

VANDERBILT



UNIVERSITY

BLUESKY ENERGY VISION

FINAL REPORT DECEMBER 2018

BlueSkyVision

In support of FUTUREVU»»

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Foreword



FutureVU, Vanderbilt University's vision for the future of our campus, focuses on the importance of collaboration and shared purpose. Collaboration among the Vanderbilt community, including students, faculty and staff and with the vibrant city of Nashville that surrounds our beautiful campus. We must also hold a shared purpose of enhancing and promoting sustainable behaviors and practices in our community.

FutureVU is guided by core principles, including an adherence to sustainable practices, to ensure changes made to the campus environment are in support of Vanderbilt's Academic Strategic Plan. To ensure the long-term success of FutureVU, Vanderbilt must strive to achieve the highest standards of sustainability with a focus on environmental, social and economic responsibility.

The early planning process of FutureVU included initial recommendations to promote sustainability. In November 2017, the leaders of FutureVU, including the Division of Administration, decided to take these guidelines a step further and introduced the BlueSky Energy Vision Study. BlueSky is a bold goal for Vanderbilt to reduce its carbon footprint by bringing together diverse campus partners to address a complex set of issues with big ideas and out-of-the-box thinking. The shared vision and collaborative approach are what will drive BlueSky toward its goal of making Vanderbilt's energy consumption more efficient.

As a top research university, we have a responsibility to model sustainable energy consumption. Vanderbilt is committed to being a leader in how we contribute positively to our environment. That commitment is reflected in the BlueSky effort. FutureVU and BlueSky are examples of what Vanderbilt does best: bringing together students, faculty and staff to consider distinct solutions to a complex set of topics. Those collaborative efforts are why Vanderbilt will achieve the BlueSky vision.

Sincerely,

Nicholas S. Zeppos
Chancellor



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Executive Summary

BlueSky Energy Vision Background

Sustainability has been an issue of increasing importance at Vanderbilt University throughout its recent history. Starting with the establishment of the Vanderbilt Environmental Advisory Committee in 2000, a variety of stakeholders have been involved in and pushed for actions on this important front as demonstrated in Figure 2. With the completion of FutureVU,¹ initiated in 2017, FutureVU calls for leadership in reducing greenhouse gas emissions to zero while creating a walkable, sustainable campus. FutureVU is driven by a core set of principles, defined with significant input from the Vanderbilt community, that recognizes the need for Vanderbilt to continue to lead on issues of sustainability. FutureVU launched the BlueSky Energy Vision Study (BlueSky Vision) in January 2018 to re-envision the campus energy infrastructure and to identify effective strategies for reducing carbon emissions on campus from the 2016 Greenhouse Gas (GHG) Emissions Baseline, Figure 1.

¹ FutureVU Executive Summary summarizes the planning process, provides a brief overview of the information gathering phase and campus analysis, and emphasizes the guiding principles.

