Princeton University
Facilities Engineering

Environmental & Energy Study Institute
International District Energy Association

District Energy & Combined Heat & Power at Princeton University

Rayburn House Office Building
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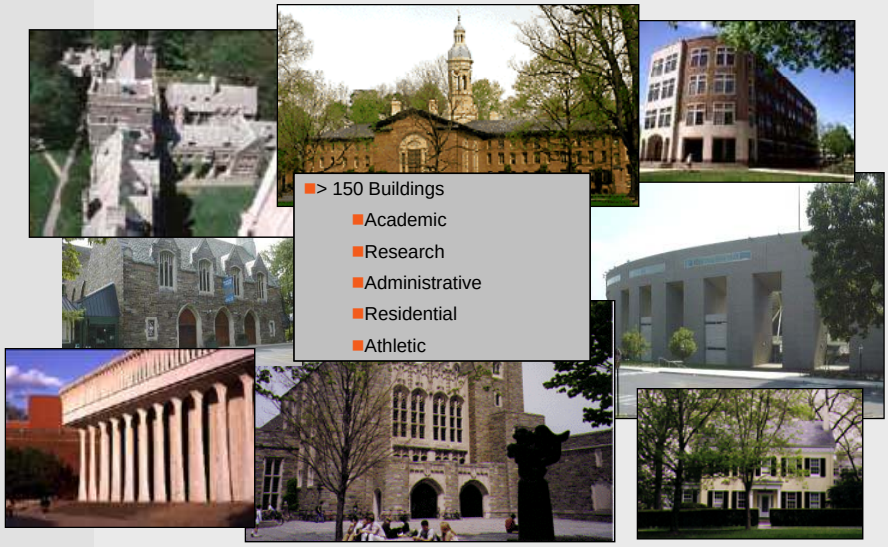
Overview

- Campus Energy Demands
- Energy Plant & District Energy Systems
- Combined Heat and Power Production
- Plant Economic Dispatch
- Historic & Projected Emissions
- Opportunities

