2019 Duke University Climate Action Plan Update

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The 2019 Duke University Climate Action Plan Update was prepared by Sustainable Duke. Please contact Sustainable Duke at sustainability@duke.edu for more information.

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Executive Summary

The world has seen unprecedented change since Duke University made the ambitious commitment to being climate neutral by 2024. A decade ago, the University thought carefully about selecting this target. Duke wanted to balance short- and long-term financial implications with the desire for near-term action that could have a more significant effect on global climate change. The University also considered years that have a particular significance beyond greenhouse gas (GHG) emissions to further engage the campus community. As such, the year 2024, the 100th anniversary of the James B. Duke's Indenture of Trust, emerged as a date with special significance to the campus that also fit into other evaluation criteria.

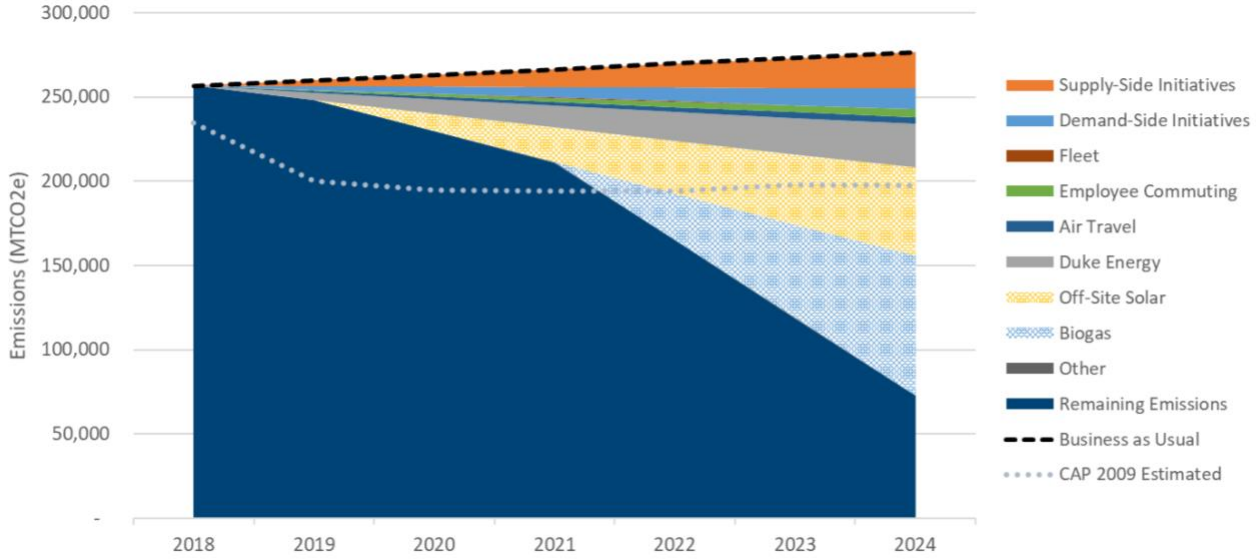
Through the work of numerous campus stakeholders, the University has seen impressive progress towards the 2024 goal with a 24% reduction in greenhouse gas emissions since the 2007 baseline. Even as Duke has grown over 3 million gross square feet (GSF) in this timeframe, emissions per GSF have fallen 39%. These emissions reductions have come primarily from investments in energy efficiency, discontinuing the use of coal in the campus steam plants, and Duke Energy reducing the carbon content of its electricity. Transportation emissions have proven more difficult to reduce given the personal nature of these decisions and have increased by 9% compared to the 2007 baseline.

After reviewing all aspects of the 2009 Climate Action Plan, assessing future needs of the campus, and working with the Campus Sustainability Committee and other stakeholders, Duke University has developed the 2019 CAP Update. This update focuses on internal emission reductions for energy and transportation, as well as how education, communication, and carbon offsets will continue to be incorporated in achieving the 2024 goal. The CAP planning process also included a new element of a 45-day public comment period on the draft to allow broad feedback and questions.

The CAP update was made available to over 50,000 internal and external stakeholders through online media, newsletters, direct emails, presentations and meetings. This outreach led to the active participation of over 350 Duke community and external community members, which generated over 50 pages of comments. All comments received from these individuals were analyzed, summarized, and presented to the Campus Sustainability Committee in addition to being responded to in the Response to Comments document and the Climate Action Plan.

This 2019 CAP Update has resulted in new projections for emissions out to 2024 to guide future decisions and investment. If all elements of the update are implemented as recommended, the University would be at an estimated 78% reduction of total greenhouse gas emissions by 2024, with approximately 73,000 MTCO2e left to address using carbon offsets (Figure 1 below). This estimate, when compared to the 2009 CAP estimate of a remaining 185,000 MTCO2e, illustrates the University's commitment to continually strive for increasing carbon reduction efforts and meeting the 2024 goal.

Figure 1: Duke University updated potential emission reductions through 2024



The emission reductions modeled in the graph above are ordered based on the University's ability to implement and control. While Duke fully intends to pursue off-site solar[1] and biogas[2], external factors will impact the timing, cost, and procurement options. If Duke made a larger biogas purchase or additional renewable purchase opportunities are made available by policy changes, it could potentially make the entire campus climate neutral or even a net carbon sink, as the University would reduce more carbon in the atmosphere than it releases. However, Duke will continue to focus on reducing on-campus emissions and on developing a diversified portfolio of carbon offset projects to minimize risk and ensure climate neutrality into the future.

With five years remaining until the 2024 target for climate neutrality and being on the heels of the recent, alarming Intergovernmental Panel on Climate Change (IPCC) report that put in stark terms the consequences inaction could have on the planet and human society, Duke's imperative is even more critical to meet or exceed this goal. Duke's leadership recognizes that making its campus climate neutral will not even register a minor change in global greenhouse gas emissions. However, this institution, with its focus on innovation, public service and global connections, is uniquely situated to be an example of climate leadership and instill this ethic in all students. If Duke University can harness its faculty expertise and student passion, while offering a concrete example of how a complex institution tackles climate neutrality, it can have far reaching effects on the surrounding community, the region and the world.

[1] Depending on the final rules issued by the Utility Commission, Duke University plans to maximize its off-campus solar power purchase to the total amount allowed by law. This would result in a reduction of GHG emissions of approximately 50,000 MTCO2e.

[2] Note that the biogas purchase modeled in the projections is based on the amount necessary to offset natural gas used in campus steam plants. Replacing approximately 10% of the fuel used in the campus steam plants in addition to associated carbon offsets would make the plants climate neutral. Neutrality results from a combination of the capture and destruction of the biogas that would have been emitted into the atmosphere plus the displacement of conventional natural gas that would have been used to fuel the campus steam plants.

2019 CAP Recommendations Summary

The 2019 CAP Update has resulted in new projections for emissions out to 2024 to guide future decisions and investment based on the following recommendations.

Energy Recommendations

Objective 1: Maximize opportunities for building energy efficiency and low carbon new construction (demand-side initiatives).

- Continue to invest in the energy efficiency of pre-CAP existing campus buildings with strategies such as HVAC optimization through building retro-commissioning, building analytics upgrades, and efficient technology such as LED lighting retrofits with a goal of 20% reduction by 2024.
- Continue to pursue Energy Use Intensity (EUI) targets for new construction and finalize the Duke Sustainable Building Framework. Consider opportunities to better track and monetize the carbon impacts of new construction to inform future campus planning.
- Further develop initiatives to educate schools, departments, and individuals on campus about their energy use and opportunities for conservation.

Objective 2: Expand campus utility infrastructure to meet energy needs in the most economically and carbon efficient way (supply-side initiatives).

- Continue district hot water conversion in buildings that do not require high-temperature steam. Utilize solar thermal technology where feasible in conjunction with new campus hot water plants.
- Continue to improve plant efficiency by tactics such as East-West steam line retirement and chilled water efficiency through technologies like thermal energy storage.
- Install heat recovery chillers in the renovation of East Campus dorms to include AC.
- Implement additional on-campus solar systems to meet 4MW goal.

Objective 3: Leverage off-campus initiatives for high-impact renewable energy.

- Support and foster the development of a renewable biogas and RNG market in N.C. that reduces reliance on fossil fuels at Duke University and provides opportunities for positive community, environmental, economic, and policy outcomes in the state.
- Continue to advocate for regulatory and policy changes in N.C. that would allow Duke University greater freedom over campus energy options. Seek collaborations with other similarly situated institutions to further amplify efforts.
- Monitor N.C. Utility Commission rulemaking for the Green Source Advantage program (HB589) that could allow Duke University to pursue off-campus, utility-scale solar. When available, maximize the University's off-campus solar power purchase to the total amount allowed by law.

Transportation Recommendations

Objective 1: Reduce emissions from daily employee commuting

- Enhance public transit access
    - Continue to advocate for local transit options that meet the needs of the university and its students and employees.
    - Develop targeted marketing of local public transit programs for employees.
    - Continue the subsidized Go-Pass program for Duke employees and students.
- Carpooling and Vanpooling
    - Develop targeted marketing and incentives for Duke's carpooling and vanpooling programs to employees who live in dense clusters.
    - Develop department-specific marketing campaigns and potential incentives to promote carpooling and vanpooling programs.
    - Expand marketing or potential incentives for https://www.sharetheridenc.org trip planning platform to employees.
- Biking and Walking
    - Adopt and implement a policy that considers infrastructure for cyclists and pedestrians during new construction and large building renovation projects.
    - Improve access to various bicycling/walking amenities on campus including increased safety lighting, showers and locker facilities, bike racks, and short-term bike storage for returning students.
    - Advocate for increased presence of sidewalks and bike lanes in high traffic areas off/near campus.
    - Develop targeted marketing on the benefits of biking and walking to employees who live 0-3 miles from campus.
- Other Recommendations
    - Create a Transportation Infrastructure, Accessibility, and Sustainability Fund where a portion of student and employee parking fees go towards development of alternative transportation programs on-campus and carbon offsets.
    - Develop additional flexible parking options, including monthly or semester-long parking passes and a parking cash-out program.
    - Develop an employee-based benefits program for the purchase of electric vehicles, which could include partnering with local dealerships to provide PERQs-related discounts, provide competitive financing options through Duke Federal Credit Union for electric vehicles, and consider subsidized/free parking for EVs on campus.
    - Expand support and emphasis on telecommuting and flexible work schedules.
    - Consider a month-long opportunity for current employees to try alternative commuting with a subsidized parking pass incentive.
    - Develop a network of current alternative commuters, which could serve as ambassadors to employees willing to try alternative options.
    - Consider developing affordable, Duke-affiliated housing on/near campus for staff, faculty and graduate students.

    - Conduct behavioral psychology research to understand what incentives or disincentives would be more effective to increase the use of alternative transportation.

Objective 2: Reduce emissions from Duke-owned vehicles

- Assess ridership on all Duke bus routes to reduce redundancy and improve access.
- Conduct a study that compares current conventional fuel vehicles with hybrid and electric vehicles for entire Duke fleet.
- Continue to replace existing Duke-owned buses with electric buses, as replacements are needed in the future.
- Implement a Green Fleet purchasing program, which sets a target for fuel efficiency and develops a list of hybrid or electric options for purchase through approved vendors.
- Create a form to be filled out prior to the purchase of a new vehicle, which clarifies whether a vehicle is actually needed and the possibility of purchasing a smaller, more efficient or alternatively fueled vehicle.

Objective 3: Reduce emissions from university-sponsored air travel

- Streamline data collection on air miles traveled to estimate emissions impact.
- Share departmental reports that outline cost and emissions impact of air travel.
- Develop a preferred airline carrier list based on sustainability metrics including options to purchase carbon offsets and use of biofuels in aircrafts.
- Consider options for distributing the cost of travel offsets to departments based on use.
- Create marketing about time and cost of air travel to destinations and compare alternatives (carpooling, train, bus, and teleconferencing).
- Encourage the consolidation of multiple meetings during a single trip by aircraft.
- Encourage the use of teleconferencing for meetings in other states or countries, particularly meetings that occur regularly.
- Follow the developments of International Civil Aviation Organization's CORISA Program to reduce emissions from international travel.

Carbon Offsets Recommendations

Objective 1: Purchase and develop local offsets that have significant environmental, economic, and social benefits

- Conduct an inventory of local projects with high co-benefits.
- Employ a portfolio-based approach to selection of projects.
- Identify ways to scale current projects to increase impact.
- Re-engage with the Offsets Subcommittee to discuss prioritization of future projects.

Objective 2: Provide educational opportunities through offset purchase and development

- Continue to build relationships with Duke resources for new project research and development like the Duke Marine Lab, Nicholas School of the Environment MEM Master's Projects, and Bass Connections.
- Investigate carbon offset projects that could connect students with Duke study abroad sites

- Continue to offer the Duke Carbon Offsets Initiative as a client for student projects, from single class projects to capstone and masters projects.

Objective 3: Serve as a partner for peer universities to expand offset opportunities

- Continue to expand the Offset Network to include new project types that peer universities can engage with.
- Leverage Duke University resources to conduct peer verification of other universities' carbon offset projects.

Education Recommendations

Objective 1: Provide opportunities to further connect all students' academic pathways to sustainability

- Expand the reach of the sustainability engagement certificate program to new disciplines and engage new faculty in teaching courses within the certificate parameters.
- Pilot a "Sustainability Expeditions" program with the goal of putting concepts of sustainability into courses across disciplines, which is similar to existing Data Expeditions and Archival Expeditions programs.
    - Data Expeditions - large datasets are used to introduce exploratory data analysis to students that solidify lessons learned in the classroom.
    - Archival Expeditions - library archival materials related to particular coursework serve as a cornerstone of undergraduate learning materials.
- Continue connections with Duke's Offices of Civic Engagement and Service Learning to expand opportunities to integrate sustainability into these efforts.
- Explore opportunities to integrate sustainability concepts into Duke's "first touch" courses in many disciplines as well as a new type of course called "Collaborative Inquiry," that Duke is exploring that could infuse concepts of sustainability with experiential education.

Objective 2: Identify new opportunities for students and faculty to utilize the campus and surrounding region as a teaching tool

- Develop educational support for students and faculty to encourage the use of Duke University's campus as a living laboratory.
    - Support could be in the form of website materials and consultation provided by Sustainable Duke, identification of existing sites that could be used for class, and facilitation of relationship building between faculty and students.
- Collaborate with existing university programs that work towards solutions to local issues by engaging students, staff, and faculty with an interdisciplinary approach.
- Create a committee of current faculty, staff, and students to further incorporate Curriculum for the Triangle Bioregion into existing coursework.

Objective 3: Expand resources for faculty to integrate the concepts of sustainability into their courses and build institutional knowledge on sustainability-related projects

- Formalize the position of Faculty Director of Sustainability in the University, including development of a formal job description, with a term length, and formal reporting relationship ties to Duke Administration.
- Expand the pilot Trillium Student Research Initiative (TSRI) to additional courses, departments and disciplines. This program enables student to provide technical assistance in adding sustainability learning outcomes into a new course by creating lesson plans, researching necessary course materials, and developing assignments to gauge critical thinking and collaboration among students.
- Develop a database of sustainability-related projects that have been conducted by students and faculty whether in the classroom, as a part of research, or as an extracurricular activity. This could expand and institutionalize past inventories of faculty research connected to sustainability topics.

Outreach and Communications Recommendations

Objective 1: Develop a robust network of Sustainability Champions in all workplaces, classrooms, labs, and dorms

- Host department-specific sustainability workshops.
- Develop a formal network of Sustainability Champions, who serve as both advocates and ambassadors of sustainability at Duke.
- Gather stories from Sustainability Champions about their experiences and share them with the Duke community.
- Host a recognition ceremony for students, staff, and faculty Sustainability Champions.
- Provide sustainability challenges to Sustainability Champions and newsletter recipients.

Objective 2: Foster a broad-reaching culture of sustainability for all students, staff, and faculty

- Increase the level of engagement by Sustainable Duke during student and employee orientation events.
- Develop departmental and school specific climate action plans.
- Continue to bolster the Green Certification program for departments, classrooms, dormitories, labs, and events.
- Integrate sustainability planning into existing Duke groups like Duke Student Government, Graduate and Professional Student Council, First-Year Advisory Council, and Resident Assistants.

Objective 3: Expand Duke's sustainability impact beyond campus boundaries

- Build relationships with Duke alumni who were involved with sustainability so they can easily connect with Sustainable Duke and current students.
- Develop an alumni-focused newsletter that shares information on sustainability at Duke.
- Share best practices and lessons learned with peer universities through conferences, sustainability consortiums, and existing email lists.

CAP Introduction and Background

In 2007, the Duke University President, Richard Brodhead, signed the American College and University Presidents' Climate Commitment (ACUPCC), which led to the development of a plan for climate neutrality for Duke University. This commitment is a part of Duke's deep-rooted belief that the University has a duty to put knowledge in the service of society to address local and global issues.

This led to the formation of a standing, presidentially-appointed Campus Sustainability Committee (CSC) comprised of faculty, staff, and students, which is currently co-chaired by Tallman Trask, Executive Vice President, and Toddi Steelman, Dean of the Nicholas School of the Environment. The CSC and numerous other stakeholders worked diligently for two years to develop Duke's comprehensive Climate Action Plan (CAP) outlining the strategies and opportunities for the campus to meet the aggressive 2024 target for climate neutrality. The plan was endorsed by the Board of Trustees in October 2009.

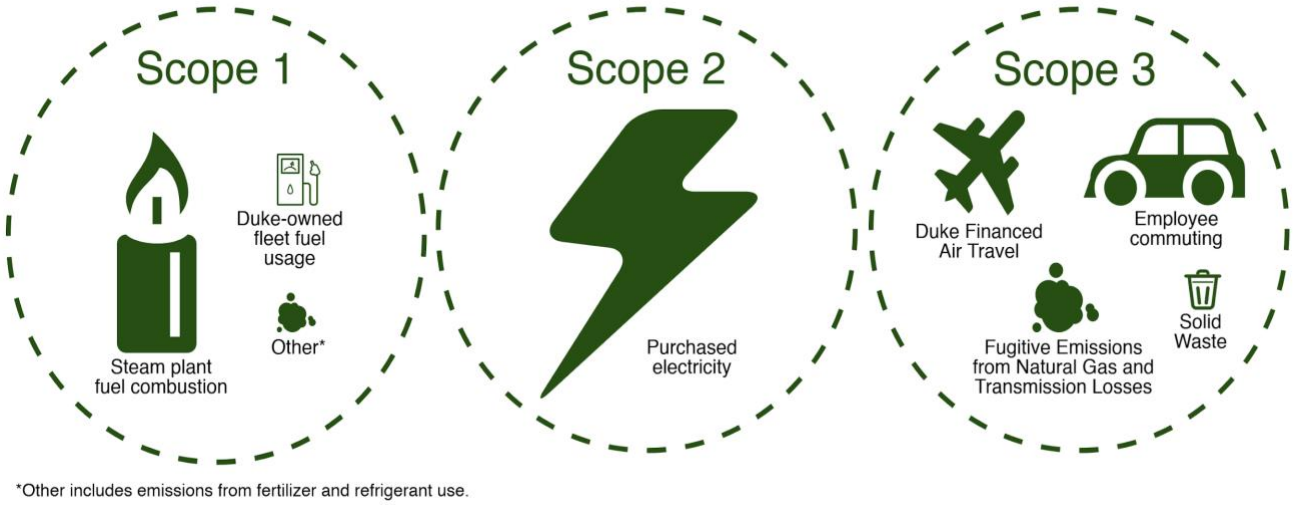
The CSC reports progress toward the CAP goals and broader efforts to include other key topics such as water, waste, food, natural resources, procurement and sustainable investment in the annual Sustainability Strategic Plan Progress Report (SSP).

