

Robert W. Rand, ASA, INCE (Member Emeritus)

RAND ACOUSTICS, LLC

65 Mere Point Road

Brunswick, ME 04011

E-mail: rrand@randacoustics.com

Telephone: 207-632-1215

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To: Kevon Martis

Re: Noise Impact Assessment Overview
Solar Facility Inverters and Transformers

I respectfully submit this general overview of noise emissions, control, and recommended noise design guidelines for grid-scale solar facilities which contain inverters and transformers.

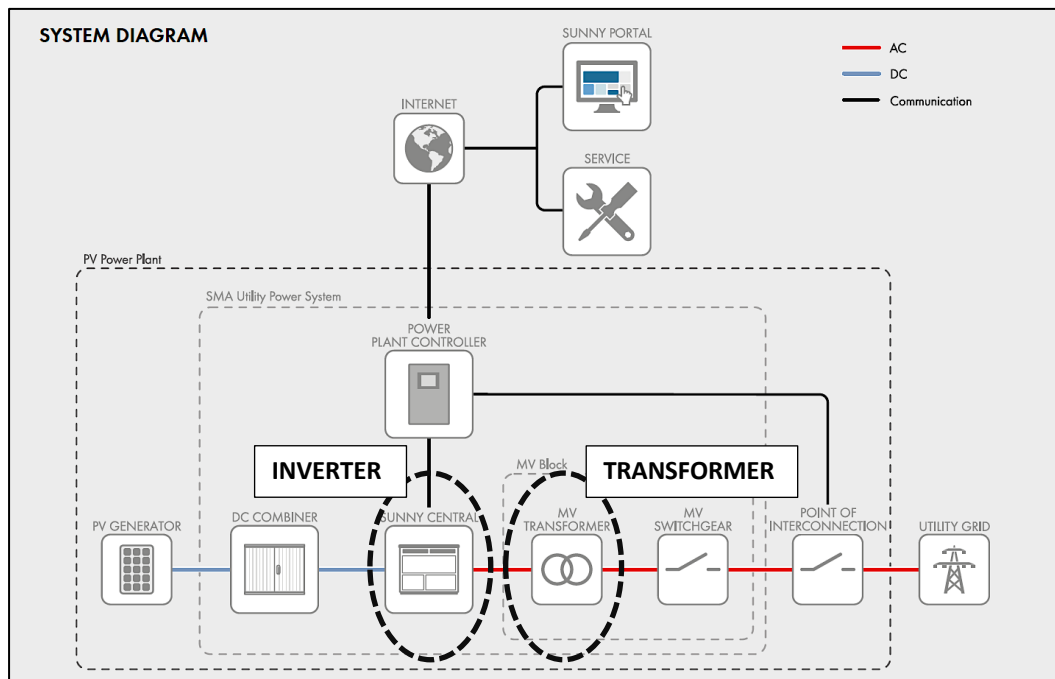
Design basis

INCE Rules of Practice require approving only noise control engineering studies, reports, or work which, to the best of the reviewer's knowledge and belief, is safe for public health, property, and welfare and in conformance with accepted practice. From years of work in power generation noise control including ten years at Stone & Webster Engineering Corporation, accepted practice includes planning to protect communities from unwanted sound and assuring facilities comply with regulatory requirements with an adequate margin of safety. Noise complaints indicate developers, regulators, and consultants failed to protect from unwanted sound.

