The Ohio State University
Climate Action Plan

Endorsed April 6, 2011

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Acknowledgments

The Ohio State University

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Energy Strategies

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April 2011

Dear Friends:

As one of the largest, most advanced research universities in the nation, The Ohio State University committed to achieving climate neutrality by joining the American College and University Presidents' Climate Commitment (ACUPCC) in 2008.

As the ACUPCC states, "We believe colleges and universities must exercise leadership in their communities and throughout society by modeling ways to minimize global warming emissions and by providing the knowledge and the educated graduates to achieve climate neutrality." At Ohio State, we also believe that our future competitiveness depends on being innovative leaders, developing the technologies and embracing the cultural changes necessary to thrive in a world that must reduce carbon emissions.

To achieve this, we have established an inventory of our greenhouse gas emissions and developed a strategic plan aimed at reaching carbon neutrality by 2050. It means using cleaner and more efficient energy, improving the efficiency of our buildings, reducing waste, and supporting better travel and commuting options—all in the context of providing a superior campus environment for education, research, and outreach.

Understanding, gaining benefit from, respecting, and protecting our environment has been a focus of The Ohio State University since its 1870 founding (as the Ohio Agricultural and Mechanical College) through the provisions of the Land-Grant Act of 1862. This Climate Action Plan is one more step toward a truly sustainable Ohio State, leveraging opportunities across constituents, activities, and divisions for a safer, more livable, and sustainable future. I am proud to present The Ohio State University's Climate Action Plan.

Sincerely,

E. Gordon Gee
President

Engaging the next generation in sustainable actions and contributing new knowledge to sustainability practices are vital institutional roles.

1 Toward a Sustainable Ohio State University

1.1 Ohio State's Successes

Founded as a federal land-grant institution, The Ohio State University has one of the largest enrollments, a highly ranked medical center, the largest self-sustaining athletics program, and research funding that ranks in the top 10 nationally. The university has a physical presence throughout the state, with research centers and academic programs that enroll more than 8,000 students beyond the Columbus campus.

Columbus Campus 2010

Established	1870
Student Enrollment	56,000
Faculty and Staff	26,500
Colleges	18
Majors	170
Research Expenditures	$721 million
Campus Buildings	450
Building Area	28 million sf
Land Area	1,762 acres

Long before the term "sustainability" became popular, Ohio State recognized the importance of environmental responsibility. The university has been recruiting and retaining world-class faculty in the fields of energy, agriculture, climate, and environment for decades. Some of the leading research occurs in Ohio State's internationally recognized research centers, including but not limited to the Byrd Polar Research Center; the Center for Energy, Sustainability, and Environment; the Center for Resilience; and the Center for Automotive Research.

Ohio State applies sustainable practices for campus development, energy, transportation, and waste management. Data increasingly are being used to inform capital decisions, and building metering and audits help the university manage and enable resource conservation. While much work remains, Ohio State recognizes the importance of celebrating the sustainability successes already achieved. The following are a sample of some actions that have been completed and already are helping to move the university forward on a more sustainable path.

- Began converting campus buses to B20 biodiesel in 2003 and switched all buses by 2005.
- Invested $1.6 million in building metering upgrades since 2006.
- Formed the Energy Services and Sustainability group in 2006.
- Signed the American College and University Presidents' Climate Commitment (ACUPCC) in 2008.
- Formed the President's & Provost's Council on Sustainability in 2008.
- In 2008, the Nationwide & Ohio Farm Bureau 4-H Center became the first LEED-certified "green" building on campus.
- Adopted a campus Green Build and Energy Policy in 2009.
- Eliminated trays in dining halls in 2009, reducing 70% of food waste while saving water and energy.
- In 2009, partnered to reclaim Dining Services' used cooking oil, one byproduct being biodiesel fuel.
- In 2010, opened a new student union with a pulper system for delivery of food waste to a local compost facility.
- Purchased 18 million kWh of green electricity in FY 2010.
- Phased in desk-side recycling in offices and an all-in-one container collection system in 2010.
- Recycled 53% of waste at Ohio Stadium and the tailgate lots during the 2010 football season.
- The Ohio Union achieved LEED Silver certification in 2010.
- Ohio State appointed its first Vice President and Enterprise Executive for Energy and Environment in 2010.

Ohio State is increasingly taking a holistic view of sustainability. The President's and Provost's Council on Sustainability adopted goals in 2009 to reduce climate impacts associated with university operations. These goals, a few of which are outlined below, were revisited and updated through recent planning efforts related to sustainability and energy. Details about current initiatives can be found on the university's sustainability website, http://sustainability.osu.edu/.

- Plan for carbon neutrality by 2050.
- Implement energy conservation initiatives.
- Expand the university's renewable energy portfolio.
- Complete annual inventory of GHG emissions.
- Encourage green computing practices.
- Reduce SOV commuting and promote alternative modes.
- Improve fleet purchasing standards.
- Consider policy for air travel tax/carbon offsets.
- Increase awareness and recycling rates.
- Work toward zero waste goal.

1.2 Ohio State's Climate Action Plan

This Climate Action Plan (CAP) describes some of the steps Ohio State has taken to reduce GHG emissions and its ideas for future steps toward a goal of carbon neutrality by 2050. This document also lays the groundwork for a university-wide conversation about the importance of climate action. This includes addressing climate neutrality in operations and building development and the core activities of the university—education, research, and outreach.

The CAP must be a living plan with periodic evaluations to measure the impact of existing actions, to explore innovative strategies, and to recognize progress. There is no reliable method to forecast the myriad of variables that may impact the GHG emissions of the university for the next 40 years. More than 300 Ohio State faculty members are engaged in research focused on energy and the environment. As such, the university fully expects that some of the solutions that will be implemented within the 2050 timeframe of the ACUPCC have yet to be discovered or fully developed. Naturally, specifics are easiest for near-term plans. As the planning horizon moves further out, specifics become less reliable.

The specific measures detailed in this CAP are focused on the near term, defined as 2010 through 2014, to generally coincide with the university's known capital budget plan. The university has begun to investigate some measures that appear to have potential merit and may be incorporated in the plan beyond 2014. These measures and others will be given additional specificity as appropriate in subsequent biennial reviews of the CAP.

This CAP has been developed within the context of several concurrent planning studies that incorporate sustainability concepts and strategies, including the One Ohio State Framework.[1] The CAP also accounts for recent changes in Ohio law (ORC Titles 33, 49, and others) that aim to reduce energy consumption or promote certain alternative or renewable fuels and therefore have the potential to reduce greenhouse gas emissions. This CAP draws information and data from these planning and regulatory sources as appropriate.

