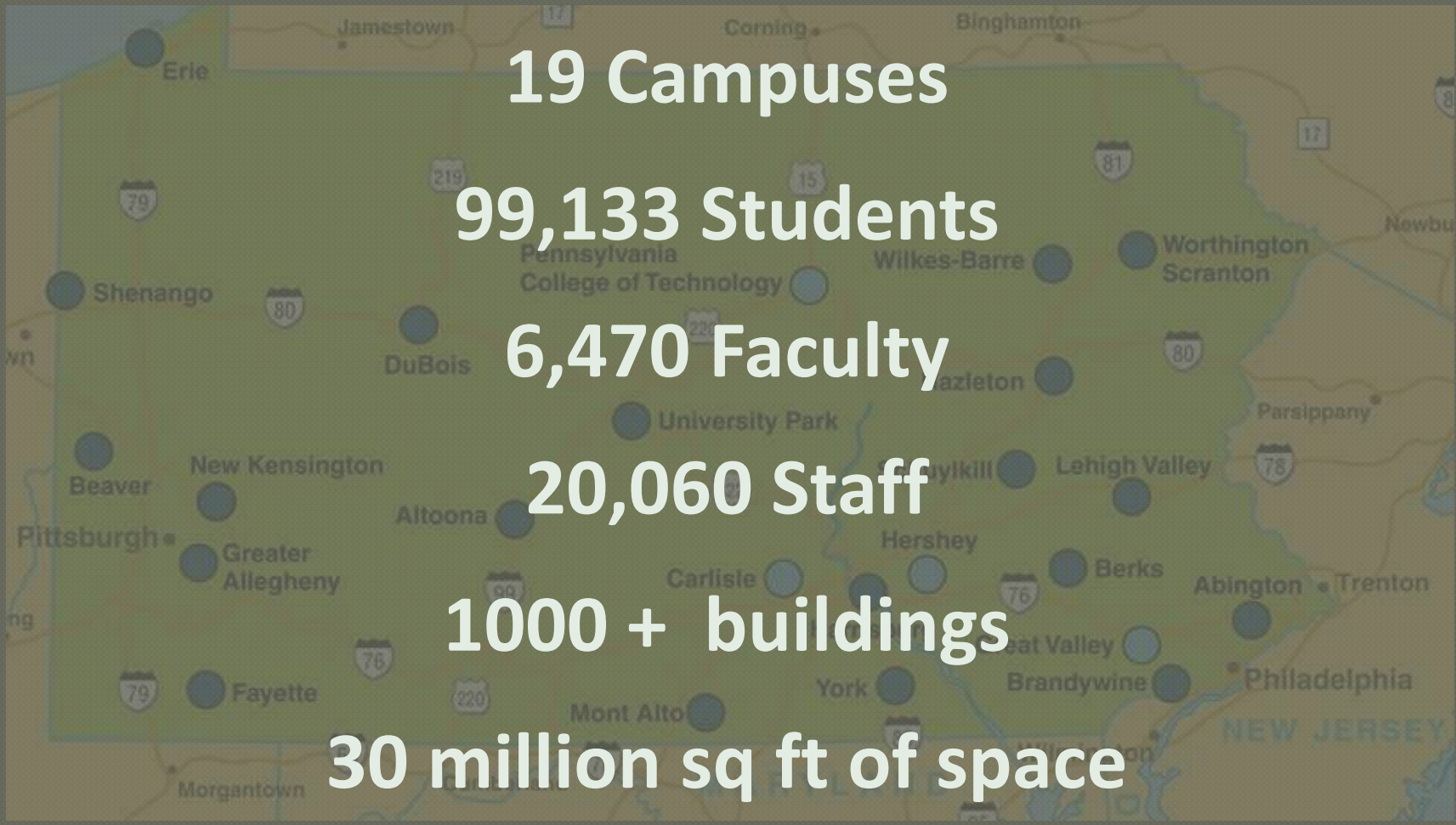

PENNSTATE
University Park
1855
Cost Savings and DeCarbonization with CHP
Penn State University
University Park, PA
ONE WAY
W. College Ave.
Zach Verbick, PE
KFI Engineers
KFI ENGINEERS
Paul Moser, PE
Penn State
SAFE
RELIABLE
EFFICIENT
STEAM SERVICES
PENN STATE'S OFFICE OF PHYSICAL PLANT


Jamestown
Corning
Binghamton
Erie
17
79
219
15
81
17
Pennsylvania
College of Technology
Wilkes-Barre
Worthington
Scranton
Shenango
80
220
80
DuBois
Hazleton
University Park
Parsippany
Beaver
New Kensington
Schuylkill
Lehigh Valley
78
322
Altoona
Pittsburgh
Hershey
Greater
Allegheny
Carlisle
Berks
Abington
Trenton
99
76
Harrisburg
Great Valley
76
Fayette
York
Brandywine
Philadelphia
79
220
Mont Alto
83
NEW JERSEY
68
70
Wilmington
Morgantown
Cumberland
MARYLAND

