Rex Healthcare Medium Voltage System Presentation

APEC 2015 March 15-19, 2015

“Maximizing the Efficiency of Hospital Distribution Systems Through the Use of Advancing Technology and Design Creativity”

- MISSION: To demonstrate the critical design requirements that maximize the functionality of a large healthcare facility’s electrical support system while ensuring the safety and welfare of patients, doctors and staff, operators, maintenance personnel, and visitors; and, to provide a backup and redundant system that provides manual and automatic alternate paths of service that minimize inconvenience to the hospital’s function and operation due to regular or routine maintenance, internal equipment failures, or utility outages.

- The design objective was to meet the above criteria by providing a new 5 Kv electrical system that met the existing hospital functions and features while increasing reliability and redundancy, and, by utilizing modern state of the art equipment and computer based programmable controls and monitoring.

- Large hospitals have necessitated the need for designers to use medium voltage systems along with large generators for distribution of the utility and emergency sources. The following is a case study of the new medium voltage system addition at the Rex Healthcare facility in Raleigh, NC

Rex Healthcare

- Rex Healthcare is a 600 bed hospital providing care for patients in Raleigh, North Carolina, Wake County, and the surrounding area. The hospital was constructed in 1978-79 and opened at its present location in 1980. In addition to its inpatient capability, it consists of 33 state of the art operating rooms, up-to-date Same Day Surgery Facilities, a fully equipped Emergency Department, a hi-tech Cancer Center, a vibrant Birthing Center, and efficient administrative facilities.

Future Heart and Vascular Facility

In addition the hospital presently has under construction a 300,000 square foot Heart and Vascular Hospital onsite. This addition is expected to come on line in 2017. Future additions both on and offsite will be developed as needed or required.

Central Energy Plant Facility

- **Construction of a $25 million onsite Central Energy Plant (CEP) began in 2011 and came on line in mid 2013. The facility includes an outdoor 5 Kw service switchgear lineup, a large indoor functional emergency generator room, three indoor 5 Kv switchgear rooms, a master control room, and a modern boiler room. A chiller addition is planned for the CEP as hospital cooling loads increase.**
  - **The recently completed electrical system addition at the CEP consists of a top-of-the-line automated distribution switching system supported by a computer PLC based programmed Supervisory Control and Data Acquisition system (SCADA). The CEP system distributes both the hospital's *utility* provided voltage source and its onsite *emergency* generator source via separate paths throughout the hospital 5 Kv distribution system. The SCADA system controls, monitors, indicates, and stores operating data including voltage, current, kilowatts, and frequency. Other load parameters at each feeder and distribution circuit breaker are displayed, as well as totalizing the system loads at the main panel. Operating parameters as well as historical records are stored which maintain printable data as required by healthcare authorities.**

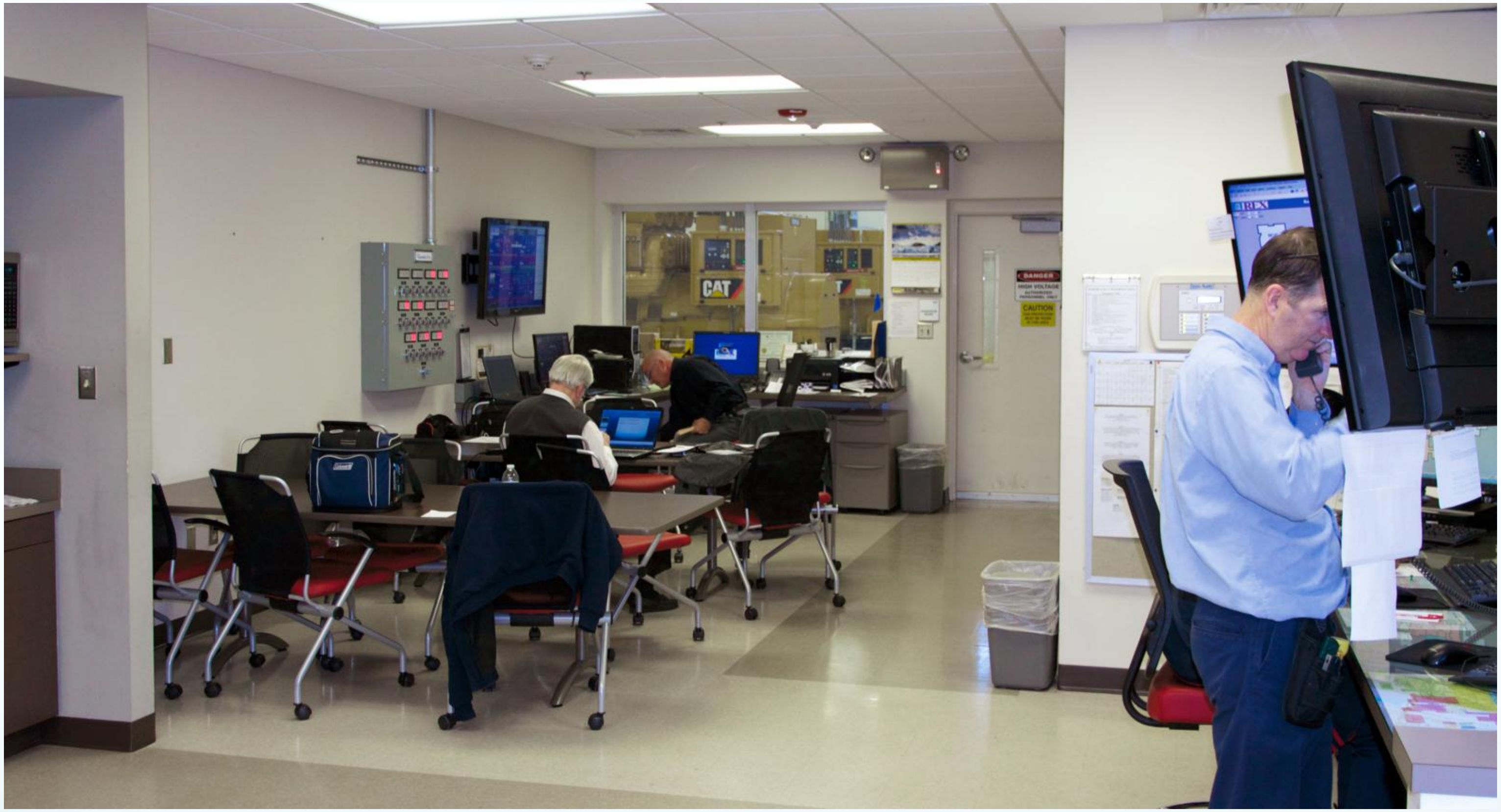
- **Out of tolerance conditions alert the control system to automatically isolate the source or failed condition, seek an available alternate path, and, when available, transfer the load to a safe and reliable alternate path.**

- **In the case of a total failure of the utility source, the system automatically initiates the generator powered *emergency* system, disconnects from the *utility* system, and transfers the *emergency* source to an alternate distribution system. The system also automatically sheds or adds loads based on the source capacity available.**

CEP facility layout
Generator room

The generator room houses two 5 Kv 3.0 Mw generators powered by 4423 HP diesel engines and one 2.25 Mw unit powered by a 3100 HP diesel engine.

Control Room



The control room consists of a main control panel screen with the system 5 Kv one line diagram, multiple monitoring screens for engines, generators, switchgear, and data. The control panel also displays operating screens for controlling the system in either an automatic or manual mode.

