March 2, 2018

Solar Industry Responses to ITWG Questions from 2/1/18

Comments on Revised Screen F – Stiffness Factor

While some members of the solar industry continue to have questions concerning the specific threshold level for the stiffness factor screen to be applied at the level of the preliminary screening analysis and about the impact of the proposed screen on smaller systems that would otherwise pass the existing preliminary review process, the solar industry has no objections to its inclusion in the modified form discussed below.

Specifically, given the nature of the impact of inverter based PV generation on the distribution system and acknowledging the concerns raised by the JU regarding the application of the modified screen at the substation level, we would recommend that the screen be applied in two different ways at the two different levels.

First, at the level of the substation, the solar industry proposes maintaining the current language of the screen concerning the impact of aggregate DER. Second, at the level of individual DER facilities, however, we continue to strongly support the modification discussed at the most recent ITWG meeting where the stiffness factor for inverter based solar PV is modified by the Z/R ratio in recognition of the actual impacts of solar PV on the feeder's voltage profile. As such we would propose the following language for the new screen F.

> "For inverter based solar PV DER, is the feeder available short circuit capacity at the medium voltage PCC divided by the rating of the individual DER multiplied by the ratio of Z/R greater than 50? For all other DER, is the feeder available short circuit capacity at the medium voltage PCC divided by the rating of the individual DER greater than 25?
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> Is the feeder available short circuit capacity at the substation divided by the capacity all aggregate DER on the feeder greater than 25?
> - Yes to both feeder and substation levels (pass screen)
> - No to either (fail screen)"

As discussed at the ITWG meeting, the goal of the current modification to the SIR is to develop a set of technically robust screens that more accurately reflect the reality of which systems require additional study and which have such minimal impacts that they can proceed to interconnection without detailed analysis. In our view, the above modification to the proposed stiffness factor screen (i.e. the inclusion of the Z/R correction) makes the technical basis of this screen more robust and more accurately reflects the impact solar PV will have on the voltage profile of the distribution grid. In addition, having both the short-circuit current ratio and the information about Z/R at the PCC would be of significant value to developers of larger systems that do not pass the preliminary screening analysis. Along with information about peak load, these two additional pieces of information on the feeder’s stiffness can help companies decided on which sites to pursue full CESIR analyses with far greater accuracy than is currently possible. As such the modification of this proposed screen we support would provide significant benefits to both the developers and the utilities by avoiding the time, cost, and effort of pursing detailed technical analyses on systems that will be likely to face unacceptably high interconnection costs due to voltage issues.

Finally, in light of the nearly unique application of this type of stiffness factor screen at the level of preliminary analysis compared to other major solar markets, the solar industry would request that the efficacy and impacts of the stiffness factor screen (particularly on developers of smaller scale systems) be evaluated six months to a year after it is implemented to determine if any modifications should be considered.

Comments on Voltage Limits / Regulator Tap Changes

The solar industry does not support a return to the earlier proposed version of the Voltage Change/Limits screen. The inclusion of the rapid voltage change limits of 3% for an individual facility and 5% for the aggregate of all facilities is likely to be far too conservative and is not representative of realistic impacts to be expected from inverter based DER. As such, we continue to believe that this element of the proposed screen would run counter to the intent of the SIR update, as it will act to unnecessarily drive more systems - not fewer - to detailed study.

As discussed at previous ITWG meetings and in their written comments on the EPRI report, the Joint Utilities have indicated that the running of power flow models during supplemental review is an important element in determining the impact of DER on the system. Specifically, they have noted the need to ensure that the voltage profile of the system stays within the ANSI C84.1 limits regardless of whether or not the rapid voltage change limits of 3% for an individual facility and 5% for the aggregate of all facilities are applied. This is significant as the primary purpose of the 3% / 5% limits on voltage variation as stated by EPRI in their earlier report was to test if voltage changes caused by the DER on a feeder are likely to violate ANSI limits.

Thus, with the more accurate information available from a power flow model testing directly for compliance with ANSI C84.1 limits and the visible flicker and voltage variation screens testing for the impact of intermittency caused by transient cloud cover all coupled with the unique features of inverter based DER such as the ability to incorporate ramp rates and soft-start capabilities after a trip, the solar industry sees no technical justification for applying the more limited rapid voltage change limits as proposed in the earlier Voltage Change/Limits screen. As such, the solar industry would instead propose to include the following two additional tests to the new Screen H with its existing test for visible flicker as number one:

“2. Can it be determined that the aggregate DER on a feeder does not cause voltage excursions outside of the ANSI C84.1 limits?

3. Can it be determined that fluctuating DER output, such as PV plants experiencing transient cloud cover, does not change the voltage at any primary regulating device more than 1/2 the regulator bandwidth and more than 3 times/hour.

- Yes to all three tests (pass screen)
- No to any of the three tests (fail screen)"

Finally, as clear from our proposed language, the solar industry continues to support the application of a new third test in the modified Screen H. In conducting such a screen, however, it is critically important to take into account a realistic change in irradiance so as to avoid needlessly driving systems to detailed study. This is particularly true given the significant time and effort required to conduct a detailed time series analysis within the CESIR to more accurately evaluate the impact of the fluctuating DER on regulator tap changes.[1] Given the concern being addressed by this screen is the possibility of increased wear and tear on voltage regulation devices, the solar industry advocates for a statistically based approach that selects a ramp rate that occurs rarely enough that excursions outside of this range are infrequent enough to cause only acceptable levels of additional wear on the devices.

