Tech Report 2:

Electrical System Existing Conditions

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14 October, 2013
University of Maryland: Prince Frederick Hall

Executive Summary

This document contains three sections to: formulate criteria for the future re-design of Prince Frederick Hall, provide details on the existing electrical system, and evaluate that system. As a university building, the systems designed for it need to have the durability to last a long time. They need to be easily maintained and renovated as future changes occur. The current design of the building reflects that idea. The distribution system is simple and functional.

Where the current design falls short is in its effort to promote sustainability. Prince Frederick Hall is designed to be a LEED Gold building, but not much is done by the electrical systems that indicates this. My future studies of the building will involve consideration of different ways that sustainability can be incorporated into this design.

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Introduction

Prince Frederick Hall is an 8 storey building on the University of Maryland's campus. The first floor has some living quarters for students, but mostly classrooms and university common space. The 2nd-7th floors are entirely dormitory housing, with amenities such as: two study lounges, a laundry room, and common bathrooms, on each floor. The roof is not accessible to students as it is used for mechanical equipment and the emergency generator. The ground floor has some classroom space, as well as offices for faculty and maintenance staff. The main mechanical and electrical rooms are also located on the ground floor; this is where campus-provided utilities enter the building.

Criteria & Scope

The following section outlines basic criteria for future re-design of this building's electrical system. Important sections from the NEC are addressed, such as: estimated load calculations, special occupancy requirements, and emergency power requirements.

1. Load Calculation

Perform a Preliminary electrical load calculation based on the building type, per square foot NEC lighting and receptacle loads and demand factors, air conditioning and heating fuel sources and special equipment anticipated. Additional per square foot load information for HVAC systems will need to be researched and identified.

dwelling unit load: **452,795 VA**

Electrical Calculations for Dwelling Units						
	No of Units	Total SF	Total Demand Load	Kitchen	Bathroom(s)	Laundry
Apartments	2	2430	63640	Y	Y	Y
Single Suites	3	1121	3149	N	Y	N
Double Suites	42	34350	94346	N	Y	N
Typ. Dorms	162	45282	138270	N	N	N
Common Laundry	21		38850			
HVAC (local)	249		114540			
			452,795	VA		

non-dwelling area load: **2,087,492 VA**

Electrical Calculations for Non-Dwelling			
	note:	Total Demand Load	
Lighting	this area includes all office, classroom, storage, and mechanical spaces	471460	
Receptacles		57384	
HVAC		1361082	
Misc. Mechanical		197566	
		2,087,492	VA

Using spreadsheets provided by www.electrical-knowhow.com and the method outlined by the 2011 NEC, I estimated the total building demand for Prince Frederick Hall. A summary of my calculations can be seen above; for full detail calculations, please see appendix page 17.
estimated total building demand load: **2,540,287 VA**

2. Power Company

Identify the power company serving the building location.

Pepco is the power company that supplies power to the University of Maryland, but the university is the provider for this specific building.

3. Rate Schedule

Make a preliminary rate schedule selection and identify the service voltage.

Service voltage to the building is 13,200 V medium voltage from the university's power grid. No rate schedule can be determined for this building.

4. Building Utilization Voltage

Select the preliminary Building Utilization Voltage and what voltage would serve each of the following loads:

- ➔ Lighting: indoor 120V
  outdoor 277V
- ➔ Receptacles: 120V for normal power
  208V for specific equipment like: dryers, kitchen equipment, and server racks, etc.
- ➔ Equipment: most mechanical equipment will be run at 480V

5. Emergency Power Requirements

Identify Emergency Power Requirements based on the IBC and your building use and occupancy, and estimate the loads and preliminary voltage and fuel source selection.

Safety systems in this building are governed by the 2009 IBC and IRC. Emergency power is required for: egress lighting, exit signs, and emergency voice/alarm communication systems in Group A occupancies. And standby power is required for: smoke control systems, and accessible means of egress elevators. Emergency power is easiest to provide with an on-site generator. This could either be diesel or natural gas-fired. Because the generator will have to run some fans and mechanical loads, it should be 277/480V to handle these loads. Some loads it will run are:

- ➔ the fire pump 23,920 VA
- ➔ emergency egress lighting 10,500 VA
- ➔ the elevator controllers 48,000 VA
- ➔ smoke evacuation fans 38,941 VA
- ➔ smoke dampers 700 VA
- ➔ firefighter receptacles 70,000 VA
- ➔ **estimated required load** **192,061 VA**

6. Special Occupancy Requirements

Identify any potential Special Occupancy Requirements based on Chapter 5 of the NEC (simply list them based on the table of contents).

