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To: FRCC Operating Entities:

June 3, 2008

Balancing Authorities  
Transmission Operators  
Generator Owners  
Generator Operators

From: FRCC Operating Committee

Re: FRCC Event Analysis Team (FEAT) Interim Recommendations Report

On February 26<sup>th</sup>, 2008 the FRCC Region was impacted by an underfrequency load shedding event that affected customers across multiple companies operating within Florida. In response to the event, the FRCC Operating Reliability Subcommittee (ORS) formed an ad hoc task force of individuals to analyze the circumstances of the event and provide any recommendations on preventing recurrence and document any lessons learned for the Region. The task force, also known as the FRCC Event Analysis Team (FEAT), is made up of FRCC committee, subcommittee and working group leaders as well as subject matter experts from within the Region and from outside the Region including NERC.

On May 29<sup>th</sup>, 2008 the FRCC Operating Committee was presented with the FEAT Interim Recommendations Report regarding the event in order to ensure that identified issue within the FEAT are proactively addressed by the FRCC as the summer operating season nears.

At its conference call meeting on June 2<sup>nd</sup>, the FRCC Operating Committee endorsed the recommendations provided in the attached report and requests that all FRCC operating entities take appropriate actions for their respective organizations with regard to these interim recommendations. Furthermore, the OC requests each entity provide a written response acknowledging receipt of this letter within 30 days. The response should identify any actions taken and/or anticipated to be taken along with actual or scheduled completion dates.

Your prompt response is appreciated. All responses to this request are to be sent to [ocreports@frcc.com](mailto:ocreports@frcc.com).

If you have any questions, please contact Eric Senkowicz at the FRCC. He can be reached at (813) 207-7980 or via email at [esenkowicz@frcc.com](mailto:esenkowicz@frcc.com).

Sincerely,

Ted Hobson, Vice Chair  
FRCC Operating Committee

Attachments

# **FRCC Event Analysis Team Interim Recommendations Report**

**Issued May 29th, 2008**

## **Section 1: Background**

On Tuesday February 26<sup>th</sup>, 2008, the FRCC Bulk Power System experienced a system disturbance initiated by a transmission system element fault which led to the loss of approximately 2300 MW of load concentrated in South Florida, the subsequent loss of approximately 4300 MW of generation within the Region and the operation of approximately 2200 MW of FRCC distribution level underfrequency load shedding, scattered across the peninsular part of Florida and affecting customers across multiple FRCC companies.

The initiating event was a three phase fault on a failed 138 kV switch at a transmission substation located West of Miami, Florida. The disabling of all local protective relay equipment while troubleshooting a transmission switch led to delayed clearing of a fault that developed on the switch. The initial phase to phase fault migrated to a three phase fault and remained on the system for approximately 1.7 seconds.

The depressed voltages in the area of the fault led to protective equipment trips of the two Nuclear generating units at Turkey Point as well as the loss of additional fossil generation at that and other sites in the Region. The delayed clearing of the fault also resulted in a damped, frequency swing with an initial amplitude of approximately +/- 0.6 Hz in South Florida and +/- 0.3 Hz in North Florida. As the frequency swing radiated up the Region, additional generation was tripped off-line due to various factors including those specifically discussed in the accompanying recommendations.

Finally, isolation of the fault and loss of generation led to the rapid damping of the over-frequency perturbation and quickly drove the Region into a local underfrequency condition. Again radiating from South Florida, this perturbation led to the underfrequency load shedding that affected several load serving entities across the Region.

The initial frequency and voltage perturbations were damped within 10 seconds without separation of the FRCC Bulk Power System from the rest of the Eastern Interconnection. All significant impacts related to the event were contained within the FRCC Region, although PMU data collection across the Interconnection provided excellent data on the inter-area oscillations that occurred on the Eastern Interconnection, as a result of the event. Underfrequency load shedding was limited to the first step of the nine potential steps (or set-points) associated with the FRCC Underfrequency Load Shedding Program. A majority of the load shed on underfrequency was restored within an hour of the start of the disturbance. Except for the transmission outages required to clear the initial fault and along with some additional operations being reviewed near the fault, the transmission system within the FRCC remained intact and did not experience any overloads. Restoration efforts were coordinated to ensure an orderly and stable restoration process without subjecting the Bulk Power System to any additional risk.

