Verizon NEBS™ Compliance: Energy Efficiency Requirements for Telecommunications Equipment

Verizon Technical Purchasing Requirements

VZ.TPR.9205

Issue 4, August 2009

CHANGE CONTROL RECORD:

Version	Date	Action*	Reason for Revision
1	*6/5/2008*	New	New document.
2	*6/12/2008*	Add	Added text to describe weighting values
3	*9/23/2008*	Add	Added baseline values for BTS equipment Added Point-to-point Microwave requirements Added Set Top Box requirements
4	*8/7/2009*	Add	Power equipment category expanded to include inverts and converters Add Media Gateway category Update External Power Adapter section Add ONT Power Supplies to CPE section

* **New, Add, Delete, Change, Reissue**

Trademark Acknowledgement – NEBS is a trademark of Telcordia Technologies, Inc.

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1.0 PURPOSE

The purpose of this Technical Purchasing Requirement (TPR) document is to provide a Telecommunications Equipment Energy Efficiency Rating (TEEER) methodology for procuring equipment assemblies used in Verizon's telecommunications networks. The intent is to foster the creation of more energy efficient telecommunications equipment by Verizon's supplier community thereby reducing the energy requirements in Verizon networks.

2.0 SCOPE

This TPR document provides the test methodology for calculating the TEEER to be used by Verizon in evaluating the supplier's equipment. This methodology is applicable to but not limited to shelf, frame and cabinet mounted DC powered network equipment to be installed in environmentally controlled environments and equipment located at the customer premises. AC powered customer premises equipment (CPE) and AC powered data center type equipment shall also be covered in this TPR.

3.0 REFERENCES

GR-63-CORE	NEBS™ Requirements: Physical Protection
VZ.NEBS.TE.NPI.2004.015	TCG Network Equipment Building Systems (NEBS) Compliance Checklist
	ENERGY STAR® Program Requirements for External Power Supplies Version 2.0
	ENERGY STAR® Program Requirements for Set-Top Boxes Version 2.0
	Power and Performance – SPECpower_ssj2008™ Version 1.00

4.0 ACRONYMS

BBU	Battery Back-up Unit
BTS	Base Transceiver Subsystem
CPE	Customer Premises Equipment
DSLAM	Digital Subscriber Line Access Multiplexer
EUT	Equipment Under Test
OLT	Optical Line Termination
ONT	Optical Network Terminal
OPSU	ONT Power Supply Unit
STB	Set-Top Box
TEEER	Telecommunication Equipment Energy Efficiency Rating
TPR	Technical Purchasing Requirement

5.0 DEFINITIONS

5.1 TEEER
A calculated value representing the energy efficiency rating of a specific product.

5.2 Forwarding Capacity
The number of bits per second that a device can be observed to transmit successfully to the correct egress interface.

5.3 Nameplate Output Power (P_{no})
The manufacturer stated output power for AC-DC or AC-AC adapters provided on the power adapter nameplate.

5.4 P_{max}
The measured input power with the EUT operating at maximum load.

5.5 P_{sleep}
The measured input power of the EUT while operating in a sleep/no activity mode.

5.6 P_{Total}
The weighted total input power to be used in the formation of the TEEER value.

5.7 P_{50}
The measured input power of the EUT while operating at 50% of maximum load.

5.8 SPECpower_ssj2008™
SPEC benchmark that evaluates the power and performance characteristics of volume server class computers.

5.9 Throughput
The number of bits passing through the data communication system expressed in bits per second.

5.10 TPR
Verizon document defining the minimum requirements for the purchase of telecommunications equipment for NEBS compliance.

6.0 EXAMPLES OF EQUIPMENT TYPES

The following list provides examples of types of equipment that this TPR document covers. Other equipment not specifically listed will also be required to be tested to this document where applicable.

Transport

- Optical Transport System
- Video Transport System
- Point-to-point Microwave Transport

Switch/Router

- Digital Switch
- Soft Switch
- Enterprise Router
- Core Router
- Edge Router
- Backbone Router
- Feature Application Router

Gateways

- Media Gateway

Access

- DSLAM
- OLT

Power

- Rectifiers
- Converters
- Inverters
- Uninterruptable Power Supply

Data Center Equipment

- Servers

CPE

- External Power Adapters
- Set-Top Boxes
- ONT Power Supplies

Wireless

- Power Amplifiers

7.0 SPATIAL REQUIREMENTS

This document supersedes all other documents with respect to equipment sizing in Verizon's network. Verizon requires equipment minimally meet the heat dissipation values as defined in GR-63-CORE Section 4.1.6.

