2019 Duke University Climate Action Plan Update
Response to Comments

April 1, 2019

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Overall CAP Document

1. Who was involved in the development of the 2018-19 CAP Update?

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 internal and external community members, which generated over 50 pages of comments. All comments received from these individuals were summarized and presented to the Campus Sustainability Committee in addition to being responded to in this Response to Comments document and with edits in the draft Climate Action Plan update.

2. What is included in Duke's scope of emissions?

The CAP breaks down Duke University's overall emissions into three distinct categories to define and address the unique attributes and scope of each. 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
    - Fuel used in Duke-owned vehicles and marine vessels
    - Fertilizer used on Duke grounds
    - Refrigerants
- Scope 2: Indirect GHG emissions from:
    - Electricity purchased from Duke Energy
- Scope 3: Other Indirect GHG emissions from:
    - Employee commuting (student commuting not included)
    - Air travel paid for by the university (student travel to and from Duke and study abroad not included)
    - Landfilled waste
    - Fugitive emissions from natural gas extraction and transport (added in 2017)
    - Transmission losses from purchased electricity (added in 2017)

In addition, criteria have been established to define the types of facilities included within scope for the CAP. The criteria focuses on which entities Duke University has direct operational control over.

- Included Entities
    - Duke University
    - School of Medicine
    - School of Nursing
    - Duke Marine Lab
- Excluded Entities
    - Duke University Health System
    - Leased Spaces
    - Duke International Campuses

3. Does the Duke University Health System have a Climate Action Plan?

Based on Duke's signing of the American College and University Presidents' Climate Commitment in 2007 and alignment with peer universities, Duke University's carbon 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. While Duke's target date for carbon 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.

4. What other sustainability planning is Duke University working on that is not included in the Climate Action Plan?

While the CAP is targeted towards emission sources that were outlined in the American College and University Presidents' Climate Commitment, Duke University recognizes that it does not include all sustainability-related topics that Duke is also working towards. Over the past decade, Duke has made great strides in expanding sustainability efforts across the operational and academic areas of campus and amplifying these efforts to the broader community. The work of the Campus Sustainability Committee to expand the CAP into a broader Sustainability Strategic Plan has guided much of this success. Since 2011, the CSC has assessed current efforts and worked to develop goals around important topics such as water, waste, food, natural resources, sustainable investment and procurement. Once the 2018 CAP update is complete, the University will revisit progress in these other areas as well as considering new emerging topics that should be addressed.

5. Why has it taken so long to execute some portions of the 2009 Climate Action Plan?

When Duke University developed its original 2009 Climate Action Plan, it set into motion a path towards carbon neutrality in 2024. This was an ambitious long-term vision for the University that would guide numerous campus decisions and strategies to meet the ultimate goal. This plan provided recommendations to reduce emissions from energy used on campus and emissions from transportation-related activities (employee commuting, air travel, and Duke-owned vehicles). It also provided recommendations on carbon offsets, which led to the creation of the Duke Carbon Offsets Initiative. Lastly, the CAP also focused on ways to improve sustainability across Duke by creating recommendations for education and campus-community outreach.

Since 2009, Duke has made significant progress on these recommendations leading to a total emissions reduction of 24%, development of alternative transportation programs, an experiential Certificate in Sustainability Engagement, and a strong communications and outreach plan that engages thousands of students, staff, and faculty every year.

While the University is on track with expected greenhouse gas emission reductions, this plan was set in the reality of a vibrant, changing campus that is impacted by numerous internal and external forces that can be hard to predict. Not all strategies recommended in the 2009 CAP have been implemented while many others have produced even greater results than expected. Recognizing this changing environment, the University began updating its Climate Action Plan in 2017 to assess progress to-date, review assumptions that may have changed and consider new strategies and technologies that will enable Duke to meet the 2024 goal. This update has also been an opportunity to engage student, staff, faculty and external stakeholders in a productive

discussion of the University's climate goals. It is the hope of the University that the 2018 CAP update will provide a clear road-map to achieving the 2024 goal and a continuation and expansion of Duke University's leadership in sustainability.