Two classrooms on the first floor are considered **assembly** spaces because they are designed to hold over 100 people. No other special occupancies apply.

7. Special Equipment

Identify any potential Special Equipment based on Chapter 6 of the NEC (simply list them based on the table of contents).

➔ electric signs:	maybe used for future design
➔ manufactured wiring systems:	maybe used for future design
➔ elevators:	necessary in 7 storey building
➔ solar photovoltaic systems:	maybe used for future design
➔ fuel cell systems:	maybe used for future design
➔ small wind electric systems:	maybe used for future design

8. Priority Assessment

Based on your building type and use, provide a priority assessment (Low/Med/High) for the following characteristics:

RELIABILITY

Med: Systems will have to withstand many different students using them. While the systems are not critical, they will have to be durable.

POWER QUALITY

Low: There will likely be many computers using the power circuits, but other than that, power quality is not extremely important.

REDUNDANCY

Low: Safety systems must function properly, but the main spaces in this building are classrooms and dorm rooms, neither are essential spaces.

INITIAL COST

Med: Extra costs could possibly be passed onto students, and should be minimized as much as possible, but the building will be around long enough to payback efficient systems.

LONG TERM OWNERSHIP COST

High: As a university building, Prince Frederick Hall is likely to be under operation for a very long period of time.

FLEXIBILITY

Med: The long term nature of this building means that it must be able to adapt to future generations needs.

9. Back-Up Power

Identify loads in the building that may desire Optional Back-up Power and determine if those loads should be provided back-up by a generator (long term) or UPS (short term) or both, and estimate the loads.

Back-up power is not necessary for any areas of this building; however, in the event of a long-term power outage, it might benefit the comfort of the building's residents to have certain non-essential systems on back-up. Some systems to consider for back-up power:

➔ tel/data connectivity	4,000 VA
➔ selected receptacles	37,620 VA (with one/room)
➔ lighting within dormitory rooms	10,868 VA

10. &11. Special Systems

Identify potential special/communications systems from the list below:

TELEPHONE/DATA

Telephone will be necessary for parts of the building, and data will be critical for all areas.

FIRE ALARM

Required throughout the building.

CATV

This will used to supply wired data connections and wireless access points.

INTERCOM

This system will probably not be used.

ACCESS CONTROL

To provide secure housing to the residents of the building, access will be controlled to residential floors and to the rooms themselves.

SECURITY

The primary security system will be access control, but cameras could be used to augment security in some areas.

12. Major Equipment

Identify major equipment that will require space in the building.

Mechanical and electrical equipment will require space in the sub-basement and ground floor. Some mechanical equipment includes: pumps, air handling units, rooftop units, vav boxes and fan coil units. Electrical equipment in the building includes: switchgear, switchboards, transformers, and generator. Some other specialty equipment is: server racks, and fire protection systems.

Existing Conditions

The existing electrical service to Prince Frederick Hall is provided by the University of Maryland. This section will further discuss this service, along with more detailed building loads, emergency systems, and other special systems.

1. Building Load

Calculate the actual connected building loads, summarized in the following categories:

LIGHTING

➔ **49,379** VA Switchgear #2 lighting

RECEPTACLE & POWER

+ 1,030,374 VA Switchgear #1 power
+ 484,119 VA Switchgear #2 power
+ 212,796 VA Switchgear #2 receptacle
+ 1,300 VA Switchgear #2 appliances

➔ **1,728,589** VA

MECHANICAL

+ 6,048 VA Switchgear #1 HVAC
+ 61,594 VA Switchgear #2 HVAC
+ 50 VA Switchgear #2 motor
+ 17,349 VA Switchgear #2 cooling

+ 36,000 VA	Switchgear #2	heating
➔ **121,041** VA		

OTHER EQUIPMENT

+ 592,885 VA	Switchgear #1	other
+ 432,539 VA	Switchgear #2	other
+ 55,000 VA	Switchgear #2	fire receptacle
➔ **1,080,424** VA		

TOTAL

➔ **2,979,433** VA

2. Rate Schedule

Identify the actual power company rate schedule in place and service voltage.

