UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

OFFICE OF
AIR AND RADIATION

Summary of Rationale for Version 1.0 ENERGY STAR® External Power Supply (EPS) Specification
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I. Introduction and Background

This memorandum provides a summary of the rationale and key inputs that culminate in Version 1.0 of the EPS specification. It contains the following information:

- Summary of the Version 1.0 specification
- Summary of key milestones in the development of the Version 1.0 specification
- Summary of comments provided by stakeholders
- EPA's rationale for deciding on key elements of the final Version 1.0 specification

II. Summary of Version 1.0 Specification

Key elements of the Version 1.0 ENERGY STAR specification for EPSs are described below.

- The goal of the ENERGY STAR EPS specification is to recognize those models with an efficient ac-dc or ac-ac conversion process. A broad array of single voltage external ac-dc and ac-ac power supplies, including those used to power computer and consumer electronics such as laptops, digital cameras, monitors, CD players, cell phones and cordless phones, are covered by this energy-efficiency specification.

- The Version 1.0 specification provides a temporary exclusion for power supplies with battery charging functions found in power tools and household appliances that produce heat, light, or motion. The exclusion is in effect from January 1, 2005 through December 31, 2005. During this time, EPA will work with stakeholders to further assess the appropriateness of the EPS test procedure for the products denoted in the exclusion. EPA will develop a second test methodology and specification for the excluded battery charging systems, as necessary. If a battery charging system test procedure and specification are not developed, the exclusion will expire on December 31, 2005 and battery charging systems will be covered by the Version 1.0 ENERGY STAR EPS specification.

- To be eligible for ENERGY STAR qualification, an EPS model must meet or exceed the criteria for both Active and No-Load Modes.

  - Active Mode efficiency is determined by testing at 100%, 75%, 50%, and 25% of rated current output and then computing the simple arithmetic average of these four values. A model's measured average efficiency must be greater than or equal to ENERGY STAR's minimum average efficiency, as provided in the table below.

Table 1: Energy-Efficiency Criteria for Active Mode

Nameplate Output Power (P_{no})	**Minimum Average Efficiency in Active Mode (expressed as a decimal)** [1]
0 to ≤ 1 watt	≥ 0.49 * P_{no}
> 1 to ≤ 49 watts	≥ [0.09 * Ln (P_{no})] + 0.49
> 49 watts	≥ 0.84

  - The second half of the ENERGY STAR specification specifies the maximum ac power that may be used by a qualifying EPS in the No-Load condition: 0.5 watts where nameplate output power is less than 10 watts and 0.75 watts where nameplate output power is 10 watts or greater.

- While specific levels were not provided when the Version 1.0 specification was published/released, EPA plans to implement a Tier 2 specification on July 1, 2006. (No-Load levels of 0.3 watts (nameplate output power less than 10 watts) and 0.5 watts (nameplate output power from 10 to 250 watts) were proposed as reasonable Tier 2 targets, but are subject to changed based on analysis of new data.) The Tier 2 requirements will be finalized by late 2005 so partners have adequate time to transition to the new levels.

- The EPS specification references a detailed test methodology titled "Test Method for Calculating the Energy Efficiency of Single-Voltage External Ac-Dc and Ac-Ac Power Supplies (August 11, 2004)." Several governmental organizations, including the China Certification Center for Energy Conservation Products (CECP), Australian Greenhouse Office (AGO), and California Energy Commission, collaborated with EPA to support the development of one internationally recognized test procedure for determining the energy efficiency of external power supplies.

- The specification requires switch mode power supplies capable of operating at multiple voltages and frequencies to be tested at both 115 volts and 230 volts. Qualification for ENERGY STAR is based on the least efficient set of test values.

- ENERGY STAR partners are required to follow the international efficiency marking protocol to indicate the energy performance of their ENERGY STAR qualified power supplies. Beginning no later than January 1, 2006, the nameplate of qualifying EPSs must be clearly and permanently marked with the appropriate Roman numeral (I – VI) that corresponds to specific minimum Active and No-Load efficiency levels.

[1] (a) "Ln" refers to the natural logarithm. The algebraic order of operations requires that the natural logarithm calculation be performed first and then multiplied by 0.09, with the resulting output added to 0.49. (b) An efficiency of 0.84 in decimal form corresponds to the more familiar value of 84% when expressed as a percentage.