Emissions Overview

The CAP identifies Duke University's overall emissions in three distinct categories to address the unique attributes and scope of each (also shown in Figure 2). These categories were outlined by the American College and University Presidents' Climate Commitment, which is the commitment that Duke University signed in 2007.

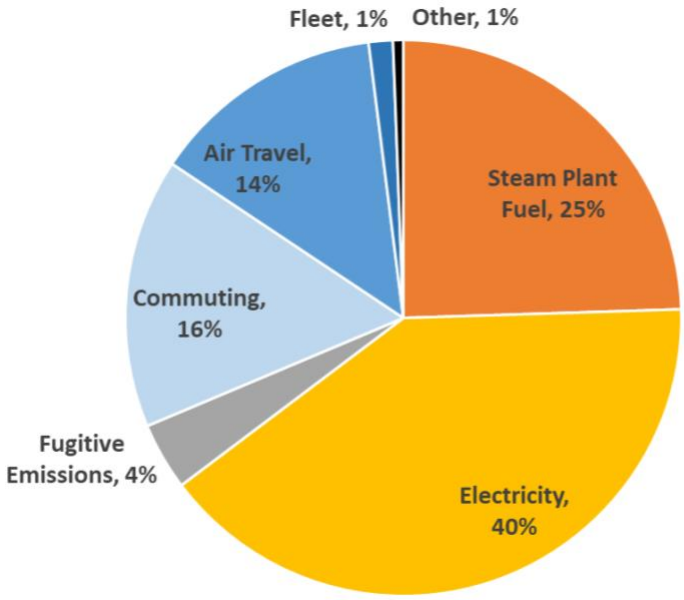
- Scope 1: Direct GHG Emissions from:
    - Fuel used on campus for heating generation (e.g. natural gas)
    - Fuel used in Duke-owned vehicles
    - Fertilizer used on Duke-owned property
    - Refrigerants
- Scope 2: Indirect GHG emissions from:
    - Electricity purchased from Duke Energy
- Scope 3: Other Indirect GHG emissions from:
    - Employee commuting
    - Air travel paid for by the university
    - Landfilled waste
    - Fugitive emissions from natural gas extraction and transport (added in 2017)
    - Transmission losses from purchased electricity (added in 2017)

Figure 2: Duke University's emission sources by scope



In 2018, overall these emission sources contributed approximately 267,000 MTCO2e of emissions. Scope 1 sources contributed 25%, Scope 2 sources contributed 40%, and Scope 3 sources contributed 35% of total emissions (specific proportions shown below in Figure 3).

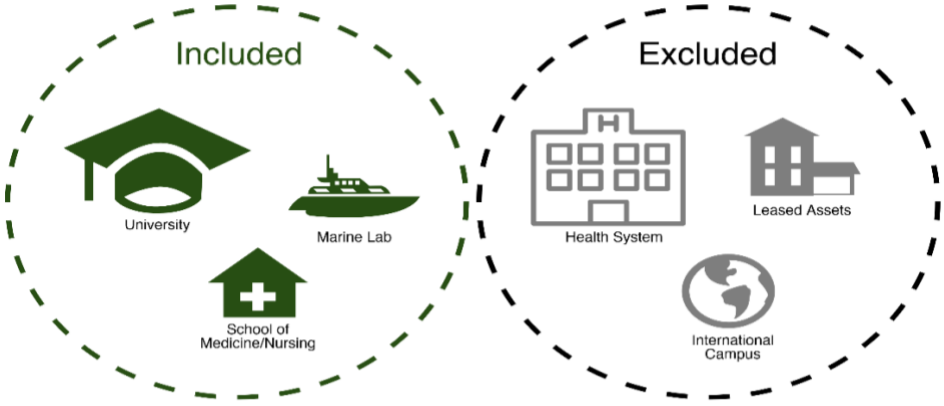
Figure 3: Duke University's 2018 Emissions by Emission Source



Based on Duke's signing of the ACUPCC in 2007 and alignment with peer universities, Duke University's climate neutrality goal encompasses the university-side of Duke (including School of Medicine and School of Nursing). Due to this, the Climate Action Plan identifies targets for the University separately from the larger Duke institution, which includes the hospital, outpatient

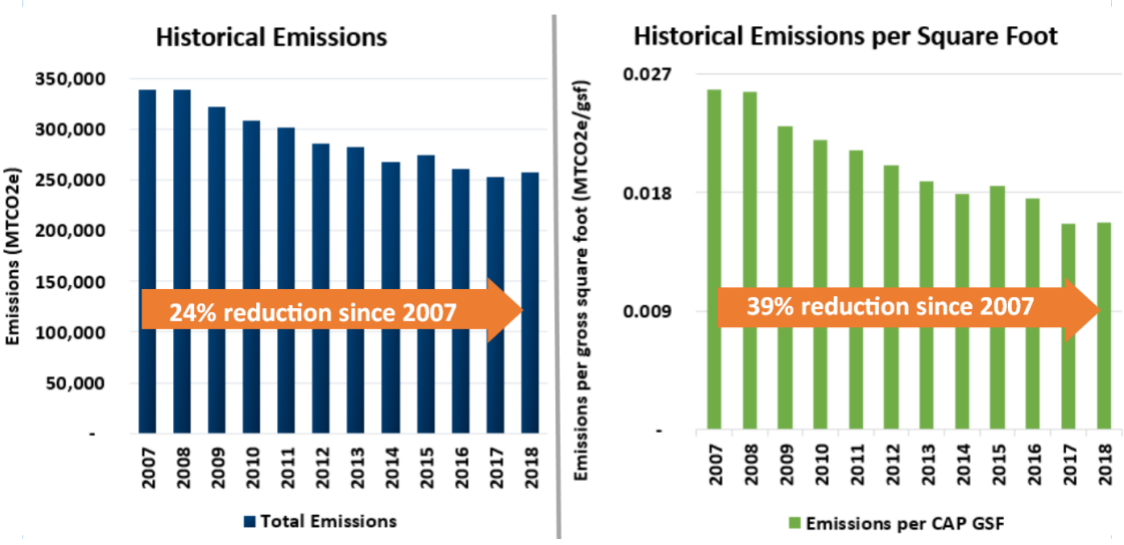
clinics, and support facilities for the health system in Durham, leased spaces, and international campuses (shown in Figure 4 below). While Duke's target date for climate neutrality will only apply to the University, it should be noted that the operational changes and future campus emission reduction measures will also result in a lower GHG footprint for the Health System facilities which are located contiguously with West Campus and share common systems and services.

Figure 4: Duke University's entities that are included in CAP goals



To date, Duke University has made significant progress in meeting CAP goals with an overall 24% reduction in greenhouse gas emissions since 2007. During this same time, Duke University increased campus building space included in the CAP by approximately 3 million square feet (25% increase since 2007). When calculating emissions per square foot, the reduction is nearly 40%. See Figure 5 for graphical comparison.

Figure 5: Historical emissions compared to historical emissions per square foot

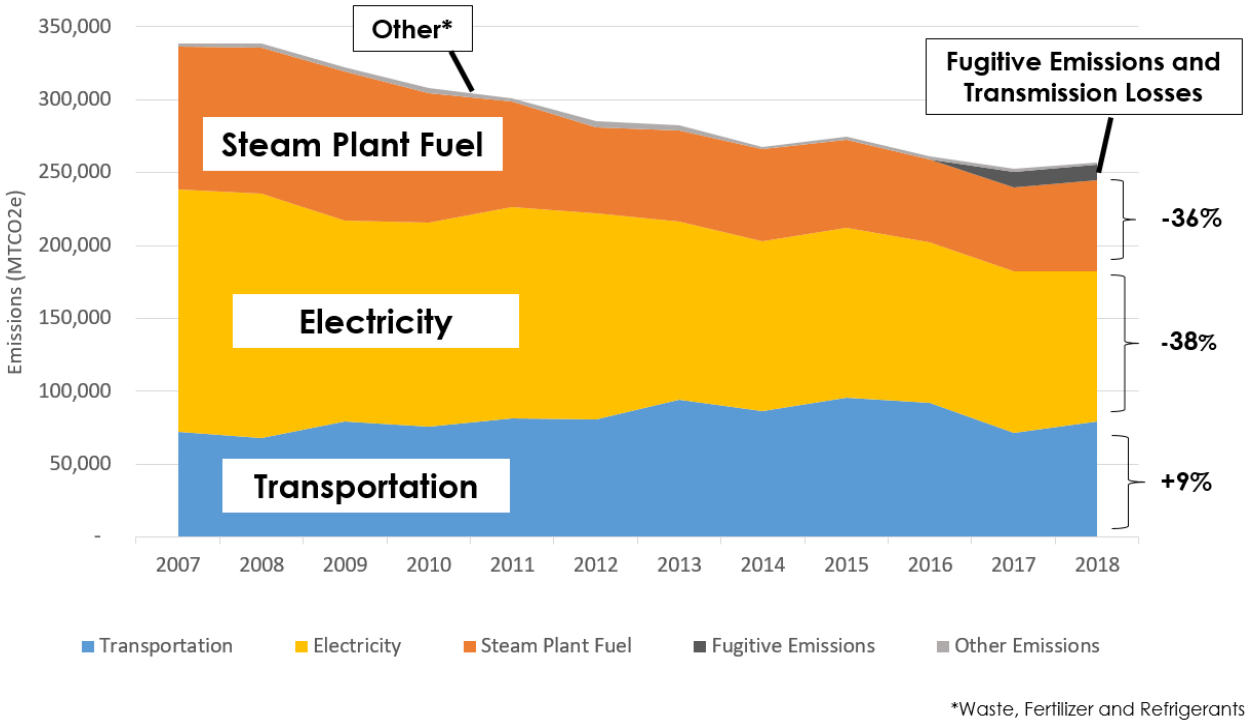


Emissions reductions have been achieved mainly by energy-related reduction strategies including the following:

- discontinuing the use of coal in the campus steam plants
- investment in energy efficiency and utility plant improvements
- Duke Energy reducing the carbon content of its electricity

These strategies have reduced energy-related emissions despite significant campus growth. Emissions from transportation sources such as employee commuting and air travel have proven harder to influence due to external factors such as where employees choose to live, fluctuating gas prices, and limited regional transportation infrastructure. As shown in Figure 6 below, the breakdown of the trend for emissions includes a reduction of 36% from steam generation on campus, a reduction of 38% for electricity emissions, and an increase of 9% in transportation-related emissions compared to the 2007 baseline.

Figure 6: Historical Changes in Major Emissions Categories



*Waste, Fertilizer and Refrigerants

While Duke is proud of the substantial progress made on the 2009 CAP strategies, it is prudent to critically assess past efforts and develop an updated CAP with only five years left before the 2024 target. This update evaluates emission reduction efforts to-date and assesses new technology and policies that will facilitate meeting the 2024 goal. This update also provides an opportunity to engage student interest and faculty stakeholders in a productive discussion of Duke's climate goals and the broader global issues facing our rapidly warming world.

2019 Climate Action Plan Update Principles

As part of the 2019 CAP Update, Duke University has developed a statement of principles on energy and climate change that will guide its pursuit of climate neutrality. These principles are based on the University's longstanding commitment to sustainability and climate leadership.

In deliberating new programs and investments towards climate neutrality, Duke University will:

- Consider the full economic, social, and environmental impact of all potential emission reduction projects.
- Strive to meet the campus energy and energy security needs with the fewest greenhouse gas emissions and greatest environmental benefits economically feasible.
- Support investment in renewable energy and renewable energy technologies while continuing to prioritize and invest in energy-efficiency measures as part of its greenhouse gas reduction efforts.
- Prioritize investment in emission reduction and carbon offset projects that benefit the environment and economy of local communities.
- Advocate for policies at the local, state, and federal levels that expand access to and affordability of renewable energy.
- Support investment in local infrastructure that would provide opportunities for the campus community to access viable options for alternative transportation.
- Utilize Duke's commitment to climate neutrality in ways that will lead to the adoption of climate change solutions at a larger scale.
- Continue and expand Duke's commitment to make knowledge of sustainability and climate neutrality part of the educational experience of all students.
- Identify and effectively engage with stakeholders both on and off campus.

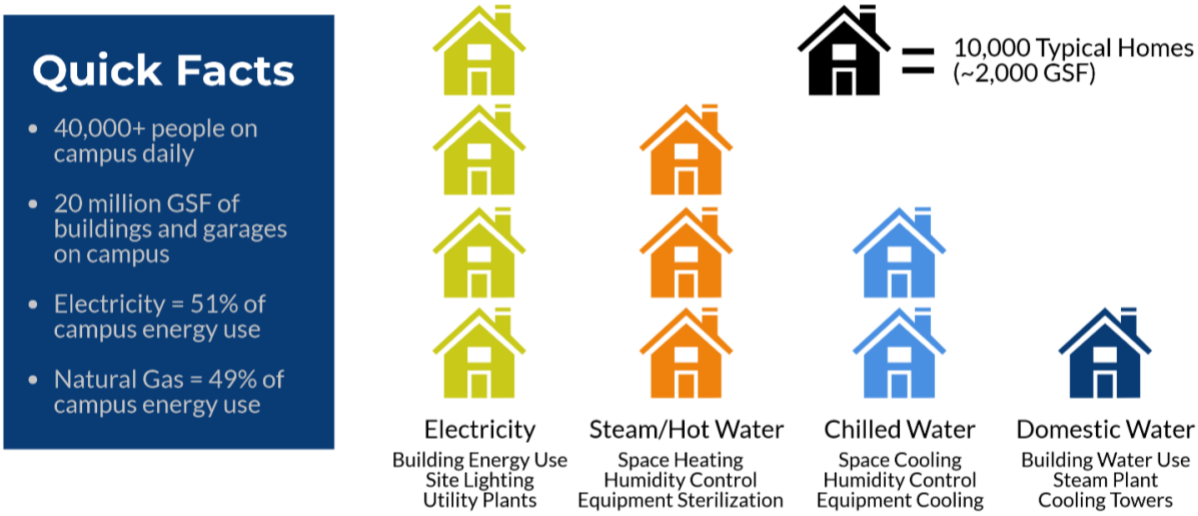
Using these principles, the Campus Sustainability Committee and other stakeholders have developed the 2019 CAP update with a focus on energy and transportation internal emission reductions and how education, communication, and carbon offsets will be incorporated into achieving the 2024 goal.

Energy

Overview

The Duke University main campus has one of the largest utility networks in the southeastern United States. The University manages heating, cooling, and electricity infrastructure for over 20 million square feet of buildings on Duke's main campus in Durham, North Carolina. Duke's annual energy use is almost evenly split between electricity and natural gas and was over 3 million MMBTU in 2018. Depending on the utility system, Duke University uses the equivalent energy and water of 10,000-40,000 typical residential homes (Figure 7).

Figure 7: Scale of Duke University's Campus Utilities



Currently, Duke University purchases electricity from Duke Energy and natural gas from PSNC Energy. Steam and hot water, which are produced by burning natural gas in two thermal energy plants on campus, are used for space heating, sterilization, humidification, de-humidification, and domestic hot water in university buildings, laboratories, clinics, and Duke University Hospital. Electricity is used for lighting, plug-in devices, and air conditioning.

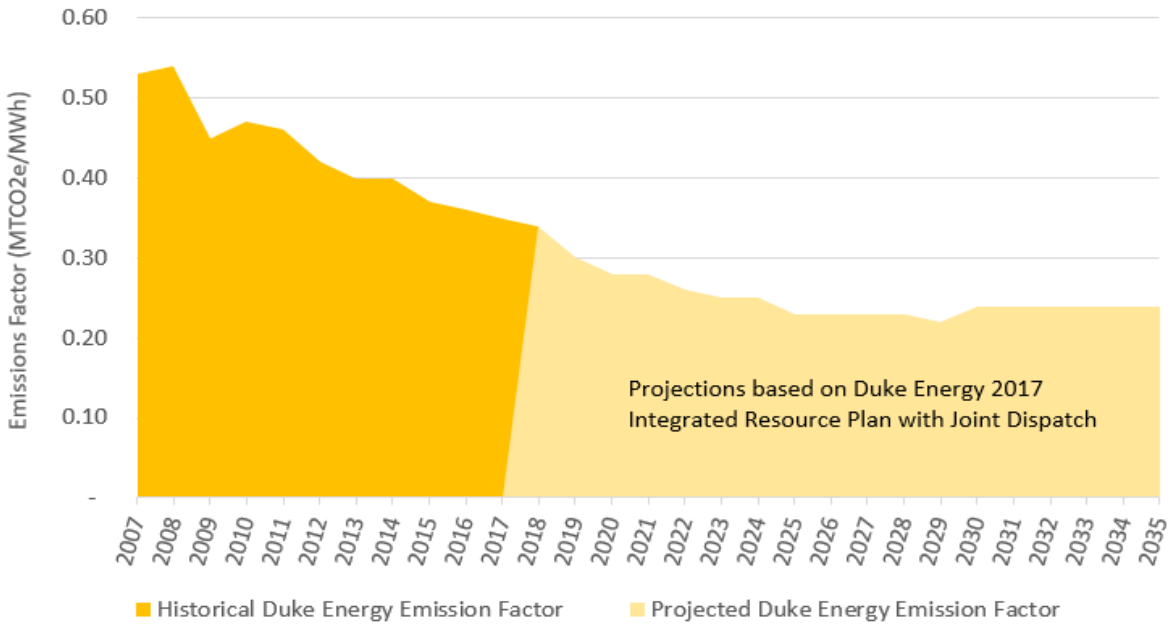
Duke's utility infrastructure consists of the following:

- 2 chilled water plants
- 2 steam plants
- 1 solar hot water plant
- Approximately 1 MW of solar photovoltaics (PV)
- 1 district hot water plant
- 5 high voltage electrical substations
- 3 central emergency generator plants
- 2 stormwater plants
- Hundreds of miles of underground pipes and wire

Duke is organized into two major organizations, Duke University and Duke University Health System. These two organizations have different governance and budgets and make decisions about their buildings and projects independently. The Facilities Management Department (FMD) only oversees the University facilities excluding housing and dining facilities which are operated by Student Affairs. Work execution toward CAP goals is therefore a decentralized process and is dependent on each groups' budget, priorities, and building types. While FMD considered the full campus and health system future demand when developing the current Energy Needs Analysis, the 2024 climate neutrality goal only includes the University, School of Medicine and School of Nursing.

