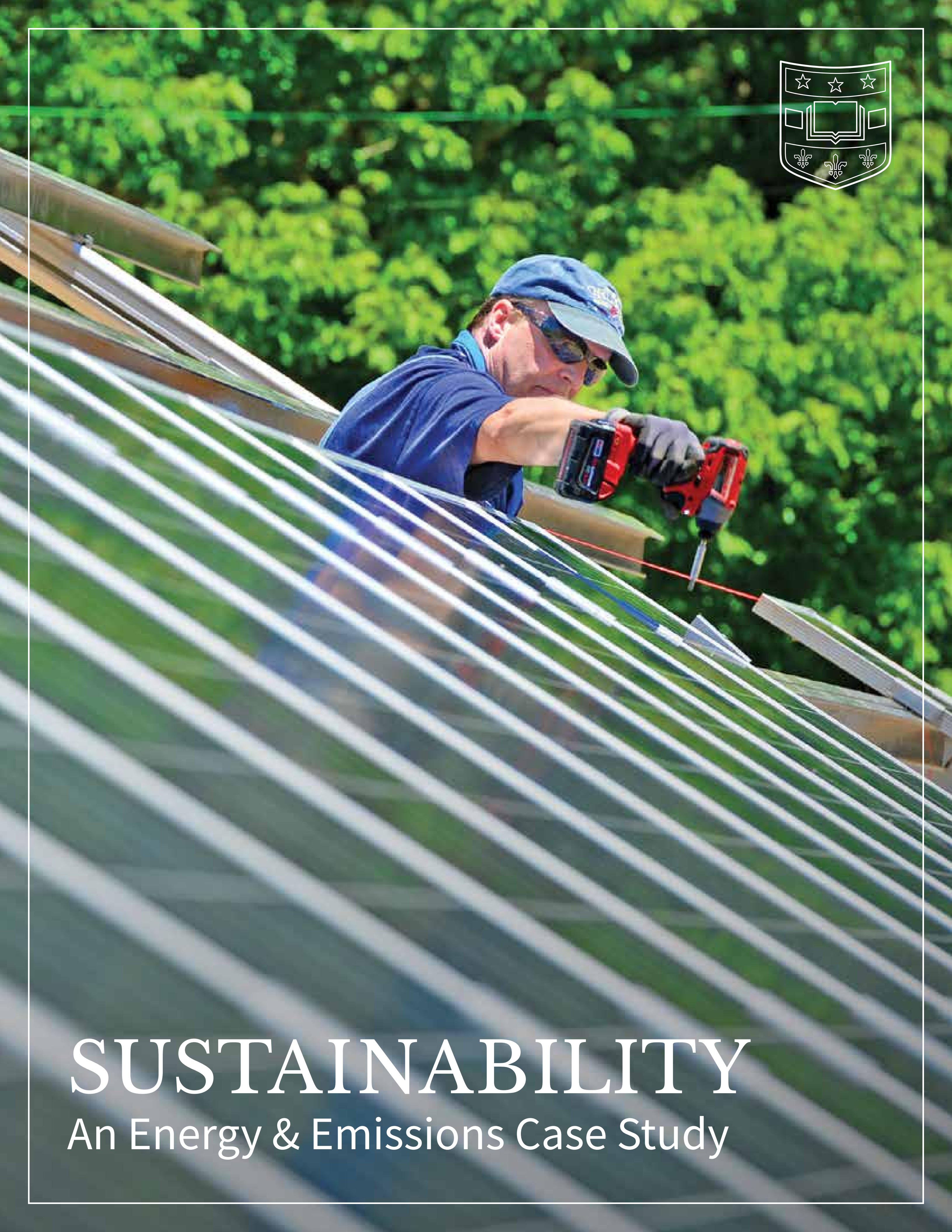