# Land Grant University – est. 1855




19 Campuses

99,133 Students

6,470 Faculty

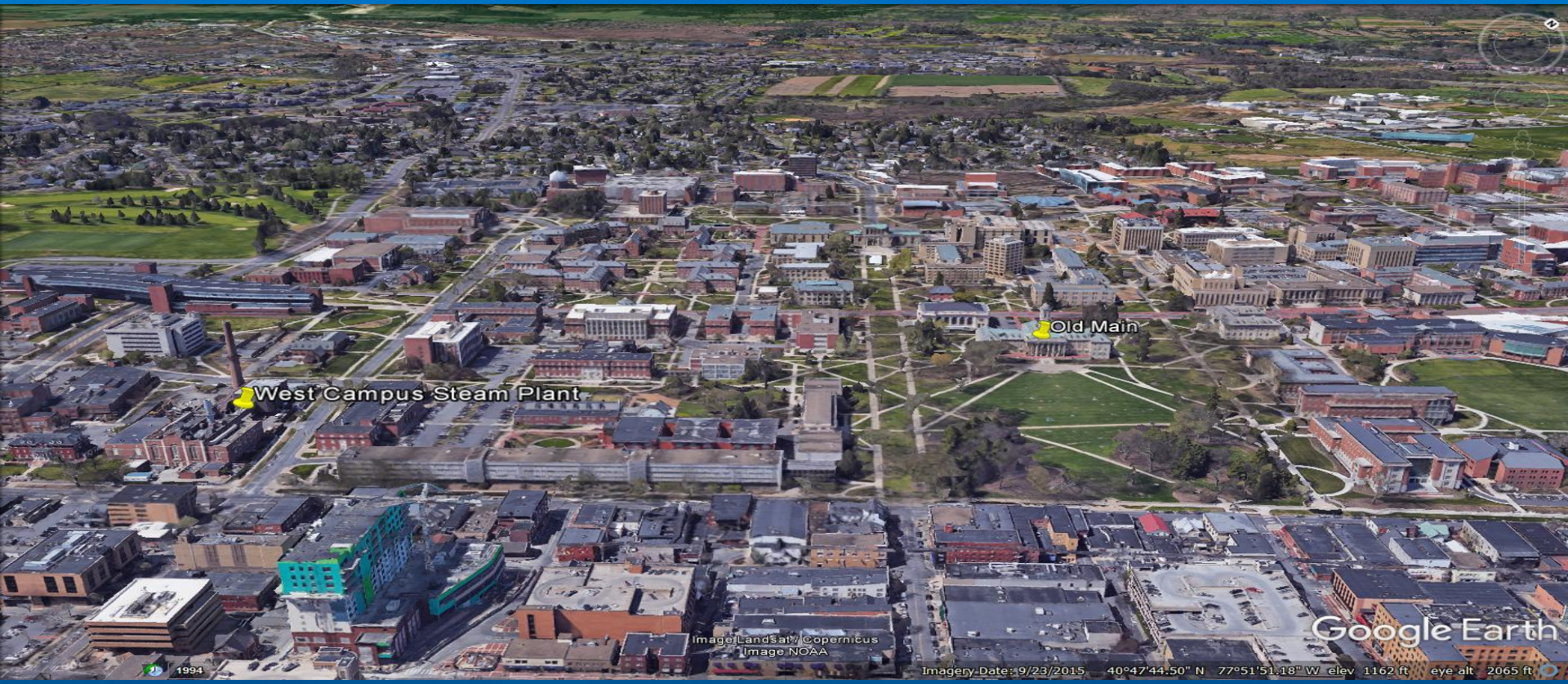
20,060 Staff

1000 + buildings

30 million sq ft of space

# University Park

# University Park



# University Park Numbers

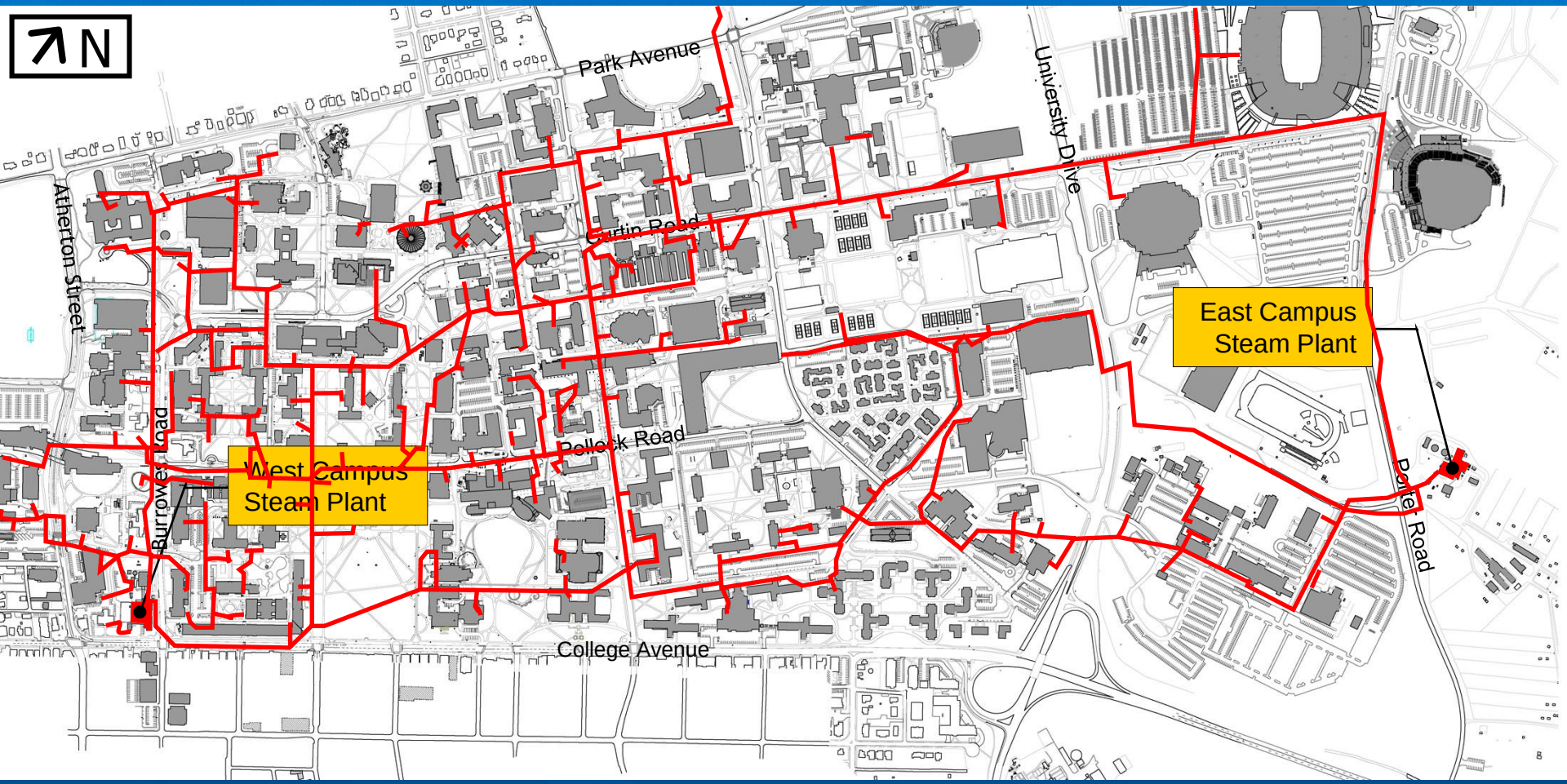
## Campus

- 1855 Established by Land Grant
- ~50,000 Students on Main Campus
- 7,342 acres of land at UP
- 600 buildings on campus
- 20 million $ft^2$ Building Space
- $4.3 billion value building replacement
- 34 years average age of buildings

## CHP System

- +200 Buildings Served w/steam
- 2 CHP Plants – ECSP, WCSP
- 430/80 kpph Demand Peak/Minimum Steam
- 50/30 mW Demand Summer/Winter Electrical
- 10 mW CHP Electrical Generation
- 17 Piping Miles of Steam Distribution
- 350/50 mgal ECSP/WCSP on site Diesel

