Comments of the Union of Concerned Scientists on the California Independent System Operator's Frequency Response Issue Paper

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The Union of Concerned Scientists (UCS) appreciates the opportunity to provide comments on the California Independent System Operator's (CAISO) frequency response issue paper.

Table of Contents

Market efficiency concerns suggest that primary frequency response and spinning reserves should be separate markets.

In the frequency response issue paper, the ISO asks, "Should the ISO develop a market product to procure frequency response?"[1] UCS believes that this product should be developed.

Different generator and resource types have a range of ability to contribute to primary frequency response (PFR) on the timescale of one minute.[2] This is because technologies differ in their ability to ramp power output very quickly. As more non-conventional resources are introduced into the grid, the potential range of ability to respond quickly to grid frequency deviations becomes larger. Some non-conventional technologies may be able to respond much more quickly than conventional generators,[3,4] while some may have longer response times, or may not be able to respond at all.

Spinning reserves and PFR should be separate market products because of the wide variation in the ability of different resources to respond on the one-minute timescale of PFR. Some resources that can provide spinning reserves on the ten-minute timescale will not be able to provide a large fraction of their response in the first one minute for PFR, whereas some resources could provide most or all of their spinning reserve capacity in one minute. This difference of perhaps ~10x in the ability to provide PFR via spinning reserves will result in large market inefficiencies if slower-responding resources are committed to provide a large fraction of spinning reserve. In a recent paper on potential new ancillary services, Brendan Kirby echoes these thoughts by stating "… while spinning reserve is defined as fully responsive within ten minutes[,] the exact response before ten minutes, though required, is not rigorously defined. This is because different generation technologies and even different generators of the same technology often have very different short term response characteristics."[5]

In acknowledgement that resources can vary in their ability to provide frequency response on different timescales, the Electric Reliability Council of Texas (ERCOT) is currently working on implementing multiple market products for frequency response (alongside other ancillary services).[6,7] While the CAISO and ERCOT

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[1] http://www.caiso.com/Documents/IssuePaper_FrequencyResponse.pdf, p. 13.

[2] For example, http://www.nrel.gov/electricity/transmission/pdfs/wind_workshop2_14undrill.pdf, Slide 35.

[3] Miller, N. W.; Shao, M.; Venkataraman, S. 2011. California ISO (CAISO) Frequency Response Study. GE Energy. p. 66-69. Online at http://www.uwig.org/report-frequencyresponsestudy.pdf

[4] Kirby, B. 2014. Potential new ancillary services: developments of interest to generators. Online at *http://www.consultkirby.com/files/01B2_Kirby_Paper_-_Potential_New_Ancillary_Services.pdf*, p.6.

[5] *Ibid*, p.4.

[6] http://www.ercot.com/committees/other/fast

systems do have important differences, California can draw upon lessons learned in Texas when creating frequency response markets.

If a PFR market product cannot be developed by fall 2016, constraints for a future market product should be developed and implemented in 2017

In the frequency response issue paper, the ISO asks, "If the ISO cannot develop a product in time for the fall 2016 release, what interim solution would be appropriate? For example, using existing or modifying spinning reserve procurement." [8]

If a market product for PFR can't be implemented by fall 2016, then this initiative should work towards formulating constraints in the market optimization that can easily be turned into market products in 2017. Doing so would speed the process of developing markets for PFR and provide information on the likely near-term market prices of PFR via shadow prices on the constraints that ensure adequate PFR. The ISO should avoid pursuing any PFR strategy that would not directly aid the creation of future frequency response market products.

If all governors were enabled and working properly, when would the ISO need additional frequency response?

This initiative would be aided by information about the current state of governors on conventional generators and other resources. Possible questions to investigate include:

- Will the ISO be in compliance with the PFR standard (NERC standard BAL-003-1) if all synchronous resources that should have governor response were to enable their response?
- What percent of the total expected response from governors is the ISO receiving today?
- Droop settings specify response as MW/Hz, but UCS is unaware of a response time in which the resource must provide this response. Is there a standard for this?
- If the ISO could enable governor response on all resources that should be responding today, in what year would the ISO expect to be out of compliance with BAL-003-1?

