Duke Farms

Smart Stewardship, Smart Operations

Duke Farms' Blueprint for Campus-Scale Clean Energy and Sustainability

Introduction

Across the United States and around the world, campus-based institutions and companies, including universities and colleges, cultural institutions, corporations, healthcare systems, and parks and arboreta, face demands to adapt and opportunities to lead. Extreme weather, rising operational costs, biodiversity loss, and complex regulatory and stakeholder pressure all require action.

Campuses and campus-like institutions typically possess multi-purpose infrastructure, open space, empowered leadership structures, and the flexibility to innovate. They are large enough to cut greenhouse gas emissions at scale and nimble enough to demonstrate replicable solutions. They have assets and operations to protect and resources to steward. Their actions can influence visitors, partner organizations, students, staff, communities, and policymakers.

But despite clear needs and opportunities, roadmaps for action are hard to find. That's why Duke Farms is sharing its experience through this blueprint and other outreach.

Duke Farms is a living laboratory to develop model strategies for nature restoration, wildlife conservation, and the clean energy transition, with the goal of building a **nature positive, carbon negative future** for the benefit of all.

Located on 2,700 acres in Hillsborough, New Jersey, the Duke Farms campus is a gathering place for global decision-makers and local neighbors to spark change. The campus is a center of the Doris Duke Foundation, which strives to build a more creative, equitable, and sustainable future. Once the estate of the industrialist J.B. Duke, and then his daughter, philanthropist Doris Duke, the Duke Farms campus comprises more than 100 buildings (many more than 100 years old) and a mosaic of forests, wetlands, agricultural grasslands, meadows, and a designed landscape visited by more than 150,000 people every year.

Through its **Natural Systems Energy Plan (NSEP)**, Duke Farms has built a roadmap to achieve carbon negativity by 2040 while enhancing biodiversity and resilience campus wide. Between August 2024 and August 2025, Duke Farms achieved the following outcomes:

- Reduced its operating carbon footprint by **25% (>300 metric tons CO_2) from a 2023 baseline**
- Switched on a new 1.16MW **solar array with battery storage**, powering all facilities on its primary circuit, meeting its 2025 goal of 100% clean electricity
- **Electrified additional fleet vehicles** and provided New Jersey's only **100% solar-powered fast EV chargers**, which delivered more than 4,000 charging sessions to the public
- Partnered to launch a **112-acre floodplain reforestation project** along the Raritan River to maximize carbon sequestration and improve flood resilience

This paper lays out a blueprint for other campuses and is built around the following action steps:

1. Establish a Baseline
2. Clarify Formal Goals
3. Identify and Prioritize Strategies
4. Implement and Optimize Solutions
5. Track, Visualize, and Refine

Why It Matters: The Case for Institutional Action

Executive leaders, boards, and operational heads of campus-based institutions face increasing risks to their infrastructure and operations, cost control and revenue demands, and pressure from a wide range of internal and external stakeholders.

In New Jersey, for example, Duke Farms is experiencing an increase in heavy rainfall events that damage infrastructure, extreme heatwaves that interrupt operations, rising operational and insurance costs, and requests and needs from many stakeholders and partners. Fire risk, utility costs, maintenance demands, and supply chain disruptions are also risks to many campuses.

Globally, the context is sobering. Atmospheric CO_2 concentrations have surpassed 419 parts per million. Governments are falling short of their Paris commitments, putting Earth on track to exceed 1.5°C of warming, which will increase the risks and pressures campuses already struggle to confront. In addition, biodiversity loss is accelerating into what many scientists call a sixth mass extinction, further weakening resilience, ecosystem services, and supply chains that sustain us all.

With leadership and deliberate planning, campus-based institutions can respond to these challenges in ways that strengthen their own operational resilience, lower costs, engage their constituents, and contribute to cleaner air, thriving biodiversity and a healthier world.

