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Manufacturer Incentives for Energy Efficient External Power Supplies: A Feasibility Study

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I. Introduction

Power supplies convert 120 volt alternating current (AC) to low voltage direct current (DC) for use by consumer electronics, office equipment, and telecommunications devices. Power supplies are relatively inefficient and unfortunately much of the incoming electricity is converted to non-useful heat rather than to power the device.

There are two main power supply technologies: linear and switching. Linear designs tend to be bulky and inefficient, often wasting 30 to 80% of the power that passes through them. Switching designs are more compact and energy efficient, switching on and off rapidly (like an electronic ballast) to deliver the amount of DC power needed. They typically waste 10 to 40% of the power passing through them.

Power supplies can either be found inside of electronic products (internal) or in separate enclosures (external) that plug into an electric outlet and then transfer the low voltage DC over thin wires to the product they are powering. External power supplies typically drive lower wattage products than internal power supplies, and are also more likely to be linear designs. By confining high voltage to an exterior circuit, they greatly simplify the UL approval process for electronics manufacturers. In addition, the heat from external power supplies can normally dissipate passively, eliminating the need for fans inside the product.

Internal power supplies, unless they are highly energy efficient, often dissipate enough heat to require some type of active ventilation. The most efficient (90+%) internal power supplies are presently designed for the internet infrastructure (servers, routers, etc.) market, where space and cooling constraints require very high efficiency. Some highly efficient external power supplies are available as well, especially in markets where buyers will pay a premium for portability (cellular phones, laptop computers, etc.). The challenge, then, is not to encourage the technological development of better power supplies, but to engage the broader use of existing, efficient technology.

The incremental cost of more efficient designs varies widely by power supply size and type. With external power supplies that provide a power output of less than 10 watts, incremental costs may only be $0.30 to $1.00 – a small amount in an absolute sense, but a fairly high percentage premium on basic products with prices of $1 to $3.[1] In the wattage range of 15 to 60 watts, typical power supply prices can be $6 to $12, but incremental costs are also higher.[2]

In total, there are about 2.5 billion power supplies in use in the United States. About 6% of the nation's electricity demand flows through them, or more than 200 billion kwh/year. As a result, there are cost effective opportunities to save about 1 to 2% of U.S. electricity use through more efficient power supplies. In order for that to happen, the market transformation community will need to build a message of value for energy efficient alternatives to products that are almost exclusively marketed on low price today.

A number of interested stakeholders from industry and government gathered at a power supplies workshop in San Francisco in January 2002 to discuss this problem and opportunities for solutions. At the workshop, Commissioner Arthur Rosenfeld of the California Energy Commission proposed that energy efficiency incentives be paid to the manufacturers/assemblers that make the actual power supply purchase decision, reintroducing an idea he first circulated in 1999.[3] This would be intended to buy down the incremental manufacturing cost of more efficient power supplies before the subsequent markup that occurs in the sales chain, yielding substantial price reductions at relatively modest cost. This paper was written to analyze that proposal and explore opportunities for pursuing it.

II. Understanding the Problem

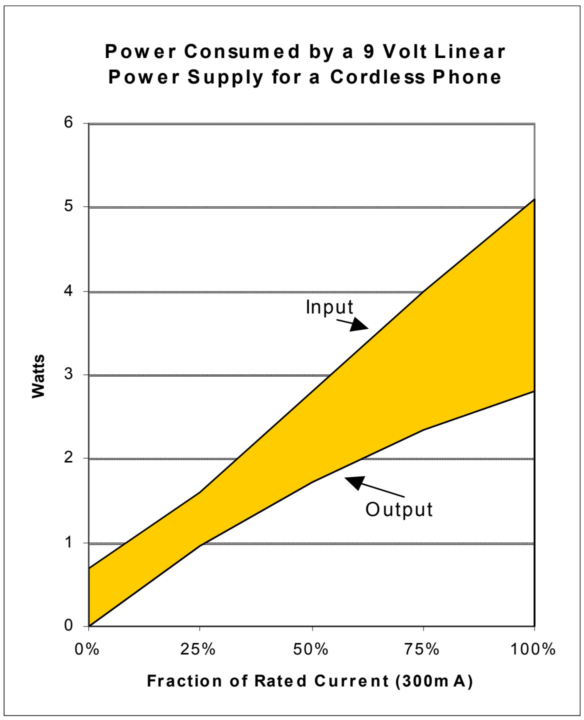
Electronic products that utilize power supplies can often operate in a variety of modes, each of which has a distinct level of power consumption. Generically speaking, there are three distinct operating modes: active, sleep/idle, and standby/off.[4] So, for example, a cordless power tool battery charger might be in active mode when the battery is connected and charging, idle mode when the battery is connected but already fully charged, and standby mode when no battery is present in its cradle. Likewise, a computer monitor might be in active mode when displaying information, sleep mode when the screen is automatically blanked after a period of inactivity, and standby mode when the user has switched it off.

