Forward-Looking Net Demand Ramping Variability Technical Brief

ERS Framework[1] Measure 6: Forward-Looking Net Demand Ramping Variability

The NERC Planning Committee and Operating Committee jointly created the Essential Reliability Services Task Force (ERSTF) to consider reliability issues that may result from the changing generation resource mix, resulting in the development of essential reliability services (ERSs) measures for examination and monitoring to identify trends. The ERSTF was converted into the ERS Working Group (ERSWG) and charged with identifying, evaluating, and developing sufficiency guidelines for each quantifiable measure.

Background

A Balancing Authority (BA) may have limited ability to control the output of many generation resources, both conventional and renewable, and existing operating practices have evolved to accommodate this situation. However, with an increasing penetration of variable generation resources, some BAs are experiencing changes in the use of conventional resources and traditional operating practices. Consequently, system ramping capability with flexible resources is becoming an important component of planning and operations. For example, the California Independent System Operator (CAISO) is experiencing challenges with net load[2] ramping and over-supply conditions. High penetrations of non-dispatchable resources are meeting a large portion of their customers' energy needs during various times of the day, resulting in the need for additional flexibility and ramping capability from the rest of the generation fleet. This is not a completely new concern for BAs as some resources and imports have a long history of non-dispatchability due to physical or contractual limitations. However, newer resources may or may not be incorporated into the dispatch process or they may be considered "must take" resources, so changing resources can contribute to increasing ramping needs. Finally, physical characteristics of resources may limit the ability to reduce active power output when committed, turn off after being on for below a minimum run time, or turn on after being off-line below a minimum down time among other constraints. The combination of all such factors can result in increased periods of over or under generation, upward and downward ramping scarcity from generation resources, and other situations that cause an overreliance on the rest of the Interconnection for balancing the operational reliability requirements of the system.

There are many ways to mitigate ramping and balancing concerns. The focus of this technical brief is to ensure that anticipated challenges are identified early so that remedial changes can be accomplished in a timely and reliable manner. Therefore, as a best practice, BAs should regularly examine the composition of their generation fleet to determine if changes are needed in their supply procurement and unit commitment or dispatch practices. This examination should be focused on the ability to adequately balance generation and load during normal conditions within their areas, meet the shared responsibility of

[1] Essential Reliability Services Working Group, Measures Framework Report, November 2015
[2] Net Load = Load – Wind & Solar Power Production

supporting Interconnection frequency, and also maintain sufficient capacity to meet BA contingency reserves and frequency response obligations.

To address the ramping and flexibility concerns, this technical brief has been developed in collaboration with the NERC ERSWG and the NERC Reliability Assessment Subcommittee (RAS) to identify trends and indications of potential balancing and ramping concerns within a BA's footprint. This technical brief presents an updated forward-looking screening methodology[3] and is intended to assist the NERC RAS in identifying BAs that may experience changes in their load patterns or their resource mix that could impact ramping and flexibility needs over time. This methodology will be used on an annual basis or as set forth by the NERC RAS to aid BAs in monitoring for potential flexibility concerns.

The flowchart in **Figure 1** outlines the screening process to perform a high-level review of an area's load and generation resource mix and assists the NERC RAS in determining if additional outreach to BAs is required. Based on the results and communications with the BA, further detailed evaluations may be needed to clarify potential shortages of ramping or flexible capability.

