

# Cornell University

## AgriTech Campus in Geneva, NY

### Electrical Master Planning, Substation, Distribution and Building Service Entrance Upgrades

Presented by:

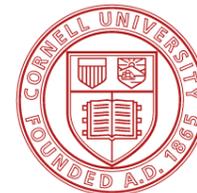
**Nik Terpak, PEng | CHA**

Electrical Project Engineer – High Voltage Electrical Group



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**CHA**

# Agenda



- Campus Electrical Master Planning Process
- Cornell University AgriTech Case Study
- Substation Upgrades
- Distribution System Upgrades
- Building Service Entrance Upgrades



# Campus Electrical Master Planning Process

## Site Survey and Investigation

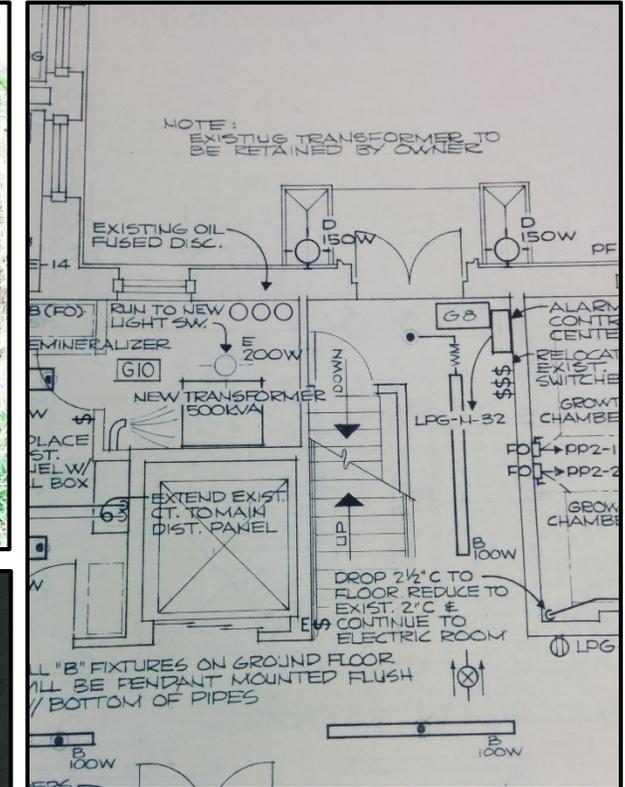
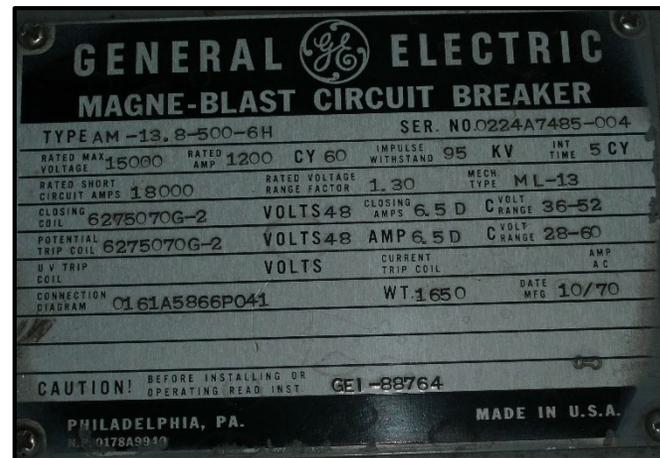
- Inspection of:
  - Main substation
  - Medium voltage distribution system
  - Building service entrances.
- Visual Inspection:
  - Equipment nameplate data age, condition
  - E-Room safety and code compliance.
- Equipment settings.
- Electrician experience and institutional system knowledge.



