California ISO

TECHNICAL BULLETIN

Load Conformance Limiter Enhancement

December 28, 2016

Revision History

Date	Version	Description	Author
December 28, 2016	1.0	Draft Proposal	Guillermo Bautista Alderete

Contents

Background

Grid operators in each of the balancing authority areas that are in the Energy Imbalance Market (EIM) area, including the ISO grid operators, can reconcile differences between actual conditions and what the market systems observe through, among other tools, the use of the load conformance tool. A load conformance is an adjustment –positive or negative– to the overall automated forecasted load requirement used in clearing the real-time market. How much the load requirement is conformed is the result of the operators' best judgement of current system operational and reliability needs that were not factored into the load forecast or the available supply expected by the market dispatch application.[1] Operators conform the load forecast used in the market for more reasons other than just load forecast errors. Other reasons include persistent resource deviations, including renewable deviations, excursion of Area Control Error (ACE), and offsetting lost capacity after forced outages before the outage card is submitted and considered by the market process. Because the adjustments are manual, these adjustments are, by nature, coarse adjustments made to respond quickly to rapidly changing system conditions and tend not to be finely tuned or gradually applied. For example, the operator may believe there is a need to make an adjustment of 100 MW due to load changes in real-time. However, the actual need may be just 83 MW. Thus, the operator may put in a load conformance of 100 MW to obtain the extra dispatch needed to address the expected system ramp conditions. It may happen that the ramp capability available to market is only 90 MW and thus, the market cannot possibly increase by the additional manually conformed value of 100 MW. The main limitation is that the operator cannot observe the precise capacity needs for a specific point of time in the upcoming near future. To know this, the operator would need to know the capacity need and the ramp capability existing in the market prior to the market clearing to determine exactly how much ramp capability exists and will be needed.

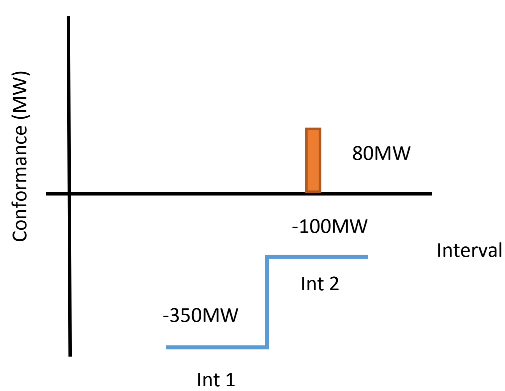
[1] In response to concerns raised regarding the use of the load conformance or the load conformance limiter tool, the CAISO committed to commence a stakeholder process to consider improvements to these tools. *Answer of the California Independent systems Operator Corporation to Comments*, November 24, 2015, p. 21. http://www.caiso.com/Documents/Nov24_2015_Answer_Comments_AvailableBalancingCapacity_ER15-861-006.pdf.

Current Logic for load conformance

The CAISO uses a load conformance limiter in the CAISO and in each of the EIM balancing authority areas to prevent manually driven over-adjustments when using load conformance from causing artificial infeasibilities – that is, one that does not reflect actual scarcity conditions. The current logic is relatively simple and relies only on information of the current binding interval and the power balance constraint infeasibility observed in the market in that current interval. When the magnitude of the infeasibility, either positive or negative, is less than the load conformance, and the infeasibility is in the same direction as the conformance (positive conformance for under-supply infeasibilities and negative conformance for over-supply infeasibilities), the load conformance limiter automatically limits the operator's adjustments to a value that is just smaller than the level of infeasibility. In the pricing run, the limiter will effectively set the market requirement to the value where the market is still feasible to meet its power balance constraint; this will allow the market to clear at the last economical signal of the market instead of relying on the relaxation of the power balance constraint infeasibility and its corresponding relaxation parameter price. The limiter will not apply in conditions when the magnitude of the infeasibility is greater than or in the opposite direction to the load conformance because in such conditions the load conformance was not the cause of the infeasibility rather underlying system conditions triggered the infeasibility.

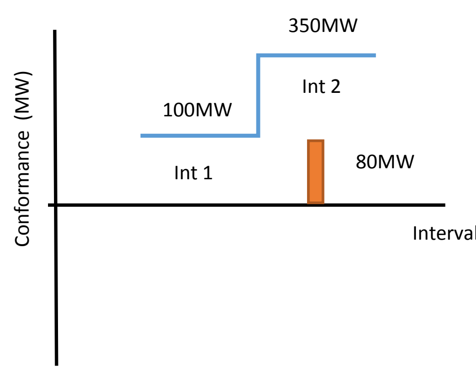
Although the current logic may capture some intended scenarios, it may not always capture the full set of intended scenarios in which manual over-adjustments cause infeasibilities and in some other instances it may apply the limiter in excess. Let us consider some cases to illustrate the different scenarios.