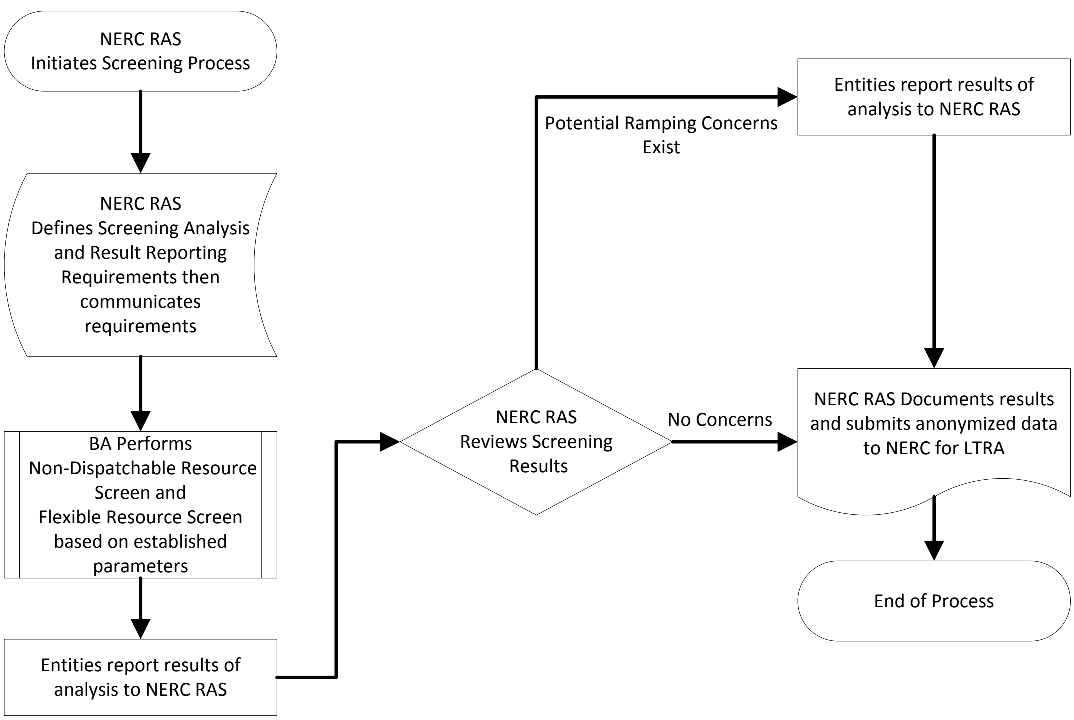

Figure 1: NERC RAS – Measure 6 Forward-Looking Screening Process

The Measure 6 Forward-Looking Screening Process will be managed by the NERC RAS. The NERC RAS will establish the appropriate screening analysis parameters and the associated reporting requirements. Once screening parameters and reporting requirements are established for the defined study period, the RAS will request that identified BAs perform the non-dispatchable resource penetration screen and the flexible

3 NERC *Essential Reliability Services Whitepaper on Sufficiency Guidelines* (December 2016)—Chapter 2

resource screen described later in this document. Once completed, the BA will provide the screening results to the NERC RAS, and the NERC RAS will determine if further analysis is warranted and include anonymized results in the NERC Long-Term Reliability Assessment (LTRA) report. Additional details of the Measure 6 Forward Looking Screening Process are described below.

NERC RAS Defines Screening Analysis and Results Reporting Requirements

The NERC RAS will define the screening analysis parameters and the associated reporting requirements for the pre-screening process. The identified screening parameters should be selected to allow for BA-specific differences. A list of examples of study parameters is the following:

- Time duration of examination period (e.g., 1 hour, 3 hours, 6 hours, etc.)
- Time of year for examination (A specific month, or season etc.)
- Evaluation threshold for non-dispatchable resource penetration screen[4]
- Study period based on load assumptions (e.g., high ramp up periods, bottoming out times followed by high ramp periods, etc.)
- Load calculation requirements (e.g., Average, Max, Sum, etc.)
- Types of non-dispatchable resources to be examined
- Types of "flexible" responsive resources to be examined
- Analysis result reporting requirements
- A list of BAs that will be requested to perform the non-dispatchable resource penetration screen and the flexible resource screen
- Contact method and results reporting time frame
- Other parameters as determined by the NERC RAS

BA Analysis and Pre-Screening

The first step in performing this pre-screening evaluation is to identify the future operating conditions that may lend themselves to ramping and flexible resource shortfalls or over-supply conditions. While determination of these "operating conditions" is somewhat subjective, these operating conditions typically correspond to operating hours when the available dispatchable system resources constitute a smaller percentage of the total committed system resources. These conditions normally correspond to operating hours when available flexible capability of the committed resources is nearing the magnitude or rate of the expected net load ramp, or when system load is expected to be low, and non-dispatchable system resources, as defined below, are meeting a large portion of the system demand.

[4] The evaluation percentage for the non-dispatchable resource penetration screen should initially be a value between 30 percent and 50 percent with the percentage selected by the NERC RAS when considering the generation resource mix of an assessment area. This evaluation percentage can be adjusted by the NERC RAS on an as need basis. It is recommended that the initial evaluation percentage be established at 40 percent based on proof of concept results.

Non-Dispatchable Resource Penetration Screen

> **Non-dispatchable resources** generally refer to those system resources that do not have active power management capability due to physical or contractual limitations. These may include, for example, nuclear generators, geothermal generators, other generators with contractual limitations, and older utility-scale renewable generators and DERs.
>
> The specific types of non-dispatchable resources to be examined will be provide by the NERC RAS as part of the screening analysis parameters.

The BA will identify the following inputs based on the screening parameters provided by the NERC RAS.

- The expected load for the identified operating screening hour(L_{CL}).
- The capacity of non-dispatchable resources $\left(R_{ND\_up} \text{ and } R_{ND\_down}\right)$ that are expected to be operational for the same year during the screening hour. Note: the amount of non-dispatchable resources may be different depending on direction of response. For example, in some areas, wind resources, solar resources and distributed energy resources (DERs)[5] are dispatchable down but not dispatchable up since they usually operate at their maximum available production.

