Energy and Emissions Reduction at Washington University

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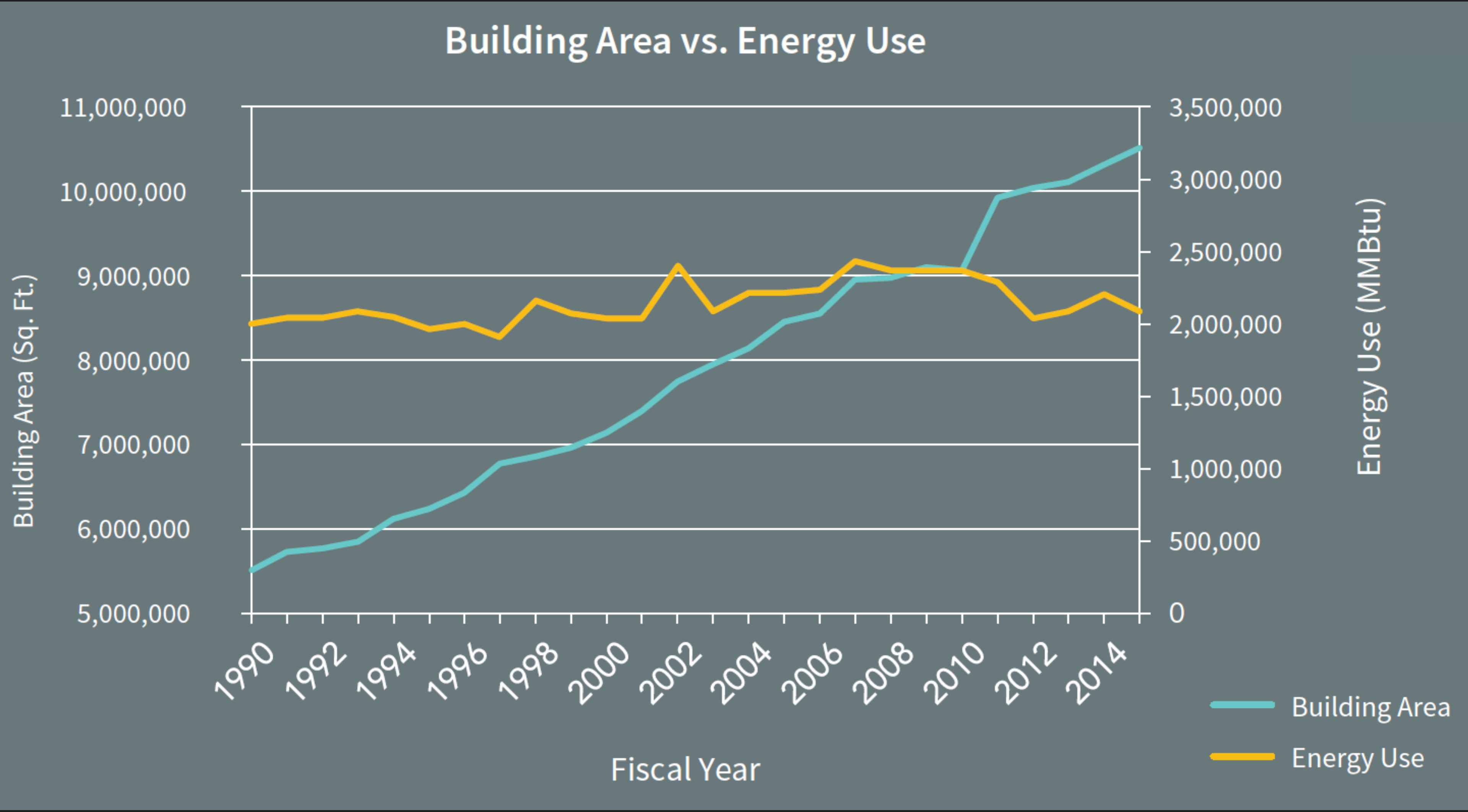
Washington University's Commitment to Sustainability

Universities play a crucial role in addressing the issues of climate change through teaching, research, and sustainable operations

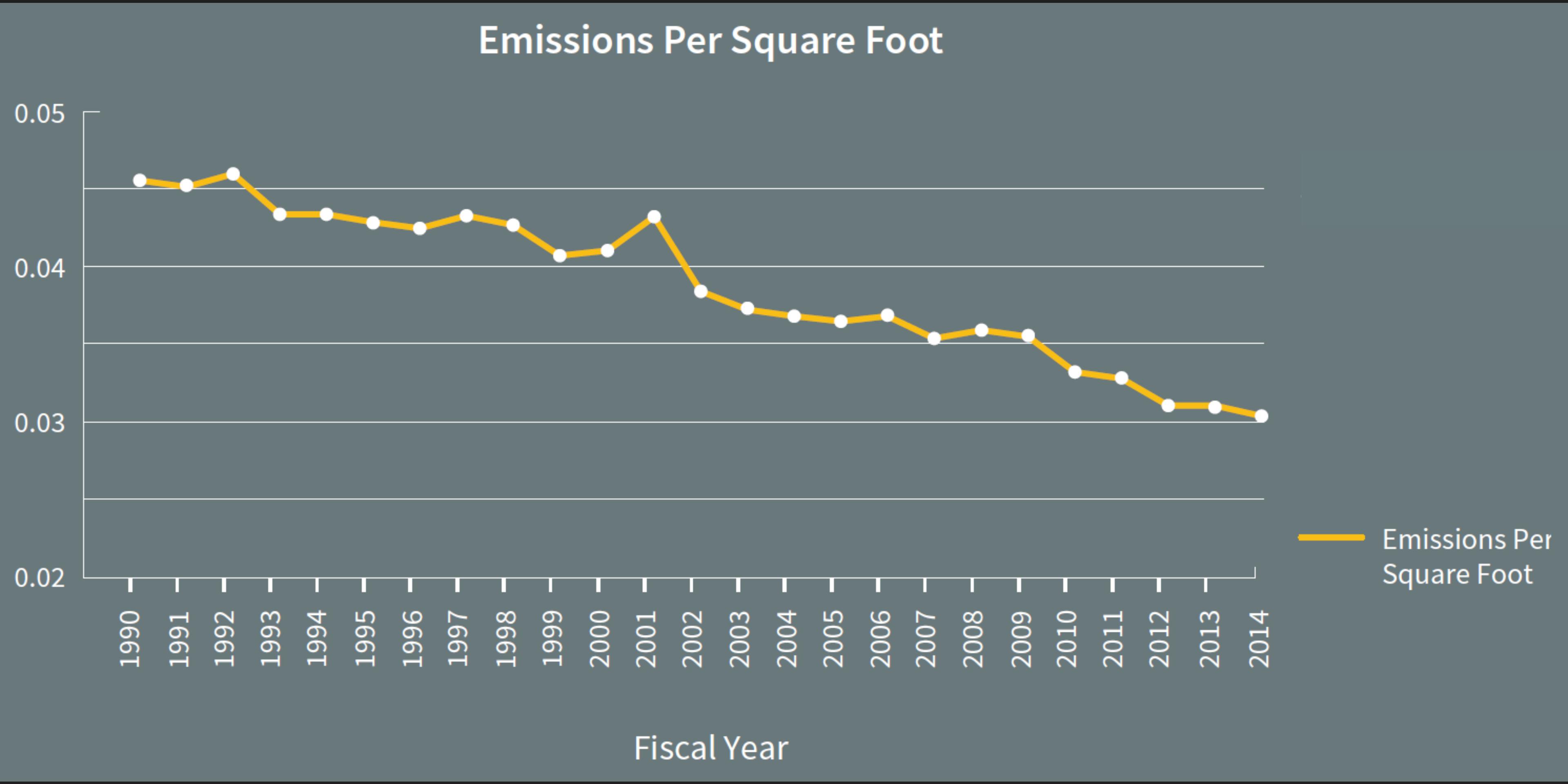
Washington University is committed to responsibly investing in projects that are financially viable, improve our operations, and advance our sustainability goals

