Agenda
Essential Reliability Services Working Group Face to Face Meeting

May 17, 2017 | 12:00 – 5:00 p.m. Eastern Time
May 18, 2017 | 8:00 a.m. – 12:00 p.m. Eastern Time

Meeting Location:
NERC Offices
3353 Peachtree Road NE
Suite 600, North Tower
Atlanta, GA 30326

In Person Participation: **MEETING REGISTRATION**
Remote Participation: Click on the registration link below for WebEx and receive access to the conference

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WebEx May 17th Meeting	**WebEx May 18th Meeting**
WebEx URL: Join WebEx meeting	WebEx URL: Join WebEx meeting
Meeting number (access code): **738 405 295**	Meeting number (access code): **739 503 451**
Meeting password: **ERSWG2017**	Meeting password: **ERSWG2017**

NERC On-Site Contact: Nicole Segal, nicole.segal@nerc.net, (404)-446-2563

Agenda Items

Wednesday, May 17, 2017 (Lunch Provided)

12:00 – 1:00 PM Working Lunch - Provided

1:00 – 1:30 PM

1. **Administrative**
   a. Welcome and Introductions –*Bob Cummings, NERC Staff*
   b. NERC Antitrust Compliance Guidelines – *Nicole Segal, NERC Staff*
   c. Facilities & Safety Briefing – *NERC Staff*
   d. Chairs Reports– *Brian Evans-Mongeon, Todd Lucas ERSWG Co-Chairs*
      i. Review March 8, 2017 Meeting Minutes –
      ii. Review latest roster – any changes?
      iii. Review Agenda
      iv. Next meeting confirmation/Future Meetings –
         (1) June 7, 2017 – 12 PM to 5 PM,
         (2) San Diego, California

1:30-3:30 PM

2. **M1 – M4 Frequency Response Measures Update – Frequency Subgroup & Ganesh Velummylum**
   a. Updates from Resources Subcommittee's April meeting
      i. M4 metrics
      ii. Evaluate and provide recommendation for needed adjustments to Resource Contingency Criteria values used in M2 analysis
   b. Update on development of forward looking M1-M4 analysis methods
      i. Refinement of modeling efforts for f response analysis

3:30 – 3:45 PM Break

3:45 – 4:30 PM

3. **M7 - Reactive Capability on the System – Voltage Subgroup**
   a. Provide materials for June standing committee meetings in regards to the retirement of M7 and the promotion of the Reliability Guideline for Reactive Planning
   b. Do we need more than the February 2017 Measure 7 Analysis Report from SAMS?

4:30 – 5:00 PM

4. **Group Discussion on other ideas and suggestions**
   a. Opportunity for participants to hit on relevant subject matters and or new discussion points.
   b. 2018 IEEE PES – T&D Conference Paper Panel Session- **Ning Kang, Argonne National Laboratory**

Thursday, May 18, 2017

8:00 – 9:00 AM

5. **M6 BA Level Net Demand Ramping Variability – Ramping Subgroup**
   a. Continue vetting process for historical CPS1 analysis (M6) and follow up with BAs identified in initial screen
   b. Vet the initial screen and forward looking analysis methods as outlined in the 2016 White Paper, to include process described in Appendix G
   c. Develop recommendations for inclusion of ramping assessments in LTRA (coordination with RAS)
   d. 9:00 –10:30 AM
6. **Distributed Energy Resources – DER Subgroup**
   a. Develop draft SAR to modify MOD-032 to replace LSE with DP.
   b. Update on draft technical brief/reliability guide to provide guidance on DER data needs for TPs, BAs, & TOPs/RCs.

c. Discussion on T-D interface topics (in reference to existing DER Final Report documentation)

i. CA ISO Lorenzo questions regarding short term forecasting of DER (TBD)

10:30 – 10:45 AM Break

10:45 –11:30 AM

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7. **Policy Subcommittee – Policy Subgroup**

a. Provide updates on reaching out to policy makers

11:30 AM – 12:00 PM

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8. **Other Measures, Open Issues and New Items**

a. Round table and parking lot discussion

b. Reminder next meeting information

12:00 PM

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ERS Measures M1-M4 Forward Looking Process Document