The BA should evaluate the ratio of non-dispatchable resources to load based on the screening parameters and the conditions identified. The BA will document the results of $\left(R_{ND\_up} \geq X\%\ of\ L_{CL}\right)$ **and** $\left(R_{ND\_down} \geq X\%\ of\ L_{CL}\right)$ for submittal to the NERC RAS.

Flexible Resource Screen

> **Flexible resources** generally refer to system resources that are available or can be called upon in a short time to respond to changing system conditions. These may include, for example, hydro generation, quick start CTs, batteries, and may include dispatchable renewable resources, etc.
>
> The specific types of flexible resources to be examined will be provided by the NERC RAS as part of the screening analysis parameters

The BA will identify the following inputs based on the screening parameters provided by the NERC RAS:

- The amount of non-dispatchable resources $\left(R_{ND\_up} \text{ and } R_{ND\_down}\right)$ that are expected to be operational for the study-year during the selected screening hour: Note: the amount of non-dispatchable resources may be different depending on direction of response. For example, in some

[5] When considering the impact of DERs in the evaluation process, if a DER is dispatchable then do not include it in R_{ND_up} **or** R_{ND_down}, if the DER is registered and is non-dispatchable then include it in R_{ND_up} **and** R_{ND_down}, or if the DER is netted with load in L_{CL}, then it should not be included in R_{ND_up} **or** R_{ND_down}.

areas wind resources and solar resources are dispatchable down but not dispatchable up since they usually operate at their maximum available production.

- The amount of flexible resources $(FR_{up} \text{ and } FR_{down})$ that are expected to be available for dispatch for the study year during the selected screening hour: Note: the amount of flexible resources may be different depending on direction of response.

The BA should evaluate the difference of non-dispatchable resources to flexible resources based on the screening parameters and the conditions identified. The BA will calculate and document the results of $(R_{ND\_up} - FR_{up})$ and $(R_{ND\_down} - FR_{down})$ for submittal to the NERC RAS. If the screening indicates that a BA does not have enough flexible resources to support their non-dispatchable resources (i.e., screening is zero or positive) additional evaluation may be needed as determined by the NERC RAS and the BA. However, a negative result does not necessarily indicate that a BA will not experience ramping issues. The BA should consider possible real-time dispatch patterns while taking into account the resource operating characteristics (e.g., unit start-up and shut-down times, unit ramping capabilitites, etc.) to reflect potential constraints during operational periods.

Additional Evaluation

If the non-dispatchable resource penetration screen or the flexible resource screen indicate potential ramping issues (i.e. non-dispatchable resource penetration screen is greater than evaluation threshold or flexible resource screen is zero or positive), the NERC RAS may request additional analysis from the BA.

If additional analysis is needed, there are additional tools that may be leveraged. The tools include, but are not limited to, the ramping capability screen (which is explicitly described in the next section of this brief) and the full production modeling assessments as documented in Appendices F and G of the December 2016 NERC *Essential Reliability Services Whitepaper on Sufficiency Guidelines*.[6]

Ramping Capability Screen

For constrained operating conditions, the ramping capability screen may be used as a tool to determine if additional detailed analysis is warranted.

The BA will identify the following inputs:

- The 98th percentile of the maximum net load[7] increase (MNL_u) or maximum net load decrease (MNL_d) that may occur for the next hour (and three hours) from the selected screening hour and is based on future renewable generation and projected load forecasts
- The contingency reserve (CR) that is needed to cover the BA's Most Severe Single Contingency (MSSC) during the constrained operating condition

The flexible resources evaluation process for both downward and upward ramping is provided next.

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[6] December 2016 NERC ERSWG Whitepaper on Sufficiency Guidelines (Appendicies F and G)
[7] The maximum net load increase (MNL_u) or maximum net load decrease (MNL_d) over one and three hours are calculated as described in Measure 6 in the ERSWG Whitepaper on Sufficiency Guidelines Appendix E.

Evaluation Process

1. Compare to ensure that the downward ramping capacity of the flexible resources (those resources that are on-line with downward ramping capability or can be brought off-line within one to three hours[8]) can cover (MNL_d).
2. Compare to ensure that the upward ramping capacity of the flexible resources (those resources that are on-line with upward ramping capability or can be brought on-line within one to three hours) can cover ($CR + MNL_u$).

Example of Ramping Capability Screen

ERCOT provided a screening test example for Measure 6 based on the future year 2019 following the screening methodology described above.

For ERCOT's non-dispatchable resources penetration screening, nuclear, wind, and solar resources are considered non-dispatchable in the upward ramp direction (R_{ND_up}). Additionally, only nuclear generation is non-dispatchable in the downward ramp direction (R_{ND_down}).

