



ENERGY STAR® Program Requirements Product Specification for Uninterruptible Power Supplies (UPSs)

Eligibility Criteria Final Draft, Version 2.0

1 Following is the Final Draft, Version 2.0 ENERGY STAR Product Specification for Uninterruptible Power
2 Supplies (UPSs). A product shall meet all of the identified criteria if it is to earn the ENERGY STAR.

3 **1 DEFINITIONS**

4 For the purpose of this specification the following definitions apply:

5 A) Uninterruptible Power Supply (UPS)¹: Combination of convertors, switches, and energy storage
6 devices (such as batteries) constituting a power system for maintaining continuity of load power in case
7 of input power failure.²

8 1) Power conversion mechanism:

9 a) Static UPS: UPS where solid-state power electronic components provide the output voltage.

10 b) Rotary UPS: UPS where one or more electrical rotating machines provide the output voltage.

11 i. Rotary UPS (RUPS) without Diesel: A rotary UPS that does not contain an integral diesel
12 engine to supply power to the load during an input power failure.

13 ii. Diesel-coupled rotary UPS (DRUPS): A rotary UPS that contains an integral diesel engine
14 that may be used to supply power to the load during an input power failure.

15 2) Power Output:

16 a) Alternating Current (Ac)-output UPS: UPS that supplies power with a continuous flow of electric
17 charge that periodically reverses direction.

18 b) Direct Current (Dc)-output UPS: UPS that supplies power with a continuous flow of electric
19 charge that is unidirectional.

20 i. Low-voltage Dc-output UPS/Rectifier: A Dc-output UPS with output voltage less than or
21 equal to 60 V. Includes both individual rectifier units for dc applications and entire Dc-
22 output UPS frames or systems, consisting of rectifier modules, controllers, and any other
23 supporting components.

24 ii. High-voltage Dc-output UPS: A Dc-output UPS with output voltage greater than 60 V.

25 *Note*: Dc-output UPSs are also known as rectifiers. A rectifier is a product that converts alternating
26 current to direct current to supply a load and an energy storage mechanism. For the purposes of
27 this document, the term “Low-voltage Dc-output UPS/Rectifier” is used because a “rectifier” may
28 also refer to an ac-output UPS subsystem.

¹ 10 CFR 430, Subpart B, Appendix Y, Section 2.27, with modifications.

² Input power failure occurs when voltage and frequency are outside rated steady-state and transient tolerance bands or when distortion or interruptions are outside the limits specified for the UPS.

- 29 B) Modular UPS: A UPS comprised of two or more single UPS units, sharing one or more common frames
30 and a common energy storage system, whose outputs, in Normal Mode of operation, are connected to
31 a common output bus contained entirely within the frame(s). The total quantity of single UPS units in a
32 modular UPS equals “n + r” where n is the quantity of single UPS units required to support the load; r
33 is the quantity of redundant UPS units. Modular UPSs may be used to provide redundancy, to scale
34 capacity or both.
- 35 C) Redundancy: Addition of UPS units in a parallel UPS to enhance the continuity of load power, and
36 classified as follows.
- 37 1) N + 0: UPS that cannot tolerate any failures while maintaining Normal Mode operation. No
38 redundancy.
- 39 2) N + 1: Parallel UPS that can tolerate the failure of one UPS unit or one group of UPS units while
40 maintaining Normal Mode operation.
- 41 3) 2N: Parallel UPS that can tolerate the failure of one half of its UPS units while maintaining Normal
42 Mode operation.
- 43 D) UPS Operational Modes:
- 44 1) Normal Mode: Stable mode of operation that the UPS attains under the following conditions:
- 45 a) Ac input supply is within required tolerances and supplies the UPS.
- 46 b) The energy storage system remains charged or is under recharge.
- 47 c) The load is within the specified rating of the UPS.
- 48 d) The Bypass is available and within specified tolerances (if applicable).
- 49 2) Stored Energy Mode: Stable mode of operation that the UPS attains under the following conditions:
- 50 a) Ac input power is disconnected or is out of required tolerance.
- 51 b) All power is derived from the energy storage system or, in the case of a DRUPS, from the
52 integrated Diesel engine or a combination of both.
- 53 c) The load is within the specified rating of the UPS.
- 54 3) Bypass Mode: Mode of operation that the UPS attains when operating the load supplied via the
55 Bypass only.
- 56 E) UPS Input Dependency Characteristics:
- 57 1) Voltage and Frequency Dependent (VFD) UPS³: A UPS that produces an ac output where the
58 output voltage and frequency are dependent on the input voltage and frequency.⁴
- 59 2) Voltage Independent (VI) UPS⁵: Capable of protecting the load as required for VFD, above, and in
60 addition from:
- 61 a) Under-voltage applied continuously to the input; and
- 62 b) Over-voltage applied continuously to the input⁶