NERC Essential Reliability Services Working Group (ERSWG) Frequency Sub-Group March 2017

1. Introduction

This short white paper provides the technical background and direction for assessing the Essential Reliability Services (ERS) Measures M1-M4 (frequency measures). This discussion focuses on the forward-looking analysis for the measures, which will complement the historical data analysis for the same measures.
At the high level forward looking analysis for M1-M4 requires:

1. A dynamic model for an interconnection, for the case reflective of the future low load/high renewable conditions (3-5 years out). The model should be benchmarked against historic generation trip events.
2. Synchronous generation in the model should be realistically dispatched around low load/high renewable conditions.

From synchronous generation commitment in the case, future system inertia (M1&M3) can be calculated, while M2 (RoCoF at 0.5s after Resource Contingency Criteria trip) can be either calculated or evaluated from simulation results. M4 (set of frequency response measures) can be evaluated from the simulation results, where RCC is tripped in the simulation.

3. Modeling Approach

Forward looking analysis for the frequency measures requires dynamic simulation of a future case for each interconnection. The selection of the interconnection-wide cases is the aspect that needs attention. The case should reasonably reflect a “low system inertia” condition. This is predominantly driven by light load, high wind, /solar conditions where synchronous inertia is at its lowest.
The selected cases can either be based on a planning case (e.g. 3-5 years out) or “Worst case” scenario, i.e. pushing the system all the way down to lowest possible system inertia (based on current frequency control practices), as found in Sufficiency Guideline.

The latter approach is more meaningful for smaller interconnections, i.e. ERCOT and Hydro Quebec (HQ), since these systems are at times operating at relatively low system inertia conditions1 already now, while former approach is preferable for Eastern and Western Interconnections since both systems are very large and system inertia is an order of magnitude higher than in ERCOT and HQ.

[1] Note that the term “system inertia:” in this document is used not only as a measure of stored kinetic energy in the system but also as a measure of unit commitment. For example low system inertia means that only few synchronous generation units are committed, and both system inertia as well as headroom for primary frequency response on these units are low.

ERCOT already created a dynamic case based on realistic dispatch representative of low synchronous inertia conditions. Quebec also creates a case that is representative of its restricted operating conditions around primary frequency response and inertia concerns.

Commented [A1]: We will add more details here once we discuss it with HQ

The Western and Eastern Interconnections need to create interconnection-wide cases that should be reflective of a reasonable dispatch for the operating conditions under study (e.g., spring light load). These are the cases that will be used for analysis.

It is very important to make sure that dynamic case is realistically dispatched. Even though "off the shelf" cases created for long term transmission studies are a good starting point, these studies have a different scope and therefore not necessarily reflect realistic unit commitment and dispatch of synchronous generation. Many generators may be left online in a case at minimum generation level. This leads to higher inertia and more frequency responsive headroom than would normally be available during high renewable low load periods in reality. Another issue could be that the Light Load case is created for a **typical** shoulder season day and is likely not representative of low load/high wind conditions. These two issues could be verified based analysis of collected Measure 1 data to date (inertia, load, and renewable generation, if available) and future load and renewable growth projection for the study year.
Additionally, if by unit (or by unit type) information is available, some analysis of unit commitment and dispatched can be carried out as follows.

- Pick several snapshots with low but different load levels
- Analyze how unit comment changes from higher to lower load conditions, what units (types of units) are de-committing or dispatching down. These "trends" can be used while re-dispatching a future case.

Once realistic dynamic cases are created, forward looking analysis for frequency Measures 1-4 can be performed as described in this process document.

4. Models and Input Data

WECC

Dynamic Model

WECC Light Spring Case for a future year can be used as a starting point.