The FEAT and its sub-teams are continuing to analyze data associated with the event to ensure all aspects of the disturbance are fully understood and substantiated. The final report will include more detailed technical analysis.

In light of the upcoming summer operating season as well as the start of the 2008 hurricane season, the FEAT is providing this Interim Recommendations Report so that the FRCC Operating Committee can be proactive in addressing some of the potential lessons learned so far by identifying potential areas for improvement. This will ensure that the FRCC Regional response to disturbances in the future is as efficient and appropriate as possible. Based on the current status of the analysis and data reviewed to date, the FEAT submits the following recommendations for consideration by the FRCC Operating Committee (Recommendations are summarized in Section 2 with additional discussion provided in Section 3):

## **Section 2: Recommendations Summary**

### **Recommendation 1:**

It is recommended that the FRCC OC request that all FRCC companies re-affirm two FRCC Handbook procedure documents, related to the event and restoration, with all FRCC control room personnel involved in the day-to-day operation of the FRCC transmission system as well as all system protection field personnel involved with installation or maintenance of transmission system protection within the FRCC. The two procedures are listed below:

- 1) *Regional Voice Communications Procedure*
- 2) *Relay Outage Coordination Procedure*

### **Recommendation 2:**

It is recommended that the FRCC OC direct that the FRCC SOS develop an independent learning activity on the *Regional Voice Communications Procedure* and administer the resultant learning activity to all FRCC Control Room operators within two months of development.

### **Recommendation 3:**

It is recommended that the FRCC OC issue an alert to all FRCC GOs/GOPs who own or operate large frame combustion turbines and request that the GOs/GOPs undertake a review of the design and settings for auxiliary and plant distribution under-voltage protection to ensure these settings appropriately coordinate with both: (1) the generator protection settings as described in the FRCC Handbook document, *FRCC Generator Coordination Requirements*, dated November 2001; and (2) the specific equipment's protection requirements.

### **Recommendation 4:**

It is recommended that the FRCC OC issue an alert to all FRCC GOs/GOPs who own or operate large frame combustion turbines, to be aware of potential turbine combustor lean blowout under certain frequency excursions. We recommend that individual GOs/GOPs consult with appropriate combustion turbine manufacturers to understand their vulnerabilities with regard to lean blowout from a system frequency disturbance. In the absence of a frequency rate of change response criteria in the FRCC Generator Coordination Requirements document (dated November 2001 - FRCC Handbook), the FEAT also recommends that the FRCC OC investigate the need for establishing a criteria.

### **Recommendation 5:**

It is recommended that the FRCC OC request that all FRCC Transmission Operators (TOPs) review their internal relay maintenance practices and procedures to ensure that removal of any relay protection includes an evaluation of the impact on system reliability. Where impacts are identified, procedures should include a system operations approval step as well as a notification to the FRCC Reliability Coordinator step (see Recommendation 1 for discussion on ***Relay Coordination Procedure***):

- 1) It is specifically recommended that FPL enhance their post-event "Interim Measures", to include explicit steps to require that any protection system maintenance performed under an approved Relay Maintenance Request that includes removal of any relay protection, be evaluated for impacts to the system reliability by either FPL or the FRCC RC.

**Recommendation 6:**

It is recommended that the FRCC OC direct that the FRCC ORS expedite a review and update \* the following FRCC handbook documents:

- 1) *FRCC Restoration Plan (Blackout and Blackstart)*
- 2) *Underfrequency Actions Due to Whole or Partial Islanding of the Florida Transmission System*
- 3) *Generation Deficiency with Separation*
- 4) *Restoration*

\* The FEAT has specific recommendations on the revision of these documents as detailed in Section 3.

### Section 3: Discussion

#### **Recommendation 1 - Discussion:**

Although the initiating cause of the event is still under review by the Field Personnel Actions Review Team (FPART), a sub-team of the FEAT, the preliminary cause is currently linked to the disabling, by a relay field engineer, of all local protective relay equipment while troubleshooting an associated 138 kV switch. The FRCC Handbook requires that “each system operator shall notify the FRCC Security Coordinator when a protective relay or equipment failure that reduces system reliability occurs.” Although the FEAT has not come to any conclusions regarding this part of the analysis, the nature of this procedure and its importance warrants that it be re-affirmed by the FRCC OC to ensure that FRCC system operators and relay field personnel understand the intent and importance of the procedure when performing maintenance on FRCC bulk power system elements.

