Codes and Standards Enhancement Initiative
For PY2004: Title 20 Standards Development

Analysis of Standards Options For Single-Voltage External AC to DC Power Supplies

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1 Introduction

The Pacific Gas and Electric Company (PG&E) Codes and Standards Enhancement (CASE) Initiative Project seeks to address energy efficiency opportunities through development of new and updated Title 20 standards. Individual reports document information and data helpful to the California Energy Commission (CEC) and other stakeholders in the development of these new and updated standards. The objective of this project is to develop CASE reports that provide comprehensive technical, economic, market, and infrastructure information on each of the potential appliance standards. This CASE report covers standards and options for single voltage external AC/DC power supplies.

2 Product Description

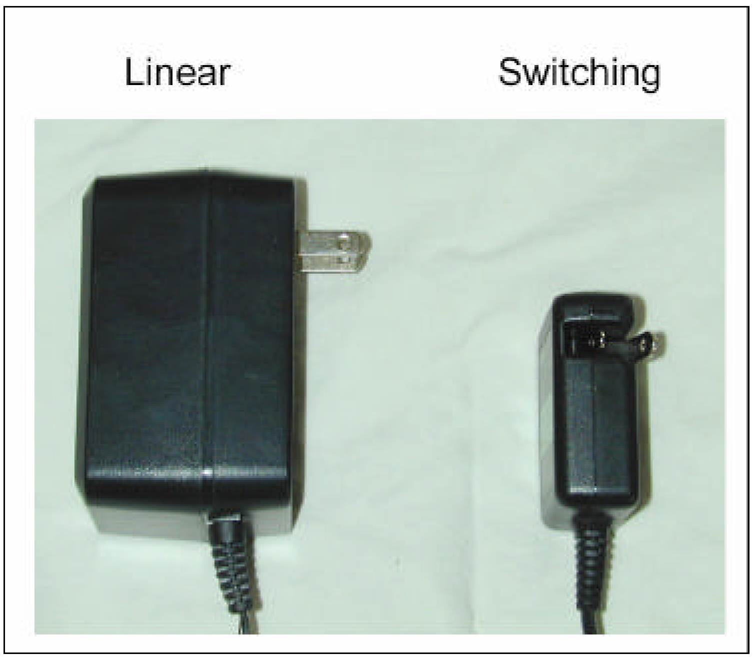
This proposed standard covers devices that convert line voltage alternating current (typically 100 to 240 volts AC) into low voltage direct current (typically 1.5 to 24 volts DC) within a housing external to the DC-consuming product itself. The proposed standard does not cover power supplies that provide more than one discrete output voltage simultaneously, but does cover power supplies that offer a user-selectable output voltage from among a range of choices. As a category, the covered products are known as “external power supplies.” They are also known as “AC adapters,” “wall packs,” “bricks,” or “transformers.” Many, but not all, power devices containing rechargeable batteries employ external power supplies.

External power supplies are easily differentiated from internal power supplies, which are located within and physically linked to the devices they are intended to power.

Figure 1 - External Power Supplies

Two major types of technologies are in widespread use: "linear" and "switching" (also referred to as switch-mode). Linear designs operate in a fashion similar to magnetic ballasts, consisting primarily of a large transformer and simple circuitry, and are similarly bulky and inefficient. Roughly, 40 to 75% of the energy passing through linear power supplies is dissipated (wasted) as heat. Switching designs are similar to electronic ballasts, and tend to be significantly more compact (see Figure 2) and energy efficient. Approximately 10 to 40% of the power passing through them is typically dissipated as heat.

Figure 2 – Comparing the size of linear and switching external power supplies with equivalent power output