# Campus Electrical Master Planning Process

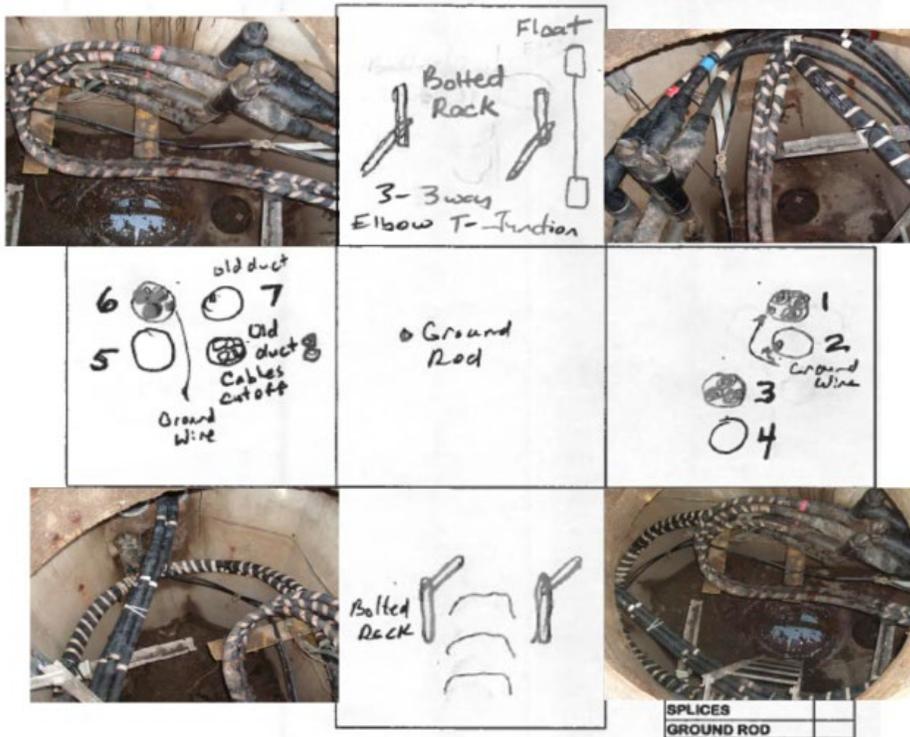
## Site Survey and Investigation

- Site Utility Survey
- Manhole Investigation:
  - Butterfly Diagrams
- Infrared Survey
- Hazardous Material Survey:
  - Asbestos, etc.
- Document Review:
  - Previous studies/engineering drawings.
  - Equipment drawings/manuals.
  - Maintenance records.
  - Historical metering data – load, PF, Harmonics.



# Campus Electrical Master Planning Process

## Site Survey and Investigation



Manhole -19							
Conduits					Cable		
Duct #	From	To	Size	Type	# of Cables	Voltage	Size
1	MH-18 Duct 4	T-Junction	4"	Rigid	3	15 kV	500 mcm
2	MH-18 Duct 3	spare	4"	Rigid			
3	T-Junction	Building 56	4"	Rigid	3	15 kV	500 mcm
4	spare	Building 56	4"	Rigid			
5	spare	MH-20 Duct 1	4"	Rigid			
6	T-Junction	MH-20 Duct 2	4"	Rigid	3	15 kV	500 mcm

MANHOLE:		MANHOLE CONDITIONS AND PROBLEMS:	
INSP. DATE		Fair to Good Condition	
INSP. BY		RACKING TYPE & CONDITIONS:	
LOCATION:		Bolted on Racking Good Condition	
SUMP	YES / NO	GROUNDING & CONDITIONS:	
DRAIN	YES / NO	GROUND ROD	YES / NO
WATER LEVEL	WET	RING GROUND	YES / NO
DIMENSIONS		STRUCTURAL CONDITIONS:	
RING DIAMETER		EXPOSED REBAR	YES / NO
FLOOR TO CEILING		CHIPPING CONCRETE	YES / NO
THROAT			



# Campus Electrical Master Planning Process

## Analysis and Evaluation

- Power System Study:
  - Arc Flash.
  - Protection Coordination.
  - Short Circuit.
- System Condition Matrix:
  - Age, condition, system study.
- System Configuration Analysis:
  - Substation/Distribution loops, building Dual Feeds / Bus Tie's.
- Electrical Room Conditions:
  - Code Compliance:
    - Working Clearance, Egress.
  - Grounding.
  - Mechanical Ventilation.
  - Fire Detection.
- Power Analysis:
  - Loading Analysis.
  - Power Factor Analysis.
  - Harmonics Analysis (if data available).