It is therefore recommended that the FRCC OC request that all appropriate FRCC companies re-affirm the FRCC Handbook procedure document, **Relay Outage Coordination Procedure**, with all FRCC control room personnel involved in the day-to-day operation of the FRCC transmission system. Additionally, the document should also be re-affirmed and reviewed with all system protection field personnel involved with installation or maintenance of transmission system protection, within the FRCC.

The Restoration Response Team (RRT), a sub-team of the FEAT, which has been tasked with evaluating the FRCC Region’s restoration response to the event, has determined that the following interim recommendations provide immediate opportunities for improvement of the Region’s ability to respond to any future disturbances.

Although the FRCC Reliability Coordinator (RC) and the operating entities under its reliability authority, responded well during the initial assessment and the transition to the system and load restoration activities, considering the magnitude of the event, the FRCC Hotline communications between the RC and the various entities lacked consistent use of “three-way” communications protocol (as described in the FRCC Handbook), during some of the phases of assessment and restoration.

It is therefore recommended that the FRCC OC request that all FRCC companies re-affirm the FRCC Handbook procedure document, **Regional Voice Communications Procedure** with all FRCC control room personnel involved in the day-to-day operation of the FRCC transmission system as well as all system protection field personnel involved with installation or maintenance of transmission system protection within the FRCC.

#### **Recommendation 2 - Discussion:**

It is recommended that the FRCC OC direct that the FRCC SOS develop an independent learning activity (ILA) on the **Regional Voice Communications Procedure** and administer the learning activity to all FRCC Control Room operators within two months of development. The procedure contains important communication protocols as described in the discussion on Recommendation 1.

The development and administration of an evaluated learning activity will help ensure that an appropriate level of training and awareness has been met by the system operators and will also re-enforce the OC's affirmation requested in Recommendation 1. The development of the ILA will also provide an added incentive for Regional system operator training coordinators to consistently administer the **Regional Voice Communications Procedure** since, by virtue of being an ILA, it can also be applied to meeting system operator re-certification training requirements.

### **Recommendation 3 and 4 - Discussion:**

During our preliminary analysis of the event, the Generator Response Team (GRT) concluded that most of the generators tripped from the plants' response to either the low voltage transient (accounted for six turbine generator trips at two sites) or frequency fluctuation (accounted for six turbine generator trips at five sites) associated with the event. It appears at this point, that while these units were operated in accordance with all applicable standards and guidelines, this particular event subjected these generating units to conditions not contemplated or addressed by present standards and guidelines, but which may have been survivable by some of these turbine generators had these conditions been recognized and addressed by the engineers or designers. Further, it is the belief of the GRT that early awareness of these two issues may enable Generator Owners (GO) and/or Generator Operators (GOP) avoid similar performance in the future. Although this information is preliminary and subject to further analysis, we submit the following descriptions below and recommend that this information be provided to the FRCC GO and GOP community in order to expeditiously increase the situational awareness regarding potential generator response behaviors to system perturbations.

#### **Generator Auxiliary Bus Under-voltage Trips**

Six large frame combustion turbine-generator trips were initiated by plant protective devices on the auxiliary bus or a plant distribution bus that was determined to be set and operating "as designed". These auxiliary protection devices actually caused the auxiliary equipment to trip which in turn resulted in the units to trip for a low voltage transient. Due to the severity and duration of the voltage transient in south Florida, the affected Turkey Point turbine-generators would not have been expected to stay online regardless of auxiliary bus protection settings.

With respect to the auxiliary or plant distribution bus protection settings, the FEAT wants to provide some direction as to how the settings should be set. However, currently there is no specific criteria for these settings to point to, absent what is provided in the FRCC Handbook as generator protection coordination requirements. Therefore, absent any auxiliary protection criteria, the generator protection coordination information in the handbook appears to be the best data point we have to start addressing the potential operational issues identified above.