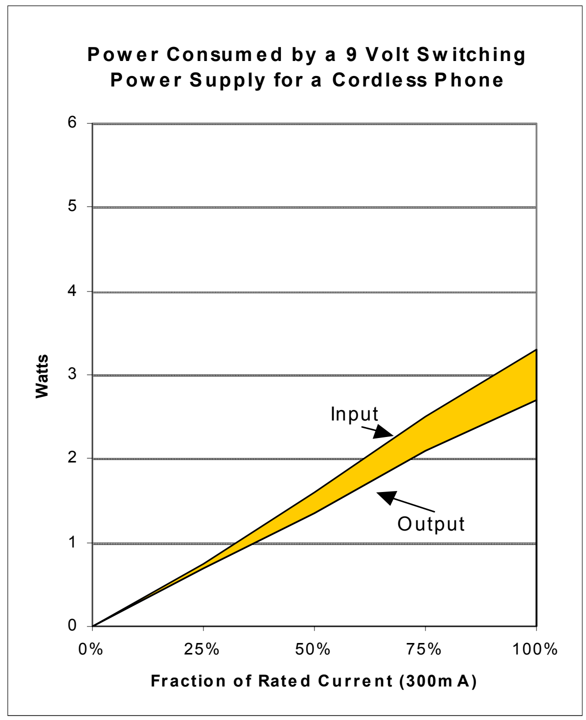
Very few products have a standby consumption of zero watts (a true or "hard" off), because power switches are normally placed in the circuit after the power supply, meaning that it remains running at all times and consuming some power. Likewise, very few products ever draw the maximum rated output from their power supplies, which tend to be oversized by 20% or more for safety purposes.

[1] See, for example, Hosfelt Electronics Catalog 2002-A, pp. 36-39, indicating prices of $0.85 to $7.95 for external power supplies between 0.3 and 16 watts.
[2] Darnell Group, *External AC/DC Power Supplies: Global Market Forecasts and Competitive Environment*, July 2000, p. 62; and Allied Electronics 2001 Product Catalog, pp. 717-723.
[3] Arthur Rosenfeld, *A Market Transformation Proposal to Promote Low-Standby Wall-Pack Power Supplies with Subsidies Directly to Manufacturers*, March 27, 1999.
[4] Note that some products have fewer than three distinct operating modes and some can have more than three.

Even though relative efficiency levels are often higher at full load than partial load in power supplies, they still tend to waste more power on an absolute basis when in active use. This is evident in Figure 1, below, which compares the efficiency of two external power supplies for a cordless phone: a linear design and a switching design. The shaded area represents the difference between input power and output power – i.e. the amount of power actually wasted in each power supply at each level of operation. Standby is represented by the far left range on each chart, sleep or idle by the area near the middle, and active mode by the area to the right. Note that the inefficient unit consumes more than 5 watts at full load, compared to a little more than 3 watts for the efficient unit.

