Energy Efficiency Standards for Power Supplies

A multitude of government energy efficiency standards and specifications have appeared over recent years that are driving the design of higher efficiency power converters. Efficiency requirements for External Power Supplies (EPSs) and other energy-using products (EuPs) from various agencies are discussed in this article, covering different power consumption modes. Resources are described that will help power design engineers understand efficiency requirements. **Richard Fassler, Power Integrations, San Jose, USA**

Since the discovery in the late 1990s that approximately 10% of electricity consumed by residential EuPs was wasted while products were supposedly 'turned off', but actually weren't [1], governments have developed programs to increase their efficiency. This drive for reduced power consumption has moved energy efficiency from being a secondary concern to the top tier of a new product's design objectives. Power supply designers must now be knowledgeable in current and future specifications and standards, not only for their power supply, but also for the EPS' end product.

A tool that automatically checks conformance to major EPS regulations (Figure 1) helps designers to solve this task. Designers simply input their measured no-load power and the four active-mode efficiency levels (and PF, if applicable) online and the calculator checks the performance to five efficiency regulations plus the Five-Star rating program. The calculator can be used for single input voltage designs, as well as universal designs.

Figure 1: Online tool for calculating power supply conformance to efficiency standards

The road to efficiency

While the end goal is the same, governments and agencies have taken different approaches to reduce EuP energy waste, some voluntary and some mandatory.

Voluntary programs typically set efficiency specifications for manufacturers to meet, if theychoose to and, in some cases, allow the use of a label identifying the product as energy efficient. Examples include the EC Code of Conduct (CoC), ENERGY STAR and 80 PLUS.

Mandatory programs have appeared in an effort to transform products quicker than voluntary programs, dictating standards which must be met in order for a product to be allowed to be sold in a region. One of the most ambitious mandatory programs to date is the EC's Ecodesign Directive. Established in 2005 to set energy and environmental performance for major EuPs, it investigates a product's lifecycle energy use. Nineteen product groups (Lots) have been identified and are in various stages of completion.

The first lot to receive final approval (Lot 6 – standby power) went into force in early 2009.

Other examples include the US Energy Independence and Security Act (EISA 2007) and the California Energy Commission's (CEC) Appliance Efficiency Regulations.

Occasionally, a hybrid approach is necessary. Korea's goal to reach a 1W standby power maximum for EuPs by 2010 relied on a voluntary efficiency labelling program. When a 2007 audit revealed that only 14% of the EuPs conformed to the goal to date, a large mandatory warning label was added to the program, to identify products (and manufacturers) who weren't supporting the national goal [2].

A new wave of voluntary efficiency programs has emerged, developed by product manufacturers. These 'stakeholder-driven' efficiency specifications transcend geographic boundaries, usually setting tighter goals than government agency programs. For example, the Climate Savers Initiative started by Intel and Google, sets increasingly tighter active-mode efficiency goals for a computer's internal power supply. In July 2009, it sets a target minimum efficiency of 88% at 50% load and 85% efficiency at 20 and 100% loads ('silver' level). This is tighter than ENERGY STAR's Computer Spec version 5.0, effective July 2009, which requires a minimum efficiency of 85% at 50% load and 82% at 20 and 100% loads ('bronze' level).

Major mobile phone manufacturers have also begun issuing tighter efficiency specifications for chargers/adapters shipped with their products. Figure 2 shows a sample list of the various Voluntary (V), Mandatory (M), and 'Stakeholder-driven' (SD) programs.

