NERC
NORTH AMERICAN ELECTRIC RELIABILITY COUNCIL

NERC SPCTF Assessment of Standards:

- **PRC-006-0 – Development and Documentation of Regional UFLS Programs**
- **PRC-007-0 – Assuring Consistency with Regional UFLS Program Requirements**
- **PRC-009-0 – UFLS Performance Following an Underfrequency Event**

March 8, 2007

A Technical Review of Standards

Prepared by the

System Protection and Controls Task Force

of the

NERC Planning Committee

Table of Contents

This report was approved by the Planning Committee on March 21, 2007, for forwarding to the Standards Committee.

Introduction

When the original scope for the System Protection and Control Task Force (SPCTF) was developed, one of the assigned items was to review all of the existing PRC-series Reliability Standards, to advise the Planning Committee of our assessment, and to develop Standards Authorization Requests, as appropriate, to address any perceived deficiencies.

This report presents the SPCTF's assessment of three of the four PRC standards pertaining to Underfrequency Load Shedding (UFLS) Programs. These standards address development and documentation of the UFLS program (PRC-006-0), consistency of the UFLS program with regional requirements (PRC-007-0), and evaluation of the UFLS program performance following an event (PRC-009-0).

Executive Summary

The review of these three standards has been grouped into one report because these three standards apply to the Planning functions associated with developing, documenting, ensuring consistency, and evaluating performance of UFLS programs. These functions are separate from the Protection function in PRC-008-0 for maintaining UFLS program equipment. Accordingly, the SPCTF recommends that these three standards be combined into one standard and reclassified as a Planning standard.

The SPCTF comments are divided into four sections. The first section contains general comments applicable to all three standards and the three subsequent sections contain comments specific to each standard. These comments are applicable regardless of whether these three standards remain independent or are combined. The SPCTF recommendations also show the comments submitted by the Federal Energy Regulatory Commission in its October 20, 2006 Notice of Proposed Rulemaking for adoption of NERC Standards (Docket Number RM06-16-000).

The SPCTF comments focus on three primary areas:

- Modify the applicable entities to ensure that only one entity is responsible for each requirement for each UFLS program.
- Provide additional requirements for development of the UFLS programs to incorporate lessons learned from the August 14, 2003 blackout investigation and to ensure interregional coordination of UFLS programs within an interconnection.
- Distinguish between the post-event assessment requirements for determining correct equipment operation versus assessing effectiveness of the program.

Issues Common to All Three Standards

Purpose

Provide last resort system preservation measures by implementing an Under Frequency Load Shedding (UFLS) program.

All four UFLS standards (PRC-006 through PRC-009) have the same stated purpose. The purpose for each should be specific to the aspect of the UFLS Program that is covered by the Standard. The purpose statement for each standard should be revised or as the SPCTF recommends below, combine the three planning related standards and revise the purpose statement in PRC-008.

The three UFLS standards that are the subject of this report relate to development and documentation, assuring consistency with regional requirements, and verifying performance of the UFLS program. These aspects of the UFLS program typically are addressed by the Planning function. These standards should be reclassified as a Planning standard and consideration should be given to combining all of the Planning related aspects into one standard.

The SPCTF has provided for consideration a draft Purpose for a combined standard addressing all of the Planning related aspects of UFLS program.

Provide requirements for development and documentation of UFLS programs coordinated between regions within an interconnection, ensuring UFLS programs are implemented consistent with regional requirements, and ensuring assessment and evaluation of UFLS programs following system events.

Requirements

A number of requirements throughout the three standards require entities to provide documentation to their Regional Reliability Organization on request. All such occurrences should be modified to “their Regional Reliability Organization or NERC.”

Assessment of PRC-006-0

Within this section of this report, the SPCTF offers comments specific to PRC-006-0. These comments are equally valid if the three subject standards were combined into one.

Applicability

4.1	Regional Reliability Organization

The SPCTF supports maintaining the Regional Reliability Organization as the applicable entity for this standard. While the SPCTF recognizes the FERC desire to have all standards applicable to users, owners, and operators of the bulk power system, UFLS programs inherently require coordination across and between regions and SPCTF believes this role is most effectively provided by the Regional Reliability Organization. If there is a need to assign additional entities responsibility as suggested by FERC, the

applicability and requirements should be modified to require that the Planning Coordinators develop and document the UFLS program under the coordination of the Regional Reliability Organization.

Requirements

R1

R1. Each Regional Reliability Organization shall develop, coordinate, and document an UFLS program, which shall include the following:

R1.1. Requirements for coordination of UFLS programs within subregions, Regional Reliability Organization and, where appropriate, among Regional Reliability Organizations.

