ENERGY STAR® Program Requirements
Product Specification for
Large Network Equipment

Preliminary Approach For
Determining Energy Efficiency
Rev. Oct-2012

1 OVERVIEW

The following test method shall be used for determining product compliance with requirements in the ENERGY STAR Eligibility Criteria for Large Network Equipment (LNE).

> **Note:** This document outlines a proposed approach that is consistent with relevant industry test procedures. It contains several noteboxes which identify specific issues that DOE is seeking comment on. Additionally, DOE welcomes comments from stakeholders on any ambiguities, suggested revisions, or concerns with the proposed test method. As the process moves forward, DOE will be working with manufacturers to view how they perform LNE testing, and will be reaching out to all stakeholders to have more in-depth conversations about the test method.

2 APPLICABILITY

The proposed test method shall be used to determine the energy efficiency of all products under the ENERGY STAR Product Specification for Large Network Equipment. Large Network Equipment is defined in this test method in section 3.B)4).

> **Note:** EPA and DOE have determined that the specification for LNE will be drafted when the LNE Test Method is nearly final. Therefore, the Applicability (Scope) of both the test method and the specification will be discussed during development of the test method.
>
> DOE has developed a preliminary LNE definition for discussion, proposed in section 3.B) 4). DOE is seeking feedback on ways to appropriately identify certain classes of network equipment as Large Network Equipment, i.e., as opposed to Small Network Equipment.

3 DEFINITIONS

Unless otherwise specified, all terms used in this document are consistent with the definitions in the ENERGY STAR Eligibility Criteria for Large Network Equipment Version 1.0 Draft 1.

> **Note:** For initial discussion, the acronyms and definitions below have been included in the test method. The entire definitions section will be moved to the eligibility criteria upon development of the Version 1.0 Draft 1 specification.
>
> DOE has reviewed the ATIS and ECR Initiative test procedures for LNE and has tentatively decided to utilize applicable sections of these documents in this Preliminary Approach. DOE has determined that the definitions contained within the referenced publications are consistent and has therefore incorporated definitions from ATIS and the ECR Initiative into this section.
>
> DOE requests comment on the applicability, consistency and clarity of the proposed definitions.

A) Acronyms and Units:

   1) ac: Alternating Current

2) ATIS: Alliance for Telecommunications Industry Solutions
3) bps: Bits per second
4) C: Celsius
5) dc: Direct Current
6) DOE: U.S. Department of Energy
7) ECR: Energy Consumption Rating
8) EPA: U.S. Environmental Protection Agency
9) Gbps: Gigabits per second
10) Hz: Hertz
11) IMIX: Internet Mix
12) NDR: Non-Drop Rate
13) OSI: Open Systems Interconnection
14) PDU: Power Distribution Unit
15) PSU: Power Supply Unit
16) RMS: Root Mean Square
17) TEER: Telecommunications Energy Efficiency Ratio
18) UPS: Uninterruptible Power Supply
19) UUT: Unit Under Test
20) V: Volts
21) W: Watt

B) Definitions:

1) Computer Network: A network of data processing nodes that are interconnected for the purpose of data communication.
2) Idle State: A state of operation in which the product is powered on, ready to pass traffic, but is not currently passing traffic.
3) Internet Mix (IMIX) Traffic: A stateless traffic profile that contains a mixture of frame sizes statistically similar to a composition observed in the Internet[1].
4) Large Network Equipment: Network Equipment that is rack-mounted, intended for use in standard equipment racks, or contains more than eleven (11) ports for wired network.
5) Maximum Demonstrated Throughput: The highest achievable system throughput at Non-Drop Rate, measured in bits per second (bps).
6) Network Device: A single functional unit of network equipment.
7) Network Equipment: A category of electronically powered devices which organize and schedule the coherent transmission of data within a single, or between at least two, computer networks.
8) Non-Drop Rate (NDR): The observed system throughput at which no packet drops are recorded.
9) Port Throughput: The sustained rate of traffic (in bps) passing through a port in either direction, including the minimally needed line overhead.
10) Port Utilization: The port throughput expressed as a percentage of its theoretical maximum.