6. How does Duke's GHG reduction efforts compare to peer institutions?

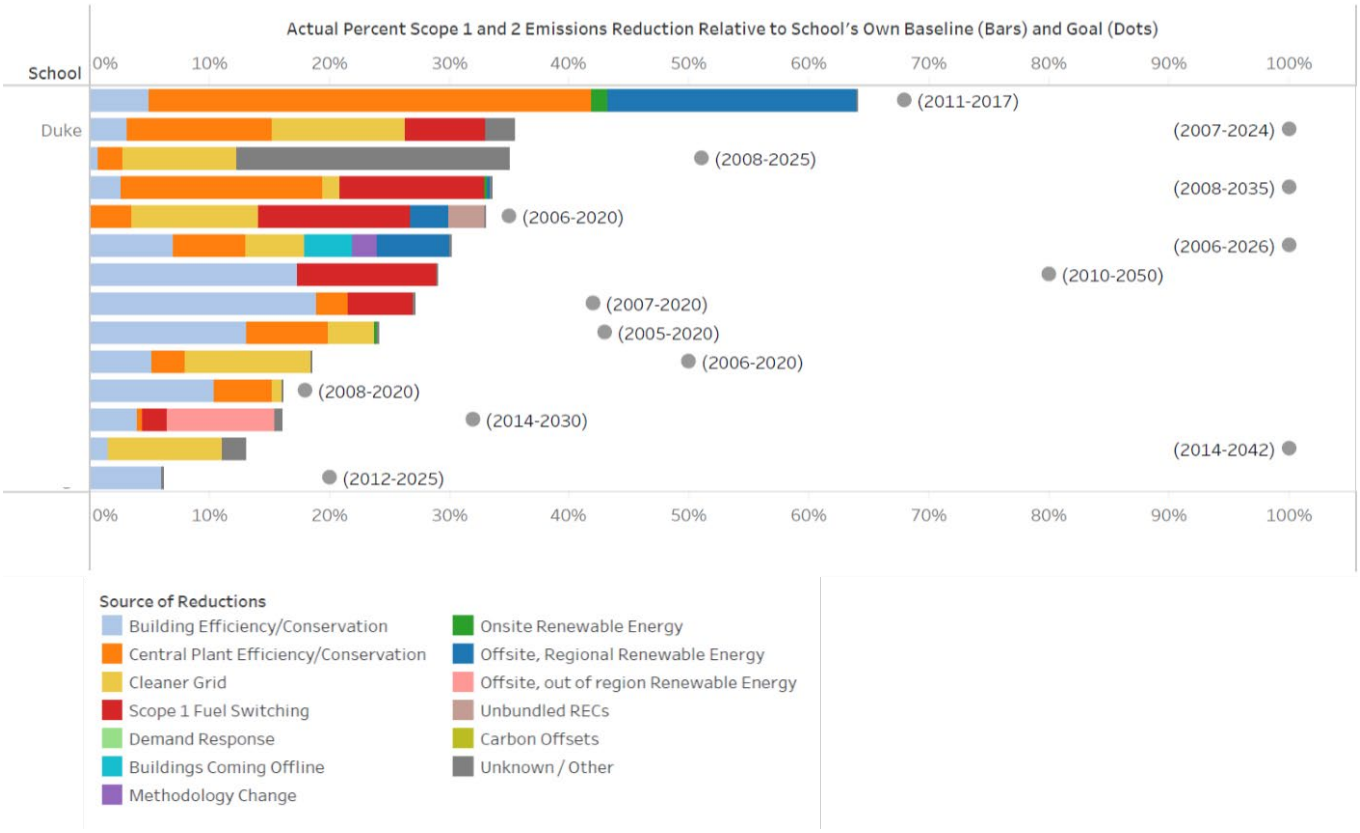
The Ivy+ Sustainability Consortium comprises 14 offices of sustainability from leading research universities in the United States. The consortium leverages its collective leadership to advance sustainability in higher education and beyond. One example of this leadership is that the consortium created the figure below to demonstrate absolute emission reductions between 2017 and their baseline emissions year (Scope 1 & 2 emissions only, Scope 3 emissions not included). The dot represents the percent emissions reduction target and target year publicly stated by each institution. Schools are organized in the chart in order of decreasing actual emissions reduction to date.

With the varied nature of emissions reporting at each school, there are some important disclaimers regarding the data summarized in the chart below. The data is self-reported by each institution and the calculation methodologies, baseline emission years, and boundaries of which type of emissions are included may differ between institutions. Therefore, this chart should not be used as a perfect comparison between institutions, but rather used to show how individual institutions are meeting their emission targets.

For example, Duke's target is 100% reduction by 2024 and has reduced Scope 1 and Scope 2 emissions by 36% from baseline. Note that this chart does not include Scope 3 emission types (e.g. commuting and air travel) that some institutions, like Duke, include in their emission reduction targets. With Scope 3 emissions included, Duke has reduced total emissions by 24%.

As is shown below, Duke is one of only 4 institutions with a 100% carbon neutrality commitment (including purchase of carbon offsets) and aims to be fully carbon neutral earlier than the other institutions. Similar to other institutions, Duke has reduced Scope 1 and 2 emissions through a variety of methods including energy efficiency/conservation, fuel switching and efficiency improvement in central plants, and reductions of emissions intensity of local grid electricity. Also important to note is that Duke is currently limited by N.C. legislation, which does not allow the ability to develop offsite, regional renewable energy (dark blue color in chart). However, bills such as House Bill 589 could address this issue in the future (*More detail on this is given in the Energy section Q#8*).

Figure 1: Ivy+ Sustainability Consortium's Scope 1 and Scope 2 emissions reductions (baseline year to 2017)



Energy

1. What was the purpose, audience, and function of Energy Needs Analysis (ENA)? How is Duke considering resiliency in campus energy planning?

This effort entailed an energy needs analysis for the utilities at Duke University, assessing the current loads and production/distribution assets, ability to recover or adjust easily to an unforeseen event or outage (resiliency assessment), the impact of future loads on the systems and impact on carbon reduction goals. The following utility systems were assessed:

- Electrical Power
- Chilled Water
- Steam
- Hot Water
- Domestic Water/Reclaim Water
- Natural Gas

Relative to the resiliency assessment, several scenarios of various durations were considered in the assessment including:

- Total outage from Duke Energy, including 44 kV distribution system which also impacts thermal utility production
- Individual Duke Energy substation failure
- Total outage of water services from City of Durham – impact on steam and chilled water plants
- Partial water outages due to water main failures – impact on steam and chilled water plants
- Natural Gas system outage

Each of the utility systems were assessed for its current ability to withstand the major outages noted above, specifically impact to hospital, clinics, research and housing. Impacts and durations of outages to campus facilities for each scenario were identified and quantified, as well as coordinated with the current load shedding schemes/plans. Alternatives were conceptually developed and assessed that could better withstand the outage scenarios and improve utility system resiliency. Low carbon alternative fuel sources were considered, such as biogas and solar photovoltaics.

While the ENA is a public document, the audience was specifically the utility engineers and other technical Facilities Management staff. Duke University will continue to build upon the results of the 2018 ENA to develop a detailed Utility Master Plan that establishes the major projects, timeline, and costs for proposed projects. Please refer to the CAP Energy Reduction Plan diagram in the 2019 Climate Action Plan document for additional details regarding the timeline and greenhouse gas impact of various technologies the University is planning to implement or study further.

2. What is the plan to finance infrastructure projects? Have the cost savings/ROI been quantified for energy infrastructure decisions?

All utility infrastructure projects are debt financed. The debt service is one component of each utilities' expenses that is converted into a unit rate. The unit rates for each utility is charged to building occupants based on metered usage. Proposed projects with cost savings are evaluated based on simple payback in years. For more complex projects, net present value method may be used to determine the relative value. Decisions between various options are not only based on payback or net present value (NPV), but also operational, maintenance, and locational considerations.

3. What is Duke doing to increase energy efficiency on campus?

Duke University's internal Energy Management team, a part of the Facilities Management Department (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.