It is therefore recommended that the FRCC OC issue an alert to all FRCC GOs/GOPs who own or operate large frame combustion turbines and request that the GOs/GOPs undertake a review of the design and settings for auxiliary and plant distribution under-voltage protection to ensure these settings appropriately coordinate with both: (1) the generator protection settings as described in the FRCC Handbook document, *FRCC Generator Coordination Requirements*, dated November 2001; and (2) the specific equipment's protection requirements.



### **Frequency Related Combustion Turbine Trips**

Six large frame combustion turbines tripped during the event when the system frequency went high (maximum 60.64 Hz as measured at Turkey Point and 60.23 Hz as measured at Duval). Preliminary analysis indicates that the trips were due to “lean blowout” of one or more combustors. For NO<sub>x</sub> control these combustors normally run very lean. The higher compressor speeds combined with governor-commanded reduced fuel flow during the high frequency transient resulted in the “blowouts”. It is important to note that the rate of change of frequency (df/dt) experienced during the event was critical in turbine-generators response. Currently, existing guidelines for generator coordination address magnitude and duration of frequency excursions, but they do not address rate of change.

It is therefore recommended that the FRCC OC issue an alert to all FRCC GOs/GOPs who own or operate large frame combustion turbines, to be aware of potential turbine combustor lean blowout under certain frequency excursions. We recommend that individual GOs/GOPs consult with appropriate combustion turbine manufacturers to understand their vulnerabilities with regard to lean blowout from a system frequency disturbance. In the absence of a frequency rate of change response criteria in the FRCC Generator Coordination Requirements document (dated November 2001 - FRCC Handbook), the FEAT also recommends that the FRCC OC investigate the need for establishing a criteria.

### **Recommendation 5 – Discussion**

As noted in the discussion of Recommendation 1 above, although the initiating cause of the event, along with the associated processes are still under review by the Field Personnel Actions Review Team (FPART), based on the review to date it is likely that the initiating event and resulting remote clearing of the fault was not postulated as a potential outcome nor is it likely that it was modeled as such in the FRCC Reliability Coordinator (RC) Contingency Analysis application. Although the FEAT has not reached any conclusions regarding this part of the analysis, the importance of understanding the impact of relay protection systems and how they impact the (N-1) operating criteria warrants that system operations personnel must be made aware of any protection changes that impact the criteria. System operations should also perform an evaluation of any removal of relay protection on their systems, especially when removal of that protection increases the number of elements involved with the clearing mode of a faulted transmission element(s) (or increases the total clearing time).

It is therefore recommended that the FRCC OC request that all FRCC Transmission Operators (TOPs) review their internal relay maintenance practices and procedures to ensure that removal of any relay protection includes an evaluation of the impact on system reliability. Where impacts are identified, procedures should include a system operations approval step as well as a notification to the FRCC Reliability Coordinator step (see Recommendation 1 for discussion on ***Relay Coordination Procedure***).

Specifically, the FPART was able to perform a detailed review of the “Interim Measures” put in place by FPL as a result of FPL’s investigation into the “human error” aspect of the initiating cause of the event. The FPART has concluded that these “Interim Measures” are effective and appropriate, however, the FPART did identify an area where these “Interim Measures” can be enhanced by adding explicit steps that require system operation supervision to evaluate and



approve relay maintenance activities and removal of relay protection with regard to potential impacts on system reliability and analysis software (i.e. EMS Contingency Analysis packages).

### **Recommendation 6 - Discussion:**

As noted in Recommendation 1, the Restoration Response Team (RRT) sub-team of the FEAT which has been tasked with evaluating the FRCC Region's restoration response to the event, has determined that the following interim recommendations provide immediate opportunities for improvement of the Region's ability to respond to any future disturbances.

In reviewing the event response and restoration the RRT noted that due to the peninsular nature of Florida that future UFLS events requiring restoration are more likely than any other type of restoration activities. Although the FRCC Handbook contains procedures that address the different restoration scenarios, they are not currently linked in a single document nor do they use a consistent format. Based on the synergies of having all "restoration" type procedures in a single cohesive document as well as the benefit to system operations personnel, the RRT determined that the following FRCC Handbook documents should be reviewed and updated on an expedited basis:

- 1) *FRCC Restoration Plan (Blackout and Blackstart)*
- 2) *Underfrequency Actions Due to Whole or Partial Islanding of the Florida Transmission System*
- 3) *Generation Deficiency with Separation*
- 4) *Restoration*