Figure 1



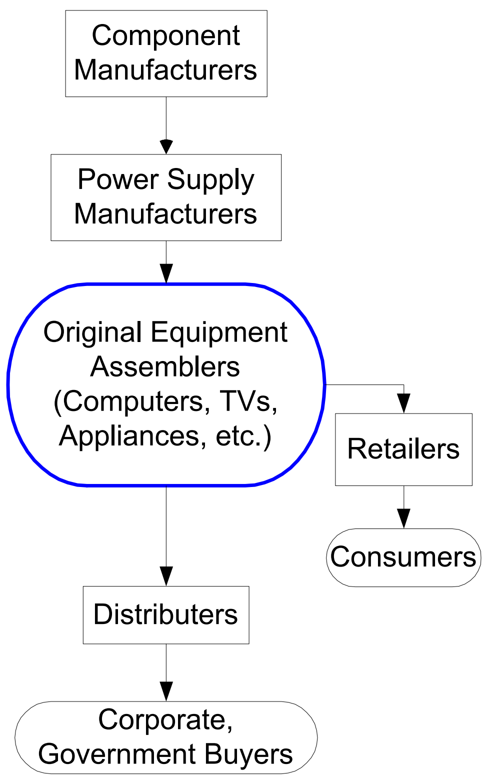


ENERGY STAR® labeling programs for consumer electronics products have relied primarily on sleep mode operation to generate energy savings so far. In most cases, products that can automatically cycle back to a lower power mode after a defined period of inactivity have been eligible to receive the label no matter what their active power consumption is. Likewise, much of the focus of recent federal activity on power supplies (recent ENERGY STAR specification changes and Executive Order 13221) has been on standby consumption. These efforts to reduce "leaking electricity" will help minimize unnecessary waste, but forgo an even greater opportunity to save energy by also addressing active power consumption.

Federal efforts to recognize and preferentially procure those products with the lowest standby power consumption may lead to the inclusion of hard off switches in many consumer electronics products or the use of special power supply designs that minimize standby consumption. However, both of these design steps can be taken without making changes to reduce active power consumption – often the largest opportunity for energy savings. Across the 2.5 billion power supply-containing products in use in the U.S., active power accounts for about 73% of total energy use. Of the more than $17 billion worth of electricity flowing through power supplies each year, about $3 to $5 billion could potentially be saved through the use of better power supplies.

And as is often the case, the companies that make the decisions about which power supply to incorporate into their consumer electronics product are not the same parties that pay the resulting energy bills for the product. As a result, they seek to minimize purchase price, even though a rational, informed consumer would elect to pay somewhat more for an efficient unit if that additional cost could be recovered through energy bill savings over a period of a few years or less. Product assemblers purchase very inexpensive, usually inefficient power supplies, bundle them with electronics products, and sell them to retailers that echo the same "low price" message to consumers. The issues of efficiency and operating costs never get raised, so consumers are unaware that more energy efficient options are available.

Figure 2 – Supply Chain for Power Supplies



After extensive discussions with power supply manufacturers and buyers, we believe that the barriers to more widespread use of efficient designs are largely informational and financial. Power supply efficiency is not widely measured and reported according to a standardized test procedure, so the energy consequences of a particular purchase decision are often not well understood. Likewise, the cost differences between very efficient switching power supplies and standard linear designs often become highly magnified as they move through the supply chain, making it appear at the retail level that the incremental cost difference is much greater than it really is. For example, Best Buy sells efficient switching power supplies made by Sony for a $29.95 retail price. These are products that may cost between $2 and $4 to manufacture, so it would not be cost effective to pay retail rebates on them to encourage their use.[5] But it may make sense to pay an assembler buydown on such products, targeting a small incentive to the place in the distribution chain (see Figure 2) where it can do the most good.

III. The Scope and Impacts of an Efficiency Incentive Program

For the purposes of this analysis, we have decided to limit consideration to six different types of products that utilize external power supplies. Three are telecommunications products (cordless phones, answering machines, and combination units) and three are miscellaneous electronic devices (internet boxes like DSL modems and Ethernet hubs, cordless tool battery chargers, and camcorders. Four of these products involve built-in rechargeable batteries. In total, the group is being considered because efficiencies of the power supplies typically provided with them are low, the products are in widespread use, and fairly good data exist on sales, efficiencies, costs, and other information needed to assess cost effectiveness.

