Solar Industry Concerns on the Implementation of IEEE 1453 Screening during CESIR Study

Interconnection Technical Working Group

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Impacts of the Current Application of IEEE 1453 Flicker Screen in CESIR Studies Using Fault Current Ratio Approximation

Impacts from Current Approximation Methodology are Substantive and Widespread

- From an initial poll of just four developers we have already identified 12 facilities studied under the new methodology since August 1 that are being held up explicitly by flicker or that are facing downsizing or high cost reconductoring requirements
- These systems are facing downsizing of as much as 75% due to the way visible flicker is currently being screened for at the CESIR level
- In addition, some systems have been delayed in starting their CESIR studies by over a month due to utility concerns over the flicker screen and subsequent requests to pre-downsize the facilities prior to study

Voltage Variation Limits

- Using the shape factor methodology agreed to previously the limits for $\Delta V/V$ should, in our view, follow from the calculations below

- $Pst = (\Delta V/V) \times (0.2/2.568\%) = 0.35$

- $\Delta V/V = (0.35) * 2.568\% / 0.2$

- $\Delta V/V = 4.49\%$

Approximation vs Actual Voltage Variation

- *National Grid*
  - In one example, a system was downsized 20% due to flicker despite a maximum voltage variation from a 0 to 100% transition of just 1.67% from power flow models
- *NYSEG/RGE*
  - In two examples, systems were downsized 61.5% and 37.5% due to flicker despite maximum voltage variations of just 2.89% and 3.00% respectively
- *Central Hudson*
  - In one example, a system required high cost reconductoring upgrades due to flicker despite a maximum voltage variation of less than 3.5%. This project could not move forward with these costs.

Heading in the Wrong Direction

- Despite the goal of improving and modernizing the flicker standards through these changes, in a study of seven CESIR reports completed by National Grid prior to the current change in methodology we found that six of the seven 2MW facilities (or more than 85%) that passed the previous flicker screening would now likely have failed under the current use of the short-circuit current approximation in the shape factor methodology

3.2 Voltage Flicker Analysis

Analysis shows that the predicted flicker and voltage fluctuations are expected to be within acceptable limits according to the tariff. However, the Company reserves the right to disconnect the SGF if unacceptable flicker and/or voltage fluctuations occur as a result of interconnection of the SGF.

Process Concerns - CESIR Delays

- In one service territory there have been extensive delays in starting CESIR studies due to requests to pre-downsize systems for flicker, limiting the opportunity for post-CESIR appeal to time series analysis at the originally proposed size
  - "The Flicker Analysis indicates that the maximum amount of solar DG at this site is 3,390kVA. Please provide design package reflective of 3,390kVA project size."
  - "The Flicker Analysis indicates that the maximum amount of solar DG at this site is 2,280kVA. Please provide design package reflective of 2,280kVA project size."
  - "The Flicker Analysis indicates that the maximum amount of solar DG at this site is 1,410kVA. Please provide design package reflective of 1,410kVA project size."
  - "The Flicker Analysis indicates that the maximum amount of solar DG at this site is 1,250kVA. Please provide design package reflective of 1,250kVA project size."

Other Process Concerns

- At least one service territory appears to be studying flicker under the current methodology not just for the individual system but for “the aggregate generation within 0.75 miles of the IPP”
- NYSEG / RG&E are, at the beginning of CESIRs, reducing proposed system sizes based on visible flicker limits and then performing the analysis based on the smaller system. There is typically limited notification or coordination with developers and this limits the possibility of later requesting a flicker time series analysis at the original system size.
- A number of utilities do not have an accepted method for performing time series analysis and have denied developers the possibility of doing so.

Our Proposal

- The screening for flicker at the CESIR level should use the same shape factor methodology with the same assumptions as at the Supplemental Review level but use the actual $\Delta V/V$ from a power flow model rather than the fault current ratio approximation

- $Pst = (\Delta V/V) \times (0.2/2.568\%)$

- $\Delta V/V = (0.35) * 0.02568 / 0.2$

- $\Delta V/V = 4.49\%$

Consistent with the Intent of IEEE 1453

7.1 Use of shape factors

The flicker severity can be computed using the following equation:

$$P_{ST} = \left(\frac{d}{d_{Pst=1}} \right) \times F \qquad (14)$$

where

F is a shape factor (see Annex C). For motor-starting without inrush mitigation, a value of unity may be used for F.