- The international efficiency marking protocol is a system to determine the minimum efficiency performance of an EPS, regardless of where it is manufactured and sold. The implementing agencies as of March 2005 are the AGO, California Energy Commission, CECP, and ENERGY STAR.

Figure 1: Illustration of International Efficiency Mark

— The Version 1.0 EPS specification is the first ENERGY STAR specification to be developed in collaboration with CECP.

III. Key Milestones of Specification Development

— The following factors influenced EPA's decision to develop a specification for EPSs:

- More than a billion EPSs are shipped worldwide each year for use in a broad array of products, including MP3 players, Personal Digital Assistants (PDAs), camcorders, digital cameras, laptops, and cordless and mobile phones.
- More than 3.1 billion power supplies are currently in use in the United States, consuming about 3 percent to 4 percent of the nation's electricity bill. On average, there are 5 to 10 EPSs in use in each U.S. home.
- Conventional EPS designs are 30 percent to 60 percent efficient while 90 percent efficiency or higher is feasible.
- Focusing on the EPS allows EPA to address Active Mode efficiency in a wide variety of electronic products. EPA's initial ENERGY STAR specifications for consumer and office electronics required efficiency improvements in Standby/Off and/or Low-Power Modes.

— The Version 1.0 specification was developed over the course of several years, which included the following key milestones:

- Approximately two years of development time dedicated to the preparation of an internationally recognized test method to measure the energy efficiency of single voltage external ac-dc and ac-ac power supplies. During this time, interested stakeholders had several opportunities to comment on draft versions of the test methodology both in writing and during meetings. EPA cosponsored two power supply workshops on January 14, 2002 and November 7, 2003 in San Francisco, CA designed to discuss the draft test method and the latest developments in power supply technology.

- Testing and evaluation of more than 600 EPS models from Australia, China, and the United States. Test data was primarily provided by three sources: University of New South Wales, CEPREI, and Ecos Consulting.
- Worldwide Power Supplies Summit hosted by EPA in Anaheim, CA on February 22, 2004. This one-day event brought together policy makers and energy-efficiency advocates who were considering the development of either voluntary specifications or regulatory standards to encourage the use of more energy-efficient power supplies in their respective markets. Representatives from Australia, Canada, China, Europe, and the United States provided input and/or attended.
- Plenary/Keynote presentations at the Applied Power Electronics Conference and Exhibition (APEC) 2004, APEC 2005, and Electronic Original Equipment Market (EOEM) Design Expo 2004.
- Participation in U.S. and Chinese stakeholder meetings to discuss the draft specifications (Dongguan, Guangdong, China – April 6, 2004; San Francisco, CA – May 24, 2004; Beijing, China – June 21, 2004).
- Several presentations and discussions with industry during international travel to Ispra, Italy in November 2004 and China in 2003-2004. EPA attended and presented at CECP's Chinese Power Supply Stakeholder Meeting in Beijing, China on June 21, 2004. In September, an ENERGY STAR representative presented at PowerChina 2004, the 10th China International Power Supply Exhibition.
- Scores of meetings and conference calls with representatives from individual manufacturers, the Power Sources Manufacturers Association (PSMA), CECP, and other stakeholders.
- Four draft specifications and one final specification released on December 29, 2004.

IV. Summary of Stakeholder Input

EPA received substantial stakeholder input in the development of the new specification. Below are three key areas of agreement between EPA, industry, and other interested parties.

- Development of a New Test Method to Determine the Energy Efficiency of EPSs. All stakeholders agreed that an existing industry-accepted test method addressing Active and No-Load Modes did not exist. As such, several organizations, including EPA, invested their resources in preparing a new test methodology with significant input from the EPS industry and international stakeholders. Where appropriate, the final test method references published specifications from the Institute of Electrical and Electronic Engineers (IEEE), the International Electrotechnical Committee (IEC), and other organizations.

- Interest in Coordinating with Other Domestic and International Standards and Voluntary Initiatives. All parties recognized the benefits of coordinating their efforts and implementing one cohesive set of *voluntary* energy-efficiency specifications for EPSs. In a letter to EPA, the PSMA Energy Committee stated, "We are pleased to see that the EPA Energy Star program effort is working in concert with other organizations world wide…We encourage you to continue working with other agencies toward a world wide single efficiency standard."

