

Resource Reliability Attribute & Additional Attribute Description

	1 Is there an existing FERC, NERC or PJM requirement for generators to provide this attribute (e.g., Tariff, Manual, NERC Standard)?	2 Is there an existing PJM Market Product in place to maintain a minimum amount of generation that can provide this attribute?	3 Do other ISO/RTOs have an existing Market Product in place to maintain a minimum amount of generation that can provide this attribute?	4 Is there an active PJM PS/IC to address concerns with adequate availability of this attribute for operational needs?	5 Does the changing resource mix, including announced retirements, warrant a change to how we satisfy this attribute within the next 5 years?	6 Is there a concern raised within the OC that we agree needs to be addressed within the 5 years? Is there a longer-term concern? What are the recommended next steps? (Green font indicates a specific recommendation for immediate action)
Inertia Inertia refers to the energy stored in large rotating generators and is a factor in helping to minimize a frequency drop if/when a sudden loss of generation occurs. This minimizes the nadir or the frequency drop immediately following the disturbance.	There are no requirements for resource to provide inertia.	No.	ERCOT has a product for very fast frequency response that is arguably inertia-like; AESO (when they island).	No.	Based on PJM's frequency response analysis and oscillation detection using highly granularity PMU data, in addition to NERC Resource Subcommittee analysis, there are no near term concerns with inertia in the EI.	The OC recommends PJM and members continue to monitor inertia. In addition, continue to monitor related industry activities, including the revisions to the BAL-003 Standard that are currently being drafted.
Primary Frequency Response (PFR) PFR is the inherent response of resources and load to locally detect and arrest changes in frequency. It is an automatic, locally detected response by resources that is not driven by any centralized system and begins within seconds after a frequency excursion. It is essential to stopping a decline in frequency and preventing the activation of automatic under-frequency load shedding (UFLS). The fast, inherent response is a larger differentiator between PFR and regulation, the latter of which follows a centralized dispatch signal from PJM.	<ul style="list-style-type: none"> • FERC Order 842, which is applicable to units in the AE2 queue (2019) and after, requires all resources, traditional and Inverter Based Resources (IBRs), to be capable of providing PFR and operating with PFR controls enabled. However, the Order does not require resources to maintain operational headroom or foot room such that PFR up or down is always available. • NERC BAL-003 sets a Frequency Respond Obligation (FRO) for each BA. 	No.	Yes – ERCOT as an example does have a PFR market product. The WECC has seen bilateral trades of PFR.	Per PJM Manual 12 requirements, PJM does monitor frequency response and reports to the OC. If a concern was identified, the Primary Frequency Response Sr Task Force (PFRSTF) could be reactivated.	Potentially – If resources are operating at full output and do not have headroom, frequency response could reduce further.	PJM has observed that PFR has been declining for the last decade due to a variety of factors, but at present there is not a need for immediate action. It is recommended that we continue to track unit response to frequency events and reactivate PFRSTF if needed. In addition, continue to monitor related industry activities, including the revisions to the BAL-003 Standard that are currently being drafted.
Reactive Capability and Supply The <u>mechanical capability</u> for a generator to <u>provide supply</u> reactive support to the grid and <u>the actual supply of reactive as needed. (i.e.) The ability to follow a voltage schedule and demonstrate performance.</u>	<ul style="list-style-type: none"> • FERC and PJM Requirements to have reactive capability if built after 2017. <u>This and</u> is listed in the unit specific ISA's: <ul style="list-style-type: none"> – min PF of 0.95 lead/0.90 lag (synchronous) – min PF of 0.95 lead/0.95 lag (non-synchronous) • VAR-002 does require units to operate with their AVR in- 	No, but there is a compensation mechanism.	No, but all ISO's have some form of compensation.	The Reactive Power Compensation Task Force is currently active and "will evaluate the standards for the provision of reactive service and the mechanism that provides for the opportunity to be compensated for reactive service."	Reactive capability and voltage support is critical to the reliability of the grid. Currently, FERC and PJM requirements do not require non-synchronous generators to provide a full range of reactive capability when their output is at or near OMW even though they are still connected to the grid and capable of provide support. With a changing resource mix that	Yes – Stakeholders should discuss this further in the RPCTF to ensure that we are able to utilize, measure, and compensate the full reactive capability of synchronous and non-synchronous generators independent of their power output and the ability of all resources to follow voltage schedules and demonstrate performance.

Resource Reliability Attribute & Additional Attribute Description

	1 Is there an existing FERC, NERC or PJM requirement for generators to provide this attribute (e.g., Tariff, Manual, NERC Standard)?	2 Is there an existing PJM Market Product in place to maintain a minimum amount of generation that can provide this attribute?	3 Do other ISO/RTOs have an existing Market Product in place to maintain a minimum amount of generation that can provide this attribute?	4 Is there an active PJM PS/IC to address concerns with adequate availability of this attribute for operational needs?	5 Does the changing resource mix, including announced retirements, warrant a change to how we satisfy this attribute within the next 5 years?	6 Is there a concern raised within the OC that we agree needs to be addressed within the 5 years? Is there a longer-term concern? What are the recommended next steps? (Green font indicates a specific recommendation for immediate action)
	<p>service and follow a voltage schedule.</p> <ul style="list-style-type: none"> PJM Manual 3 Section 3.11 specifies that individual generating units greater than 20MVA or generators that aggregate to 75MVA or greater that connect to a common bus must follow a voltage schedule 				will at times involve transferring energy over longer distances depending upon local vs regional meteorological conditions (i.e. cloudy in parts of the RTO but sunny in others), local reactive support will be needed. Utilizing the reactive support from non-synchronous generators that are not capable of providing their full (or any) MW output would help ensure local voltage and reliability is maintained.	
<p>Ramping Ramping is upward or downward control by resources over a period of time needed to maintain load-generation balance. This is most needed at times of major load shifts, especially during the winter evening ramps, when increases in load coincide with decreases in solar output, and are potentially amplified by wind output changes.</p>	Not directly.	No.	Yes – CAISO does have a ramping product.	No.	As additional forecast uncertainty is introduced to near-term operations and energy dispatch by the changing resource mix, there will be a need for additional generating reserves to account for these uncertainties, while ensuring that existing energy and reserve products can be maintained.	<p>Recommend continued evaluation of the regulation performance and “pegging,” along with continued and enhanced wind/solar forecasting metrics are periodically reviewed by the OC to determine if a ramping product is recommended.</p> <p>In addition, monitor the NERC SAR “Fuel Assurance with Energy-Constrained Resources” that may result in changes to, or new, NERC Standards to address concerns with ramping</p>
<p>Regulation Regulation is the requirement of generators to control Area Control Error (ACE) and frequency deviations.</p>	No.	Yes – Reg A and Reg D.	Yes, including several Reg Up and Reg Down products in MISO, SPP, ERCOT and CAISO.	A PJM PS/IC “Regulation Market Redesign” was approved to redesign regulation market. Work will begin in 2Q22 at the MIC . This will include market design, signal design and regulation requirements.	Yes.	Recommend reviewing the existing regulation market signals and consider future system needs as part of the Regulation Market Redesign Issue Charge in the MIC

Resource Reliability Attribute & Additional Attribute Description

	1 Is there an existing FERC, NERC or PJM requirement for generators to provide this attribute (e.g., Tariff, Manual, NERC Standard)?	2 Is there an existing PJM Market Product in place to maintain a minimum amount of generation that can provide this attribute?	3 Do other ISO/RTOs have an existing Market Product in place to maintain a minimum amount of generation that can provide this attribute?	4 Is there an active PJM PS/IC to address concerns with adequate availability of this attribute for operational needs?	5 Does the changing resource mix, including announced retirements, warrant a change to how we satisfy this attribute within the next 5 years?	6 Is there a concern raised within the OC that we agree needs to be addressed within the 5 years? Is there a longer-term concern? What are the recommended next steps? (Green font indicates a specific recommendation for immediate action)
Flexibility Flexibility is a reliability attribute that measures the ability of a unit to turn on and off quickly and frequently in a single operating day. Three characteristics that commonly determine a resource's flexibility are cycling capability, quick-start time and low minimum run times.	Yes – PJM Capacity Performance requires units to operate to their “physical parameters” when offer capped or during Tariff/Manual defined emergencies.	Not directly, with the exception of the existing ancillary service markets that incent fast start and ramping capability for synch, primary and operating reserve.	Quick start only.	No.	Not at this time given announced retirements, but retirements are not typically announced with multi-year lead times.	If these attributes are not valued, acquired and compensated, there could be retirements of existing resources that have flexibility and are utilized to serve load at times when renewables may not have an energy source or times of unexpected system volatility (i.e. large unit trips, load variations, etc.) The OC recommends the Energy Price Formation Senior Task Force (EPFSTF) consider how to value flexibility within existing or modified ancillary services. In addition, monitor the NERC SAR “Fuel Assurance with Energy-Constrained Resources” that may result in changes to, or new, NERC Standards to address concerns with flexibility.
Fuel Assurance Fuel assurance considers the ability of a balancing authority to withstand disruptions to fuel supply chains and delivery mechanisms that hinder generator performance (i.e., cold weather performance in 2014). PJM’s Evolving Resource Mix and System Reliability paper defined fuel assurance as “the ability of a resource to maintain economic maximum energy output for 72 hours, based on the definition of fuel-limited resources within the PJM Manual 13: Emergency Operations Attachment C.”	No, but Capacity Performance is intended to incent fuel assurance.	RPM assumes fuel assurance. Capacity Performance incents this through the penalty/bonus structure but there is no specific market product	ISO-NE has worked to incorporate a fuel-security reliability review methodology into its Forward Capacity Market. ISO-NE has also considered the inclusion of opportunity costs in energy market supply offers for oil and dual-fuel resource with limited energy production and improved energy emergency forecasting and reporting protocols.	The annual Fuel Security Analysis is reviewed by the OC and MRC to identify any fuel and energy assurance concerns.	Not at this time given announced retirements, but retirements are not typically announced with multi-year lead times.	If these attributes are not valued, acquired and compensated in the near term, there could be retirements of traditional resources that are necessary to serve load at times when renewables may not have an energy source. The OC recommends the RASTF should explore how to value this attribute. In addition, monitor the NERC SAR “Fuel Assurance with Energy-Constrained Resources” that may result in changes to, or

Resource Reliability Attribute & Additional Attribute Description

1 Is there an existing FERC, NERC or PJM requirement for generators to provide this attribute (e.g., Tariff, Manual, NERC Standard)?	2 Is there an existing PJM Market Product in place to maintain a minimum amount of generation that can provide this attribute?	3 Do other ISO/RTOs have an existing Market Product in place to maintain a minimum amount of generation that can provide this attribute?	4 Is there an active PJM PS/IC to address concerns with adequate availability of this attribute for operational needs?	5 Does the changing resource mix, including announced retirements, warrant a change to how we satisfy this attribute within the next 5 years?	6 Is there a concern raised within the OC that we agree needs to be addressed within the 5 years? Is there a longer-term concern? What are the recommended next steps? (Green font indicates a specific recommendation for immediate action)
---	---	---	---	--	---

					new, NERC Standards to address concerns with fuel assurance
--	--	--	--	--	---

<p>Energy Assurance</p> <p>Energy assurance refers to the concept of managing energy assurance to account for variability in solar irradiance and wind speed. This is a factor for both longer-term planning as well as near-term operations</p>	<ul style="list-style-type: none"> No, but the RPM auction does utilize an ELCC model to help to more accurately reflect the capacity contribution of renewable resources. Renewable resources are required to provide meteorological data and solar irradiance data for PJM's renewable forecasts of expected energy production Energy Storage Devices are required to telemeter their state of charge to PJM 	<p>The Day-Ahead and RT Markets <u>clear generation to meet demand and all ancillary services requirements, which by definition are designed to maintain energy assurance.</u></p>	<p>Yes – DA and RT Markets <u>similar to PJM.</u></p>	<p>The annual Fuel Security Analysis is reviewed by the OC and MRC to identify any fuel and energy assurance concerns.</p> <p>In addition, we may need to update reserve procurement procedures for times of high uncertainty (icing, wind cut-off) depending upon geographic clustering of new resources.</p>	<p>Yes. A key component to maintaining energy assurance is have accurate wind and solar forecasts.</p> <p>PJM will need to ensure accurate wind/solar forecasting that relies on accurate and consistent data reporting from resources.</p> <p><i>To ensure this data reporting occurs, PJM and Stakeholders, though the OC, need to evaluate and streamline the methods for data submission. In addition, we may need to review the penalty structure in place if the data reporting requires in the PJM Manuals are not followed. A potential PS/IC will be brought forward to the OC to explore these concerns.</i></p> <p>In addition, monitor the NERC SAR “Fuel Assurance with Energy-Constrained Resources” that may result in changes to, or new, NERC Standards to address concerns with energy assurance.</p>
---	---	--	---	--	---

Resource Reliability Attribute & Additional Attribute Description

	1 Is there an existing FERC, NERC or PJM requirement for generators to provide this attribute (e.g., Tariff, Manual, NERC Standard)?	2 Is there an existing PJM Market Product in place to maintain a minimum amount of generation that can provide this attribute?	3 Do other ISO/RTOs have an existing Market Product in place to maintain a minimum amount of generation that can provide this attribute?	4 Is there an active PJM PS/IC to address concerns with adequate availability of this attribute for operational needs?	5 Does the changing resource mix, including announced retirements, warrant a change to how we satisfy this attribute within the next 5 years?	6 Is there a concern raised within the OC that we agree needs to be addressed within the 5 years? Is there a longer-term concern? What are the recommended next steps? (Green font indicates a specific recommendation for immediate action)
Black Start Black start capability is necessary to restore the PJM transmission system following a system-wide blackout. PJM black start resources are able to self-start and close to a de-energized bus within three hours without electrical assistance from the grid or stay online and operate at reduced levels when automatically disconnected from the grid.	No. NERC Standards only apply to generators that are black start. They do not require any specific generator or MW amount of generation to have black start capability.	No. Only cost recovery.	No.	Yes. The Fuel Requirements for Black Start Resources (FRBSR) is currently active at the OC	Yes – Refer to the FRBSR work	Looking beyond the 5-year horizon, if black start capable resources and/or critical load units retire, restoration plans will be impacted which could increase potential restoration times. Valuing both fuel assurance and flexibility now, may mitigate this concern. <i>Recommend monitoring the OC FRBSR activities and the RASTF activities for Flexibility and Fuel & Energy assurance</i>
System Stability System stability refers to three perspectives: 1. Transient (angular) stability 2. Small signal stability, which is a degree of damping performance 3. Voltage stability, which looks at dynamic voltage recovery performance	<ul style="list-style-type: none"> • NERC PRC-024 requires specific voltage and ride through capabilities. • IEEE standard for non-BES IBRs. 	No	No	No	No	No changes to market products are needed. PJM will continue to monitor stability in Planning and Operations to ensure local and regional reliability is maintained.
Load Following/Dispatchable The ability for a generator to receive and respond, in real time, to a dispatch signal to adjust the MW output of the resource.	No.	<u>No, but all generation is incented to follow PJM dispatch via market signals. Resources that do not flow are subject to deviation charges.</u>	No	Yes. <u>The “Renewable Dispatch” PS/IC was approved at the 1/13/22 OC.</u> <u>In addition, a new PS/IC “Operating Reserve Clarification for Resources Operating as Requested by PJM” is being considered at the MIC that will look to strengthen incentives or supply resources to follow PJM dispatch.</u>	Yes. With more potential volatility on the system, it is important to ensure that resources follow dispatch as closely as possible. If resources have the capability to follow but do not, this may result in reliability issues (ACE imbalance) or a need to unnecessarily increase the amount of existing regulation and/or reserve PJM procures.	<i>Yes. Recommend monitoring these concerns via the “Renewable Dispatch” and “Operating Reserve Clarification for Resources Operating as Requested by PJM” Issue Charges,</i>
Extreme Weather Performance The ability for generators to perform under extreme weather conditions such as extreme heat, extreme cold, high wind, icing, etc.	NERC Standards EOP-011-2, IRO-010 and TOP-003-5 have been approved but are not yet effective/enforceable. The Standards require winterization	No	No	No	Extreme event performance is and will continue to be necessary to ensure the reliability of the grid.	<i>Recommend the RASTF consider specific unit performance requirements to manage extreme events.</i>

**Resource Reliability
Attribute & Additional
Attribute Description**

<p>1 Is there an existing FERC, NERC or PJM requirement for generators to provide this attribute (e.g., Tariff, Manual, NERC Standard)?</p>	<p>2 Is there an existing PJM Market Product in place to maintain a minimum amount of generation that can provide this attribute?</p>	<p>3 Do other ISO/RTOs have an existing Market Product in place to maintain a minimum amount of generation that can provide this attribute?</p>	<p>4 Is there an active PJM PS/IC to address concerns with adequate availability of this attribute for operational needs?</p>	<p>5 Does the changing resource mix, including announced retirements, warrant a change to how we satisfy this attribute within the next 5 years?</p>	<p>6 Is there a concern raised within the OC that we agree needs to be addressed within the 5 years? Is there a longer-term concern? What are the recommended next steps? (Green font indicates a specific recommendation for immediate action)</p>
<p>actions and data sharing, but do not have specific performance requirements.</p>					