We strive to serve as a model to other large Midwestern institutions

Sustainability Successes



Sustainability Successes



Sustainability Successes

Strategic Plan for Sustainable Operations

- In 2010, the University's first *Strategic Plan for Sustainable Operations* was published with a focus on energy and emissions reduction
- Recently completed *2015 – 2020 Strategic Plan for Sustainable Operations*
  - Reports progress since 2010
  - Establishes goals and targets for next five years
  - Outlines in-depth action plans, including specific strategies, metrics, and due dates

Updated Strategic Plan

2010 Sustainability Plan

Overarching goal:

Reduce the university's greenhouse gas emissions to 1990 levels by 2020 without purchasing carbon offsets

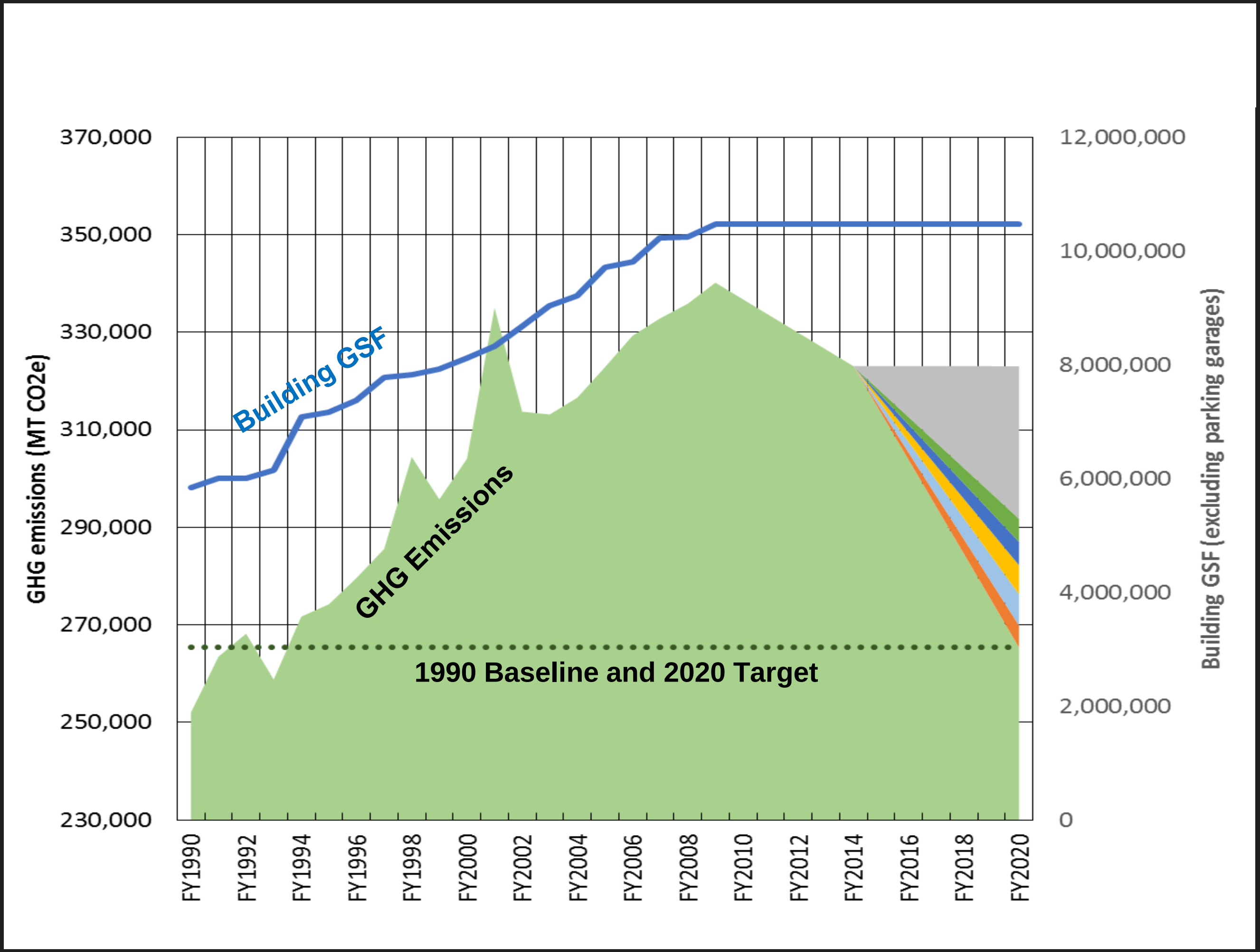
Progress since 2010:

Decreased carbon emissions by 17,199* metric tons of carbon dioxide, despite adding more than 585,000 square feet of new space.

**17,199 MT is a 5% reduction and is equivalent to taking more than 3,600 cars off the road.*

2010 Greenhouse Gas Reduction Goal

Reduce emissions to 1990 levels by 2020, including campus growth **1990 – 2010**, without purchasing carbon offsets or RECs.

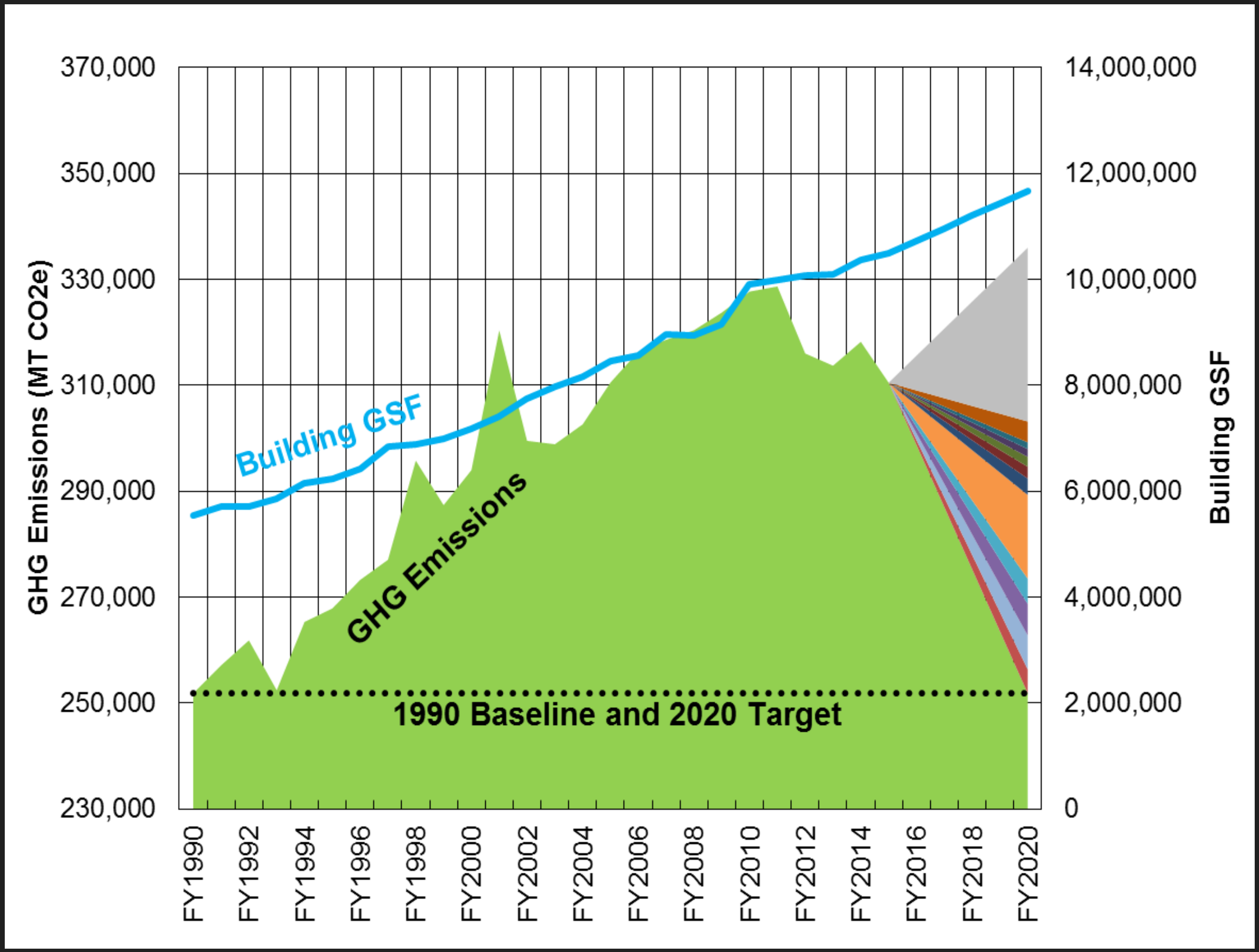


Reduction needed 2015 – 2020:

32,000 from grid
<u>26,000 from WU</u>
58,000 metric tons

2015 Greenhouse Gas Reduction Goal

Reduce emissions to 1990 levels by 2020, including campus growth **1990 – 2020**, without purchasing carbon offsets or RECs.



