ENERGY STAR Test Procedure for Determining the Power Use of Small Network Equipment

First Draft
December 7, 2009

Note: This draft test procedure is intended for stakeholder review of EPA's initial proposal for testing small network equipment. It will be the basis for a December 10th stakeholder online meeting. EPA's primary goals for this document are to generate feedback on the structure of the test procedure, proposed revisions, and areas for clarification. EPA will review feedback from the stakeholder online meeting and incorporate feedback as necessary into a second draft of this document. EPA will provide an additional period of time during December and January for stakeholders to review and comment on the second draft.

Early questions, comments, and feedback should be forwarded to networking@energystar.gov.

1. Overview

The following protocol shall be followed when testing products for compliance with the ENERGY STAR Version 1.0 Small Network Equipment (SNE) specification.

2. Applicability

Products must be tested with hardware and software in the default "as-shipped" configuration, unless otherwise specified in this document.

Note: Consistent with other ENERGY STAR programs, all testing will be conducted with SNE configured as it ships by default to customers unless specific instruction in the test setup requires otherwise. EPA includes this requirement to ensure that any energy-saving features impacting testing mirrors the features likely to be utilized by the customer.

3. Definitions

Unless otherwise specified, all terms used in this test procedure are consistent with the definitions in the Version 1.0 ENERGY STAR Eligibility Criteria for Small Network Equipment.

Note: Definitions will ultimately be included in section 1 of the SNE specification. Unless otherwise specified, all other terms used in this document are consistent with the definitions contained in the Small Network Equipment Framework Document.

Below are additional terms referenced in this draft test procedure. These definitions, along with other stakeholder suggestions, will be included in the SNE specification definitions section as the test procedure is incorporated into a draft specification.

- UUT: An acronym for "unit under test," which in this case refers to the network equipment being tested.
- WLAN Test Client: A WLAN client is a device that is capable of establishing an 802.11x link with an AP and sending and receiving data to and from the AP.

4. Test Setup

4.1. Quality Control

EPA recommends that all testing be conducted in facilities that follow quality control guidelines specified in ISO/IEC 17025, and that all test equipment be annually calibrated by an accredited laboratory.

Note: The quality control language above is referenced in other ENERGY STAR specifications. This recommendation is intended to provide stakeholders with guidance on laboratory capabilities likely to be applied in testing of SNE.

4.2. Reporting

a) Power Measurements: All power figures shall be reported in watts, accurate to the second decimal place. For loads greater than or equal to 10 W, three significant figures shall be reported.

4.3. Instrumentation

Note: The Power Analyzer, Measurement Accuracy, and Test Condition requirements reference provisions for IEC 62301, *Household electrical appliances – Measurement of standby power*. These requirements are widely applied for ENERGY STAR testing where measurement of low power levels is required.

a) Power Analyzer[1]: Power analyzers used for testing must meet the following requirements:

1. Current crest factor of > 3 throughout the rated operating range. Analyzers that do not specify current crest factor must be capable of measuring a current spike of at least 3 times the maximum amperage measured during any 1-second sample;
2. Frequency response of at least 3 kHz;
3. Power resolution of 1 mW or better; and
4. Lower bound on the current range of 10mA or less.

In addition to the above requirements, the following attributes are recommended:

1. Calibration with a standard traceable to the U.S. National Institute of Standards and Technology (NIST); and
2. Capable of averaging power measurements over any user selected time interval (this is usually done with an internal calculation dividing accumulated energy by time within the analyzer, which is the most accurate approach); or capable of integrating energy over any user selected time interval and integrating with a resolution of 1 second or less.

b) Measurement Accuracy: Measurements of power of 0.5 W or greater shall be made with an uncertainty of less than or equal to 2% at the 95% confidence level. Measurements of power of less than 0.5 W shall be made with an uncertainty of less than or equal to 0.01 W at the 95% confidence level. The power measurement instrument shall have a resolution of:

1. 0.01 W or better for power measurements of 10 W or less;
2. 0.1 W or better for power measurements of greater than 10 W up to 100 W; and
3. 1 W or better for power measurements of greater than 100 W.