[1] For further information regarding IMIX, refer to Spirent Communications – Test Methodology Journal: IMIX (Internet Mix) Journal, March 2006.

11) Router: A network device that determines the optimal path along which network traffic should be forwarded as its primary function. Routers forward packets from one network to another based on network layer information.

12) Switch: A network device that filters, forwards, and floods frames based on the destination address of each frame as its primary function. The switch operates at the data link layer of the Open Systems Interconnection (OSI) model.

13) System Throughput: Sum of link-rate throughput on all system ports in the egress direction (bps), including all protocol overhead.

14) System Utilization: The system throughput expressed as a percentage of the system's theoretical maximum.

15) Traffic Profile: The statistical distribution of the size/type of the data packet load sent through equipment under test.

16) Unit Under Test (UUT): The network equipment device being tested.

4 TEST SETUP

A) Input Power: Input power shall be as specified in Table 1 and Table 2. The frequency for input power shall be as specified in Table 3.

Table 1: Input Power Requirements for Products with Nameplate Rated Power Less Than or Equal to 1500 W

Product Type/Market	Supply Voltage	Voltage Tolerance	Maximum Total Harmonic Distortion
North America, Taiwan, Europe, Australia, New Zealand	230 V ac and/or 115 V ac	+/- 1.0 %	2.0 %
Optional Testing Conditions For Ac-Dc Japanese Market	100 V ac		
Dc systems*	48 V dc	+/- 1.0 V	
	380 V dc	+/- 4.0 V	

Table 2: Input Power Requirements for Products with Nameplate Rated Power Greater Than 1500 W

Product Type/Market	Supply Voltage	Voltage Tolerance	Maximum Total Harmonic Distortion
North America, Taiwan, Europe, Australia, New Zealand	230 V ac and/or 115 V ac	+/- 4.0 %	5.0 %
Optional Testing Conditions For Ac-Dc Japanese Market	100 V ac		
Dc systems*	48 V dc	+/- 1.0 V	
	380 V dc	+/- 4.0 V	

**Note: The voltage requirement for dc systems covers both positive and negative ground systems.*

Table 3: Input Frequency Requirements for All Products

Supply Voltage	Frequency	Frequency Tolerance
100 V ac	50 Hz or 60 Hz	+/-1.0%
115 V ac	60 Hz	
230 V ac	50 Hz or 60 Hz	

B) Ambient Temperature: Ambient temperature shall be within 23 °C ± 5 °C over the duration of the test.

C) Relative Humidity: Relative humidity shall be within 15% and 80%.

D) Power Meter: The power meter shall report true Root Mean Square (RMS) power and at least two of the following measurement units: voltage, current, and power factor. Power meters shall possess the following attributes:

1) Calibration: The meter shall have been calibrated within a year of the test date, by a standard traceable to National Institute of Standards and Technology (USA) or a counterpart national metrology institute in other countries.

2) Crest Factor: An available current crest factor of 3 or more at its rated range value. For analyzers that do not specify the current crest factor, the analyzer must be capable of measuring an amperage spike of at least 3 times the maximum amperage measured during any 1 second sample.

3) Minimum Frequency Response: 3.0 kHz.

4) Minimum Resolution:

a) 0.01 W for measurement values less than 10 W;

b) 0.1 W for measurement values from 10 W to 100 W; and

c) 1.0 W for measurement values greater than 100 W.

5) Logging: The meter must be capable of reading and logging at least 1 set of power measurements per second, and each measurement shall be recorded in watts. Each recorded data point shall be an average of the measured power, using a data averaging interval that is equal to the time period between each subsequent power measurement.