Relative voltage change (d) can be evaluated as the ratio of load power change (ΔS_i) to the short-circuit power (S_{SC}). The following equation may be used for balanced three-phase loads:

$$d = \frac{\Delta V}{V_r} \approx \frac{\Delta S_i}{S_{SC}} \qquad (15)$$

Table 4—P_{st} = 1 test points for rectangular voltage fluctuations (Walker [B46])

Col.1 Changes per minute	Col.2 Fluctuation Frequency Hz	Col.3 Pst=1 Relative voltage changes for unit flicker severity for 230 V lamps ΔV/V (%)	Col.4 Pst=1 Relative voltage changes for unit flicker severity for 120 V lamps ΔV/V (%)

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Our Proposal

- This screening level of 4.49% for the voltage fluctuation of a 0 to 100% transition should be applied to the individual systems and not to aggregate generation
- It is important to note that while the 4.49% screening level is near the ANSI C84.1 voltage limits, the ANSI limits will remain in effect and so no deviations over the standard 114 to 126 V range will be allowed regardless of the flicker results
- The size of the 4.49% limit for flicker is, in our view, simply the mathematical statement that visible flicker is not likely to ever be a concern for solar PV as facilities will likely run into other limits (such as ANSI C84.1) first

Even with the Use of $\Delta V/V$ Elements of Extreme Conservativeness in Shape Factor Approach Remain due to 0 to 100% Transition in 1 second

Implied Cloud Speed

- 2MW Cornell facility in CNY
- Minimum cloud width to completely cover facility = 200 m
- Therefore, implies cloud speed of 200 m/s (447 mph) to go from 100 to 0% in one second
- Then this must repeat