# Combined Heat and Power – Penn State

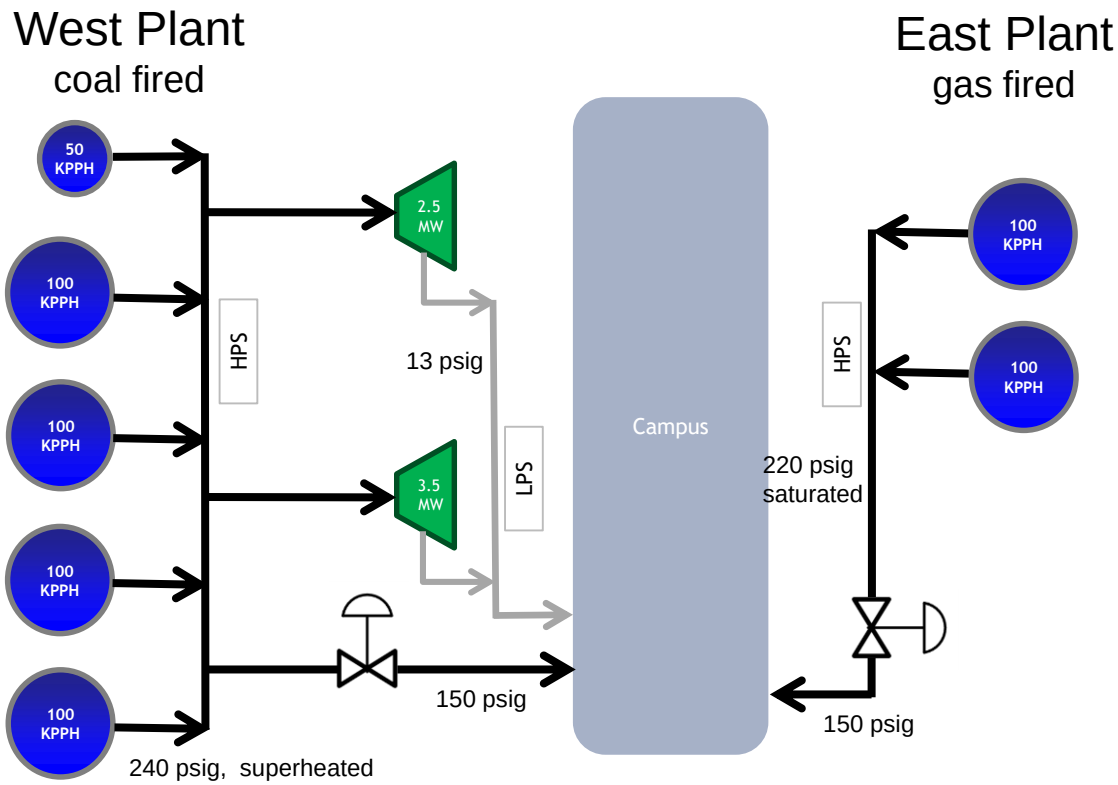


# Penn State - Steam Services

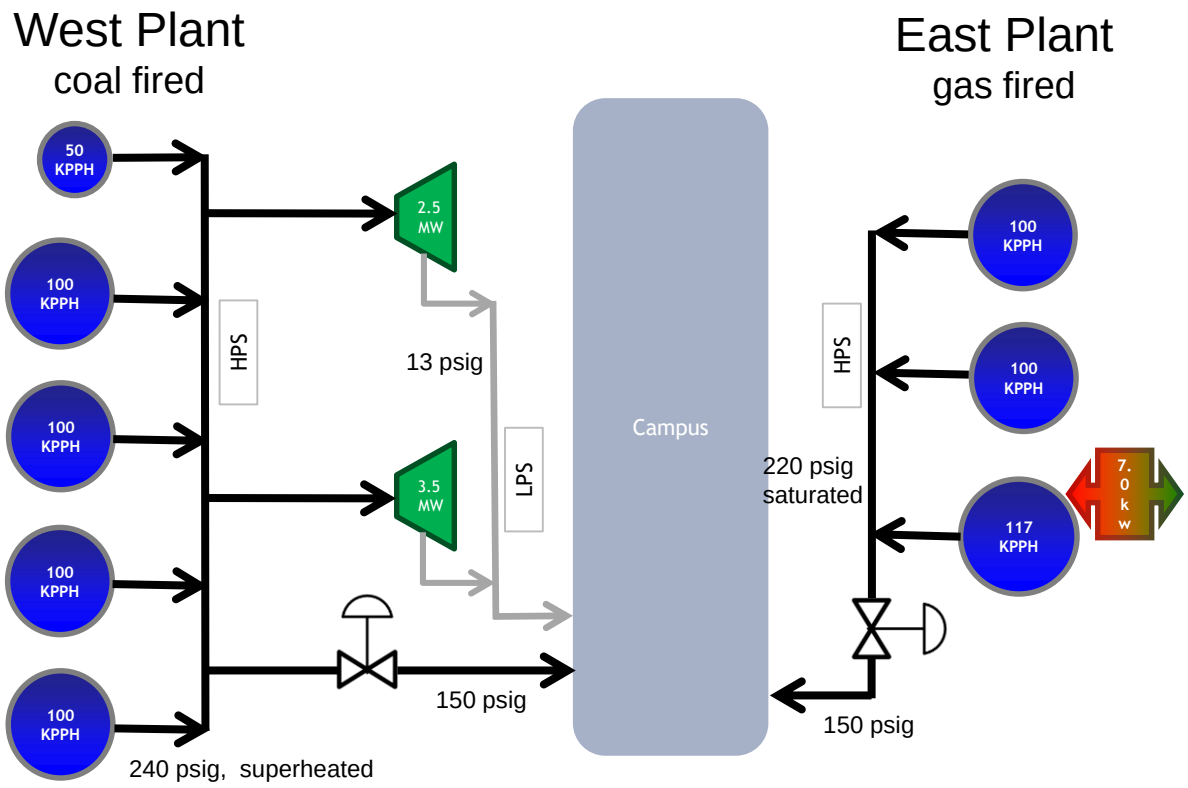

ONE WAY
W. College Ave.
WHITE LOOP


ONE WAY
W. College Ave.
EMERGENCY

# CHP – Prior to 2010



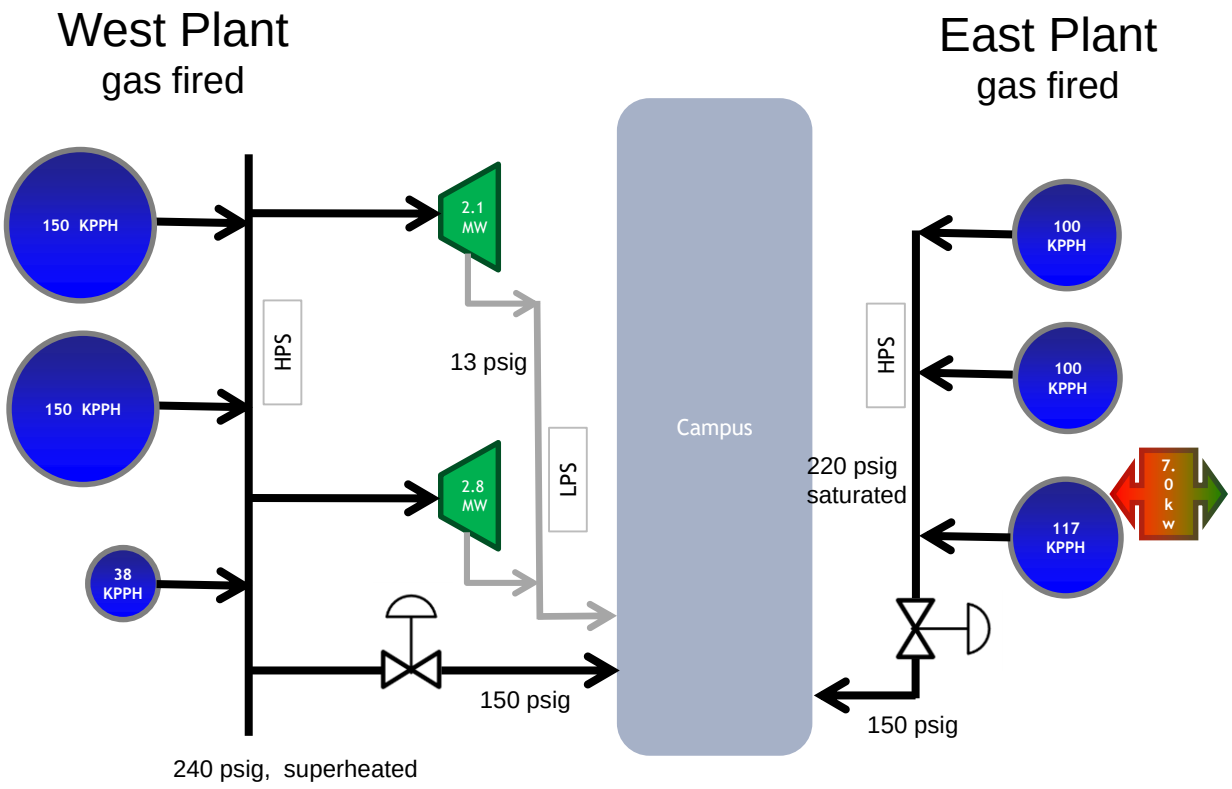
# East Plant Addition - 2010




$20 million capital investment

$2-2.5 million reduction in utility budget per year

# West Plant Conversion to Gas - 2016



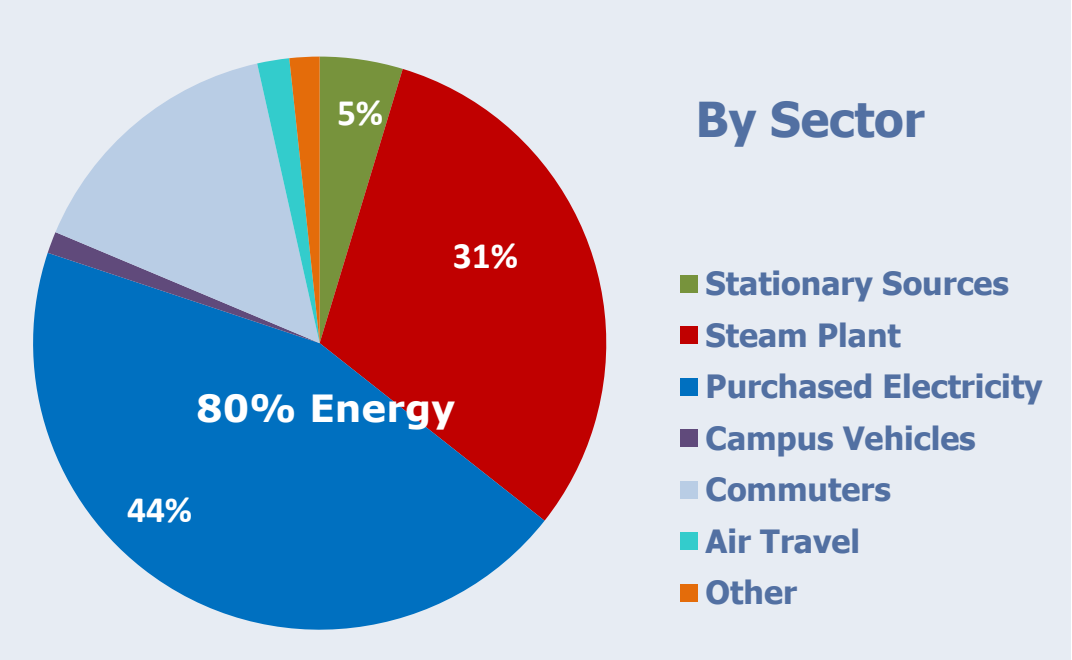

AED

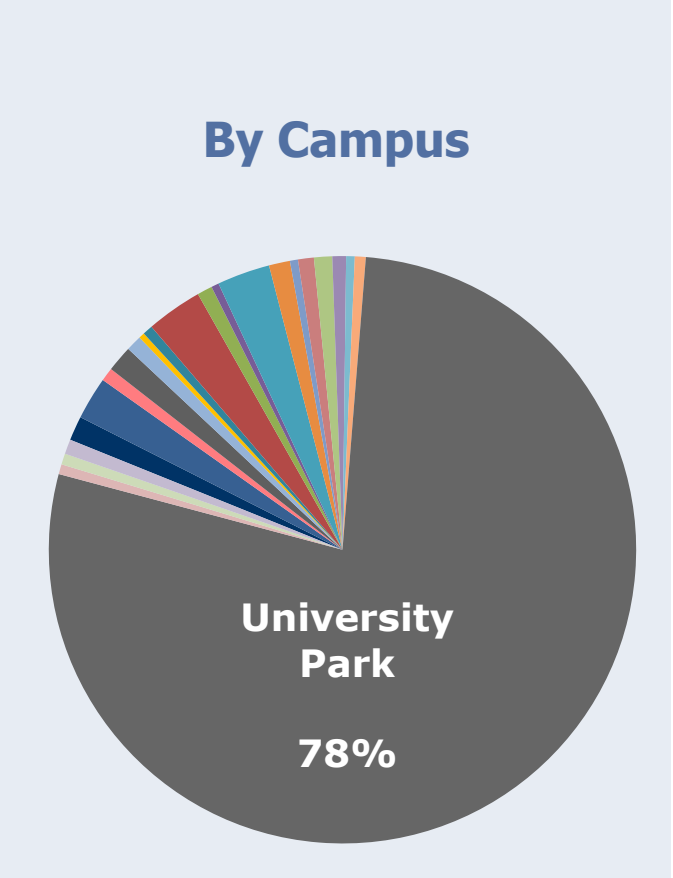
# PSU Energy Savings

- Annual Savings Since FY 2008-2009
  - 30 million kwh
  - 35,000 tons coal
  - Total Fossil Fuel use has been flat, but on site electric has increased from 5% to 25%
- Added over 1.5 million square feet in new buildings in the same time period
- Utility Rebates – received $2M in support of projects
- Energy Conservation Program Total since 2000:
  - Annual Avoided Costs for all projects to date: $8.5M
  - Annual Avoided costs based current energy rates: $14M
  - Total invested to achieve current annual avoided cost is $68M

# Distribution of PSU GHG Emissions

- Penn State's GHG Inventory primarily includes direct emissions and emissions from purchased electricity
- Energy at University Park is the largest contributor



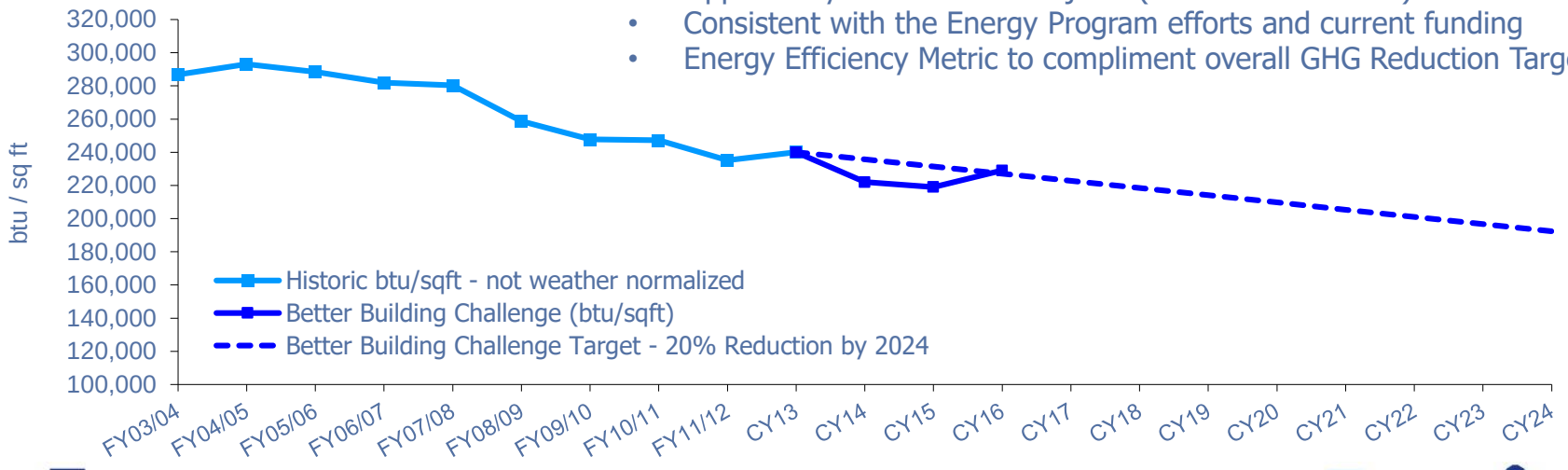
# Building Energy Reduction

- 20% energy reduction in 28m square feet of existing buildings by 2024

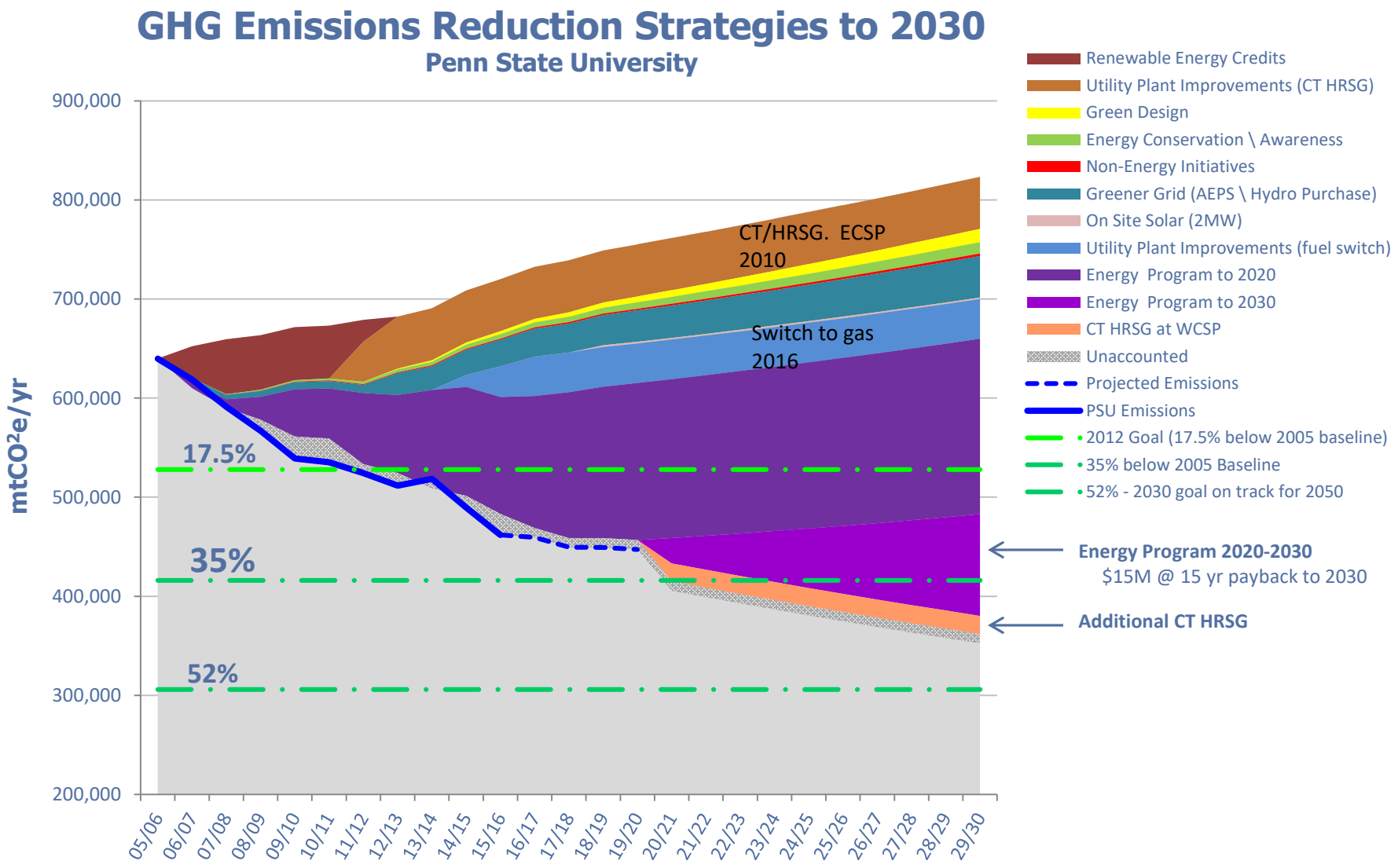
DOE – Better Building Challenge

- Provides a Framework for Tracking & Benchmarking
- Highlights Penn State leadership in incorporating energy efficiency into routine business operations
- Opportunity to Showcase Projects (Results & Solutions)
- Consistent with the Energy Program efforts and current funding
- Energy Efficiency Metric to compliment overall GHG Reduction Targets

