

nuveen

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Impact insights

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Data center growth is driving global energy demand

Artificial Intelligence (AI) is seemingly everywhere, all the time, all at once. The proliferation of AI deployment and corresponding data center construction boom is among the most talked about investment megatrends of the last couple years. Data centers also support the secular trends of increasing remote work and school, the ubiquity of mobile phones, and Software as a Service (SaaS) business models — all of which rely heavily on cloud computing and storage. Data centers are projected to drive more than 20% of global electricity demand growth over the next 5 years.¹

By now, equity investors are familiar with the hyperscaler thesis embedded in Microsoft, Amazon, Alphabet (Google), Meta (Facebook), and Oracle. Yet bond investors need not feel left out. In addition to corporate bonds issued by the aforementioned companies, data center related investment opportunities are expanding rapidly. These credit investments are financing the infrastructure of the cloud computing information superhighway. In our view, they fit well within multisector bond portfolios by offering diversification and alpha potential — as well as a new opportunity to direct capital to specific environmental and sustainable outcomes within impact mandates.

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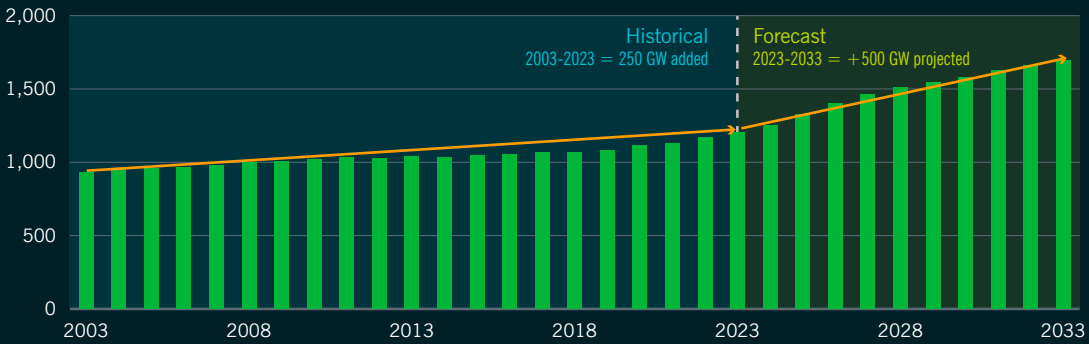
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The energy mix required to meet consumer, commercial, and data center demand will span natural gas, nuclear, and renewables (solar, wind, hydro). Solar and wind generation offer the fastest construction timelines, bringing capacity to market quickest to address supply/demand imbalances. This fact, along with efficiencies of scale in renewable technology compared with the variability of fossil fuel prices, are key reasons we believe renewables will continue to ascend.

Until battery storage helps overcome the issue of renewable generation intermittency, baseload power generated by gas, nuclear, and other sources will help meet data centers’ 24/7 energy demand as well. Therefore, innovations in energy efficiency and carbon capture and storage (CCS) will contribute to meeting demand, while attempting to minimize society’s carbon footprint as we enjoy the productivity gains and standard of living improvements brought about by technological advancement.

The spectrum of investment opportunities for intentional, impact-oriented investors covers: 1) physical data centers; 2) power suppliers; and 3) decarbonization efforts. Some bonds are issued by data center owners or developers, representing the most direct connection to this investment megatrend. The commercial mortgage-backed securities (CMBS) and asset backed securities (ABS) sectors are prominent examples, with issuance in both sectors growing rapidly in recent years. Recent Moody’s research expects “Europe to follow the U.S. trend, where data centre ABS and CMBS issuance has grown significantly since 2020, surpassing \$10 billion of new issuance in 2024.”² Outside of the securitized sector, there are a small number of U.S.-based investment grade data center REITs that are likely to be frequent issuers as the industry grows, with the potential for additional green bond issuance in the future. However, only a subset of recent and forthcoming issuance will qualify under Nuveen’s direct and measurable impact framework.