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.

- 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

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 2018 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.

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.

4. Would it be useful to create Energy Use Intensity (EUI) targets by building type on campus?

EUI is a useful metric for making relative comparisons between similar buildings. However, it is less useful for absolute evaluations of building performance. EUI helps building managers and Duke's Facilities Management Department (FMD) focus on where to invest resources to more deeply investigate potential areas of savings.

However, the factors that influence EUI over time are varied, and many different parties have a role in potential solutions to lowering EUI. Influencing factors include: hours of occupancy, number of occupants; type of activities, age of building systems, age of building envelope, HVAC control technology type, and relative level of occupant participation in energy savings behavior (such as eliminating space heaters, minimizing the use of "mini-fridges", and centralizing print/copy resources).

Retroactively developing full building energy models is a fantastic academic learning exercise in that it teaches the modeler how to understand the myriad ways that buildings use energy. However, if performed with the goal of only setting EUI targets as a hypothetical performance metric, it is of lesser value to facility operators. These modeling exercises require substantial time, personnel, and financial resources for Duke FMD that can be better used in other energy management activities.

5. Why are some buildings too cold or too hot at times during the year?

There are multiple factors contributing to the temperatures of campus buildings and how those temperatures are perceived by building occupants. For most campus buildings, Duke manages cooling, heating and humidity control through its chilled water system, steam and hot water plants. Duke tries to maintain building temperatures within a comfort range based on outdoor temperatures and conditions. Factors such as age of the infrastructure of a building or primary design function of the building can affect the cooling/heating of a building. Building occupants may also have varied expectations about what constitutes comfort.

6. How is Housing and Residence Life incorporating sustainability and energy efficiency into residence halls on campus?

Housing & Residence Life (HRL) consistently seeks ways to increase the sustainability of its residence halls and work practices. Some simple examples include gradually installing more low flow shower heads, LED lighting, and water bottle filler stations each year. HRL staff have also implemented sustainable housekeeping practices using environmentally friendly cleaning supplies.

When planning new residence halls, HRL follows the University's sustainable building guidelines including working with Facilities Management to select building energy systems that support sustainability practices. Systems for new buildings meet the University standards for energy efficiency and major renovation projects introduce central chilled water to cool buildings much more efficiently than current window air conditioning units.

7. What is the solar capacity on campus – what does Duke University have, where could this expand, what are the limits?

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 5 main accounts associated with the 5 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 5 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.

8. How has Duke engaged with the N.C. House Bill 589 process and how will it respond once rules are determined? What is the potential impact on Duke University's greenhouse gas emissions?

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. In February 2018, the University joined with two other peer institutions, Wake Forest University and Davidson University, to file a letter of support with the N.C. Utilities Commission regarding HB589.

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. If Duke University could take advantage of the maximum solar purchase allowed by the new regulations, it would result in a reduction of greenhouse gas emissions of approximately 50,000 MTCO2e or 23% of the projected total emissions reductions needed to become climate neutral for 2024.

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.

9. What is the potential for other renewables on campus such as wind and geothermal?

Unlike coastal resources, wind power is not economical in the piedmont area of N.C. due to inconsistent wind patterns. For additional information, the NREL "Wind Prospector" online tool shows available wind resources in the eastern U.S. There is also currently a moratorium on wind power development in North Carolina and current state law does not provide an ability for Duke University to directly purchase off campus wind power. Geothermal has been studied numerous times for various buildings on campus. All of the studies showed that the required land for a geothermal field was too great for Duke University to commit to that purpose.

10. Has Duke University considered energy storage options?

As part of the recent Energy Needs Analysis (ENA), the University has considered energy storage to meet campus needs. An alternative to installing new engine generator units is an energy storage system that stores electrical power for use as standby power during outages. To provide one day of capacity for emergency chilled water, the energy storage device would need to store approximately 150 MWh. Utility-scale chemical battery systems to date are mostly lithium-ion systems, like batteries in cars, laptop computers, and mobile phones. Costs are declining but this system would still cost approximately $50 million, compared to the estimated $9 million for standby engine generators. Emerging chemical energy storage technologies for grid applications such as flow batteries could substantially reduce cost but are not readily available at this time.

Traditional mechanical energy storage systems such as compressed air energy storage and pumped hydro are not viable on campus. Pumped hydro is the most common type of energy storage in the world but requires large reservoirs of water at different elevations that are most often modification of existing geography and not completely manufactured as would be required at Duke University. There is a similar emerging technology that uses a crane to stack large concrete blocks when charging energy and then lowers the blocks to discharge the energy, but it is not readily available yet and not likely to be cost competitive for standby power. Grid-scale compressed air energy storage is rare and usually only utilized in combination with natural rock caverns that are air tight, which do not exist at Duke University. There is an emerging technology that uses liquid air energy storage to reduce the capacity of the storage system required allowing for fabricated pressure vessels to be used, but again this is not readily available or cost-competitive for standby power systems.

There are currently no known chemical or mechanical energy storage devices that are economically viable for a standby power system. These technologies are in use today as components in electric grid generation balancing every day. The everyday use of such systems can justify the high capital cost. These technologies are not typically applied in lieu of generation systems for providing standby power on a limited-use basis.

A more viable type of energy storage that Duke University is considering is thermal. A field-erected stratified chilled water thermal energy storage (TES) tank could be provided to load-level the emergency chilled water load as needed. The total amount of stored chilled water requires approximately 2 million gallons of useable TES. Mechanical or chemical energy storage devices are not feasible for sustained standby power to supply emergency chilled water during normal power failure, but TES could be used to level the emergency chilled load and reduce the need for standby generation.

The University is already moving forward with the recommendation from the ENA to study the addition of a thermal energy storage tank for chilled water. This tank would to 2 to 5 million gallons in size and would allow Duke University to produce chilled water at night when rates are cheaper and efficiencies are higher. The University would then pump that chilled water to the

buildings during the day. Duke University is also studying thermal energy storage for hot water in conjunction with heat recovery chillers for East Campus buildings and any future buildings on Central Campus.