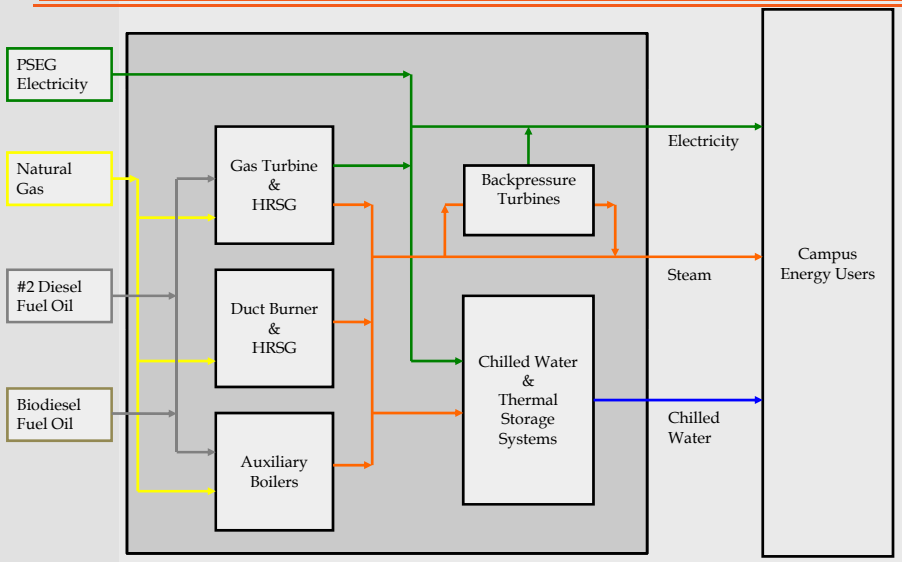
Energy Demands at Princeton



Energy Equipment & Peak Demands

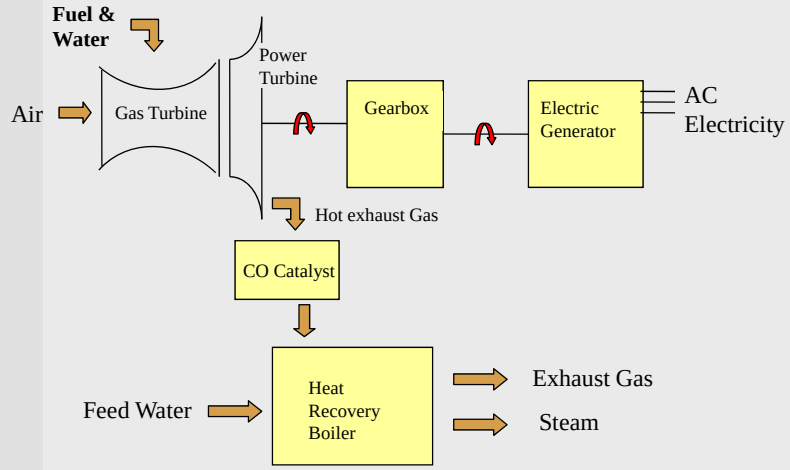
	Rating	Peak Demand
Electricity		
(1) Gas Turbine Generator	15 MW	27 MW
Steam Generation		
(1) Heat Recovery Boiler	180,000 #/hr	
(2) Auxiliary Boilers	300,000 #/hr	240,000 #/hr
Chilled Water Production		
(3) Steam-Driven Chillers	10,100 Tons	
(5) Electric Chillers	10,700 Tons	13,800 Tons
(1) Thermal Storage Tank	40,000 Ton-hours	
*peak discharge	10,000 tons (peak)	

