The University of Massachusetts
Electrical System Modifications Resulting in Increased Operating Reliability of CHP Facility
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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
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
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.
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.
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
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).
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 CLR's
  – 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.
New Campus Supply System
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 3rd line
- 13.8 kV auto transfer scheme
- Campus wide SCADA backbone with expansion capabilities
- Interconnected campus wide fiber optic loop for protection/metering/SCADA
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.
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