The University of Massachusetts

Electrical System Modifications Resulting in Increased Operating Reliability of CHP Facility

Presented by:

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Agenda

- Introduction to the University of Massachusetts Amherst
- UMA Distribution System & CHP Interconnection Challenges
- System Modelling Approach
- System Study Results
- System Study Recommendations
- New Campus Supply System
- CHP Design Takeaways

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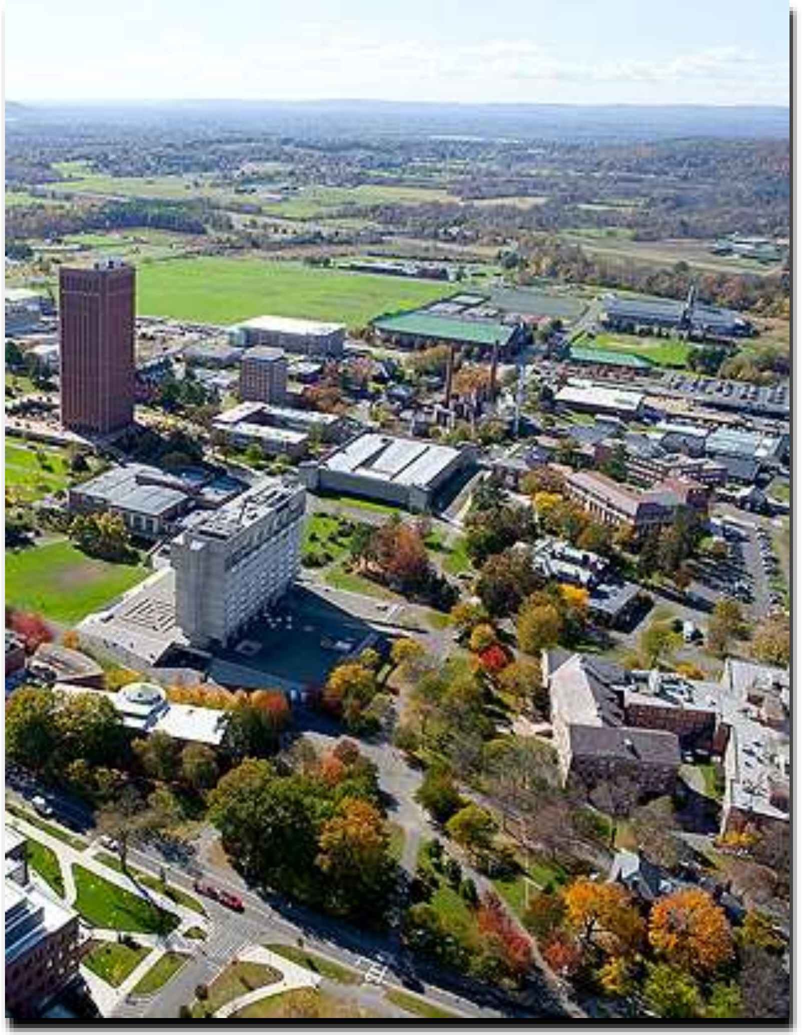
The University of Massachusetts Amherst



- Founded in 1863 as a Public University
- UMA main campus covers 1,450 acres and consists of 316 Buildings (35 built in the last 10 years), with over 12.7 M gross ft^2 of building space
- 30,340 students (grad and undergrad) – 2017/18
- New Central Heating Plant - 2009
  - 9 MW Gas Turbine Generator
  - Two (2) Steam Turbine Generators (4 MW & 2 MW)
  - Three (3) steam boilers (325,000 lbs/hr)
  - Solar hot water system - 2016
- New 115/13.8 kV 56 MVA Tillson Substation - 2016
- 15,000+ Solar Panels providing 5.3 MWdc - 2016