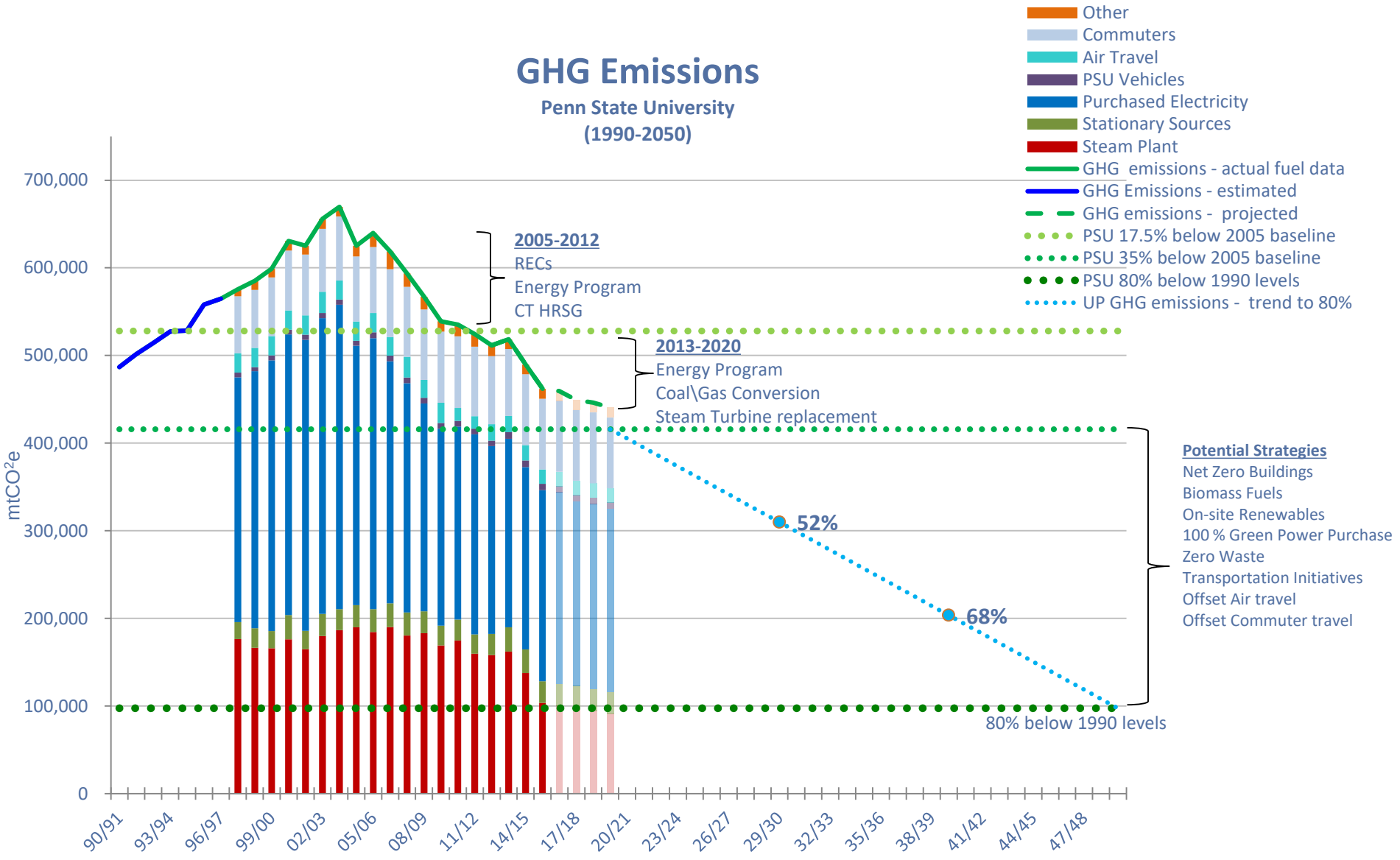
Better Buildings® CHALLENGE
U.S. DEPARTMENT OF ENERGY



# Progress to Date

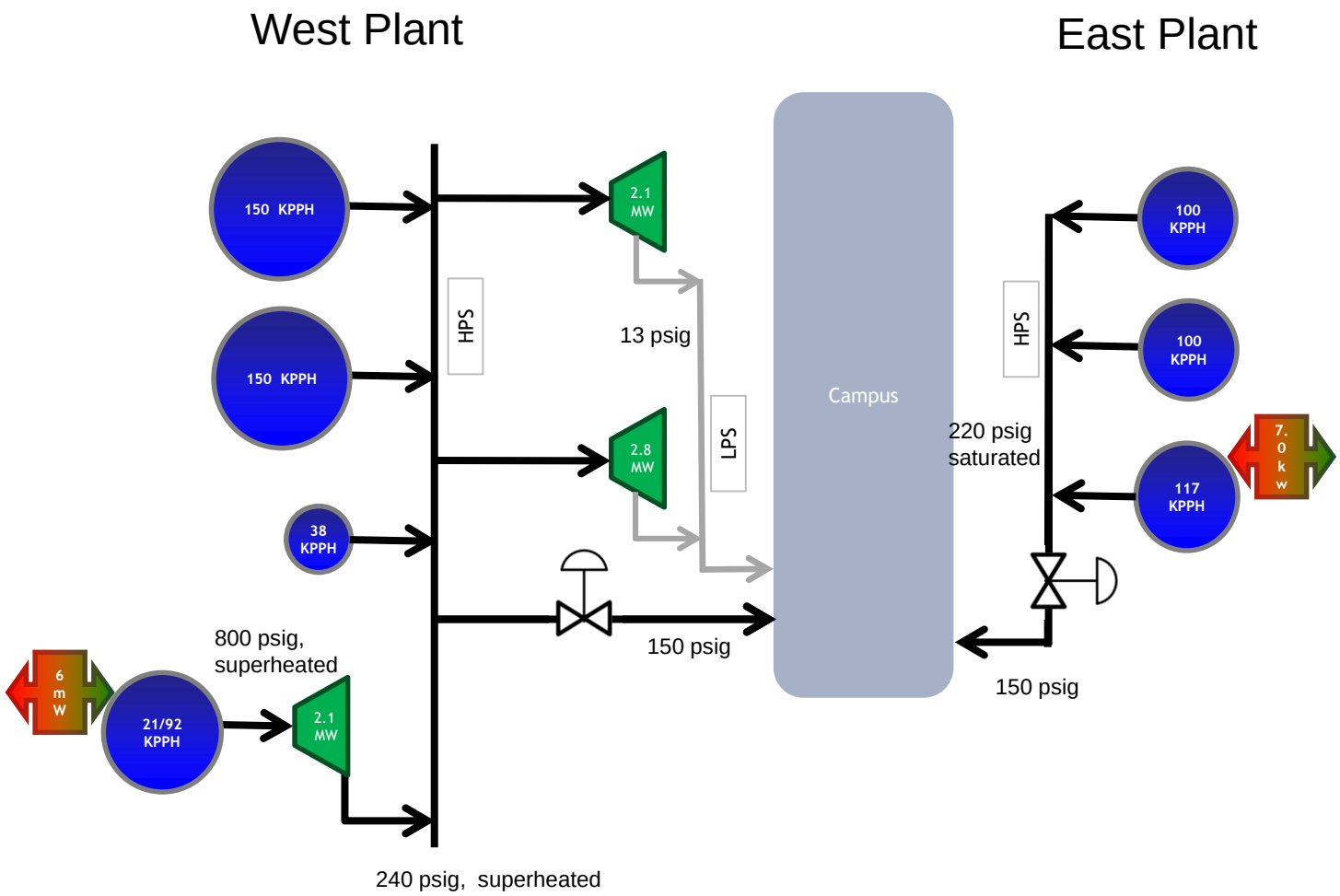


# Progress to Date

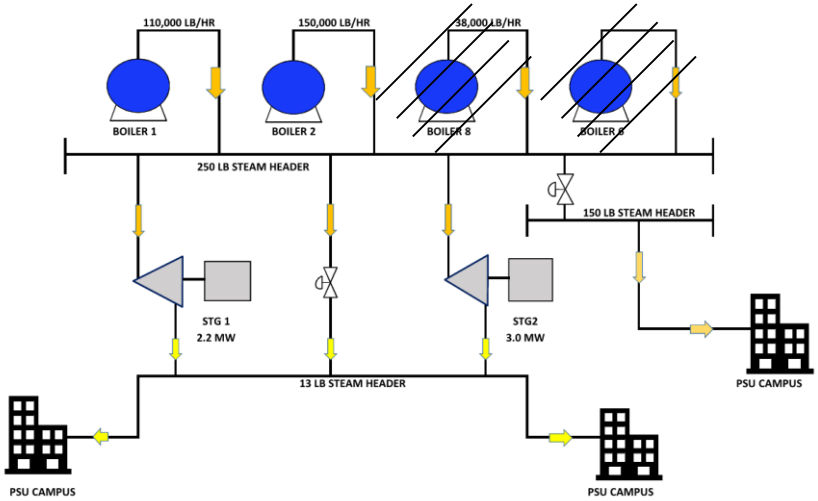



Penn State GHG Emissions include stationary sources, purchased electricity, OPP & Fleet vehicles and estimated commuter miles, air travel, waste, refrigerants and animal management.

