Integrated Central Energy Systems At Princeton University

District Energy, CHP, Microgrids: Resilient, Efficient Energy Infrastructure
Tuesday, December 6

Room G50 Dirksen Senate Office Building

Ted Borer, PE, CEM, LEED AP

etborer@princeton.edu

Simple Take-Aways

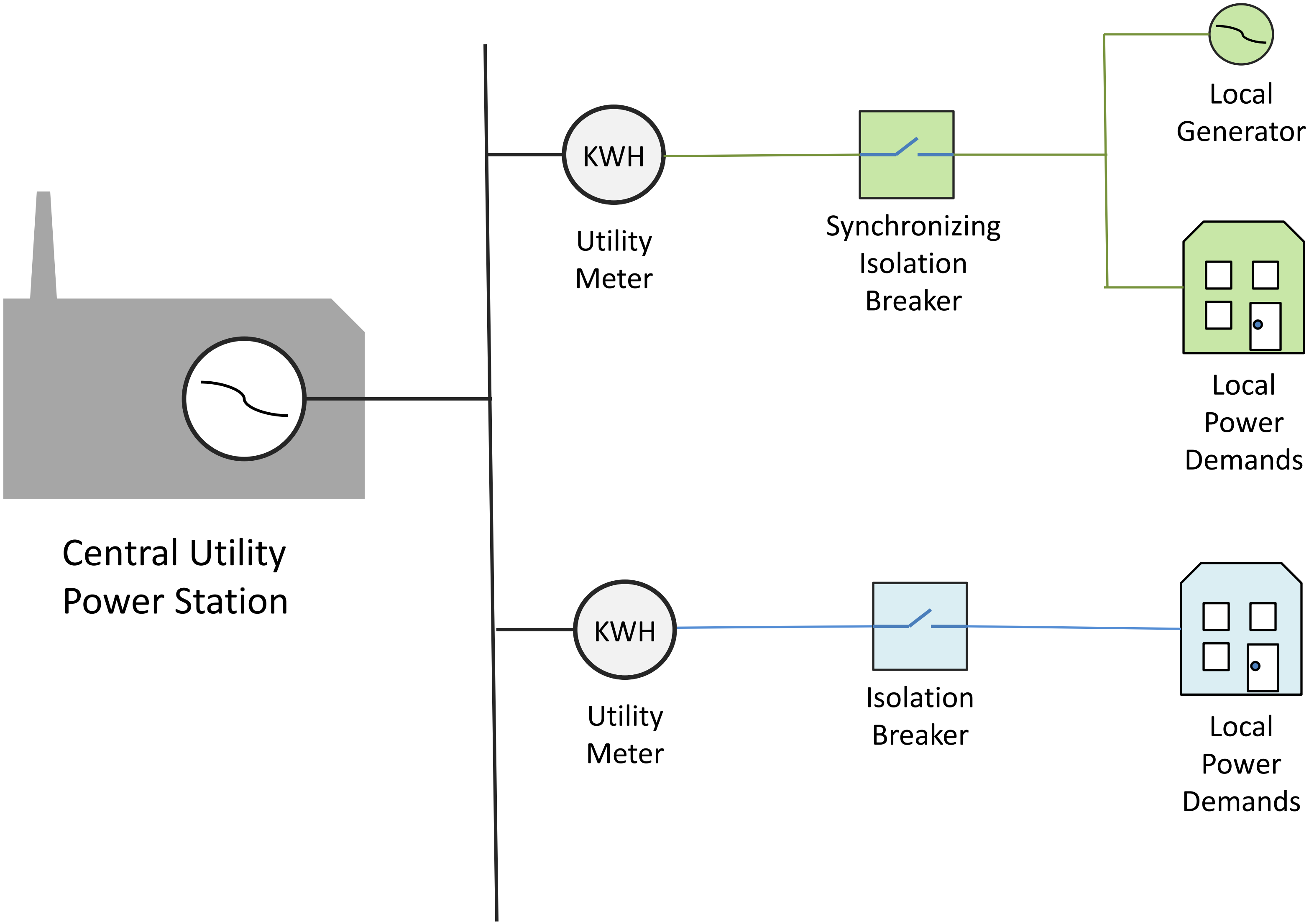
Macro-grid with microgrids can deliver higher reliability with lower total installed capacity.

Highly-integrated microgrid systems exist today.

They offer numerous benefits to the host, local community, and larger grid including: financial, reliability, resilience, environmental, diversified risk, and grid services.

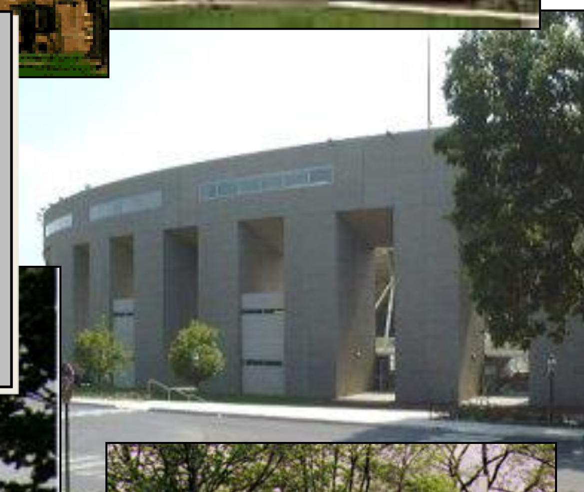
Princeton offers one example of thought-process and technologies.

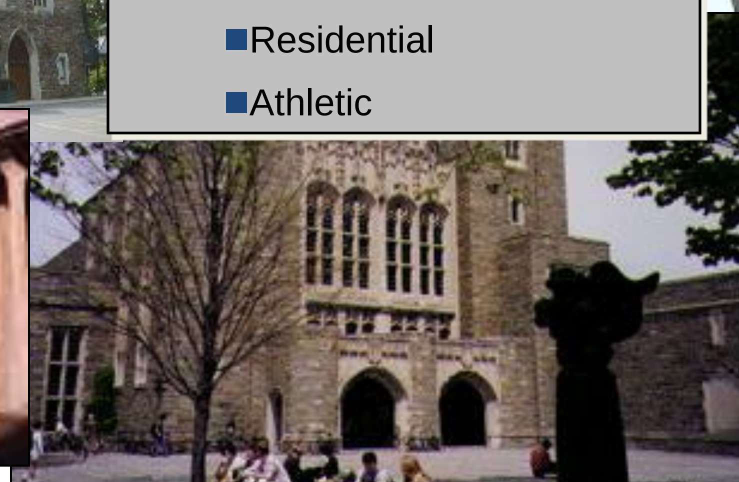
Simple Microgrid Concept



Energy Demands at Princeton

- > 180 Buildings
    - Academic
    - Research
    - Administrative
    - Residential
    - Athletic