Four Separated Switchgear Lineups

Outdoor utility service

Indoor generator paralleling

Indoor utility fed

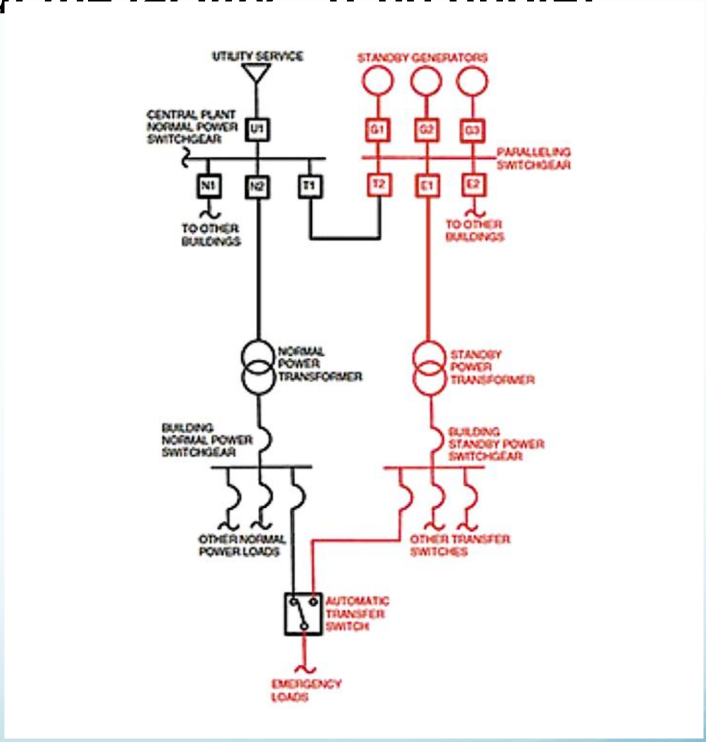
Indoor emergency fed

- **Along with the adjacent outdoor utility fed outdoor 5 Kv switchgear lineup, the CEP houses three separated 5 Kv switchgear rooms.**
  - **The utility fed *outdoor* switchgear lineup provides two circuit breaker feeds to the *indoor utilit*y switchgear which provides *utility* voltage to the CEP *indoor* switchgear. The outdoor switchgear is sized for future *utility* transformer upgrades.**
  - **The *utility* fed *indoo*r switchgear then provides a circuit breaker which feeds the *utilit*y source to the hospital service building (SB) switchgear. Both of these lineups at the CEP and service building will also feed future campus loads with the *utilit*y source.**
  - **The *indoor* generator fed paralleling switchgear lineup allows circuit breakers to close to this bus when the generators parallel with each other, and, then close two outgoing circuit breakers which provide the generator voltage source to the *indoor emergency* distribution switchgear. This switchgear is sized for future generator upgrades.**
  - **The *indoor emergenc*y switchgear lineup fed by the paralleled generator source then feeds the paralleled *emergency* source to the hospital's service building switchgear. Both of these lineups at the CEP and service building will also feed future campus loads with the *emergenc*y source.**
  - **Two circuit breakers in each of the two *indoor* distribution switchgear lineups at the CEP maintain the *utilit*y source on both the *utilit*y fed switchgear bus as well as on the *emergenc*y switchgear bus when the system is not on the generator source. These circuit breakers also allow the generator source to parallel with the *utility* source.**

- **The CEP design allows the addition of a future chiller facility which will house up to eight (8) 1600 ton chillers fed from the CEP *utilit*y and *emergency* switchgear.**

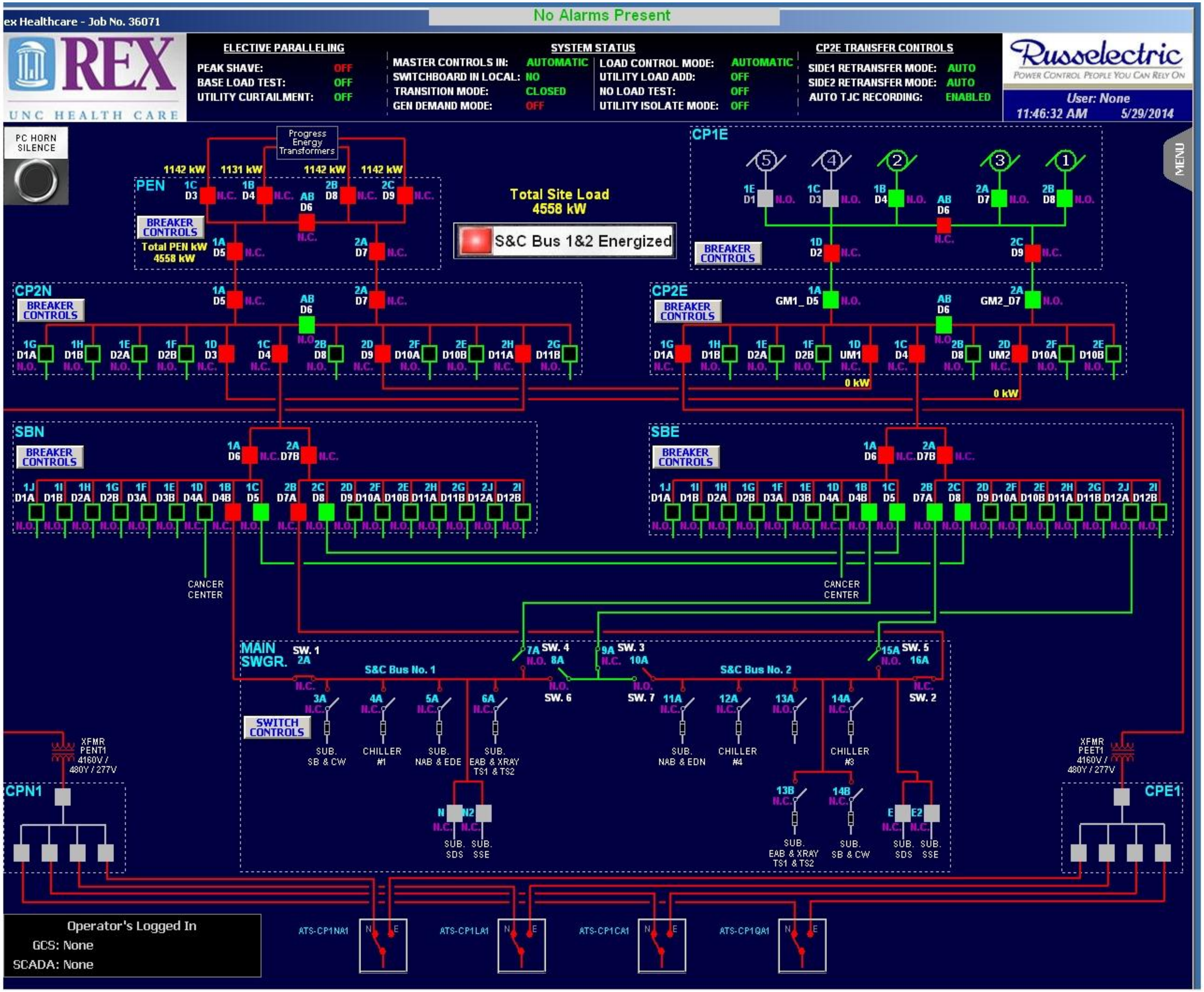
“Trends In Standby Power Systems for Healthcare Facilities” by Timothy Coyle, PE, Engineering Systems, July 2014

(Quote) ***“Larger healthcare facilities require more standby power due to size and the impracticality of evacuating a large patient census during an extended utility outage. Sufficient capacity is required to permit normal or near normal operations of the facility. Higher power demands lead to the use of larger generators at higher voltages to allow practical and economical distribution of power throughout the facility.”*** **(End quote)**