For example 2022 Light Spring Case was used in NREL's Western Frequency Response Transient Stability Study (phase III of Western Wind and Solar Integration Study (WWSIS), looking at frequency response in WECC with 21%, 44% and 53% of instantaneous renewable penetration http://www.nrel.gov/docs/fy15osti/62906-ES.pdf).
Verification that the WECC LSP'22 case is indeed representative of high renewable, low load situation needs to be done. Historic load data collected for Measure 1 and future load/renewable projections can be used for this verification.

Commented [A2]: What could be the sources for future projections?

During the WWSIS study extensive checking of dynamic modelling was done for conventional generation, wind, solar generation, and load modelling.
The model can be further improved based on results of governor survey that's being carried out by NERC Resource Subcommittee and based on progress of composite load with DG modelling efforts in the West.

Commented [A3]: Troy, I am not sure if the timeline for the governor survey would allow this?

Unit Commitment and Dispatch

In Phase II of WWSIS study unit commitment and dispatch was performed in Plexus (production cost simulation tool) for a full year for the scenario with 26.5 GW of wind and solar (TEPPC scenario). In Phase III the results from Plexos were filtered to capture periods of operation that were close to that in WECC LSP'22 case in terms of load and renewable generation (i.e. day-time, spring, load within 10GW of WECC LSP'22 case, wind and solar close to WECC case, about 1% of time in a simulated year). The goal was to look at impact on difference in classes of generation v.s. changes in wind and solar production to get clearer insight on the operation "rules" (unit commitment and dispatch) that apply during low load periods. Then apply those rules to unit commitment and dispatch to WECC LSP'22 case.

For forward looking M1-M4 study commitment and dispatch rules established in WWIS Phase III can be applied, or similar rules developed based on analysis of historic low load conditions.

Commented [A4]: Need to double check this with the report and check what TEPPC abbreviation means)

Commented [A5]: We can work with Nick and WECC within ERSWG to come up with detailed process for how this can be done.

EI

Dynamic Model Options

EIPC will come up with EI dynamic model either detailed or simplified model can be used as long as benchmarking to historic generation trip events is showing good correspondence.

MMWG Light Load case can be used as a starting point. Verification that this case is indeed representative of low load high wind situation needs to be done. Historic load data collected for Measure 1 and future load/renewable projections can be used for this verification.

Commented [A6]: What could be the sources for future projections?

Possibly, the model can be further improved based on results of governor survey that's being carried out by NERC Resource Subcommittee.

Unit Commitment and Dispatch

Unit commitment and dispatch during historic low to moderate load conditions can be analyzed to derive commitment "rules" that can be applied to the future case. The goal is to understand what units (type of units) are first to dispatch down/come offline as the load decreases.

Some insight can be gained from NREL Eastern Renewable Generation Integration Study (ERGIS) looking at up to 50% instantaneous renewable penetration in EI (also includes HQ) http://www.nrel.gov/docs/fy16osti/64472-ES.pdf. The study was similar to WWSIS however frequency response was not specifically studied there. The study concentrated on unit commitment and dispatch and system balancing down to 5-min resolution. Same production cost simulation software as in WWSIS was used (Plexos). Similar filtering of low load high wind conditions from Plexos simulation results and matching of generation with light load high renewable conditions can be done, to obtain realistic unit commitment and dispatch rules.

5. Analysis

This section provides some details about how future looking Measures 1-4 can be assessed. Once a dynamic model of an interconnection is set up Measure 1-3 can be calculated while Measure 4 requires simulation in which RCC generation is tripped and frequency performance of an interconnection is examined.

Measure M1: Interconnection Synchronous Inertia

Measure M1 analyzes the interconnection synchronous inertia value. In the forward looking time horizon, the best approach is to use the interconnection-wide models available for dynamic simulations that include the necessary information.

Each interconnection-wide dynamics-ready case is composed of a dynamics file that includes the inertia values for each unit in the case. The units that are committed and dispatched in that case will have a corresponding inertia constant and those can be reported to determine the total interconnection-wide inertia value.

Inertia is calculated as

$$Inertia_{Synchronous} = \sum H * MBASE$$

This simply means that the inertia constant value is multiplied by the MVA base of the machine to get the synchronous inertia value, expressed as MVA*s. Automation scripts (Python, epcl) can be created to extract this information with ease.