The first step to achieving climate neutrality begins with understanding the nature of the problem.

2 Greenhouse Gas Emissions Inventory

2.1 Toward Climate Neutrality

Climate neutrality is defined as:

> *having no net GHG emissions, to be achieved by minimizing GHG emissions as much as possible, and using carbon offsets or other measures to mitigate the remaining emissions if necessary. The sources of emissions covered under the ACUPCC are Scope 1, Scope 2, and two elements of Scope 3: commuting, and air travel paid by the institution. The concept of "carbon neutrality," "climate neutrality," or "GHG neutrality" has been evolving and there is currently no universally agreed upon definition of the term ... for the purposes of the ACUPCC the above definition is used for all three terms.*[2]

A greenhouse gas emissions inventory provides a detailed profile of annual GHG emissions, by energy source and use and in terms of climate impact.

This inventory considers all of the major greenhouse gases that contribute to anthropogenic climate change, in accordance with Intergovernmental Panel on Climage Change (IPCC) guidelines.

2.2 Emissions Inventory Process

Methodology

The FY 2009 inventory of Ohio State's greenhouse gas emissions is the most recent and forms the basis of this report. The primary means of collecting data and reporting on the GHG inventory is through the

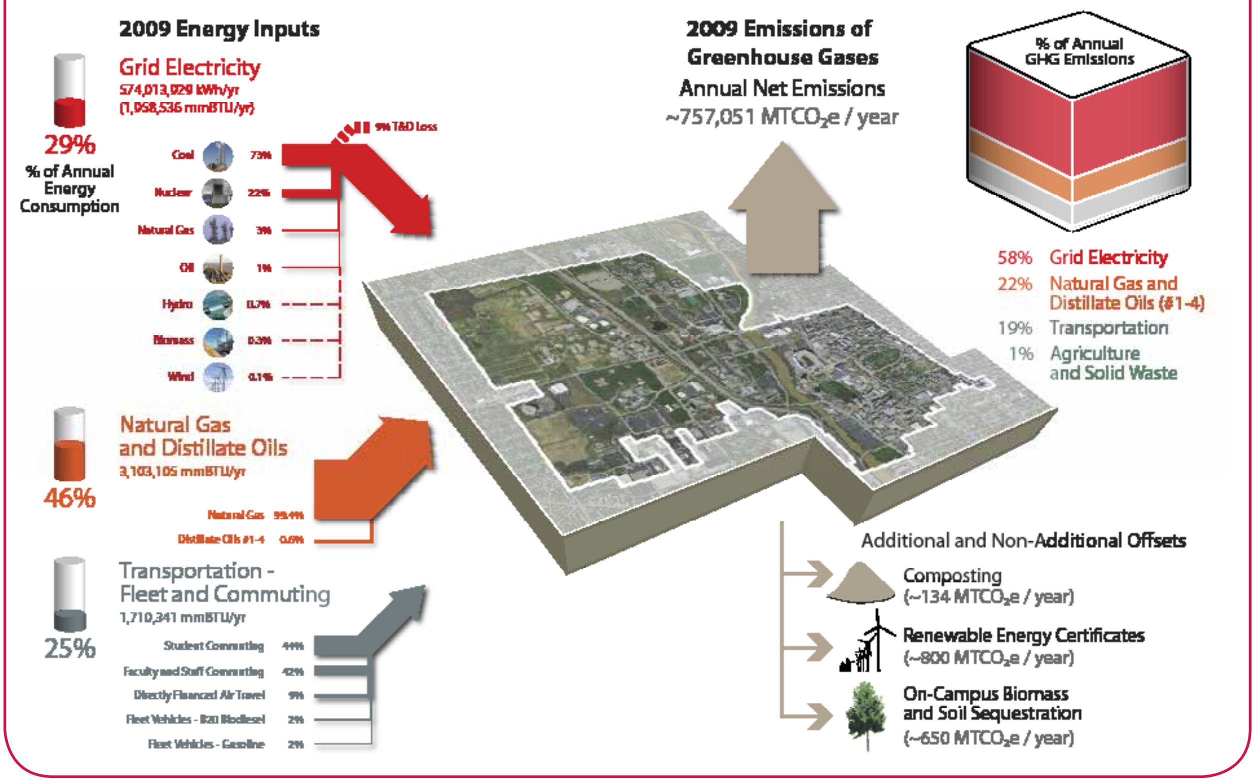

Figure 2.1 - Energy Inputs and Greenhouse Gas Emissions

Data: The Ohio State University CACP

use of the Campus Carbon Calculator developed by the non-profit group Clean Air – Cool Planet (CACP). Version 6.4 of the calculator was used for this report. The CACP calculator is the preferred tool of the ACUPCC for emissions inventory purposes because it is comprehensive and based upon the standard methodologies codified by the GHG Protocol Initiative.

Data for this report has been provided by Ohio State's Energy Services and Sustainability (ESS) group, a program in Facilities Operations and Development. Most emissions information has been collected and recorded with student support and represents data for FY 2009 (from July to June), unless otherwise noted. Additional analysis about energy use and other material throughputs have come from various sources at the university and from Ohio State's consultants. The consultants also provided content, including data, diagrams, and energy strategies for Scope 1, 2, and 3 emissions.

Organizational Boundaries

The emissions inventory and the CAP in general cover Ohio State's Columbus Campus. It includes more than 80,000 students, faculty, and staff; covers nearly 1,800 acres; and is located approximately 3 miles north of the downtown Columbus central business district.

Operational Boundaries

Operational emissions are divided into three categories by the degree of control that an organization has over the creation of those emissions. Scope 1 emissions are directly controlled by the university. Scope 2 emissions are indirectly controlled by the university through its use of energy produced off campus, such as electricity. Scope 3 emissions are from sources that are neither owned nor operated by the university, such as commuting.

2.3 Sources of Emissions

Nearly all of Ohio State's GHG emissions are related to energy use. This includes electricity, natural gas, and liquid fuels such as gasoline and diesel. Some minor, non-energy sources of emissions exist and are included in this report. Figure 2.1 depicts the energy inputs and greenhouse gas outputs for Ohio State.

Figure 2.2 shows Ohio State's FY 2009 greenhouse gas emissions by scope. Scope 2 emissions from purchased electricity account for more than half of annual GHG output. The remaining portion is split fairly evenly between Scopes 1 and 3.