There is no specific rate schedule for this building as it is a University campus building; however, Pepco is the power supplier for the University of Maryland.

3. Building Utilization Voltage

Determine the Building Utilization Voltage, describe the fundamental design concept verbally including what voltage serves each of the following loads:

- ➔ Lighting: all indoor 120V
  all outdoor 277V
- ➔ Receptacles: most are 120V
  some 208V for tel/data racks, dryers, kitchen equipment, and fire receptacles
- ➔ Equipment: AHU's at 480V
  pumps at 480V

4. Emergency Power Requirements

Identify and total all loads connected to the Emergency Power System, describe the power source, fuel source, size, voltage and describe the fundamentals of the Emergency Power Distribution System.

Emergency power is supplied by the university. Emergency circuits have their own breakers in the switchgear. Additionally, a 350kW (600 A CB) natural gas generator is located on the roof of the building to power:

- ➔ egress lighting & exit signs
- ➔ smoke evacuation fans & dampers
- ➔ elevator controllers & cab lighting
- ➔ sewage pump
- ➔ fire pump
- ➔ firefighter receptacles
- ➔ tel/data racks

The main feed from the generator is connected to a series of three disconnect switches. One goes to the fire pump. The next goes to an emergency panel that feeds: smoke evacuation fans, smoke dampers, and elevator cab lighting. The third disconnect switch feeds another emergency panel that provides power via a series of distribution panels to residential floor egress lighting, elevator pit receptacles, elevator sump pumps, sewage pump, tel/data racks, and firefighting receptacles.

5. Special Occupancy Requirements

Identify any Special Occupancy Requirements found in the design documents (drawings and specifications) based on Chapter 5 of the NEC (simply list them based on the NEC table of contents) and where you found them (drawings or specifications).

The building is broken into four IBC occupancy types:

- ➔ residential: R-2 1st floor, 2nd-7th floors
- ➔ assembly: A-3 ground floor, 1st floor, 2nd-7th floors
- ➔ business: B ground floor, 1st floor
- ➔ storage: S-2 lower level SCUB, ground floor, 1st floor

The special occupancy types that apply from the NEC are for the assembly spaces. In the case of NEC, assembly spaces are only for the "gathering together of 100 or more persons" (518.1), so this governs 2 classrooms on the first floor.

6. Special Equipment

Identify any Special Equipment found in the design documents (drawings and specifications) based on Chapter 6 of the NEC (simply list them based on the NEC table of contents) and where you found them (drawings or specifications).

- ➔ elevators: 5 located throughout the building

7. Building Equipment

Determine and document the following based on the design documents (drawings and specifications, most of this information will typically be found in the specifications). Include voltage and phase for each.

MAIN SERVICE EQUIPMENT

The building is connected to the University of Maryland's medium voltage (13,200V) power grid. (2) ductbanks serve as the connection from this grid to Prince Frederick Hall:

- ➔ (1) 4 way concrete encased ductbank with 4- 5" PVC conduits, (2) sets of (3) 500kcmil + 2/0G (15KV cable)
- ➔ (1) 2 way concrete encased ductbank with 2- 5" PVC conduits, (1) sets of (3) 500kcmil + 2/0G. (15KV cable)

MAIN SERVICE TRANSFORMERS

(2) 3000kVA (13.8kV - 480/277V) liquid filled transformers, measuring 117" X 91", are located on a concrete pad outside on the north side of the building.

MAIN SERVICE DISTRIBUTION

The main feed into the building, from the main service transformers, is (1) 12 way concrete encased ductbank with 12- 4" PVC conduits, (8) sets of (4) 500kcmil + 2/0G. This provides (480/277V) power to switchgear#1 and switchgear#2, in the basement level, room M0226. Both are 3000A, 480/277V, 3PH, 4W each. Switchgear#1 is primarily for equipment, and switchgear#2 is primarily for lighting and power in occupied spaces. Distribution to the residential floors and mechanical pumps occurs through (4) switchboards.