Duke University receives nearly all of its electricity needs from Duke Energy and this electricity accounted for 40% of Duke University's emissions in 2018. Since 2007, Duke Energy has reduced its emissions per megawatt-hour by 36% by changing its fuel mix. From 2005 to 2017 the percent of coal-fired generation decreased and was replaced by expansions of natural gas-fired generation and renewable energy. Duke Energy plans to invest $11 billion in continued expansion of natural gas fired generation and renewable energy in the future. See Figure 8 to see how emissions have changed since 2007 and how they are projected to change through 2035.

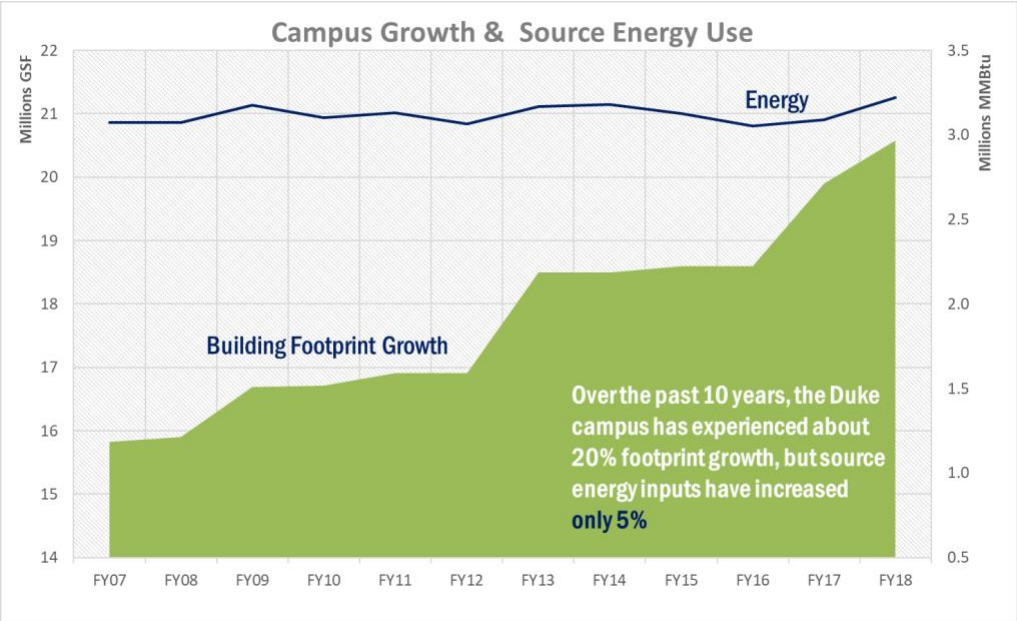
Figure 8: Duke Energy Historical and Projected Carbon Intensity (MTCO2e/MWh)



Energy Efficiency on Campus

Duke University's internal Energy Management team, a part FMD, consists of building systems engineers, automation engineers, analysts, and technicians. These dedicated professionals continuously research and implement supply-and demand-side energy, water, and operational efficiency improvements, resource cost management strategies, and data management and analysis methods. As shown in figure 9, through energy/plant efficiency work and growth on West, East, and Central Campuses over the past decade, Duke University's energy use has stayed relatively consistent.

Figure 9: Historical Campus Growth Compared to Energy Used on Campus

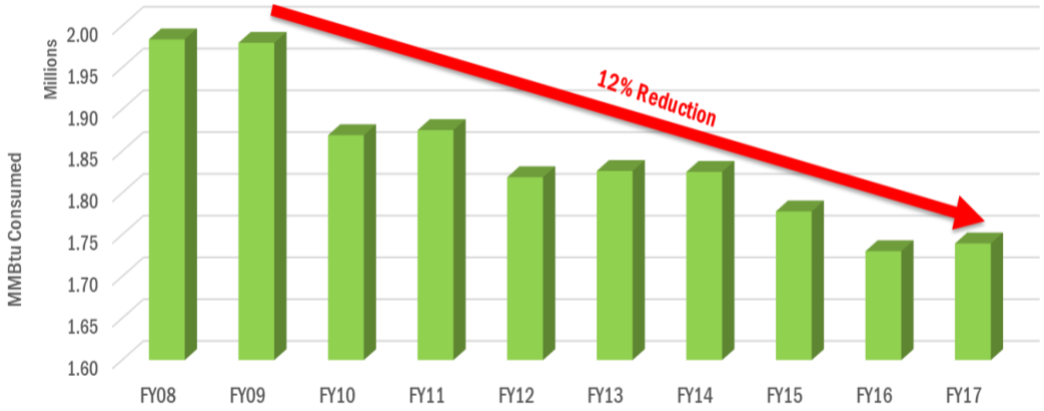


Energy Efficiency Projects

Duke University invests significant resources into ensuring existing campus buildings operate as efficiently as possible. Through strategies such as the ones listed below, the University has reduced energy use in building constructed prior to 2008 (pre-CAP buildings) by 12% as of FY17 (also see figure 10).

- HVAC Temperature and Scheduling
- LED Site Lighting
- Retro-Commissioning
- Thermal Plant Efficiency
- Waste Heat Recovery
- Parking Lot LED Lighting
- Steam, Electric, Water Metering Upgrades
- Building Energy Audits
- Building LED Lighting
- District Steam to Hot Water Conversion

Figure 10: Energy Use in Buildings Constructed Prior to 2008



A key energy efficiency strategy employed by FMD is retro-commissioning, or "existing building commissioning," a systematic process for identifying and implementing operational and maintenance improvements in a building to ensure continued good performance over time. The intent of the process is to optimize the performance of building subsystems as well as how they function together. Retro-commissioning focuses on operations and maintenance improvements and diagnostic testing, although needed capital improvements may be identified and recommended through the process.

Duke's Energy Management team has broad experience executing retro-commissioning projects. An example of a large project completed in 2016 was ~$1M project in French Family Science Center to tune-up and calibrate laboratory exhaust systems. This project achieved its engineering performance improvement objectives, and has had the side benefit of avoiding over $650,000 in energy expenditures since completion. While, retro-commissioning projects like these often result in huge energy savings, they don't necessarily reduce the peak utility demand and thus reduce the system capacity required to serve the buildings.

Using less energy can be the fastest, most cost-effective method of reducing Duke University's carbon footprint. The University has made significant progress in reducing the energy needs of its campus, even as it grows with major renovations and new construction, and it will continue to pursue energy efficiency in the future. The 2019 Climate Action Plan includes projects to expand efficiency measures in central plants and buildings, as well as ongoing implementation of newer technologies across campus, such as LED lighting to further reduce energy related GHG emissions.

Duke University maintains nearly 1000 utility meters to track energy consumption and demand profiles for all of the buildings connected to the campus-owned utility systems. This is true not just for electricity and water, but for steam, chilled water, and hot water utilities as well. The majority of the campus energy load, including 100% of chilled water and hot water utilities, and 95% of the steam utility, can be measured to the 15-minute interval level. While there are still some older metering devices that aren't digitally connected, these are read monthly for consumption data. The University also has a multi-year plan to upgrade those in locations where additional data is useful for improving system operation and efficiency.

As part of this upgrade, FMD is also halfway through implementation of a new "Energy Data Analytics" program. This is a project to capture significantly more building operating information, specifically related to heating and cooling systems, into a single database, so that the University can perform "continuous commissioning" on building systems while reducing energy consumption and cost. This project has significant IT system design challenges such as how to obtain data from devices and systems that predate the modern internet and current plug-and-play expectations of technology. This project is nearly a year in progress, and will take approximately another year to be fully operational.

Renewable Energy on and off Campus

Current Solar on Campus

Duke University has explored and invested in on-campus renewable energy projects as part of its strategy to reduce carbon emissions on campus while meeting growing energy needs. As of spring 2019, Duke has 900 KW of solar photovoltaics (PV) and hot water (shown as equivalent kW) installed in the following locations:

- Bryan Center - 80 kW solar hot water
- Smart Home - 10 kW solar PV
- Grainger Hall - 45 kW solar PV and 15 kW solar hot water
- Research Drive Parking Garage - 750 kW solar PV

Duke is currently subject to regulatory limits to on-campus solar installations, and in other cases PV is not a cost effective option when compared to other alternatives for reducing the campus greenhouse gas footprint.

Limits to on-campus solar

Based on current N.C. regulations, Duke University is only allowed to develop and utilize 1MW of net-metered solar electricity per account on campus – any additional capacity must be sold back to Duke Energy at a loss. The sell-back of solar-generated power is only valued at Duke Energy's avoided-cost price per kWh, which is much lower than what Duke University pays for grid electricity. The University has five main accounts associated with the five campus substations where the campus systems interconnect with Duke Energy's grid, so current on-campus production and use is limited to 5MW. Duke University has advocated that Duke Energy support increasing these limits.

In order to sell any excess solar capacity back to Duke Energy, power lines would have to connect from solar installations back to one of the five substations on campus. The operational and financial implications of running such lines across campus is prohibitive, so the most feasible location for solar installations is near one of the five substations

There are also several other constraints or considerations that go into decisions regarding on-campus solar. Some rooftops are oriented poorly as a solar resource, either because of the direction the building roof is facing or because their proximity to adjacent buildings or tree canopy results in shading that limits heat or power generation. In addition to these issues, a large proportion of Duke University buildings house research and health-care facilities which require space on the roof for exhaust systems and other HVAC equipment that cannot be obstructed by solar PV or thermal equipment. With regards to ground-mounted solar installations, these projects have to consider trade-offs such as the removal of campus tree canopy and other competing uses for that land (e.g. new buildings).

Future Solar Feasibility at Duke

Duke FMD has performed feasibility studies to evaluate on-campus locations for solar PV installations and provide lifecycle cost estimates for installing and operating those systems. The solar PV and thermal marketplace is evolving, as are the federal and state policy constraints that influence renewable energy in Durham. The University is currently finalizing a scope of work for a more detailed study that will build on previous work. Specifically, the study will:

- Review available campus spaces that are suitable as a solar resource;
- Develop a detailed understanding of the architectural and structural work required to integrate PV and/or solar thermal systems into roofs;
- Confirm and update on-campus electrical/thermal interconnection practices, for both current facilities and potential future sites;
- Review and confirm the ways in which PV interconnection design impacts operations and maintenance activities required to keep the campus grid operating reliably and safely.

When design solution options are identified, FMD will evaluate potential funding options, and perform lifecycle cost modeling exercises to evaluate the positive and negative costs incurred should the University desire and is allowed to increase on-campus PV generation. The results of this study will be shared with the Campus Sustainability Committee as soon as it is available, likely sometime in early 2020.

As the University continues to evaluate the potential for on-campus solar, the use of renewable energy for the scale of University operations and energy needs is also constrained by other regulatory and economic factors.

Regulatory and Economic Constraints for Renewable Energy at Duke University

Due to N.C. law, electricity can only be sold by investor-owned utilities (e.g. Duke Energy) and electric membership corporations (EMCs). This limits the ability for Duke University to enter into Power Purchase Agreements (PPA) for off-site renewable energy generation. However, regulation proposed in late 2017 in the N.C. General Assembly may open new solar opportunities for Duke University by early 2019. University officials are closely following the North Carolina HB589 as it may be an opportunity for Duke University to build economically feasible, large-scale solar off-campus that has not previously been an option.

Under review by the North Carolina Utilities Commission as of October 2018, Duke Energy has proposed a utility-scale renewable energy procurement program called “Green Source Advantage (GSA)”. This program will be available to nonresidential customers who have energy demands of at least 1 MW of peak demand at a single location, or an aggregate of 5MW or more of peak demand across multiple locations. There will be up to 600 MW of total capacity, with 100 MW for military installations, 250 MW for The University of North Carolina institutions, and 250 MW set aside for other large nonresidential customers (e.g. Duke University). Customers can choose to purchase any amount up to 125% of their maximum annual peak demand, which for Duke University would be

125% of 81.6 MW, or just over 100 MW with the potential to reduce Duke's carbon footprint by approximately 50,000 MTCO2E.

Depending on the final rules issued by the Utility Commission, Duke University plans to maximize its off-campus solar power purchase to the total amount allowed by law. A supplier and sites have been identified for solar power but due to confidentiality agreements, the University is unable to provide further details until the rules and contracts are finalized. Beyond this program, which would allow Duke University to source approximately a third of purchased electricity from renewable sources, there are not currently any regulations that permit off-site renewable power purchases. However, the University is committed to purchasing large amounts of off-site solar if it becomes available.

With regards to electricity alone, the University requires electrical power around the clock, and unfortunately, solar photovoltaic systems can't generate at night, nor are they steady in output. Energy storage is also not economically feasible to make up the balance of energy needs (*For additional information regarding energy storage analysis review ENA section 9.2*). Facilities Management has studied, and continues to study, options for integrating renewable energy into the campus supply mix.

Within the campus energy profile, it should be noted that almost half the energy used on campus is to produce steam or hot water. Solar and other renewables, do not offer cost effective options for producing this thermal energy. The University is actively exploring, methane-capture biogas as a renewable option to produce steam on campus.

A final limiting factor to making solar and other renewables more cost effective for the university is the tax-exempt status of the institution. Unlike residential or commercial customers in N.C., Duke University's nonprofit status means it is not directly eligible for potential state or federal tax rebates connected to renewables, which can have a significant impact on the overall cost of a project.

2009 CAP Energy Recommendations Update

When Duke University first established its climate neutrality goal, approximately 78% of emissions came from energy-related sources. These sources included fuel burned in the campus steam plants and purchased electricity. The 2009 Climate Action Plan set clear goals and recommendations to reduce this footprint.

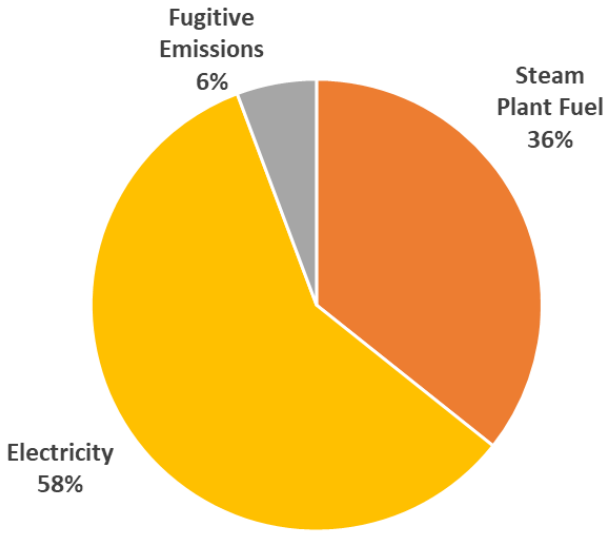
- *Establish green building energy consumption standards and an approval protocol for building energy consumption review -- implement, measure and report on energy use targets by Building Tech Rating.*
    - After assessing the University's LEED building implementation and results, Duke University adopted a new Sustainable Building Policy (i.e. LEED+) in 2015 that would build on the LEED foundation but address some of the lessons learned. This included Duke specific energy and water reduction requirements as well as life-cycle cost assessment of building energy systems. Duke is currently exploring additional opportunities to improve and track its high performance building efforts.

- *Beginning in 2010, implement energy conservation measures in existing buildings with the goal to realize a 15% reduction in energy use over a 20 year period (2010 – 2030).*
    - As of FY17, Duke University had already achieved a 12% reduction in energy use in buildings constructed prior to 2008.
- *Discontinue the use of coal as soon as possible. Duke should complete the gas-fired East Plant steam plant construction and start-up in 2010 and initiate the West Campus steam plant conversion from coal in 2012*.
    - In 2010, the East Campus Steam Plant was re-commissioned as a high efficiency natural gas plant. In 2011, Duke University ended the use of coal in both on-campus steam plants.
- *Continue to urge, monitor, and review Duke Energy's progress towards emissions reductions while exploring on-campus electricity generation options. Additionally, Duke should install 4MW solar PV array by 2012*.
    - Duke University engages actively with Duke Energy and other stakeholders to advocate for decarbonization. While current N.C. law limits the ability for Duke University to enter into Power Purchase Agreements (PPA) for off-site renewable energy generation, regulation proposed in late 2017 in the N.C. General Assembly may open new solar opportunities. The University is committed to purchasing large amounts of off-site solar if it becomes available.
    - As of fall 2018, Duke has 900 KW of solar photovoltaics and solar thermal installed on campus. The University is also currently initiating a more detailed feasibility study to assess the additional, available campus spaces that are suitable as a solar resource.
- *Research alternative technologies and explore and implement conversion to biogas, solar PV, solar thermal, combined heat and power or other technologies by 2030*.
    - Over the past decade, the University has worked continuously to explore the economic, environmental and utility system impacts of new technologies and implement them where feasible on campus.
- *Pursue plant efficiency improvements such as distribution system upgrades, thermal storage, chilled water expansion and upgrade, and boiler plant heat recovery*.
    - Over the past 10 years, the Duke campus has experienced approximately 20% footprint growth, but source energy inputs have increased only 5%. Much of these efficiency gains have been realized through expansion of centralized utilities, steam plant/system efficiency measures, hot water conversion efforts and other building efficiency projects.

The implementation of previously discussed strategies has significantly reduced the University's overall energy-related greenhouse gas emissions. Duke University also added fugitive emissions from the production of natural gas used in campus steam plants and transmission losses from purchased electricity to the greenhouse gas inventory in 2017.

