Northwest Energy Efficiency Alliance
Natural Resources Defense Council
Appliance Standards Awareness Project

July 6, 2020
Via Electronic Mail

Mr. Jeremy Dommu
U.S. Department of Energy
Office of Energy Efficiency and Renewable Energy
Building Technologies Office
EE-5B, 1000 Independence Avenue SW
Washington, DC 20585-0121

Re: Docket Number EERE-2020-BT-STD-0006: Energy Conservation Standards for External Power Supplies

Dear Mr. Dommu,

Northwest Energy Efficiency Alliance (NEEA), Natural Resource Defense Council and the Appliance Standards Awareness Project (ASAP) submit the following comments in response to the Department of Energy's (DOE) request for information (RFI) regarding energy conservation standards for external power supplies: 85 Fed. Reg. 30636 (May 20, 2020).

We support DOE's efforts to update the external power supply (EPS) standards. Collectively, we submit the following comments on this RFI, along with supporting data detailing current EPS designs attached in an Excel Workbook.

Comments

1. We recommend that DOE proceed with updating EPS standards, as the latest research and information on power electronics technology indicate higher efficiency is technically feasible and likely cost-effective (RFI Issues 26, 35 and 36).

Since the last DOE EPS standards update in 2014, the power supply industry has made innovative technology advances to increase EPS efficiency, predominantly due to market and global industry trends:

- *Consumer demand for smaller EPS designs and shorter charge times for electronics,* such as laptops, tablets and cell phones. Efficient power conversion is needed to meet the challenging thermal requirements imposed by smaller housings and higher output powers.

- *Power electronics chip sets that enable higher efficiency levels are readily available on the market today to improve efficiency of active mode and reduce no-load power.* Active mode efficiency is appreciably higher for "basic voltage" EPSs (1 to 6 percentage points higher) and substantially higher for "low voltage" EPSs (7 to 10 percentage points higher). For example, an EPS reference design from a market-leading U.S.-based integrated circuit (IC) company achieves active mode efficiencies 10 percentage points higher than current DOE levels for 5V/3A designs.[1] For lower power output EPSs (18 watts), typically used with mobile phones, no load values can be one-tenth of the current 100 mW requirement.[2] See attached Excel Workbook for further details on active mode efficiency and no load power use values of current technology.
- *EU's more stringent Code of Conduct (CoC) version 5 Tier 2 levels already influence the U.S. market*. Many EPS products are designed to have universal input (70 V ac to 240 V ac) so that a single adaptor design can accommodate products shipping within a global market. Information in the RFI confirms this influence noting that 73% of EPS products listed in DOE's Compliance Certification Management System (CCMS) database met or surpassed the CoC Tier 2 levels.[3]
- *Many technologies are likely cost-effective.* Power electronics silicon manufacturers reported that high efficiency chipsets already sell in relatively large volume. However, these efficient solutions are not currently utilized in all EPS products, so an increase in sales volume associated with a more stringent standard means that the incremental price is likely to drop further, enabling further cost-effective energy savings.

Together these points illustrate that the opportunity to update EPS standards is timely, appropriate and feasible, and we strongly urge DOE to proceed with this effort. Furthermore, data on current EPS efficiency reveal that opportunities to improve active mode efficiency and no load are similar to those in the prior rulemaking.[4] Given this, we estimate that energy

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[1] Summary of data available in attachment. Note that efficiency is taken at end of board, not at the end of the output cord. Some small losses are expected given resistance in the cord. Design Example Report from Power Integrations: 60 W USB PD Type C Power Supply Using InnoSwitch 3-CP GaN-based INN3279C-H215. p. 2. Available at: https://ac-dc.power.com/sites/default/files/product_document/design_example/der-601_60watt_usb_pd_type_c_power_supply_using_innoswitch3-cp.pdf, accessed 30 June 2020.

[2] Summary of data available in attachment. Note that efficiency is taken at end of board, not at the end of the output cord. Some small losses are expected given resistance in the cord. Design Example Report from Power Integrations: 18 W USB PD Power Supply Using InnoSwitch3-CP (INN3264C-H201) and Cypress CCG3PA (CYPD3175) USB PD Controller. p. 29. Available at: https://ac-dc.power.com/sites/default/files/PDFFiles/der-628_18watt_usb_pd_charger_using_innoswitch3-cp_and_cypress_controller.pdf, accessed 30 June 2020.

[3] 85 Fed. Reg. 30646.

[4] Margin of improvement available in active mode efficiency and no load demonstrated in the attachment to this letter is similar to those margins in candidate standards level (CSL) 2, which was the standards level ultimately adopted by DOE in its 2014 final rule. In DOE's analysis, margins of improvement for active mode efficiency for 2.5 W, 18 W, 60 W, and 120 W output EPSs were approximately 13, seven, two, and two percentage points, respectively. More information on the analysis of CSL 2 can be found in Chapter 5 of DOE's January 2014 Technical Support Document (EERE-2008-BT-STD-0005-0217), page 5-17 through 5-21, available at: https://www.regulations.gov/document?D=EERE-2008-BT-STD-0005-0217.

savings from this rulemaking are likely similar to the prior rulemaking, yielding nearly one quad (quadrillion British thermal units (BTU)) of savings over a 30-year period.[5]

2. We recommend DOE remove the definitions of direct and indirect power supplies and collapse Class A direct and Class A indirect power supplies into a single product class (RFI Issue 8).

