

# Limits to the hosting capacity of the grid for equipment emitting high-frequency distortion

Math Bollen, Frans Sollerkvist

STRI AB

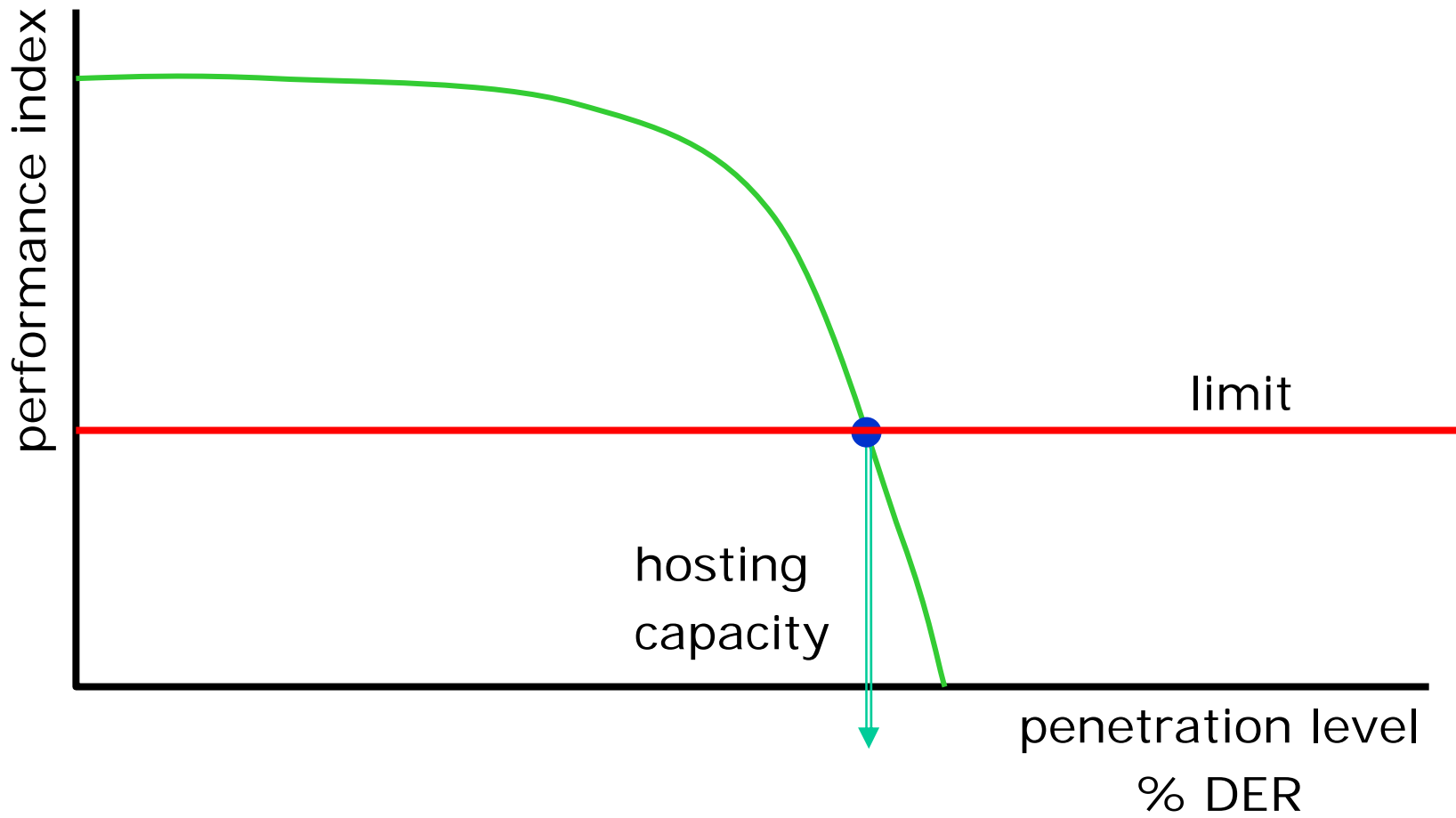
Anders Larsson, Martin Lundmark

Luleå University of Technology

# Distributed Energy Resources and Harmonics

- Emission up to 2 kHz: is not a serious concern.
- New resonances may occur due to the capacitance of the DER unit. Has been observed around 1 kHz. Risk below 500 Hz is small.
- High frequency distortion, 2 kHz and higher.