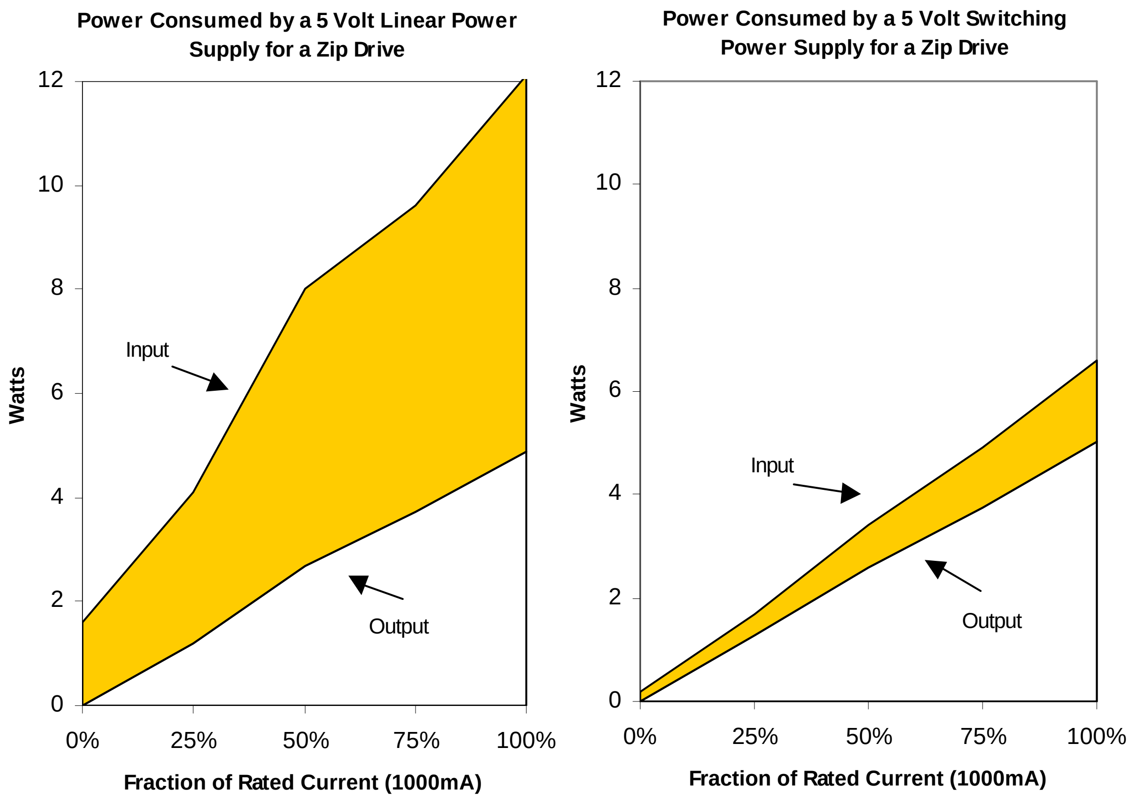
External power supplies tend to be used more commonly in relatively low wattage applications, and are more likely to be linear. Internal power supplies tend to be used more commonly with relatively higher wattage products, and are more likely to be switching.

There are four key reasons manufacturers typically utilize an external design. First, it confines the high voltage power to a separate circuit, eliminating the need for the costly, time-consuming process of acquiring safety approvals such as UL listing for the main device itself. Second, it removes weight and physical size from the main product, which is especially valuable in portable products such as cellular phones and laptop computers that are designed to operate on rechargeable batteries. Third, it removes one of the major sources of waste heat from inside the product's case, often eliminating the need for active ventilation and helping to protect sensitive electronic components. Finally, it permits a product to be used in the U.S., Europe, or Asia by only changing the power supply or fitting an adapter plug to it. Many switching power supplies can automatically operate at 50 or 60 Hz and at voltages ranging from 100 to 240 volts AC.

The efficiency differences between linear and switching external power supplies can be seen in Figure 3, which illustrates the input and output wattages for two different types of power supplies used by an Iomega Zip 100 external disk drive. The shaded area represents the amount of electricity wasted (i.e. converted to heat) at various load levels by the power supply. Determining how much energy a power supply consumes can be confusing because power supplies are a component of a larger system. However, when identically rated DC output power supplies are compared, the output should be the same, but the input will vary depending on efficiency. In this way, energy consumed by only the power supply is isolated from the useful output of the power supply.

Power supplies are rated by their maximum output current (indicated by 100% on the charts); however, they typically operate at some fraction of that level. Efficiencies of a given external power supply are commonly lower at part load than at full load (and by varying amounts), so testing across a range of load conditions is essential. In the no-load or standby condition, indicated by 0% on the charts, there is also some amount of power wasted, though low standby designs can keep that to 0.3 watts or less.