Reduction needed 2015 – 2020:

32,800 from grid

51,300 from WU

84,100 metric tons

Financials

$28M investment

7.4-year payback

Strategies to Achieve Energy and Emissions Goal

- Improve efficiency of existing infrastructure
  - Utility systems
  - Existing buildings
- Build highly efficient new buildings
- Invest in renewable energy where financially responsible
- Explore next generation low-carbon energy systems

Improve Efficiency of Existing Infrastructure

Energy Efficiency in Existing Infrastructure

- Utility systems
  - Replace boilers
  - Transition to heat recovery chillers
  - Shift to water distribution system for newest section of campus
- Existing buildings
  - Building metering
  - Lighting retrofits
  - Retrocommissioning

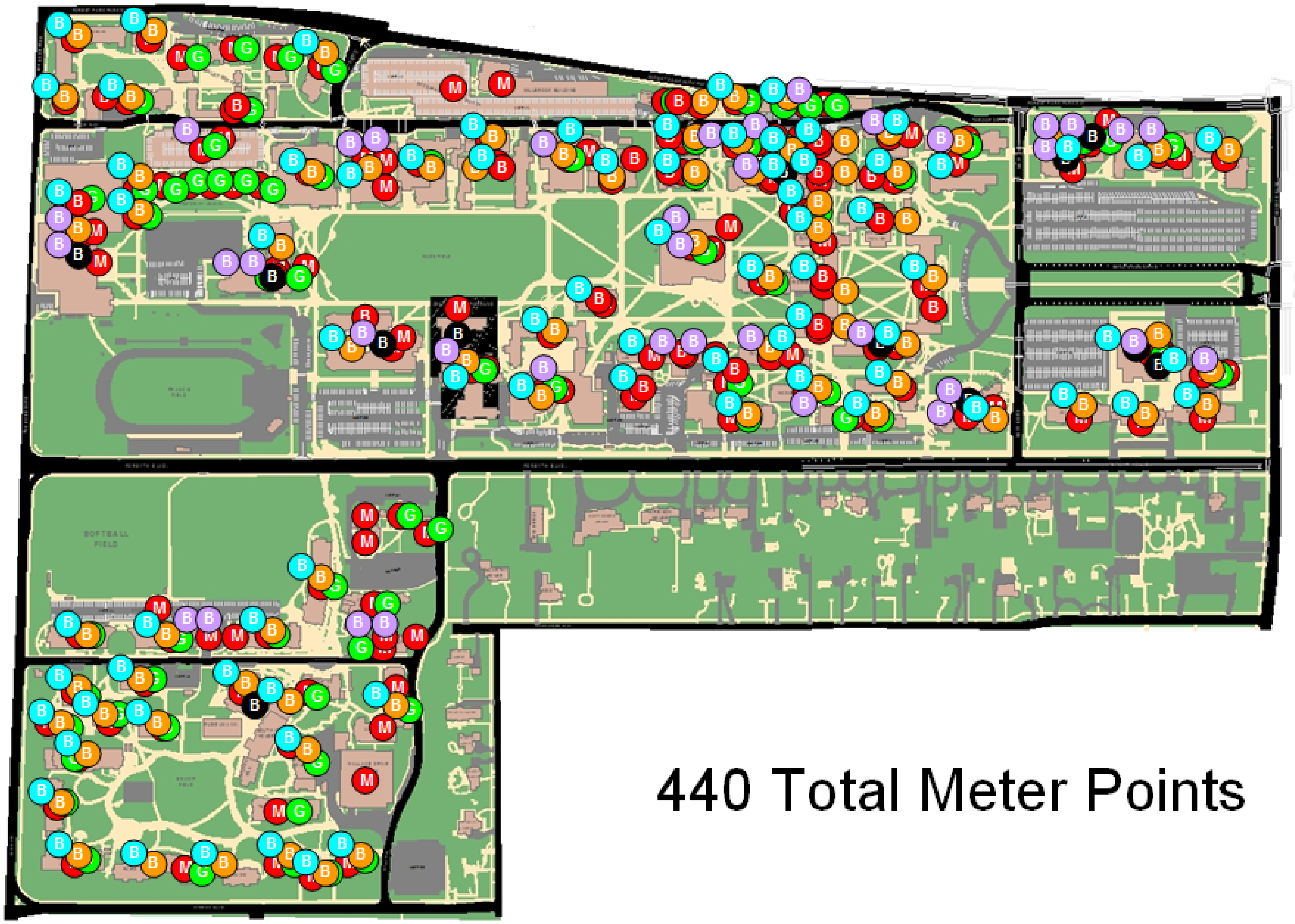
Building Metering

Danforth and Medical campuses recently completed the installation of energy meters in all buildings – over 700 meters

Allows us to:

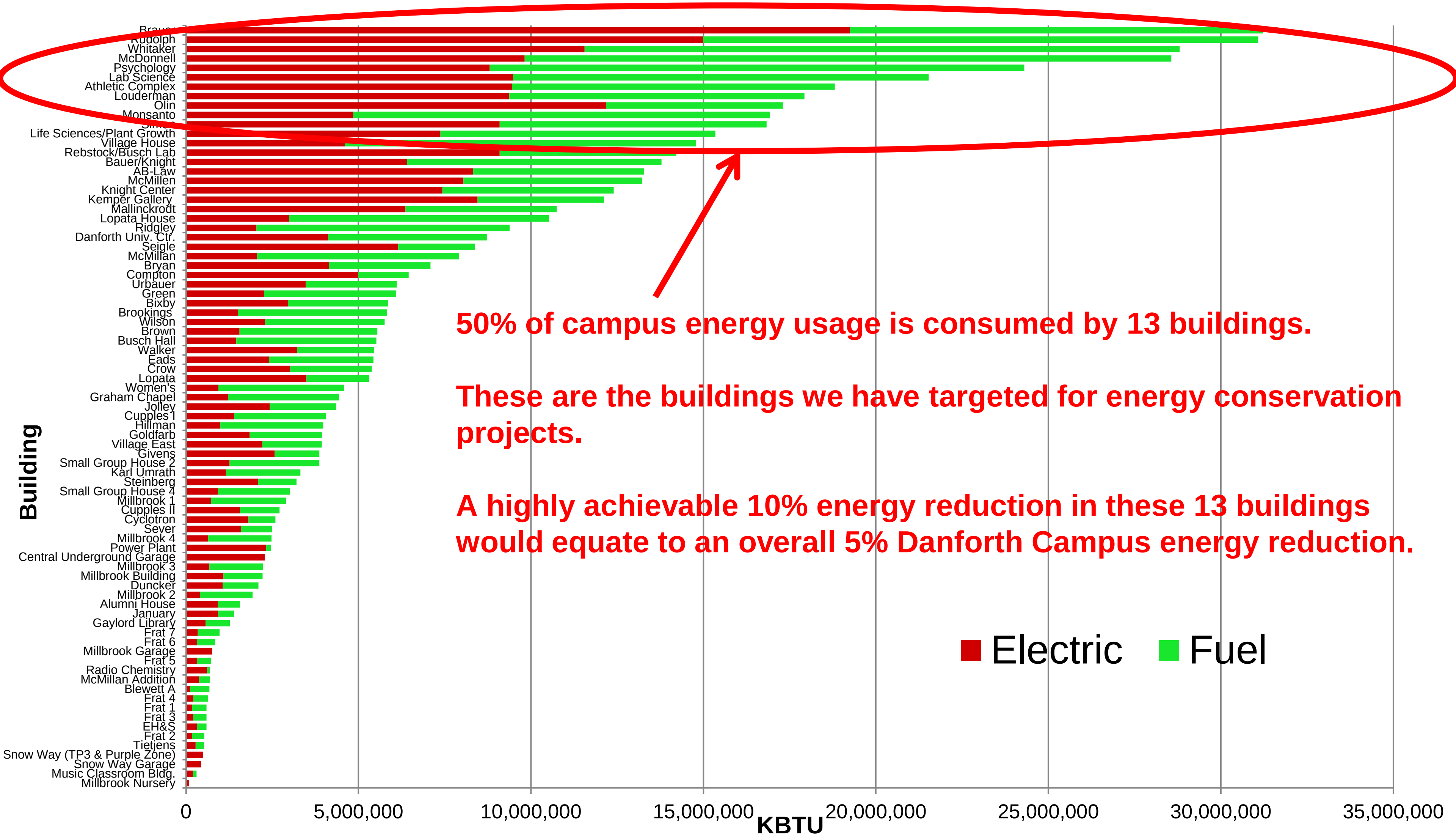
- Quickly flag and correct inefficiencies
- Identify unusually inefficient buildings to target for energy conservation projects
- Support incentive programs to encourage users to conserve energy
- Verify that new construction and energy efficiency projects are operating as designed