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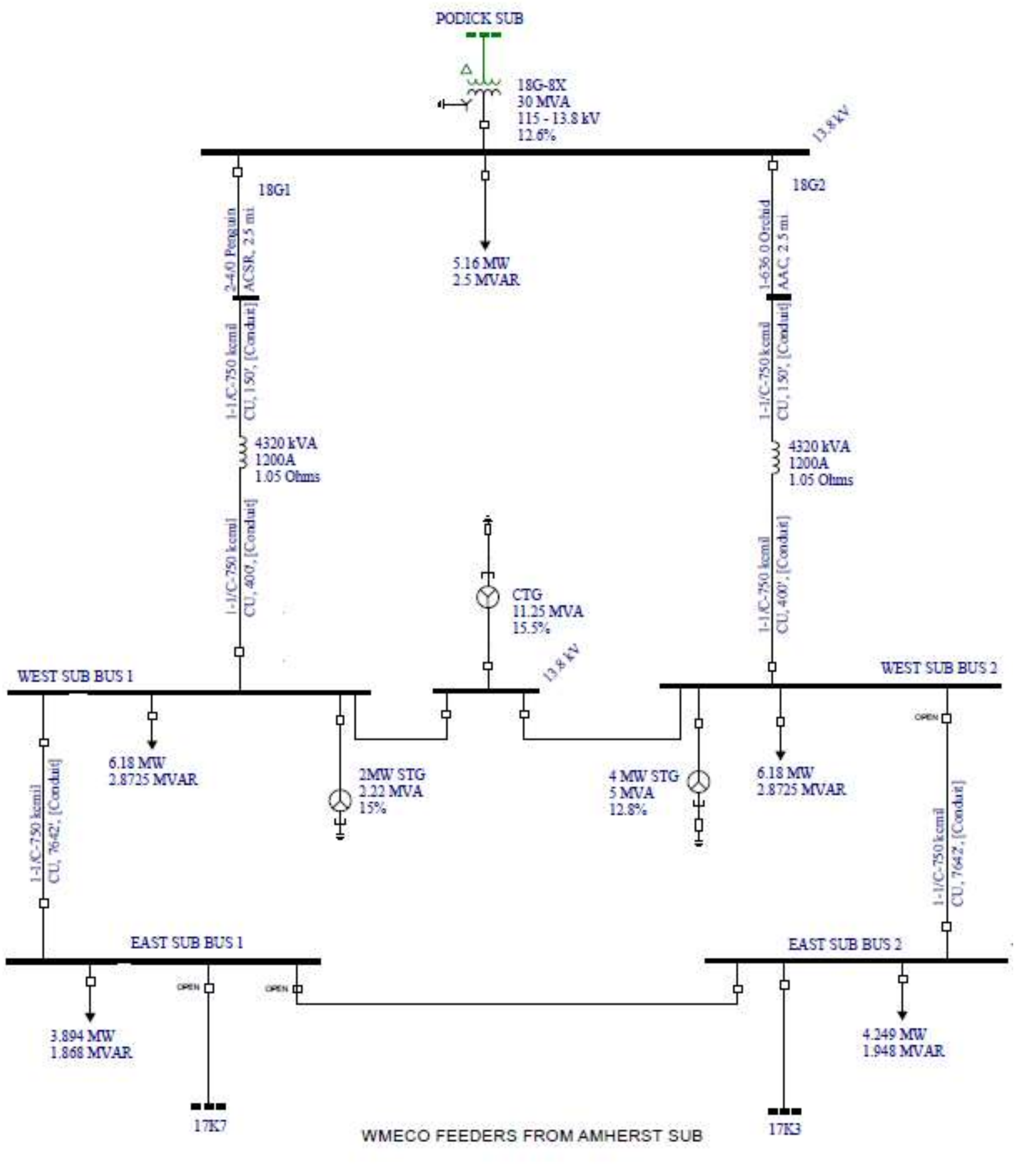
UMA Distribution System & CHP Interconnection Challenges



- 13.8 kV supply system consisting of 4 O/H feeders fed from two different utility substations.
- 22 MW+ peak campus load and growing
- 15 MW of in-house CHP generation
  - 9 MW CTG
  - 4 MW STG
  - 2 MW STG
- Capacity limited supply feeders running up to 2.5 miles through heavily treed areas and along roadways.
- Since 2006, there have been as many as 50 unplanned outages/yr due to utility system issues.