³ 10 CFR 430, Subpart B, Appendix Y, Section 2.27.1

⁴ This UPS architecture does not provide both over and under-voltage corrective functions like those in voltage independent and voltage and frequency independent systems.

⁵ 10 CFR 430, Subpart B, Appendix Y, Section 2.27.3

⁶ An output voltage tolerance band narrower than input voltage window shall be defined by the manufacturer. The output of the VI UPS is dependent on ac input frequency and the output voltage shall remain within prescribed voltage limits (provided by additional corrective voltage functions, such as those arising from the use of active and/or passive circuits).

- 63 3) Voltage and Frequency Independent (VFI)⁷: A UPS where the device remains in normal mode
64 producing an ac output voltage and frequency that is independent of input voltage and frequency
65 variations and protects the load against adverse effects from such variations without depleting the
66 stored energy source.
- 67 F) Single-normal-mode UPS: A UPS that functions in Normal Mode within the parameters of only one
68 set of input dependency characteristics. For example, a UPS that functions only as VFI.
- 69 G) Multiple-normal-mode UPS: A UPS that functions in Normal Mode within the parameters of more than
70 one set of input dependency characteristics. For example, a UPS that can function as either VFI or
71 VFD.
- 72 H) Bypass: Power path alternative to the ac converter.
- 73 1) Maintenance Bypass (path): Alternative power path provided to maintain continuity of load power
74 during maintenance activities.
- 75 2) Automatic Bypass: Power path (primary or stand-by) alternative to the indirect ac converter.
- 76 a) Mechanical Bypass: control is via a switch with mechanically separable contacts.
- 77 b) Static Bypass (electronic bypass): control is via an electronic power switch, for example
78 transistors, thyristors, triacs or other semiconductor device or devices.
- 79 c) Hybrid Bypass: control is via switch with mechanically separable contacts in combination
80 with at least one controlled electronic valve device.
- 81 I) Reference Test Load: Load or condition with a power factor of greater than 0.99 in which the output
82 of the UPS delivers the active power (W) for which the UPS is rated.⁸
- 83 J) Unit Under Test (UUT):
- 84 1) For UPSs capable of operating at 115 V and 60 Hz that use National Electrical Manufacturer
85 Association (NEMA) 1-15P or 5-15P plug⁹: The combination of the UPS and battery being
86 tested¹⁰.
- 87 2) For all other UPSs: The UPS undergoing the test, configured as though for shipment to the
88 customer, and including any accessories (e.g., filters or transformers) necessary to meet the
89 test setup as specified in Section 3 of the ENERGY STAR Test Method.
- 90 K) Power Factor: Ratio of the absolute value of active power P to the apparent power S .
- 91 L) Product Family: A group of product models that are (1) made by the same manufacturer, (2) subject
92 to the same ENERGY STAR certification criteria, and (3) of a common basic design. For UPSs,
93 acceptable variations within a product family include:
- 94 1) Number of installed modules;
- 95 2) Redundancy;
- 96 3) Type and quantity of input and output filters;
- 97 4) Number of rectifier pulses;
- 98 5) Energy storage system capacity;
- 99 6) For any diesel coupled rotary UPS, the diesel engine's make, model, and capabilities may vary. If
100 sold in the US, the engine of the representative model must meet the requirements in Section 3.5
101 below; and

⁷ 10 CFR 430, Subpart B, Appendix Y, Section 2.27.2

⁸ 10 CFR 430, Subpart B, Appendix Y, Section 2.24

⁹ 10 CFR 430, Subpart B, Appendix Y, Section 1, reworded

¹⁰ 10 CFR 430, Subpart B, Appendix Y, Section 2.28, reworded

102 7) Software or jumper settings that affect rated output power.