Figure 3 - Input and Output Wattages for Linear and Switching Power Supplies

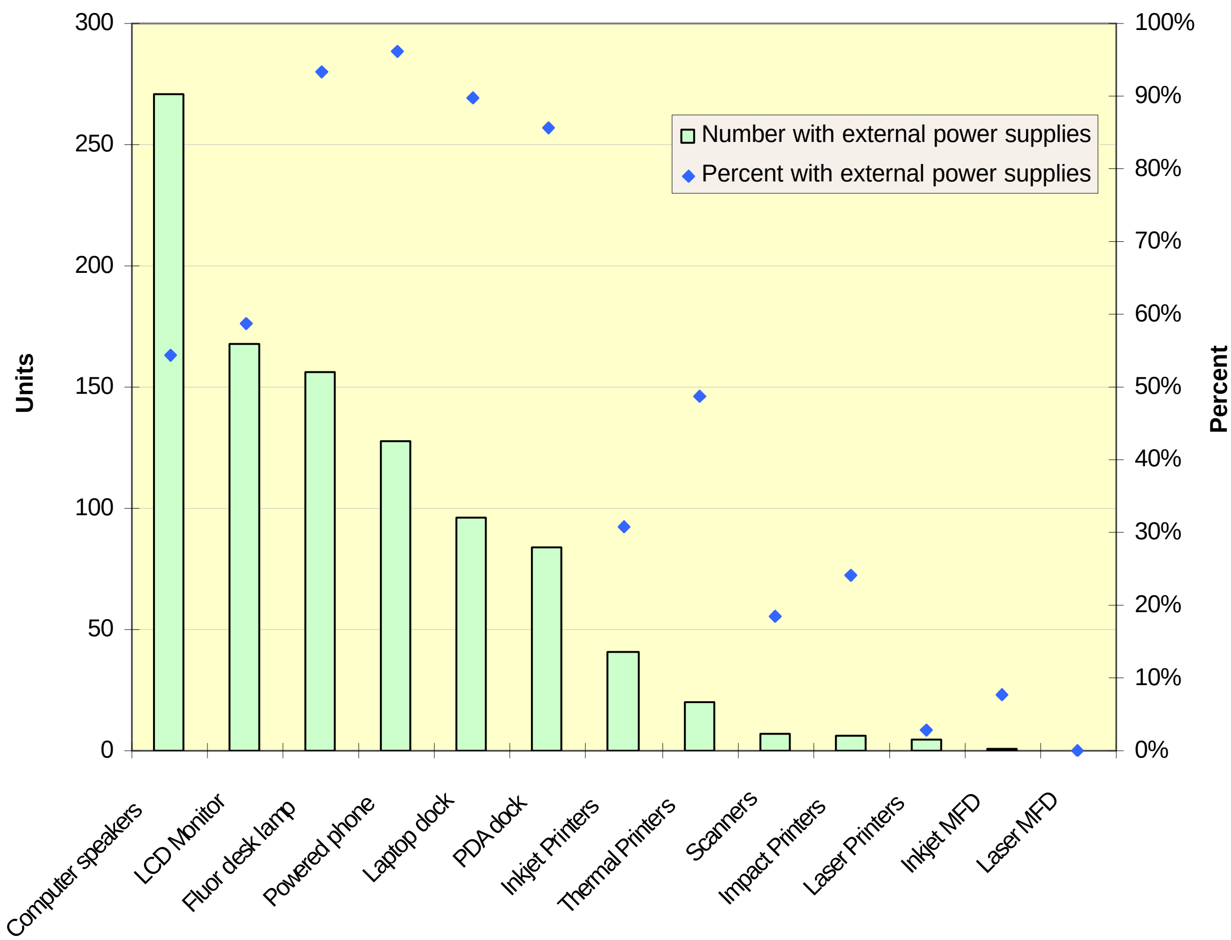


3 Market Status

3.1 Penetration

More than a billion external power supplies are sold globally each year, and the average U.S. home contains perhaps 5 to 10 of them.[1] Saturation studies have not yet been completed in the commercial sector, though a recent census by LBNL researchers found high concentrations of external power supplies in various office buildings (see Figure 4).

Figure 4 – LBNL Office Census Findings in California, Pennsylvania, and Georgia[2]



Typical applications that have an external power supply include: laptop computers, cordless phones and answering machines, video games, computer speakers, cordless tools, etc. Including commercial uses, there are roughly 1.3 billion of these products in operation in the U.S. alone.[3] Apportioned on a population basis, this indicates that about 145 million may be in use in California.

3.2 Sales Volume

Based on market research obtained from Darnell Group and other research conducted by Ecos Consulting, we believe that the current North American market for external power supplies is about 250 million units per year and the California market is about 27.5 million units per year. Linear designs account for about 46% of the total, and switching designs the remaining 54%.[4] Again, apportioned on a population basis, we assume California sales of approximately 12.7 million linear units and 14.8 million switching units in 2003. Even though switching units are on average more efficient than linear units, it is not possible to predict with precision how many units are currently being sold at each wattage that would meet a particular proposed efficiency standard. Table 1 estimates approximate California sales by wattage and application.[5]

A small number of external power supplies are sold by themselves as replacements or upgrades by retailers, but the vast majority is shipped with the products that use them. As a result, any effort to regulate their efficiency by the state of California necessarily involves monitoring or enforcement of the sales of a wide variety of electronic products.

Table 1 – Key Product Categories Shipped with External Power Supplies (California estimates)[6]

		Wattage Range					
Communications Segment	**2003 Units (millions)**	**<5**	**5-10**	**>10-20**	**>20-50**	**>50-100**	**>100**
Cellular	8.1	50%	40%		9%	1%	
Cordless Phones	2.2	10%	40%	50%			
LAN Equipment	0.1		100%				
Modems	0.4		20%	65%	13%	1%	1%
PBX	0.2			100%			
Set-Top Boxes	0.5	15%	85%				
Total	**11.6**						
Computer Segment		**<5**	**5-10**	**>10-20**	**>20-50**	**>50-100**	**>100**
Flat Panel Monitor	0.2				90%	10%	
Flatbed Scanners	1.0	4%	10%	30%	55%	1%	
Handheld Computers	0.2		10%	50%	39%	1%	
Notebook Computers	1.2				80%	20%	
Portable Barcode Reader	0.2			50%	49%	1%	
Printers	2.2			50%	49%	1%	
Total	**5.2**						
Consumer Segment		**<5**	**5-10**	**>10-20**	**>20-50**	**>50-100**	**>100**
Camcorder	0.4		80%	20%			
Digital Camera	0.4	9%	60%	20%	11%		
Portable Audio	0.9	80%	20%				
Power Tools	1.0	25%	45%	20%	10%		
Total	**2.7**						
Medical Segment		**<5**	**5-10**	**>10-20**	**>20-50**	**>50-100**	**>100**
Medical	3.3	20%	25%	35%	16%	2%	2%
Total	**3.3**						
		<5	**5-10**	**>10-20**	**>20-50**	**>50-100**	**>100**
Other	4.6	15%	50%	15%	5%	15%	0%
Total	**4.6**						
Grand Total	**27.4**						