Of course, any meaningful change is grounded in clear commitments. In confronting its own needs and responsibilities, Duke Farms established three guiding principles to underpin its sustainability work:

- **Take Responsibility:** Address the climate crisis, environmental quality impacts, and human public health risks by being accountable for Duke Farms' energy footprint. Fulfill that responsibility by changing the way Duke Farms obtains and uses energy, with a focus on physical reductions in fossil fuel use.
- **Set A High Bar:** Take a comprehensive and rigorous approach to develop and implement the Natural Systems Energy Plan, and "do it right" to deliver authentic and high-integrity physical emission/impact reductions (not just accounting offsets). Lead by example as a sustainable energy trailblazer, with a focus on innovation and synergies that Duke Farms is uniquely able to pursue.
- **Expand Our Impact:** Demystify sustainable energy, conclusively demonstrate feasibility, and illustrate a path to action for other energy users. Duke Farms has intentionally prioritized solutions that can be replicated by others and intends to have an impact beyond its borders that will accelerate and expand deployment of sustainable energy solutions.

The Blueprint: Duke Farms' Natural Systems Energy Plan

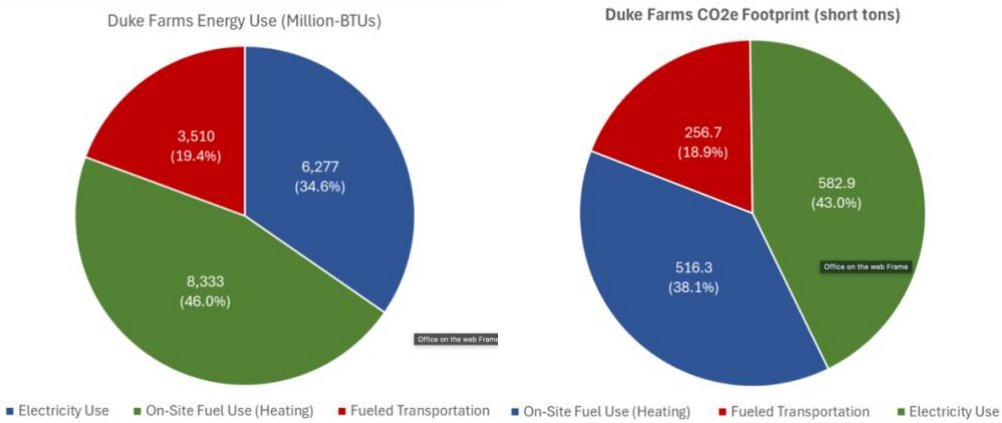
Step 1: Establish A Baseline

A credible plan begins with a comprehensive baseline. Like many institutions, Duke Farms has engaged in multiple efforts to quantify its energy uses and carbon footprint over the last 15 years, including a partnership with Rutgers University to measure a comprehensive 100-year campus carbon footprint, which clarified that natural climate solutions (like tree planting) and a small onsite solar array could not offset the campus operating emissions. It was clear that significant operational changes would be required, which required additional data collection.

Next, Duke Farms worked with Gabel Associates to set detailed 2023 energy use and carbon footprint baselines. The planning team established a baseline inventory of all the buildings and structures on the property (more than 100, many of which are more than 100 years old) and energy supply and usage data using a combination of Scope One and Scope Two accounting. The baseline captured energy sources and how different supplies were used for different purposes across the campus.

The baseline captured raw energy consumption in units suitable for the supply (kWh for electricity, gallons for fuel, therms for natural gas, etc.) and then converted these inputs to normalized energy units (BTUs) so that consumption can be compared and carbon emissions can be computed using standard engineering factors and data about the supply mix associated with grid-supplied electricity. This approach results in a very granular view of energy use that can be used to prioritize decarbonization opportunities.

The figures below summarize major uses of energy and resulting carbon emissions. The detailed spreadsheet templates underlying these calculations are available from Duke Farms.



Duke Farms also chose to include the energy use and environmental footprint of all employees commuting to work on the property, which turned out to be significant. Visitor energy use for approximately 150,000 visitors annually, however, was not included in the baseline.

