SUSTAINABILITY · UVA
From the Grounds Up

UNIVERSITY OF VIRGINIA

NITROGEN ACTION PLAN

V1.0 April 2019

Contents

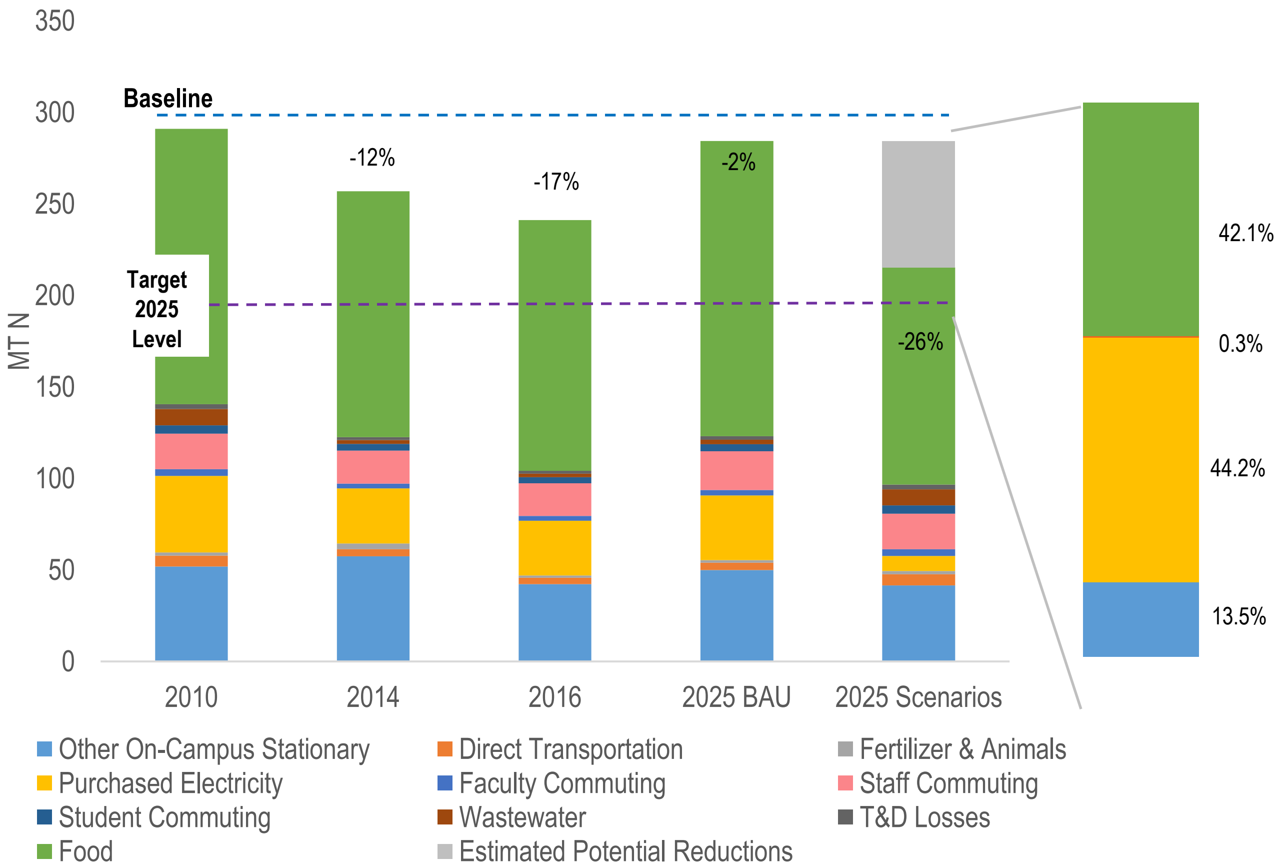
Executive Summary

The University of Virginia (UVA) is committed to reducing the universities nitrogen (N) footprint across its Grounds. In 2013, UVA's Board of Visitors passed a resolution to reduce University-wide N emissions **25 percent below 2010 levels by 2025**. This followed the UVA's Board of Visitors approval of a goal to similarly reduce UVA's greenhouse gas (GHG) emissions in 2011. Additionally, UVA signed on to the Department of Energy's Better Buildings Challenge, which established a goal to reduce building energy use intensity (EUI) 20 percent below 2010 levels by 2020. In 2016, UVA launched its first Sustainability Plan with long-term goals and actions through 2020.

UVA's Nitrogen Action Plan seeks to bring alignment and clarity to UVA staff, faculty, students, and alumni actively and collaboratively implementing strategies within the plan. Additionally, this Action Plan aims to provide the UVA community and its partners with a transparent roadmap of specific strategies for how the University will meet its nitrogen footprint reduction goal, currently projected to require a reduction of approximately 73 metric tons N. As of Calendar Year 2016, UVA has reduced its emissions 17 percent (equivalent to 49 metric tons) below 2010 levels. However, projected growth and expansion at the university will nearly nullify these reductions if we continue to run at a business as usual scenario.

The strategies and their projected impacts outlined in this Action Plan represent potential opportunities to reduce the N footprint across the various sectors of the University, as illustrated in Figure 1 below. For reference, the blue dashed line is the baseline for reductions and the purple dashed line is the 25 percent reduction goal value.

Figure 1: N progress, anticipated growth, and projected impact of N reduction strategies.