By contrast, products like LCD computer monitors, laptop computers, inkjet printers, and cellular phones were not included, even though they have huge sales volumes and substantial power consumption. For most of these products, power supply efficiency levels are already fairly high, and the incremental cost of squeezing additional savings from them appears less promising. As additional data become available, this may change, however.

Appendix A includes an analysis of the six different product types, with a chart for each showing the relative contributions of each operating mode to total power supply energy consumption, total savings potential, incremental costs, and estimated payback periods. Though we have measured performance data on a wide variety of external power supplies, much of the information in these tables regarding hours of operation in different modes, power use in each mode, and incremental costs involves approximations and assumptions. We believe the incremental costs to the companies that manufacture improved power supplies tend to be about $0.50 to $1.00/unit, but manufacturers have been unable to confirm this precisely. Payback periods range from 4 months to about 2 years, suggesting that all of these products are promising candidates for an assembler incentive in the range of $0.50 to $1.00 per unit. The summary table at the end of Appendix A describes the overall savings opportunity if sufficient funding were available to pay the incremental cost of all 90+ million units sold each year.

Obviously, such a program depends for its success on having a broad base of funding across multiple geographic areas, so may logically need to be coordinated through an organization like CEE. If this program were to be run nationally in 2003, it would need to be included in utilities' and regional organizations' program plans in the fall of 2002, to receive budget approval. An initial goal might be to assemble $10 million of funding from regional organizations and utilities in California, the Northwest, the Midwest, the Northeast, and New York for a pilot test of the concept. This is approximately 0.6% of

[5] In addition, retail rebates for standalone power supplies would be very difficult to prove cost effective, since it is difficult to know for which end use such power supplies are being purchased. When external power supplies are bundled with a particular device by the assembler, that end use's duty cycle and power demands can be verified, laying the groundwork for assessing cost effectiveness.

the annual funding available from systems benefit charges in 22 states, according to ACEEE.[6]

It is too early to say what the program duration should be. However, it seems likely that the program would need to run for at least two years of sequential funding to make use of lessons learned in the first year, better target the appropriate technologies, etc.

Incentive levels could either be varied to match estimated incremental costs, or simply established at $1/unit for simplicity, with the slight "overpayment" helping to offset the cost and effort assemblers would need to expend to track sales and help utilities establish that savings were occurring in the right places and amounts to justify their investment. This is no simple challenge with such a program, since the power supply manufacturing typically occurs in China or Taiwan, while the assembly/incorporation of the power supply into the final product could occur virtually anywhere. Likewise, many electronics products are made to operate on a wide variety of voltages, allowing assemblers to ship identical products virtually anywhere in the world.

Utilities would require some proof that incentivized products are being shipped to the U.S. market, and perhaps some type of tracking card or specialized bar coding that would allow sampling and monitoring of sell-through in particular retail channels. For these product categories, a substantial volume of sales occurs via mail order catalogs and internet transactions as well, so those channels would need to be tracked along with traditional retail stores.

Given these tracking challenges, it is obviously desirable to select a small number of eligible product categories and operate the incentives over as wide a geographic area as possible. If, instead, each regional organization or utility chose to incentivize a particular product type, the vast majority of sales of that product would be outside of that funder's territory, making each individual program non-cost effective. Ideally, such a national program would be tightly synchronized, with individual participants' funding allocated on a number of customers basis. The tracking would ideally allocate sales inside and outside of funders' *collective* service territory first to determine cost effectiveness, and be relatively less concerned about variations *within* the area they collectively serve.

Analyzing a hypothetical program in which $10 million of incentives were paid out at $1 per power supply, we allocated most of the money to the biggest, most cost effective savings opportunities, with smaller amounts to the other technologies. In total, as shown in Table 1, the resulting energy savings would be more than 600 million kwh, yielding an overall cost of saved energy of about 1.6 cents/kwh. Incentives would reach approximately 10 to 15% of the targeted power supplies sold nationally – a large enough impact to assess the ability of future such efforts to shift manufacturer behavior.

[6] U.S. DOE, *FEMP Focus*, January/February 2002, p. 20.