- Inclusion of Ac-Ac EPSs in the ENERGY STAR Test Method and Specification. A few stakeholders suggested that EPA expand its EPS specification to cover ac-ac models in addition to ac-dc models. EPA agreed to the change for the following reasons: 1) As external power supplies, ac-ac units have some functional similarities to ac-dc units and are found in

some of the same high-volume products, such as cordless phones; 2) Test data indicates that a range of efficiencies currently exist in the market, allowing EPA to differentiate the better performers through ENERGY STAR; 3) Including ac-ac power supplies provides designers with flexibility and doesn't inadvertently favor one type of power supply over the other; 4) Other regions of the world, such as the European Union, are including ac-ac power supplies in their EPS specifications; and 5) Only minor changes to the Test Method were needed to incorporate ac-ac models.

There were also a number of concerns raised by stakeholders that EPA has sought to address. The following is a summary of nine key concerns and their resolutions:

- Battery Charging Systems. Some stakeholders argued that battery charging systems found in small household appliances and power tools should not be covered by the EPS specification because the test method did not appropriately measure the energy consumed by these products. After thoroughly vetting the issue with industry and interested parties, EPA decided to temporarily exclude these products in order to investigate them further and, as necessary, develop a test method and specification that will best capture their energy savings opportunities. This exclusion was implemented to allow for additional research and test procedure development while not delaying the introduction of the overall EPS specification.

- EPS Definition. EPA's preliminary draft definition covered models with wattage ratings less than or equal to 180 watts. In response to stakeholder feedback, EPA expanded the scope to 250 watts to keep pace with market trends. In addition, the requirement for "only two output wires" was removed from the definition based on stakeholder input and the test method was revised to require manufacturers to measure the positive and negative wires and to put the others aside for testing purposes. Finally, given the complexity of the EPS definition, EPA developed a complementary flowchart to graphically depict the scope of the specification and test procedure.

- Specification Levels and Effective Dates. EPA received various, and sometimes contradictory, suggestions from stakeholders for changing the proposed specification levels and effective dates. Based on careful analysis, EPA decided to modify the Tier 1 Active Mode specification to require slightly less stringent minimum average efficiencies. For No-Load Mode, EPA chose a less aggressive 0.5-watt specification (nameplate output power less than 10 watts) for Tier 1, but proposed a 0.3-watt specification for Tier 2 and moved up the effective date by six months. For models with nameplate output power at 10 watts or higher, EPA proposed a maximum Tier 2 level of 0.5 watts.

- Testing at 115 Volts and 230 Volts. Not all stakeholders agreed that it was necessary to test switch mode power supplies capable of operating at multiple voltages and frequencies at both 115 volts and 230 volts. For example, one organization commented: "It is excessive to require switch mode power supplies to be tested at both 115 V and 230 V. Linear transformer based power supplies for the U.S. market will only be able to operate at 115 Vac input voltage so it would be more appropriate to make this the test condition for switch mode supplies also." EPA, however, disagreed and did not change this requirement. ENERGY STAR qualifying external power supplies will be sold into a global marketplace and will be used in numerous countries by international travelers. By qualifying models under the least efficient set of test values, EPA ensures that models meet the ENERGY STAR performance

levels in multiple markets and mitigates any potential variations in tested values across markets.

- Measuring Efficiency at Multiple Loading Rates. While some stakeholders preferred to measure efficiency only at 100% of rated load or alternatively only at 50%, 75% and 100% of rated load (i.e., not including 25%), EPA maintained the average of four loading rates approach. The benefits of this approach are twofold: 1) it better reflects usage patterns as many electronic products with external power supplies are rarely operating at 100% of rated load, and 2) it recognizes that efficiency often varies across load conditions and rather than favor one load condition (or a few load conditions), it provides an average value for determining ENERGY STAR qualification.

- Output Voltage. Some stakeholders suggested that the specification be revised to account for output voltage. However, research conducted on EPA's behalf indicated that output voltage has a limited effect on the efficiency of better performing power supplies (and is a less significant factor than wattage). The analysis indicated that high current, low voltage power supplies are relatively less efficient designs and represent a small subset of the market, and as such, did not warrant a special allowance in the ENERGY STAR specification.