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[7] Electric Reliability Council of Texas (ERCOT). 2013. ERCOT concept paper: Future ancillary services in ERCOT. Draft version 1.1. Austin, TX. Online at *http://www.ercot.com/content/news/presentations/2014/ERCOT_AS_Concept_Paper_Version_1.1_as_of_11-01-13_1445_black.pdf*

[8] http://www.caiso.com/Documents/IssuePaper_FrequencyResponse.pdf, p. 13.

If enabling existing governor response would allow BAL-003-1 compliance in late 2016 and in 2017, then perhaps efforts in this initiative should be focused on developing the long-term, ideal market product for PFR.

Will the ISO be able to trade PFR response with other BAs?

It will be important to understand the potential for the ISO to purchase PFR from other areas that may be long on PFR, or sell to other areas that are short on PFR. If it will not be possible to trade PFR between balancing areas, then it would be helpful for this initiative to discuss the barriers to doing so. If it will be possible to trade PFR, then this initiative should estimate the response that could be expected from other areas, and include the ability to trade PFR in constraints and/or market products.

Increasing the spinning reserve requirement to cover the PFR requirement could raise costs and GHG emissions significantly.

The ISO's frequency response issue paper states, "[T]he ISO is evaluating whether our current procurement of spinning reserves can meet the new frequency response obligation. One consideration is that a generator may not be capable of providing as much frequency response capacity as spinning reserve capacity. Consequently, the ISO may have to modify spinning reserve procurement to ensure it obtains an adequate quantity of frequency response."[9]

It would be informative to understand the magnitude of expected upward response on the one-minute and ten-minute timescales from different technologies. This information would help to determine how much spinning reserve would be needed from each technology to provide a given amount of PFR. Ideally the ISO and stakeholders would quantify the one-minute response as a percentage of committed spinning reserve for a variety of conventional and non-conventional technologies.

It is unlikely that many resources, especially in the near term, will be able to provide 100% of their spinning reserve in one minute. Obtaining PFR from spinning reserve will likely raise the spinning reserve commitment in many hours, which would also raise system costs. This could be especially inefficient if slower resources are chosen to meet the increased spinning requirement.

The ISO should also consider the greenhouse gas (GHG) emission impacts of holding significantly more spinning reserve requirement. Without further analysis it is unclear what generators would be most likely to meet any marginal increase in spinning reserve requirement, but at least some additional natural gas generators would be likely to be committed to meet the requirement. Running more gas generators at low power output (to ensure enough headroom to provide the spinning reserve) will decrease their efficiency, thereby increasing GHG emissions.

[9] http://www.caiso.com/Documents/IssuePaper_FrequencyResponse.pdf, p.13

Also, at times of low net demand, the minimum load burden of conventional generators committed to provide PFR via spinning reserve could crowd out renewable generation, causing renewable curtailment and GHG emissions. This situation should be avoided if at all possible.

Increasing the spinning reserve requirement to cover the PFR requirement could cause inefficient new capacity procurement

Increasing the spinning reserve requirement could unnecessarily increase the need to procure new capacity. In the California Public Utilities Commission Long Term Procurement Plan, it has been proposed that spinning reserve violations will be counted as loss of load events,[10] with the rationale that load would be curtailed to maintain enough spinning reserve. If the ISO increases the spinning reserve requirement to provide adequate PFR, this could trigger additional need for system capacity on a MW-for-MW basis. This need could and should be better addressed through efficient procurement of fast-ramping resources that can meet PFR needs, rather than procuring new system capacity to meet increased spinning reserve needs. While it remains to be seen whether reserve violations of a PFR market product would constitute loss of load events, splitting PFR away from spinning reserve would reduce the magnitude of any reserve violations and therefore the potential for and magnitude of new capacity procurement.