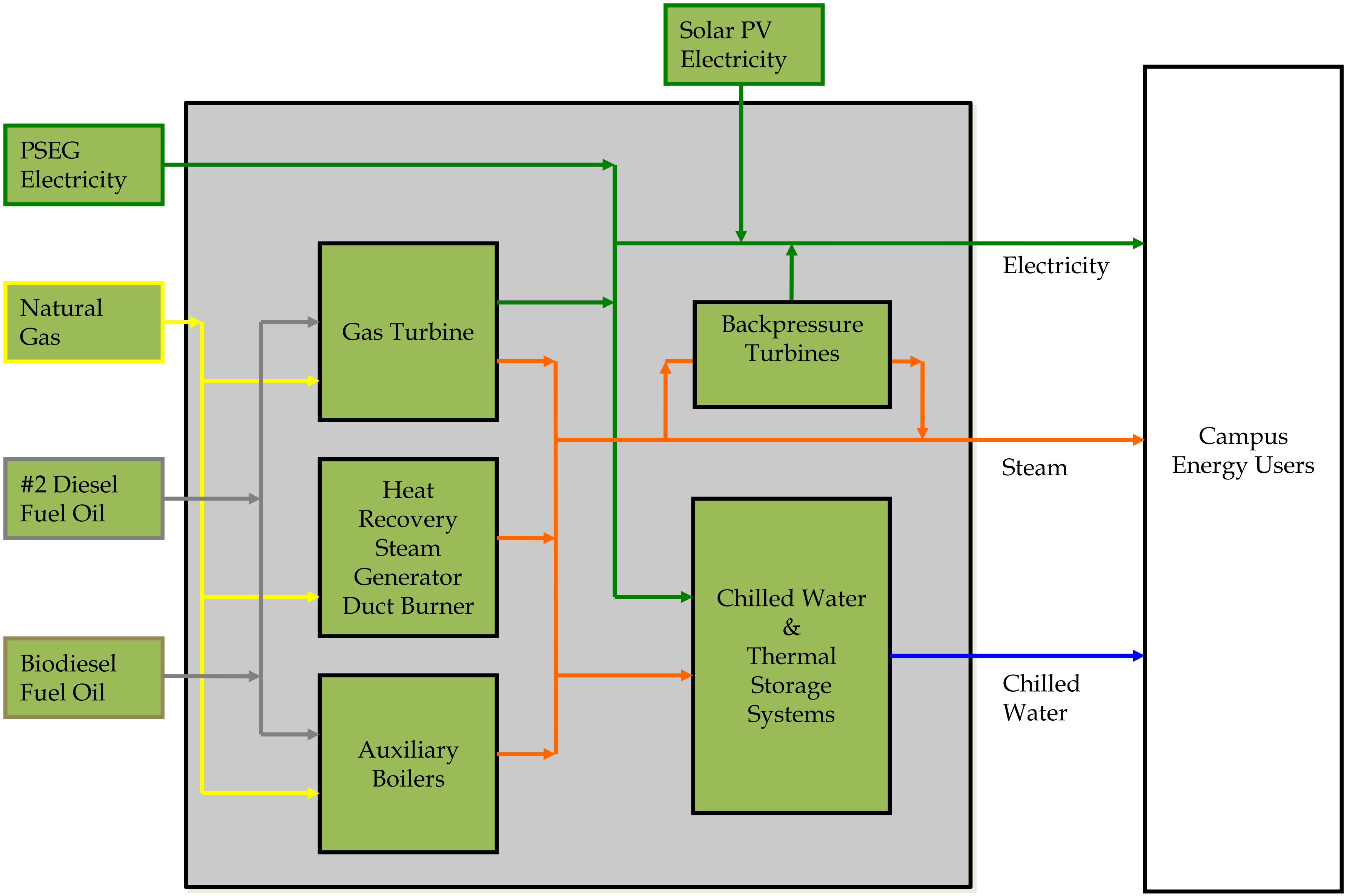




Energy Equipment & Peak Demands

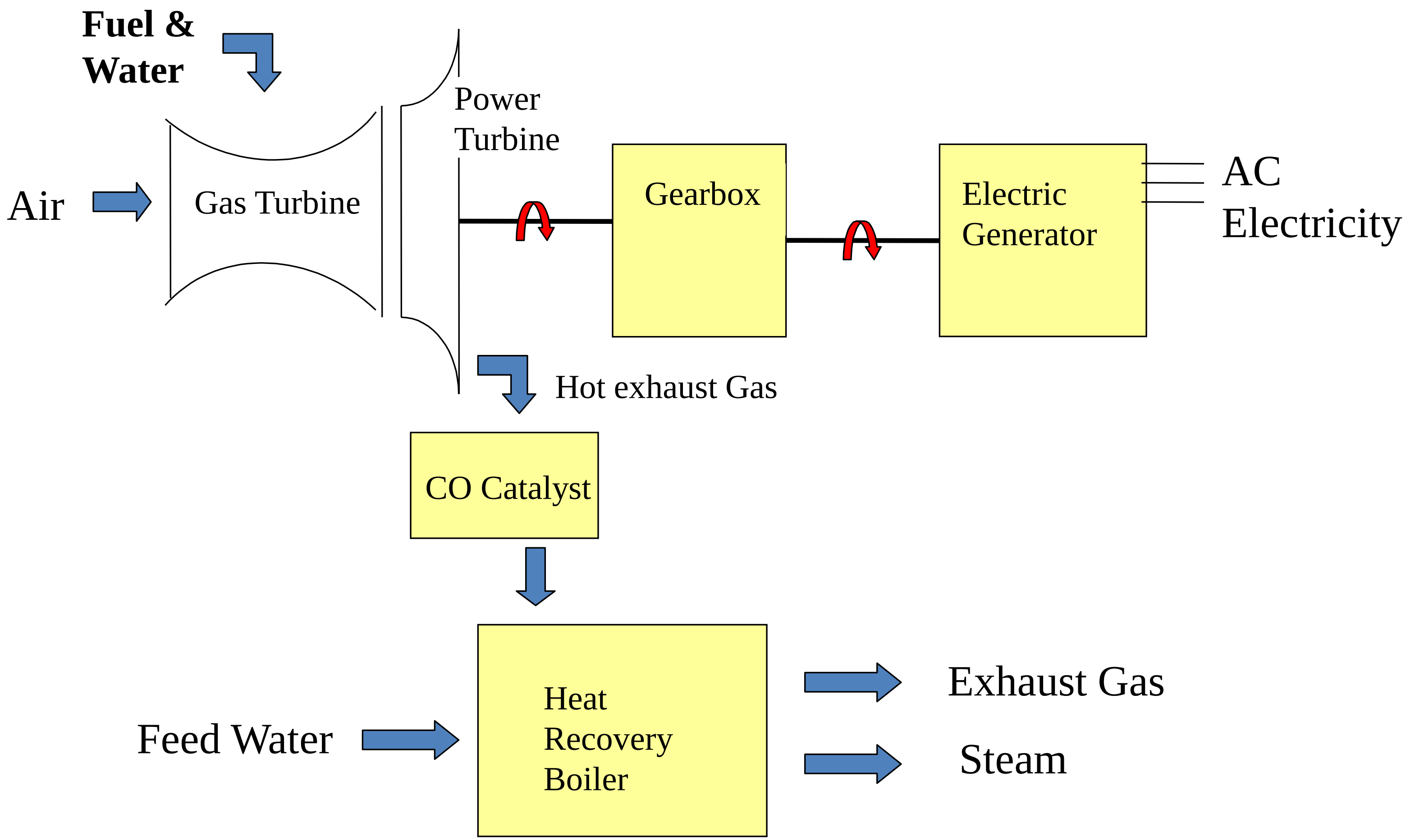
	Rating	Peak Demand
Electricity		
– (1) Gas Turbine Generator	15.0 MW	27 MW
– Solar Photovoltaic System	4.5 MW	
Steam Generation		
– (1) Heat Recovery Boiler	180,000 #/hr	
– (2) Auxiliary Boilers @ 150 ea.	300,000 #/hr	240,000 #/hr
Chilled Water Production		
– (3) Steam-Driven Chillers	10,100 Tons	
– (5) Electric Chillers	10,700 Tons	15,000 Tons
– (1) Thermal Storage Tank	40,000 Ton-hours	
• *peak discharge	10,000 tons (peak)	