Total Meter Points



440 Total Meter Points

Identifying High-Use Buildings

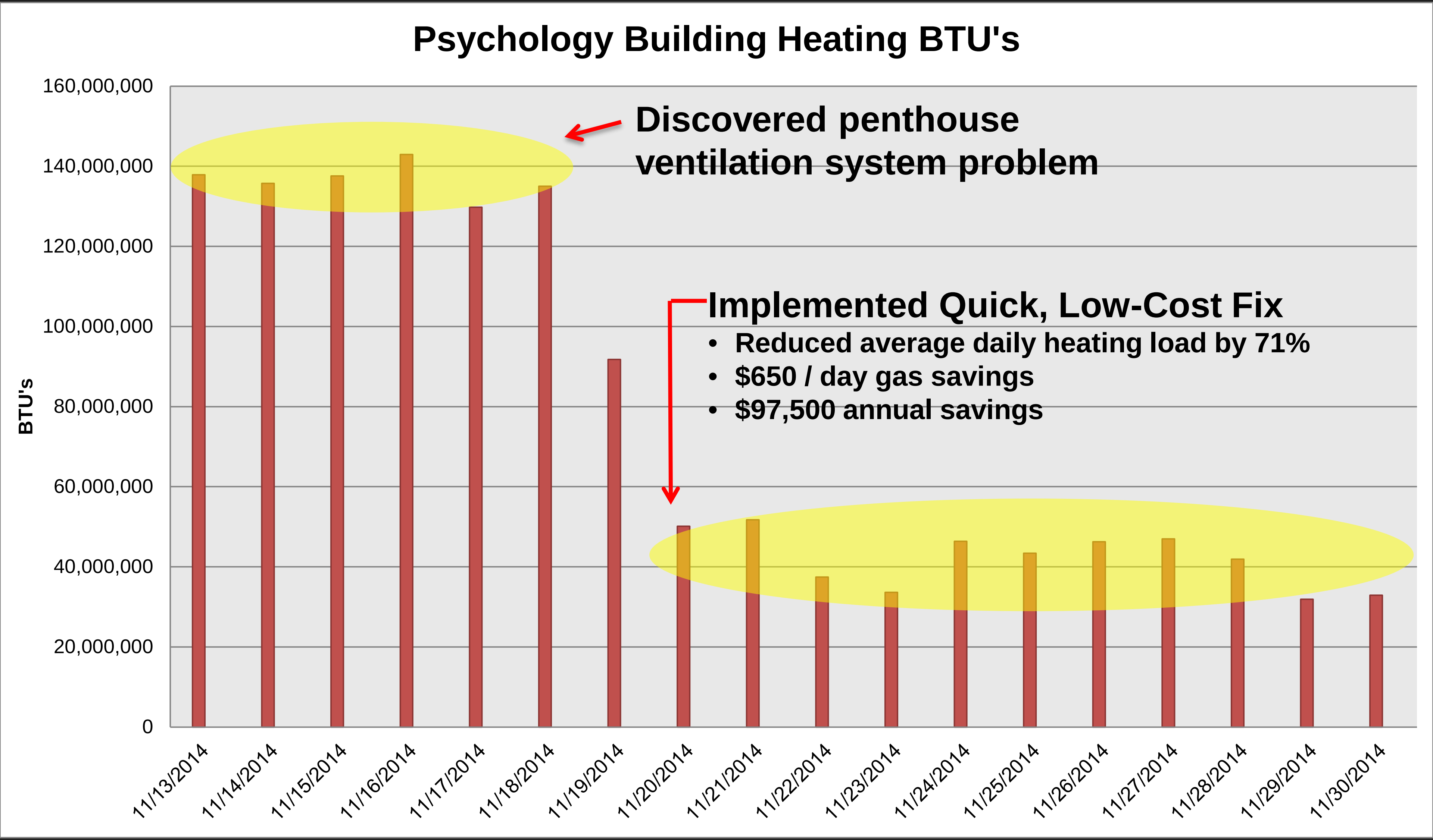


50% of campus energy usage is consumed by 13 buildings.

These are the buildings we have targeted for energy conservation projects.

A highly achievable 10% energy reduction in these 13 buildings would equate to an overall 5% Danforth Campus energy reduction.

Meters – Flag and Correct Anomalies



Retro-Commissioning – Laboratory Sciences

RCx Implementation Included:

- Occupancy controlled lighting, Temperature, and Airflow
- Modify sequence of operation for auditorium air handling unit
- Reduce unoccupied exhaust from teaching labs