6) Measurement Accuracy: The measurement uncertainty introduced by the instrument that measures the input power supplied to the product under test, including any external shunts, must adhere to the following standards:

a) Power measurements with a value greater than or equal to 0.5 W shall be made with an uncertainty of less than or equal to 2% at the 95% confidence level.

b) Power measurements with a value 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

E) Traffic Generator/Analyzer: All data ports on the UUT shall be connected to a traffic generator/analyzer for the full test duration.

Note: Sections 4.E), 5.1.F), and 5.2.D) of this test method state that all data ports on the UUT must be connected to the traffic generator/analyzer during testing. DOE recognizes that this configuration may not be representative of how LNE is connected during normal operation, and is requesting stakeholder feedback regarding the number of UUT data ports used during testing. Specifically, how many ports should be connected during testing? How does the number of connected ports affect LNE performance and power consumption?

1) Number of Ports: The traffic generator/analyzer shall have a total number of properly functioning ports which is equal to or greater than the total number of data ports on the UUT.

2) Data Format: The traffic generator/analyzer shall be capable of generating test data which are correctly formatted for processing by the UUT.

a) Available Packet Sizes: The traffic generator/analyzer shall be capable of generating test data with packet sizes in the range of 28 Bytes to 1500 Bytes.

b) Generated Packet Size Statistical Distribution: The traffic generator/analyzer shall be capable of generating test data consisting of packet sizes whose generation frequency is statistically described by the Accurate IMIX distribution, defined in Table 4.

i. Ranged Packet Sizes: The last three rows of this table represent a range of packet sizes. Any size within the indicated range shall be generated with equal (uniform) probability if a packet is to be generated from one of these rows.

Example: There is a 10.8% chance that a packet will be generated with a size within the range of 40 and 80 Bytes. If a packet with a size in this range is to be generated, all sizes from 40 to 80 will have an equal chance of being generated. Therefore, the overall probability that a packet will be generated that is 55 Bytes long is: (10.8% / 41) ≈ 0.26%.

Note: DOE understands that the costs to acquire a traffic generator/analyzer capable of generating Accurate IMIX traffic with enough ports to support full capacity testing can be high. DOE is interested in stakeholder feedback on other possible methods for generating network traffic that are representative of normal operation. DOE is also interested in feedback on test setups other than a single traffic generator/analyzer that can support full capacity testing.

Table 4: Accurate IMIX Packet Distribution[2]

Packet Size (Bytes)	Proportion of Total Generated Packets	Proportion of Total Generated Bandwidth
28	1.20%	0.08%
40	35.50%	3.51%
44	2.00%	0.22%
48	2.00%	0.24%
52	3.50%	0.45%
552	0.80%	1.10%
576	11.50%	16.40%
628	1.00%	1.50%
1420	3.00%	10.50%
1500	10.00%	37.10%
40 – 80 (range)	10.80%	1.60%
80 – 576 (range)	11.80%	9.60%
576 – 1500 (range)	6.90%	17.70%

Note: DOE is proposing the use of an IMIX traffic model for testing Large Network Equipment. An IMIX traffic model is a statistical cross-section of the packet sizes, in bytes, which are generated during testing. Each IMIX traffic model will dictate the probability that a packet of a certain byte length will be generated at a port at any given point in time.

DOE is presently considering the use of IMIX traffic models listed in Annex C IMIX Traffic of ATIS – 0600015.03.200. This document contains three tables, each of which describes the statistical cross section of measured internet packet sizes at a different level of granularity. The three tables represent "Simple IMIX", "Complete IMIX (informative)", and "Accurate IMIX (informative)", which when compared to realistic Internet traffic have correlation values of 0.892, 0.985, and 0.999 respectively. DOE is presently considering the use of the Accurate IMIX due to its high correlation with realistic internet traffic, but is seeking feedback from stakeholders as to whether this would constitute "normal use" for Large Network Equipment.

