TULANE UNIVERSITY

2014 Climate Action Plan

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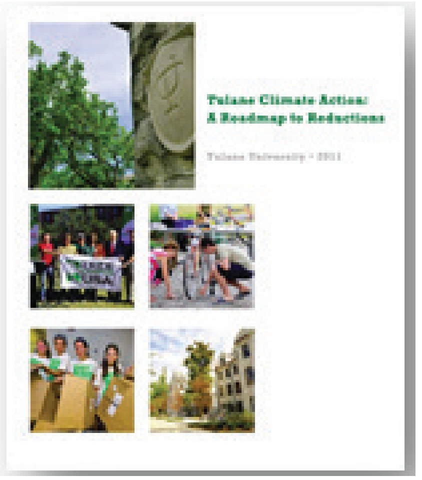
APPENDICES

I. EXECUTIVE SUMMARY

The 2014 Tulane University Climate Action Plan is a guide for university investment and activity to reduce its greenhouse gas (GHG) emissions. Specific to the Uptown and Downtown campuses, it describes a variety of investments to be undertaken addressing carbon-improved energy supply and distribution systems, reduced building energy demand, focused university community engagement, and better employment of low-carbon transportation options. It charts progress towards climate neutrality for the two campuses, to be realized in 2050.

This document is the product of extensive involvement by faculty, staff, and students. It stretches the collective knowledge of the practical to embrace the community's ambitions to use less energy, use less GHG-intensive energy, and ensure that the students' social and academic experiences at Tulane University prepares each one to become an effective leader addressing climate change.



Tulane University's commitment to reduce its greenhouse gas emissions is nearly a decade-long. In 2008, its then-emerging interest assumed greater significance when the University pledged to join the American College and University Presidents' Climate Commitment (ACUPCC), a network that has grown to nearly 700 higher education institutions that have made a public commitment to reduce their institution's GHG emissions in tandem with prioritizing support of research and education about climate change. Soon after, the University announced that it would immediately reduce its GHG emissions through purchasing energy efficient equipment, designing new buildings and major renovations to a minimum standard of LEED Silver, encouraging use of public transportation and the University shuttle system, and investing in energy conservation. In 2011, Tulane University authored "Tulane Climate Action: A Roadmap to Reductions."

> While climate change is a subject of research, learning and innovation across our academic disciplines, it should also inform how we build, operate and use our campus facilities. Every member of our university community has role to play in addressing the challenge of climate change.

The 2014 Tulane University Climate Action Plan builds upon the efforts of the draft plan. Each of its assumptions, aspirations and strategies have been revisited and many have proven still relevant, as described in this document. Employing much of the same passion, vision, and direction, this plan extends the University's GHG emissions reduction activity to 2050, offering a more comprehensive and detailed description of the necessary steps in this process, with specific focus on the Uptown and Downtown Campuses. The plan describes the University decision to:

- improve energy technologies,
- more aggressively manage building energy demand,
- leverage student involvement in support of the plan,
- enhance energy efficiency in future buildings and major renovations, and
- manage transportation services to reduce associated carbon emissions.

The 2014 Tulane University Climate Action Plan describes near-term, mid-term, and long-term investment portfolios. Using 2007 as the base year for GHG emissions reduction, this plan describes University activity that will reduce its GHG emissions at the Uptown and Downtown campuses by 15% in 2020, by 30% in 2025, and to climate neutrality by 2050.

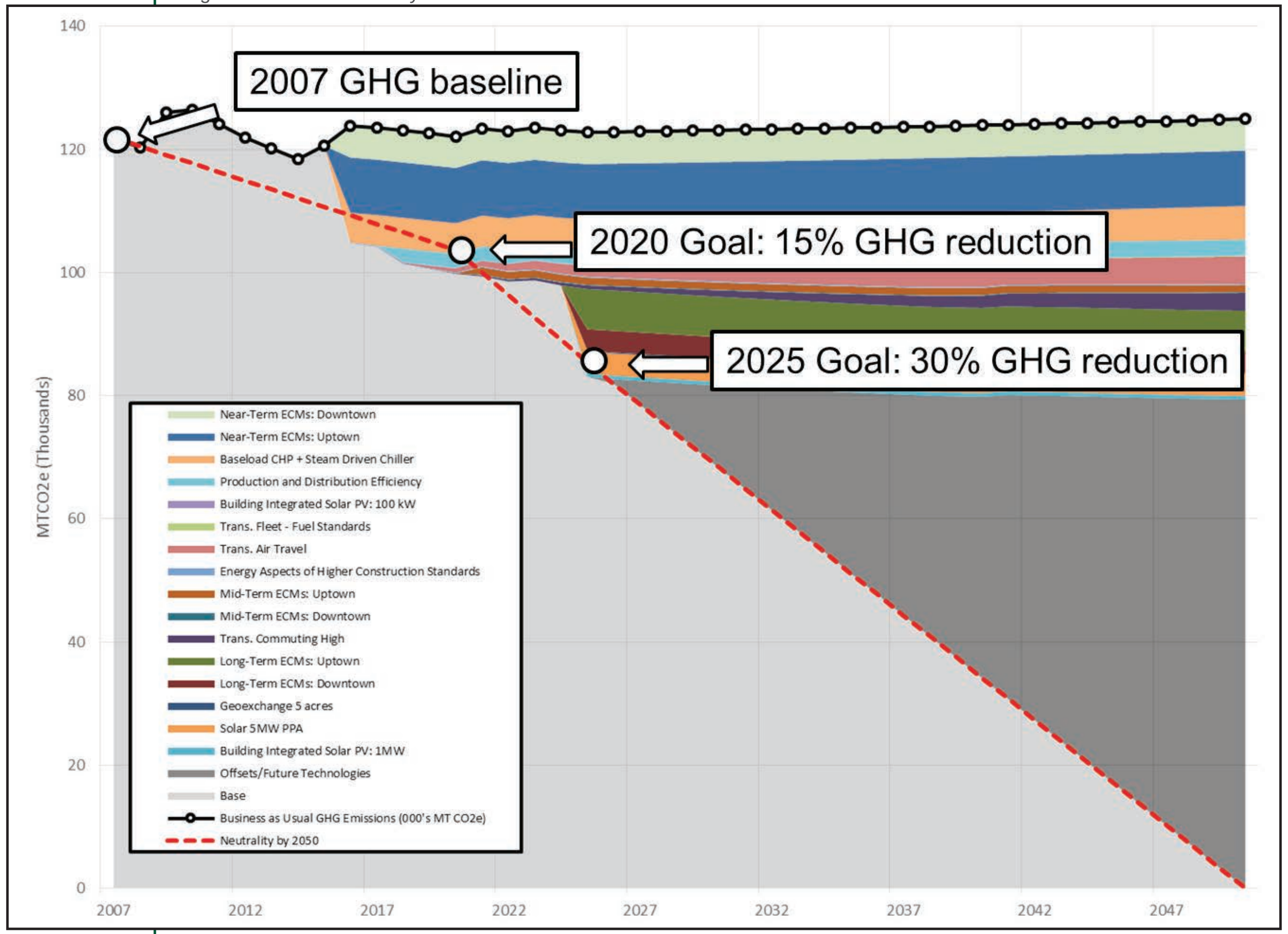
> Through this plan the University commits to an active and long-lasting investment in improving the energy efficiency of its building stock

The near-term portfolio is powerful. It intends to capture immediately available and important efficiency gains in campus energy supply and distribution, advancing building energy demand management, introducing renewable energy sources, and gaining efficiency within the campus fleet. It launches a new dimension of Tulane University's sustainability imprint, a Building and Energy Literacy Campaign. This campaign's intention is to advance University research, teaching, and learning about climate change, in part by creating a suite of activities that highlight the connection to sustainable campus living. This will help each member of the Tulane University community recognize their opportunity to reduce energy/GHG emissions in their capacity as individuals who manage, operate and occupy campus buildings. The campaign will be long-lived, at least through the duration of this report's study period. The near-term portfolio is estimated to cost \$21.9 million, reduce GHG emissions by 23,000 MTCO2e per year, and yield an average annual savings of \$2.6 million (2014 \$).

The mid-term portfolio perpetuates the strengths of its predecessor phase and introduces an ambitious strategy to encourage the University community to walk, bicycle and take transit – low and no-carbon options. During this phase, in 2024, Tulane University will rededicate its commitment to GHG emissions reduction through an update of its climate action plan. The mid-term portfolio is estimated to cost \$5.5 million, reduce GHG emissions by 2,800 MTCO2e per year, and will yield an average annual cost of \$544,000 (2014 \$).

Projections for the long-term -- 2025 to 2050 – call for the University to invest in low- and fossil fuel-free energy sources, in building energy demand management, in improved transportation, and in the Building and Energy Literacy Campaign. Less specificity is offered about investments for this phase because utility prices and options, technologies, and fuel source availability are expected to be markedly different within a decade. Revisiting and updating the 2014 Tulane University Climate Action Plan in 2024 will enhance the certainty about long-term investments described in this plan. The long-term portfolio is estimated to cost $58.5 million, reduce GHG emissions by 12,500 MTCO2e per year, and yield an average annual savings of $435,000 (2014 $).

Figure 1: Tulane University GHG Emissions Reduction Over Time



II. THE PLAN'S DEVELOPMENT

Tulane University's two main campuses partnered in developing the 2014 Tulane University Climate Action Plan. Faculty, staff and students identified and planned for means of institutionalizing the most effective strategies for reducing University GHG emissions on their campuses. The ultimate presentation of information combines data from both campuses as is appropriate to the single ownership and organizational structure of the University.

The plan accounts for GHG emissions for University owned-and-operated properties located on the Uptown and Downtown Campuses. It addresses[1] :

- Scope 1 GHG emissions – all direct emissions from sources that are owned and controlled by the University such as emissions from fossil fuels burned on site and from University vehicles (owned and leased),
- Scope 2 GHG emissions – indirect emissions that come from consumption of purchased utilities such as electricity,
- A subset of Scope 3 GHG emissions – indirect emissions that come from transportation related activities in vehicles not owned or controlled by the University and electricity-related activities (such as transmission and distribution losses). This study excludes emissions otherwise defined as Scope 3, such as emissions associated with vendor supply chains, outsourced services for wastewater treatment and for waste disposal, and site remediation.

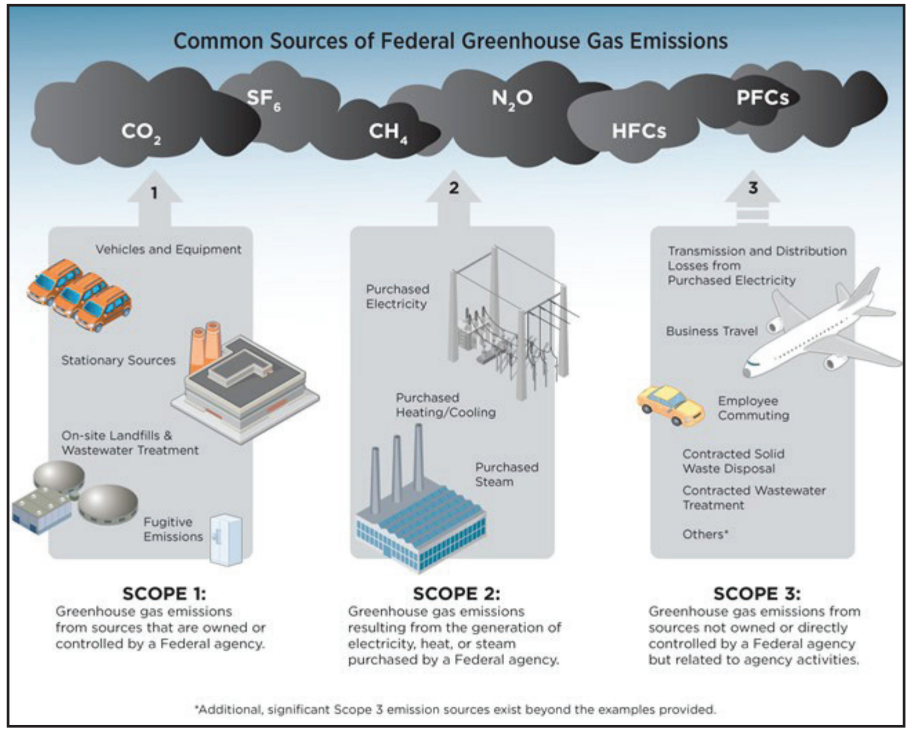


Figure 2: Greenhouse Gas Scope Emissions Types[2]

The goal of the plan is for the University to reach climate neutrality by 2050. This ambitious goal is justified for a number of reasons. The University, as signatory to the ACUPCC, relies on the pledge's 2009 guidance[3] to signatories that they address climate

1 The reader may notice that the University's annually generated reports on University GHG emissions addresses a broader geography. Employing the operational control approach, it reports on total emissions for Tulane University holdings in New Orleans, LA; Covington, LA; Belle Chasse, LA; Biloxi, MS; Madison, MS; and Houston, TX. It also expands Scope 3 emissions count to include waste disposal. To focus on the properties that generate the greatest GHG emissions, this CAP is specific to the Uptown and Downtown Campuses. It excludes waste management, which represent a small fraction of total GHG emissions, and other forms of Scope 3 emissions that are not relevant to University activities or are not measured by the University.

2 The sources of a university's GHG emissions are very similar to those of federal facilities, which are shown in this graphic. USEPA http://www.epa.gov/greeningepa/ghg/

3 Implementation Guide: Information and Resources for Participating Institutions, Version 1.1, 2009

neutrality for their institutions. While the pledge itself is to “achieve climate neutrality as soon as possible”, the program’s guidance references the Intergovernmental Panel on Climate Change (IPCC) work and its 2050 target to reduce global emissions by 50% to 85% below the 2000 level. Established in 1988, the IPCC uses both 2050 and 2100 as benchmark years for describing the dimension of activity needed to reduce greenhouse gas emissions and stabilize the climate system. Use of these years has become standard across the community of scholars involved in the study of climate science and, specifically, 2050 is employed by entities, such as those in industry and higher education, in planning their own mitigation activities. Including a goal of climate neutrality is an important reminder for the University community that addressing climate change will be an ongoing, long-term challenge.

A starting point for Tulane University in considering the goal of climate neutrality for 2050 is to understand the GHG emissions the University would generate if it maintained current utility infrastructure, building and fleet/transportation management and operations practices, and grows according to its established trajectory. Tulane University is projecting a nearly even student population over the term of this study with limited need for additional building square footage. University energy management practices and utility costs were used to project a Business-as-Usual (BAU) profile for the University’s GHG emissions and energy management system cost over the course of the CAP term of study (to 2050). Referred to as the BAU scenario, this suggests that Tulane University’s two main campuses will grow from just under 119,000 MTCO2e in 2014 to approximately 125,000 MTCO2e in 2050. Potential cost and savings associated with emissions reduction ideas were evaluated relative to this BAU scenario.

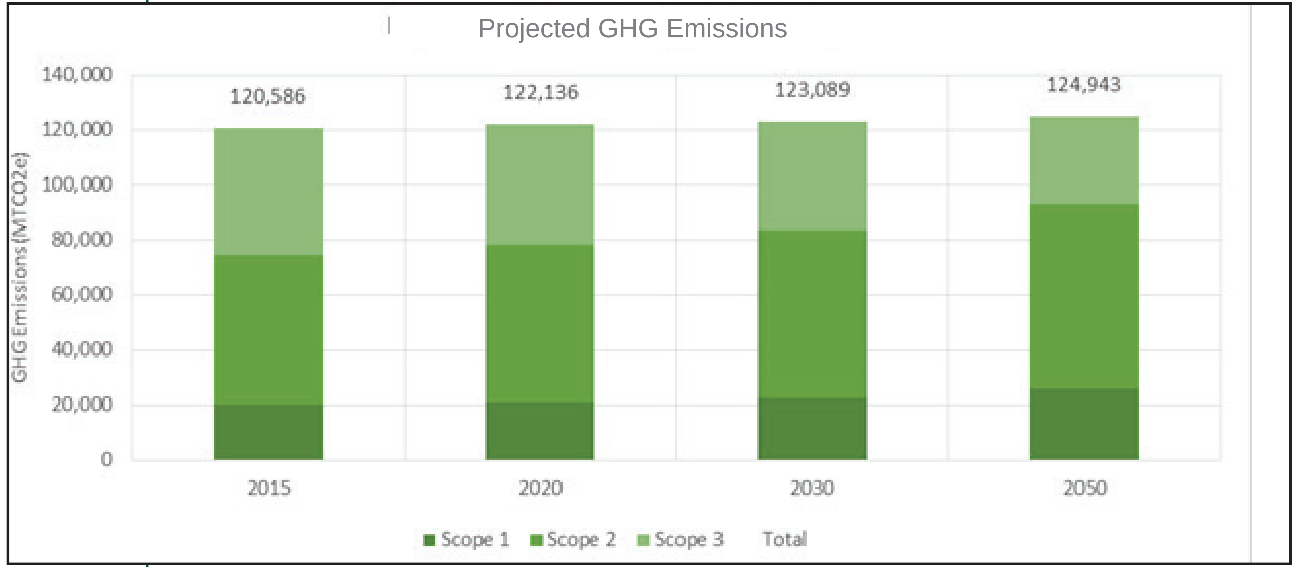


Figure 3: Tulane University Business-As-Usual Reference Case: Projected Emission (1,000 MTCO2e)

	2015	2020	2030	2050
Scope 1	20.2	21.2	22.8	25.9
Scope 2	54.3	56.9	60.5	67.0
Scope 3	46.1	44.0	39.8	32.0
Total	**120.6**	**122.1**	**123.1**	**124.9**

EMISSIONS REDUCTION OPPORTUNITY: IDEA GENERATION AND QUALITATIVE SCREENING

The plan was guided by a steering committee of University administrators and faculty and by four working groups constituted with faculty, staff, and students. At the start of the planning process, the steering committee established the University vision for the plan.

Vision for Path to Climate Neutrality

Tulane University will make prudent investments to:

- Reduce GHG emissions in the near, mid and long-term
- Apply the University mission of teaching, research and service to propel broad awareness of and involvement in University greenhouse gas emission reductions
- Educate undergraduates to become leaders in addressing climate change
- Enable continued student involvement in campus sustainability
- Design new buildings and renovations/restorations that ambitiously reduce building energy demand/GHG emissions
- Operate and maintain Tulane University campuses to reduce GHG emissions
- Affirmatively purchase equipment and supplies that reduce energy use/GHG emissions

The CAP planning process invited every form of GHG management option to be considered. Then, through a process of applying University-articulated criteria (both qualitative and quantitative) the most compelling options were more rigorously considered. Fundamental to this screening process was adoption of a hierarchy that has proven to be effective for others as they reduce their GHG emissions. That is:

- The most effective step is to **avoid** carbon-intensive activities
- The second is to **reduce** emissions through efficiency
- Third is to **replace** high-carbon energy sources with low carbon alternatives
- Finally, **offsets** -- credits procured for GHG emissions reduction that are accomplished by a third party -- are considered[4].