Background: Solar Facility Noise Overview

1. Noise is unwanted sound; sound that is annoying, interfering with activities such as sleep, degrading of amenity. Zoning and regulations establish noise limit standards on the predicate to protect people from unwanted sound and prevent high annoyance.
2. Grid-scale solar facilities contain inverters and transformers. Solar inverters convert DC voltage from panels to AC voltage. Transformers step that voltage up to grid voltages. Inverters and transformers emit tonal noise due to magnetostriction, and emit broadband fan noise where components are fan-cooled. Typical A-weighted noise levels for each grid-connect system component are in the range of 65-68 dBA at 10 meters.
3. Transformer noise consists of primary tonal components at 120, 240, 360 and 480 Hz. Additional harmonics continue at higher frequencies but are generally not considered in noise control planning. Fan noise is broadband in nature and is generally not objectionable with sufficient distance provided the fans do not emit significant tonal noise themselves. Quiet transformers (Best Available Technology) can be purchased at up to 15 to 20 dB below normal NEMA ratings. If a quieter transformer is incorporated in a facility design, the lowered sound level rating should be used in place of the regular NEMA rating during noise impact estimates.
4. Inverter noise emissions include unfamiliar-sounding chopped tonal noise components at approximately 3000, 6000 and 9000 Hz [video for inverter SMA Type TCS 1600 MV-2F at https://www.youtube.com/watch?v=H-_G2p0y31I accessed 10 Nov 2020].

5. Cost-effective noise controls for transformer and inverter noise are readily available and used worldwide for decades. These include full building enclosures, industrial site noise barriers, acoustic slotted masonry block barriers, and reactive barrier panels.
6. Facility components: An example system diagram is shown from SMA, a world-around solar component supplier headquartered in Germany. The SMA design overview below shows the components used in a large facility (inverter and transformer components are outlined with ovals).



SMA Solar Technology AG, SC2200-3000-EV-DS-en-59.pdf, 1 April 2020.

Review of Noise Criteria

1. Regulations should state a permitting predicate to prevent annoyance by prohibiting audible excessive tonal sounds from solar components within residential property lines. "A prohibition on producing any audible prominent tones, as defined by using the constant level differences listed under ANSI S12.9-2005/Part 4 Annex C (sounds with tonal content), at the outside of any existing nonparticipating residence or at any point on residential property where audible tonal sound would result in activity interference." Regulations should require that audible prominent tones shall be flagged and reduced in level with noise control implemented as required to drop below prominent tone thresholds.
2. ANSI Standards provide a neutral consensus-body reference for noise guidelines for compatibility with land use. Environmental noise compatibility for land use can be formally assessed using ANSI S12.9 Parts 4 & 5 which establish guidelines for compatibility of a new intrusive noise source for various land uses including rural residential land use. See this letter's Supplement A.

3. ANSI S12.9 establishes by tabular computation that day-time and night-time intrusive noise levels are compatible with quiet rural residential land use when total intrusive long-term average sound levels do not exceed 40 and 30 dBA, respectively.
4. Tonal noise is assigned a 5-dB penalty in many jurisdictions to account for its highly objectionable noise character. However, when evaluating compatibility to land use with ANSI S12.9 Part 5, pure tone/impulse corrections should be ignored, since this factor is already incorporated into the present standard.
5. Noise criteria and regulations should be established at the property line, which is in accordance with standard practice for zoning.
6. Individual noise producing components should be assessed for contribution to a total noise level using a noise “budget” to assign noise controls as required to meet noise criteria with an adequate margin of safety. Decades of best practices established margins of safety for power generation noise in the range of 2-5 decibels depending on site specifics including the fluctuations in facility noise, effects of site layout, topography and atmospheric on noise propagation to nearby residential properties, and factoring sound meter tolerances.
7. Appropriate noise criteria then fall in the range of 35 to 38 dBA daytime and 25 to 28 dBA at night. These criteria are consistent with ANSI Standards for land use compatibility in quiet rural residential properties and prevent unwanted sound from intrusive tonal noise with an adequate margin of safety.
8. Regulations should require use of Best Available Technology to ensure the lowest practical noise emissions. Facility applicants should be required to show their equipment is Best Available Technology and that facility designs shall not impact people with unwanted sound and shall not create high annoyance.
9. Given the many readily available and time-proven noise control options for transformers and inverters, there should be no objection to applying these criteria and safety margins to protect people from unwanted sound.

Thank you for your consideration of this letter. If you have any questions, please contact me.