Example 1. In this first example, consider that in the current binding interval there is a load conformance of negative 100 MW (Int 2) and a power balance constraint infeasibility of 80 MW (under-supply). In this example, the load conformance is actually reducing the market requirements by 100 MW. The previous interval (Int 1) had a load conformance of negative 350 MW and no power balance constraint infeasibility.



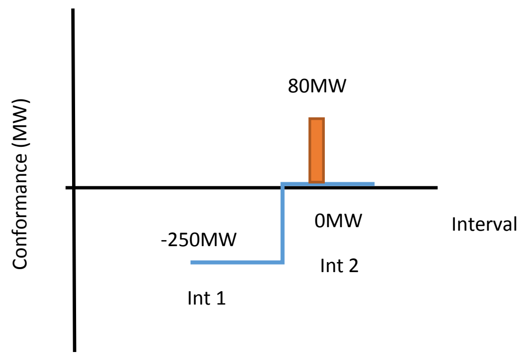
Under the current logic, the load conformance limiter would not apply. Although the magnitude of the infeasibility is smaller than the magnitude of the load conformance, the limiter does not trigger because the infeasibility and the conformance are in different directions. This assumes that a negative conformance cannot result in a positive power balance constraint infeasibility. This is the main limitation of the existing logic, which is to rely solely on information of the current interval. In reality the power balance constraint infeasibility of 80 MW can be attributed to the load conformance change from negative 350 MW (previous interval) to negative 100 MW (current interval), which effectively means an actual increase to the market requirements of 250 MW. The power balance constraint infeasibility does not reflect actual scarcity in that interval but rather is triggered by the 250 MW load conformance increase between the two intervals that leads to the power balance constraint infeasibility (under-supply).

Example 2. In this second example, consider modifying the pattern of the load conformance in example 1 as shown in the following illustration:



In this example, load is conformed by a positive 350 MW in the current interval (Int 2) after it had been conformed by a positive 100 MW in the prior interval (Int 1). The current logic will trigger the load conformance limiter because the power balance constraint infeasibility of 80 MW is smaller than the load conformance of 350 MW. Similar to the previous case, the infeasibility is actually caused by the load conformance change of 250 MW (350 MW minus 100 MW) and not by the full load conformance of 350 MW.

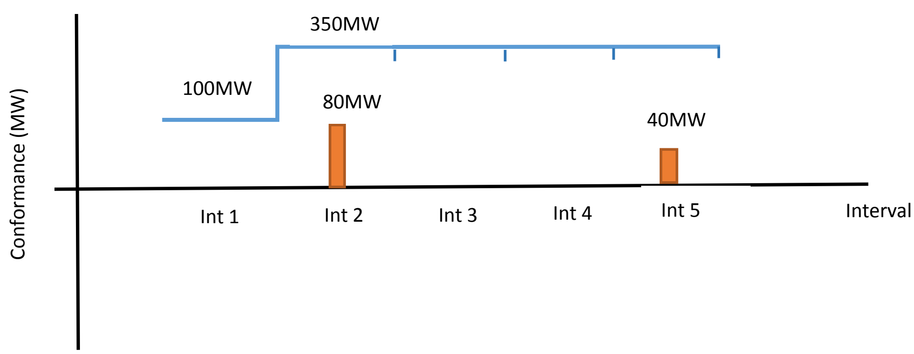
Example 3. In this third example, the scenario is further modified as illustrated in the following graph.



In this example, the load was conformed by negative 250 MW in the prior interval (Int 1) and there was no conformance in the current interval (Int 2). Under the current logic, the load conformance limiter would not trigger because there is no load conformance applied to the current interval when a power balance constraint infeasibility of 80 MW is observed. Similar to the two previous examples, the infeasibility was caused by the load conformance change of 250 MW (which is 0 minus [-250 MW]). This example illustrates the case where the load conformance limiter should apply even in some when there is no actual load conformance in the current interval.

These first three examples highlight the need to include in the load conformance limiter not just the absolute values of the infeasibility and load conformance in the current interval, but to the relative change of load conformance and infeasibility between current and previous intervals.