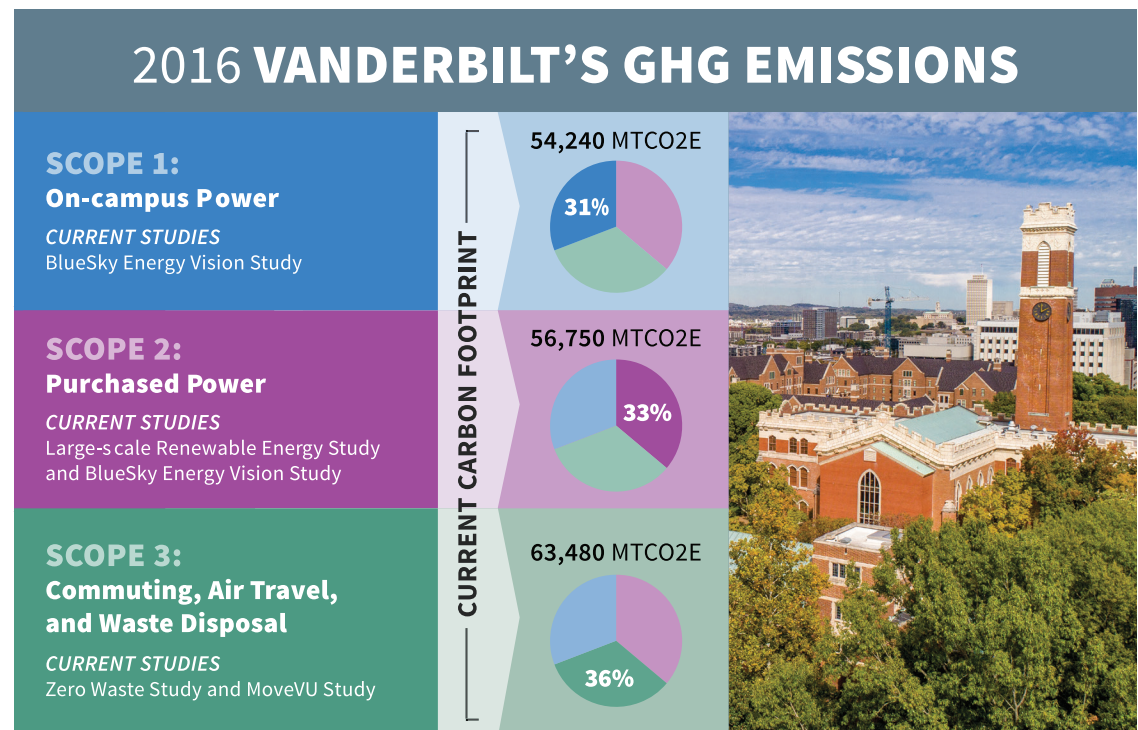


Figure 1. Vanderbilt's 2016 Greenhouse Gas Emissions Baseline

Vanderbilt University Sustainable Action Timeline

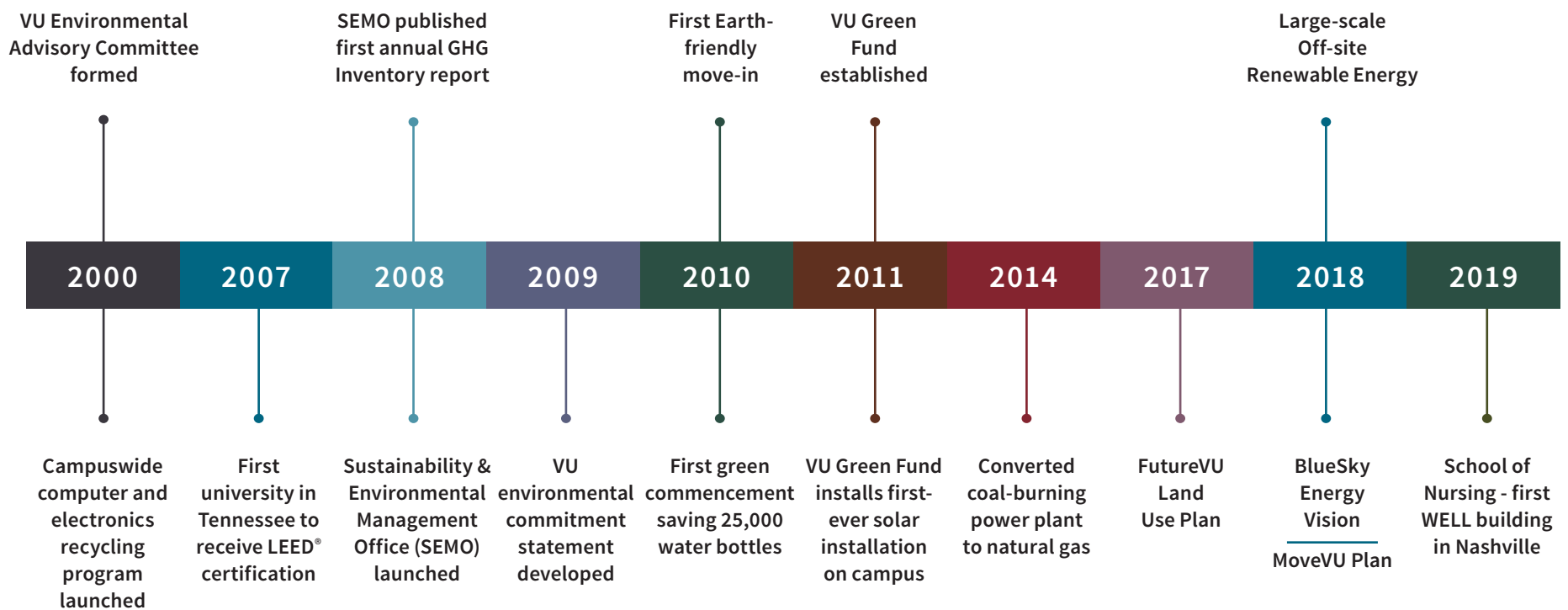


Figure 2. Vanderbilt Leadership Major Sustainable Action Timeline

A VIBRANT, CONNECTED & PEOPLE-CENTERED VANDERBILT

FutureVU Principles: Vanderbilt University

- Is an internationally recognized research university with strong partnerships among its schools
- Believes diversity and inclusion are integral to its mission
- Is a community of neighborhoods
- Is a historic, multilayered and vigorous campus
- Is a university that resides in a unique and distinctive park setting
- Is a walkable and sustainable campus
- Is a citizen of Nashville and the region



