IV. Analysis 2: Supplying Power to Emergency System using Medium Voltage Generator

The City Hospital's emergency distribution system is currently designed to utilize two 2 MW generators supplying power at 480V to power Phase 1, in the event of an interruption of normal power. A medium voltage system such as 4160V has some advantages and disadvantages that has been considered and dispelled during the course of this research. The pros and cons has been weighed, the conclusion I derived is that the final choice between choosing to supply emergency power at 480V or 4160V depends on various quantifiable and some unquantifiable factors like the preference of the owner, the impact on the budget, the local authority having jurisdiction, the availability of the system, impact to the distribution system, etc. There has to be some tradeoff between available design alternatives.

Some of the advantages that will be gained in supplying emergency power at medium voltage are;

- The cost saving due to different sized wires: The savings that can be gained by the change in wire size is reflected in the unit of power which is:

  Kilowatts (KW) = Power Factor (PF) * Volt Amperes (VA)
  Volt Amperes (VA) = Volt (V) * Amperes (A)

  The amount of power that the hospital need is unchanged so we will assume in this scenario that it is a constant. We can choose to increase the voltage, thereby reducing the amount of amperes that is transmitted in the feeders from the generator to the emergency switchgear. This reduction in amperes enables us to be able to use feeders of lower ampacity to transmit the power to the emergency switchgear. The price of the feeders generally increase with the ampacity of the wire, so using smaller feeders (feeders with less ampacity) will give us some cost savings. The longer the distance between the generator and the emergency switch gear, the more the savings gained in using a medium voltage emergency power supply. This is the same reason why the normal power serving the hospital is medium voltage.

Some of the disadvantages of supplying emergency power at medium voltage are;

- Facilities maintenance staff would prefer not to maintain medium voltage system due to the amount of caution and knowledge required to maintain them. They have to be specially trained and authorized to handle this voltage. I believe due to the fact that the normal distribution system already utilizes medium voltage, the facility staff would already be trained to work with medium voltage systems.

- Emergency systems upstream of the automatic transfer switches are typically inactive until normal power fails and the generators are started. Medium voltage cable has a tendency to fail when it's energized after sitting in a de-energized state. This problem is worse at higher voltages, but still exists to a lesser degree at 5kV class systems. This problem can be avoided, by regularly scheduled maintenance which has the added benefits of prolonging the life of the generator and adhering to manufacturers safe practice guidelines.

Problem Statement

This technical analysis will consist of quantitative and qualitative investigation of the advantages of using a medium voltage generator (4160V) instead of the low voltage generator (480V) currently used, and the effects this substitution will have on the emergency distribution system. The hospital is currently using (2) 2MW diesel powered generator at 480V as emergency power. My research is to determine which voltage would be more advantageous in terms of cost, installation, support, etc.

Methodology

1. Review literature on using medium voltages on construction projects
2. Review case studies of Hospitals that uses Medium voltage
3. Review City Hospital electrical drawings and specifications for information about the (2) 2MW diesel generators
4. Conduct an analysis using 4160V generator
5. Compare costs, installation, materials used between existing system and 4160V analysis

Solution

Currently Designed system:

The current design as shown is appendix D, shows two 2MW generator. Each connected via 32#600 & 8#400 - (8) 4”C to a 3000A emergency switchboard. The two switchboards are then tied together using a bus duct, then synchronized using a Kurt key interlock.

Proposed Alternative Design:

The proposed redesign replaces the two 2MW generators supplying power at 480V with two 2MW generator supplying power at 4160V. A transformer will be placed downstream of the generators to step the voltage back down to the utilization level of 480/277V. This change in

supply voltage will cause a change in the quantity and size of the feeders serving the emergency switchboard.

$$2\,MW = 2{,}000{,}000W$$

$$KiloWatts\,(KW) = Power\,Factor\,(PF) \times Volt\ Amperes\,(VA)$$

$$*\,Assume\,a\ Power\,Factor\,(PF)\,of\ 0.8$$

$$Volt\ Amperes\,(VA) = Volt\,(V) \times Amperes\,(A)$$

$$2{,}000{,}000W \div 0.8 = 2{,}500{,}000\ VA = 2.5\,MVA$$

To size the feeder connecting the generator to the transformer:

$$\frac{2.5MVA}{\sqrt{3} \times 4160V} = 347A$$

We will need a feeder with an ampacity greater that 347A.

Sizing Feeder:

Using the feeder schedule in NEC Table 310-16 (See Appendix D for an extraction of actual table from NEC), a copper feeder of temperature rating of 75 degree Celsius will be used. From the table it was determined that the next highest feeder with an ampacity greater than 347A is the 500 MCM feeder which has an ampacity of 380A.

Sizing of Conduit:

Using the NEC [Chapter 9, Tables 1 to 7], the known feeder size and the number of feeders needed to be run in the conduit, a 3-1/2” conduit will be used. Therefore power is going to be transmitted from the generator to the transformer that steps down the voltage via 4#500MCM - 3-1/2”conduit.