# Campus Electrical Master Planning Process

## Master Plan Report

- Power System Study.
- Arc Flash Stickers.
- Equipment Condition Matrices.
- Prioritized Improvement List:
  - Substation, Distribution, Buildings.
  - Equipment upgrades.
  - System re-configurations.
  - AF, coordination improvements.
- ROM Costs for improvements.
- High level schedule, based on resources.

**Table X4 - Building Electrical Service Entrance System Condition Rating**

CATEGORY	Exposed Primary System	Primary Fused Switch Age/condition	Xfmr Age condition	Room Condition	Arc Flash/Fault Level	Secondary Gear Duty Rating	Secondary Gear Age/Condition	TOTAL SCORE	RANK
<b>Weighting Factor</b>	<b>10</b>	<b>5</b>	<b>7</b>	<b>2</b>	<b>15</b>	<b>15</b>	<b>7</b>	<b>61</b>	
Blg 36	0	3	3	1	4	0	3	119	11
Blg 34 A and B	0	4	4	3	5	0	4	157	4
Blg 74	0	4	4	3	4	0	4	142	7
Blg 74A	0	4	4	2	5	0	4	155	5
Blg 4	5	5	5	4	4	0	5	213	1
Blg 1	0	4	4	1	4	0	4	138	10
Blg 5	0	4	4	2	4	0	4	140	8
Blg 10	0	2	2	1	4	0	2	100	12
Blg 10K	0	3	3	1	4	0	3	119	11
Blg 35	0	4	4	2	5	2	4	185	2
Blg 53	0	5	5	3	4	0	4	154	6
Blg 56	0	4	4	1	4	0	4	138	9
Blg 41	0	5	5	1	3	0	5	142	7
Blg 39&40	0	5	5	1	5	0	5	172	3

<b>Exposed Primary System</b>		<b>Arc Flash Fault Level</b>	
0	N/A	0	N/A
5	Hazardous Condition	1	NFPA 70E Hazard Cat 1
<b>Age/Condition</b>		2	NFPA 70E Hazard Cat 2
0	New	3	NFPA 70E Hazard Cat 3
1	1-5 years	4	NFPA 70E Hazard Cat 4
2	6-15 years	5	> 40 cal/cm2
3	16-25 years	<b>Secondary Gear Duty Rating</b>	
4	26-35 years	0	N/A
5	35+ years	1	60 to 70%
<b>Room Condition</b>		2	70 to 80%
0	N/A	3	80 to 90%
1	very good condition	4	90 to 100%
2	good condition	5	> 110% of Rating
3	fair to questionable condition		
4	Poor condition		
5	Needs attention		



# Campus Electrical Master Planning Process

## Master Plan Report

**Table X2 - Man Hole Condition Rating**

CATEGORY	Structural Integrity	Drainage System	Grounding	Racking System	TOTAL SCORE	RANK
<b>Weighting Factor</b>	<b>10</b>	<b>3</b>	<b>2</b>	<b>3</b>	<b>18</b>	
EMH-1	2	1	0	2	29	12
EMH-2	3	1	0	2	39	11
EMH-3L	3	1	5	2	49	8
EMH-3S	3	5	5	2	61	3
EMH-4	2	5	5	2	51	7
EMH-5	2	1	5	2	39	11
EMH-6	2	5	5	2	51	7
EMH-7	2	1	0	2	29	12
EMH-8S	2	1	0	2	29	12
EMH-8L	4	5	0	2	61	3
EMH-9	3	5	0	2	51	7
EMH-10L	4	5	0	1	58	5
EMH-10S	4	1	0	2	49	8
EMH-11	3	1	5	4	55	6
EMH-12	2	5	5	2	51	7
EMH-12A	4	5	5	5	80	1
EMH-12B	2	5	5	5	60	4
EMH-13	4	5	0	2	61	3
EMH-14	3	2	0	2	42	10
EMH-15	3	5	5	2	61	3
EMH-16	2	5	2	2	45	9
EMH-17	2	5	5	2	51	7
EMH-18	2	5	2	2	45	9
EMH-19	3	5	2	2	55	6
EMH-20	4	5	5	2	71	2
EMH-21	1	1	5	2	29	12
EMH-22	2	3	5	2	45	9
EMH-23	4	4	2	5	71	2
EMH-24	2	1	2	2	27	13