103 M) Abbreviations:

104 1) A: Ampere

105 2) ac: Alternating Current

106 3) dc: Direct Current

107 4) DRUPS: Diesel coupled rotary UPS

108 5) RUPS: Rotary UPS

109 6) THD: Total Harmonic Distortion

110 7) UPS: Uninterruptible Power Supply

111 8) UUT: Unit Under Test

112 9) V: Volt

113 10) VFD: Voltage and Frequency Dependent

114 11) VFI: Voltage and Frequency Independent

115 12) VI: Voltage Independent

116 13) W: Watt

117 14) Wh: Watt-hour

118 2 SCOPE

119 2.1 Included Products

120 2.1.1 Products that meet the definition of an Uninterruptible Power Supply (UPS) as specified herein
121 including Static and Rotary UPSs and Ac-output UPSs and Dc-output UPSs/Rectifiers are eligible
122 for ENERGY STAR certification, with the exception of products listed in Section 2.2. Products
123 eligible for certification under this specification include:

124 i) Consumer UPSs intended to protect desktop computers and related peripherals, and/or home
125 entertainment devices such as TVs, set top boxes, DVRs, Blu-ray and DVD players;

126 ii) Commercial UPSs intended to protect small business and branch office information and
127 communication technology equipment such as servers, network switches and routers, and
128 small storage arrays;

129 i) Data Center UPSs intended to protect large installations of information and communication
130 technology equipment such as enterprise servers, networking equipment, and large storage
131 arrays; and,

132 ii) Telecommunications Dc-output UPSs/Rectifiers intended to protect telecommunication
133 network systems located within a central office or at a remote wireless/cellular site.

134 2.2 Excluded Products

135 2.2.1 Products that are covered under other ENERGY STAR product specifications are not eligible for
136 certification under this specification. The list of specifications currently in effect can be found at
137 www.energystar.gov/products.

138 2.2.2 The following products are not eligible for certification under this specification:

- 139 i. Products that are internal to a computer or another end-use load (e.g., battery-
140 supplemented internal power supplies or battery backup for modems, security systems,
141 etc.);
- 142 ii. Industrial UPSs specifically designed to protect critical control, manufacturing, or
143 production processes or operations;
- 144 iii. Utility UPSs designed for use as part of electrical transmission and distribution systems
145 (e.g. electrical substation or neighborhood-level UPSs);
- 146 iv. Cable TV (CATV) UPSs designed to power the cable signal distribution system outside
147 plant equipment and connected directly or indirectly to the cable itself. The “cable” may be
148 coaxial cable (metallic wire), fiber-optic, or wireless (e.g., “Wi-Fi”);
- 149 v. UPSs designed to comply with specific UL safety standards for safety-related applications,
150 such as emergency lighting, operations or egress, or medical diagnostic equipment; and,
- 151 vi. UPSs designed for mobile, ship board, marine or airborne applications.
- 152 vii. Hybrid UPSs that can deliver more than 10% of their rated output power through both ac
153 and dc outputs.

154 3 CERTIFICATION CRITERIA

155 3.1 Significant Digits and Rounding

- 156 3.1.1 Unless otherwise specified, all calculations shall be carried out with actual measured (unrounded)
157 values and only the final result of a calculation shall be rounded.
- 158 3.1.2 Unless otherwise specified, compliance with specification limits shall be evaluated using exact
159 values without any benefit from rounding.
- 160 3.1.3 Calculated efficiency values shall be rounded to the third decimal place, as specified in Section
161 4.3.5 of Appendix Y to Subpart B of 10 CFR 430.
- 162 3.1.4 Directly measured or calculated values that are submitted for reporting on the ENERGY STAR
163 website shall be rounded to the nearest significant digit as expressed in the corresponding
164 specification limit.

165 **Note:** EPA proposes to extend the Department of Energy (DOE) rounding rule to all products—not just
166 those within the scope of the DOE test procedure. This will avoid confusion from having two sets of
167 rounding rules for interpreting the specification. EPA is expressing this rounding rule in terms of the
168 decimal place rather than as a percentage, which is consistent with ENERGY STAR specification
169 nomenclature. In addition, EPA has clarified the statement in Section 3.1.1 that it applies in the absence
170 of the DOE rounding rule.