Scope 1 Emissions

Scope 1 represents direct emissions from sources owned or controlled by the university. This includes the combustion of fossil fuels to support Ohio State facilities and the university vehicle fleet. Also included are emissions related to agriculture and livestock as well as the fugitive emissions from refrigerant use. The primary sources of the university's Scope 1 emissions are:

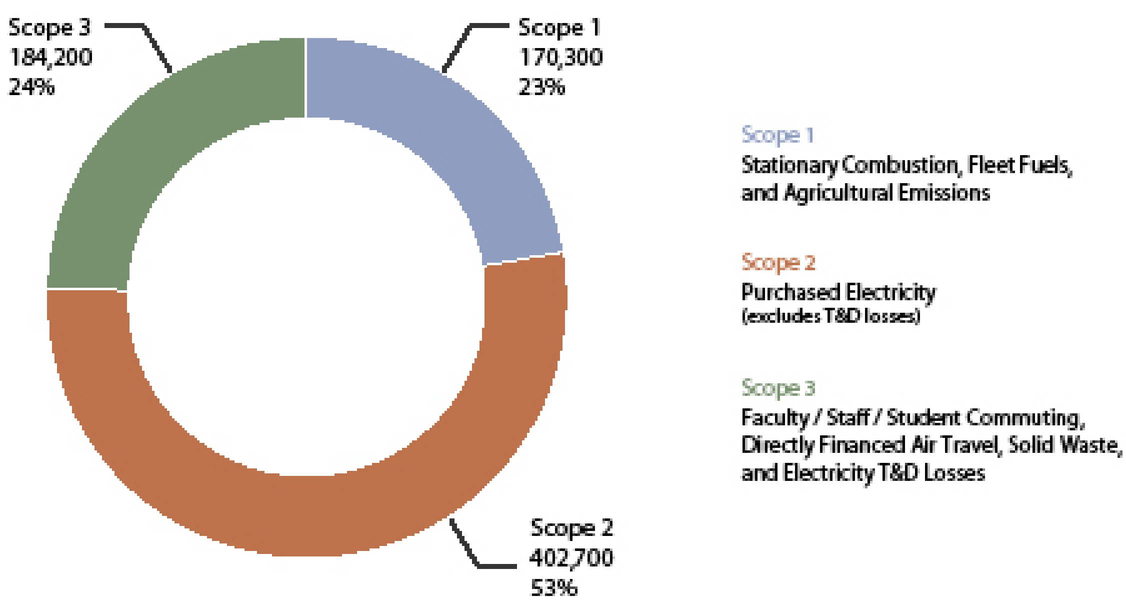

Figure 2.2 - 2009 GHG Emissions by Reporting Scope - MTCO$_2$e
Image: Mithun
Data: The Ohio State University

- Stationary combustion of natural gas and fuel oil.
- Use of motor vehicle fuels across the university fleet.

In a typical year, 80-85% of the natural gas delivered to campus is used at the McCracken utility plant to provide steam to 135 buildings of the 400+ buildings on the Columbus campus. The remaining natural gas is piped directly to smaller combustion units that are distributed across campus and used primarily for hot water. Consumption of natural gas accounts for approximately 22% of the university's annual GHG emissions.

Ohio State operates nearly 900 vehicles in its fleet. This includes approximately 150 passenger cars, 50 buses, 250 vans, and 440 trucks. About 15% of the university's fleet uses B20 biodiesel, representing about half of total fuel consumption. The remaining non-electric vehicles predominantly use gasoline. In all, Ohio State's fleet contributes less than 1% of the university's total annual emissions.

Ohio State is nationally recognized for its food and agricultural sciences programs. These programs use fertilizers and maintain dairy cows, poultry, and other livestock, all of which contribute approximately 0.01% of the university's annual greenhouse gas emissions, mostly in the form of nitrous oxide (N_2O) and methane (CH_4). In total, Scope 1 emissions are approximately 23% university emissions.

Scope 2 Emissions

Scope 2 emissions are from energy produced elsewhere and delivered to campus by a utility provider. Ohio State's only Scope 2 emissions are from electricity delivered to campus by the local utility, American Electric Power (AEP). While the university purchases electricity through AEP, it actually receives its electricity supply through a complex distribution system known as "the grid." Grid electricity has a climate impact that is directly related to the fuel sources used at the power plants generating that electricity. The Environmental Protection Agency provides GHG emissions estimates for electricity generated within each subregion based upon the mix of fuels used. Ohio State is located geographically within the electric utility region named the Reliability First Corporation – West or RFCW. Most of the electricity within the RFCW subregion is produced by burning coal.

In 2009, the university consumed more than 570 million kilowatt hours of electricity, equivalent to the amount required to power approximately 60,000 Ohio homes.[3] Because of the subregion's heavy reliance on coal and because Ohio State has already eliminated its coal-fired boiler from the central plant, consumption of grid electricity is the university's single largest source of greenhouse gases, representing approximately 53% of the university's total annual emissions.

As noted in the earlier description of regulatory context for this CAP, new state laws related to energy efficiency and portfolio standards will cause the fuel mix of "the grid" to change. The deployment of yet-unproven technologies such as Carbon Capture and Sequestration (CCS) or cellulosic biofuels also may change the environmental footprint of more conventional fossil-fuel technologies. Scope 2 emissions are expected to decrease eventually based on these advancements.

Scope 3 Emissions

While many corporate inventories consider Scope 3 emissions to be optional, the ACUPCC requires the reporting of certain Scope 3 emissions that are directly related to university activity. The following emissions are included in this plan:

- Student, faculty, and staff commuting to campus.
- Transmission and distribution (T&D) losses for purchased electricity.
- Solid waste management.
- Directly financed air travel (for faculty and staff business purposes).

Solid waste generated on campus is delivered to two landfill sites in the region. The Solid Waste Authority of Central Ohio (SWACO) requires that all solid waste generated in Franklin County must be delivered to the Franklin County landfill. Approximately 8,000 tons (70%) of Ohio State's solid waste is delivered to this facility that actively captures and flares methane gas released from decomposing matter. An additional 3,400 tons (30%) of solid waste from The Ohio State University Medical Center is delivered to another landfill that properly disposes of medical waste not suited for the Franklin County landfill.

Under EPA regulations, most landfills are required to collect methane gas and prevent its escape into the atmosphere as fugitive emissions. Typically this methane is "flared." This on-site burning of methane produces some CO_2, but consuming the methane, which has a global warming potential 32 times that of CO_2, substantially reduces the climate impact.[4] The publicly-owned SWACO facility is currently producing compressed natural gas (CNG) for use as a vehicle fuel, with plans to greatly expand output to serve an emerging CNG infrastructure within the state. SWACO is planning to generate some electricity on site through combustion of methane in microturbine engines.[5]

In May 2010, Ohio State's Office of Transportation & Parking Services conducted a transportation survey to learn more about commute patterns of the university community including mode-split and total annual vehicle miles traveled by Ohio State commuters. The survey showed that more than 80% of faculty and staff commutes are made in SOVs. About 58% of graduate and 35% of undergraduate commutes are in SOVs. In all, faculty and staff drive roughly 90 million miles commuting to and from campus each year. Graduate and undergraduate students add another 148 million vehicle miles.