Plant Energy Balance

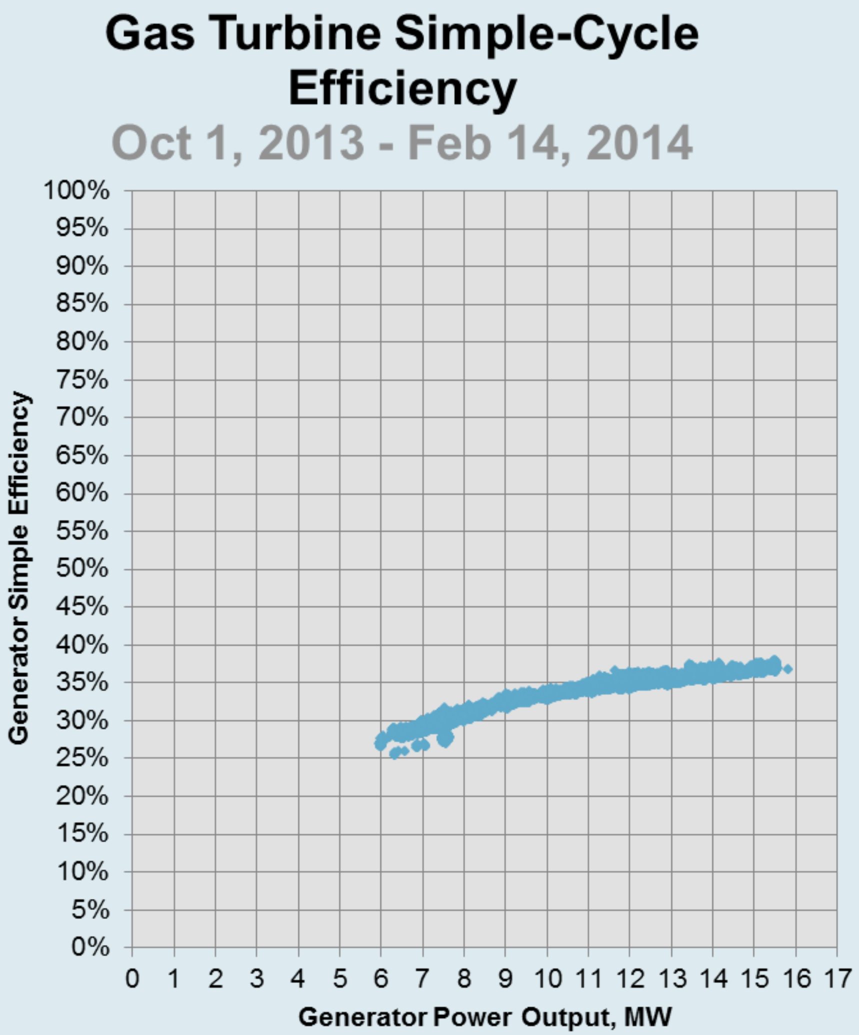


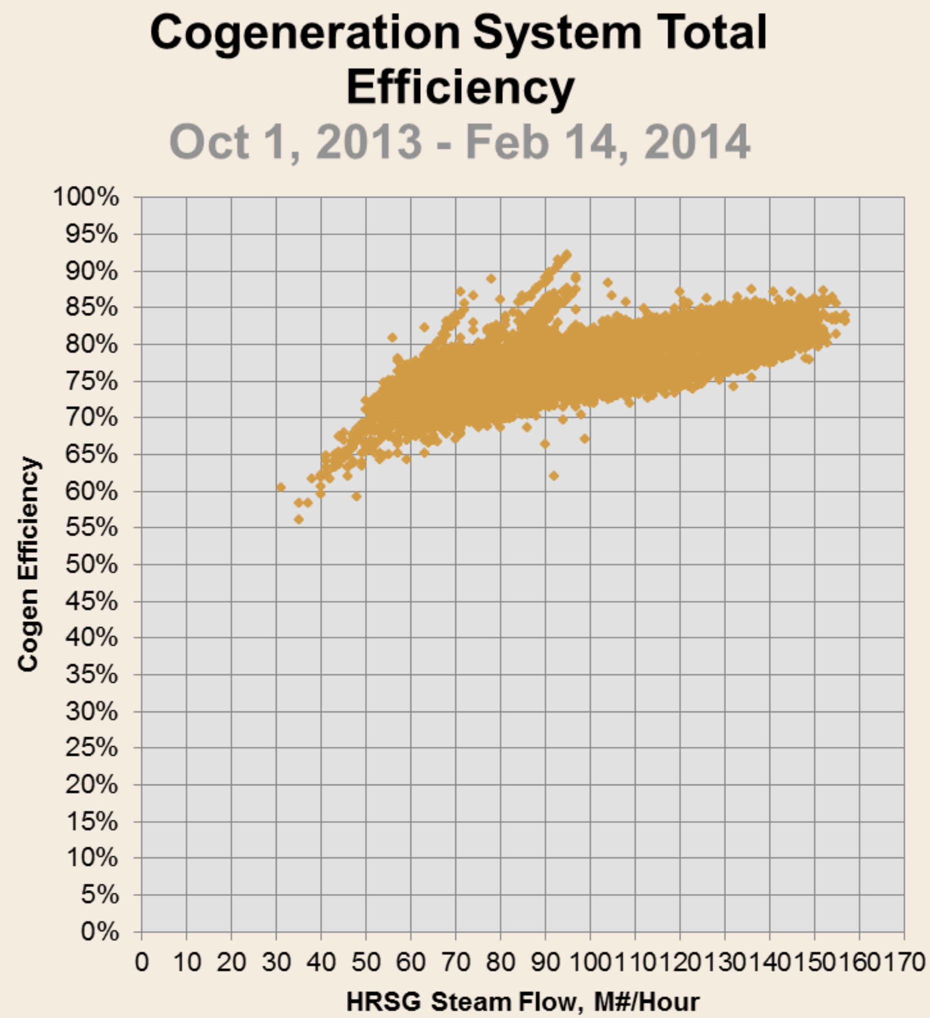
Campus District Energy Systems

Combined Heat & Power, "Cogeneration"