In order to mitigate high-density equipment and promote energy efficiency, Verizon will accept equipment with the following maximum nominal sizes within the Switching Office.

Height = 7 feet
Width = 23 inches (typical rack width)
Depth = 42 inches

8.0 GENERAL CONDITIONS FOR MEASUREMENT

8.1 General

Testing is to be performed at or witnessed by a Verizon approved ITL as found on the Verizon NEBS webpage www.verizonnebs.com .

8.2 Environmental Criteria

8.2.1 Temperature

The equipment shall be evaluated at a temperature of 25°C ±3ºC

8.2.2 Humidity

The equipment shall be evaluated at a relative humidity of 30% to 75%

8.2.3 Pressure

The equipment shall be evaluated at site pressure between 860 to 1060 mbar

8.3 Test Equipment and Set-up

Power measurements shall be made with a suitably calibrated voltmeter and ammeter, or power analyzer. The power measurement instrument shall have a resolution of 0.1W or better for active power. Power measurements shall be taken immediately adjacent to the powered product being evaluated. Support equipment shall be provided to verify proper operation of the equipment under test.

8.4 Test Voltage

8.4.1 DC Powered Equipment

The input to the EUT shall be at a DC voltage of –53V ±0.25.
Equipment using voltages other than -48Vdc shall be evaluated at ±0.25 of its nominal voltage.

8.4.2 AC Powered Equipment

The input to the EUT shall be the specified voltage ±1% and the specified frequency ±1%.

9.0 MEASUREMENT APPROACH

9.1 Utilization Conditions

EUT shall be configured as a typical installation for Verizon. The equipment shall be fully loaded with all card slots populated with functioning modules and all redundancies in place. The equipment shall have all cables installed as in a typical deployment. All system functions or features that increase power consumption shall be activated during testing. If the equipment has any energy saving features that are controlled by internal software then they should be enabled for testing. The EUT shall be tested at the following utilization conditions:

Table 1: Utilization Conditions for EUT

Percentage of Utilization	
Utilization Condition 1	100%
Utilization Condition 2	50%
Utilization Condition 3	0%

Utilization Condition 1 shall be defined by the equipment manufacturer and based on the type of equipment to represent a 100% duty cycle.
Utilization Condition 2 shall represent a 50% duty cycle.
Utilization Condition 3 shall represent a 0% duty cycle. The equipment will be powered but performing no useful work (idle/sleep mode).

*Note – For Power equipment, please refer to the utilization conditions is Section 9.4.2

9.2 Testing Sequence

With the equipment configured as stated above, the EUT shall be operated at 100% utilization for at least 15 minutes prior to conducting power measurements.

After the 15 minute initialization period, the EUT input power shall be monitored as outlined in Section 8.3 to assess the stability of the EUT. If the power level does not drift by more than 5% from the maximum value observed, the EUT can be considered stable and the measurements can begin.

With the equipment operating under normal maximum power conditions, record the average input power to the equipment under test over a 15-minute time period for Utilization Condition 1. This value shall be recorded as P_{max}.

Repeat power input measurements for Utilization Condition 2 and Utilization Condition 3 and record these values at P_{50} and P_{sleep} respectively.

The total power consumption for the EUT shall be represented by the weighting formula

$P_{Total} = (0.35 \times P_{max}) + (0.4 \times P_{50}) + (0.25 \times P_{sleep})$

Where P_{max} is the average power measured during Utilization Condition 1, P_{50} is the average power measured during Utilization Condition 2 and P_{sleep} is the average power measured during Utilization Condition 3.

9.3 Weighting Values

Verizon assigned weighting values to accommodate for the variable utilization of equipment in each duty cycle. Because typical telecommunications equipment in the field does not run at a constant duty cycle rate it was necessary to assign the values in the weighting formula listed in Section 9.2. Each weighting has been assigned a specific value based on Verizon's knowledge and experience of the operations of telecommunications equipment within its network. Typical Switching equipment runs nearest to the 50% utilization point and thus was given the greatest weighting in the formula. Although most telecommunications equipment does not have an idle/sleep mode, a relatively high weighting value was given as this may be the area of greatest savings in terms of reduced power consumption.