171 3.2 Energy Efficiency Requirements for Ac-output UPSs

- 172 3.2.1 Single-normal-mode UPSs: Average loading-adjusted efficiency (Eff_{AVG}), as determined per
173 Appendix Y to Subpart B of 10 CFR 430, or if not applicable, as calculated per Equation 1, shall
174 be greater than or equal to the Minimum Average Efficiency Requirement (Eff_{AVG_MIN}), as
175 determined per Table 2, for the specified rated output power and input dependency characteristic.

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Equation 1: Calculation of Average Efficiency for Ac-output UPSs and High-voltage Dc-output UPSs

$$Eff_{AVG} = t_{25\%} \times Eff|_{25\%} + t_{50\%} \times Eff|_{50\%} + t_{75\%} \times Eff|_{75\%} + t_{100\%} \times Eff|_{100\%}$$

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Where:

- Eff_{AVG} is the average loading-adjusted efficiency,
- $t_{n\%}$ is the proportion of time spent at the particular $n\%$ of the Reference Test Load, as specified in the loading assumptions in Table 1, and
- $Eff|_{n\%}$ is the efficiency at the particular $n\%$ of the Reference Test Load, as measured according to the ENERGY STAR Test Method.

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Table 1: Ac-output UPS Loading Assumptions for Calculating Average Efficiency

Rated Output Power, P , in watts (W)	Input Dependency Characteristic	Proportion of Time Spent at Specified Proportion of Reference Test Load, $t_{n\%}$			
		25%	50%	75%	100%
$P \leq 1500 \text{ W}$	VFD	0.2	0.2	0.3	0.3
	VI or VFI	0	0.3	0.4	0.3
$1500 \text{ W} < P \leq 10,000 \text{ W}$	VFD, VI, or VFI	0	0.3	0.4	0.3
$P > 10,000 \text{ W}$	VFD, VI, or VFI	0.25	0.5	0.25	0

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Table 2: Ac-output UPS Minimum Average Efficiency Requirement

Minimum Average Efficiency Requirement (Eff_{AVG_MIN}), Where:			
<ul style="list-style-type: none"> • P is the Rated Output Power in watts (W), • E_{MOD} is an allowance of 0.004 for Modular UPSs applicable in the commercial 1500–10,000 W range, • \ln is the natural logarithm; and • The requirement shall be rounded to the third decimal place for certification and reporting. 			
Rated Output Power	Input Dependency Characteristic		
	VFD	VI	VFI
$P \leq 350 \text{ W}$	$5.71 \times 10^{-5} \times P + 0.962$	$5.71 \times 10^{-5} \times P + 0.964$	$0.011 \times \ln(P) + 0.824$
$350 \text{ W} < P \leq 1500 \text{ W}$	0.982	0.984	
$1500 \text{ W} < P \leq 10,000 \text{ W}$	$0.981 - E_{MOD}$	$0.980 - E_{MOD}$	$0.0145 \times \ln(P) + 0.800 - E_{MOD}$
$P > 10,000 \text{ W}$	0.970	0.940	$0.0058 \times \ln(P) + 0.886$

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Note: In response to the Draft 2 proposal, EPA received multiple comments requesting that the Agency consider staging this revision such that the proposed levels would be relaxed in this version and a second specification revision would further increase stringency once the anticipated, new DOE standards go into effect. The Agency appreciates this suggestion, but continues to believe that the proposed levels are currently achievable by an adequate selection of products and a single specification process saves partner and government resources.

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In this Final Draft, EPA retained its original assumptions used for determining efficiency requirements as presented as part of Draft 2. EPA has also applied the DOE rounding rule to the requirements and expanded its dataset with additional models certified over the past year to ensure the most recent products in the market are captured as part of its analysis and confirmed that the requirements previously proposed in Draft 2 continue to recognize the top performing models in the market and will continue to do so after the anticipated publication of the DOE Final Rule.

