A Path to Neutrality – Princeton University Infrastructure Master Plan

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CampusEnergy2019
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Utility System Key Attributes

- Chilled Water – 20,000 Tons
- Steam – 300,000 PPH
- Power Generation (CHP) – 15 MW
- Power Generation (Solar) – 4.5 MW (AC)
- Chilled Water TES – 40,000 Ton-Hours
- Chilled Water and Steam Piping – 70,000 LF
PRINCETON UNIVERSITY OVERVIEW

EXISTING WEST PLANT SITE

PROPOSED NEW EAST PLANT SITE
UTILITY AND ENERGY INITIATIVES

Recent Energy Conservation Modifications:

• CHW Pumps converted to high efficiency
• VFDs on CHW and Condenser Water Pumps
• VFD on Turbine Enclosure Fan
• Re-circuit chiller condenser water to series flow
• Energy studies & retrofits, re-commissioning
• Review & re-tune building energy controls
• > 100,000 lamp/fixture replacements with LEDs
ELECTRICAL CONSUMPTION
CHILLED WATER CONSUMPTION
CAMPUS ENERGY USE INTENSITY
REDUCED GHG EMISSIONS
INFRASTRUCTURE MASTER PLANNING

Primary Issues Addressed

• Capacity
• Reliability and Resiliency
• Future Load Growth
• Heating Hot Water Conversion
• GHG Emissions Reduction
• Financial Stewardship
INFRASTRUCTURE MASTER PLANNING

Infrastructure/Utility Drivers

• Aging/inefficient infrastructure
• Steam >100 years with serious degradation
• CHP core engine reaching obsolescence
• Several chillers are 1960s and 1970s vintage
• Increasing interest in water stewardship
• Limited real-estate in suburban environment
INFRASTRUCTURE MASTER PLANNING

The 2026 Campus Plan – *Next 10 Years in 30 Year Context*

- 10% Undergraduate Increase
- Expansion and Enhancement of Educational Mission
- Collaboration with Corporate and Non-Profit to Serve Teaching and Research
INFRASTRUCTURE MASTER PLANNING

The 2026 Campus Plan – Impacts to Utility Infrastructure

• Campus Growth – 812,400 GSF
• Heating – 17.4 MMBTU/hr
• Cooling – 2,300 Tons

Unmitigated Impacts from Growth

• GHG – 1,446 MTCO$_2$e annually
• Water – 16.8 MGal annually
IMP STEPS – OUR PROCESS

Master Planning Approach

• Part of a Large, Multidiscipline Campus Plan
• Strategic Framework - Goals and Priorities
• Steering Committees/Advisory Groups
  ▶ Staff and Students
  ▶ Industry Leaders
  ▶ Peer Institutions
  ▶ Local Community
### IMP STEPS – OUR PROCESS

#### PHASE 1

<table>
<thead>
<tr>
<th>Baseline</th>
<th>Hot Water Conversion</th>
<th>Heat Recovery</th>
<th>Geoexchange</th>
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<td>Baseline with Solar PV</td>
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#### On-Site Generation
- EGS – Power
- Biodiesel CHP – unfired
- Biomass to Boiler then to Condensing STG
- Biomass Gasified to GTG
- NG Combined Cycle with BPT
- NG CHP
## IMP STEPS – OUR PROCESS

### PHASE 2

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* PV/Biofuels applied to all options
Final Recommendations

- Conversion from steam to hot water heating
- New 6,800 ton heat pump chiller East Plant
  - Designed for future expansion
  - No combustion/no cooling towers
- New heating hot water capacity at West Plant
- New heating hot water distribution network
- Installation of geoexchange well fields
- Hot and cold TES
Key Impacts of IMP by 2026:

- 380,000 MMBTU reduction in natural gas consumption
- 1.6 MW increase in peak electrical load
- 58.7 MGal annual reduction in domestic water consumption
- 20,000 MTCO$_2$e annual reduction in GHG emissions
NEXT STEPS

Communicate and Sell the Plan!
► Finance, Administration, Campus Community

Implement Capital Projects
► Near-Term Projects are First Priority

Adjust Plans and Priorities as appropriate
► UMPs must be kept current and relevant
► Update UMP every five years
LESSONS LEARNED

- Thermal storage can maximize flexibility and minimize costs
- Maximize efficiency and energy source flexibility with CHP
- PPAs can be a cost effective GHG reduction measure
- Hot water heating provides substantial benefits
- Building conversions represent a large investment
- Phased conversion can ease campus burden and prevent overbuilding
- Value real estate in “3-D”
- CO$_2$ neutrality through on-campus means is a challenge
PROGRESS UPDATE

IMP Project Implementation

• Planning team selected for design
• Currently in early design phase
• Building conversion investigations – How Low Can You Go?

Increased Renewable Procurement

• On site and off site
• Solar