

**Duke University  
UTILITIES & ENGINEERING  
Electrical System Management**

**Centralizing Emergency Power Generation**

**June 2017**

**Mark Demana PE**

**Aurel Selezeanu PE**

# Centralizing Emergency Power - Agenda

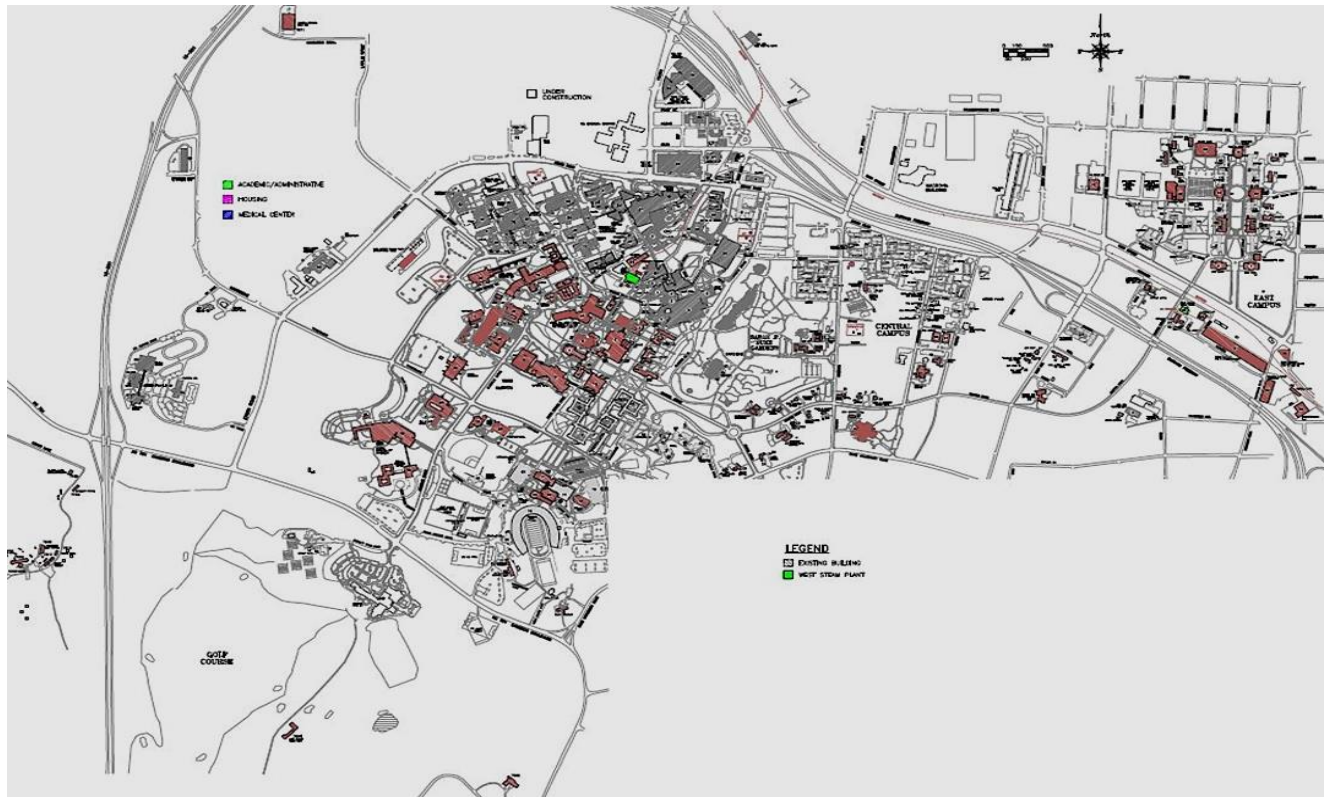
- ✦ General University Information
- ✦ Electrical System Overview
- ✦ Centralizing Emergency Power - A Study
- ✦ Justifications and Selling It
- ✦ Implementation
- ✦ Pros / Cons



# Duke University Overview

## ✦ Duke University, Durham NC

- Began in 1892 as Trinity College, and became Duke University in 1924.
- Approximately 1,300 acre academic campus
- 175 buildings
- Over 30 stationary gensets from 30 to 1500kW.