Agency / Industry Group	Location	Vol/Man	Products covered*
ENERGY STAR	US (with int'l reach)	V	EPS, BCS, TV, STB, computers, imaging equip, servers, lighting...
EC Code of Conduct	Europe	V	EPS, STB, broadband equip, servers
80 Plus	US	V	IPS for computers, servers
EC Ecodesign Directive for EuPs	Europe	M	EPS, appliances, TV, STB, computers, imaging equip, servers, lighting...
US EISA2007	US	M	EPS, BCS, lighting
NRCanada	Canada	M	EPS, BCS
Department of Climate Change (ex-GHO)	Australia	M	EPS, BCS, TV, STB, computers, imaging equip, servers, lighting...
Cal Energy Comm (CEC)	California	M	EPS, BCS, TV, lighting
China Standards Certification Center	China	V/M	EPS, TV, DVD, imaging products
KEMCO	Korea	V/M	EPS, BCS, TV, STB, computers...
Climate Savers	US	V (S-D)	Computers, servers
OMTP (GSMA)	Int'l	V (S-D)	Mobile phone chargers

EPS = External power supply, BCS = Battery charging system, STB = Set-top box, IPS = internal power supply * Finalized or in progress

Figure 2: Sample list of key efficiency programs

Regulation landscape

Early efficiency regulations were typically uncomplicated, targeting only standby or no-load power consumption. Over the years, programs have become more comprehensive, covering multiple modes of a product's typical use in an effort to improve efficiency. Single-output EPSs, targeted early on due to their ubiquitous nature and ease of voltage/current measurement, must now be designed for high efficiency at low loads as well as full loads in order to be compliant. Another example, televisions, initially had standby-mode only efficiency specifications, but now must meet both standby and active-mode consumption levels.

In 2001's EC CoC, only a no-load power (EPS connected to the mains but nothing connected to its output) consumption limit had to be met. Today, the Code of Conduct and all other major single-output EPS efficiency programs include minimum active-mode efficiency, as well. Other country EPS specifications (Australia, New Zealand, Korea, and China) exist, but those programs are based on versions of the following four major specifications.

Harmonised test method and efficiency calculations

The EPS no-load power consumption is equal to the AC active input power without any load connected to the output. The efficiency is calculated by dividing the unit's measured active output power by the active AC input power, measured at each load condition of the specification. The average efficiency is calculated as the arithmetic mean of the efficiency values calculated at these load conditions, a simple arithmetic average of active mode efficiency [3]. The test method can be downloaded at **www.energystar.gov/ia/partners/prod_development/downloads/power_supplies/EPSupplyEffic_TestMethod_0804.pdf**

The average efficiency calculation is then compared to the minimum efficiency limit calculated using the formula in the specification, for the corresponding nameplate output power level. For example, to conform to the EC CoC EPS efficiency specification, a 15W power supply must consume no more than 0.3W of no-load power from the mains. In addition, the minimum average efficiency is defined as $\geq [0.08 * \ln(P_{no})] + 0.585$ where $\ln(P_{no})$ is the natural log of the supply's nameplate output power (expressed in watts). In this example, the supply's minimum average efficiency would need to be 80.2%.

EC Code of Conduct

The CoC, a voluntary specification based on a negotiated agreement between independent experts and representatives of member states and industry, issued version 3 (v3) of its EPS specification in late 2007 (1/1/09 effective date). It consists of a no-load power maximum and active-mode efficiency minimum for power supplies ≤250W. The intent was to harmonise 100% with ENERGY STAR's v2 EPS draft, but fell short due to ENERGY STAR EPS specification changes after the CoC v3 was finalised. Included in v3 is a new category for mobile phone EPSs ≤8W. The new mobile phone specification tightens no-load power consumption.