Shape Factors Decreasing with Ramp Rate

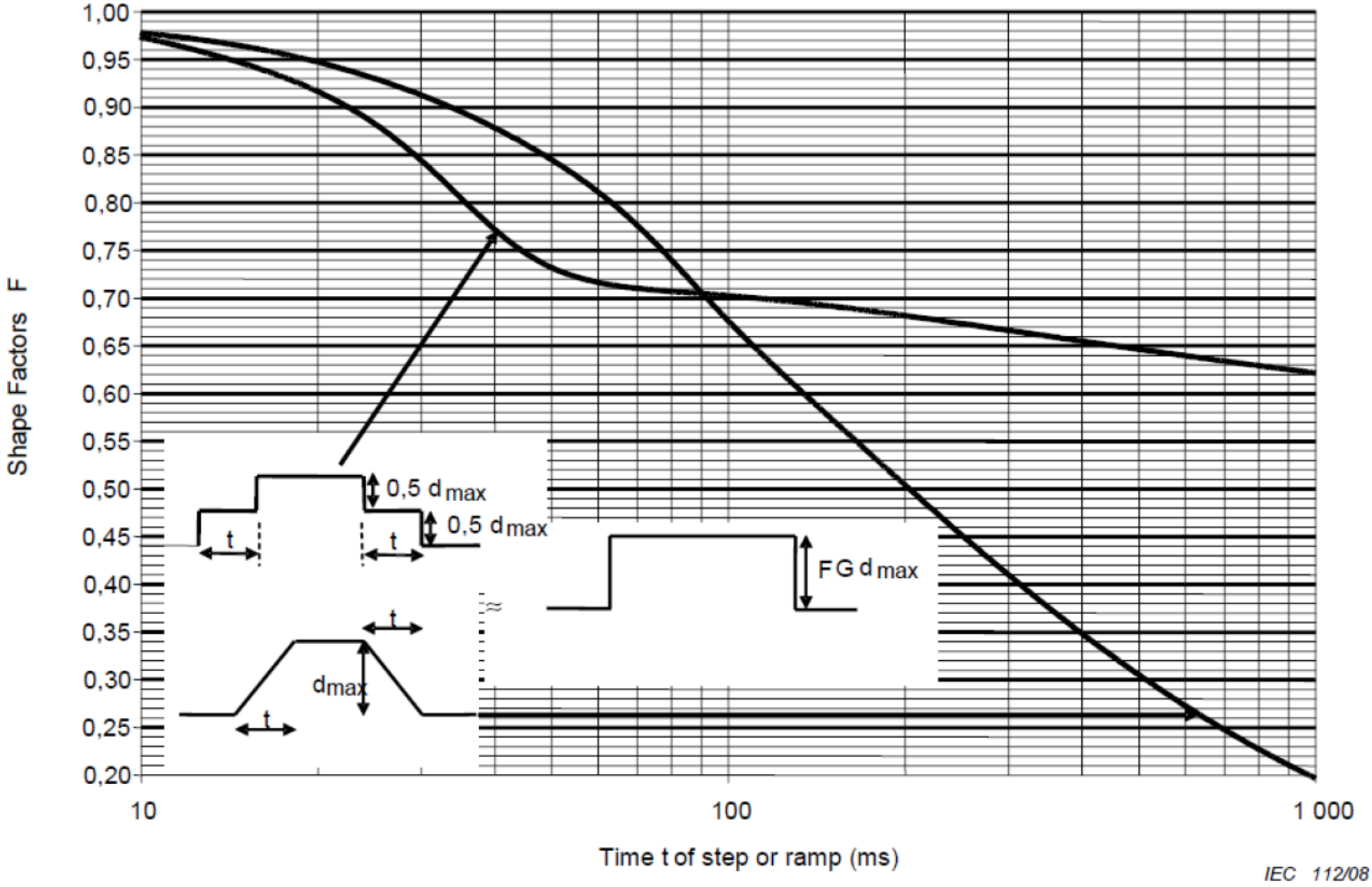

Figure C.2—Shape factor for double step and double ramp changes

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Geographic Dispersion Reduces Fluctuations at MW Scale Facilities