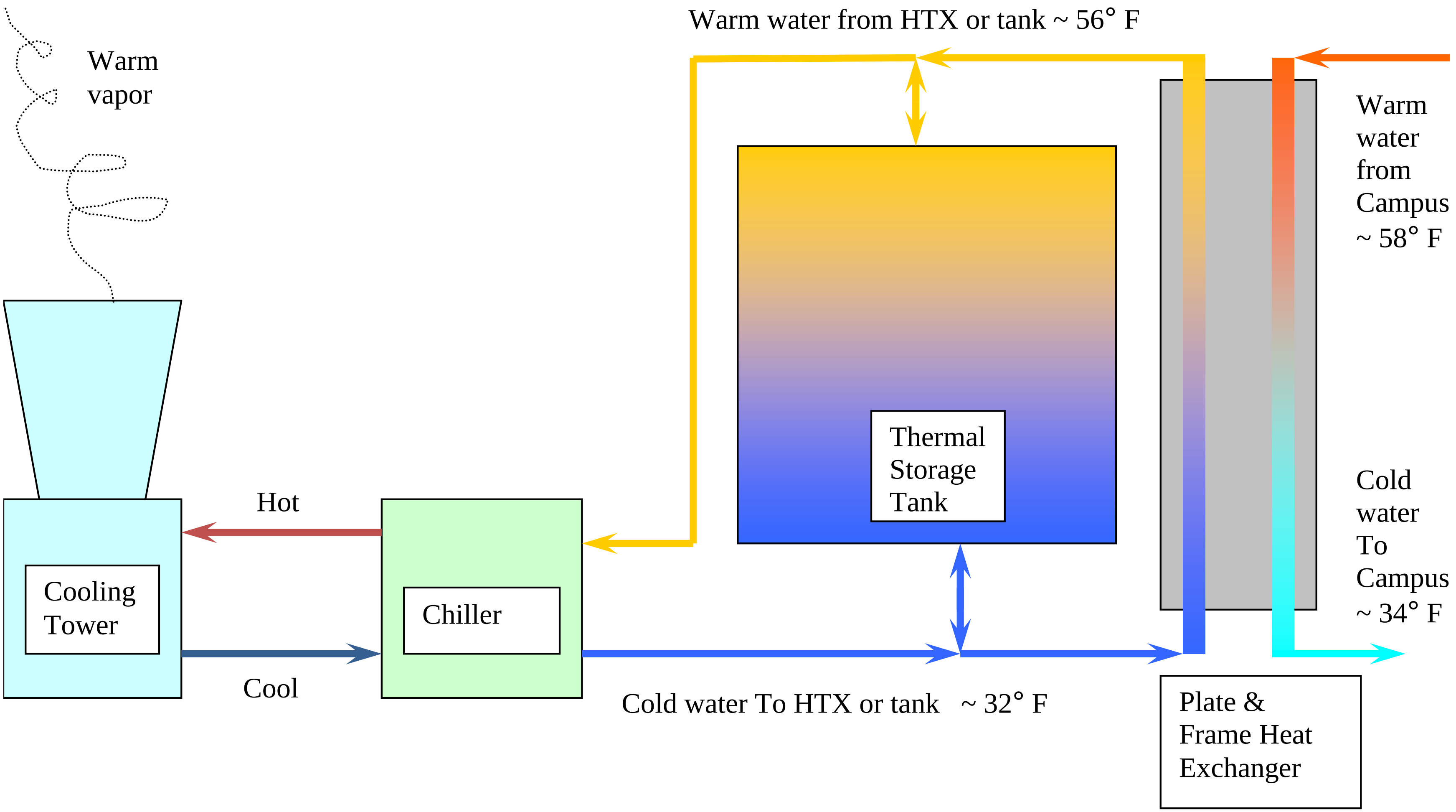


How Much More Efficient is Combined Heat & Power?