11. Why would Duke University continue to invest in natural gas infrastructure? Is the University considering electrification?

Nearly 50% of all of Duke University's energy needs is supplied by burning natural gas in campus boiler plants. This heat is transported to buildings in the form of steam or hot water where it is used for heating, sterilization and humidity control. Electrifying this heat production would cost the university at least an additional $100M. In addition, Duke Energy would have to upsize its electrical service to the campus as the additional demand would exceed the current system capacity. Currently steam and hot water production is backed-up by on-campus storage of fuel oil in case of a loss of gas service. To replicate this necessary back-up ability, Duke University would be required to install ten or more diesel generators. Finally, the cost of producing this equivalent amount of heat with electricity is more than three times as expensive as with natural gas, adding over $20M a year in operating cost. This would double the current utility rates for all campus building occupants. For these reasons, the University continues to believe the pursuit of biogas to replace natural gas is both more environmentally impactful and economical than electrification.

12. Will Duke University consider Combined Heat and Power (CHP) or Co-Generation again in the future?

As of April 2018, Duke University announced that it delayed indefinitely plans to build a freestanding Combined Heat and Power (CHP) plant and will instead focus its attention on expanding opportunities to use biogas and other environmentally friendly fuels for its growing energy needs.

However, CHP or cogeneration provides a more efficient way to generate electricity and capture thermal energy that would otherwise be wasted at a typical electrical power plant. This waste heat can be transferred as steam or hot water to operate research and health care equipment, provide space heating, and control humidity in buildings. Another important benefit of cogeneration on campus is enhanced energy security in case of a grid outage due to a major weather event or system failure. A cogeneration facility could provide an on-campus source of electricity for emergency back-up needs in the medical center, research buildings, and other priority areas.

The University will continue to explore technologies such as cogeneration that could meet the capacity and resiliency needs of the institution.

13. It is hard to compare the Combined Heating and Cooling (CHC) system to Combined Heat and Power (CHP) as the cost comparisons are not as fully fleshed out for CHP – why is this the case?

Duke University generating its own electricity (Co-gen or CHP) would be required by law to move to a different rate structure from Duke Energy. This analysis will be part of a future study to better understand which rates would be applicable, which Duke University accounts they would apply to (Duke has five accounts with Duke Energy on campus), and the impact of various operating modes of the power generation system. The proposed CHP did not incur any of these issues since Duke Energy would have owned the system and the power generated was transmitted on their system.

14. What are Duke University's future growth projections?

Duke University'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.

15. What are the future plans for Central Campus and how will this impact campus utility demand?

The strategic task force on the future of Central Campus is charged with proposing a plan that makes the best use of the area of campus known as "Central Campus" and that will be made available when the student housing on this site is demolished. The plan should be strategic and envision uses of the land—build, sell, leave vacant—that will serve the university well over the next fifty years.

All potential uses for Central Campus will be evaluated based on the strategic value relative to the President's Strategic Framework and the Provost's Strategic Plan "Together Duke." Any projects that are developed will be reviewed through the existing capital review processes established by the Capital Review Committee and the Resource Committee.

The Central Campus Task Force has met twice (09/2018 and 11/2018) and will meet again in February and May of 2019. The work of the Task Force is not complete at this time. Therefore, it is too early to predict the recommendations of the Task Force and what impact they may or may not have on the CAP. The only known impacts at this time is that the demolition of the existing buildings that will occur in summer 2019 will have a reduction in the GHG emissions of the campus.

16. The Energy Needs Analysis provides a good guide for the next decade to meet Duke University's utility needs but how is Duke planning longer term or for transformative technologies?

The Energy Needs Analysis is meant to be a roadmap for the next decade but does not preclude the University from continually assessing emerging new technologies and the changing

economic market for renewables. Engineers from Duke FMD and its network of nationally recognized engineering consultants continually research and share information regarding new technologies. New technologies are always evaluated for their impact both financially, environmentally and to the campus systems with an understanding that the University's utility infrastructure must still maintain its high standard of reliability to critical buildings.

17. How is Duke University being strategic about energy needs – load shifting, energy storage, etc.?

The Facilities Management Department works continuously to meet the campus energy and energy security needs with the fewest greenhouse gas emissions and greatest environmental benefits in the most economically efficient way. The University is already studying the addition of a thermal energy storage tank for chilled water. This tank would to 2 to 5 million gallons in size and would allow Duke University to produce chilled water at night when rates are cheaper and efficiencies are higher. The University would then pump that chilled water to the buildings during the day. Duke University is also studying thermal energy storage for hot water in conjunction with heat recovery chillers for East Campus buildings and any future buildings on Central Campus.

Biogas

1. What is Duke University's motivation/vision for biogas development in N.C.? Could it be more cost effective to flare and get the offsets rather than spend money developing the Renewable Natural Gas (RNG) infrastructure?

Duke's work on biogas development in North Carolina is motivated by a desire to avoid emissions of greenhouse gases and develop markets for the use of that biogas, either through payments for carbon offsets or for renewable natural gas (RNG) refined from biogas.

Biogas can be sourced from livestock operations such as swine, poultry and dairy farms, as well as agricultural waste such as crop residues, waste water treatment plants and landfills. These sources produce large amounts of methane, a greenhouse gas with a global warming potential 24-36 times greater than carbon dioxide.

Biogas sources best suited for supplying RNG are large and closely situated to pipeline interconnection points. Using biogas for RNG that replaces and/or suppresses the use of conventional natural gas means less demand for conventional natural gas, fewer wells, and less fugitive emissions that can result from the transport of natural gas. Although little to none of the University's gas is sourced from natural gas derived through hydraulic fracturing or "fracking", when RNG is used to replace fracked gas, its use helps to mitigate and/or prevent problems associated with fracking. Regardless of how replaced natural gas is derived, it is always better to use renewables in the place of geologic supplies.