Voltage Fluctuations at 500 kW Site

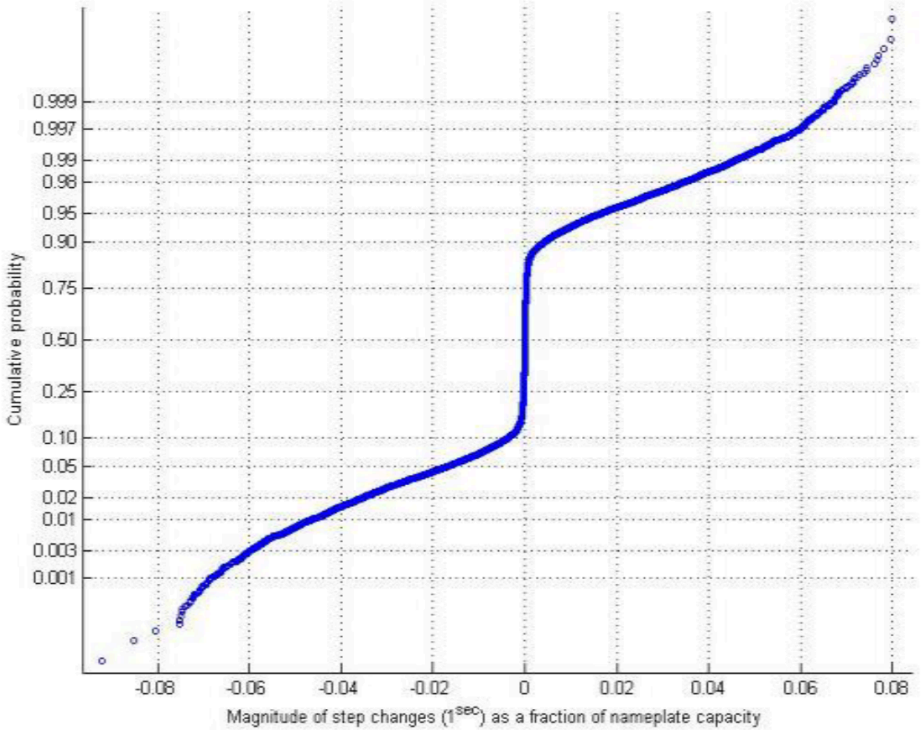
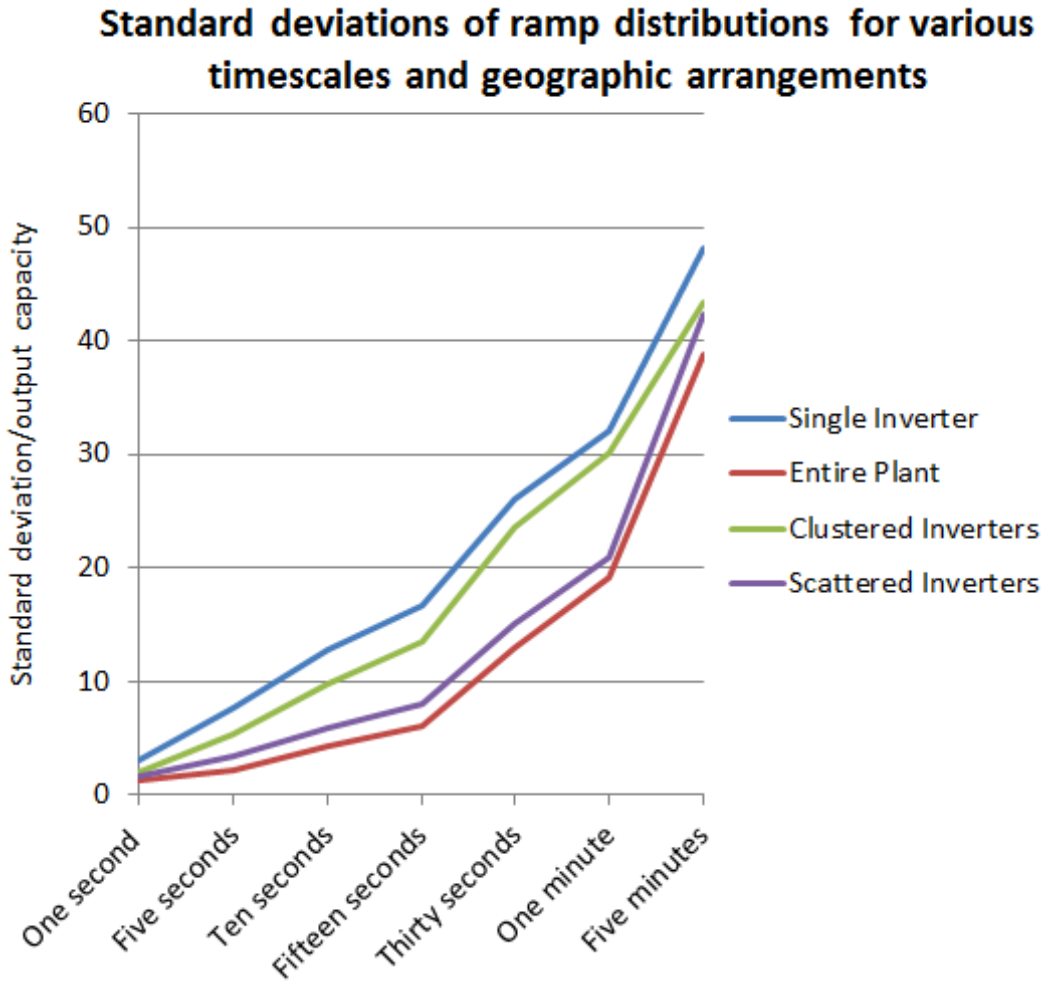


Figure 3a: Cumulative distribution function of 1-second

- "Even during a highly variable day, all 1-second step changes were well below 10% of the system's rated capacity and less than 1% of the step changes were larger than 5% of the nameplate capacity."

