Webinar Q&A: Evolution of ERCOT's Frequency Control and Ancillary Services for Higher Levels of Inverter-Based Generation

Question From:		Company	Question	Answer
Ao	Teng	Guzman	What would be the impact to the RTLMP if the new fast frequency response product is implemented?	There will be no impact since right now AS are procured in the day ahead market (cooptimized with energy).
			also how does system inertia feed into the ORDC calculation	All reserve are included into ORDC calculation. Adding FFR should not change anything since total RRS amounts not expected to change due to FFR addition.
			does ERCOT publish system inertia?	No, but this data is not confidential
			when did ERCOT implement N-2 contingency?	It's implemented by NERC standard BAL-003, so once that standard was approved
Roozbeh	Torkzadeh	Universidad Loyola Andalucia	How do you handle the inertia sources within the deacceleration periods after recovering the frequency?	I don't quite understand this question. Synchronous generators will recover their speed as frequency is recovering (recovering frequency is the indicator of inertia soucres recovering back to their normal speed), so this is just inherent part of the process. If the question is about emulated/synthetic inertia capability of wind turbines, we do not have any with this capability in ERCOT and even if we had this rather falls into fast frequency response than inertia.
Brendan	Kirby	Consultkirby.com	What technology is providing the 0.25 second response? Thanks!!	We expect that mainly storage will praticipate in FFR, also some Load Resources on our system indicated they would be able to respond in 0.25 seconds.
Syed	Ahmad	FERC	Could you please explain what is the difference between frequncy restoration resrve and frequency containtment reserve? Are the same product?	On that slide (on the left hand side and on the next slide) I tried to use general names for frequency reserves, before introducing ERCOT names (in the boxes). This names discribe function of the reserve, frequency containment reserve - contains/arrest frequency, frequency then setteles at some steady state level belo 60 Hz, frequency restoration reserve, helps to restore frequency back to 60. Replacmenet reserve is to replanish the other two reserves to be prepared for the next event. In ERCOT RRS is used as frequency containment reserve, Regulation is used as frequency restoration reserve, portion of RRS (if any still remaining) and Non-Spin used as replacement reserve
			Are RRS products comes from market?	All Ancillariy services, RRS, Reg and Non-Spin are procured in the day ahead market co-optimized with energy.

ELI	MASSEY	MISO	Is relying on storage to provide rapid frequency response really viable? Batteries are still expensive to build and it isn't clear to me that developers of storage facilities will be paid enough for rapid frequency response compared to other revenue flows	We currently have 99 MW of storage. The only service where they can participate right now (before FFR is implemented) is Fast Responding Regulation (subproduct of Reg), this subproduct is limited to 65 MW, so this service is already oversubscribed. We have about 1.9 GW of storage projects currently in the interconnection queue, mainly co-located with solar. That being said with crtical inertia being set at 100 GWs we can operate withoug FFR at all (if nobody shows up). However with FFR we will be able to lower critical inertia, that's the main advantage of this product.
Nick	Steffan	Terraform Power	Hi Julia! Is there anything barring battery storage from providing both ECRS and FFR?	Hi, Nick, good to hear from you! For FFR battery storage would be a great candidate (as long as it can meet 0.25 s respons time and 15-minute sustain time). For ECRS the sustain time would be for the entire hour, so from that perspective storage would be limited to it's hourly capability.
Majid	Rahimi Chatri	SNC Lavalin	I believe that the same concept may apply to smart grid systems. Is there any study extended to that area as well?	Our system can be also viewed as smart. If you mean smaller microgrids, sure this concept can also be used. I believe similar concepts are already being used on some small island systems.
David	Jacobson	Manitoba Hydro	Does ERCOT have RoCoF ride though requirements for generators (eg 4 Hz/sec).	No, we surveyed our synchronous generaotrs and found that RoCoF protection is not being used at the plants.
			Any thought about doing the N-2 outage (2750 MW) in day ahead but allowing more risk (n-1 outage) in real time?	We procure AS in the day-ahead market. So once we bought the reserves they are fixed. Currently we are only starting work on real time energy and AS cooptimization, if implemented, we potentially could change reserve requirements in real time, however NERC BAL-003 standards sets N-2 as the criteria for us.
Binod	Shrestha	SaskPower	Question to presenter: What technology is being used for Fast Frequency Response that was discussed?	Storage and Loads mainly, I think. But the service is defined and technology agnostic, anyone who passes qualification testing can participate. I believe wind and solar may also be able to provide if it made economic sense for them to keep reserve on their resources.
n	Aubut	HQ	By what mean do you manage to physically get the Load ressources to bring down their consumtion?	On our side all we see is that their underfrequency relay opens the braker of some industrial process at most 0.5 s after frequency reached 59.7 Hz and load of this resource imidiately is reduced by the MW amount of that industrial process.. I am not sure what is actually happening with industrial process when this happens.