Introduction

University Nitrogen goals

The Board of Visitors Sustainability Commitment states: “The University of Virginia will undertake to reduce both annual greenhouse gas emissions and the amount of reactive nitrogen lost to the environment to levels 25 percent below year 2009 and 2010 amounts, respectively, by the year 2025.” The published Greenhouse Gas Action Plan lays out the strategy for achieving the former goal. This document lays out the strategy for achieving the nitrogen (N) goal.

Reactive N is defined as any N that is biologically, photochemically, or radiatively active. Reactive N includes all forms of N except the unreactive N_2, which accounts for about 78 percent of N in Earth’s atmosphere. Examples of reactive N include N oxides ($NOx = NO + NO_2$), nitric acid (HNO_3), nitrous oxide (N_2O), ammonia (NH_3), nitrate (NO_3), and N-containing particles in the atmosphere. Unless otherwise stated, reference to N in this document means reactive N.

Humans create N through the Haber-Bosch process, the cultivation of legumes, and the combustion of fossil fuels. The first two support food production, and the third supports energy use. The Haber-Bosch process also supplies NH_3 for industrial processes. Globally, anthropogenic sources of N are twice as large as natural terrestrial sources. This dominance is so great that human interference with the N cycle was recently identified as one of three global issues where the rate of change cannot continue without significantly impacting Earth-system functioning.

During agricultural production, N is applied as fertilizer or created by the cultivation of legumes (e.g., soybeans). Some of that N is then lost to the environment during each step of the production process. Loss pathways include fertilizer not taken up by a crop, crop processing waste, livestock waste products, and consumer-level food waste. Only about 20 percent of the N used in food production is contained in food products that are consumed; the rest is lost to the environment. When N is consumed as protein in food, it is ultimately released to the environment as human waste, except for sewage that is treated in a sewage treatment facility with N removal technology.

Once in the environment, N causes a cascade of negative impacts. For example, NOx emitted from fossil-fuel combustion drives production of photochemical smog, and together with NH_3 emitted from agricultural processes, leads to the production of pollutant aerosol. Both processes have negative consequences for the health of biota, including humans. Deposition of atmospheric HNO_3 and acidic N-containing particles contributes to acidification of soils and fresh waters. Together with N in surface runoff, this leads to eutrophication of fresh and coastal water bodies, with associated losses of biodiversity. The declining health of the Chesapeake Bay and associated mitigation efforts by surrounding states illustrates the importance of these processes regionally. N_2O is an important greenhouse gas that contributes to global warming and is the major anthropogenic chemical contributing to stratospheric ozone depletion. These and other wider-ranging impacts are significantly degrading the quality of both our environment and health; thus, they warrant concerted efforts to mitigate emissions.

The extensive and detrimental effects of reactive N indicate the importance of managing N efficiently to reduce its loss to and impact on the environment. A first step in managing N at UVA is assessing the current contribution from the University. This was done with the N Footprint Tool (NFT), developed at UVA in 2009 by Allison Leach as part of her undergraduate thesis, and then further refined with help from Andrew Greene, Office of the Architect, and the Sustainability Office. It provided the basis for the BOV commitment in September 2013 for a 25 percent reduction in UVA’s N footprint.

The NFT was the first institution-level N footprint model ever constructed. The use of this tool has allowed the University to assess and reduce its N footprint. In addition, it served as the starting point for other institutions who wish to decrease their impact on the environment. More specifically, it led to the development of the NFT Network, a 20+ collection of institutions of higher education that are determining their own N footprints.

In November 2017, a new integrated campus carbon and N footprint tool was launched, called SIMAP (Sustainability Indicator Management and Analysis Platform). This tool brings together the NFT and the Campus Carbon Calculator, which is a campus carbon (C) footprint tool used by thousands of campuses and based at the University of New Hampshire. This is an important step towards understanding and improving institutional sustainability because tracking the two footprints together provides a broader picture of a campus' environmental impacts. SIMAP also includes the C and N footprint of food production, which is a new addition for the C footprint tool. The overlap between C and N footprints in the energy sector also provides further support for energy conservation strategies.

In 2016, UVA launched its first Sustainability Plan and outlined both long-term goals and short-term actions through 2020, which was later revised to 2025 in the case of the N reduction goal. Included in the Sustainability Plan is a commitment to significantly reduce the use of coal on-Grounds and to increase the percentage of UVA's energy derived from renewables, two activities that will greatly improve UVA's ability to meet its GHG goal.

Purpose of the Action Plan

The primary purpose of UVA's Nitrogen Action Plan is to bring alignment and clarity to UVA staff, faculty, students, and alumni actively and collaboratively implementing strategies within the plan. The Nitrogen Action Plan also aims to provide the UVA community and its partners with a transparent roadmap of specific strategies for how the University plans to meet its Nitrogen reduction goal. The Action Plan is and will continue to be updated as needed, to incorporate new and innovative ideas and technologies. Each version of the Action Plan will be presented to the University Committee on Sustainability for review. For each key area outlined in the plan, detailed implementation plans will be developed in order to fully realize projects.