Critical operating conditions for the non-dispatchable resource penetration screen are assumed to occur during minimum load conditions (e.g., $L_{CL} = 25.5\ GW$ on a February night). The amount of non-dispatchable generation in the upward ramp direction during this time is expected to be $R_{ND\_up} = 21\ GW$[9] and in the downward ramp direction $R_{ND\_down} = 5{,}150\ MW$. Thus, the non-dispatchable resource penetration screen shows that in the upwards direction, about 84 percent of the expected minimum load is supplied by non-dispatchable generation, and looking in the downwards direction, 20 percent of minimum load is supplied by non-dispatchable generation. Therefore, the ramping capability screen is only done for the upward direction.

ERCOT performed the ramping capability screen by using the net load profiles that were produced for the *2016 LTRA*. The net load profiles (load minus wind production and solar production) were created by using ERCOT's long term load forecast, and ERCOT's wind and solar planning profiles applied to existing wind and solar generation resources and planned resources with signed Interconnection agreements and financial commitments. The load and renewable profiles are of hourly resolution, so the DNV GL's SFLEX[10] tool was used to convert them into one-minute resolution profiles.

Once the profiles with one-minute resolution were obtained, net load (NL) was calculated as load minus wind production minus solar production. Next, the net load ramps were calculated using a 60-minute sliding window, which accounts for intra-hour ramps. For example, the one-hour ramps were calculated as $NL_{61} - NL_1$, $NL_{62} - NL_2$ and so on. Since critical operating conditions for non-dispatchable resource

[8] Note in some areas an operator cannot order committed generation offline. In this case de-commitment should not be counted towards downward ramping capability.

[9] Installed capacity of wind generation in the studied scenario is over 21 GW, 16.5 GW is assumed to be available in the selected screening hour based on hourly wind profiles.

[10] DNV GL - Energy, Reserve Requirements for 2014 VER Integration, Maximum Generation Renewable Energy Penetration Study: Addendum, Prepared for Los Angeles Department of Water and Power, Doc. No. 20530005B-HOU-R-01, Issue C, http://www.oasis.oati.com/LDWP/LDWPdocs/Reserve_requirements_for_2014_VER_integration_final.pdf

penetration screens occurred in February at night, upward net load ramps in the night time hours of February and March[11] are included in this analysis.

Calculating the 98 percentile[12] of upward net load ramps in the night time hours of February and March yielded the following:

- A maximum net load increase $\boldsymbol{MNL_u} = 4{,}847\ \text{MW}$ over one hour
- A maximum net load increase $\boldsymbol{MNL_u} = 11{,}341\ \text{MW}$ over three hours

Adding the contingency reserve requirement $\boldsymbol{CR} = 1{,}404\ \text{MW}$[13], yields

- A one-hour flexible capacity need of 6,251 MW
- A three-hour flexible capacity need of 12,745 MW

To determine if the generation fleet could meet these flexible capacity needs, ERCOT used the results of a 2019 production cost simulation that was prepared for ERCOT's 2016 Long Term System Assessment[14] report (Current Trends scenario). For example, a night time February hour with minimum load was selected; during this hour, the on-line generators alone were capable of ramping up 3,365 MW in one hour and 9,441 MW in three hours. Therefore, the on-line generators could not meet the worst-case ramps, $\boldsymbol{MNL_u}$ while maintaining the contingency reserve. However, during the screening hour, every unit that can come on-line within 30 minutes was off-line in the simulation. Those generators can provide an additional 3,601 MW within 30 minutes; including these units gives a one-hour ramping capability of 6,966 MW, which is 715 MW greater than the 6,251 MW ramp plus contingency reserve. Including these units in the three-hour time frame gives a ramping capability of 13,042 MW, which is 297 MW greater than the 12,745 MW ramp requirement plus contingency reserve. While these seem like small remaining margins, there are more units in the fleet that can come on-line within one to three hours to help serve the one-hour and three-hour ramps. However, in this example, ERCOT did not consider the capability of these additional units. The results are summarized in Table 1.

Table 1: Results of ERCOT Ramping Capability Screen Example for Year 2019

Attribute	One-Hour Time Frame	Three-Hour Time Frame
98th percentile net load ramp ($\boldsymbol{MNL_u}$)	4,847 MW	11,341 MW
98th percentile net load ramp + contingency reserve ($\boldsymbol{MNL_u} + \boldsymbol{CR}$)	6,251 MW	12,745 MW
On-line generator ramping capability	3,365 MW	9,441 MW
On-line generator ramping capability + 30-minute start capacity	6,966 MW	13,042 MW

[11] March is included to increase sample size, since similar wind conditions are typical for both months.
[12] 98th percentile is taken as the "maximum" ramp to exclude data quality driven outliers
[13] Contingency Reserve here is assumed equal to ERCOT's Responsive Reserve requirement expected to be served by generation in the nighttime hours of February based on 2017 Ancillary Service Requirements. Responsive Reserve is frequency containment reserve after large generator trip events and will normally not be used to address ramping issues.
[14] ERCOT's 2016 Long Term System Assessment Report