Total Campus

- 333 acres
- 177 buildings
- Total physical plant:
9 million square feet
- Real estate (54 buildings)
2.7 million square feet

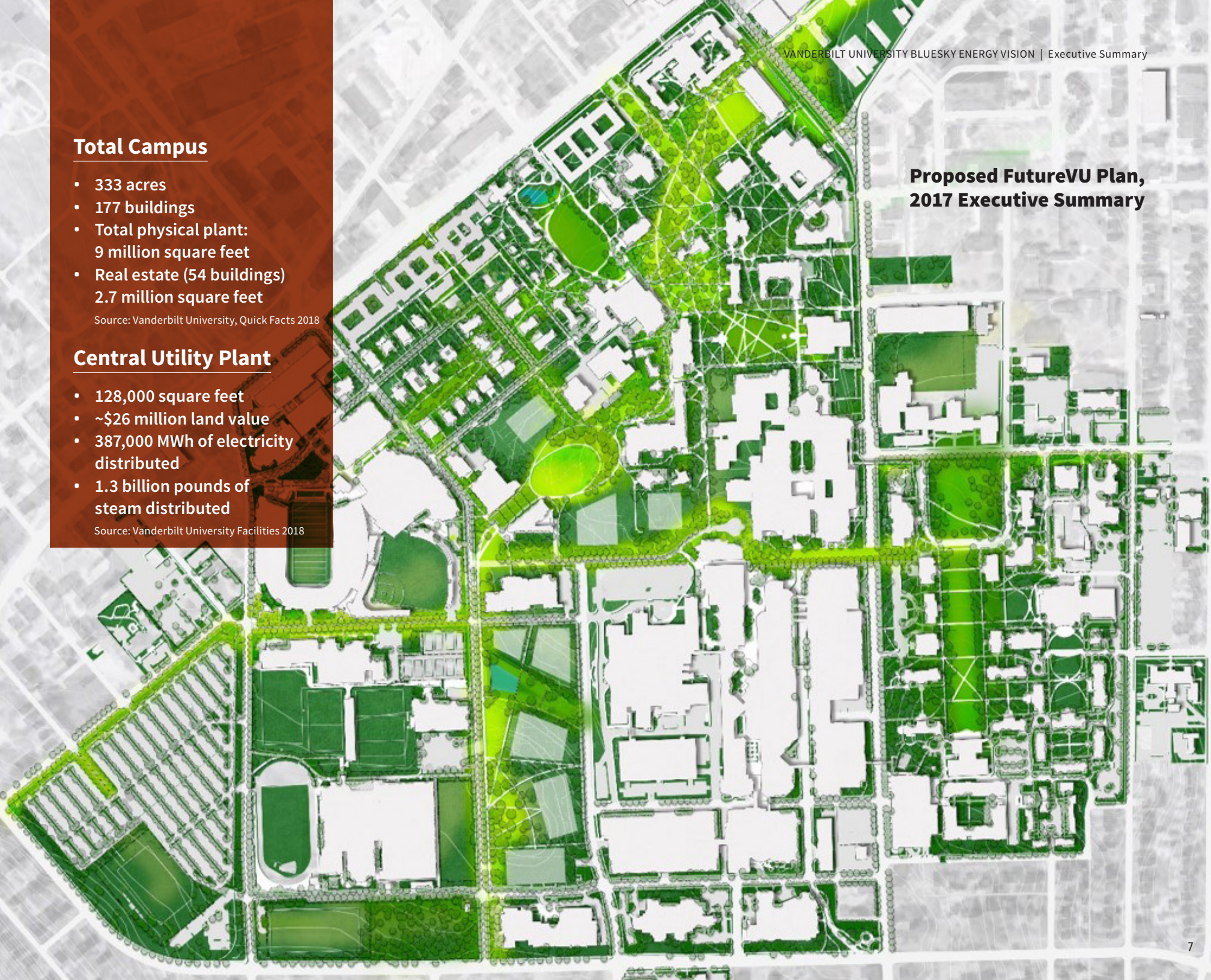
Source: Vanderbilt University, Quick Facts 2018