The approximate mode split for all commuters for a typical academic quarter is as follows:

Drive Alone (SOV)	70%
Walk	10%
Bus	7%
Bicycle	5%
Carpool	4%
Other	4%

Directly financed air travel, as estimated in FY 2009, contributes almost 4% of annual net emissions. Currently the university does not have an automated tracking mechanism for directly financed air travel.

Ohio State's purchase of Renewable Energy Certificates (RECs) includes:

- 2,280,000 kWh in FY 2008
- 1,140,000 kWh in FY 2009
- 18,000,000 kWh in FY 2010

3 Achieving Climate Neutrality

3.1 Overview of Mitigation Strategies

Achieving climate neutrality will require aggressive reductions, avoidance, and neutralization in existing and future GHG emissions. One thing is clear – there is no single solution. Many strategies will need to be implemented to meet the overall goal. Not every strategy will be feasible given the uncertainties of future operational needs, financial requirements, and technology developments. Ohio State will set priorities based on the relative impact of various reduction opportunities, as described in this chapter.

The current and near-term strategies have been most clearly defined (Fig. 3.1). Note that the increase in GHG emissions (2013-2014) is largely attributable to the expected completion of the 18-story, 1 million GSF addition to the Medical Center. The longer-term strategies discussed below are some of those under investigation at Ohio State.

A number of direct emission mitigation strategies have been identified for emissions related to building and infrastructure energy use. Some of the strategies slow the rate of increase in emissions; others eliminate emissions through efficiency and behavioral change. For the near-term strategies, Ohio State has already identified likely reductions to an average annual GHG abatement of more than 125,000 $MTCO_2e$. Beyond the clarity of the near-term strategies, Ohio State has begun to look at mid- and long-term strategies that could involve further reductions of nearly 500,000 $MTCO_2e$ by 2050; however, meeting the climate neutral target likely will require more than these

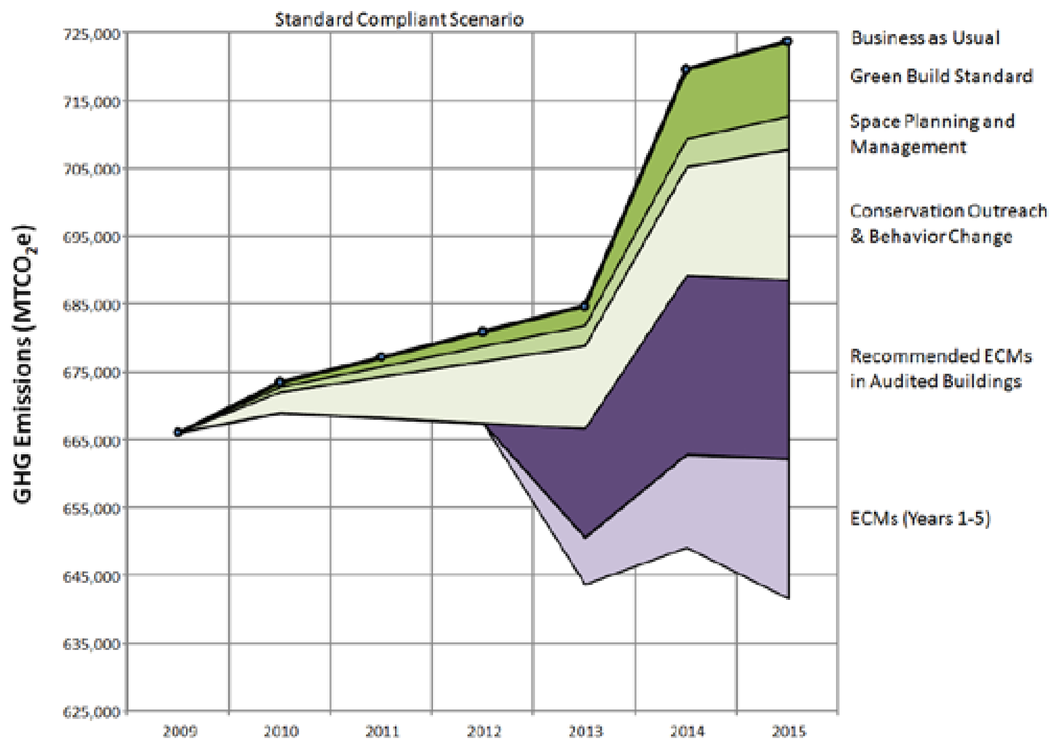

Figure 3.1 - Energy Strategies - Reduction from Business-As-Usual
Image: AEI
Data: AEI, The Ohio State University

strategies. Additional abatement strategies may include innovations yet to be developed, changes to commuter patterns based on a transportation management plan, and/or the purchase of offsets representing CO_2e reductions elsewhere. In this context, the suite of mitigation strategies described above will need to be continually evaluated over time as existing technologies improve and new technologies are developed.

3.2 Building and Infrastructure Energy Strategies

There are three primary means of addressing Ohio State's energy-related GHG emissions. The first is to avoid emissions from occurring altogether. The second is to optimize existing energy systems by improving efficiency and reducing demand. The third is to replace fossil fuel energy with alternative or renewable sources that are less harmful. Figure 3.2 shows a variety of opportunities for reducing the climate impact of Ohio State's operations.

Near-term strategies that have been identified as most feasible include:
- Green building standards.
- Space planning and management.
- Energy conservation measures and behavioral change.

Possible strategies for mid- and/or long-term evaluation include:
- Combined heat and power plant (CHP).
- Heat recovery chillers.
- Regional chiller plants.
- Back pressure steam turbines.
- Geothermal heating and cooling.