Table 1

	Internet Boxes	Answering Devices	Cordless Phone	Combo Cordless / Answering	Cordless Tools	Video Camera	Total or Average
Allocated Incentive (millions $)	$2.5	$2.5	$2.0	$1.0	$1.0	$1.0	$10.0
Energy Saved (million kWh / year)	93.5	32.9	18.1	7.0	7.2	10.6	169.3
Energy Cost Saved (million $ / year)	$7.5	$2.6	$1.4	$0.6	$0.6	$0.8	$13.5
Simple Payback (years)	0.33	0.95	1.38	1.78	1.73	1.18	0.74
Lifetime Energy Saved (million kWh)	**280.5**	**131.8**	**72.2**	**28.1**	**36.2**	**63.4**	**612.3**
Lifetime Cost Saved (million $)	**$22**	**$11**	**$6**	**$2**	**$3**	**$5**	**49.0**
Cost of Saved Energy	**$0.009**	**$0.019**	**$0.028**	**$0.036**	**$0.028**	**$0.016**	**$0.016**

IV. Next Steps

This concept will be presented at ACEEE's Market Transformation Symposium in Washington DC on March 25, 2002. If sufficient interest develops, NRDC will likely work with other organizations to assemble interested funders later in the year.

A likely outcome in the near- to mid-term of such an initiative would be state and/or federal efficiency standards. Members of the power supply industry itself have commented that the products are ripe for such standards, because they are largely invisible commodities driven to price-focused competition over pennies of cost. Efficiency standards would level the playing field, allowing power supply manufacturers to compete on the basis of greater technological innovation and delivery of value, rather than simply lowest commodity manufacturing cost.

Appendix A – Assessing Cost Effectiveness of Candidate Technologies

Combo Phone / Answering Machine

Standard Power Supply

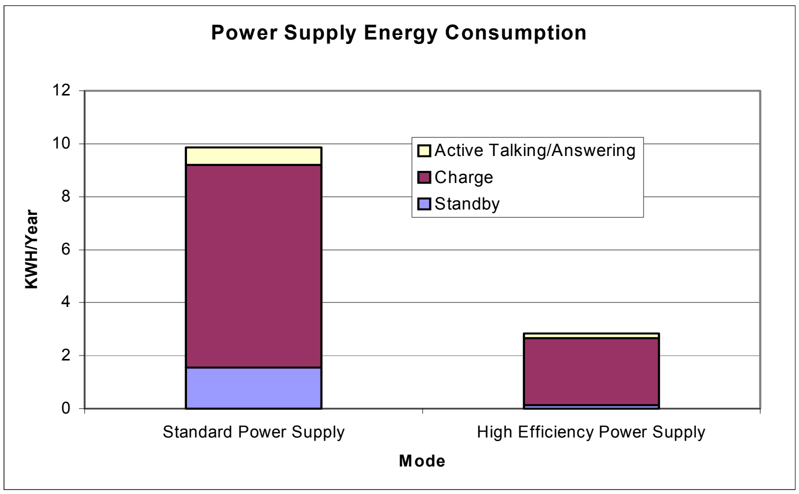
Operating Mode	% time	Input Watts	Efficiency	Wasted Watts	Output Watts	kwh/year
Standby	35%	1.1	54%	0.5	0.6	1.55
Charge	59%	3.7	60%	1.5	2.2	7.65
Active Talking/Answering	6%	3.1	60%	1.2	1.9	0.65

9.86 Annual kWh

High Efficiency Power Supply

Operating Mode	% time	Input W	Efficiency	Wasted Watts	Output Watts	kwh/year
Standby	35%	0.6	93%	0.04	0.6	0.14
Charge	59%	2.7	82%	0.49	2.2	2.52
Active Talking	6%	2.2	85%	0.33	1.9	0.17

2.83 Annual kWh



Annual Saved kWh	**7.03**
Cost of Measure	**$0.75**
Cost of Kwh	**$0.08**
Annual Energy Cost Saved	**$0.56**
Simple Payback Years	**1.33**

