APPENDIX F: Background Paper on Methodology for Calculating Locational Effectiveness Factors

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Background Paper on Methodology for Calculating Locational Effectiveness Factors

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Background

The ISO is providing in this document information about the general methodology used for calculating locational effectiveness factors (LEFs) for the LA Basin area, to provide stakeholders further information on the estimated effectiveness of some resources are in mitigating identified reliability constraints in the LA Basin and San Diego local capacity requirement areas. This background information is being provided in advance of the ISO 2014-2015 Transmission Planning stakeholder meetings on November 19 – 20, 2014. The general methodology discussion from this background paper, as well as further details for locational effectiveness factors for the long-term 2024 local capacity requirement (LCR) studies will be included in the final ISO 2014 – 2015 Transmission Plan.

Overview

Calculation of the LEFs will be demonstrated based on thermal loading concerns or post-transient voltage stability concerns. While the LEFs based on thermal loading concerns are more straightforward, the LEFs based on post-transient voltage stability concerns are more complex depending on the locations and quantity of resources to be added at a specific location for larger area mitigation. Thus, the LEFs due to post-transient voltage stability concerns will be demonstrated using nodal or zonal analysis approach.

Methodology for Calculating LEFs Based on Thermal Loading Constraints

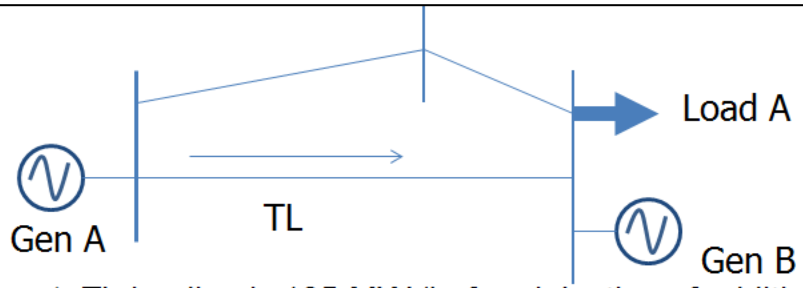
Calculation of the LEFs based on thermal loading constraints is a rather straightforward process because they do not change significantly based on the operating point of the system. The following is a step-by-step process for determining the LEFs based on thermal loading constraints.

- Identify critical transmission loading concerns (i.e., overloading of transmission facilities); the worst overloading concern is identified for the purpose of calculating the LEFs.
- Increase output from each generator (or other resources such as preferred resources), one by one, in an LCR area by an incremental amount (i.e., 10 MW).
- Rerun power flow studies to determine new loading on the identified overloaded transmission facility.
- The LEF for each resource is calculated as the following:

LEF = [Trans. Loading (after) – Trans. Loading (before)] / 10 MW

The following is an example of determination of the LEFs based on identified loading constraint.

Fig. 1 – Example of Calculating LEFs Based on Thermal Loading Contraints



- TL loading is 105 MW (before injection of additional 10 MW at Gen B)
- TL loading is 100 MW (after injection of additional 10 MW at Gen B)
- TL loading is 110 MW (after injection of additional 10 MW at Gen A)
- Gen B LEF = [100 – 105] / 10 = -0.5
  - Gen B is 50% effective in reducing loading on TL
- Gen A LEF = [110 – 105] / 10 = 0.5
  - Gen A is **not** effective in reducing loading on TL (loading is further exacerbated after increasing its output)

Methodology for Calculating LEFs Based on Voltage Stability Constraints

Calculation of the LEFs based on voltage stability constraints is a complicated process because they can change based on the operating point of the system and are dependent on the following:

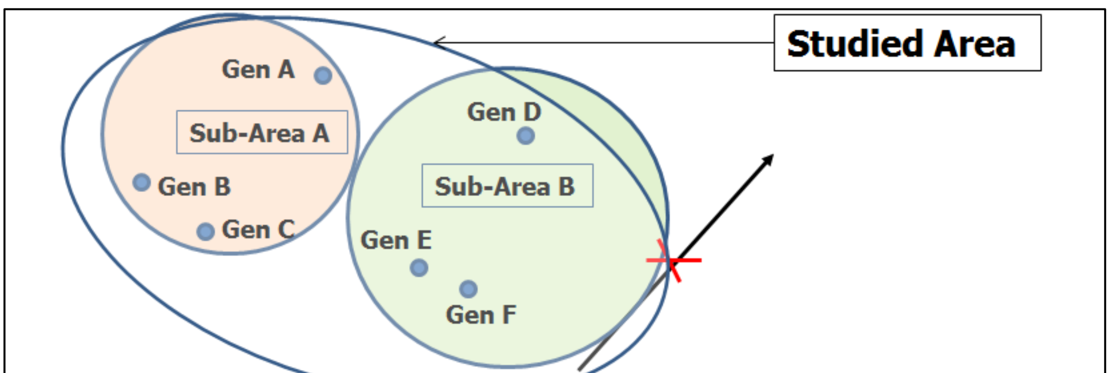
- Amount of resources (i.e., generation, demand response, energy storage, AAEE, etc.) assumptions in the power flow study model, and
- Level of transmission upgrade assumptions.

There are two potential methodologies in determining LEFs in an LCR area:

- If the considered LCR area is small and the resource requirements needed for mitigating identified voltage stability concerns are relatively low enough to be modeled at individual bus, then the nodal analysis is the better method to determine LEFs at each bus.
- However, if the LCR area encompasses a relatively large area, and the resource requirements needed to mitigate voltage stability are large, then a zonal analysis is a more realistic method of determining LEFs. This approach allows for a more practical, realistic and consistent study result.

The following is an example of calculating the LEFs based on nodal analysis due to voltage stability constraints for an LCR area with relatively "realistic" incremental resource additions[1] at each individual bus. Because the LCR area in this example is small, the variation among the effectiveness factors is limited and the amount required at the node being studied to meet the need is 2000 MW or less which could plausibly fit on one node.

Fig. 2 – Example of Calculating LEFs Based on Voltage Stability Constraints (Nodal Analysis Approach)

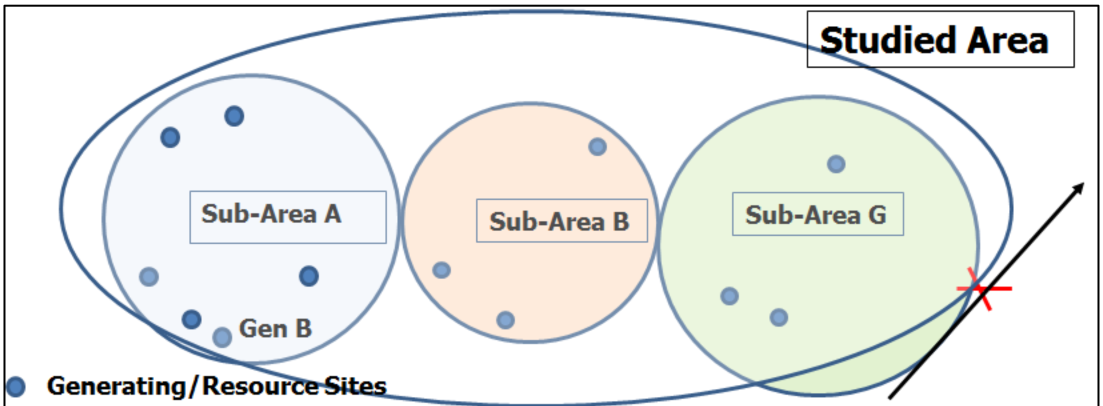


	Gen A	Gen B	Gen C	Gen D	Gen E	Gen F
Additional Capacity Need* (MW)	2,000	1,800	1,600	1,200	1,150	1,180
LEF (%)	57.5	63.9	71.9	95.8	100.0	97.5

[1] Relatively "realistic" incremental resource addition is the amount of resource additions that could feasibly be developed at a particular bus (i.e., substation), or locations that could roll up to a specific transmission substation to provide electrically equivalent net qualifying capacity as if were modeled at that substation.

Figure 3 below illustrates calculations of the LEFs based on voltage constraints for a large LCR area which requires a large amount of incremental resources in a sub-area for mitigating voltage stability concerns. For comparison purposes, each individual sub-area is studied to determine the level of incremental resources needed to mitigate the voltage stability concerns. The amount of incremental resources in each sub-area area are then compared to determine the LEFs based on the most effective sub-area.

Fig. 3 – Example of Calculating LEFs Based on Voltage Stability Constraints (Zodal Analysis Approach)



	Sub-Area A	Sub-Area B	Sub-Area C
Additional Capacity Need* (MW)	16,000	7,000	3,000
LEF (%)	18.8	42.9	100.0

It is noted that for the example above, more than one study scenario may be required to determine the boundary of sub-areas. This may involve further sensitivity in the event that certain critical transmission or resource assumptions do not materialize due to uncertainty associated with permitting and commercial issues. Not having critical facility additions as planned could adversely affect the LEFs that were calculated with that those facility additions assumed.

<u>Discussion on Calculations of the LEFs Based on Voltage Stability Constraints</u>

In determining the LEFs of local area resources to mitigate identified regional voltage stability concerns, either nodal or zonal analysis approach has its advantages or disadvantages as discussed in more details below:

1. **Nodal Analysis:**

- **Advantages:**
  - Specific LEF for each bus is known
- **Disadvantages:**

  If additional required capacity is extremely large in the least effective locations, then this method is not practical. Adding large amounts of resources at specific bus is typically not feasible and would result in delivery issues as well as causing the power flow case to diverge. Studying smaller amounts would not reasonably account for the variation in effectiveness as the operating point changes.

2. **Zodal Analysis:**

- **Advantages:**
  - A zonal analysis provides a practical and feasible method for modeling large amount of incremental resource needs, because they can be spread out across several buses or substations in the vicinity in a sub-area to address a large LCR area voltage stability concern.
  - For a large LCR study area, the zonal analysis approach enables a consistent study approach to compare the most and least effective locations.
  - This study approach also tends to avoid other reliability issues (i.e., delivery issues) since large amounts of incremental resources needed are spread out to multiple buses rather at one specific bus.
  - This study approach enables a power flow solution when a large amount of incremental resources are spread out to several buses as needed rather than modeling large quantity of resources at one single bus (i.e., in the range of tens of thousands of MW).
- **Disadvantages:**
  - This study approach does not result in having an LEF for each bus, and establishing the sub-area boundaries can be an iterative process.

Conclusions

For thermal loading constraints, calculating the LEF at each bus is a rather straightforward process because it does not need to model large amount of incremental resources to identify the effectiveness factor for each bus. The same approach cannot be applied for voltage stability issues in the larger local areas as a large amount of incremental resources may be needed to mitigate the reliability issue.

For voltage stability constraints, it is more complex to determine the LEF at each specific bus if the capacity requirement is too large to model to obtain a power flow solution to mitigate the reliability issue.

The Nodal analysis approach for determining the LEFs due to voltage stability concerns performs well if the study area is relatively small and the incremental resource needs are not too large and are feasible for modeling at specific bus.

The Zonal analysis approach for determining the LEFs due to voltage stability concerns is used when a large amount of incremental resources are needed and the LCR area is large.

Multiple studies need to be performed to evaluate different scenarios with various levels of baseline resource and transmission upgrade assumptions to see how the LEFs could change under different scenarios. The LEFs are very sensitive to changes in baseline resource, transmission upgrade and demand assumptions.