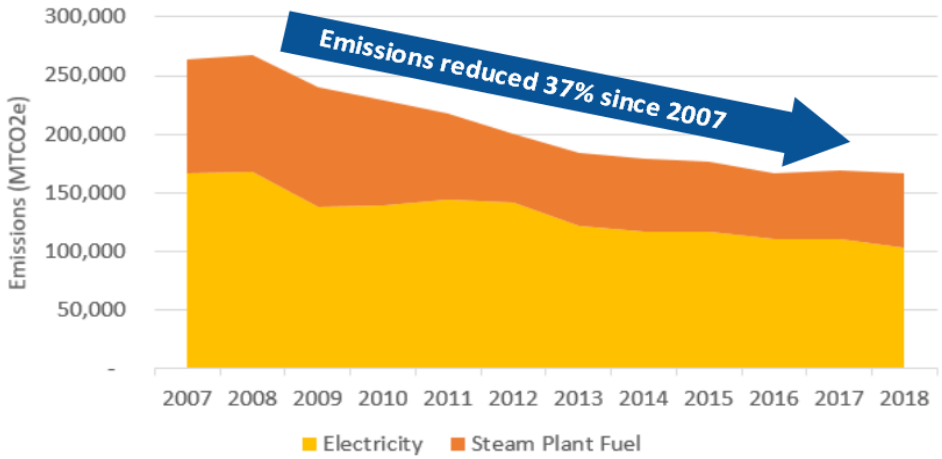
In 2018, 69% of Duke University's total greenhouse gas footprint came from energy-related emissions (approximately 176,000 MTCO2e). When considering only energy related emissions (69% of Duke's total emissions), electricity and steam plant fuel use make up the large majority. (shown in figure 11 below).

Figure 11: Emissions Breakdown from Energy-related activities (2018)



Since 2007 energy-related emissions have been reduced by 37%, despite campus growth of over 3 million GSF in CAP buildings (Figure 12).

Figure 12: Historical energy emissions per emission type



In the spring of 2018, Duke University made the decision to develop an Energy Needs Analysis to identify ways to reduce emissions while meeting the energy needs of a growing campus and health system. The next section will summarize aspects of the Energy Needs Analysis.

2018 Duke University and Health System Energy Needs Analysis

Duke University works diligently to efficiently and reliably meet the energy needs of a growing campus with complex academic, research, and health care operations. The 2018 Energy Needs Analysis (full-report available) assessed the current loads and production/distribution assets, ability to recover or adjust easily to an unforeseen event or outage (resiliency assessment), and the impact of future loads on the systems for the University and Health System. The campus and health system's historical growth rate since 1930 has averaged 250,000 – 300,000 gross square feet per year. This benchmark was used for planning purposes within the CAP and the Energy Needs Analysis. The following utility systems were assessed: Chilled Water, Steam, Hot Water, Electrical Power, City Water, Reclaimed Water, and Natural Gas.

Each of the utility systems were assessed for their current ability to meet the following system needs:

- Utility Resiliency and Reliability
- Near-Term Utility Infrastructure Upgrades
- Growth in Campus Energy Needs
- Carbon Reduction Goals

Low carbon alternative fuel sources such as biogas and solar photovoltaics were also considered for use in these systems.

The study found there are several solutions that could be implemented to satisfy the system needs identified previously. The basic description of these options is noted below:

- **Separate Heating and Cooling** (SHC) – Business as usual case, with separate heating and cooling plants, plus continuous duty central generating plant for standby power system needs.
- **Combined Heat and Power** (CHP) – Simultaneous generation of heat and power to meet a large portion of the standby power system needs as well as heating system needs. Provide separate chillers to meet cooling system needs.
- **Combined Heating and Cooling** (CHC) – Simultaneous generation of heating and cooling using Heat Recovery Chillers (HRC) to satisfy heating and cooling need for a portion of campus. Additional heating, cooling and packaged generators are required to meet additional system needs.

These design options are not mutually exclusive and a combination of the options could also be utilized in a **Hybrid Generation** (HYGEN) system.

The Energy Needs Analysis assessed the economic, carbon and utility impacts for numerous scenarios with the technologies referenced above. The following is a brief overview of the options that were evaluated for campus hot water, steam, chilled water and stand-by power.

Steam and Hot Water

Steam and hot water are used for space conditioning, hot water heating, hospital medical equipment sterilization, dining services, pool heating, dishwashing, and other process uses. The university has recognized a need to replace some aging and inefficient infrastructure on campus, address future campus growth, and provide a backup source of steam in case of emergencies, including limited supply of fuel or a city-water outage. Some technologies that can be used to meet these needs include:

- Steam
    - Gas-fired boilers to produce steam, which could be fueled by biogas.
    - Co-generation of power with hot water and/or steam produced from waste heat.
    - Electric boilers to produce steam, which can partially be supplied by solar PV.
- Hot Water
    - Heat exchangers used to produce hot water from steam produced in existing boilers.
    - Co-generation of power with hot water and/or steam produced from waste heat.
    - Heat produced by Heat Recovery Chillers during the production of chilled water.

Chilled Water

The centralized production and distribution of chilled water is the most efficient and economical method to cool Duke University's campus, including the School of Medicine, School of Nursing, and Duke Hospital. The system provides chilled water for process equipment cooling and building air conditioning in a reliable and cost-effective manner. The university recognized a need to ensure reliable chilled water in case of emergencies such as electricity/city-water outages. Technologies that can be used to meet these needs include:

- Diesel generators distributed across campus to support particular buildings/systems.
- Co-generation of power with hot water and/or steam produced from waste heat.
- Thermal energy storage tank where chilled water is produced at night when electricity demand is lower and then used during the day.

Standby Power

Electricity is central to the generation of chilled water and powering of Duke's complex research and medical facilities. The university has recognized a need to ensure that electricity is available in cases of emergencies to provide reliable backup power and chilled water for campus. Some technologies that can be used to meet these needs include:

- Diesel generators distributed across campus to support particular buildings/systems.
- Co-generation of power with hot water and/or steam produced from waste heat.
- Batteries that store power and discharge when needed.

Of the options above, battery storage and electric boilers are not considered feasible at the current time due to prohibitive cost. A full description of all reviewed technologies including those determined not viable is publicly available in the Energy Needs Analysis Report.

Energy Needs Analysis Conclusions and Next Steps

Duke University will continue to build upon the results of the 2018 Energy Needs Analysis to develop a detailed Utility Master Plan that establishes the major projects, timeline, and costs for proposed projects. This energy analysis has shown that no single technology or system approach effectively meets all of the complex campus and health system needs and therefore, a hybrid approach is necessary. Solutions must be tailored to the unique differences of parts of campus, and the operability of technologies is critical to maintaining a high level of system reliability.

Based on the analysis all of the technologies deemed feasible over a 30-year life cycle, each option is within 5% difference in cost from one another. The University can also best manage annual utility investments by making incremental improvements to systems versus a wholesale implementation of a single system.

The study also found that no single on-campus technology makes a significant enough impact towards carbon reduction goals. Duke University will continue to make on-campus reductions and investment in on-campus renewables to maximize internal carbon reductions, but only off-campus, large-scale solar and methane-capture biogas have the potential to drive energy emissions to zero.

Biogas/Renewable Natural Gas Overview – An Evolving Focus

As described in this document, a considerable portion of Duke University's strategy for meeting its climate neutrality goals and energy needs involves biogas and renewable natural gas (RNG) derived from biogas. Specifically, the University has sought to achieve carbon offsets through the capture and destruction of biogas[3] by running its steam plants on RNG or, ideally, a combination of both practices.[4] Importantly, regardless of which application the University pursues, it is driven by a desire to leverage its climate and renewable energy goals to help address other long-standing environmental, social justice and economic issues across North Carolina. Because North Carolina has significant supplies of biogas, the University considers it particularly appropriate to seek emission reductions by developing this resource.[5]

[3] The capture and destruction of biogas from livestock operations qualifies as a carbon offset pursuant to the Climate Action Reserve's U.S. Livestock Project Protocol, available at http://www.climateactionreserve.org/how/protocols/us-livestock/. The U.S. Livestock Project Protocol is one of five protocols recognized for compliance purposes under California's Cap-and-Trade Program, which California implemented as part of its 2006 Global Warming Solutions Act or AB32, See Climate Action Reserve, available at http://www.climateactionreserve.org/how/california-compliance-projects/.

[4] It is possible to generate carbon offsets and renewable energy from livestock projects involving the capture and use of biogas to produce electricity or RNG because the act of capturing and destroying the methane creates an offset, while creating a renewable energy source from the biogas that is captured constitutes a renewable energy source or credit. See CAR Livestock Project Protocol FAQs, available at http://www.climateactionreserve.org/how/protocols/us-livestock/livestock-project-protocol-faqs/#q01

[5] See National Renewable Energy Laboratory, Energy Analysis, Biogas Potential in the United States, available at https://www.nrel.gov/docs/fy14osti/60178.pdf.

Early Focus on Agricultural Sources of Methane

One of the first ways Duke sought to incorporate biogas into its climate neutrality goals was through the capture and destruction of biogas from the state's 2000+ swine farms to garner carbon offsets. This decision was motivated by two factors. First, biogas from swine waste lagoons is a major contributor to total biogas produced in North Carolina, which ranks third in the country in terms of biogas resource potential. Equally important was the opportunity to improve waste management on swine farms by advancing options to achieve comprehensive swine manure management, starting with the capture of methane emissions.[6]

In making this decision, Duke weighed the potential social, environmental, and economic benefits and impacts of swine biogas offsets and waste-to-energy projects. After careful consideration, it determined that trying to move a complicated issue forward was better than turning away from a problem because it will be difficult. Based on this careful assessment and believing that limiting emissions from swine lagoons could eventually lead to comprehensive waste management, Duke University robustly pursued biogas capture at farms.

Using biogas from livestock operations such as swine farms has multiple direct climate benefits. First, its capture and destruction can generate carbon offsets by avoiding methane emissions by preventing those emissions from being released. These carbon offsets can be applied against baseline emissions the University cannot avoid. Second, the biogas can be used to generate electricity or a renewable alternative to natural gas thus curtailing fossil fuel-based emissions.

While substantial effort has been applied to achieving carbon reductions from swine waste emission controls, in more recent years Duke has placed increasing emphasis on finding ways to replace the conventional natural gas it uses with RNG produced from state biogas resources. Use of RNG at Duke is consequential because nearly half of the University's operations rely on natural gas. If the University could avoid some or all of its use of conventional natural gas, it could dramatically reduce its baseline emissions. Moreover, in cases in which RNG is sourced from livestock operations, the University not only displaces conventional natural gas with a renewable but it also helps farmers avoid methane emissions their farms would otherwise have emitted, making livestock operations a particularly attractive climate focus.

Distinguishing Between Biogas and Renewable Natural Gas

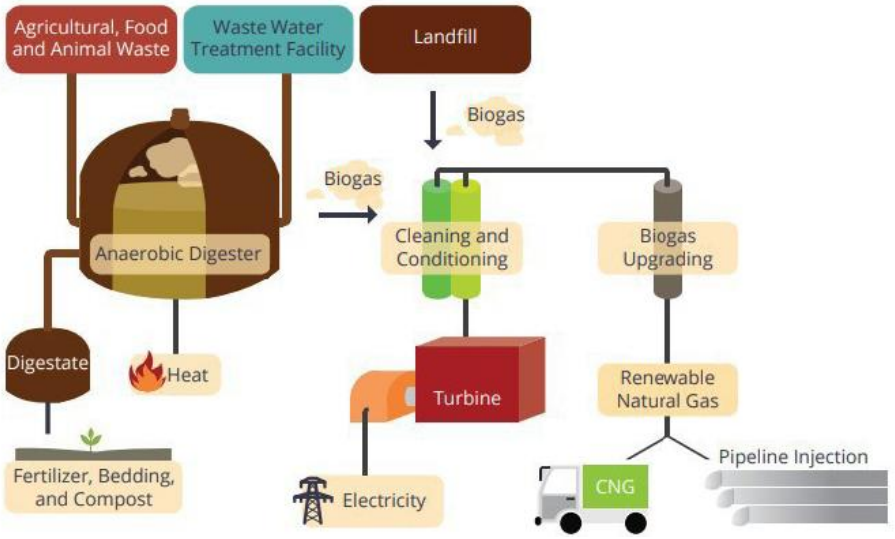
Biogas and RNG are fuel sources created from the breakdown of organic waste, except that RNG is refined from biogas and meets conventional natural gas pipeline standards. Key to biogas (and RNG) creation is the decomposition of organic waste in oxygen-free or anaerobic environments. Bacteria that thrive in these environments feed off the waste and respire mostly methane and carbon dioxide, methane being the majority constituent in biogas and RNG and possessing a global

[6] It has been Duke University's perspective that if it provided a demand signal to spur GHG emission avoidance from swine waste as well as new learning about waste management it could help the state find a path by which farms could transition to waste management that meets stringent environmental performance standards, a new source of renewable energy and carbon-driven economic benefits for rural areas.

warming potential 28-36 times greater than carbon dioxide.[7] Biogas can be used in its unrefined state to run small-scale power generating equipment such as microturbines and generators, or it can be refined to the same composition and pressure of natural gas and injected as RNG, "a pipeline-quality gas that is fully interchangeable with conventional natural gas," into a natural gas pipeline.[8,9,10]

RNG is beneficial because it can be used in place of geologically derived natural gas – a fossil fuel – which means that its use avoids the emissions of methane that would otherwise have been released. In cases in which natural gas is derived from extraction processes such as hydraulic fracturing ("fracking"), using RNG in its place also helps avoid the negative effects associated with the practice. Another often overlooked advantage of biogas – and RNG – is that supply is continuous. Meaning, the continuous availability of RNG means that it can supplement other renewables when they are not available, such as when the sun sets or the wind dies down.

Figure 13: Biogas Technology Diagram courtesy of EPC Biennial Report (2018)



[7] See U.S. EPA "Understanding Global Warming Potentials," available at https://www.epa.gov/ghgemissions/understanding-global-warming-potentials.

[8] The U.S. Department of Energy provides information about RNG, biogas and conventional natural gas production through its Alternative Fuels Data Center, available at https://afdc.energy.gov/fuels/natural_gas_renewable.html.

[9] The American Biogas Council provides information about the process involved in upgrading biogas to biomethane/RNG at https://americanbiogascouncil.org/resources/how-to-make-rng-biomethane/

[10] The University intervened in a 2016 docket before the NC Utilities Commission to determine the standards "alternative gas" must meet to be injected into Piedmont Natural Gas's local distribution network. The University took this step because the injection standards involve questions concerning the treatment of alternative gas or RNG by regulated local distribution company, which could affect the cost of the RNG and the timing of its availability. See North Carolina Utilities Commission (NCUC), Docket G-9 Sub 698, Application of Piedmont Natural Gas Co., Inc. for Approval of Appendix F to its North Carolina Service Regulations. The NCUC issued its approval of Appendix F and established a pilot program for alternative gas/RNG injection on June 19, 2018. See NCUC, Order Approving Appendix F and Establishing Pilot Program, available at https://starw1.ncuc.net/NCUC/PSC/PSCDocumentDetailsPageNCUC.aspx?DocumentId=41b1c3db-a22e-4e3f-9744-0b8a335d5399&Class=Order.

Entities that handle organic waste, like sewage treatment plants, landfills, livestock operations and farms, can take advantage of the biogas their waste creates, using it to generate power, thereby reducing fuel costs and avoiding carbon emissions. A good example of these multiple benefits at work can be found at the Loyd Ray Farms, where Duke University partnered with Duke Energy and a Yadkin County swine farmer to build the first swine waste-to-energy system in the state to produce electricity from biogas and generate carbon offsets. The electricity generated by the microturbine at Loyd Ray Farms powers pollution control equipment additional to the anaerobic digester, making it possible for the farm to significantly reduce ammonia, nutrients, pathogens and odors (plus prevent wastewater discharge to surface and groundwater). The electricity generated is counted by Duke Energy as renewable energy certificates (RECs) pursuant to the North Carolina Renewable Energy and Energy Efficiency Standard (NC REPS)[11] swine waste mandate, while the methane emissions the project avoids are certified to the Climate Action Reserve's Livestock Project Protocol, providing carbon offsets for the University.

Biogas and Swine Waste Management in North Carolina

In North Carolina, swine waste is managed through lagoon and sprayfield systems, which allow constituents in the waste like ammonia and nutrients to be released to the atmosphere or taken up by crops planted on sprayfields, which the farmer manages in accordance with state-issued permits and a farm-specific nutrient management plan. Biogas projects involve capturing waste emissions – either via an anaerobic digester or a covered lagoon – which helps to reduce odors and pathogens and protects against releases of waste during heavy rain or catastrophic storm events. The productive use of biogas also can generate income for farmers which they in turn arguably can apply towards additional pollution control equipment and/or methods that, combined with the digester or covered lagoon, would constitute a comprehensive or innovative waste management system.

Such comprehensive waste management, however, has been elusive in North Carolina for nearly three decades, leaving some neighbors disproportionately affected by the more negative aspects of large-scale pork production, such as increased odors at property lines, release of pathogens, ammonia emissions, and heightened nutrient loading to fields and watersheds. Because the majority of farms are located in eastern North Carolina, which is one of the poorest regions of the state, the negative effects associated with waste management are often borne by those who live below the poverty line, who in turn are disproportionately made up of communities of color.

[11] Until 2012, utility compliance with the swine waste set-aside in the 2007 NC REPS could only be met through on-site electricity generation from swine waste. In 2012, the NCUC ruled that utilities could use "Directed Biogas" to comply with the NC REPS swine mandate. See NCUC, Order on Request for Declaratory Ruling, Mar. 21, 2012, available at https://starw1.ncuc.net/NCUC/ViewFile.aspx?Id=c932476f-064a-4a17-ad0b-ce46cab46200. The NC REPS established a requirement that utilities derive 0.2% of their total electricity from swine waste by 2018, making North Carolina the first and only state to require renewable electricity generation from animal waste. N.C. is the only state with a REPS that includes set-asides for electricity production from animal waste, including swine and poultry waste.

Issues around waste and its impacts are well documented in academic literature and, while the state and industry have made efforts to find and implement improvements, very few farms have systems in place that meet the full environmental performance standards.[12] Duke University's position has been that efforts to control GHG emissions from animal manure could bridge to and accelerate broad scale implementation of the environmental performance standards, while immediately helping to address odors and pathogens. To prove this potential, the University incorporated biogas control and power generation as part of a larger comprehensive waste management system that meets all of the performance standards at the Loyd Ray Farms project.

Thanks in part to the University's efforts to test a full-scale waste-to-energy system and create a roadmap for development of the state's swine waste-derived biogas, the pork industry is expected to embark soon on a major biogas development effort while compliance with the swine waste-to-energy requirement of the NC Renewable Energy and Energy Efficiency Portfolio Standard (NC REPS) appears finally to be within reach

Next Steps on Biogas and RNG

Duke University's evolution from carbon offset procurer to direct RNG user stems in large part to changes in economics, technology, and policies around the capture and use of biogas in N.C. In addition, increasingly lucrative incentives for renewable compressed natural gas and liquified natural gas replacements for fossil-derived transportation fuels are accelerating RNG project development.[13] The University's investment in Loyd Ray Farms, and subsequent analysis of the energy production capability of biogas based on the experience gained from the project, have helped not only to create an RNG market in NC but also opened the door for the University to run parts of its campus on RNG. As the University gains access to RNG supplies, it will continue to do its part to make RNG available to all North Carolinians.