202 After considering stakeholder feedback regarding the lack of models available at the proposed levels,
203 EPA has moved the breakpoint for the VFD and VI low-power sloped requirement lines from 300 W to
204 350 W and decreased the VFD < 350 W and the VI 1500 W < P ≤10,000 W requirements. These changes
205 have allowed for the incorporation of additional product to allow for additional consumer choice. The other
206 requirements remain unchanged from Draft 2.

207 3.2.2 Multiple-normal-mode UPSs that Do Not Ship with the Highest Input Dependency Mode Enabled
208 by Default: If the Multiple-normal-mode UPS does not ship with its highest input dependency
209 mode enabled by default, its average loading-adjusted efficiency (Eff_{AVG}), as calculated per
210 Equation 1, shall be greater than or equal to:

211 i. The Minimum Average Efficiency Requirement (Eff_{AVG_MIN}), as determined per Table 2, for
212 the rated output power and lowest input dependency mode provided by the UPS.

213 3.2.3 Multiple-normal-mode UPSs that Ship with the Highest Input Dependency Mode Enabled by
214 Default: If the Multiple-normal-mode UPS does ship with its highest input dependency mode
215 enabled by default, its average loading-adjusted efficiency (Eff_{AVG}), as calculated per Equation 2,
216 shall be greater than or equal to:

217 i. The Minimum Average Efficiency Requirement (Eff_{AVG_MIN}), as determined per Table 2 for
218 the rated output power and lowest input dependency mode provided by the UPS.

219 **Equation 2: Calculation of Average Efficiency for Multiple-normal-mode Ac-output UPSs**

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$$Eff_{AVG} = 0.75 \times Eff_{LOW} + 0.25 \times Eff_{HIGH}$$

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222 *Where:*

- 223 ▪ Eff_{AVG} is the average loading-adjusted efficiency,
- 224 ▪ Eff_{LOW} is the average loading-adjusted efficiency in
225 the lowest input dependency mode (i.e., VFI or VI), as
226 calculated per Equation 1, and
- 227 ▪ Eff_{HIGH} is the average loading-adjusted efficiency in
228 the highest input dependency mode (i.e., VFD), as
229 calculated per Equation 1.

230 **3.3 Energy Efficiency Requirements for Dc-output UPSs/Rectifiers**

231 3.3.1 High-voltage Dc-output UPSs: Average loading-adjusted efficiency (Eff_{AVG}) for High-voltage Dc-
232 output UPSs/Rectifiers, as calculated per Equation 1, shall be greater than or equal to the
233 Minimum Average Efficiency Requirement (Eff_{AVG_MIN}), in Table 3, subject to the following
234 requirement.

235 i. High-voltage Dc-output UPSs shall be treated as VFI when referencing Table 1.

236 3.3.2 Low-voltage Dc-output UPSs/Rectifiers: Average loading-adjusted efficiency (Eff_{AVG}) for Low-
237 voltage Dc-output UPSs/Rectifiers, as calculated per Equation 3 shall be greater than or equal to
238 the Minimum Average Efficiency Requirement (Eff_{AVG_MIN}), in Table 3. This requirement shall
239 apply to complete systems and/or individual modules. Manufacturers can qualify either, subject to
240 the following requirements:

241 i. Complete systems that are also modular shall be certified as Modular UPS Product
242 Families with a particular model of module installed,

243 ii. Certification of individual modules will have no bearing on the certification of modular
244 systems unless the entire systems are also certified as specified above.

245 **Equation 3: Calculation of Average Efficiency for Low-voltage Dc-output UPSs**

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$$Eff_{AVG} = \frac{Eff|_{30\%} + Eff|_{40\%} + Eff|_{50\%} + Eff|_{60\%} + Eff|_{70\%} + Eff|_{80\%}}{6}$$

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**Table 3: High Voltage Dc-output UPS and Low-voltage Dc-output UPS/Rectifier
Minimum Average Efficiency Requirement**

Minimum Average Efficiency Requirement (Eff _{AVG_MIN})
0.955

249 **3.4 Power Factor Requirements**

250 3.4.1 The measured input power factor at 100 percent of the Reference Test Load shall meet the
251 minimum level specified in Table 4: UPS Minimum Input Power Factor Requirement for all VFI
252 and VI Normal Modes required for certification.

