NERC Lessons Learned

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Battery Energy Storage System Cascading Thermal Runway

Transmission Facilities

March 29, 2021

Problem Statement

- Remote alarm triggered at 16:55 PST by fire in a BESS
- Explosion a 20:04 PST injured firefighters and significantly damaged the BESS
- Cause of fire identified as a cascading thermal runaway event
- BESS was performing a solar smoothing function
- Battery cell in the BESS experience sudden voltage drop during charging cycle
- The thermal runaway event activated the smoke detection system and cascaded into neighboring cells and their batteries

Details

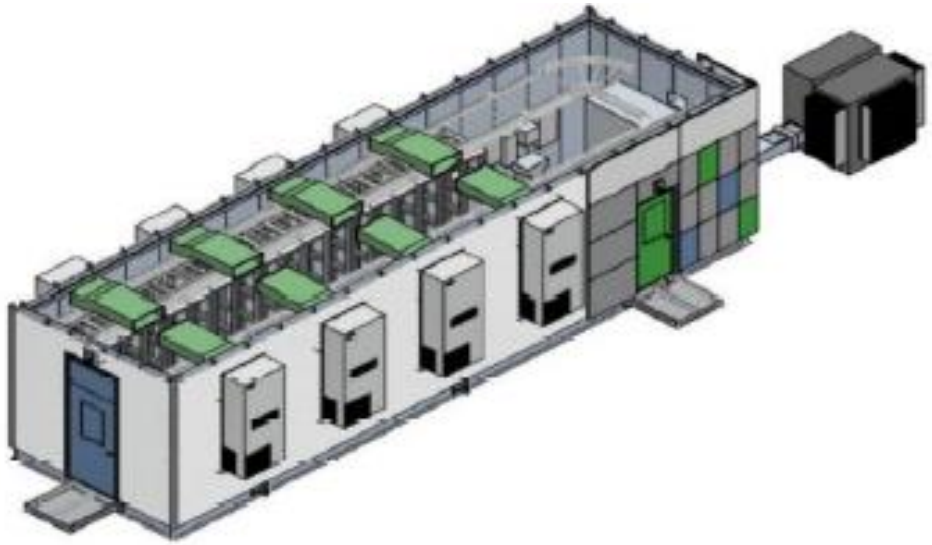

Figure 1: General Layout of the BESS (Image credit: APS) [1]

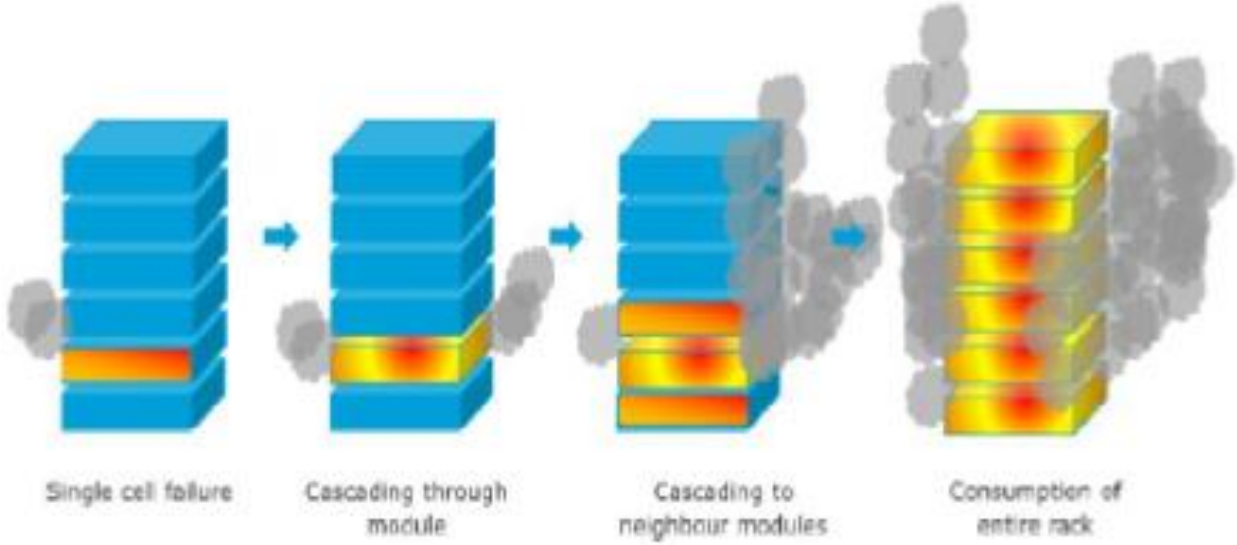

Figure 2: A single cell failure propagated through one Module (Image credit: APS) [1]

Details

Figure 3: BESS Exterior after event (Image credit: APS) [1]