Duke Farms

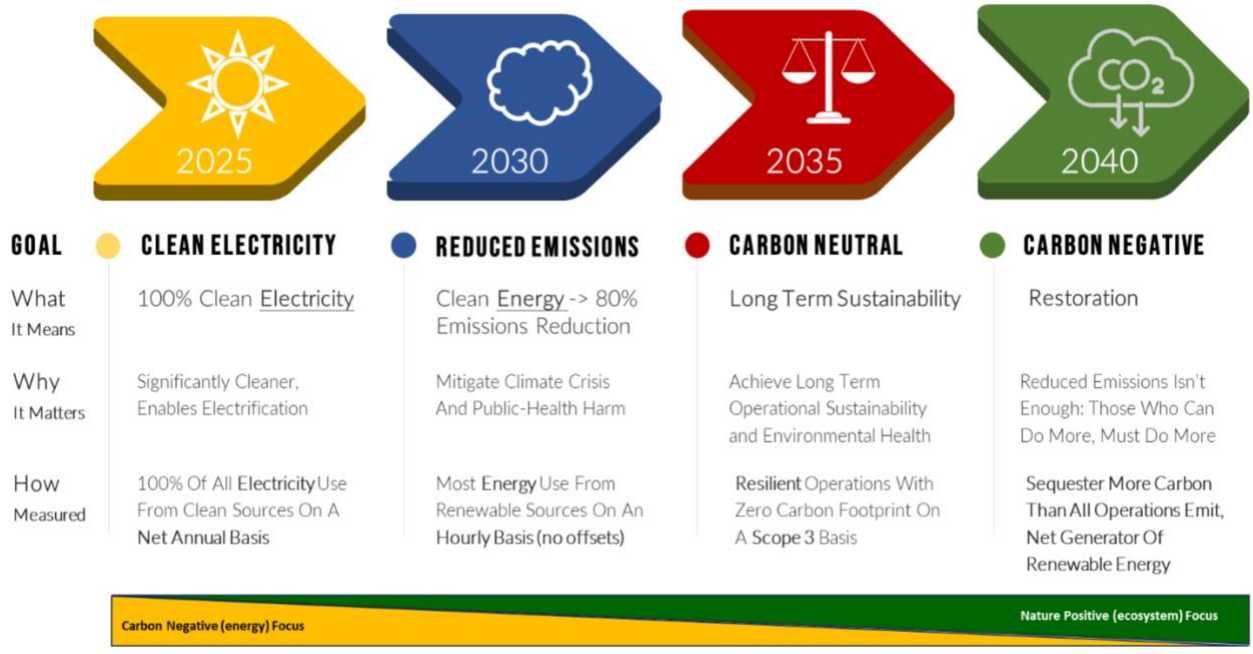
Step 2: Clarify Formal Goals

As its baseline came into focus, Duke Farms began setting Natural Systems Energy Plan goals in the context of its broader nature positive, carbon negative mission. The goals prioritize rapidly reducing operational emissions early in the process and including more nature-based solutions for carbon removal and other natural restoration goals over time. The goals are organized into four five-year phases, a much more measurable and accountable approach than setting single, long-range targets 20 or 30 years into the future:

- 100% clean electricity by 2025
- 80% emissions reduction by 2030
- Carbon neutrality by 2035
- Carbon negative by 2040

At this stage, Duke Farms has focused its carbon accounting and goal setting on Scope 1 and Scope 2 emissions but also conducted an employee travel survey to quantify commuting emissions (Scope 3). Duke Farms plans to continue accounting for other aspects of Scope 3 emissions and setting goals to reduce those, but that will be a multi-year undertaking.

By design, Duke Farms' goals are both aligned with and additive to major sustainability frameworks at global, national, and state levels, demonstrating how big-picture climate, energy, and biodiversity goals can be realized through integrated local action. This alignment also unlocks funding opportunities from a variety of public and private sources to underwrite the transition.