3.3 Penetration of High Efficiency Option

As noted above, about 54% of all external power supplies are switching designs, which are more efficient than linear designs but still vary widely in efficiency. In the two scenarios analyzed here, 25% and 40% of the power supplies currently sold can meet the active mode requirements of the proposed specification. Virtually all of these are switching designs. Enough qualifying power supply models are currently available from a wide enough assortment of manufacturers to ensure a ready supply of qualifying units once standards take effect.

4 Savings Potential

4.1 Baseline Energy Use

Usage estimates were derived from a variety of sources including: LBNL studies of office equipment and consumer electronics[7]; a DOE-funded Arthur D Little study of office equipment energy use[8]; various DOE reports regarding residential and commercial energy use[9]; various private sector market research sources[10]; and Ecos Consulting estimates of power use, number of products in use, and duty cycles developed in cooperation with Carrie Webber of LBNL.[11]

Rather than developing assumptions of existing efficiencies for external power supplies, Ecos obtained 134 different models currently in use and directly measured their efficiency. Many of the power supplies were "universal" designs, capable of operating at multiple output voltages, yielding 197 efficiency plots. In addition, the Center for Energy Conserving Products (CECP) in China furnished data for 500 additional external power supplies tested in Guangzhou by the lab CEPREI. Its initial tests were conducted on the basis of percentage of nameplate *power* output instead of percentage of nameplate *current* output (as called for in the test procedure), so unregulated units with widely varying voltages (about 30% of the units they tested) were not included in our final data assessment. Similarly, the University of New South Wales, Australia, tested 47 models in January 2004.

Each set of measurements consists of five pieces of information: power use at the no-load condition, efficiency at 25% load, efficiency at 50% load, efficiency at 75% load, and efficiency at 100% load. In each case, those efficiencies were calculated by applying a known resistance to the DC side of the power supply, measuring output power, and dividing it by measured input power on the AC side. In general, most power supplies exhibited lower efficiencies under partial load conditions than under full load, but for many the percentage efficiency does not drop significantly until a load of below 25%.

To best estimate energy use from measured input power, it was necessary to create a duty cycle that estimated the amount of time the power supply is expected to operate at each of the measured loading levels. These duty cycles vary widely by product, and they can only be considered estimates until substantial additional end use metering is conducted. A summary of total energy use by mode is shown in Table 2, with a more detailed distribution of energy use by product type illustrated in Table 3.

Table 2: Baseline California External Power Supply Energy Use

Annual Baseline Energy and Stock Estimates	
Units in use	145.1 million
Energy Use in Active Mode	5,299 GWh
Energy Use in No Load	249 GWh
Total Energy Use	5,548 GWh

Table 3 – Estimated Duty Cycles and Efficiencies by Power Supply Wattage

	Unplugged		No Load		25% Rated Load		50% Rated Load		75% Rated Load		100% Rated Load		Totals
Output Power Bin (watts)	Fraction of time at load	Average Eff at Load	Fraction of time at load	Average Eff at Load	Fraction of time at load	Average Eff at Load	Fraction of time at load	Average Eff at Load	Fraction of time at load	Average Eff at Load	Fraction of time at load	Average Eff at Load	Weighted Average Active Mode Efficiency
<2.5	35%	NA	25%	NA	20%	33%	14%	42%	5%	45%	1%	46%	38%
2.5-<4.5	20%	NA	15%	NA	20%	48%	30%	55%	14%	57%	1%	56%	53%
4.5-<6	30%	NA	25%	NA	20%	53%	15%	59%	9%	61%	1%	61%	57%
6-<10	10%	NA	10%	NA	24%	58%	30%	66%	25%	67%	1%	66%	64%
10-<24	10%	NA	20%	NA	28%	63%	26%	70%	15%	72%	1%	71%	68%
>24	15%	NA	15%	NA	34%	78%	25%	81%	10%	83%	1%	84%	80%

4.2 Proposed Test Method

While test procedures have already been established by FEMP and IEC[12] for measuring standby power, very few test procedures offer any guidance for measuring active mode efficiency. IEEE 1515-2000 provides a very general description of active mode efficiency testing, but lacks specifics regarding loading conditions.

With funding from the CEC's PIER program, Ecos Consulting and EPRI-PEAC began drafting an active mode efficiency test procedure in July 2003. It has been posted at www.efficientpowersupplies.org for comment by stakeholders worldwide since August 2003.[13] A stakeholder technical workshop to review detailed comments was held in San Francisco on November 7, 2003. Final stakeholder comments were received by EPA's ENERGY STAR program in mid-January, 2004, and the procedure was finalized February 13, 2004. It is entitled "Test Method for Calculating the Energy Efficiency of Single-Voltage External Ac-Dc Power Supplies."