DOE's 2014 rule divided EPS products into two categories—direct and indirect—and subjected them to different standards levels: VI (higher) and IV (lower), respectively. We are aware of no technical justification for these categories to remain in place. Our research indicates:

- *The direct/indirect categories are unnecessary.* Both direct and indirect EPS convert ac to lower voltage dc and leverage the same technologies to improve efficiency. In this RFI, DOE notes that 70% of the indirect Class A EPS products in fact already meet level VI standards.[6] Furthermore, regulations in Canada and Europe do not make this distinction between direct and indirect.
- *The distinction between direct and indirect is confusing.* The definitions of direct and indirect are based on how the end use product (and not the EPS) is designed and used. Thus, these categories can be confusing to some power supply companies that typically certify EPS products on behalf of their customers. DOE confirms that it has received "many questions regarding EPSs that provide direct operation with a different consumer product containing batteries and or a battery charging system."[7]
- *The categories leave achievable energy savings untapped.* DOE estimates 22% of shipments of all EPS products are indirect[8] and therefore subject to the lower standard level IV, effectively reducing cost-effective savings for U.S. consumers. Assuming energy savings of these level IV indirect class A EPSs is similar to savings achieved in the prior rulemaking, we estimate collapsing Class A direct and Class A indirect into a single product class could result in 0.08 quads of energy savings over a 30-year period.[9]

For these reasons, we strongly urge DOE to remove the definitions of direct and indirect from the existing standard and collapse Class A direct and Class A indirect power supplies into a single product class.

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[5] Final Rule. Energy Conservation Standards for External Power Supplies. Issued by Energy Efficiency and Renewable Office. 2 Feb 2014. Section C, National Benefits. Available at: https://www.regulations.gov/document?D=EERE-2008-BT-STD-0005-0219, accessed 30 June 2020.

[6] 85 Fed. Reg. 30641.

[7] Ibid.

[8] Ibid.

[9] Given the following: 1) DOE estimated indirect class A EPSs represent 22% of the market, 2) this class was not subject to a change in standards level in the 2014 final rule, and 3) DOE estimates 70% indirect class A EPS already meet level VI, we calculate the savings using a market size ratio of indirect class A EPS (22%) to EPS market with increased standards in 2014 (78%) and then assume 70% of that indirect class A EPS market already meets level VI. We then multiply that percentage of the market by the total energy savings associated with the last final EPS rule issued 2 Feb 2014. (Section C, National Benefits. Available at: https://www.regulations.gov/document?D=EERE-2008-BT-STD-0005-0219, accessed 30 June 2020.)

3. We recommend that DOE address interoperable wireless power supplies (IWPS) with efficiency standards (RFI Issue 2).

Since the last EPS standard was completed, much in the industry has changed, especially with wireless power charging of consumer products. Wireless power improves consumer convenience and enables hermetically sealed devices, but this type of energy transfer also has an inherent energy penalty regardless of the technology employed. If left unaddressed, research indicates this technology could nearly double national energy use of battery chargers by 2030,[10] bringing thirty-year national energy use of battery chargers to 2.6 quads.[11] More recent 2019 research expanded the number of forecast scenarios and found that by 2030 the total energy use of wired and wireless chargers could be even larger—4.5 quads over a thirty-year period—effectively tripling national energy use of all battery chargers.[12] Much of this forecasted growth in energy use is with battery-powered products that employ interoperable wireless power supplies (IWPS). However, other non-battery products likely to come to market—such as wirelessly powered blenders, toasters and food processors—are not included in these energy growth estimates so they may be underestimated.[13]

This expected energy use increase is based on analyst predictions of double digit compound annual growth rates (CAGR) in an already established wireless power market sized at $11B in 2019.[14] Specifically, Global Market Insights forecasts CAGR at 14% from 2020 to 2026 and Allied Market Research[15] anticipates a CAGR of 23% from 2020 to 2027. Analysts agree the growth is driven by increased adoption of wireless power in consumer products, and that the largest share of this worldwide market is in North America. With this, available estimates reveal wireless power is expected to significantly increase energy use. DOE's current standards process for the EPS (as well as for battery chargers; more on this below) offers an excellent opportunity to help curb anticipated growth in this category.

[10] Foster Porter, Suzanne and Pierre Delforge. "Wireless Power for Residential Devices: What is the Energy Penalty of Cutting the Cord?" In American Council for an Energy-Efficient Economy (ACEEE) Summer Study on Energy Efficiency in Buildings. August 2018. Pacific Grove, California, United States. pp. 5-13. Available at https://www.aceee.org/files/proceedings/2018/index.html#/paper/event-data/p147.