- Power Factor Correction. Regarding power factor correction (PFC), a few stakeholders recommended that EPA adopt the same approach and goals as the European Code of Conduct, which provides two power allowances for PFC capability. Through research on this issue, EPA learned: 1) there are no automatic or inherent efficiency penalties associated with power factor correction if it is taken into account in the initial design stages of a power supply; and 2) there are designs available that meet PFC requirements and the ENERGY STAR performance thresholds. EPA decided not to include any power allowances under Tier 1, but agreed to collect power factor correction (PFC) data during the ENERGY STAR product qualification process and then analyze it when determining Tier 2 performance levels (for both Active and No-Load).

- Multiple Tap or Switch Selectable Models. Draft 1 of the ENERGY STAR EPS specification did not specifically address multiple tap or switch selectable models. After reviewing stakeholder feedback, EPA added Section 4.C to Draft 2, which allows for testing at the highest and lowest voltage outputs of the switch selector power supply. This approach ensured that the power supply is energy efficient while minimizing the manufacturers' testing requirements (i.e., manufacturers are not asked to test at every switch-selectable voltage).

- Safety Standards. Linear power supply transformers have built-in impedance to regulate current in the case of a battery fault; this is a safety consideration that limits active power efficiency in linear power supplies. One commenter expressed concern that for some products included under this definition, the ENERGY STAR specification for power supplies would encourage manufacturers to abandon this safety precaution. To prevent this, EPA added Section 4.A, Safety Standards, to ensure that product quality and safety are never compromised for energy efficiency. Given the volume of standards in the United States and worldwide (for both external power supplies and the end-use products they power) and the likelihood that they will be revised over time, EPA decided to incorporate all appropriate standards by general reference rather than by enumerating all of them.

V. EPA Rationale for Specification

EPA uses a consistent set of criteria in the development and revision of specifications for ENERGY STAR qualified products. These criteria guide EPA in its decision making and help EPA ensure that the ENERGY STAR mark will continue to be a trustworthy symbol for consumers to rely upon as they purchase products for the home or business and so that their purchases will deliver substantial environmental protection. These criteria include:

- Significant energy savings and environmental protection potential on a national basis;
- Efficiency level is technically feasible while product performance is maintained or enhanced;
- Labeled products will be cost-effective to the buyer;
- Efficiency can be achieved with several technology options, at least one of which is non-proprietary (i.e., not exclusive to proprietary technology);
- Product differentiation and testing are feasible; and
- Labeling would be effective and recognizable in the market.

Below EPA addresses the Version 1.0 EPS specification relative to each of these criteria.

- Expected Energy Savings and Environmental Benefits. EPSs that earn the ENERGY STAR mark will on average be 35 percent more efficient than conventional models. EPA projects a potential U.S. energy bill savings of $636 million, electricity savings of over 9 billion kWh, and prevention of 5.13 million metric tons (MtC) of carbon dioxide pollution over the time period of 2005 to 2015 due to the new specification. A table outlining these results and the key assumptions is provided below.