The governments of California, the U.S., China, Australia, Brazil, and Canada have all signed a letter addressed to manufacturers worldwide stating their intent to employ this test procedure in future policy measures regarding external power supply efficiency. The intent is to establish a single, consistent test method for use in efficiency standards and labeling programs in North and South America, Asia, and Australia, so that any efficiency values characterized in one region or context will be directly comparable to those in another. Europe's Code of Conduct process has elected to use only portions of the test procedure, so its results will not be directly comparable to those reported in other regions. The testing that forms the basis for the standards levels recommended in this report was conducted in accordance with the basic provisions of the draft test method, though minor improvements in the methodology for no-load testing during the evolution of the test method would lead to slight changes in the no-load wattage values for some units that have not yet been retested.

4.3 Efficiency Measures

Most external power supplies contain a transformer, which employs two different coils of wire and the magnetic field between them to lower the output voltage to the desired level. These devices operate at the 60 Hz frequency of the AC grid. Switching power supplies improve efficiency first by shrinking or eliminating the transformer. More importantly, they operate at much higher frequencies, where they are able to deliver low voltage power in brief pulses that can be utilized or skipped as needed to match the load more closely. Among switching designs, there are a range of efficiencies as well, with resonant transition and quasi-resonant designs providing somewhat better efficiencies than standard pulse width modulation (PWM) designs.[14] All AC-DC power supplies also contain rectification, which converts alternating current to direct current. Varying options for rectification are not specifically examined here for energy savings potential.

4.4 Standards Options Analysis

After analyzing the data and dividing the power supplies into groups according to maximum rated output wattage, we identified standard levels that could be met by a designated fraction of the tested power supplies in each category. Though efficiencies of greater than 90% are achievable with the best technologies, the proposed standards are somewhat less stringent to ensure that the required efficiencies are achievable at reasonable incremental cost. Two efficiency standards were analyzed for this report, Tier One and Two: market penetration for Tier One is 40% and market penetration for Tier Two is 25%. We recommend the active mode standards levels for external power supplies in Table 4 below. Note that "Efficiency" refers to the average of the percentage efficiencies measured at 25%, 50%, 75%, and 100% of nameplate current output.

Table 4: Proposed Standards Levels in Active Mode

Proposed Standards	***Nameplate Power Supply Output***		
Tier 1 (top 40% of market)	***<=1 Watt***	***>1 to 60 Watts***	***>60 Watts***
	Efficiency > 0.48(Watts)	Efficiency > 0.89Ln(Watts) + 0.48	Efficiency > 84%
Tier 2 (top 25% of market)	***<=1 Watt***	***>1 to 51 Watts***	***>51 Watts***
	Efficiency > 0.50(Watts)	Efficiency > 0.09Ln(Watts) + 0.50	Efficiency > 85%

Proposed no load requirements are as follows: For Tier 1, power consumption shall be no more than 0.5 watts in units with a nameplate output power of 0 to 10 watts and no more than 0.75 watts in units with a nameplate output power of more than 10 watts. For Tier 2, power consumption shall be no more than 0.5 watts for all covered units.

Table 5 below summarizes average energy savings per power supply and statewide if all existing stock were upgraded to higher efficiency.

Some power supplies are able to meet higher efficiency requirements at full load than at a fraction of full load. Thus, it is possible to obtain somewhat greater energy savings from a standard whose efficiency requirements are based on an average over a range of load conditions, rather than just at full load.

Table 5: Annual Energy Savings Estimates

Annual Energy Savings Estimates

Standards Level	*Mode of Operation*	*Per Unit*	*Total California*
Tier 1	*Active Mode*	2.75 kWh	399 GWh
	No Load	1.01 kWh	146 GWh
	Total	3.76 kWh	545 GWh
Tier 2	*Active Mode*	3.37 kWh	489 GWh
	No Load	1.07 kWh	156 GWh
	Total	4.44 kWh	645 GWh
Incremental Gain	*Total*	0.68 kWh	100 GWh

Note: within each Tier, the active mode energy savings are about 75% of the total energy savings.

Energy savings are calculated from the input wattages of power supplies with the same output wattage, but different efficiencies. So, for example, a 10 watt power supply operating at 50% efficiency would consume 20 watts of input power (10/0.5) at full load, while a 10 watt power supply operating at 80% efficiency would consume 12.5 watts of input power (10/0.8) at full load. Savings are calculated not on the basis of barely meeting the proposed standards levels, but on the average efficiency difference between the average compliant product and the average non-compliant product already measured.

5 Economic Analysis

5.1 Incremental Cost

Efforts to calculate the incremental cost of a more efficient power supply technology are confounded by at least four different factors:

- The manufacturing cost of a power supply rises with its output wattage. As wattage increases, the cost of the copper and other components required to manufacture a linear design rises more rapidly than a comparable cost curve for switching technology, meaning that switching designs are inherently less expensive to manufacture than linear designs above a certain wattage (roughly 20 to 40 watts). See Figure 8 for a conceptual characterization of those cost differences.