# West Plant CHP Addition – Q3 2021



# WC CHP Addition - Goals

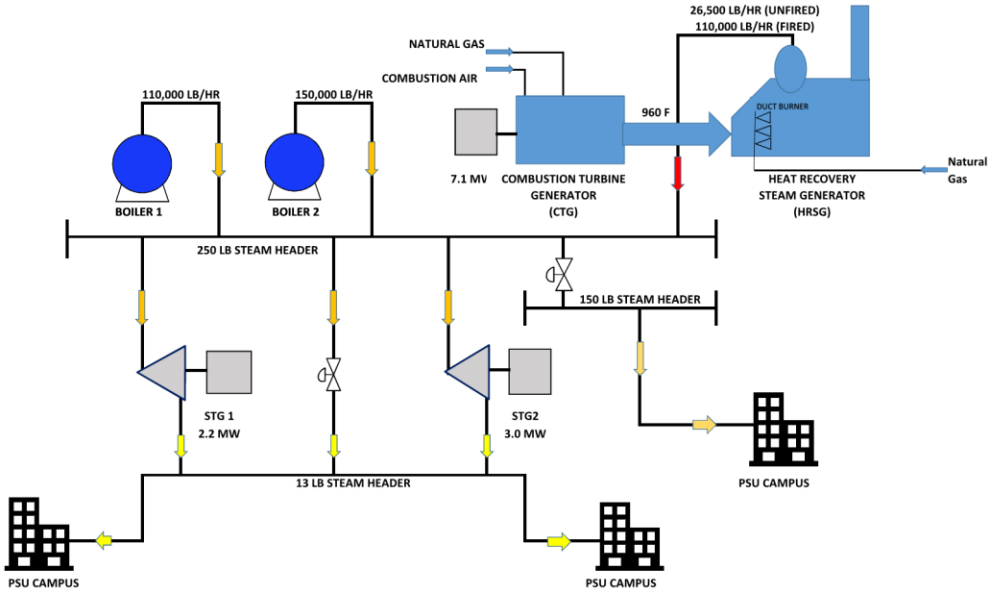



## Goals

- Increase Firm Steam Capacity
- Increase Efficiency
- Decrease Greenhouse Gas Emissions (16,000 $MTCO2_e$ reduction
- Improve Resiliency
- Electrical System Upgrades
- Budget – 15 Year payback

## Initial Plan

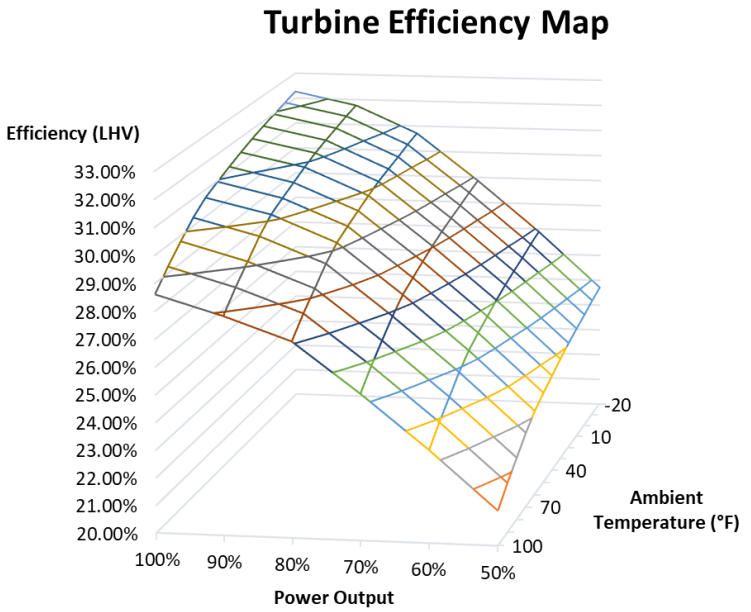
- Nominal 7.1MW Gas Turbine
- 250 psig, 126,000 lb/hr HRSG
- Natural Gas Compressor
- New Stack
- Demolition of both Boiler 6, Boiler 8, and DA-6



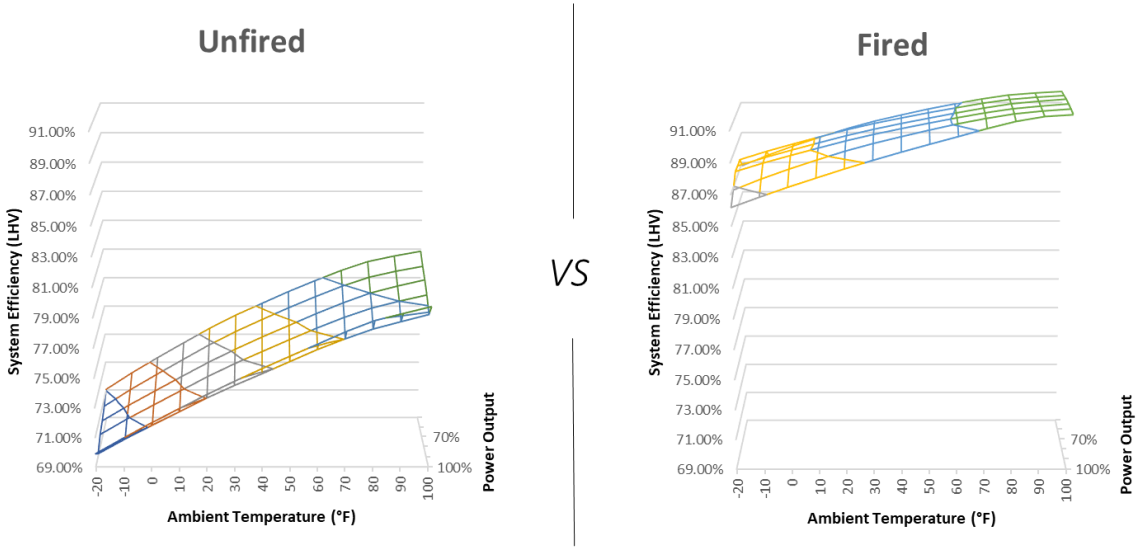
# CHP Right Sizing

## CHP Sizing Drivers

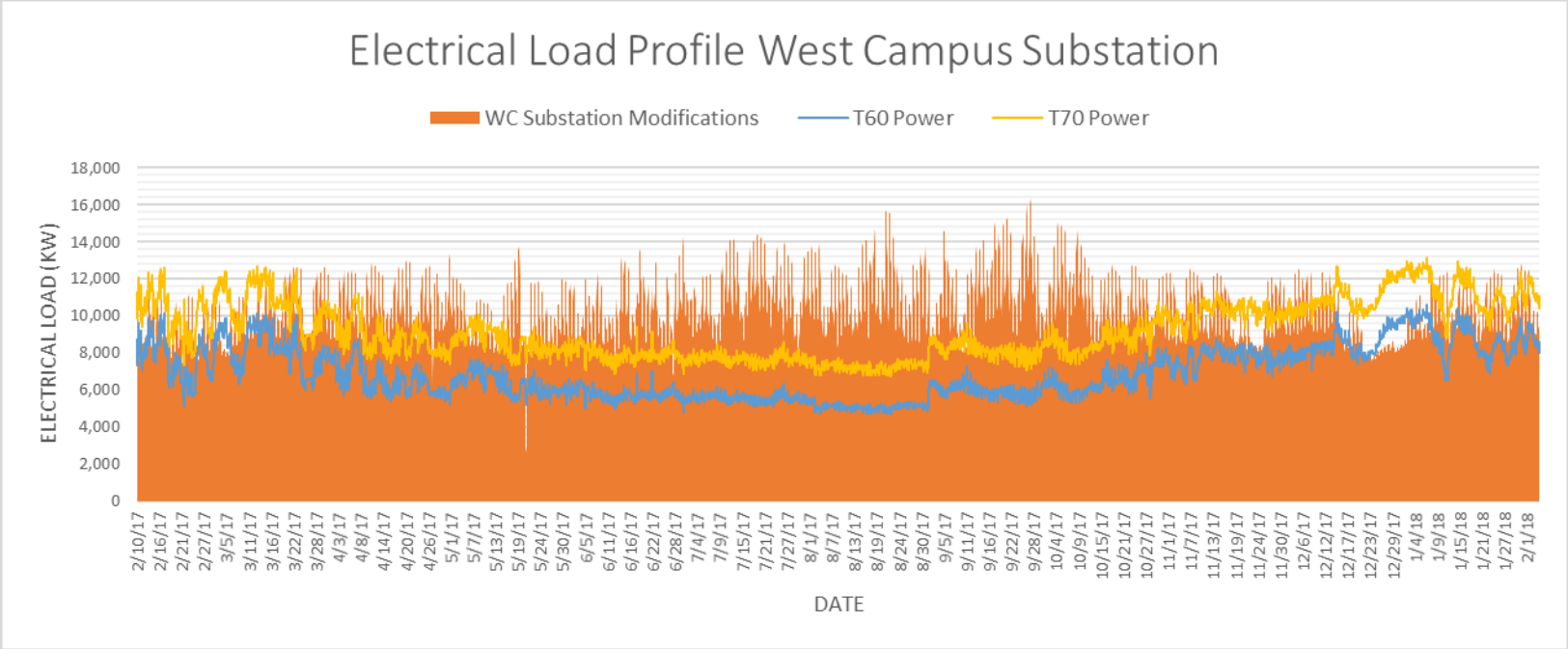
- Electric Load Matching
- Thermal Load Matching
- Gas Turbine Efficiency
- HRSG Efficiency
- Overall Capacity




| WC CHP Generation | T70 | | |
|---|---|---|---|
| | GT Utilization Factor | HRSG Util. Factor | Annual Energy |
| | (%) | (%) | (MWH) |
| Potential Output | 100% | 52% | 79,800 |
| Electrical Load Limited | 82% | 52% | 67,300 |