Answering Machine

Standard Power Supply

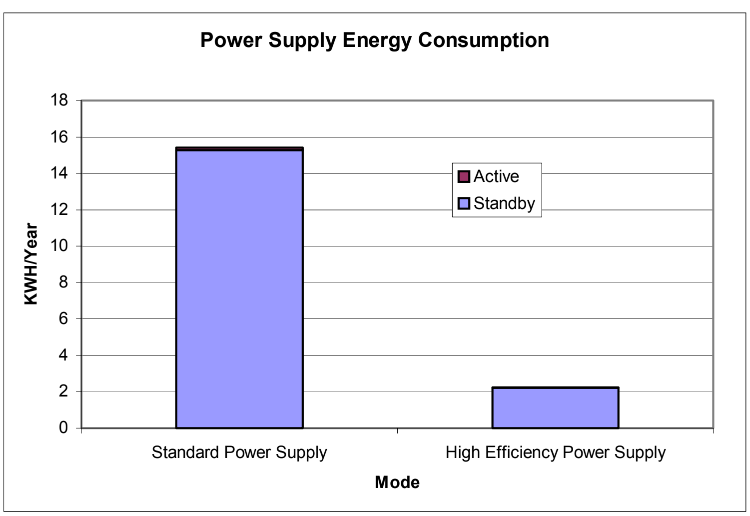
Operating Mode	% time	Input Watts	Efficiency	Wasted Watts	Output Watts	kwh/year
Standby	99%	3.2	45%	1.8	1.4	15.27
Active	1%	3.6	55%	1.6	2.0	0.14

15.42 Annual kWh

High Efficiency Power Supply

Operating Mode	% time	Input W	Efficiency	Wasted Watts	Output Watts	kwh/year
Standby	99%	1.7	85%	0.3	1.4	2.21
Active	1%	2.3	85%	0.3	2.0	0.03

2.24 Annual kWh



Annual Saved kWh	**13.18**
Cost of Measure	**$0.50**
Cost of Kwh	**$0.08**
Annual Energy Cost Saved	**$1.05**
Simple Payback Years	**0.47**

Internet Box

Standard Power Supply

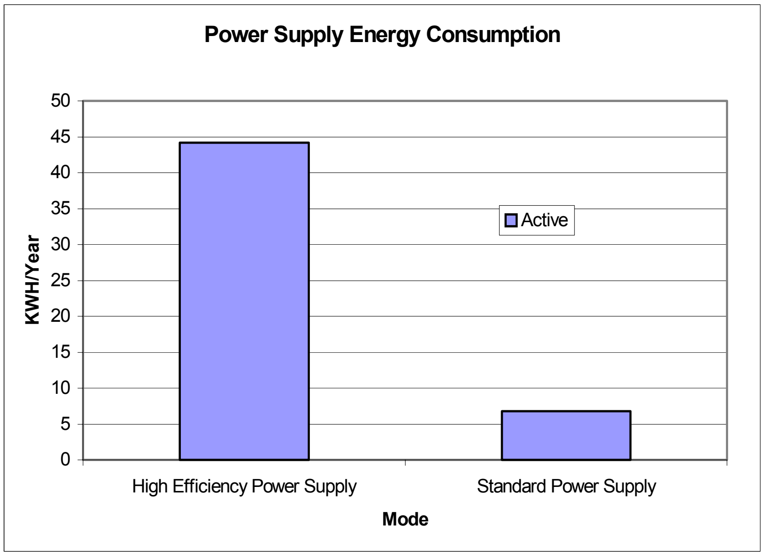
Operating Mode	% time	Input Watts	Efficiency	Wasted Watts	Output Watts	kwh/year
Active	100%	12	58%	5.0	7.0	44.18

44.18 Annual kWh

High Efficiency Power Supply

Operating Mode	% time	Input W	Efficiency	Wasted Watts	Output Watts	kwh/year
Active	100%	7.7	90%	0.8	7.0	6.78

6.78 Annual kWh



Annual Saved kWh	37.40
Cost of Measure	$1.00
Cost of Kwh	$0.08
Annual Energy Cost Saved	$2.99
Simple Payback Years	0.33