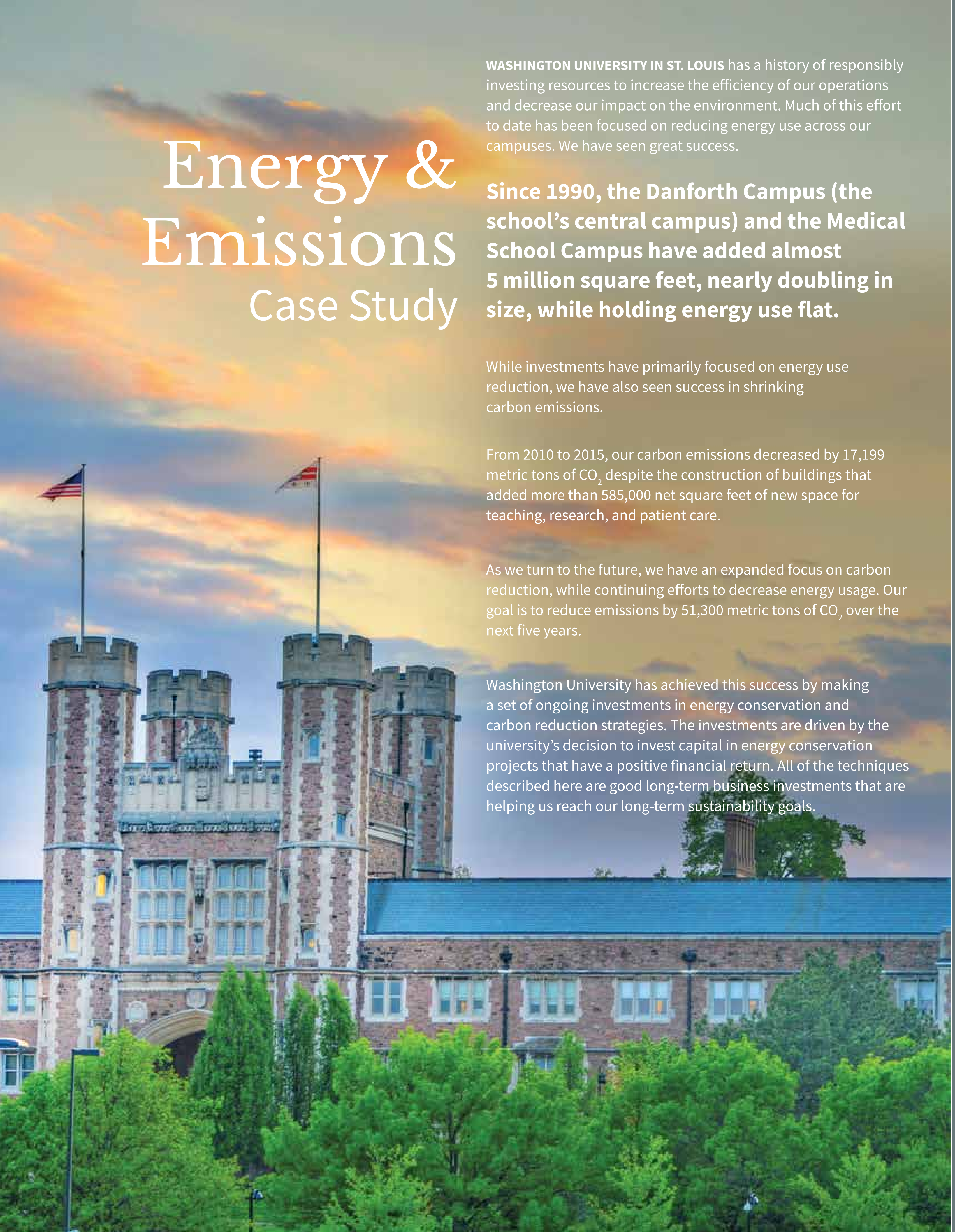