PV Power Ramp Rates, Sampling Frequency and Effect on Grid Voltage, Presented at European Photovoltaic Solar Energy Conference, Sept 2013

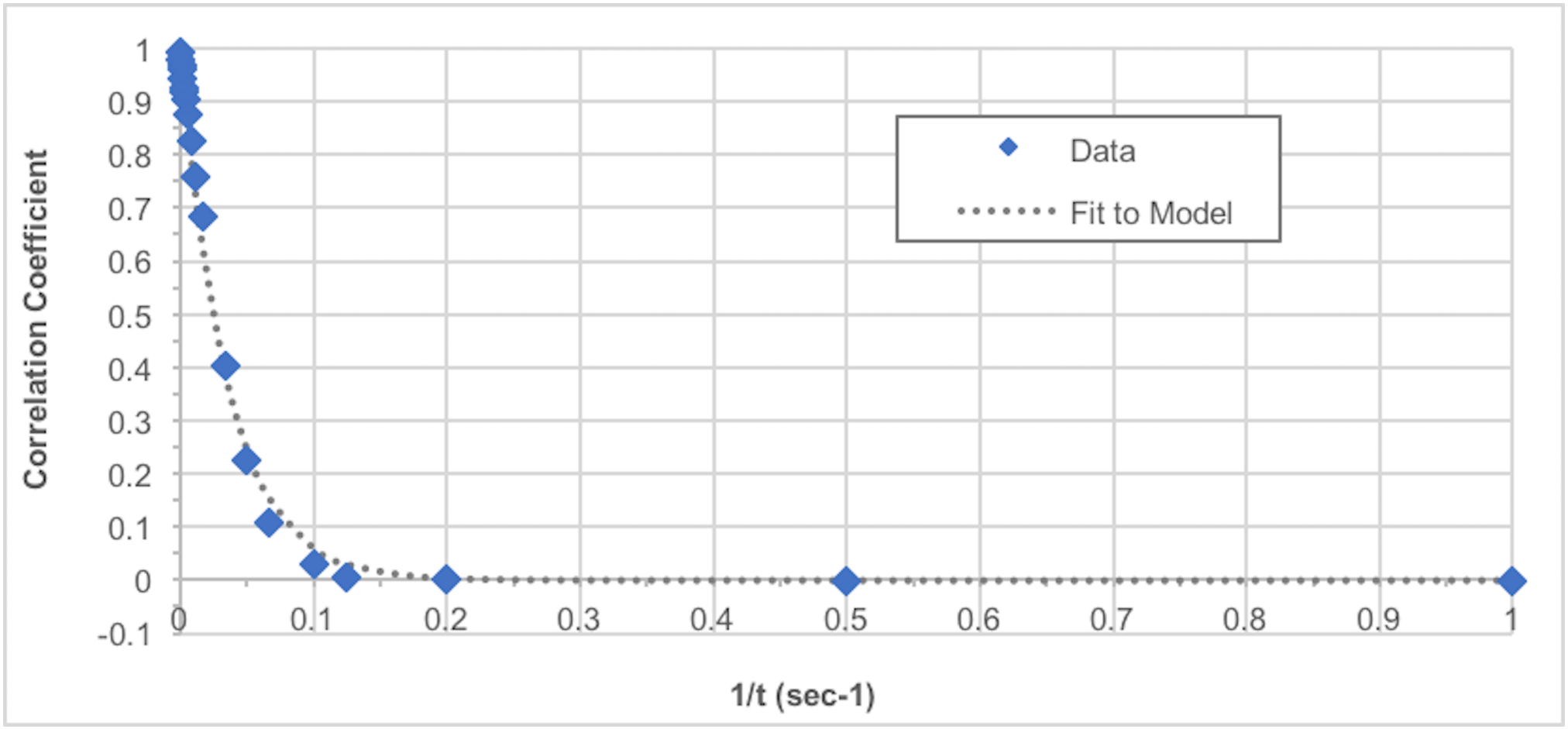
Geographic Smoothing of Power Ramp Rates



- For real systems the geographic smoothing over MW scale arrays reduce the actual fluctuations in output substantively.
- Geographic smoothing between different arrays will be even more dramatic arguing strongly against the 100% to 0% transition for all PV within a 0.75 mile radius as is apparently being done by some New York utilities.

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

Correlations in Fluctuations at 1 sec



Correlation coefficient of two irradiance sensors separated by typical distance between panels in a 2W facility.