Energy star

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Figure 3: Major EPS standards summary

	ENERGY STAR EPS v2 & EC CoC v4 & Ecodesign Directive Tier 2 (2011)	ENERGY STAR EPS v2 & EC CoC v4 & Ecodesign Directive Tier 2 (2011)	EISA '07 & EC Ecodesign Directive Tier 1 (2010)
Nameplate Output Power (Pno)	Min Ave Efficiency in Active Mode (Standard PS)	Min Ave Efficiency in Active Mode (Low Voltage PS) [3]	Min Ave Efficiency in Active Mode
≤ 1 watt	≥ 0.480 * Pno + 0.140	≥ 0.497 * Pno + 0.067	0.5* Pno
> 1 to ≤ 49 watts	≥ [0.0626 * Ln (Pno)] + 0.622	≥ [0.0750 * Ln (Pno)] + 0.561	
> 1 to ≤ 51 watts	≥ [0.0626 * Ln (Pno)] + 0.622 *(Ecodesign only)*		≥ [0.09 * Ln (Pno)] + 0.5
> 49 watts	≥ 0.870	≥ 0.860	
> 51 watts	≥ 0.870 *(Ecodesign only)*		≥ 0.850
	No-load power [1, 2, 4]	No-load power [2, 4]	No-load power
< 50 watts	0.3 W	0.3 W	0.5 W
≥ 50 to ≤ 250 watts	0.5 W	0.5 W	0.5 W

NOTES: 1. AC-AC is ≤ 0.5 W for all power levels. 2. No-load spec for mobile handheld battery powered apps ≤ 8 W is ≤ 0.25 W until 12/31/10, ≤ 0.15 W after 1/1/11 3. Low Voltage PS defined as < 6V and ≥ 550 mA 4. For Ecodesign, power levels are ≤ 51 watts and > 51 watts * As of April 2009

Agency (EPA), ENERGY STAR is one of the most visible efficiency certifications worldwide. It works closely with countries around the world to harmonise efficiency standards. ENERGY STAR's EPS v2 spec became effective November 1, 2008. New in this version are an active-mode specification for 'low voltage' supplies (defined as with an output of <6V and ⩾ 550mA), separation of no-load power consumption for AC/AC and AC/DC power supplies, and power Factor Correction of ⩾ 0.9 at 100% rated load at 115VAC/60Hz for power supplies ⩾100W.

Also, for EPSs with a universal input voltage range, testing needs to be done at both 115V at 60Hz and 230V at 50Hz, with the least efficient set of test values used to determine qualification. Certain types of battery chargers and EPSs for medical equipment are exempt. However, this specification is being incorporated into ENERGY STAR telephony, television, set-top box, imaging equipment, computer, display, and audio video efficiency specifications.

US EISA 2007

The Energy Independence and Security Act of 2007 was signed into law in December 2007 to move the United States toward greater energy independence and security. EISA 2007 is a comprehensive document and sets the first federal mandatory efficiency standards for EPSs, among other products. The EISA 2007 EPS efficiency limits were adopted from California's CEC EPS standard. Certain battery chargers and EPSs for medical equipment are exempt.

EC Ecodesign Directive

On October 17, 2008, the member states Regulatory Committee passed the EPS standard (study lot 7) on to the European Parliament for final scrutiny and approval. One year after the 'regulation comes into force', it will align with the US EISA 2007 standard. Two years after coming into force, it will tighten up to align with ENERGY STAR's EPS v2. EPSs for medical equipment and certain battery chargers are exempt.

Figure 3 summarises the differences and similarities of the major EPS programs (excluding low voltage models and mobile phone specs). Figures 4 and 5 provide a visual comparison of efficiency and no-load requirements.

Horizontal standby efficiency

A number of countries are embracing a 1W (maximum) horizontal standby power consumption policy. The European Parliament recently passed Ecodesign Directive Lot 6, mandating this for a broad range of EuPs by 2010, tightening to 0.5W by 2013.