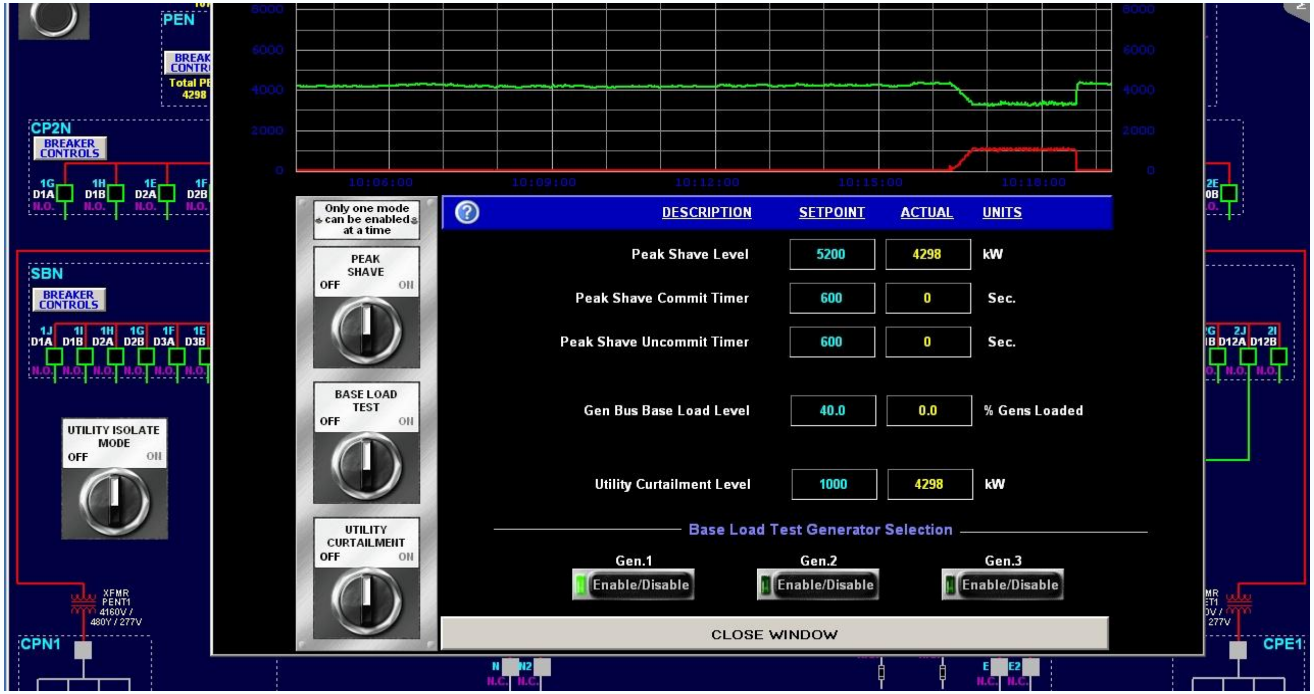


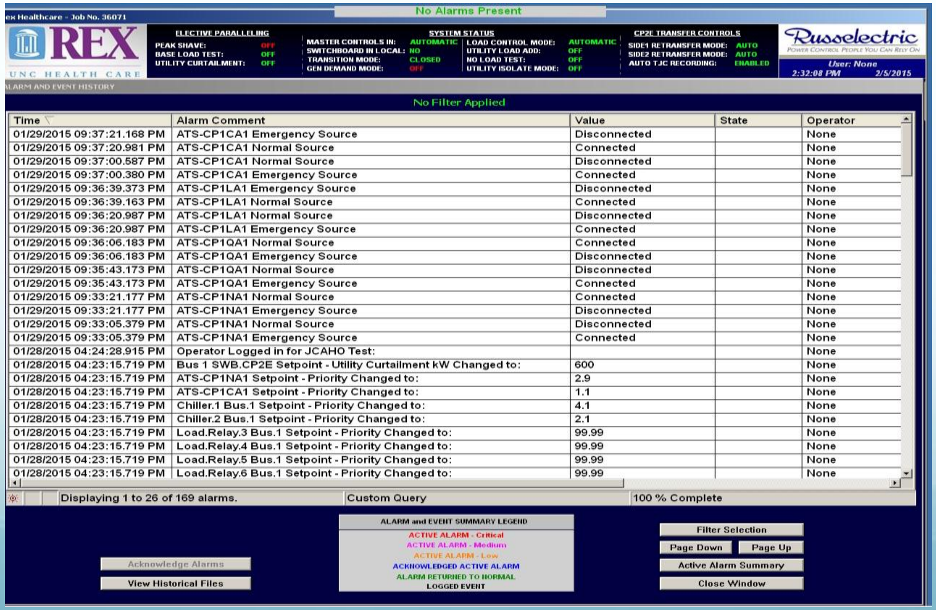
The concept connects the *utility* and the *emergency* sources for paralleling, and, it can maintain voltage on the *emergency* distribution system when the generator source is not on line.

5 Kv Electrical Distribution



SCADA Control and Data





Load Data

The hospital's total connected load is approximately 20,000 Kw.

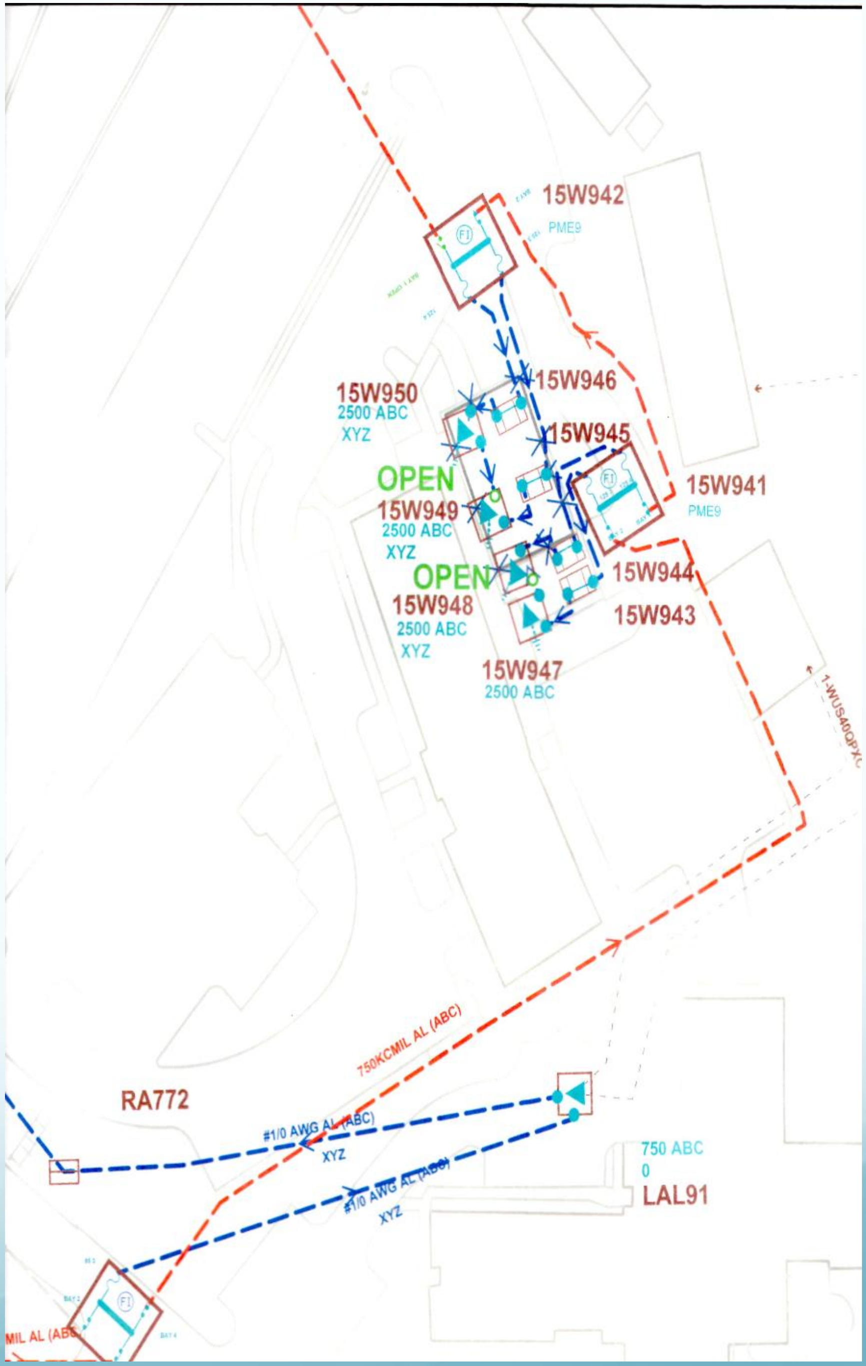
- The hospital's present peak load is approximately 5,200 Kw.
  - Approximately 3600 Kw is on the hospital preferred emergency bus.
  - Approximately 1600 Kw is on the hospital non-preferred or normal bus.
  - Future 5 year peak demand load is projected to be approximately 7,500 – 8,000 kw