Limits in IEEE 1453 are Probabilistic

Probabilistic Limits in IEEE 1453

8.1 Flicker requirements

8.1.1 Limits

Flicker will be assessed at the PCC using an instrument in compliance with IEC 61000-4-15. The example customer contribution (emission limits) to the flicker measured at the PCC shall be 0.8 or less for the short term flicker (P_{st}) and 0.6 or less for the long-term flicker (P_{lt}).

Based on the measurement period of at least a week, the following criteria should be met for compliance:

- 95% probability value should not exceed the emission limit.
- 99% probability value may exceed the emission limit by a factor (1−1.5) depending on system conditions to be determined by the system operator.

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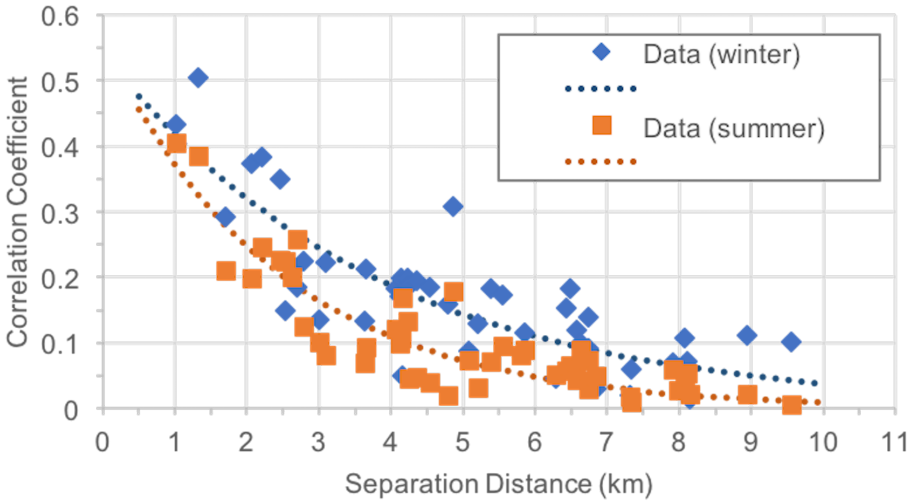
Voltage Fluctuations of System Ensembles

Table IV: 99.7% of all power deltas are smaller than the values listed below (in fractions of nameplate capacity).

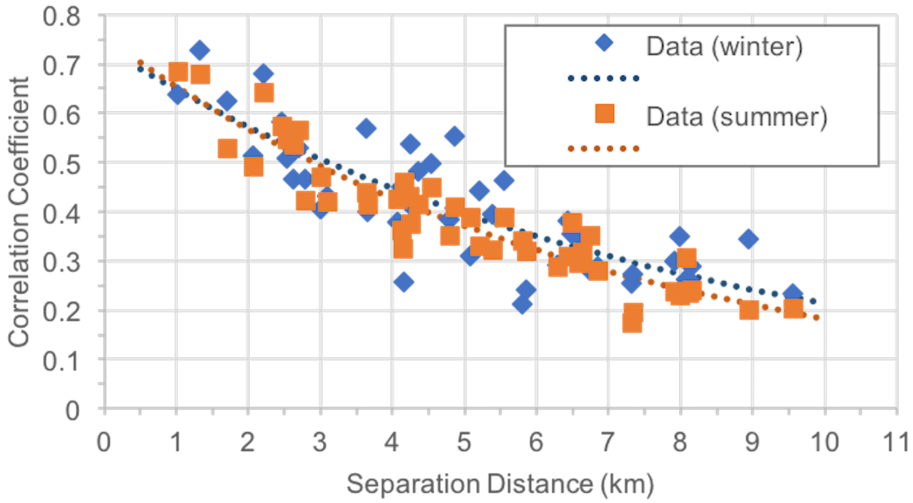
ensembles	*1-min*	*10-min*	*60-min*
S11 (11)	16%	16%	28%
S12 (3)	27%	21%	26%
S13 (7)	34%	28%	32%
S14 (1)	53%	42%	44%
L11 (23)	11%	10%	16%
L12 (3)	34%	25%	28%
L13 (14)	32%	21%	27%

11-Month Power Output Variability Study of a PV System Fleet in New Jersey, Presented at European Photovoltaic Solar Energy Conference, Oct 2012