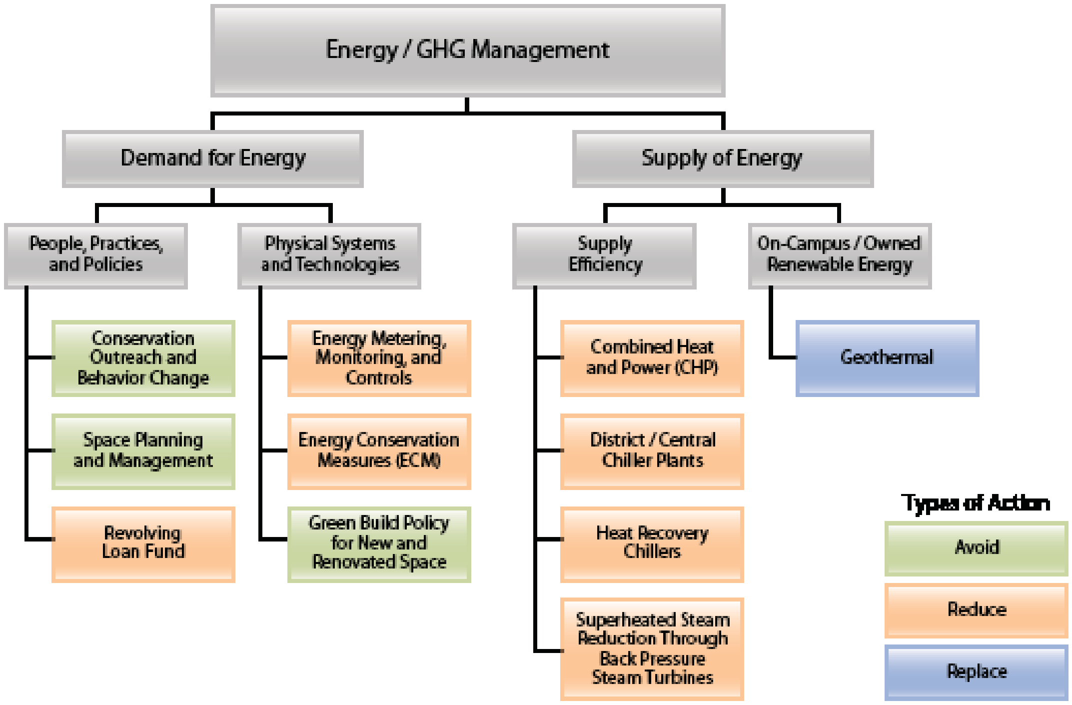

Figure 3.2 - Building and Infrastructure Energy Strategies
Image: AEI

Near-Term Strategies

Green Building Standards
The Green Build and Energy Policy for new and renovated space is an extension of planning work conducted in response to 2008 changes in state law. The policy recommends immediate Energy Utilization Index (EUI) targets for the various space types likely to be built as part of the campus evolution, consistent with the One Ohio State Framework.

These targets are all lower than the current campus average Energy Utilization Index and are estimated to be between 20-30% more efficient than ASHRAE Standard 90.1-2004. The initial EUIs recommended for 2010 also are assumed to significantly decrease each decade until 2050 where the goal is to reach net zero. As modeled in this plan, a 5% cost premium is maintained throughout the planning period to achieve the recommended performance standards. Figure 3.3 describes summary metrics associated with possible costs and benefits of the green build strategy.

IRR*	PV of Incremental Capital Cost* 2010 $Millions	Levelized Cost per $MTCO_2e$ Avoided*	Average Annual GHG Abatement* ($MTCO_2e$)
N/A	$90	$10	28,700

Figure 3.3 - Green Building Standards - Standard Compliant Scenario
Source: AEI

 *See Appendix - Definitions.

Space Planning and Management

An important principle articulated in the One Ohio State Framework is the concept of "no net new academic space." If and when the university constructs new academic space, it also intends to plan for deconstruction and removal of existing academic space. Growth of supporting uses (such as residential life) and auxiliary uses (such as the Medical Center) may be justified to meet university goals. As an example, the Medical Center will add a net 660,000 sq.ft. when its Cancer and Critical Care Tower opens in 2014.

The historic trend (reference case) for campus space growth has been to add approximately 200,000 gross square feet (GSF) on an annual basis. Capping academic space growth, while permitting some supporting use development, results in a net decrease of approximately 50,000 GSF to the reference case. The university has benefitted from this strategy since 2010. Figure 3.4 represents the climate impacts of this strategy.

IRR*	PV of Incremental Capital Savings* 2010 $Millions	Levelized Savings per $MTCO_2e$ Avoided*	Average Annual GHG Abatement* ($MTCO_2e$)
N/A	$470	$2,106	12,600

Figure 3.4 - Space Planning and Management
Source: AEI

Conservation Outreach and Behavioral Change

Building on the Scarlet, Gray & Green energy conservation outreach initiative, Ohio State will strive to expand its conservation outreach and behavioral change to reach a broader campus population with initiatives that target energy use by students, faculty, and staff. The goal is to educate the community and promote the responsible use of energy while discouraging wasteful energy practices. A secondary goal is to educate the campus population about the role of energy in society and to foster a sense of responsibility toward environmental conservation (Fig. 3.5).

IRR*	Levelized Savings per $MTCO_2e$ Avoided*	Average Annual GHG Abatement* ($MTCO_2e$)
N/A	$120	19,200

Figure 3.5 - Conservation Outreach and Behavioral Change
Source: AEI

*See Appendix - Definitions.

Energy Conservation Measures

In addition to the outreach efforts to evoke behavioral change, a broad umbrella of "energy management" strategies includes several energy conservation opportunities. Specific conservation measures for approximately 3 million GSF of recently audited campus buildings and ongoing investments in energy conservation measures are anticipated (Figs. 3.6 and 3.7). Taken together, the projects provide an average annual abatement of nearly 26,400 $MTCO_2e$. Improved electronic metering is another critical component of energy management needed to enable

	IRR*	PV of Incremental Capital Cost* 2010 $Millions	Levelized Savings per $MTCO_2e$ Avoided*	Average Annual GHG Abatement* ($MTCO_2e$)
Recommended ECMs in Audited Buildings	34%	$11	$130	26,400
ECMs (years 1-5)	22%	$20	$114	30,700

