**NPCC Directory #1 *Design and Operation of the BPS***

**Roadmap to Implement Future Revisions to Address Reliability Contributions and Challenges Brought Forward by Changing Technologies and Load Characteristics**

NPCC RSC Endorsed 12/06/2022

NPCC RCC Endorsed 12/08/2022

**Background:**

The electric industry is undergoing two significant simultaneous and accelerating transitions:

(1) To distributed decarbonization of electricity generation[1].
(2) To further electrification of the economy (i.e., Building Heat Pump based Electrification, and Electric Vehicle charging).

Some Areas within the NPCC Region have mandatory future zero carbon goals through legislation which are required to be achieved in certain future years.

In recognition of these extraordinary simultaneous changes to the power generation and delivery system technologies and load characteristics, the NPCC Board of Directors established a NPCC Corporate Goal for 2022 (#II-1)[2] to:

> *Develop future revisions to NPCC Directory #1 to address reliability contributions and challenges of changing technologies and load characteristics.*

**Prologue:**

This roadmap has been developed in accordance with the NPCC Strategic focus area to '*reliably integrate the resources brought forward by societal decarbonization*,' on a future schedule established by the Task Force on Coordination of Planning (TFCP) and the Task Force on Coordination of Operation (TFCO) which share jurisdiction over Directory #1.

Notwithstanding, the current administrative review of Directory #1, any future revisions resulting from the proposed review will meet the NPCC Reliability Principles shown in Appendix A, and the Definition of Adequate Level of Reliability shown in Appendix B.

Recent power system disturbance events, and energy and capacity shortfalls in Texas and California[3] have highlighted the need to reexamine the design basis for the NPCC Bulk Power System. The NPCC Board of Directors has directed that the existing design basis for both operations and planning be reviewed in order to stay ahead of the rapid changes that are occurring within the industry to assure the continued reliable operation of the NPCC Bulk Power System.

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[1] Several states and Canadian provinces have legislated varying timelines and degrees of reduced or eliminated carbon emissions with programs that increases electrical demand

[2] NPCC 2022 Corporate Reliability Goals

[3] See CAISO Summer 2022 Performance Report. The report outlines the challenges and future steps needed to address variable/intermittent generation and load side changes emanating from the accelerating transition to renewable resources. Several areas for improvement are noted starting on page 15.

While other efforts, most notably within NERC, are underway, it may not be prudent for NPCC to await these outcomes. For example, the passage of the U.S. Inflation Reduction Act and Bipartisan Infrastructure Law are expected to accelerate the transition toward carbon free generating resources[4]. Additionally, NERC's own experience[5] with NERC development projects suggests that it can take longer than anticipated for an ERO wide consensus on standards and/or guidance to be finalized.

NPCC Members have for many years adapted to late arriving NERC standard requirements and the development of NPCC's Criteria should be an initiative-taking and forward-looking process that does not risk having events overtake the ability of the reliability Criteria to address these emerging challenges.

System resilience (Appendix C) has always been a natural and integral part of the NPCC Criteria, and these revisions will further enhance that component of the reliability Criteria, especially in light of the greater variability of generating resources and load (reference Appendix A). Likewise, extreme weather events are a reality that should be reexamined in any review that considers the enhancement of the design Criteria of the Northeastern North American Bulk Power System.

Furthermore, some NPCC Areas are already exploring additional resource adequacy metrics for use in supplementing the existing Criteria and this effort will work in parallel with activities underway in the industry (e.g., US DOE, NERC) to examine and develop one or more additional design Criteria which may be used to modify and enhance the current resource adequacy methodology.

Finally, the TFCP and the TFCO will determine all schedule and scoping initiatives during any future review of Directory #1.

**Next Steps:**

In light of the changes in power system resources and their performance profiles, the focus of this roadmap is to provide NPCC members with guidance on the review of NPCC's Directory # 1-*Design and Operation of the Bulk Power System*, which is the primary document NPCC Members use to design their systems to assure reliable performance of the electric systems within and between the five Areas[6] that constitute the NPCC Region.