# Hosting Capacity



# DER units with PE interface

- Emission of one unit
- Joined emission of multiple units
- Source impedance
  - This gives the voltage distortion as a function of the number of units
- Indices and limits
  - This gives the hosting capacity

# Emission of one unit

Estimated current	Description
1.5%	2250-W PV inverter
0.3%	Laboratory setup
12%	DFIG inverter.
3.3%	100-kW microturbine
5%	110-W PV inverter
2.4%	150-W PV inverter
3.1%	100-kW PV system

- Values used to estimate hosting capacity:
  - 1 - 3% (small units)
  - 0.5 - 1.5% (large units)

# Distortion due to multiple units

- To include attenuation and diversity is a complex problem.
- It was decided to choose for a simple summation law:

$$I_N = \sqrt{N} \times I$$

# Source Impedance

- From measurements in low-voltage networks the following 95% value was found for the phase-to-neutral impedance:

$$Z(f) = \frac{f}{1000Hz} + 1\Omega$$

- The resulting harmonic voltage distortion is:

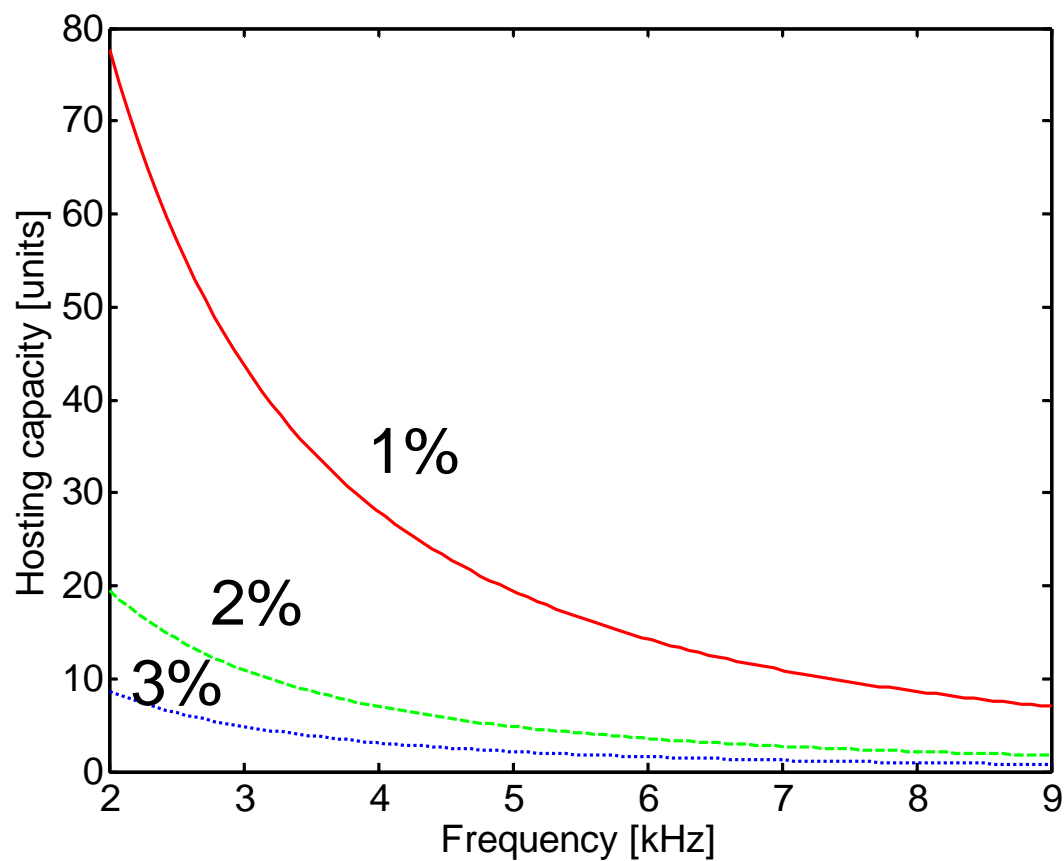
$$V_N(f) = \sqrt{N} \times Z(f) \times I_{rel} \times I_{nom}$$