Figure 3.6 - Near-Term Energy Conservation Measures
Source: AEI

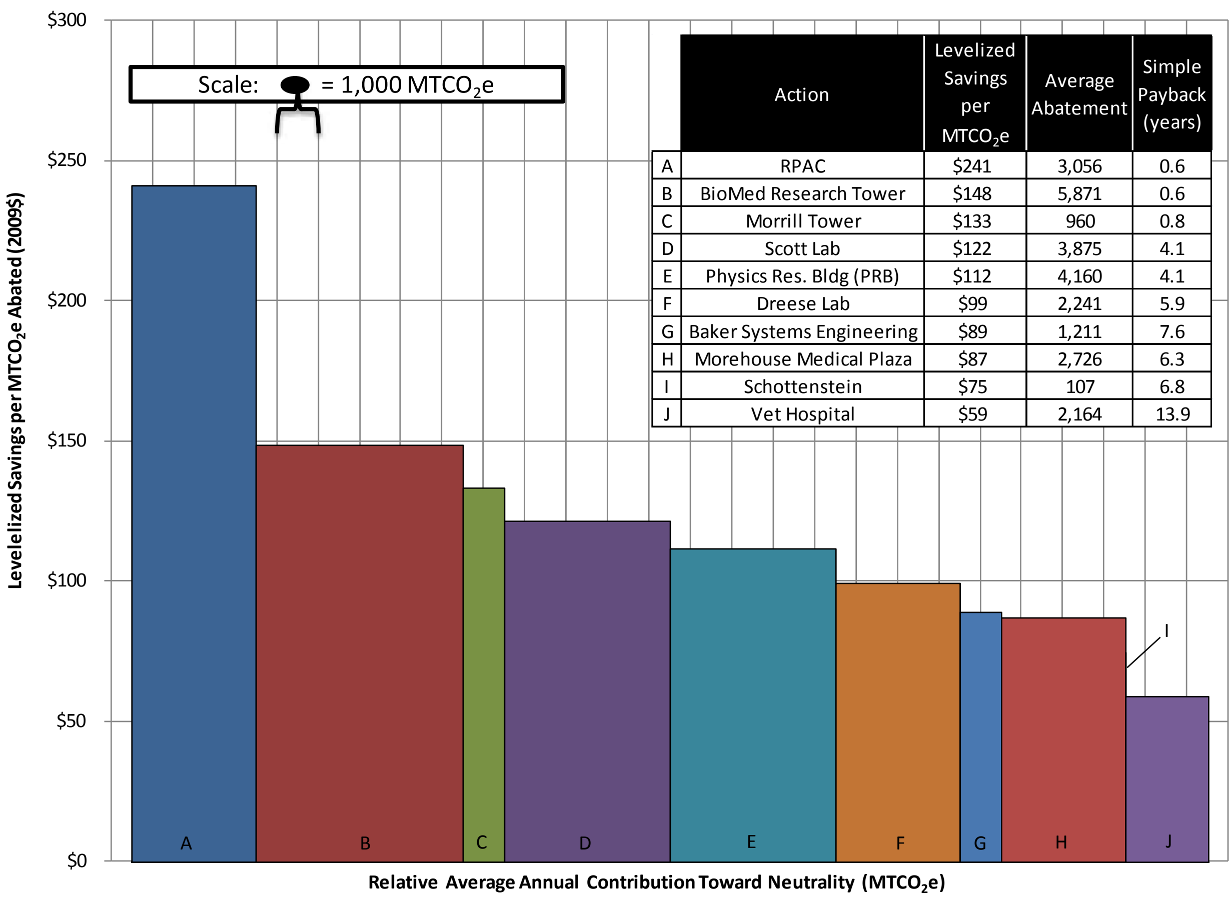

Figure 3.7 - Immediate Energy Conservation Measure Abatement Diagram
Image: AEI

tracking of consumption and savings. A revolving loan fund would provide a mechanism to implement energy conservation measures while simultaneously sharing energy cost avoidance with building users, increasing the size of the fund, and addressing long-term payback opportunities. A consumption-based utility rate model using metered energy use is another potential strategy.

Mid- to Long-Term Strategies

Combined Heat and Power Plant

The largest single carbon mitigation strategy currently being evaluated as part of Ohio State's long-term CAP is development of an on-campus combined heat and power (CHP) facility that would produce approximately 85% of total campus demand for steam and approximately 45% of the total campus demand for electricity. Conversion to such a CHP system would (1) increase the efficiency of energy delivery by eliminating utility distribution losses and (2) reduce CO_2 emissions by switching much of the campus electricity from the utilities' coal-fired generation sources to an on-campus natural gas-fired source.

Energy Conservation Measures

See the description of Energy Conservation Measures in the previous Near-Term Strategies section. Two additional rounds of energy conservation measures are anticipated as funding becomes available, as additional meters are installed, and as priorities are established.

Heat Recovery Chillers

Heat Recovery Chillers (HRC) can be used to recover heat that is typically rejected to the atmosphere through cooling towers and utilize this heat for building heating systems. The installation of HRC systems potentially can reduce the amount of central cooling and heating plant demands, peak output, and related energy consumption and GHG emissions. These systems usually are best applied in densely developed precincts or individual buildings and therefore may have suitability on campus. Initial reviews of campus development and central plant distribution plans suggest there may be opportunities for implementation of HRC systems in the Medical Center district and the research area of the Academic Core.

Regional Chiller Plants

A conversion from the existing building-based unitary chiller systems that are distributed throughout campus to a larger regional chiller plant(s) could provide significant operational efficiency associated with maintenance and energy consumption. The *Energy and Infrastructure Plan* examines possible development of a 10,000- to 12,000-ton East Regional Chilled Water Plant (ERCWP) to aggregate chilled water production in the Academic Core and north residential district and provide the additional capacity needed for additional research buildings. Such a plant, if financially feasible, could provide approximately 30% energy savings for chilled water production in the region. The *Energy and Infrastructure Plan* forecasts that, if density growth continues, a second regional chiller plant may be feasible after 2020. As Ohio State

progresses on its CAP and infrastructure plans, the associated reviews will include further analyses of the feasibility of regional chiller plants.

Back Pressure Steam Turbines

Steam turbines can be used to produce power through a reduction in steam pressure and enthalpy. Building-level steam turbines can be used in lieu of or in parallel to steam pressure reducing stations to utilize the pressure drop to produce power. Ohio State is examining the potential feasibility of deploying building-level back pressure steam turbines. While the technological advantages of back pressure steam turbines are well understood, the current laws of the State of Ohio require constant monitoring of these units by facilities personnel. As such, implementation of small scale turbines is not feasible economically at this time. Ohio State will continue to monitor these statutes and advances in turbine technologies that may make future implementation feasible.

Geothermal Heating and Cooling

Geothermal heating and cooling may provide additional energy savings and associated CO_2 emission reductions. While these systems currently rely on relatively carbon-intensive electrical grid sources, their overall efficiency creates a net positive carbon reduction. Ohio State has been evaluating some areas of campus that may be suitable to use for vertical borefields in a geothermal system. The most likely regions of campus are residential districts where land availability aligns with building heating and cooling load profiles. The 600,000 GSF renovation and addition to the south residential district will include a large geothermal system integrated into the available land area around the immediate buildings and a large green space to the north. Evaluations of additional geothermal applications will follow in the coming years.