At Tulane University, as with many other higher education institutions, there is a specific interest that offsets be avoided or, if purchased, that they support GHG emissions reduction activity that benefits the New Orleans region. For example, there

4 These are generally cost effective as a cost per ton of emissions avoided, but less appealing because they do not offer operational or facility enhancement value to the university.

is opportunity to purchase carbon offsets related to wetlands restoration, a goal of importance across the entire state coastline. These offsets promise the additional benefit of connection as Tulane University students, some acting through the School of Science and Engineering, are directly involved in not just the study, but the field experience of restoring Louisiana wetlands.

The Energy Demand Working Group was concerned with characteristics of the building stock, campus design standards, space use efficiency, energy conservation measures, and operating standards and policies. The group's articulation of its objectives and strategies for reducing GHG emissions was to:

- Recommend energy conservation measures (ECMs) by building type and/or applied to standard building operating schedules
- Recommend means of improving building temperature control to minimize the perception that buildings are being overcooled in summer
- Broaden use of ENERGY STAR® equipment
- Address summer building use scheduling to reduce cooling and electricity use to unused and occasionally used buildings
- Employ energy demand-limiting strategies in new construction and renovation projects. Examples include using card controls in residence hall rooms that would control room temps and automatically shut off lights and certain electronic equipment
- Institute behavioral change programs
- Elevate use of renewables as a priority by applying affirmative consideration of its educational and research value to the campus

Group objectives were framed by key assumptions:

- The University will consider both first and life-cycle cost in selecting ECMs
- The University will consider new means of financing ECMs, such as a revolving loan fund
- The University will not charge administrative and academic units for their utility use

The Energy Supply Working Group was concerned with purchased and produced utilities, utility plant assets and distribution systems, commodity fuels, carbon pricing and risk, and climate change adaptation measures. The group's articulation of its objectives and strategies for reducing GHG emissions was to:

- As feasible, employ low fossil fuel use and fossil fuel-free energy supply approaches such as on-campus solar energy, thermal water storage, geothermal, thermal energy storage, and solar thermal reheat.
- Assess the viability of approaches that are more energy efficient: combined heat and power for the Uptown Campus, using the Uptown campus absorption chiller, installing heat recovery chillers, installing plate and frame heat exchangers, installing a steam turbine generator, employing variable flow systems in the plant and buildings, updating the current steam system or replacing it with a hot water system, upgrading building level chillers, improving insulation of the central chilled water system, and improving thermal distribution.
- Assess the GHG emissions reduction potential of air handling unit condensate water reuse and of implementing heat recovery within buildings as a GHG emissions reduction technique.

Group objectives were framed by key assumptions:

- The University design process will put greater emphasis and value on installation of building-level low fossil fuel and fossil fuel-free energy systems.
- The University development officers will integrate this plan's recommendations as an objective for their efforts.
- The University will continue to engage the development community in pursuit of partnerships for financing and operating campus energy systems.

The Student Global Citizenship Working Group was concerned with research, curriculum, student-oriented initiatives, and creating an overall structure to develop the perspective and capabilities of Tulane University students to promote GHG emissions reduction on campus, locally and globally. The core issue for this group was to offer an opinion as to whether Tulane University's sustainability initiatives are sufficiently oriented to the issue of climate change and to advancing the goals of the Tulane University 2014 Climate Action Plan. The group concluded that more was needed and that the most compelling student-related need or opportunity associated with this plan is to bring greater focus to climate change at the university, and to invest significant effort in motivating behavioral change, particularly as relates to building energy demand management.

Figure 4: Tulane University Vision for Student Engagement in Climate Change

The Student Global Citizenship Working Group interpreted the Tulane University's Office of Sustainability directive to students on what they can do for the purposes of this emissions reduction plan. Green.Tulane.edu informs students what they can do: Learn more about climate change, Act to reduce GHG emission and Advance understanding of global warming.

The group's articulation of its objectives and strategies for reducing GHG emissions was to:

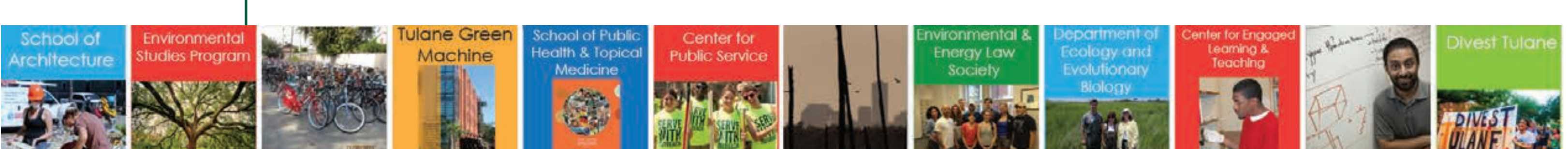
- Establish a class GHG emissions reduction goal (challenge) for each entering class and use this as a means of organizing a number of student-engaged strategies.
- Develop campus residential life as an experience that advances University GHG emissions reductions.
- Establish a database of opportunities and guide students towards campus involvement —through the Center for Public Service, New Day Challenge, Tulane Interdisciplinary Experience Seminar (TIDES), Center for Engaged Learning and Teaching (CELT), learning grants, student organizations etc. -- which more obviously

relates to understanding and reducing campus GHG emissions reduction.

- Feature study of climate change and means of reducing GHG emissions in the classroom, including offering a student course in "Greening the Ivory Tower" with a focus on the potential represented by building design and use.
- Develop leadership and activity through a building-specific program for GHG emissions reduction.
- Regularly host events that feature green initiatives accomplishments and campus research relating to GHG emissions reduction.
- Leverage others to lead through example – address campus deferred maintenance, ensure that building design guidelines are consistent with CAP goals and strategies, and improve campus waste and recycling systems.

Tulane University Building and Energy Literacy Campaign	
Campaign Leadership	Establish/guide progress towards an energy reduction goal for each incoming class. Measure building energy use and make data available to the university community.
	Provide for fundamentals of staff resource allocation and capital needs.
	Develop a communication aspect of the campaign (internally and externally). Employ social media.
	Regularly evaluate progress.
Behavioral Change	Establish a goal of 3% behavioral change related building energy demand reduction within a decade.
	Develop and regularly present building type-specific "users' guides" information to building occupants and building management staff.
	Create a structure of financial incentives for behavioral change. Inform, reinforce and "nudge". Engage a variety of forms of communication.
	Provide for engagement of volunteered and "owned" buildings such as labs, office/administration and residential (need sub-metering).
Classroom Learning	Develop a specific and visible role for the School of Architecture.
	Offer TIDES courses related to climate change and campus sustainability. Offer courses in "greening the ivory tower".
	Generate a spectrum of classroom applications for campus energy and energy campaign data.
Experiential Learning	Encourage development of energy and sustainability-related proposals for the New Day Challenge. Establish specific and visible role for CELT. Support the development of student proposals that advance the literacy campaign. Engage RAs in additional ways. Encourage behavioral change as theme for their monthly activities.
	Create ways for the perspective of behavioral change advocates to be part of the building design process. "Building captains" to take on more expansive responsibilities over longer timeframe. Hold annual poster sessions for students to share their climate change and sustainability related research.
	Regularly inform student organizations about university GHG emissions reduction progress for their guidance and participation.

Figure 5: Elements of Tulane University's planned Building and Energy Literacy Campaign. This initiative should be launched with release of the 2014 Tulane University Climate Action Plan.
Studies consistently show that campaigns like this one thrive when university leadership's involvement is viable.



The Transportation/Planning Working Group's objective was to propose means of reducing University GHG emissions associated with commuting patterns, campus growth plans and coordination of campus growth plans with municipal and regional plans. It also included reduction associated with air travel and University fleet operations.

The group's articulation of its objectives and strategies for reducing GHG emission was to:

- Reduce single occupancy vehicle use for students and employees.
- Coordinate with the New Orleans Regional Transit Authority in pursuit of services that are more appealing to the Tulane University community.
- Focus on developing opportunity for vanpools, shuttles and/or rideshare opportunities, particularly for longer distances areas such as Northshore/Covington and New Orleans East.
- Create fleet equipment purchase and use policies to rationalize use, improve maintenance, and phase out inefficient equipment.
- Increase the fuel efficiency of the University fleet, including the shuttle system and Tulane University Police Department vehicles.
- Develop a no-idling policy.
- Continually refine the shuttle system routes to reduce fuel use without substantially affecting service.
- Identify policies and supporting programs to limit or reduce travel, in particular air travel, without negatively impacting the research and education missions of the University.
- The University plans to expand its on-campus housing for the Uptown Campus. In so doing, the University will work to limit associated increases in student vehicles and promote the use of walking and biking for those living off-campus.
- The University is planning to develop satellite facilities in the greater New Orleans area. As this occurs, the University will create opportunities and incentives for non-single occupant vehicle transportation between campuses and satellite facilities.

In developing the 2014 Tulane University Climate Action Plan, Tulane University surveyed its faculty, staff, and students to identify their current travel patterns and their attitudes towards changing these. This process revealed:

- While auto use has seen some decline over the past eight years, the car remains dominant as mode for commuting, particularly for employees.
- Many survey respondents are interested in alternative (non-auto) modes, but feel that the options don't meet their needs. Over a third of the respondents indicated they would increase their bus usage if service frequency, coverage and/or reliability were improved. Only one fifth indicated that they would not use the bus in any

circumstances.

- Employees, and particularly students, live close to campus. Over half of employees and 85 percent of students live within four miles of campus. These individuals are well within what could be provided by transit and in many cases bikeable distance.
- Many use the Tulane Shuttle to commute to campus, particularly Downtown students. There is potential to use this to complement or supplement local bus service with careful review of current residence locations.

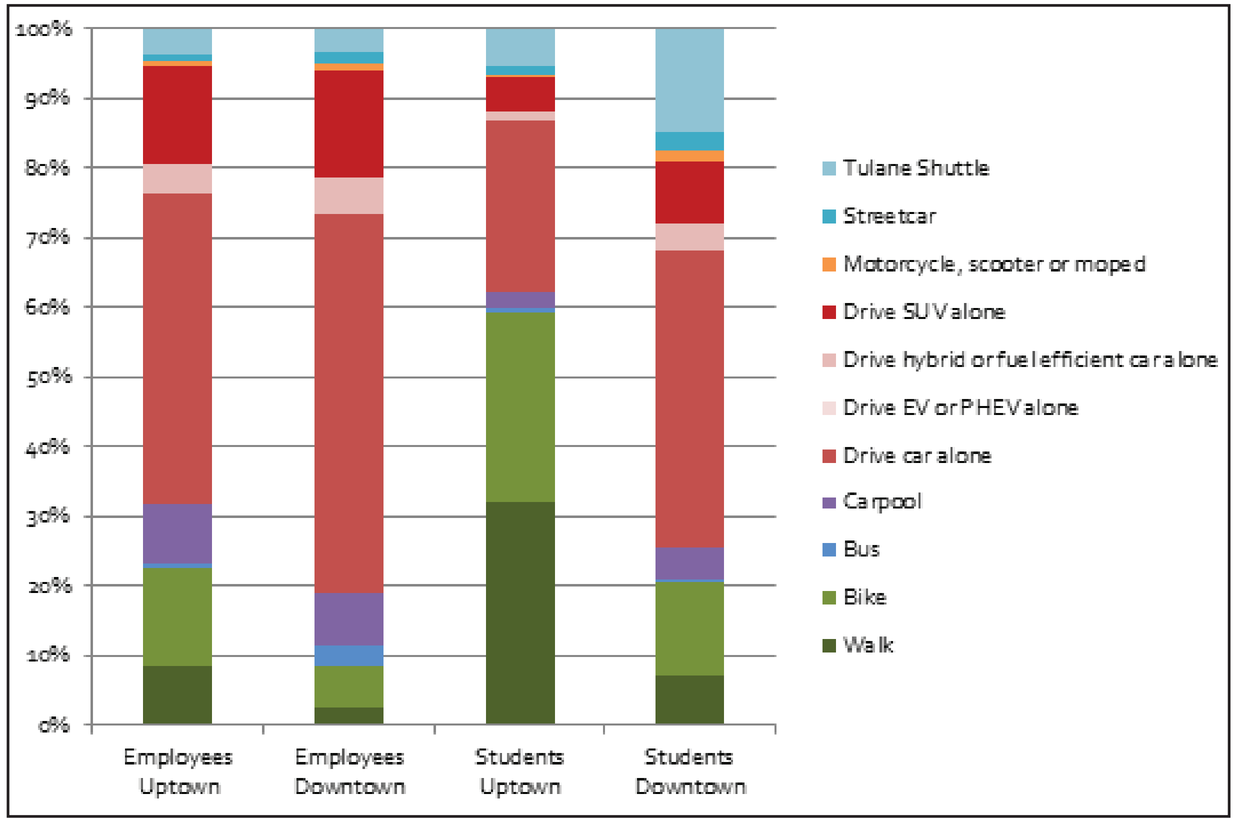


Figure 6: Tulane University Commuting Patterns

The group's recommendations can be characterized as providing University driven incentives and disincentives that, with regulatory changes and market-based incentives, will work to transition the University commuting patterns to be less carbon-intensive. Ultimately, the University-driven elements rest on motivating behavioral change. Recognizing the uncertainty of what will work and to what extent, the Transportation/Planning Working Group identified a broad range of investments to evaluate and recommend. This ensures a robust understanding of the potential benefits of greater reductions coupled with associated costs and other tradeoffs.

The plan recognizes limitations to University programs and policies to affect commuter behavior change. For example, Tulane has achieved a lot of success in promoting bicycles and faces a short-term challenge of simply offering enough bicycle parking. On the other hand, while there is strong interest in enhanced bus service, such changes will require a continued and sustained long-term effort by the University to coordinate with the New Orleans Regional Transit Authority.

Each option considered was evaluated based on the existing mode split, survey responses, residence patterns, and historical efficacy of similar potential programs at other institutions. The analysis incorporates local and national electricity grid and fleet efficiencies to predict emissions improvement that will occur beyond university systems and their implications for University mode shift. Those that offer the greatest reductions include policies and programs to affect residential location choice, bringing a greater proportion of students and employees within walking and bicycling distance of campus.

STRATEGY EVALUATION

Each of the plan's working groups proposed and vetted strategies for GHG emissions reduction that best fit its group's perspective. The groups screened their ideas, applying considerations such as:

- readiness of the resource/measure for implementation
- relevance to Tulane University's mission and dedication to effective student engagement
- fit to the University utility context
- effectiveness of GHG emissions reduction, first and operating costs, and
- ease of operations and of implementation

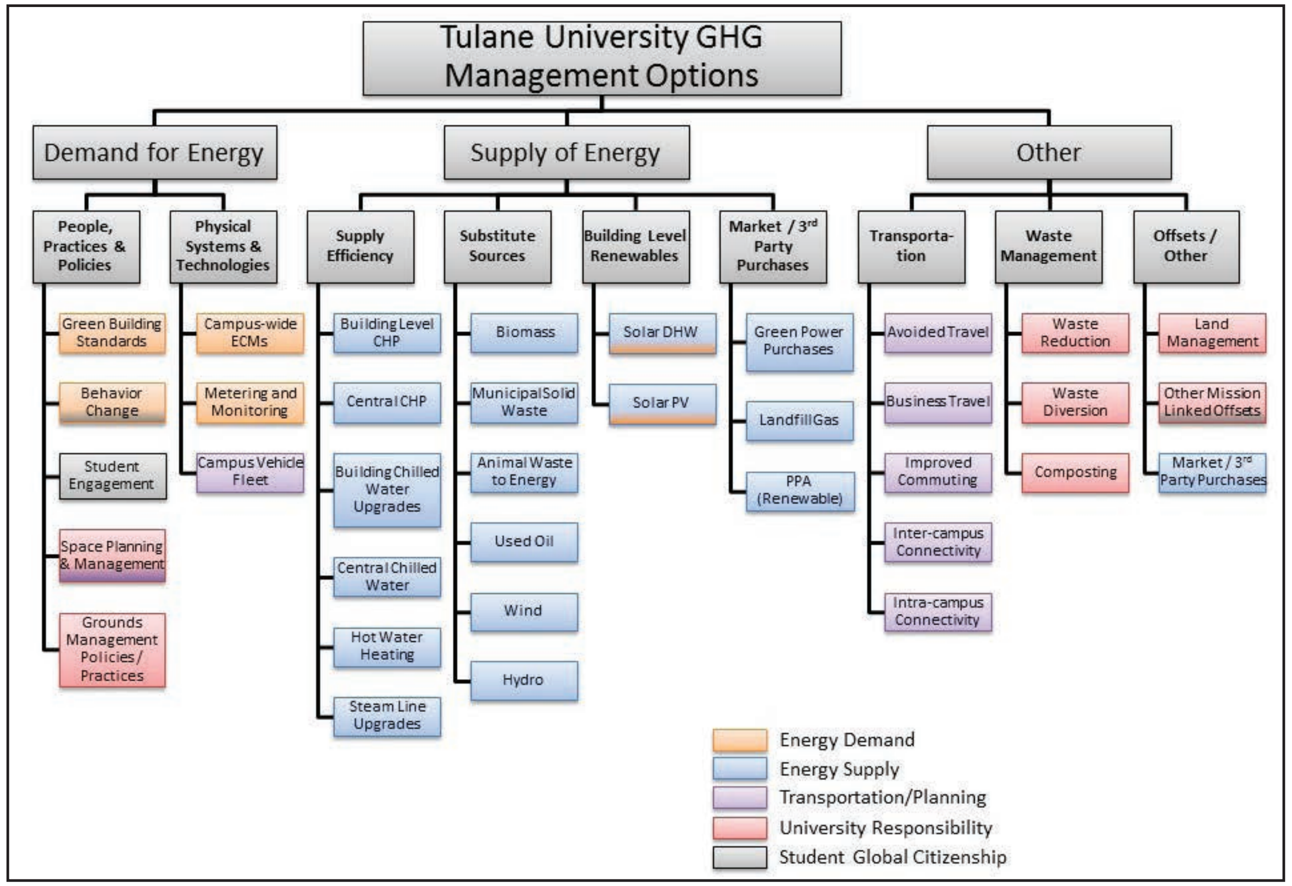


Figure 7: GHG Management Options
This planning process invited every form of GHG management option for initial consideration. Through the efforts of the working groups and steering committee, options were tested qualitatively and quantitatively until refined to those that constitute the portfolio proposed in this report.

The ideas that best addressed the working groups' objectives for this study were analyzed for their potential effectiveness as GHG emissions reduction steps. As illustrated in Figure 8[5], each opportunity proposed for consideration is expressed in the essential metrics of average annual financial impact (cost or savings) per metric ton of carbon emissions avoided and GHG emissions reduction impact (average annual reduction of metric tons of carbon emissions).