With such a statistical view in mind, and in order to retain a level of conservativeness that is consistent with the needs of a supplemental review, the solar industry continues to support the use of a 0% to 75% change in system output. This recommendation is consistent with the application of a similar screen in Minnesota and with our analysis of solar irradiance data. Specifically, as noted in our July 2017 presentation, we analyzed nine years of data from a single NREL irradiance sensor at Oak Ridge (2008-2017) and found that the 99% fluctuation level at 1 minute intervals was just 38%. In fact, more than 99.98% of all fluctuations over these nine years were less than 75%. In addition, the EPRI data from single irradiance measurements in New York show that ramps of greater than 75% occurred on less than 2% of the days in that year and that more than 99.9% of the fluctuations in irradiance were again less than 75%. Thus, the existing data supports the conclusion that the use of a 0% to 75% change in system output is likely to be highly conservative and represent a minimal impact on the maintenance requirements for voltage regulation devices when coupled with the screen's

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[1] As noted in our June 2017 comments, the need for such detailed analyses if the simple screen is failed is consistent with the findings of the 2013 report from Sandia National Laboratory which concluded that

"QSTS [Quasi-Static Time Series] analysis is necessary to accurately quantify the effects of PV on voltage regulation device operations. The analysis should be an estimate of the long term, e.g. annual, difference in operations that can be expected due to PV. It is necessary to run both the base case and the PV case for comparison in order to quantify the impact due to PV."

Robert J. Broderick, Jimmy E. Quiroz, Matthew J. Reno, Abraham Ellis, Jeff Smith, and Roger Dugan, "Time Series Power Flow Analysis for Distribution Connected PV Generation", Sandia National Laboratories, January 2013 (SAND2013-0537) p. 18

requirement that voltage excursions do not exceed half the bandwidth of the regulation device.

Of particular note in supporting this recommendation is the fact that both the NREL and EPRI irradiance data represent single point measurements. As we have discussed at length at recent ITWG meetings, the impact of geographic smoothing which occurs over the spatial scale of solar facilities likely to pursue supplemental review will act to substantively reduce the actual fluctuations in system output as compared to that implied from measurements by single devices.[2] As a result, using the NREL and EPRI data as a guide and selecting a ramp that will occur only very rarely even for a single point measurement layers two conservative assumptions for this screen that, in our view, provide adequate protection for voltage regulation devices.

Comments on Flicker Screening / Detailed Analysis:

The solar industry strongly supports the detailed flicker analysis methodology proposed by Pterra at the flicker workshop and detailed at the most recent ITWG meeting. We agree that such analyses, when needed, will most likely require being done outside of the CESIR timeline and at some additional cost. We view such analyses as analogous to detailed risk of islanding studies that can be requested by developers if the simpler screening analyses fail.

Given the time, effort, and cost of such studies, the solar industry feels very strongly that the appropriate screening analysis to conduct at the level of the CESIR would be to apply the Pst limits based on the shape factor approach with the same assumptions about ramp rate and repetition rate as those used in the first step of the proposed Screen H, but with the actual $d = \Delta V/V$ calculated from a power flow model. In IEEE 1453-2015 section 7, the shape factor methodology is laid out in detail. In sub-section 7.1 where the specific use of the shape factors is described, the standard is clear and explicit that the intent of the screen is to test

$$P_{st} = \left(\frac{d}{d_{Pst=1}}\right) \times F$$

where $d = \Delta V/V$. The remainder of the sub-section goes on to describe methods of estimating $\Delta V/V$ when it's value is not available. These simplified approximations for $\Delta V/V$ are the basis for the visible flicker test in the proposed screen H, but the clear intent of the Pst limit under the shape factor methodology in IEEE 1453 is that it is testing the relative voltage fluctuation. This can be seen elsewhere in the standard as well. For example, in Table 4 where the $d_{Pst=1}$ limits are found, it also makes

[2] For example, we noted in our July 2017 presentation that in a 2012 Sandia study of a large-scale PV plant, the standard deviation of ramp rate distributions was reduced by a factor of three between a single inverter as compared to that for all 96 inverters in the entire system at the level of one second and by a factor of two at the level of thirty seconds.

Shedd, S., Hodge, B., Florita, A., Orwig, K., 2012. A Statistical Characterization of Solar Photovoltaic Power Variability at Small Timescales. 2nd Annula International Workshop on Inegration of Solar Power into Power Systems Conference, Lisbon, Portugal.

clear that these “[r]elative voltage changes for unit flicker severity for 120 V lamps” are for “∆V/V (%)”.

Thus, at the level of a detailed CESIR analysis, the use of the actual ∆V/V from a power flow model in the shape factor methodology from section 7 of IEEE 1453-2015 would appear most fully consistent with the language and intent of the standard.

Finally, as we have noted on multiple earlier occasions, the solar industry believes, based on our analyses of irradiance fluctuations and extensive experience with such systems in the real-world, that visible flicker is very unlikely to be a concern for solar PV. The fact that the shape factor limit on ∆V/V, even with the extremely conservative assumptions of a 1 second ramp from 0% to 100% in plant output and that such changes re-occur every minute for an extended period of time, comes out to 4.49% is further evidence for this conclusion. Specifically, it is very likely that other voltage issues (such as violations of the ANSI C84.1 limits or impacts on voltage regulation devices which are studied at the CESIR level) will become important well before a system would trigger the need for a more detailed visible flicker screen based on this limit. Given this, we strongly recommend the use of the more accurate actual ∆V/V value in the CESIR screen for visible flicker based on the shape factor methodology with the same set of assumptions as those used in the simplified screen H test and only when that screen is failed should the option be offered for a detailed study using the Pterra approach.