Table 2: Cumulative Savings from ENERGY STAR Qualified EPSs

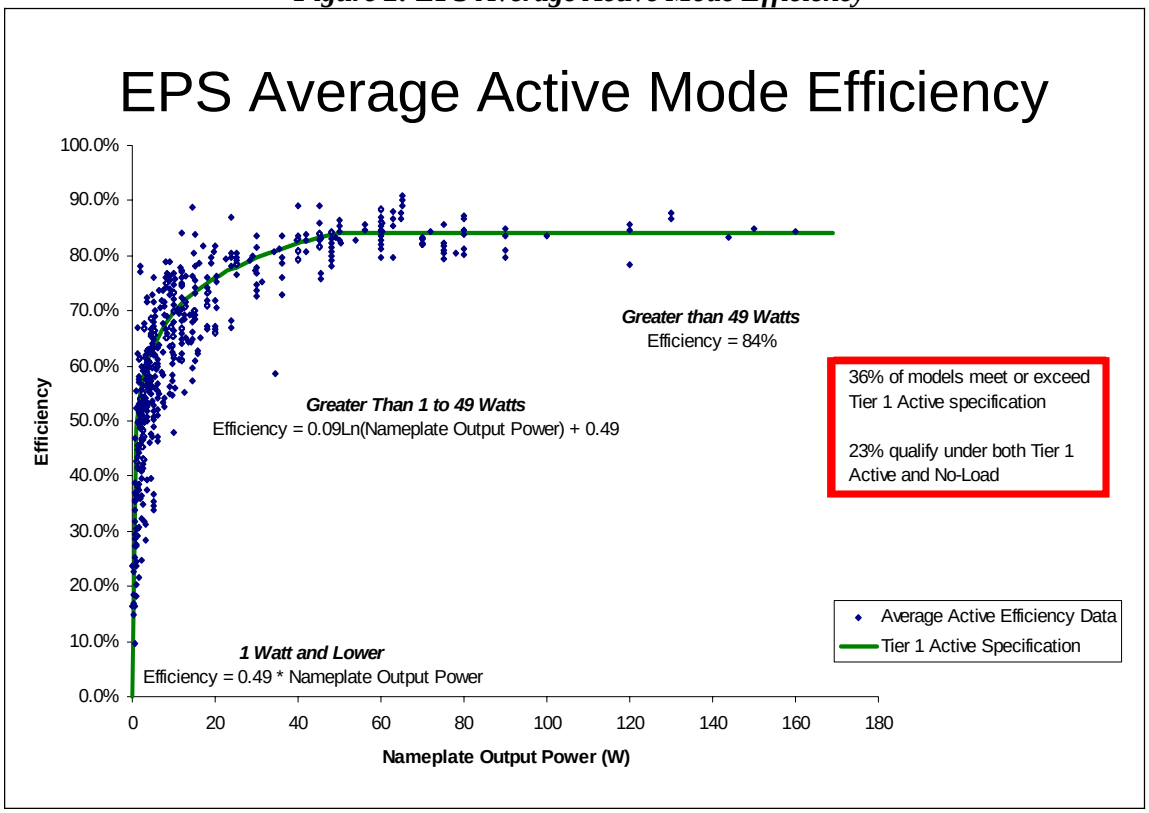
EPS Cumulative Savings from the Version 1.0 Specification	
U.S. energy bill savings	$636 million
U.S. energy savings	9.025 billion kWh
U.S. carbon savings	1.4 million MtC
U.S. carbon dioxide savings	5.13 million metric tons
Key Assumptions	• The price of electricity varies by year and by sector (residential or commercial), ranging between 6.8 and 8.6 cents/kWh during 2005 to 2015. • The percentage of stock and new shipments that are ENERGY STAR is assumed to steadily rise from 2005 to 2015. By 2015, 50% of stock is ENERGY STAR and 51% of shipments are ENERGY STAR.

- Technical Feasibility/Impact on Product Performance/Functionality. EPA believes the energy use requirements of this specification to be technically feasible and to not adversely impact product performance for the following reasons:

  - The Tier 1 levels for both Active and No-Load represent the top 23% of models from EPA's data set, which includes over 600 models tested in Australia, China, and the

United States. Thirty-six percent of the tested models meet or exceed the Active thresholds; 39% of the tested models meet or exceed the No-Load thresholds.

Figure 2: EPS Average Active Mode Efficiency



- Energy-efficient EPSs offer additional benefits beyond energy savings. They are often smaller in size (footprint) and lighter in weight than conventional models, making them easier to store and transport.

- Several industry stakeholders provided support for the Tier 1 specifications. For example:

  - In its written comments on Draft 4 of the specification, Phihong USA stated, "Fundamentally accept all Tier 1 requirements."
  - Similarly, BIAS Power Technology, Inc. provided the following viewpoint: "The efficiency standards for power supplies under 5 watts is easily achieved..."

- For Tier 2, EPA did not establish efficiency levels prior to publishing the final specification. Rather, a Tier 2 effective date of July 1, 2006 was chosen and the following process was put in place: 1) collect efficiency data (based on the ENERGY STAR Test Methodology) on a wide range of external power supplies (varying in terms of size, efficiency, manufacturer, cost, and other parameters) sold in markets throughout the world; 2) analyze the data to identify the top 25 percent in terms of energy efficiency; 3) release the proposed Tier 2 specification for stakeholder review and comment (focusing on the technical elements of Tier 2 and not on all programmatic details); and 4) finalize the specification by late 2005 so partners have adequate time to transition to the new levels.