[1] *Characteristics of approved meters taken from IEC 62301 Ed 1.0: Measurement of Standby Power*

c) Test Conditions

Table 1: Test Conditions

Supply Voltage	**Maximum Power**	**≤1.5 kW**	**> 1.5 kW**
	North America/Taiwan:	115 (± 1%) V ac, 60 Hz (± 1%)	115 (± 4%) V ac, 60 Hz (± 1%)
	Europe/Australia/New Zealand:	230 (± 1%) V ac, 50 Hz (± 1%)	230 (± 4%) V ac, 50 Hz (± 1%)
	Japan:	100 (± 1%) V ac, 50 Hz (± 1%)/60 Hz (± 1%)	100 (± 4%) V ac, 50 Hz (± 1%)/60 Hz (± 1%)
	China	220 (± 1%) V ac, 50 Hz (± 1%)	220 (± 4%) V ac, 50 Hz (± 1%)
Total Harmonic Distortion (THD) (Voltage)		< 2% THD	< 5% THD
Ambient Temperature	23°C ± 5°C		
Relative Humidity	10 – 80 %		

References:

- IEC 62301: Household Electrical Appliances – Measurement of Standby Power, Sections 4.2, 4.3, 4.4;

4.4. Data Source/Transfer Requirements

A network traffic generator shall be used to simulate traffic and monitor the reliability of links. The generator shall be configured for the correct traffic topology and traffic profile, and as follows:

1. All data transfers shall occur via TCP;
2. The “data rate” shall be defined as the total average bits per second passing over a link in both directions. Data rates shall be expressed as the rate of data in the TCP data frame;
3. The test traffic used shall contain random data in a variety of packet sizes based on an internet traffic mix (IMIX) sent in random intervals. See references for more information;
4. The data shall be evenly split between the two data directions for a given link unless specified otherwise in this test procedure;
5. Port numbers shall be randomized from the available pool of TCP ports.

Table 2: Data Source/Transfer References

References	Description
http://spcprev.spirentcom.com/documents/4079.pdf	Spirent, Test Methodology Journal, IMIX (Internet Mix) Journal, March 2006
http://www.ixiacom.com/library/test_plans/display?skey=testing_pppox	IXIA Library: Test Plans, Broadband PPPoX and L2TP Testing

5. UUT Configuration

5.1. Supplied Power Configuration

1. Mains-powered: Power consumption of UUT shall be measured and tested from an ac source to the UUT.
2. Low-voltage Dc Powered: For products powered by standard low-voltage dc (e.g. Power over Ethernet [IEEE 802.3af or .3at], or USB), a commercially available device (e.g. PoE power injector or powered USB hub) shall be used, with the brand and model of the device recorded. This device shall be considered the external power supply for the unit for this test. If a standard low-voltage dc supply is shipped with the UUT, it must be used in testing. If the UUT manufacturer sells an appropriate standard low-voltage dc supply, then a model from the UUT manufacturer must be used.

Note: An alternative to the above would be to measure the dc power directly, and multiply this by some factor to account for typical ac-dc conversion losses. The above approach is proposed as it simplifies the test procedure.

5.2. Wired Port UUT Configuration

Only Ethernet ports are considered network ports in 4.4 above. Ethernet connectivity and all other wired ports shall be configured for testing as follows:

1. Data Connections: Non-Ethernet wired ports (e.g. USB, analog connections, POTS, audio), shall not be connected, unless a secondary device and cable are shipped with the UUT (e.g. an external disk with a USB connection).
2. Network Link Maintenance: The UUT's WAN port shall be connected to a live source. Network links shall be continuously maintained, disregarding brief lapses when transitioning between link speeds.
3. Ethernet Port Connection Rate: Ethernet ports shall be connected at the maximum supported link rate unless specified otherwise in this test procedure.
4. Ethernet Cabling: Ethernet cables used in testing shall be 2 meters in length.
5. Power over Ethernet (PoE): PoE capability shall be configured in the default setting as it is shipped to the customer.
6. Efficient Networking Protocols: If the device supports IEEE 802.3az, the connected devices must also support it; if it supports LLDP for .3az, the connected devices must also support it.

Note: EPA intends to include other wired LAN physical layers as they reach the market to a sufficient degree.

5.3. Wireless UUT Configuration

1. Wireless network conditions:
   - i. Random SSID;
   - ii. 128-bit WPA2 encrypted network;
   - iii. 5 GHz band for IEEE 802.11n networks;
   - iv. 2.4 GHz band for IEEE 802.11g networks;
   - v. An appropriate channel for the network (support OFDM over DSSS over FHSS if configurable); and

vi. Interference robustness or other interference mitigation technology turned on.

Note: EPA is considering the following conditions for a wireless test client serving the UUT. Using a single wireless client connected over fixed attenuation cable(s) is an attempt for a simple, consistent test environment. EPA is interested in industry comment on standard testing practices for wireless APs as well as suggestions on the best way to test AP energy use.

Wireless testing shall be done with a single WLAN Test Client.

1. Cable connected;
2. Set attenuation set to 70dB ± 1dB;
3. Set the client to forward traffic from and to the traffic generator (see 4.5 below);
4. For devices supporting multiple antennas, connect a cable between each antenna port and a corresponding port on the WLAN client;
5. For devices supporting multiple hardwired antennas, connect a cable between each test port and a corresponding port on the WLAN client.