Video Camera

Standard Power Supply

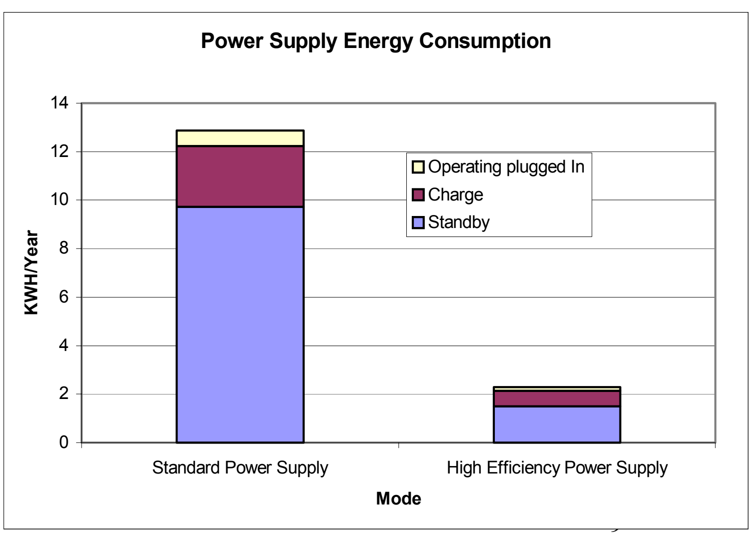
Operating Mode	% time	Input Watts	Efficiency	Wasted Watts	Output Watts	kwh/year
Standby	88%	3	58%	1.3	1.7	9.72
Charge	10%	7	59%	2.9	4.1	2.52
Operating plugged In	2%	9	60%	3.6	5.4	0.63

12.87 Annual kWh

High Efficiency Power Supply

Operating Mode	% time	Input W	Efficiency	Wasted Watts	Output Watts	kwh/year
Standby	88%	1.9	90%	0.2	1.7	1.49
Charge	10%	4.9	85%	0.7	4.1	0.64
Operating plugged In	2%	6.4	85%	1.0	5.4	0.17

2.30 Annual kWh



Annual Saved kWh	10.57
Cost of Measure	$0.75
Cost of Kwh	$0.08
Annual Energy Cost Saved	$0.85
Simple Payback Years	0.89

Cordless Phone

Standard Power Supply

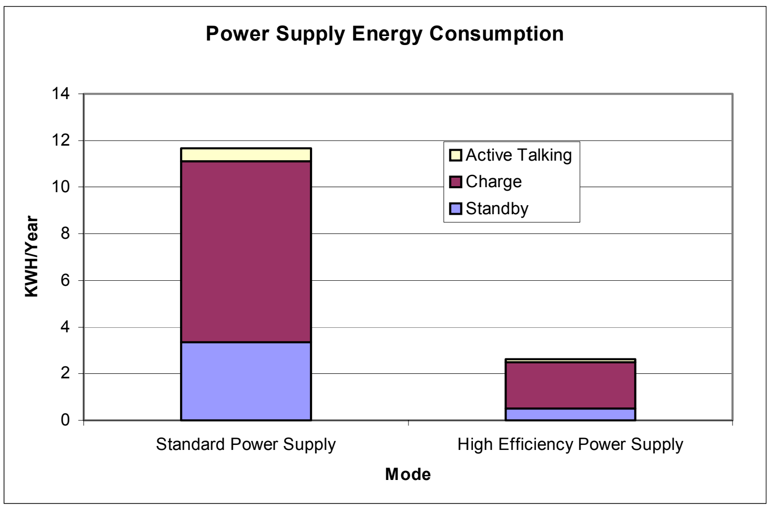
Operating Mode	% time	Input Watts	Efficiency	Wasted Watts	Output Watts	kwh/year
Standby	35%	2.6	58%	1.1	1.5	3.35
Charge	60%	3.6	59%	1.5	2.1	7.76
Active Talking	5%	3.1	60%	1.2	1.9	0.54