Outlying and smaller sources are considered better candidates for on-site biogas capture and destruction. Biogas sources too far away from RNG transport infrastructure can be captured to be flared or used to generate electricity on site or for back-up power in the case of emergencies such as hurricanes or flooding. This approach was used at the Loyd Ray Farms project, which uses electricity from biogas to power the components of its system that make it possible for the farm to meet the environmental performance standards.

Options for biogas, however, are not limited just to capture and flaring or RNG development. Rather, an array of options exist and must continue to be pursued to keep these emissions out of the atmosphere. This is particularly important when it comes to curbing GHG emissions because the earlier the emissions are avoided the better the climate change outcomes.

2. Is Duke University only pursuing swine-based biogas?

No. The University is exploring many other sources beyond swine waste-derived biogas. North Carolina is the third richest state when it comes to biogas potential, which comes from a host of

sectors, including agriculture waste (crop residues) and animal waste (including poultry, swine and dairy), wastewater treatment plants, landfills and food waste.[1]

Of these sources, swine farms constitute one of the greatest opportunities to avoid GHG emissions in North Carolina because they generate high volumes of methane at high density relatively close to pipeline interconnection points. Duke's initial efforts focused on carbon offsets from swine farms because the farms collectively not only emit significant amounts of methane gas but also, as part of the agricultural sector, have historically had few incentives, economic or regulatory, to control the GHGs they emit. Moreover, working with swine farmers offered the potential to improve overall waste management, meaning better outcomes for rural communities, a start to addressing social justice concerns and improving the environment through improved waste management. The University also realized that its investment in carbon offsets from swine farms could help to catalyze the use of biogas to generate electricity under the NC Renewable Energy and Energy Efficiency Portfolio Standard (NC REPS). Finally, biogas as an energy source provides an around-the-clock, homegrown renewable energy source.

At the time Duke began work in the biogas realm, North Carolina's development of swine waste-derived biogas was more conceptual and needed to be proven. Duke undertook a project in conjunction with Duke Energy and Google at Loyd Ray Farms to test the feasibility of the concept, which led to an effective model that is now being replicated at a broader scale.

Thanks to the Loyd Ray Farms project and the University's follow-on research to map biogas development, swine biogas is gaining a foothold in the mainstream marketplace. This is also due to developments such as the pork industry's commitment to reduce GHG emissions, the formation of new companies dedicated to developing RNG from swine waste biogas, renewable transportation fuel mandates and ongoing incentives through the NC REPS.

Duke is now considering other sources that have fewer incentives and, in some cases, more barriers to development. The other sources include agricultural waste such as crop residues, other livestock operations such as dairy farms, waste water treatment plants and landfills. Co-digestion of poultry litter also appears promising, particularly considering that North Carolina is the third largest poultry producer in the nation.

[1] Duke University is currently participating in a research effort to pinpoint exactly how much biomethane potential North Carolina has, from what sectors it is derived and what are the options for its use (e.g., renewable natural gas, transportation fuel, replacement for petroleum-based raw materials in plastics). The North Carolina Energy Policy Council recommended the analysis in its July 2018 report. See Energy Policy Council, Biennial Report (May 2018) at 73, available at https://files.nc.gov/ncdeq/Energy%20Mineral%20and%20Land%20Resources/Energy/Energy%20Policy%20Council/2018%20EPC%20Biennial%20Report%20-%20FINAL.pdf.

3. How does Duke University intend to engage communities potentially impacted by its biogas purchases?

Duke University has actively been engaging with representatives of community and non-profit environmental groups to share its approach to biogas development. In these conversations, the University has discussed its approach to improve waste management, reduce odors from farms and create alternative energy sources all while minimizing methane emissions into the atmosphere.

Duke has adopted principles articulated in the 2018 Climate Action Plan Update that guide its biogas development efforts. Specifically, when making biogas purchasing decisions, the University will prioritize investment in emission reduction and carbon offset projects that benefit the environment and economy of local communities; it will advocate for policies at the local, state, and federal levels that expand access to and affordability of renewable energy; and identify and effectively engage with stakeholders both on and off campus.

The University has been conducting outreach to various organizations and has made efforts to meet with community members and organizations with whom communities have been working. The University is interested in hearing community members' concerns and sharing its research so that the health and environmental impacts associated with biogas sources such as swine farms can be addressed.

The University also has been active in encouraging educational events on the science of swine waste management and biogas and promotes whenever possible new research projects on advancements in policy and technology around waste management.

Duke plans to continue to engage with stakeholders from communities as well as other universities, industry, government, its student body and nonprofits to accelerate comprehensive solutions as it continues to support immediate steps to control GHG emissions from swine farms.

4. How can Duke University make biogas procurement decisions more transparent?

The University will provide as many details as it can about the purchases it is considering. How much information can be shared, however, can be limited because of confidentiality agreements that restrict which details it may share. As the RNG market matures, that issue should be less and less of an issue, as purchasing should become more akin to buying other sources of power that are bought and sold in commodity fashion. The consequence of the innovative nature of biogas and RNG development means in many cases that the University is considering biogas purchases from entities that have created proprietary processes and must protect confidential business information.

Nevertheless, the University welcomes the chance to discuss its overall approach to biogas and RNG. It has been active in discussing plans and options with students, stakeholders and government bodies and seeks opportunities to actively engage in educational, information sharing and outreach events.

One such avenue is the Campus Sustainability Committee (CSC), which consists of approximately 30 faculty, staff and students, and offers an opportunity for members to provide input and bring feedback to the committee from the groups they represent. The CSC has also strived to be responsive to the University community and allow further discussion and input through several existing and ad hoc subcommittees. One such example includes the special subcommittee charged with studying the feasibility of building a combined heat and power plant (CHP) on campus, which was established in fall 2016. The subcommittee, comprised of faculty, students and staff, reviewed the proposed CHP project including emissions methodology, economic/environmental impact, contract terms and the potential to fuel the plant with biogas. The subcommittee submitted a report to university administrators in April 2017.