In addition to shifting focus from carbon offsets to RNG, Duke University is also anticipating a pivot toward other biogas sources beyond swine waste. It is intentionally seeking to expand the sources from which it obtains RNG so that it can use its demand signal to catalyze alternative supplies that receive less consideration as a source of RNG. Sources being considered include food processing plants, co-digestion of poultry litter, landfill-derived biogas, biogas from wastewater treatment plants, crop residues, and dairy operations.[14] In all cases and opportunities, the University will continue its commitment to considering the broader impact of every biogas and RNG purchase.

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[12] The environmental performance standards include the elimination of discharge of animal waste to surface and groundwater, substantial elimination of atmospheric ammonia emissions, substantial elimination of odors beyond property boundaries, substantial elimination of pathogens and substantial elimination of nutrient and heavy metal contamination. See N.C.G.S. § 143-215.10I (Performance standards for animal waste management systems that serve swine farms; lagoon and sprayfield systems prohibited.), available at https://www.ncleg.net/EnactedLegislation/Statutes/pdf/BySection/Chapter_143/GS_143-215.10I.pdf.

[13] An example includes the federal Renewable Fuel Standard Program (RFS). For information about the RFS, see U.S. EPA, Federal RFS, available at https://www.epa.gov/renewable-fuel-standard-program.

[14] For more examples of biogas sources, see USDA's Biogas Opportunities Roadmap available at https://www.usda.gov/oce/reports/energy/Biogas_Opportunities_Roadmap_8-1-14.pdf; see also U.S. DOE's Alternative Fuels Data Center, available at https://afdc.energy.gov/fuels/natural_gas_renewable.html; National Renewable Energy Laboratory (NREL) Biogas Potential in the United States, available at https://www.nrel.gov/docs/fy14osti/60178.pdf.

2019 CAP Energy Recommendations

Objective 1: Maximize opportunities for building energy efficiency and low carbon new construction (demand-side initiatives).

- Continue to invest in the energy efficiency of pre-CAP existing campus buildings with strategies such as HVAC optimization through building retro-commissioning, building analytics upgrades, and efficient technology such as LED lighting retrofits with a goal of 20% reduction by 2024.
- Continue to pursue Energy Use Intensity (EUI) targets for new construction and finalize the Duke Sustainable Building Framework. Consider opportunities to better track and monetize the carbon impacts of new construction to inform future campus planning.
- Further develop initiatives to educate schools, departments and individuals on campus about their energy use and opportunities for conservation.

Objective 2: Expand campus utility infrastructure to meet energy needs in the most economically and carbon efficient way (supply-side initiatives).

- Continue district hot water conversion in buildings that do not require high temperature steam. Utilize solar thermal technology where feasible in conjunction with new campus hot water plants.
- Continue to improve plant efficiency by tactics such as East-West steam line retirement and chilled water efficiency through technologies like thermal energy storage.
- Install heat recovery chillers in the renovation of East Campus dorms to include AC.
- Implement additional on-campus solar systems to meet 4MW goal.

Objective 3: Leverage off-campus initiatives for high-impact renewable energy.

- Support and foster the development of a renewable biogas and RNG market in N.C. that reduces reliance on fossil fuels at Duke University and provides opportunities for positive community, environmental, economic, and policy outcomes in the state.
- Continue to advocate for regulatory and policy changes in N.C. that would allow Duke University greater freedom over campus energy options. Seek collaborations with other similarly situated institutions to further amplify efforts.
- Monitor N.C. Utility Commission rulemaking for the Green Source Advantage program (HB589) that could allow Duke University to pursue off-campus, utility-scale solar. When available, maximize the University's off-campus solar power purchase to the total amount allowed by law.

If Duke University implemented the recommendations and specific strategies above to reduce energy-related greenhouse gas emissions, it is projected that overall energy emissions could be approximately negative 20,000 MTCO2e in 2024 (see Figures 14 and 15 below). This includes the offsets generated by destroying methane when burning biogas as a renewable fuel.

Figure 14: Potential energy emission reductions through 2024

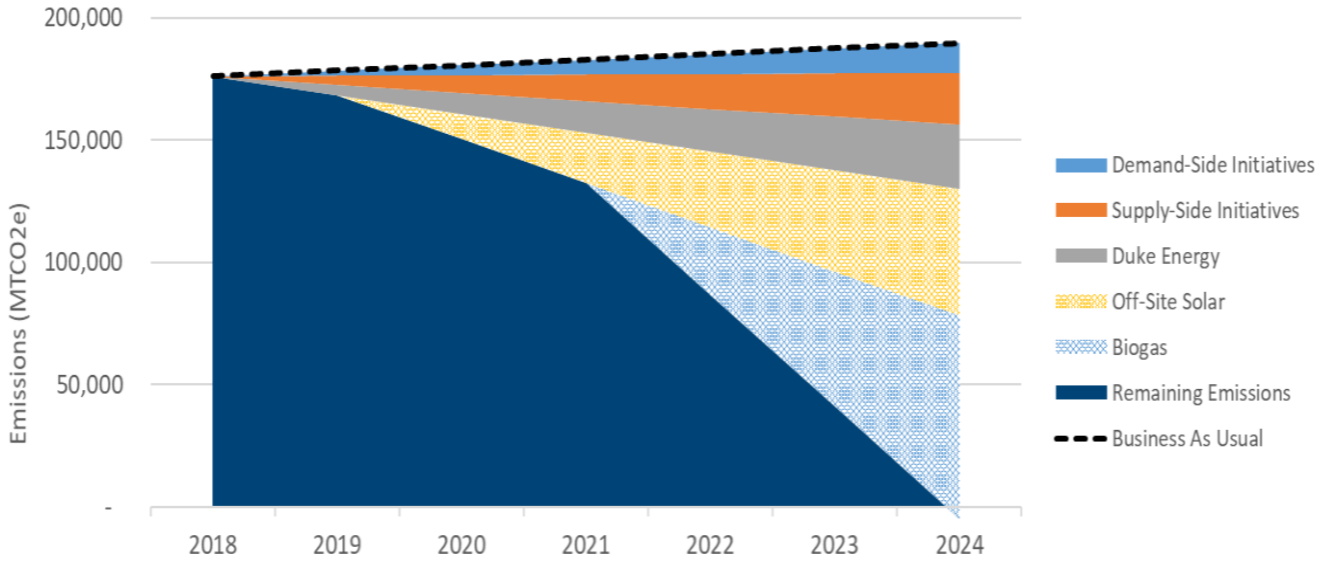


Figure 15: 2019 CAP Energy Carbon Reduction Plan

Timing	Buildings / Demand-Side Initiatives	Reduction by 2024 (MTCO2e)	Comments
2019 and on	HVAC Optimization	5,700 - 7,000	500K GSF/yr of bldg HVAC recommisioning
2019 - 2022	LED Lighting	3,300 - 4,000	31 university buildings totaling 2.9M GSF
Ongoing	New Construction Efficiency	2,000 - 2,400	Improvements from 2009 CAP BAU
	Buildings / Demand-Side Total	**11,000 - 13,400**	**6-7% of energy emissions**

	District Energy / Supply-Side Initiatives	Reduction by 2024 (MTCO2e)	Comments
2013 - 2024	District Hot Water Conversion	7,200 - 8,800	Continued conversions of buildings
TBD	CHW Thermal Storage	TBD	
2022 - 2024	Cogeneration	TBD	Timing, size, operation, & fuel TBD
2019-2024	Solar PV	1,800 - 2,200	Up to 4MW total on-campus installations
2021 - 2023	Solar Hot Water	1,100 - 1,400	Installations at new hot water plants
2022 - 2023	EC Heat Recovery Chillers	2,700 - 3,300	Assumes renovated dorms on East Campus
2019 - 2020	Central Campus bldgs removal	1,100 - 1,400	BOT Task Force determining future use
TBD	Gas Boiler additions	TBD	
2022 - 2023	East-West steam line retirement	1,400 - 1,800	Accounts for 5-7% of all system losses
2020 - 2022	CHW Efficiency Improvements	3,900 - 4,700	Thermal Energy Storage & other actions
	District Energy / Supply-Side Total	**19,200 - 23,600**	**10-12% of energy emissions**

	Demand + Supply-Side Initiatives	Reduction by 2024 (MTCO2e)	Comments
	On Campus Total	**30,200 - 37,000**	Approximately 19% of current inventory

	Off Campus Actions	Reduction by 2024 (MTCO2e)	Comments
Ongoing	Duke Energy GHG reductions	23,400 - 28,600	Based on Duke Energy's estimates
2020 and on	Utility scale solar PPA	46,800 - 57,200	Max. allowable under HB 589 of 104MW
2021 and on	Biogas supply	80,000 - 86,000	153K - 187K DTs of animal waste biogas
	Off Campus Total	**150,200 - 171,800**	**86-102% of energy emissions**

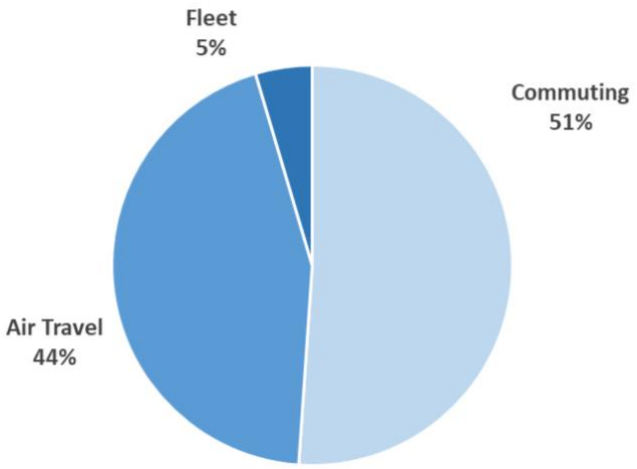
	All Initiatives and Actions	Reduction by 2024 (MTCO2e)	Comments
	Total Est. GHG Emission Reductions	**180,400 - 208,800**	
	2024 Est. Energy GHG Emissions	**187,100 - 192,700**	Low growth at 1%, high growth at 1.5%
	FY 2018 Energy GHG Emissions	**176,300**	

Transportation

Overview

Transportation is central to the function of Duke University, whether it is the nearly 700 Duke-owned vehicles that travel around campus each day, the commuting of tens of thousands of employees to and from work, or flights to conferences, research sites, and athletic events. Each of these activities has an emissions impact that is included in Duke's climate action goal of climate neutrality by 2024. As of fiscal year 2018, transportation-related activities account for nearly 79,000 metric tons or 31% of Duke's overall emissions. When considering only transportation related emissions (31% of Duke's total emissions), commuting and air travel contribute the most to emissions. (shown in figure 16 below).

Figure 16: Emissions Breakdown from Transportation-related activities (2018)

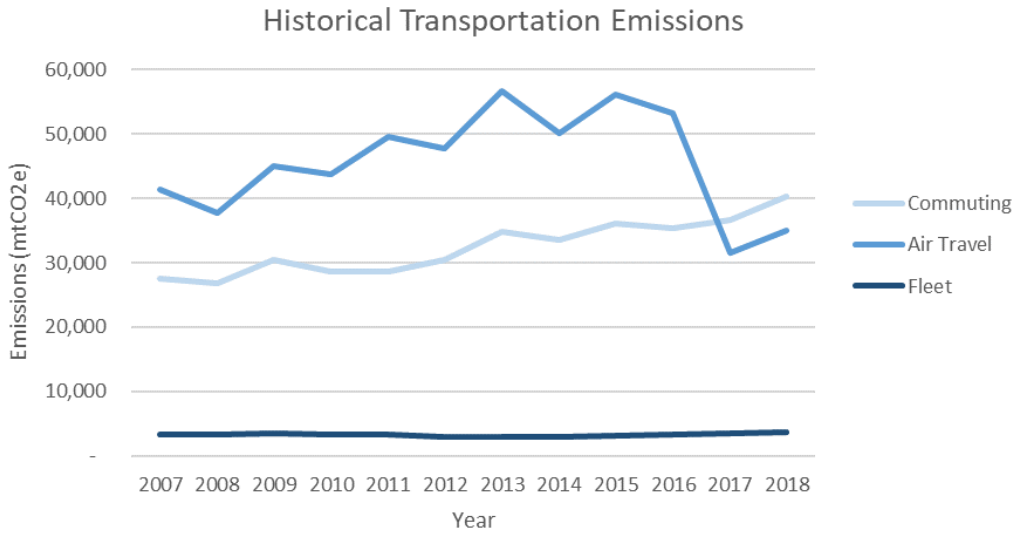


During the last decade, Duke has made many efforts to reduce transportation emissions, including the hiring of two transportation demand management employees, advocacy for regional alternative transit options, and development of employee-based programs for carpooling, biking, and regional bus transit. However, due to the personal nature of commuting and air travel decision-making, it has been difficult to reduce emissions. Despite the efforts above to impact emissions from transportation-related activities, emissions have increased by 9% compared to the 2007 baseline.

Figure 17 below shows that emissions from employee commuting have increased by 46%, Duke-owned vehicle emissions increased by 8%, and emissions from air travel have decreased by 15%[15] compared to a 2007 baseline.

[15] In 2017, Duke University updated the emission factor for air travel as it was updated by the University of New Hampshire's Campus Carbon Calculator. The emission factor went from .00077 MTCO2e/passenger mile to .00048 MTCO2e/passenger mile to reflect improved airplane fuel efficiency over the past decade.

Figure 17: Historical transportation emissions per emission category



During the same time frame, the number of employees working for the University, School of Medicine, and School of Nursing has increased by 14%, employees are living 3 miles farther away on average (compared to 2007), the number of students has increased by 17%, and vehicles and aircraft have become more fuel efficient. However, the emission increases seen from population growth and distance travelled are outpacing these fuel efficiency improvements.

The following sections highlight the progress towards the 2009 CAP recommendations and outline new recommendations from the Transportation subcommittee of Duke's Campus Sustainability Committee to further decrease campus transportation emissions. It is important to note that the purchase of carbon offsets for these harder to control emissions could be important in the near future. Based on research by the Duke Carbon Offsets Initiative, an average cost of a carbon offset is between $8-15 depending on the project type and environmental, economic, and social co-benefits associated with the project. Therefore, decisions regarding the financial investment in alternative transportation initiatives should also weigh the costs of offsetting these emissions in 2024 and beyond.

2009 CAP Transportation Recommendations Update

When Duke University first established its climate neutrality goal, approximately 21% of emissions came from transportation-related sources. This included emissions from employee commuting, air travel, and Duke-owned fleet vehicles. The 2009 Climate Action Plan set clear goals and recommendations to reduce this footprint, which are outlined below along with highlights of progress since 2009.

- *Duke should develop a comprehensive Transportation Demand Management program to incentivize alternative transportation use.*
    - A TDM department was created and staff were hired to carry out the program goals of increasing adoption of alternative commuting options.

- There are benefits for students and employees who live off campus and are a part of a carpool or vanpool permit. Some of these benefits include free or reduced parking, reduced fuel costs, and reducing their environmental impact. To learn more, visit Duke's Parking and Transportation's carpooling and vanpooling webpages.
- There are many amenities and benefits for students and employees who bike commute. Some of these benefits include free bike registration, two free daily parking passes per month, bike safety trainings, access to showers around campus, and discounts at local cyclist shops. To learn more, visit Duke's Parking and Transportation's bicycling website.
- Duke provides access to 15 vehicles through it carshare partnership with Enterprise. Students and employees can register for this program and learn how to rent the vehicles by visiting Duke's Parking and Transportation's carshare webpage.

- *Duke should study whether an affiliated housing program at Duke University would incentivize employees to live closer to campus.*
  - Duke realizes the importance of available housing close to campus and plans to assess the feasibility of developing additional on-campus or near-campus housing.

- *Duke should continue to engage in regional transportation discussions in support of viable, alternative commuting options for the Duke and Durham community.*
  - Duke Parking and Transportation is actively engaged with GoTriangle, local government organizations, and universities to discuss the future of commuting in the Triangle area.

- *Duke should create a better mechanism for tracking annual employee air travel emissions impact.*
  - Sustainable Duke has and continues to actively work with Duke's Employee and Travel Reimbursement department on solutions to more easily track air miles traveled by Duke University.
  - Sustainable Duke is engaging with peer universities to learn about and develop best practices for air travel data collection.

- *Duke should develop air travel emissions impact reports for departments based on actual use.*
  - Sustainable Duke is piloting air travel impact reports with departments in 2019 starting with the Nicholas School of the Environment.

- *Duke should market and increase use of technology that enables virtual meeting to replace air travel needs.*
  - Duke University provides access to virtual meeting technologies like Jabber and Cisco IP Communicator, as well as VPN services. This in tandem with other existing conference calling services makes it easier for students and employees to connect with others.

- *Duke should establish a "Green Policy" for fleet replacement to ensure that purchased vehicles are efficiency and appropriately sized.*
  - Sustainable Duke over the past decade has worked with key departments (Parking and Transportation, Facilities, and Duke Police) on campus to explore alternative options for more sustainable transportation.

- Sustainable Duke is serving as a client for a master's project at the Nicholas School during the 2019-2020 academic year. This project will investigate current and near-future available hybrid or electric vehicles for the university fleet and potentially employee-owned vehicles.

- *Duke should replace 10 diesel-fueled buses with 60-foot articulating, hybrid buses.*
  - Duke University's Parking and Transportation department has replaced many buses with articulating, hybrid buses. Now, Duke has purchased two fully electric buses with plans to continue replacing aging buses with electric buses.
  - Since 2012, Duke's Parking and Transportation department has reduced the average age of its bus fleet by 33% and increased the average fuel efficiency of its bus fleet by 25%.

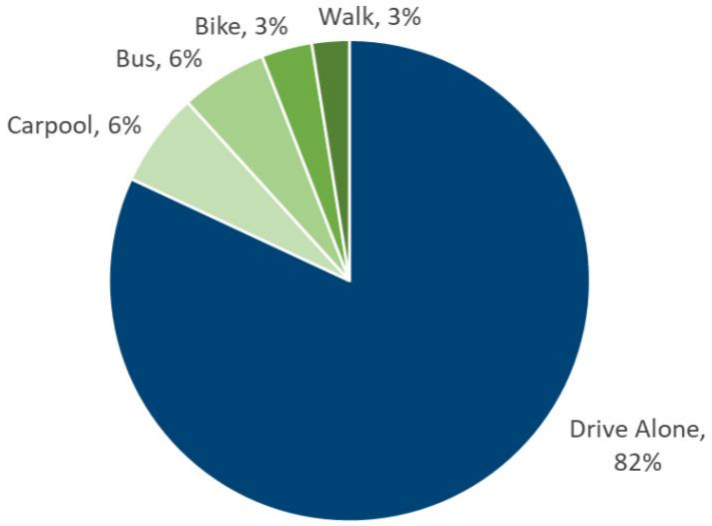
- *Duke should encourage the utilization of local/regional bus transit through transit pass subsidy, advocating for improved local transit service and eliminating redundant services.*
  - Duke provides a subsidized GoPass to students and employees, which allows them to ride the GoDurham, GoRaleigh, and GoTriangle buses. The GoPass is free for students and $25/year for employees. The average annual use is 450,000 rides via GoPass users. To learn more, visit Duke's Parking and Transportation's GoPass webpage.
  - Duke has worked closely with regional bus transit providers to improve services to campus and the health system.