# Duke University Electrical Power System

## ✦ Electric Power Distribution

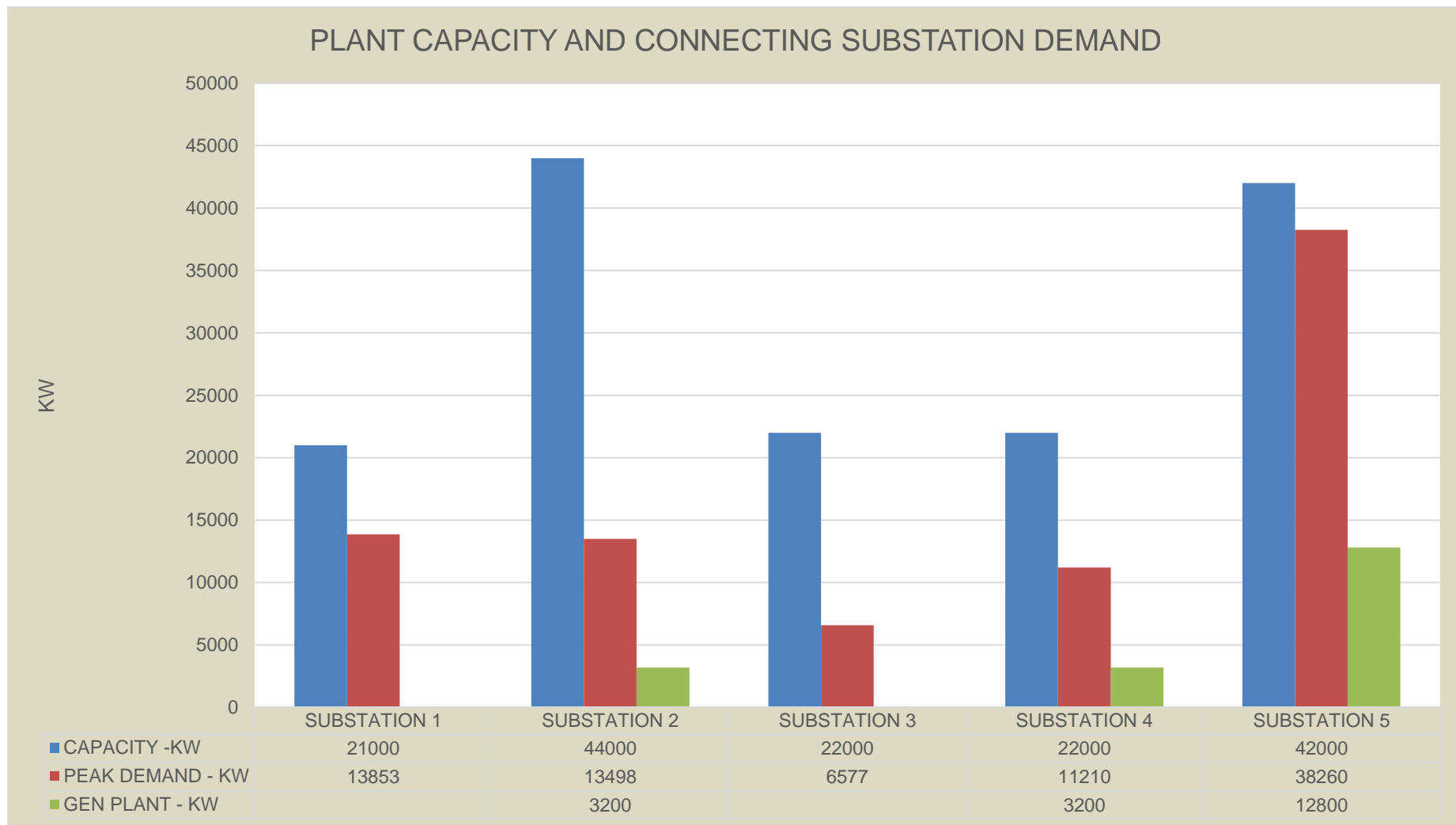
- 5 POD Substations – Serving the University and Hospital System
  - Loop fed with dual 44kV UG Feeders.
  - N+1 Redundancy at each.
- E power - Pre 2014: Central Generator Plant #1
  - 4 Stationary 3.25MW Engine Driven 4160V Gensets
  - Primarily support for Chiller Plant