5.4. UUT Network Settings:

1. Enable Network Address Translation (NAT) for IPv4 networks;
2. Enable IPv6 Link Local, Neighbor Solicitation, Neighbor Discovery, Router Solicitation and Router Advertisement

Note: This condition is intended to provide local IPv6 functionality inside IPv4 gateway scenario.

3. Enable Single Class C Subnet;
4. Enable single hop (router TTL + 1) to source on WAN side;
5. Enable DHCP and assign each configured test client an address by the DHCP service in the router, or assign one in a manner typical of DHCP;
6. IPsec shall not be enabled.

5.5. UUT Preparation

1. Record the manufacturer and model name of the UUT. Also record all basic information about the UUT's configuration.
2. Connect the UUT to network resources as follows (the UUT must maintain live links in all specified connections for the duration of testing):
    a. Modem (DSL, Cable, or ONT):
        i. Connect the UUT's WAN port to a live source at the maximum supported link rate.
        ii. Connect one LAN port to a test client. If more than one connectivity option is available including Ethernet, the Ethernet port must be used.

    b. Wired Switch/Router:
        i. Connect two of the UUT's available ports to a test client and ensure that live links are maintained throughout testing on both connections.
        ii. If one UUT port is identified as the uplink or WAN port, it must be one of the two ports connected for testing.

    c. Access Point:

i. Connect the uplink port to a test WAN source and ensure that an active link is maintained.

d. IHAD (DSL, Cable, or ONT):
   i. Connect the WAN port to a live source at the maximum supported link rate.

3. Connect the power analyzer or analyzers to an ac or dc voltage source set to the appropriate voltage and frequency for the test.

4. Plug the UUT into the measurement power outlet on the power analyzer, as follows:
   a. No other devices – e.g. power strips or UPS units – may be connected between the meter and the UUT;
   b. If the UUT uses an external power supply (EPS), the EPS is considered part of the UUT. Plug the EPS input into the measurement power outlet on the meter;
   c. The power analyzer shall remain connected until all testing is complete.

5. Record the ac voltage and frequency.

6. Allow the UUT to reach its fully ready state (all required links active).

6. Test Procedure

6.1. Procedure Structure

The test procedure is composed of a common section plus additional sections that are used only for certain product types. All SNE products shall complete section A plus any other applicable sections in order and as shown in the following table.

Table 3: Test Procedure Structure

	6.2. All	6.3. Modems	6.4. Wired	6.5. Wireless
Modem	X	X		
IHAD	X	X	X	X
Wired Switch / Router	X		X	
Wireless Router	X			X
Wired/Wireless	X		X	X

If a procedure step specifies a transfer rate unsupported in *either* direction, that step shall be skipped.

If a procedure step specifies a transfer rate supported in *only one* direction, record the maximum transfer rate for that direction and complete the procedure step using that rate in the supported direction, only.

6.2. Power Measurement Procedure

The following procedure shall be used for each test component in Section 6.3 below.

1. Reset the power analyzer (if necessary).
2. Begin recording elapsed time.
3. Set the analyzer to begin accumulating true power values at an interval of greater than or equal to 1 reading per second.
4. Accumulate power values for 5 minutes and record the average (arithmetic mean) value observed during that 5 minute period.
5. Record the test procedure step and measurements on the test report. If a step is repeated at an additional link rate, provide the additional measurements in the test report in an additional column labeled with the link rate for that column.

Note: EPA will provide a test report template to all stakeholders in the format requested above. Consistent with data collection efforts for other ENERGY STAR product areas, a single test report template will be used during specification development.

6.3. Tests

a) All Devices

Note: This test is the base level test of the device in the minimum configuration without passing data.

1. Measure the power of the device in the initial configuration as per 6.2 above.

b) Modems and ONTs (including IHADs)

Note: This section is intended to test the modem functionality of the device. The intent of tests at different utilization levels is to determine if utilization impacts power consumption. A logarithmic set of port throughputs is used to ensure broad coverage of device capability.

1. Connect one LAN port if the device currently only has a WAN connection (IHADs only). Ensure the Ethernet ports are connected at their highest supported link rate. Measure the power consumption as per 6.2 above.
2. Run data at 1.0 Mb/s (0.5 Mb/s in each direction) between the WAN and LAN ports. Measure the power consumption as per 6.2 above.
3. Run data at 10 Mb/s (5 Mb/s in each direction) between the WAN and LAN ports. Measure the power consumption as per 6.2 above.
4. Run data at 100 Mb/s (50 Mb/s in each direction) between the WAN and LAN ports. Measure the power consumption as per 6.2 above.
5. Run data at 1000 Mb/s (500 Mb/s in each direction) between the WAN and LAN ports. Measure the power consumption as per 6.2 above.
6. If the Ethernet port in use is supporting 1 Gb/s link rate, repeat section b with the port set for a 100 Mb/s link rate.

c) Wired Switches (including IHADs)

Note: EPA anticipates that scaling the data transfer rate in this procedure will demonstrate the power savings attainable through use of IEEE 802.3az at 1 Gb/s.