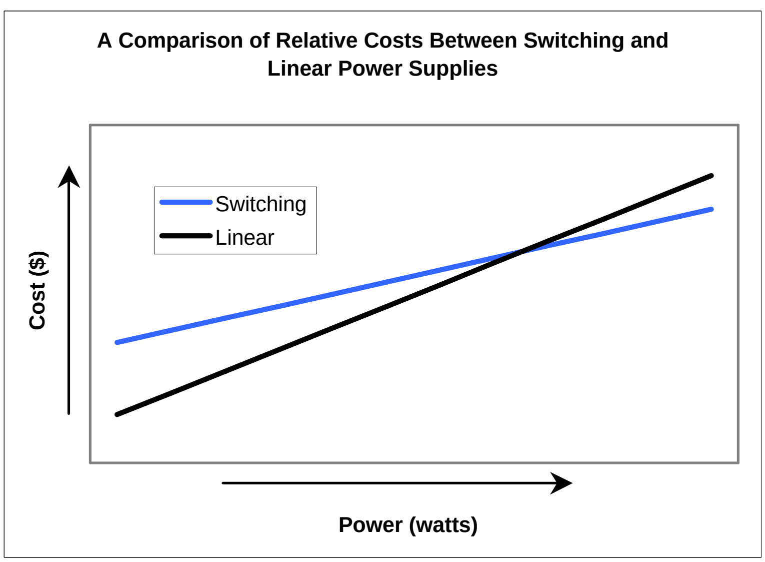
- Within the various switching technologies, there are a variety of technological solutions with varying costs and performance characteristics. Some designs yield very low no-load power consumption and modest efficiencies in active mode, while others yield very high efficiencies in active mode while still keeping no-load consumption below 0.75 or 0.5 watts.

- High efficiency power supplies are often smaller and lighter than their low efficiency counterparts are. Therefore, any calculation of unit cost that does not include shipping and other benefits will exaggerate the incremental cost of an efficient power supply.

- Pricing information for individual unit purchases of individual models can often be obtained in the marketplace, but obtaining firm, large volume quotes from manufacturers of competing technologies is difficult. Likewise, estimating the resulting markup from the power supply manufacturer to the OEM manufacturer of the finished product incorporating that power supply, and the final retail markup is very challenging.

After interviewing a number of manufacturers of highly efficient power supplies, we believe the incremental costs are between 8 and 15% for most models, decreasing as wattage increases.[15] Two sources at Power Integrations, a leading manufacture of switch mode power supply integrated circuits made to increase efficiency and lower standby losses, have asserted that incremental costs are very low and shrinking further over time. Balu Balakrishnan, President of Power Integrations reports an incremental cost of about $0.30 for low power applications. Power Integrations' Cliff Walker has stated that an incentive of $0.50 per external power supply would be higher than what is needed to offset any resulting incremental cost. Many equivalently sized external power supplies sell for virtually identical prices, regardless of whether they employ linear or switching technology.[16]

Figure 5: A Comparison of Relative Costs



5.2 Design Life

Because external power supplies are passively cooled and not typically affected by the heat output of the devices they are powering, their functional lifetimes can be quite long. A typical cause of *failure* would be a short developing in their electrical connectors or output cords. The more likely cause of the *retirement* of a power supply is the functional obsolescence of the device it is powering. For example, many consumers upgrade their cellular phones every three years, discarding or returning their cellular phone and still functional power supply. However, other devices like cordless telephones might have a functional lifetime of 10 years or more before replacement.

While power supplies would not normally be expected to fail after 7 years, they may become obsolete and fall into disuse for other reasons, when consumers upgrade to newer computers and telephones, for example. Therefore, a typical service life might be in the range of 5-9 years. For the life cycle cost analysis, we used a 7-year PV rate for simplicity. Additionally, our modeling estimates that power supplies sold in 2005 continue to be in used through 2011 (contributing to energy consumption), but are removed from service in 2012.

5.3 Lifecycle Cost

Life-cycle-cost-estimates are illustrated below. Note positive savings for all power supply sizes, with the higher efficiency level estimated to be slightly more cost effective.