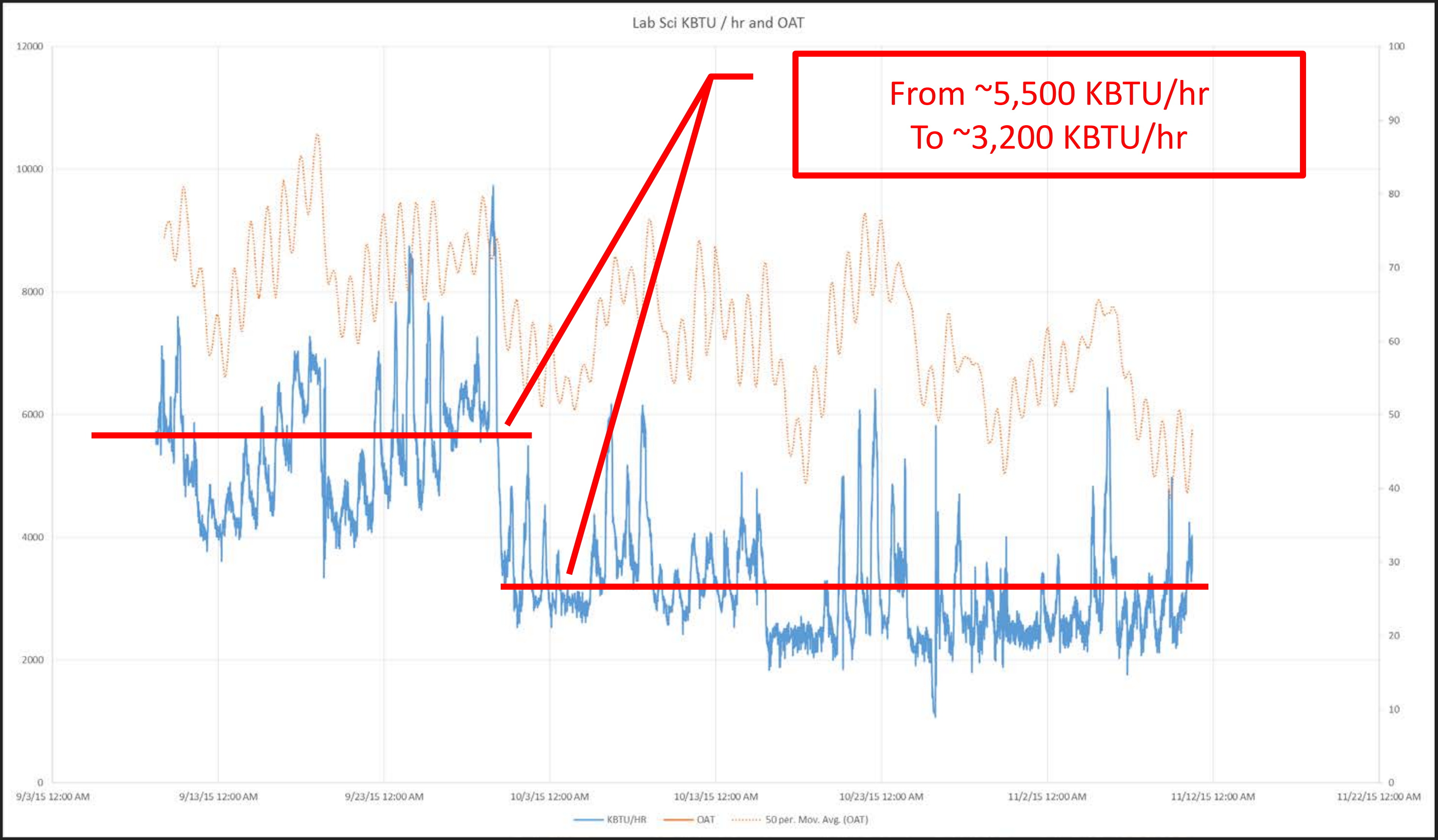
Cost

RCx Study	$71,600
Implementation	$193,700
Total	$265,300

Savings

Yearly	$83,800
Simple Payback	3.2 years
NPV_{20}	$977,556
Carbon (MT)	1,289

Retro-Commissioning Results – Laboratory Sciences



Highly Efficient New Buildings

Build Highly Efficient New Buildings

Two standards adopted in 2010:

- LEED Silver minimum
- 30% ASHRAE 90.1-2007 energy efficiency minimum

Progress since 2010:

- 1.4 million square feet of new buildings and major renovations
- 95% of this space has exceeded LEED Silver minimum
  - 22% LEED Platinum
  - 73% LEED Gold

New Buildings – Enhanced Energy Standard

Updated goals:

- 30% ASHRAE 90.1-2010 energy efficiency minimum for new construction
- 20% ASHRAE 90.1-2010 energy efficiency minimum for major renovations
- Project design should include life-cycle cost analysis, utilizing new standards in Financial Modeling Guidelines

Recent New Construction Projects

Lofts of Washington University

- Student housing and commercial space
- LEED Platinum
- **46% better than ASHRAE 90.1-2007**
- 75kw of solar PV
- Solar thermal provides 25% of domestic hot water

Hillman Hall

- Office, classroom, and event space
- LEED Platinum
- **41% better than ASHRAE 90.1-2007**
- 50kw of solar PV
- Solar thermal for domestic hot water

Renewable Energy

Solar PV Projects

- **Total of 580 kw of solar PV installed,** including roof ballast-mounted, fixed ground-mounted, dual-axis ground-mounted trackers, and solar carport

- All polycrystalline PV with string inverters. First microinverter project planned for summer 2016

- No battery storage

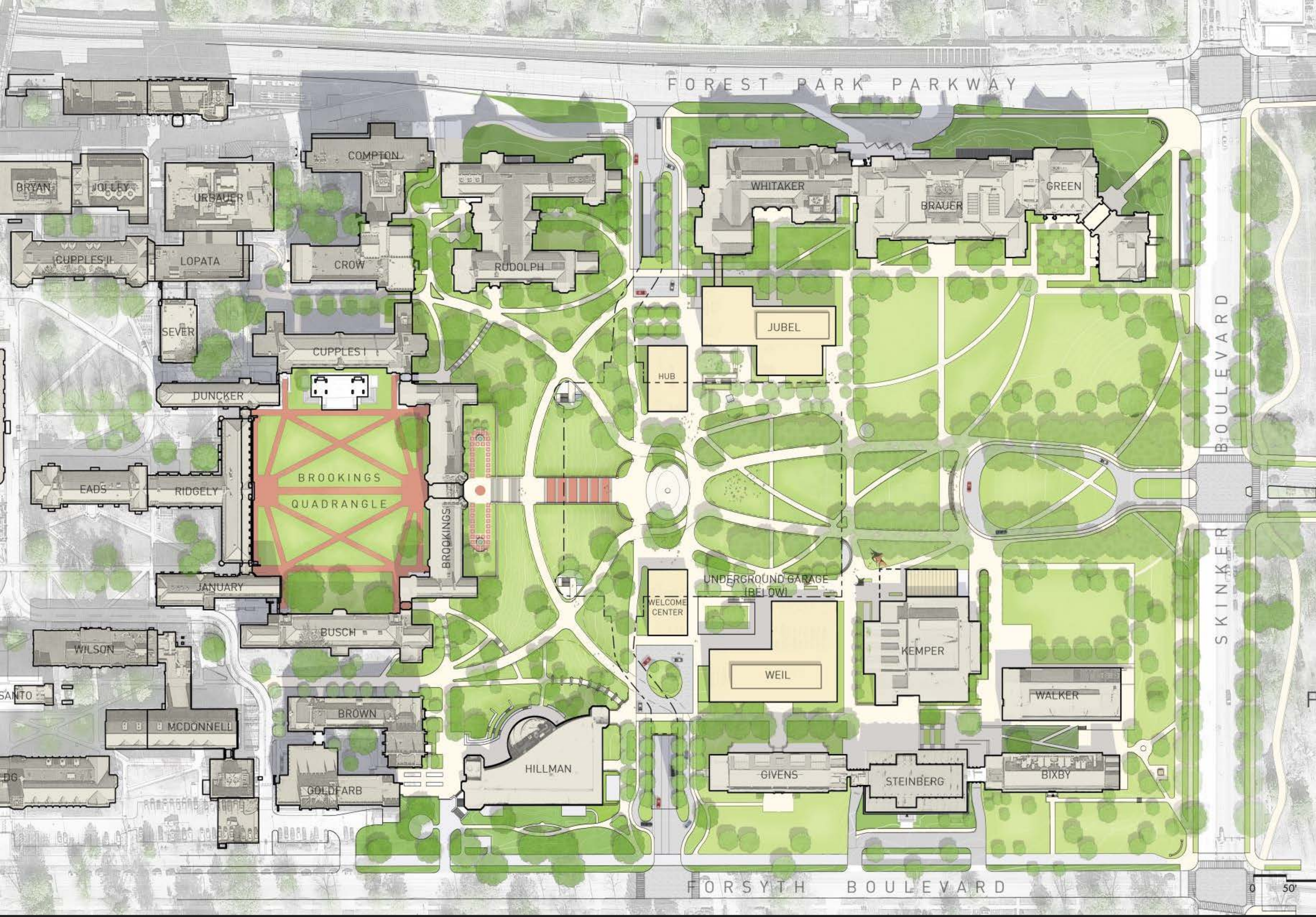
- Regulatory environment presents challenges for large-scale customer solar

Planning for Renewables

- Our buildings are built to last over 100 years
- As solar costs drop and traditional energy costs rise, we will likely be able to add on-site solar to both save costs and reduce carbon emissions
- New buildings and major renovations are being planned to streamline future addition of solar, including:
  - Maximizing open roof space
  - Minimizing shading from equipment or architectural features
  - Minimizing roof protrusions that will impact layouts
  - Including chases to electrical and equipment rooms for easier installation