Plant Energy Balance

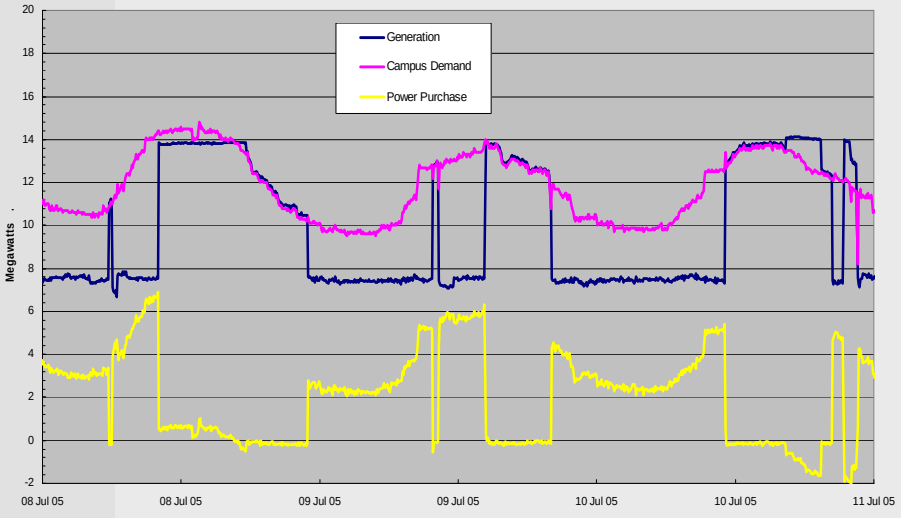


Campus District Steam System

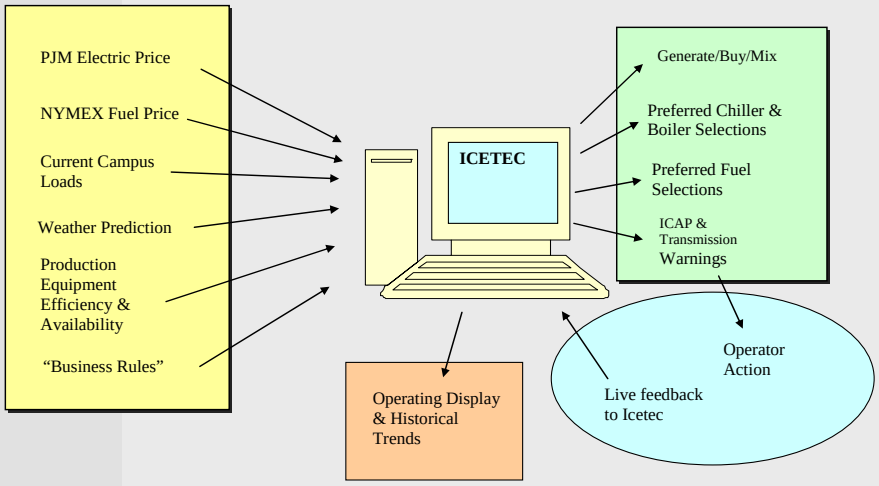
Combined Cycle "Cogeneration"



Princeton Power Demand
With Cogen Dispatch To Minimize Cost



Princeton Economic Dispatch System



TES Economic Dispatch Screen

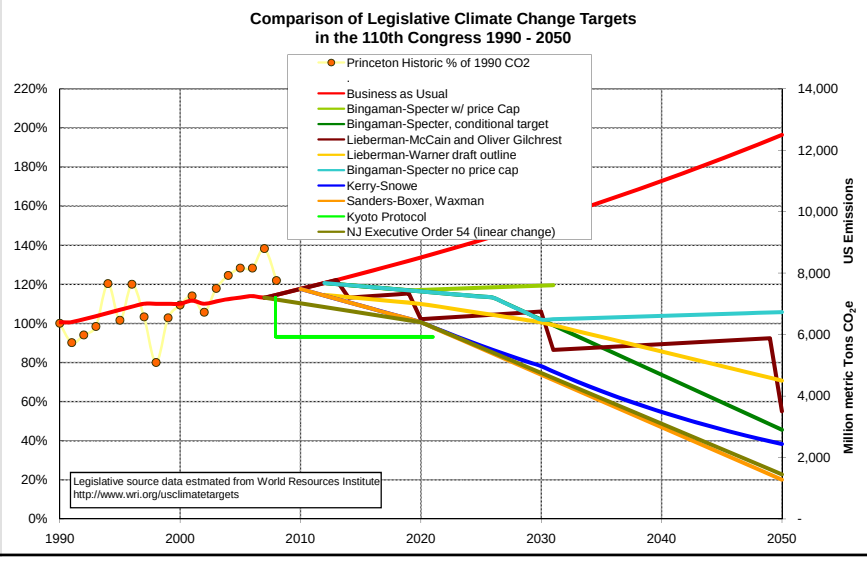
THIS Is The Smart Grid

- 2005 Peak Grid Demand Hour: 27MW
- 2006 Peak Grid Demand Hour: 2 MW
- This frees 25 MW of system capacity for use elsewhere by the local grid – and saves $$$!

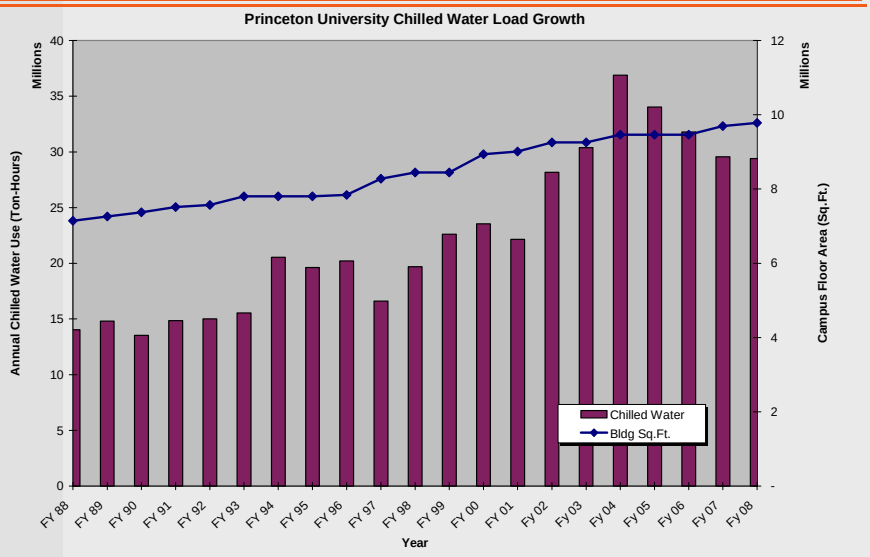
HOW?...