In addition to providing progress to date on decreasing UVA's N footprint, this action plan provides an overview of the strategies that could be used between now and through 2025 to attain the reduction goal of 25 percent relative to the 2010 N footprint. In some cases, the strategies will be easy to implement; in other cases, they will be more challenging. This is especially true in the food sector because N is needed to grow food, and the process of getting the N into the food is very inefficient. In this regard, none of the strategies will be cast in stone, and all will be subject to review in the future. However, given that UVA was the first institution to determine its N footprint and to set a goal to reduce it, UVA will also be the first institution to show how the goal can be obtained.

Nitrogen Footprint and progress to date

Setting system boundaries

The University houses a diverse population of faculty members, students and staff of various disciplines and lifestyles. In 2010, the UVA full-time population included 18,019 full-time degree seeking students, 4,571 part-time or non-degree seeking students, 12,189 full-time employees, and 1,550 part-time employees. Each member of the UVA community contributes to the system's overall N footprint in distinct ways. A student living on the University Grounds is likely to contribute a large portion of their personal footprint to the overall UVA N footprint because much of their energy use and food consumption will take place in UVA-owned facilities. In contrast, a student living off-Grounds may not have a meal plan and much of their personal energy use will occur in privately-owned facilities. For employees, the UVA N footprint will include their commutes to the university and energy use and food purchased associated with their activities on-Grounds.

In an effort to fairly account for all N lost to the environment as a result of the UVA community's activities, the system lines for the UVA N footprint are bounded by the University's geographical presence as well as the "upstream" consequences of University activities.

The model surveys UVA's main campus in Charlottesville, Virginia, divided among the University's Central Grounds, Health System, and North Grounds. This model takes into account the N lost to the environment due to food consumed in the UVA dining venues, energy used at UVA, animals used in research facilities, fuel used by the University's fleet, and on-Grounds fertilizer application. Any N losses due to food or energy consumption that occur in off-Grounds housing units not provisioned by the university are not included in this model.

The Sustainability Indicators Management and Analysis Platform (SIMAP) is currently being used to calculate and track the university's N footprint. This tool splits both the carbon and N footprints into scopes based on the relation to the university. Scope 1 includes sources of direct campus losses from: stationary sources, mobile sources, and fugitive losses such as fertilizer use, chemicals and refrigerants, and animal husbandry. Scope 2 includes losses from purchased electricity and purchased and sold renewable energy. Scope 3 includes losses from "upstream" and "downstream" activities such as daily commutes by faculty, staff, and students, production and distribution of goods such as food, losses from wastewater and waste treatment.

The upstream N losses include: a) the N released in the production and transportation of food ordered and served in university dining venues, b) the N released to the environment due to municipal sewage treated off-Grounds, and c) the N released in the transportation of commuters to and from UVA. Despite the consideration of food production, upstream production losses associated with other goods purchased by the university, including paper, furniture, and research supplies, are not included in this model at this time due to data and analytical constraints.

Additionally, the model recognizes that UVA fits into the larger system of Charlottesville and operates within the city framework. Thus, N removal in the Rivanna Water and Sewer Authority (RWSA) sewage treatment facility is factored into the UVA N model. N recycled back into the Charlottesville community that leaves the university system, such as through food waste donations and composting, is subtracted from the overall footprint because it has left the UVA system and is then re-used.

As data and reporting methodologies improve in coming years, total emissions figures will be recalculated. The numbers cited in this report are based on most current methodology. These values should not be compared with future results without first accounting for variations caused by inventory methodology. Future reports will evaluate differences in methodology and provide the relevant context for cross-referencing information over time.

The Baseline

UVA's baseline N footprint was 290 MT N in 2010. The food sector (consumption and production) contributed approximately 52 percent of the total N losses. Energy-related activities (electricity, heating, transportation) contributed approximately 45 percent of the total and wastewater contributed the remaining 3 percent of the total footprint.

2014 N Footprint

In 2014, the N footprint was 257 MT N, a decrease of 11 percent below the 2010 N footprint. The energy sector's N losses decreased from 130 MT N to 117 MT N, the food sector's N losses decreased from 150 MT N to 134 MT N, and the wastewater sector's N losses decreased from 9 MT N to 2 MT N. The energy sector N reductions were caused by a decrease in purchased electricity and coal consumption, resulting in less NOx emissions than the baseline. The food sector N decreases were primarily due a reduction in meat purchases. Finally, the wastewater sector N losses decreased due to a one-time only improvement in wastewater treatment at the RWSA sewage treatment facility, as Charlottesville switched over to tertiary water treatment.