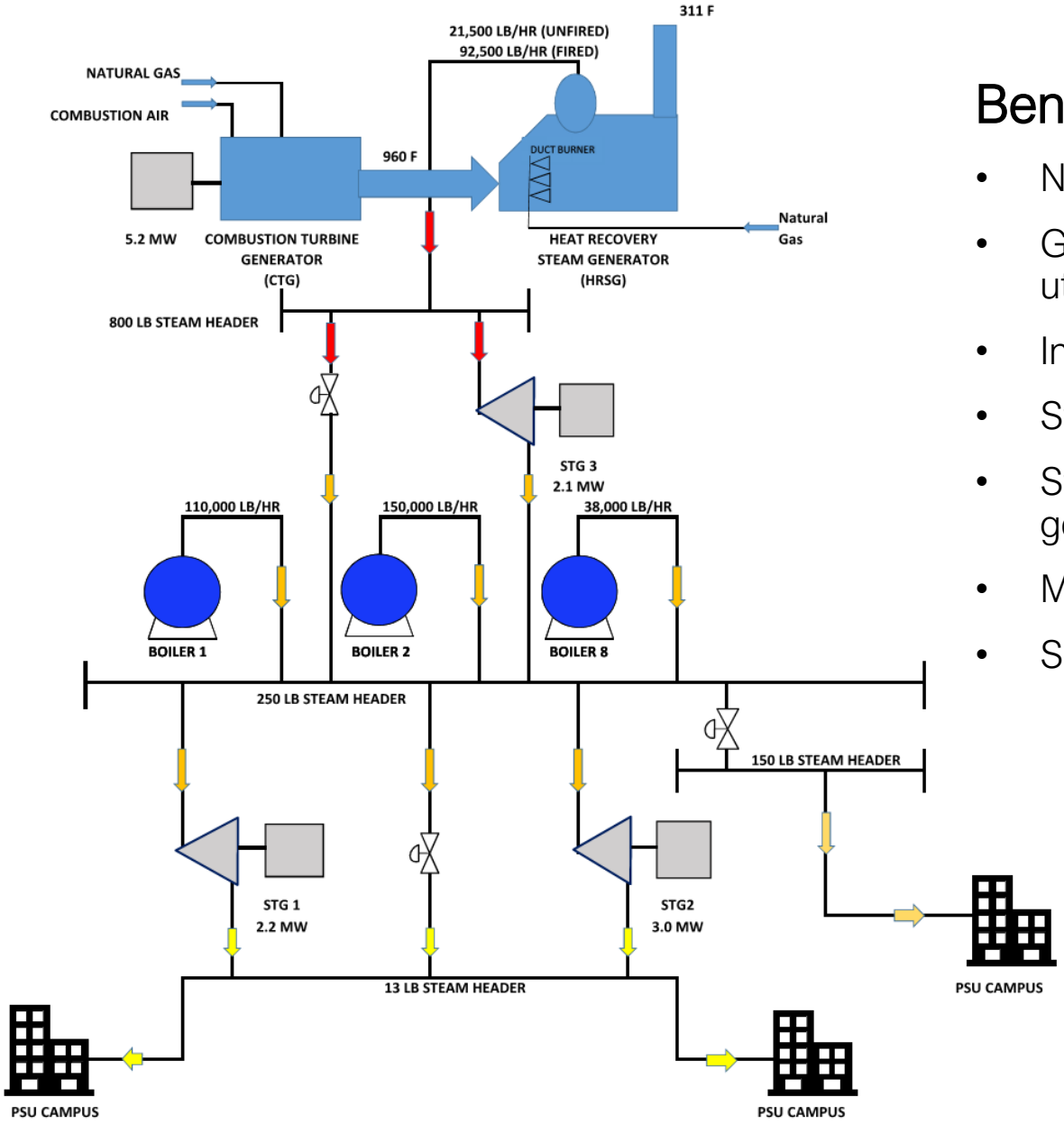


# CHP Right Sizing (cont.)




| WC CHP Generation | T70 | | | T60 | | |
|---|---|---|---|---|---|---|
| | GT Utilization Factor | HRSG Util. Factor | Annual Energy | GT Utilization Factor | HRSG Util. Factor | Annual Energy |
| | (%) | (%) | (MWH) | (%) | (%) | (MWH) |
| Potential Output | 100% | 52% | 79,800 | 100% | 82% | 59,300 |
| Electrical Load Limited | 82% | 52% | 67,300 | 94% | 82% | 56,400 |
| Substation Modifications | 93% | 52% | 74,400 | 99% | 82% | 58,800 |

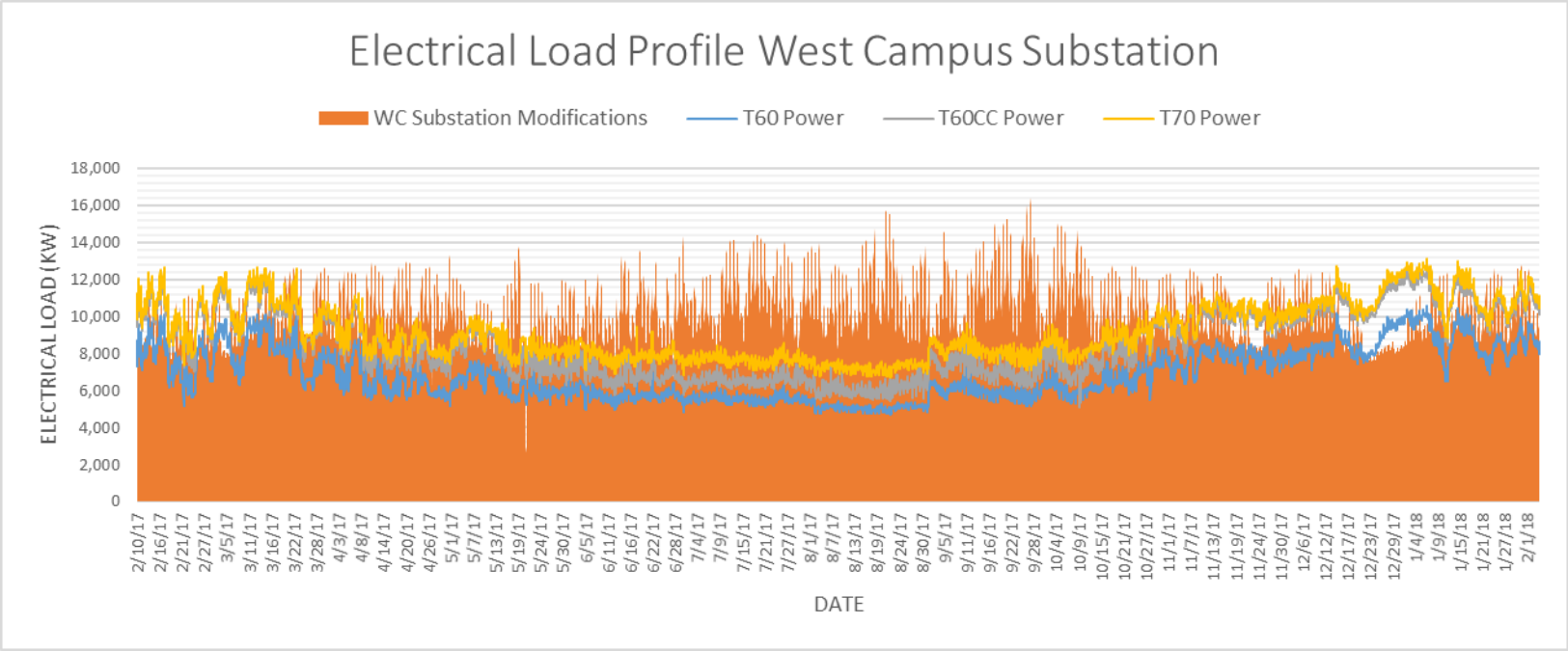
# Combined Cycle Option




## Benefits

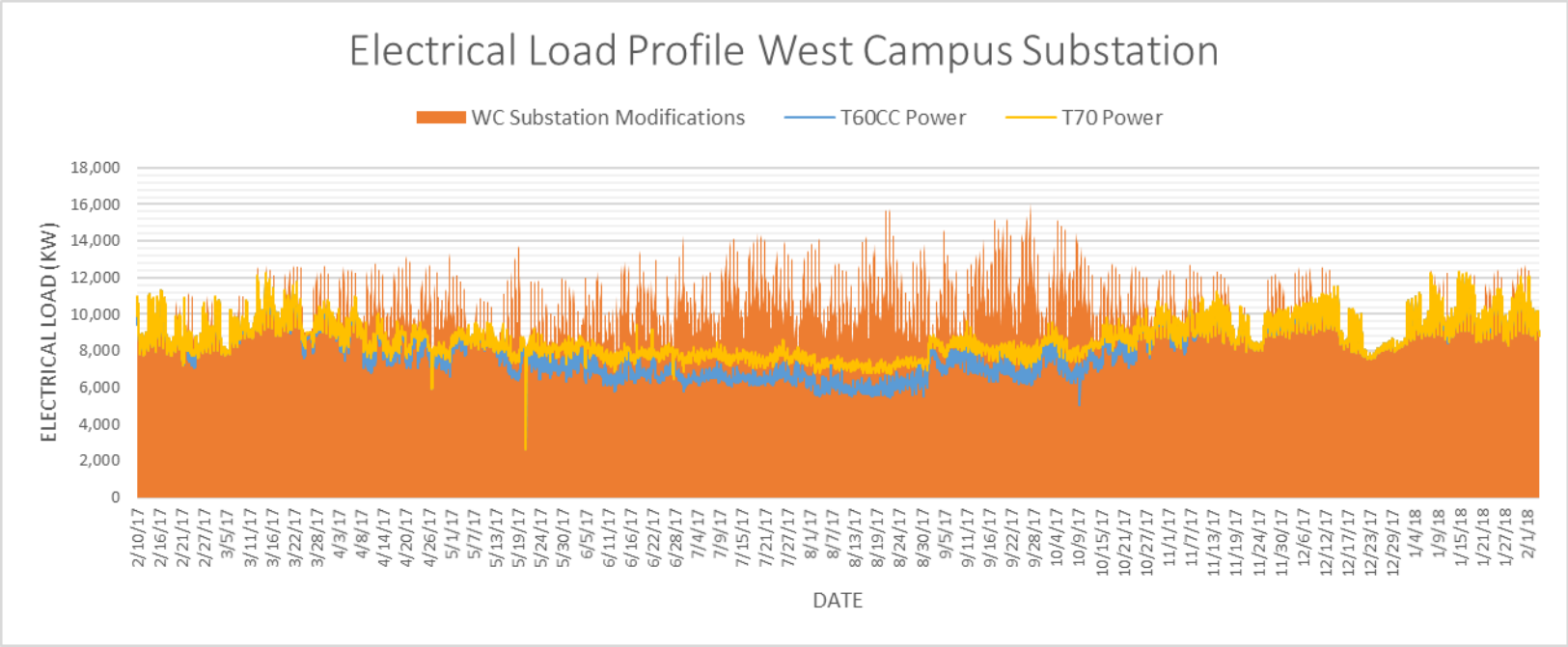
- No Natural Gas Compressor
- Gas Turbine has nearly 99% utilization factor
- Increased Duct Burner Utilization
- Steam Turbine can take swings
- Still meets nominal power production goals
- Maintains Boiler 8 operation
- Space conservation