Central Utility Plant

- 128,000 square feet
- ~\$26 million land value
- 387,000 MWh of electricity
distributed
- 1.3 billion pounds of
steam distributed

Source: Vanderbilt University Facilities 2018

Proposed FutureVU Plan, 2017 Executive Summary



Crafting the BlueSky Vision

In order to develop a road map to reduce on-site emissions to zero, the BlueSky process uses a backcasting technique (rather than forecasting) to work backward from the desired future state, plotting necessary actions and milestones to achieve future goals. The BlueSky Vision supports FutureVU Guiding Principles and Vanderbilt's Academic Strategic Plan. Vanderbilt continues to demonstrate its commitment to its core values of teaching and student involvement (2018 Princeton Review Top 50 Green Colleges) and research and discovery (2018 Reuters Top 10 World's Most Innovative Universities). In 2018, 63% of students surveyed for the Princeton Review's "College Hopes & Worries Survey" reported that information about a college's commitment to the environment would positively influence their application or enrollment decisions.



Figure 3. Student participant at a visioning session (courtesy of Vanderbilt)

Crafting the BlueSky Vision included understanding how digital transformation and innovative research collaborations among faculty, students and staff will lead the university far beyond today's constraints. Further, planned strategic investments in expanding renewable energy sources, reducing energy consumption, and increasing energy storage will be integral to transforming the campus energy infrastructure.



Figure 4. Jason F. McLennan at a visioning session (courtesy of Vanderbilt)

Faculty, students, and staff looked to the blue sky and imagined a verdant, walkable campus with clean air supporting a healthy, resilient community. They imagined resources freed from external-flowing energy expenses reinvested in local, renewable energy infrastructure and in time redirected to the educational mission of the university. They imagined Vanderbilt as a center of energy research and innovation attracting funding and talent from around the world.



Engaged Stakeholders

A diverse group of faculty, students, and staff were engaged to share ideas for the BlueSky Vision. These university stakeholders emphasized the relationship between the university's reputational value and providing energy leadership within the region, the importance of taking a long-term view, and the need to positively impact the community.

Stakeholders determined that a successful BlueSky Vision would:

- Reduce Scope 1 (on-site direct) and 2 (purchased indirect) greenhouse gas emissions to zero by 2050
- Conserve energy and water
- Improve social, environmental and economic resilience
- Demonstrate leadership within the region and globally
- Help recruit and retain the best faculty and students
- Generate research initiatives and attract research funding
- Reduce operational and utility expenses
- Improve health and wellbeing
- Inspire and prepare students to solve the challenges of their future