# Indices and Limits

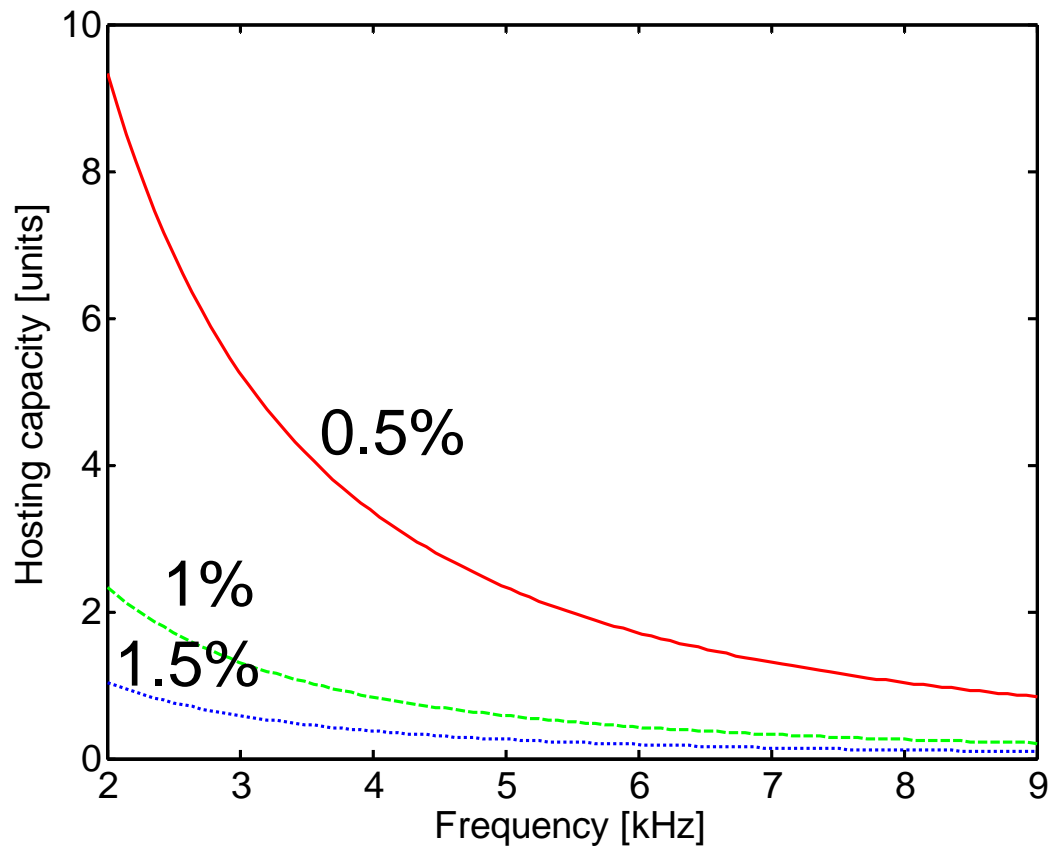
- There are no standards above 2 kHz
- The 200-Hz band is recommended in IEC 61000-4-7
- Harmonic subgroups are prescribed in IEC 61000-4-30
- Voltage characteristics are given in EN 50160
- Compatibility levels are given in IEC 61000-2-2
- Planning levels are given in IEC 61000-3-6
  - after some reasoning
- 0.5% voltage distortion per 200-Hz band is acceptable.