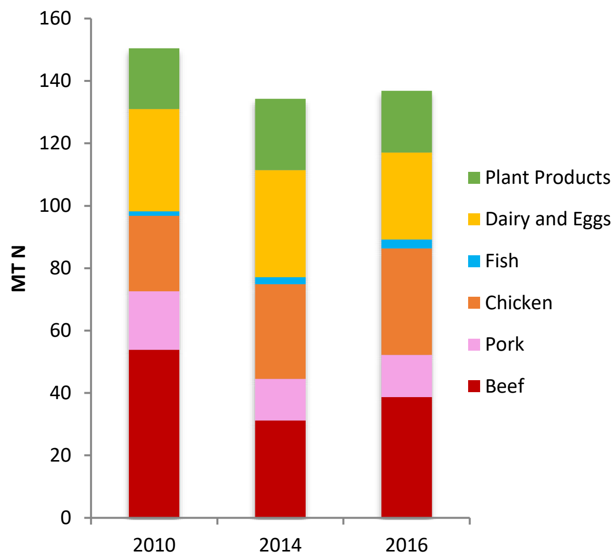
2016 N Footprint

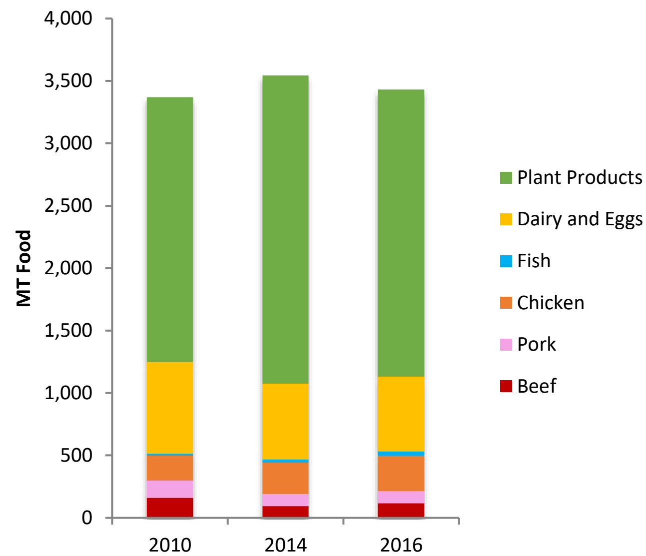
In 2016, the N footprint was 241 MT N, a decrease of 17 percent below the 2010 N footprint. From 2014 to 2016, the main driver of the N loss reductions was in the energy sector which experienced a decrease from 117 MT N to 101 MT N. This was specifically driven by a decrease in on-campus stationary energy use that resulted in a decrease of N losses from 57 MT N to 42 MT N. Despite decreases in total food weight purchases, there was a slight increase in the food sector from 134 MT N to 137 MT N due to an increase in beef purchasing.

Food Sector contributions to the Nitrogen Footprint

The food sector comprises the majority of UVA's N Footprint. Because of this, it is important to consider how the food sector's contributions have changed over time, and what within the food sector drives these N losses. Figure 2 illustrates the N losses from food within 6 major categories as well as how much food weight is purchased amongst those categories. While less than a quarter of food weight purchased at UVA is meat, it accounts for over half of the N losses for food. Beef contributes the largest N losses per ton purchased, due to its low N efficiency in production. This helps explain why a small increase in beef purchasing in 2016 can drive overall increases in the food sector's N footprint. The Food and Dining scenarios outlined in this document aim to address these observations.

Figure 2: Food sector composition for 2010, 2014, and 2016 measured in nitrogen and by weight





Outlook for the future

While it is heartening that great progress has been made towards UVA's 25 percent reduction goal, it is sobering to see what will happen by 2025 if no further action is taken. Due to projected growth in student and staff numbers and gross square footage of facilities, UVA's N footprint will increase to 284 MT N with business as usual projections, very nearly what it was in 2010, with a minimal 2 percent reduction in nitrogen emissions (**Figure 1**). This necessitates the implementation of new initiatives as outlined in the following scenarios in this document.

Understanding the University's Nitrogen Footprint

The university's N footprint in our baseline year of 2010 was 290 metric tons of N. This is equivalent to fertilizer for ~4,500 acres of corn, or NOx emitted to the atmosphere from ~47,000 people's yearly travel, or sewage treatment for ~35,000 individuals over a year. Reducing the N footprint of the university can produce fewer detrimental environmental effects in our local communities within the Chesapeake Bay region.

The average per capita N footprint for a full-time equivalent UVa attendee (student/faculty/staff member) was about ~14 kg N/capita/yr in 2010. This dropped to ~12 kg N/capita/yr in 2016 as the N footprint of the university decreased to 241 MT N.

This compares to the US average footprint of 39 kg N/capita/yr. However, the system bounds for the university population is limited to activities occurring on grounds. The N footprint calculation does not consider at-home energy use, food purchased outside of the university, and personal transportation outside of commuting to and from the university. Individual N footprints for personal activities can be calculated using calc.nprint.org.

Greenhouse gas and energy reduction scenarios:

The greenhouse gas (GHG) and energy reduction scenarios outlined in this Nitrogen Action Plan were previously published in UVA's GHG Action Plan. The GHG Action plan was developed by the Energy and Emissions Task Force, facilitated by the Office for Sustainability and comprised of individuals across several disciplines in Facilities Management, Parking and Transportation, the Green IT Working Group, and the Offsets Task Force. The strategies in the GHG Action Plan aim to reduce GHGs and energy by decreasing the fossil fuel combustion and purchased electricity needed to power UVA. These strategies include the co-benefit of reducing nitrogen. Below are brief descriptions of the GHG and energy reduction scenarios as well as their associated nitrogen impacts. For more information regarding these strategies, please refer to the GHG Action Plan.