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UMA Distribution System & CHP Interconnection Challenges

- No direct interconnection protection between UMA and utility (i.e. no transfer trip, etc.)
- Fault current limited distribution system requiring UMA to install current limiting reactors on incoming supplies to CHP.
- Utility substation using older and standard distribution protection technology requiring CHP interconnection to be set very sensitively.
- UMA had to employ a load shedding scheme to shed a significant portion of the campus anytime the CHP tripped as supply lines were not capable of supporting load.
- UMA had to do daily load switching to maximize generation benefit but not overload supply lines.

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System Modelling Approach

- A power system model was created to study the existing UMA distribution system and CHP interconnection.
- Load flow analyses were used to verify existing system voltage performance issues during CHP trips and then evaluate the effectiveness of potential remedies.
- Key issues to address were:
  - Increase capacity of incoming feeders from Podick
  - Minimize the supply system voltage drop during CHP trips to 95%
  - Ensure utility fault levels remain acceptable.
- Corrective measures to study:
  - Adjustment of generator PF
  - Addition of fixed capacitors & location
  - Reconductoring O/H lines
  - Isolation transformers/ current limiting protectors

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System Study Results

- Multiple CHP trip scenarios were studied which included:
  - Base Case – 18G1 & 18G2 in Service

Generator PF	Supply Capacity	Increase
Existing = 80%	11.13 MW	n/a
90%	12.61 MW	13%
95%	14.11 MW	27%

  - One line in service – 18G1

Generator PF	Supply Capacity	Increase
Existing = 80%	7.27 MW	n/a
90%	8.2 MW	13%
95%	10.02 MW	38%

  - One line in service – 18G2

Generator PF	Supply Capacity	Increase
Existing = 80%	6.62 MW	n/a
90%	7.55 MW	14%
95%	9.28 MW	40%

System Study Results

- Reconductoring of 18G2 was considered but there was only a 3% increase in supply line capacity.
- Short circuit on utility lines was ~ 110% of 6 kA limit even with CLRs.
- Isolation transformer option in place of CLRs - could limit fault current to desired value – resulted in line capacity drop of 11% (14.6 to 12.6 MW) due to additional impedance.
- Current limiting protector on CTG – achieved fault current limit without additional impedance – expensive to replace after activation ($18K).

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System Study Recommendations

- Short term measures:
  - Increase UMA generation PF to 90%
  - Review PF on utility supplies maximum generator PF without incurring PF penalties.
  - Install 2400 kVAr of fixed capacitors to allow for higher generator PF of 95% or better.
  - Review fault duty limitations locations on utility system and see if equipment replacements can be implemented to remove need for CLRs
  - Install CLP on CTG if utility equipment can't be replaced.
- Long Term Measures:
  - Construct 115/13.8 kV substation with suitable capacity for future load growth and on-load tap changers for good voltage control.
  - Install automatic capacitor banks to maximize generator PF.

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New Campus Supply System

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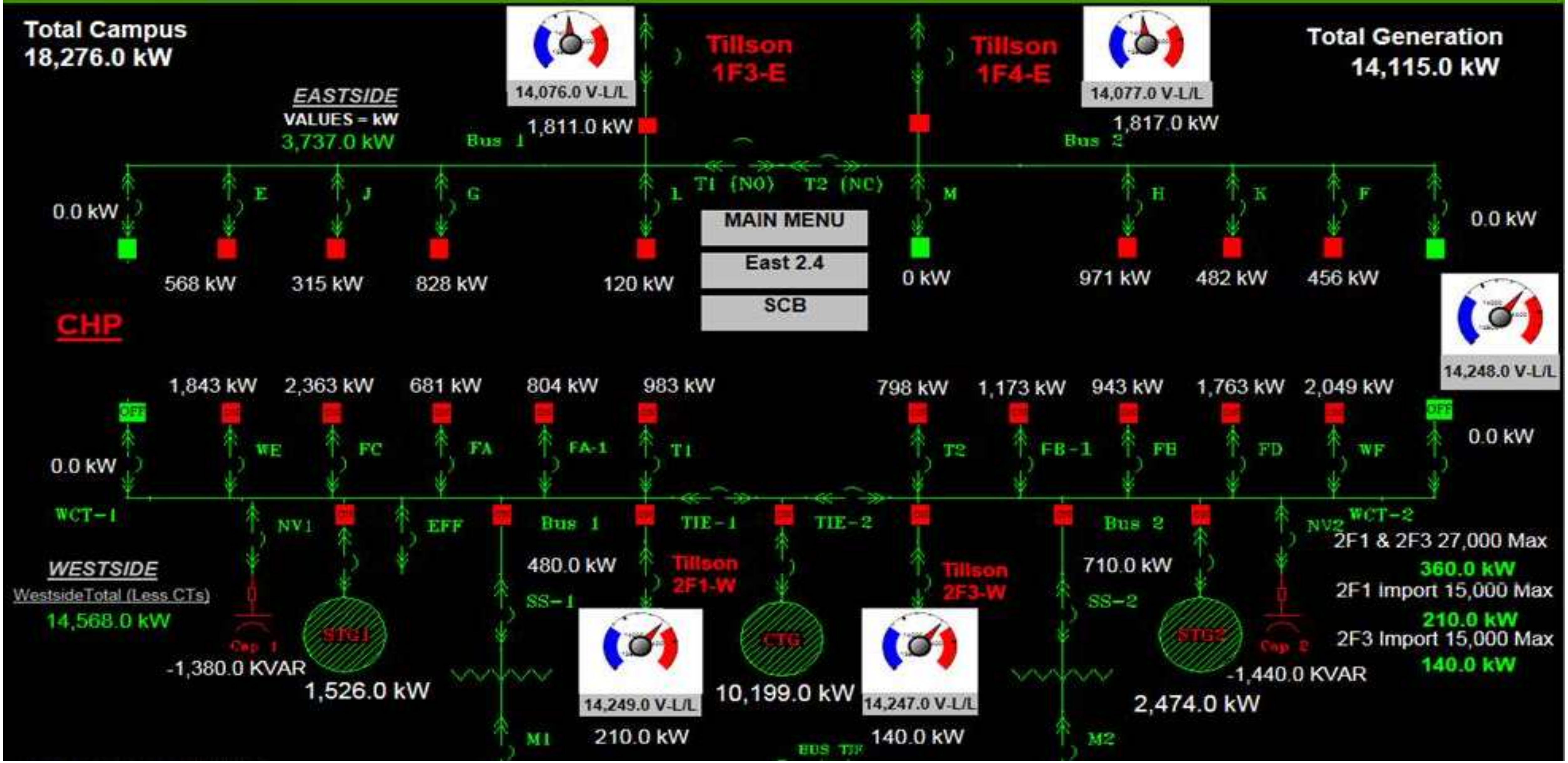
New Campus Supply System

- 115/13.8 kV, 56 MVA substation c/w on-load tap changers
- 2 x 100% redundancy – transformers & distribution feeders
- No feeder capacity limitations with room for more than doubling of campus load.
- 2 x 115 kV line transmission taps with provision for 3^{rd} line
- 13.8 kV auto transfer scheme
- Campus wide SCADA backbone with expansion capabilities
- Interconnected campus wide fiber optic loop for protection/metering/SCADA



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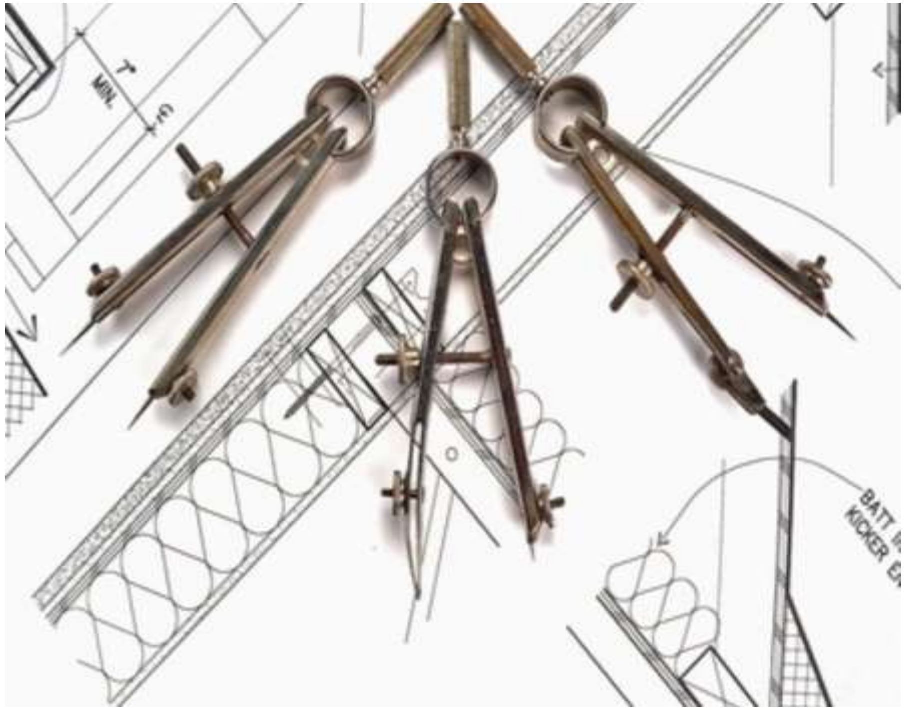
CHP Design Takeaways



- Match load requirements with incoming feeder capacity. Use supply voltage Rule of Thumb = 1 MVA/kV.
- Avoid O/H lines where possible – high exposure to faults (animals/accidents/weather) can cause havoc with generation. Ensure utility has an active tree-trimming program.
- CHP Interconnection protection – utilize direct transfer trips/directional/differential line protection to provide better selectivity.
- Avoid running generators at lower than 95% PF – use capacitors for base MVAr needs for better voltage regulation.
- Locate capacitors as close to the load as possible.

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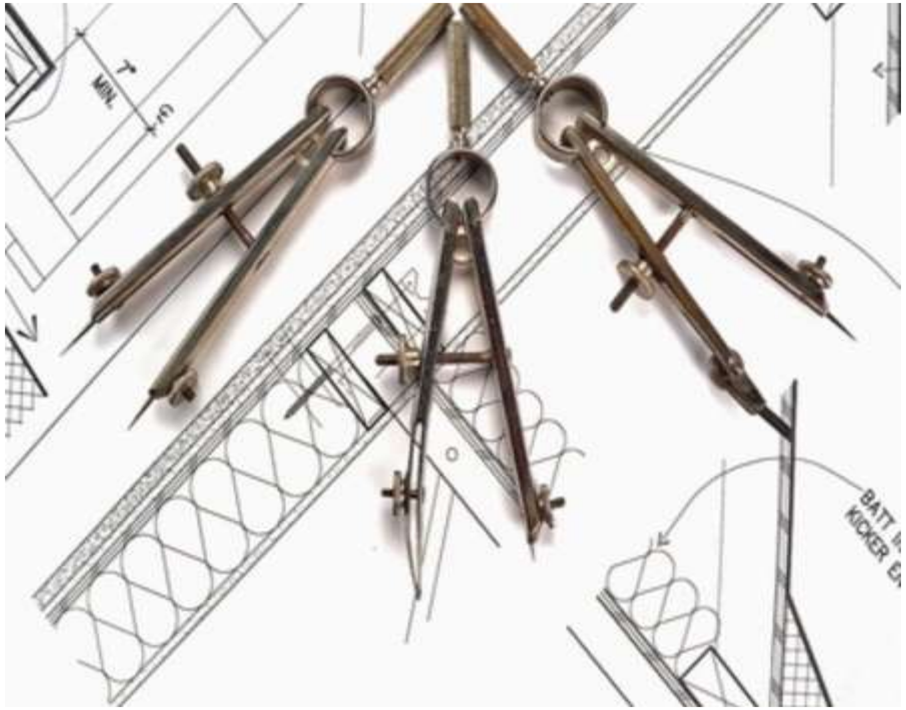
CHP Design Takeaways



- Check fault duty of utility system to ensure special current limiting equipment won't be needed.
- Regular tree-trimming plan for O/H lines is a must. Typically once every 5 years.
- Supply line route diversity – 2 lines (distribution lines especially) running beside each other does not provide a significant increase in reliability over a single line.
- Ensure load flow analysis is done for normal and upset CHP conditions to ensure system voltage is acceptable.
- Load tap changers on transformers help for long term supply voltage corrections but not short term upsets (Typically > 30 sec TD).

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Thank you

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