Figure 4: All modules in Rack 15 were severely damaged by thermal runaway while leaving nearby racks mostly intact (Image credit: APS) [1]

Corrective Actions

- Improve training, emergency response planning, and procedures for first responders, operations, and maintenance personnel
- Work with suppliers, industry experts, and standards bodies to:
  - Minimize or eliminate cell-to-cell and module-to-module heat transfer to stop thermal runaway
  - Implement fire detection and suppression system designs to fully manage a thermal runaway
  - Implement design changes incorporating monitoring and remote reporting of flammable gas concentrations and implement ventilation systems to mitigate

Lessons Learned

- Conduct hazard mitigation analysis
- Develop a pre-incident guide for future training of utility personnel and fire services
- Conduct training, familiarization tours and exercises with your local fire department

Catastrophic Failure of 345kV Oil Filled Metering Current Transformer in a Transmission Substation

Transmission Facilities

March 29, 2021

Problem Statement

- Catastrophic failure of 345 kV C-phase transformer caused the CT to explode causing fire an spread of glass shrapnel across switchyard
- Fault also led to tripping of 345 kV South Bus, removing Capacitor Bank #2 and inverter based controlled reactive device
- 345 kV Breaker scheduled maintenance led to open-ended Line B
- Entity conducted a root cause analysis

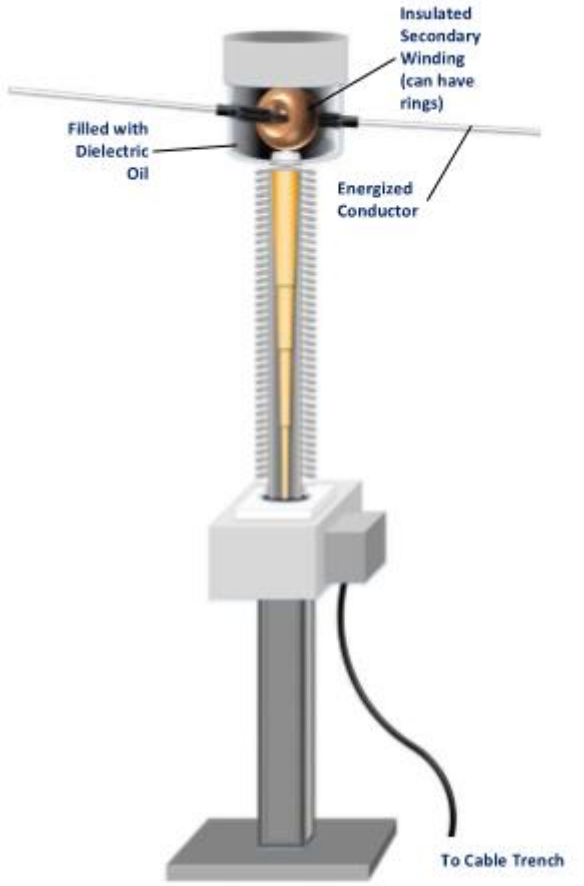

Figure 5: Wire Wound CT Simplified Cutaway [2]