# Cornell University – AgriTech Campus

## Campus Summary



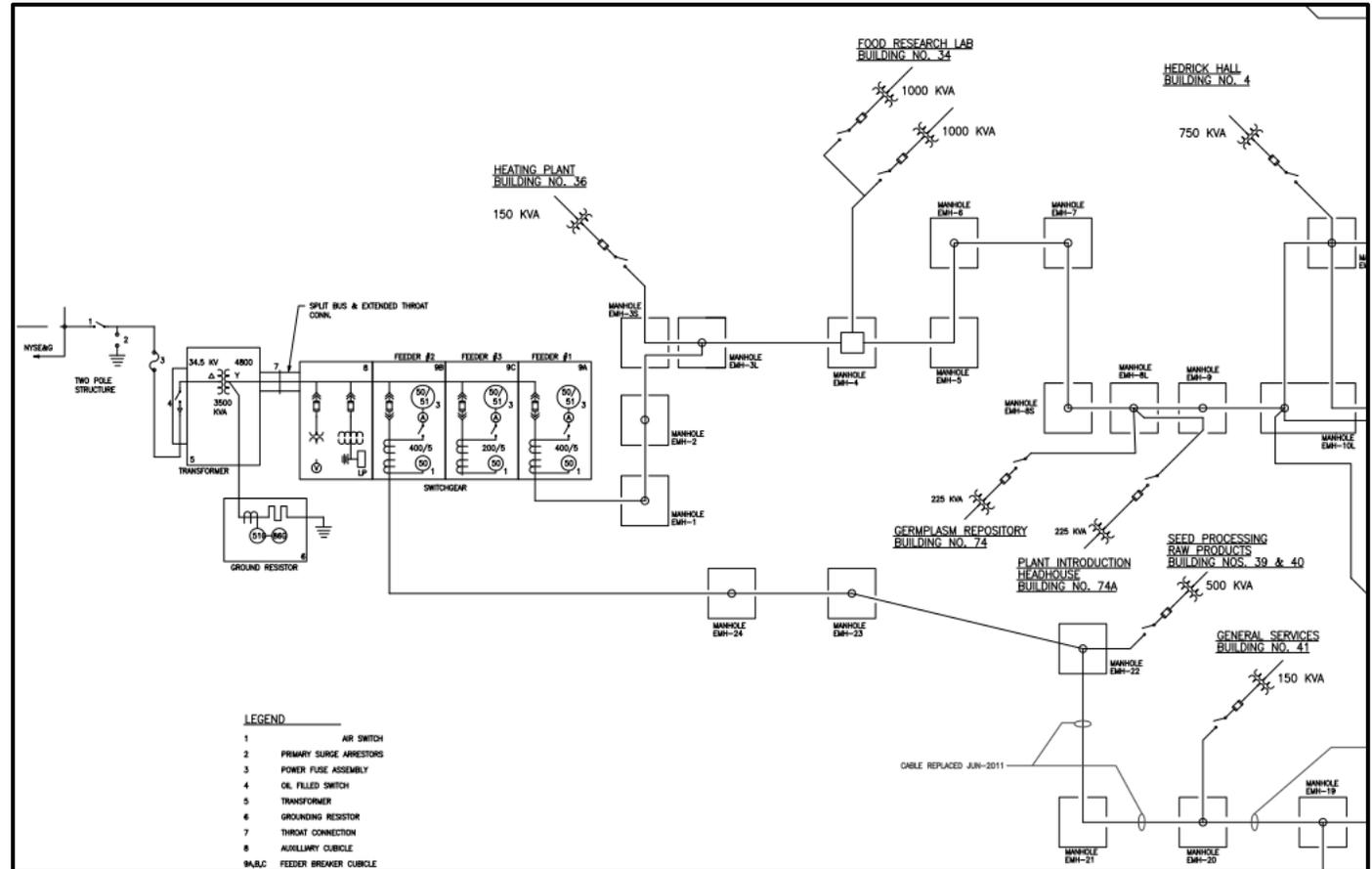
- 8 nearby research farms, totaling 850 acres.
- 65,000 square feet of greenhouse space.
- Fruit and vegetable processing facilities
- Refrigerated and controlled atmosphere storage.
- 3MW Electrical Substation.
- 14 Buildings:
  - Research facilities, laboratory buildings and office space.



# Cornell University – AgriTech Campus

## Electrical System Summary

- 34.5kV Substation:
  - 34.5kV overhead line switch
  - 34.5kV-4.8kV, 3MVA Transformer.
  - 4.8kV switchgear with 2 loop feeders.
  - Peak load of 1.5MVA.
- 4.8kV Distribution:
  - Underground distribution loop of 500kcmil in concrete ductbanks.
  - Manhole 3-way junctions and splices to buildings.
- 14 MV building service entrances:
  - Switches, transformers, LV (208 or 480V) gear.



# Main Substation Assessment

- Equipment age of ~50 years, past expected life.
- 34.5kV switch marked 'Do Not Operate', manufacturer instruction.
- Transformer:
  - On-load tap changer (OLTC):
    - Monitored change counter.
  - Infrared identified some radiator blockages.
  - ~40% peak loaded.
- 4.8kV switchgear:
  - Old electro-mechanical relays – lack of coordination.
  - One breaker unable to electrically switch.



# Main Substation

## Recommendations

- Replace all major equipment and cable.
- Slightly Downsized Transformer.
- Maintain OLTC.
- Replace 4.8kV switchgear with SF6 relay-managed pad-mount switch.
- Install in empty substation space, to minimize construction outage.



# Medium Voltage Distribution Assessment

- Manhole and Conduit evaluation:
  - ~40% of ductbank was found to be compromised (not useable).
  - One manhole found to be structurally concerning (old, brick).
- 4.8kV System Considerations:
  - Capacity vs. Cable Size vs. Conduit fill.
  - Vs. 4.16kV system – high TX replacement costs.
- Cable/Switch evaluation:
  - Majority of cable is ~50 years old, past its expected life: Experienced failures 2011.
  - Manhole junction configuration and one mid-way loop switch:
    - Lack of selective switching and increased outage impact.
    - Poor access, operability of manhole junctions.
    - Unsafe mid-point switch



# Medium Voltage Distribution

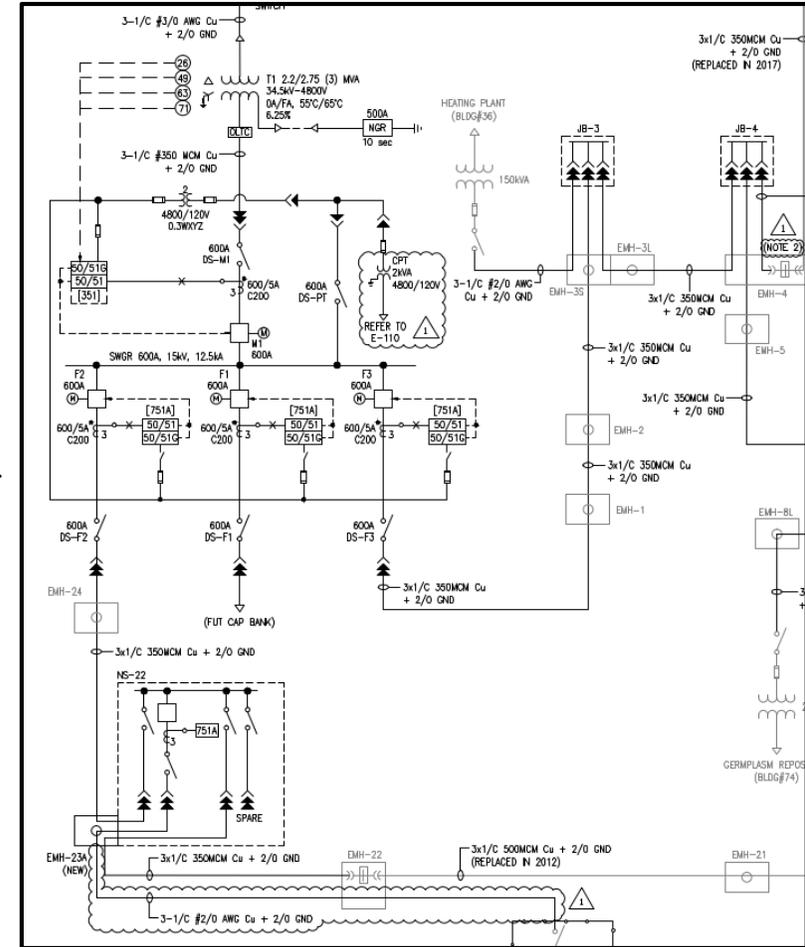
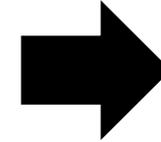
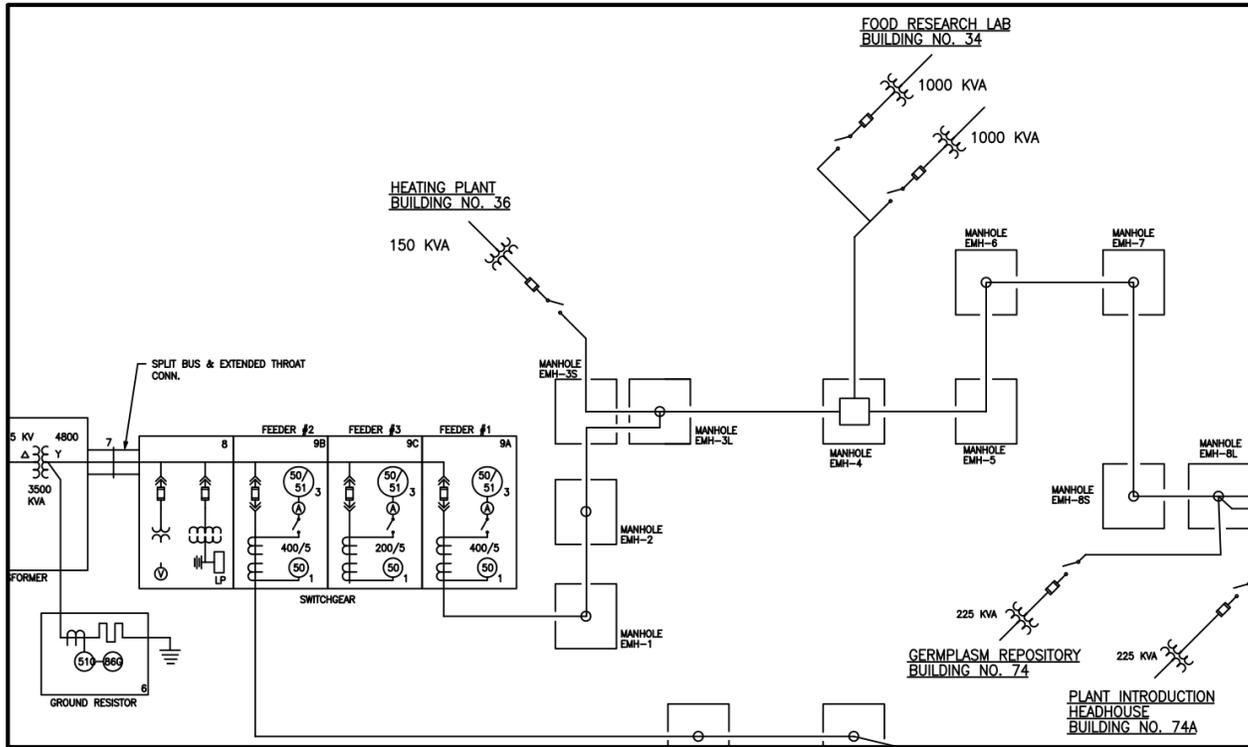
## Recommendations



- Replace all old cable (50 years old).
- Install new ductbank, as needed, to abandoned compromised ductbank sections.
- Install strategically placed pad-mounted loop switches to allow for more selective switching and reduce the impact of outages.
- Install pad-mounted junction boxes to provide easier access to remove building junctions during switching.
- Construction phasing switching orders:
  - Configured to replace all cable with five ~4h building outages.