- CHP Power Generation
- Steam-Driven Cooling
- Thermal Storage
- Demand-Side Management

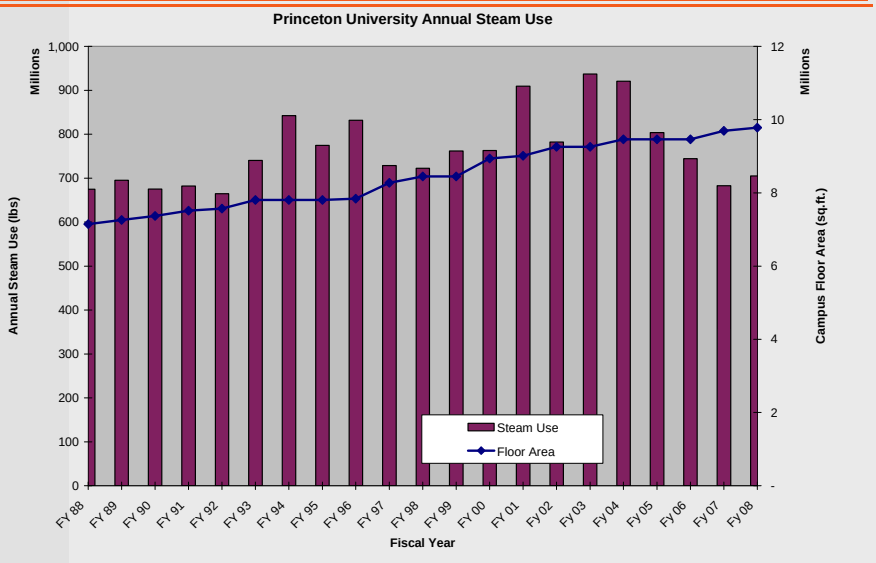
Climate Change Legislation



Reduced Chilled Water Use



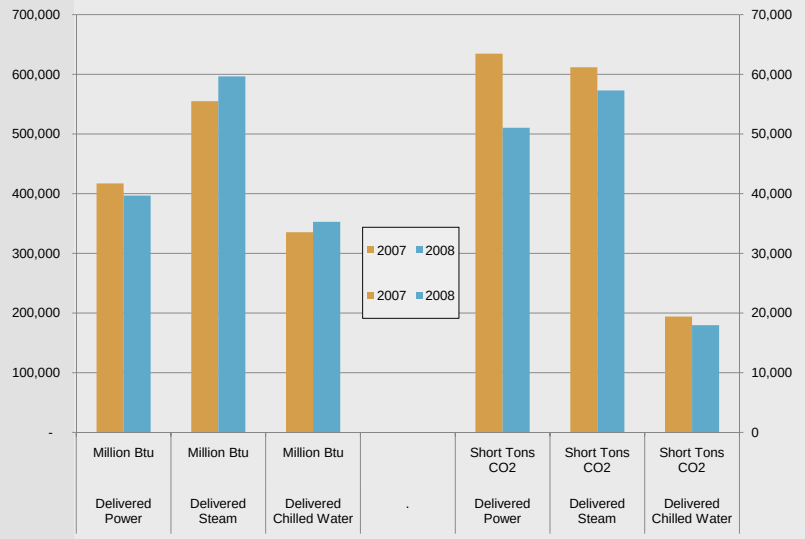
Reduced Annual Steam Energy



FY 2008 Summary

- Goal: Return to 1990 CO_2 emissions by 2020.
- 1990 Baseline: 105,000 short tons
- FY 2007: 145,000 short tons
- FY 2008: 128,000 short tons
- 12% improvement this year due to:
  - Improved energy production and delivery
  - Repairs & upgrades
  - Economic dispatch
  - PSEG accounting correction