			Is it a complete autonomous system at each load ressource or is there a signal from the control room that is sent to call for the load ressources to participate to support the frequency?	Frequency response from load resources is completely autonomous. They do telimiter to us their production in real time (so that we know how much reserve we have on Load Resources). Also there is an option for us to contact them in case we need them to come off earlier, during energy scarcity or energy emergency alert situations, there are rules in ERCOT protocols for that.
David	McMullin	Enercon	How are wind variations accounted for during the Responsive Reserve product time frames?	Responsive reserve will be deployed during frequency events, depending on technology providing the reserve, the response time is either 0.5 second (for load resources) or 10-12 seconds (for generation resources) if wind varies during those timeframes it will be reflected in system frequency and amounts of reserve deployed. Note that wind and solar resources on our system also have primary frequency response, so if they have headroom (under curtailment conditions) they will provide frequency response as well.
Mark	Robinson	AES	Does ERCOT have any Battery Energy Storage Systems (BESS) that are 75 MVA, or higher?	Not yet but there are some in the interconnection queue
Jim	zhang	mcgill	Question: 1. Is the inertia from motor load counted into the total inertia calculation? or it's too small to be neglected? 2. if there is a system frequency event occured in Eastern Interconnection, does ERCOT response to it through HVDC based on some algrithm or not at all? 3. Are wind farms (with type 3 or 4 generator) contributed to the total inertia calculation? 4. Is there any synthetic inertia from inverter based generators within ERCOT system?	1. Load inertia is not counted into total inertia calculation, this is because we don't have real time telemetry from most of the loads and wouldn't be able to account in real time for motors going in and out of service. That being said we calculate load damping after large frequency event and we know that in winter it is around 1.5% per Hz and in summer 2.4% per Hz. 2.No. DC-ties are murchant ties, there is no requirement to respond, there are rules regarding DC-tie operation during energy emergency alerts on either side, I believe. 3. Type 3 and 4 do not provide inertia as their rotating masses are decoupled frome the system through converter. If you are talking about inertia emulation, it is a type of frequency response (with associated time delays), while synchronous inertia is inherent to synchronous generators. We don't have any turbines in ERCOT equipped with inertia emulation, if we had we would consider it as means to possibly set critical inertia lower, depending on their response times. 4. No. But there are turbines with the capability that would be able to activate it if it is incentivised.

