\$40/MWh).
- Voluntary RECs **of any quality** are really cheap, roughly \$1 or \$2/MWh (see: <http://apps3.eere.energy.gov/greenpower/markets/certificates.shtml?page=5>)
- The premium for "better" voluntary RECs depends on the requirements. The green-e website (http://www.green-e.org/base/re_products#res) links to many providers of voluntary RECs.
- \$20/MWh is consistent with the current costs for DTE's GreenCurrents Program, which is mostly biomass and a bit of wind. (https://www2.dteenergy.com/wps/portal/dte/business/productsPrograms/details/GreenCurrents!/ut/p/b1/jdDBcolwFAXQb-kH1MQkQFwC0YBW0QBR2TiliCCIWggVr2_poovOlPbt3sy5i3tBADYguIR1moRVWl7CvPsDdYfpy0lqvrPyJq4BbSF9pBou5Gz4CbYdcHThkg5A0O4AW1ozivlc-18e_nl6_Cs_BUG6LwZNVAzgQKMqRgQjShVVgRoGkkXnESv1h13Z6bVNmvCaH6z9w3xLJms75peZK8lxmsc0g4QsV2lI3qqDMxqZ3ra6p25ev4tWBjeCHSe5x66lfOM033CIRBjxL7w2Z8l3Rvvnw9mWe5M6E0Ur7axeLBHd6ccSrEHQW0EZ_gQKtim0PR0bPkYlkm_Qs_EX6BlxYZVFDK6Fv2njs7Aa_ekDxSXbDg!!/dl4/d5/L2dBISEvZ0FBIS9nQSEh/)

Green House Gas Trends based on 1% Growth Projection vs 2020 and 2030 Goals With Renewable Power Source (RPS) - DTE

Assistance

Revised: 07/01/15 (by SCF)



Legend / Definitions

"BAU" = Business As Usual.
 "REC" = Renewable Energy Credits.
 "RIN" = Renewable Fuel Identification Number.
 Scenario "A" = Projected Greenhouse Gas Production without mitigation.
 Scenario "B" = Renewable Wind Energy Credit (REC).
 Scenario "C" = North Campus Research Center (NCRC) Gas Turbine.

Scenario "D" = University of Michigan Energy Management Program (EMP).
 Scenario "F" = DTE Renewable Power Source (RPS), up to 20% of total power generated by renewables by 2020, up 31% by 2030.
 Scenario "E" = Central Power Plant (CPP) Gas Turbine Project (15 MW generation).
 Scenario "G" = Landfill Gas (LFG) Project - Use 100% of gas recovered from the landfill site on U of M Campus.
 Scenario "H" = RECs and / or RINs to market. **Partial Campus GHG Offset, 50% from current 2025 target to Net-Zero GHG Campus.**
 Scenario "I" = Conversion of all RECs to RINs to market. **"Net-Zero" GHG Campus?**