To ensure an appropriately transparent, rigorous, and quantitative approach to measuring its impact, Duke Farms is developing a formal carbon accounting framework using external resources like the Oxford Offsetting Principles taxonomy and classification. At this stage, the focus is on all energy use (Scopes 1 and 2), employee commuting (Scope 3), and land-induced emissions. Over time, more Scope 3 sources and other uses will be included. The framework

also articulates the mix of physical mitigation solutions, offsets (high-quality accounting constructs like SRECs or Class I RECs), and removals (like trees and soils).

Step 3: Identify and Prioritize Strategies

With a clear baseline and measurable goals in place, it's time to identify a wide range of possible mitigation and adaptation strategies and then prioritize and selected approaches into a strategic framework informed by:

- technical considerations
- project economics
- funding strategies and cost assessments
- quantification of the anticipated impact

In other words, not all possible actions can be undertaken at once, but a well-designed plan will identify clear phases based on opportunity, feasibility, and expected environmental and fiscal impact.

Strategies fall into five broad categories: energy conservation, energy efficiency, clean electricity, electrification, and specialized solutions.

A. Energy Conservation

Energy conservation focuses on operational practices that reduce energy use without requiring major capital investment. At Duke Farms, this has included measures such as optimizing HVAC schedules, reducing nighttime lighting in non-essential areas, and managing irrigation more efficiently. While seemingly modest, these actions deliver immediate cost savings and emissions reductions. For peer institutions, energy conservation is often the lowest-hanging fruit: policies, training, and awareness campaigns can reduce demand before more expensive upgrades are made.

B. Energy Efficiency

Efficiency involves technology upgrades that improve the performance of existing systems. Duke Farms has replaced legacy lighting with LEDs, installed advanced building controls to optimize energy flows, and pursued LEED standards for renovated buildings. Many of its 100+ buildings are historic, yet efficiency retrofits have been possible without undermining their heritage value. For universities, museums, and cultural institutions, this demonstrates that efficiency improvements can be integrated sensitively while delivering long-term value.

C. Clean Electricity

The campus's shift to clean electricity has been one of its most visible transformations. The original 2012 solar array provided about half of Duke Farms' electricity. In 2024, a new 1.16MW solar array paired with a 1,774 kWh battery system expanded that capacity to cover 100% of current demand on the main distribution backbone. By leveraging state incentives and federal tax credits, Duke Farms achieved this without jeopardizing financial sustainability. Onsite renewables paired with storage not only reduce emissions but also insulates Duke Farms from grid volatility and outages.

D. Electrification

Electrification is a linchpin of the strategy. Fossil-fuel boilers for space and water heating are being phased out in favor of heat pump systems, which now serve both residential cottages and larger buildings. Duke Farms is also shifting its vehicle fleet to EVs, beginning with champions among the operations and field staff who piloted EV adoption and expanding through procurement of vans, trucks, and maintenance carts. Duke Farms also offers the state's only 100% solar powered EV chargers in its parking lot—facilitated by state and utility incentives—and served 4,000 charging sessions to the public last year, making Duke Farms one of New Jersey's most-used EV charging sites. Replicability here lies in sequencing: Start where technology is viable and reliable and expand as the market matures. For example, Duke Farms has not yet replaced its diesel tractors because suitable commercial EV models are not available, but staff are tracking developments to act when feasible.

E. Specialized Solutions

Every campus will have unique infrastructure or circumstances that require specific approaches to address. At Duke Farms, the historic Orchid Range greenhouse will require a custom geothermal system to provide consistent heating and cooling while preserving delicate ecosystems. Other specialized solutions include rotational grazing techniques in grasslands to balance carbon emissions with biodiversity goals. For other institutions, specialized solutions may involve laboratories, data centers, or cultural facilities with unique energy profiles. These circumstances offer opportunities for creativity and leadership and should be embraced, not avoided.

Step 4: Implement and Optimize Solutions

The centerpiece of Duke Farms' recent implementation efforts is a 1,159-kW onsite solar array and 800 kW battery storage system that provides 100% of the campus' primary electricity needs on a net annual basis. The system has singlehandedly reduced Duke Farms' carbon footprint by about 25% from the 2023 baseline and provides a powerful learning platform for staff, visitors, partner organizations, elected officials, and many others. It is also a strong validation of Duke Farms' vision and commitment. A signature implementation achievement can build significant momentum for a long-term plan by giving stakeholders a vision and a sense of pride.

