

1. The Template does not state which of potentially conflicting goals of “operating procedures” would be most important:
  - a. Keeping the network from collapsing for as long as possible  
—OR—
  - b. Preventing long-term equipment damage
2. The Template states, “Determining that a geomagnetic disturbance (GMD) is significant enough to warrant the initiation of special operating procedure(s) depends on the geographical location of the power system/equipment in question coincident with the location of the GMD measurement and forecast.” This is a general and qualitative statement that does not specify which geographic locations would be most affected by GMD; rigorous modeling, validated by empirical data, would be required to determine these locations.
3. The Template does not recommend any advance assessment of network vulnerability to GIC, including mathematical modeling of transmission lines predicted to have GIC flows under a range of solar geomagnetic storm intensities.
4. The Template does not recommend any advance assessment or inventory of equipment vulnerable to GIC; for example:
  - a. Transformers that may overheat or vibrate when subjected to GIC over a threshold criteria
  - b. Transformers that may consume reactive power when subjected to GIC over a threshold criteria.
  - c. Relays that may trip when subjected to harmonics over a threshold criteria
5. The Template does not recommend advance modeling of the effects of proposed “Real Time Actions” on network stability. Nonetheless, the Template recommends actions which would affect power generated/transmitted and could also affect network stability:
  - a. “Selective load shedding”
  - b. “System reconfiguration”
  - c. “Remove transformer(s) from service if imminent damage due to overheating”
  - d. “Remove transmission line(s) from service (especially lines most influenced by GMD)”
6. Nearly all major networks have “State Estimators” with simulation capability, but the Template does not recommend use of State Estimators to evaluate “Real Time Actions”, either in real-time or in advance of solar storms.

7. The Template does not recommend instrumentation of transformers and transmission lines for GIC flows, especially at instrumentation points that modeling would predict would experience higher than average GIC flows. Instead, the Template seems to take that approach that whatever instrumentation that is already in place would be sufficient to enable operator action.
8. The Template does not recommend establishment of threshold criteria for operator action based on forecasted or observed solar storm indicators. For example:
  - a. No recommendation for specific operator actions based on common space weather measures such as the K Index
  - b. No recommendation for specific operator actions based on observed dB/dt at publicly available instrumentation points
  - c. No recommendation for specific operator actions based on observed GIC, either in-network, or at publicly available instrumentation points
9. The template does not recommend establishment of threshold criteria for operator action based on network measurements. For example:
  - a. Percent reactive power reserve
  - b. Percent system voltage swing
  - c. Percent MVAR swings
  - d. Amps of GIC (Except for the threshold criterion of “10 Amps” of GIC for transformers where “actual limits are unknown”)
  - e. Percent temperature rise or absolute temperature rise at instrumentation points in transformers
10. The Template states, “Regarding the effects of GIC on transformers, real-time mitigation (after a storm is already in progress) should not be taken based solely on a single indicator (e.g., increased GIC). At least one additional indicator should be monitored to determine if the transformer is actually being adversely affected (e.g., increased MVAR loss, abnormal temperature rise, etc).” There is no analytic or modeled basis for this statement; prudence and mathematical modeling may indicate that a single extreme indicator would be sufficient for action.
11. The Template states, “10 amperes per phase GIC is a good starting point for potential impacts on heavily loaded transformers when actual limits are unknown.” This appears to be a rule of thumb based on past experience. There is no analytic or modeled basis for 10 amperes being a prudent limit. Moreover, no duration is specified for the limit of “10 amperes per phase GIC” when duration of GIC could significantly affect impacts on transformers.
12. The Template states, “DC bias is only a concern if GIC flow exceeds AC current flow.” There are no modeling, analysis, and/or test results to support this statement.

Comments on Operating Procedures Template  
Foundation for Resilient Societies, Thomas Popik

13. The Template states, “Newer transformers may have significantly higher GIC withstand capability if specified at the time of construction.” Specifications for GIC withstand that are untested do not provide sufficient assurance for electric reliability.
14. The Template states, “For vulnerable transformers, the OEM can perform analytical withstand studies to better define a particular design's GIC vs. Time withstand capability.” Analytical withstand studies that are not validated with testing do not provide sufficient assurance for electric reliability.
15. The Template contains no provision for drills, practice, or testing of “operating procedures” in advance of solar storm conditions.