Boundaries of islands that form during major system disturbances are based on the physical characteristics of the system and the operational conditions at the time of the disturbance. Islands form based on how generators respond as cohesive groups and do not respect company, political, or regional boundaries. The standard should require that UFLS programs always are coordinated between Regional Reliability Organizations when more than one Regional Reliability Organization exists within an interconnection.

The standard should include a requirement that the UFLS program include a clearly stated design objective. For example, a clearly stated design objective is: "The UFLS program will prevent frequency from dropping below 57.5 Hz and will recover frequency to above 58.5 Hz in 10 seconds and above 59.5 Hz in 30 seconds while the system is 25 percent deficient in resources to meet load demand. Frequency decline will be arrested for an initial rate of frequency decline of 2 Hz/sec or less."

The design objective may vary between interconnections (or between regions) based on characteristics of the system (e.g. inertia, maximum generation deficiency, etc.). The design values should have technical justification and consider the generator underfrequency trip points.

R1. Each Regional Reliability Organization shall develop, coordinate, and document an UFLS program, which shall include the following:

R1.2. Design details shall include, but are not limited to:

R1.2.1 Frequency set points.

R1.2.2 Size of corresponding load shedding blocks (% of connected loads.)

R1.2.3 Intentional and total tripping time delays.

R1.2.4 Generation protection.

R1.2.5 Tie tripping schemes.

R1.2.6 Islanding schemes.

R1.2.7 Automatic load restoration schemes.

R1.2.8 Any other schemes that are part of or impact the UFLS programs.

The first three items (R1.2.1 through R1.2.3) are design aspects of the UFLS program, while the last five items (R1.2.4 through R1.2.8) relate to other protections or control systems with which the UFLS

program must be coordinated. SPCTF recommends inserting the words "Coordination with" at the beginning of requirements R1.2.4 through R1.2.8.

Additional Requirement Under R1.2

SPCTF also recommends an additional requirement under R1.2:

R1.2.9 Coordination with Under-Voltage Load Shedding (UVLS) programs.

Additional Items to be Considered

The standard should include the following additional items to be considered in the design of the UFLS program:

- A requirement that when voltage supervision is utilized on UFLS program relays, the basis of determining the undervoltage supervision setpoint shall be documented. The undervoltage supervision setpoint of the UFLS relays shall be modeled in assessments of the UFLS program to ensure that the program operates in accordance with the design objective.
- Requirements that the UFLS program design studies include:
    - Identification of potential islands that may form crossing regional boundaries. Where such islands are identified, coordination with the affected Regional Reliability Organization should be required to ensure the effectiveness of the combined regional UFLS programs in arresting and recovering the frequency within the island.
    - Simulation of initiating disturbances and non-coincident tripping of circuits across the island boundary.
    - Sensitivity studies to assess the impact of unexpected load or generation loss near the electrical center of system swings during island formation.
    - Assessment should be made of coordination between the UFLS program and tripping of generators during underfrequency conditions. Generator trip points should be modeled in assessments of the UFLS program to ensure that the program operates in accordance with the design objective.

R2

> **R2.** The Regional Reliability Organization shall provide documentation of its UFLS program and its database information to NERC on request (within 30 calendar days).

The Standard should be more explicit in defining what type of documentation is required.

R3

> **R3.** The Regional Reliability Organization shall provide documentation of the assessment of its UFLS program to NERC on request (within 30 calendar days).

The Standard should be more explicit in defining what type of documentation is required.

The standard should explicitly require that the Regional Reliability Organization have evidence that the UFLS program has been reviewed with adjacent Regional Reliability Organizations and their concurrence has been obtained that the regional UFLS programs are effectively coordinated to arrest and recover the frequency within interregional islands.

Measures

The measures should be modified consistent with the recommended modifications to the requirements above.

Assessment of PRC-007-0

Within this section of the report the SPCTF offers comments specific to PRC-007-0. These comments are equally valid if the three subject standards were combined into one.

Applicability

4.1	Transmission Owner required by its Regional Reliability Organization to own a UFLS program.
4.2	Transmission Operator required by its Regional Reliability Organization to operate a UFLS program.
4.3	Distribution Provider required by its Regional Reliability Organization to own or operate a UFLS program.
4.4	Load-Serving Entity required by its Regional Reliability Organization to operate a UFLS program.

Only one entity can be responsible for ensuring consistency of each program with the regional requirements. The standard should be applicable only to those Functional Model entities that own a UFLS program. The owner is the entity with the direct responsibility and ability to ensure that the program it owns meets the regional requirements. The Transmission Operator and Load-Serving Entity should be removed from the Applicability section.