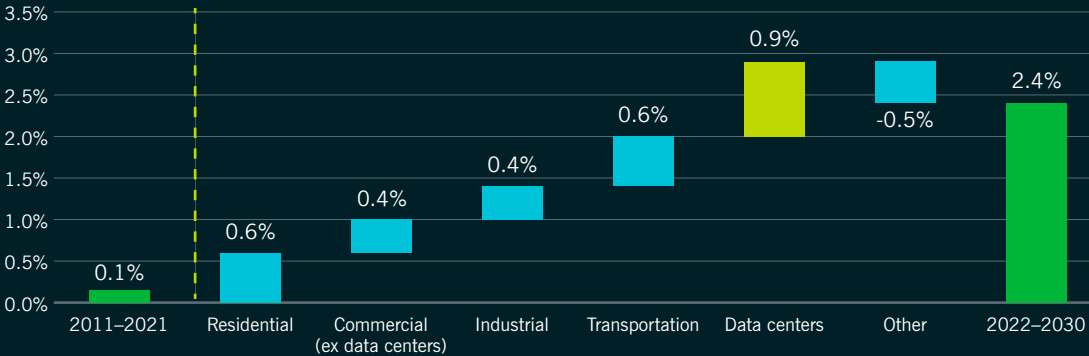
FIGURE 1: U.S. ELECTRIC POWER SECTOR GENERATION CAPACITY (GW)



Source: U.S. Energy Information Administration (EIA)

FIGURE 2: DATA CENTERS TO BE THE LARGEST COMPONENT OF DEMAND GROWTH

U.S. electricity demand CAGR (2022–2030 vs 2011–2021)



Source: U.S. Energy Information Administration (EIA)

FINANCING DATA CENTERS

For data center ABS to qualify as an impact investment, we look for industry leadership in energy efficiency, as well as transparency into the source of electricity powering the site. This reporting and substantiation can come from the issuer’s impact reporting or from data sets like ENERGY STAR (see page 8). Both of our data center ABS impact holdings (as of May 31, 2025) are collateralized by a first lien mortgage and the associated leases from hyperscalers or colocators (businesses housing their own servers). For CMBS, our current impact holding is backed by two Northern Virginia data center properties classified as LEED Gold and LEED Silver.

FINANCING POWER SUPPLY

Development of new generation capacity and ensuring grid stability are additional investment opportunities necessary to ensure sustainable growth of these power-hungry facilities. Data center operators can purchase electricity directly from renewable-only subsidiaries or enter into long-term, clean energy power purchase agreements (PPAs) with their local utility.

Utility bonds can be issued for general corporate purposes at the holding company or operating company levels, but we prefer use of proceeds deals with transparency through to the specific projects or assets being financed. This enables our team to identify and target renewable generation and distribution. There are compelling utility green bonds that specify the physical asset or a list of eligible spending categories under an issuer’s published framework. In some instances, such as Duke Energy, San Diego Gas & Electric, Northern States Power, and Ameren Illinois, we invested in secured, first lien debt that helps finance renewable generation capacity and/or infrastructure enhancement.

FINANCING DECARBONIZATION

Blended finance offers an adjacent avenue for directing capital at the megatrend, by simultaneously developing programs that generate carbon reduction or removal credits. These decarbonization efforts are effectively sponsored by hyperscalers seeking to mitigate their growth into energy-intensive businesses. For example, the 2024 reforestation-linked outcome bond, for which Nuveen was anchor order, will generate carbon removal units (CRUs) through the replanting of native species on deforested land in Brazil. Microsoft contracted to purchase all CRUs generated by the program, which offers upside to the bondholders. Our confidence in Microsoft as an extremely high quality offtaker of the credits is informed by its AI, software, cloud and hyperscaler business lines. Read more about the project on page 9.

We expect Europe to follow the U.S. trend, where data centre ABS and CMBS issuance has grown significantly since 2020, surpassing \$10 billion of new issuance in 2024.

Source: <https://events.moodys.com/data-centres-europe-capacity-to-double-by-2028-but-energy-access-and-regulation-may-constrain-growth>

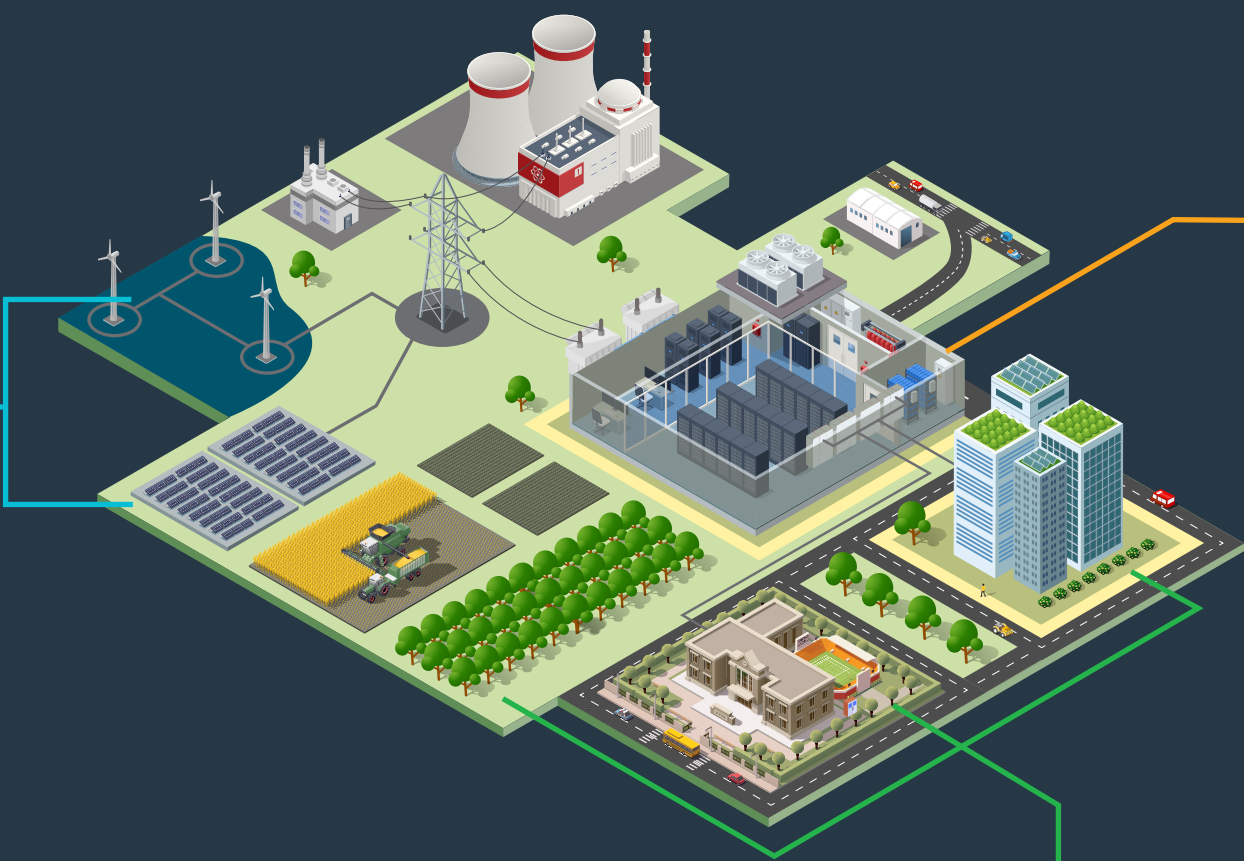
Investing for impact in public fixed income markets:

Data center and related impact investment examples

FINANCING POWER SUPPLY

- ContourGlobal Power**
Fixed Income Sector: High Yield Corporate Utility
Finances renewable energy generation assets, battery storage and coal decommissioning projects globally.
- New York State Electric & Gas Corporation**
Fixed Income Sector: Corporate Utility
Finances transmission and distribution network projects that connect renewable generation across New York state.

KfW (Kreditanstalt für Wiederaufbau)
Fixed Income Sector: Government-Related Agency
Green bonds issued by KfW held in Nuveen impact portfolios had an installed renewable energy capacity of 1030 MW and generated over 1.8 million MWh of renewable energy in calendar year 2023.³



FINANCING DATA CENTERS

- Switch**
Fixed Income Sector: Asset-Backed Securities (ABS)
Finances eight data centers, five of which have an ENERGY STAR rating of 91 or better.³ The issuer's sustainability initiatives include: 1) 100% renewable energy through power purchase agreements. 2) Patented technology to make cooling more efficient. This is primarily air cooling, which offers an additional advantage for its operations in Nevada, by lowering water demand in a water-stressed region.
- Turkcell**
Fixed Income Sector: Emerging Market Corporate Industrial
Finances data centers across Turkey. Turkcell committed to build all new data centers to LEED Gold or better. Nuveen made its participation in the transaction contingent on commitments from the issuer to include LEED certifications in all sustainability bond reporting.

FINANCING DECARBONIZATION AND CLIMATE ALIGNED PROJECTS

- Abilene Christian University**
Fixed Income Sector: Municipals
Finances energy improvement projects and the development of solar generation assets. New renewable generation is expected to exceed 100% of electricity demand for the school and result in ~29% reduction in energy use and elimination of scope 2 emissions.⁴
- Amazon Reforestation Bond**
Fixed Income Sector: Supranational
Generates carbon removal units through the replanting of native species on deforested land in Brazil, boosting biodiversity and supporting local communities.

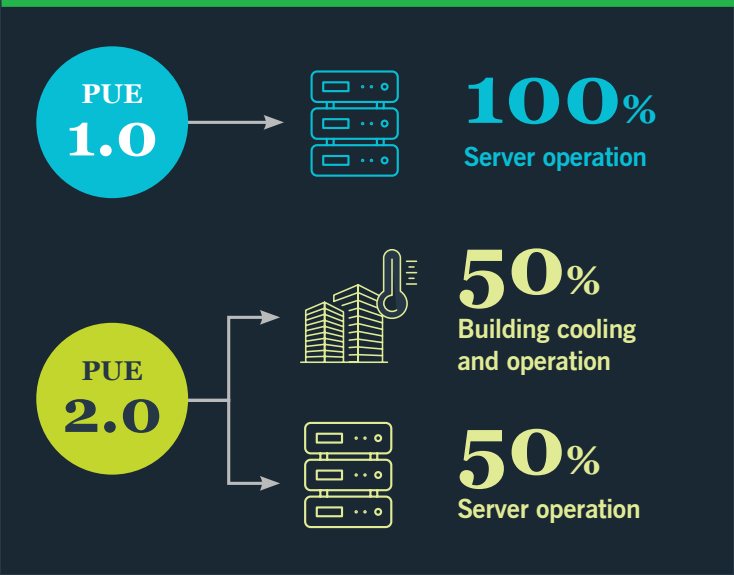
WFCM 2024 SVEN
Fixed Income Sector: Commercial Mortgage-Backed Securities (CMBS)
Sven is a 71-story apartment tower located in Queens, NY, and is the first multifamily residential building in the world to receive LEED Platinum status.⁵ Some of the sustainable on-site features include treatment of wastewater for non-potable re-use and co-generation that eliminates the need for a separate heating system.

Understanding data center sustainability metrics

Data centers are not new. Your college graduate nephew's eighth birthday photos and your neighbor's latest Amazon order of socks and toothpaste have spent their entire virtual lives in data centers. But the pre-ChatGPT era was mostly about storage, a passive set-and-forget business with predictable growth based largely on smartphone and online sales growth. ChatGPT and other AI platforms upended the data center model. Data centers are no longer where content subsists, it's where content begins.

It turns out that content generation is extremely energy intensive with potentially parabolic growth. Some of the larger new AI-driven data centers are planning on peak power demand of 1 GW — the equivalent of a nuclear reactor. This level of demand growth was never contemplated as part of the energy transition away from fossil fuels and threatens to extend the curve towards peak emissions. But our approach to maximizing impact is predicated on driving capital to those sectors where GHG emissions reduction is greatest. That said, as data centers emerge as a potential opportunity set for impact investors, the standards and data available to holistically assess their environmental impact remains limited.

The most frequent metric in data center sustainability reporting is Power Usage Effectiveness (PUE). PUE offers a basic snapshot of energy efficiency by dividing total facility energy use by the energy used directly by IT equipment. A PUE of 1.0 represents maximum efficiency, meaning all power consumed by the data center operates the servers. By comparison, a PUE of 2.0 means only half the energy consumption operates the equipment, while the other half powers building operations. Most of that is likely to be cooling. A data center with a 1.5 PUE devotes 50% more power to non-server functions than a 1.25 PUE center.