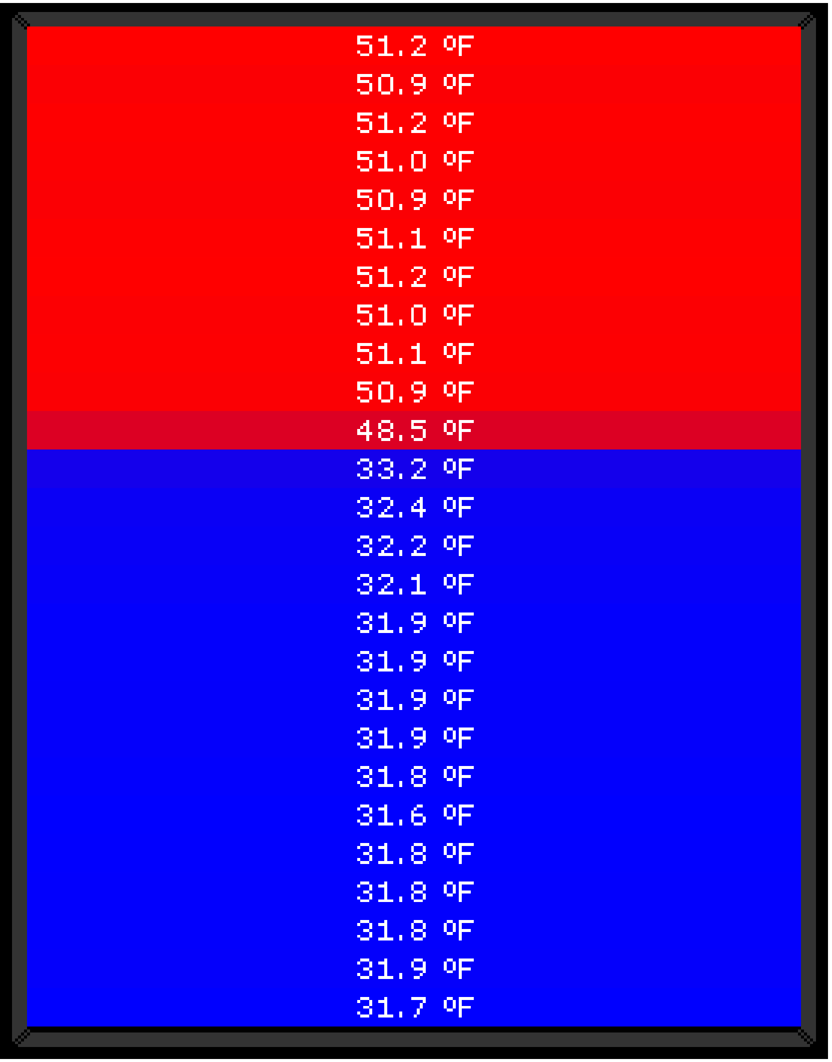


Chilled Water Thermal Storage



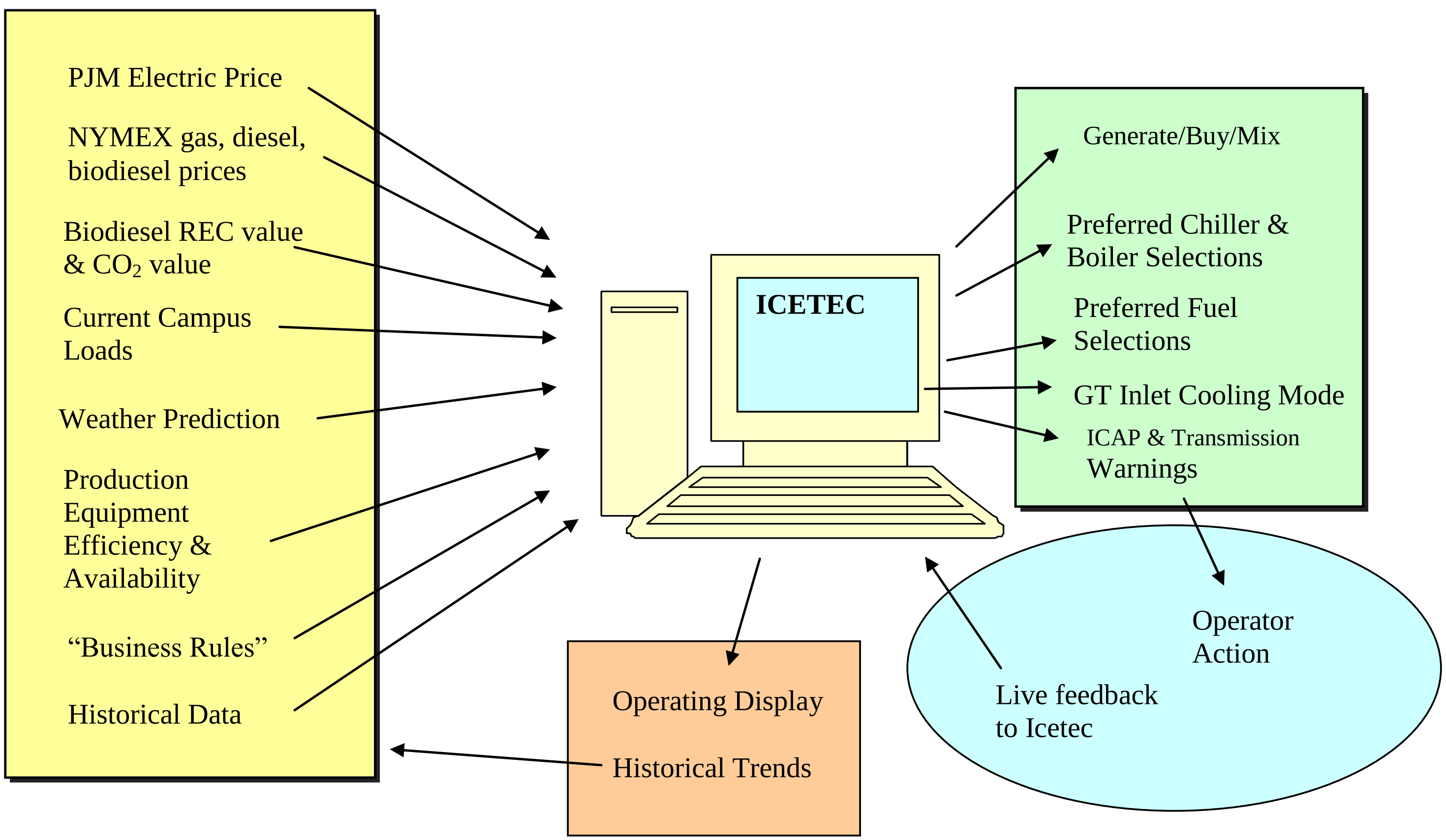
Thermal Energy Storage Tank

Temperature Stratification

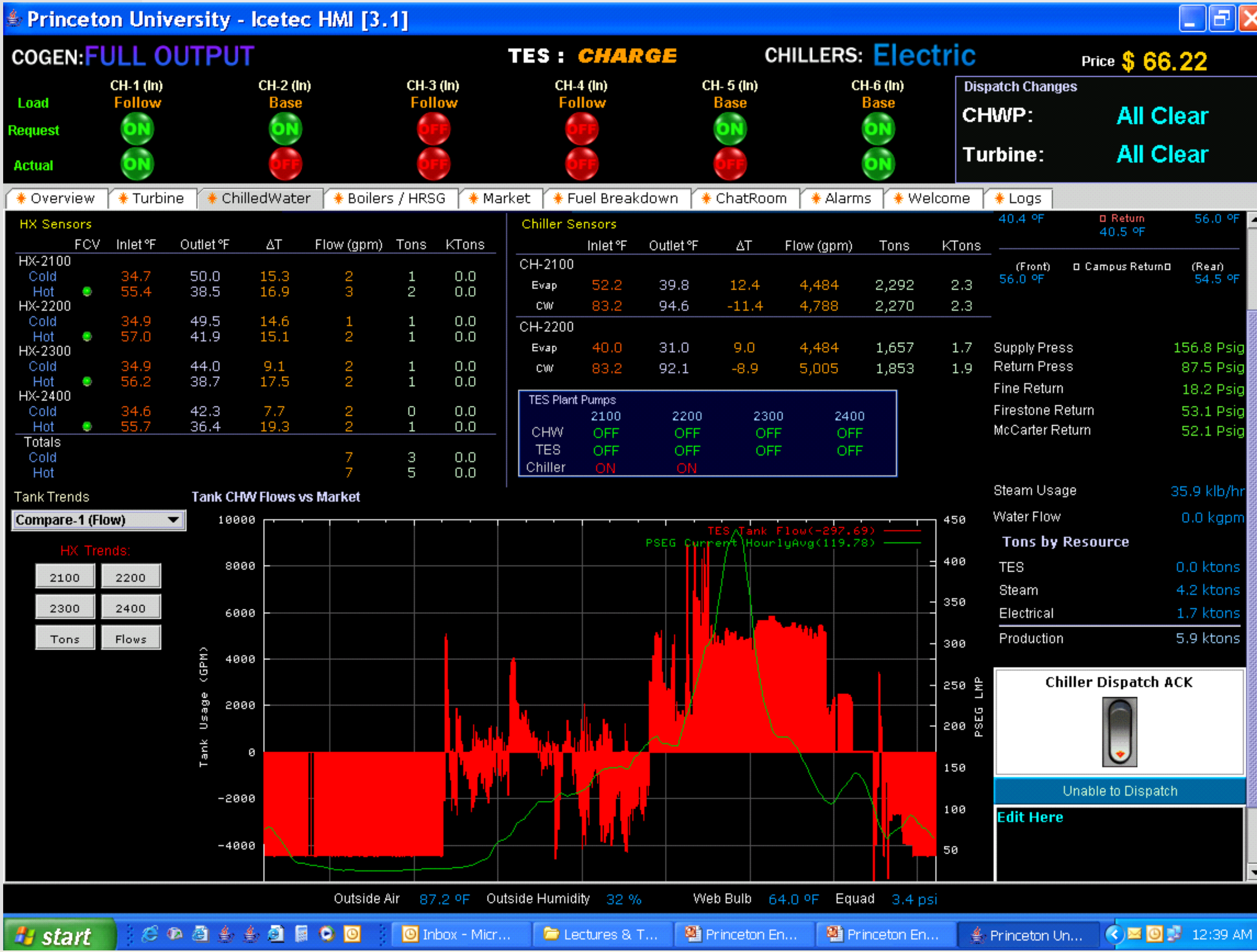



0466
www.AerialPhotosofNJ.com

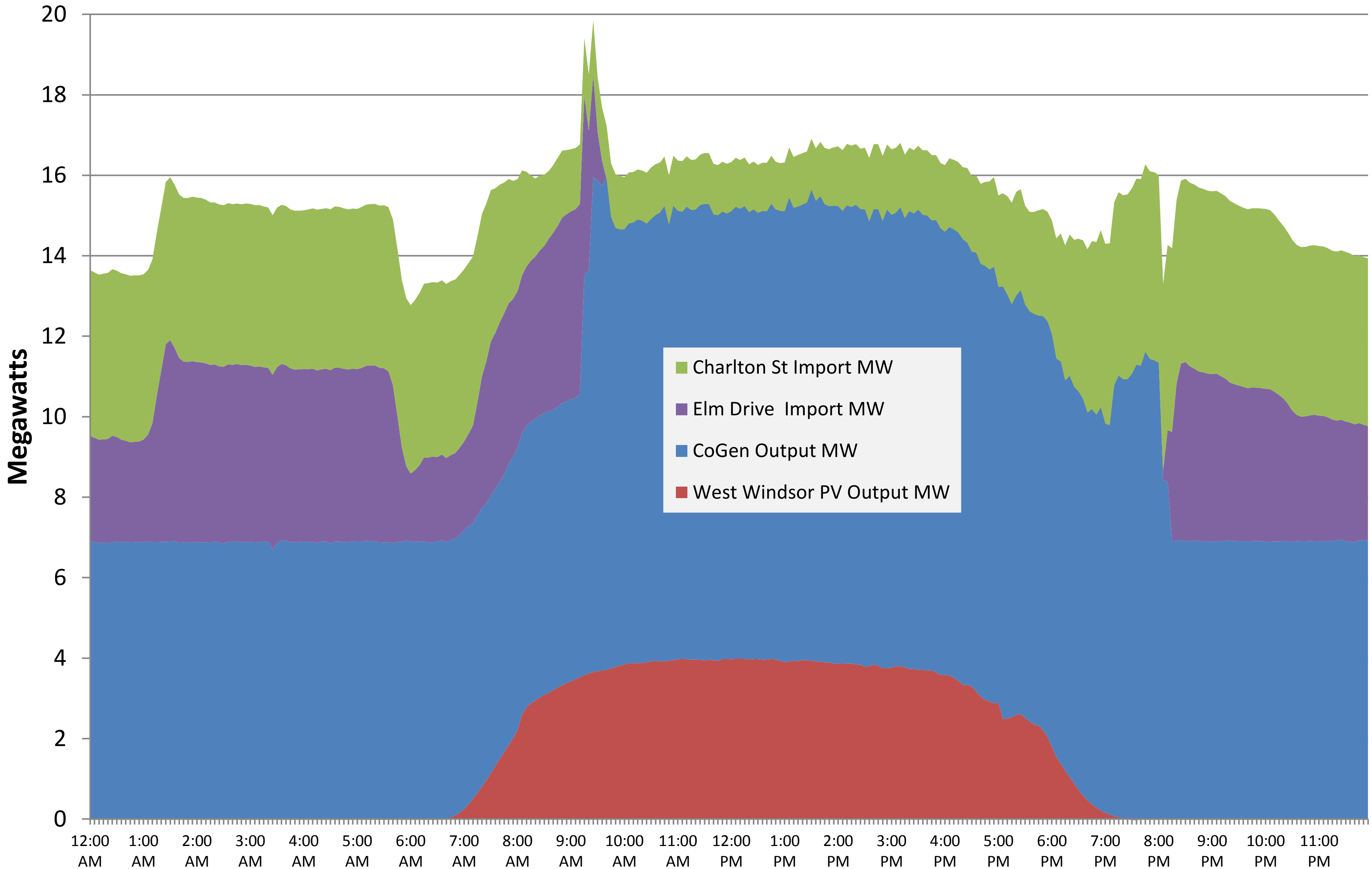
Princeton Economic Dispatch System



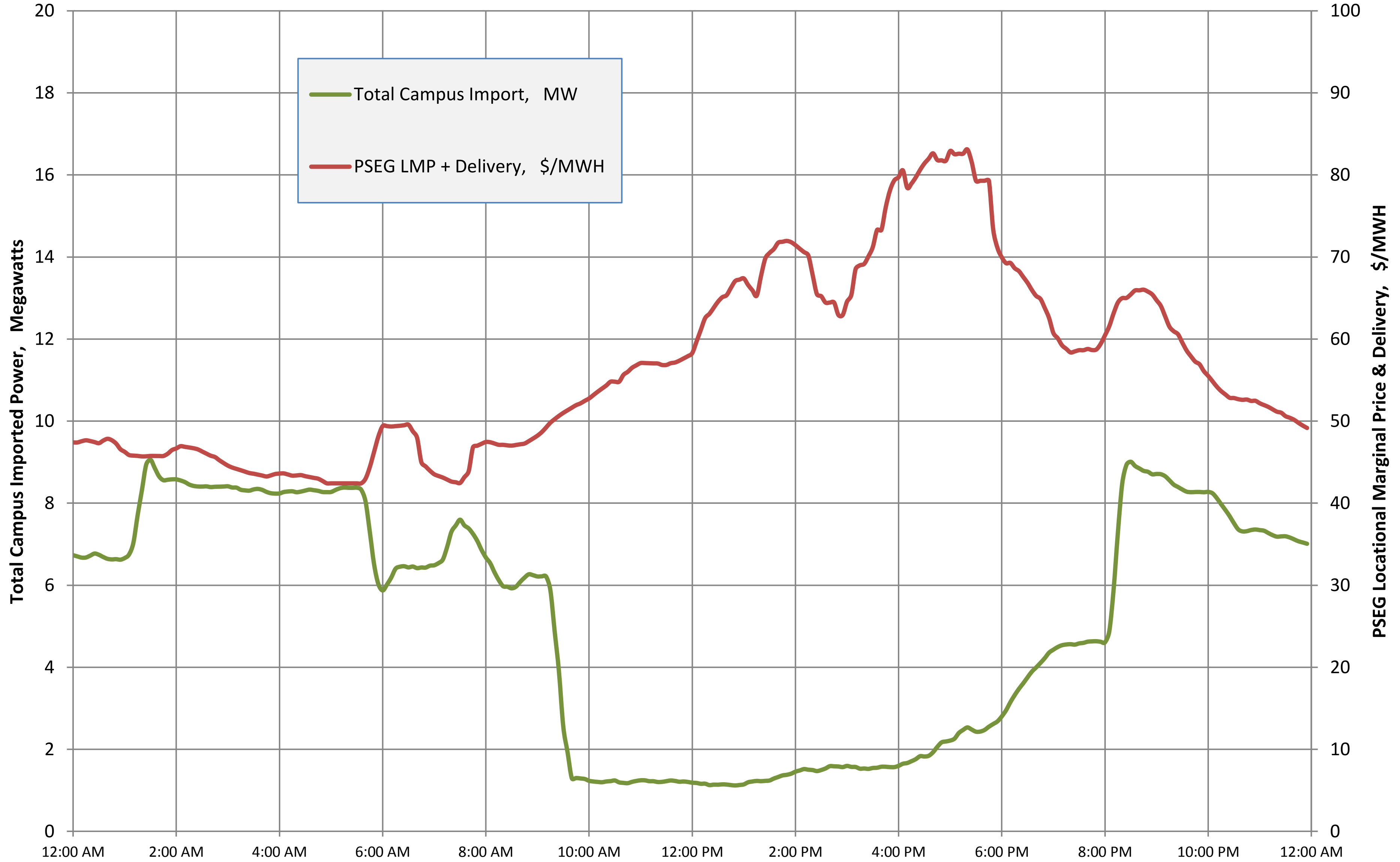
TES Economic Dispatch Screen



Main Campus Power, Generated & Purchased During PV System Testing August 30, 2012



Purchased Power and Power Price
During Solar PV Testing August 30, 2012



When it goes right…

Hurricane Sandy fan letter - Message (H

File | Message | Adobe PDF

Delete | Reply | Reply All | Forward | Move to: ? | To Manager | Team E-mail | Move | Tags | Editing | Zoom

Delete | Respond | Quick Steps | Move | Zoom

You replied to this message on 11/2/2012 9:16 AM.

From: Peter Maag <maag.peter@gmail.com> Sent: Thu 11/1/2012 7:01 PM
To: Edward T. Borer Jr.
Cc:
Subject: Hurricane Sandy fan letter

Hi Ted,

This is Peter Maag of the cross country team. I was in contact last year to organize a power plant tour for the team over one of our breaks. I graduated this spring, but I happened to be on campus this past week throughout the storm. Just wanted to make sure you got at least one well-deserved fan letter for keeping the lights on.

When I saw the news that a 100 year storm was about to slam Princeton while I visited, I was immediately grateful that I would be on campus. I was pretty confident that it would be one of the most reliable places for power in the whole region. I had to work remotely for a couple days, so power was essential. Thanks for keeping the juice flowing throughout my stay!