Requirements

R2

R2. The Transmission Owner, Transmission Operator, Distribution Provider, and Load-Serving Entity that owns or operates a UFLS program (as required by its Regional Reliability Organization) shall provide, and annually update, its underfrequency data as necessary for its Regional Reliability Organization to maintain and update a UFLS program database.

As stated under the applicability section, only one entity can be responsible for providing data for each UFLS program. The owner of the UFLS program is the appropriate entity to provide this data. There is no role for the Transmission Operator or Load-Serving Entity to fulfill in this requirement.

R3

R3.	The Transmission Owner and Distribution Provider that owns a UFLS program (as required by its Regional Reliability Organization) shall provide its documentation of that UFLS program to its Regional Reliability Organization on request (30 calendar days).

The Standard should be more explicit in defining what type of documentation is required. Specifically, how is the documentation required under this requirement different than the documentation required under R2?

The Standard should be modified to state that the "Transmission Owner and Distribution Provider that owns an UFLS program shall provide its documentation of that UFLS program to its Regional Reliability Organization and/or NERC on request (30 calendar days)

Measures

The measures should be modified consistent with the recommended modifications to the requirements above.

Assessment of PRC-009-0

Within this section of the report the SPCTF offers comments specific to PRC-009-0. These comments are equally valid if the three subject standards were combined into one.

Applicability

4.1	Transmission Owner required by its Regional Reliability Organization to own a UFLS program.
4.2	Transmission Operator required by its Regional Reliability Organization to operate a UFLS program.
4.3	Load-Serving Entity required by its Regional Reliability Organization to operate a UFLS program.
4.4	Distribution Provider required by its Regional Reliability Organization to own or operate a UFLS program.

Only one entity can be responsible for assessing the performance of each UFLS program. The standard should be applicable only to those Functional Model entities that own a UFLS program. The owner is the entity with the direct responsibility and ability to assess performance of the UFLS program equipment following a system event. The Transmission Operator and Load-Serving Entity should be removed from the Applicability section.

The Regional Reliability Organization should be added as an applicable entity for this standard. The rationale for this recommendation is provided below under the discussion of Requirements.

Requirements

R1

R1. The Transmission Owner, Transmission Operator, Load-Serving Entity, and Distribution Provider that owns or operates a UFLS program (as required by its Regional Reliability Organization) shall analyze and document its UFLS program performance in accordance with its Regional Reliability Organization's UFLS program. The analysis shall address the performance of UFLS equipment and program effectiveness following system events resulting in frequency excursions below the initiating set points of the UFLS program. The analysis shall include, but not be limited to:

R1.1. A description of the event including initiating conditions.

R1.2. A review of the UFLS set points and tripping times.

R1.3. A simulation of the event.

R1.4. A summary of the findings.

This requirement includes two distinct tasks that should be broken into separate requirements. Assessing the performance of the equipment (i.e., whether it operated as designed for the conditions observed during the event) is distinctly different from an assessment of whether the UFLS program design is adequate (i.e., whether operation of the UFLS program as designed is adequate to meet the program objectives with regard to arresting frequency above a given threshold and recovering frequency within a specified time).

The UFLS program owner is the appropriate entity to assess the performance of equipment during the event. The UFLS program owner is the entity best equipped to assess operation of the relay and the amount of load shed, and collect load shedding data for an event.

As the entity responsible for developing the UFLS program requirements for the region, the Regional Reliability Organization is the most appropriate entity to perform simulations, assess the overall system performance, and if necessary recommend modifications to the UFLS program requirements.

This requirement should be revised to clarify that UFLS relay operation on an isolated portion of the distribution system due to factors such as the presence of distributed generation or motor deceleration[1] is not within the scope of this Standard.

R2

R2. The Transmission Owner, Transmission Operator, Load-Serving Entity, and Distribution Provider that owns or operates a UFLS program (as required by its Regional Reliability Organization) shall provide documentation of the analysis of the UFLS Program to the Regional Reliability Organization and NERC on request 90 calendar days after a system event.

For the reasons sited above for R1, this requirement also should be divided into two separate requirements.

1 Note on potential misoperation — That type of UFLS relay operation should be documented and analyzed as an unintentional relay operation (misoperation) and such events should be covered under PRC-004 — Analysis and Mitigation of Transmission and Generation Protection Misoperations.

The first requirement should be for the Transmission Owner and Distribution Provider that own an UFLS program (as required by its Regional Reliability Organization) to provide documentation of the analysis of the performance of UFLS equipment to its Regional Reliability Organization and NERC on request after a UFLS system event.