Example 4. This fourth example illustrates a case where the load conformance limiter may be triggering but the manual load conformance did not actually cause the infeasibility.



Under this example, assume that the load conformance of 350 MWs value now remains constant for multiple intervals. As explained in example 2, the load conformance change introduced at the beginning of the time period between intervals 2 and 1 caused the first infeasibility of 80 MWs. Under the current logic, the limiter would trigger for such an infeasibility.

In the subsequent intervals, although the load conformance remained constant in the system after the first infeasibility, there were no subsequent infeasibilities following the 80 MWs infeasibility. This implies the system had sufficient ramp capability to internalize the 350 MWs load conformance. However, a few intervals later, there is an infeasibility of 40 MWs in interval 5 even when the load conformance has remained constant. This means that the original change of the load conformance did not cause the infeasibility because the system absorbed the conformance before the infeasibility of 80 MW, and there must have been another change happening in the system that together with the standing load conformance prompted the infeasibility. Under the current logic, in the 40 MW infeasibility case, the limiter would still trigger because (i) the infeasibility is smaller than the load conformance and (ii) the infeasibility and the load conformance are in the same direction. One element in support of this conclusion is that if the 350 MW of load conformance was not in the market, the 40 MW infeasibility would not occur implying that the load conformance contributed to but was not the sole cause of the infeasibility. A counterargument is that the market fully absorbed the original conformance of 350 MW in previous intervals and a new infeasibility was really prompted by the actual changes in the system (such as a load forecast change, unit deviation, etc.) rather than being triggered by the magnitude of the change in manual load conformance.

Proposal for enhanced logic

These simple examples highlight how the triggers for the current load conformance limiter logic should be enhanced. The proposed enhanced load conformance limiter logic has the following characteristics:

1. It is based on the change of load conformance and infeasibility between current interval and previous intervals
2. It is not limited to relying only on the load conformance in the current interval.
3. It is not subject to having the power balance constraint (PBC) infeasibility in the same direction of the load conformance.
4. It builds up a memory of the change in load conformance for the outcome from previous determinations about whether the load conformance limiter was applied.

The enhanced logic can be captured with the following formula:

$$C_i = (PBC\_inf_i - PBC\_inf_{i-1}) - (Conf_i - Conf_{i-1}) + \max(0, C_{i-1}) \quad (1)$$

Where i is the index for current interval and $(i-1)$ stands for previous interval

C_i is the remaining available capability to absorb power balance constraint infeasibilities in current interval

$(PBC\_inf_i - PBC\_inf_{i-1})$ is the change of power balance constraint infeasibility between current and previous intervals

$(Conf_i - Conf_{i-1})$ is the change of load conformance between current and previous intervals

$\max(0, C_{i-1})$ is the carry-over capability from previous interval.

Once the remaining capability C_i is estimated, the load conformance limiter will be triggered if and only if $C_i < 0$.

In any given interval when the power balance constraint infeasibility is 0, C_i is reset to 0.

The logic captured with expression 1 is applicable for intervals with under-supply infeasibilities. For over-supply infeasibilities, the expression is adjusted as follows

$$C_i = (PBC\_inf_i - PBC\_inf_{i-1}) - (Conf_i - Conf_{i-1}) + \min(0, C_{i-1}) \qquad (2)$$

With the load conformance limiter triggering when $C_i > 0$.

The current logic of load conformance limiter is a special case of the more general proposed expression when all terms related to the previous interval are ignored from the proposed formula as follows

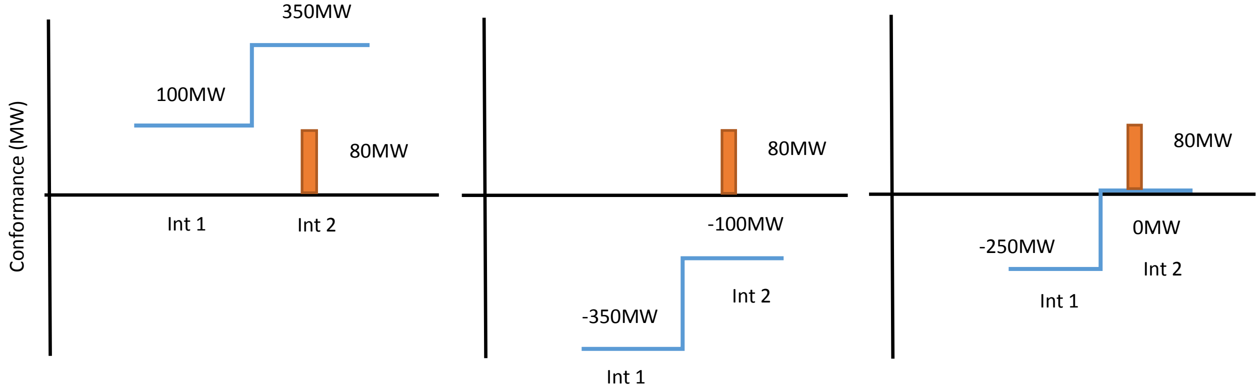
$$C_i = (PBC_{inf} - Conf_i) \qquad (3)$$

And the test would be $C_i < 0$? to apply the limiter.

Thus, the current logic is a specific variation of the proposed enhancement.

The following examples are used to illustrate how the proposed enhancement to the load conformance limiter would trigger.

Example 5. Consider the cases illustrated in examples 1 through 3 with the proposed logic.



For the first example, start with $C_0 = 0$ and then calculate C_1 as follows

$$C_1 = (80 - 0) - (0 - 250) + \max(0{,}0) = -170$$

C_1 =-170<0? Yes, then the load conformance limiter applies.

For the second example, start with $C_0 = 0$ and then calculate C_1 as follows

$$C_1 = (80 - 0) - (-100 + 350) + \max(0{,}0) = -170$$

C_1 =-170<0? Yes, then the load conformance limiter applies.

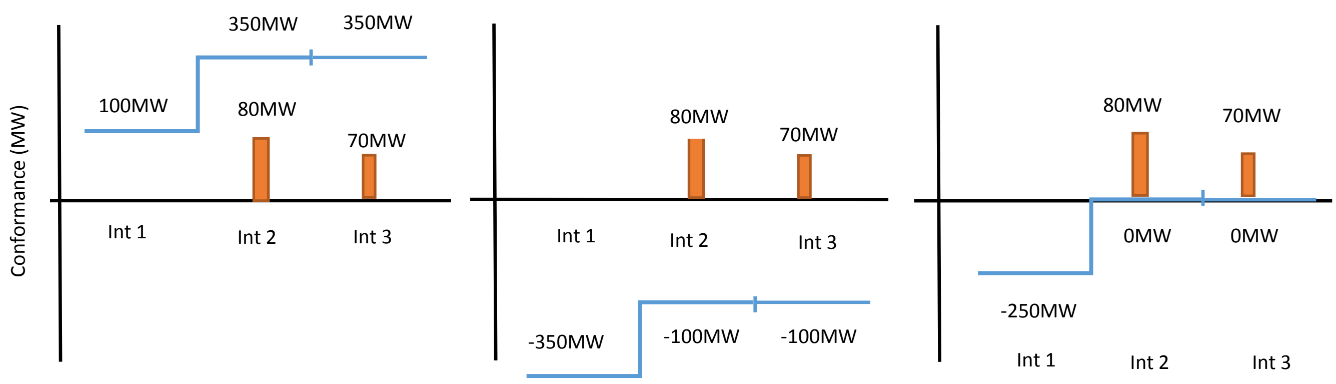
For the third example, start with $C_0 = 0$ and then calculate C_1 as follows

$$C_1 = (80 - 0) - (0 + 250) + \max(0{,}0) = -170$$

C_1 =-170<0? Yes, then the load conformance limiter applies.

As discussed in the previous sections, in each of these three cases the load conformance limiter should apply since the load conformance change drove the infeasibility. The proposed logic captures all these three scenarios properly.

Example 6. Using the previous example, consider other scenarios by building up a subsequent interval (Int 3).



For the first example, start with $C_1 = -170$ as estimated from previous interval and then calculate C_2 as follows

$$C_2 = (70 - 80) - (350 - 350) + \max(0, -170) = -10$$

C_2 =-10<0? Yes, then the load conformance limiter applies.

For the second example, start with $C_1 = -170$ as estimated from previous interval and then calculate C_2 as follows

$$C_2 = (70 - 80) - (100 - 100) + \max(0, -170) = -10$$

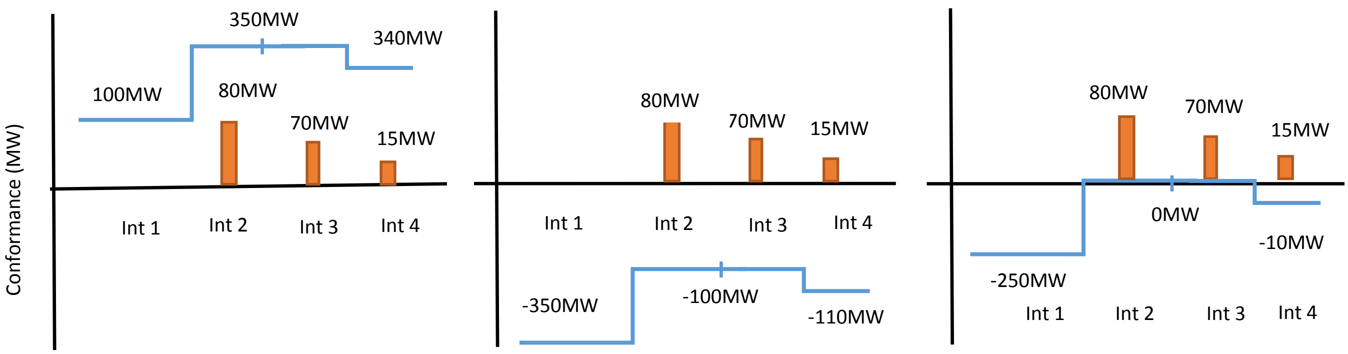
C_2 =-10<0? Yes, then the load conformance limiter applies.

For the third example, start with $C_1 = -170$ as estimated from previous interval and then calculate C_2 as follows

$$C_2 = (70 - 80) - (0 - 0) + \max(0, -170) = -10$$

C_2 =-10<0? Yes, then the load conformance limiter applies.

Example 7. Continue building the prior examples by assuming the load conformance is decreased in interval 4 as shown in the following cases.



For the first example, start with $C_2 = -10$ as estimated from previous interval and then calculate C_3 as follows

$$C_3 = (15 - 70) - (340 - 350) + \max(0, -10) = -45$$

C_3 =-45<0? Yes, then the load conformance limiter applies.

For the second example, start with $C_2 = -10$ as estimated from previous interval and then calculate C_3 as follows

$$C_3 = (15 - 70) - (-110 + 100) + \max(0, -10) = -45$$

C_3 =-45<0? Yes, then the load conformance limiter applies.

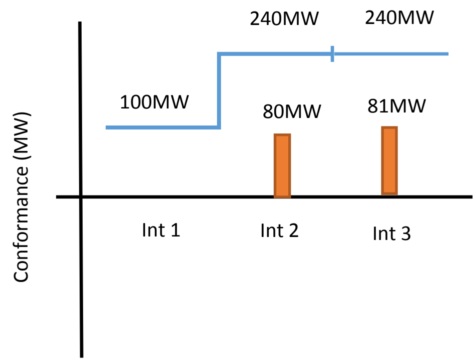
For the third example, start with $C_2 = -10$ as estimated from previous interval and then calculate C_3 as follows

$$C_3 = (15 - 70) - (-10 - 0) + \max(0, -10) = -45$$

C_3 =-45<0? Yes, then the load conformance limiter applies.

In all three cases, the load conformance limiter would apply, even when the most recent load conformance in interval 4 was an actual reduction with respect to the previous load conformance. This is because the 15 MW infeasibility is still a consecutive left-over infeasibility from the original load conformance change of 250 MW.

Example 8. Assume in this case the load conformance is actually increased from 100 MW to 240 MW. Consider the third interval for analysis.



By starting the calculation from the first interval, for the third interval we have that $C_1 = -60$ and then calculate C_2 as follows

$$C_2 = (81 - 80) - (240 - 240) + \max(0, -60) = 1$$

C_2 =1<0? No, then the load conformance limiter does not apply.

The logic for this scenario is that the limiter does not apply because the under-supply infeasibility actually increases with respect to the previous interval even when the load conformance remains constant. This means that some other factor drove the 1 MW increase in infeasibility rather than the change in the load conformance. One counter-argument could be that although the additional MW of infeasibility was created by another factor, most of the infeasibility could still be a left-over effect from the original change. However, trying to identify what portion of the infeasibility in the current interval was actually caused by another factor or from the original load conformance change could not be determined only with the information available about conformance and infeasibility.

Next Steps

The ISO will hold a stakeholder call on January 11, 2017 to review the proposed enhancement. Stakeholders are encouraged to submit any questions in advance of the call at initiativecomments@caiso.com. After the ISO addresses stakeholder comments and concerns, the ISO will proceed with including the final logic in the Business Practice Manual and will start evaluating the implementation timeline.