Exploring Next Generation Low-Carbon Energy Systems

Enhancements to the East End of the Danforth Campus



FOREST PARK PARKWAY
COMPTON
BRYAN
JOLLEY
URBAUER
CUPPLES II
LOPATA
CROW
RUDOLPH
WHITAKER
BRAUER
GREEN
SEVER
CUPPLES I
JUBEL
HUB
DUNCKER
BROOKINGS QUADRANGLE
EADS
RIDGELY
BROOKINGS
JANUARY
UNDERGROUND GARAGE (BELOW)
WELCOME CENTER
BUSCH
WILSON
KEMPER
WEIL
WALKER
SANTO
MCDONNELL
BROWN
HILLMAN
GIVENS
STEINBERG
BIXBY
GOLDFARB
SKINKER BOULEVARD
FORSYTH BOULEVARD
0
50'

View of Central Green and Brookings Allée

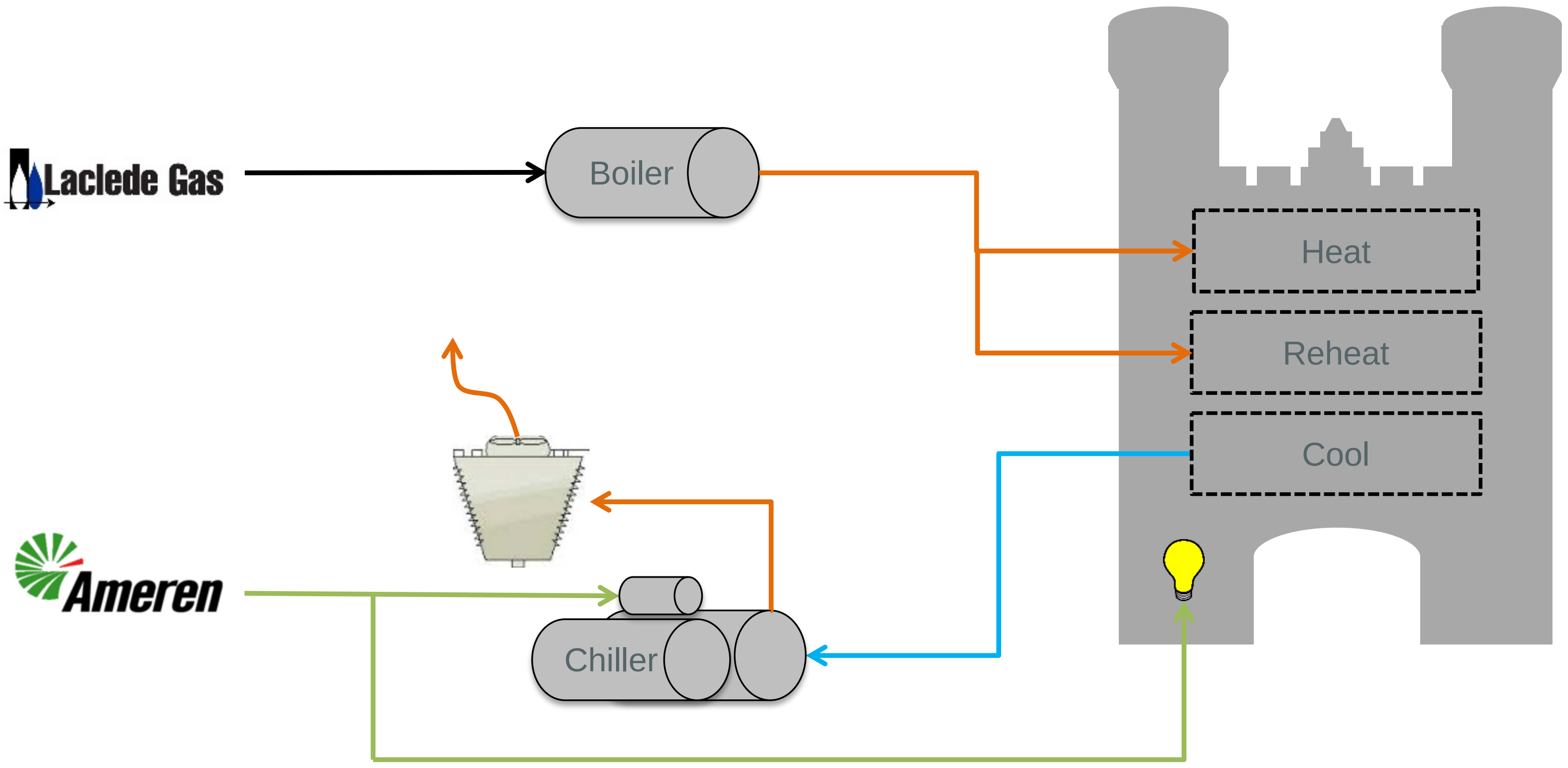
Unique Opportunities on East End

Scale
The multi-building scale of the enhancements to the east end of the Danforth Campus presents an opportunity to develop a district-scale heating and cooling solution.

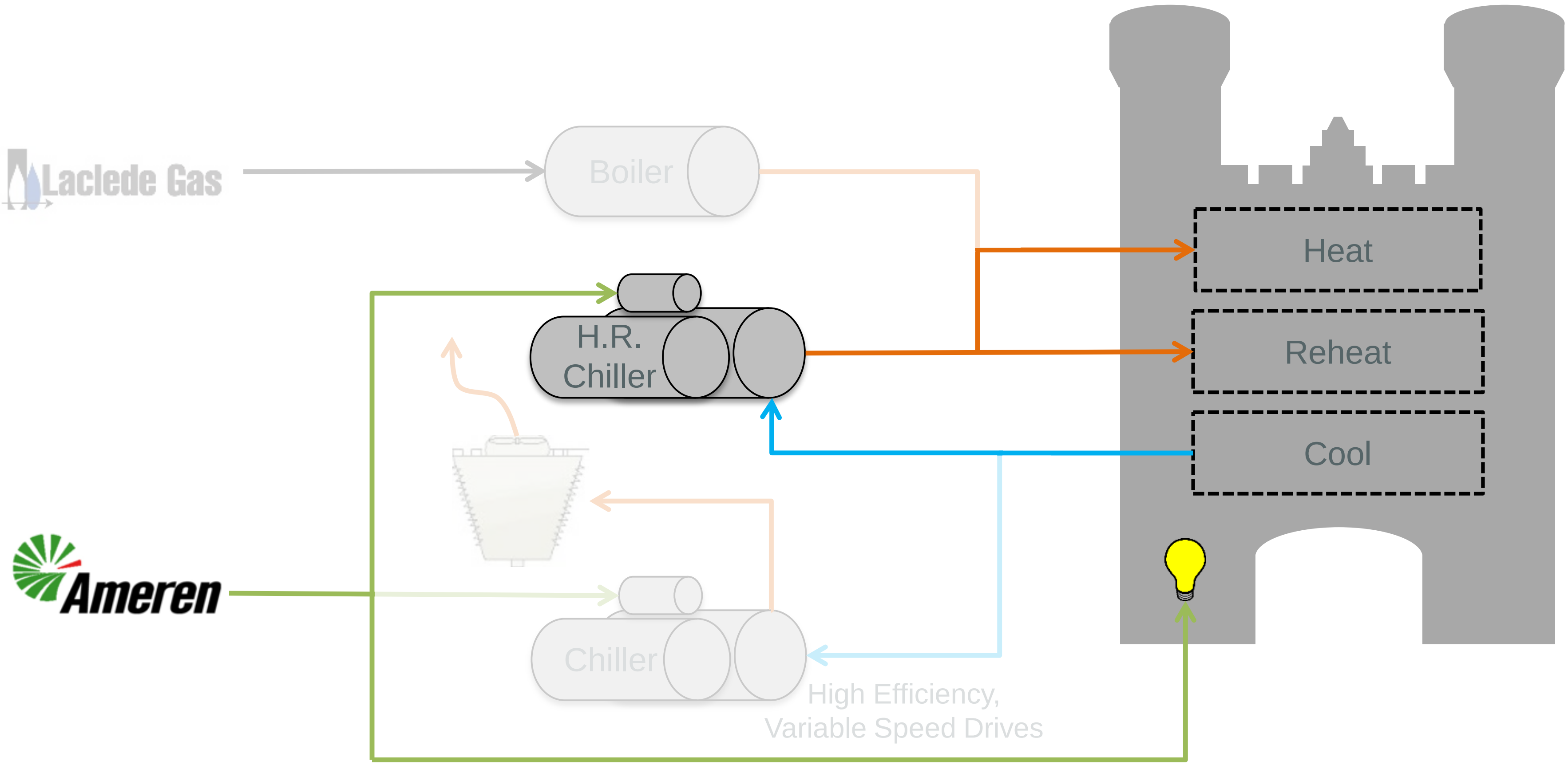
Water Distribution
The east end section of campus is the only section of the campus on a hot water distribution system; the other areas are steam. Hot water distribution systems can more easily be integrated with high-efficiency equipment, geoexchange, and solar thermal energy.