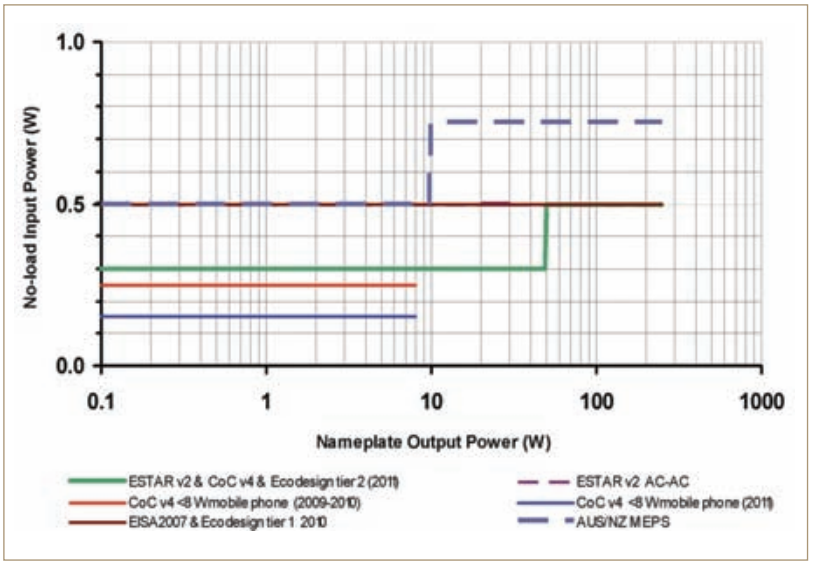

Figure 4: Major EPS no-load summary

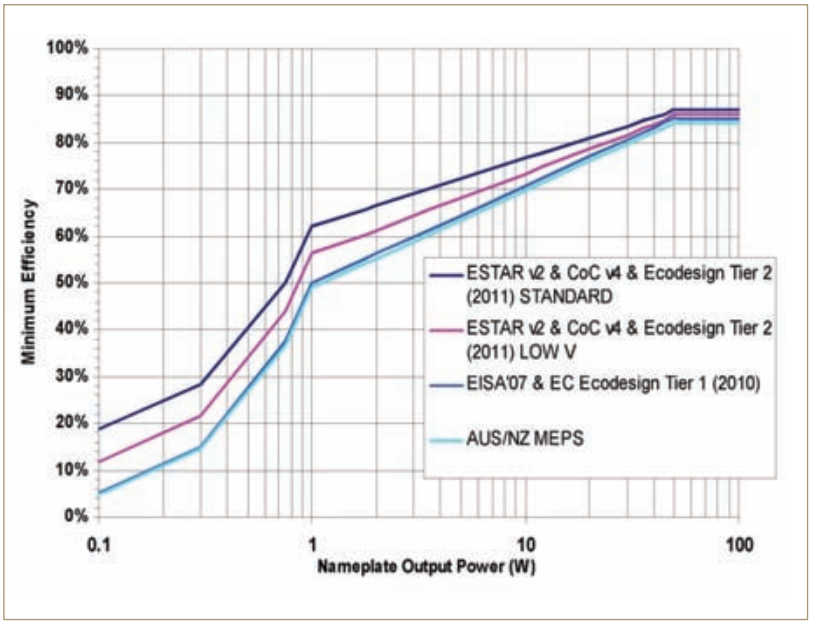

Figure 5: Major EPS active-mode summary

Although most agencies strive for harmonisation, differences appear, making it necessary for design engineers to review specifications often. Here are some ways to keep abreast of pending changes to current specifications and new efficiency programs, and to add input to help shape new regulations.

Conclusion

Today's energy efficiency specifications and standards for EuPs have become more complicated and target different modes of operation. There are four major EPS efficiency programs which are shaping external power supply design. More than ever, power supply designers need to have a strong knowledge of worldwide current and proposed regulations for EPSs and their end products. Knowing how to quickly access this information and the design assistance via the web is vital… and it's achievable.

Literature

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[2] Kim, Yungrae; New Energy Efficiency Policy Tool, presented at IEA International Standby Conference, India. April, 2008.

[3] Calwell, C; Foster, S.; Reeder, T.; Mansoor, A.: Test Method for Calculating the Energy

Efficiency of Single-Voltage External Ac-Dc and Ac-Ac Power Supplies. CEC, 2004.