9.4 Power Equipment

9.4.1 General

Equipment is to be configured as would be for a typical Verizon deployment. Input power measurements shall be taken immediately adjacent to the input terminals. Output measurements shall be taken from the main output distribution bus. Breakers and fuses shall not be included for the calculations and measurements.

9.4.2 Power Utilization Levels

Power Equipment testing will be performed at utilization levels of 100% and 50%.

$P_{Out\ Total} = (P_{Out\ max} + P_{Out\ 50})/2$

$P_{In\ Total} = (P_{In\ max} + P_{In\ 50})/2$

10.0 TEEER FORMULATION

10.1 TEEER Formulas

The total average power, P_{Total}, calculated from above, will be used in the calculation of the TEEER. Using the type of equipment that most closely resembles the equipment tested calculate the TEEER for the given system.

Table 2 TEEER Formulas

Equipment Type	TEEER Formula
Transport	-log(P_{Total} / Throughput)
Switch/Router	-log(P_{Total} / Forwarding Capacity)
Media Gateway	-log(P_{Total} / Throughput)
Access	(Access Lines / P_{Total}) + 1
Power	($P_{Out\ Total}$ / $P_{In\ Total}$) x 10
Power Amplifiers (Wireless)	(Total RF Output Power / Total Input Power) x 10

Note: Round the TEEER value to the nearest hundredth decimal point

The TEEER value calculated as described above is a number that represents an energy efficiency rating on a scale of 1 to 10, with 1 representing the lowest energy efficiency rating and 10 representing the highest.

10.2 Examples of TEEER Formulations

Transport

Throughput = 40 Gbps
P_{max} = 1,000 W
P_{50} = 950 W
P_{sleep} = 900 W

P_{Total} = (0.35 x 1000) + (0.4 x 950) + (0.25 x 900) = 955 W

TEEER = -log (P_{Total} / Throughput)
= -log (955 / 40,000,000,000)
= -log (0.000000023875)
= 7.62

Switch/Router

Forwarding Capacity = 160 Gbps
P_{max} = 4,320 W
P_{50} = 3,000 W
P_{sleep} = 1,500 W

P_{Total} = (0.35 x 4320) + (0.4 x 3000) + (0.25 x 1500) = 3,087 W

TEEER = -log (P_{Total} / Forwarding Capacity)
= -log (3087 / 160,000,000,000)
= -log (0.00000001929375)
= 7.71

Access

Access Lines = 284
P_{max} = 120 W
P_{50} = 80 W
P_{sleep} = 40 W

P_{Total} = (0.35 x 120) + (0.4 x 80) + (0.25 x 40) = 84 W

TEEER = (Access Lines / P_{Total}) + 1
= (284 / 84) + 1
= 4.38

Power

$P_{Out\ max}$ = 800 W
$P_{Out\ 50}$ = 400 W
$P_{In\ max}$ = 844 W
$P_{In\ 50}$ = 462 W
$P_{Total\ Out}$ = (800 + 400)/2 = 600
$P_{Total\ In}$ = (838 + 462)/2 = 650

TEEER = ($P_{Total\ Out}$ / $P_{Total\ In}$) x 10
= (600 / 650) x 10
= 9.23

Power Amplifiers (Wireless)

Sectors = 3
Carriers = 8
RF Output Power/Carrier, measured at the input of the Antenna P1= 20.0W
Input Power/Watt of output power P2 = 11.425W
Total Input Power for 3 Sector, 8 Carriers Amplification = Sectors x Carriers x P1 x P2
= 3 x 8 x 20 x 11.425 W
= 5484W
Total RF Output Power for 3 Sector, 8 Carriers = Sectors x Carriers x P1
= 3 x 8 x 20 W
= 480W

TEEER = (Total RF Output Power / Total Input Power) x 10
= 480 / 5458 x 10
= 0.875

10.3 Verizon's Minimum TEEER Pass/Fail Requirements

The TEEER value calculated from above shall meet the minimum TEEER value allowable as defined in Table 3.

The below pass/fail criteria are based on averages of typical equipment located in Verizon equipment spaces with an additional 20% improvement value.