DISTRIBUTION TRANSFORMERS

(9) transformers are located within the building:

- ➔ (4) are in the main electric room (room M0226), on the ground floor.

    - T-3: 480V to 208Y/120V 3φ 30kVA
    - T-4: 480V to 208Y/120V 3φ 75kVA
    - T-5: 480V to 208Y/120V 3φ 500kVA [this feeds a switchboard]
    - T-6: 480V to 208Y/120V 3φ 500kVA [this feeds a 2nd switchboard]
- (1) is also on the ground floor (emergency service room M0228), but is for emergency power.
    - T-7: 480V to 208Y/120V 3φ 150kVA
- (1) is also on the ground floor (electric room 0102), but located outside the main electric room.
    - T-8: 480V to 208Y/120V 3φ 112.5kVA
- (3) are on the roof (electric room 8212), (1) of those is for emergency power only and is connected to the generator.
    - T-9: 480V to 208Y/120V 3φ 45kVA
    - T-10: 480V to 208Y/120V 3φ 15kVA
    - T-11: 480V to 240/120V 1φ 25kVA

PANELBOARDS

On the dormitory floors, 250A panels distribute to (10) 100A panels [MP*floor*A-D and NP*floor*A-D]that provide power to receptacles and lights in the dorm rooms.

MAIN RISERS AND FEEDERS

(2) main risers feed power to the upper floors. Each of these comes from a 1600A panel [MDPNP &MDPMP].

CONDUCTORS

- main building feed: copper 500kcmil
- feeders: All copper. Stranded for No 8 AWG and larger, solid for No 10 AWG and smaller.
- branch circuits: All copper. Stranded for No 8 AWG and larger, solid for No 10 AWG and smaller. (Except VFC cable)

CONDUIT

- ductbanks: schedule 40 PVC
- raceways: ARC (aluminum rigid conduit), GRC (galvanized rigid steel conduit), and IMC (intermediate metal conduit)
- feeders: EMT (electrical metallic conduit), IMC (intermediate metal conduit), and RMC (rigid metal conduit)
- homeruns: EMT (electrical metallic conduit)
- local connections within rooms: MC cable

RECEPTACLES

Types of receptacles used: straight-blade, GFCI, twist-locking, and floor boxes. 1 in 10 receptacles to be hospital-grade TVSS.

SWITCH AND RECEPTACLE FACEPLATES

- finished spaces: stainless steel, satin finish
- unfinished spaces: stainless steel satin finish
- damp locations: cast aluminum
- specialty receptacles: painted to match device color
    - emergency power system receptacles: red
    - TVSS receptacles: blue

- isolated ground receptacles: orange

MOTOR STARTERS

Magnetic motor starters are used for: smoke, exhaust, and stair pressurization fans. Chillers use VSD-type starters.

UPS

Not used for this building.

8. Back-Up Power

Identify loads in the building that are provided with Optional Back-up Power and describe if those loads are connected to a back-up generator or UPS or both, and their loads, voltage and phase.

A 350kW natural gas generator is mounted on the roof. This provides power to required emergency loads, but a few loads are on the generator that are not required, such as the telecom/data racks.

9. & 10. Special Systems

Identify special/communications systems found in the design documents from the list below. Identify any of these systems that are integrated with each other or other special systems such as lighting control, BAS systems, demand shifting or demand management systems.

TELEPHONE/DATA

Telecom service is provided by the university. Main service entered the building on the northwest corner. Most outlets are dual tel/data outlets wired with Cat5e. All classrooms, first floor corridors, and study lounges have their own wireless access point. Data is distributed throughout the upper residential floors through two tel/data rooms on each floor. Dormitory rooms have coax connections and data connections, no telephone connections are provided in these areas.

FIRE ALARM

The main FACP is located on the first floor, in the fire alarm control room. The fire alarm control room is within the envelope of the building, but separated by a firewall and only accessible from a door on the outside. A FATC is located on each dormitory floor, and on the ground floor, in an electrical closet. Each dorm room is equipped with a alarm speaker, strobe, and smoke alarm.