[11] "Energy Conservation Program: Energy Conservation Standards for Battery Chargers; Final Rule," 81 Fed. Reg. 113 (June 13, 2016). Office of Energy Efficiency and Renewable Energy, Department of Energy (DOE). Docket Number EERE-2008-BT-STD-0005, RIN 1904-AB57. Section I.C. Available at https://www.regulations.gov/document?D=EERE-2008-BT-STD-0005-0256.

[12] Rubin, Eric, et al. "Global Forecast for Energy Use for Wireless Charging." Electronic Devices and Network Annex (EDNA) of Technical Collaboration Programme on Energy Efficient End-use Equipment (4E TCP) of International Energy Agency (IEA). July 2019. pp. 12 -14. Available at: https://edna.iea-4e.org/library.

[13] A kitchen appliance wireless interoperability standard is under development by the wireless power consortium (WPC). Information can be found at https://www.wirelesspowerconsortium.com/kitchen/.

[14] Global Market Insights (GMI) Wireless Charging Market Industry Trends: https://www.gminsights.com/industry-analysis/wireless-charging-market, accessed 23 May 2020.

[15] Allied Market Research "Wireless Charging Market Projected to Hit $49,304.1 Million By 2027." Available at: https://www.alliedmarketresearch.com/press-release/wireless-charging-market.html, accessed 23 May 2020.

Currently, the dominant use for wireless power is to charge batteries of portable products. There are two primary methods of wireless charging: dedicated charging systems and IWPS certified to the Wireless Power Consortium[16] (WPC) interoperable Qi standard or another industry-recognized standard. Dedicated wireless charging systems are product specific and not intended for interoperability. Available now for multiple years from influential companies such as Bosch, Apple and Philips, they are similar to wired chargers in that they have specific equipment for a certain product or product group and a limited range of recommended batteries for use. Figure 1 provides some examples of dedicated wireless battery chargers. Dedicated wireless chargers, which are not currently covered by DOE test procedures and standards, are appropriate for inclusion in the scope of the consumer battery charger test procedure and standards.[17]

Figure 1. Examples of dedicated wireless battery chargers
Left to right: Bosch WC18CF-102 wireless charging power tool system,[18] Apple Watch Magnetic Charger,[19] and Phillips Norelco - S9000 Prestige.[20]

Like dedicated chargers, IWPS are not covered by DOE standards either. But for several important reasons, the EPS standards process may be the appropriate channel for this product category. These WPC Qi-certified wireless power mats and stands are primarily used with smart phones and other small electronics (Figure 2), and they have a theoretically infinite number of batteries and non-battery powered end use devices that could receive wireless power via the power supply mat or stand. This feature makes it difficult to define one specific battery system that they should be tested with (as is required in the in the battery charger test procedure). Smart phones and wearables (such as ear buds and watches) are the most common battery-

[16] https://www.wirelesspowerconsortium.com, accessed 23 May 2020.
[17] NEEA submitted comments 3 June 2020 related to the battery charger standards RFI. Docket number EERE-2020-BT-TP-0012: Test Procedures for Battery Chargers. Available at: https://www.regulations.gov/document?D=EERE-2020-BT-TP-0012-0008.
[18] https://www.homedepot.com/p/Bosch-18-Volt-Lithium-Ion-Wireless-Charger-and-Mobile-Holster-for-2-0-Ah-Battery-WC18CH/205951656, accessed 23 May 2020.
[19] https://www.bestbuy.com/site/apple-watch-magnetic-charging-cable-1m-white/6334720.p?skuId=6334720, accessed 23 May 2020.
[20] https://www.bestbuy.com/site/philips-norelco-s9000-prestige-qi-charge-electric-shaver-dark-brushed-chrome/6317109.p?skuId=6317109, accessed 24 May 2020.

charged devices that employ an IWPS, but the technology can also directly power devices without batteries, such as coffee mugs with embedded warmers (Figure 2).[21]

Figure 2. Examples of interoperable wireless power supplies in use
These IWPS from Belkin[22] (left) and Tzumi[23] (middle) advertise compatibility with any separately sold Qi-certified phone. The Belkin device on the left also mentions compatibility with Qi-certified tablets, headphones or any other Qi-certified device. The non-battery-powered device on the right is a cup with an embedded warmer that works with Qi-certified IWPS.[24]

It's this universality that suggests the IWPS is more appropriate for testing and standards approaches taken with the EPS than with dedicated battery chargers. Specifically, we recommend that DOE develop an alternate test procedure for those IWPS that are: 1) certified to an interoperable wireless standard (such as Qi or AirFuel),[25] and 2) clearly state in marketing materials and set up instructions that they are for use with a wide range of end-use products certified to the same standard.

Table 1 provides an overview of distinct technology characteristics between the wireless charging technology types, as well as a summary of our recommendations for both.

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[21] Because IWPS power products without batteries, they would fall into DOE's current definition of Direct Operation EPSs.
[22] https://www.belkin.com/us/p/P-F8M741/, accessed 24 May 2020.
[23] https://www.bestbuy.com/site/tzumi-10w-qi-certified-fast-charge-wireless-charging-pad-for-iphone-android-black/6346474.p?skuId=6346474, accessed 24 May 2020.
[24] https://www.amazon.com/dp/B07TVPTKL5/ref=dp_cerb_3, accessed 23 June 2020.
[25] For a summary of interoperability standards, see Foster Porter and Delforge 2018, pp. 5-5 to 5-6. Available at https://www.aceee.org/files/proceedings/2018/index.html#/paper/event-data/p147.

Table 1. Characteristics of IWPS and Dedicated Wireless Chargers

Interoperable Wireless Power Supplies	Dedicated Wireless Chargers
• Designed to industry interoperability standard • Product marketing and literature indicate for a range of end-use products certified to an industry-recognized wireless power standard • Does not limit consumer to specific end-use products or batteries for use with the equipment • <u>May</u> give examples of popular products commonly used with the product (such as a list of popular smart phone models from various manufacturers)	• Designed for a specific end-use product • May be sold with the end use product, as an accessory or as an aftermarket product • Product marketing and product set up instructions specify a limited range of wireless power receivers/batteries for use with the system • <u>May</u> be certified to an industry-recognized wireless power interoperability standard for the purposes of consumer confidence and/or safety, but marketing and set up instructions <u>do not</u> recommend use with unrelated products also certified to that standard[26]
We recommend DOE develop a test procedure and standards for IWPS.	**We recommend DOE include dedicated wireless chargers in the scope of the current battery charger test procedure and standards.**

We also urge DOE adopt technology neutral definitions of IWPS to enable future products to be tested and considered, regardless of whether they use inductive, magnetic resonant, radio frequency or other energy-delivery technology.[27] A technology-neutral approach mirrors the existing procedure for EPS (testing with all types of circuit topologies and silicon technologies) and it enables technologies to compete freely in the marketplace to deliver the best wireless power solution to consumers without being handicapped by technology-specific test procedures. Therefore, we recommend the following definitions for IWPS:

An interoperable wireless power supply:
1) *transmits energy without a wired connection to a receiving device, and*
2) *specifies in its user manual or other product literature that it is capable of general interoperability with receiving devices that are certified/designed to the same established industry standard.*

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[26] The Philips Norelco Shaver is an example of a product that is certified to an interoperability standard, but clearly indicates that the charger should only be used with the equipment provided in the package. Instructions do not indicate equipment is interoperable. See the user manual for details: https://files.bbystatic.com/7JN%2BggzGPYa5qpPa0MLbBg%3D%3D/8d6d59a4-3243-4e5c-bd8c-3f55b7c16d10.pdf, accessed 23 May 2020.

[27] For a summary of current technologies, see Foster Porter and Delforge 2018 pp. 5-4 to 5-5. Available at https://www.aceee.org/files/proceedings/2018/index.html#/paper/event-data/p147.

4. We recommend DOE analyze existing technologies and strategies to improve the efficiency of interoperable wireless power supplies (RFI Issue 2).

Industry measurements indicate that efficiency of IWPS may vary significantly. Active mode efficiency can range from 25 to 60% and the highest standby powers can be 60 times greater than the lowest.[28,29] Because IWPS are made up of a system of components, active mode efficiency and standby power can be improved with strategies and technologies currently employed in wired EPSs. Therefore, we suggest DOE investigate these options to apply to IWPS:

- *Ac-dc power conversion improvement:* Increases efficiency of power supply of IWPS through improved transformers, resonant switching, synchronous rectification, advanced core materials and other technologies outlined in Table II.3 and II.4 on page 30642 of this RFI. This may be especially important for low internal load points where IWPS are plugged in, but not providing power to an end-use device.
- *Higher internal system voltage:* Reduces resistive and conversion losses and reduces system current.[30]
- *Reduced fixed energy consumption:* Lowers standby power of control electronics in associated with the wireless power control and reduces standby losses associated with ac-dc power conversion.

Of note, the first and third suggestions would also be applicable for small kitchen appliances that use an IWPS, a market category primed for rapid market adoption given the consumer convenience these products provide. Additionally, there are ways of increasing efficiency of inductive and magnetic resonant transmitters, commonly used in IWPS. These strategies—which also may apply to small kitchen appliances—include:

- *Increasing efficiency of wire coils used:* Coil losses can be reduced by using thicker wires, such as Litz Wire. Transmission frequency can be optimized for efficiency.[31]
- *Minimizing stray energy:* Displacement (both horizontal and vertical) can affect efficiency and can stray (leaked) energy can vary depending on transmitter design.[32]

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[28] Perzow, J. 2015. "Wireless Power Standards Force Efficiency Trade-Offs." Piscataway, NJ: Wireless Power Consortium. Available at: www.wirelesspowerconsortium.com/blog/112/wireless-power-standards-force-efficiency-trade-offs.

[29] Wireless Power Consortium (WPC). 2020. Comments in response to DOE RFI for Battery Charger Test Procedures. Available at: https://www.regulations.gov/document?D=EERE-2020-BT-TP-0012-0004.

[30] Geist, T., H. Kameth, S. Foster Porter and P. May-Ostendorp. 2006. Designing Battery Charger Systems for Improved Energy Efficiency: A Technical Primer. Sacramento: California Energy Commission. Available at: https://www.kannahconsulting.com/wp-content/uploads/2016/08/1270_BatteryChargerTechincalPrimer_FINAL_29Sep2006-1.pdf.

[31] Ecova. 2014. "Market Survey of Battery Charger Systems in Canada." Prepared by Ecova for Natural Resources Canada. Unpublished.

[32] Wireless Power Consortium (WPC). 2017b. "Transfer Efficiency." Piscataway, NJ: Wireless Power Consortium https://www.wirelesspowerconsortium.com/knowledge-base/magnetic-induction-technology/effficiency/transfer-efficiency.html.

Manufacturers can minimize stray energy by designing the IWPS transmitter to reasonably limit the positions available for the end use product to rest relative to the transmitter. IWPS "connected" signals could provide reasonable limits on the range of displacement allowed.

- *Implementing power management strategies:* Smart power management to reduce power in low power mode conditions are feasible with the sophisticated communication protocols typically used for IWPS.[33] For instance, when a product is still in range of an IWPS, but no longer requires power (a common example is a cell phone on a IWPS with a fully charged battery).

These IWPS efficiency improvement opportunities offer DOE proven approaches worthy of investigation for standards opportunities.

5. We recommend DOE develop a new test procedure for interoperable wireless power supplies (RFI Issue 3).

A testing approach similar to wired EPS is warranted for IWPS (as defined in our comments on RFI Issue 2 above) for number of practical reasons, namely that IWPS:

1) convert household electric power to alternate output power to operate a consumer product
2) do not contain any battery charger circuitry,
3) can operate a variety of products and loads that generally contain batteries but are not required to contain batteries to be compatible with the power supply,
4) are designed as voltage sources (like most external power supplies),
5) require testing at a range of loading points (various current outputs since a dedicated load is unknown) to evaluate the efficiency when the IWPS is transmitting power, and
6) require a separate low power mode test to capture various low power states.

Furthermore, although IWPS are similar to wired external power supplies, DOE will need to consider and incorporate specific product nuances along with other industry protocols for a new test procedure appropriate for IWPS. In sum, their increased spatial flexibility and sophisticated communication protocols mean additional aspects of testing are needed to capture their relative efficiency, which are discussed further below.

5.1. Spatial flexibility and the active mode efficiency test. A key consumer benefit of the IWPS is that the products they power do not need to be physically connected or placed in an exact physical location to receive power. The distance that may be between the IWPS and the product it powers depends upon the specific technology: tightly coupled inductive (millimeters), loosely coupled magnetic resonance (centimeters), and uncoupled radio frequency (RF), ultrasonic and infrared (meters). Although this spatial flexibility is critical to the

[33] Kinetic Technologies. 2018. "Beyond Compliance: How to Build a Really Great Wireless Power Receiver Product. Making Engineering into Art." Presentation at IEEE PELS Workshop on Emerging Technologies: Wireless Power Transfer (WoW). Montreal, Canada. 5 June.

value proposition of wireless technology, it is well accepted that the specific location of the product receiving the power greatly impacts the energy transfer efficiency. Given this, we recommend that DOE test the efficiency of IWPS devices at multiple locations in three-dimensional space.

5.2. Sophisticated communication protocols and the low power mode tests. Two low power modes need to be considered for testing IWPS, including:

- when the IWPS is not supplying power and there are no receiving products in the physical range of operation, and
- when the IWPS has receiving products within range, but they no longer require power (such as a state when a battery-powered product has a full battery charge).

Furthermore, in order to evaluate the representative power use in these low power states, industry standard communication protocols also need to be considered in test procedure design. Some standards, such as Qi, have multiple communication codes that can be transmitted from the product under power to the IWPS to request that power be supplied (or not). The power use associated with each of these communication codes needs to be tested, as any of these codes could be present in field use. For example, for the Qi protocol, codes from battery-charged products to the IWPS to indicate power is no longer needed because the battery is full varies. These codes could include “charge complete,” “end-power-charge-complete” and “charge status 100”. The operation and low power mode energy use of the Qi IWPS (transmitter) may differ substantially for these three codes or combinations of codes.[34] Input from industry experts is needed to decipher which code combinations are most appropriate to test.

5.3. Incorporating and leveraging industry developed test protocols. To expedite test procedure development, we recommend DOE leverage aspects of established industry-developed test protocols for IWPS. We are aware of at least two such procedures to measure efficiency of wireless chargers: ANSI/CTA 2042.3 (2018) and WPC Task Force Test Procedure. Elements of each may be appropriate for DOE use in developing its own protocol; however, we find that the WPC Task Force test procedure possesses certain specifications worth noting, including:

- *Use of random test points.* The WPC’s test protocol includes a technique for determining semi-random active mode test locations for measuring the efficiency of wireless energy transfer. This addresses the differences in efficiency associated with the expected range of displacements between the IWPS and the product under power in the field without encouraging manufacturers to design to a fixed test pattern that may not be representative of real world use.[35] While the tool employed in the WPC draft is

[34] Kinetic Technologies. 2018. “Beyond Compliance: How to Build a Really Great Wireless Power Receiver Product. Making Engineering into Art.” Presentation at IEEE PELS Workshop on Emerging Technologies: Wireless Power Transfer (WoW). Montreal, Canada. 5 June.