To provide a rough estimate of how much additional capacity would cost, we take the cost of new entry for a combined cycle gas turbine (CCGT) as ~$150/kW-yr.[11] We also assume that the average hourly spinning reserve procurement from 2012-2014 of ~850 MW[12] could be doubled by adding the PFR requirement to the spinning reserve requirement. This doubling is hypothetical because there is not currently enough information to determine the increase in spinning reserve requirement that would result from adding a PRF requirement. Rather, we assume a doubling to demonstrate possible cost impacts of increased spinning reserve commitment. Also, while there could be significant hourly variation in spinning reserve requirements for PFR, for lack of data we do not include this dynamic in our calculation.

If the spinning reserve requirement were increased by 850 MW and the ISO system doesn't have enough capacity to meet this need, this would equate to $**128** million / year (850 MW * $150/kW-yr * 1000 kW/ MW) in new capacity procurement costs. It should be noted that this calculation is inconsistent with the state's loading order

[10] Reardon, N.; Velasquez, C.; White, K.; Young, P. Proposed Revisions to LTPP Modeling Methodology. Draft Energy Division Staff Proposal. California Public Utilities Commission: Energy Division. 7/24/2015.

[11] The Brattle Group and Astrape Consulting. Resource Adequacy Requirements: Reliability and Economic Implications. 09/2013. p. 36. Online at http://www.ferc.gov/legal/staff-reports/2014/02-07-14-consultant-report.pdf

[12] http://www.caiso.com/Documents/2014AnnualReport_MarketIssues_Performance.pdf, p. 111.

for capacity procurement, so depending on the cost of non-gas system capacity, the cost for system capacity could be higher than calculated here.

The cost of new capacity is much higher than procuring the same amount of spinning reserve (850 MW) at current market prices. Spinning reserve in the day ahead market in 2014 had a weighted-average price of $4.21 / MW.[13] If we ignore the dynamic that spin from resources with a higher opportunity cost (higher on the supply curve) would have to be procured as the spin requirement is increased, this translates to $4.21 / MW * 850 MW spin per hour for PFR = $3,600 / Hr, or $**31** million per year. Procurement of new capacity resulting from an increased spinning reserve requirement could cost four times ($128 million / $31 million = 4.1x) more than procuring additional spinning reserve in ISO day ahead market. The ISO should strive to avoid this situation by creating a separate market product or products for PFR that will more efficiently represent the fast-responding capabilities of each resource.

More information is needed about the cost and ability of non-conventional resources to provide PFR.

In the frequency response issue paper, the ISO asks, "WECC standards apply only to synchronous generators. Should the ISO explore a requirement that non-synchronous generators have primary frequency response capability?"[14]

In general the answer is yes, but the cost impacts of this requirement should be considered before making a decision about whether to require PFR capability from non-synchronous resources. For some existing resources it could be expensive to provide PFR capability because a large retrofit would be required. It is also possible that the cost impact for some new resources would be large. If the ISO requires PFR from non-synchronous resources, it should first be shown that the cost impacts of imposing this requirement are not large. Another way to go would be to create a PFR market and allow resources to decide whether to offer PFR capability through the price of the PFR product.

Specific questions that should be investigated, ideally in conjunction with stakeholders that represent non-conventional resources:

- Is there any marginal cost of requiring new wind and solar generators to have PFR capability? This marginal cost would not include the cost to actually provide PFR by pre-curtailing the renewable resource to create headroom. If a market product were to be developed, the cost of pre-curtailment would instead be included in bids by renewable generators to provide PFR.

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[13] http://www.caiso.com/Documents/2014AnnualReport_MarketIssues_Performance.pdf, p. 113

[14] http://www.caiso.com/Documents/IssuePaper_FrequencyResponse.pdf, p. 13.