SUSTAINABILITY

An Energy & Emissions Case Study



Energy & Emissions
Case Study

WASHINGTON UNIVERSITY IN ST. LOUIS has a history of responsibly investing resources to increase the efficiency of our operations and decrease our impact on the environment. Much of this effort to date has been focused on reducing energy use across our campuses. We have seen great success.

Since 1990, the Danforth Campus (the school's central campus) and the Medical School Campus have added almost 5 million square feet, nearly doubling in size, while holding energy use flat.

While investments have primarily focused on energy use reduction, we have also seen success in shrinking carbon emissions.

From 2010 to 2015, our carbon emissions decreased by 17,199 metric tons of CO_2 despite the construction of buildings that added more than 585,000 net square feet of new space for teaching, research, and patient care.

As we turn to the future, we have an expanded focus on carbon reduction, while continuing efforts to decrease energy usage. Our goal is to reduce emissions by 51,300 metric tons of CO_2 over the next five years.

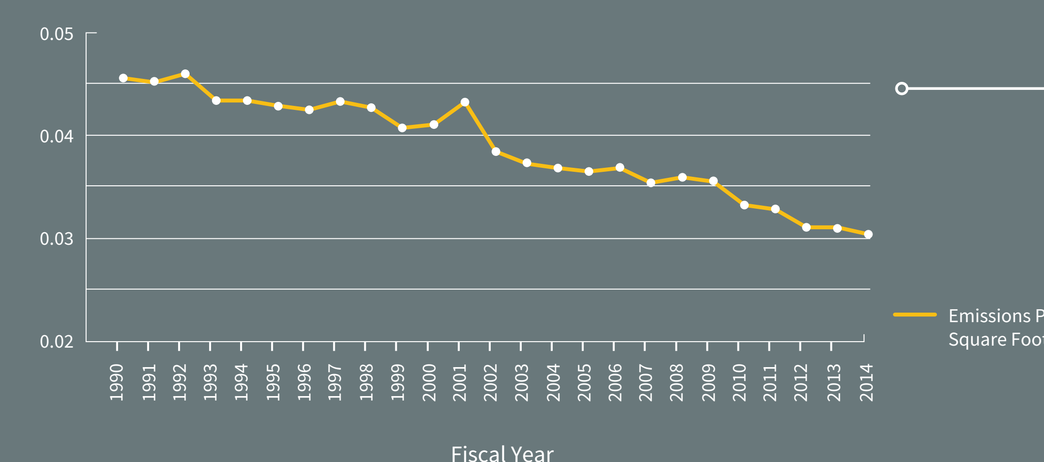
Washington University has achieved this success by making a set of ongoing investments in energy conservation and carbon reduction strategies. The investments are driven by the university's decision to invest capital in energy conservation projects that have a positive financial return. All of the techniques described here are good long-term business investments that are helping us reach our long-term sustainability goals.

Our Progress at a Glance

Building Area vs. Energy Use

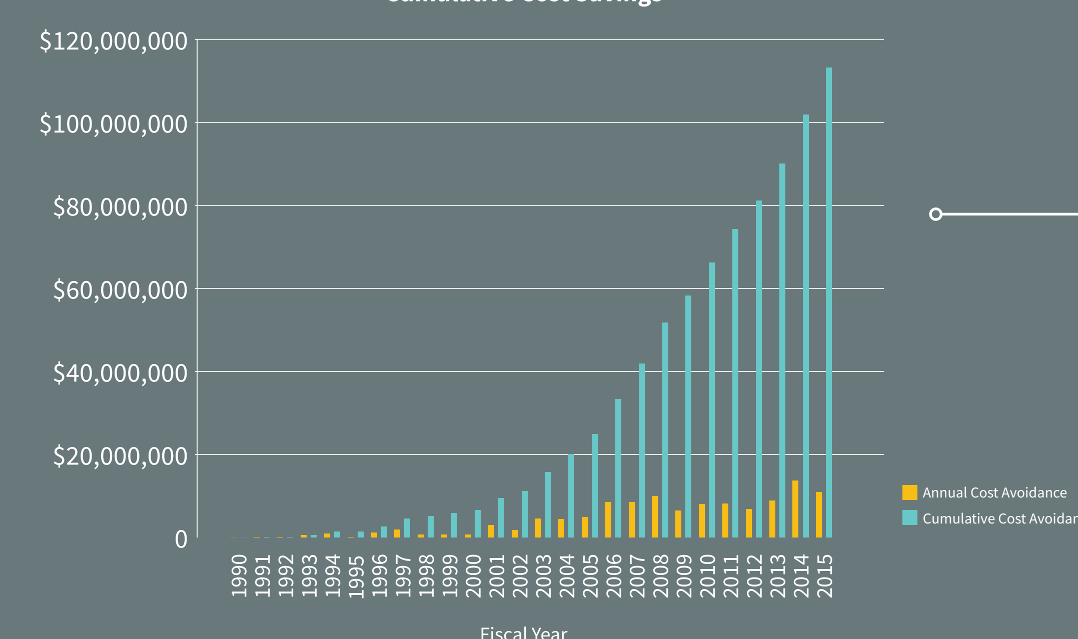
Building Area vs. Energy Use: Even though Washington University's building area has nearly doubled in size, our energy use has held flat.

Emissions Per Square Foot



Emissions Per Square Foot: University emissions per square foot have declined by 33 percent over the last 25 years.