Respectfully Submitted,



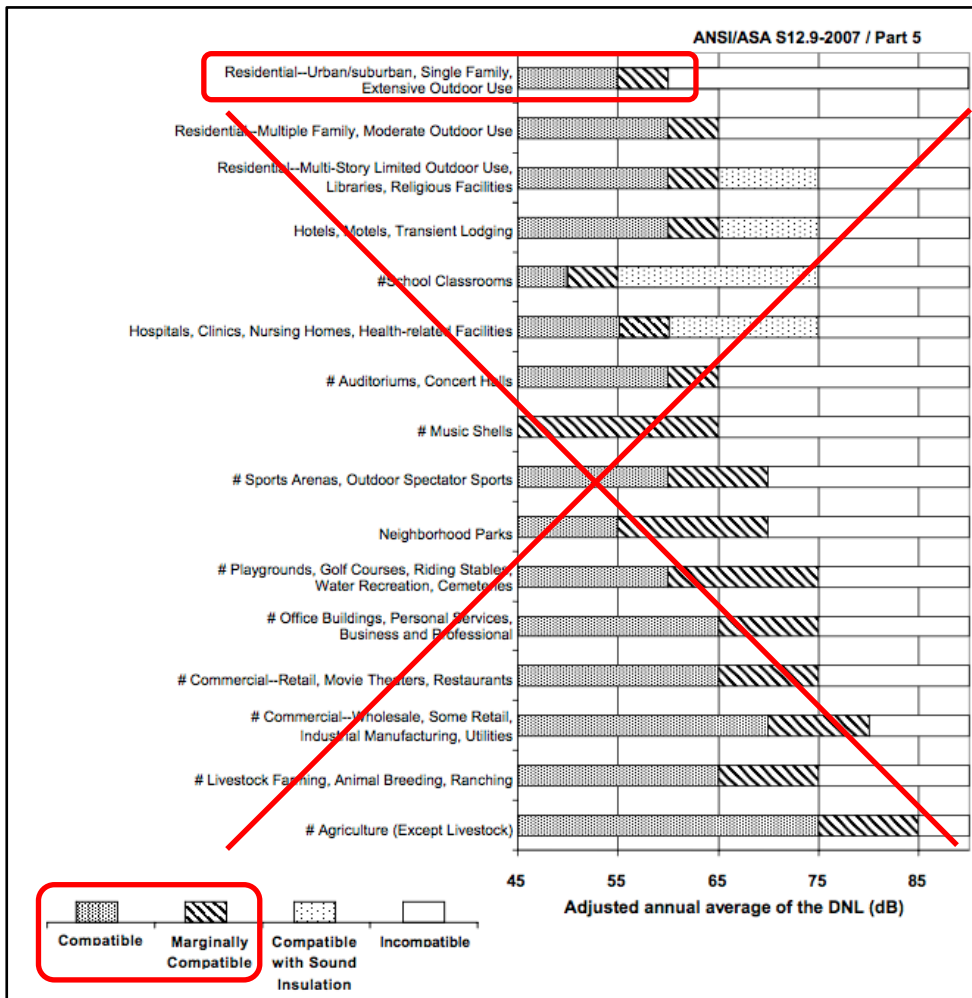
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Attached:

- Supplement A: ANSI Siting Criteria For Compatibility, Rural Residential Land Use

Supplement A: ANSI Siting Criteria For Compatibility, Rural Residential Land Use

ANSI S12.9 Parts 4 & 5 provides methods for determining noise level thresholds for compatibility with land use. Part 5 Annex A provides that "compatibility of a land use with the outdoor noise environment is assessed by comparing the predicted or measured annual average of the total day-night adjusted sound exposure or the annual average of the adjusted day-night average sound level at a site with the guidance criteria given in Figure A.1."



ANSI S12.9 Part 5 Figure A.1, with markups. Lists a range of land uses, including at the top, "Residential-Urban/suburban, Single Family, Extensive Outdoor Use". This category was selected as a basis for evaluation of compatibility for rural residential land use.