Sizing of Transformer:

A transformer is needed for the 4160V system to step down the voltage supplied to the switch board to 480V. To maximize the savings gained from using medium voltage the transformer is located in the C.U.P., in the Emergency Switchgear room. The transformer that is being specified is the VPE transformer. Transformer capacity is rated in Kilovolt-amperes (KVA) and it remains constant. The constant KVA allows us to form a relationship for finding the

amperage on the secondary side of the transformer. The transformer that would be utilized is a 2500KVA transformer. We are using a 2500KVA transformer because of the generator size is 2000KW and a power factor of 0.8. We multiply them and get 2500KVA.

To get the size of the amperage on the secondary side:

Primary Current X Primary Voltage = Secondary current X Secondary Voltage

$$V_P \times I_P = V_S \times I_S$$

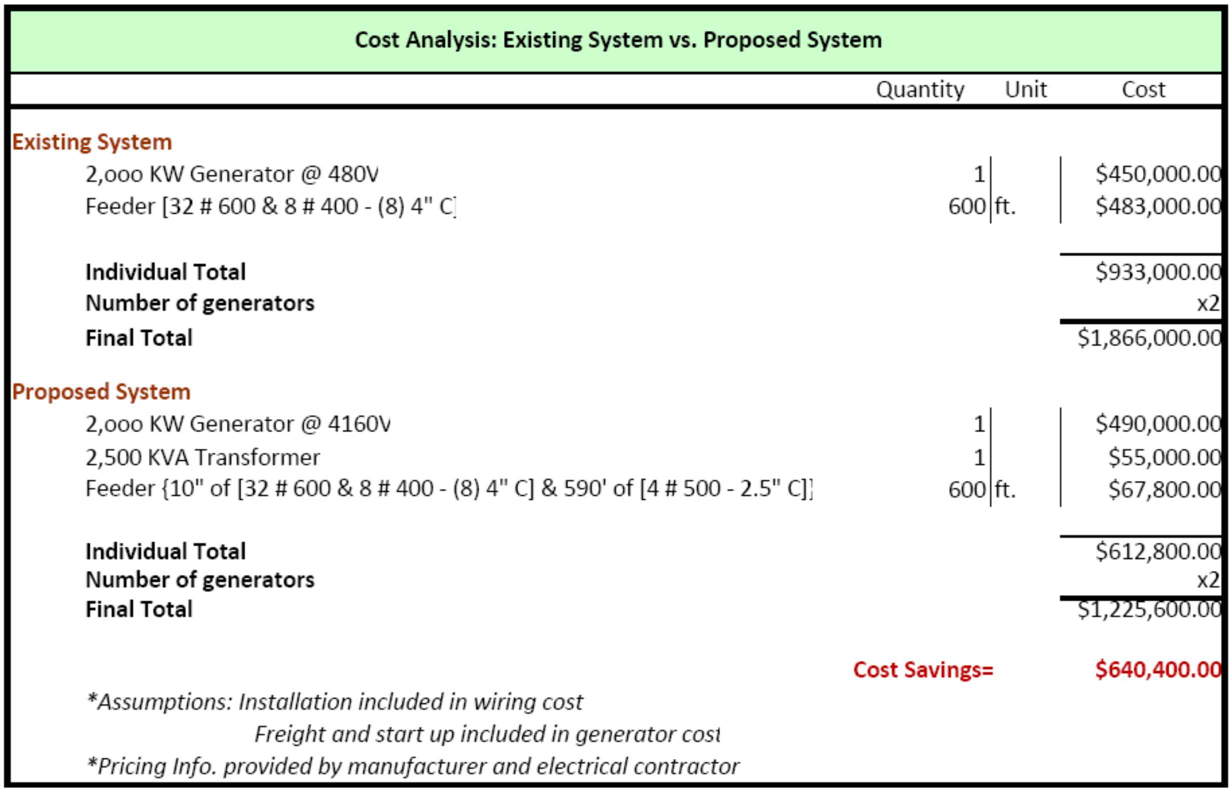
$$4160V \times 347A = 480 \times ?A$$

$$?A = 3007.33A$$

Now we can connect the transformers secondary to the existing emergency switchgear. The approximate vertical length of run is 150’. The approximate horizontal run is 500’.

Cost Analysis:

The difference in cost, installation, equipment, and materials used between the existing system and proposed system can be found in Figure 5.15.



Cost Analysis: Existing System vs. Proposed System	Quantity	Unit	Cost
Existing System			
2,ooo KW Generator @ 480V	1		$450,000.00
Feeder [32 # 600 & 8 # 400 - (8) 4" C]	600	ft.	$483,000.00
Individual Total			$933,000.00
Number of generators			x2
Final Total			$1,866,000.00
Proposed System			
2,ooo KW Generator @ 4160V	1		$490,000.00
2,500 KVA Transformer	1		$55,000.00
Feeder {10" of [32 # 600 & 8 # 400 - (8) 4" C] & 590' of [4 # 500 - 2.5" C]}	600	ft.	$67,800.00
Individual Total			$612,800.00
Number of generators			x2
Final Total			$1,225,600.00
	Cost Savings=		$640,400.00

**Assumptions: Installation included in wiring cost*
Freight and start up included in generator cost
**Pricing Info. provided by manufacturer and electrical contractor*

Figure 5.15: Cost Analysis-Existing System vs. Proposed System