Measure M2: Rate of Change of Frequency

M2 analyzes the rate-of-change-of-frequency (ROCOF) at the minimum synchronous inertia conditions. The ROCOF will be calculated as the rate of change of frequency within the first 0.5 seconds following the disturbance on the system[2].

$$ROCOF_{0.5} = \frac{f_{0.5} - f_0}{t_{0.5} - t_0} = \frac{f_{0.5} - f_0}{0.5} \quad (1)$$

where $f_{0.5}$ and f_0 are the frequency measurements at time $t_{0.5}$ and t_0. The ROCOF within the first 0.5 seconds captures system inertial movement prior to the majority of primary frequency response from generation and load. Therefore, it can be correlated or discussed in respect to system inertia.

The ROCOF calculation will be applied to the Resource Contingency Criteria (RCC) for each interconnection, as determined by the NERC Frequency Working Group (FWG). The current RCC for each interconnection is provided in Table 2. The values defined correspond to select contingencies used for BAL-003-1.1 requirements and interconnection frequency response obligations (IFRO). If operating restrictions would limit the RCC, then that will be accounted for as part of the case creation and contingency definition. For example, Hydro Quebec limits generation dispatch for low inertia conditions such that the 1700 MW RCC cannot occur. This mitigates a potential severe contingency where inertial conditions are of concern.

Table 2: Resource Contingency Criteria (RCC) for Each Interconnection

Texas	Eastern	Western	Quebec

[2] Rate of change of frequency is df/dt, the approximation as $\Delta f/\Delta t$ is only valid for a small Δt

2750 MW	4500 MW	2740 MW	1700 MW

Rate of change of frequency over the first 0.5-second window after the contingency is calculated as:

a. For systems where load damping constant D is not available:

$$\text{RoCoF} = \Delta P_{MW}/(2^* (KE_{min}\text{-}KE_{RCC}))^*60 \;\; [\text{Hz/s}] \qquad (2)$$

Note: Here with load damping constant *D* assumed to be 0, RoCoF is independent of a time window (for the first few seconds before governor response becomes effective). KE_{RCC} is kinetic energy of the largest contingency, i.e. *H*MVA* of the largest unit(s) as defined by RCC in BAL-003-1.

b. For systems where load damping constant *D* is available, use the following equation to calculate frequency deviation at 0.5 seconds:

$$\Delta f_{0.5} = \frac{\Delta P_{MW}}{D \cdot P_{load}} . \left(1 - e^{\frac{-0.5 \cdot D \cdot P_{load}}{2 \cdot KE_{min} - KE_{RCC})}}\right) \cdot 60 \quad [\text{Hz}] \qquad (3)$$

P_{load} is system load during minimum kinetic energy conditions KE_{min}.

Corresponding RoCoF is calculated as

$$\text{RoCoF} = \frac{\Delta f_{0.5}}{0.5} \quad [\text{Hz/s}] \qquad (4)$$

This calculation can be verified based on the simulation results once the simulation is carried out for Measure 4 as described below.

Measure M3: BA Synchronous Inertia

M3 is very similar to M1, except that it is calculated on a smaller area basis. The backward-looking assessment for M3 uses BA data for measuring synchronous inertia. This is due to the availability of the data and reporting structure at NERC. However, BA information is not easily attainable for the forward-looking assessment. Therefore, a modified approach will be used that continues to use the interconnection-wide cases developed for future looking analysis. Those cases contain an “Area”, “Zone”, and “Owner” field used for various reasons in the cases. The “Area” field is not a 1:1 match to BA footprint; however, The Areas can be mapped to BAs fairly easily and data for inertia can be extracted in this manner.

The same set of cases and assumptions used for M1 will apply to M3. The only difference is reporting on an Area-wide basis. While BA- or Area-wide synchronous inertia is not particularly relevant or useful in the context of a changing resource mix and ERS, it is a useful data point to collect for trending to understand how the interconnection’s BAs or Areas are changing over time in terms of synchronous inertia.