# 2015 – Substations - Capacity & Demand

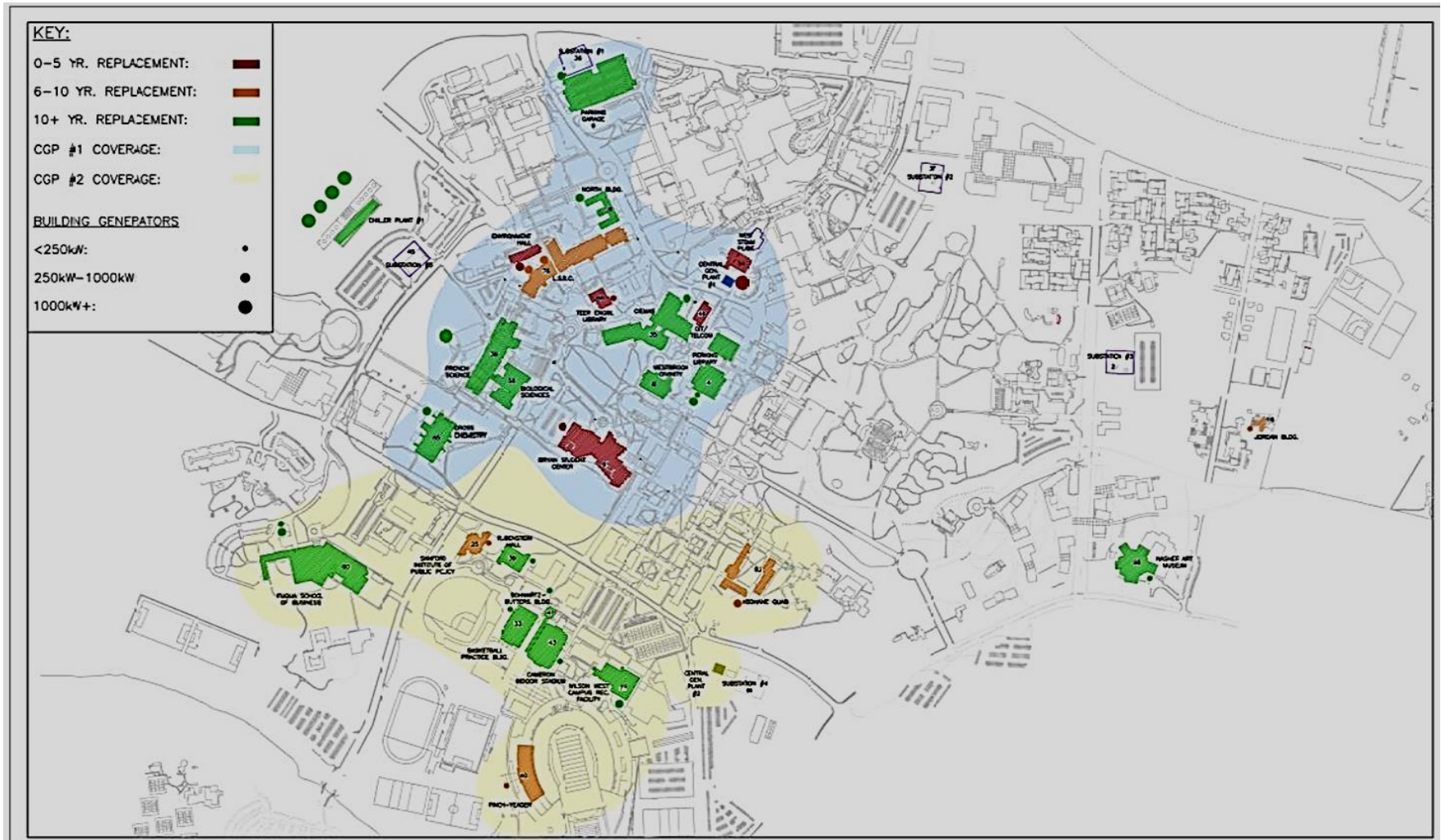
## Generator Plants – Actual and Future Capacity

(Redundancy Not Included for Substations)



# Centralized Emergency Power?

## Analyzing the Existing Emergency Power Generation



# The Numbers

- 10 units to be replaced within 10 years.
- Plus 3 new facilities coming on line in 2014/15.
- ~ 2900kW required for 1<sup>st</sup> CGP.