2019 CAP Transportation Recommendations

Objective 1: Reduce emissions from daily employee commuting.[16]

In fiscal year 2018, Duke University's employee commuting contributed over 40,000 metrics tons of carbon dioxide equivalent, which is 16% of Duke's total emissions included in the annual inventory. According to the annual transportation survey, a majority of this is the result of more than 80% of university employees driving alone to work (see figure 18 below for complete mode share breakdown). However, over the last 10 years, the average drive alone rate has been 74%, which shows that 2018 may be an atypical year.

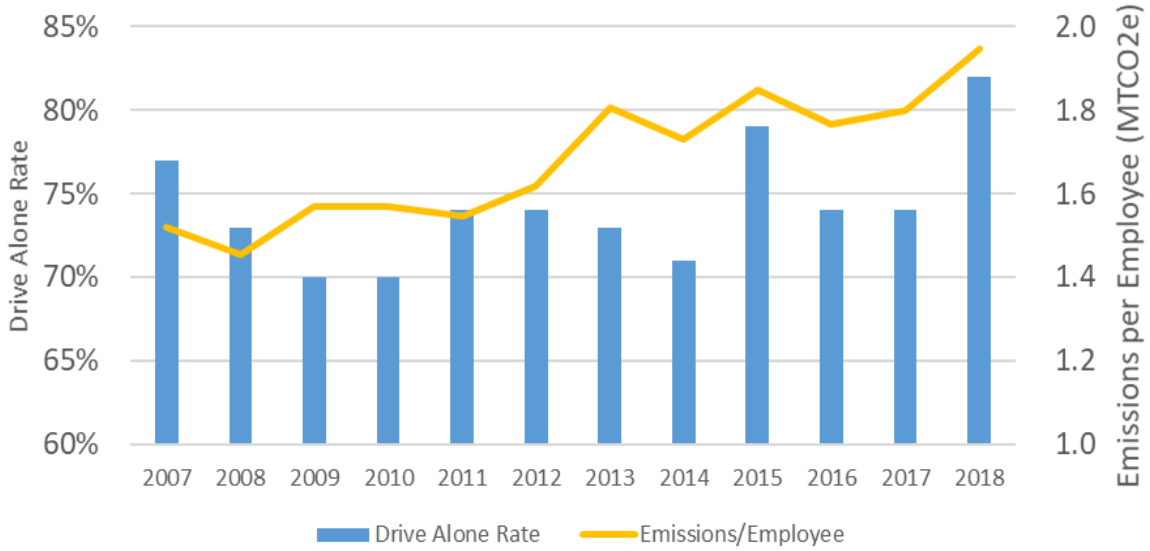
Figure 18: Duke University's employee commuting mode share (2018)



Duke has developed a variety of programs, which encourage the use of alternative transportation such as carpooling or walking. These programs include improvements in carpooling and vanpooling options, provision of subsidized transit options, and increases in the cost of parking on campus. Despite these programs, drive alone rate and commuting emissions per employee have increased over time as shown in Figure 19 below.

[16] Per Duke University's Climate Action Plan, only emissions from University employee commuting are included in the annual greenhouse gas (GHG) inventory. Therefore, emissions from student and Duke University Health System (DUHS) employee commuting are not included. However, recommendations that improve employee commuting options are also likely to convey to students and DUHS employees.

Figure 19: Duke's drive-alone rate compared to commuting emissions per employee



This increase is partly due to external factors that Duke does not have direct control over including employees moving farther away from campus, fluctuations in gas prices, need for flexibility when commuting, and regional transit planning. To try and reverse this trend of emission increases, the Transportation subcommittee and other campus stakeholders developed the broad recommendations below that could lead to a reduction in drive alone rates over the next decade.

- Enhance public transit access
    - Continue to advocate for local transit options that meet the needs of the university and its students and employees.
    - Develop targeted marketing of local bus transit routes and programs for employees.
    - Continue the subsidized Go-Pass program for Duke employees and students.
- Carpooling and Vanpooling
    - Develop targeted marketing and incentives for Duke's carpooling and vanpooling programs to employees who live in dense clusters.
    - Develop department-specific marketing campaigns and potential incentives to promote carpooling and vanpooling programs.
    - Expand marketing or potential incentives for https://www.sharetheridenc.org trip planning platform to employees.
- Biking and Walking
    - Adopt and implement a policy that considers infrastructure for cyclists and pedestrians during new construction and large building renovation projects.
    - Improve access to various bicycling/walking amenities on campus including increased safety lighting, showers and locker facilities, bike racks, and short-term bike storage for returning students.
    - Advocate for increased presence of sidewalks and bike lanes in high traffic areas off/near campus.
    - Develop targeted marketing on the benefits of biking and walking to employees who live 0-3 miles from campus.

- Other Recommendations
    - Create a Transportation Infrastructure, Accessibility, and Sustainability Fund where a portion of student and employee parking fees go towards development of alternative transportation programs on-campus and carbon offsets.
    - Develop additional flexible parking options, including monthly or semester-long parking passes and a parking cash-out program.
    - Develop an employee-based benefits program for the purchase of electric vehicles, which could include partnering with local dealerships to provide PERQs-related discounts, provide competitive financing options through Duke Federal Credit Union for electric vehicles, and consider subsidized/free parking for EVs.
    - Expand support and emphasis on telecommuting and flexible work schedules.
    - Consider a month-long opportunity for current employees to try alternative commuting with a subsidized parking pass incentive.
    - Develop a network of current alternative commuters, which could serve as ambassadors to employees willing to try alternative options.
    - Consider developing affordable, Duke-affiliated housing on/near campus for staff, faculty and graduate students.
    - Conduct behavioral psychology research to understand what incentives/disincentives would be more effective to increase the use of alternative transportation.

Objective 2: Reduce emissions from Duke-owned vehicles

Duke University owns and operates a fleet of 915 vehicles which range from 24 buses that transport people around campus to 210 trucks, 155 vans, and 95 cars used by Duke Facilities Management Department, Duke Parking and Transportation, and Duke Police. Duke has opportunities to reduce the impact of campus fleet by purchasing vehicles that are more efficient or utilize alternative fuels such as electricity. Some progress has already been made on this evolution of fleet vehicles. Duke has replaced several buses with hybrid models and is in the process of acquiring two fully electric buses in 2020.

In fiscal year 2018, Duke University's fleet contributed 3,600 metrics tons of carbon dioxide equivalent, which is 1% of Duke's total emissions included in the annual inventory. Below are recommendations to reduce emissions from Duke-owned vehicles.

- Assess ridership on all Duke bus routes to reduce redundancy and improve access.
- Conduct a study that compares current fleet to hybrid and electric for entire Duke fleet.
- Continue to replace existing Duke-owned buses with electric buses, as needed.
- Implement a Green Fleet purchasing program, which sets a target for fuel efficiency and develops a list of hybrid or electric options for purchase through approved vendors.
- Create a form to be filled out prior to the purchase of a new vehicle, which clarifies whether a vehicle is actually needed and the possibility of purchasing a smaller, more efficient or alternatively fueled vehicle.

Objective 3: Reduce emissions from university-sponsored air travel

Duke University includes emissions from domestic and international air travel that is paid for or sponsored by the university. This includes travel from Duke Athletics, travel to conferences and research sites, and flights through DukeEngage. In fiscal year 2018, Duke University's air travel contributed 35,000 metrics tons of carbon dioxide equivalent, which is 14% of Duke's total emissions included in the annual inventory. Over the past ten years, aircraft have become much more fuel efficient leading to an overall emissions reduction of 15% compared to 2007. However, the number of passenger-miles flown by Duke has increased nearly 20 million miles (a 36% increase from 2007).

In addition to the leadership by airlines to be more fuel efficient, there are potential future programs that will also curb emissions from airlines. The International Civil Aviation Organization (ICAO) will begin piloting its Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) program in 2021. The goal of CORSIA is to ensure carbon neutral growth in 2020 and beyond by offsetting emissions above the baseline (average of CO2 emissions between 2019 and 2020). CORSIA will offset CO2 emissions from international travel from countries that have volunteered to participate. This list of 79 countries, which represents 75% of international air travel activity, includes the United States. At Duke University, international travel accounted for 35% of all university-sponsored air travel in 2018, which has an estimated emissions impact of 12,250 MTCO2e. Assuming growth in international air travel at Duke University, there could be some CO2 emissions that are offset by airlines. Duke University will continue to track the developments of this over the next few years.

Reducing the impact of air travel can be difficult since travelling is central to faculty research, study abroad, and sharing of information at conferences, which are all important and necessary university functions. However, below are recommendations to make travel as efficient as possible.

- Streamline data collection on air miles traveled to estimate emissions impact.
- Share departmental reports that outline cost and emissions impact of air travel.
- Develop a preferred airline carrier list based on sustainability metrics including options to purchase carbon offsets and use of biofuels in aircrafts.
- Consider options for distributing the cost of travel offsets to departments based on use.
- Create marketing about time and cost of air travel to destinations and compare alternatives (carpooling, train, bus, and teleconferencing).
- Encourage the consolidation of multiple meetings during a single trip by aircraft.
- Encourage the use of teleconferencing for meetings in other states or countries, particularly meetings that occur regularly.
- Follow the developments of International Civil Aviation Organization's CORISA Program to reduce emissions from international travel

Summary of 2019 CAP Transportation Recommendations

Overall emissions from transportation-related activities have risen by 9% compared to Duke's 2007 emissions baseline. Total transportation emissions were 79,000 MTCO2e in fiscal year 2018 (July 1, 2017 - June 30, 2018). Employee commuting accounted for 51%, air travel accounted for 44%, and fleet accounted for 5% of total transportation-related emissions at Duke.

Recommendations to reduce these emissions are summarized below and are sorted based on estimated financial and internal emission reduction impact (see figures 20, 21, and 22). The cost and impact estimates do not fully encompass all potential costs and benefits of each recommendation. The financial impact only considers costs and savings to Duke University and not costs or savings to individual employees. The emission reduction impact only considers emissions that are included in Duke's greenhouse gas inventory and therefore do not include all other benefits that could be associated. Note that recommendations in **bold** could be implemented in the immediate or near-term.

Figure 20: Employee commuting recommendations

Low Cost and Lower Impact	Low Cost and Higher Impact
● **Develop a Transportation Infrastructure, Accessibility, and Sustainability Fund to go towards development of alternative commuting options and offsets** ● **Advocate for increased presence of sidewalks and bike lanes in high traffic areas on/near campus.** ● **Expand marketing of ShareTheRideNC trip planning platform** ● **Develop a network of current alternative commuters, which could serve as ambassadors to employees willing to try alternative options.** ● **Continue subsidy of GoPass program for Duke employees and students**	● **Continue to advocate for local transit options that meet the needs of the university and its students and employees** ● **Develop targeted marketing about alternative commuting for employees** ● Develop additional flexible parking options including monthly- or semester-long parking passes ● Develop employee-based benefits program for electric vehicle purchase ● **Support and expand telecommuting and flexible schedule options** ● **Consider a month-long opportunity for current employees to try alternative commuting with a subsidized parking pass incentive.**

High Cost and Lower Impact	High Cost and Higher Impact
● Adoption and implementation of policy for cyclist and pedestrian infrastructure for new construction and major renovations ● Improve access to EV charging stations on campus ● Improve access to various cycling/walking amenities on campus	● Develop a parking cash out program which benefits employees who choose to use alternative commuting ● Develop affordable, Duke-affiliated housing near campus for employees

Figure 21: Duke-owned fleet recommendations

Low Cost and Lower Impact	Low Cost and Higher Impact
● **Assess ridership on all Duke bus routes to reduce redundancy and improve access** ● **Update the new vehicle purchasing form to include questions regarding need, necessary size, efficiency of proposed options, and fuel type**	● **Conduct a study that compares conventional fuel to electric for the entire Duke fleet** ● Implement a Green Fleet purchasing program that sets a target fuel efficiency per vehicle type
High Cost and Lower Impact	**High Cost and Higher Impact**
	● **Electrification of buses as replacements are required**

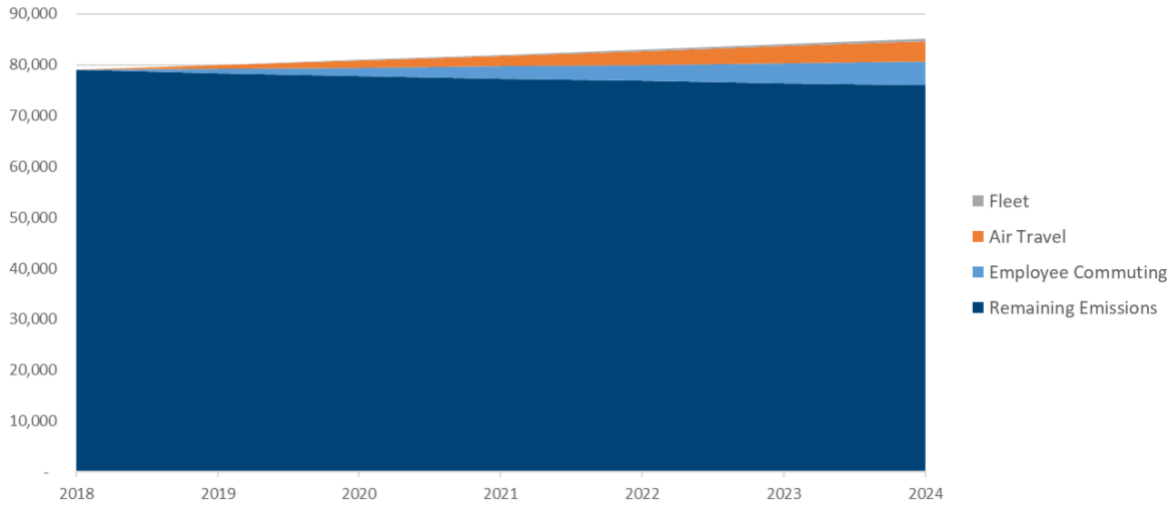
Figure 22: Air travel recommendations

Low Cost and Lower Impact	Low Cost and Higher Impact
● **Streamline data collection on air miles traveled to accurately estimate impact** ● **Develop a listing that ranks airline carriers based on sustainability metrics** ● **Create marketing about time and cost of air travel compared to alternatives like carpooling, train, bus, and teleconferencing)**	● **Share departmental reports that outline cost and emissions impact of air travel** ● Consider options for distributing cost of carbon offsets for air travel emissions to departments based on use ● **Follow the development of the International Civil Aviation Organization's CORSIA program**

Using conservative estimates, the recommendations in the previous sections have the potential to reduce transportation-related emissions by at least 2% annually. These emissions are also connected to employee growth and trends of living further way from campus, which lead to an overall increase in emissions assuming all other variables are held constant. However, depending on level of investment and adoption rates of these recommendations, the impact on emissions could be greater than 2%. For example, if many employees over the next decade plan to purchase a new vehicle and Duke provides incentives to choose an electric vehicle, emissions from employee commuting could decrease much more than 2% per year.

Figure 23 below shows that by 2024, an emissions reduction of 4% could conservatively be anticipated.

Figure 23: Potential transportation emission reductions through 2024



Carbon Offsets

Overview

Despite Duke University's aggressive approach to reducing emissions on campus, the University expects that there will still be emissions in 2024 that need to be offset to get to the goal of zero. With this need in mind, the Offsets subcommittee made recommendations to the CSC on ways to mitigate emissions remaining after on-campus reduction strategies have been implemented. Based on these recommendations, the Duke Carbon Offsets Initiative (DCOI) was created in 2009. Since creation, the DCOI has developed an innovative swine-waste-to-energy project, a residential energy-efficiency program, several urban forestry projects, and is in the process of developing a wetland restoration project. It has also purchased carbon credits from domestic projects, as well as projects in Guinea Bissau and Mexico.

The DCOI, with guidance from the Offsets subcommittee of the Campus Sustainability Committee, has also developed a strategy for decision-making surrounding offset purchase and project development. The strategy highlights the following key objectives that are central to any carbon offset used by the University:

- Prioritize local and regional offsets that provide significant environmental, economic, and societal co-benefits beyond the benefits of greenhouse gas reduction
- Implement the strategy in a way that provides educational opportunities for students and faculty
- Facilitate and catalyze high-integrity, unique offset projects by serving as a resource for other institutions

Background on Carbon Offsets and Co-Benefits

Carbon offsets are a mechanism for reducing atmospheric greenhouse gas emission levels globally by incentivizing activities, technologies, and behaviors that will either prevent additional GHGs from entering the atmosphere, or remove GHGs currently in the atmosphere. A carbon offset is a commodity traded globally in both compliance and voluntary carbon markets (Duke operates within the voluntary market) that represents one ton of carbon dioxide or equivalent greenhouse gases. One carbon offset equals one ton of GHG emissions reduced that would not have occurred in the absence of the carbon offset project that enabled that reduction. Carbon offset projects must be completed according to a legitimate protocol or methodology. These documents are typically housed on greenhouse gas program registries (such as the American Carbon Registry, Climate Action Reserve, and Verified Carbon Standard), and are used to determine what activities can result in the generation of carbon offset credits, and how those activities should be carried out.

In addition to the emissions reduction aspect of a carbon offset, Duke also considers the co-benefits that are associated with a carbon offset project. Common co-benefits include financial savings, job creation, improved air quality, increased animal habitat, reduced human health risks, creation of educational value for students, and development of beneficial partnerships.

For more information on the criteria the Duke Carbon Offsets Initiative analyzes when performing due diligence on carbon projects and determining what projects to develop and support, please read the Offsets and Co-benefits Guide.

2009 CAP Carbon Offsets Recommendations Update

When Duke University first established its climate neutrality goal and developed its Climate Action Plan, it was known that carbon offsets would play a role in helping Duke meet its goal by 2024. The 2009 Climate Action Plan set clear goals and recommendations to reduce this footprint, which are outlined below along with highlights of progress since 2009.