Table 1: UVA GHG and energy nitrogen reduction scenarios

Scenario Type	Section	Scenario Name	Percent Reduction	MT N Reduced
1. Energy Generation Optimization	1.1	Fuel optimization	3.26%	9.5
	1.2	Chilled water plant efficiency improvements	0.41%	1.2
	1.3	Heat plant efficiency improvements	0.14%	0.4
	1.4	Distribution efficiency/LTHW	0.34%	1.0
	1.5	Dominion electricity grid improvements	0.55%	1.6
2. Renewable Energy	2.1	On-grounds solar	0.14%	0.4
	2.2	Off-grounds utility scale solar (UVA Hollyfield)	1.41%	4.1
	2.3	Off-grounds utility scale solar (UVA Puller)	1.27%	3.7
	2.4	Additional off-grounds utility scale solar	3.51%	10.2
3. Existing Buildings	3.1	Existing building improvements	2.10%	6.1
4. New Construction and Major Renovations	4.1	Green Building Standards	0.41%	1.2
	4.2	Green Building Standards (Stretch)	0.41%	1.2
5. Green Labs	5.1	Green Labs	0.27%	0.8
6. Transportation	6.1	Gasoline fleet improvements	0.10%	0.3
	6.2	Diesel fleet improvements	0.34%	1.0
7. Awareness and Individual Action	7.1	Outreach and engagement	0.21%	0.6
8. Green IT	8.1	Green IT	0.14%	0.4
Total		**All scenarios**	**-15.02%**	**43.7**

1. Energy generation optimization

UVA generates most of its heating and cooling energy in district energy plants, then distributes that energy to facilities through an extensive underground network of steam, medium-temperature hot water (MTHW), low-temperature hot water (LTHW), and chilled water piping. Centralized energy generation has many energy efficiency benefits and presents many opportunities to further reduce energy and water use as well as N losses.

1.1 Fuel optimization: The UVA Main Heat Plant uses coal, natural gas, and distillate fuel oil to generate steam and heating hot water to heat the majority of its facilities. UVA is currently working to understand and remove the barriers in natural gas supply to eliminate the use of coal.

1.2 Chilled water plants efficiency improvements: The University uses electricity and water in its chiller plants to generate 42°F water, which it uses to provide air conditioning to its facilities. Because the chiller plants consume more than 20 percent of the purchased electricity and 25 percent of the water at the University, it is a primary target for energy and water efficiency initiatives and N reduction strategies.

1.3 Heat plant efficiency improvements: Driving the thermal efficiency of the Main Heating Plant from the 80-82 percent range to 83-85 percent is an integral element of the work of heat plant operating staff. Leading up to 2020, a focus will be placed on optimizing UVA's plants. Work beyond then will focus on maintaining efficiency gains and implementing other strategies for the district energy systems on-Grounds

1.4 Distribution efficiency/Low Temperature Hot Water (LTHW): UVA operates an existing district heating system centered on the Main Heating Plant, which produces saturated steam and MTHW for campus heating and other uses. LTHW generation and distribution systems can be more efficient than steam systems and even MTHW because energy generation is much more efficient at lower temperatures plus less heat is lost in distribution between the points of generation and consumption. Furthermore, LTHW systems can to take advantage of more efficient technologies such as waste heat recapture that then reduces electrical and water consumption.

1.5 Dominion electricity grid improvements: Emission factors for purchased electricity take into account the fossil fuels used to generate the electricity. While emission factors for purchased electricity in this area of the country have remained relatively stable since 2010, it is anticipated that Dominion will decrease their use of coal in electricity generation and increase their renewable energy or use of natural gas between 2017 and 2025.

2. Renewable energy

Renewable energy is an important strategy being utilized by UVA to reduce its energy dependence on fossil fuels. The transition from fossil fuel generated electricity to renewable energy such as solar power, will assist UVA reduce its GHG emissions and N losses.

2.1 On-grounds renewable: UVA is working with consultants to develop and identify optimal locations and funding mechanisms for additional building-mounted PV and solar thermal projects on Grounds.

2.2 Off-grounds utility-scale: UVA and its Darden School of Business have entered into a solar power partnership with Dominion Virginia Power. The UVA Hollyfield Solar project, owned by Dominion, who will construct and operate it, is expected to produce an estimated 17 megawatts of alternating current (AC) power, a figure representing about 10 percent of the University's electrical demand.

2.3 Additional off-grounds utility-scale: UVA continues to explore other utility-scale solar opportunities and seeks to add another utility-scale renewable project in the future. UVA will also actively pursue additional installations and will move forward as funding allows.

3. Existing buildings

UVA owns approximately 550 buildings ranging in age from 210 years old to newly constructed. These buildings span from just a few dozen square feet to over a million square feet and serve an array of functions including academic and medical research, education, patient care, housing, and office space. While the majority of UVA's buildings present opportunities to improve energy efficiency, the wide range of buildings require various types of interventions and building-specific implementation plans.

3.1 Existing buildings: To successfully achieve energy reductions across the building portfolio, projects will be identified and implemented as systematic technology rollouts, as building-specific optimization, or through enhanced preventative maintenance activities.

4. New construction and major renovations

UVA continues to expand research activities, medical services, patient visits, academic offerings, and associated support services. To meet this growth, there are extensive and continuous construction projects to build new and renovate existing facilities. The additional space presents opportunities to improve energy efficiency and sustainability while simultaneously adding to the GHG footprint of the University. UVA developed Green Building Standards (GBS) under the Facility Design Guidelines that prescribe minimum requirements for all new construction and major renovation projects. The GBS embed requirements for equipment efficiency as well as design guidelines based on best practices for energy efficiency at UVA. The most significant element that will affect the energy efficiency of new and renovated buildings on-Grounds is a requirement to achieve a minimum 25 percent reduction in energy use intensity (EUI) as compared to an EUI of a similar usage type building, to be determined by UVA. Projects will also be required to evaluate the feasibility of deeper energy reductions and demonstrate that the project analyzed options through energy modeling and life cycle costing.