By this point, you've probably realized that I have n[...] the Princeton cogeneration plant. I'm assuming this [...] common. That being said, I'd love to hear a war sto[...] storm. Did anything out of the ordinary happen (or[...]

The Christian Science MONITOR

Lessons from Sandy: how one community in storm's path kept lights on

President Obama toured Sandy-hit areas Thursday, even as some communities still wait for power. Princeton University avoided power outages by using a 'microgrid' – and the idea is spreading.

[...]rk Clayton, *Staff writer* / November 15, 2012

President Obama, accompanied by New York City Mayor Michael Bloomberg, New York Gov. Andrew Cuomo, and Sen. Charles Schumer (D) of New York, hugs Debbie Ingenito Thursday on Staten Island's Cedar Grove Avenue, a street significantly impacted by hurricane Sandy.

Carolyn Kaster/AP

YouTube

2:22 / 4:42

Princeton's Cogeneration Plant Provides Power During Hurricane

DailyPrincetonian · 254 videos | Subscribe 144 | 1,362

Like | About | Share | Add to

Published on Nov 1, 2012
Operators of Princeton's Cogeneration Plant explain how they responded to the University's power needs during Hurricane Sandy this week.

Proclamation

Office of the Mayor
Township of Princeton

WHEREAS, Super Storm Sandy struck the Princeton Community on October 29, 2012; and

WHEREAS, the unprecedented amount of damage caused by the storm resulted in over half of Princeton roads being closed by fallen trees and most residents being without power and some for up to twelve (12) days; and

