

Energy Efficient Infrastructure for
More Resilient Local Economies

Princeton University Campus Microgrid

April 2013, 562 Dirksen Senate Office Building

Edward “Ted” Borer, PE
etborer@princeton.edu

International District Energy Association

Environmental and Energy Study Institute

Energy Demands at Princeton



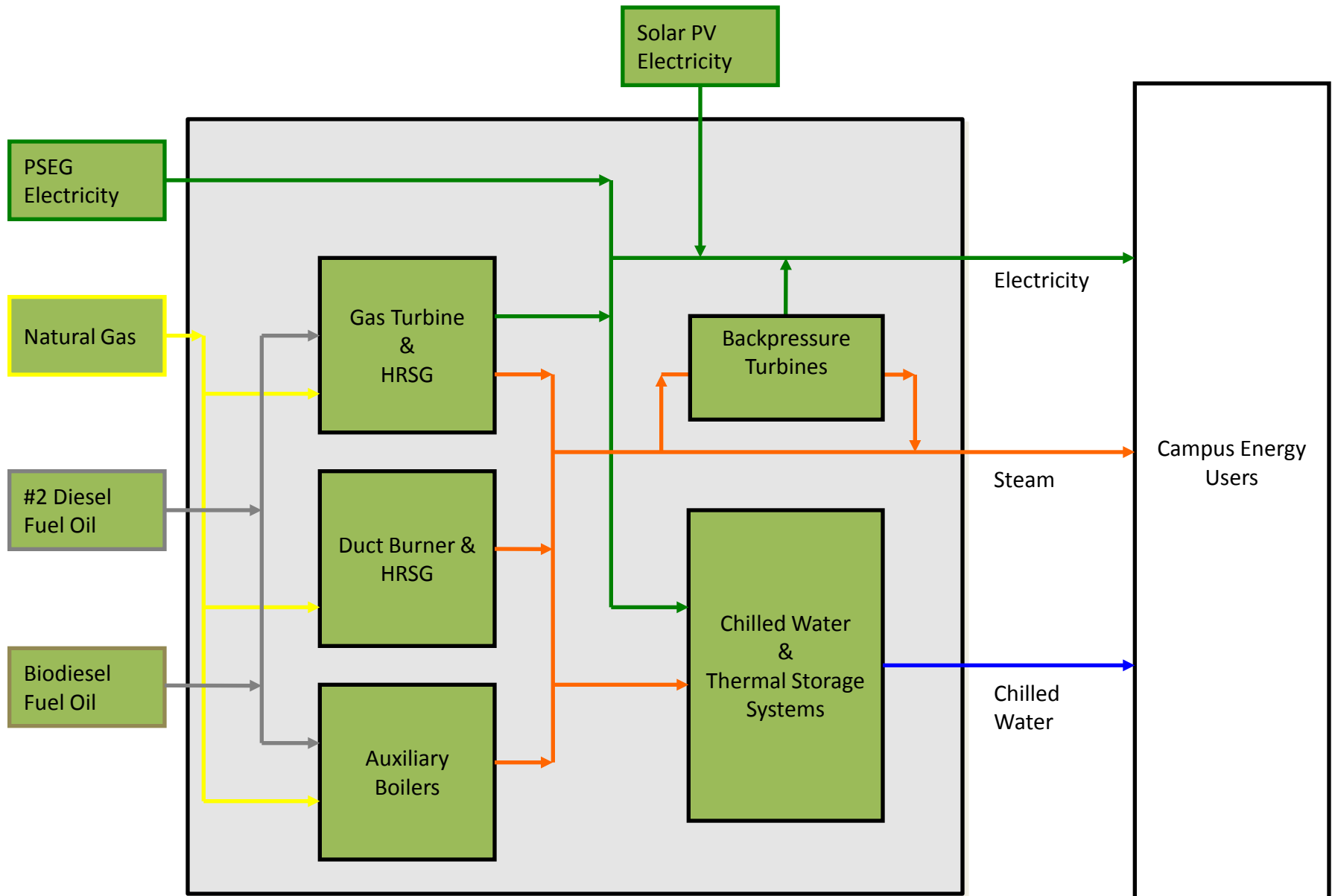
- ~ 180 Buildings
 - Academic
 - Research
 - Administrative
 - Residential
 - Athletic