5. Green Labs

UVA's research activities and medical testing laboratories require energy intensive infrastructure. There are a multitude of facilities on-Grounds, which house research and medical testing with varying requirements for handling hazardous chemicals and biological agents. Additionally, the laboratories require power-hungry equipment to preserve and support research. The energy reduction approach with UVA's laboratory spaces is right-sizing equipment and infrastructure relative to the need of the Principal Investigator's research.

6. Transportation

GHG emissions are generated by Facilities Management's vehicle fleet burning fossil fuels such as gasoline. Some of these vehicles transport people and materials to and from job sites, and other machines use distillate oil (diesel and gasoline) to perform work, like blowing leaves and mowing lawns. As the workforce at UVA continues to increase, the UVA bus and vehicle fleets will consequently increase as well.

2.4 Gasoline fleet improvements: UVA has started assessing the fleet through a LEAN Initiative for Facilities Management. Through this process, UVA has laid groundwork that will result in improved processes, reduced waste, and better use of resources. The end goal is to define a high-value fleet that allows UVA staff to perform their duties efficiently, with the least amount of fuel consumed.

2.5 Diesel fleet improvements: Parking and Transportation has developed a long-range fleet replacement plan that will result in more fuel-efficient buses that are built to adhere to more recent emission regulations issued by the Environmental Protection Agency. As new buses are put into service, older and less fuel-efficient buses will be retired. UTS buses are also equipped with various levels of technology that allow Parking and Transportation to evaluate idle times and passenger count trends. These technologies could be used to improve route efficiency, reduce idling, and optimize vehicle miles traveled.

7. Awareness and Individual Action

Outreach and engagement programs aimed at reducing energy use on-Grounds have been in existence for over a decade. The 2016-2020 UVA Sustainability Plan includes a goal to further increase sustainability awareness and outlines educational strategies to expand programs that translate awareness into action.

8. Green IT

Computer use and IT infrastructure are extensive throughout UVA, consuming an estimated 5 percent to 15 percent of all electricity on-Grounds, but the diffuse operation and management of IT equipment creates a challenge for assessing and understanding the N footprint. Through the Green IT Working Group, other inter-departmental IT committees and task forces, and the Office for Sustainability, UVA will begin cataloging computing systems across Grounds as a first step toward assessing opportunities for improving efficiency

Food and Dining Scenarios:

The production and application of fertilizer, biological fixation of nitrogen in legumes, and livestock waste production are all upstream pathways in food production that release reactive nitrogen into the environment, which is included in scope 3 analysis of UVA's N footprint. Food accounted for 52 percent of UVA's N footprint in 2010, and 57 percent in 2016. As a major contributor of nitrogen emissions, and an increasingly large portion of UVA's nitrogen emissions, it is important to work with relevant stakeholders, including UVA Dining and the UVA Health System Dining, to develop food specific scenarios to mitigate these associated nitrogen losses.

Table 2: UVA food and dining nitrogen reduction scenarios

Scenario Type	Section	Scenario Name	Percent Reduction	Mt N Reduced
1. Plant-Forward and Vegetarian Scenarios	1.1	15% vegetarian meal replacement	-4.10%	11.93
	1.2	Meat-focused Cafe becomes plant forward	-2.20%	6.38
	1.3	Plant forward Castle	-0.46%	1.33
	1.4	Plant forward themed meals (3 total/month)	-0.77%	2.23
	1.5	Plant forward Fridays in all dining halls	-0.10%	0.30
2. Sustainable Meat Scenarios	2.1	20% beef subbed with chicken	-2.18%	6.33
	2.2	Blended Burgers in all dining halls	-0.28%	0.80
3. Health System Scenarios	3.1	10% beef subbed with chicken	-0.31%	0.90
	3.2	15% burgers replaced with Beyond Burgers	-0.25%	0.73
	3.3	5% beef subbed with chicken	-0.16%	0.46
	3.4	Mindful Mondays	-0.05%	0.15
	3.5	One station with no beef for 6 months	0.00%	0.01
4. Other Food Scenarios	4.1	50% avoidable food waste reduced	-0.18%	0.53
	4.2	50% of food is sustainable	-0.05%	0.15
Total		**All scenarios**	**-11.09%**	**32.23**

1. Plant-forward & Vegetarian Scenarios

Meat and animal products have higher virtual nitrogen factors due to resource intensity as food sources go up trophic levels. Increasing purchases of plant sources of nutrition, while decreasing meat and animal product purchases, is a strategy for nitrogen footprint reductions.

A number of these scenarios involve encouraging "Plant Forward" meals. Aramark has been introducing new Plant Forward recipes that are intended to be healthier and more sustainable, while still being tasty for all types of eaters. Plant Forward meals are frequently vegetarian or vegan, but when they do include meat, the portion is limited to 2 oz in implementation of the recipes. These recipes are derived from concepts in "Menus of Change," which defines "plant-forward" food as: A style of cooking and eating that emphasizes and celebrates, but is not limited to, plant-based foods—including fruits and vegetables (produce); whole grains; beans, other legumes (pulses), and soy foods; nuts and seeds; plant oils; and herbs and spices—and that reflects evidence-based principles of health and sustainability.