# T70 vs. T60CC Results



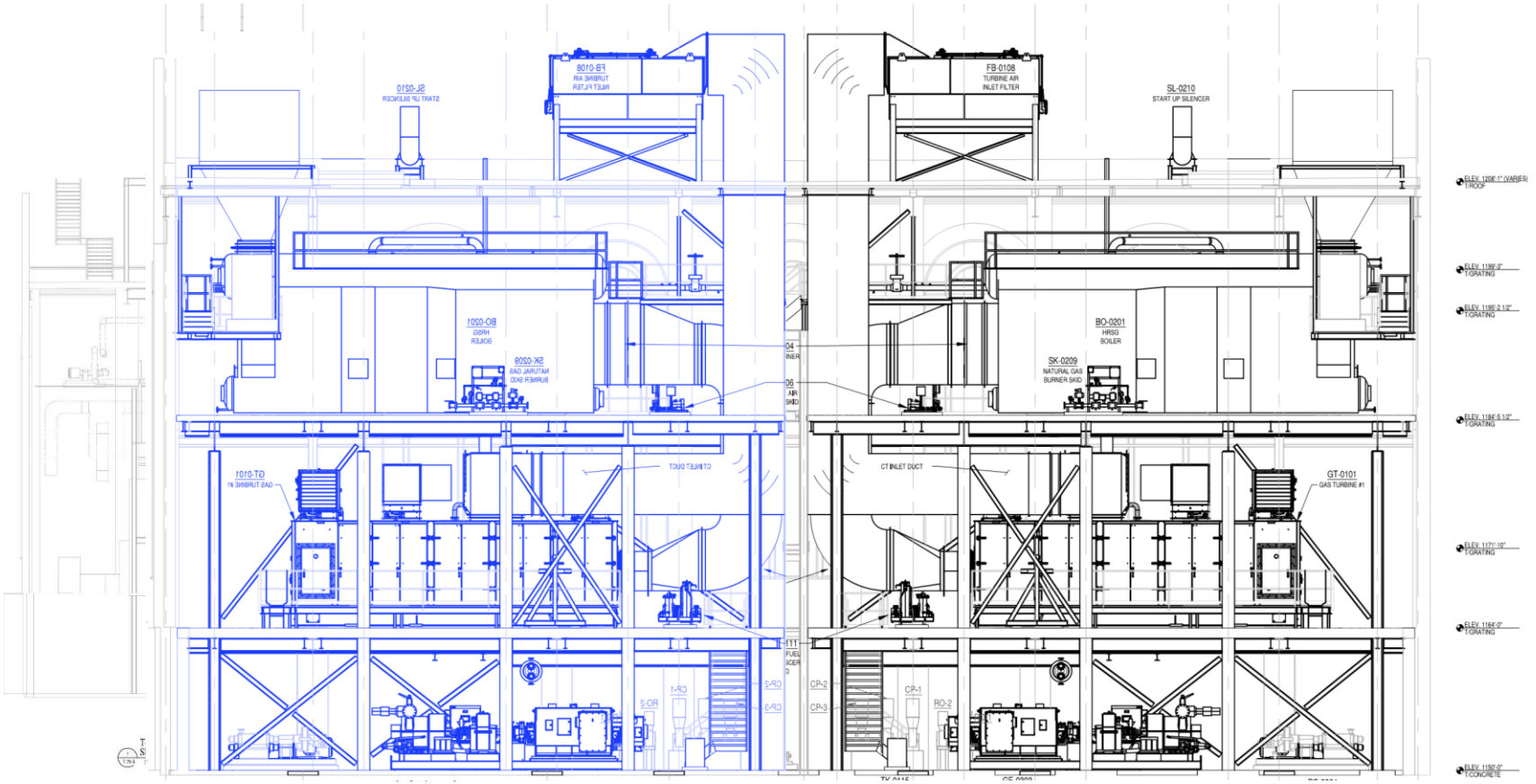

| WC CHP Generation | T70 | | | T60CC | | |
|---|---|---|---|---|---|---|
| | GT Utilization Factor | HRSG Util. Factor | Annual Energy | GT Utilization Factor | HRSG Util. Factor | Annual Energy |
| | (%) | (%) | (MWH) | (%) | (%) | (MWH) |
| Potential Output | 100% | 52% | 79,800 | 100% | 82% | 73,500 |
| Electrical Load Limited | 82% | 52% | 67,300 | 94% | 82% | 63,500 |
| Substation Modifications | 93% | 52% | 74,400 | 99% | 82% | 69,800 |

# T70 vs. T60CC Results

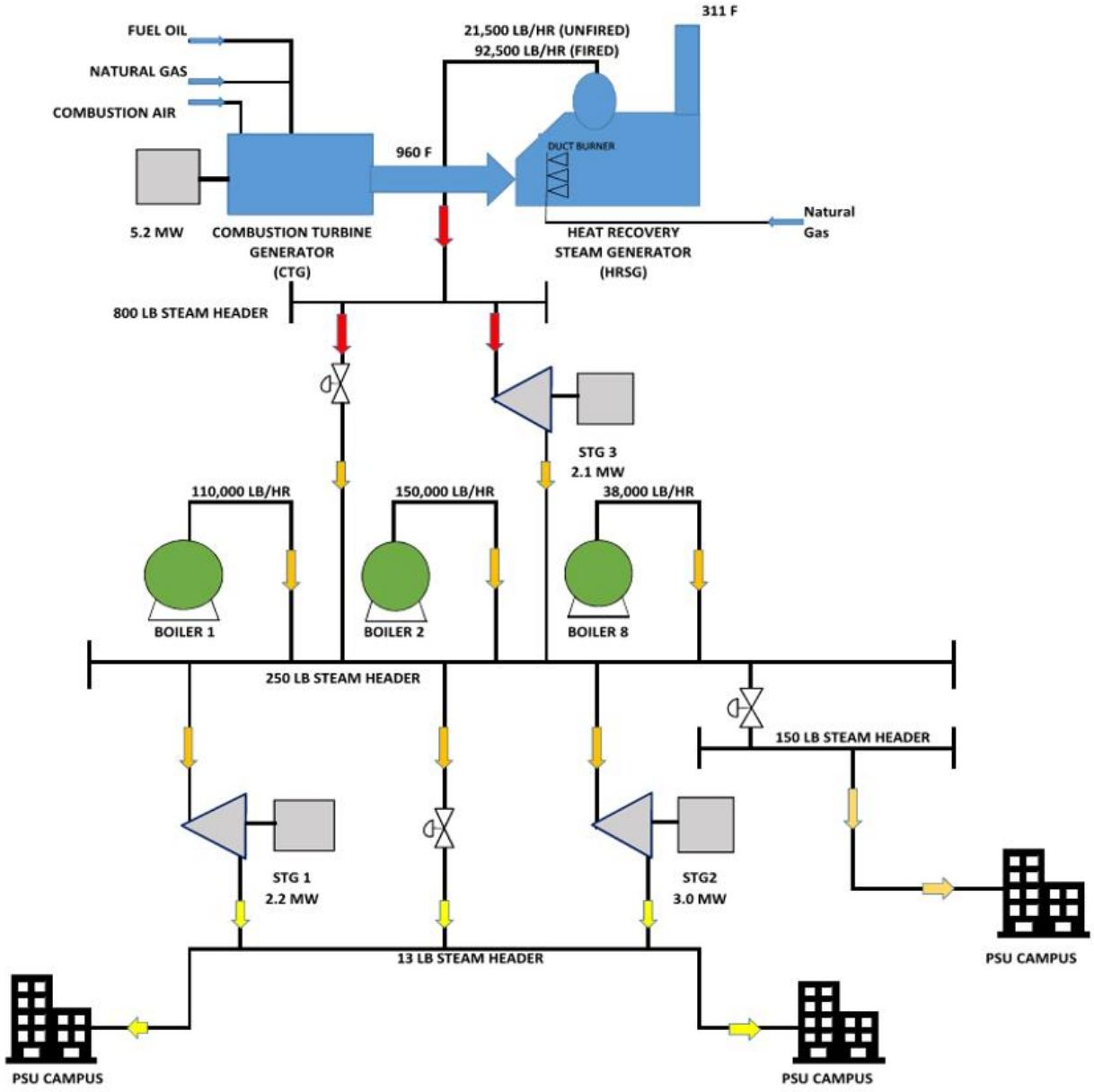



| Attribute | T70 | T60CC |
|---|---|---|
| GT Utilization (%) | 93% | 99% |
| HRSG Utilization (%) | 52% | 82% |
| Fuel Conversion Eff. Ave. (%) | 86.2% | 90.4% |
| New Total Generation (MWh) | 61,300 | 56,700 |
| Annual Power (MWh) | 74,800 | 69,800 |
| Peak Plant Power Production (MW) | 12.3 | 12.2 |
| CO2e Annual Reduction (tons) | 25,600 | 24,000 |
| Gas Compressor Required? | Yes | No |
| Net Annual Savings ($) | $2.72M | $2.71M |