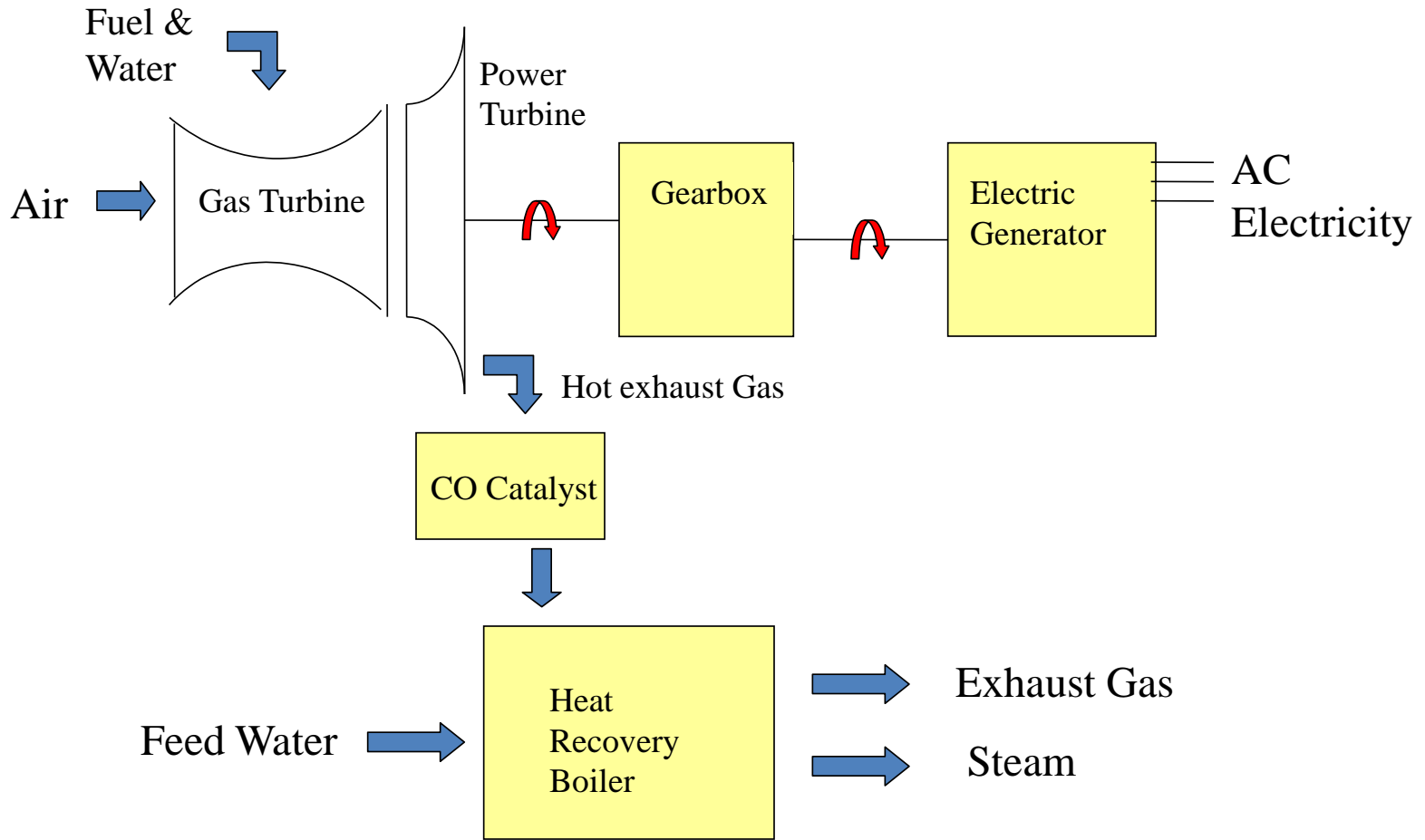
Energy Equipment & Peak Demands

	<u>Rating</u>	<u>Peak Demand</u>
• Electricity		
– (1) Gas Turbine Generator	15 MW	27 MW
– Solar Photovoltaic System	5 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 Flows



Combined Cycle “Cogeneration”