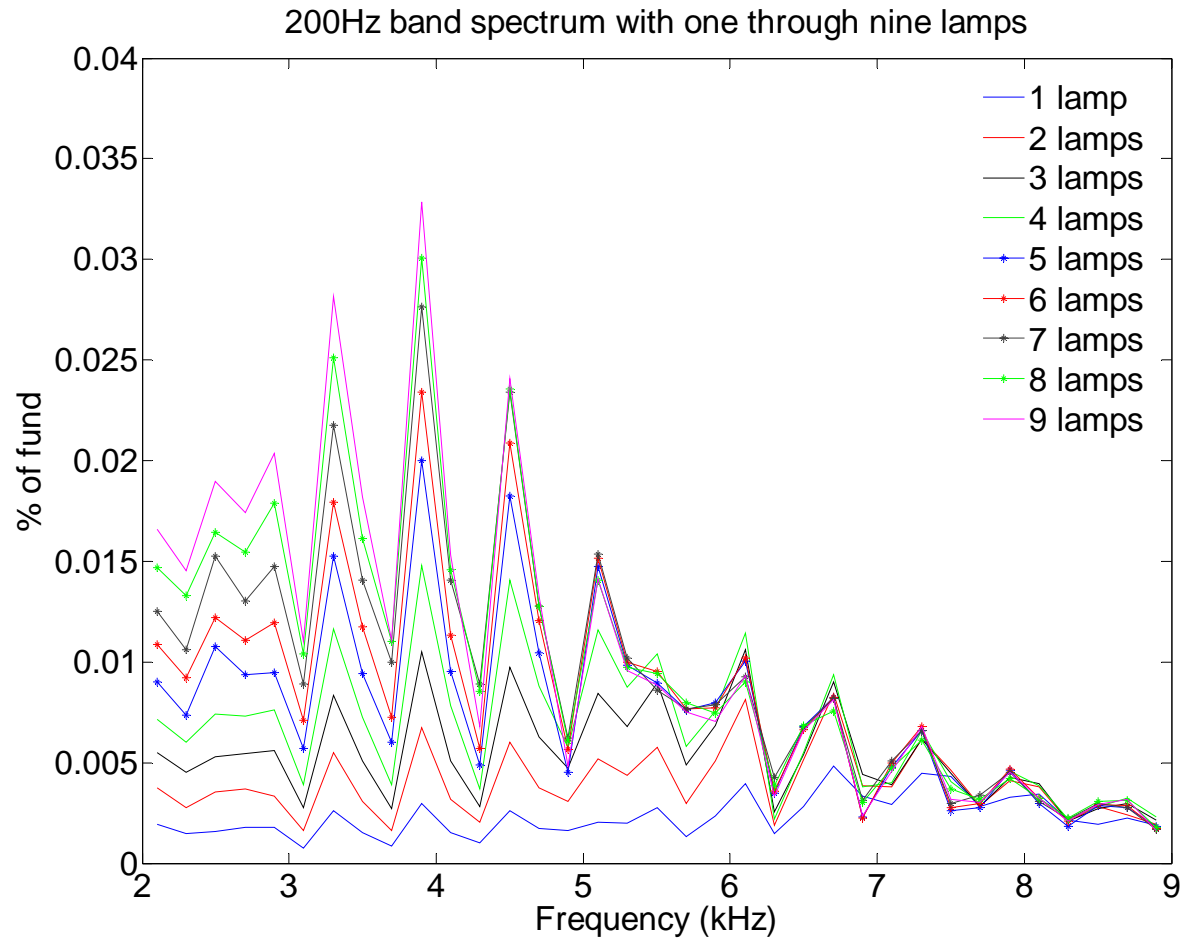
# Single-phase units, 1 kW



# Three-phase units, 10 kW



# Fluorescent lamps





# Conclusions

- Combining standards gives a limit of 0.5% for the voltage distortion in the range 2-9 kHz.
- Resulting hosting capacity:
  - About 1 for 10-kW DER units.
  - About 10 for 1-kW DER units.
  - About 100 for fluorescent lamps
- Coordination is needed between emission limits and voltage distortion limits above about 1 kHz.