The last three rows of Table 4 specify a range of possible packet size values that can be generated. As it is currently written in ATIS, the ranges are 40-80, 80 to 576, and 576 to 1500. This indicates that the packet sizes of 80 and 576 are counted twice. If the Accurate IMIX traffic model is used, DOE proposes that ranges be rewritten as: 40 to 79, 80 to 575, and 576 to 1500. This minor modification would divide the packet sizes into three non-overlapping ranges. DOE requests comment on this proposal.

3) Throughput: The traffic generator/analyzer shall be capable of generating, transmitting to, receiving from, and analyzing test data on all connected ports at a rate exceeding the UUT's maximum rated throughput.

  a) Throughput Incremental Granularity: The traffic generator/analyzer shall be capable of increasing and decreasing the data throughput transmitted to all the UUT's connected ports

[2] "Table C.3: Accurate IMIX (Informative)", Annex C: IMIX Traffic, ATIS – 0600015.03.2009

by an incremental amount that is equal to or less than 1% of the UUT's maximum rated throughput.

> **Note:** DOE is requesting stakeholder feedback on whether 1% of maximum rated throughput is an appropriate load increment requirement for testing.

4) Data Recording: The traffic generator/analyzer shall be capable of accurately measuring and recording the test data throughput at each UUT port to verify that the correctly specified test data throughput is consistently applied to each port during testing.

5 TEST CONDUCT

5.1 Active Mode Efficiency Test Configuration

Power and efficiency shall be tested and reported for the Large Network Equipment being tested. Testing shall be conducted as follows:

A) As-shipped Condition: Products shall be tested in their "as-shipped" configuration, which includes both hardware configuration and system settings, unless otherwise specified in this test method.

> **Note:** DOE recognizes that many LNE may require configuration prior to first use. Therefore, DOE requests stakeholder feedback on whether it is reasonable to expect manufacturers to ship devices in a "ready-to-function" state. Specifically, DOE is requesting information on initial configuration setup for different types of LNE products.

B) Measurement Location: All power measurements shall be taken at a point between the ac or dc power source and the UUT.

C) Air Flow Management: Any air flow directly surrounding the UUT during testing shall only be generated by fans or cooling devices that are standard components of the UUT. The use of external fans or cooling devices to purposefully direct air at, or away from, the UUT during testing is prohibited.

> **Note:** The Air Flow Management requirement is included to clarify that external cooling equipment, such as localized air fans directed at the UUT, are not permitted. However, DOE recognizes that large data center equipment is generally cooled to avoid overheating the components and data center space.
>
> DOE has specified an ambient temperature requirement during testing (Section 4.B)). DOE is requesting feedback on if the specification in Section 4.B) is sufficient, or if additional air flow specification(s) is(are) necessary. If additional specifications are necessary, DOE requests specifics, supported by literature references.

D) Power Supplies: All power supply units (PSUs) must be connected and operational.

1) UUTs with Multiple PSUs: All power supplies must be connected to the ac or dc power source and operational during the test. If necessary, a Power Distribution Unit (PDU) may be used to connect multiple power supplies to a single source. If a PDU is used, any overhead electrical use from the PDU shall be included in the power measurement of the UUT. When the UUT is a specific module in a modular (or racked) system, any unused power supplies shall be disconnected.

E) Power Management: All power management and/or power-saving features available on the UUT shall be disabled during testing.

1) The entire Large Network Equipment Test Method may be voluntarily repeated with power management and/or power-saving features enabled.

Note: DOE recognizes that LNE may be commonly designed with optional power management and/or power-saving features. When enabled, these features may configure the system to operate in a mode which consumes less energy. LNE designed with power-saving features may require advanced configuration before it can be used. There may also be many available combinations of power-saving modes available on each LNE. In order to provide a more consistent test method, DOE is proposing that power-saving options be disabled during testing. This ensures that all LNE are compared at the same base-line operating mode. DOE requests stakeholder feedback on whether power management and/or power-saving features are commonly available in LNE, what functions these features perform, and if these features are enabled by default when shipped.

DOE proposes that the test method can be voluntarily repeated with power management and/or power-saving features enabled if such features are available.