- *Duke should establish a Carbon Offsets Initiative that will investigate the potential to develop an aggregating entity that could generate high quality, local offsets to meet Duke's and other university's neutrality goals*
    - The Duke Carbon Offsets Initiative (DCOI) was created in 2009 by the Office of the Executive Vice President of Duke University. The DCOI was the first office of its kind at a higher education institution in the U.S. and still is one of the only offices that does carbon offset-specific work.
- *Duke should balance fiscal risks and offset goals through a portfolio approach that considers potential compliance obligations under federal cap-and-trade or tax legislation; credibility and measurability of projects; cost of projects; community and environmental co-benefits; links to education, research, and service; and mitigation of risk through a diversity of project types, suppliers, and locations.*
    - As mentioned above, the DCOI has developed a variety of carbon offset projects. It also has purchased carbon offsets from energy efficiency projects, destruction of ozone depleting substances, land and forest conservation, and clean cookstoves. All projects have a variety of environmental, economic, and societal co-benefits and have provided many academic opportunities for students.
    - The DCOI has supervised over a dozen student-based interdisciplinary projects, served as a client for multiple semester-long courses, and has managed dozens of student interns. Some project highlights include an 2018-2019 masters project which examined the use of land conservation to avoid deforestation as a carbon offset project type and a Bass Connections project that created a website (solveanimalwaste.com) that connects meat consumers, producers, and advocates to information on animal waste management best practices.
- *Duke University's offset portfolio should leverage its resources by catalyzing local and regional offset opportunities, capitalizing on existing research from the Duke community, maintaining an active role in project development, and engaging the full range of institutions and schools within its campus.*
    - Students have been central to the development of carbon offset projects. Below are examples of how students have collaborated with the DCOI to research new carbon offset programs.
        - Student research assistants have co-authored, and subsequently updated, the DCOI Urban Forestry Protocol that seeks to provide support to city

governments promoting urban forest canopy cover goals through carbon financing (view Urban Forestry protocol).

- Students engage with the carbon offset process by acting as carbon offset peer verifiers, guided by faculty or staff, in performing the assessment of a peer institutions' carbon offset project. This assessment is facilitated by OffsetNetwork.org and directly results in the determination of project impact and carbon credit generation – credits that will be applied to that peer institution's Carbon Commitment (formerly ACUPCC) goals through Second Nature or emissions reduction targets through AASHE Stars.
- The DCOI has served as a client for over a dozen master's projects or Bass Connections projects over the past decade. Examples are below.
    - Analysis of the Potential for Using Forest Management to Achieve Emission Reductions at Duke Forest (2010-2011)
    - An Analysis of Renewable Energy, Energy Efficiency, and Carbon Offsets at Duke University (2014-2015)
    - Distributed Solar Generation for Duke University Employees (2014-2015)
    - Marketing Home Energy Efficiency: Benefits and Barriers to Adopting a Home Energy Efficiency Program (2015-2016)
    - Animal Waste Management and Global Health (2016-2017)

- In addition to the progress outlined above, the DCOI has worked with Duke faculty to develop and purchase offsets based on their areas of research. Below are some recent examples.
    - Swine Waste to Energy with Dr. Marc Deshusses
    - Peatland restoration with Dr. Curtis Richardson
    - Sustainable Forestry with Dr. Elizabeth Shapiro-Garza

- *Duke University's near term strategy should catalyze pilot offset projects and accelerate preliminary research in NC in at least the following categories: swine waste-to-energy, forest management and afforestation, and energy efficiency.*
    - The DCOI has developed projects and conducted research in each of these areas over the past decade.
        - Swine waste-to-energy: The DCOI in partnership with Loyd Ray Farms, Duke Energy, Google, and Cavanaugh Solutions developed a swine waste-to-energy project in Yadkinville, NC. This project digests the waste in an anaerobic digester in order to generate methane, which is used to generate renewable electricity by fueling an on-site microturbine.
        - Forest Management and Afforestation: The DCOI has collaborated with local municipalities, companies, and other universities to generate carbon offsets from tree plantings in the urban environment. Through this collaboration, thousands of trees have been planted since the plantings began in 2016.
        - Energy Efficiency: Since 2012, the DCOI has pioneered pilot programs to help Duke employees reduce home energy use and increase renewable energy use through education, incentives, and discounts. Building on the experience gained through these pilot programs, the DCOI has charted the path to

scalable change by connecting Duke employees and other employers across North Carolina to Home Energy North Carolina (HENC) who will continue to present these educational workshops.

2019 CAP Carbon Offsets Recommendations

Objective 1: Purchase and develop local offsets that have significant environmental, economic, and social benefits

When evaluating the value of a carbon offsets project, it is important to assess it on a variety of elements external to the carbon emission reduction. These elements, more commonly known as co-benefits, are the additional environmental, economic, and social benefits that also result from a carbon offset project. The DCOI developed a guidance document on offsets and co-benefits, which assists students, staff, and faculty at Duke University as well as those at peer universities. Some recommendations for expanding these efforts are below:

- Conduct an inventory of local projects with high co-benefits and/or projects
- Employ a portfolio-based approach to selection of projects
- Identify ways to scale current projects to increase impact
- Re-engage with the Offsets Subcommittee to discuss prioritization of future projects

Objective 2: Provide educational opportunities through offset purchase and development

Since Duke University is a leading educational institution, developing or purchasing carbon offsets should incorporate students throughout the process. Through collaboration with students and faculty at Duke University and other peer institutions, the DCOI has developed unique projects, drafted new carbon offset protocols, and purchased offsets from impactful projects. To continue building on past successes, DCOI has identified the following recommendations:

- Continue to build relationships with Duke resources for new project research and development like the Duke Marine Lab, Nicholas School of the Environment MEM Master's Projects and Bass Connections.
- Investigate carbon offset projects that could connect students with Duke study abroad sites
- Continue to offer DCOI as a client for student projects, from single class projects to capstone and masters projects

Objective 3: Serve as a partner for peer universities to expand offset opportunities

Serving as a resource to other institutions has always been a fundamental part of the DCOI's mission. Because it is the only office in higher education focusing solely on carbon offsets, the DCOI has gained experience and knowledge that other universities may be able to use when developing their own offsets strategies. Recommendations for DCOI to continue and expand in this capacity are:

- Continue to expand the Offset Network to include new project types that universities can engage in
- Leverage Duke University resources to conduct peer verification of other universities' carbon offset projects

Education

Overview

By its signature on the American College and University Presidents' Climate Commitment, and through the University Climate Action Plan, Duke has committed to take actions that will make "climate neutrality and sustainability a part of the education and other curricular experience of all students." Sustainability is defined as meeting the needs of the present without compromising the ability of future generations to meet their needs. This must be achieved in a manner that is ecologically sound, socially just, and economically viable.

To this end the Education subcommittee of Duke's Campus Sustainability Committee has defined sustainability literacy as the following: To achieve sustainability literacy, a student should:

- Know about the interconnections and interdependency of ecological, social, and economic systems. They should demonstrate understanding of how the health of these systems determines the sustainability of natural and human communities and cultures at local, regional, national, and global levels.
- Be engaged in inquiry and systems thinking and use information gained through learning experiences in, about, and for the environment to understand the structure, components, and processes of natural and human-built environment
- Be prepared to use the above knowledge and skills to apply them in the service of society in solving climate and environmental issues and to incorporate these principles in their professional and civic life.

2009 CAP Education Recommendations Update

Over the past decade, sustainability has been infused in Duke's academics through a variety of initiatives based on the recommendations put forth by the Campus Sustainability Committee in 2009. The 2009 Climate Action Plan summarized these recommendations, which are outlined below along with highlights of progress since 2009.

- *Duke should charge a campus committee to consider incorporating sustainability into the depth and breadth of the student experience.*
    - The Education Subcommittee of the Campus Sustainability Committee, with support from Sustainable Duke, helped to develop and implement numerous opportunities for all Duke students to engage with sustainability.
    - In 2012, Duke officially created the position of Faculty Director of Sustainability to continue expansion of academic sustainability efforts across campus.
    - The Trillium Sustainability Fellows program, modeled after the Piedmont Project at Emory University, provides an avenue for faculty to learn to infuse sustainability concepts into syllabi regardless of discipline. The Trillium Sustainability Workshop is offered annually to any faculty, staff, or students with current or future teaching responsibilities. To date, 180 faculty and staff across 17 institutions have become Trillium Fellows.

    - Building off of the Trillium Sustainability Fellows program, Sustainable Duke developed a pilot program that seeks to incorporate sustainability into existing or new coursework. This Trillium Student Research Initiative program provides students with a paid summer internship where they are matched with a faculty member who is interested in incorporating sustainability into their existing courses or a new course.
    - Sustainable Duke, in partnership with Duke's faculty director of sustainability, has piloted a Sustainability Literacy Test for students in select courses to gauge existing knowledge.
    - Sustainable Duke develops a list of all courses each semester that incorporate sustainability-related themes in the classroom so students can easily identify sustainable courses during course registration.
- *Duke should consider expanding programs to support students with a personal and professional interest in the environment and sustainability.*
    - In 2016, Duke University launched a new experiential Certificate in Sustainability Engagement for undergraduate students. This unique certificate provides students greater opportunities to use knowledge they gained in the classroom in real-world experiences. As of spring 2019, the program has almost a dozen students with two students who graduated in May 2018 and 4 planned for May 2019.
- *Duke should continue to foster new and existing research efforts in sustainability and climate change*
    - Campus as Lab (CAL) is a Sustainable Duke initiative that seeks to develop project ideas and solutions to global and local issues by using Duke University's campus and the local Triangle area as a living laboratory. A CAL project connects students, faculty, and staff together to explore new ideas, carry out experiments, and create solutions to sustainability issues by utilizing sites on campus such as the Duke Forest, the Duke Reclamation Pond, or the Student Wellness Center. All CAL projects are characterized by using data-driven analysis and diverse stakeholder engagement to develop effective recommendations.
- *Duke should continue to foster knowledge in service to society through creative partnerships in the local community.*
    - Duke has initiated a program called the Curriculum for the Triangle Bioregion (C4TB), where all academic institutions in the three-county area, which also geographically share the Piedmont Bioregion (EPA Ecoregion 3), work together to share and produce place-centered curricula and activities to anchor student learning in the geography and culture where they eat, work, and play. An inaugural workshop was held in September 2017, which engaged 19 attendees from 4 institutions from the Triangle.

2019 CAP Education Recommendations

With these current and ongoing initiatives, Duke has offered more than 2,000 courses from nearly 50 departments that are related to sustainability. In May 2018, 36% of students graduated from a program with sustainability-related learning outcomes. With the goal of having each student

develop a working knowledge of sustainability, the following objectives and recommendations have been made.

Objective 1: Provide opportunities to further connect all students' academic pathways to sustainability

- Expand the reach of the sustainability certificate program to new disciplines and engage new faculty in teaching courses within the certificate parameters
- Pilot a "Sustainability Expeditions" program with the goal of putting concepts of sustainability into courses across disciplines, which is similar to existing Data Expeditions and Archival Expeditions programs.
    - Data Expeditions - large datasets are used to introduce exploratory data analysis to students that solidify lessons learned in the classroom.
    - Archival Expeditions - library archival materials related to particular coursework serve as a cornerstone of undergraduate learning materials
- Continue connections with Duke's Offices of Civic Engagement and Service Learning to expand opportunities to integrate sustainability into these efforts.
- Explore opportunities to integrate sustainability concepts into Duke's "first touch" courses in many disciplines as well as a new type of course called "Collaborative Inquiry," that Duke is exploring that could infuse concepts of sustainability with experiential education

Objective 2: Identify new opportunities for students and faculty to utilize the campus and surrounding region as a teaching tool

- Develop educational support for students and faculty to encourage the use of Duke University's campus as a living laboratory.
    - Support could be in the form of website materials and consultation provided by Sustainable Duke, identification of existing sites that could be used for class, and facilitation of relationship building between faculty and students.
- Collaborate with existing university programs that work towards solutions to local issues by engaging students, staff, and faculty with an interdisciplinary approach
- Create a committee of current faculty, staff, and students to further incorporate Curriculum for the Triangle Bioregion into existing coursework.

Objective 3: Expand resources for faculty to integrate the concepts of sustainability into their courses and build institutional knowledge on sustainability-related projects

- Formalize the position of Faculty Director of Sustainability in the University, including development of a formal job description, with a term length, and formal reporting relationship ties to Duke Administration.
- Expand the pilot Trillium Student Research Initiative (TSRI) to additional courses, departments and disciplines. This program enables a graduate student to provide technical assistance to add sustainability learning outcomes into a new course including creation of lesson plans, researching necessary course materials, and developing assignments to gauge critical thinking and collaboration among students.
- Develop a database of sustainability-related projects that have been conducted by students and faculty whether in the classroom, as a part of research, or as an extracurricular activity. This could expand and institutionalize past inventories of faculty research connected to sustainability topics.

Outreach and Communications

Overview

Duke University is dedicated to promoting sustainable behavior changes and education among students, faculty, and staff in ways that directly impact the reduction of greenhouse gas emissions on campus. Over the past decade, Sustainable Duke in partnership with many other departments, including Facilities Management, Parking and Transportation, Duke Dining, Human Resources, News and Communications, and the Nicholas School of the Environment, has elevated the presence of sustainability at Duke University through the robust communication and outreach strategy outline in the 2009 Climate Action Plan. Major highlights include:

2009 CAP Outreach and Communications Recommendations Update

Over the past decade, Duke's sustainability impact has been shared broadly with the Duke community based on recommendations put forth by the Campus Sustainability Committee in 2009. The 2009 Climate Action Plan summarized these recommendations, which are outlined below along with highlights of progress since 2009.

- *Duke should build community for grassroots engagement, through existing and new sustainability networks, to enhance awareness of campus sustainability efforts among internal audiences and the impact of the behaviors on Duke's emissions.*
    - Over 10,000 signatures from students, staff, and faculty for the Duke Sustainability Pledge.
    - 200 students have been a part of the Green Devils, a student-based group of Sustainable Duke who have made lasting sustainable impacts on campus since 2006.
    - The University features sustainability efforts in each issue of the Working@Duke magazine that is distributed to all employees.
- *Duke should foster changes in behavior among internal audiences that reduce emissions at Duke through tactics such as issuing campus challenges to change individual behavior and engaging community members at points of access.*
    - Hosted over 100 sustainability-related workshops that engage students, staff, and faculty.
    - Development of campus-wide competitions, such as the Green Devil Smackdown, UnPark Yourself, and the Green Devil X Challenge, which have motivated behavior change and educated the Duke community about sustainability.
    - Development of Duke sustainability signs to prompt behavior change were distributed to all residence halls and many academic buildings to promote a campus culture of sustainability.
    - Development of a broad-reaching Green Certification program that includes certification for workplaces, labs, classrooms, events, dorms, and Greek life with over 20,000 student, faculty and staff participants.
- *Duke should set goals and measure and report on progress through tactics such as making climate change personal to the campus community with the development of a Duke specific carbon calculator and telling stories through the eyes of others.*

    - Developed a Duke-specific carbon calculator that has been used by 7,500 Duke students, staff, and faculty.
    - Development of a Duke sustainability "I Believe" series to showcase personal stories and ways that individuals within the Duke community connect to sustainability.
- *Duke should enhance perception of the University internally and externally as a sustainability leader in higher education through tactics such as development of a sustainability media kit, branding the Climate Action Plan, and developing an email engine to communicate sustainability initiatives.*
    - Adoption of the "Green Devil" for Sustainable Duke branding across campus
    - Development and distribution of an annual Sustainability Strategic Plan to provide an update on Duke's progress towards its goals.
    - Development and growth of a Sustainable Duke newsletter that goes out to 10,000 internal and external subscribers.
    - Actively participated in peer university networks and presented at a variety of sustainability in higher education conferences.
- *Duke should leverage the University's unique attributes through research and sharing and implementing change in the local community.*
    - Sustainable Duke in collaboration with Duke's Sanitation and Recycling Services has worked to make all on-campus football games zero-waste. In 2015, Duke became the first ACC school to have a zero-waste game day by diverting 94% of all waste generated away from a landfill and instead recycled or composted it.

2019 CAP Outreach and Communications Recommendations

Building on the successes of the past decade, it is now time to develop even more far-reaching communications efforts to engage the Duke community and further reduce campus emissions towards the climate neutrality target. The strategies outlined below are recommendations from the Communications subcommittee of the Campus Sustainability Committee.

Objective 1: Develop a robust network of Sustainability Champions in all workplaces, classrooms, labs, and dorms

Duke University has a strong network of students, staff, and faculty who are interested and engaged with sustainability on campus. These members of the Duke community have helped increase the sustainability of campus through their work in their departments, labs, and dorms. It is time to build on this momentum by developing relationships with individuals who are interested in sustainability at Duke, but are not yet engaged. To meet the objective outlines above, the following recommendations have been made.

- Host department-specific sustainability workshops.
- Develop a formal network of Sustainability Champions, who serve as both advocates and ambassadors of sustainability at Duke.
- Gather stories from Sustainability Champions about their experiences and share them with the Duke community.
- Host a recognition ceremony for students, staff, and faculty Sustainability Champions.
- Provide sustainability challenges to Sustainability Champions and newsletter recipients.

Objective 2: Foster a broad-reaching culture of sustainability for all students, staff, and faculty

Duke University is home to more than 35,000 students, staff, and faculty (excluding Health System). Each of these people are decision makers in the sustainability of their daily life whether it is energy use on campus, personal dietary choices, and commuting habits. While it is difficult to reach every single one of these individuals, it is important to find ways to engage them where they live, learn, and work. Below are some recommendations to broaden current sustainability impact by reaching out to established organizations and events.

- Increase the level of engagement by Sustainable Duke during student and employee orientation events.
- Develop departmental and school specific climate action plans.
- Continue to bolster the Green Certification program for departments, classrooms, dormitories, labs, and events.
- Integrate sustainability planning into existing Duke groups like Duke Student Government, Graduate and Professional Student Council, First-Year Advisory Council, and Resident Assistants.

Objective 3: Expand Duke's sustainability impact beyond campus boundaries

Over the past decade, Duke has built strong relationships with students, staff, and faculty on campus. However, with the transient nature of the community, mainly the student population, it can be difficult to maintain institutional knowledge on sustainability and capture the impact of student work beyond graduation. Therefore it is important to build lasting connections through Duke's alumni network. It is also beneficial to collaborate with peer institutions to amplify the sustainability efforts of higher education. Below are some recommendations to develop new and long-term relationships.