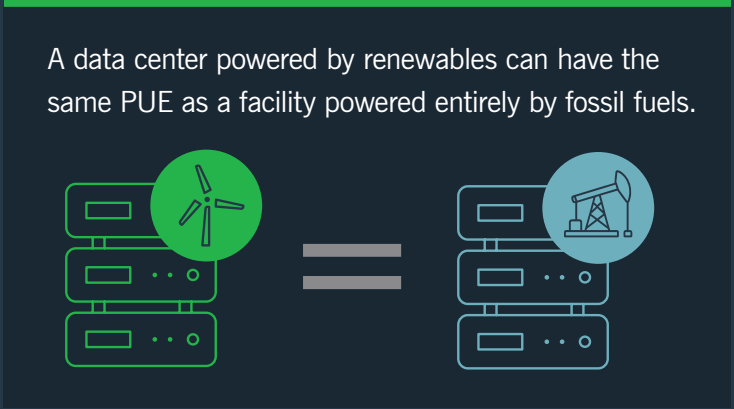
So PUE is useful, especially in assessing operational efficiency and capital needs, but it was never intended as a comprehensive measure of environmental impact: 1) It tells us nothing about energy source, whether it's powered by renewables or fossil fuels; 2) It doesn't account for broader sustainability criteria such as carbon emissions and water consumption, which is especially important for data centers located in areas facing water scarcity; 3) It reveals little about where the efficiency is coming from (is it more efficient servers with better chips, better cooling, better configuration, or is it related to the management of cooling and ventilation in the facility); and 4) PUE is a ratio, which conveys nothing about total power consumption.

It is also difficult to determine what is considered industry leadership using PUE alone. For instance, many green-labeled data center transactions use a PUE of 1.5 as the benchmark of sustainability. Yet global average PUE is around 1.5. Further, PUE can vary based on operational conditions such as weather, which can affect cooling and energy use, making comparisons difficult across countries, regions, or seasons. As a standalone metric, it lacks the transparency and context we need as long-term, sustainability focused investors.

Given these limitations, our team looks for more holistic measures of sustainability when evaluating data center transactions, such as LEED and ENERGY STAR certifications.

LEED (Leadership in Energy and Environmental Design) building certification considers a myriad of metrics beyond energy efficiency, including site selection, water efficiency, renewable energy use, materials, and indoor environmental quality. Our team focuses on the two highest certification levels: Platinum and Gold. Highly certified buildings signal to investors a strong commitment to sustainability, but also opportunities for lower operating costs and increased property value, which are important for assessing creditworthiness.

ENERGY STAR certification provides a standardized and data-driven calculation that utilizes PUE, but also provides facility-specific benchmarking. ENERGY STAR's benchmarking capability enables us to target the top-performing data centers versus peers by measuring a data center's actual PUE relative to its expected PUE, and ranking that against other measured data centers. This helps us assess energy efficiency leadership,



and helps us identify those operators limiting the need for new fossil fuel generation. Our team has chosen to participate in deals where the data centers place in the top 25% of comparable facilities in terms of energy efficiency.

Portfolio level averages tell us little about the underlying impact of an individual facility or security. We consistently engage with issuers as transactions come to market to push for the transparency and granularity we want, including site-level disclosure of energy savings in absolute terms, renewable energy use, carbon emissions, water use, and more. As data centers proliferate and require capital to expand, we believe higher quality, comparable sustainability data will be essential for mobilizing impact capital at scale. ENERGY STAR does not fully solve the limitations of PUE to the impact investor, but we view it as an interim improvement until more granular data emerges.

An homage to ENERGY STAR



The Trump administration has proposed funding cuts at the Environmental Protection Agency (EPA) and U.S. Department of Energy (DOE) that puts the ENERGY STAR program in jeopardy. Nuveen's fixed income impact team opposes neutering or defunding this long-standing resource. ENERGY STAR enables transparency and standardization of energy efficiency information for myriad professional and consumer uses.

ENERGY STAR's Portfolio Manager is a free web-based tool used to track and report on building energy use. Benchmarking in Portfolio Manager identifies opportunities for energy savings in buildings. According to the American Council for an Energy-Efficient Economy, dismantling the program would significantly impair energy savings across the nation. The program saves families and businesses more than \$40 billion dollars every year, yet costs only about \$30 million annually to run.⁶

Established in 1992 by the EPA under President George H.W. Bush, ENERGY STAR is a voluntary labeling program for energy efficient products, homes, buildings and manufacturing plants jointly managed by the EPA and the DOE. The program aims to reduce energy consumption, drive utility cost savings, and reduce emissions of pollutants — thereby improving associated environmental and health impacts. Today, ENERGY STAR is the most widely recognized symbol for energy efficiency in America; about 90% of households recognize the blue label, helping consumers make informed decisions backed by a credible source.⁷