— Cost-effectiveness. EPA believes that the Version 1.0 specification can be achieved cost-effectively for the following reasons:

- Some manufacturers are already meeting the new energy-efficiency targets and providing these models to purchasers at competitive prices. It is precisely these products that should be highlighted to purchasers when they are in the market for EPSs.
- There are many criteria that an engineer must consider when designing a new product. While efficient designs may have incremental costs of $0.30 to $1 or higher based on power supply size and type, their smaller size and weight can reduce shipping, packaging, inventory, and other costs. In the article "Select the right power adapter," which appeared in *Portable Design*, Keith Hopwood, Phihong USA Inc., explained:

  > "Specifying a linear wall adapter may appear to be economically advantageous when compared to selecting a more expensive switching power adapter. However, a compact switching power adapter can save space and increase portability, providing other cost advantages…With appropriate design, meeting the new standards [EU's Code of Conduct, ENERGY STAR, etc.] shouldn't increase the system cost."

- EPA provides lead time with the phase-in of any new specifications so that manufacturers can incorporate energy efficiency into their products during the regular design and manufacturing cycle. EPA understands that attempting to retrofit existing products can be expensive, but such retrofitting should not be necessary.

— Several Technology Options, including some with Non-proprietary Technology. EPA designs its ENERGY STAR specifications to be performance-based. This means that it strives to recognize the better performing external power supplies in terms of energy efficiency without differentiating based on technology. Of note, there are both linear and switch mode models in EPA's data set that would currently qualify as ENERGY STAR under the Tier 1 specification. While a greater percentage of the qualifying models are switch mode, linear models are represented, indicating that energy-efficient designs are not only achievable, but also available in today's marketplace.

— Testing Procedure. It was clear early in specification development that a new test procedure for determining the energy efficiency of EPSs was needed. The new procedure referenced in the Version 1.0 specification went through multiple rounds of stakeholder review and comment, beginning in the summer of 2003, and was built upon IEC 62301 and IEEE 1515-2000. It was successfully used to generate hundreds of test data points by labs in several countries. Representatives from the following countries reviewed the draft procedure and provided their support in a letter dated December 18, 2003 for one internationally recognized test method: Australia, Brazil, Canada, China, and the United States. Additional information on the EPS Test Method is available at www.efficientpowersupplies.org.

- A well-defined test procedure ensures that repeatable results can be generated, objective comparisons can be made between products, and loopholes can be avoided. The ENERGY STAR test method for EPSs can be found at http://www.energystar.gov/powersupplies.

— Product Differentiation and Labeling. Market research and test data analysis showed that product performance varies within a sufficient range to allow for meaningful differentiation to the purchaser.

- **EXAMPLE**: Within EPA's data set, EPSs with a nameplate output power of 3 watts had average Active efficiencies of 31.9% to 67.8% and No-Load consumption of 1.9 to 0.2 watts. Similarly, EPSs with a nameplate output power of 60 watts had average Active efficiencies between 88.5% and 79.8% and No-Load consumption of 2.7 to 0.2 watts.

EPA believes an ENERGY STAR mark for EPSs serves an important role in the U.S. marketplace due to the absence of any other objective basis for buyers to identify and manufacturers to promote highly efficient power supplies. In addition, EPA is helping to stimulate demand for efficient power supplies by: 1) launching a complementary initiative to promote end-use products with ENERGY STAR qualified EPSs. Participating manufacturers may display the ENERGY STAR EPS graphic (below) on their external product packaging, Internet site, and similar materials (see ENERGY STAR Program Requirements for End-Use Products with External Power Supplies for details); and 2) phasing the EPS specification into existing ENERGY STAR product specifications (e.g., telephony, imaging, computers/laptops, etc.), where appropriate, and when those specifications are revised. The first product category to incorporate the EPS specification (i.e., end-use products must incorporate an ENERGY STAR qualified EPS) is Telephony.