2007 & 2008
Energy Delivered & CO2 Emissions – Common Units

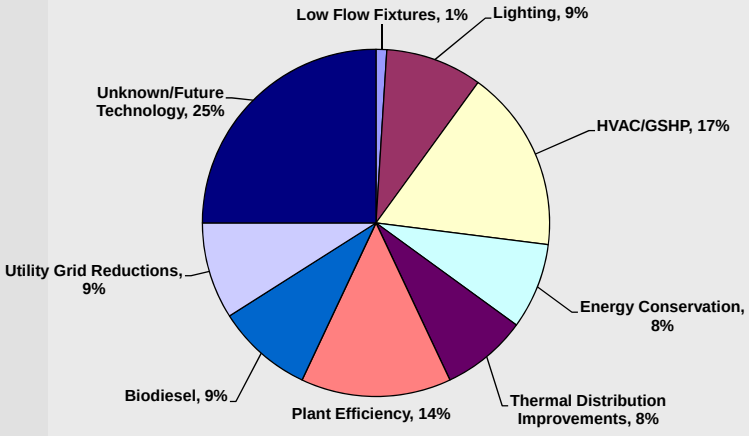


2008 vs. 2007 Changes

- **We purchased less energy but delivered more of it to campus.**

- Purchased power is ~1/3 of our CO2. PSEG changed CO2 accounting methodology to better reflect the mix of power delivered. That reduced our purchased power emission rate by 16%.
- Campus power consumption (outside the plant) was reduced by ~ 5%.
- There were 5% more heating & 2% more cooling degree-days '08 vs.'07
- We burned half as much diesel fuel and a little less natural gas.
- We reduced thermal losses through repairs, insulation, trap & valve upgrades.
- We improved condensate recovery from 67% to 83%.
- We ran the cogeneration system at a higher average efficiency (fewer hours on-line at low efficiency).
- We used more "free cooling" and a lower-emission mix of chillers; (1% less steam and 14% more electric).
- We used economic dispatch more effectively.