The program has driven innovation by incentivizing the construction and production of energy resilient products and infrastructure. Recent Lawrence Berkley National Laboratory analysis shows that despite a steady rise in electricity demand, energy savings generated by ENERGY STAR and other federal programs — like the DOE Appliance and Equipment Standards Program — have helped offset demand, thereby reducing energy strain and bolstering grid resilience.⁸

ENERGY STAR's Portfolio Manager tool allows operators and investors alike to assess operational efficiency. It provides data on energy use and sources, water consumption, CO₂-emissions, and more, enabling users to easily identify underperforming facilities and systems. The data can be used to enforce mandatory benchmarking laws and encourage system improvements. The Washington State Department of Enterprise Services, for example, uses Portfolio Manager to help identify opportunities for energy savings in buildings occupied by state government, colleges, municipalities and schools. In the private sector, buildings that meet certain ENERGY STAR criteria are typically deemed more attractive by tenants due to the potential for lower operating costs, which we believe makes them more valuable for investors and developers.

Since 1992, ENERGY STAR and its partners helped prevent 4 billion metric tons of greenhouse gas emissions from entering our atmosphere. In 2020 alone, the program's emissions reductions were equivalent to more than five percent of U.S. total greenhouse gas emissions.

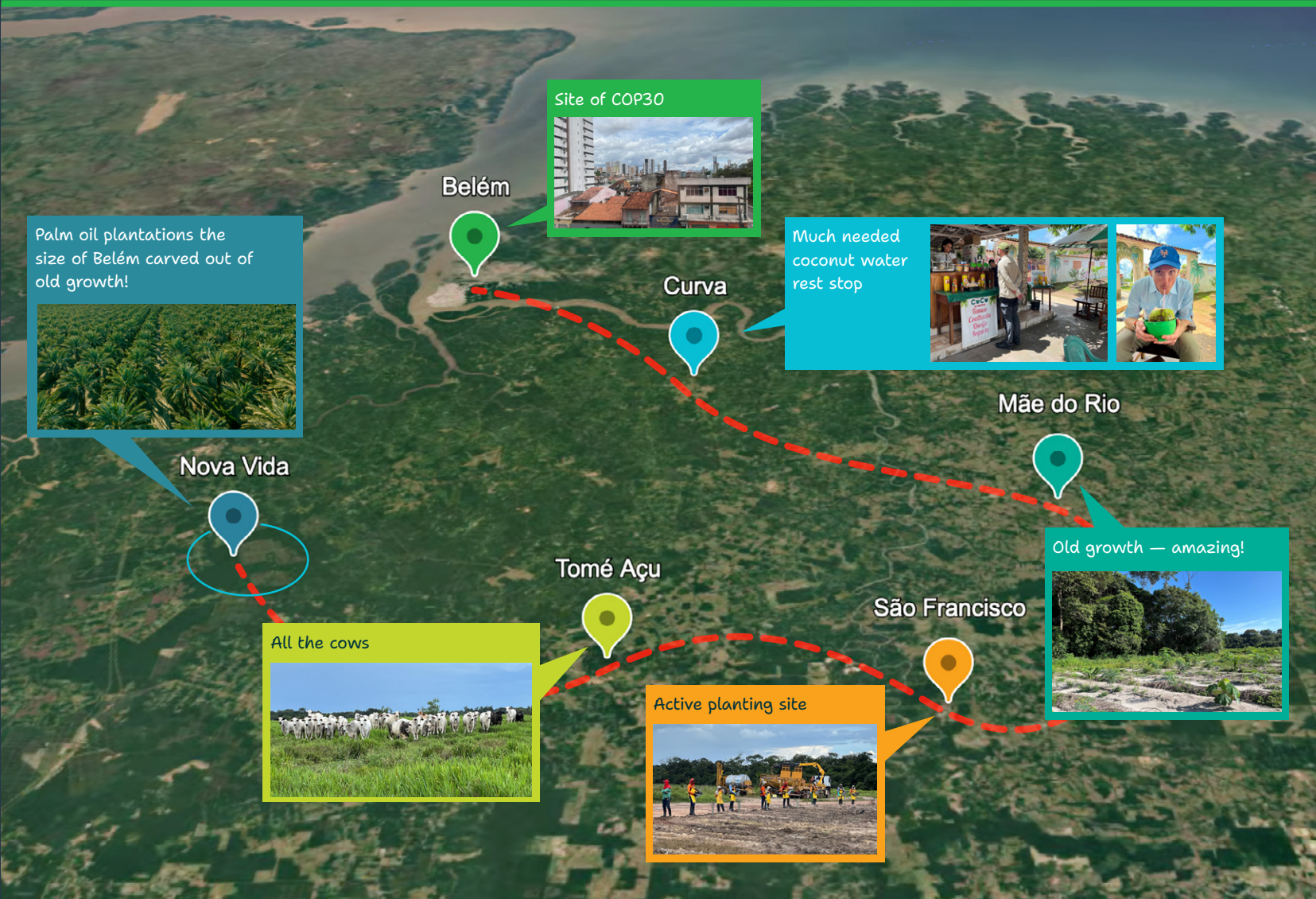
Source: Obtained from <https://www.energystar.gov/about/impacts>