WHEREAS, the community immediately came together by opening an emergency operations center and working to ensure safety of Princeton residents by providing shelter, opening roads, and deploying emergency staff and equipment where needed; and

WHEREAS, the University became an integral part of the storm relief effort by staffing the emergency operations center and in opening up the University's dining facilities to feed the over 200 municipal staff members involved in the emergency operations; and

WHEREAS, it became apparent that many of the community's designated polling locations would be without power and not available for use on Election Day; and

WHEREAS, the University immediately responded by agreeing to open Jadwin Gymnasium as a polling location for seven (7) voting districts, and providing staff to assist as needed; and

WHEREAS, the University opened the Carl Field Center on Campus for residents, provided cots for the John Witherspoon School shelter, deployed University staff to keep Washington Road open and placed University Volunteer Fire Program members on standby to assist the Princeton Fire Department; and

NOW, THEREFORE, I, Chad Goerner, Mayor of the Township of Princeton, County of Mercer, State of New Jersey, do hereby commend

PRINCETON UNIVERSITY

For joining together with Township and Borough during Super Storm Sandy and in providing critically needed assistance that helped to return normalcy to the Princeton Community.

GIVEN UNDER MY HAND AND SEAL
THIS 17th DAY OF DECEMBER, 2012.

Chad Goerner, Mayor

Upendra J. Chivukula @UChivukulaNJ 14 Jan

Did you know that @Princeton University ran on almost full power post-Sandy because of their combined heat and power system? #NJAssembly