Cumulative Cost Savings



Cumulative Cost Savings: The university's reduction in carbon emissions and energy use have resulted in significant cost savings.

How Have We Achieved Success

Major Utility Improvements

Much of our increased efficiency has come from a set of investments in major utility systems across our campuses. As a group, these improvements are the biggest factor in our success in energy and carbon reduction and have resulted in a positive financial return.

Conversion to Natural Gas

Over a decade, both campuses switched from using coal boilers to using high efficiency dual fuel boilers, which utilize natural gas and fuel oil. Simultaneously, the university's central campus moved from a centralized main steam plant to 11 regional thermal plants to maximize distribution efficiency across campus by minimizing thermal loss. These changes resulted in more reliable steam production, a reduction in labor, less thermal distribution loss, and a decrease in CO_2 emissions.

High Efficiency Boilers

As part of the conversion from coal to natural gas, inefficient boilers from the 1930s–1940s were replaced with new high efficiency boilers for more efficient steam production. These new boilers have higher combustion efficiency due to the boiler design and more advanced control of the combustion air.

Heat Recovery Chillers

Due to the size and complexity of institutional buildings, there are many university buildings that require simultaneous cooling and heating. To efficiently meet this need, the university has replaced traditional chillers with heat recovery chillers that capture what would otherwise be wasted heat from the cooling process to provide heating where it is needed. The heat recovery chillers are significantly more efficient and have allowed the university to turn off gas boilers from May to October that would otherwise have operated year-round.

Lighting Retrofits

The university is engaged in ongoing retrofits of interior and exterior campus lighting. To date, these efforts have included the conversion of four campus parking garages and 400 exterior site lights to LEDs and over 5 million square feet of interior space upgraded to efficient T8 lamps with electronic ballasts. We project that these lighting upgrades are saving us $709,000 annually, as well as reducing our carbon emissions by 8,800 metric tons per year.

Our lighting projects have underscored the importance of doing full life-cycle cost analyses. Certain projects were not justifiable on energy savings alone; however, when we factored in labor and material savings from using lamps with significantly longer life spans, the projects were clear winners.

Building Metering

The university's two major campuses have completed a $5.9 million project to install energy meters in all buildings. The meters measure usage of electricity, natural gas, hot water for heating, and cold water for cooling. The project, consisting of 500 meters on the Danforth Campus and 230 meters at the School of Medicine, is complete and in its first year of operation. We have already discovered and are working to correct operational deficiencies in several buildings that were previously unknown.

On both campuses, these systems enable us to:

- Quickly flag and correct inefficiencies.
- Establish energy-use benchmarks based on space type and identify outlier buildings to target for energy conservation.
- Support incentive programs to drive user engagement in energy conservation.