Waste Heat
Waste heat that is normally rejected through cooling towers can be an asset with thermal storage and thermally-driven cooling.

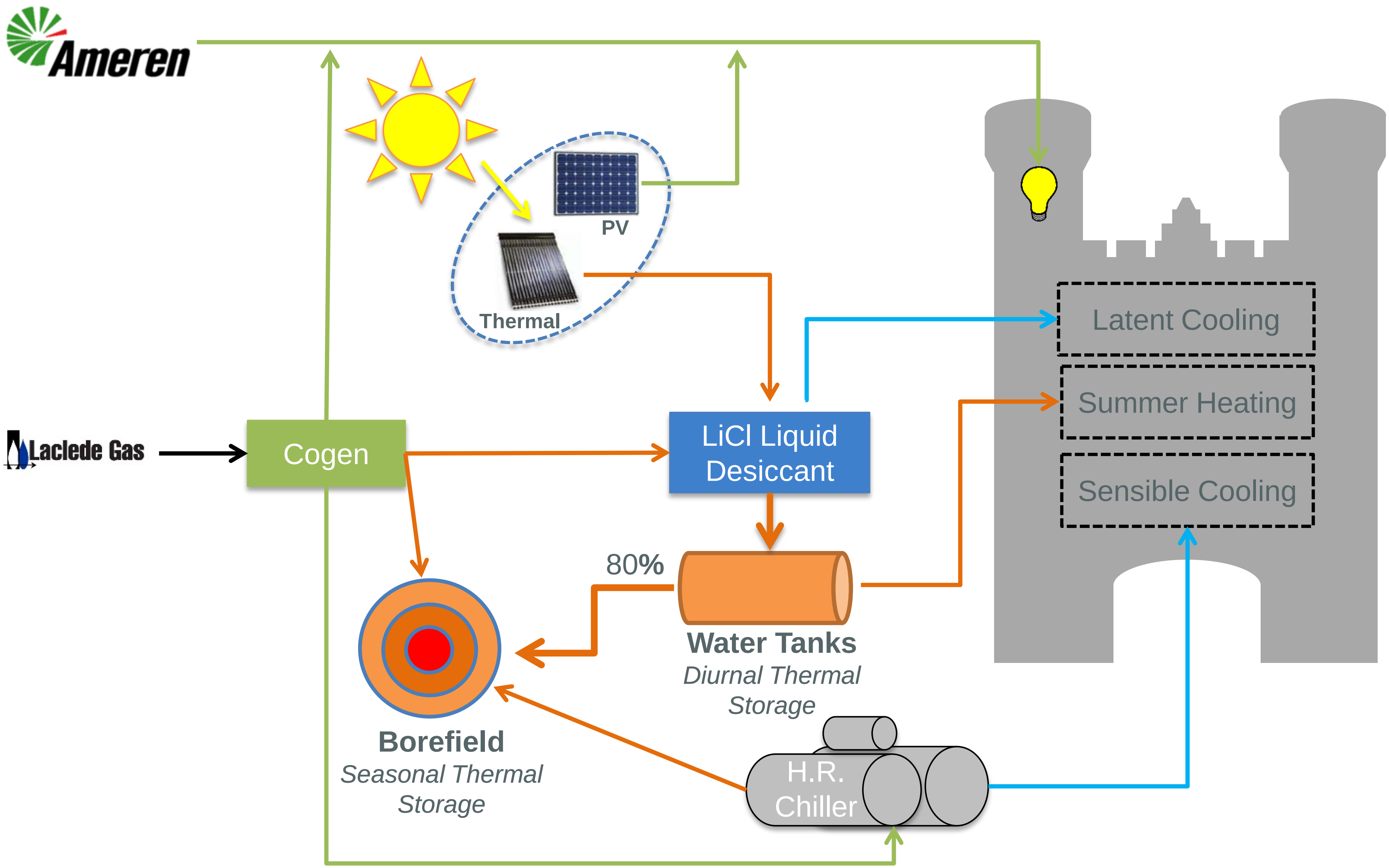
Energy & Emissions – Industry Standard



Energy & Emissions – WUSTL Standard



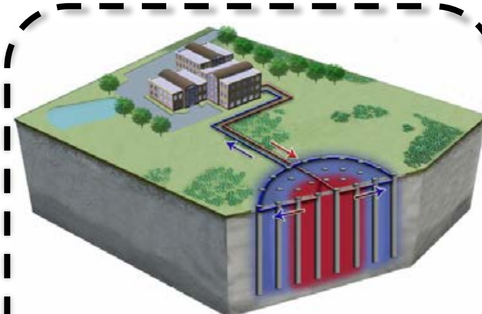
Potential System - Summer



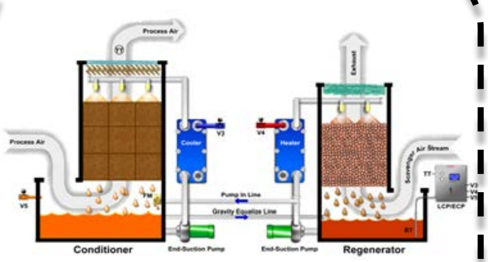
Integration = Innovation

New Technology

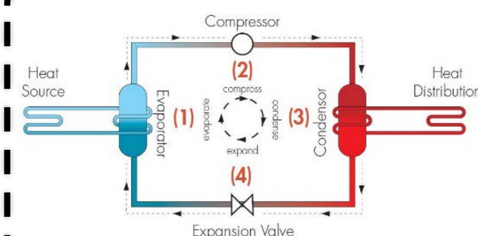
Standard Technology



Existing Technology



Standard Technology



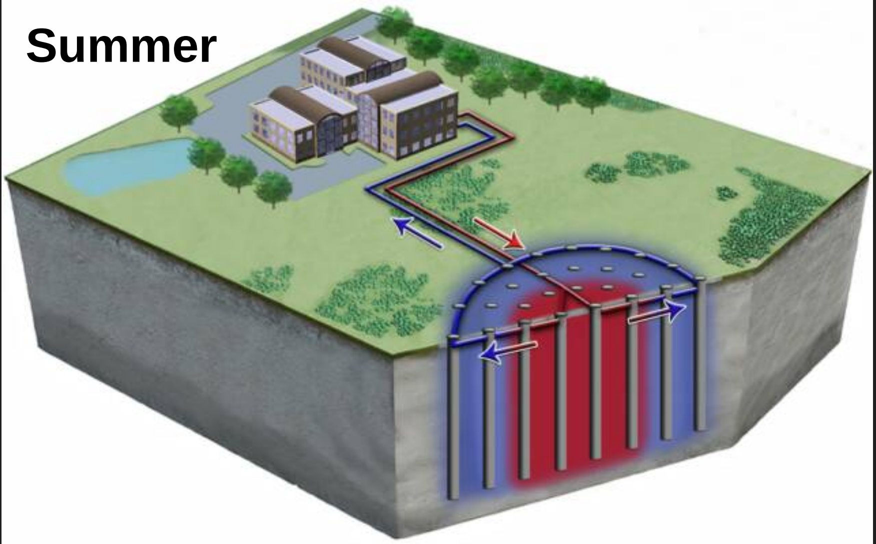
Standard Technology

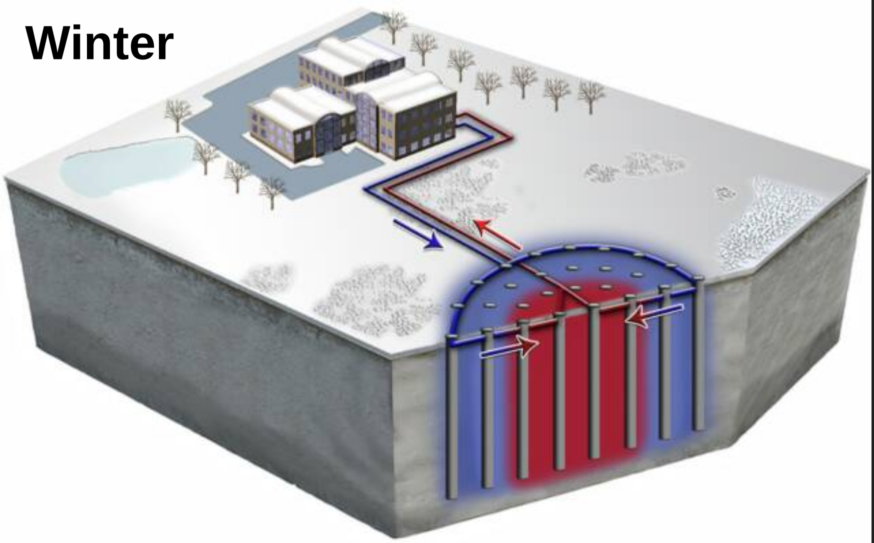
Borehole Thermal Energy Storage (BTES)

BTES is a form of seasonal thermal energy storage that involves sending heat into bedrock through closed-loop wells in the summer to create an underground hot rock that retains heat until it is needed for space heating in the winter.

The heat is extracted in winter and can be distributed to heat buildings through a district hot water loop.

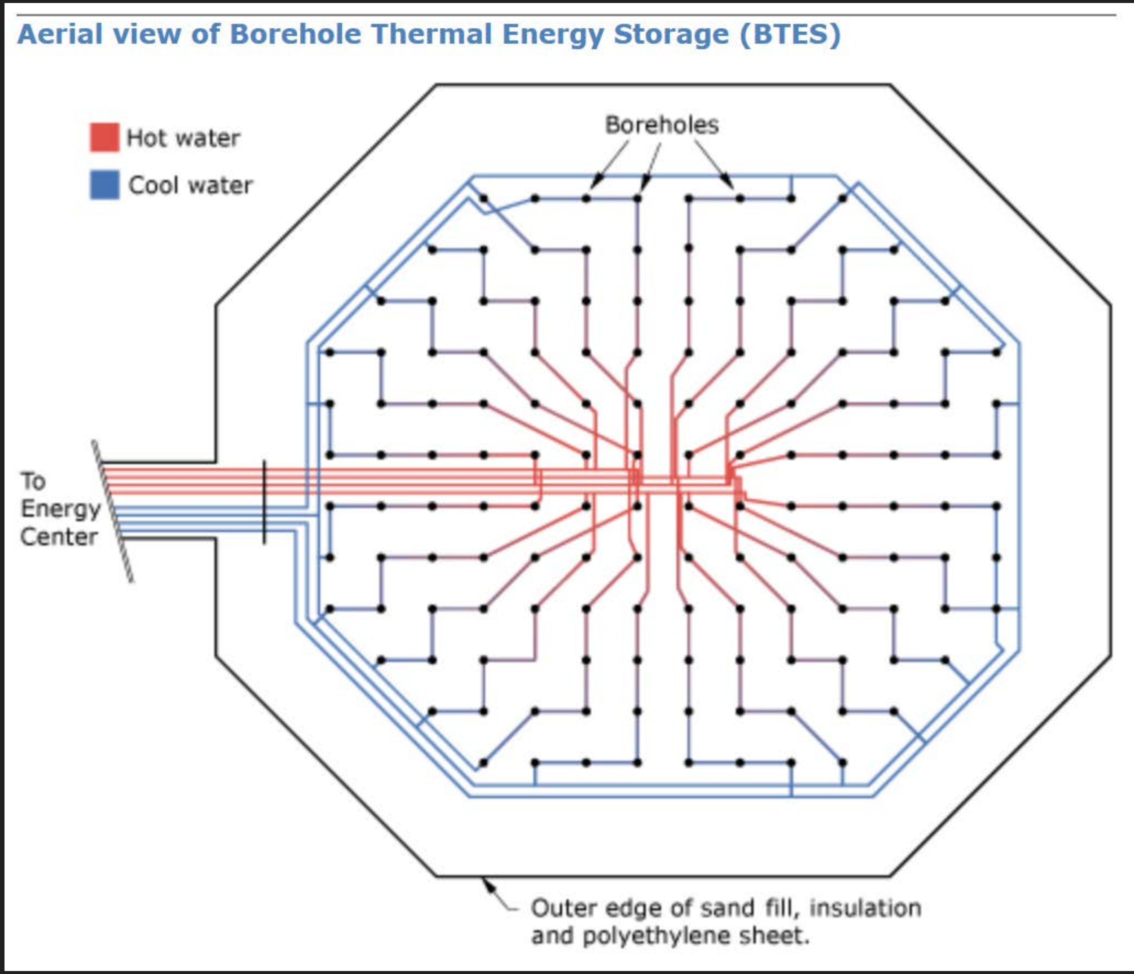
Heat is actively generated and stored in BTES systems, whereas ground source heat pump systems use the earth's steady temperature as a heat source and heat sink.