INTERCOM

No system in this building.

ACCESS CONTROL

The main form of access control is through magnetic door contacts and card readers. Areas protected with this system are: mechanical and electrical rooms, tel/data rooms, all elevators, all access points on the first and ground floors, and all dormitory rooms. Residential floors have RF readers installed above the ceiling.

SECURITY

Three blue-light emergency phones are located around the outside of the building, not more than 600 feet away. Six exterior CCTV cameras are mounted around the perimeter, on the roof level, of the building; signal is provided to these cameras via 6-strand fibre.

EMERGENCY RADIO COVERAGE

An in-building radio amplification system will be installed to boost radio signals for emergency responders. This system is not yet designed, and is specified to be installed after building construction by a certified professional.

11. Systems Square Footage

Identify each of the dedicated electrical and communications systems spaces in the building, the total SF of those spaces, and calculate the percentage of the total building SF.

TELEPHONE/DATA

The only part of the building that doesn't have tel/data service is a few parts of the ground floor mechanical/electrical rooms. So many wireless access points mean that even rooms without wired connections, have data regardless. This means that approximately 90% of the building has access to telephone and/or data.

FIRE ALARM

All 100% of the building is protected by a fire alarm system.

INTERCOM

None.

ACCESS CONTROL

All access points into the building are secured with card readers, thus 100% of the building is protected with access control.

SECURITY

All grounds outside the building are monitored via security cameras.

EMERGENCY RADIO COVERAGE

TBD after building construction.

12. Energy Reduction

Identify any Energy Cost Savings or Energy Reduction techniques designed into the building electrical systems such as PV Arrays, Fuel Cells, Cogeneration, Demand Reduction, Demand Shifting, Wind Generation, etc. Is the Building LEED Certified.

This building planned to achieve LEED Gold. The electrical systems credits outlined in the specifications are:

- ➔ Credit EQ 4.1: VOC content of sealants
- ➔ Credit EQ 4: products must comply with requirements of the California Department of Health Services' VOC testing standard practice
- ➔ Credit EA 5: continuous metering of equipment for energy consumption data (for all VFD's)

13. Single Line Diagram

Provide a complete single line/riser diagram of the existing distribution system.

See appendix, page 16, for single line diagram.

System Evaluation

The current systems in the building are sufficient to provide safety and comfort to the occupants. Systems used in Prince Frederick Hall represent a standard for university building design that very much based on durability and longevity. However, this building is targeting a LEED Gold certification, and it seems like more could be done by the electrical systems to accomplish this.

1. Estimated vs Actual Loads

Compare your estimated and actual connected building loads and explain any differences and discrepancies.

LIGHTING
- ➔ actual: **49,379** VA

RECEPTACLE & POWER
- ➔ actual: **1,728,589** VA

MECHANICAL
- ➔ actual: **121,041** VA

OTHER EQUIPMENT
- ➔ actual: **1,080,424** VA

TOTAL
- ➔ actual: **2,979,433** VA

DWELLING UNITS

estimated: **452,795** VA

NON-DWELLING AREAS

estimated: **2,087,492** VA

TOTAL

estimated: **2,540,287** VA

Two different methods were used to break down the different types of loads for each of the actual loads and estimated loads. The actual loads are based on the VA demand listed at the switchgear level. This was originally divided into categories (lighting, receptacle, mechanical and other) by the electrical engineer. My estimations are based on the NEC's method for calculating demand load. Because my building contains dwelling and non-dwelling spaces, I chose to divide my calculations in this way.

2. Power Company Rate Schedule

Power Company Rate Schedule – are other alternatives to the one in place available, and would you suggest investigating any changes to the rate schedule or service voltage and discuss why and how you would evaluate the alternatives and make a choice. Are there optional riders that could be taken advantage of to provide cost savings.

As power is supplied to this building via the University, rates are fixed.

3. Building Utilization Voltage

Building Utilization Voltage and fundamental distribution concepts – Would you suggest any changes and why you might suggest those changes. Describe how you would evaluate the options and make a choice. Look for design alternatives that, without changing the quality of materials, might provide cost savings, improve flexibility, improve reliability, or improve power quality. Address any effects those changes might have on the dedicated spaces required, mechanical systems, structural systems, etc.