# Layout Optimization



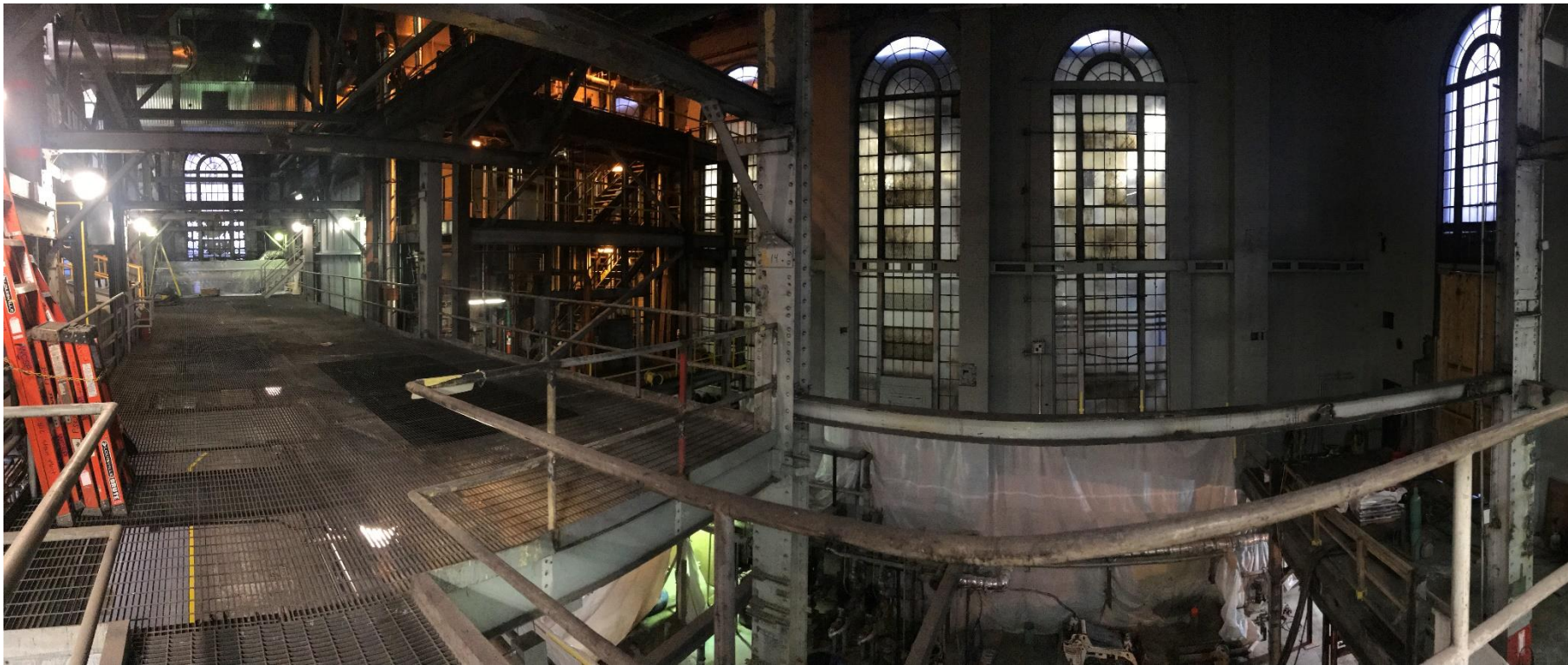
# Optimized CHP

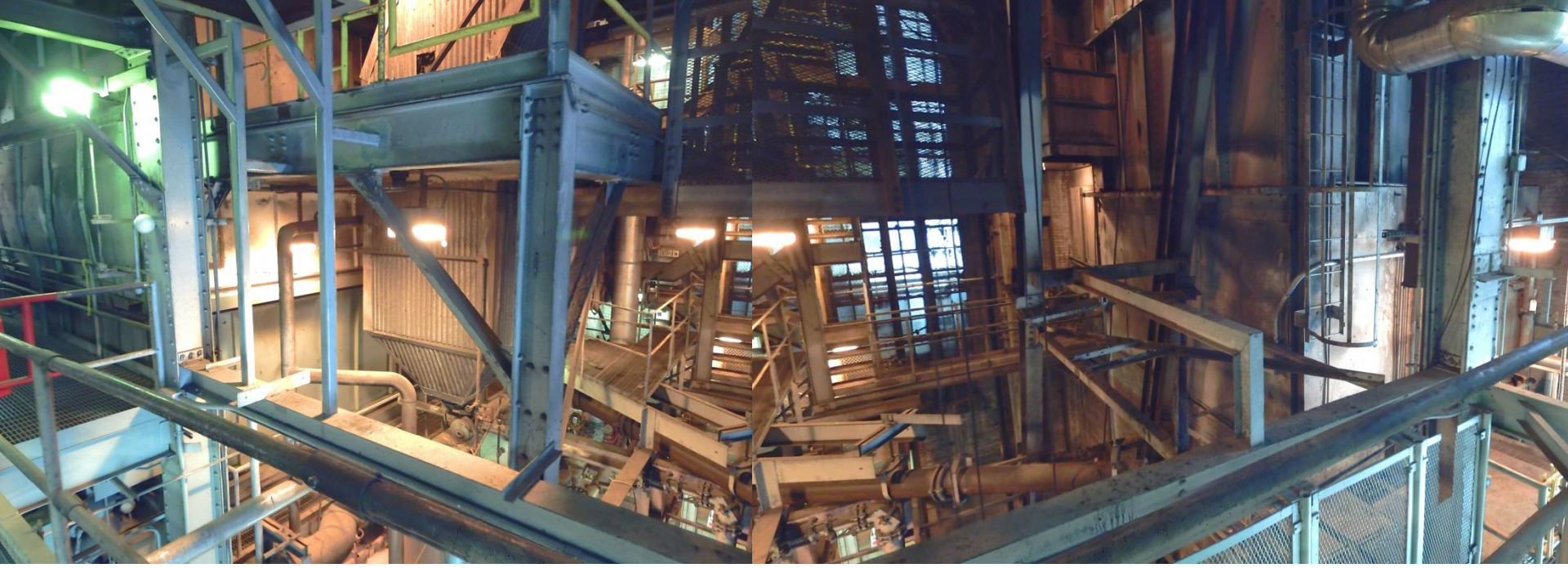


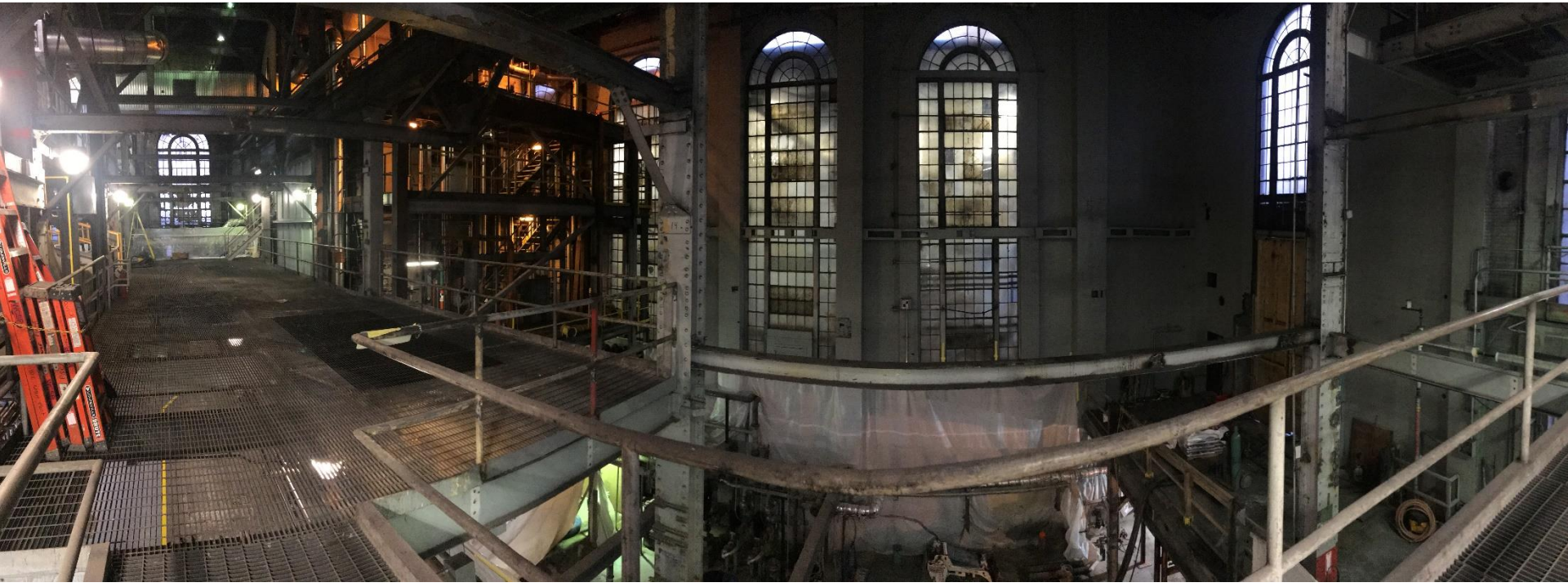

## Result

- Firm Steam Capacity – 92,500 lb/hr HRSG
- Efficiency – Combined Cycle CHP with >$2.7M annual savings
- GHGEmissions – >20,000 $MTCO2_e$ reduction
- Resiliency – 7MW nominal generation, Black Start
- Electrical System Upgrades – New West Campus Switch Station
- 14% peak electrical, 25% of average
- Budget – 12 Year payback


STOCK
EQUIPMENT CO.
CHAGRIN FALLS, OHIO



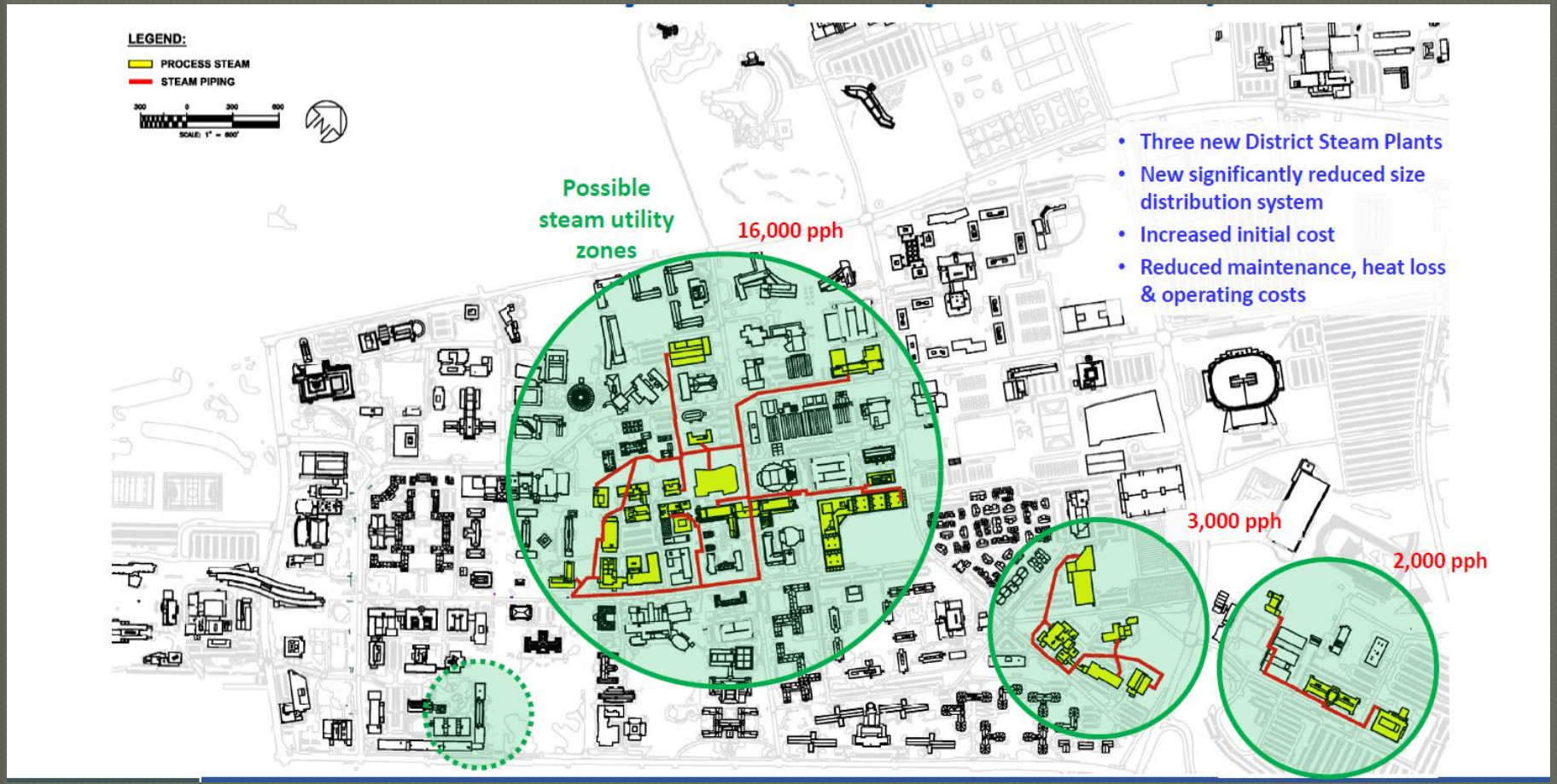




# What Else are We Thinking about?

# Renewable Fuels

# Hot Water Distribution



Thank you