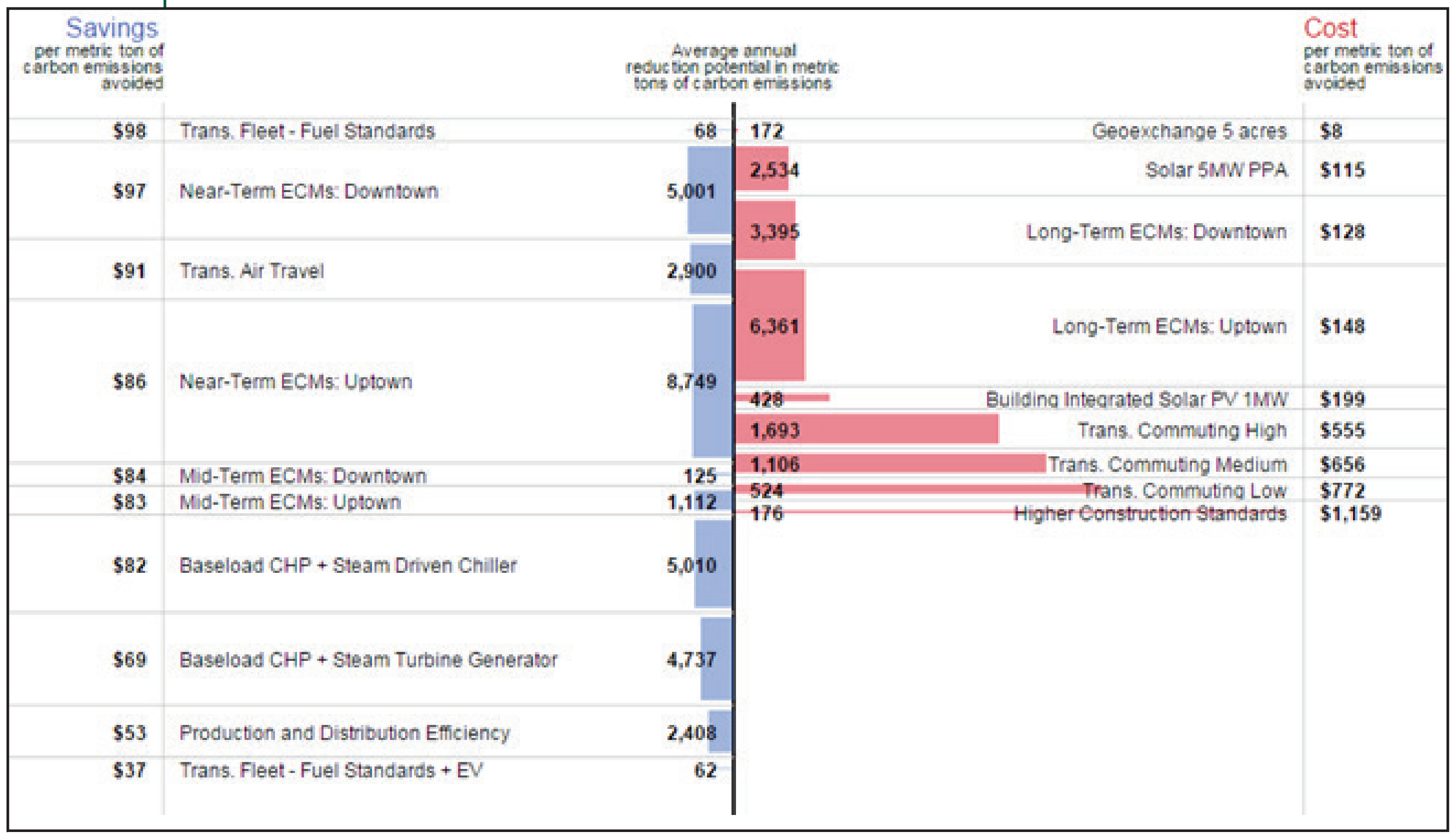


Figure 8: Tulane University Abatement Potential

The width of the bars in Figure 8 indicate monetary savings (blue) or cost (red) per metric ton of potential GHG emissions avoided. The height of each bar indicates the average annual GHG emissions reductions over the life of the project. The chart provides for easy comparison across GHG emission reduction activities. For example, a program to install 5 acres of geoexchange is estimated to cost $8 per ton of GHG reduction and could potentially reduce the GHG emissions by approximately 172 metric tons per year on average. This would compare to base loading the combined heat and power (CHP) system with a waste heat steam driven chiller, which could both save money and reduce GHG emissions (by an average of more than 5,000 metric tons per year). For a more detailed description of these opportunities, see Appendix B.

Each working group's recommendations were then compared to each other to measure their respective GHG emissions reduction impact as absolute and cost-per-ton of emissions reduced. Wedge diagrams[6] were created to represent proposed investments. At this point in the process, forums were held to provide for community-wide input. The response to the working groups' efforts and new ideas elicited in these sessions were then incorporated to make a final set of recommendations for a near (2015 through 2019[7]), mid (2020 through 2024) and long-term (2025 to 2050) profile of investments in GHG emissions abatement at Tulane University. The project's steering group reviewed and advanced these strategies, preparing them as recommendations to President Fitts and the Board of Tulane.

5 Note that Figure 8 presents the best of the University's options and this does not equate to a portfolio as some options are exclusive of each other.

6 Climate carbon wedges are a graphical representation used to show the carbon impact over time of a certain activity or set of activities.

7 Portfolio dates in this report reference fiscal years.

III. TULANE UNIVERSITY'S PATH TO CLIMATE NEUTRALITY

The process of creating this plan was rich in enthusiasm and ideas. The plan's investment profile is generally guided by concern for financial return on investment. Exceptions to this have been made in recognition of technologies that are of critical value because of their visibility and/or the learning opportunity that they offer to the University community. In general, these technologies tend to be less appealing financially in the near term. Thus, the plan has emphasized their use in the long-term when it is expected that they will be better established in terms of reliability, more affordable, and more cost effective.

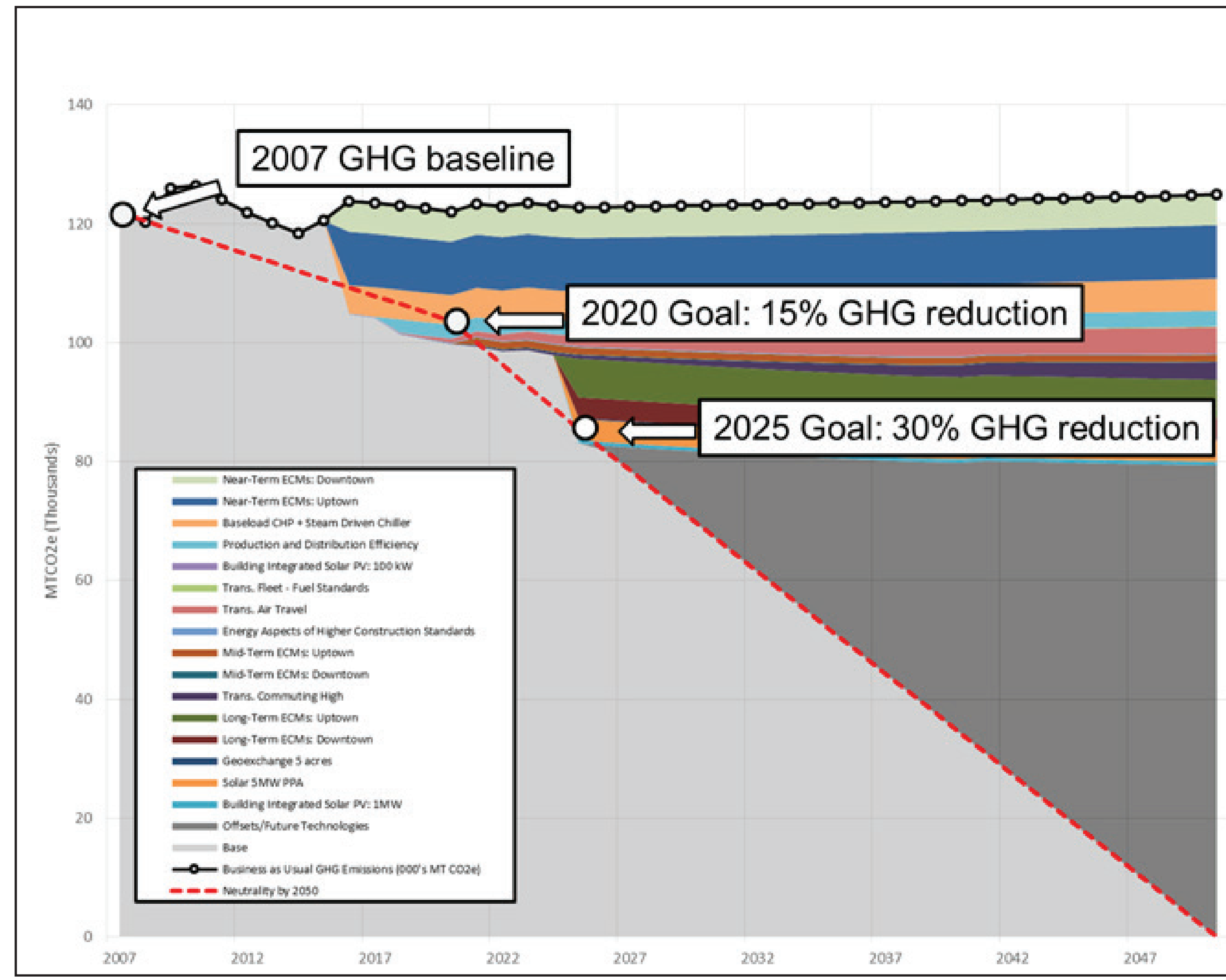


Figure 9: Tulane University Historic and Projected GHG Emissions[8].

8 This graphic adjusts the historic emissions from 2007 to 2013 from those published values in the draft CAP to adjust for changed study of campus properties and emission sources. The scaling was done by comparing gross square feet from the University's 2007 ACUPCC submission. The adjusted GSF from the 2014 Tulane University Climate Action Plan was 7% lower than then the reported 2007 ACUPCC gsf values.

KEY INVESTMENTS

First, the single individual investment with the largest potential impact on campus GHG emissions (Uptown Campus) is use of a combined heat and power system (also referred to as co-generation or cogen) in the main utility plant of the Uptown Campus. Figure 10 diagrams conceptually the efficiency of a combined heat and power system compared to traditional grid sources of electricity. At Tulane, the plan is to re-employ the campus' existing combined heat and power plant which has been operated only a few hundred hours a year because of a period of time when the historic rates of electricity and gas rendered it cost prohibitive to operate as a base load resource. Through the CAP planning process use of this technology was revisited, initially based only on the fact that it is generally a very effective means of reducing GHG emissions. The result suggests that investment in base load use of the combined heat and power system, coupled with a steam driven chiller to utilize waste heat, is likely the optimal way to maximize savings per metric ton of carbon emissions avoided, maximize average annual reduction potential (expressed in metric tons of carbon emissions) and provide cost savings compared to the BAU scenario.

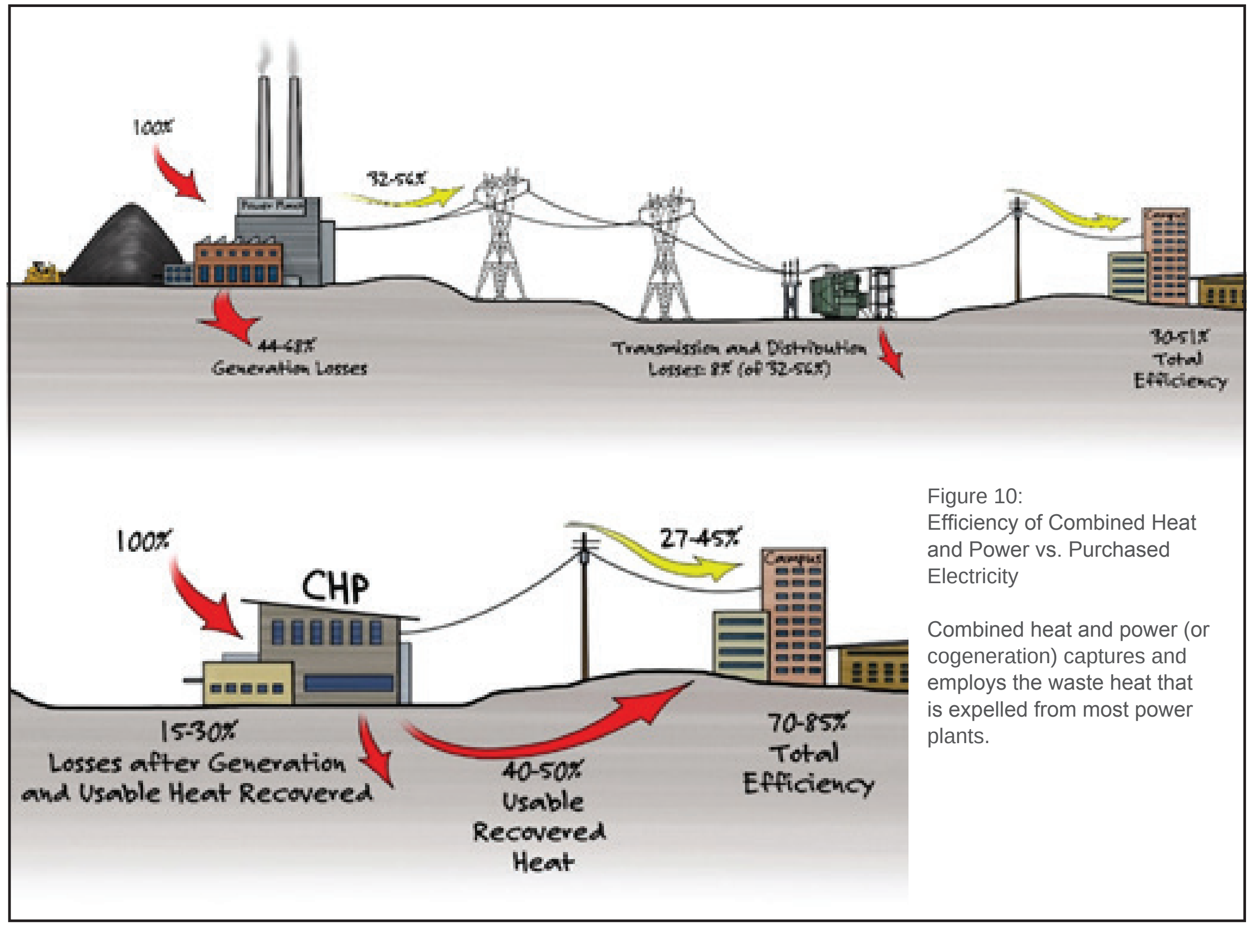


Figure 10:
Efficiency of Combined Heat and Power vs. Purchased Electricity

Combined heat and power (or cogeneration) captures and employs the waste heat that is expelled from most power plants.

Second, the move to combined heat and power is coupled with an equally significant type of energy investment: use of **low/no fossil fuel-based technologies**. In the last decade, there has been continued interest in and advocacy on the part of Tulane University students and faculty for these technologies, specifically for solar hot water and solar photovoltaic panels on campus buildings. While the University has examined the potential of using these technologies, both through direct funding and through partnership with third parties, the potential projects' financial return-on-investment have not warranted their development in either new construction or existing buildings. With creation of this plan, the University has revisited this dilemma and arrived at additional strategies that should change the fate of building integrated renewable energy technologies on both campuses.

- In revisiting campus design standards the University will include description of low/non fossil fuel investments in ways such that they are more likely to be proposed and less likely to be subject to budget cutting during the design process.
- The University will pursue opportunities to secure external gifts specific to this project type.
- The University will develop a mechanism to isolate avoided energy costs realized through other CAP investments and hold those to specifically reinvest in low/no carbon technologies.

> Over the last decade there has been continued interest in bringing solar hot water and solar photovoltaic systems to campus buildings

Third, through this plan the University commits to an active and long-lasting investment in improving the **energy efficiency of its building stock.** While the energy conservation measure (ECM) investment strategy is comprehensive in addressing both technology and building management/operations, a few elements of it deserve highlighting:

- Through the Building and Energy Literacy Campaign (described below), the entire campus community will be educated about individuals' ability to reduce energy use in buildings. This will be enhanced through a series of programs and projects to motivate change and measure its impact.
- The New Orleans climate represents challenges to achieving thermal comfort in buildings and can result in inefficient energy use through dehumidification and reheat. A need to improve thermal comfort and to address the perception on campus that energy is being wasted due to overcooling buildings during hot, humid conditions were discussed as objectives for this plan. The climate in New Orleans requires dehumidification of the ventilation air in order to maintain indoor comfort conditions. Figure 11 illustrates the number of hours during typical office building occupancy (7 a.m. to 7 p.m.) when the outdoor temperature conditions require dehumidification.

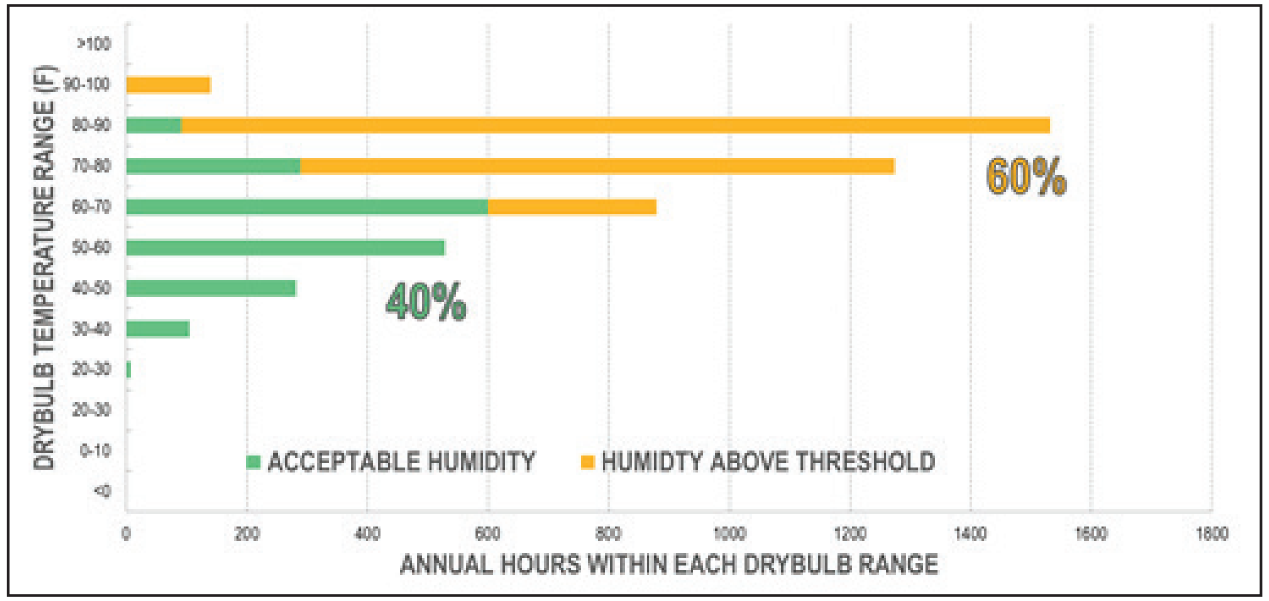


Figure 11: Outdoor air humidity vs Dry-bulb temperature comparison

Dehumidification is typically achieved by cooling the air and condensing moisture out. To avoid overcooling the indoor spaces, the air must then be reheated if the load in the space does not call for full cooling. Both of these processes require significant energy input and based on the campus energy profile, significant hours of simultaneous heating and cooling/dehumidification are likely occurring. Figure 12 shows the Uptown campus energy use profile with chilled water use increasing significantly during the warmer months while steam use only decreases approximately 30%. This points to the need for reheat energy.