Onsite Utility Owned 25 Kv Primary Source Equipment

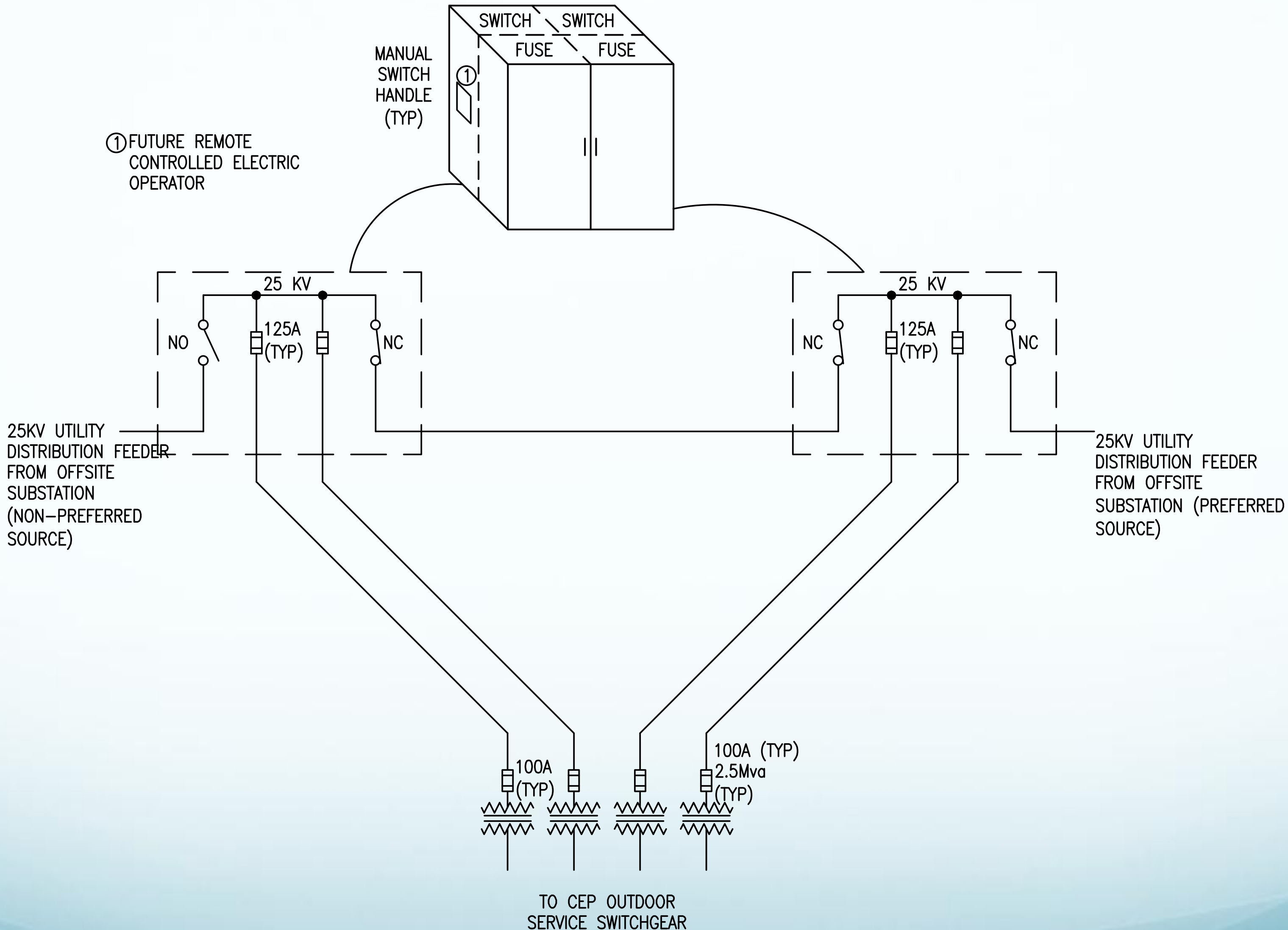
Separate 25 Kv Utility Sources

Two utility owned 25 Kv feeders from separate offsite substations each feed an onsite pad mounted distribution dead front switchgear unit.

- **Two 4-bay enclosed pad mounted 25 Kv switchgear units with two switch bays and two fuse bays each (total 4 switches, 4 fuse)**



- **There are three normally closed (NC) switches in the two units, one for the incoming preferred source and two inboard switches wired in series from one unit to the other. And, one normally (NO) switch for the non-preferred incoming *utility* source. This allows one 25 Kv source or the other to energize both *utility* switchgear units.**
  - **The switches are manually operated (see note below)**
  - **Open transition switching is required for the two incoming switches**
  - **Note: The hospital is in early negotiations with the serving *utility* and is seeking to add electric operators to the two incoming switches, one NO and one NC, which would allow the *utility* to remotely operate the switches and control the 25 Kv *utility* sources. This would provide a faster response when the preferred source is lost, OR, the hospital could take ownership of the 25 Kv pad mounted units and automatically control the switching arrangement. For instance, on loss of the *utility* preferred source, the SCADA system would automatically transfer the hospital load to the non-preferred source, if available, via open transition without initiating the engine/generator system. However, the generator engines would start and transfer the hospital load to the *emergenc*y source if neither *utility* source is available.**



UTILITY 25 KV ONE LINE

CEP Substation Yard

- **The switchgear cabinet doors are lockable. External manual switch operators are accessible without opening the cabinet door.**
- **Two dead front fuse bays each (total 4)**
- **Two fuse bays (125 amps) from one unit feed *utility* owned pad mounted transformers 1 and 2**
- **Two fuse bays (125 amps) from the second unit feed *utility* owned pad mounted transformers 3 and 4**
- **The fuse compartments are dead front to allow disconnecting the fuses from the source for fuse inspection or replacement**
- **Two incoming switches, one NC in one 4-section unit and one NO in the other unit. This allows either 25 Kv *utility* source to feed the hospital transformer primaries. The preferred source switch is NC while the non-preferred source switch is NO. The interior switches are NC.**

- **The two 25 Kv pad mounted u*tility* units are looped together via two NC switches, one in each unit, for operation from one or the other source. Or, from separate sources with the "tie" switch open in the outdoor switchgear lineup described below, and the opening of one or both loop connected NC switches and closing the NO non-preferred switch.**

25 Kv Utility Service Feeders

- **Rated *utility* cable is installed underground in direct buried rigid PVC conduit.**
- **Maintained by the *utilit*y to the transformer primaries**

Four (4) *utility* owned pad mounted transformers

- **Grounded "wye to wye" primary to secondary**
  - **14.4/23 Kv to 2.7/4.16 Kv**
  - **2500 Kva each, 10 Mva total, 350 amps each, 1400 amps total capacity at 4,160 volts**
  - **Transformers manufactured to match**
    - **Voltage and frequency**
    - **Impedance**
    - **Same manufactured batch and series (consecutive model numbers)**

- **Each transformer has internal primary bayonet fuses (100 amps) rated for the transformer windings.**

- **All four transformer primaries are fed from the 25 Kv preferred source but can be manually switched via open transition by the *utility* to the non-preferred source.**

- **The four transformers are individually metered but are totalized for single point billing.**

- **The transformers are owned and maintained by the *utility*.**

Hospital **owned medium voltage cable from each transformer secondary to the hospital outdoor service switchgear, to the CEP *indoor* switchgear, and to the service building *indoor* switchgear at the hospital.**

- **Medium voltage feeder specifications and testing**
  - **Service and distribution feeders are installed in rigid PVC conduit and in concrete duct banks.**
  - **Cable is rated at 8 Kv for added insulation value and long term service**
  - **Each service feeder is rated for 50% future transformer upgrade, ie, from 2500 Kva to 3750 Kva.**
  - **The service feeders are matched in run lengths to best ensure balanced loads and voltage drop on the transformer feeders which feed the hospital's *outdoor* service equipment. Paralleled runs to the CEP, 3000 amp capacity, and, to the service building, 2000 amp capacity, at the hospital are matched in length.**
  - **Copper tape shield with 25% overlap and a PVC low friction jacket for ease in pulling was used throughout the project.**

Conduit

- Rigid PVC conduit in a concrete duct bank
- Spare conduit for 150% future transformer service feeder upgrade
- Spare conduit for 100% future distribution feeders from the CEP to the service building, a distance of 800 feet

Grounding and Equipment Testing

An integrated grounding system was installed and tested to ensure a low impedance path to ground at the service, at all switchgear lineups, controls, cable and cable shield, and miscellaneous equipment.

- Copper ground mats
- Driven ground rods
- Ground loops

During installation all equipment sections, bussing, and circuit breakers were installed and subjected to “hi pot” testing as were the cable and terminations after mechanically but before electrically connecting.