The second requirement should be for the Regional Reliability Organization to provide documentation of the analysis of the effectiveness of the UFLS program to NERC on request after an UFLS system event.

The requirement for performing the analysis within 90 days should be removed because it is not reasonable. The time required to perform the analysis varies with the severity and scope of the event, and can often take more than a year.

Measures

The measures should be modified consistent with the recommended modifications to the requirements above.

FERC Assessment of PRC-006-0, PRC-007-0, and PRC-009-0

In the October 20, 2006 Notice of Proposed Rulemaking for adoption of NERC Standards (Docket Number RM06-16-000), the Federal Energy Regulatory Commission commented on these three standards.

The Commission identified two concerns with PRC-006-0. The first is that a Regional Reliability Organization is identified as the sole applicable entity, and the second is that the standard lacks specificity for an integrated and coordinated approach for the protection systems for generators, transmission lines, and UFLS and UVLS programs.

SPCTF believes that the recommended modifications above address both of the issues. On the first issue the SPCTF believes that in the case of defining the UFLS program requirements the inherent need for coordination makes it appropriate for the Regional Reliability Organization to serve as the applicable entity. As noted above, additional applicable entities such as the Planning Coordinators could be assigned responsibility under the coordination of the Regional Reliability Organization. On the second issue, SPCTF believes the recommended modifications to requirement R1.2 address the concerns raised by the Commission.

The Commission identified no substantive issues with PRC-007-0 and proposed to approve PRC-007-0 as mandatory and enforceable.

The only issue identified by the Commission with PRC-009-0 is that there are no similar reporting requirements for Under-Voltage Load Shedding (UVLS) operation in the proposed Reliability Standards that are associated with UVLS programs. The Commission proposed to approve PRC-009-0 as mandatory and enforceable.

Conclusion and Recommendation

The SPCTF recommends that the existing draft Standards Authorization Request that is included in the "Draft Reliability Standards Development Plan: 2007–2009" be modified to include the observations from the SPCTF assessment of PRC-006-0, PRC-007-0, and PRC-009-0.

The SPCTF also recommends that these three standards be combined into one standard and be re-classified as a Planning standard, since the functions defined in these three standards are primarily carried out through the Planning function.

Appendix A — System Protection and Control Task Force

Charles W. Rogers
Chairman / RFC-ECAR Representative
Principal Engineer
Consumers Energy Co.

W. Mark Carpenter
Vice Chairman / ERCOT Representative
System Protection Manager
TXU Electric Delivery

John Mulhausen
FRCC Representative
Manager, Design and Standards
Florida Power & Light Co.

Joseph M. Burdis
ISO/RTO Representative
Senior Consultant / Engineer, Transmission and Interconnection Planning
PJM Interconnection, L.L.C.

William J. Miller
RFC-MAIN Representative
Consulting Engineer
Exelon Corporation

Deven Bhan
MRO Representative
Electrical Engineer, System Protection
Western Area Power Administration

Philip Tatro
NPCC Representative
Consulting Engineer
National Grid USA

Philip B. Winston
SERC Representative
Manager, Protection and Control
Georgia Power Company

Dean Sikes
SPP Representative
Manager - Transmission Protection, Apparatus, & Metering
Cleco Power

David Angell
WECC Representative
T&D Planning Engineering Leader
Idaho Power Company

W. O. (Bill) Kennedy
Canada Member-at-Large
Principal
b7kennedy & Associates Inc.

John L. Ciufo
Canada Member-at-Large
Manager Reliability Standards (P&C/Telecom)
Hydro One, Inc.

Jim Ingleson
ISO/RTO Representative
Senior Electric System Planning Engineer
New York Independent System Operator

Evan T. Sage
Investor Owned Utility
Senior Engineer
Potomac Electric Power Company

James D. Roberts
Federal
Transmission Planning
Tennessee Valley Authority

Tom Wiedman
NERC Consultant
Wiedman Power System Consulting Ltd.

Henry (Hank) Miller
RFC-ECAR Alternate
Principal Electrical Engineer
American Electric Power

Baj Agrawal
WECC Alternate
Principal Engineer
Arizona Public Service Company

Michael J. McDonald
Senior Principal Engineer, System Protection
Ameren Services Company

Jonathan Sykes
Senior Principal Engineer, System Protection
Salt River Project

Fred Ipock
Senior Engineer - Substations & Protection
City Utilities of Springfield, Missouri

W. O. (Bill) Kennedy
Canada Member-at-Large
Principal
b7kennedy & Associates Inc.

Bob Stuart
Director of Business Development, Principal
T&D Consultant
Elequant, Inc.