This analysis evaluates compatibility for rural residential land use (homes), similar to the top category in Figure A.1, and does not evaluate for compatibility in farm fields proper (agricultural use). Part 5 Annex A Figure A.1 includes a footnote, "For residences in quiet rural areas (e.g., not near busy roads, busy railroads, grain elevators, etc.), the +10-dB adjustment in ANSI S12.9 Part 4 clause F.3.4.2 should be used." This adjustment was applied in this analysis to be conservative for homes away from busy roads and rail.

For each category a range of acceptable annual average day-night sound levels are listed for Compatible, Marginally Compatible, Compatible with Sound Insulation, and Incompatible. For the Residential-Urban/suburban, Single Family category, "Compatible" ranges up to 55 Ldn, and "Marginally Compatible" extends to 60 Ldn. Intrusive noise levels above 60 Ldn are "Incompatible".

Compatible land use is defined in ANSI S12.9 Part 5:

3.1 compatible land use. *Land use consistent with the outdoor noise environment such that the annual average of the total day-night adjusted sound exposure or the annual average of the adjusted day-night average sound level at a site is not greater than the compatibility limit designated for that land use.*

3.2 land use. *Existing or intended use of a specifically delineated land area or parcel.*

3.3 land use category. *A logical grouping of a set of related land uses.*

The ANSI S12.9 Part 4 adjustment from urban to quiet rural local conditions is a reduction of 15 dBA, including 10 dB for "quiet rural settings" (ANSI S12.9 Part 4 Section F.3.4.2) and 5 dB for unfamiliar intrusive noise (ANSI S12.9 Part 4 Section F.3.4.1). These two factors are additive (ANSI S12.9 Part 4 Section F.3.4.3). In practice, these factors may be used to either 1) adjust measured or predicted levels upward to assess against ANSI land use compatibility ratings, or 2) adjust ANSI land use compatibility ratings downward to assess measured or predicted sound levels. The comparative result is the same. For this calculation, the compatibility noise ratings were adjusted downward *for direct comparison to facility long term average (Leq) noise predictions.*

The tables below summarize the calculation utilized to determine land use compatibility noise criteria for rural residential land use, using ANSI S12.9 Parts 4&5 assuming a quiet rural area. "Criteria" means the level that should not be exceeded- the highest allowable long-term average (Leq) noise level. The more stringent "Night" criteria are highlighted.

Criteria for "Compatibility" per ANSI S12.9:

Factor	Day-Night Sound Level (DNL)	Day Sound Level:	Night Sound Level:	Average Level (Leq*):
Part 5 Figure A.1 Residential Urban/suburban, Single Family Compatible, at the edge of Marginal Compatibility:	55	55	45	49
Adjust: 10 dB for quiet rural settings (Part 4 F.3.4.1):	-10	-10	-10	-10
Adjust: 5 dB for unfamiliar intrusive noise (Part 4 F.3.4.3):	-5	-5	-5	-5
Criteria for "Compatibility", dBA:	40	40	30	34

(continued)

Criteria for "Marginal Compatibility" per ANSI S12.9:

Factor	Day-Night Sound Level (DNL)	Day Sound Level:	Night Sound Level:	Average Level (Leq*):
Part 5 Figure A.1 Residential Urban/suburban, Single Family Marginal Compatibility, at edge of Incompatible:	60	60	50	54
Adjust: 10 dB for quiet rural settings (Part 4 F.3.4.1):	-10	-10	-10	-10
Adjust: 5 dB for unfamiliar intrusive noise (Part 4 F.3.4.3):	-5	-5	-5	-5
Criteria for "Marginal Compatibility", dBA:	45	45	35	39

* The energy-equivalent average level (Leq) equivalent to a 24-hour day-night level (DNL) is computed as 6.4 dB less than the day-night level due to level weighting of -10 dB from 10 pm to 7 am.

The ANSI S12.9 calculation concludes that for unfamiliar intrusive noise in quiet rural areas, long-term average (Leq) noise levels lower than 30 dBA are "compatible"; long-term Leq noise levels between 30 and 35 dBA are "marginally compatible"; long-term Leq noise levels exceeding 35 dBA at night are "incompatible".