Although full consensus was not reached by the subcommittee with respect to whether to proceed on a CHP plant, the subcommittee was generally unanimous in its recommendations in support of biogas and the need for a stakeholder process. Those included:

- Duke University should pursue biogas with vigor for on-campus steam generation including a development timeline and an economic and practical feasibility study.
- If a CHP is built, the plant should be powered by sufficient biogas in year one to make it carbon neutral (accounting for additional methane destruction), and should be 100% biogas by year 5.
- A more comprehensive stakeholder process is needed before finalization.

As a result of the report's recommendations, a decision to move forward with the proposed CHP project was postponed in May 2017, subject to further pursuit of biogas purchases. In April 2018, Duke University announced it would delay indefinitely plans to build a freestanding CHP plant and will instead focus its attention on expanding opportunities to use biogas and other environmentally friendly fuels to meet its growing energy needs.

As the University continues to explore biogas procurement, the CSC will make it a standing item at its quarterly meetings and hopes to share those updates through the Sustainability website. Those updates are expected to include the status of purchasing activities to the extent such details can be shared, policies and questions about potential policy issues, technology and technological breakthroughs, outreach and engagement, and other developments in the biogas and RNG marketplace.

5. What is the timeline for biogas decision-making and project development?

The short answer is the University would like to purchase RNG (derived from biogas) as soon as possible. The reality is that no marketplace yet exists for RNG in North Carolina, and projects can take a long time to develop.

Making a successful purchase is dependent on finding the right combination of price, biogas type and transport method(s). Individual projects, pricing and supplies are constantly in flux as the market for RNG and biogas takes shape, technology improves, transport mechanisms evolve and policies change. Even after a purchase is made, it can take between 18 months and two years for a project to be constructed and RNG injected for delivery.

While a specific timeline is not set, the University is currently in discussion with several promising project developers. It hopes to invest in enough RNG and other associated carbon reductions by 2024 to make the University climate neutral in that year and each year thereafter.

The University is also considering seeking CSC input on what project types to pursue and prioritize. It is considering this step in order to increase transparency regarding the sources from which it plans to procure RNG, even if it is not able to disclose all of the details related to specific suppliers or projects.

6. How does Duke University calculate the emissions reductions from biogas in the CAP?

The assumptions associated with biogas greenhouse gas emissions reductions in the Climate Action Plan are based on Duke University's desire to continue to promote and encourage a market for the development of agricultural anaerobic digestion projects. This will reduce greenhouse gas emissions in two key ways: by reducing the methane emitted from the agricultural operation and by replacing a quantity of fossil fuel natural gas with a renewable natural gas, known as displacement. The details of this process and the calculation for emission reductions are described below.

Agricultural Operation Emissions Reduction

This category of emissions reductions is calculated by comparing emissions in the baseline scenario, which is the agricultural operation before the anaerobic digestion system is in place, to the emissions after the system is installed, called the project scenario.

The baseline scenario is the agricultural operation in its unmodified state, where animal waste is typically stored in an open-air lagoon. This type of storage creates an anaerobic environment where the waste decomposes and emits methane to the atmosphere. Baseline emissions are calculated by taking into account the livestock type, quantity, and excretion rate. These figures are then used to determine the quantity of volatile solids available for degradation, or how much animal waste would decompose and result in methane emissions.

The project scenario calculates emissions associated with the anaerobic digester system. The categories that comprise project scenario emissions are venting emissions, effluent pond emissions, storage/treatment emissions, and digester leakage. These emission levels will vary system to system; however, some of the categories can have zero emissions. For example, a proposal Duke University evaluated involved a system with only effluent pond and digester leakage emissions (common among most anaerobic digester systems).

Also included in the project scenario emissions calculations are the increased energy use associated with running the anaerobic digester, changes in diesel fuel used on the farm, emissions associated with transporting the biogas, and emissions resulting from the eventual combustion of the biogas. The emission reductions are then calculated by comparing the baseline scenario and project scenario for the anaerobic digestion system.

Natural Gas Displacement

The other emission reduction that would result from Duke University purchasing biogas would occur from the biogas replacing a quantity of traditional natural gas in the pipeline. The main emissions reductions associated with this displacement are those associated with the production and transportation of traditional natural gas.

Because the biogas the University would be purchasing will be produced from a renewable source in North Carolina, it wouldn't have to be extracted from deep in the earth and transported through several hundred miles of pipeline. Such a purchase would allow Duke to realize emissions reductions equal to the emissions associated with extracting, processing, and transporting traditional natural gas of a quantity equal to the biogas purchased by the University.

Additionality

In order to have a legitimate carbon offset project, the project must achieve additional reductions as compared to what would have happened if the project had not occurred – in other words, what emissions are reduced as compared to business as usual. This requirement is called additionality and can be determined via a number of tests. The first step, however, is to confirm that no legal requirement exists for the project to occur.

Once it is confirmed that the project is not required by law, further tests are applied to ensure that the project is truly additional. That is, would the project not have occurred but for the potential to generate carbon offsets? The tests can focus either on the financial aspects of the project, the barriers that stand in the way of such projects being implemented, or whether the practice is commonplace. Some carbon offset registries (i.e., organizations that register and track carbon offsets) use a combination of these tests plus other factors to ensure that a project is not receiving a subsidy for achieving emission reductions that would otherwise have happened without the subsidy.

Before any carbon accounting organization will register an offset it requires registrants to complete a test to prove additionality. For example, the University was required to provide proof of additionality as part of its registration of the Loyd Ray Farms project with the Climate

Action Reserve pursuant to the Livestock Project Protocol. Any future biogas projects would undergo similar scrutiny to ensure additionality standards are met.

Regarding whether the practice of capturing biogas on swine farms is so commonplace that it cannot be considered additional, only a minute fraction of North Carolina's swine operations are undertaking biogas capture projects, on the order of less than 10 farms out of more than 2,300. Over time, however, the practice of biogas capture and destruction could move towards becoming a common practice as more projects are developed and more farmers become accustomed to the practice. With respect to all projects that destroy GHGs – be they related to the capture of biogas on swine farms, planting trees to sequester carbon pursuant to the Urban Forest Project Protocol, or the reduction of ozone depleting substances - the University is not only continually striving to create a diverse project portfolio to garner carbon offsets and RNG, but also will hold each project to the highest standards, including with respect to additionality.