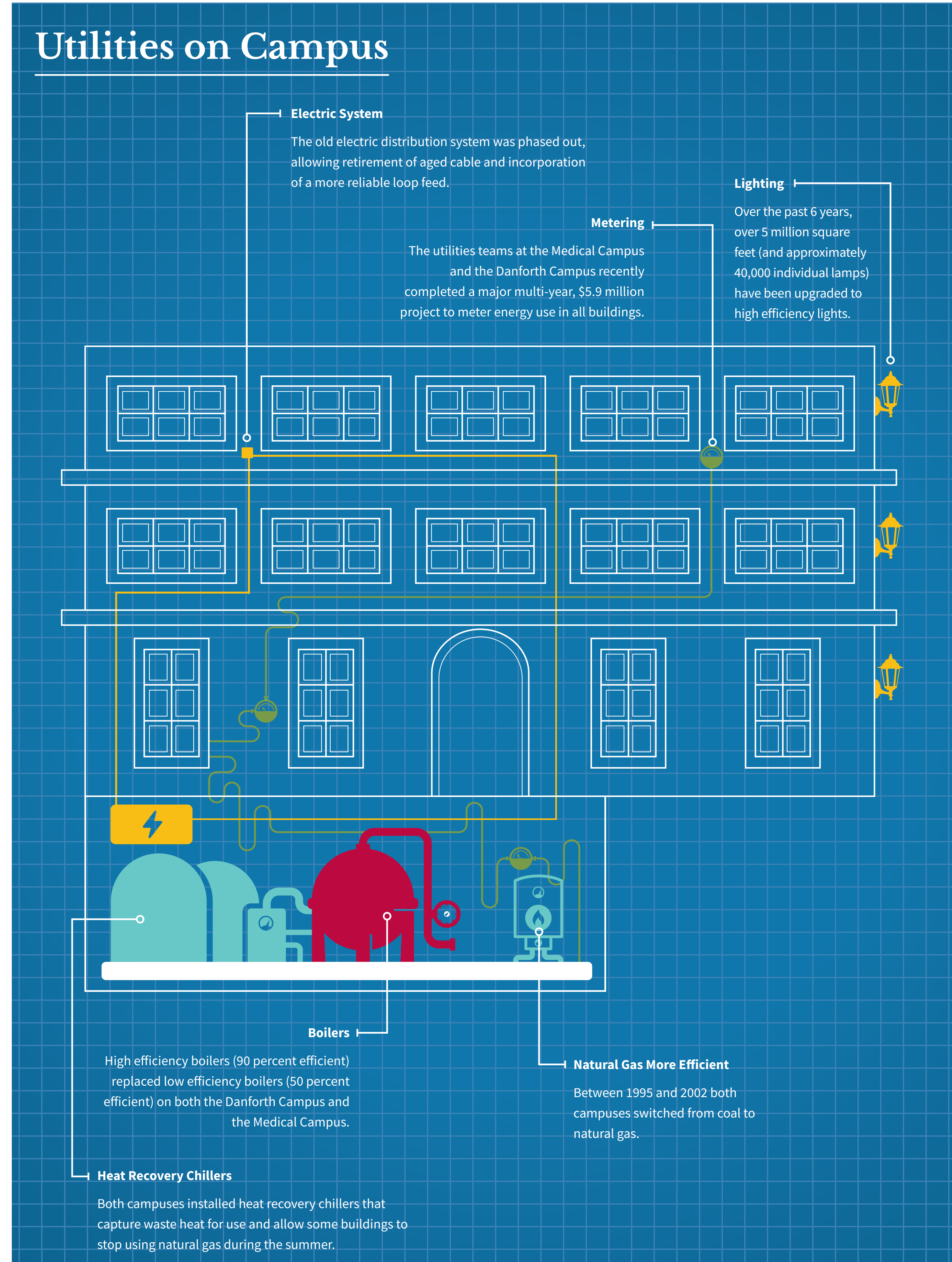
Example: In a business school building, the meters detected an unusually high amount of chilled water for cooling. An investigation discovered that a software override was causing the system to constantly read the outside air temperature as greater than 90 degrees, regardless of the actual temperature. This caused the system to cool all incoming outside air, even if it was below 55 degrees and did not require cooling. After the software override was released, there was an immediate reduction of approximately 100 tons in cooling energy. This allowed one of the chillers on the loop to be turned off entirely resulting in a savings of $28,000 a year in energy costs.

Upgraded Electric System

Beginning in the 1990s, the university began a comprehensive upgrade of the electric systems on campus. Upgrades included a new electrical substation dedicated to the portion of campus that houses undergraduate dorms, and a new main substation with the capability to meet future campus growth and improve electric reliability. We also replaced our radial electric distribution system with a loop distribution system, allowing the retirement of aged cable and creating a more reliable system.

Other Major Improvements

- A decentralized heating plant converted to low pressure steam.
- New HVAC systems and controls on the Medical Campus to help meet energy conservation goals.



Very Efficient New Buildings and Major Renovations

Washington University has adopted two key green building standards: a LEED Silver minimum and the requirement that projects perform 30 percent better than the ASHRAE 90.1-2010 energy efficiency standard, a leading national energy standard for buildings.

Since 2010, the university has built 14 new buildings totaling 1.5 million square feet.

- 95 percent of the total square feet built has exceeded our LEED Silver building minimum
- 22 percent of the space is certified LEED Platinum
- 74 percent of the space is LEED Gold

Operating costs of new buildings are at least 30 percent lower than those of a standard building.

The Living Learning Center — which is part of the university's ecological field station, Tyson Research Center — is one of the first buildings in the world to receive Living Building Challenge certification. This is the most stringent green building rating system in the world, requiring net-zero energy and net-zero water operations.

Example: Hillman Hall (Brown School) – LEED Platinum

- *Designed to be 41 percent more efficient than a conventional building*
- *50 kw rooftop solar array*
- *A roof deck with planting beds*
- *Site design featuring a large rain garden and dynamic outdoor spaces that are fully integrated with bike and pedestrian infrastructure to reduce parking demand*

Energy Conservation Investments

For the past 20 years, university leadership has had a policy of providing up-front capital support for energy conservation projects with positive long-term financial returns. In 2013, we committed to invest \$30 million in energy conservation projects prior to 2020. By mid-year 2015, we had completed \$6.5 million of projects with an additional \$3.9 million of projects in-progress. This long-range view has enabled the investment necessary to halve energy use per square foot over the last 25 years.

Departments have historically looked at payback period or net present value (expected income minus the cost of the project) to determine which projects to fund. This approach has allowed us to identify projects with strong financial and environmental returns, many of which are described here. Until recently, however, the university did not have a standardized financial model used across departments, resulting in some inconsistency in application and some missed opportunities.

In 2014, Executive Vice Chancellor Hank Webber tasked a cross-campus energy and emissions working group — consisting of key staff from the Facilities teams, Financial Planning, and the Office of Sustainability — with standardizing and publishing the university's financial modeling guidelines for projects that impact utility costs, including energy, water, and storm water. The goal was the creation of a standard to be used by staff and consultants to ensure that all potential projects would be modeled using a consistent set of assumptions based on the best available data. The final document outlines standardized assumptions for:

- Utility costs
- Escalators
- Life-cycle cost analyses
- Payback periods
- Net present value
- Carbon saved per dollar spent
- Financial analyses both with and without the social cost of carbon

(Those interested in obtaining a copy of these guidelines can go to tinyurl.com/financialmodelingguidelines.)

The updated guidelines give university leadership confidence that all potential projects have been evaluated using the same criteria. Once applied to a suite of potential projects, the updated guidelines identified a greater number of projects with strong financial return and significant carbon reduction than were previously known, allowing the university to adopt a more aggressive 2020 greenhouse gas reduction goal.

Staff Training and Engagement

Staff members' knowledge and leadership are crucial in the university's mission to reduce its environmental impact.

The university has energy engineer roles at both campuses, 12 staff members are LEED Accredited Professionals, 95 staff members have received Facility Management Professional accreditation, and 43 staff members have received Sustainability Facility Professional accreditation.

The university's energy and emissions working group meets at least bi-monthly. The working group oversees a broad range of energy conservation measures including utility system upgrades, lighting retrofits, retro-commissioning, and behavior change. The group is also tasked with proposing policy changes and the development of standards, such as the financial modeling guidelines.

Next Steps

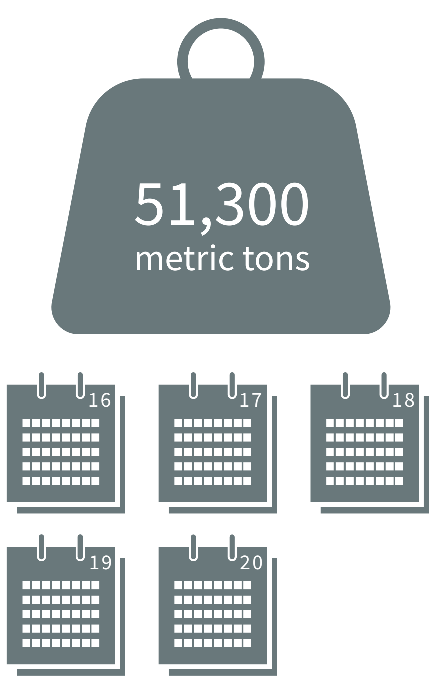
Updated 2020 Goal

The university has set an ambitious goal to reduce greenhouse gas emissions to 1990 levels by 2020, representing a reduction of 51,300 metric tons of CO_2.

In 2010, the university set a goal to reduce greenhouse gas emissions to 1990 levels by 2020 without purchasing carbon offsets. Five years into this effort, we have updated this goal to make it even more ambitious. Our new goal is to reduce greenhouse gas emissions to 1990 levels by 2020 including all campus growth, which requires reducing emissions by 51,300 metric tons of CO_2 by 2020. This new goal nearly doubles the reduction required by the previous goal.

As ofJuly 2015, we are 14 percent of the way to meeting our new goal. We continue to identify and invest in projects that provide a positive financial return and help us further reduce energy use and emissions.