BlueSky Vision Project Timeline

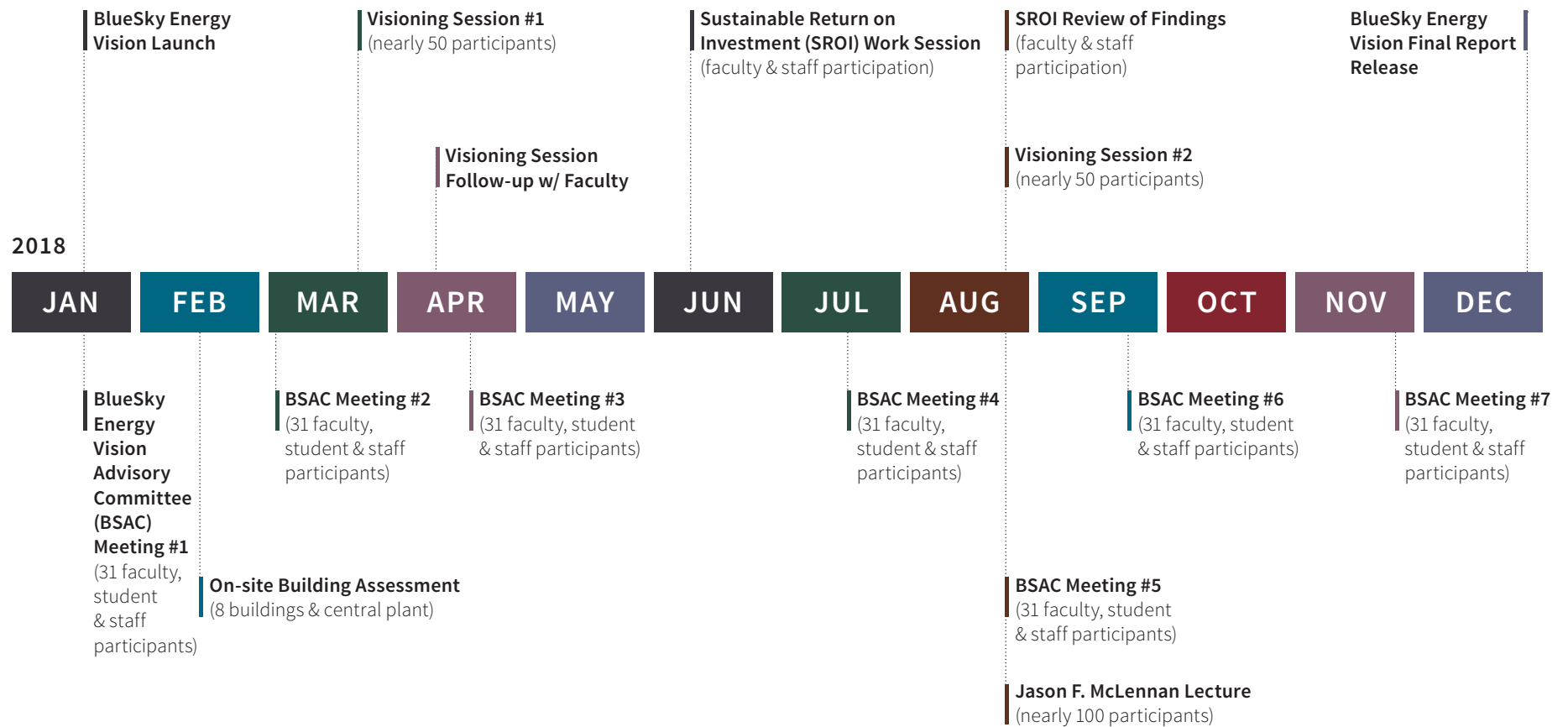


Figure 5. BlueSky Vision Project Timeline

Achieving a Net Zero + Resilience (Net Positive) energy campus was identified by the stakeholders as the goal for the BlueSky Vision. The visioning and faculty follow-up sessions identified ways to achieve this goal that included the following:

Develop a Living Building on campus

Maximize solar and solar-ready building opportunities on campus

Reduce the Energy Use Intensity (EUI) of buildings on campus

Create accountability for energy use at the user or building manager scale

Develop a research fund for sustainable projects

Capture water and reuse it for irrigation or toilet flushing

Install a visible, on-site, biological waste water treatment system

Consolidate summer classes and allow work-from-home policies to reduce summer loads

Create a coalition of top 100 Tennessee Valley Authority (TVA) customers to influence the use / purchase of renewable energy

BlueSky Vision Opportunity for Leadership

The BlueSky Vision is critical for the planet, has taken a triple-bottom line approach to ensure economic, social and environmental factors are considered, and will allow us to attract top faculty and students. Among the 600-plus institutional signatories of the university President's Climate Leadership Commitments (PCLC) (formerly known as the American College and University President's Climate Commitment or ACUPCC), many are aiming for climate-neutral campuses by 2050 or sooner. Many are choosing to reduce Scope 1 and 2 emissions by reducing energy consumption for buildings and infrastructure and increasing renewable energy production. This represents nearly 20 percent of the students in the U.S. studying at institutions committed to making energy and carbon reductions a part of their educational model.

While the race is on, there is a space for leadership in becoming the first university to demonstrate how to dramatically reduce consumption, attain net zero energy, and incorporate resilience (energy storage) into the model. As a resilient campus, Vanderbilt can lend safety and security to its critical operations in the event of a disruption. Vanderbilt can provide the much-needed model of dramatic conservation, infrastructure innovations, and the economic advantages that a clean energy economy provides, such as green jobs, savings, and reinvested wealth. Energy storage and cutting edge green buildings also provide ample opportunity for faculty and student collaboration on research and innovation.