Reflections from the forest: World Bank Amazon reforestation bond

In August 2024, Nuveen's ESG/impact fixed income team was lead order in a nine year World Bank outcome bond to support reforestation of the Amazon rainforest in Brazil. Nuveen invested \$75 million in the innovative \$225 million transaction, which finances replanting of degraded and deforested farmland with native tree species.

The bond offered a below market coupon at issue, which provided the source of funding for Mombak, a Brazilian-based company, to acquire or partner with landowners in the state of Pará. Yet a successful outcome improves the bondholder return meaningfully over a conventional World Bank bullet bond. A portion of the coupon depends on the amount of CO₂ removed from the atmosphere by the reforested land until the bond matures.

The bond is the first to link investors' financial returns to the amount of carbon removed from the atmosphere via generation of carbon removal credits. Before the deal was announced, Nuveen engaged with Mombak to ensure impact reporting would include not just carbon sequestered, but also key performance indicators focused on forest health, biodiversity and community impact, which illustrate societal benefits within the local economy.



The notes below were compiled by associate portfolio manager Adam Guerino during his May 2025 visit to several Mombak reforestation sites.

I arrived in Belém, the capital and largest city in the northern Brazilian state of Pará. From the United States, I had to connect through Brasília, Brazil’s capital, situated in the center of the country. We were bound for Mãe do Rio, a decent sized town about a 3.5 hour drive southeast of Belém, to visit sites where Mombak is reforesting farms with native species. Mombak acquires land for some projects, and enters into landowner partnerships for others, methodically restoring the indigenous ecosystem while providing a new source of income for ranchers and landowners.

Cattle ranching is a critical part of Brazil’s economy, but it has taken a toll on the natural environment. The livestock sector represents roughly 7% of the country’s GDP;⁹ and as the world’s largest beef exporter, cattle represents an estimated 20% of the sector. (Brazil is second to the United States in beef *production*, but exports more.) According to the World Economic Forum, about 40% of all deforestation in the Brazilian Amazon since 2001 has occurred in the state of Pará, with cattle ranching being by far the biggest driver of forest clearance.¹⁰

On the ride to Mãe do Rio, I saw plenty of cattle farms and far more palm oil plantations than I expected (and they’re huge hulks of darkness that stretch along for miles). Our hotel was on the main drag, past which trucks roll through all night long including huge tandem trailers packed with cattle. I realized over the course of the trip that this level of changed landscape and some urbanization really warps your perspective. It felt like I was only ever in a rural area — flattened farmland away from a major population center; I never felt like I was in the Amazon (or what once was). It’s only after visiting a site with

some old growth remaining alongside degraded pastureland that I got a sense of the forest that previously dominated the landscape.

Turmalina is Mombak’s oldest site, replanted in March 2023. It predates the Amazon reforestation-linked bond issued in August 2024. At least half the growth was already over my head. It wasn’t a long walk to feel like I was in thriving, natural forest — not saplings planted in neat rows two years prior. So just like my previous comment about not realizing I was in the Amazon when surrounded by farms and cattle, it was hard to picture an empty field when seeing even a mere two years of regrowth. Most of the growth well over my head were recovery species that grow fast and provide important shade for the slower-growing species that become the main carbon sinks. The recovery species might last 15–30 years while the slower growth species live for 50+ years.