The university has been very successful in its campaign to reduce energy use. While we will continue to target further reductions, we recognize that there is a need to give equal attention in the future to reducing carbon emissions. Our experiences to date have demonstrated that projects that result in energy and cost savings do not always reduce carbon emissions because there are different levels of emissions from different energy sources. Emissions reduction must be an explicit focus of decision-making to ensure projects contribute to our greenhouse gas reduction goal.



51,300

metric tons of CO_2 **over the next five years. A 51,300 MT reduction is equivalent to taking 10,800 cars off the road.**

The Lofts of Washington University is an off-campus student housing complex that has been designated LEED Platinum. The four buildings — 46 percent more efficient than conventional buildings — get 10 percent of their electricity and 25 percent of their hot water from rooftop solar panels. The Lofts also features a water-harvesting cistern for irrigation, south facing sun shades, and a rain garden.

Strategies to Meet 2020 Carbon Reduction Goal

In order to meet its 2020 reduction goal, the university will utilize three major strategies.

Continued Investment in Financially Sound Projects

We will continue to implement the projects outlined in the case study and will work to identify projects that provide a positive financial return while advancing our goals of energy and emissions reduction. As technology evolves and staff expertise expands, the university will identify additional financially sound energy reduction projects.

$3 Million Retro-Commissioning Study Program

Using metering data, we are improving the efficiency of building systems.

Now that all university buildings have been metered, our facilities teams are looking closely at the biggest users on both campuses to identify ways to reduce their energy usage and emissions.

The Danforth and Medical campuses recently initiated a retro-commissioning program aimed at reducing our energy use, reducing our greenhouse gas emissions, and improving occupant comfort. Retro-commissioning involves studying and adjusting building systems, including equipment and control systems, to ensure they are performing optimally. In order to focus our efforts, we used building-level metering data to identify the buildings with the highest energy usage (both total energy use and energy use per square foot). The metering data revealed that 35 of our 100-plus buildings use more than 70 percent of the energy on the Danforth Campus. Eight buildings were selected for the pilot phase of in-depth retro-commissioning studies. The studies are taking place in 2015, with implementation of the recommendations to follow in 2015 and 2016.

Example: Pilot studies of a few buildings are already producing encouraging results. The initial study of a biomedical engineering building resulted in recommendations that are projected to reduce the building's greenhouse gas emissions by over 20 percent, with predicted cost savings that would exceed the university's investment in less than one year.

↓20%

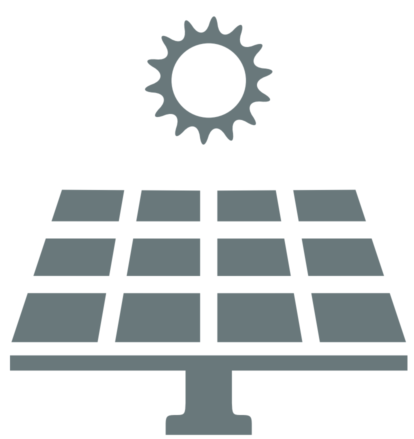
reduction in a building's greenhouse gas emissions

Continued Investment in Renewable Energy

New building designs anticipate future integration of renewable energy.

Washington University's greenhouse gas reduction strategies have traditionally focused on energy conservation. With the rise in utility rates and the concurrent significant reductions in the cost of renewable energy, the university is now planning for a near-future in which on-site and off-site renewable energy will be cost-competitive with grid electricity. This includes designing buildings and building systems for easy future integration of on-site generation. In addition, the university is studying a range of innovative energy system concepts based largely on renewable energy for the future build-out of sections of our Danforth campus.

Example: In 2014 and 2015, Washington University added 548 kilowatts of solar photovoltaics to university-owned property, including the Danforth Campus, Medical Campus, Tyson and other satellite locations. The new arrays represent our first major investment in renewable energy. The investment will pay off by producing enough emission-free energy to power the electrical usage of 65 average U.S. homes and save the university more than $100,000 over the first 10 years alone. The installations include roof-mounted systems, ground-mounted arrays, and a solar carport that engineering students plan to link to an electric vehicle charging station. The university also installed solar thermal panels for heating domestic hot water on a LEED Platinum off-campus student housing project and the Brown School's Hillman Hall.



548

kilowatts of solar photovoltaics added to university-owned property

Washington University in St. Louis