Vaibhav	Thorat	ABB Ltd	How exactly does a load response work in 0.45sec	Load resource participating in RRS is equipped with underfrequency relay, the relay is measuring system frequency all the time, as soon as frequency of 59.7 Hz is detected, relay is activated and will trip the breaker of that industrial process after at most 0.5 second (less is allowed more is not). Many load resources participating are setting their relays at slightly higher frequency than 59.7 Hz and slightly faster time than 0.5 s to make sure they respond. Thorough event analysis is carried out after every event that should have caused load resource trip, to make sure load resources responded as intended. There is also relay testing done every 2 years, actual events (if any happned) can be used in lieu of the tests.
Damian	Flynn	UCD	How big a contribution do you think that the load naturally (e.g. synchronous motors) provides to the system inertia, and have you thought about also including an online estimation of load inertia?	We don't have online telemetry from motor loads we estimate load daming fdrom large frequency events to be 1.5% per Hz in winter and 2.4 % per Hz in summer, but it's not a constant number so we cannot accuratly include it in inertia estimation. That being said the studies to determine critical inertia and RRS requirements were had frequency sensitivity baked into load models, and therefore critical inertia number and RRS requirements already reflect load response that we'd typically see on our system.
Edgar	DeMeo	Renewable Energy Consulting Services, Inc.	In responding to drops in frequency, do transmission constraints ever come into play?	I don't quite understand the question. If the question is about reserves locked behind transmission constraints, then the answer is no for RRS and Reg, because both are deploye automaticaly. RRS will be deployed purely on frequency and will violate the constraints for some seconds, Reg is deployed on ACE (which in ERCOT is proportional to frequency deviation) in real time will do the same thing but in general operators tend to move Reg behind constraints if they see it happening. Non-spin is dispatched through real time economic dispatch and it takes transmission constraints into account.
Steve	Drouilhet	Sustainable Power Systems, Inc.	Has there been any consideration of increasing system inertia as opposed to increasing fast frequency response?	Increasing inertia would be either by bringing additional synchronous generation online, that market outcome says is not needed for energy. Synchronous generators once started have to operate at certain min gen, that is non-economic (otherwise that generator would be online anyway). Installing synchronous condencers would be another option, but in ERCOT this would be conisdered transmission asset that would go into ratebase, we think AS market product is more effective and competitive way. Also Syn Con's inertia might not be as high as that of a synchronous generator and we would need very many condenders to address inertia.

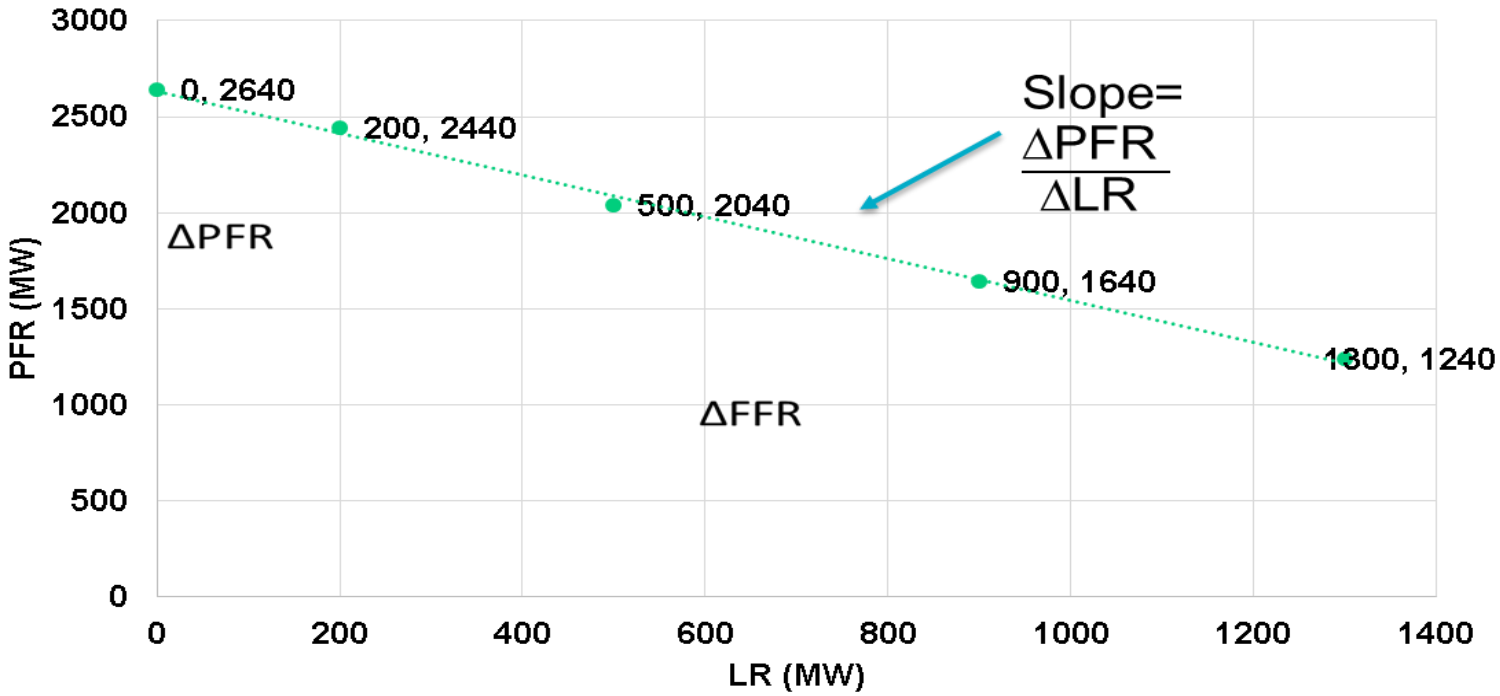
John	Hingtgen	CEC	Are any of the other ISO's doing similar things with inertia management?	In Australia, Ireland, UK do similar things, but both Western and Eastern Interconnections are large interconnections with not so high of a share of inverter-based generation. In Hydro Quebec they are controlling their largest contingency (dispatching their largest hydro plant down) rather than setting critical inertia. We cannot do that since we cannot dispatch nuclear unit down.
reddy	tudi	Stornetic Gmbh	Can you comment on what the compensation is for frequency response and for fast frequency response?	FFR will be subproduct of RRS so the compensation will be the same, similarly to haw currently Load Resources and Generation Resources providing RRS are paid the same even though the Load Resources are faster and more effective at times of low inertia. This decision was made through our market stakeholder process. The advantage of having all these "tools" withing one RRS product is in alowing more technologies to participate.
			Are there any plans for Ercot for compensating resources for inertia?	Not for now
			did they consider flywheel energy storage for FFR instead of condensors?	FFR is technology agnostic anyone who can pass qualification testing can provide. I am not sure if 15 minutes sustain time requirement would be viable for flywheel? Also you said "instead of condencers" I think there is a misunderstanding here. Synchornous condensers would not be used here, since FFR service is about MW injection, SynCons are used for reactive power/voltage support. They could potentially help with inertia but as I said on the webinar, their inertia contribution is relatively low.
Soundrapandian	Sankar	Black & Veatch	How do you ensure the inertia constants used in the study represent the actual turbine-generator inertia constant?	We did comparison to typical values by generator type and worked with generator owners to correct values that didn't look right. We also banchmarked actual freuqency from historic events to simulated freqeuncy from the network model and we get a very good fit expecially in inertia timeframe, which makes us believe that inertia constants are fairly accurate.
GUANCHI	LIU	Electric and Electrical Engineering	Thanks for the great presentation!I just wonder why solar and wind participation in PFR can migitate the effect of overshoot brought by LR?	Thank you. Wind and solar provide a lot of "legroom" for overfrequency event and respond faster than synchronous generators. That's why it was found in the studies that they are helpful in meetingating frequency overshoot when load reasources are tripped.