CO_2 Reduction Goals

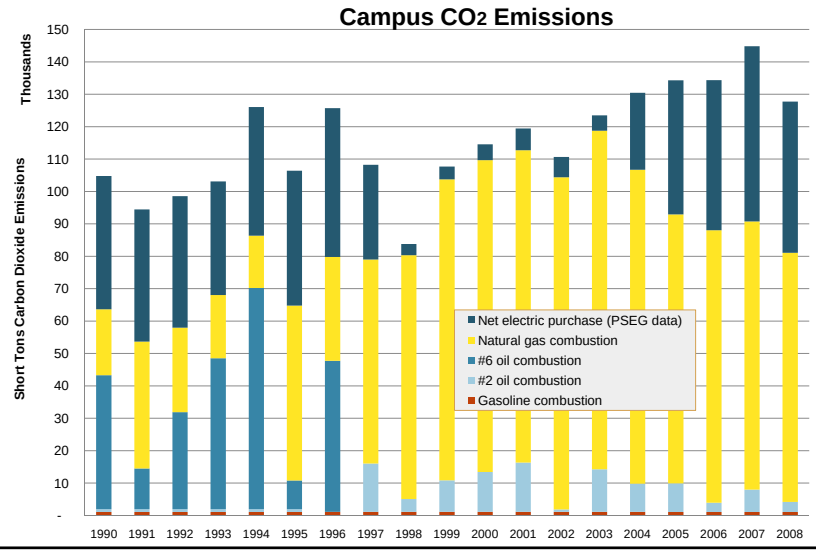


Ongoing Opportunities

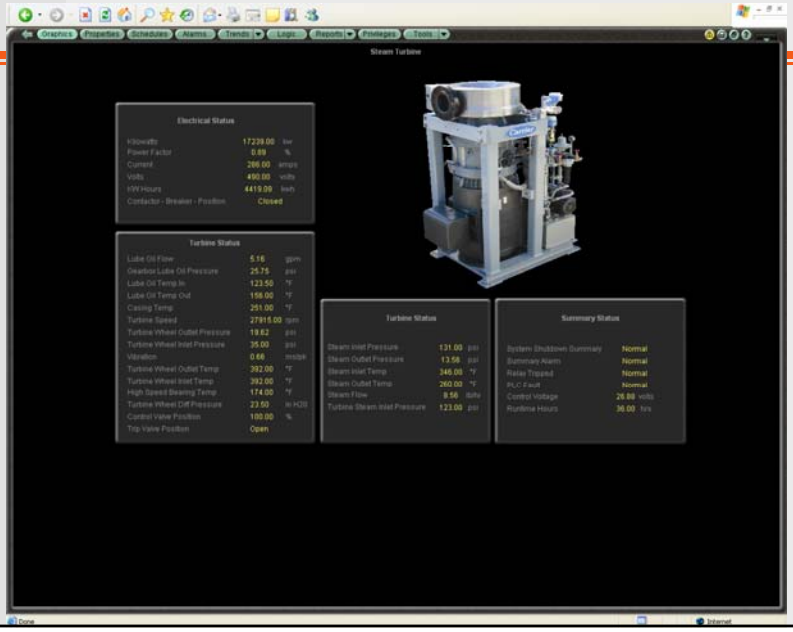
- Ground Source Heat Pumps
- Backpressure Steam Turbine-Generators
- Cogen Plant Efficiency Upgrades
- Real-time emissions calculation
- CHW-HTW Heat Pumps
- Biodiesel
- Energy Star & Smart Start Programs