Details

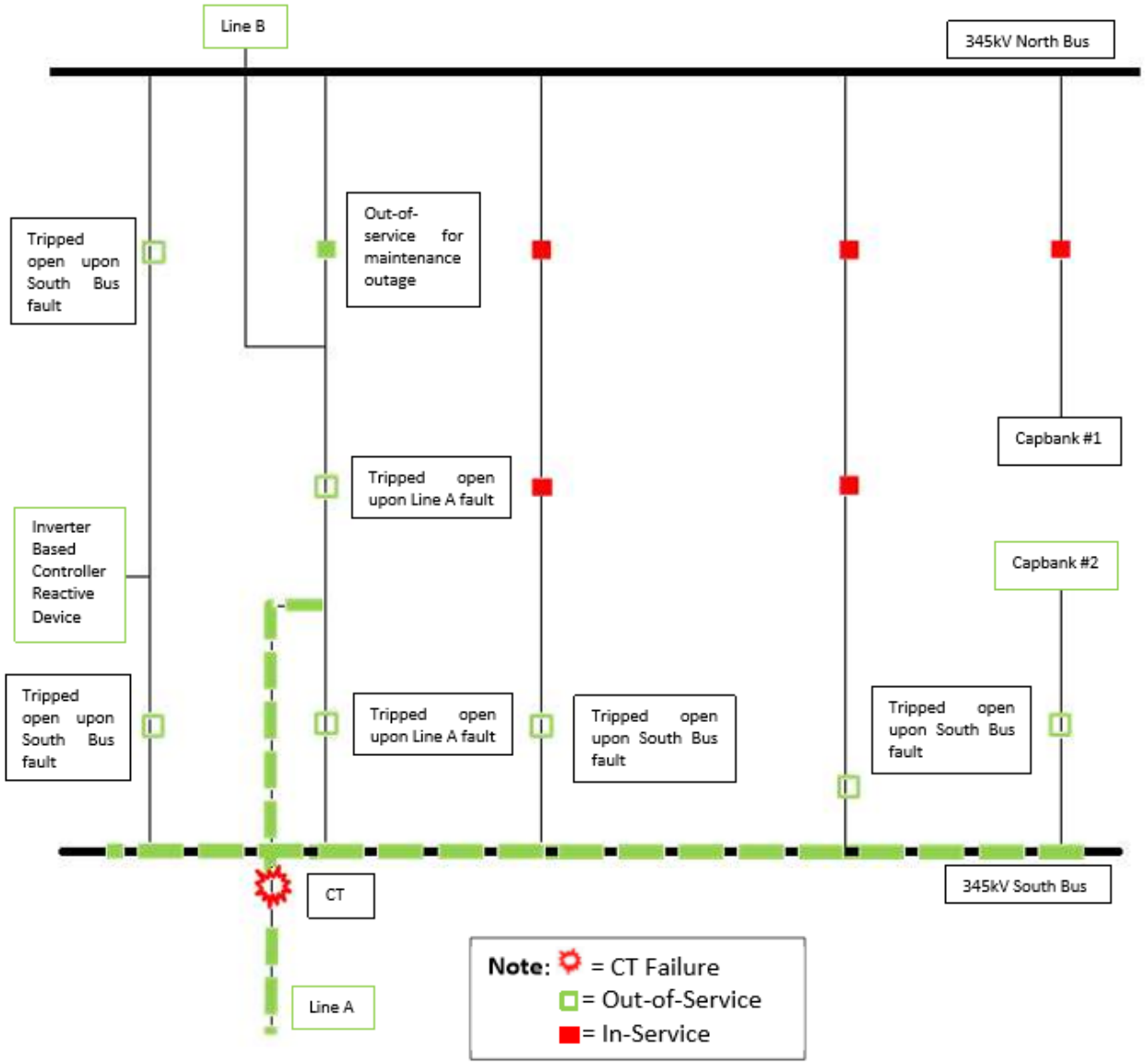

Figure 6: Reference Map [2]

Details

Figure 7: Switchyard Shrapnel after the explosion [2]

Lessons Learned

- Plan was devised to replace all similar CTs
- Entity re-evaluated its maintenance and testing program
- Oil-filled electromagnetic CTs should be evaluated for removal/replacement
- Formalize industry-wide equipment lesson sharing
- Obtain better understanding of failure modes and mechanisms
- Entities should evaluate inspection, maintenance, testing steps and associated frequencies for similar oil-filled equipment
- Use polymer instead of ceramic insulators
- Consider replacement with optical CT

Controlled Islanding due to Wildfire Event

Bulk Power System Operations, Generation Facilities, Transmission Facilities

April 13, 2021

Problem Statement

- Wildfire in a transmission right of way (ROW) on a critical transmission corridor
- Entity was requested to de-energize all transmission lines
- A part of the system was separated and firefighters were assisted

Details

- The fire needed all lines open in system section between area with large amount of conventional generation and a load center
- The main concern was the amount of transfer from the area with generation
  - A higher level would’ve made performing a controlled separation difficult
- Transfers in the corridor were reduced to zero before separation

Corrective Actions

- Utilization of an available HVDC tie, which had frequency controller functionality, helped regulate the frequency of the island
- An energy consumer brought up their demand in the island so that the entity could keep more generators on-line, thereby avoiding startup time delay when system operation returned normal
- Minor updates are required in the internal control document on forest fire response procedure to change the wordings for better clarity

Lessons Learned

- Provide clear instructions for using aerial fire suppression and the de-energization of the corridor
- Inform first responders and large-scale fire response personnel of location of HV equipment
- Improve coordination with firefighters and inspect impacted structures on associated lines
- Collaborate with GOs and GOPs to assess their procedures for operating in islanded mode
- Request that GOs perform the frequency response test on their blackstart capable machines

References

[1] Battery Energy Storage System Cascading Thermal Runaway
https://www.nerc.com/pa/rrm/ea/Lessons%20Learned%20Document%20Library/LL20210301_Battery_Storage_Cascading_Thermal_Runaway.pdf

[2] Catastrophic Failure of 345 kV Oil Filled Metering Current Transformer in a Transmission Substation
https://www.nerc.com/pa/rrm/ea/Lessons%20Learned%20Document%20Library/LL20210302_Catastrophic_Failure_of_345kV_Oil_Filled_Metering_CT.pdf

[3] Controlled Islanding due to Wildfire Event
https://www.nerc.com/pa/rrm/ea/Lessons%20Learned%20Document%20Library/LL20210401_Controlled_Islanding_due_to_Wildfire_Event.pdf

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