- What is the cost to require storage devices, demand response resources, or other non-conventional resources to have PFR capability?
- Are there important technologies that would be excluded by a requirement to have PFR capability?
- Would existing resources be included in the requirement? If so, how many existing resources have this capability now, or could add the capability without much additional cost (such as a software update?).

Under frequency load shedding for frequency response should be pursued.

Under frequency load shed (UFLS) – the disconnection of demand when frequency dips below a certain level – could be particularly effective in providing frequency response, and does not necessarily require new technology to implement. Electricity customers could be compensated for being voluntarily disconnected in the event of an under frequency event. For example, some customers could have their demand trip offline at 59.7 Hz instead of a lower value, perhaps 59.5 Hz.

A study by GE and the ISO[15] has shown this strategy to be very successful at arresting frequency decline. The study modeled the tripping of 1,379 MW of pumps and pumped storage hydro plants at 59.7 Hz, and found that in the case of a large decline in frequency, frequency response was comparable to 12 GW of headroom on conventional generation. In this case, UFLS was almost ten times more effective than conventional response.

UFLS has different characteristics than governor response, and is consequently being divided into different markets by ERCOT's future ancillary services team.[16,17] To comply with BAL-003-1, UFLS cannot likely replace all governor response because UFLS will not respond to frequency excursions above the UFLS threshold. However, UFLS and a separate PFR product could work together to ensure BAL-003-1 compliance in an economically efficient fashion.

UCS analyses show the potential for the provision of frequency response from conventional generators to cause renewable curtailment

The PFR requirement will be much more likely to bind at low net demand (demand minus wind and solar production) levels, when many conventional resources will be switched off, and the remaining resources may be causing renewable curtailment

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[15] Miller, N. W.; Shao, M.; Venkataraman, S. California ISO (CAISO) Frequency Response Study. GE Energy. 09/11/2011. p. 71-73. Online at http://www.uwig.org/report-frequencyresponsestudy.pdf

[16] http://www.ercot.com/committees/other/fast

[17] Electric Reliability Council of Texas (ERCOT). 2013. ERCOT concept paper: Future ancillary services in ERCOT. Draft version 1.1. Austin, TX. Online at *http://www.ercot.com/content/news/presentations/2014/ERCOT_AS_Concept_Paper_Version_1.1_as_of_11-01-13_1445_black.pdf*

and/or may be exposed to negative marginal prices due to their minimum load burden on the system.

Two recent analyses from UCS show the potential for the provision of frequency response and other essential reliability services to cause renewable curtailment at higher levels of renewable generation. In these studies, regional generation requirements – a set of requirements developed by the ISO as a proxy for a number of essential grid reliability services (including PFR) that have historically been provided by conventional generation – were found to cause between 11 and 39 percent of the total renewable curtailment.[18,19] The analyses show that conventional generators could be kept online to provide essential grid services like PFR, thereby crowding out renewable generation.

The ISO's frequency response initiative should strive to address frequency response needs in a way that efficiently allows both conventional and non-conventional resources to participate. Doing so will be an important step towards ensuring grid reliability while minimizing renewable curtailment and reducing GHG emissions from electricity generation.

[18] Nelson, J.H.; Wisland, L. M. Achieving 50 Percent Renewable Electricity in California. 08/2015. Union of Concerned Scientists. Online at http://www.ucsusa.org/California50RPSAnalysis

[19] Nelson, J. 2014. Prepared opening testimony of Dr. Jimmy Nelson on behalf of the Union of Concerned Scientists and Sierra Club, including Errata. Proceeding R.13-12-010, September 24. San Francisco, CA: California Public Utilities Commission. Online at *https://content.sierraclub.org/coal/sites/content.sierraclub.org.coal/files/docs/2014-09-30%20Testimony%20Dr.%20Jimmy%20Nelson%20on%20behalf%20of%20the%20UCS%20and%20SC.pdf*