Collapse Reply Retweet Favorite

Hurricane Sandy Student Video

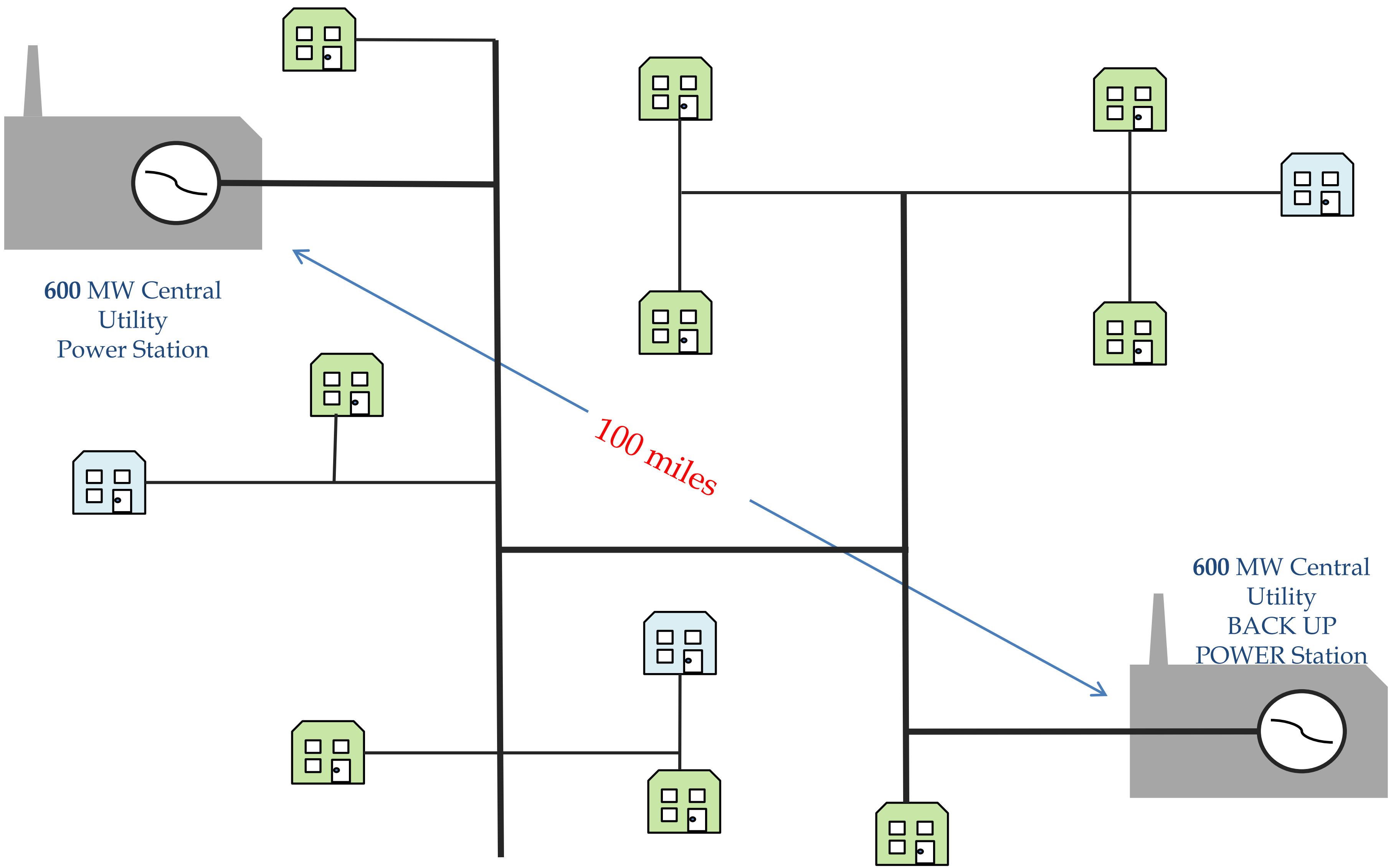
- http://youtu.be/WtjIj91imSQ

Utility Grid With Simple Redundancy

12 x 50 MW = **600 MW Demand**

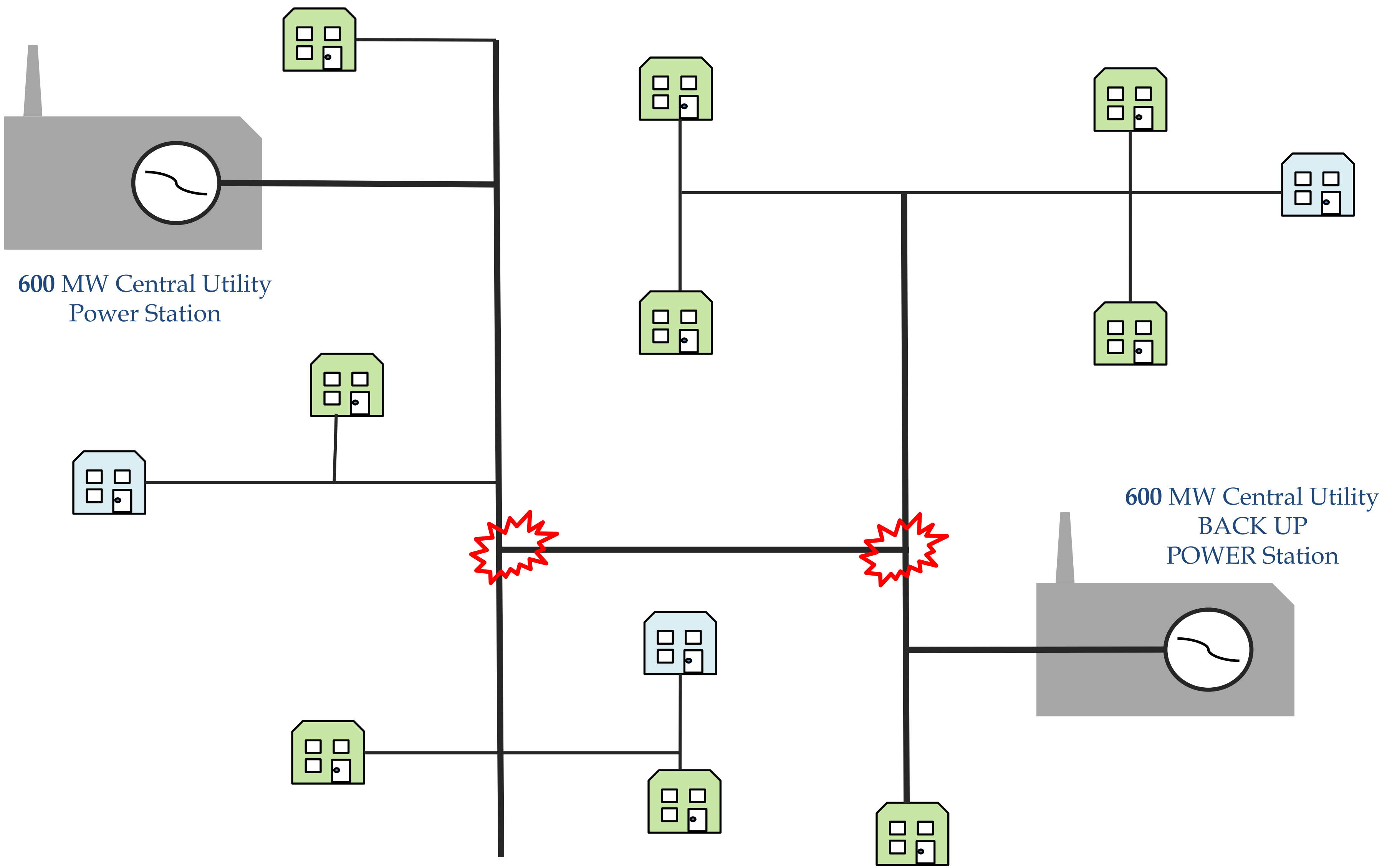
600 MW + 600 MW Back-Up = **1200 MW Installed Generation**

"N-1 Redundancy"



Utility Grid Vulnerability Points

12 x 50 MW = 600 MW Demand, 600 MW + MW Back-Up



Utility + Distributed Microgrids = Diversity
Increased Resiliency, Less Idle Capacity

12 x 50 MW = **600 MW Demand**

400 MW Utility + 400 MW Microgrids = **800 MW Installed Capacity**

"*Near* N-2 Redundancy" + Reduced *Scale* of Emergencies