11.66 Annual kWh

High Efficiency Power Supply

Operating Mode	% time	Input W	Efficiency	Wasted Watts	Output Watts	kwh/year
Standby	35%	1.7	90%	0.2	1.5	0.51
Charge	60%	2.5	85%	0.4	2.1	1.97
Active Talking	5%	2.2	85%	0.3	1.9	0.14

2.63 Annual kWh



Annual Saved kWh	**9.03**
Cost of Measure	**$0.50**
Cost of Kwh	**$0.08**
Annual Energy Cost Saved	**$0.72**
Simple Payback Years	**0.69**

Cordless Tool Battery Charger

Standard Power Supply

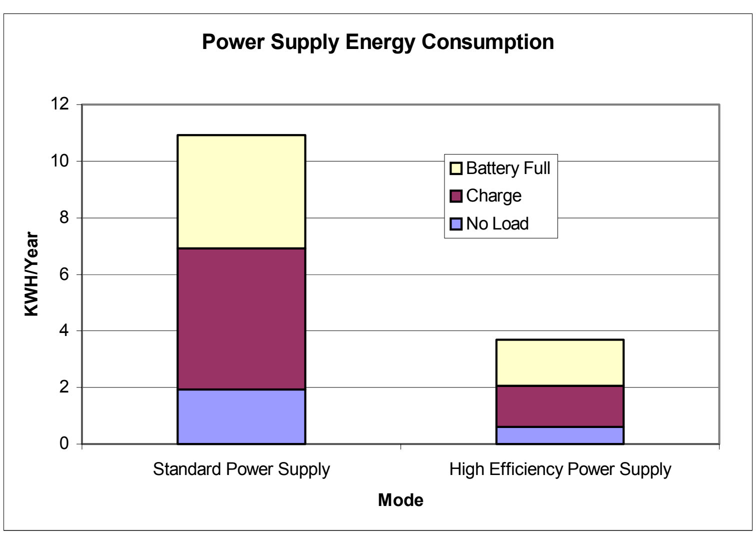
Operating Mode	% time	Input Watts	Efficiency	Wasted Watts	Output Watts	kwh/year
No Load	50%	1	56%	0.4	0.6	1.93
Charge	10%	15	62%	5.7	9.3	5.00
Battery Full	40%	3	62%	1.1	1.9	4.00

10.92 Annual kWh

High Efficiency Power Supply

Operating Mode	% time	Input W	Efficiency	Wasted Watts	Output Watts	kwh/year
No Load	50%	0.7	80%	0.1	0.6	0.61
Charge	10%	10.9	85%	1.6	9.3	1.44
Battery Full	40%	2.3	80%	0.5	1.9	1.63

3.68 Annual kWh



Annual Saved kWh	**7.24**
Cost of Measure	**$1.00**
Cost of Kwh	**$0.08**
Annual Energy Cost Saved	**$0.58**
Simple Payback Years	**1.73**

Summary Table

	Internet Boxes	Answering Devices	Cordless Phone	Combo Cordless / Answering	Cordless Tools	Video Camera	Total
Unit Energy Savings (kwh/year)	37.4	13.2	9.0	7.0	7.2	10.6	84.4
Unit Energy Savings ($/year)	$2.99	$1.05	$0.72	$0.56	$0.58	$0.85	$6.76
Unit Incremental Cost	$1.00	$0.50	$0.50	$0.75	$1.00	$0.75	
Simple Payback (years)	0.3	0.5	0.7	1.3	1.7	0.9	
Units Sold in 2001 (millions)	12.7	22	29	20	7.7	3.2	94.6
Life Expectancy (years)	3	4	4	4	5	6	
Lifetime Energy Saved / Unit (kwh)	112	53	36	28	36	63	328.8
Lifetime Energy Saved / Unit ($)	$8.98	$4.22	$2.89	$2.25	$2.90	$5.07	$26.30
Lifetime Energy Saved Total (Million kWh)	**1,425**	**1,160**	**1,047**	**562**	**279**	**203**	**4,676**
Lifetime Cost Saved Total (millions of $)	**$114**	**$93**	**$84**	**$45**	**$22**	**$16**	**$374**