Some observations on the current version of Directory #1 include:

- The Resource Adequacy Criteria and associated metric currently in Directory #1 were developed and implemented at a time when meeting peak demand in an Area's peak season was appropriate as the sole design basis used for projecting resource adequacy. It was assumed that if the peak season demand could be reliably[7] served, all other periods during the year would be adequately served. That may no longer be the case for all NPCC Areas due to accelerating industry changes.

[4] See NREL Report 81644 – Examining Supply-side Options to Achieve 100% Clean Electricity by 2035
[5] See NERC's October 2022 Whitepaper: Enhancing NERC Standard Processes wherein NERC identifies several standards development project which have taken inordinately long periods of time to come to fruition, page 3.
[6] The NPCC geographic region includes the State of New York and the six New England states as well as the Canadian provinces of Ontario, Québec and the Maritime provinces of New Brunswick and Nova Scotia.
[7] Reference Requirements 4-6 in the current version of D1

- Variable resources upon which the renewable resource mandates are dependent, will cause the power system to become more reliant upon generating resources that are not dispatchable. This fundamental change in resource availability is not adequately covered or considered in the current Directory #1 construct.
- The most severe single contingency for some NPCC Area's may be a weather event (wind lull, or solar lull) or a gas pipeline contingency and this should be considered in a revision of Directory #1 as these risks have been identified[8].

In the NPCC Region, Bulk Power System (BPS) Planning[9] (Design and Operation) methods must identify and adopt new processes which in the opinion of its Members are needed to evaluate, identify, and mitigate risks to reliability on an initiative-taking and preemptive basis.

As outlined in the NPCC Strategic Plan 2022-2025[10], NPCC has taken note of the need to enhance system resilience, assure energy self-sufficiency for NPCC as a whole and within each Area while reliably integrating the generating resources brought forward by societal de-carbonization objectives. NPCC, in its Strategic Plan, focuses its efforts on supporting NERC and ERO activities to develop resilience metrics by reviewing and updating NPCC Reliability Criteria[11]

**The Key Reliability Challenges have already been clearly identified by the Electricity Industry and its Stakeholders:**

These industry changes may require significant modifications to the NPCC Criteria contained in Directory #1 in order to adequately manage future operating circumstances. From the NERC Reliability Issues Steering Committee (RISC) Prioritization Report there are several identified reliability risks which are currently not being addressed in Directory #1. The key NERC RISC Prioritization risks at issue for the Directory #1 review are:

- Changing Resource Mix
- Resource Adequacy and Performance (e.g., energy adequacy in all hours)
- Challenging Natural Events

Additionally, in its ERO Reliability Risk Priorities Report[12], the NERC RISC identifies numerous detailed risks to Bulk Electric System reliability. These risks are the result of significant changes to the power system which will require new models, more advanced tools, and grid infrastructure improvements.

New circumstances as expected by NERC's Board of Directors require new and revised Criteria and contingency testing. Examples may include the loss of a major gas pipeline, or in the context of the new

[8] For example in ISO NE: Letter of G. van Welie to DOE Energy Secretary Granholm August 29, 2022
[9] In this document the term Bulk Power System is used in reference to the elements determined to be part of NPCC's Bulk Power System by way of the A-10 testing; "Classification of Bulk Power System Elements"

[10] NPCC Working Draft STRATEGIC PLAN 2022-2025
[11] Pages 6-7 of the NPCC Working Draft STRATEGIC PLAN 2022-2025 covering resilience metrics, revising NPCC Reliability Criteria, Assessing gas-electric interdependencies, etc.
[12] NERC RISC Reliability Risk Priorities Report July 2021

renewable/inverter-based generation paradigm, a wind or solar lull will become a critical contingency test that should be examined to preserve resilience and reliability.

**Directory #1's Current Objective:**

The current objective of Directory #1 is to provide a "design-based approach" to the design and operation of the Bulk Power System to a level of reliability that will not result in the loss or unintentional separation of a major portion of the system for any of the contingencies referenced. The limited intent of this approach is to avoid instability, voltage collapse and widespread cascading that will impact a neighboring Area(s). Loss of small portions of a system (such as radial portions or local networks) may be tolerated provided these do not jeopardize the reliability of the remaining NPCC Bulk Power System.

The combined stresses of higher electric loads due to decarbonization (e.g., heating, transportation), challenging weather, and the replacement of legacy dispatchable generating resources with variable energy resources (solar, wind, battery-based storage) were not anticipated when the current Directory #1 Criteria was developed.

Within the NPCC Region, the technique for achieving its historically high level of reliability is to require that the Bulk Power System be designed and operated to meet the performance requirements for the representative contingencies as specified in Directory #1. These contingences, which were selected decades ago, should be reviewed to determine if they provide an adequate level of stress to evaluate the performance and resilience of the decarbonized NPCC Bulk Power System and if they simulate the appropriate challenging weather impacts on power system performance.

The contingencies for transmission stress testing, the projected loading levels ( reflecting expected accelerating electrification trends), and simulation methods (limited ability to simulate inverter-based resource control system performance) currently in use by NPCC Members should be reviewed to consider these factors and analysis should be designed based on regional or local need or requirements.

A new stress testing paradigm should be developed by NPCC Members, to assure reliable operation of the Bulk Power System in the decarbonized, societal electrification in the future. At a minimum, contingency events should be selected and applied on Bulk Power System elements that represent present and emerging plausible situations.

**Stressors of the Bulk Power System that should be considered as Directory #1 is reviewed and modified:**

The most significant applicable **stressors** of the Bulk Power System that are occurring in the industry include:

- **Resource Adequacy Assessment Scopes—Network Realities vs. Political Boundaries:** Current resource planning and resource adequacy assessments are often performed using a political or utility boundary that does not adequately consider potentially significant inter-area electrical impacts and interactions due to the interconnected nature of the bulk power system outside of that limited scope. The result may be resource, energy, and/or transmission capacity insufficiencies in an operational timeframe.

- **Resource Adequacy Does Not Necessarily Equal Energy Adequacy:** Resource adequacy assessments have focused on generation and transmission capacity available to serve peak demand. With the previous resource mix, real-time energy adequacy was assumed under that capacity umbrella and transmission was not highlighted as a requirement; however, recent challenging weather events have shown energy adequacy in all hours to be a new dimension of significant risk given the changing resource mix and system performance versus assumptions used in previous resource mix studies.

- **Technology with Different Design and Performance Characteristics:** The continued integration of substantial amounts of new resource technologies (e.g., DERs, grid and distribution system-connected inverter-based resources, energy storage) will result in challenges in forecasting anticipated net demand. The dynamic and transient performance and response of these technologies also brings new challenges including control and protection systems complexity.

- **Ensuring Sufficiently Flexible Resources to Meet Demand:** With the expected volume of wind and solar resources and their characteristic fuel-driven commitment and dispatch capabilities as well as the characteristics of other resources that may constrain their near-term ability to respond, sufficient amounts of flexible resources will be needed to meet demand when the less flexible resources are unavailable. The flexible resources will need to be dispatchable within the forecasting period of the fuel driven or less flexible resources becoming unavailable.

With the increasing load and variability of resources the current approach embedded in Directory #1 (e.g., the do no harm to any neighboring Area principle) is likely to be not adequate for a decarbonized future where multiple NPCC Areas are expected to become energy limited for an unknown number of hours per year. Furthermore, it is not known if those hours will overlap and if any overlap will limit inter Area assistance in times of need; each Area may need to look to its internal resources and limit reliance on a neighboring Area(s) for support in times of need more than it does today.

Planning to avoid negative impacts to neighboring Areas will neither preserve nor enhance the reliability of any Area in the face of the accelerating industry changes. In the prior paradigm all or most generating capacity was fully controllable and dispatchable and therefore a capacity management-based approach with its Loss of Load Expectation Criteria (of disconnecting firm load due to peak season generating resource deficiencies Criteria , on average, no more than 0.1 days per year) was adequate. Now an all-hours approach will be needed, and such an approach is not well supported by the existing language of the objective or the Directory #1 Criteria. This discussion should be undertaken by NPCC Members in the course of this effort.

The tables that follow identify those requirements and aspects of Directory #1 which are to be reviewed considering the foregoing discussion. The existing Criteria and the corresponding system stress related issue(s) are identified, along with a high-level description of the proposed task to address the risk issue and enhance or preserve power system reliability in the face of the changes outlined. While the NPCC

Member review activity is being conducted, consideration should be given to these industry concerns in light of the challenging aspects of the changing weather environment in each Area:

- Energy Adequacy (all hours)
- Resource Adequacy (potential additional metrics which may provide more insight into system reliability performance )
- Essential Reliability Services (frequency response and voltage support capability of New Renewable Generation Technology for examples)
- Demand magnitude and yearly/daily profile changes due to electrification
- Electric -Gas interdependency (gap in the existing Criteria)
- Inverter Based Resources ride through after routine system disturbances (gap in the existing Criteria)

Furthermore, consideration should be given to what similar activities NERC is currently engaged in that may be used to enhance NPCC requirements to the extent possible while avoiding unnecessary duplication.

The following Table (Table#1) outlines a proposed approach to the multi-faceted task at hand.

**Table 1 Existing Directory #1 Objective and Requirements Review**

| | Current Directory #1 Objective, Requirements and Appendices | Industry Risk or Challenge | Suggested Task definitions to Manage Future Reliability and Resilience Risks |
|---|---|---|---|
| 1 | Objective statements in Directory #1 | Consider all the power system (generation, delivery system, and load) stressors noted in the forgoing paragraphs of this document. | Develop new Directory #1 objective statement(s) that go beyond the current approach of providing design Criteria that simply avoids limiting negative reliability impacts to neighboring Areas. A whole of NPCC approach should be considered recognizing the interdependence between Areas may be greater than ever. |
| 2 | R4 Each Planning Coordinator or Resource Planner shall probabilistically evaluate resource adequacy of its Planning Coordinator Area portion of the bulk power system to demonstrate that the loss of load expectation (LOLE) of disconnecting firm load due to resource deficiencies is, on average, no more than 0.1 days per year. | LOLE based methods may work as a performance metric in a generation capacity-oriented system where on peak (seasonal) capacity can be planned and its operation scheduled with some reasonable level of assurance that it will perform.<br>In a largely Energy limited resource future, the resource adequacy performance measurement approach and related metrics need to address energy adequacy in all hours several years in advance for planning purposes and several weeks in advance for operational purposes. | Review resource adequacy related modelling methods and work . Identify new metrics implemented by NPCC Member s and other industry organizations, (DOE, Energy labs, IEEE, EPRI, etc.) and explore changes to NPCC resource adequacy metrics used to establish NPCC Criteria.[13] Consider new processes to be implemented in a modified R4 that involve a suitable all-hours Energy Adequacy related modelling approach and related Criteria. Example metrics to be considered include, but are not limited to, LOLE, LOLH, EUE, and largest single curtailment of firm load. Maintaining the current LOLE Criteria is an option if it deemed by NPCC members to be adequate to the purpose. However additional metrics may |

[13] See reports from the NYSRC and NRRI on the subject of resource adequacy metrics and methods for examples.

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| | | | provide better and more meaningful measures of reliability and resilience. |
| 3 | R6 Each Reliability Coordinator shall coordinate outages and deratings of resources to verify adequate resources will be available to meet the forecasted demand and reserve requirements. Appendix F provides guidance for Operational Planning Coordination. | Forecasting electric demand will be even more challenging as new load patterns emerge. The increased magnitude of Variable Energy Resources is already presenting challenges to short-term operational planning and long-term system expansion planning activities. The increase to building and transportation electrification, changing weather patterns and advanced pricing methods to provide load modifying incentives to end users at the retail level are also confounding factors creating challenges for load forecasting processes. | Identify best practices used for near term operational and long-term load forecasting techniques in light of the changing resources and load mix[14]. Consider modifying Directory 1 Appendices to encourage the approaches in use and to apply in load forecasting and resource adequacy on an hourly basis considering the stressors listed above.<br><br>Review Appendix F and consider more comprehensive Multi Area collaboration in the light of forecasted wide, multi-area weather events. Address issues related to simultaneous stressors impacting neighboring Areas and the increasing likelihood of the unavailability of any assistance from neighboring Areas during such events.<br><br>Develop revisions to Appendix F in light of the key stressors listed above. |
| 4 | R7 Each Transmission Planner and Planning Coordinator shall plan its bulk power system to have sufficient transmission *capability to meet the respective requirements as specified in Table 1* while serving forecasted demand | Issue – resilience in light of greater dependence on the reliable performance of the transmission system to deliver remotely located renewable resources to load areas. | Because dependence on transmission is likely to increase, review Directory #1 Table 1. Evaluate contingency tables considering new power system stressors listed above, and if necessary, make recommendations for Criteria changes, Table 1 changes or the changes to the |

[14] Two examples are the recent NYISO decision to preserve 350 MW of operating reserve when calling for public appeals and the ISO-NE decision to forecast 27 days forward on an energy basis to deal with gas availability issues.

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| | | | performance assessment expectations ii, v, viii, to Table 1. |
| 5 | R8 Each Transmission Planner and Planning Coordinator shall assess the impact of the extreme contingencies listed in Table 2. Appendix C provides guidance for testing and analyzing extreme contingencies | Issue -– resilience in light of greater dependence on the reliable performance of the transmission system to deliver remotely located renewable resources to load areas during challenging weather events. | Review and consider modifying Directory #1 Table 2 to consider a wide multi-Area weather event occurring simultaneously, and/or sequentially over multiple operating areas greater than a single NPCC Area that will stress the power delivery system**.** In light of the key stressors listed above make recommendations, if necessary, for Table 2 changes, Criteria changes and review the Performance Assessment expectations i, ii, for changes. |
| 6 | R9 Each Transmission Planner and Planning Coordinator shall assess the impact of extreme system conditions, one condition at a time, subject to contingencies as listed in the "Extreme System Conditions" category of Table 2. | With the increase in variability of resources, to preserve resilience and reliability, operating margin policies should be reviewed to prepare for occurrence of challenging weather conditions which may occur in any hour, not just during the peak seasonal hour. | R9 Consider developing modifications and potential new Criteria for operating reserve margin requirements in each NPCC Operating Area, tailored to its penetration of variable, intermittent resources, to ensure resource adequacy in all hours under challenging weather conditions including the key stressors listed above. |
| 7 | Appendix D - Guidelines for Area Review of Resource Adequacy | The all-hours requirement for resource adequacy is not addressed in the current version of Appendix D and is a clear present risk going forward. | Reference the Task related to R4 above considering new metrics for Resource Adequacy. Consider adding a new component to Directory #1 Appendix D activities to require a simultaneous, all-hours forecast analysis for the NPCC region as a whole to assure that no Area is establishing an infeasible, neighboring system assistance reliance for the expected future when intermittent resources form a major component of the resource portfolio in a number of NPCC Areas. |

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| 8 | Appendix F | The all-hours requirement for resource adequacy is not addressed in the current version of Appendix F | Reference the task in R6 and add a new component to the Appendix F activities to require a simultaneous, all- hours analysis for the NPCC region as a whole (rather than twice yearly as specified in 2.1 and 2.2), to assure that no Area is establishing an infeasible neighboring system assistance reliance for the expected future when intermittent resources form a major component of the resource portfolio in a number of NPCC Areas. |

**Identifying and Filling the Gaps:**

The stressors listed above have already created reliability gaps with respect to the existing Bulk Power System design Criteria methods for some NPCC Areas. These gaps have become apparent as a result of events in other areas of North America and prudence dictates that NPCC adopt a lessons learned approach from those events and adapt any associated methods and processes. For example, while Directory # 1 has had within it a resource adequacy topic for many years, there is no specific Criteria to address electric-gas interdependency. The decision to include new or modified Criteria to consider fuel dependency risks explicitly is a topic for consideration by NPCC Members .

The recent performance limitations of Inverter-based Resources (IBR) in the period immediately following a transmission line trip and reclose operation will likely require new planning or interconnection Criteria. This topic should be considered for inclusion in the revised NPCC Directory #1 in order to provide uniform NPCC-wide design Criteria on this issue before additional significant amounts of inverter-based resources are commissioned[15][16].

The table below identifies some high-profile specific issues which are not covered in the existing NPCC Directory #1 and that should either be added as new topics, or melded into the revised document as a review of existing Criteria are conducted.

**Table 2 – Activities to address reliability and resilience gaps**

| Issue or challenge – tie to stressor | Proposed Task to Manage the issue |
|---|---|
| Electric – Gas interdependency | Consider including in expanded existing Criteria, or create new Criteria to mitigate the impacts on resilience and reliability of gas supply disruptions, which may represent a more impactful electric system contingency than the purely electric system contingencies currently used as simulation-based stress tests. |
| Common mode failure to stay on-line of Inverter Based Resources (IBR) | Consider including in expanded existing Criteria, or create new Criteria to address IBR performance gaps (stability, disturbance ride through, frequency control) until all new IBR based generating technology can be made compliant with IEEE 2800-2022 which provide uniform technical minimum requirements for the interconnection, capability, and lifetime performance of inverter-based resources. Recognize that the amount of pre-IEEE-2800 IBR generation is significant and will not likely be required to modify their control systems. |

[15] NERC Guidance on Inverter based Resources March 2020

[16] EPRI-NAGF-NATF-NERC Joint Webinar on IEEE Standard 2800-2022

**Conclusion:**

Initial drafts of this document were reviewed and commented on by the Reliability Coordinating Committee (RCC), the Regional Standards Committee (RSC), the TFCP and the TFCO. All comments were considered and where applicable, enhancements to the document are reflected in this version.

Two main and opposing viewpoints received from NPCC Members were as follows: 1) Since NERC is actively engaged in several of the technical areas of concern, NPCC should wait to conduct a further review of the Criteria in Directory #1 until NERC has completed its work 2) The unprecedented pace of change within the industry and the lack of timeliness and urgency (as reported by NERC itself) of its standard development projects suggests that NPCC should move forward expeditiously and address these issues within its Criteria.

As suggested by an NPCC Member, an approach towards reconciling these opposing views, would be to divide the Directory #1 review effort into two phases. The scope of the first phase would be tailored to address only resource adequacy issues. Upon completion of the first phase other elements of the Criteria (i.e. contingency assessments) could be considered and informed by the outcome of the first phase. In this manner, progress on the Criteria can be achieved while also allowing time for NERC efforts to develop.

The intent of this Roadmap is to initiate the reliability discussion and provide a path forward to the appropriate NPCC technical groups and committees.

## Appendix A – NPCC Reliability Principles

NPCC's reliability principles (taken from the NPCC 2018 Strategic Review) include:

1. Focus on the most important system components: To focus resources to those portions of the power delivery system most important (critical) to overall reliability, NPCC Members employ and are updating the mechanism(s) for identifying those facilities that are most critical to the reliable planning and operation of the power delivery assets in the NPCC region . These critical facilities collectively are identified as the NPCC Bulk Power System .

2. Application of Criteria beyond NERC requirements to identified critical facilities: Where, in the opinion of NPCC's Membership, the NERC standards do not specify a necessary performance or design outcome in each technical, operation or planning area, NPCC Criteria govern the design of their respective portions of the NPCC Bulk Power System planning and operation activities.

3. NPCC Members support the Criteria: NPCC's Full Members in accordance with the NPCC Bylaws are committed to designing and operating their systems to meet the NPCC Criteria under peer review of the NPCC Full Members.

4. No conflict with NERC Requirements: The NPCC Criteria supplement, improve upon where necessary, benefit, and do not conflict with or duplicate the results-based performance requirements of NERC standards where they apply to the NPCC Bulk Power System. NPCC adjusts its regional Criteria to retire or adapt to any new NERC requirements as they come into effect, as necessary.

5. Include design specifications where needed: The NPCC Criteria and related guidelines and procedures provide design Criteria and practices to assure implementation. This contrasts with NERC which is limited through its standards requirements to only identifying a minimum "reliability result." NPCC Directories go into greater detail regarding how to accomplish a given reliability result addressing the "how" of a given reliability result is to be achieved.

6. Resilience has always been an element of NPCC Criteria: Based on experience, resilience is a necessary constituent part of reliability, and it is important both to electricity consumers and regulatory authorities in NPCC's footprint. See Appendix C for details on the attributes of Resilience.

## Appendix B – Adequate Level of Reliability

The basic attribute of a reliable bulk power system of having adequate generating resources and transmission delivery capability to reliably meet projected customer electricity demand and energy requirements[17]. The ERO's definition of an Adequate Level of Reliability[18] still holds true no matter what future evolves and can provide the guidance needed for this NPCC review of Directory #1.

The Bulk-Power System ("System") will achieve an adequate level of reliability when it possesses the following characteristics:

1. The System is controlled to stay within acceptable limits during normal conditions.

2. The System performs acceptably after credible Contingencies.

3. The System limits the impact and scope of instability and cascading outages when they occur.

4. The System's Facilities are protected from unacceptable damage by operating them within Facility Ratings.

5. The System's integrity can be restored promptly if it is lost; and

6. The System has the ability to supply the aggregate electric power and energy requirements of the electricity consumers at all times, considering varying load and generation patterns, scheduled, and reasonably expected unscheduled outages of system components

Simulations are used to assess and analyze the impact of selected contingencies as a way to evaluate the adequacy of the generation and delivery systems. At a minimum, contingency events should be selected and applied on bulk power system elements that represent plausible situations.

[17] Current language from Directory #1

[18] ERO Definition of An Adequate Level of Reliability

## Appendix C-Resilience

Resilience is a topic that has not been explicitly considered during past reviews during the development of the current version of Directory #1. The Strategic Review of the NPCC Criteria in 2018 , concluded that resilience is a necessary component of a reliable system. Previously resilience was not specifically called out as an element of the NPCC Criteria, however it is a reliability gap that should be addressed in the next review of Directory #1. Based on industry experience, resilience is now a necessary component of reliability, and it is important both to electricity consumers and regulatory authorities in NPCC's footprint. In the past NPCC Criteria provided substantial resilience benefits to the NPCC Bulk power system by providing or enhancing:

a. Robustness – The ability to absorb shocks and continue operating .

b. Resourcefulness – The ability to detect and manage a crisis as it unfolds.

c. Rapid recovery – The ability to get services back as quickly as possible in a coordinated and controlled manner.

d. Adaptability – The ability to apply new lessons from events.

Preservation of resilience will require that the Criteria in NPCC Directory #1 be reviewed considering the accelerating changes in the industry and in order for NPCC Member systems to stay ahead of unfolding industry developments.