3.3 Transportation Strategies

By far the largest percentage of transportation-related carbon emissions can be attributed to commuting. Currently 70% of the daily trips to campus are in SOVs. Reducing the number of commuters who drive alone will have the greatest impact of all transportation strategies. Reducing intra-campus travel also could make a difference.

Among actions that Ohio State is currently pursuing or will be investigating are:

- A Transportation Management Plan to help set priorities.
- Incentives such as university-supported subsidies for transit use.
- Opportunities to increase vanpool use.
- Deployment of electric fleet vehicles and charging stations for fleet and commuter use.
- Improvements in the campus environment for pedestrians and bicyclists.
- Amenities at remote parking locations and enhanced shuttle services.
- Changes to the parking system and rates.
- Continued partnership with the Central Ohio Transit Autority to expand transit access.
- Increased number of students, faculty, and staff living near campus.

Directly financed air travel makes up 21% of the transportation-related carbon emissions. While air travel is important to many university activities, the use of teleconference, video conference, and web-based conferences is on the rise and will be encouraged as a replacement to air travel when possible. The university also will consider requiring the purchase of offsets for air travel that occurs for university-related activities.

3.4 Role of Offsets

What are Offsets?

Carbon offsets are a means of reducing the net impact of an institution's activities through financially supporting projects that elsewhere, beyond the campus, remove CO_2 or other greenhouse gases from the atmosphere or prevent them from reaching the atmosphere in the first place. Organizations can purchase an offset to compensate for their emissions.

Signatories of the ACUPCC are encouraged to invest in on-campus emissions reductions first, but offsets can be a means of demonstrating progress and commitment.

Carbon offsets are subject to multiple and stringent criteria. Selection of offset options can be evaluated in terms of effectiveness, link to the university mission, and other university goals such as supporting the broader community. Standards developed by the Chicago Climate Exchange, Climate Registry and Clean Development Mechanism (CDM) provide ways to evaluate potential offsets.

Current Ohio State Offsets and Related Actions

The ACUPCC recognizes that most energy projects supported by Renewable Energy Credits (RECs) do not meet the Protocol requirements for offsets. But RECs directly support the development of alternative energy and are important contributors to sustainable energy infrastructure. The university plans to expand its purchase of RECs to 3% of annual electricity demand, equivalent to approximately 17 million kWh at current consumption.[6]

The science of how much carbon is sequestered in the landscape - including trees, soils, and other plant communities - is still being explored. Dr. Rattan Lal at Ohio State has developed a method of quantifying carbon sequestration in plants and soils. Using this information, it is estimated that the campus landscape, including a modest stand of second-growth trees at Waterman Farm, removes some 650 metric tons of CO_2 per year from the atmosphere.[7] Because this amount of sequestration comes from the existing landscape, it is associated with existing conditions and cannot be used as an additional offset. Future plantings will provide offset opportunities. While the benefits are likely to be small in scale when compared to other strategies, the planting of additional trees will be encouraged because many important environmental benefits such as support of habitat, shading, sense of place, pollutant filtration, and water balance are obtained as a result.

Sustainability presents The Ohio State University with one of its most compelling and interdisciplinary teachable opportunities.[8]

4 Education, Research, and Outreach

4.1 Integration with the University's Mission

Sustainability efforts should be embedded into the full range of university activities and must tie directly to its founding mission. Integrating sustainability work and themes into the activities of students, faculty, and staff is a natural complement to Ohio State's land-grant mission, its exceptionally broad range of teaching and research endeavors, and its historic action orientation. This includes embracing opportunities to use the campus as a living laboratory; identifying new opportunities for teaching, learning, and conducting research; and enhancing the institution's service to its communities.

This section of the CAP is informed by the insightful white paper *Sustainability Planning at OSU: Beyond the Physical Campus* (March 22, 2010) authored by Professors Joseph Fiksel, Rick Livingston, Jay Martin, and Steve Rissing on behalf of the Sustainability Advisory Group to the President's and Provost's Council on Sustainability.

4.2 Education

Ohio State is committed to providing an educational experience that inspires a new generation of global citizens. Accordingly, sustainability education is thoughtfully and intentionally integrated into the student experience by putting students first.

Sustainability initiatives driven by Ohio State's interested faculty and passionate students include concentrations in majors and minors, customized interdisciplinary degrees, graduate specializations and seminars, and other opportunities for student involvement.

In moving forward, the university wants to heighten environmental and social awareness campus-wide by spotlighting the many dimensions of sustainability. Opportunities for doing so could range from performing a baseline survey of sustainable literacy and educational needs for incoming students to developing a coordinating framework of graduate education options that include sustainability content.

4.3 Research

As one of the country's leading research universities, Ohio State has made important contributions to sustainability science, technology, and human behavior. The university strives to integrate the recognized works of its faculty researchers and apply this expertise to problems on local, regional, national, and international scales.

The university has established the Institute for Energy and Environment as a mechanism for coordinating some of the research efforts and also is served by internationally recognized research centers, including but not limited to the Center for Automotive Research; the Byrd Polar Research Center; the Center for Energy, Sustainability, and Environment; and the Center for Resilience.

The following is a partial list of areas of sustainability research excellence at Ohio State.

- College of Arts and Sciences – assessment of climate change and associated changes in the aquasphere, geosphere, and biosphere.
- Fisher College of Business – sustainability in supply chain management, product development entrepreneurship, enterprise strategy, and social responsibility.
- College of Engineering – sustainable technologies for energy, mobility, manufacturing and waste recovery; life cycle assessment of ecological impacts.
- College of Food Agricultural and Environmental Sciences – carbon cycling, ecosystem adaptation, natural resource economics, bio-based products, and renewable energy.
- College of Public Health – impacts of changes in climate, lifestyle, technology, and environmental conditions on human health and well being.

Some of the initiatives that have already emerged to connect Ohio State's sustainability research to ongoing campus enhancements include:

- Research about improved management of food waste, including life cycle assessment, sponsored by Energy Services and Sustainability.
- Efforts to develop sustainable infrastructure include completion of three rain gardens, the planned construction of another, and planned construction of a green roof.

- Studies by student groups of energy use and efficiency of campus buildings that have resulted in grants and physical improvements to reduce energy use.
- Environmental restoration and renewable energy production initiatives at Waterman Farm.
- Investigation of geothermal and photovoltaic energy systems and other alternative energy technologies.

To accelerate its steps forward, Ohio State will make efforts to coordinate campus sustainability initiatives with ongoing and emerging research programs and multiply opportunities for developing new knowledge, refining methodologies, and experimenting with technological innovations.