Figure 6. Participants at the Visioning Session (courtesy of Vanderbilt)

BLUESKY VISION RECOMMENDATION

BlueSky Vision Recommendation

The BlueSky Steering Committee, supported by the BlueSky Vision Advisory Committee and informed by outcomes of the 10-month study, recommends the following:

Vanderbilt, by the year 2050, will:

- be a leader in energy conservation
- produce on-site clean (without combustion) and renewable energy
- procure off-site renewable energy to mitigate campus greenhouse gas emissions
- store sufficient clean energy to provide campus resilience

The BlueSky Vision Study recommendation:

- supports FutureVU Guiding Principles
- embodies Vanderbilt's core values of teaching, research, and discovery
- establishes Vanderbilt as a leader among its peers, community, and the region
- incorporates impactful economic, environmental, and social factors





The Pathway to Net Zero Energy + Resilience

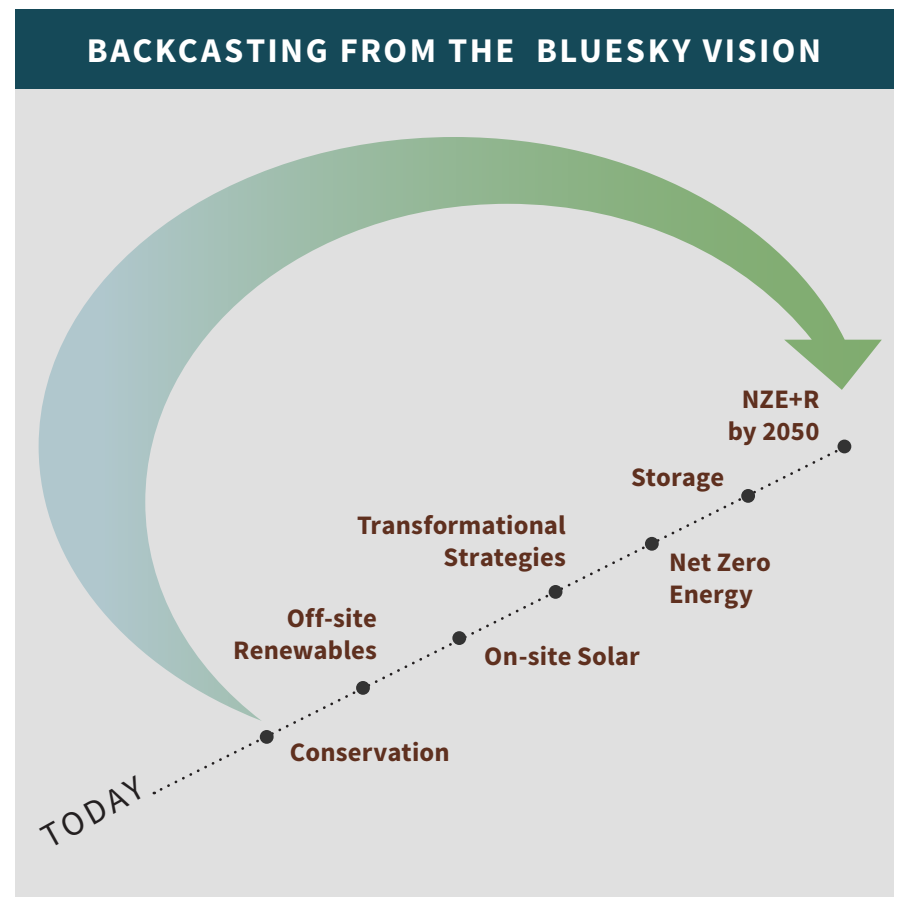
The 10-month study utilized a backcasting approach with Net Zero Energy + Resilience (referred to as “NZE+R” in this report) as the goal and worked back to the current state to develop an implementation plan supported by an Action Timeline² and Performance Targets.³

“Among our higher education clients, we find that many are trying to lead (or even race) to be the first net zero campus. However, there is a void (or a space for leadership) in the realm of Net Positive Energy. We think Vanderbilt could move into that space and distinguish themselves as a true leader. With a Net Positive focus, you will become a center for innovation in the Southeast, and in the nation.”

JASON F. MCLENNAN

² Provided on pages 42 and 43 of the Full Report

³ Provided on pages 46 and 47 of the Full Report



There are three primary points on the pathway to NZE+R:

ENERGY CONSERVATION

For the next 10 to 12 years, perform retro-commissioning for one million square feet of buildings each year and create a schedule and budget for corrective actions. Beginning today, every capital project is an opportunity to:

- Apply new design standards and performance targets
- Test new technologies and systems
- Implement energy conservation measures (ECM) that have a favorable benefit-cost ratio
- Provide flexible building systems that can connect to renewable technologies and future innovations in infrastructure
- Develop feedback loops with measurement technology for ongoing commissioning and operational improvements

RENEWABLE ENERGY

Begin the transition to:

- Install renewable energy across campus
- Develop a large-scale renewable energy strategy and portfolio for off-site renewable energy

TRANSFORMATIONAL STRATEGIES

Evaluate, design, and implement strategies that will:

- Utilize passive sources of heating and cooling
- Implement the most efficient and effective infrastructure solutions
- Transition from combustion-based to renewable sources of energy
- Store energy for resilience



from 2016 baseline
**GHG Emissions
Reduction: 28%**

2025

**GHG Emissions
Reduction: 61%**

2035

**GHG Emissions
Reduction: 100%**

2050

2050 Timeline and Milestones

By 2025

- update policies, procedures and design standards aligned with the performance targets
- perform retro-commissioning
- implement energy conservation measures with the most favorable benefit-cost ratio
- evaluate and design infrastructure and technology improvements
- pursue large-scale off-site renewable power purchase agreements and begin to install renewable energy across campus
- measure results, share lessons learned and celebrate early wins

By 2035

- continue with ongoing commissioning
- continue implementation of energy conservation measures across campus
- begin to implement infrastructure and technology improvements
- continue off-site renewable power purchase agreements and installation of renewable energy across campus as technology and costs improve
- publish and share results to provide leadership outside the institution

By 2050

- continue with ongoing commissioning
- maintain energy efficiency measures
- continue to innovate
- continue infrastructure and technology innovations
- include energy storage strategies for resilience
- transfer technologies and intellectual property to the industry and publish the results of long-term studies with the community, nation and world

Potential Greenhouse Gas Emissions Reductions

By implementing the three primary points on the pathway to NZE+R (energy conservation, renewable energy, and transformational strategies) it is possible to reduce Scope 1 and 2 emissions significantly over time.