Transportation

1. What are some examples of how Duke University has incentivized use of alternative transportation since the 2009 Climate Action Plan?

- Carpooling/Vanpooling
    - There are benefits for students and employees who live off campus and have vehicles 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.
- Bicycling
    - 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.
- GoPass
    - 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. To learn more, visit Duke's Parking and Transportation's GoPass webpage.
- Carsharing
    - Duke provides access to 15 vehicles through its 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.
- Telecommuting and Flexible Work Arrangements
    - Duke University provides guidance for employees regarding telecommuting and other flexible working arrangements. For more information, visit the Human Resources' flexible work options webpage.

2. Which sources of transportation emissions are included in Duke University's CAP?

By Duke University signing the American College and University Presidents' Climate Commitment, it committed to reducing emissions from the following transportation-related sources: employee commuting to and from work, air travel paid for by Duke University, and emissions from Duke-owned vehicles. These transportation emissions accounted for approximately 31% of the University's overall greenhouse gas emissions in FY18. Like many other scope 3 (indirect) emission categories that are very personal in nature and hard to track,

student commuting and student air travel to and from campus or for study abroad are not included in Duke's carbon neutrality goal.

3. What is the current status of bike-sharing at Duke University?

Through partnerships with the City of Durham and Duke University, two independent companies, LimeBike and Spin, operated bike sharing in Durham. However, in early 2019 both LimeBike and Spin discontinued its non-motorized bike-share program in Durham.

On trend with many other medium and large cities in the U.S., the City of Durham is expected to transition to electric scooters in the spring of 2019. Once the City of Durham issues permits to companies, Duke University plans to enter agreements with most approved vendors to allow their products on campus.

4. What is the current status of Duke University's ride-hailing partnerships?

Duke has formed a new partnership with Lyft to provide free transportation for employees and students to certain locations near campus. The partnership replaces Duke's previous pilot program with Uber and will provide enhanced service for students with transportation to and from the Shepherd Nature Trail in Duke Forest. Employees and students will both have free transportation to and from the Duke Lemur Center and the Duke Campus Farm. For more information on the Lyft ride-hailing program, visit Duke's Parking and Transportation's Lyft Rides Program webpage.

5. How many Duke University employees have registered hybrid vehicles or electric vehicles?

As of January 2019, there are 105 registered electric vehicles and 1,365 registered hybrid vehicles that are owned by Duke employees. However, this data is subject to how accurately individuals keep their parking permit data up-to-date and therefore, could underreport the number of low-emission vehicles on campus.

6. What is the current and future status of electric vehicle charging infrastructure on campus?

Duke currently has 19 electric vehicle charging stations around campus with plans to increase charging infrastructure prior to 2020 within Health System areas on campus due to increased demand. Duke's Parking and Transportation Office is also currently assessing expansion into other areas of campus dependent on future grant funding.

7. Could it be possible to make the Chargepoint electric vehicle chargers free to use?

With limited charging infrastructure on campus, it is necessary to make sure that it is appropriately used. Therefore, the charging fee structure is such that it is $0.75/per hour for the first 4 hours of use and then increases dramatically to encourage users to move their

vehicle so that others can charge their vehicles. To learn more about Duke's Chargepoint infrastructure, visit Duke's Parking and Transportation's Electric & Low Emission Vehicle webpage.

8. What is Duke University's position on light rail in Durham?

On February 27, 2019, Duke informed GoTriangle that it would not be able to sign a cooperative agreement for the donation of land and rights of way to the Durham-Orange Light Rail Transit (DOLRT) project due to significant unresolved issues regarding segment of the line that would run above Erwin Road directly adjacent to Duke's hospital, research laboratories and clinics. While Duke and Go Triangle have worked with intensity and good faith over the past few months to address these issues, the fact remains that the proposed DOLRT alignment down Erwin Road is too risky, and potentially dangerous, to the health, safety and livelihood of too many people in this community, and the future viability of the medical and research enterprise at Duke.

Over the past twenty years, as the light rail project has gone through many changes in its proposed route, equipment, funding sources and cost, Duke has been consistent about the significant challenges created by placing a rail line down Erwin Road adjacent to a hospital and biomedical research center. You can read more about the specific issues of concern to Duke here.

Duke enthusiastically supports the creation of a comprehensive regional transit network for this dynamic and diverse area, one that serves everyone and makes the best and effective use of all modes of transportation and new technologies. The University recognizes the transformative effect such a plan could have on members of the community, particularly those in underserved parts of the region. It is a high priority for the continued vitality of the Triangle, and Duke recommits its time and attention to seeking innovative and sustainable solutions.

9. What is the size and distribution of vehicle type of Duke University's current fleet?

In fiscal year 2019, there were 915 Duke-owned vehicles registered. Some of the most common vehicle types include trucks (210 registered trucks), vans (157 registered vans), sedans (95 registered sedans), and SUVs (85 registered SUVs). There are also 24 buses that transport the Duke community around campus. Duke University has purchased large capacity, articulating, hybrid buses and is in the process of procuring two new electric buses that will be on campus starting in 2020. Duke Parking and Transportation has plans to purchase additional electric buses in the future as replacements for existing 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%.

10. Does the emissions forecast for fleet emissions take into account new electric bus purchases?

The forecasted emissions reduction for all transportation related activities is conservatively estimated to be 2% reduction annually. Emission reductions from increased fuel efficiency and electrification of Duke's fleet is included in this conservative estimate. However, the scope and timing of further electrification could effect this impact.

11. Has the Campus Sustainability Committee considered a cap on air travel for departments?

Members of the Campus Sustainability Committee and other campus stakeholders have voiced the idea of limiting air travel or potentially creating incentives to reduce this travel. However, given the primary educational mission and global reach of the University, these type of policies would have to be very carefully considered and evaluated against the potential negative impacts. The University's current approach is to focus on education on impacts and possible alternatives rather than set any type of limit or penalty.