F) I/O and Network Connection: All UUT ports shall be in an active state and passing or ready to pass traffic. All ports shall be connected to the traffic generator/analyzer for the entirety of the test.

   1) System Configuration Ports: Any port on the UUT which is solely intended for infrequent device configuration may be left disconnected during testing.

G) Workload Generation: A traffic generator/analyzer conforming to the requirements listed in section 4.E) shall be used to simulate traffic and collect the performance-related results according to the test conditions. Configure the traffic generator/analyzer for the correct traffic workload and traffic profile based on the data in Table 4.

5.2 UUT Preparation

A) Record the UUT manufacturer, model name, and configuration details including, but not limited to, number of ports, port throughput, additional built in interface ports, and number of fans.

B) If the UUT is a rack device, install it in a test rack. If the UUT is not a rack device, place it in a stable location where it will not be disturbed. Once set up, the UUT shall not be physically moved until testing is complete.

   1) If the UUT is a blade switch, then the UUT shall be populated in the first slot (i.e. slot #1) of the blade chassis and shall not be physically moved until testing is complete.

Note: DOE is interested in feedback from stakeholders on the proposed test configuration of blade switches. DOE is also interested in information regarding other possible types of Large Network Equipment in the market which use the blade form factor. What other factors need to be taken into consideration when testing blade-based equipment as opposed to standard rack-mount equipment?

C) Configure the traffic generator/analyzer for the correct traffic workload and profile as described in section 4.E).

D) Connect all UUT ports to the traffic generator/analyzer in either the full mesh topology or the dual-group partial mesh topology based on its product class using Table 5 or Table 6.

   1) Full mesh topology shall be used when each of the UUT's ports are designed to perform equal roles and are capable of handling the same traffic bandwidth. During testing, traffic is permitted between all ports on the UUT. Example equipment that may be tested using this topology include core routers and carrier Ethernet switches.

      Note: Full mesh topology is defined as "T1 (full mesh)" in Appendix C of ECR Initiative – Network and Telecom Equipment – Energy and Performance Assessment Draft 3.0.1, December 14, 2010

   2) Dual-group partial mesh topology shall be used when the UUT's ports can be functionally partitioned into two groups, with all ports in either group capable of performing equal roles and handling the same traffic bandwidth. During testing, traffic is not permitted between any ports on the UUT which are in the same functionally partitioned group. Example equipment that may be tested using this topology includes edge routers and access routers.

Note: Dual-group partial mesh topology is defined as “T2 (dual-group partial mesh)” in Appendix C of ECR Initiative – Network and Telecom Equipment – Energy and Performance Assessment Draft 3.0.1, December 14, 2010.

Table 5: Class Definitions and Connection Topologies for Routers[3]

Class	Topology
Access Router	*TBD*
Edge Router	Dual-Group Partial Mesh
Core Router	Full Mesh

Table 6: Class Definitions and Connection Topologies for Ethernet Switches[3]

Class	Topology
Access or High Speed Access Switch	*TBD*
Distribution/ Aggregation Switch	Dual-Group Partial Mesh
Core Switch	Full Mesh
Data Center Switch	Full Mesh

Note: DOE is interested in receiving feedback on whether the proposed topologies are representative of LNE connections in normal operation. Stakeholders are also encouraged to comment on other topologies that could be used to connect the UUT to the traffic generator/analyzer. Furthermore, are the qualifications outlined in the ECR Initiative document clear enough to determine which topology to use when testing a given UUT?

DOE would like to point out that the term *TBD* in Table 5 and Table 6 indicate that there presently no designated topology for the Access router/switch class. DOE is interested in receiving feedback on what sort of topology would be appropriate for testing an Access router and an Access switch.

E) Connect the UUT to an appropriate ac or dc voltage source using the following guidelines:

1) No uninterruptible power supply (UPS) units shall be connected between the power meter and the UUT;

2) The power meter shall remain connected until all testing is complete;

3) Power values shall be recorded from the power meter in a way that is consistent with the requirements in section 4.D)5) of this document.

F) Verify that the UUT is configured in its as-shipped configuration.

G) Record the input root mean square (rms) voltage and input frequency.

[3] Appendix C of ECR Initiative – Network and Telecom Equipment – Energy and Performance Assessment Draft 3.0.1, December 14, 2010

6 TEST PROCEDURES FOR ALL PRODUCTS

6.1 Power and Efficiency Testing

A) Power on the UUT, either by switching it on or connecting it to mains power.

B) Let the UUT stabilize for 15 minutes.

> **Note:** ATIS requires a minimum UUT warm-up/stabilization time of 15 minutes, while the ECR Initiative requires at least 4 hours to settle potential temperature and humidity differences, before testing. DOE is interested in receiving stakeholder feedback on the benefits provided by a four hour stabilization requirement, compared to a 15 minute stabilization requirement.
>
> In order to minimize the total testing time, DOE is proposing a stabilization time of 15 minutes, based on the ATIS test procedure. DOE is interested in receiving feedback as to whether this is an appropriate amount of time required for most LNE to power on, complete any boot/test sequences, and reach temperature equilibrium.

C) Qualification: Determine the maximum load (L_{max}) that can be sustained at Non-Drop Rate (NDR). Any method may be used to obtain this value, but the method used shall be reported. There is no time limit for this run. The run is complete after L_{max} is determined. Record L_{max}.

D) The following tests shall be completed in the order specified and shall have no greater than 300 seconds idle time between them.

1) Full Load:

a) Apply L_{max} , obtained in section 6.1C) to the UUT for 15 minutes.

b) Record power values over the entire 15 minute test period.

c) Calculate and report the average power value (P_{100}).

2) Low Utilization:

a) Determine the low utilization percentage (U%) for the UUT, as defined in Table 5 for Routers and in Table 6 for Switches. Determination of U% is dependent upon the UUT product type and class.

> **Note:** The ATIS test procedure currently defines qualitative product classes for LNE, based largely on the product's application/end-use.
>
> For testing, DOE is interested in classifying LNE using more consistent and quantitative methods. DOE requests stakeholder feedback on alternate, quantitative methods by which to classify different types of LNE for testing..

b) Calculate and report the low utilization throughput (L_u), by multiplying L_{max} and U% ($L_u = U\% * L_{max}$)

c) Run the test for 15 minutes.

d) Record power values for the entire 15 minute period.

e) Calculate and report the average value (P_u).

Table 7: Class Definitions, TEER calculation parameters, and load parameters for Routers[4]

Class	Partial-Utilization (U%)	Weight Multipliers[5] a, b, c
Access Router	10	a=0.10; b=0.80; c=0.10
Edge Router	10	a=0.15; b=0.75; c=0.10
Core Router	30	a=0.10; b=0.80; c=0.10

Table 8: Class Definitions, TEER calculation parameters, and load parameters for Ethernet[6] **Switches**

Class	Partial-Utilization (U%)	Weight Multipliers[5] a, b, c
Access or High Speed Access Switch	10	a=0.10; b=0.80; c=0.10
Distribution/ Aggregation Switch	10	a=0.15; b=0.75; c=0.10
Core Switch	30	a=0.15; b=0.75; c=0.10
Data Center Switch	30	a=0.10; b=0.80; c=0.10

Note: DOE is interested in stakeholder feedback regarding whether the utilization levels provided in in Tables 7 and 8 are representative of normal operation. DOE is also interested in feedback on any additional utilization levels that should be tested.

3) Idle:

a) Remove the load by idling the packet rate on all configured ports record power values for 15 minutes. Load reduction shall not be achieved by disconnecting or shutting down ports.

b) Calculate and report the average value (P_{idle}).

E) If packet loss occurs during any of the tests specified in section 6.1 E), F), and G), the UUT must be retested beginning with section 6.1C).