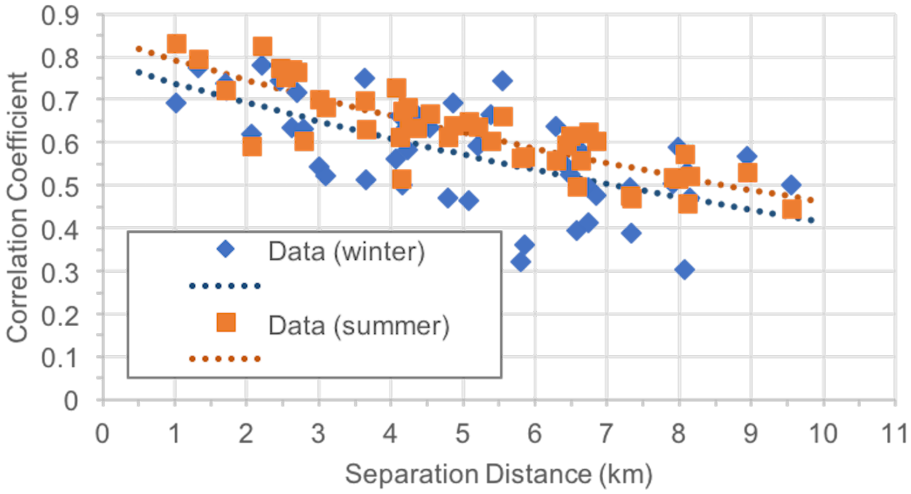
Correlations in Fluctuations with Distance



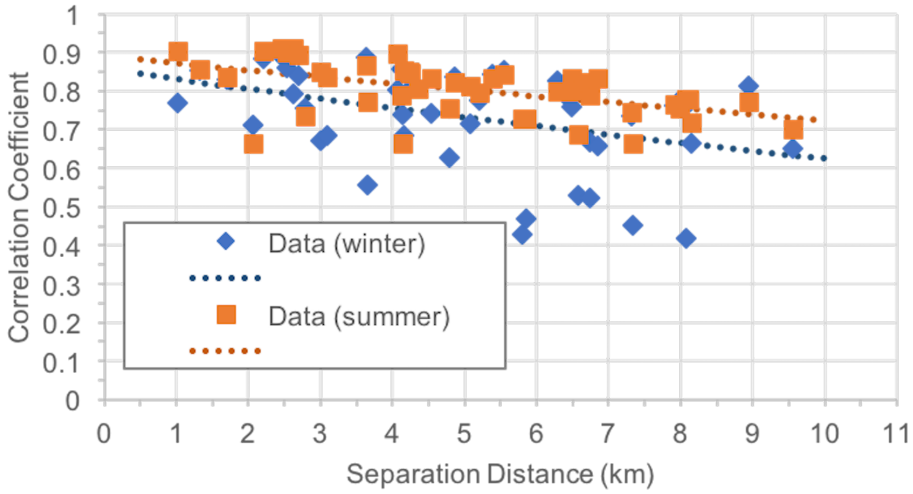
(a) 5 minutes



(b) 15 minutes



(c) 30 minutes



(d) 60 minutes

99th Percentile Fluctuations in NREL Single Point Irradiance Data

Data Source	Resolution	99th Percentile Fluctuation (8am to 8pm)
Oak Ridge (nine years of data)	1 minute	38%
Elizabeth City State University (six years of data)	5 minute	43%
Bluefield College (seven years of data)	5 minute	43%

Conclusions

- The current use of the approximation for $\Delta V/V$ in the CESIR studies using fault current ratios is likely to have become a significant and widespread barrier to solar PV development on the distribution system in New York
- There is an urgent need for all utility territories to switch the screening methodology for visible flicker to use the actual $\Delta V/V$ from a power flow model for individual facilities under CESIR review
- There is an urgent need for all utility territories to identify methods to conduct time series analyses for systems that fail the revised screening methodology using $\Delta V/V$
- There is a need for all utility territories to study systems at the originally proposed size to allow identification of other potential interconnection barriers and thus enable developers to decide if time series analyses are worth while for systems that fail the revised flicker screen