Onsite Hospital Owned Generator System

Onsite Hospital Owned Generator System

- **Three hospital owned and operated diesel fired engine/generators located at the CEP.**
- **Two 3.0 Mw units rated 4.16 Kv, 520 amps each and one 2.25 Mw relocated existing unit rated 4.16 Kv, 390 amps.**
- **Each generator control is equipped with a load sharing module. Load sharing allows all three generators to assume a proportional load based on the generator capacity, ie, divides the total load on all three units such that the same percent load of each unit capacity is connected on each unit. This reduces the possibility of unbalanced voltage and circulating currents between generators.**
- **Each engine is equipped with an electronic governor for engine speed control which allows the engines to match phasing and parallel the generators with each other.**

Indoor generator SCADA control panel

- **A synchronizer for each generator is located in the SCADA control panel which monitors the phase angle of the generator output and by controlling the engine speed, the phase angles are matched and the synchronizer closes the paralleling circuit breakers to the bus when the phase angles match within a 12 degree window. The speed and condition which the sources parallel are determined by adjusting the *gain* and *stability* in the synchronizer. The *gain* will determine how fast the units will try to match phasing without over shooting the window, while the *stability* will determine how smooth the sources close to each other.**

- **The programmable primary and backup PLC's allow set point adjustments, timed sequences, delays, system monitoring and analysis, load add and shed functions via the SCADA program. This allows functions to coordinate with each other and to also help meet the needs and requirements of the operating functions of the system while delivering the desired results or outcomes to the hospital.**

Generator Units Matching and Paralleling Integration

- Matched voltage and frequency
- Matching 2/3 pitch
- Load sharing modules
- Local generator unit control panels and remote SCADA data monitoring and control.
- The engines are served by two 40,000 gallon underground diesel fuel tanks located adjacent to the CEP which pump to a 150 gallon day tank located at each engine.

Hospital Owned CEP 5 Kv Electrical Switchgear System

Outdoor utility service

Indoor generator paralleling

Indoor utility fed

Indoor generator fed

Specifications and Description

- **Utility Fed Outdoor Switchgear**
  - **CEP outdoor utility source service equipment**
    - **Rated 5 Kv, 3000 amps**
    - **Split bus arrangement with NC "tie" circuit breaker**
    - **Two incoming draw out circuit breakers on each side of the tie, total 4, provide mains for the outdoor *utility* fed service split bus switchgear from the four transformers.**
    - **One outgoing draw out circuit breaker on each side of the tie, total 2, feed the CEP indoor *utility* voltage fed switchgear. (For loss of either bus or the two transformers feeding the bus on one side of the tie circuit breaker, the SCADA system automatically sheds non-essential loads and feeds the hospital's essential or emergency load with the two remaining transformers.)**
    - **The system can then automatically add non-essential load based on remaining transformer capacity available.**

- **Except for peak summer loads, loss of either side of the bus allows the remaining bus and the two transformers to carry the hospital's total demand load. Load shedding occurs should the hospital load exceed capacity of the two remaining transformers.**
- **Loss of one transformer or feeder requires no change in the status of the system, only an alert to check, service, or replace the transformer, circuit breaker, or feeder**

CEP 5 Kv Generator Fed Paralleling Switchgear

- **Rated 5 Kv, 3000 amps**
- **Split bus arrangement with NC "tie circuit breaker**
- **Two incoming draw out 1200 amp circuit breakers on each side of the tie switch feed two generator sources to one side of the bus, while one 1200 amp circuit breaker feeds one generator source to the other side of the tie switch. A spare circuit breaker is provided for a future generator. Each generator circuit breaker closes to the bus when paralleled with the first generator source on the bus.**

- **One 3.0 Mw generator**
- **One 2.25 Mw generator**
- **With NC tie circuit breaker between**
- **One 3.0 Mw generator**
- **One future generator**
- **Loss on one or more units initiates the load shed function, if required, with load add should additional capacity become available**
  - **One outgoing circuit breaker on each side of the tie circuit breaker, total 2, feed the CEP *indoor emergency* fed switchgear.**
  - **For loss of one or two generators, the system analyzes the load condition and sheds loads in lower priority order, or the hospital non-essential load.**
  - **Any one remaining generator can then carry the hospital emergency or essential load.**
  - **Except for peak summer load, loss of one generator allows the remaining two generators on line to carry the entire hospital load. In high peak situations, the system automatically sheds lower priority loads as necessary.**
  - **Recovery of a lost generator source allows the system to automatically add load in priority order.**

Utility and Emergency Source Indoor Distribution Switchgear

- **The CEP *indoor* utility source switchgear lineup and the separated *emergency* source switchgear.**
  - **Rated 5 Kv, 3000 amps**
  - **Split bus arrangement with center NO "tie" circuit breaker**
  - **Loss of one side of the bus does not affect the other**
  - **Both of the *indoo*r switchgear distribution lineups consist of one incoming draw out circuit breaker on each side of the tie switch, total 2. The *utility* fed *indoor* switchgear is fed from the outdoor service switchgear with *utility* voltage and the *emergency* indoor switchgear is fed from the *indoor* generator paralleling switchgear with the generator source on each side of the NO tie switch.**
  - **Each indoor lineup also consists of one *utility/emergency* source paralleling circuit breaker on each side of the tie switches, 4 total. This connects the CEP *emergency* fed switchgear to the *utility* fed switchgear. This allows paralleling of the sources at the *emergency* switchgear circuit breakers. And, allows utility voltage to be present on the emergency bus when the generator source is not on line.**

One circuit breaker in the *utility* fed switchgear feeds the hospital owned outdoor *non-emergency* load pad mounted transformer. This feeds the CEP low voltage secondary 480 vac *non-emergency* support equipment from the *utility* fed indoor switchgear.

- **And, one circuit breaker in the *emergency* fed switchgear feeds the hospital owned outdoor *emergency* load pad mounted transformer. This feeds the CEP low voltage secondary 480 volt *emergency* support equipment from the generator fed switchgear.**

- **Note that when the *utility* source is available, both hospital owned transformer primaries are fed by the *utility* source from the utility fed switchgear and from *emergency* switchgear. However, the *emergency* hospital owned transformer primary is fed by the *emergency* source with the loss of the *utility* source. The *non-emergency* transformer primary can also be fed by the generator source when capacity is available based on priority.**

- **Each lineup consists of one outgoing circuit breaker which feeds the *indoor* service building's (SB) *utility* and *emergency* fed lineups at the hospital.**
  - **Rated 5 Kv, 2000 amps.**
  - **This provides both a *utility* and *emergency* source via separate paths to the hospital.**

- **A future 5 Kv feeder circuit breaker from the *utility* and *emergency* switchgear will feed the proposed chiller facility.**

- **Spaces for other future loads are provided**

Service Building utility fed

Service Building generator fed

Original distribution

The service building (SB) *indoor utility* fed switchgear lineup and the separated *emergency* fed switchgear lineups provide hospital internal 5Kv distribution temporarily to the hospital's original switchgear and will eventually feed the hospital's departmental substations.

- **Rated 5 Kv, 2000 amps**
- **Two 2000 amp rated concrete encased cable feeder duct banks from the CEP to the hospital's SB, approximately 800 feet, along with 100% spare conduit, one for the *utility* voltage source and one for the *emergenc*y voltage source, provide both sources to the hospital from the CEP.**
- **Each switchgear lineup has a split bus but with no tie circuit breaker. Each bus is fed by a 2000 amp main circuit breaker feeding the separated 5 Kv, 2000 amp busses.**
  - **Loss of one bus allows the hospital to feed the entire hospital load by manually switching the hospital's internal primary substation switches to the alternate bus source and, where required, the automatic transfer of downstream ATS's to the remaining bus source.**
  - **Or, the hospital can manually transfer the loads on the hospital's original switchgear bus that is fed from the failed upstream bus to the opposite bus fed from the remaining energized upstream bus.**

Hospital's original switchgear at the service building (SB)

- **Rated 5 Kv, 1200 amps**

- **The original switchgear is a three bus arrangement.**

- **The original hospital switchgear is fed by a 1200 amp distribution circuit breaker from each bus in the new indoor *utility* fed switchgear. Each circuit breaker feeds the hospital's original switchgear busses 1 and 2 via a *utility only* path.**