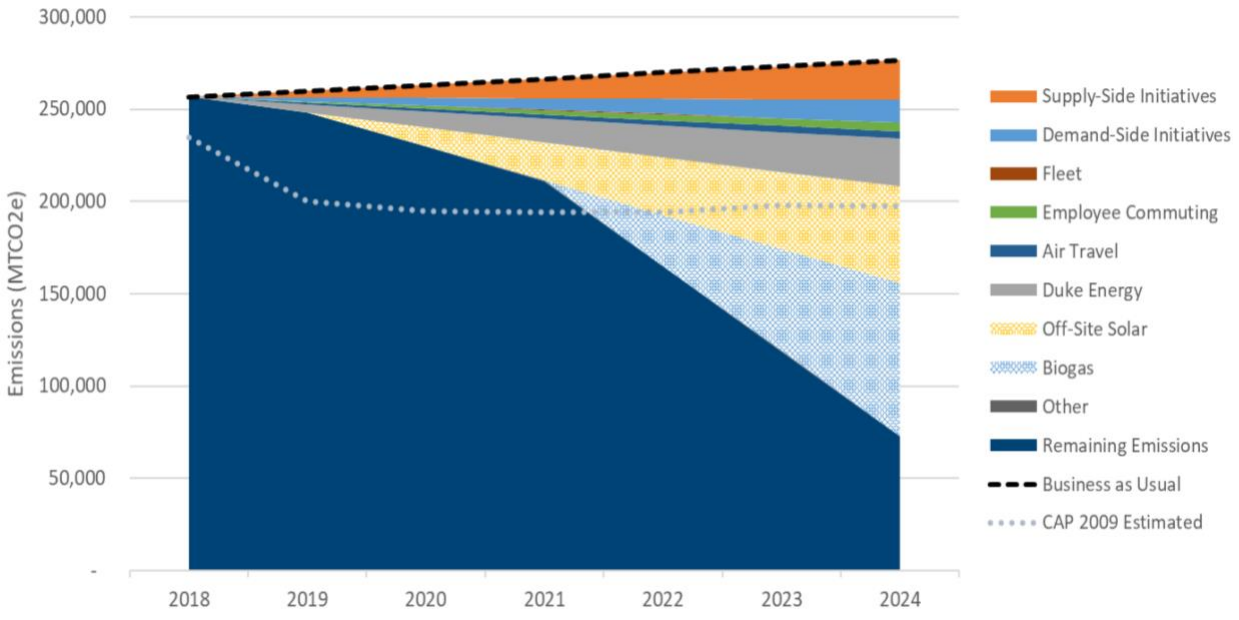
- Build relationships with Duke alumni who were involved with sustainability so they can easily connect with Sustainable Duke and current students.
- Develop an alumni-focused newsletter that shares information on sustainability at Duke.
- Share best practices and lessons learned with peer universities through conferences, sustainability consortiums, and existing email lists.

Conclusion

After reviewing all aspects of the 2009 CAP, assessing future needs of the campus and working with the Campus Sustainability Committee to develop new recommendations, Duke University has developed new projections for meeting the 2024 goal of climate neutrality. If all elements of the 2019 CAP Update are implemented as recommended, the University would be at an estimated 78% reduction of total greenhouse gas emissions by 2024, with approximately 73,000 MTCO2e left to address using carbon offsets (Figure 24 below).

The emission reductions modeled in Figure 24 below are ordered based on the University's ability to implement and control. While Duke fully intends to pursue off-site solar and biogas, there are external factors that will impact the timing, cost and procurement options. It should be noted that the biogas purchase modeled in the projections is based on the amount necessary to offset natural gas used in campus steam plants. Replacing approximately 10% of the fuel used in the campus steam plants, would make them climate neutral. Neutrality results from a combination of the capture and destruction of the biogas that would have been emitted into the atmosphere plus the displacement of conventional natural gas that would have been used to fuel the steam plant. If Duke made a larger biogas purchase it could potentially make the entire campus climate neutral or even a net carbon sink, as the University would reduce more carbon in the atmosphere than it releases. However, Duke will continue to focus on reducing on-campus emissions and developing a diversified portfolio of carbon offset projects to minimize risk and ensure the campus continues to meet its climate neutrality goal into the future.

Figure 24: Duke University updated potential emission reductions through 2024



Appendix 1: Sustainability Progress Timeline

Below is a timeline of sustainability at Duke University based on the categories included in Duke's annual Sustainability Strategic Plan Progress Report. Please note that this list is not exhaustive of all sustainability progress at Duke University.

Campus Sustainability Planning

- 2004 - Sustainable Duke was created.
- 2005 - Duke Environmental Policy was created.
- 2007 - Duke University signed the American College and University Presidents' Climate Commitment and formed a Presidential-level Campus Sustainability Committee.
- 2009 - Duke's first Climate Action Plan was published.
- 2011 - Duke begins development of a Sustainability Strategic Plan to integrate the following topics into University strategic planning on an annual basis:
    - Water
    - Waste
    - Food
    - Natural Resources
    - Sustainable investment
    - Procurement
- 2017 - Duke initiated an update to the Climate Action Plan.

Carbon Offsets

- 2009 - The Duke Carbon Offsets Initiative was established.
- 2011 - The Duke Carbon Offsets Initiative partnered with Google, Inc. and Duke Energy created the Loyd Ray Farms swine waste-to-energy project in Yadkinville, NC.
- 2013 - The Loyd Ray Farms swine waste-to-energy project generated its first verified carbon offsets.
- 2013 - The DCOI has partnered with South Carolina's Help My House program energy efficiency program to purchase carbon offsets.
- 2014 - The DCOI developed a draft urban forestry-based carbon offset protocol to encourage the planting and maintenance of trees in urban settings.
- 2016 - The DCOI partnered with Second Nature to develop guidance on carbon offset project development and management that can be used by peer universities.
- 2016 - The DCOI convened an academic & professional committee to develop Peer Verification as an alternative to 3rd party accredited verification for offset project review.
- 2017 - The DCOI partnered with Oberlin College and University of Florida to develop a web-based carbon offset project database called the Offset Network.
- 2017 - The DCOI urban forestry partnerships has led to the planting of over 6,000 trees around the United States over the past year.

- 2017 - The DCOI developed an educational workshop that is designed to educate employees about home energy efficiency.
- 2017 - The DCOI led a peer verification training to enable schools to verify each other's offset projects as academic opportunities, hosted by Arizona State University.
- 2018 - The DCOI partners with Delta Airlines to offset Duke's 2017 air-travel emissions and plant 1,000 trees in Durham targeting historically redlined neighborhoods.
- 2018 - The DCOI completes peer validation through Offsetnetwork.org, with American and Elon students evaluating the success of Duke's urban forest plantings in NC.

Infrastructure

- Energy
    - 2010 - East Campus Steam Plant is re-commissioned as a high efficiency natural gas plant.
    - 2011 - West Campus Steam Plant began conversion to a high-efficiency natural gas plant and Duke University ended the use of coal in on-campus steam plants.
    - 2011 - Solar thermal system is installed on the Bryan Center providing 40% of the building's hot water needs.
    - 2013 - Duke developed a strategic plan to convert campus steam distribution to a more efficient hot water distribution system.
    - 2013 - Duke installed a condensing economizer at the West Campus Steam Plant, which increased the efficiency of the plant by 5-7%.
    - 2014 – Duke Implemented energy efficiency measures in the School of Medicine, which is estimated to produce $2 million in savings in fiscal year 2014.
    - 2017 - Duke finalized the planning stages for a large-scale LED lighting retrofit project that is estimated to greatly reduce lighting energy used in 1.3 million square feet of campus buildings.
- Buildings
    - 2012 - Duke has 25 LEED certified buildings and 10 registered buildings.
    - 2014 - Duke finalized a green building guideline that focuses on energy and water efficiency.
    - 2014 - Duke has 29 LEED certified buildings and 9 registered buildings.
    - 2015 - Duke has 30 LEED certified buildings and 9 registered buildings.
    - 2015 - Duke University's Board of Trustees approved the updated Sustainable Building Policy.
    - 2016 - Duke has 41 LEED certified buildings and 4 registered buildings.
    - 2016 - Duke established a University Green Building Energy Consumption Standard to ensure new building projects prioritize utility efficiency.
- Water
    - 2010 - Duke University added cisterns and wells for Chiller Plant 2, which provide 40 million gallons of non-potable water annually.
    - 2013 - Duke implemented water-reduction measures for the 6 highest water-consuming University buildings.
    - 2013 - Construction began on the Water Reclamation Pond.

    - 2014 - Water efficiency retrofits have been completed in 15 campus buildings, which are estimated to save 15 million gallons of water per year.
    - 2015 - The Water Reclamation Pond was completed and saved 90 million gallons of water in the first year of operation.
    - 2016 - Duke completed the third phase of a multiyear water audit, which led to the installation of low-flow plumbing hardware in the top 30 water consuming buildings.
- Land Use and Natural Resources
    - 2010 - Construction began on Phase 4 of the Stream and Wetland Assessment Management Park (SWAMP) site.
    - 2013 - Duke adopted a campus wood policy to preserve Duke's trees on campus.
    - 2015 - Duke developed a draft framework for evaluating campus natural landscapes on their ecological, programmatic, cultural, pedagogical, and aesthetic value.
    - 2015 - Duke formally recognized the importance of Anderson Woods and Chapel Woods based on their educational, conservation-based, and aesthetic value.

Campus Operations

- Transportation
    - 2007 - Duke Bikes was launched.
    - 2010 - Replaced 10 campus buses with two hybrid, articulated buses and 6 ultra-low-sulphur diesel buses.
    - 2012 - More than 1,300 students and employees have signed up for Duke's WeCar program.
    - 2012 - More than 7,000 students and employees have signed up to be GoPass card holders, which allows them to use regional public transportation for free.
    - 2013 - Duke hired its first transportation demand manager to develop alternative transportation strategies for student and employee commuters.
    - 2014 - Duke developed transportation reports for individual schools to provide targeted outreach and promotion of sustainable transportation options at Duke.
    - 2014 - Duke hired a transportation demand management outreach coordinator.
    - 2017 - Duke developed a Bicycle and Pedestrian Plan, which lists recommendations to improve the university's alternative commuting opportunities.
    - 2017 - Duke has installed 14 new electric vehicle charging stations, bringing the total to 19 charging stations.
- Food and Dining
    - 2011 - The Duke Campus Farm was established, which is a 1-acre food production and educational farm.
    - 2011 - The Duke Campus Farm produced 6,400 pounds of produce in first year of operation
    - 2012 - Composting food waste is incorporated for all campus eateries.
    - 2013 - The Duke Campus Farm had over 1,300 volunteer hours and production increased by 40%.
    - 2014 - Duke drafted a definition of sustainable food for Duke in six product categories.

    - 2014 – Duke developed broad guidelines for best practices in setting and maintaining sustainable sourcing goals in dining services.
    - 2016 - Duke's Marketplace, an East Campus dining facility, became Marine Stewardship Council certified.
    - 2017 - Duke hired its first Sustainability and Quality Control Manager for Duke Dining.
    - 2017 - The Duke Campus Farm grew more than 13,000 pounds and 40 varieties of produce for campus dining facilities and DCF's Community Supported Agriculture (CSA) members.
- Waste and Recycling
    - 2007 - Duke's first-year picnic became a waste free event.
    - 2010 - Duke University's Free Store expanded efforts to provide donated office supplies to other offices at no charge.
    - 2012 - Duke services 1,600 recycling bins around campus.
    - 2013 - An audit of Duke's waste streams was conducted.
    - 2013 - Recycling rate for Duke University was 30%.
    - 2014 - Recycling rate for Duke University was 37%.
    - 2015 - Duke piloted a Zero-Waste Game Day program for football games played in Wallace Wade Stadium.
    - 2016 - Through waste-free football efforts, Duke Football had the first waste-free ACC game, which diverted 93% of waste collected at the game and during tailgating.
- Procurement
    - 2005 - Duke established a partnership with Staples Advantage to identify and label "Green" office products.
    - 2012 - Duke Surplus donated more than 10,000 items and recycled more than 350,000 pounds of electronic waste.
    - 2014 - Sustainable Duke in partnership with Duke Student Government passed a resolution to limit the amount of free printing for students resulting in a 24% reduction in undergraduate printing.
    - 2017 - Duke Procurement partnered with the Office of Institutional Equity to develop training and tools to educate the Duke community to identify and use local women-owned, minority-owned, and veteran-owned businesses.
    - 2017 - Duke Surplus has diverted over 60,000 items from the landfill through donations to local businesses since 2013.

Education and Engagement

- Education
    - 2010 - Duke establishes the Trillium Project, a faculty learning community dedicated to increasing the prevalence and quality of sustainability concepts in academic courses.
    - 2010 - Sustainable Duke began publishing a list of academic courses that incorporate environmental, economic, and social aspects of sustainability.
    - 2012 - Duke created the position of Faculty Director of Sustainability.

    - 2012 - The Duke Green Classroom Certification program was created.
    - 2013 - The Theory and Practice of Sustainability (ENVIRON 245) was created, which is the gateway course for students in the undergraduate Sustainability Engagement Certificate.
    - 2013 - 35% of Duke graduates earned degrees in programs with sustainability learning outcomes
    - 2013 - 9 master's projects from the Nicholas School of the Environment were focused on campus sustainability issues.
    - 2013 - The Trillium program has trained 52 fellows since inception.
    - 2014 - Duke initiated a pilot of an international Sustainability Literacy Test on campus to assess changes in undergraduate sustainability literacy.
    - 2016 - Duke approved the new undergraduate experiential certificate in Sustainability Engagement.
    - 2016 - The Trillium program has trained over 115 fellows since inception.
    - 2017 - Duke developed the new Curriculum for the Triangle Bioregion initiative, which engages students with concepts of environmental education and sustainability in the context of Duke's local community.
    - 2018 - Duke launches a pilot Trillium Sustainability Fellowship program, which pairs an undergraduate researcher with a faculty member to integrate sustainability into academic curricula
- Communications
    - 2011 - The Duke Green Workplace Certification was created.
    - 2012 - The Green Devil Smackdown competition was created and brought together 63 teams of students, staff, and faculty to compete in a variety of sustainability challenges and quizzes.
    - 2013 - Sustainable Duke's workshop through Learning and Organizational Development has educated 263 employees since inception.
    - 2014 - The Battle of the Schools sustainability competition resulted in a 390% increase in the number of green certified laboratories.
    - 2015 - The Duke Carbon Offsets Initiative piloted a program for Duke employees to install residential solar at a discount leading to the installation of over 150 kilowatts of solar capacity around the Triangle.
    - 2016 - Since the inception of the Green Certifications program, over 10,000 Duke students, staff, and faculty have participated in the certifications.
    - 2017- The Leading for Sustainability trainings have reached 11 different departments and over 200 staff in 2 years.

Appendix 2: Campus Sustainability Committee Members

The Duke University Campus Sustainability Committee (CSC), a standing committee appointed by the President, is responsible for making recommendations to guide campus sustainability policies, championing these sustainability initiatives, and communication them to each member's respective constituencies to foster a more sustainable campus community. Below is the 2018/19 membership.

Faculty		Term Ends
Toddi Steelman (Co-Chair)	Nicholas School of the Environment	
Fred Boadu	Pratt School of Engineering	2019
Charlotte Clark	Nicholas School of the Environment	2020
Ellen Davis	Divinity School	2020
Lee Ferguson	Pratt School of Engineering	2019
Rick Larrick	Fuqua School of Business	2019
Dirk Philipsen	Sanford School of Public Policy	2020
Tim Profeta	Nicholas School of the Environment	2020
Valerie Sabol	School of Nursing	2019
Rebecca Stein	Cultural Anthropology	2020
Jonathan Wiener	Law School	2020
Administrators		
Tallman Trask (Co-Chair)	Executive Vice President	
Matthew Arsenault	Program Manager, Duke Carbon Offsets Initiative	
Tavey Capps	Director, Sustainable Duke	
Carl DePinto	Director, Parking & Transportation	
Jason Elliott	Assistant Director, Sustainable Duke	
Joe Gonzalez	Associate Dean, Residence Life	
Mark Hough	Office of University Architect	
Anne Light	Office of Public Affairs & Government Relations	
Leonora Minai	Director of Communications	
John Noonan	Vice President, Facilities	
Jane Pleasants	Assistant Vice President, Procurement	
Tanja Vujic	Director, Biogas Strategy	
Students		
Divya Dayanidhi	The Environmental Alliance	2019
Tara Early (President)	Duke Sustainability Board	2019
Robert Harris	Graduate & Professional Student Council	2019
Caroline Heitmann	Duke Climate Coalition	2019
Thomas Hessel	Duke Student Government	2019
Layne Marshall	Duke Sustainability Board	2019
Olivia McKinney	Duke Student Government	2019
Emily Millar	Duke Climate Coalition	2019
Cameron Oglesby (President)	The Environmental Alliance	2019
Amanda Ullman	Graduate & Professional Student Council	2019

Appendix 3: CAP Update Process

Sustainable Duke, in collaboration with Facilities Management Department, Parking and Transportation, Human Resources, and the Campus Sustainability Committee, developed the CAP Update. With a goal of full transparency, the CAP Update was shared publicly during a 45-day open comment period (November 2, 2018 – December 17, 2018).

While the CAP Update was available on Sustainable Duke's website, it was also sent out to the following organizations and entities during the request for comment period.

Newsletters/Email Outreach

- Sustainable Duke – 10,000 members
- Duke Today article – Duke community and public
- Working@Duke - 40,000 employees
- Chronicle articles - Duke community and public
- Grad/Prof Student Council – 9,000 students
- Undergrad Env. Affairs Board – 200 students
- Environmental Alliance – 950 subscribers
- Duke Climate Coalition – 2,000 subscribers
- NSOE community – 800 members
- NSOE Board of Visitors – 30 members
- NSOE Alumni Council – 17 members
- Energy Initiative – 2,600 subscribers
- Greener Durham social media – 2,000 followers
- Ivy+ Sustainability Network – 45 members
- Int. District Energy Association – 2,000 members
- Local Env. Organizations – including Environmental Defense Fund, Natural Resource Defense Council, NC Sierra Club, NC Conservation Network, NC Sustainable Energy Association, Southern Alliance for Clean Energy, NC Clean Tech Center, NC State University, UNC

Aside from the outreach outlined above, Sustainable Duke and Facilities Management Department hosted presentations and held meetings for in-person commenting.

Presentations/Meetings

- Campus Sustainability Committee – 32 members
- CarbonNetZero – 55 attendees
- Duke Student Government – 60 students
- Durham Environmental Affairs Board – 20 attendees
- NSOE faculty meeting – 5 faculty
- ENV245 – 30 students
- ENV First Year Seminar – 25 students
- Environmental Alliance – 5 students
- Duke Climate Coalition – 5 students
- Green Devils – 15 students

This outreach led to the active participation of over 350 Duke community and external community members, which generated over 50 pages of comments. All comments received from these individuals were analyzed, summarized and presented to the Campus Sustainability Committee in addition to being responded to in the Response to Comments document and the Climate Action Plan.