U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Power Quality Myths and Misconceptions: What you need to know

Lightfair

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Power quality fundamentals

- Power quality broadly describes the fitness of electric power delivered over networks to drive electric loads in a manner that allows the loads to function as intended without significant reduction in performance or lifetime
- Power quality is a system characteristic, not a component characteristic. There are many ways in which electric power can be of poor quality and many more causes of such poor quality power.
- Power quality can be degraded by displacement between voltage and current waveforms, and distortion of voltage or current waveforms
- Displacement can be lagging or leading
  - Inductive loads (e.g. motors and magnetic transformers) cause lagging displacement
  - Capacitive loads (e.g. most SMPS and LED sources) cause leading displacement
- Voltage waveform distortions typically created by generators
- Current waveform distortions typically created by loads

Power quality fundamentals

- Power quality degradation typically results in higher RMS currents, and harmonic currents
- Higher RMS currents
  - Lead to greater electricity transport (I^2R) losses
  - Require greater wire, circuit breaker, transformer, etc. sizes
- Harmonic currents
  - Can degrade performance of electronic equipment
  - Can damage some electronic equipment
  - Some (odd multiples of three) matter more than others
- Phase-cut dimming controls degrade the power quality of any circuit they are operating on, regardless of the light source technology being controlled

Power quality metrics

- Common power quality metrics (e.g. power factor and THD) are useful but imperfect (not unlike CCT and CRI)
  - (True) power factor is a measure of displacement and distortion
  - THD is a measure of current (THD-I) or voltage (THD-V) distortion
- Proper use of power quality metrics requires an understanding of what they are attempting to characterize, and their limitations.
- Low(er) power factor loads do not consume more energy, but they do draw more RMS current
- A component in an electrical system (such as a lighting fixture on a circuit) with low power quality metrics does not necessarily degrade the power quality of the system, due to the potential for compensating effects among connected, interacting components in that system.

Energy transport losses are relatively small

Independent Statistics & Analysis
eia U.S. Energy Information Administration

Sources & Uses | Topics | Geography

FREQUENTLY ASKED QUESTIONS

How much electricity is lost in transmission and distribution in the United States?

According to EIA data, national, annual electricity transmission and distribution losses average about 7% of the electricity that is transmitted in the United States.

EIA has estimates for total annual losses related to electricity transmission and distribution (T&D) and other losses in the State Electricity Profiles.

National level data are in the U.S. Total Profile (see link a bottom left of the Profiles page). The data are in "Table 10: Supply and Disposition of Electricity" of each Profile; scroll down each Profile page to find Table 10 and see the row for Estimated Losses in the Table.

To calculate T&D losses as a percentage, divide Estimated Losses by the result of Total Disposition minus Direct Use. Direct Use electricity is electricity that is generated at facilities that is not put onto the electricity transmission and distribution grid, and therefore does not contribute to T&D losses.

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Power quality math is not simple

	LED Source A	LED Source B	LED Source C	A + B + C
Power	13W	6.1W	11W	30.1W
Power Factor	0.90	0.92	0.91	0.96
THD-I	46%	36%	39%	23%

Field Example: Aberdeen Federal Building

- 7 stories, 210,466 square feet in Aberdeen, South Dakota
- Targeted baseline lighting (Summer 2010)
  - 4,981 fluorescent T8 4' lamps x 28 watts = 139,468 watts
  - 2 fluorescent T8 2' lamps x 14 watts = 28 watts
  - Total targeted baseline lighting = 139,496 watts
  - Whole building power factor measured at/by utility meter = 0.8614 (averaged 15 minute data for June-July 2010)
- Retrofit lighting (Fall 2010)
  - 4,981 LED T8 format 4' lamps x 14 watts = 69,734 watts
  - 2 LED T8 format 2' lamps x 7 watts = 14 watts
  - Total retrofit lighting = 69,748 watts
  - LED T8 format lamp power factor = 0.60
  - Whole building power factor measured at/by utility meter = 0.8603 (averaged 15 minute data for June-July 2011)

ANSI C82.77-2002 requirements

Input Power (P)	Minimum PF	Maximum Line Current THD (fundamental)
P≤ 35 Watts	0.5	200%
35W<P≤60W	0.8	80%
60W<P≤100W	0.9	50%
P>100W	0.9	20%

Table 1 - Residential Integrally ballasted medium screw base compact light sources

Integrally ballasted medium screw base (E26) compact light sources (CFL, HID, or halogen types) for use in commercial lighting equipment indoors or outdoors have the same requirements as shown in Table 1

Input Power (P)	Minimum PF	Maximum Line Current THD (fundamental)
P≤ 120 Watts	0.5	200%
120W<P≤150W	0.9	32%
P>150W	0.9	20%

Table 2 - Residential indoor hard-wired and portable luminaires for all lighting applications

Input Power (P)	Minimum PF	Maximum Line Current THD (fundamental)
All	0.9	32% and the requirements of ANNEX I

Table 3 - Commercial indoor hard wired ballasts or luminaires

LED products are generally performing well

- While LED products currently on the market have widely varying performance in most areas, their power quality impact appears on average to be better than the incumbent they are replacing, within ANSI C82.77-2002 guidelines, or both.
- According to DOE LED Lighting Facts data, for LED products reporting PF and/or THD for operation at full output:

		PF Mean	PF 80% >	THD Mean	THD 80% >
Omnidirectional or Directional lamps with a medium screw base	1Q13	0.857	0.759	N/A	N/A
	1Q14	0.883	0.791	N/A	N/A
Linear Replacement Lamps	1Q13	0.959	0.945	14.9%	17.9%
	1Q14	0.966	0.953	13.9%	16.8%
Troffers	1Q13	0.980	0.978	9.1%	13.2%
	1Q14	0.982	0.983	8.7%	12.7%
Outdoor Area/Roadway Luminaires	1Q13	0.981	0.973	7.0%	10.0%
	1Q14	0.986	0.996	8.1%	10.5%

Relativity

	Mobile Phone A	LED Source B
Power	6W[1]	9.5W
THD-I	126%[1]	13%

[1]Charging, with 35% remaining battery life

Managing risk

- Concerns over the power quality of a new technology replacing an incumbent should be weighed in context with:
  - the power quality of the incumbent
  - the relative power or current draw vs. the incumbent
  - the power quality and relative power or current draw of other connected components in the system.
- Specify ANSI C82.77-2002 recommendations today
- The next update to ANSI C82.77 (currently under development) will take into account the expected market adoption of LED sources
- Be aware of power quality design trade-offs
  - Cost, components, potentially lifetime and reliability
  - Some LED driver architectures commonly used in low-cost replacement lamps have a fundamental power factor vs. flicker trade-off
- Contact DOE if:
  - You have any evidence of a power quality problem caused by the installation of LED sources
  - You are planning a large retrofit of LED sources with power quality performance that does not meet ANSI C82.77-2002 recommendations

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Questions?

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