In implementing the Natural Systems Energy Plan so far, staff and leadership have learned innumerable technical lessons regarding solar power, batteries, heat pumps, EVs, and more—all of which they are eager to discuss in detail with other practitioners—and several big-picture implementation lessons have also emerged:

- **Phase the Big Challenges.** A solar array and battery backup system take time to design and implement. Duke Farms had also learned many important lessons from a smaller solar array, which provided about 50% of its electricity, over the preceding decade. Another area in which Duke Farms is phasing its implementation is in the electrification of certain buildings and building systems, targeting high-impact facilities and/or low-hanging fruit, while putting smaller-impact sites on the back burner and taking the time to build solid plans for upgrading the most challenging sites. Retrofitting began

with cottages and has expanded to larger facilities, replacing oil-fired boilers with high-efficiency heat pumps.

- **Cultivate Internal Champions.** People, of course, are key to change. Duke Farms' electrician became a key driver of cultural change when he asked for an electric van and talked up its reliability and operational benefits to all his colleagues, some of whom had been skeptical about EVs. Management must invest in people and culture to enable change and create conducive internal environments.
- **Engage Stakeholders.** Duke Farms deliberately engages visitors, partners, community leaders, and other stakeholders in its change efforts through educational signage, facilities tours, workshops, and other outreach. In 2023, Duke Farms leveraged a relationship with the State of New Jersey and the local utility to install fast EV chargers in its parking lot (which run on solar electricity), and these chargers have become among the most used in the whole state, providing more than 4,000 charging sessions in the last 12 months. This engages the community in Duke Farms' mission and helps address Scope 3 emissions from visitor commutes.

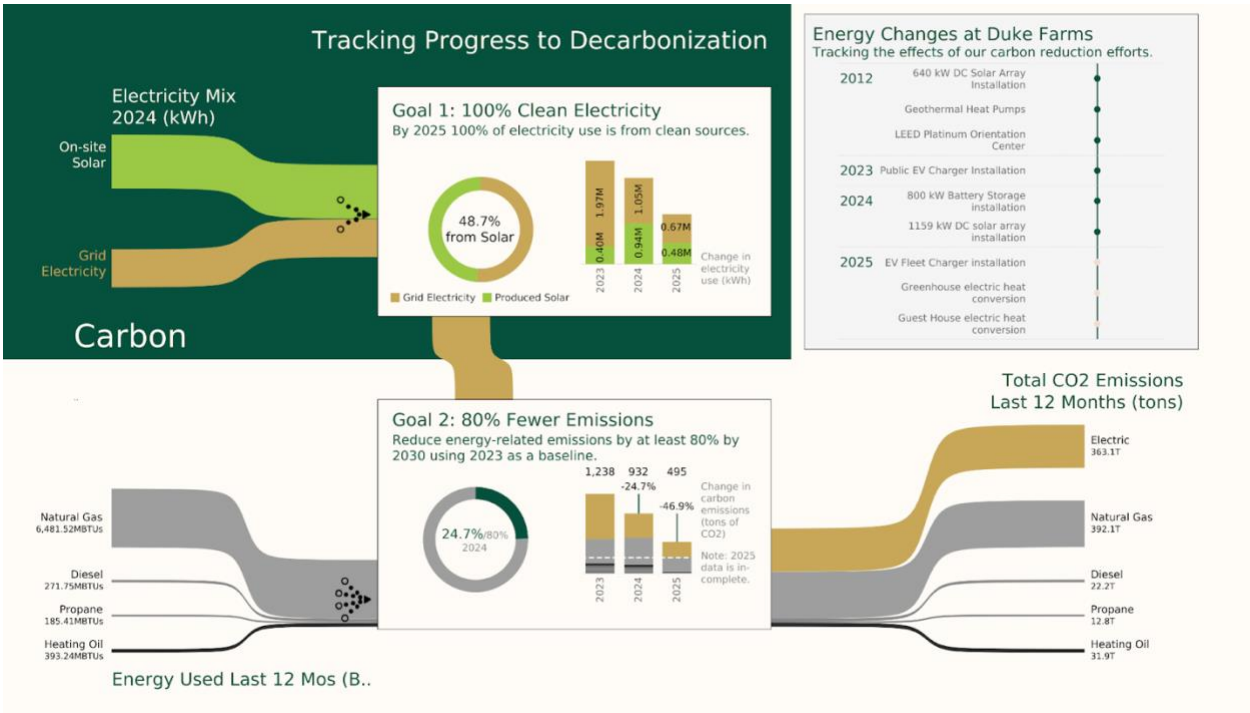
Step 5: Track, Visualize, and Refine

In 2024, Duke Farms implemented a real-time energy and emissions dashboard to serve as the operational backbone of its monitoring system. The dashboard tracks:

- Monthly and annual electricity generation and consumption, including contributions from onsite solar and grid purchases
- Fuel use across fleet and equipment, including trends as electrification progresses
- Building-level performance, showing where efficiency upgrades are working and where gaps remain
- Emissions profiles across Scope 1 and Scope 2, with pilot data on selected Scope 3 sources like staff commutes
- Biodiversity indicators, reflecting Duke Farms' commitment to integrating land stewardship with energy management

The dashboard is a management tool and a transparency tool. Staff and leadership use it to make real-time adjustments. It also provides evidence for board members, funders, policymakers, and visitors that Duke Farms' progress is tangible and measurable.

The monitoring system embodies Duke Farms' philosophy of adaptive management. Data informs decisions, feedback loops are continuous, and accountability is shared.



Overcoming Common Barriers

Both in planning and in implementation, barriers are commonplace. Here is how Duke Farms has identified and tackled some of these along the way.

Financial Barriers

High upfront costs and other financial barriers are common deterrents. Solar arrays, battery systems, new EVs, and electrification projects require significant capital. Duke Farms addressed these needs through a combination of federal tax incentives, state-level clean energy programs, utility partnerships, and long-term financial modeling that emphasized lifecycle savings over upfront expenditures. For example, the new solar system and battery storage will reduce annual operating costs while insulating the campus from future utility price volatility.

Technical Barriers

The clean energy technology sector is evolving rapidly, and every campus will face unique questions about design and implementation of effective solutions. Duke Farms has found success by appointing and empowering staff champions to monitor and pilot new technologies; creating partnerships with universities, manufacturers, and utilities; and consulting with experts in specific technical areas to supplement staff expertise and design feasible local solutions in phased and manageable timelines.

Cultural Barriers

Technology alone does not drive transformation, of course. People do. At Duke Farms for example, resistance surfaced around fleet electrification, when some staff voiced concerns about safety and reliability of EVs. Progress resumed only when internal champions—notably an electrician and a motor pool coordinator—emerged as advocates. Their lived experience with EVs helped shift peer perceptions and normalize adoption. For managers, this underscores the need to invest in staff culture, governance, and engagement, making sustainability a shared mission rather than simply a top-down management demand (though support and urgency from the top is also essential).

Policy and Governance Barriers

Regulatory frameworks can both enable and slow progress. Duke Farms aligned its goals explicitly with several state laws and incentive programs, ensuring credibility and unlocking partnerships. Even so, the team ran into unintended regulatory barriers and loopholes that required regular work with government officials, utilities, and electricity sector experts to resolve. This requires patience and a commitment to long-term goals. Internal governance was equally important; board alignment and management accountability created a durable mandate to act. Executive leadership has kept the board informed and engaged at every meeting about goals, progress, and financial implications of the work.

Let's Talk More

Sustainability is the pathway to resilience, cost savings, and greater mission impact. If the approach and lessons learned laid out in this brief paper interest you and your institution—and if the brief overview here raised additional questions about methods, resources, cost, cost savings, revenue options, etc.—the Duke Farms team would love to talk more.
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