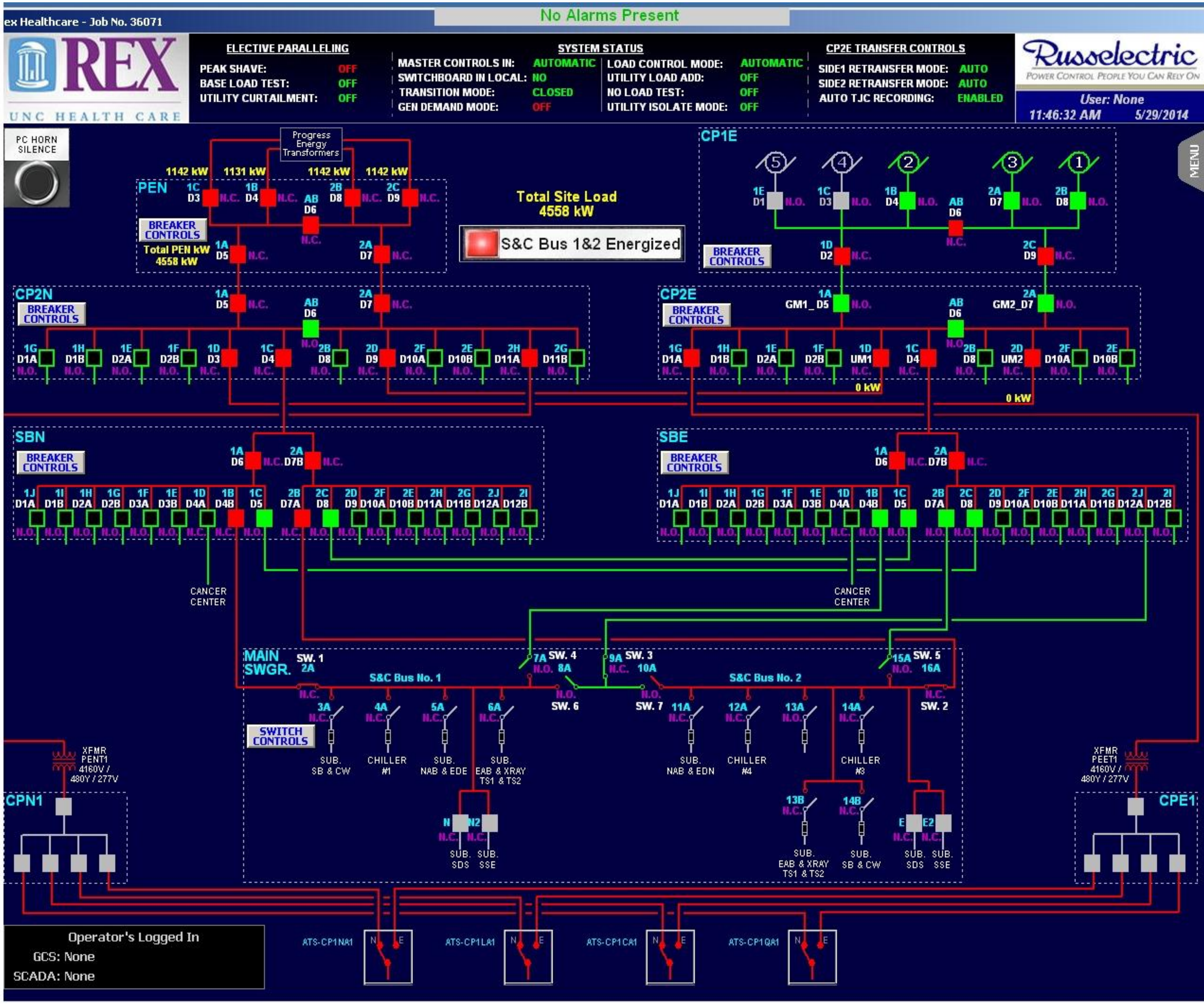
- **The hospital indoor e*mergency* fed switchgear busses feed the original switchgear busses 1 and 2 via an *emergency* only path. when the *utility* source is lost. (The SB *emergency* switchgear also feeds a non-loaded third bus in the original switchgear which backs up busses 1 and 2 via NO switches in which one or the other switch automatically closes to the lost bus.)**

- **Busses 1 and 2 feed the hospital in-house double pole, single throw substation transformer primary switches.**

- **Or, to each end of double ended substation transformer single pole, single throw primary switches.**

The original switchgear built in 1978 will be phased out as existing transformer substation loads are selectivity transferred to the new SB switchgear described above.

Circuit breaker spaces for feeding the proposed Heart and Vascular facility and future additions are included in the new switchgear.



ex Healthcare - Job No. 36071
No Alarms Present
REX
UNC HEALTH CARE
ELECTIVE PARALLELING
PEAK SHAVE: OFF
BASE LOAD TEST: OFF
UTILITY CURTAILMENT: OFF
SYSTEM STATUS
MASTER CONTROLS IN: AUTOMATIC
SWITCHBOARD IN LOCAL: NO
TRANSITION MODE: CLOSED
GEN DEMAND MODE: OFF
LOAD CONTROL MODE: AUTOMATIC
UTILITY LOAD ADD: OFF
NO LOAD TEST: OFF
UTILITY ISOLATE MODE: OFF
CP2E TRANSFER CONTROLS
SIDE1 RETRANSFER MODE: AUTO
SIDE2 RETRANSFER MODE: AUTO
AUTO TJC RECORDING: ENABLED
Russelectric
Power Control People You Can Rely On
User: None
11:46:32 AM
5/29/2014
PC HORN SILENCE
Progress Energy Transformers
1142 kW
1131 kW
1142 kW
1142 kW
PEN
BREAKER CONTROLS
Total PEN kW
4558 kW
Total Site Load
4558 kW
S&C Bus 1&2 Energized
CP1E
MENU
CP2N
CP2E
0 kW
0 kW
SBN
SBE
CANCER CENTER
CANCER CENTER
MAIN SWGR.
S&C Bus No. 1
S&C Bus No. 2
SWITCH CONTROLS
SUB. SB & CW
CHILLER #1
SUB. NAB & EDE
SUB. EAB & XRAY TS1 & TS2
SUB. NAB & EDN
CHILLER #4
CHILLER #3
SUB. EAB & XRAY TS1 & TS2
SUB. SB & CW
SUB. SDS
SUB. SSE
SUB. SDS
SUB. SSE
XFMR PENT1 4160V / 480Y / 277V
XFMR PEET1 4160V / 480Y / 277V
CPN1
CPE1
Operator's Logged In
GCS: None
SCADA: None
ATS-CP1NA1
ATS-CP1LA1
ATS-CP1CA1
ATS-CP1QA1

CEP Indoor Paralleling Switchgear and Utility Source Failure

- **One incoming draw out circuit breaker on each side of the tie circuit breaker, total 2, in the *indoor emergency* switchgear and one is on each side of the tie circuit breaker in the *indoor utility* fed switchgear, total 2. This allows the paralleled generator source to parallel with the *utility* source. This path also maintains *utility* voltage on the CEP *emergency* switchgear busses as long as *utility* voltage is present and the generator source is not on line.**

  - **One circuit breaker in the *emergency* switchgear is connected to a circuit breaker in the *utility* fed switchgear and another circuit breaker in the *emergency* switchgear is connected to the *utility* fed switchgear on the opposite side of the switchgear tie switch**

  - **Operation of the two circuit breakers in the indoor *emergency* switchgear allows the generator source to parallel with the *utility* source; and, the two circuit breakers in the *utility* fed indoor switchgear allow the generator source to disconnect from the *utility* source.**

Failure of Both 25 Kv Primary Utility Sources

- **Initiate emergency source**
  - **The four transformer *utility* source *outdoor* circuit breakers open along with the four interconnecting utility disconnecting and paralleling circuit breakers connecting the CEP *indoor* *utility* source and emergency source switchgear. By opening the interconnecting circuit breakers, the two sources are prevented from connecting until they are paralleled.**
  - **One or the other of the 3.0 Mw units is programmed to start and close to the paralleling switchgear bus first. This unit will then close to the CEP *emergency* switchgear which will close to the service building *emergency* fed switchgear and pick up the *emergency* load only on the hospital's original switchgear *emergency* preferred bus.**
  - **Meanwhile, the remaining two engines automatically start, the generators parallel with the first unit on the paralleling bus, then close to the CEP *emergency* switchgear bus which increases the generator capacity on the service building *emergency* bus. The generator source then closes to the remaining hospital load.**

- **The two circuit breakers in the service building *utility* source switchgear feeding the original hospital switchgear open, followed by opening the two downstream electric switches in the *utility* source path to the hospital's original bus 1 (*emergency* load) and bus 2 (*non-emergency* load)**

- **The *emergency* path electric switch closes to the hospital original switchgear to the *emergency* bus 1, followed by the closing of the upstream circuit breaker in the service building *emergency* switchgear. If sufficient generator capacity is available, the electric switch to bus 2 closes and the upstream circuit breaker in the service building *emergency* switchgear closes.**

- **The entire hospital is now on the generator source.**

Return to Utility

- With the return of the *utility* source, after a time delay to ensure stability in the *utility* voltage source, the four circuit breakers in the CEP outdoor service switchgear close along with the two paralleling interconnect circuit breakers in the CEP *utility* fed switchgear. This returns *utility* voltage to the line side of the two open paralleling circuit breakers in the CEP *emergency* source switchgear

- The *emergency* source then parallels with the *utility* source and the synchronizer closes the two circuit breakers in the CEP *emergency* switchgear. The paralleled sources are now feeding the hospital load.