4.4 Outreach

Ohio State plays a major role in shaping the intellectual, economic, and social environment in Central Ohio. On a broader scale, The Ohio State University Extension services reach every county in the state, while the university's researchers and alumni are active throughout the world.

One example of Ohio State's collaboration on regional development is the Ohio By-Product Synergy network (www.OhioBPS.org), organized by the university's Center for Resilience in collaboration with the U.S. Business Council for Sustainability Development, Mid-Ohio Regional Planning Commission, and the Ohio Department of Natural Resources. This network helps businesses convert waste materials into valuable byproducts, thereby protecting the environment while stimulating the local economy. Ohio State has incubated similar networks in other areas.

The arts and humanities also play a critical role in promoting a regional culture of sustainability. For example, the Wexner Center's film "From Field to Screen" focused on local food systems and sustainable agriculture, while a grant from OSU CARES supported a "Ways of Knowing Water" exhibit that highlighted the efforts of local watershed protection groups.

In support of the CAP, Ohio State is committed to continuing its unified approach to sustainability outreach that is interwoven with its education and research activities.

5 Future Considerations and Tracking Progress

This CAP exists amid constantly evolving economic and financial, technological, political, and social contexts. The financial implications of reaching climate neutrality are very serious. Substantial investments into the tens of millions of dollars may be necessary. Not all potential strategies will be economically feasible. Of those that are feasible, the initial capital costs, payback periods, and impacts on CO_2 emissions will have significant variations. Additionally, even strategies that may appear to have a net positive payback over time may not be feasible if initial capital costs are prohibitively high. These issues need to be considered as strategies for achieving carbon neutrality are weighed as part of the university's future capital planning discussions.

Content experts will continue to assess and make recommendations to update the CAP periodically as appropriate. The university will learn from its initial steps and adjust forward-looking plans as appropriate. With the availability of funding expected to decrease significantly in the coming years, identifying specific timing for strategies is difficult and will be reassessed as part of the university's and the state's normal required processes and procedures of capital planning and the regular review and update of this CAP. Assessment of the fiscal environment and the outcomes of external climate policies also will play an important role in the ongoing development of climate policy and action within the university. The university is deeply committed to continually improve its emissions footprint with a goal of carbon neutrality by 2050.

Successful implementation of the CAP requires campus-wide involvement to address climate neutrality in core activities of the university—research, curriculum, outreach, operations, and building development. Regular reports outlining progress will be submitted to the President's and Provost's Council on Sustainability, university leaders, and other key stakeholders.

6 Appendix

Acronyms

BTU	British Thermal Unit
CACP	Clean Air - Cool Planet (emissions calculator)
CH_4	methane
CO_2	carbon dioxide
CO_2e	carbon dioxide equivalent
EPA	Environmental Protection Agency
ESS	Energy Services and Sustainability
EUI	Energy Utilization Index
FOD	Facilities Operations and Development
GHG	greenhouse gas(es)
GWP	global warming potential
IRR	Internal Rate of Return
IPCC	Intergovernmental Panel on Climate Change
IUC	Inter-University Council of Ohio
kW	kilowatt
kWh	kilowatt-hour
LEED	Leadership in Energy and Environmental Design
mmBTU	million BTU
$MTCO_2e$	metric tons of carbon dioxide equivalent
MWh	megawatt-hour
N/A	not applicable
N_2O	nitrous oxide
PV	present value
REC	renewable energy certificate
T&D	transmission and distribution (grid electricity)
TBD	to be determined

Sources

1 http://oneframework.osu.edu
2 ACUPCC Implementation Guide
3 http://www.puco.ohio.gov/PUCO/Consumer/Information.cfm?id=8076
4 http://blog.cleveland.com/business/2008/12/roadell_hickman_the_plain_deal.html
5 http://www.nocawma.org/documents/SWACO.pdf
6 Communication with The Ohio State University
7 Calculated from information provided by Professor Rattan Lal at Ohio State University
8 Sustainability Planning at OSU: Beyond the Physical Campus
9 Project Economics and Decision Analysis, Vol. I: Deterministic Models, M.A. Main, p. 269.

Definitions

The tables in Chapter 3 include summary quantitative metrics that describe the possible costs and benefits of each abatement opportunity. A brief description of each summary metric follows.

Average Annual GHG Abatement ($MTCO_2e$)

The average annual GHG emissions abated as a result of implementing this abatement opportunity reflected in $MTCO_2e$. This value is simply the result of summing the GHG emissions abated over the economic life of the abatement option and dividing that sum by the economic life of the abatement option

Discount Rate

Any net present value (NPV), present value (PV), or levelized cost represented in the tables were calculated using a real discount rate of 2.4%. This is equivalent to a nominal interest rate of 4.5%.

Internal Rate of Return (IRR)

The rate of return used in capital budgeting to measure and compare the profitability of investments. It also is called the discounted cash flow rate of return (DCFROR) or simply the rate of return (ROR). In specific terms, the IRR of an investment is the interest rate at which the net present value of costs (negative cash flows) of the investment equals the net present value of the benefits (positive cash flows) of the investment.[9] Simplistically, the higher the IRR, the more desirable the investment. Mathematically, the IRR cannot be calculated when the net present value of an investment is less than zero or when every value in the cash flow stream is either always negative or always positive. These two cases will be shown as N/A for the IRR value in the table.

Levelized Cost or Savings per $MTCO_2e$ Avoided

The net cost or savings associated with reducing 1 metric ton of CO_2e ($MTCO_2e$) as a result of implementing this option. The cost/savings are levelized using the discount rate described above. A levelized cost or savings is the present value of the total costs and savings of each abatement opportunity over its economic life, converted into equal annual payments per $MTCO_2e$ abated. If the column heading indicates that the value in the table is a savings, then the abatement opportunity will be a net savings to the university per $MTCO_2e$ abated over the economic life of the investment. If the column heading indicates that the value in the table is a cost, then the abatement opportunity will be a net cost to the university per $MTCO_2e$ abated over the economic life of the investment.

PV of Incremental Capital Cost or Savings

The present value (PV) of the incremental capital investments (new capital minus any avoided capital) that will be required to implement this abatement opportunity. If the column heading indicates that the value in the table is a cost, then the PV of the new capital required is greater than the PV of the capital that is avoided, resulting in a net capital outflow over the life of the investment. If the column heading indicates that the value in the table is a savings, then the PV of the capital that is avoided is greater than the PV of the new capital required, resulting in a net capital inflow over the life of the investment.