Thank you

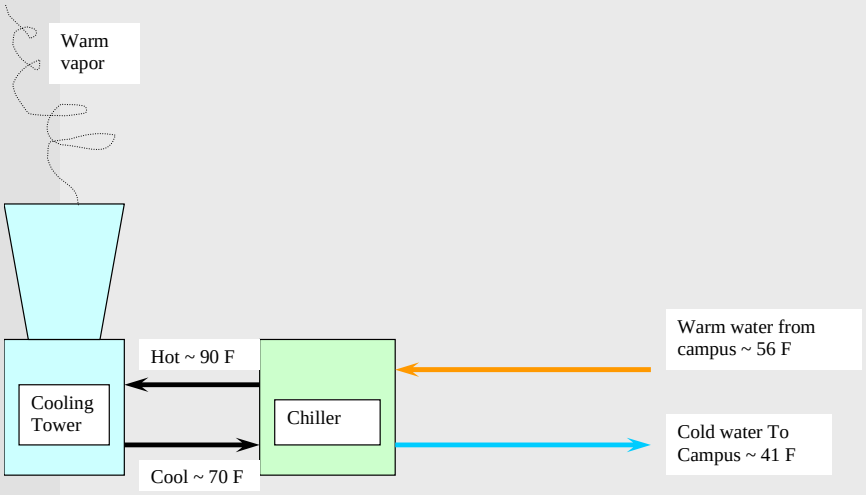
CO_2 Emissions by Source



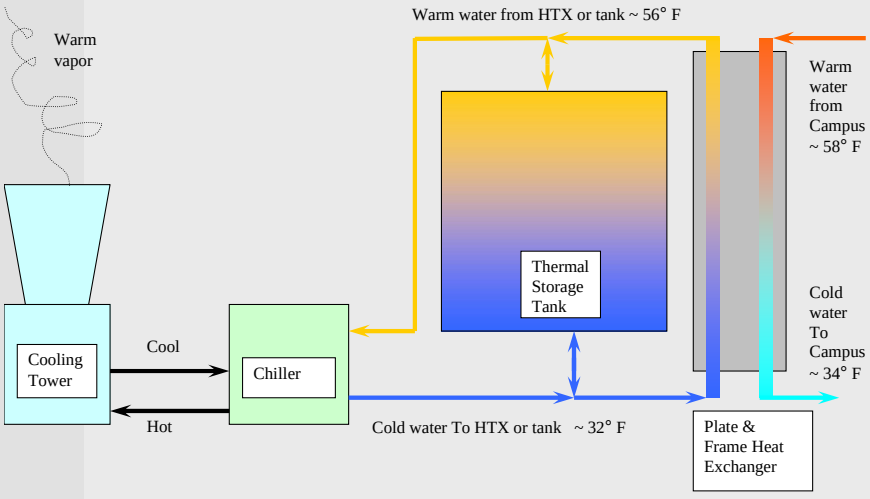
Backpressure Turbine - Generators



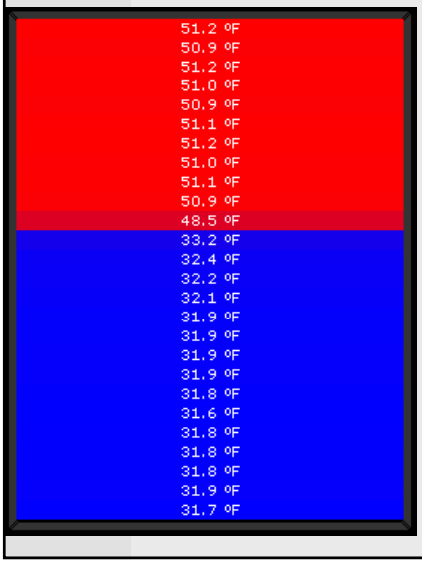
Chilled Water Campus Loop



Chilled Water Thermal Storage



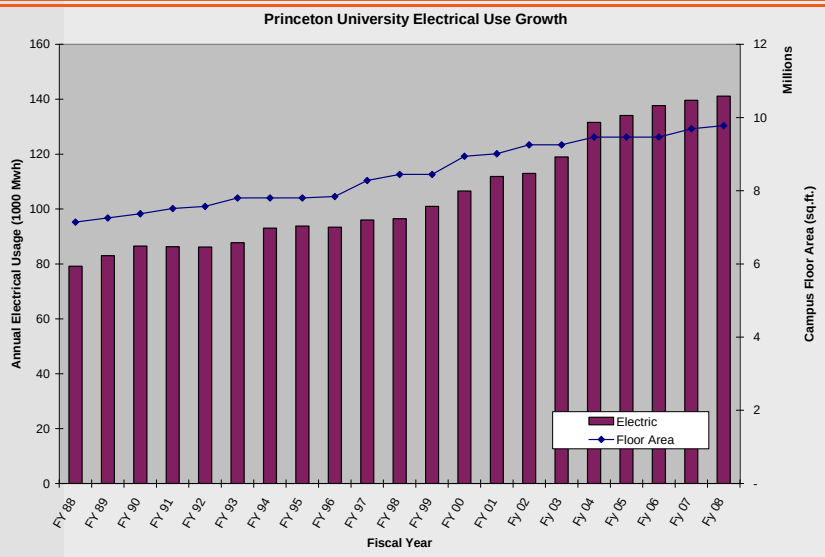
TES Tank Stratification



Reducing Cost and Emissions with TES

- **Purchase daily power at least cost**
- **Reduce energy use**
  - High efficiency equipment selection
  - Equipment operates at full load design point
  - More efficient: lower night time wet-bulb temperature
  - Reduced transmission losses
  - Lower storage temp → increased campus differential temperature → lower pumping energy required
- **Increase Reliability and Ease of Operation**
  - De-coupled production from demand
  - Increase night-time load, reduced daytime load
  - Easier daytime maintenance
  - Reduced peak demand
  - Excellent low-load performance

Growing Electrical Demand



Campus and CHW Power Use