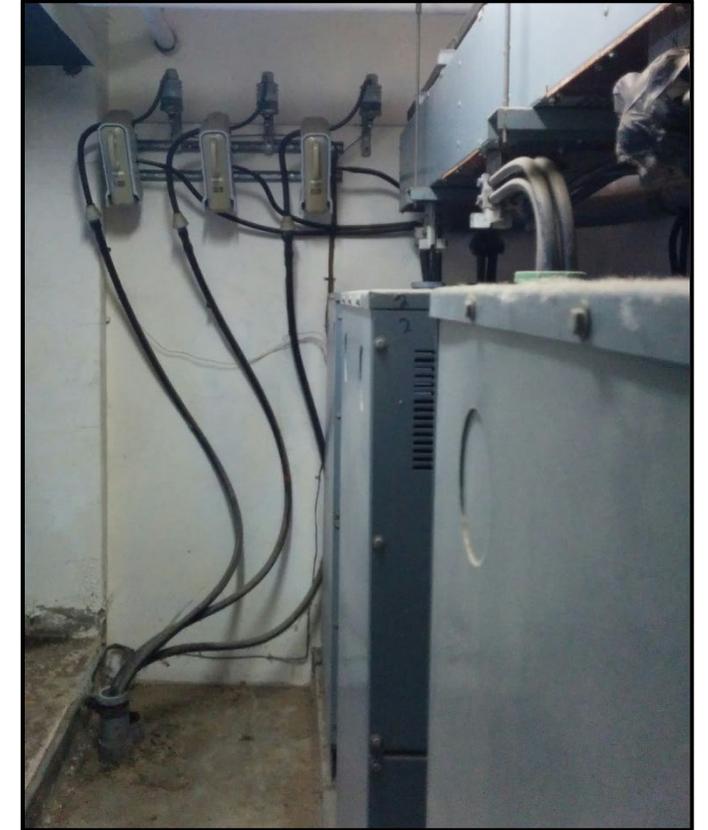


# Medium Voltage Distribution Recommendations



# Building Service Entrance Upgrades Assessment

- 85% of building entrances ~50 years old, past design life.
- 30% of buildings had 'extreme danger' arc flash conditions.
- Areas of unsafe equipment or conditions:
  - Manufacturer 'Do Not Operate' direction.
  - Exposed fuse cutouts in E-Room.