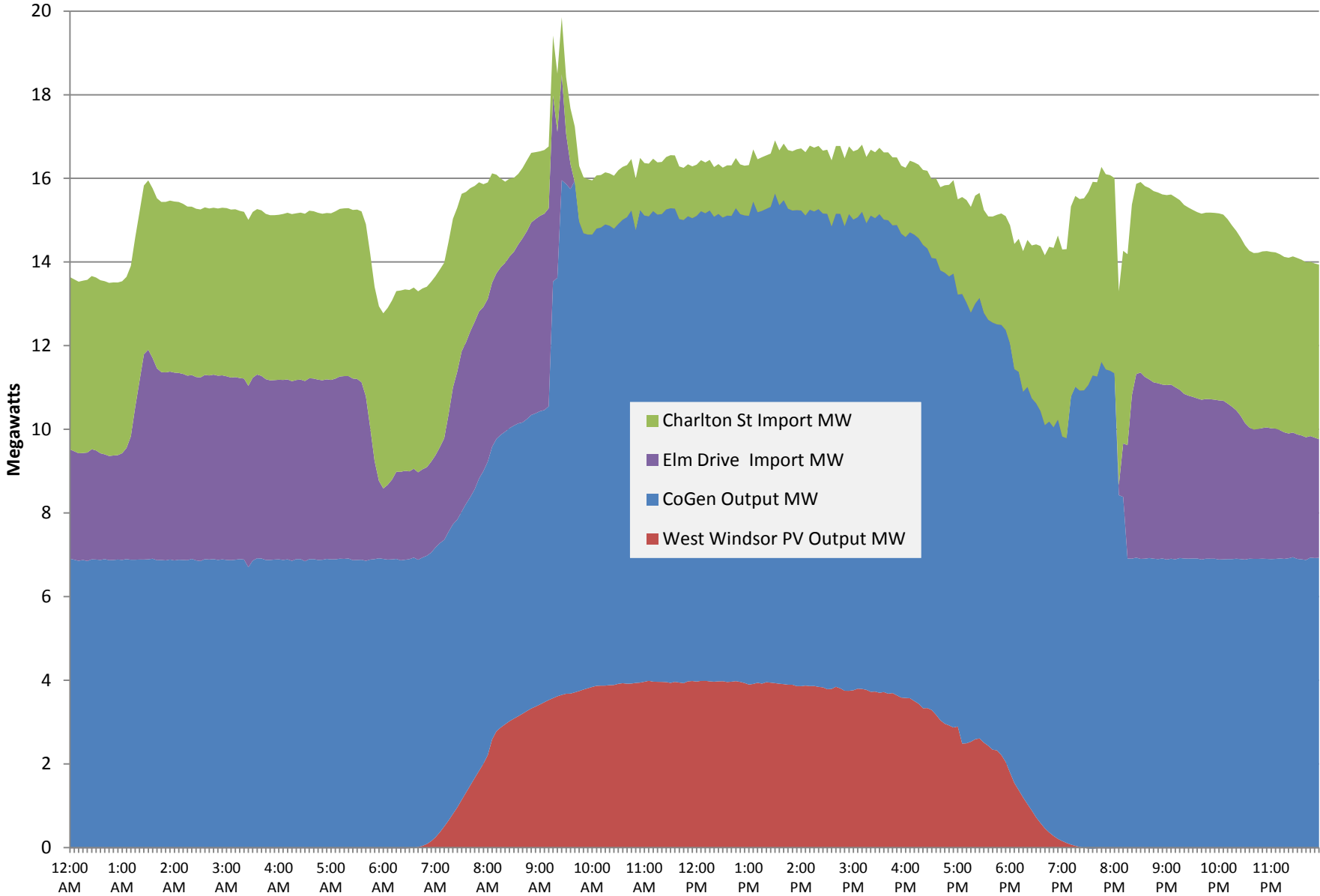


Campus District Energy Systems



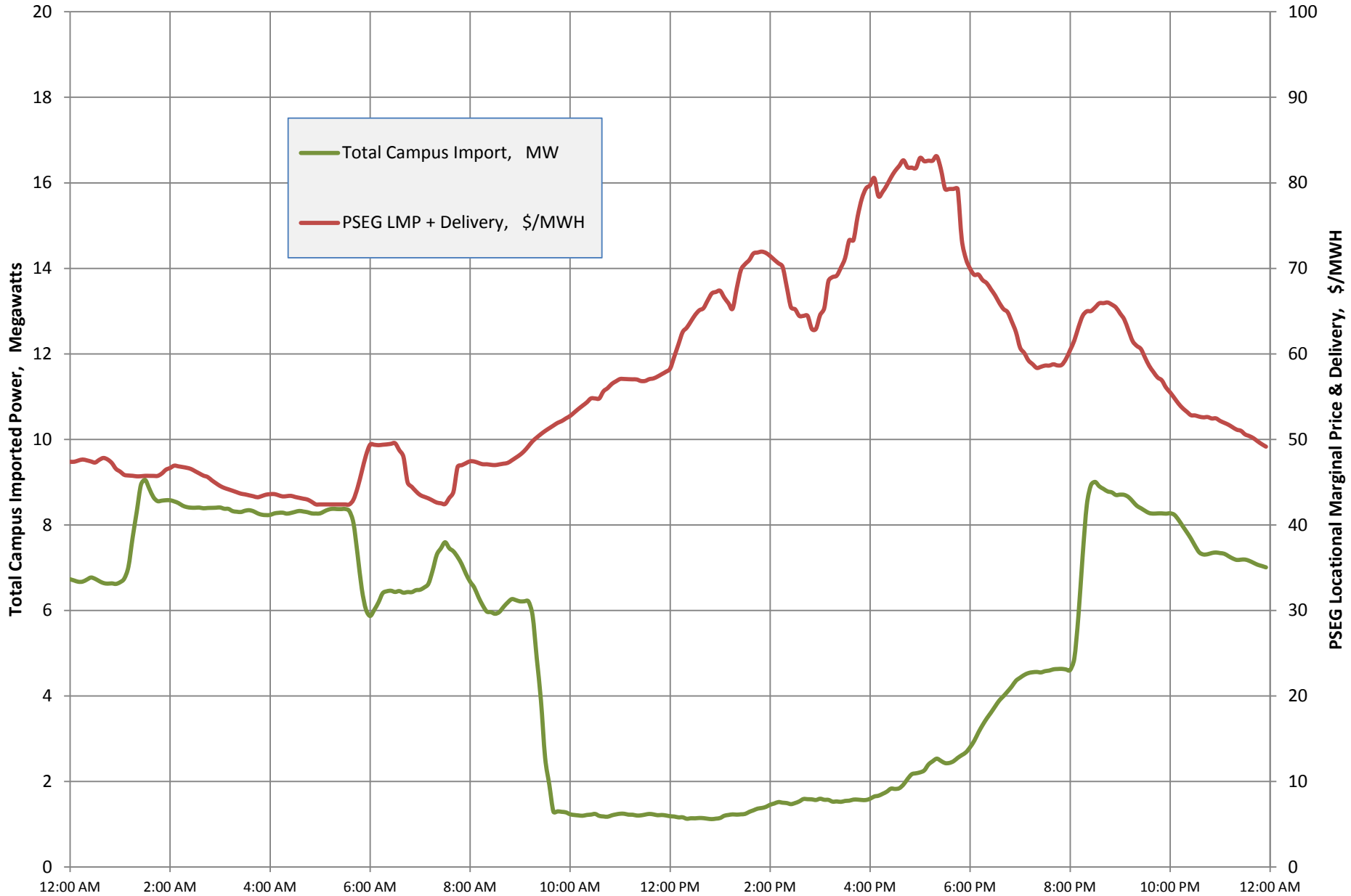
Campus Power, Generated & Purchased

August 30, 2012



Purchased Power and Power Price

August 30, 2012

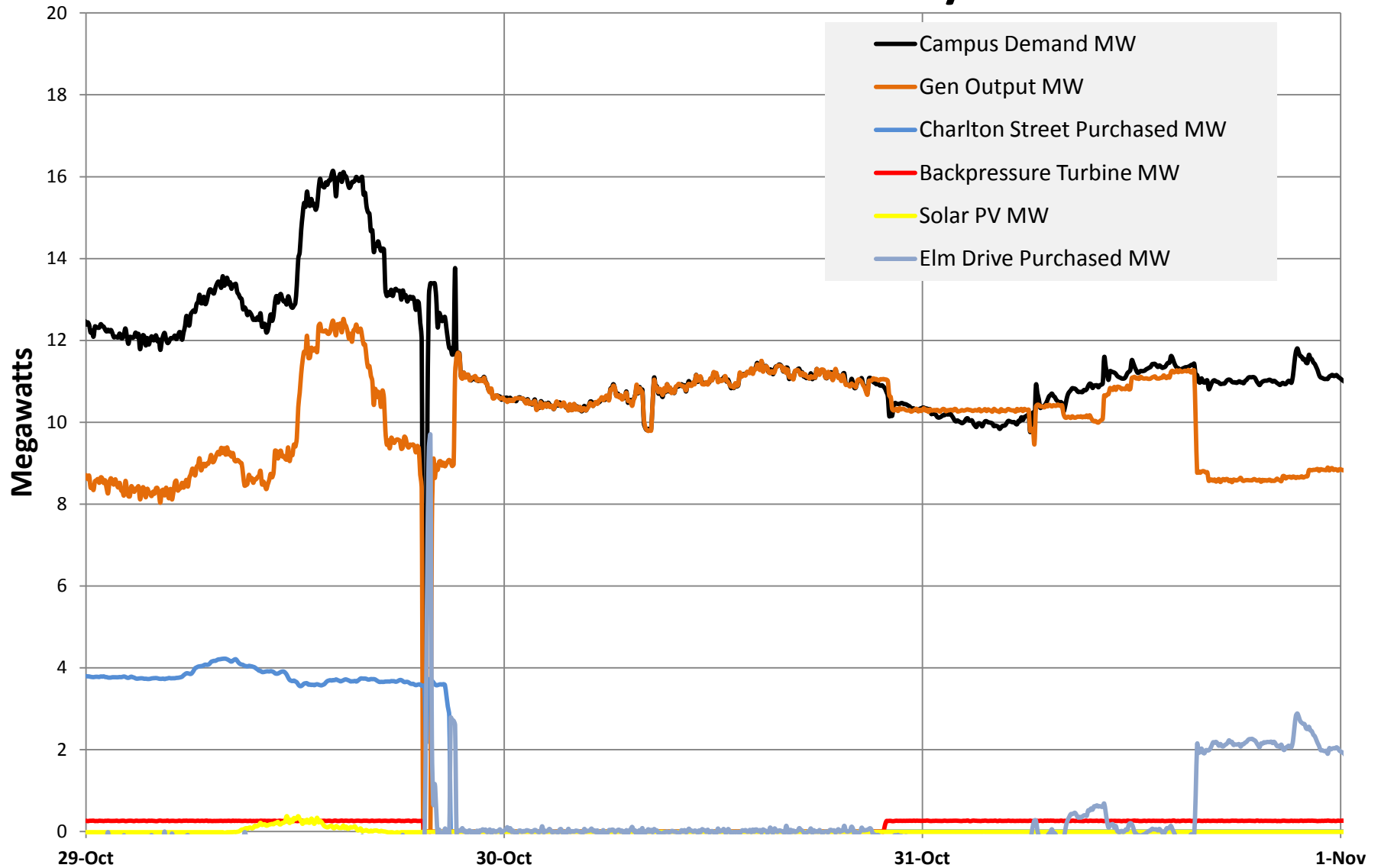


Economic Dispatch

- “ICETEC” Expert system recommends economic dispatch of all major assets



Campus Power During Hurricane Sandy



Must Do

For Microgrid Reliability

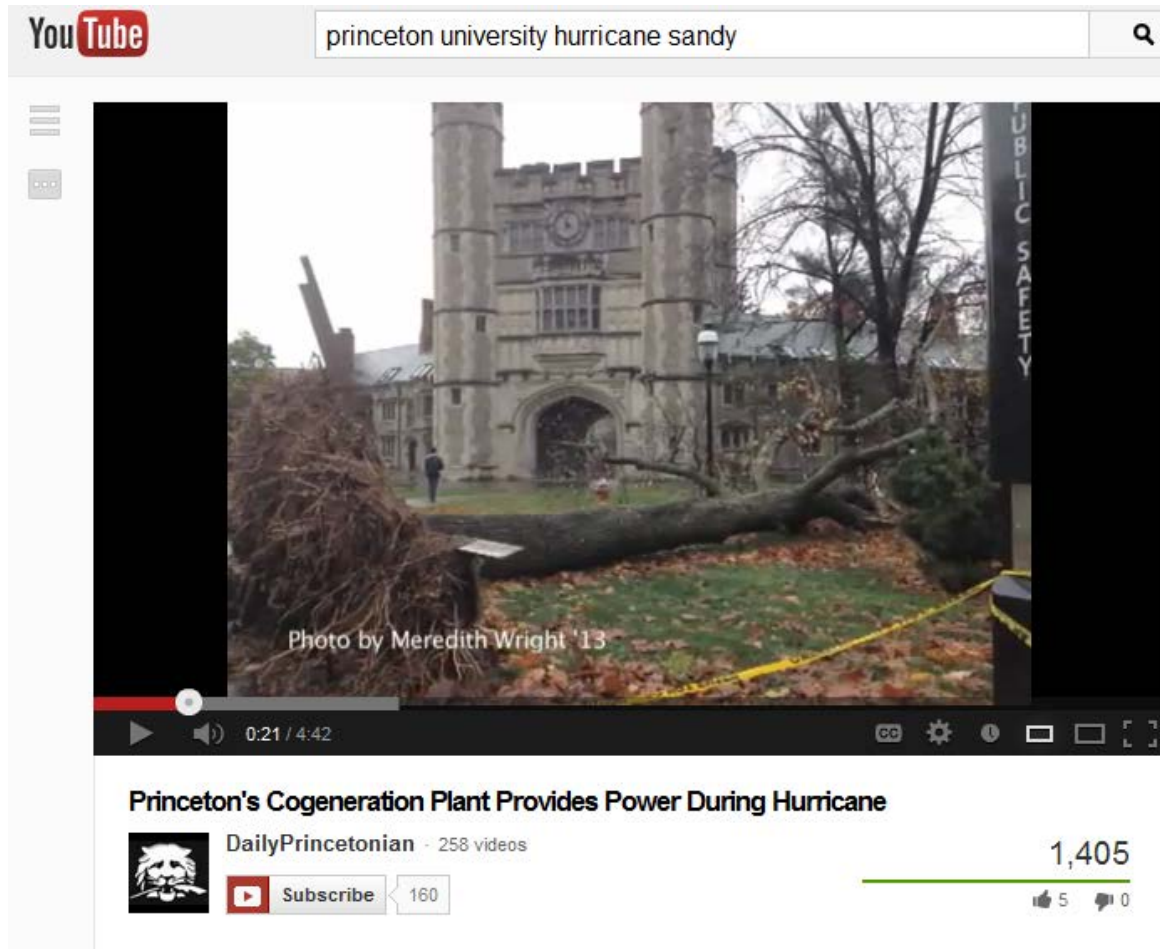
- Base-load generators behind the meter
- Ability to run isochronous (off the grid)
- Black start capability
- Load-shed capability

Make Life Better Every Day