Table 6: Power Supply Life Cycle Cost Summary Tier 1

Power Supply Output Wattage	7 year PV Rate	Average Annual kWh Saved	Base Cost	% Cost Increase	PV of Energy Savings	Incremental Cost	Net Savings
<2.5	0.699	1.87	$3.00	10%	$1.31	$0.30	$1.01
2.5-<4.5	0.699	2.91	$3.00	10%	$2.03	$0.30	$1.73
4.5-<6	0.699	2.93	$4.00	10%	$2.05	$0.40	$1.65
6-<10	0.699	3.66	$5.00	10%	$2.56	$0.50	$2.06
10-<24	0.699	6.04	$7.00	9%	$4.22	$0.63	$3.59
>24	0.699	8.35	$10.00	8%	$5.84	$0.80	$5.04

Table 7: Power Supply Life Cycle Cost Summary Tier 2

Power Supply Output Wattage	7 year PV Rate	Average Annual kWh Saved	Base Cost	% Cost Increase	PV of Energy Savings	Incremental Cost	Net Savings
<2.5	0.699	2.01	$3.00	15%	$1.40	$0.45	$0.95
2.5-<4.5	0.699	3.32	$3.00	15%	$2.32	$0.45	$1.87
4.5-<6	0.699	3.18	$4.00	15%	$2.22	$0.60	$1.62
6-<10	0.699	4.48	$5.00	15%	$3.13	$0.75	$2.38
10-<24	0.699	7.65	$7.00	14%	$5.35	$0.98	$4.37
>24	0.699	10.43	$10.00	13%	$7.29	$1.30	$5.99

6 Acceptance Issues

Economic implications will be minor overall. Producers of traditional linear transformer technologies, primarily in from Asia, will be most affected. This will be offset, to a degree, by the Chinese industry's efforts to increase the complexity of products produced in the country and the Chinese government's work to establish efficiency standards there in alignment with standards in California and nationally through ENERGY STAR®. Consumers will pay slightly more for products already yielding low profit margins for the manufactures. It also seems clear that more efficient designs, generally being physically smaller and lighter in weight than their inefficient counterparts, are generally favored by consumers seeking portability, retailers attempting to minimize inventory costs, and manufacturers wanting to minimize shipping costs (see Figure 9).

6.1 Infrastructure Issues

Virtually the entire semiconductor industry faces a surplus capacity condition as of this writing, high efficiency power supplies are constructed using semiconductors (manufactured by companies like Bias, OnSemi, Power Integrations, etc). Virtually the entire semiconductor industry, including these manufactures, faces a surplus capacity condition and could easily accommodate more throughput. We are not aware of any constraints on those products' availability in the global marketplace large enough to affect a California standard (or be affected by it).

6.2 **Existing Standards**

Figure 6: Efficient Units (Left) Appeal to Consumers

Currently there are no restrictions on the active mode of external power supplies. However, there is momentum internationally to pursue this great energy savings opportunity through mandatory standards and voluntary specifications. For example, the European Union has modified its present "Code of Conduct" to include consideration of active mode efficiency. The U.S. EPA ENERGY STAR® program announced its active and no load draft specification at APEC in February 2004. China and Australia are currently developing active and no load standards. In addition, internal computer power supply efficiency is restricted by Intel's PC Design Guide Specification, setting precedence.[17]

Australia's Greenhouse Office is also planning to pursue mandatory efficiency standards and voluntary efficiency labeling. China is planning to pursue both types of efficiency measures as well. The U.S. EPA has also announced a proposed ENERGY STAR labeling program for external power supplies that achieve efficiencies at roughly the top 25% of the market, which would correspond to the “Tier 2” level proposed here.

7 Recommendations

An efficiency standard for power supplies in California can catalyze action both nationally and internationally, since it could be referenced by other agencies worldwide. California’s standards process is also helping to ensure the development of consensus test procedures for the measurement of power supply efficiency, which could in turn be adopted by other standards proceedings.

Given the timing of the other activities and the scale of the cost effective energy savings opportunity identified, we recommend that the CEC move quickly to conduct workshops regarding power supply efficiency, assess support for the proposed standards levels, and adopt a standard with any needed modifications. This will ensure the maximum likelihood of influencing other energy savings both in the U.S. and abroad. California should also consider harmonizing its timetables and levels with parallel standards efforts underway in Australia and China.

We propose the following standards language in Section 1605.3 in section (v):

(v) Power Supplies. The efficiency in active mode of single-voltage external AC to DC power supplies manufactured on or after the dates indicated in Table V shall not be less than the applicable values shown in Table V; and the energy consumption in the no-load mode of single-voltage external AC to DC power supplies manufactured on or after the dates indicated in Table V shall not be more than the applicable values shown in Table V.

Table V

Standards for Single-Voltage External AC to DC Power Supplies

<table>
<tr><th>Proposed Standards</th><th colspan="3">Nameplate Power Supply Output</th></tr>
<tr><td rowspan="2">Tier 1 (top 40% of market) Effective 01/01/06</td><td><=1 Watt</td><td>>1 to 60 Watts</td><td>>60 Watts</td></tr>
<tr><td>Efficiency > 0.48*(Watts)</td><td>Efficiency > 0.89Ln(Watts) + 0.48</td><td>Efficiency > 84%</td></tr>
<tr><td colspan="4">No load requirements: power consumption shall be no more than 0.5 watts in units with a nameplate output power of 0 to 10 watts and no more than 0.75 watts in units with a nameplate output power of more than 10 watts.</td></tr>
<tr><td rowspan="2">Tier 2 (top 25% of market) Effective 01/01/08</td><td><=1 Watt</td><td>>1 to 51 Watts</td><td>>51 Watts</td></tr>
<tr><td>Efficiency > 0.50*(Watts)</td><td>Efficiency > 0.09Ln(Watts) + 0.50</td><td>Efficiency > 85%</td></tr>
<tr><td colspan="4">No load requirements: power consumption shall be no more than 0.5 watts for all covered units.</td></tr>
</table>

We propose that the first tier of the standards become effective in 2006 with the second tier taking effect in 2008. While greater lead times are often required with many electrical products, these external power supplies are normally provided by third party manufacturers to the assemblers of finished electrical components. As a result, these assemblers can simply rewrite the purchase specifications they provide to power supply manufacturers, without needing to redesign the product to which the power supply is connected.