# Building Service Entrance Upgrades

## Recommendations

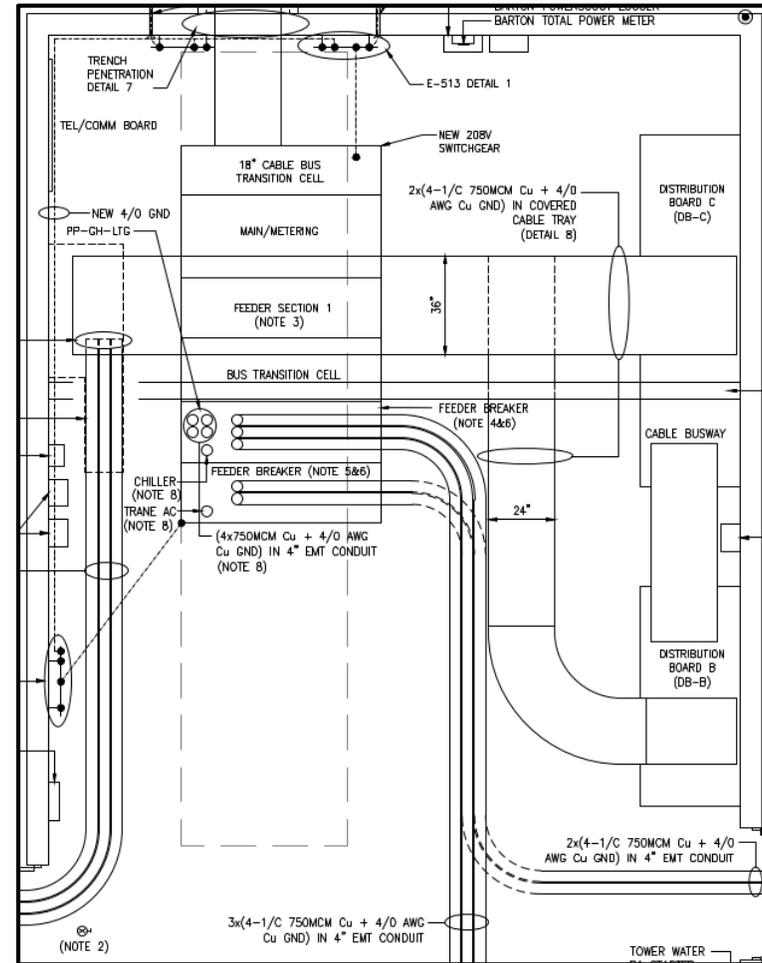
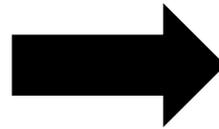
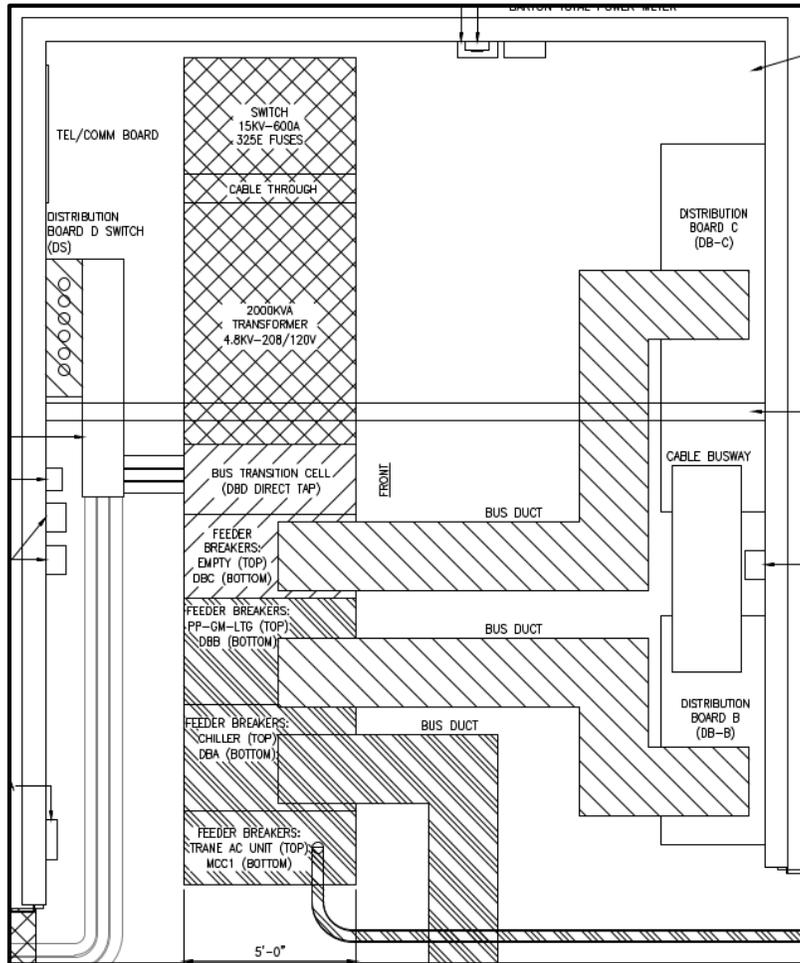


- All services past their design life should be upgraded.
- Priority list of building upgrades produced.
- Top 5 priority buildings included arc flash safety hazards or unsafe equipment conditions.
- Recommended to perform 5 top priority upgrades in one construction package:
  - New MV switch, MV transformer and LV switchgear.
- Construction phasing plans (staged demo/install) produced to install in parallel and use temporary generators to keep all outages to >8h.



# Building Service Entrance Upgrades

## Recommendations



# Completed Upgrades

## Main Substation

- All equipment and cabling replaced, per recommendations.
- All old equipment removed.

## Distribution

- New ductbank installed and all old cable replaced.
- New pad-mounted switches and junction boxes installed, per recommendations.
- All old cable removed.

## Building Service Entrances

- Upgrades to be completed in 2020 for 5 highest priority buildings.



# Completed Upgrades



# Questions?



**CHIA**



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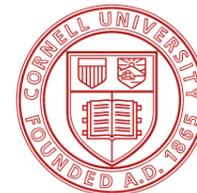
Electrical Master Planning, Substation, Distribution  
and Building Service Entrance Upgrades

Thank you



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