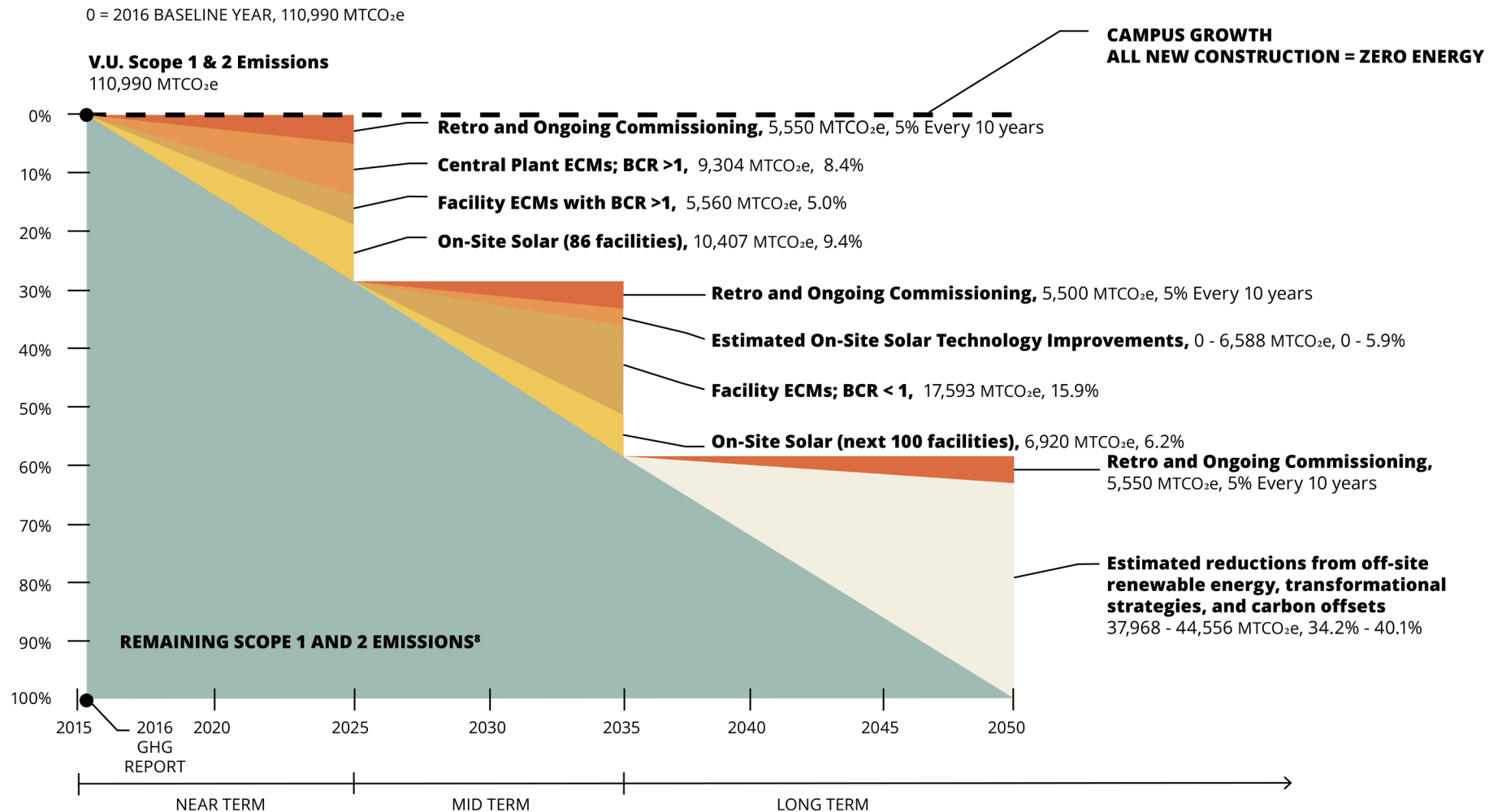


Figure 7. Potential Scope 1 & 2 Greenhouse Gas Emissions Reductions with all BlueSky Vision Strategies

Implementation Next Steps

Vanderbilt's commitment to the recommendation of Net Zero Energy + Resilience by 2050 is the first step in the timeline. Vanderbilt Facilities commits to performing deeper dive analyses and continuous reviews of operating and design protocols to inform recommendations to the Vanderbilt Public Utility Commission of near- to mid-term projects that are economically, environmentally, and socially impactful.

Projects recommended for implementation will recognize the initial cost to implement energy conservation measures, retro-commissioning, energy metering and monitoring, renewable energy, energy storage, and infrastructure and technology improvements. The recommendations will also recognize the longer-term view of a return on investment that encompasses a cleaner, more independent and resilient energy future and the transformative trajectory of integrating faculty, student, and staff collaborations with education, research, and discovery.

GHG EMISSIONS REDUCTIONS FROM 2016 BASELINE



Into the Future

Vanderbilt is taking bold and visionary steps to shape its future and to be a leader - a leader in the Nashville community, a leader among universities, and an example for future leaders of our country. The BlueSky Vision sets the university's energy and greenhouse gas emissions reductions strategies for the next 30 years. This is just the first step.

The implementation process will require dedication, input, and support from the Board of Trust, the Chancellor and senior leadership as well as our faculty, students and staff. The BlueSky Vision of Net Zero Energy + Resilience by 2050 establishes the foundation upon which current and future university leadership can lead Vanderbilt to successful achievement of this vision.



Glossary

ADJUSTED INTERNAL RATE OF RETURN (AIRR)

Measure of the annual percentage yield from a project investment over the study period; a relative measure of cost effectiveness.

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS (ASHRAE)

Organization devoted to the advancement of indoor-environment-control technology in the heating, ventilation and air conditioning (HVAC) industry. ASHRAE also publishes a set of standards and guidelines relating to HVAC systems and issues (including energy efficiency), that are often referenced in building codes and used by consulting engineers, mechanical contractors, architects, and government agencies.

ENERGY USE INTENSITY (EUI)

Expressed as energy per square foot per year and is calculated by dividing the total energy consumed by the building in one year (measured in kBtu) by the total gross floor area of the building.

SAVINGS INVESTMENT RATIO (SIR)

Measure of economic performance for a project alternative that express the relationship between its savings and its increased investment cost (in present value terms) as a ratio.

BENEFIT-COST RATIO (BCR)

Determines whether an alternative's benefits outweigh its economic costs from societal triple bottom line perspective, and a BCR that is equal to (or greater) than 1 indicates that the alternative is worth pursuing. The BCR is calculated by dividing the life cycle value of the project's benefits by the life cycle value of the costs and measures the societal return on each dollar invested in the ECM.

LOW-TEMPERATURE (OR LOW-TEMP) THERMAL (LTT)

An LTT system operates with heating water at temperatures below 140F (60C) (ideal temperature for LTT is 120F and that is what is recommended for Vanderbilt) that can be generated with standard, single stage heat pump/ heat recovery chiller which is the primary energy conversion technology of a LTT system. Using low-temperature heating water opens the possibilities for integrating recovery of various forms of free low-grade waste thermal or renewable energy as the primary energy sources for the LTT system. Typically, a LTT system recovers heat between simultaneous heating and cooling and is complemented by additional low-grade thermal energy sources/ sinks, and long-term thermal storage such as geo-exchange.

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