[35] Personal communication with Louis Starr (NEEA). John Perzow (WPC). 27 May 2020.

applicable to products in the Qi standard, NEEA supports the same conceptual approach for other IWPS technologies.

- *Low power mode tests.* The WPC developed a draft low power mode test to address power at end-of-charge and for various sleep states that may not normally be part of the DOE EPS test protocol. Recognizing and defining a range of low power modes will be important to development of a representative test protocol. [36]
- *Multiple loading points for energy transfer efficiency.* The test protocol tests the IWPS at multiple loading points (25%, 50%, 75% and 100%) of rated output power, representing the range of possible outputs that it may be required to supply in field use.[37]
- *Metric approach of average active mode efficiency and a low power mode value.* This is a similar to DOE's approach for wired EPS.[38]

Industry has made substantial progress that DOE can leverage in its own test procedure development process, but opportunities for additional research and stakeholder input remain. We understand that WPC is undertaking research to confirm whether a single receiver test load can fairly represent the rank of a IWPS. [39] The research will help determine whether a single receiver can predict rank in the field, or if other measurement techniques (such as measurement of the strength of the energy-transmitting field) are needed.[40]

Additional comment is needed from manufacturers with market-relevant technologies to support the development of test procedure that enables a level playing field for all market actors. Where possible, we encourage DOE to develop protocols for IWPS that are technology neutral (see comment 3). While inductive charging technology certified to the WPC Qi standard is the most popular today, other technologies, such as the Energous Power Hub RF interoperable power supply,[41] could be forthcoming within the development timeframe of DOE's test procedure effort.

5.4. Alternative test procedure approach: Start with low power mode. Finally, in the event that test procedure development for IWPS is time-sensitive, we encourage DOE to develop an interim test procedure that at a minimum addresses the energy use of low power modes. Focusing on low power modes in the near term would enable energy savings in this mode of operation and give DOE, industry and stakeholders additional time to develop and agree on an IWPS active mode testing approach.

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[36] Ibid.

[37] Wireless Power Consortium (WPC). 2018. "Measuring Wireless Power-Transfer Efficiency in the Real World." Presentation at IEEE PELS Workshop on Emerging Technologies: Wireless Power Transfer (WoW). Montreal, Canada. 5 June.

[38] Ibid.

[39] Personal communication with Louis Starr (NEEA). John Perzow (WPC). 27 May 2020.

[40]An example of a company making equipment that would enable such measurements is nok9 (https://www.nok9.com).

[41] https://energous.com/applications/ecosystem/, accessed 30 May 2020.

6. We recommend that auxiliary power supplies—including universal serial bus (USB) ports, USB-C ports and IWPS—be considered EPSs (RFI Issue 1).

Research clearly demonstrates that the trend in power delivery for consumer devices is toward universality and interoperability. Auxiliary power supplies embedded in a variety of consumer products—like those shown in Figure 3–are a distinct, fast-growing sub-category of the EPS. We strongly agree with DOE's indication to expect "the presence of embedded USB ports to become even more commonplace."[42] Market signals suggest the same: Many small battery-powered consumer products, such as Bluetooth speakers and rechargeable toys, no longer ship with an EPS in the box but instead provide a USB cord that consumers can use with an auxiliary power supply or a USB-based EPS from another product. IWPS can serve in an auxiliary setting too. They are found embedded in desktop lamps and alarm clocks, for example, and sold widely at a variety of major retail stores (Figure 3).

Figure 3. Auxiliary IWPS embedded in tabletop lamps
These IWPS embedded in table lamps and alarm clocks are available from major retailers and mainstream manufacturers. Left to right: IKEA LED work lamp with wireless charging,[43] Target's Project 62™ LED Qi-Certified Charging Table Lamp[44] and iHome Wireless Charging Bluetooth Dual Alarm Clock with Speakerphone (iBTW39).[45]

<u>However, auxiliary power supplies are not covered by DOE testing and standards and could use significantly more energy in active and/or no load than a standalone EPS.</u> Further, although they offer the benefit of reducing landfill waste by allowing consumers to reuse USB-based EPS and auxiliary power supplies for new products, many of these products also have longer lifetimes than a conventional EPS. Together, this means that auxiliary power supplies may be using more energy for a longer period of time compared to a standard EPS.

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[42] 85 Fed. Reg. 30639.
[43] https://www.ikea.com/us/en/p/riggad-led-work-lamp-w-wireless-charging-white-40385642/, accessed 18 June 2020.
[44] https://www.target.com/p/led-qi-certified-charging-table-lamp-black-includes-energy-efficient-light-bulb-project-62-153/-/A-53221610, accessed 18 June 2020.
[45] https://www.ihomeaudio.com/iBTW39G/, accessed 18 June 2020.

