



WG C2.21 Report on Lessons learnt from emergencies and near misses

Ben Li, Convener WG C2.21/C2.23



WG C2.21 Report on Lessons Learnt from Recent Emergencies and Blackout Incidents

- Purpose of WG C2.21

Review **recent disturbances and near misses** for lessons learnt, identify main causes and trends, and explore means to detect or prevent the occurrences, and avoid or minimise the impact of such events

- Work Group formed in 08/2010
- Membership: 22 members from 17 countries
- Presented initial findings at 2012 Large Disturbances Workshop
- Providing an update on the WG's findings at this workshop



WG C2.21 Report on Lessons Learnt from Recent Emergencies and Blackout Incidents

■ Activity Overview

- Developed the criteria for events to be analyzed
- Developed main cause categories
- Developed event analysis report template
- Analyzed 18 events, identified main causes and possible remedies
 - Events spanning from 2002 to 2013
 - Include events in Asia, Australia, North America, South America and Europe
- Target to publish a Technical Brochure and Electra Paper at end of 2014
- WG will be disbanded, but a follow-up WG C2.23 will continue to analyze events to expand data base



WG C2.21 Report on Lessons Learnt from Recent Emergencies and Blackout Incidents

- Criteria/type of events to be analyzed:
 - Large-scale, widespread interruptions to transmission system and loads;
 - Declared emergency or confirmed insecure state (can be after the fact);
 - Cascade tripping of transmission/generation facilities;
 - Sustained low-frequency oscillations or frequency excursions with or without frequency scheme operations;
 - Unplanned system splitting or islanding.
- Not concerned with local, distribution level disturbances



WG C2.21 Report on Lessons Learnt from Recent Emergencies and Blackout Incidents

- Root Cause Categories - 10 Groups
 1. Primary equipment failure
 2. Design and application errors
 3. Secondary equipment failure
 4. Communication/control system failure
 5. Natural phenomena (beyond those designed for)
 6. Operator errors
 7. Errors in maintenance
 8. Security related
 9. Inadequate investment and complexity of systems (Lack of Mitigating Measures)
 10. Excessive risk taking and/or inappropriate risk management
 11. Others (any causes not covered by above)
- Additional detail (specificity) under each group
(see technical brochure)



WG C2.21 Report on Lessons Learnt from Recent Emergencies and Blackout Incidents: Main Causes Identified

Main Cause	Primary	Secondary	Total Contributions
Natural phenomena	8	0	8
Communication/control system failure	4	1	5
Design and application errors	4	0	4
Operator errors	4	0	4
Primary equipment failure	3	0	3
Others (Insufficient Training)	2	1	3
Secondary equipment failure	1	1	2
Inadequate investment and complexity of system	2	0	2
Errors in maintenance	1	0	1
Excessive risks or inappropriate risk management	1	0	1
Security related (sabotage, etc.)	0	0	0



WG C2.21 Report on Lessons Learnt from Recent Emergencies and Blackout Incidents

- Key Observations
 - The top 5 main causes:
 - Natural phenomena (8)
 - Communication/control system failure, including lack of situation awareness (5)
 - Design and application errors (4)
 - Operator errors (4)
 - Primary equipment failure (3)
 - Assessment of Control Center Performance
 - Nothing suggests that any system control centers exhibited below expectation performance
- Possible remedies for the 5 main causes, in two fronts:
 - Reduce likelihood of occurrence
 - Contain and minimise impact of disturbance



WG C2.21 Report on Lessons Learnt from Recent Emergencies and Blackout Incidents

Remedies for Events Caused by Natural Phenomena

Measures to Prevent or Reduce Likelihood of Occurrence	Measures to Minimise or Reduce Impact
None specifically identified	• Improve forecast (demand, weather, hydrology, bush fire, resource availability, etc.) capability, i.e. use of advanced models • Increase resilience of transmission equipment • Operate the power system in a more secure mode than normal • Pro-active mobilisation of staff • Better forest/bush fire containment methods



WG C2.21 Report on Lessons Learnt from Recent Emergencies and Blackout Incidents

Remedies for Events Caused by Communication/Control System failure

Measures to Prevent or Reduce Likelihood of Occurrence	Measures to Minimise or Reduce Impact
• Provide full redundancy of EMS, SCADA, voice communication system, etc. • Provide full capability back-up control centers • Perform more rigorous update of EMS database and capability • Provide wide-area view and analysis capability to operators, with frequent exchange of system data with other TSOs	• Deploy resource to enhance observability and controllability, such as by mobilising /dispatching staff to critical stations • Setting up emergency control centre and/or staffing backup control centre



WG C2.21 Report on Lessons Learnt from Recent Emergencies and Blackout Incidents

Remedies for Events Caused by Design and Application Errors

Measures to Prevent or Reduce Likelihood of Occurrence	Measures to Minimise or Reduce Impact
• Implement a special maintenance plan for vital substations • Annual revision of controllers tuning and protection systems tuning at key substations and generating plants • Periodic review of system protection philosophy	None specifically identified



WG C2.21 Report on Lessons Learnt from Recent Emergencies and Blackout Incidents

Remedies for Events Caused by Operator Errors

Measures to Prevent or Reduce Likelihood of Occurrence	Measures to Minimise or Reduce Impact
• Provide sufficient and frequent operator training, with aid of simulators • Provide state-of-art information and control system - SCADA/EMS and emerging WAMS/WACS • Develop on-line equipment diagnostic systems and environment monitoring information systems	• Effective use of system information and controls (SCADA/EMS) and security analysis, including overload relief measures • Effective use of data from on-line equipment diagnostic systems, environment monitoring information systems (storms, lightning's, geomagnetic storms, etc.) • Effective use of System Integrity Protection or Special Protection Schemes • Enhance Inter-TSO coordination to help minimise operator errors



WG C2.21 Report on Lessons Learnt from Recent Emergencies and Blackout Incidents

Remedies for Events Caused by Primary Equipment Failure

Measures to Prevent or Reduce Likelihood of Occurrence	Measures to Minimise or Reduce Impact
• New Investments • Strengthen maintenance program • Strengthen connection requirements to meet certain level of reliability performance	• Installing Special Protection System as a “safety net” to contain potential cascading • Carry adequate replacement equipment inventory to minimise down time.



WG C2.21 Report on Lessons Learnt from Recent Emergencies and Blackout Incidents

■ Next Steps

- Develop a Technical Brochure and an Electra Paper to wrap up lessons learnt so far
 - Target for publication at end of 2014
- Charge a standing work group to:
 - Continue analyzing additional events to enlarge review base
 - Refine root causes and their grouping as appropriate
 - Revise report template as appropriate
- A follow-on WG (C2.23 System Restoration Procedures and Practices) has been formed to:
 - Compare procedures and practices in system restoration; and,
 - Expand the data base on lessons learnt from disturbances



WG C2.21 Report on Lessons Learnt from Recent Emergencies and Blackout Incidents

Questions?



ben@benli.ca

Workshop – “Large Disturbances” – 25 August – Cigre Session Paris 2014