- CHP or combined cycle
 - not necessary in emergency response
 - make the equipment more cost-effective
 - Run more often, thus more reliable
 - Most problems happen in non-emergency situations
- Permitting for non-emergency use
 - not necessary for emergency response
 - more cost-effective by increasing capacity factor
 - run more often, thus more reliable
 - usually adds emissions controls
- Energy storage
- Underground utility distribution

Hurricane Sandy Student Video

- <http://youtu.be/Wtjlj91imSQ>



The screenshot shows a YouTube video player interface. At the top, the YouTube logo is on the left, and a search bar contains the text "princeton university hurricane sandy" with a magnifying glass icon on the right. The video player itself shows a still image of a large, stone building with two prominent towers, likely a part of Princeton University. The building is partially obscured by a large, fallen tree trunk and a pile of branches in the foreground. A yellow caution tape is strung across the scene. The text "Photo by Meredith Wright '13" is overlaid at the bottom of the image. Below the video player, the video title "Princeton's Cogeneration Plant Provides Power During Hurricane" is displayed. Underneath the title, the channel name "DailyPrincetonian" is shown with a small profile picture of a lion's head and the text "258 videos". To the right of the channel name, the number "1,405" is displayed. Below the channel name, there is a "Subscribe" button with a play icon and a counter showing "160". At the bottom right, there are icons for likes (5) and dislikes (0).

Net Result Of Cogeneration and District Energy

Results Delivered

- High efficiency
- Clean
- Low Carbon Footprint
- Low Life-Cycle Cost
- Reliable
- Resilient
- Grid support

Applicability

- Universities
- Healthcare
- Military bases
- Cities
- Industries, e.g.,
pharmaceutical and refining

Thank you