[4] Table 1, Section 5.2 of the ATIS-0600015.03.2009 standard
[5] Weight multipliers used in 7.A) Equation 1
[6] Table 2, Section 5.2 of the ATIS-0600015.03.2009 standard

7 METRIC

A) The Telecommunications Energy Efficiency Ratio shall be calculated and reported as follows:

Equation 1: TEER Metric Calculation

$$\boldsymbol{TEER} = \frac{\boldsymbol{L_{max}}}{\boldsymbol{a} * \boldsymbol{P}_{\mathbf{idle}} + \mathbf{b} * \boldsymbol{P}_{\mathbf{u}} + \mathbf{c} * \boldsymbol{P}_{\mathbf{100}}}$$

Where:

Where:

- *a, b, and c are weight coefficients selected such that* $a + b + c = 1$
  - *Appropriate values are specified in Tables* 5 *and* 6
- L_{max} *is the maximum throughput of the UUT (Gbps)*
  - *Defined in section 6.1.C)*
- P_{100} *is the power consumption during the Full Load Test (W)*
  - *Defined in section 6.1.D)1)*
- P_u *is the power consumption during the Low Utilization Test (W)*
  - *Defined in section 6.1.D)2)*
- P_{idle} *is the power consumption during the Idle Test (W)*
  - *Defined in section 6.1.D)3)*

Note: Additional information about the TEER calculation and a, b, c can be found in section 5.2 “TEER Metric Definition” of the ATIS-0600015.03.2009 standard.

The ECR Initiative proposes a similar metric, called the Energy Consumption Rating (ECR), as well as two variations on this metric: ECR-Variable Load (ECR-VL) and ECR-Extended Idle (ECR-EX). The ECR variation, shown in Equation 2, is most similar to TEER. A comparison of the TEER and ECR-VL metrics is shown in Table 9.

Equation 2: ECR-VL Metric Calculation

$$ECR\text{-}VL = \frac{a * P_{100} + \mathbf{b} * P_{50} + \mathbf{c} * P_{30} + \mathbf{d} * P_{10} + \mathbf{e} * P_{\mathrm{idle}}}{a * L_{\max} + \mathbf{b} * L_{50} + \mathbf{c} * L_{30} + \mathbf{d} * L_{10}}$$

Table 9: Comparison of TEER and ECR-VL Metrics

Metric	TEER	ECR-VL
Unit used for metric	Gigabits-per-second per watt (Gbps/W)	Watts per gigabit-per-second (W/Gbps)
Utilization levels corresponding to the power consumption measurements included in the metric	100%, [10% or 30%], 0%	100%, 50%, 30%, 10%, 0%
Weighting applied to power consumption measurements used to calculate metric	All power measurements are weighted based on product class (a, b, c)	All power measurements are weighted based on product class (a, b, c, d, e)
Utilization levels corresponding to the throughputs included in the metric	100%	100%, 50%, 30%, 10%
Weighting applied to utilization levels measurements used to calculate metric	No weighting applied to throughput	All throughputs are weighted based on product class (a, b, c, d)

DOE is proposing the use of TEER in the Preliminary Approach since it requires fewer weight-constants and focuses more specifically on a utilization level for each product class. This will simplify determination of the required weight-constants, create greater test consistency within each product class, and reduce overall testing time. DOE requests feedback from stakeholders on the proposed TEER metric. Specifically, does TEER provide a more representative efficiency metric than ECR-VL?

8 REFERENCES

A) Alliance for Telecommunications Industry Solutions (ATIS) – 0600015.03.2009 Energy Efficiency for Telecommunication Equipment: Methodology for Measurement and Reporting for Router and Ethernet Switch Products.

B) ECR Initiative – Network and Telecom Equipment – Energy and Performance Assessment Draft 3.0.1, December 14, 2010.

C) Spirent Communications – Test Methodology Journal: IMIX (Internet Mix) Journal, March 2006.