Derek	Stenclik	Telos Energy	Can you provide more information on who is providing load RRS today? Is it LSEs with their large industrials or demand aggregators?	I had a list in the comments of my slide that talks about Load Resources, but just in case it will be not visible in the pdf version, here it is again. Load Resources providing frequency response (as a part of Responsive Reserve Service) are single site loads (no aggregation), 100-250 MW: Industrial process plants that produce chemicals, each site >150 MW, and consist of several process lines each about 50 MW. Air separation plants that extract industrial gasses, each site ≤ 100 MW Natural gas compression sites that are part of pipeline operation Oil field loads (from couple of kW to tens of MW), Industrial process loads (i.e. cement plants, manufacturing plants), Very few large commercial sites, mainly data centers. The participation from broader range of customers is limited due to: Instantaneous interruption that a Resource should be able to withstand and Costs of real time telemetry equipment (a requirement for participation is to add dedicated communication systems to send site data to ERCOT).
			Are you considering the locational needs for FFR to avoid a potential system separation event?	No, I believe we operte the system such that system separation (and keeping both parts of the system operational after) is not possible
Ambrose	Yung	IESO	What technology is being used for the Fast Frequency response?	FFR will only be imeplemented by 1/2020. The service is technology agnostic but we believe that storage and loads could be potential providers.
Shutha	Pulendran	IESO	Is ERCOT working on introducing resources that could provide only inertial response through a separate market mechanism ?	Not at the moment
			How did you come up with the ratio of equivalent load response to generation as 2.5 etc.?	We did a series of dynamic studies at different inertia levels. In each study 2750 MW is tripped, the criteria is not to touch UFLS for this event. For a given study case we start with 1150 MW of PFR and then see how much LR is needed to fullfill the criteria, then text a different (higher) PFR level and again see how much LR needs to be added. And so on for several (5, I believe) PFR levels. We found that for a given inertia condition there is a linear relationship between PFR and LR needed, the slope is the equivalency ratio at that inertia level. I pasted an illustration of this below. The study is then repeated for a different inertia level.
			Is it because load is considered faster than generation here?	Yes, exactly.