GENERATOR REPLACEMENT LIST				
Duke University West & Central Campus				
Building	Gen #	Install Date	Gen Size (kW)	Load (kW)
<b>0-5 Year</b>				
West Campus Union	N/A	2014	N/A	300
Bryan Center	7791GEN-01	1982	300	91
North Bldg	7756GEN-01	Temp	250	226
Teer Eng Lib	7766GEN-01	1984	130	17
WCSP	7754GEN-01	1988	1500	1000
OIT Building	N/A	2014	N/A	300
Environment Hall	N/A	2014	N/A	200
			<b>Total:</b>	<b>2134</b>
<b>5-10 Year</b>				
LSRC	7776GEN-01	1994	600	560
LSRC	7776GEN-02	1995	300	56
HH Jordan Bldg	7196GEN-01	1995	80	48
Sanford Inst.	7725GEN-01	1995	150	90
Finch-Yeager	7740GEN-01	1995	36	22
			<b>Total:</b>	<b>776</b>
<b>10+ Years</b>				
Schwartz Butlers	7741GEN-01	1999	130	78
Fuqua Business School	7760GEN-01	1999	230	138
Wilson Rec Center	7777GEN-01	1999	350	210
WEL Student Dorm	7795GEN-01	2001	500	300
Library Services	7970GEN-01	2001	100	60
Art Museum	7198GEN-01	2004	100	60
CIEMAS	7735GEN-01	2004	800	448
Gross Hall	7765GEN-01	2004	400	338
Perkins Lib	7704GEN-01	2005	500	174
Westbrook Divinity	7708GEN-01	2005	100	39
Rubenstein Hall	7739GEN-01	2005	50	30
Cameron Indoor Stadium	7743GEN-01	2005	30.4	18
French Science	7738GEN-01	2006	2000	920
Center for Ath Excell	7733GEN-01	2007	50	30
Fuqua Business School	7760GEN-02	2007	500	300
Parking Garage 9	7557GEN-01	2009	250	55
			<b>Total:</b>	<b>4750</b>
			<b>Total:</b>	<b>7660</b>



# Economics

**TABLE No. 2: CENTRAL GENERATING PLANT ECONOMICS**  
**DUKE UNIVERSITY**

OPTION	DESCRIPTION	CAPITAL COSTS (NPV)			ANNUAL COSTS (NPV)		NET PRESENT VALUE OF COSTS (\$)	DISCOUNTED PAYBACK (YEARS)
		EQUIPMENT COST (\$)	DISTRIBUTION COST (\$)	TOTAL CAPITAL COSTS (\$)	FUEL AND MAINT. COSTS (\$)	TOTAL ANNUAL COSTS (\$)		
1 CGP	CENTRAL GENERATING PLANT WITH (2) 3MW GENERATORS	4,200,000	600,000	4,800,000	1,600,000	1,600,000	(6,400,000)	10
2 REPAIR and REPLACE	DECENTRALIZED APPROACH, REPAIR / REPLACE EXISTING	1,700,000	0	1,700,000	6,700,000	6,700,000	(8,400,000)	--
ANALYSIS VARIABLES		NOTES:						
DISCOUNT RATE		5.0%	1. OPTION 1 ASSUMES 1ST GEN INSTALLED IN YEAR 1, 2ND INSTALLED IN YEAR 15					
ESCALATION RATE		3.0%	2. OPTION 1 EQUIP COSTS INCLUDE TWO GENS, SWITCHGEAR, CGP SITE WORK, & BLDG XFMRs					
ANALYSIS PERIOD (YEARS)		30	3. OPTION 2 EQUIP COSTS INCLUDE AGING GEN REPLACEMENT & NEW BLDG GENS					
			4. DISTRIBUTION COSTS INCLUDE DUCT BANK, CABLE, CONDUIT, SWITCHES FOR CGP LOOPS					



# Non-Financial Aspects



- Aesthetics
- Noise
- Exhaust Irritation

# Implementation

- ✓ Code compliance
  - AHJ / Fire Marshal / Elevator
  - NFPA 110 / 101 / 70
- ✓ Coordinating building vacancy
  - No LS systems during transition
  - Backup to sensitive / critical loads
- ✓ Interfacing with various types and ages of transfer switches.
- ✓ Normally Energized or Not?
  - Start Stop control





# Pro / Con

## ✓ Building sites

- New construction – simple site planning
- Existing facilities – smaller equipment, clean appearance



## Pro / Con

- ✓ CGP built to be very quiet
  - 70dB at 25'
  - Located near other utility plants
- ✓ Exhaust
  - Designed to push up and away
  - Located away from sensitive facilities
  - Cleaner burning engine





# Central Generator Plant #2 - System Highlights

- ✦ Located at West Campus Steam Plant
- ✦ Provides 3.2 MW
- ✦ Provides Stand-by power for West Campus Steam Plant and several West Campus Buildings
- ✦ Completed 2016



# Central Generator Plant #3 - System Highlights

- ✦ Located at Chiller Plant #1
- ✦ Provides 3.2 MW
- ✦ Provides Stand-by power for Chiller Plant #1 and several West Campus Buildings and Athletic area
- ✦ Completed 2016



# Q & A

✦ ?