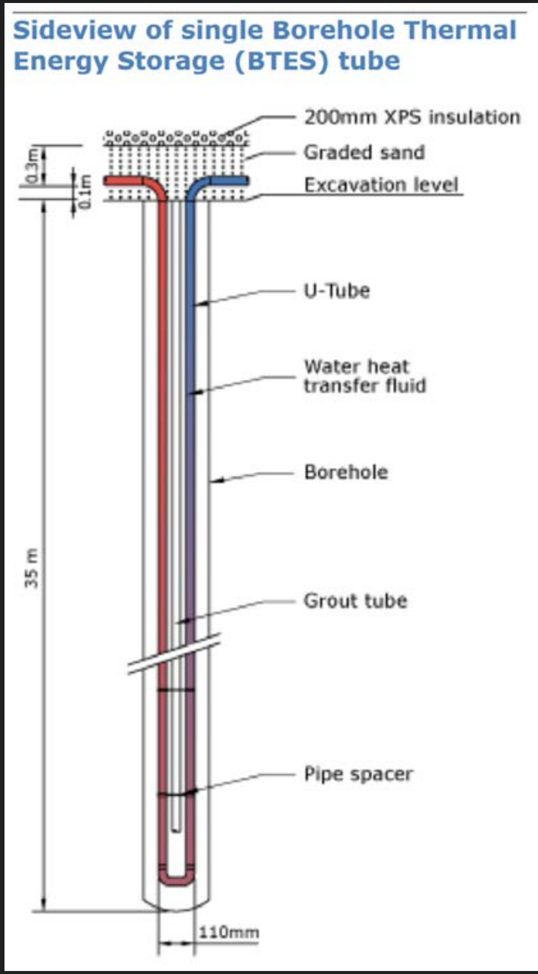




Borehole Thermal Energy Storage

Heat is exchanged with the earth as water moves through closed loop pipes located in a network of vertical wells.





Impact of the District Energy System

Peak Power Reduction
The district energy system is projected to reduce the peak power demand by at least 3 megawatts over the baseline energy system. System optimization may lead to greater reductions.

Carbon Reduction
Carbon emissions are projected to be 4,000 metric tons lower each year.

Resilience
With multiple modes of generation and storage, the system will provide buffers against component failure, grid outages, or loss of natural gas delivery.

Opportunity for Demand Response
The system and the buildings served could be designed to include demand response controls.

Adaptability
The system provides flexibility to evolve as energy technologies evolves.

WU Approach to Energy and Emissions Reduction

Energy efficiency first.

Plan for renewable energy.

Design flexible systems that can evolve as new technologies are introduced, the grid is modernized, and the financial landscape shifts.

Pursue next generation resilient systems with multiple modes of generation and multiple modes of storage.