Carbon Offsets

1. What are carbon offsets?

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 represent 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, increase animal habitat, reduced human health risks, creation of educational value for students, and development of beneficial partnerships. Duke University also prioritizes local, state and regional offsets that provide co-benefit to the Duke community. For more information on the criteria the Duke Carbon Offsets Initiative (DCOI) analyzes when performing due diligence on carbon projects and determining what projects to develop and support, please read the DCOI Offsets and Co-benefits Guide.

2. What are some examples of carbon offset projects that the Duke Carbon Offsets Initiative (DCOI) has developed?

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 capture methane, which is used to generate renewable electricity by fueling an on-site microturbine.

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.

Urban Forestry: 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.

3. What are some examples of past Duke Carbon Offsets Initiative (DCOI) projects that have involved students?

- 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 UF 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)

4. How many carbon offsets does Duke University estimate it will need starting in 2024?

This number is dependent on the success of the emission reducing strategies outlined in the Climate Action Plan. Based on current plans, it is estimated that Duke will have approximately 73,000 metric tons of emissions that will need to be offset in 2024 (78% reduction compared to 2007 baseline). However, the estimated carbon offsets needed in 2024 could be higher or lower depending on the success of the recommended emission reduction strategies and other external factors.

5. Does the Duke Carbon Offsets Initiative (DCOI) have a goal of how many carbon offsets will come from local projects?

Though Duke has developed offset projects and purchased offsets from projects outside of North Carolina (and even outside of the U.S.), local projects that are accessible to students and faculty are given the highest priority. This prioritization has resulted in the development of several projects and the purchase of many offsets in North Carolina. As Duke is an international institution with research, operations, and regular student activity occurring around the globe, the DCOI extends project consideration to include compelling projects from around the world, however a project outside North Carolina must include a strong existing Duke relationship and student engagement opportunities.

DCOI is committed to continuing its focus on North Carolina and, to the extent possible, local offset projects towards its mission to provide a diverse portfolio of high-quality offsets to the university. While limiting the geographic scope under consideration also limits the amount and types of projects possible, DCOI acknowledges the importance of investing in visible and accessible projects to the Duke community. Balancing the attention on project proximity to Duke with high standards for legitimate climate impact and project co-benefits will be key in the years leading up to our 2024 carbon neutrality goal.

Academics

1. What are some of the ways Duke University has progressed on its education recommendations in the 2009 Climate Action Plan?

Below are details about progress on different recommendations from the 2009 CAP:

- *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.

2. How many students at Duke University are enrolled in degree-seeking programs that are environmentally or sustainability-focused?

Sustainable Duke works to track students that graduate with degrees that have sustainability learning outcomes. As of academic year 2017-18, 37% of students met this criteria, which has steadily increased since the 2009-10 baseline of 28%.

3. What is the Experiential Certificate in Sustainability Engagement?

After several years of work from the Education Subcommittee of the Campus Sustainability Committee, Duke University approved a new undergraduate experiential Certificate in Sustainability Engagement in fall 2015. This was the first opportunity for undergraduates to officially demonstrate a dedication to and expertise in sustainability studies. To earn the Certificate in Sustainability Engagement, students must take four courses, complete two experiences, and create a public-facing ePortfolio. Their pathway is guided by a self-selected thematic emphasis that weaves throughout the experiences and elective courses.

This certificate facilitates learning, research, and civic engagement that confronts the interconnections between environmental, economic, and social aspects of sustainability. It encourages students to put theory into practice – delve into the complex world of sustainability outside the classroom – where personalities, politics, competing priorities and resource constraints interplay. Students are required to connect multiple disciplines, such as environmental science, economics, public policy, and/or social justice while fostering critical analysis, systems thinking, and practical skills to create engaged leaders in sustainability. 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. For more information visit https://sustainability.duke.edu/academics/certificate.

4. What is Sustainable Duke's Campus as Lab (CAL) program?

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.

The program will officially be launched in the spring of 2019 and students will be invited to submit their past and current projects in an online databased designed by Sustainable Duke.

5. What are some ways that faculty could incorporate sustainability into their courses?

- The Green Classroom Certification was created to provide faculty with the opportunity to reduce the environmental impact of their courses and classrooms at Duke University while demonstrating eco-friendly behaviors to students.
- 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 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 who is interested in incorporating sustainability into their existing courses or a new course. Contact sustainability@duke.edu for more information.

Communication

1. How has Duke University progressed on its recommendations in the 2009 Climate Action Plan?

Below are details about progress on different recommendations from the 2009 CAP:

- *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.

2. What are Sustainable Duke's current outreach and communication methods?

Sustainable Duke communicates through the following methods:

- Social Media
    - Facebook, Instagram, Twitter
- Bi-weekly email-based newsletter to a listserv with 10,000 members
- Weekly "This Week at Duke" events email
- Weekly "Office Hours" on Duke's West Campus
- Campus Sustainability Committee
- Sustainability workshops for the Duke community
- Sustainability-related feature story in each Working@Duke magazine
- Ad-hoc tabling events and meetings to engage the Duke community broadly

3. What does Sustainable Duke envision for the Sustainability Champions program?

Sustainable Duke relies on students, staff, and faculty to help push the needle of sustainability forward in their dorms, classes, workplaces, and labs. Sustainable Duke has hosted dozens of sustainability workshops, which have engaged hundreds of students, staff, and faculty about how they can be more sustainable in their respective corners of campus. The Sustainability Champion program seeks to formalize this effort by recognizing these individuals who want to have a larger impact on campus. While the program has yet to be fully formalized, potential components of the program would include participating in a sustainability workshop, certifying their space through Sustainable Duke's Green Certification program, attempting monthly sustainability challenges, and acting as a sustainability ambassador in their dorm, class, workplace, or lab.

4. What is the Green Grant fund and how is it used by Sustainable Duke?

The Green Grant program managed by Sustainable Duke began in 2005 with the purpose of assisting Duke students, staff, and faculty help make Duke more sustainable. The Green Grant is $50,000 annually and has be used to put on conferences, conduct research, attend conferences, and start new sustainability programs. To learn more, visit Sustainable Duke's Green Grant webpage.