Given their increasing prevalence, expected growth in number and longer lifetimes, we recommend that DOE include auxiliary power supplies, both wired and wireless, in its test procedure and standards development process. Additionally:

- *We recommend that auxiliary power supplies be tested with other main functions turned off or set at the lowest power consuming level.* Measuring active mode input power (ac) and output power (dc) and no load in the exact same way as current EPS products will ensure consistency and clarity for chip set designers and subsystem assemblers designing to meet requirements for both EPSs and auxiliary power supplies.
- *We recommend that these auxiliary power supplies meet the identical standard as other EPS products of the same type.* They can incorporate the same power electronics and technologies as stand alone EPSs.

7. We recommend DOE measure and report a 10% loading point separately from the active mode power measurement (RFI Issues 33, 34, 39, 40 and 41).

A variety of prevalent end use products—laptops, printers, tablets, power tool chargers, etc.—are coupled with an EPS. They spend a significant amount of time in low power modes, often around the 10% loading point, which loads the EPS relatively lightly. Technical research and industry market trends support incorporating a 10% loading point separate from the active mode power measurement. First, a high active mode efficiency (measured at 25, 50, 75, and 100% of output current) of an EPS does <u>not</u> typically guarantee that lower loading points (between 0 and 25%) are efficient as well. Similarly, a low no load power level is also not indicative of high efficiency at 10% load. Second, EU CoC and Ecodesign requirements have already addressed EPS efficiency at lower loading conditions by adding an efficiency measurement at 10% load, and in the case of CoC, setting a separate efficiency target for the 10% loading level.[46] Therefore, we recommend that DOE:

- *Harmonize with the EU approach for measuring low load efficiency at 10% load.* This will enable clarity and consistency in the worldwide power electronics marketplace at no significant incremental test burden to manufacturers as they are already testing this 10% load point to meet reporting requirements in the EU.
- *Create a separate minimum efficiency requirement for the 10% loading point.* If a separate efficiency requirement is infeasible, then we encourage DOE to enable testing and optional reporting to DOE's Compliance Certification Management System (CCMS) so that EPA ENERGY STAR® can use the data to create incentives for the most efficient EPSs in the market. Reporting the 10% load point separately may more effectively support DOE's EPS energy use calculations at low power mode conditions as well.
- *Retain the 25, 50, 75, 100% active mode measurement separate from 10% load point*, as active mode measurement is standardized across the world.

[46] European Commission. "Code of Conduct of Energy Efficiency External Power Supplies Version 5." 29 October 2013. p. 4. Available at: https://e3p.jrc.ec.europa.eu/sites/default/files/documents/publications/code_of_conduct_for_eps_version_5_-_final.pdf

8. We encourage DOE to consider no load candidate standards levels that are more closely tailored to no load levels achievable in current EPS designs (RFI Issues 30 and 31).

DOE's current no load standard has four output power ranges (< 1 W, 1 – 49 W, 49 – 250 W and > 250 W). The data contained in the attachment to this letter not only demonstrate an opportunity to reduce no load values within current defined output power ranges, but also point to an opportunity to define additional output power ranges with more stringent no load requirements. In Table 2 we developed an example of possible output power ranges and their associated no load requirements for EPSs (less than 250 W) from no load data in our attached Excel Workbook.

Table 2. No Load Input Power Maximum for Output Power Ranges 0 to 250 W

<table>
<tr><th>Output Power Range</th><th>Proposed No Load Maximum Input Power (mW)</th><th>Current DOE (Level VI) for AC-DC Single Voltage EPS</th></tr>
<tr><td><18 W</td><td>15 mW</td><td rowspan="4">100 mW</td></tr>
<tr><td>18 – 20 W</td><td>25 mW</td></tr>
<tr><td>20 W – 30 W</td><td>30 mW</td></tr>
<tr><td>30 W – 45 W</td><td>35 mW</td></tr>
<tr><td>45 W – 65 W</td><td>40 mW</td><td>≤ 49 W output power: 100 mW
> 49 W output power: 210 mW</td></tr>
<tr><td>65 W – 100 W</td><td>50 mW</td><td rowspan="2">210 mW</td></tr>
<tr><td>100 W – 250 W</td><td>150 mW</td></tr>
</table>

Creating more output power categories may also increase harmonization with other markets. The EU CoC already defines an additional no load category for EPSs with output power less than 8 watts, and in Tier 1, sets a more stringent no load input power value for that output power range.[47]

9. We encourage DOE to consider including commercial and industrial power supplies within the scope of the external power supply test procedure and standards.

We have begun looking into energy savings opportunities associated with commercial and industrial power supplies. Our initial research suggests the efficiency of many of these power supplies can be cost-effectively improved. Furthermore, some commercial power supplies—such as those found in desktop computers and computer servers—are also used in homes and therefore may be considered consumer products. DOE could leverage industry-supported 80 PLUS test procedures and efficiency levels to enable test protocol development and standards.[48] 80 PLUS currently addresses key commercial and industrial power supply markets,

[47] European Commission. "Code of Conduct of Energy Efficiency External Power Supplies Version 5." 29 October 2013. p. 3. Available at: https://e3p.jrc.ec.europa.eu/sites/default/files/documents/publications/code_of_conduct_for_eps_version_5_-_final.pdf.