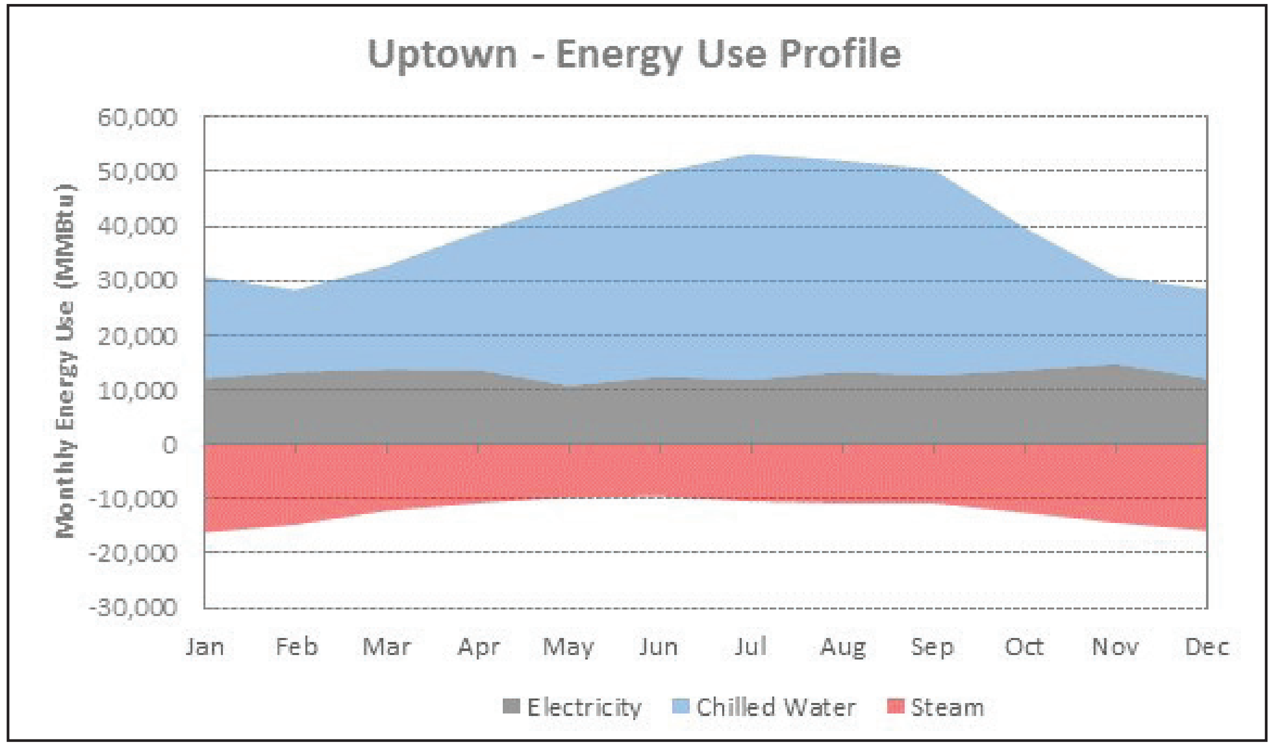


Figure 12: Uptown campus energy use profile

Achieving Thermal Comfort

This plan examined measures to minimize energy use while improving comfort in University buildings. Minimizing the amount of ventilation air to that required for indoor air quality is the first step to avoiding energy use associated with outdoor air conditioning. Regular retro-commissioning efforts should include aligning ventilation air setpoints and controls to those required by code and demand control ventilation, which adjusts to changes in building occupancy over the course of a day.

Once ventilation air is minimized, alternative methods of conditioning the air can be used to reduce energy use. Exhaust air heat recovery systems use the cool dry air being exhausted from buildings to precondition the ventilation air and reduces the amount of chilled water and steam necessary to complete the process. Dedicated outside air systems with desiccant dehumidification isolate the interior space loads from the ventilation loads and optimize the impact of exhaust air energy recovery.

Temperature setbacks and HVAC equipment scheduling also reduce energy use, but must be balanced with the need to control moisture within buildings and avoid additional reheat. When systems are scheduled off at night, ventilation and exhaust systems must be included in the operational protocols to avoid moisture migration and long startup periods. Seasonal setbacks can be used during warmer conditions as thermal comfort is a function of outdoor conditions. When occupants enter buildings from hot, humid outdoor conditions, they are more willing to accept warmer conditions inside as comfortable. For this to be effective, cooling at the primary system level has to be adjusted along with thermostat deadbands in order to prevent excessive reheat energy requirements described above. Employing these system and controls strategies will help improve comfort and reduce energy use and should be considered in the development of more specific construction standards

At this writing, the Uptown Campus buildings have electric meters and the Downtown buildings are largely independently metered for electricity and natural gas use. Building level chilled water or steam use is not metered on all Uptown Campus buildings and no submetering (i.e. lights, fans, plug load, etc.) is installed at either campus. A pilot energy dashboard project is being pursued on four buildings, but otherwise, active energy management through the use of building level and submetered energy end use has not been employed. The University's efforts to reduce energy use have primarily been achieved through employing campus energy standards and performance contracts with Johnson Controls, Inc. on both the Uptown and Downtown campuses. The campus energy standards have resulted in several LEED certified buildings and the performance contracts have replaced outdated primary cooling and heating systems downtown along with multiple building level upgrades such as variable speed pumping and lighting retrofits, but actual measured energy reduction has been limited to comparing overall campus energy use data, which has been inconclusive at this point.

For the University to achieve its ambitious greenhouse gas emissions reduction goals, the University needs to implement building level metering for all utilities (electricity, steam, chilled water, natural gas, and water) and submetering for end use data (lights, plug load, fans, pumps, heating and cooling). With this data, the University's facility management staff can actively manage energy use through the following methods:

- Benchmark and monitor energy use to establish a known starting point from which to measure future use and diagnosis problems such as equipment failures and overrides so quick corrective action may be taken. These data serve as a foundation for ongoing building commissioning, minimizing the need for future, more extensive commissioning efforts and improving the efficiency of the retro commissioning efforts when they are required.
- Measure impact and success of system upgrades and operational changes associated with energy conservation measures. When building upgrades are implemented, it is important to understand how the changes actually impacted energy use so future efforts can more appropriately target past successes and continuously improve performance.
- Inform future campus construction standards. As building energy use data become richer, it can be used to update campus design and construction standards that lead to the desired greenhouse gas reduction levels.
- Educate building occupants and students on building energy use and encourage behavioral change by supplying data to building dashboard visualization platforms.

Tulane University's commitment to extended use of its existing building stock is exemplified in the fact that the Uptown Campus was listed on the National Register of Historic Places in 1978. This provides compelling reason to revisit existing design standards to ensure that renovations include improvements that reduce building energy use as necessary to support the University's greenhouse gas emission reduction goals. Currently, the Tulane University standards (Green Building Design and Construction Standards & Guidelines, 2011) require performance that is measured as a percent better than an established guide (LEED) or standard (ASHRAE 90.1). The challenge with this approach is twofold. First, the baseline is constantly changing with each update of the guides and standards which will require the University to adjust the percent savings accordingly. Second, the guide and development timeline is not necessarily in line with Tulane's GHG emissions reduction schedule. For instance, LEED was last updated in 2009 and recent updates have been delayed. The University will likely have better outcomes if it additionally expresses performance standards in terms of its GHG emissions reduction targets and schedule. An example would be using metrics such as energy use intensity (kBtu/square foot/year) and performance requirements specific to certain systems (such as ventilation control, setbacks and shutdowns). As building metering is extended to all of University buildings and for each utility, the University will generate data that will be invaluable to subsequent revisiting of campus standards for the purpose of improving building energy performance.

Finally, the University is committed to helping students and employees travel with a low carbon impact. As travel is often tied to residence and reflects the regional transportation network, the 2014 Tulane University Climate Action Plan recognizes that such change will require a sustained, long-term effort. The approach it adopts is multi-faceted and is intended to grow over time as successful programs are reinforced and efforts respond to external changes. Key elements include:

- Education, awareness, and travel support – these programs would raise awareness of travel options and provide individualized support and information to help employees and students shift to lower carbon intensity modes.
- Incentives – as changing travel choice may represent some level of inconvenience, incentives aim to reward participation and lessen the burden. They can range from rewards to local restaurants and sporting goods stores for not driving to actual cash rebates for a lower-intensity mode.
- Transit subsidies – work with RTA and students and employees to develop a program to promote usage of the regional transit system by the university community. This might be in the form of a U-Pass program or reduced-price (up to complete subsidy) transit passes for those primarily using transit.
- Bicycle infrastructure improvements – expand bicycle parking in the short term. Over time, spending would increase to cover additional bicycle-related improvements such as bicycle locker rooms.
- Shuttle fuel efficiency enhancements – the university would work to enhance the fuel efficiency of its shuttle fleet to lessen the impacts of those commuting to campus via university shuttle.
- Housing incentives program – a comprehensive set of incentives to encourage employees and students to live close enough to campus to walk or bike, primarily. This could be in the form of housing subsidies, loan guarantees/discounts, or assistance with closing costs. It may also be possible to work more broadly to partner with private developers and/or local government to redevelop parcels close to Tulane campuses to provide additional capacity and/or enhanced quality.

This plan endorses the actions aimed at achieving roughly a fifty percent reduction in commuting-related GHG emissions, relative to the BAU. This represents a substantial commitment to enhancing travel options and supporting commuters in their ability to reduce their commuting footprint. The programs above outline the broad strokes of the plan, but its ultimate success will require commitment from Tulane University to raise awareness of travel options and ensure that they respond to commuters' needs. Achieving such a noticeable reduction in commuting-related GHG emissions will rest on the number of individuals whose commute has no carbon impact: those who walk and bike to campus. A balance of incentive and disincentives will be necessary, as incentive-based programs are almost never as effective as those which are accompanied by some level of disincentive such as increasing parking prices or reducing the number of spaces provided.

Providing university-driven incentives and disincentives will transition commuting patterns to be less carbon-intensive

The plan recognizes that because travel patterns are tied to behavior and long-term patterns, including housing choice, it must reflect Tulane's values and priorities to succeed. The university should expect that its commuting program costs will vary as participation grows and as participation rates reach trigger points where it will be necessary to recalibrate programs to perpetuate reduced single occupant vehicles (SOV) use. Establishing a dedicated revenue stream at the start of the plan's implementation term will provide campus transportation planners with finances to support their desired agility to evolve these programs.

INVESTMENT PORTFOLIOS

Near-term investments are those for which Tulane University identifies compelling reason for immediate implementation (occurring 2015 through 2019). These measures are estimated to achieve a 15% reduction from the University's base year GHG emissions (2007). These investments use existing equipment, are in harmony with other campus investments, offer synergistic opportunities within the category of near-term investments, and represent the greatest return on investment (savings per metric ton of carbon emissions avoided). Tulane University's near-term portfolio features investments in energy conservation, employing the University's underused cogeneration assets, and investing in steam production and distribution efficiency.

Near-Term Portfolio (2015 through 2019)	
Average annual tons MTCO2e reduced	23,000
Capital cost (2014 $)	$21,900,000
Annual savings (2014 $)	$2,600,000
Payback period (across near-term portfolio)	12 years

Table 1: Impact of Near-Term Portfolio

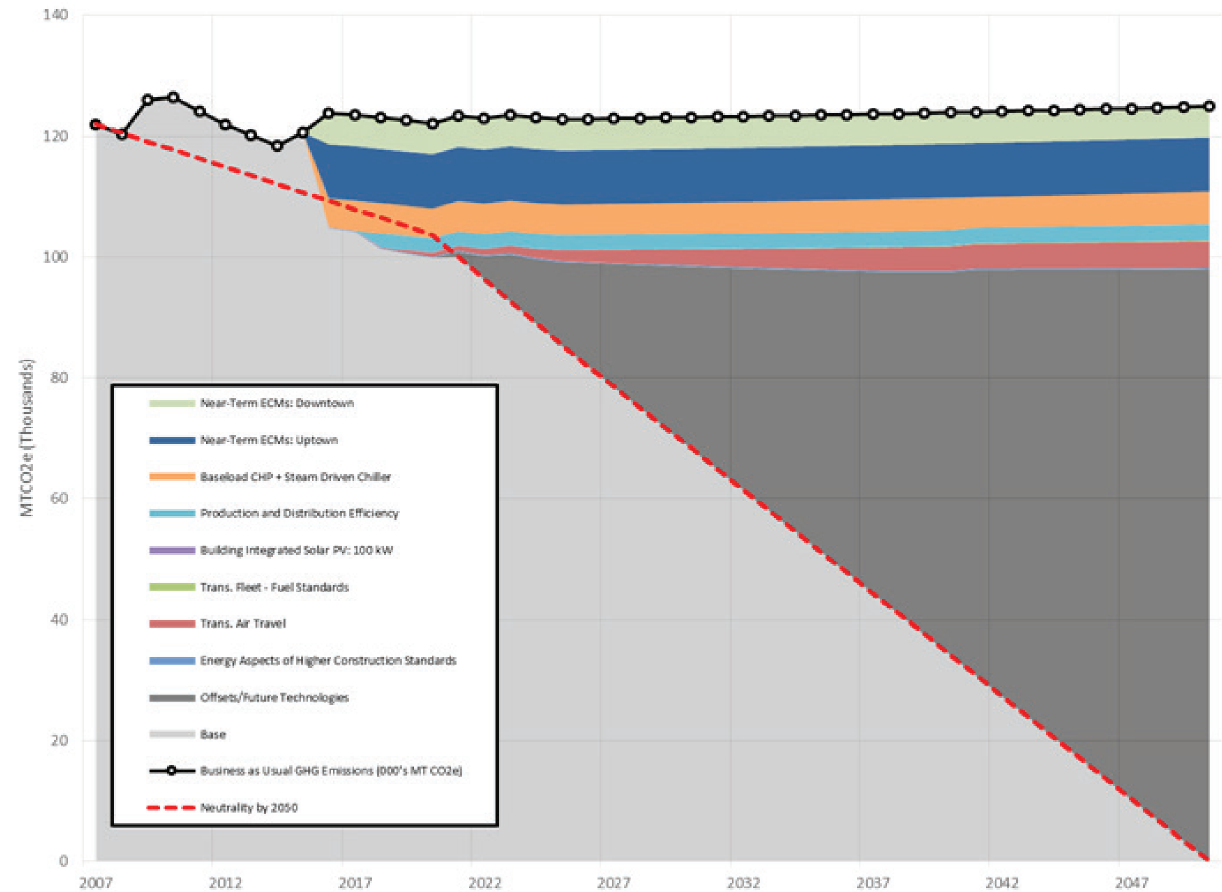


Figure 13: Near-Term Portfolio (2015 to 2019)

Mid-term investments are, as a category, financially less compelling than that of the near-term phase. Once developed, these measures will expand on the impact of near-term investments to yield a 21% reduction from the University's 2007 GHG emissions level. They are synergistic within the category of mid-term investments, build well off the impact of the immediate investments, include technologies that are projected to gain cost effectiveness, and/or are assigned to this timeframe to allow for the preparation time needed to implement the measures and sequence with other investments. Tulane University's mid-term portfolio is to occur 2020 through 2024 and it features investments in energy conservation and transportation programs. It is also planned that the University will revisit its climate action plan during this term, ten years after development of this document.

Mid -Term Portfolio (2020 through 2024)	
Average annual tons MTCO2e reduced	2,800
Capital cost (2014 $)	$5,500,000
Annual costs (no savings) (2014 $) Payback period (across portfolio)	$544,000 Not applicable

Table 2: Impact of Mid-Term Portfolio

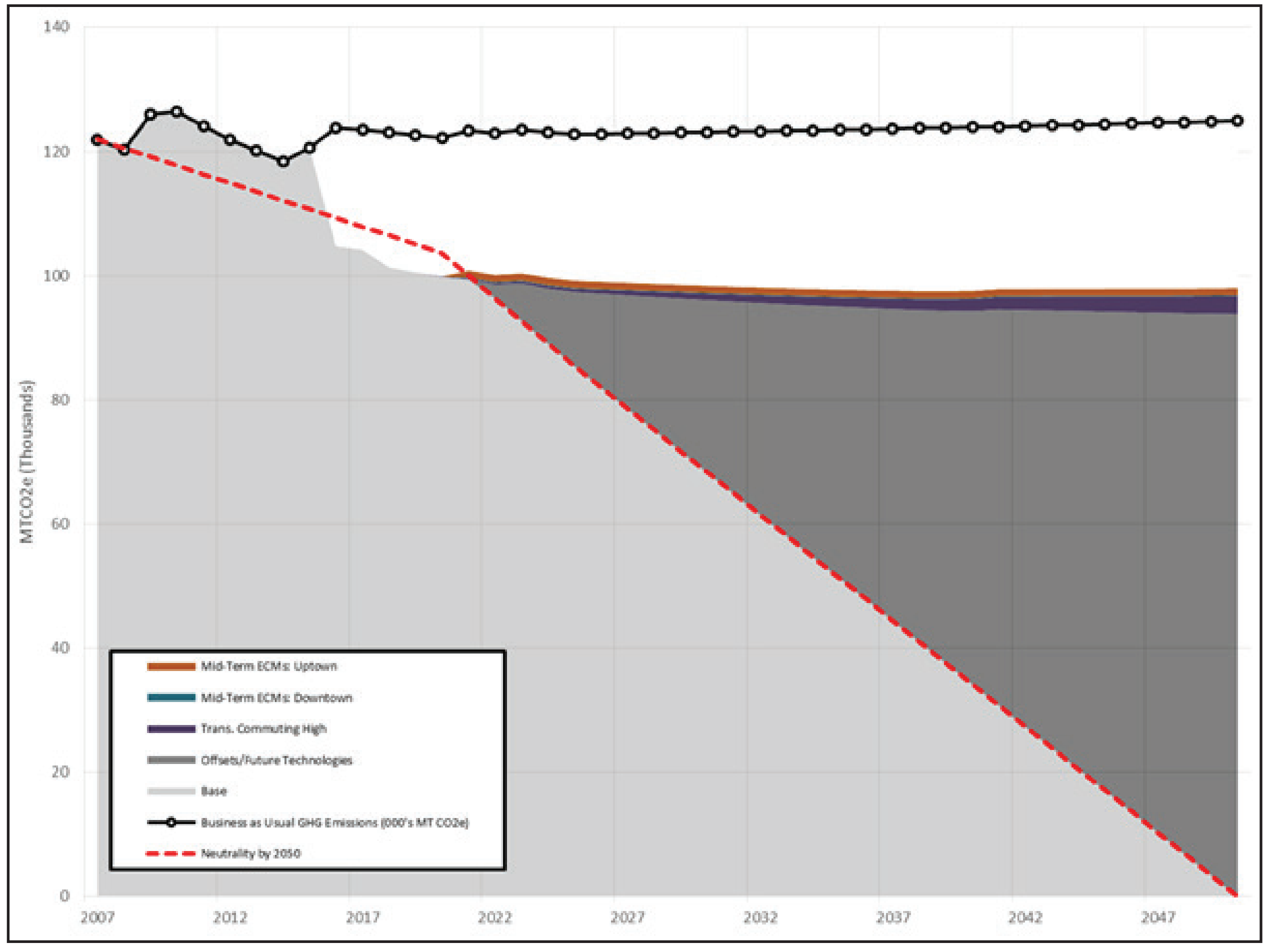


Figure 14: Mid-Term Portfolio (2020 to 2024)

Long-term investments are scheduled for 2025 to 2050 and are intended to take the University to climate neutrality. This is a period of less certainty, so more of the investment opportunities aren't specific. The expectation is that technologies will develop and costs will change. For example, the cost of solar installations might justify an expanded scale of installations, third party arrangements to purchase renewable energy-sourced electricity might become more available and affordable, and partner arrangements for on-campus energy investments may become more attractive. Changes like these in the next decade will position Tulane University to bring considerably greater certainty to this document's long-term investment portfolio when the University next updates the CAP, expected to be drafted within a decade of this report. In the interim, this report recommends that long-term investments include energy conservation, renewable energy (1 MW PV, solar thermal) technologies, and offsets and/or future technologies.