Though outside the scope of the CEC proceeding, one logical extension of this standards proposal would be the inclusion of electronic products with internal power supplies on the list of devices eligible for state-funded incentives. If, for example, computers and televisions with highly efficient internal power supplies were eligible for an energy efficiency procurement, promotion, and incentive programs, it would help build a parallel market for energy efficient internal power supplies.

8 References

[1] Personal Communication, Balu Balakrishnan, VP of Engineering and Strategic Marketing, Power Integrations, May 2001. See also Alan Meier, Standby Energy Use and Energy Savings Opportunities, presented at EPA/PG&E/NRDC/LBNL-sponsored power supplies workshop, San Francisco, January 14, 2002.

[2] Andrew Fanara, US EPA, Transforming the Market for Power Supplies through ENERGY STAR, presentation at EEDAL 2003, October 1, 2003. Note that the LBNL census includes one product type that does not utilize an AC-DC power supply – compact fluorescent desk lamps.

[3] Market estimates made by Travis Reeder and Chris Calwell, Ecos Consulting and Carrie Webber, LBNL. August 2003. See also Ecos Consulting, Power Supply Efficiency: What Have We Learned?, prepared for the California Energy Commission's Public Interest Energy Research program, February 2002.

[4] The split on a dollars basis is far more pronounced, with more than 82% of the dollars estimated to be spent on switching designs. See Darnell Group, External AC/DC Power Supplies: Global Market Forecasts and Competitive Environment, July 2000, p. 67.

[5] The "other" category includes a variety of miscellaneous products such as gaming equipment, industrial controls, external data storage, test equipment, multiplexers, etc.

[6] Segments and Units are from Darnell Group, External AC/DC Power Supplies: Global Market Forecasts and Competitive Environment, July 2000. All values are scaled to 2003 California estimates from year 2000 national estimates assuming a 23% increase in unit sales over that period and California accounting for 11% of

national sales. The percentage distribution across power ranges was estimated by Travis Reeder and Chris Calwell using less precise data from Darnell Group and anecdotal sources.

[7] Sources include: Kaoru Kawamoto, Jonathan G. Koomey, Bruce Nordman, Richard E. Brown, Mary Ann Piette, and Alan K. Meier, Electricity Used by Office Equipment and Network Equipment in the U.S., LBNL-45917, August 2000; Karen Rosen and Alan Meier, "Energy Use of U.S. Consumer Electronics at the End of the 20th Century" in Proceedings of The Second International Conference on Energy Efficiency in Household Appliances, Naples, Italy, September 2000.

[8] Kurt Roth, Fred Goldstein, and Jonathan Kleinman, Energy Consumption by Office and Telecommunications Equipment in Commercial Buildings Volume 1: Energy Consumption Baseline, Arthur D. Little, Inc., 2002.

[9]Energy Information Administration, A Look at Residential Energy Consumption in 1997, 2000, p. 80.

[10] Darnell Group Inc., External AC/DC Power Supplies: Global Market Forecasts and Competitive Environment, July 2000; Appliance, "Statistical Review: 47th Annual Report – A Ten Year Review 1990-1999 of the U.S. Appliance Industry," May 2000; eBrain Market Research, "U.S. Factory Sales of Consumer Electronics," Consumer Electronics Data Book, Consumer Electronics Association, 2000.

[11] Chris Calwell and Travis Reeder, Power Supplies: A Hidden Opportunity for Energy Savings, Natural Resources Defense Council, 2002.
[12] www.eren.doe.gov/femp/resources/standby_power_approach.html and IEC 62301: Household Electrical Appliances – Measurement of Standby Power, Draft Version 2c, 2002.

[13] Travis Reeder and Chris Calwell, Ecos Consulting, and Arshad Mansoor, EPRI/PIAC; Proposed Test Method for Calculating the Energy Efficiency of Single-Voltage External AC/DC Power Supplies, Review Draft. July 30, 2003.

[14] Brown, Marty. Power Supply Cookbook. 2nd Ed. Butterworth-Heinemann, 2001, pp. 1-10.

[15] Personal communication, Steve Nolan and Michael Archer, Celetron, March 2002.

[16] Hosfelt Electronics, Inc (Compare #56-845 and #56-615 with the same outputs and price but one switching and one a transformer), 2001-A.

[17] http://energyefficiency.jrc.cec.eu.int/html/s_b-ParticipantsCoC.html