I was struck by the thoughtfulness of Mombak’s replanting program upon seeing it in person, even though this was one of the compelling selling points when we were evaluating the deal before the bond was issued. Seeing it in person reinforced that this is a fully formed agricultural operation, rather than your local arbor day event for planting some new trees in a park or neighborhood.

Fast growing trees and plants, like eucalyptus, may appear vibrant and healthy more quickly, but monocultures weaken ecosystems over time, according to biologists. Mombak plants around 1,500 trees per hectare, while a mature, natural forest in this region will have about 500 trees per hectare. Initially, they were planting about 100 different species per hectare. But as the team learned what works best in terms of growth and



survivability, they are down to about 50 species per hectare, going back to replant small plots that didn't take for whatever reason. Mombak establishes on-site nurseries when sites are located far apart, and works with local greenhouses, bolstering their economic viability. At the nurseries, saplings are delivered, inspected, and placed into biodegradable pots for planting.

Once the pastureland is cleared of the large tufts of grass used to feed cattle, the actual planting goes quite fast. Workers walk together in teams, each with a tool for spiking seedlings into the earth. The devices are long metal tubes, and look similar to oversized caulk guns. Every few steps, they reload the tool with a new seedling in its biodegradable pot, shoot it into the ground, and then repeat the circuit with remarkable speed and precision. Each worker can deposit up to 2,000 seedlings a day, which is more than a hectare of plantings. The process isn't random or haphazard, either. Seedlings are placed in a specific order with alternating species depending on the site. A tractor full of seedlings follows the planters into the field so they can reload on the go. It rained part of every day of the trip, and it poured the day I watched this particular planting, which seemed like a good omen for these newly planted seedlings.

As the new forest grows, the ecosystem and local communities can benefit. I didn't have any notable wildlife encounters, but workers showed me images from their phones of sloths and even a big cat on replanted land. The new trees also bear fruit that locals harvest, primarily as botanicals for hygiene products. The locals noted that the

Mombak trees, in their natural state, bear more fruit than the local farms that grow the fruit. This yield will be enjoyed for years as the recovery species thrive, but eventually won't be as plentiful under a mature canopy.

The positive potential impact for the local economy is more profound when you consider the possibility of greater numbers of landowners tapping into carbon removal credits generated by their property. Many second and third generation ranchers and farmers would prefer not to continue in the family business. At Tomé Açu, a partnership farm, planting was completed about a year ago. The rancher is nearing retirement and was intrigued by being able to work less and generate passive income off his land. So the site is partially reforested and partially a still-active ranch. But the rancher said he expects a 60% improvement in income over what he could earn by continuing to fully ranch the land.

Overall, it's quite obvious that Mombak is doing exactly what they said they would do. Farms are being reforested, native trees are growing, locals are working, the community is receiving benefits from the forest, and ranchers are able to generate passive income. I was left impressed with the professionalism, organization, and effectiveness of Mombak's operations, which I attribute to the entrepreneurial, for-profit nature of the enterprise. One of the primary stumbling blocks to scale nature-based solutions is revenue generation, and this is an impressive example of what can be done by solving the revenue puzzle.



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Endnotes

- 1

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Investing in fixed income investments involves risks such as market risk, credit risk, interest rate/duration risk, call risk, tax risk, political and economic risk, derivatives risk, and income risk. Credit risk refers to an issuers ability to make interest and principal payments when due. Typically the value of, and income generated by, fixed income investments will decrease or increase based on changes in market interest rates.

Responsible investing incorporates Environmental Social Governance (ESG) factors that may affect exposure to issuers, sectors, industries, limiting the type and number of investment opportunities available, which could result in excluding investments that perform well. Because its social screens exclude some investments, the strategy may not be able to take advantage of the same opportunities or market trends as strategies that do not use such criteria.

Nuveen considers ESG integration to be the consideration of financially material environmental, social and governance (ESG) factors within the investment decision making process. Financial materiality and applicability of ESG factors varies by asset class and investment strategy. ESG factors may be among many factors considered in evaluating an investment decision, and unless otherwise stated in the relevant offering memorandum or prospectus, do not alter the investment guidelines, strategy or objectives. Select investment strategies do not integrate such ESG factors in the investment decision making process.

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