Note that for the Texas and Quebec Interconnections, M1 and M3 are the same since the BA and the interconnection footprint are equivalent.

Measure M4: Interconnection Frequency Response

M4 is a set of sub-measures or calculations that can be applied to any measurement, either from actual system data or from a simulation. The sub-measures use a time range of 16 seconds before the contingency to 52 seconds after the contingency. For simulations, where frequency starts at nominal value, the time range can be from the point of contingency to 52 seconds after since frequency remains constant until the contingency occurs. The cases from M1 (and M3) will be used for the analysis. The contingencies from M2 for the RCC will be used for the simulation. The M4 sub-measures will be applied to the median frequency signal derived from frequencies across the interconnection in the simulation. This will be performed by extracting a number of frequency measurements from the simulation and then taking a median value of those signals. This approach will closely map to the way FNET calculates its system frequency measurement.

Policy Briefing on Reactive Power

Essential Reliability Services Working Group (May 2017)

The NERC Planning and Operating Committees jointly created the Essential Reliability Services (ERS) Working Group to identify necessary services for reliability of the bulk power system (BPS). The group has been working on these issues since 2014 and previously proposed a measure related to reactive power capabilities that are essential for the management of voltage across the system (identified as Measure 7 in earlier reports). The original concept was to compile appropriate data on reactive capabilities by balancing authority (BA) and identify informative trends in those capabilities due to changes in the resource mix. This briefing summarizes the outcome of work on this measure and describes the path forward. This policy briefing distills results from other documents and does not create new findings or recommendations. References and links to the documents are provided and these orginal documents should be consulted for additional details when needed.

Voltage must be controlled to protect system reliability and move power where it is needed during normal operations and following system disturbances, and managing reactive power is the means by which system operations maintains the necessary voltage levels to ensure reliable operation. However, voltage issues tend to be local in nature, such as in sub-areas of the BPS. So, while the importance of reactive power is clear, the question was whether a measure of reactive power capability would be logical and useful for developing trends for larger areas such as a BA or interconnection.

The NERC System Analysis and Modeling Subcommittee (SAMS), with assistance from the NERC Performance Analysis Subcommittee (PAS), conducted a proof of concept data collection and subsequent analysis of the proposed Measure 7 data and reported their results in February 2017. Their findings show that at the level of a BA, the proposed measure would not provide useful, consistent, and informative reactive capability trends related to a changing resource mix due to a variety of factors. SAMS further believes that the recent FERC Order 827 helps to alleviate BPS-level concerns of reactive deficiency due to a changing resource mix by requiring (consistent with earlier recommendations of the ERS Working Group) that all new resources connecting to the transmission system must have reactive power capability.

However, the ERS Working Group's "Whitepaper on Sufficiency Guidelines" (Chapter 3) discussed the importance of sub-area treatment for reactive and voltage issues, and NERC SAMS reiterated that reactive power planning practices are best applied at a local level. SAMS developed the "Reliability Guideline for Reactive Power Planning" that provides a comprehensive overview of reactive power planning techniques and industry best practices. SAMS recommended the use of this guideline, in conjunction with interconnection studies, planning assessments and operational studies that are already done as part of established NERC planning and operating standards, rather than use of proposed ERS Measure 7. The ERSWG agrees and recommends that NERC's Operating Committee and Planning Committee withdraw ERS Measure 7 from further consideration. The ERS Working Group recommends use of the Reliability Guideline for Reactive Power Planning, applied on a sub-area basis in conjunction with existing NERC planning and operating standards, to support the reactive power needs of the BPS, thereby ensuring sufficiency and reliability with a changing resource mix.

<u>For Further Information</u>

Reliability Guideline for Reactive Power Planning (December 2016) is strongly recommended to ensure locally-appropriate reactive power capabilities on an ongoing basis. Also refer to Chapter 3 of the ERS Whitepaper on Sufficiency Guidelines.

Measure 7 Analysis – System Analysis and Modeling Subcommittee (February 2017) provides details on the analysis that lead to the recommendations that are described above.