Test with minimum ports used.

1. Ensure device has two connected LAN ports. Ensure the Ethernet ports are connected at their highest supported link rate. Measure the power consumption as per 6.2 above
2. Run data at 1.0 Mb/s (0.5 Mb/s in each direction) between the LAN ports. Measure the power consumption as per 6.2 above.
3. Run data at 10.0 Mb/s (5.0 Mb/s in each direction) between the LAN ports. Measure the power consumption as per 6.2 above.
4. Run data at 100 Mb/s (50.0 Mb/s in each direction) between the LAN ports. Measure the power consumption as per 6.2 above.
5. Run data at 1000 Mb/s (500 Mb/s in each direction) between the LAN ports. Measure the power consumption as per 6.2 above.

Test with half of ports used.

6. If the device has more than two Ethernet ports, connect half of the Ethernet ports (rounding up if an odd number of total ports). Connect each port sequentially (a 5 port product would have ports 1-3 connected and 4, 5 disconnected). The Ethernet or other LAN ports must be connected at their highest supported link rate. If the device specifies an uplink port, the device specified port must be one of the used ports; otherwise, the first port is the uplink port. Measure the power consumption as per 6.2 above.
7. Run data at 1.0 Mb/s (0.5 Mb/s in each direction) between the LAN ports. Measure the power consumption as per 6.2 above.
8. Run data at 10.0 Mb/s (5.0 Mb/s in each direction) between the LAN ports. Measure the power consumption as per 6.2 above.
9. Run data at 100 Mb/s (50.0 Mb/s in each direction) between the LAN ports. Measure the power consumption as per 6.2 above.
10. Run data at 1000 Mb/s (500 Mb/s in each direction) between the LAN ports. Measure the power consumption as per 6.2 above.

Test with all ports used.

11. Connect all Ethernet ports. The Ethernet ports must be connected at their highest supported link rate. If the device specifies an uplink port, the device specified port must be one of the used ports; otherwise, the first port is the uplink port. Measure the power consumption as per 6.2 above.
12. Run data at 1.0 Mb/s (0.5 Mb/s in each direction) between the LAN ports. Measure the power consumption as per 6.2 above.
13. Run data at 10.0 Mb/s (5.0 Mb/s in each direction) between the LAN ports. Measure the power consumption as per 6.2 above.
14. Run data at 100 Mb/s (50.0 Mb/s in each direction) between the LAN ports. Measure the power consumption as per 6.2 above.
15. Run data at 1000 Mb/s (500 Mb/s in each direction) between the LAN ports. Measure the power consumption as per 6.2 above.
16. If these test have been run using links supporting 1 Gb/s traffic, repeat section c) with all links set to support 100 Mb/s traffic.

d) **Devices with Wireless Connectivity**

Note: The wireless tests are intended to target the general set of 802.11x APs.

1. Ensure only one LAN port is connected to the UUT. Ensure the Ethernet port is connected at its highest supported link rate. If the device specifies an uplink port, the device specified port must be used; otherwise the first port must be used. The WLAN must be configured for the highest supported link rate. Record the supported rate for the network port, the wireless link and the version of 802.11 being used for this test. Measure the power consumption as per 6.2 above.
2. Run data at 0.1 Mb/s (0.05 Mb/s in each direction) between the LAN port and the WLAN client. Measure the power consumption as per 6.2 above.
3. Run data at 1.0 Mb/s (0.5 Mb/s in each direction) between the LAN port and the WLAN client. Measure the power consumption as per 6.2 above.

4. Run data at 10 Mb/s (5 Mb/s in each direction) between the LAN port and the WLAN client. Measure the power consumption as per 6.2 above.
5. Run data at 100 Mb/s (50 Mb/s in each direction) between the LAN port and the WLAN client. Measure the power consumption as per 6.2 above.
6. Repeat section d) for each supported version of 802.11x at the highest supported link rate for that version.

7. Reporting

7.1. Data Reporting Requirement

The test results shall be reported to EPA or the European Commission, as appropriate, taking care to ensure that all required information has been included.

7.2. Required Information

The following characteristics shall be reported.

1. Manufacturer and model name
2. Basic information about the configuration

Note: EPA intends to further develop this section in future versions of the test procedure. At this time, EPA anticipates that UUT type, UUT physical connection options, and UUT supported wireless standards would be among the characteristics required for reporting.

As referenced in the power measurement procedure, EPA intends to develop a data collection form to accompany the test procedure that will provide the required recording format for all included tests.