Long -Term Portfolio (2025 to 2050) (excludes offsets and new technologies)	
Average annual tons MTCO2e reduced	12,500
Capital cost (2014 $)	$58,500,000
Annual savings (2014 $) Payback period (across portfolio)	$435,000 Not applicable

Table 3: Impact of Long-Term Portfolio

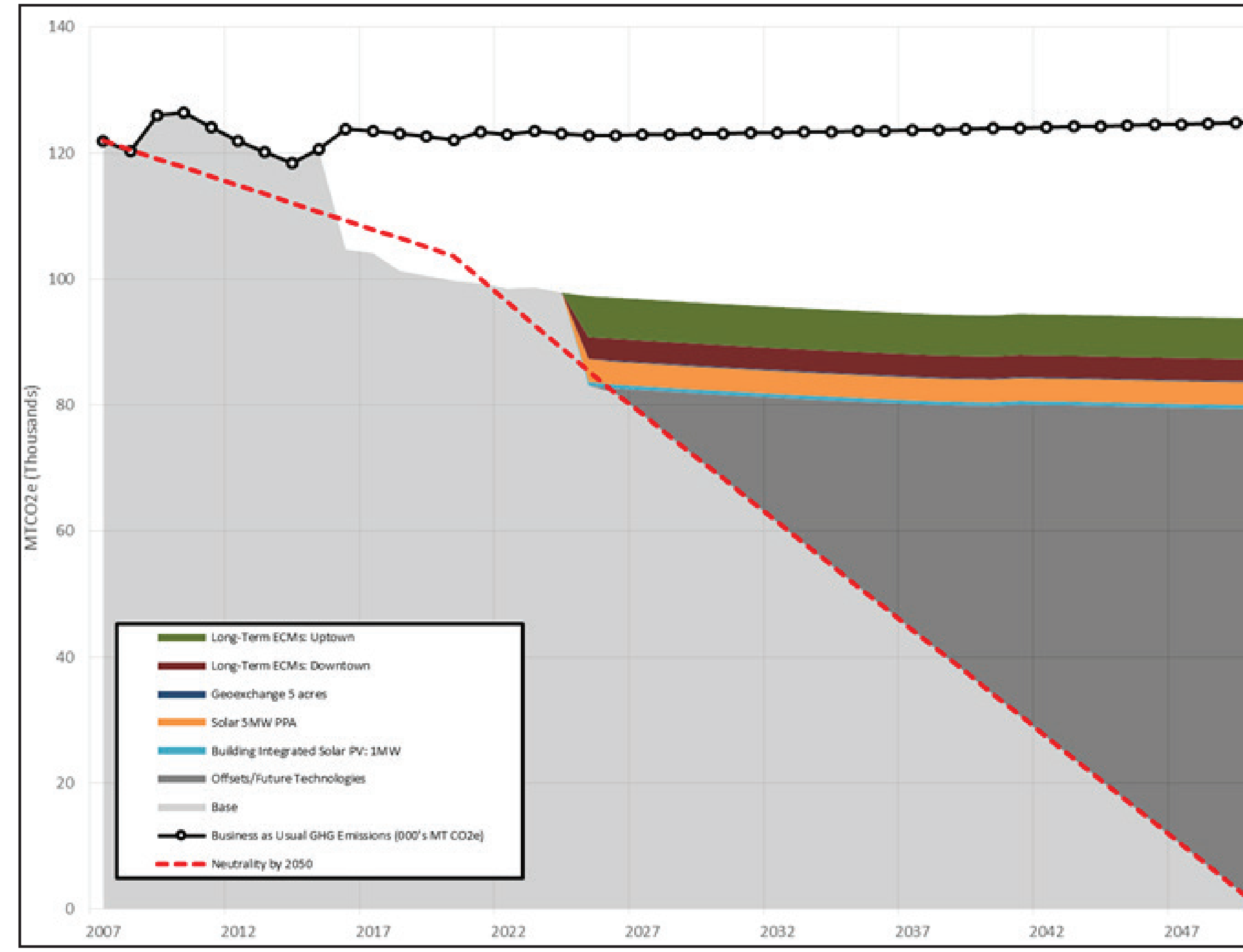


Figure 15: Long-Term Portfolio (2025 to 2050)

Each portfolio should be considered to extend from its respective start date to 2050. The total capital and total operating & maintenance costs for each portfolio include the costs from start date to 2050. For example, while the Near-Term Portfolio includes $6M for higher energy efficiency standards for new construction, that total includes costs for new construction built beyond the near term. For a more detailed presentation of this information, see Appendix A: Schedule of Investments.

IV. CLIMATE ACTION PLAN AS A LIVING DOCUMENT

Tulane University's Office of Sustainability is responsible for guiding and coordinating implementation of this plan. Organizationally assigned to the University Planning Office, the Office of Sustainability is the University's reference source, coordinator, student guide, and planner of University GHG emissions reduction activities. It authors the University's reports on campus sustainability and GHG emissions[9]. It also leads the coordination of development of information about sustainability and its dissemination and consideration within the University community.

Tulane University plans to finance its greenhouse gas emissions reduction activities through a combination of bonding for capital expenses, operating budget, a revolving loan fund, alumni support, and student investment. Of emerging interest is a Tulane University revolving loan fund to invest in energy conservation, energy efficiency and other GHG emissions reduction measures. At least fifty colleges and universities have such funds. According to Greening the Bottom Line, a study published by the Sustainable Endowments Institute (2011), revolving funds that allocate funds in a "self-directed" manner are gaining popularity at colleges and universities throughout the U.S. These funds are focused on investing in energy conservation and efficiency as well as other aspects of sustainable operations. For a detailed exploration of revolving loan funds for energy conservation and energy efficiency, see Appendix D.

The University's mission is to "create, communicate and conserve knowledge in order to enrich the capacity of individuals, organizations and communities to think, to learn and to act and lead with integrity and wisdom". In the context of this plan, the university's mission has been interpreted to bring emphasis to the role of organizations and communities. Thus, an essential aspect of making this a living document is ensuring that its interpretation is carried forward through campus organizations, both existing and yet to be born, and that the plan impacts not just the college community, but that of the city and the region. The plan conceives of Tulane University students acting with the University's imprimatur to reduce greenhouse gas emissions through their individual and collective actions – in study, research, community service and engagement, as contributors to campus investment decisions and as building occupants.

9 This reporting is outside of any permit-related reporting undertaken by University Environmental Health and Safety staff.

Staff Resources for the Tulane University Office of Sustainablity

Ensuring that the 2014 Tulane University Climate Action Plan is successful will require increased staff resources within the Office of Sustainability to engage the university community and guide resources for implementation. In this plan, cost estimates for the Near-Term Energy Conservation Measures include an annual budget of $270,000 for a Building and Energy Literacy Campaign, which includes increased staffing. To start exploration of this issue, the report looked to the staff size and profile of climate action plan-implementing offices at other, comparable institutions. These institutions are like Tulane in that they are privately owned, made an early (2008) commitment to the ACUPCC, have a completed climate action plan and robust sustainability profile, and are of comparable size. The research on staffing revealed that:

- each has an office director (Director of Sustainability)
- each has between 2 and 4 program-specific professional staff (titles are Sustainability Manager Sustainability Coordinator, Sustainability Project Coordinator, Stakeholder Engagement Coordinator, and Recycling/Zero Waste Manager)
- half of them have an administrative staff person and
- they have as many as 24 student interns

APPENDIX A: SCHEDULE OF INVESTMENTS & GHG REDUCTIONS, 2015 THROUGH 2024

CAPITAL EXPENDITURES

	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Near-Term Portfolio										
Baseload CHP + Steam Driven Chiller	$1,950,000									
Higher Construction Standards	$1,818,000	$1,386,000	$522,000				$1,584,000		$540,000	
Near-Term ECMs: Uptown		$4,000,000								
Near-Term ECMs: Downtown		$2,000,000								
Building Integrated Solar PV: 100 kW			$381,900							
Production and Distribution Efficiency				$5,900,000						
Trans. Fleet - Fuel Standards		$20,000	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000
Trans. Air Travel		$40,000	$40,000	$40,000	$40,000	$40,000	$35,000	$35,000	$30,000	$30,000
Mid-Term Portfolio										
Mid Term ECMs: Uptown							$1,300,000			
Mid-Term ECMs: Downtown							$150,000			
Trans. Commuting High						$100,000	$102,000	$104,000	$106,000	$108,000
Long-Term Portfolio										
Long-Term ECMs: Uptown										
Long-Term ECMs: Downtown										
Geoexchange 5 Acres										
Building Integrated Solar PV: 1 MW										
Grand Total	**$3,768,000**	**$7,446,000**	**$963,900**	**$5,960,000**	**$60,000**	**$160,000**	**$3,191,000**	**$159,000**	**$696,000**	**$158,000**

OPERATIONAL EXPENDITURES

INCREMENTAL OPERATING COSTS	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Near-Term Portfolio										
Baseload CHP + Steam Driven Chiller	$ 203,844	$ 203,844	$ 203,844	$ 203,844	$ 203,844	$ 203,844	$ 203,844	$ 203,844	$ 203,844	$ 203,844
Higher Construction Standards	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Near-Term ECMs: Downtown		$ 300,000	$ 300,000	$ 300,000	$ 300,000	$ 300,000	$ 300,000	$ 300,000	$ 300,000	$ 300,000
Near-Term ECMs: Uptown		$ 600,000	$ 600,000	$ 600,000	$ 600,000	$ 600,000	$ 600,000	$ 600,000	$ 600,000	$ 600,000
Building Integrated Solar PV: 100 kW			$ 1,900	$ 1,900	$ 1,900	$ 1,900	$ 1,900	$ 1,900	$ 1,900	$ 1,900
Production and Distribution Efficiency				$ 50,000	$ 50,000	$ 50,000	$ 50,000	$ 50,000	$ 50,000	$ 50,000
Trans. Fleet - Fuel Standards				$ -	$ -	$ -	$ -	$ -	$ -	$ -
Trans. Air Travel				$ 20,000	$ 20,000	$ 20,000	$ 20,000	$ 20,000	$ 20,000	$ 20,000
Mid-Term Portfolio										
Mid Term ECMs: Uptown							$ 40,000	$ 40,000	$ 40,000	$ 40,000
Mid-Term ECMs: Downtown							$ 4,000	$ 4,000	$ 4,000	$ 4,000
Trans. Commuting High							$ 405,700	$ 429,400	$ 454,100	$ 477,900
Total	**$ 203,844**	**$ 1,103,844**	**$ 1,105,744**	**$ 1,175,744**	**$ 1,175,744**	**$ 1,175,744**	**$ 1,625,444**	**$ 1,649,144**	**$ 1,673,844**	**$ 1,697,644**

INCREMENTAL OPERATING SAVINGS	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Near-Term Portfolio										
Baseload CHP + Steam Driven Chiller	$ (603,844)	$ (693,844)	$ (703,844)	$ (695,844)	$ (733,844)	$ (763,844)	$ (723,844)	$ (673,844)	$ (643,844)	$ (683,844)
Higher Construction Standards	$ (8,000)	$ (20,000)	$ (22,000)	$ (23,000)	$ (24,000)	$ (24,000)	$ (28,000)	$ (28,000)	$ (29,000)	$ (30,000)
Near-Term ECMs: Downtown		$ (720,000)	$ (720,000)	$ (750,000)	$ (790,000)	$ (800,000)	$ (790,000)	$ (800,000)	$ (790,000)	$ (790,000)
Near-Term ECMs: Uptown		$ (1,250,000)	$ (1,270,000)	$ (1,320,000)	$ (1,380,000)	$ (1,400,000)	$ (1,390,000)	$ (1,400,000)	$ (1,380,000)	$ (1,390,000)
Building Integrated Solar PV: 100 kW			$ (8,400)	$ (8,500)	$ (8,900)	$ (9,300)	$ (9,400)	$ (9,400)	$ (9,400)	$ (9,300)
Production and Distribution Efficiency				$ (310,000)	$ (330,000)	$ (340,000)	$ (360,000)	$ (360,000)	$ (360,000)	$ (370,000)
Trans. Fleet - Fuel Standards				$ (1,299)	$ (2,599)	$ (3,898)	$ (5,198)	$ (6,497)	$ (7,797)	$ (9,096)
Trans. Air Travel				$ -	$ -	$ (23,700)	$ (47,400)	$ (71,100)	$ (94,800)	$ (118,500)
Mid-Term Portfolio										
Mid Term ECMs: Uptown							$ (160,000)	$ (160,000)	$ (170,000)	$ (170,000)
Mid-Term ECMs: Downtown							$ (18,000)	$ (18,000)	$ (19,000)	$ (19,000)
Trans. Commuting High							$ (1,700)	$ (3,400)	$ (5,100)	$ (6,900)
Total	**$ (611,844)**	**$ (2,683,844)**	**$ (2,724,244)**	**$ (3,108,643)**	**$ (3,269,343)**	**$ (3,364,742)**	**$ (3,533,542)**	**$ (3,530,241)**	**$ (3,508,941)**	**$ (3,596,640)**

Note: Savings are shown as if measures are implimented in isolation. Implemented together, the improved efficiency of one measure may reduce the savings of another.

NET OPERATING SAVINGS	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Near-Term Portfolio										
Baseload CHP + Steam Driven Chiller	$ (400,000)	$ (490,000)	$ (500,000)	$ (492,000)	$ (530,000)	$ (560,000)	$ (520,000)	$ (470,000)	$ (440,000)	$ (480,000)
Higher Construction Standards	$ (8,000)	$ (20,000)	$ (22,000)	$ (23,000)	$ (24,000)	$ (24,000)	$ (28,000)	$ (28,000)	$ (29,000)	$ (30,000)
Near-Term ECMs: Downtown		$ (420,000)	$ (420,000)	$ (450,000)	$ (490,000)	$ (500,000)	$ (490,000)	$ (500,000)	$ (490,000)	$ (490,000)
Near-Term ECMs: Uptown		$ (650,000)	$ (670,000)	$ (720,000)	$ (780,000)	$ (800,000)	$ (790,000)	$ (800,000)	$ (780,000)	$ (790,000)
Building Integrated Solar PV: 100 kW			$ (6,500)	$ (6,600)	$ (7,000)	$ (7,400)	$ (7,500)	$ (7,500)	$ (7,500)	$ (7,400)
Production and Distribution Efficiency				$ (260,000)	$ (280,000)	$ (290,000)	$ (310,000)	$ (310,000)	$ (310,000)	$ (320,000)
Trans. Fleet - Fuel Standards				$ (1,299)	$ (2,599)	$ (3,898)	$ (5,198)	$ (6,497)	$ (7,797)	$ (9,096)
Trans. Air Travel				$ 20,000	$ 20,000	$ (3,700)	$ (27,400)	$ (51,100)	$ (74,800)	$ (98,500)
Mid-Term Portfolio										
Mid Term ECMs: Uptown							$ (120,000)	$ (120,000)	$ (130,000)	$ (130,000)
Mid-Term ECMs: Downtown							$ (14,000)	$ (14,000)	$ (15,000)	$ (15,000)
Trans. Commuting High							$ 404,000	$ 426,000	$ 449,000	$ 471,000
Total	**$ (408,000)**	**$ (1,580,000)**	**$ (1,618,500)**	**$ (1,932,899)**	**$ (2,093,599)**	**$ (2,188,998)**	**$ (1,908,098)**	**$ (1,881,097)**	**$ (1,835,097)**	**$ (1,898,996)**

GHG EMISSIONS

		2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
	Business as Usual GHG Emissions (MT CO2e)	**120,586**	**123,815**	**123,480**	**123,028**	**122,580**	**122,136**	**123,378**	**122,938**	**123,452**	**123,017**	**122,761**
Near-Term Portfolio Reductions		**4,853**	**19,071**	**19,313**	**21,938**	**22,268**	**22,515**	**22,785**	**23,062**	**23,300**	**23,578**	**23,796**
1	Baseload CHP + Steam Driven Chiller	4,796	4,796	4,965	4,968	4,968	4,968	4,968	5,011	5,011	5,036	5,036
2	Energy Aspects of Higher Construction Standards	57	144	152	152	152	152	179	179	188	188	191
3	Near-Term ECMs: Uptown	0	8,992	8,992	8,992	8,992	8,992	8,992	8,992	8,992	8,992	8,992
4	Near-Term ECMs: Downtown	0	5,140	5,140	5,140	5,140	5,140	5,140	5,140	5,140	5,140	5,140
5	Building Integrated Solar PV: 100 kW	0	0	61	61	61	61	61	61	61	61	61
6	Production and Distribution Efficiency	0	0	0	2,229	2,308	2,309	2,314	2,319	2,324	2,360	2,365
7	Trans. Fleet - Fuel Standards	0	0	3	7	11	15	19	22	26	30	34
8	Trans. Air Travel	0	0	131	388	636	878	1,112	1,338	1,558	1,771	1,977
Mid-Term Portfolio Reductions		**0**	**0**	**0**	**0**	**0**	**94**	**1,460**	**1,554**	**1,648**	**1,742**	**1,836**
1	Mid-Term ECMs: Uptown	0	0	0	0	0	0	1,143	1,143	1,143	1,143	1,143
2	Mid-Term ECMs: Downtown	0	0	0	0	0	0	129	129	129	129	129
3	Trans. Commuting High	0	0	0	0	0	94	188	282	376	470	564
Long-Term Portfolio Reductions		**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**14,423**
1	Long-Term ECMs: Uptown	0	0	0	0	0	0	0	0	0	0	6,537
2	Long-Term ECMs: Downtown	0	0	0	0	0	0	0	0	0	0	3,489
3	Geoexchange 5 acres	0	0	0	0	0	0	0	0	0	0	182
4	Solar 5MW PPA	0	0	0	0	0	0	0	0	0	0	3,606
5	Building Integrated Solar PV: 1MW	0	0	0	0	0	0	0	0	0	0	609
6	Offsets/Future Technologies	0	0	0	0	0	0	0	0	0	0	0
Total GHG Emissions Reduction potential		**4,853**	**19,071**	**19,313**	**21,938**	**22,268**	**22,609**	**24,245**	**24,616**	**24,948**	**25,320**	**40,055**
	% reduction from BAU	4%	15%	16%	18%	18%	19%	20%	20%	20%	21%	33%
	% reduction from 2007 baseline	4%	16%	16%	18%	18%	19%	20%	20%	20%	21%	33%
	Goals						15%					30%

2007 Baseline GHG Emissions (MT C02e)
121,951

APPENDIX B: ABATEMENT OPTIONS PROFILES

The following opportunities are represented in this document's abatement profile and in the plan's model (recommended investments).

NEAR-TERM PORTFOLIO

Air Travel	
Promote more efficient air travel by prioritizing air carriers with lower emissions per passenger-mile. This could result in an agreement of a preferred airline, for example. Develop programs to support increased electronic communication including distribution of webcams, etc.	**Capital (2014 $)** • $40,000/yr in 2015 (throughout project life with decrease to $25,000/y in 2024 **O&M (2014$)** • Approximately ¼ FTE to support programs • Savings from avoided travel grows to $450,000/yr by 2036 (5% of total travel expenditure) **Change in Demand** • Additional ½% reduction in air travel emissions from improved carrier efficiency • ½% reduction in travel for 20 years (2017-2036) **Change in Supply** • None **Impact on GHG Emissions** • Decrease in Scope 3 **Start Date** • 2015 **Useful Life** • Indefinite **Average Annual Savings (2014 $)** • 303,000 **Simple Payback** • more than 36 years

Building and Energy Literacy Campaign	
Integrated activities that bring greater University focus to climate change. This is intended to stimulate behavioral change to reduce University GHG emissions in part by linking the issue between classroom and other aspects of the university experience. Phase 1 – Integrate building energy information into student and staff community through social media, curricula, incentive programs and educational guides Phase 2 – Set targets for each class and hold contests Phase 3 – Tulane to establish itself as national expert (Note: O&M charge appears as part of ECMs)	**Capital (2014 $)** • None **Annual O&M (2014 $)** • $270,000 **Change in Demand** • Reduce purchased fuels • Reduce purchased electricity **Change in Supply** • None **Impact on GHG Emissions** • Net reduction in scope 1 & 2 **Start Date** • 2015 **Useful Life** • 40 years **Average Annual Savings (2014 $)** • $335k **Simple Payback** • **< 1 year**

Building Integrated PV	
Install a 100kW and a 1MW building integrated solar photovoltaic (BIPV) system. Additional Information: • PV Watts-solar resource	**Capital (2014 $)** • $381,000 (100kW); $3.8M (1MW) **Annual O&M (2014 $)** • $1,900 (100kW); $19,000 (1MW) **Change in Demand** • None **Change in Supply** • Reduce Purchased Electricity **Impact on GHG Emissions** • Reduce scope 2 **Start Date** • 2015 (100kW); 2025 (1MW) **Useful Life** • 25 years **Average Annual Savings (2014 $)** • $8,060 (100kW); $80,600 (1MW) **Simple Payback** • more than 36 years

Combined Heat and Power with Steam Driven Chiller	
Baseload the current Combined Heat and Power (CHP) system year-round and add a 2000 ton steam driven chiller to utilize waste steam (turbine), when available, from the CHP system to produce chilled water. Additional Information: Incremental Capital: • Steam Driven Chiller = $1.8M • CHP = 150,000 Incremental O&M • Steam Driven Chiller = $70,900/yr • CHP = 132,994/yr *Source: York Estimate* Mutually exclusive with other CHP options	**Capital (2014 $)** • $1.95 M **O&M (2014 $)** • $203,844/yr **Change in Demand** • None **Change in Supply** • Reduce purchased electricity • Reduce purchased fuels **Impact on GHG Emissions** • Reduce scope 1 & 2 **Start Date** • 2015 **Useful Life** • 25 years (Steam Driven Chiller), 50 years (CHP) **Average Annual Savings (2014 $)** • $508,000 **Simple Payback** • 5 years

Energy Conservation Measures (Near-Term)	
ECMs with a combined simple payback of less than 7 years. Downtown ECMs (10 buildings): • Variable Speed Drive Pumps • Demand Control Ventilation • Temperature Setbacks • Equipment Scheduling • Building Metering • Retro-Commissioning • Demand Management • Lighting Upgrade Uptown ECMs (41 buildings): • Variable Speed Drive Pumps • Demand Control Ventilation • Fume hood Decommissioning • Temperature Setbacks • Building Metering • Equipment Scheduling • Retro-Commissioning • Demand Management • Lighting Upgrade	**Capital (2014 $)** • $2.0M (DT), $4.0M (UT) **Annual O&M (2014 $)** • $300,000 (DT), $600,000 (UT) **Change in Demand** • Reduce purchased fuels • Reduce purchased electricity **Change in Supply** • None **Impact on GHG Emissions** • Net reduction in scope 1 & 2 **Start Date** • 2015 **Useful Life** • 40 years **Average Annual Savings (2014 $)** • $611,000 (DT), $990,000 (UT) **Simple Payback** • **5 years (DT), 6 years (UT)**

Fleet – Fuel Standards	
Establish fuel purchase standards for fleet vehicles to achieve reductions in fuel use. Program pays ~$2,000 premium for higher than average efficiency vehicle (for 10 vehicles per year). *Mutually exclusive with other fleet options*	**Capital (2014$)** • $20,000/yr (throughout project life) **O&M (2014$)** • Savings grow to over $45,000/y in 2050 **Change in Demand** • 43% reduction of gasoline by 2050 • 20% reduction of diesel by 2050 **Change in Supply** • None **Impact on GHG Emissions** • Decrease in Scope 1 **Start Date** • 2015 **Useful Life** • Indefinite **Average Annual Savings (2014 $)** • $24,000 **Simple Payback** • more than 36 years

Higher Energy Component of Design Standards	
This resource option increases building energy standards for new construction to 31% savings above ASHRAE 90.1 2007 (10% above ASHRAE 90.1 2013). Additional Information: • $9/SF increase in construction costs for new buildings	**Capital (2014 $)** • $3.7 M (2015-2019): $2.3 M (after) **Annual O&M (2014 $)** • No incremental over BAU **Change in Demand** • Reduce purchased fuels • Reduce purchased electricity **Change in Supply** • None **Impact on GHG Emissions** • Reduce scope 1 & 2 **Start Date** • 2015 **Useful Life** • More than 36 years **Average Annual Savings (2014 $)** • $32,000 **Simple Payback** • more than 36 years

Production and Distribution Efficiency

This resource option increases the plant production and distribution efficiency by 1) adding a condensing economizer on the existing boilers, 2) conducting chilled water retro-commissioning activities and 3) decreasing steam distribution losses from 15% to 10%.

Additional Information:

- Example chilled water retro-commissioning projects include control valve replacement or updates and variable speed drive pumping

Capital (2014 $)
- $5.9 M

O&M (2014 $)
- $50,000

Change in Demand
- None

Change in Supply
- Reduce purchased fuels
- Reduce purchased electricity

Impact on GHG Emissions
- Reduce Scope 1 & 2

Start Date
- 2015

Useful Life
- 40 years

Average Annual Savings (2014 $)
- $400,000

Simple Payback
- 18 years

MID-TERM PORTFOLIO

Commuter – High Investment (Live/Work)

Invest in commuter incentives to reduce single occupant vehicle (SOV) commuting. Additional investments and programs to promote students and employees living close to campus.

- Transit incentive
- Additional shuttle service
- Commuter incentives & marketing,
- Staff support (0.5->1.5FTE)
- Housing program: loan, capital, staff support (up to 1.5 FTE)
- Additional bike infrastructure (grows to $150,000 in 2050)
- Shuttle fleet fuel efficiency program/ standards

Mutually exclusive with other commuter options

Capital (2014$)
- $100,000/yr grows to $160,000/yr in 2050 (shuttle and bikes)

O&M (2014$)
- $400,000/yr grow to $1.2 M/yr in 2050 (this includes savings in reduced downtown parking expenditures of $400,000 in 2050)

Change in Demand
- Reduction in SOV for employees 45% Uptown and 50% Downtown and for students of 25% Uptown and 40% Downtown, relative to the BAU

Change in Supply
- Not applicable

Impact on GHG Emissions
- Net reduction in combined Scope 1 and 3

Start Date
- 2020

Useful Life
- 40 years

Average Annual Costs (2014$)
- $742,000

Simple Payback
- No payback

Energy Conservation Measures (Mid-Term)

ECMs with a combined simple payback of less than 12 years.

Downtown Campus ECMs (2 buildings):
- Lighting Controls

Uptown Campus ECMs (22 buildings):
- Lighting Controls

Capital (2014$)
- $150,000 (DT), $1.3 M (UT)

Annual O&M (2014$)
- $4,000 (DT), $40,000 (UT)

Change in Demand
- Reduce purchased fuels
- Reduce purchased electricity

Change in Supply
- None

Impact on GHG Emissions
- Reduction in Scope 1 and 2

Start Date
- 2020

Useful Life
- 40 years

Average Annual Savings (2014$)
- $17,200 (DT), $149,000 (UT)

Simple Payback
- 10 years (DT and UT)

LONG-TERM PORTFOLIO

Building Integrated PV	
Install a 100kW and a 1MW building integrated solar photovoltaic (BIPV) system. Additional Information: • PV Watts-solar resource	**Capital (2014 $)** • $381,000 (100kW); $3.8M (1MW) **Annual O&M (2014 $)** • $1,900 (100kW); $19,000 (1MW) **Change in Demand** • None **Change in Supply** • Reduce Purchased Electricity **Impact on GHG Emissions** • Reduce scope 2 **Start Date** • 2015 (100kW); 2025 (1MW) **Useful Life** • 25 years **Average Annual Savings (2014 $)** • $8,060 (100kW); $80,600 (1MW) **Simple Payback** • more than 36 years

Energy Conservation Measures (Long-Term)	
ECMs with a combined simple payback more than 30 years. Downtown ECMs (10 buildings): • Constant Volume to Variable Air Volume • Exhaust Air Heat Recovery • Fume Hood VAV • Plug Load Management • Window Replacement • Solar Thermal Uptown ECMs (41 buildings): • Constant Volume to Variable Air Volume • Dedicated Outside Air Systems • Fume Hood VAV • Plug Load Management • Window Replacement • Solar Thermal	**Capital (2014$)** • $16 M (DT), $38 M (UT) **Annual O&M (2014$)** • 375,000 (DT), $500,000 (UT) **Change in Demand** • Reduce purchased fuels • Reduce purchased electricity **Change in Supply** • None **Impact on GHG Emissions** • Reduction in Scope1 and 2 **Start Date** • 2025 **Useful Life** • 40 years **Average Annual Savings (2014$)** • $212,000 (DT), $604,000 (UT) **Simple Payback** • **Approximately (assumed to be) 40 years**

Green Power Purchases	
Purchase green power from the electric utility company. Green Power Purchases allow consumers to purchase renewable energy certificates (RECs).	**Capital (2014 $)** • None **Annual O&M (2014 $)** • $7/MWH to represent a typical price. Actual cost will depend on contract negotiations. **Change in Demand** • None **Change in Supply** • None **Impact on GHG Emissions** • Reduce scope 2 **Start Date** • 2025 **Useful Life** • Indefinite **Average Annual Costs (2014 $)** • $128,000 **Simple Payback** • Not Applicable

Greenhouse Gas Offsets	
This option purchases offsets for all natural gas in order to reduce, avoid, or destroy the equivalent of a ton of emissions. Offsets generally represent direct emission reductions or sequestration. It prices GHG offsets at $/ MTCO2e.	**Capital (2014 $)** • None **Annual O&M (2014 $)** • $10/MTCO2e to represent at typical price. Actual cost will depend on contract negotiations. **Change in Demand** • None **Change in Supply** • None **Impact on GHG Emissions** • Reduce scope 1 **Start Date** • 2025 **Useful Life** • Indefinite **Average Annual Costs (2014 $)** • $310,000 represents the cost of offsets after RECs have been purchased for the electricity portion of the energy consumption. **Simple Payback** • Not applicable

Horizontal Geo-exchange	
A horizontal geoexchange installed on 5 acres of Uptown Campus open space. This resource option provides 97 tons of heating and cooling capacity.	**Capital (2014$)** • $660,000 (half payment in two consecutive years) **Annual O&M (2014$)** • $7,250 **Change in Demand** • None **Change in Supply** • Reduce purchased fuels **Impact on GHG Emissions** • Net reduction in Scope 1 and 2 **Start Date** • 2025 **Useful Life** • 40 years **Average Annual Savings (2014$)** • $26,500 **Simple Payback** • 25 years

Solar PPA	
Purchase 5 megawatt of solar power through a Purchase Power Agreement with environmental benefits attributed to the University.	**Capital (2014$)** • None **Annual O&M (2014$)** • $145/MWH to represent a levelized cost of electricity. Actual cost will depend on contract negotiations. **Change in Demand** • None **Change in Supply** • None **Impact on GHG Emissions** • Reduce scope 2 **Start Date** • 2025 **Useful Life** • Indefinite **Average Annual Savings (2014$)** • $475,000 **Simple Payback** • Not Applicable

ANALYZED, NOT RECOMMENDED

Combined Heat and Power with Steam Turbine Generator	
Baseload the current Combined Heat and Power (CHP) system year-round and add a 545 kW steam turbine generator to utilize waste steam, when available, from the CHP system to produce electricity. Additional Information: Incremental Capital • Steam Turbine Generator = $3.3M • CHP= $150,000 Incremental O&M • Steam Turbine Generator = $30,000 • CHP = $132,944 Source: Dresser- Rand/AEI *Mutually exclusive with other CHP options*	**Change in Demand** • None **Change in Supply** • Reduce purchased electricity • Reduce purchased fuels **Impact on GHG Emissions** • Reduce scope 1 & 2 **Start Date** • 2015 **Useful Life** • 40 years (steam driven chiller), 50 years (CHP) **Average Annual Savings (2014 $)** • $485,000 **Simple Payback** • **8 years**

Commuter – Low Investment	
Invest in commuter incentives to reduce single occupant vehicle (SOV) commuting: • Transit incentive (paid passes/ rides) • Additional shuttle service • Commuter incentives & marketing, • Staff support (0.5->1FTE) • Additional bike infrastructure (grows to $50,000 in 2050) *Mutually exclusive with other commuter options*	**Capital (2014 $)** • None **O&M (2014$)** • $264,000/yr in 2020 growing to $458,000/y in 2050 • Savings in reduced downtown parking of $110,000 in 2050 **Change in Demand** • Reduction of SOV by 10-15% **Change in Supply** • Increase programs, shuttle service **Impact on GHG Emissions** • Reduce Scope 3, Increase Scope 1 **Start Date** • 2020 **Useful Life** • Indefinite **Average Annual Costs (2014 $)** • $378,000 **Simple Payback** • Not Applicable

Commuter – Medium Investment (Live/Work)

Invest in commuter incentives to reduce single occupant vehicle (SOV) commuting. Additional investments and programs to promote students and employees living close to campus.

- Transit incentive
- Additional shuttle service
- Commuter incentives & marketing,
- Staff support (0.5->1.25FTE)
- Housing program: loan, capital, staff support (up to 1 FTE)
- Additional bike infrastructure

Mutually exclusive with other commuter options

Capital (2014 $)
- None

O&M (2014$)
- $404,000/yr in 2020 growing to $879,000/yr in 2050
- Savings in reduced downtown parking of $240,000 in 2050

Change in Demand
- Reduction of SOV by 15-25%

Change in Supply
- Increase programs, shuttle service
- Impact on GHG Emissions

Reduce Scope 3
- Increase Scope 1

Start Date
- 2020

Useful Life
- Indefinite

Average Annual Costs (2014 $)
- $641,000

Simple Payback
- Not Applicable

Hot Water Conversion

Convert Uptown Campus steam distribution system to hot water.

Additional Information:
- Capital cost assumes steam to hot water building conversion: $20/sf x 4 M GSF. Hot water condensing boiler + piping upgrades + other plant conversion costs: $10 million.

Capital (2014 $)
- $90 M

Annual O&M (2014 $)
- No incremental

Change in Demand
- None

Change in Supply
- Reduce purchased fuels
- Impact on GHG Emissions
- Reduce scope 2
- Increase scope 1

Start Date
- 2025

Useful Life
- 40 years

Average Annual Savings (2014 $)
- $137,000

Simple Payback
- **more than 36 years**

t – Fuel Standards + EV

Establish fuel purchase standards for fleet vehicles to achieve reductions in fuel use. Additionally, aim to have 15% of all fleet mileage on electric vehicles by 2050.

- Program pays ~$2,000 premium for higher than average efficiency vehicle (for 8 vehicles per year).
- Program pays ~$10,000 premium for electric vehicles; shrinks to $5,000 by 2025 (for 2 vehicles per year)

Mutually exclusive with other fleet options

Capital (2014$)
- $36,000/yr in 2015 decreasing to $26,000/y in 2025

O&M (2014$)
- Fuel savings grow to $65,000/y in 2050
- Electricity costs depend on generation

Change in Demand
- 43% reduction of gasoline by 2050
- 20% reduction of diesel by 2050
- Additional 125kWh of electricity demand in 2050

Change in Supply
- None

Impact on GHG Emissions
- Decrease Scope 1
- Potential increase in Scope 2
- Net reduction of fuel GHG (relative to BAU) of 39%
- At current EGRID rates, net impact is ~ same as low investment scenario

Start Date
- 2015

Useful Life
- Indefinite

Average Annual Savings (2014 $)
- $27,000

Simple Payback
- More than 36 years

APPENDIX C: KEY ASSUMPTIONS

Building Growth[10]:

- Identified growth for 2015-2025
  - Yulman Stadium (62,512 sf, 2015)
  - Zimple/Greenbaum (66,621 sf, 2015)
  - Howard Tilton Library Addition (72,826 sf, 2015)
  - New Dining Commons (up to 80,000 sf, 2016)
  - Richardson Memorial renovations and addition (74000 sf, 2016)
  - Business School addition (44,000 sf, 2017)
  - Social Work building redevelopment/addition (14,000 sf, 2017)
  - Dorm at Bruff Commons location (99,000 sf, 2021)
  - Dorm at Caroline Richardson (77,000 sf, 2021)
  - Additional Uptown Campus development (60,000 sf, 2023)
  - Reily Center Expansion (20,000 sf, 2025)
- Assumed growth for 2026-2050
  - 20,000 sf/year (between the Uptown and Downtown Campuses)

Enrollment:

- 2011 enrollment of 13,359 students (of which 6,506 were undergraduate students, 5,021 were graduate/professional students and 1,832 were continuing studies students) will remain essentially stable through 2025. 2025 projections are for a total of 13,750 students of which approximately 6,400 will be undergraduate students, approximately 5,200 will be graduate/professional students and 2,150 will be continuing studies students.

Utilities:

- Baseline Uptown Campus Supply Configuration
  - Sources of steam include two natural gas boilers and a heat recovery steam generator.
  - Sources of electricity include purchases from the grid and an on-site combustion turbine generator used for back-up purposes.
  - Sources of chilled water included five central electric chillers and a variety of distributed electric chillers.
- Baseline Downtown Campus Supply Configuration
  - 3 plants including the Medical School plant, the Tidewater plant and the Murphy plant as well as other distributed heating and cooling assets.
  - Medical School plant includes:
    - Three natural gas saturated steam boilers
    - Two electric chillers
  - Tidewater plant includes:
    - Two hot-water boilers
    - Two electric chillers
  - Murphy plant includes:
    - Two electric chillers
  - The Downtown Campus has no electric generation capabilities
- Purchased electricity is assumed to cost approximately $62 per MWh in 2015 increasing to $95 per MWh by 2050, denominated in 2015 dollars.
- Natural gas is assumed to cost $8 per MMBTU in 2015 increasing to nearly $13 per MMBTU by 2050, denominated in 2015 dollars.

Borrowing rate for capital of 5% per annum.

10 This study's model includes construction of buildings opened before 12/31/14.

APPENDIX D: REVOLVING LOAN FUND

A revolving loan fund typically describes the provision of financing to small entities or small projects that might not otherwise qualify for traditional financing. The repayment of these loans is held in the fund and reinvested with other, similar investments. In academic settings, these funds are used to promote sustainability objectives. More than seventy campuses have such "green" revolving fund that invest in energy conservation/ energy efficiency. Here, the captured savings from avoided utility costs are used to repay the revolving loan fund. These campuses include:

- California Institute of Technology: an $8M fund established in 2009
- Harvard University: a $12M fund established in 2001
- Iowa State University: a $3M fund established in 2008
- Massachusetts Institute of Technology: a $2M fund established in 2007
- Stanford University: a $25M fund established in 1993
- University of Colorado Boulder: a $.6M fund established in 2008
- University of Illinois at Urbana-Champaign: a $2M fund established in 2009
- University of Notre Dame: a $2M fund established in 2008
- University of Virginia: a $1M fund established in 2010

In developing a fund it is important for the University to understand boundaries and expectations. The following is a starting set of topics to consider:

- Expectations with respect to financial performance and payback
- Types of projects that are eligible for funding
- Metrics (quantitative & qualitative) used to compare opportunities and set priorities for allocating funds
- How are funds administered, i.e. who proposes, analyzes, makes decisions, monitors and verifies performance of the fund
- How to measure and monitor individual "investment" and program performance
- Fund size
- Source of funds
- To what extent and how are benefits shared with "customers"
- What is the relationship to rate design/cost recovery

Generally, these investment funds have been allocated primarily to energy saving opportunities that will provide a high probability of return on investment. Sample investments include lighting upgrades, insulation within buildings and the distribution system, water efficiency projects and energy-saving software installations. The metrics used for comparison and prioritization of projects vary depending primarily on the source of the monies used to establish the fund, but the primary metrics are energy savings, dollar savings and payback that will result from the investment. For example, the Iowa State University Live Green Loan Fund document states that "the fund may be used for any project that supports sustainability or energy conservation that ultimately results in savings.[11]" Though data is limited and long-term data is lacking, Greening the Bottom Line reports that "the data shows that GRF performance is strong.[12]"

11 Live Green Loan Fund, Loan Fund Objectives and Procedures, Iowa State University, http://www.livegreen.iastate.edu/loan/docs/objectives.pdf.

Fund administration models vary across these institutions. Tracking of fund performance and administration falls to the institution's office of sustainability, the facilities/operations group or the executive level finance office. The predominant administrative model is a committee with a cross-functional membership to represent the variety of interests throughout the institution. These committees may include faculty, staff, students and even external 3rd parties. The committee usually reports to an executive administrator who is ultimately responsible for ensuring fund performance.

Caltech appears to represent standard practices in describing its allocation process as one that is "grounded in transparency, clearly identified performance assumptions and auditable financial performance criteria ... [that] doesn't end with the completion of the projects, but continues on an operational level to improve the skill set of facilities maintenance staff and building users."[13] Generally recognized standards can be considered to be:

- a transparent, open process for opportunity identification and recommendation that allows all members of the campus community the opportunity to recommend options,
- a systematic and transparent approach to opportunity evaluation and prioritization,
- a rigorous method of establishing a performance baseline as well as ongoing measurement, verification to ensure realization of a "real" return on the funds invested,
- a method for establishing accountability and responsibility after funds have been invested and
- a mechanism of returning the savings to the fund so the monies can be reinvested or returned to the original source.

Measurement and verification practices vary, but the primary examples of excellence establish a meaningful, weather-adjusted performance baseline on the buildings where projects will occur and rigorously track building energy performance accounting for all changes that have taken place within that building. This will include operational and occupancy changes in addition to the changes resulting from the fund investment. Caltech, for example, establishes at least a one-year baseline on each of the buildings that will be invested and works with the finance and accounting specialties within the organization to audit and verify performance results, thus ensuring a true return on investment[14].

Administrative budgets are the primary source of initial funds at the studied institutions.

12 Greening the Bottom Line, A Sustainable Endowments Institute Report, Sustainable Endowments Institute, 2012 p. 28. http://greenbillion.org/wp-content/uploads/2012/11/Greening-the-Bottom-Line-2012.pdf.

13 Onderdonk, J., Berbèe, M., Caltech Energy Conservation Investment Program, California Institute of Technology, http://sustainability.caltech.edu/documents/59-cecip_summary_brief_-_april_2011.pdf.

14 Cowell, J., personal communication, August 2011.

Other example sources of capital identified include student fees provided specifically for the establishment of a revolving fund and funds provided by the endowment. The typical process involves a key administrator deciding that he or she will champion the revolving fund, allocate a seed amount of capital to the fund, and a trial period where a small fund is tested.

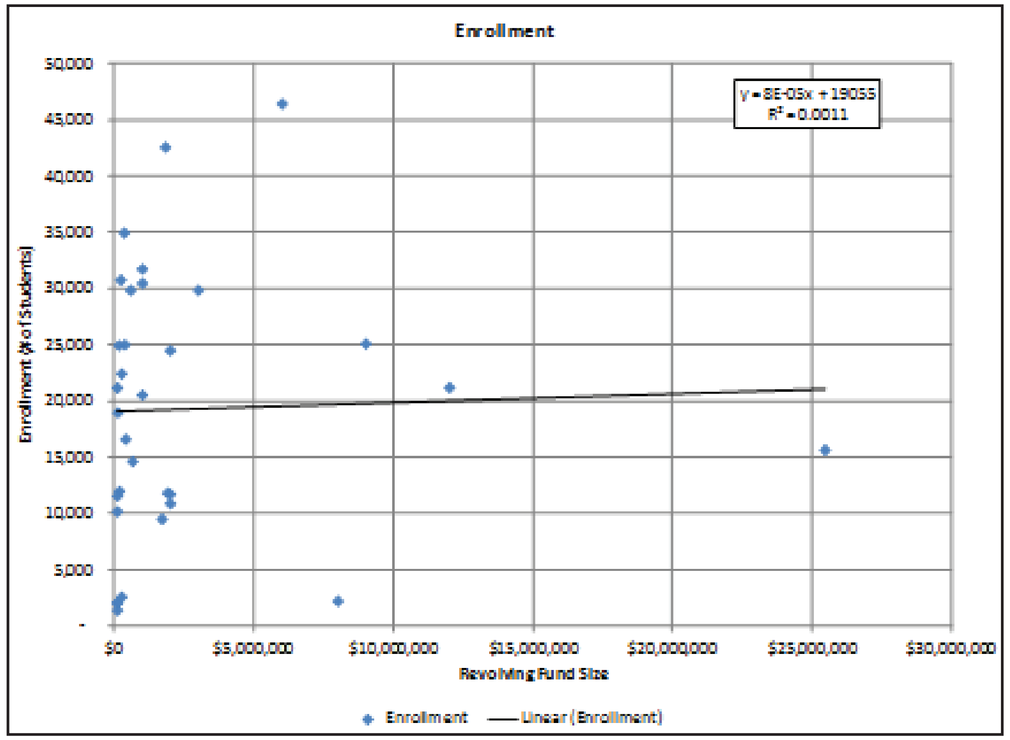


Figure 16 shows that there appears to be no correlation between student population and fund size.

There is a positive correlation between fund size and endowment size, but it does not sufficiently qualify as the key determinate. For example, Figure 17 shows two areas highlighted where schools with large endowments have a relatively small fund and schools with small endowments have a relatively large fund.

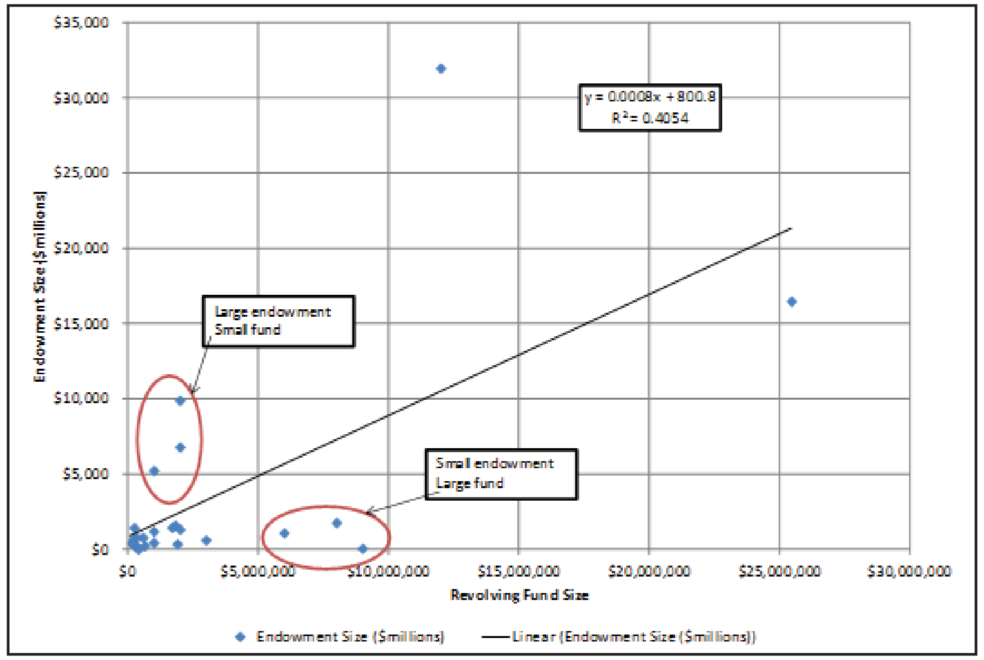


Figure 17: Enrollment Size (Millions)

APPENDIX E: ENERGY CONSERVATION

Figure 18: ECM description and screening table

		Screening	
ECM	Description	Uptown	Downtown
CV to VAV	Convert constant volume supply air flow systems to variable volume through the addition of variable speed motors on fans, control devices on zone level equipment, and system level controls where necessary. This can reduce fan energy and possibly reheat energy.	Proceed	Eliminate
VSD Pump	Convert constant speed chilled water and hot water distribution systems to variable speed. For buildings using constant speed chilled and/or hot water pumps, convert to variable speed motors with two-way control valves and static pressure reset controls to reduce pumping energy during part load conditions.	Proceed	Eliminate
DCV	Add CO2 based demand control ventilation to air handling units. This strategy allows the ventilation rate to respond to building occupancy rates. During periods of low occupancy, ventilation will reduce beyond the design minimum, reducing energy use associated with preconditioning of outside air.	Proceed	Proceed
DX to CHW	Where unitary direct expansion (DX) cooling equipment is used for space cooling, convert to chilled water based system served from the central cooling plant and chilled water distribution system. System and zone level equipment will need to be converted to chilled water coils.	Proceed	Proceed
DOAS/DH	Cooling and dehumidifying outdoor air requires a significant amount of energy. Traditional return air systems mix outside air with ventilation air and use chilled water to cool and dehumidify the air. In lieu of this approach, use dedicated outside air systems with desiccant dehumidification and exhaust/relief air recovery to precondition outdoor air.	Proceed	Proceed
EA HR	In buildings with high outside air ventilation requirements, use enthalpy wheel or runaround water loop exhaust air energy recovery devices to precondition ventilation. Choice of heat recovery will depend on building type and whether cross contamination of supply air is a concern.	Proceed	Proceed
Radiant	In lieu of all air based systems, use radiant cooling devices such as chilled panels and floors to provide cooling.	Eliminate	Eliminate
HPC	In buildings with year-round or near year-round heating and cooling loads, use a heat pump chiller to serve base cooling load and recover heat to supplement heating loads. Buildings with significant reheat requirements during the cooling season or process cooling loads during the heating season are good candidates.	Eliminate	Eliminate

Mixed Mode Ventilation	Use operable windows and louvers to ventilate buildings during acceptable outdoor conditions and turn off the central ventilation system. This is applicable for residential, office, classroom, and recreational spaces where loads are relatively low, the likelihood of use is better and connection to the outdoor environment is desirable.	Proceed	Proceed
FH VAV	Convert constant volume fume hoods to variable volume with occupant based controls. Proximity sensors will reduce flow to the hood when not in use.	Proceed	Proceed
FH DCx	Where fume hoods are located in teaching laboratories, decommission (turn off) fume hoods during closed hours. This typically requires a nightly check to confirm fume hoods are not in use and then turning off the system. This will exclude research labs, where experiments may run through the evening.	Proceed	Proceed
Temperature Setbacks	Use seasonal and off hour space temperature setpoint setbacks in lieu of maintaining the same setpoint temperature during all hours and seasons. Higher space temperatures are acceptable during warm ambient conditions and vice versa.	Proceed	Proceed
Scheduling	For buildings that are closed in the evenings/weekends, schedule equipment off during closed hours and use night cycle control to maintain space conditions.	Proceed	Proceed
Building Metering	Install building/tenant level metering, benchmark energy use, and continuously monitor usage. Installation of building level metering is currently underway, and active monitoring of meter data will provide facilities managers with a tool for maintaining and reducing energy use over time.	Proceed	Proceed
Retro-Cx	Implement a retro-commissioning program to sustain intended building performance in older buildings with no recent renovations or Cx efforts. Building system performance tends to increase as systems age. The retro-commissioning process keeps systems tuned and operating efficiently, but requires either outside Cx agents or active Cx by current or new Facilites Services personnel.	Proceed	Proceed
Demand Management	Implement behavioral based programs such as energy reduction focused competitions, education programs, and pledges. Residence hall or department based competitions could encourage reducing energy use.	Proceed	Proceed
Billing	Where students in residential facilities and departments are not billed for energy use, implement departmental/tenant billing as incentive to maintain and improve building performance.	Eliminate	Eliminate
Lighting Upgrade	Upgrade light fixtures to reduce installed lighting power density: T8 with high efficiency ballast and 32W lamps will be baseline for improvement.	Proceed	Eliminate
Lighting Controls	Use occupancy and schedule based controls to reduce light use when spaces are not being utilized	Proceed	Eliminate
Plug Load Management	Use occupancy based plug load management devices to turn off computers and non-essential electric equipment when work spaces are unoccupied. Scheduled control of outlets or power strip devices capable of sensing occupancy are potential methods for implementing.	Proceed	Eliminate
Window Replacement	Install high performance glazing (consistent with ASHRAE 90.1-2013 minimum energy performance) in buildings identified by ISES survey as needing replacement.	Proceed	Proceed
Roof Replacement	Upgrade roof insulation (consistent with ASHRAE 90.1-2013 minimum energy performance) in buildings identified for roof replacement by the ISES survey.	Proceed	Eliminate
Wall Upgrade	Upgrade exterior wall insulation (consistent with ASHRAE 90.1-2013 minimum energy performance) in buildings identified for structural and wall maintenance by ISES survey.	Proceed	Proceed
Solar Thermal	Install solar thermal systems for domestic/service and building hot water heating needs in buildings with year-round reheat/heating water and regular DHW loads.	Proceed	Eliminate
Performance Standards	Implement sustainable building performance standards with minimum energy reduction targets with a scheduled implementation for all renovations and new construction.	Proceed	Proceed

MEASURE ANALYSIS

Preliminary ECM screening included characteristics related to campus readiness such as the practicality of implementing a technology given Tulane's staffing resources, general boundary conditions such as whether GHG emissions would be expected to decrease as a result of implementing and its relationship to the Business as Usual approach such as an appropriate critical mass of buildings the ECM would be applicable to. This screening process limited a few ECMs from further consideration including radiant cooling, distributed heat pump chillers and individual user based billing.

Based on the preliminary screening, the remaining ECMs were carried forward into the analysis phase. The analysis phase included a spreadsheet based energy model using hourly weather data for a set of representative building types applicable to the campus. The building types were broken down into a primary, secondary, and other space type with internal loads and utilization profiles assigned to each space type. The specific space program types were developed using the University's Archibus data. The following building types were included:

1. Classroom
2. Office
3. Laboratory
4. Residential
5. Library

6. Recreational
7. Mixed Use

Each building type model was developed based on campus building space program from Tulane’s Archibus database. ECMs were selected for analysis on a particular building type based on further screening that included general applicability, building size and age, Tulane’s facility condition index report (ISES), JCI performance contract activities, and input from Tulane’s Facilities Services staff. When an ECM made it through this level of screening it was assigned as applicable to the specific building and accounted for based on the results of the energy analysis for that building type. For example, the Boggs Center for Energy was assigned as a Laboratory building type and all ECMs screened as applicable to the building were included in the analysis by using potential energy savings results from the Laboratory energy model and assigned on a per unit area basis.

In addition to energy savings analysis, investment costs and operations and maintenance costs were estimated for each ECM based on previous consultant experience and industry research and applied on a per unit area basis. ECM costs include construction cost and soft costs for design and engineering and are meant to provide a range order of magnitude cost estimate for implementation. Additional construction contingencies and University specific soft costs are not included in the ECM costs, and it is expected that specific project costs will require more detailed cost estimates. ECMs with initial payback periods of less than 4, 8, and 30 years were included the near, mid and long term bundles respectively. Based on discussions with the working group and additional input from the CAP steering committee and campus users, modifications to the ECM bundling were made to optimize their impact on the plan.

In this manner, an approximate order of magnitude for implementing ECMs across the campus was developed and used to estimate the potential GHG reductions and costs.

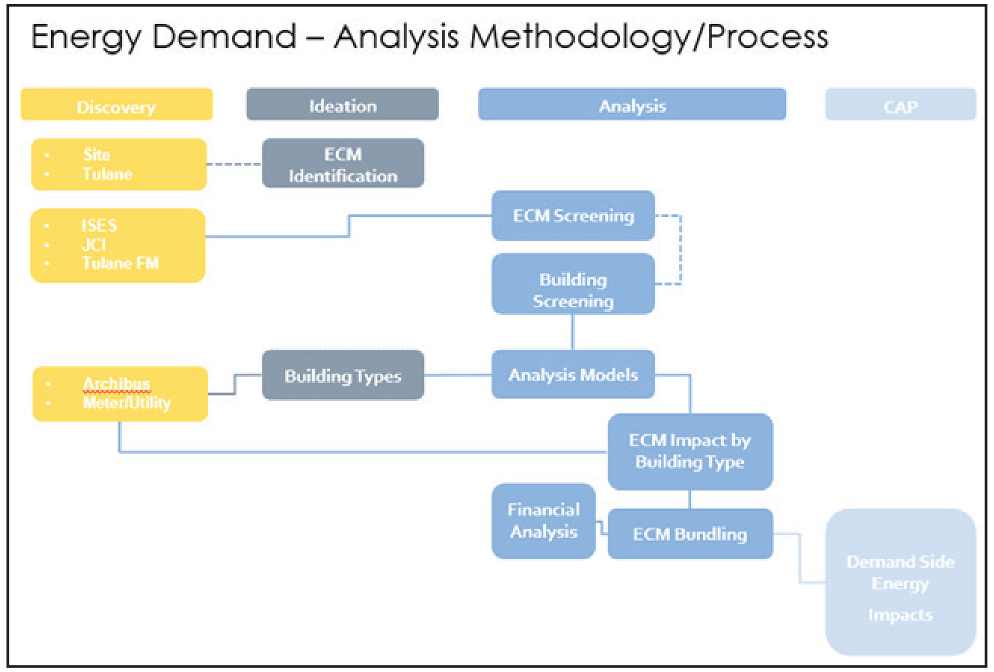


Figure 19: Energy conservation measure selection and analysis methodology

APPENDIX F: IMPLEMENTING RECOMMENDED ENERGY CONSERVATION MEASURES

A significant component of the Near-Term Investment portfolio, both in GHG emissions reductions and capital cost investments, is the Near-Term ECM bundle. Implementation of the recommended ECMs is integral to Tulane achieving the first stage of the CAP’s GHG reduction goals. As outlined in Appendix E, selection of the ECMs was based on an analysis process meant to identify energy reduction strategies effective for Tulane and provide an order of magnitude estimate of emission reductions and implementation costs. The Demand Side ECM Screening tool developed for Tulane serves as a reference tool for the ECM screening and analysis process and includes which ECMs are applied at each building along with their relative GHG impact and capital and O&M costs. This tool can be used to support the ECM implementation process by providing facility staff information to target next steps.

The Near-Term ECM bundle largely consists of lower cost control and operations related measures and Table 5 lists which ECMs were identified for each building.

Table 5: Near-Term ECM implementation by building

No.	Building	Near-Term ECM: Building Metering	Retro-Cx	Temperature Setbacks	Scheduling	Demand Mgmt	VSD Pump	Demand Control Ventilation	Fume Hood Decommissioning	Lighting Upgrade
D001A	SCHOOL OF MEDICINE A	Yes	Yes	Yes	NA	Yes	NA	Yes	NA	NA
D001B	SCHOOL OF MEDICINE B	Yes	Yes	Yes	Yes	Yes	NA	Yes	NA	NA
D001C	SCHOOL OF MEDICINE C	Yes	Yes	Yes	Yes	Yes	NA	Yes	NA	NA
D002	ENVIRONMENTAL SCIENCE BUILDING	Yes	Yes	Yes	Yes	Yes	Yes	Yes	NA	NA
D003	TIDEWATER BUILDING	Yes	Yes	Yes	NA	Yes	NA	Yes	NA	NA
D004	JOHNSTON HEALTH AND ENV RESEARCH BLDG	Yes	NA	NA	NA	Yes	NA	NA	NA	NA
D005	ELKS PLACE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	NA	Yes
D006	DEMING PAVILION	Yes	Yes	Yes	Yes	Yes	Yes	Yes	NA	NA
D008	MURPHY BUILDING	Yes	Yes	Yes	NA	Yes	Yes	Yes	NA	Yes
D915	1555 POYDRAS	Yes	Yes	Yes	Yes	Yes	Yes	Yes	NA	Yes
O001	UNIVERSITY SQUARE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	NA	Yes
O002	THE PAPILLON APARTMENTS	Yes	Yes	Yes	Yes	Yes	Yes	Yes	NA	Yes
U001	Gibson Hall	Yes	Yes	NA	NA	Yes	NA	NA	NA	NA
U002	Tilton Memorial Hall	Yes	Yes	Yes	Yes	NA	NA	Yes	NA	NA
U004	Richardson Memorial	Yes	Yes	Yes	NA	Yes	NA	Yes	NA	NA
U005	Richardson Building	Yes	Yes	Yes	NA	Yes	NA	Yes	NA	NA
U006	Norman Mayer	Yes	Yes	Yes	NA	Yes	NA	Yes	NA	NA
U007	Hebert Hall	Yes	Yes	NA	NA	Yes	NA	Yes	NA	NA
U010	Stanley Thomas Hall	Yes	Yes	NA	Yes	Yes	NA	Yes	NA	NA
U012	Mechanical Services	Yes	Yes	Yes	Yes	Yes	NA	Yes	NA	NA
U015	Boggs Center For Energy	Yes	Yes	Yes	Yes	Yes	NA	Yes	NA	NA
U018	Merryl & Sam Israel Jr.	Yes	Yes	Yes	Yes	Yes	NA	NA	Yes	NA
U019	Percival Stern Hall	Yes	Yes	Yes	Yes	Yes	NA	Yes	NA	NA
U025	Joseph M Jones	Yes	Yes	Yes	Yes	NA	NA	Yes	NA	NA
U029	Lavin-Bernick Center for University Life	Yes	Yes	Yes	Yes	Yes	NA	Yes	NA	NA
U030	Central Building	Yes	Yes	NA	NA	Yes	NA	Yes	NA	NA
U032	School Of Law	Yes	Yes	Yes	Yes	Yes	NA	Yes	NA	NA
U038	Monroe Hall	Yes	Yes	Yes	NA	Yes	NA	Yes	NA	NA
U039	Goldring/Woldenberg Hall 1	Yes	Yes	NA	NA	Yes	NA	Yes	NA	NA
U040	Goldring Woldemberg Hall 2	Yes	Yes	NA	Yes	Yes	NA	Yes	NA	NA
U042	Robert Sharp Hall	Yes	Yes	Yes	Yes	Yes	NA	Yes	NA	NA
U043	Mcalister Auditorium	Yes	Yes	NA	NA	Yes	NA	NA	NA	NA
U044	Irby Hall	Yes	Yes	Yes	NA	Yes	NA	Yes	NA	NA
U045	Paterson House	Yes	Yes	Yes	Yes	Yes	NA	Yes	NA	NA
U046	Wall Residential College	Yes	Yes	Yes	Yes	Yes	NA	Yes	NA	NA
U047	Phelps House	Yes	Yes	Yes	Yes	Yes	NA	Yes	NA	NA
U052	Butler House	Yes	Yes	Yes	Yes	Yes	NA	Yes	NA	NA
U055	William Mayer Residences	Yes	Yes	Yes	Yes	Yes	NA	Yes	NA	NA
U056	Warren House	Yes	Yes	Yes	Yes	Yes	Yes	Yes	NA	NA
U060	Howard Tilton Library	Yes	NA	Yes	Yes	NA	NA	NA	NA	NA
U068	Dixon Hall	Yes	Yes	NA	NA	Yes	NA	Yes	NA	NA
U069	Dixon Performing Arts Center	Yes	Yes	NA	NA	Yes	NA	Yes	NA	NA
U070	Elleonora P. Mcwilliams Hall	Yes	Yes	NA	NA	Yes	NA	Yes	NA	NA
U074	Newcomb Hall	Yes	Yes	NA	NA	Yes	NA	Yes	NA	NA
U075	Josephine Louise House	Yes	Yes	Yes	Yes	Yes	NA	Yes	NA	NA
U083	Woldenberg Art Center	Yes	Yes	Yes	Yes	Yes	NA	Yes	NA	NA
U085	Facilities Services	Yes	Yes	NA	NA	Yes	Yes	Yes	NA	NA
U096	Willow Residences	Yes	Yes	Yes	Yes	Yes	NA	Yes	NA	NA
U098	Aron Residences	Yes	Yes	NA	NA	Yes	NA	NA	NA	NA
U106	Reily Recreation Center	Yes	Yes	Yes	NA	NA	NA	Yes	NA	NA
U111	Wilson Athletic Center	Yes	Yes	NA	NA	NA	NA	Yes	NA	NA
	Total Building Count	51	49	36	29	46	9	45	1	5

APPENDIX G: STEPS FOR IMPLEMENTING THE NEAR-TERM ECM BUNDLE

1. Use the Demand Side ECM Screening Tool to confirm ECMs are applicable to the indicated buildings.

2. Identify and install building level chilled water and steam (or heating hot water) meters and complete any remaining building level electric meters. The cost analysis assumed $0.45/SF for installing both chilled water and steam (or hot water) meters at the buildings.

   Data collection from building level meters should begin immediately on all buildings with the goal of benchmarking energy use and cost for each building which then can be used to track building performance. The International Performance Measurement and Verification Protocol (IPMVP) provides methodologies for energy measurement and comparison and includes measurement and verification plan recommendations. Tulane should develop a standard measurement and verification plan template that can be implemented on each building with a central data collection and storage point. This data will be used to support the commissioning process, assessment of ECM impacts and future retrofit alternatives, and to assess savings from energy conservation measures.

3. Implement a phased retrocommissioning program with target completion of 2020. Retrocommissioning is the process of commissioning applied to existing buildings with the goal of improving existing system operation. With use and time, existing systems may no longer be operating as initially intended or as optimally as possible. While Tulane's Facilities Services staff consistently works to keep buildings operational, no expansive commissioning program exists. Building commissioning identifies operational intent, adjusts operational conditions as necessary to meet the building's utilization requirements, and documents equipment requirements and setpoints. To maintain the benefits of commissioning, subsequent building operations need to include utilization of energy meter data to check for consistent performance and continued documentation of all operational changes so that changes in performance can be identified.

   Based on current number of buildings identified, approximately 10 buildings will need to be retrocommissioned per year. The cost analysis included an allowance of $0.40/SF for completing retrocommissioning work. Tulane's retrocommissioning program should be developed with the intent to retrocommission on a regular basis. Once the process is set up and additional measures such as metering and demand management are in place, future retrocommissioning efforts will be reduced, but continuous retrocommissioning is necessary to achieve persistent benefits. Once complete, additional campus buildings that were not included due to size and age may be rolled into the program.

4. While building equipment scheduling and temperature setbacks are being utilized on some campus buildings largely through the past performance contracting with JCI, there are additional buildings where these measures should be implemented. The cost analysis assumes the building automation systems will require upgrades in order to implement scheduled equipment shutoffs during unoccupied hours and temperature setpoint setbacks during unoccupied hours along with seasonal adjustments to heating and cooling setpoints. The cost assumption was $0.50/SF. The buildings identified for these measures should be assessed for specific control upgrade needs and any system limitations. The setpoints and schedules used in the analysis are listed in Table 6.

   Tulane Facilities Services staff should coordinate this effort with the retrocommissioning work described above as there is some potential overlap. Where possible, implementing scheduling and setbacks should proceed as an independent effort. When buildings are scheduled for commissioning and control systems exist with equipment scheduling and setback capabilities, these efforts can be integrated into the commissioning process.

	Occupied Cool (deg F)	Occupied Heat (deg F)	Unoccupied Cool (deg F)	Unoccupied Heat (deg F)	Cooling Seasonal Adj (deg F)	Heating Seasonal Adj (deg F)	Occupied Start (time)	Occupied End (time)	Building Operation On (time)	Building Operation Off (time)
Classroom	74	72	78	68	+2	-2	6:00 AM	8:00 PM	6:00 AM	8:00 PM
Office	74	72	78	68	+2	-2	6:00 AM	8:00 PM	6:00 AM	8:00 PM
Lab	74	72	74	72	+2	-2	6:00 AM	8:00 PM	24HR	24HR
Residential	74	70	78	68	+2	-2	24HR	24HR	24HR	24HR
Library	74	72	78	68	+2	-2	7:00 AM	4:00 AM	7:00 AM	4:00 AM
Recreation	74	68	78	68	+2	0	6:00 AM	10:00 PM	6:00 AM	10:00 PM
Mixed	74	72	78	68	+2	-2	6:00 AM	8:00 PM	6:00 AM	8:00 PM

Table 6: Space temperature setpoints and occupancy schedules used in the ECM analysis

5. Energy savings associated with the demand management ECM will occur through implementation of the Building and Energy Literacy Campaign intended to stimulate behavior based GHG emissions reductions. The analysis assumes a 3% energy reduction in classroom, office, mixed use and laboratory buildings. Given the campaign is dependent on building level energy use data, the success of this ECM is dependent on implementation of the metering ECM and developing platforms for sharing this information with students and staff.

6. The remaining ECMs in the Near-Term bundle will require HVAC and lighting system modifications and building surveys should be performed to verify system design modifications before proceeding.

   - VSD Pumps: The analysis assumed constant volume heating hot water and chilled water pumping systems were in place and that variable frequency drives (VFD) would be added. The energy savings estimates are based on variable speed pumping and investment costs are $0.05/SF. Equipment surveys to determine the number of VFDs and control system modifications necessary should be performed to verify scope and cost impact.
   - DCV: The analysis assumed constant outside air volume based on ASHRAE 62.1 ventilation requirements for the typical building types being analyzed. Estimated energy savings are based on adding CO2 monitors and outside air damper controls at the primary return and outside air mains. Estimated costs are $0.05/SF for implementation. Equipment surveys to determine the number of monitors, dampers, and control modifications required should be completed to verify scope and cost impact.
   - FH DCx: Fume hood decommissioning was recommended at only one building, the Merryl and Sam Israel Jr Environmental Science Building, based on the teaching focus of the labs and the potential for turning hoods off completely during unoccupied hours. This ECM requires staff to confirm hoods are not in use and turning off the system when the labs are not being used. Costs assume the fume exhaust system has variable flow capability and only require localized shutoff controls to be added along with control interlocks to the primary system.
   - Lighting Upgrade: Based on discussions with Tulane Facilities Services staff, the lighting upgrade ECM savings were estimated assuming potential savings from switching from standard 32W T8 fluorescent lamps to 25W T8 lamps. The costs are based on relamping only, and no fixture replacement. Building surveys should verify lamp type and number of lamps to be replaced.

APPENDIX H: TERMS AND ACRONYMS

Abatement	A lessening or reduction of GHG emissions
Abatement curve	A standard graphic used to represent the estimated volume of GHG emissions reduction for each option of a portfolio and the annual cost/savings associated with each
ACUPCC	American College and University Presidents' Climate Commitment
BAU	Business as Usual: the expected pattern if current practices are extended over time
Carbon offsets	Credits procured for GHG emissions reduction that are accomplished by a third party
CAP	Climate Action Plan, a set of strategies to reduce an entity's greenhouse gas emissions
CHP	Combined heat and power (or cogeneration) refers to the simultaneous generation of electricity and heat from a single fuel source and can provide on-site generation of electricity and recovery of waste heat
Energy Use Intensity	Referred to as EUI, the metric of kBtu/square foot/year is used to compare building energy performance across classes or categories of buildings
GHG	Greenhouse gases, primarily carbon dioxide, methane, nitrous oxide and fluorinated gases
ECM	Energy conservation measure is an investment made in a building with the expectation that it will reduce building energy demand. ECMs vary widely in terms of first cost, savings, and longevity of savings.
MTCO2e	Metric tons (1,000kg) of carbon dioxide equivalent
Mode split	The percentage of travelers that use different types (modes) of transportation
Portfolio	A collection of strategies which are combined towards a specific goal
Reference case	Distinct from BAU, a reference case recognizes the influence of contextual changes such as those driven by regulations or industry trends commonly assumed to occur because of in-place investments or reserves
Geoexchange	Sometimes referred to as ground source heat pumps or geothermal technology, geoexchange is used to provide building heating and cooling and operates by using ground or water sources as a heat source and heat sink.
GHG Scope	Standard categorization of greenhouse gases: • Scope 1 are direct emissions from the University and includes items such as fuels and refrigerants. • Scope 2 are indirect emissions from purchased electricity and purchased steam • Scope 3 are indirect emissions from activities such as commuting, air travel and waste disposal
Payback Period	The period of time at which cumulative savings exceeds cumulative capital or the net cumulative cash flow, accounting for outflows and inflows, exceeds zero.
Savings/Cost	Savings or Cost per metric ton of carbon emissions avoided refers to a calculation of annual financial impact for recommended investments. This number is the present value of the changes in the cost of purchased fuels, electricity, operating expenses and investment capital for every unit of GHG avoided.
Solar PPA	Solar purchase power agreement is a financial agreement that provides for a third party to develop and maintain on-campus solar energy installations
SOV	Single occupant vehicle -— a vehicle with just the driver and no passengers, normally the most carbon-intensive form of personal transport
TDM	Transportation demand management – the employment of strategies to reduce traffic through change in schedule and in mode
Wedge diagram	A standard graphic used to illustrate the carbon impact of GHG reducing activities as compared to the Business-as-Usual or reference case

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