I wouldn't suggest any changes to the building utilization voltages at this time. If changes occur in regards to equipment selection that require a different voltage, then I may need to revisit this aspect of design. However, I do not intend to change the voltage of any equipment that is already in place.

4. Emergency Power System

Emergency Power System- Are there any noted discrepancies between identified code requirements in Part 1 with the as-designed conditions. Would you suggest any changes, particularly to the power source or fuels source, describe why you might suggest those changes. Describe how you would evaluate the options and make a choice. Address any effects those changes might have on the dedicated spaces required, mechanical systems, structural systems, etc.

There is additional room on the roof of the building, where the current generator is located, if I should want to add capacity. This would potentially require a re-evaluation of the structural support in this area. The University of Maryland is also in the process of researching expanded use of fuel cells, so this might be a good option to look into as well. If this turns out to be a viable option, I would evaluate the two systems based on reliability, operation time, and maintenance costs.

5. Building Equipment

Based on your assessment in Part 1, Item 8, compared to your as-designed conditions, would you suggest any changes to the following items, and explain why you would suggest those changes. Address any effects those changes might have on the dedicated spaces required, mechanical systems, structural systems, etc.

MAIN SERVICE EQUIPMENT

I believe that the main electrical room could be organized better to streamline equipment locations. With the large voltages in this space, it is unlikely that any noticeable voltage drop would affect the system, but I would like to determine the reasoning for the current placement of equipment. This will help me decide if re-organization of the electrical room would produce any benefit.

DISTRIBUTION SYSTEM

There is not a need to change the distribution system at this time. As I make other changes throughout the building, this may need to be re-evaluated.

CONDUCTORS

Due to the long-term nature of this building, it was a good decision to use all copper wiring. I intend to continue this trend for any changes I make to the design.

CONDUIT

I do not intend to make any changes to existing conduit; any redesign I do will conform with the current design.

RECEPTACLES

Current specifications call for 1 in 10 normal power receptacles to be TVSS type receptacles

SWITCH AND RECEPTACLE FACEPLATES

These are specified to match university standards, I will not make any changes to these.

MOTOR STARTERS

If more efficient options seem reasonable, I would consider estimating a ROI for this component of the building; however, this will most likely fall outside my scope.

UPS

The occupancies in this building are such that a UPS system would not be very beneficial, and it would add a lot of extra expense.

6. Back-Up Power

Optional Back-up Power and UPS systems – Describe any changes you might suggest and explain why.

Internet connectivity is currently provided on the back-up generator. That the the only non-required system that is on the generator, and it seems like this would be the most important to the residents of the building. As it is unlikely that power would be down for very long, I would not suggest additional changes to this system.

7. Cost of Ownership

Identify changes that could reduce the cost of ownership – more efficient transformers, UPS systems, VSD's, higher quality equipment. Describe how you would evaluate those changes.

As reliability is the most important aspect of the systems, I would like to research the use of more efficient equipment for this building. This could include components like transformers, motors, or generators. Since the building will potentially have many years to recoup the costs of more efficient equipment, I will use ROI calculations to evaluate if something is worth the university's investment. Additionally, I believe that optimized lighting controls would reduce the cost of ownership for the university.

8. Additional Systems

Identify any potential systems integration you might suggest that is not already incorporated into the design. Discuss what the advantages and disadvantages would be and how it would affect other systems.

I don't anticipate adding any additional mechanical or electrical distribution systems. However, I would like to further investigate better lighting control systems. This would affect individual lighting circuits, and if optimizing lighting controls reduces overall power usage, the university would benefit from this change.

9. Energy Savings

Identify any Energy Cost Savings or Energy Reduction techniques that could be designed into the building electrical systems such as PV Arrays, Fuel Cells, Cogeneration, Demand Reduction, Demand Shifting, Wind Generation, etc. What effect would LEED Certification have on the electrical systems design (if it is not already LEED Certified).

The current design does not utilize any kind of PV arrays or wind turbines on the building. I would like to complete a return on investment analysis of some renewable electricity generation systems. Similarly, the high frequency use of the elevators in a dormitory building make it a prime application for regenerative braking. I would also like to study more on this topic.