- The *utility* source gradually assumes the hospital load and when the load reaches approximately 80% on the u*tility* source, the generators disconnect from the paralleling switchgear, the *utility* source assumes all of the hospital load, and the generators run without load for a preset cool down period.

Loss of the Preferred 25 Kv Utility Source

- **Same as above for loss of both *utility* sources except once the hospital is on the generator source, a *utility* operator can manually transfer the service transformer primaries to the non-preferred 25 Kv source and the *utility* transformers and the hospital load return to the *utility* alternate 25 Kv source.**

- **The *utility* source then gradually assumes the hospital load as above and the generators shutdown after cool down.**

System Testing and Revenue Benefit

- **All systems testing is done to minimize inconvenience to all hospital functions and operations, staff, patients, and visitors.**
  - **Closed transition in and out of tests prevent interruptions or "blinks."**
  - **ATS transfer tests are done without starting the generator system because there is a voltage source on both sides of the ATS's. (*Utility* voltage is present on both sides of all ATS's when *utility* voltage is present to the *utility* fed service building switchgear and to the hospital original switchgear busses 1 and 2.)**
  - **As a result all ATS's are tested via closed transition and without starting the engines or interrupting the voltage source to any hospital load.**

Utility Isolation Test

- **This test checks the operation of the complete *emergency* and *utility* systems including the engines and generators, distribution system, *emergency* and *utility* side circuit breaker operations, and the CEP installed ATS's. (All hospital existing ATS's will soon be interconnected to the new SCADA system for control and monitoring and will be tested along with the newer ATS's.)**
- **Initiate by setting the SCADA isolation test switch on the control screen to the "on" position**
- **The generator engines automatically start and parallel with each other, then parallel with the *utility* source and close to the load. The hospital load is slowly assumed by the generator source. Once the generator source assumes approximately 80% of the hospital load, the system then disconnects from the *utility* source and remains on the generator source as long as the test switch is in the "on" position.**

- **Once the test switch is returned to the “off” position and after a preset time delay, the *utility* source is closed in and the generator source parallels with the *utility* source as described above. The hospital load gradually returns to the *utility* source and when the load on the *utility* source assumes approximately 80% of the load, the generator source disconnects from the paralleled sources and all hospital load returns to the *utility* source. The generators run without load for a preset cool down period and shutdown.**
- **Should conditions dictate, ie, approaching storm, scheduled utility outage, etc, the hospital can initiate the isolation test and remain in the test indefinitely or until safe to return to the *utility* source.**

- **The test is run without any interruption of voltage to the hospital.**

Curtailment

- Based on a hospital contracted Kw amount with the serving *utility*, the curtailment program is initiated by a *utility* company alert for the hospital to curtail to the contracted set point Kw. The hospital then assumes all load above the set point until notified to return all load to the *utility* source.
  - The curtailment program is initiated on the SCADA control screen by manually switching the test switch to the "on" position.
  - The generator engines start, the generators parallel with each other, parallel with the *utility* source, and assume all of the hospital load above the set point.
  - Upon notification from the *utility*, the switch is returned to the "off" position.
- Once curtailment is removed, the *utility* source gradually assumes the curtailment set point load, the generator source disconnect from the system, and the engines run without load for a preset cool down period and shutdown.
- The function runs without interruption of voltage to the hospital.
- The contract agreement provides a fixed credit to the hospital usage billing each month regardless of any alerts.

Peak Shaving

- **Based on the hospital set point *demand* KW, the peak shaving program will automatically initiate should the hospital load reach the set point, ie, as the peak demand Kw is approached.**
  - **The engines start automatically and the generators parallel, then parallel with the *utility* source. The generator source then assumes all load above the demand set point and remains on line with the *utility* until the load recedes to a set point level below the demand set point, and after a preset delay, returns all load back to the *utility* source.**
  - **Once the time delay elapses, the *utility* will assume the hospital load, the generators disconnect from the system, the engines run for a preset cool down period without load and shutdown.**
- **This function runs without a voltage source interruption to the hospital.**
- **The peak shave program prevents the hospital load from exceeding its monthly demand set point and avoids higher 12 month demand charges.**

Base load test

- A base load test is required by state authorities to be run monthly for a minimum of 30 minutes while carrying a minimum of 30% load of the capacity of each generator.
  - This test is initiated by switching the test switch to the "on" position on the SCADA system control screen.
  - The engines automatically start and the generators parallel with each other and then parallel with the *utility* source. The generator source then assumes 30% or *greate*r of the generator capacity depending on the set point, and runs with this load for at least 30 minutes or until the test switch is returned to the "off" position.
  - Once the test is complete the program gradually returns the hospital load back to the utility source, the generators disconnect from the system, the engines run for a preset cool down period without load and shutdown.
  - The recorded test data is monitored by the regulating authorities.
- This test is done without any voltage interruption to the hospital.

Simulator

- **The hospital has available a simulator to train, troubleshoot, and demonstrate the exact features and operations of the electrical distribution of the *utility* and *emergency* sources without affecting the live system.**
- **System failures can be simulated and recovery reviewed prior to initiating a correction or adjustment in the live system.**
- **The above tests along with other testing can be run on the simulator in order to have an understanding of what occurs in the system prior to initiating any measures in the live system.**

System Changeover from the Original 5 Kv System to the New System

- **As the CEP project stages were completed and as electrical system phases were put in service, the hospital had the difficult task of transferring the hospital load from the existing substation and switchgear to the new substation and switchgear, and, from the existing generator system to the new generator system. In addition, this had to be done while other switchgear installations were still in progress at the service building, and, without taking the hospital out of service.**

- **The hospital load was gradually transferred from the old system to the new as construction and installation materialized. This included transferring from an existing *utility* substation at the service building to the new *utility* substation at the CEP, and, transferring from an existing generator system at the service building to a new generator system at the CEP.**

- **Using the flexibility in both the new and existing systems, along with a written step by step transfer sequence, existing hospital loads were transferred from one system to the other by utilizing the existing hospital switchgear busses and, as available, the new switchgear busses.**

- **Most loads were transferred via closed transition when sources were in phase which avoided hospital interruptions**
  - **By using the redundancy in the existing system and the added flexibility in the new system, loads were incrementally and gradually over a period of weeks, transferred from the old system to the new system.**
  - **This involved using the original utility 5.0 Mva substation and the new utility 10 Mva substation to gradually transfer load from one source to the other. This created situations whereas a portion of the hospital load was on the new *utility* and *emergency* systems while a portion of the load was on the old *utility* and *emergency* systems.**

- **By transferring all of the hospital loads to a single bus in the original switchgear, this allowed work to be done on the alternate isolated non-loaded bus. The new service building *emergency* fed bus was used as both the *utility* fed bus and the *emergency* fed bus while the old generators were removed, allowing the *utility* fed switchgear at the service building to be installed in the vacate room, assembled, and tested which covered a two month period.**
- **By using the hospital's existing low voltage split bus load center switchboards, loads were transferred from one side of a 480 Vac tie switch to the other side and then returned when upstream work was complete.**
- **When sources were in phase or when fed by the same substation, loads were transferred via closed transition.**
- **Momentarily open transition transfers occurred when not in phase or when fed by difference substations.**