[48] "80 PLUS Certified Power Supplies and Manufacturers." Plug Load Solutions. Implemented by CleaResult. Available at: https://www.plugloadsolutions.com/80PlusPowerSupplies.aspx, accessed 6 July 2020.

including those for desktop computers, computer servers and other industrial applications. In its recent EPS test procedure Notice of Proposed Rulemaking (NOPR), DOE asked for comment on its definition of commercial and industrial power supplies.[49] We request that DOE consider amending its proposed definition to ensure that commercial and industrial power supplies used with consumer products are included within the scope and test procedure for external power supplies.

10. We offer the following brief comments on other RFI issues:

We recommend that DOE measure and report power factor at all active mode loading conditions (RFI Issue 30). Requiring measurement of power factor at all loading conditions (10, 25, 50, 75, and 100% of output current) can enable DOE to evaluate energy savings opportunities associated with reducing losses in building wiring. Technologies exist to improve power factor and may yield cost-effective savings, especially for higher power EPSs.

Standby may be more important for wireless power products (RFI Issue 27). As discussed in comment 4 above, initial industry measurements reveal high variation in IWPS standby power. Relative to wired EPSs, the IWPS category likely has greater opportunity for savings with standby power test procedure and standards.

Regulatory burden of EPS standards is not substantial given existing market channels for EPS design and certification (RFI Issue 51). End use product manufacturers typically rely on EPS suppliers to certify compliance to DOE EPS standards. The regulatory burden for end use product manufacturers is minimal, even for those manufacturers that manage compliance of the end use product as well (e.g., battery charger manufacturers). This well-established market channel is unlikely to change with future standards revisions.

We encourage DOE to add specific resonant switching technologies as well as bridgeless power factor correction (PFC) to the list of technology options for consideration (Issue 14). Many different resonant switching technologies improve efficiency for active mode, including line-commutated converters (LCC), quasi-resonant valley switching fly back converters, and zero-voltage switching (ZVS) topologies. Furthermore, given that many higher power universal input voltage EPSs (powering end-use products such as laptops and power tools) are required to include PFC for use in Europe and elsewhere, we encourage DOE to consider bridgeless PFC as well. Bridgeless PFC enables higher efficiency PFC, supporting improved active-mode efficiency for these EPSs.

We support DOE's approach of baseline efficiency levels (RFI Issue 16) and use of modeling to establish a max tech level in the engineering analysis (RFI Issue 18). We support DOE using the standard as the baseline efficiency level. Furthermore, we support DOE utilizing modeling to

[49] Notice of Proposed Rule. Test Procedure for External Power Supplies. Issued by Energy Efficiency and Renewable Office. 6 December 2019. Section III.A. Available at: https://www.federalregister.gov/documents/2019/12/06/2019-25516/energy-conservation-program-test-procedure-for-external-power-supplies

establish the maximum tech level rather than relying exclusively on efficiencies of commercially available product. We encourage DOE to ground the model in empirical data on specific technology performance.

Summary

We appreciate that DOE plans to update the current EPS standard and that it seeks data and comments by requesting information from the public.

We offer the following recommendations and thoughts concerning this test procedure:

1. We recommend that DOE update EPS standards, as the latest information on power electronics technology means higher efficiency is technically feasible and likely cost-effective (Issue 26, 35 and 36).
2. We recommend DOE remove the definitions of direct and indirect power supplies and collapse Class A direct and Class A indirect into a single product class (Issue 8).
3. We recommend that DOE address interoperable wireless power supplies with efficiency standards (RFI Issue 2).
4. We recommend DOE analyze existing technologies and strategies to improve the efficiency of interoperable wireless power supplies (RFI Issue 2).
5. We recommend DOE develop a new test procedure for interoperable wireless power supplies (RFI Issue 3).
6. We recommend that auxiliary power supplies—including universal serial bus (USB) ports, USB-C ports and IWPS—be considered EPSs (RFI Issue 1).
7. We recommend DOE measure and report a 10% loading point separately from the active mode power measurement (RFI Issues 33, 34, 39, 40 and 41).
8. We encourage DOE to consider no load candidate standards levels that are more closely tailored to no load levels achievable in current EPS designs (RFI Issues 30 and 31).
9. We encourage DOE to consider including commercial and industrial power supplies within the scope of the external power supply test procedure and standards.
10. We provide additional comments on power factor testing (RFI Issue 30), the importance of standby for wireless power products (RFI Issue 27), regulatory burden (RFI Issue 51), technology options (Issue 14) and engineering analysis (RFI Issues 16 and 18).

Thank you for considering our comments.

Sincerely,

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Attachment: NEEA EPS Chipset Efficiency Data (Excel Workbook)