253 **Table 4: UPS Minimum Input Power Factor Requirement**

Minimum Power Factor Requirement
0.90

254 **3.5 Diesel Coupled Rotary UPS Emissions Requirements**

255 3.5.1 Diesel coupled rotary UPS systems intended for sale in the US must demonstrate that their diesel
256 engines are in compliance with Clean Air Act regulations, 40 CFR part 60 subpart IIII. Compliance
257 shall be demonstrated via presentation of a certificate of conformity with this regulation at the time
258 of certification.

- 259 i. Systems intended for sale outside the US are not subject to this requirement.
- 260 ii. Only the representative model(s) for testing, as specified in Section 4.2, shall demonstrate
261 compliance with Clean Air Act regulations.

262 **4 TESTING**

263 **4.1 Test Methods**

264 4.1.1 When testing UPSs, the test methods identified in Table 5 shall be used to determine ENERGY
265 STAR certification.

266 **Table 5: Test Methods for ENERGY STAR Certification**

Product Type	Test Method
UPSs capable of operating at 115 V and 60 Hz that use NEMA 1-15P or 5-15P plug	Uniform Test Method for Measuring the Energy Consumption of Battery Chargers incorporated in Appendix Y to Subpart B of 10 CFR 430, Section 4: Testing Requirements for Uninterruptible Power Supplies
All other UPSs	ENERGY STAR Test Method for Uninterruptible Power Supplies, Rev. Nov-2017

267 **4.2 Number of Units Required for Testing**

268 4.2.1 Representative Models shall be selected for testing by either the sampling requirements defined
269 in 10 CFR 429.25, which references 10 CFR 429.11, or the following requirements:

- 270 i. For certification of an individual product model, a product configuration equivalent to that
271 which is intended to be marketed and labeled as ENERGY STAR is considered the
272 Representative Model;
- 273 ii. For certification of a Modular UPS Product Family where models vary by number of
274 installed modules or Product Family where models vary by software or jumper settings that
275 affect rated output power, the manufacturer shall select the maximum and minimum
276 configurations to serve as Representative Models—i.e., the system shall meet the eligibility
277 criteria in both its maximum and minimum non-redundant configurations. If the maximum
278 and minimum configuration Representative Models meet the ENERGY STAR certification
279 criteria at their respective output power levels, all intermediate configuration models within
280 a Modular or software- or jumper-set UPS Product Family may be certified to ENERGY
281 STAR.
- 282 iii. For certification of a UPS Product Family where the models are related by a characteristic
283 other than the number of installed modules or software or jumper settings, the highest
284 energy using configuration within the Product Family shall be considered the
285 Representative Model with the exception of energy storage system variations—the
286 manufacturer may select any energy storage system for the test, within the requirements of
287 the ENERGY STAR Test Method. Other products within a Product Family do not have to
288 be tested for certification, but they are expected to meet relevant ENERGY STAR
289 certification criteria and may be subject to verification testing sometime after initial
290 certification.

291 4.2.2 A single unit of each Representative Model shall be selected for testing.

292 4.2.3 All tested units shall meet ENERGY STAR certification criteria.

293 **5 EFFECTIVE DATE**

294 5.1.1 Effective Date: The Version 2.0 ENERGY STAR UPS specification shall take effect on **October**
295 **1, 2018**. To qualify for ENERGY STAR, a product model shall meet the ENERGY STAR
296 specification in effect on its date of manufacture. The date of manufacture is specific to each unit
297 and is the date on which a unit is considered to be completely assembled.

298 5.1.2 Future Specification Revisions: EPA reserves the right to change this specification should
299 technological and/or market changes affect its usefulness to consumers, industry, or the
300 environment. In keeping with current policy, revisions to the specification are arrived at through
301 stakeholder discussions. In the event of a specification revision, please note that the ENERGY
302 STAR certification is not automatically granted for the life of a product model.

303 **6 CONSIDERATIONS FOR FUTURE REVISIONS**

304 6.1.1 Communications Criteria: EPA will continue to monitor the market and consider use-cases for
305 UPS connected capabilities, such as demand response, that can save energy or help balance
306 grid loads. If a U.S. market for grid-connected demand response capable UPSs starts to develop,
307 EPA may reconsider including optional connected functionality criteria.