Re-sizing the Emergency Load on the Hospital's Original Preferred Emergency Bus

- **Because of the magnitude of the *emergency* load on the hospital's original switchgear preferred bus, at least two of the three hospital's new generators had to be on line and paralleled before connecting the *emergency* load to the source. (The *emergency* load exceeded the capacity of any one of the CEP generator sources.) This was causing a delay in getting the hospital *emergency* load on the generator source when a *utility* outage occurred. The problem was due to the uncontrolled time it took to get two large engine masses started and the generators paralleled.**

- **The following solution was initiated:**
  - **Reduce the load on the hospital preferred *emergency* bus by transferring *non-emergency* or lower priority loads from the preferred *emergency* bus to the non-preferred bus, and, by delaying other lower priority loads from connecting to the *emergency* source.**
    - **The chiller load was already delayed in re-starting when a *utility* outage occurred.**
    - **The circuit breaker feeding the hospital's *non-preferred* bus was programmed to delay closing until the second generator was on line.**

- All low voltage chiller support load, ie, pumps, fans, etc. were transferred to the hospital non-preferred *emergency* bus
- Since the hospital data center is on a long term uninterruptable source (UPS), the data center automatic transfer switch (ATS) was delayed in transferring until the second generator was on line.
- All lower priority automatic transfer switches (ATS's), for instance, equipment ATS's serving air handler units, exhaust fans, and other lower priority loads, were delayed in transferring until the second generator was online.

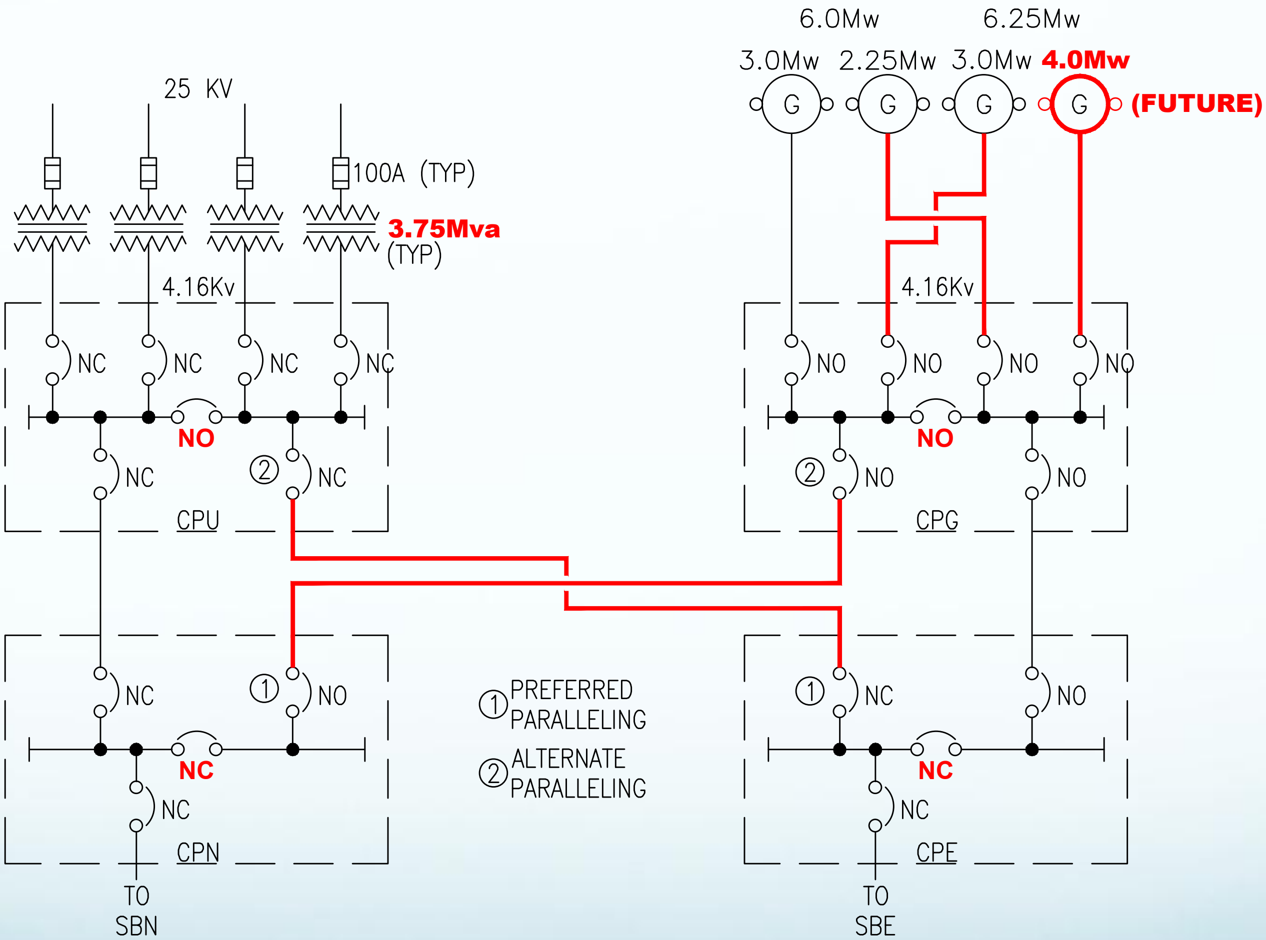
- By reducing load on the preferred *emergency* bus and delaying loads from transferring to the *emergency* source, the load on the hospital's preferred *emergency* bus was reduced so that the first generator on line could carry that load. As a result the hospital *emergency* load was back on line when a *utility* failure occurred much faster, and, all lower priority loads were connected to the emergency source when the second generator was online and paralleled in an acceptable time.

- These changes allowed the hospital to meet its desire to get its emergency load on line in a timely fashion and its non-priority load on line without an inconvenience to the hospital.

Long Term System Upgrade

- **Create two separate operating 5 Kv systems or plants to meet long term load additions**
  - **Open "tie" switch in the *outdoor utility* fed switchgear to create two utility fed busses**
  - **Upgrade *utility* transformers to 3750 Kva**
  - **This creates two separated *utility* source plants of 7500 Kva each, one on each side of the now open tie circuit breaker**
  - **Close the tie circuit breaker in the *indoor utility* fed switchgear which creates one *utility* source fed bus**

- **Add fourth generator**
  - **Open "tie" switch in the indoor paralleling switchgear to create two emergency busses**
  - **Match two 3.0 Mw units, total 6.0 Mw**
  - **Match 2.25 Mw unit with a new 4.0 Mw unit, total 6.25 Mw**
  - **This creates two separate generator source plants, one 6.0 Mw and one 6.25 Mw, one on each side of the now open tie circuit breaker**
  - **Close the tie circuit breaker in the indoor *emergency* fed switchgear which creates one *emergency* source fed bus.**



PROPOSED 2017 UPGRADE

Redirect one of the feeders from the *outdoor utility* fed switchgear to the CEP *emergency* switchgear main circuit breaker, and, one of the feeders from the *indoor* generator paralleling switchgear to the *indoor utility* fed switchgear main circuit breaker.

- **Disconnect one main feeder from the *indoor* CEP generator paralleling switchgear and connect it to the *indoor utility* fed outdoor switchgear main circuit breaker.**
- **Disconnect one main feeder from the *outdoor utility* fed switchgear and connect it to the *indoor emergency* switchgear main circuit breaker.**
- **This basically crosses one of the *utility* source feeders with one of the paralleled generator *emergency* source feeders.**

Each of the indoor switchgear lineups that feed the hospital and other CEP fed future loads would now be fed by both the *utility* source, NC, and by the *emergency* source, NO. (When a *utility* failure occurs, both *utility* fed circuit breakers would open and both *emergency* fed circuit breakers would close.)

In this case, one plant would normally feed the *emergency* load while the other plant would feed the *non-emergency* load. However, each plant would back up the other should there be a failure in one or the other plant.

Changing Technology and Code Compliance

- **Can code authorities keep up with advancing technology?**
  - **Most codes are revised and issued every three years**
  - **Technology and new ideas are changing every day**

- **Should design creativity using advanced technology challenge code interpretations?**
  - **Code vagueness**
    - **Unclear as to the application**
    - **Exceptions which cause confusion**
  - **Over-interpretation of codes**
    - **By its language**
    - **Even by single words**
    - **By contradicting cross references**