Table 3 Pass/Fail Criteria

Equipment Type	Minimum TEEER Allowable
Transport	7.54
Optical and Video	7.54
Point-to-Point Microwave	5.75
Switch/Router	7.67
Media Gateway	6.54
Access	2.50
Power	9.20
Rectifier	9.20
Converter	9.10
Inverter	9.00
Power Amplifier (Wireless)	1.05

11.0 DATA CENTER EQUIPMENT

Server type equipment shall be tested using the methods and procedures as defined in the SPECpower_ssj2008™ specification. The value derived from SPECpower_ssj2008™ will be used in the formula provided below to arrive at a TEEER value for that server. In order to calculate the SPECpower_ssj2008™ value, this benchmark program must be obtained from the website www.spec.org . SPECpower_ssj2008™ is the first industry-standard SPEC benchmark that evaluates the power and performance characteristics of volume server class computers. The initial benchmark addresses the performance of server side Java.

Table 4 Server TEEER Formation

Equipment Type	TEEER Formula
Server	(SPECpower_ssj2008™) / 100

The TEEER value calculated from above shall meet the minimum TEEER value allowable as defined in Table 5.

The below pass/fail criteria are derived from average results published by SPEC for test runs of SPECpower_ssj2008™ with an additional 20% improvement value.

Table 5 Pass/Fail Criteria

Equipment Type	Minimum TEEER Allowable
Server	6.53

12.0 CPE EQUIPMENT

12.1 External Power Adapters

Customer premises equipment that is supplied with either an AC-to-AC adapter or AC-to-DC adapter shall follow the methods and procedures of the most current version of the ENERGY STAR® requirements for external power adapters. ENERGY STAR® requirements for external power supplies can be found at the following website (www.energystar.gov). An external power supply model must meet or exceed a minimum average efficiency for Active Mode, which varies based on the model's nameplate output power.

- Calculate the model's single average Active Mode efficiency value by testing at 100%, 75%, 50% and 25% of rated current output and then computing the simple arithmetic average of these four values as specified in the Energy Star Test Method.
- Based on the model's nameplate output power, select the appropriate equation from Table 6 and calculate the minimum average efficiency.
- Compare the model's actual average efficiency is greater than or equal to the minimum average efficiency, the model has satisfied the requirement

Table 6: Energy-Efficiency Criteria for Ac-Ac and Ac-Dc External Power Supplies in Active Mode: Standard Models

Nameplate Output Power (P_{no})	Minimum Average Efficiency in Active Mode (expressed as a decimal)
0 to ≤ 1 watt	≥ 0.480 x P_{no} + 0.140
> 1 to ≤ 49 watts	≥ [0.0626 x Ln (P_{no})] + 0.622
> 49 watts	≥ 0.870

Table 7: Energy-Efficiency Criteria for Ac-Ac and Ac-Dc External Power Supplies in Active Mode: Low Voltage Models

Nameplate Output Power (P_{no})	Minimum Average Efficiency in Active Mode (expressed as a decimal)
0 to ≤ 1 watt	≥ 0.497 x P_{no} + 0.067
> 1 to ≤ 49 watts	≥ [0.0750 x Ln (P_{no})] + 0.561
> 49 watts	≥ 0.860

Table 8: Energy Consumption Criteria for No Load

Nameplate Output Power (P_{no})	Maximum Power in No Load	
	Ac-Ac EPS	Ac-Dc EPS
0 to < 50 watts	≤ 0.5 watts	≤ 0.3 watts
≥ 50 to ≤ 250 watts	≤ 0.5 watts	≤ 0.5 watts

12.2 Set-Top Boxes

Set-Top Box equipment efficiency shall follow the methods and procedures of the most current version of the ENERGY STAR® requirements for Set-Top Boxes. ENERGY STAR® requirements for Set-Top Boxes can be found at the following website (www.energystar.gov). A Set-Top Box model must meet or exceed a minimum average efficiency for base functionality (see Table 8), plus allowances for specific, additional functionalities (see Table 9) present across a duty cycle.

To calculate the allowance for a given device, the sum of the base functionality allowance and all applicable additional functionalities allowances are added. This value is compared to the measured values following the procedures as stated in the ENERGY STAR® Set-Top Box test procedures to determine compliance.