Dale	Bradshaw	1947	What is the frequency of monitoring inertia? Seconds or minutes?	It's updated every 4 seconds
			What is 1150 MW PFR on the Critical Inertia Study?	Great question! We have a requirement that minimum 1150 MW of RRS should come from generation (i.e. through PFR or governor response in other words). This is because Load Resources will only start responding if frequency reaches 59.7 Hz, but BAL-003 sets IFR obligation for us even for the first 0.3 Hz of freuency deviation. IFRO is in MW/Hz which for 0.3 Hz for ERCOT is 1150 MW.So since it's a minimum requirement we assume we'll always procure at least that and then in the critical inertia study let the frequency fall to measure time between 59.7 Hz and 59.3 Hz and determine if it's more or less than responsice time of Load Resources. If it's more we continue decreasing inertia in the study if it's less then we found our critical inertia.
			By Load Resources do you refer to aggregated demand side management?	Yes it is a demand side management in other words, only fast and automatic/autonomous. They are all sigle site resouces, no aggregation participated so far. See my response to Derek Stenclik above for types of resources participating and why it would be difficult for an aggregation to participate
			What is ECRS?	ERCOT Contingency Reserve Service, this will be a new service implemented by 1/2022, it will separate 10-minute energy component that is currently bundled into RRS in a separate service. What I mean by 10 minute component is that in certain situations currently RRS may be relieased to real time economic dispatch and full respose to the dispatch signal is expected withing 10 minutes. This is usually used during energy scaricity events or as replacement reserve for frequency events with frequency nadir at or below 59.91 Hz
Bill	Shemley	PacifiCorp	Are the loads participating in FFR compensated for providing this service?	FFR has not been implemented yet, implmenetation is by 1/2020. Loads participating in RRS are compensated same $/MW as generators participating in RRS, usually generation offers set the prices for RRS
			Are the loads participating in the FFR program directly connected to the system operator or is it just by UFLS?	Loads participating in RRS now and possibly participating in FFR in the future, have/will have underfrequency relay at their site that measures frequency and automatically trips the site or industrial process beaker in 0.5s (or less) after frequency reaches the trigger point (currently 59.7 Hz).
Sam	Meybodi	Energinet	Does ERCOT have any reserve which is activated without a deadzone, i.e 17 mHz for PFR?	Not that we are aware of but it's not prohibited

			Do you have separate reserves for balancing and rejection of large disturbances? Do you see any meaningful difference between these two?	For balancing net load (load minus wind minus solar) variability Regulation is used, between 5 minute real time energy dispatch runs. A lot of balancing is happening just through 5 minute economic dispatch runs too. For larrge disturbances RRS is used. So yes we do separate them and we totatlly think it's needed. Being a single interconnection we cannot affort disturbance reserve to be depeleted by seconds to second or minute to minute variability.
			Do you see HVDC as potential source of FFR?	FFR is technology agnostic anyone who can pass qualification testing can provide. Theoretically they should be capable to.
			Thanks for the great talk!	Thank you!

For the question from Shutha Pulendrar from IESO



PFR/LR Equivalency Ratio= - Slope= $-\frac{\Delta PFR}{\Delta LR}$

Interpretation: To replace 1MW of LR, $-\frac{\Delta PFR}{\Delta LR}$ MW of PFR is needed

(1MW FFR = $-\frac{\Delta PFR}{\Delta LR}$ MW PFR)