- **1.1 15% vegetarian meal replacement:** In this scenario, dining would aim to increase the number of vegetarian meals served by 15 percent in all dining halls. This can be achieved through continued promotion of existing vegan stations and other vegetarian options in the dining halls, and by increasing awareness about options and the ability to ask for dishes without meat.
- **1.2 Meat focused cafe becomes plant forward:** In this scenario, a food cafe that serves meat-focused dishes would be replaced with a plant forward Restaurant.
- **1.3 Plant forward Castle:** This scenario was implemented in Fall of 2018 and replaced a previously burger focused dining location with an entirely plant forward establishment. This location now serves plant forward meal options, that makes plants the focus of dishes, and offers plant-based, chicken, and fish protein options.
- **1.4 Plant forward themed meals:** In this scenario, there would be 3 total plant forward themed meals each month, circulating amongst the 3 main dining halls (Fresh Food Co., Ohill, and Runk), and applying to all of the meal stations.
- **1.5 Plant forward Fridays in all dining halls:** In this scenario, one traditionally meat and animal-product focused station at each of the three main dining halls (Fresh Food Co., Ohill, and Runk) would serve a plant-forward meal instead on every Friday.

2. Sustainable Meat Scenarios

Although meat products overall have higher virtual nitrogen factors, white meats are more nitrogen efficient than red meats, and strategies can be implemented to make items involving red meat more sustainable. By developing strategies that address this and decrease red meat purchasing, demand for meat products can still be met while decreasing associated nitrogen emissions.

- **2.1 20% beef subbed with chicken**: In this scenario, 20 percent of beef served in all dining locations would be replaced with chicken. Stations can be analyzed for opportunities to switch beef items for chicken, and meat mixtures can be explored in order to dilute the presence of beef.
- **2.2 Blended Burgers all dining halls:** This was implemented in 2018 and makes all dining hall burgers a blend of 80 percent beef and 20 percent mushrooms.

3. Health System Food Scenarios

The Health System food purchases accounted for 20 percent of the total food weight purchased in 2016. However, its Dining System operates independently of Central Grounds Dining. This necessitates individualized scenario creation for the Health System in order to ensure progress in all sectors with great potential to increase UVA's nitrogen footprint.

3.1 10% beef subbed with chicken: In this scenario, 10 percent of all the beef served within the UVA health system would be replaced with chicken. This can be implemented by discussing new menu items with the chefs at the health system and coming up with new recipes that use chicken instead of beef.

3.2 15% burgers replaced with Beyond Burgers: In this scenario, 15 percent of the beef patty burgers served in the health system would be replaced with entirely plant-based "Beyond Burgers." This can be achieved by hosting a launch event for these patties in order to communicate this option to the public.

3.3 5% beef subbed with chicken: In this scenario, 5 percent of all the beef served within the UVA health system would be replaced with chicken. This can be implemented by discussing new menu items with the chefs at the health system and coming up with new recipes that use chicken instead of beef.

3.4 Mindful Mondays: In this scenario, the health system would aim to serve meatless options on Mondays and advertise it as "mindful" to be appealing to all people.

3.5 One station has no beef for 6 months: In this scenario, one of the eight stations in the health system cafeteria that traditionally serves beef would stop serving beef for 6 months and offer alternative proteins.

4. Other Food Scenarios

This section includes other initiatives relating to food that impact nitrogen losses.

4.1 50% avoidable food waste reduced: In this scenario, half of all food waste that had been overproduced, overcooked, or expired would be avoided. This can be achieved through analysis of LeanPath reports to look for areas of opportunity to decrease food waste. Communication of this goal to managers and their teams will help them improve their practices to reach this goal.

4.2 50% sustainable food purchases: In this scenario, UVA Dining will aim to purchase 50 percent of food served at the university that is considered sustainable by AASHE STARS standards.

Wastewater Scenarios:

Table 3: UVA wastewater reduction scenarios

Scenario Type	Section	Scenario Name	Percent Reductions	MT N Reduced
1. Wastewater	1.1	Stormwater retention reductions	0.07%	0.2
Total		**Wastewater scenarios**	**0.07%**	**0.2**

1. Wastewater Scenarios

1.1 Stormwater retention reductions: Efforts to reduce the amount of N in stormwater have a minimal effect on the University's N footprint. However, these scenarios are important to include in the N action plan for consistency. This storm water retention scenario includes implementing strategies to reduce the N content of stormwater before reaching the Rivanna Wastewater Treatment Plant which will in turn reduce the amount of N the university is producing via wastewater.

Research and Development

Ongoing research and development of new methods to track and reduce the university's N footprint is essential to meeting our reduction goal. New projects allow the university to see a broader picture of the intuition's environmental impact and test potential reduction strategies. These research projects are conducted by the university's Nitrogen Working Group (NWG) and mostly student led with internship support from the Office of Sustainability. Below, a short description of current projects is listed:

- **Scope 3 calculation expansions:** The NWG is expanding into measuring Scope 3 emissions, which include purchased goods and services (paper, etc.), along with upstream and downstream emissions. A pilot study of the emissions of purchased paper good is ongoing in Clark Hall but will eventually expand to other purchased products and the wider University. This work will give a broader picture of UVA's nitrogen emissions and show new areas in which to improve.
- **Sustainable food labeling research:** The NWG's Food Labeling Research Team studies how environmental impact labeling and social psychology interventions can influence students to make more sustainable food choices. This research could help UVa reach its institutional N footprint reduction goals because students' food choices make up a large portion of the institutions' footprint. Ultimately, we hope to use these findings to inform targeted marketing efforts at University Dining locations.
- **Educating students about plant-based benefits:** A student run contracted independent organization (CIO), Veggies of Virginia, conducts and annual "Plant-Based Pledge for Earth Week" campaign to educate other students about the environmental impact of animal agriculture. In this campaign, students are exposed to information about how plant-based diets, and a proportion of them subsequently adjust their behavior to consume fewer animal products, saving a multitude of nitrogen resources and decreasing their N footprint.
- **Community NFT:** The community nitrogen footprint tool addresses the N footprints associated with losses outside of the institution setting. Using this tool in the city of Charlottesville and Albemarle County can help the university determine their impact on the N footprint of the surrounding community.
- **N Footprint of hydroponics:** The NWG, in partnership with Babylon Micro-Farms, Inc, is investigating whether produce grown in a hydroponic system generates less N pollution then conventionally raised produce. Initial results for lettuce show that hydroponic production is less than half as polluting than conventional production. Future experiments will work on how to make the former systems even more N-efficient.

Offsets

UVA is committed to meeting its GHG and N reduction goals. If it appears that internal reductions will not be enough to meet the 2025 target year, UVA recognizes a possible need to purchase offsets as a short-term reduction strategy. As outlined in this and the GHG Action Plan, internal mitigation strategies, avoiding, reducing, and replacing sources of emissions and N, will be prioritized. Offsetting emissions and N losses on a short-term basis would allow the University to cover any identified gap between the University's actual reductions and the reduction target.

The offsets UVA would prioritize, if necessary, would include co-benefits, such as a local project that provides educational opportunities and/or N benefits. Approaches to purchasing offsets may include (but are not limited to) purchasing carbon dioxide equivalent offset-credits from the voluntary carbon market, creating and verifying GHG offsetting projects on Foundation property, and the acquisition of renewable energy credits (RECs). As UVA considers creating offset projects on Foundation lands with both carbon and N benefits, UVA will follow Second Nature's guidelines for producing peer-reviewed and innovative offsets.

For more information regarding UVA's position on offsets, please refer to the GHG Action Plan.

Conclusion

In 2010, UVA was the first institution to determine its N footprint; in 2013, it was the first institution to set a goal to reduce it. With this document, it becomes the first institution to show how the goal can be obtained. Thus, this document not only provides UVA with a roadmap on how to meet the goal, but it also sets the example for other schools to use as a starting point in their own assessments. Efforts to share knowledge on how the nitrogen footprint tool can be used began in 2013 with support from the US EPA to begin the Nitrogen Footprint Tool (NFT) Network. The NFT Network began as a collection of 8 schools calculating their N footprint and has expanded to 20+ schools involved in tracking and calculating N footprints. In 2017, the Sustainability Indicators Management and Analysis Platform (SIMAP) launched out of the University of New Hampshire with cooperation from UVA which combined the carbon and N footprint institution calculators in an online platform. To date, there are 400+ institutions tracking their GHG and N footprints in this platform. UVA is a leader in N footprint calculations, tracking, and goal setting among these universities!

To learn more about the N footprint, please see the resources below:

General Information on reactive nitrogen and nitrogen footprints

- N-print website: http://www.n-print.org/
- Leach, AM, JN Galloway, A Bleeker, JW Erisman, R Kohn, J Kitzes. 2012. A nitrogen footprint model to help consumers understand their role in nitrogen losses to the environment. *Environmental Development* 1 pp. 40-66.
- Erisman, JW, JN Galloway, S Seitzinger, A Bleeker, N Dise, AM Leach, W de Vries. 2013. Consequences of human modification of the global nitrogen cycle. *Philosophical Transactions of The Royal Society B*. 368.1621.
- Galloway, JN, J Aber, JW Erisman, S Seitzinger, R Howarth, E Cowling, J Cosby. 2003. The nitrogen cascade. *BioScience*. 53, 4. 341-356.

Nitrogen Footprint Calculators

- Personal N footprint: calc.nprint.org
- Institution N footprint (SIMAP): unhsimap.org/home
- Chesapeake Bay Nitrogen Footprint: https://secure.cbf.org/site/SPageNavigator/bay_footprint.html
- Community Nitrogen Footprint: https://libraetd.lib.virginia.edu/public_view/fn106z48v

Calculating an Institution N Footprint: Methodology

- Leach, AM, AN Majidi, JN Galloway, A Greene. 2013. Toward institutional sustainability: A nitrogen footprint model for a university. *Sustainability: The Journal of Record* 6: 211-219.

- Special Issue in *Sustainability: The Journal of Record* on Nitrogen Footprints: https://www.liebertpub.com/toc/sus/10/2

This action plan was assembled by the Nitrogen Working Group, a subset of the Environmental Stewardship Subcommittee which is under the Committee of Sustainability in the University of Virginia's Office of Sustainability. Essential members within the Nitrogen Working Group included: Rachel McGill, Alicia Zheng, Elizabeth Dukes, Andrew Pettit, and James Galloway. Collaboration with the University of Virginia dining coordinators, UVA health system dining coordinators, and facilities management was essential in making this action plan possible.