Table 9: Base Functionality Annual Energy Allowance

Base Functionality	Tier 1 Annual Energy Allowance (kWh/year)
Cable	70
Satellite	88
IP	45
Terrestrial	27
Thin-Client/Remote	27

Table 10: Additional Functionality Annual Energy Allowance

Additional Functionalities	Tier 1 Annual Energy Allowance (kWh/year)
Additional Tuners	53
Additional Tuners – Terrestrial/IP	14
Adv. Video Processing	18
DVR	60
High Definition	35
Removable Media Player	12
Removable Media Player/Recorder	23
Multi-Room	44
CableCard	15
Home Network Interface	20

Example: High Definition, Cable Set-top Box with DVR

Annual Energy Allowance (kWh/year) = Base Functionality + Additional Functionalities
Annual Energy Allowance (kWh/year) = 70 + 60 + 35
Annual Energy Allowance (kWh/year) = 165

12.3 ONT Power Supplies

12.3.1 General

Equipment is to be configured as would be for a typical Verizon deployment. Input power measurements shall be taken immediately adjacent to the input terminals of the OPSU. Output measurements shall be taken immediately adjacent to the output terminal of the BBU. A resistive load may used to represent the ONT. Testing will be performed with the battery in a fully charged state.

12.3.2 ONT Power Supply Load Levels

ONT Power Supply testing will be performed at load levels of 100% and 50%.

$P_{Out\ Total} = (P_{Out\ max} + P_{Out\ 50})/2$

$P_{In\ Total} = (P_{In\ max} + P_{In\ 50})/2$

Table 11 ONT Power Supply TEEER Formation

Equipment Type	TEEER Formula
ONT Power Supply	$(P_{Out\ Total} / P_{In\ Total})$ x 10

The TEEER value calculated from above shall meet the minimum TEEER value allowable as defined in Table 12.

Table 12 Pass/Fail Criteria

Equipment Type	Minimum TEEER Allowable
ONT Power Supply	7.20

13.0 EFFECTIVE DATE

The effective date of this TPR shall be June 5, 2008. On January 1, 2009, all equipment provided to Verizon shall meet the minimum TEEER values as described in this document.

14.0 TEST REPORT

A test report shall be prepared that contains all necessary information:

- Date and location of test
- Physical equipment configuration
- Software Version operating on system
- Equipment physical dimensions
- Activated features and functions during testing
- Non-activated features and functions during testing
- Explanation of configuration chosen/tested
- Description of equipment's functionality verification
- Support equipment used to verify operation of equipment
- Description of test equipment used for making measurements with calibration dates
- Deviations from standard
- Duration of input energy measurement
- P_{idle}, P_{max} , P_{50} and P_{Total}
- Telecommunication Equipment Energy Efficiency Rating (TEEER)
- All recorded test data

A sample Test Report Format can be found on the following pages.

Verizon TEEER Compliance Report

CUSTOMER NAME: Company Name
Company Address
Company City, State

PRODUCT: Product Name
Product Model Number

TESTED TO:

Verizon Technical Purchasing Requirement
VZ.TPR.9205, Issue 1, June 5, 2008

Date:
Report Number:

VERIZON INDEPENDENT TESTING LABORATORY

XYZ Lab
Address
City, State

Issued By: _____ Date: _____

Lab Director: _____ Date: _____

Executive Summary

The ***Vendor Name, Equipment Name, Model Number***, as submitted, was evaluated to VZ.TPR.9205, Telecommunications Energy Efficiency Rating, Issue 1. The ***Equipment Name, Model Number*** was found to have a TEEER of ***X.XX***. The ***Equipment Name, Model Number*** *conforms/does not conform* to the requirements of VZ.TPR.9205.

Test Data

Product:	
Vendor:	
Test Technician:	
Test Location:	
Test Date:	

TEEER:	
P_{Total}:	
P_{max}:	
P_{50}:	
P_{Sleep}:	
Throughput, Forwarding Capacity or Access Lines:	

Equipment Under Test	
Hardware Configuration	
Slot 1:	
Slot 2:	
Slot 3:	
Slot N:	
Equipment Dimensions	
Height:	
Width:	
Depth:	
Software	
Firmware version:	

Activated Features or Functions:	Disabled Features or Functions

Environmental Test Conditions		
Criteria	Start of Test	End of Test
Start Time		
Ambient Temperature:		
Humidity:		
Pressure:		
Feed Voltage:		
Supply Current:		
Test Equipment		
Hardware Vendor:		
Model:		
Serial Number:		
Calibration Date:		
Hardware Vendor:		
Model:		
Serial Number:		
Calibration Date:		
Support Equipment		
Hardware Vendor:		
Model:		
Serial Number:		
Calibration Date:		
Hardware Vendor:		
Model:		
Serial Number:		
Calibration Date:		
Hardware Vendor:		
Model:		
Serial Number:		
Calibration Date:		

Calculations:

Other Notes:

Photos of Test Set-up: