Preparatory study for implementing measures of the Ecodesign Directive 2009/125/EC

DG ENTR Lot 9 - Enterprise servers and data equipment

Task 1: Scope

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Glossary

AN	Access Network
B2B	Business-to-business
CEEDA	Certified Energy Efficient Data Centre Award
CISC	Complex Instruction Set Computer
CoC	Code of Conduct
CPU	Central Processing Unit
CRAC/HVAC	Computer Room Air-Conditioning/Heating, Ventilation and Air-Conditioning,
DAS	Direct Attached Storage
EC	European Commission
ECR	Energy Consumption Rating
EEE	Electrical and Electronic Equipment
EMC	Electromagnetic Compatibility Directive
EPA	US Environmental Protection Agency
EPEAT	Electronic Product Environmental Assessment Tool
ErP	Energy-related Products
EU	European Union
HDD	Hard Disk Drive
HiNA	High Network Availability
HPC	High Performance Computing
LCA	Lifecycle Assessment
LAN	Local Area Network
LVD	Low Voltage Directive
MAN	Metro Area Network
MEErP	Methodology for the Ecodesign of Energy-related Products
NAS	Network Attached Storage
OD	Optical Disk
OEM	Original Equipment Manufacturer
PBB	Polybrominated Biphenyls
PBDE	Polybrominated Diphenylethers
PCF	Product Carbon Footprints
PDU	Power Distribution Units
PSU	Power Supply Unit
REACH	Registration, Evaluation, Authorisation and Restriction of Chemicals
RISC	Reduced Instruction Set Computer
RoHS	Restrictions of the use of Hazardous Substances Directive
SAN	Storage Area Network
SERT	Server Efficiency Rating Tool
SKU	Stock Keeping Unit
SLA	Service Level Agreement
SNIA	Storage Networking Industry Association
SPEC	Standard Performance Evaluation Corporation
SSD	Solid State Devices
SVHC	Substances of Very High Concern
TEER	Telecommunications Energy Efficiency Ratio
TTFD	Time to First Data
UPS	Uninterruptible power supply
WAN	Wide Area Network

1. Introduction

The main objective of this chapter is to set a solid foundation for the ENTR Lot 9 preparatory study by defining the product scope for enterprise servers and data equipment, and to understand these products from a functional and technical point of view. It thus defines the scope of enterprise servers and data equipment to be considered for analysis (section 2), lists existing test standards at the EU, Member State and third country levels (section 3), and lists existing legislation at the EU and third country levels (section 4).

The general scope of the ENTR Lot 9 has been defined by the European Commission (EC) as "enterprise servers and data equipment". This constitutes a very wide range of products. The objective of this chapter is therefore to determine the main product groups that are the subject of ENTR Lot 9 and will be covered in the full analysis. In the following sections, the full product spectrum will be examined based on its main functionality, with the objective to limit the full spectrum of server, storage and their related network equipment to a relevant product scope for ENTR Lot 9. It is the project team's intention to define this basic product scope efficiently and with a focus on environmental and economic significance. The existing complexity of the market needs and ongoing activities with respect to energy efficiency requires a proper reflection in order to set the scope realistically.

2. Product scope

2.1. Existing definitions and categories

2.1.1. PRODCOM categories (Eurostat)

PRODCOM classifies enterprise servers and data equipment in the categories NACE 28.12 “Manufacture of loaded electronic boards”, NACE 28.20 “Manufacture of computers and peripheral equipment” and NACE 28.30 “Manufacture of communication equipment”. The products covered under these categories, and which are relevant for this study, are presented below:

- Servers:
  - **26201400** – Digital data processing machines: presented in the form of systems;
  - **26201500** – Other digital automatic data processing machines whether or not containing in the same housing one or two of the following units: storage units, input/output units;
- Storage equipment:
  - **26202100** – Storage units;
  - **26203000** – Other units of automatic data processing machines (excluding network communications equipment (e.g. hubs, routers, gateways) for LANs and WANs and sound, video, network and similar cards for automatic data processing machines);
- Server- and storage-related network equipment:
  - **26302320** – Machines for the reception, conversion and transmission or regeneration of voice, images or other data, including switching and routing apparatus;
  - **26302370** – Other apparatus for the transmission or reception of voice, images or other data, including apparatus for communication in a wired or wireless network (such as a local or wide area network), other than transmission or reception apparatus of HS 84.43, 85.25, 85.27 or 85.28.

These categories include wide ranges of products, and it is not clear exactly which devices each category covers, as the aggregation level of data remains relatively high.

2.1.2. EN-, IEC- and ISO-standards

A huge volume of ENs has been published and/or is being developed by CENELEC in support of European legislation/regulation as laid down in the WEEE, RoHS, EMC and LVD Directives and the REACH Regulation. Most of these ENs do transpose pertinent International Standards developed by the IEC. A variety of those ENs is applicable, amongst others, to enterprise servers and data equipment. Aspects addressed cover e.g. electrical safety, EMC, material declaration and reduction of hazardous substances. Regarding the energy consumption of enterprise servers and data equipment in operation, international standardisation activities are going on in ISO/IEC (in Technical Committee JTC 1/SC 39). The resulting ISO/IEC standards will be transposed into ENs by CENELEC TC 215 in due time.

There are to date no available definitions relevant/specific enough for ENTR Lot 9 products.

2.1.3. ENERGY STAR® Specifications for Computer Servers and Data Centre Storage

There are separate ENERGY STAR requirements documents for server and storage systems. ENERGY STAR server V2 specifies submission of SERT data, among other criteria, for the certification of server systems. The Storage requirements were published on August 8 of 2013 and are titled “Version 1.0 ENERGY STAR Data Center Storage Specification.

Version 2.0 ENERGY STAR® specification for computer servers took effect on December 16, 2013, and aims to differentiate energy efficient computer servers in order to support a more environmental-oriented procurement of products. Version 2.0 is a considerable enhancement of the first version (2009) and reflects the deep analysis and development work that has been done by the U.S. Environmental Protection Agency

(EPA) and the European Commission (EC) in the past years. The most important aspect in conjunction with the ENERGY STAR® specifications is the joint development of energy-performance test standards (SPEC SERT and SNIA Emerald; see sections 3.5.1.2 and section 3.5.2) in collaboration with industry stakeholders. It needs to be underlined that the development of energy-performance test standards for servers and storage equipment demanded a thorough analysis of typical products, their performance and application specific properties, as well as system implementation and operator aspects. The knowledge and conclusions derived from the test standard development process are a major source of information and demands therefore significant consideration within the ENTR Lot 9 study.

2.1.3.1. Definitions in version 2.0 ENERGY STAR® specification for computer servers

This current specification[1] provides a quite comprehensive set of definitions for e.g. types of server products, server components, and operational aspects. The specification defines a particular product scope – covering the majority of the market – and excludes products that are custom-made for high availability and specific performance. Finally, the energy efficiency requirements cover multiple aspects from the efficiency of the power supply unit to idle and active modes (see section 4.1.13 for a detailed description – this section only presents definitions).

The definition section in the specification covers a broad taxonomy of server types and subcategories including:

- Computer servers: *"A computer that provides services and manages networked resources for client devices (e.g., desktop computers, notebook computers, thin clients, wireless devices, PDAs, IP telephones, other computer servers, or other network devices). A computer server is sold through enterprise channels for use in data centres and office/corporate environments. A computer server is primarily accessed via network connections, versus directly-connected user input devices such as a keyboard or mouse […]"*
- Managed servers: *"A computer server that is designed for a high level of availability in a highly managed environment […]"*
- Blade server: *"A computer server that is designed for use in a blade chassis. A blade server is a high-density device that functions as an independent computer server and includes at least one processor and system memory, but is dependent upon shared blade chassis resources (e.g., power supplies, cooling) for operation. A processor or memory module that is intended to scale up a standalone server is not considered a Blade Server."*
- Fully fault tolerant servers
- Resilient server
- Multi-node server: *"A computer server that is designed with two or more independent server nodes that share a single enclosure and one or more power supplies. In a multi-node server, power is distributed to all nodes through shared power supplies. Server nodes in a multi-node server are not designed to be hot-swappable".*
- Microservers: *"Microservers are an emerging form factor of servers designed to process lightweight, scale out workloads for hyper-scale data centres. Typical workloads suited for microservers include static web page serving, entry dedicated hosting, and basic content delivery, among others. Because of the microserver's high-density and energy-efficient design, its infrastructure (including the fan and power supply) can be shared by tens or even hundreds of physical server nodes, 1 eliminating the space and power consumption demands of duplicate infrastructure components. Even within the microserver category, there is no one-size-fits-all answer to system design or processor choice. Some microservers may have high-performing single-socket processors with robust memory and storage, while others may have a far higher number of miniature dense configurations with lower power and relatively lower compute capacity per node."*[2]
- Server appliances
- High performance computing system

[1] Available at: http://www.energystar.gov/products/specs/enterprise_servers_specification_version_2_0_pd
[2] http://www.intel.com/content/www/us/en/servers/microservers.html

- Direct current server
- Large Servers

Full definitions are provided in Annex 1. The specification also defines sub-categories according to components, form factor, and operational modes. The definitions are the result of a complex and long stakeholder process, making them current and sensible.

The following product scope is eligible under Version 2.0:

> *"Blade-, Multi-node, Rack-mounted, or Pedestal form factor computer servers with no more than four processor sockets in the computer server (or per blade or node in the case of blade or multi-node servers). "*

While products explicitly excluded from Version 2.0 are:

> "*Fully Fault Tolerant Servers; Server Appliances; High Performance Computing Systems; Large Servers; Storage Products including Blade Storage; Network Equipment"*

Noteworthy is the fact that the specification clearly distinguishes between single unit products and more complex (modular) product systems such as multi-node server systems and blade server systems. System aspects include for instance:

- All possible PSUs must comply;
- Temperature measurement and fan speed management;
- Power measurements with half-populated chassis (blade system);
- Homogeneous configuration of all servers in a system under test.

2.1.3.2. Definitions in version 1.0 ENERGY STAR® specification for data centre storage equipment

The Version 1.0 ENERGY STAR® Specification for Data Centre Storage[3] took effect on December 2, 2013. It belongs to the suite of datacentre equipment specifications, which currently includes Computer Server and Uninterruptible Power Supply specifications (specification for Large Network Equipment are under development).

This specification aims to differentiate energy efficient data centre storage equipment to help data centre operators select products that will save them money on their energy bills, assist manufacturers of efficient equipment in increasing sales, and drive down the energy use of data centres, estimated to be more than 2% of total US electricity consumption.

The Version 1.0 Specification requires all products to test and submit data using the Storage Networking Industry Association (SNIA) Emerald Power Efficiency Measurement Specification V2.0.2 (see section 3.5.2 for detailed description – this section only presents definitions).

The specification provides the following definition of a **storage product***: "A fully-functional storage system that supplies data storage services to clients and devices attached directly or through a network. Components and subsystems that are an integral part of the storage product architecture (e.g., to provide internal communications between controllers and disks) are considered to be part of the storage product. In contrast, components that are normally associated with a storage environment at the data centre level (e.g., devices required for operation of an external SAN) are not considered to be part of the storage product. A storage product composed of integrated storage controllers, storage media, embedded network elements, software, and other devices. For purposes of this specification, a storage product is a unique configuration of one or more SKUs prepared for sale to an end user as a storage product."*

Definitions of other product types are also provided:

- Storage Device: *"A collective term for disk drives (HDDs), solid state drives (SSDs), tapes cartridges, and any other mechanisms providing non-volatile data storage. This definition is specifically intended to exclude aggregating storage elements such as RAID array subsystems, robotic tape libraries, filers, and file servers. Also excluded are storage devices which are not directly accessible by end-user application programs, and are instead employed as a form of internal cache"*.

[3] http://www.energystar.gov/products/specs/data_center_storage_specification_version_1_0_pd

- Storage Controller*: "A device for handling storage request via a processor or sequencer programmed to autonomously process a substantial portion of I/O requests directed to storage devices (e.g., RAID controllers, filers)."*

Products that meet all of the following conditions are eligible for ENERGY STAR® certification (storage version 1.0), with the exception of products listed in Section 2.2:

- meet the definition of a Storage Product provided in the document;
- are comprised of one or more SKUs and be able to be purchased in a single order from a storage product vendor;
- are characterised within the Online 2, 3, or 4 Storage Taxonomy categories (see Annex 1[4]) with the following additional criteria;
    - a) contain a controller with advanced data recovery capability;
    - b) support Block I/O storage functions either entirely or as an additional capability; and
    - c) implement scale-up or scale-out storage.

According to Section 2.2 the following products are specifically excluded from certification under this specification:

- Personal / Portable Data Storage Products;
- Computer Servers;
- Blade Storage Products;
- Direct Attached Storage Products;
- Network Attached Storage Products that cannot perform block I/O;
- Storage Products capable of object based storage;
- Storage devices in the following categories of the taxonomy: Near-online, Removable Media Library, Virtual Media Library, Adjunct Storage Products, and Interconnect Elements;

2.1.3.3. ENERGY STAR® Definition of data centre network equipment:

Even if the specification for Large Network Equipment is currently under development, the Version 1.0 specification for Small Network Equipment[5] already provides the following definitions:

- Network Equipment: "*A device whose primary function is to pass Internet Protocol (IP) traffic among various network interfaces / ports"*.
- Small Network Equipment (SNE): "*Network Equipment that is intended to serve users in either small networks or a subset of a large network. SNE includes a) all Network Equipment with integral wireless capability and b) other Network Equipment meeting all of the following criteria:*
    - Designed for stationary operation;
    - Contains no more than eleven (11) wired Physical Network Ports;
    - Primary configuration for operation outside of standard equipment racks;
    - Meets the definition of one or more of the Product Types defined below".
- Large Network Equipment: "*Network Equipment that is rack-mounted, intended for use in standard equipment racks, and/or contains more than eleven (11) ports for wired network."*

Additionally, a definition of network equipment can be found in the V2.0 server specification for computer servers: *"A device whose primary function is to pass data among various network interfaces, providing data*

[4] The ENERGY STAR storage taxonomy are consistent with the terminology developed by the Storage Networking Industry Association Green Storage Initiative as defined in "SNIA EmeraldTM Power Efficiency Measurement Specification" Version 2.0.2.

[5] http://www.energystar.gov/products/specs/sites/products/files/SmallNetworkEquipment_V1_ENERGYSTAR_ProgramRequirements_Nov2013_0.pdf

connectivity among connected devices (e.g., routers and switches). Data connectivity is achieved via the routing of data packets encapsulated according to Internet Protocol, Fibre Channel, InfiniBand or similar protocol."

2.1.4. Storage Networking Industry Association (SNIA)

The SNIA Green Storage TWG Taxonomy makes the distinction of six product group categories with differing operational profiles (in line with Annex 1):

- **Online**: Storage system for very fast random or sequential I/O request. The main distinction criteria is maximum TTFD of <80ms.
- **Near Online**: Storage system for moderate response time with maximum TTFD of >80 ms.
- **Removable Media Library**: System for sequential I/O request with long response time. This is an automated or manual media loader such as a tape or optical library.
- **Virtual Media Library**: System for very fast sequential I/O request with maximum TTFD of <80ms. The media are not removable and intended for long-term data storage.
- **Adjunction Product**: Special purpose storage service, dedicated data path form host to storage device, no end-user access, maximum TTFD of <80ms
- **Interconnect element**: Managed interconnect elements within a storage area network such as switch or extenders.

SNIA also divides the spectrum of storage products into a number of product complexity levels, represented as rows in Table 1. It also separates them by functional aspect, as shown in the columns. Note the shaded areas are not covered by the currently released version of the SNIA Emerald™ Power Efficiency Measurement Specification (see section 3.5.2).[6]

Table 1: SNIA taxonomy overview

Category Level	Online	Near Online	Removable Media Library	Virtual Media Library
Consumer/Component	Online 1	Near Online 1	Removable 1	Virtual 1
Low-end	Online 2	Near Online 2	Removable 2	Virtual 2
Mid-range	Online 3	Near Online 3	Removable 3	Virtual 3
	Online 4			
High-end	Online 5	Near Online 5	Removable 5	Virtual 5
Mainframe	Online 6	Near Online 6	Removable 6	Virtual 6

2.1.5. Top-Runner Program (Japan)

The Japanese Top-Runner-Program currently (2011) covers server-type computers under the specifications of "Computers and hard disk drives". The next revision is planned for 2015.

2.1.5.1. Definition of Server Computers and classification

Server-type computers refer to a computer that is designed to operate 24 hours a day and provide services on a network, and which can be accessed only via a network.

Server computers are furthermore classified and distinguished by the CPU type and number of I/O slots. The following definitions apply:

- Dedicated CISC (Complex Instruction Set Computer): Used in high-functionality processors with a diverse instruction set. It is primarily used in mainframe servers and similar products.
- RISC (Reduced Instruction Set Computer): This type of processor uses a simplified instruction set in order to prioritize high speed, and is primarily used in UNIX servers and similar devices.

[6] http://snia.org/sites/default/files/EmeraldMeasurementV2_0_2.pdf

- IA64, IA32: These are typical architectures for general-purpose CISC microprocessors that are universally used in products from personal computers to high-functionality servers. IA32 is a 32-bit microprocessor architecture, and is primarily used in products such as IA servers. IA64 is a 64-bit microprocessor architecture, and is primarily used in products such as high-functionality servers.

Table 2 : Server-type computers categories considered in Top-Runner Program

CPU Type	No. of I/O slots	No. of CPU sockets	Category name
Dedicated CISC	Less than 32	-	A
	32 or more	-	B
RISC	Less than 8	-	C
	8 to less than 40	-	D
	40 or more	-	E
IA64	Less than 10	-	F
	10 or more	-	G
IA32	0	-	H
	1 to less than 7	Less than 2	I
		2 to less than 4	J
		4 or more	K
	7 or more	-	L

2.1.5.2.Definition of data storage HDD

The following definitions are provided by the Top-Runner Program for storage equipment:

- “Individual disk” refers to a single disk drive. For individual disks, cases that bear a type name shall be considered 1 unit.
- “Sub-system” refers to a product with multiple disk drives. For sub-systems, the magnetic disk control unit and HDD shall together be considered 1 unit. (For products that only use a magnetic disk controller that is built into a computer, cases that bear a type name shall be considered 1 unit.).

2.1.6. Ecodesign Regulation for computers and computers servers

The Ecodesign Regulation for computers and computer servers (N°617/2013)[7] introduced the following definitions:

- ‘Computer server’ means a computing product that provides services and manages networked resources for client devices, such as desktop computers, notebook computers, desktop thin clients, internet protocol (IP) telephones, or other computer servers. A computer server is typically placed on the market for use in data centres and office/corporate environments. A computer server is primarily accessed via network connections, and not through direct user inputs devices, such as a keyboard or a mouse;
- A computer server has the following characteristics:

  (a) Designed to support computer server operating systems (OS) and/or hypervisors, and targeted to run user-installed enterprise applications;
  (b) Supports error-correcting code (ECC) and/or buffered memory (including both buffered dual in-line memory modules (DIMMS) and buffered on board (BOB) configurations);
  (c) Placed on the market with one or more AC-DC power supply(ies);

[7] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2013:175:0013:0033:EN:PDF

(d) All processors have access to shared system memory and are independently visible to a single OS or hypervisor.

- A 'Small-scale server' is a type of computer that typically uses desktop computer components in a desktop form factor but is designed primarily to be a storage host for other computers and to perform functions such as providing network infrastructure services and hosting data/media, and which has the following characteristics:

  (a) Designed in a pedestal, tower, or other form factor similar to those of desktop computers such that all data processing, storage, and network interfacing is contained within one box;

  (b) Designed to be operational 24 hours per day and 7 days per week;

  (c) Primarily designed to operate in a simultaneous multi-user environment serving several users through networked client units;

  (d) Where placed on the market with an operating system, the operating system is designed for home server or low-end server applications;

  (e) Not placed on the market with a discrete graphics card (dGfx) meeting any classification other than G1.

- 'Blade system and components' refers to a system composed of an enclosure ('blade chassis') into which different types of blade storage and servers are inserted. The enclosure provides shared resources on which servers and storage depend. Blade systems are designed as a scalable solution to combine multiple computer servers or storage unites in a single enclosure, and are designed for technicians to be able to easily add or replace (hot-swap) blades (e.g. blade servers) in the field.
- 'Server appliance' stands for a computer server bundled with a pre-installed operating system and application software that is used to perform a dedicated function or set of tightly coupled functions. A server appliance delivers services through one or more networks, and is typically managed through a web or command line interface. Server appliance hardware and software configurations are customised by a vendor to perform a specific task, including network or storage, and are not intended to execute user-supplied software.
- A 'Multi-node server' is a system composed of an enclosure where two or more independent computer servers (or nodes) are inserted, sharing one or more power supplies. The combined power for all nodes is distributed through the shared power supply(ies). A multi-node server is designed and built as a single enclosure and is not designed to be hot-swappable.
- 'Dual-node server' refers to a common multi-node server configuration consisting of two server nodes.
- 'Computer server with more than four processor sockets' are computer servers containing more than four interfaces designed for the installation of a processor.

2.2. Definition of preliminary product scope

According to the ENTR Lot 9 call for tender, the formal scope is "enterprise servers and data equipment", which is relatively vague and potentially covers a very broad range of products. The Ecodesign working plan document also considered the vague following product category: "enterprise servers, data storage and ancillary equipment". As a result, during the project internal kick-off meeting, servers, data storage, and network equipment that is professionally used and typically installed in server rooms or data centres was specifically mentioned as the basis for the scope by the European Commission representative.

Based on the analysis of existing definitions in section 2.1 and on product scope criteria, the objective of this section is to define a preliminary product scope.

The development of the ENERGY STAR® specifications for computer servers, data storage equipment and associated network equipment has reached a great level of analysis, maturity and acceptance within the global industry. In particular, Japan, Korea, and China are monitoring the ENERGY STAR® program in conjunction with their own regulatory activities for servers. Against that background**, the definitions provided in these specifications appear as the most broadly accepted, current, and accurate** available in standards or policy schemes. Therefore, whenever possible, the project team suggests **harmonizing the definitions to be used within ENTR Lot 9 with the product definitions of the ENERGY STAR® specifications** of computer servers, data centre storage, and associated network equipment, for the corresponding products that are covered by Lot 9.

The selected product scope in ENERGY STAR® covers the majority of server and storage equipment in the market (see 4.1.13 for detailed description), but given that the Ecodesign Directive goes beyond the

considerations of ENERGY STAR®, other enterprise server and storage products may be relevant for potential ecodesign measures that are currently not covered by ENERGY STAR® requirements.

2.2.1. Product scope criteria

At first sight, enterprise servers, storage and associated network equipment are understood as professional equipment, which is marketed and sold through enterprise channels in a business-to-business (B2B) environment (see respective phrase in the ENERGY STAR® definition of computer servers). Such equipment comprises a minimum hardware and software configuration. Despite stand-alone equipment, the 19-inch computer rack cabinet is the most common way to mount an enterprise server, enterprise storage and related network equipment. The rack cabinet provides mounting options for multiple modules of different height and sometimes contains integrated cooling and airflow support technology.

This sub-section provides some preliminary criteria, used in order to refine and specify in more details the intended scope of DG ENTR Lot 9 in the following subsections.

- **Product vs. system approach**: The European Ecodesign Directive (2009/125/EC), also commonly called Energy-related Products (ErP) Directive, **implements a product approach**. That means that possible implementing measures are addressing single products and not interactive systems or complete installations. That also means that compliance can be assessed by market authorities on a fully functional product, independently and under defined conditions. The scope of ENTR Lot 9 shall therefore **comprise only fully functional singular equipment (products) and not complete installations**, such as data centres for example. Enterprise servers, storage and associated network equipment, despite their important interdependencies shall therefore be considered and analysed separately in the context of this study, at the individual product level.
- **Volume vs. custom made products**: In the current market environment, the original equipment manufacturer (OEM) offers different product types and configurations for various purposes (e.g. server for mail, web, file, database, terminal, communications and other specific applications, controllers, storage devices, storage media, I/O type and other storage and network relevant components). The customer can typically select from a variety of possible configurations (e.g. type and number of CPUs, memory capacity and network interfaces). The OEMs also customise product solutions according to the specifications of customers and their service level agreement (SLA) requirements. Mainframes or fully fault tolerant servers are typically custom-made. Enterprise server and data equipment can be applied not only in conventional business but also in specialised markets such as telecommunications, banking, research, internet service provider, etc. Although the same product is used, the set-ups and utilisation might vary considerably from conventional purpose use. Because the purpose of the Ecodesign Directive is primarily to target products with significant sales and impacts, and because Ecodesign measures may not be realistic for implementation from a practical point of view for custom made products, **ENTR Lot 9 primarily focuses on typical volume products**.
- **Operating location**: This criterion considers where the equipment is operated and by whom. Enterprise servers, enterprise storage and related network equipment are typically pooled and operated in larger numbers (systems) in order to fulfil their intended service. The equipment is often installed in separated (server) rooms or data centres with a customized infrastructure for power distribution, air conditioning, monitoring, safety, and administration. Given the use of the term “enterprise” in the Lot 9 title and based on discussions with the EC and stakeholders, Lot 9 primarily targets **equipment, which is installed in a professional environment (separated server rooms, or data centres).** However, because a given device can be used in different environment based on the user’s will, it could be that some products, labelled and sold as “enterprise” (professional) equipment, are eventually installed in other environments and used in a specialised way.
- **B2B-market**: This selection criterion considers the market channels through which the equipment is sold / purchased. In respect to the term “enterprise” in Lot 9 title and given the above bullet point, Lot 9 targets **professional equipment, which is sold in a Business-to-Business environment**.
- **IT vs. Infrastructure**: This selection criterion considers the fact that **infrastructure equipment** (e.g. support equipment necessary for functional, safe and reliable operation) **not actually handling data is out of scope**, as they are not formally part of the IT products (see first bullet point), even if their operation are highly interdependent. Rack cabinets, room-level undisruptive power supply (UPS) and power distribution units (PDU), air conditioning (CRAC/HVAC) as well as safety, lighting, monitoring and control equipment are therefore out of scope.
- **Quality of service**: This selection criterion considers the legal framework and service condition under which the equipment is operated. The specific requirements for the operation of certain servers (e.g. legal, safety, availability for critical mission) may prevent the implementation of potential ecodesign

measures. Further assessment will be made throughout the study regarding this type of requirements, to ensure the relevance of potential ecodesign requirements for all covered products.

2.2.2. Enterprise servers

2.2.2.1. Product definition and preliminary scope

The ENTR Lot 9 product scope for enterprise servers includes products that are:

- Defined as computer servers according to the definition of the ENERGY STAR® specification for computer servers (version 2.0)
- Modular and having different form factors
- Marketed and sold through enterprise channels

The ENTR Lot 9 product scope for enterprise servers excludes products that are:

- Intended for private end-users (domestic) or embedded (machinery) applications

The ENTR Lot 9 study is not excluding at this point specific types of enterprise servers such as mainframes or high performance computer systems from the study.

2.2.2.2. Functional unit

Enterprise servers consist of hardware and software elements and provide different computing services or task specific applications via a network. The provided functionality and performance (e.g. latency, bandwidth), the scalability and form factor (i.e. the physical design and dimensions of the product, e.g. multi-node, blade system), as well as configuration for a specific service level (e.g. availability, resilience) follow the intended purpose or application and consequently defines the design and component configuration of the product.

Table 3 below provides some parameters that can be used to characterise servers.

Table 3: Server characterisation parameters

Processor Architecture	Form factor and modularity	Serviceability	Performance / Application
• x86 (Intel, AMD) • Unix (SPARC RISC) • Other (e.g. ARM)	• Pedestal (tower) • Rack-optimized • Blade system • Multi-node • Large / Mainframe • Embedded / Barebone	• Managed • Unmanaged • Operation System	• Micro server • HPC server • Fully fault tolerant server • Resilient server • Server appliances • Large / mainframe

The specific configuration and utilisation aspects (characterisation parameters) are defining the product specific performance, energy and resource consumption over the actual lifetime of the product. This in turn would define the product specific functional unit. Due to the fact that enterprise servers show tremendous variety with respect to their configuration and actual utilisation, it is not possible to define specific functional units e.g. based on certain performance parameters.

As an example, where a server product is incorporated into another product as a functional unit, such as the use of a server as a storage controller, or special purposed to operate as an appliance for security or COMS purposes, those servers have specific requirements that need to be taken into account. In the case where the server is incorporated as a functional unit within another product type, it will have to serve application specific functions which precludes conformance with server specific requirements. Where a server is used as an appliance for security, storage Capacity Optimization Methods (COMS) or other functionality, it is specifically configured to optimize application specific functionality such as data or network security or a compression function on data moving to one or more storage products.

For the purpose of this study, a “general functional unit” that reflects the material composition and energy consumption of an enterprise server over its standardized lifecycle will be used (see Task 3 report regarding use pattern).

2.2.3. Enterprise storage

2.2.3.1. Product definition and preliminary scope

The ENTR Lot 9 product scope for enterprise storage includes products that are:

- Defined as storage product according to the definition of the ENERGY STAR® specifications for data centre storage equipment (version 1.0)
- Marketed and sold through enterprise channels

The ENTR Lot 9 product scope for enterprise storage excludes products that are:

- Private (domestic) and portable data storage products, computer servers, computers with storage capacities, and network equipment.

2.2.3.2. Functional unit

Enterprise data storage equipment is understood as fully functional data storage equipment, consisting of hardware and software elements and providing data storage services directly attached or through a network to (remote) clients. The provided functionality and performance (e.g. capacity, latency), storage media, scalability and form factor, as well as service level (e.g. availability, resilience) follow the intended purpose or application and consequently define the design and component configuration of the product. Data storage equipment are operated free standing (pedestal) or in a cabinet (rack-mounted) and are most often installed in a separated server room or data centre.

Table 4 below provides some parameters that can be used to characterise storage products.

Table 4: Storage equipment characterisation parameters

Storage Product System	Chassis (Form factor)	Storage Media / Device	Storage Application
• Network Attached Storage (NAS) • Storage Area Network (SAN) • Direct Attached Storage (DAS) • Tape Library	• Pedestal (stand-alone) • Rack-optimized (rack-mounted) • Blade system	• Hard Disk Drive (HDD) • Solid State Devices (SSD) • Hybrid SSD-HDD • Magnetic Tape (Tape Library) • Optical Disk (OD)	• Online Storage • Near-online Storage • Virtual Media Library • Removable Media Library

The specific configuration and utilisation aspects (characterisation parameters) are defining the product specific performance, energy and resource consumption over the actual lifetime of the product. This in turn would define the product specific functional unit. Due to the fact that enterprise storage systems show tremendous variety with respect to their configuration and actual utilisation, it is not feasible to define specific functional units e.g. based on certain performance parameters.

For the purpose of this study, a “general functional unit” that reflects the material composition and energy consumption of an enterprise storage system over its standardised lifecycle will be used (see Task 3 report regarding use pattern).

2.2.4. Server and storage related network equipment

Network equipment is a device that is providing connectivity and passing data through wired or wireless network interfaces. The equipment can work based on physical layer (OSI layer 1), on data link layer (OSI layer 2), or on network layer (OSI layer 3). It is important to recognise the fact that the same types of network equipment are operated in different networks under different operative conditions and quality of service requirements.

Figure 1 illustrates the different network levels and typical types of equipment implemented in these networks.

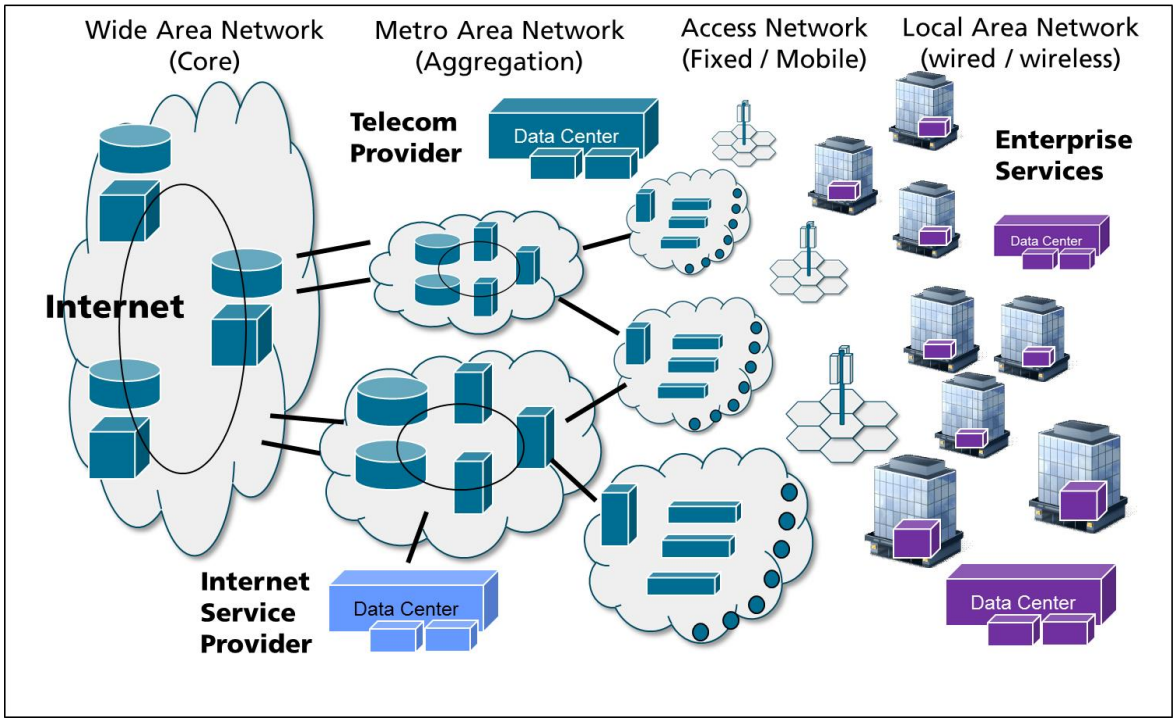

Figure 1: Telecom networks and network equipment

The tables below present the different types of network and typical associated equipment.

- Wide Area Network (WAN)

WAN scope	WAN Equipment
• International telecommunication • Optical transport backbone (core)	• Core router • Optoelectronic switches • Optical cross connect • WDM optical transport system • Signal amplifiers (EDFA), etc.

- Metro Area Network (MAN)

MAN scope	MAN Equipment
• Regional aggregation networks • Regional transport networks	• Edge router • Network gateways • Optoelectronic switches • Ethernet switches • Optical add-drop multiplexer, etc.

- Access Network (AN)

AN scope	AN Equipment
• Fixed line access networks • Mobile radio networks	• Optical line terminals • Optical network unit • Splitter • Multiplexer (DSLAM) • Radio base stations (macro, micro, pico) • Antenna systems, etc.

- Local Area Network (LAN)

LAN scope	LAN Equipment
• Indoor computer networks • Indoor wireless networks	• Gateways (customer premises equipment) • Routers • Switches • Bridges • Hubs • Repeater, etc.

Network equipment includes bridges, switches, routers, gateways, etc. and can be utilised in different networks, by modifying the configuration and operation setting of such equipment. In general, we have to consider the following aspects with regards to the product definition of network equipment:

- In terms of functionality and performance, network equipment covers a great variety of different devices that apply not only different data transmission technologies (e.g. wired, wireless) but also work on the physical, data link or network layer (transmitting, switching, routing, etc.). **This heterogeneity makes it difficult to define a primary performance parameter or simple functional unit across all network equipment**.
- A given type of network equipment can be utilised in different networks and with different quality of service requirements. The telecommunication industry and its quality of service requirements (e.g. availability, emergency call, data security, etc.) are regulated on national and EU level.
- Considering ecodesign of network equipment without the higher-level network architecture, topology and service requirements, would only achieve minimal improvements. By nature, network equipment does not operate independently and interacts with one or multiple links, and its performance must be judged based on the performance of the overall network system.

2.2.4.1. Product definition and preliminary scope

As a result, given all these challenging considerations, i.e. the heterogeneous product spectrum used across different environments, the product complexity and modularity, and the system interaction, **the project team formulates the recommendation to analyse all network equipment in a separate preparatory study, to enable the best assessment possible.**

Datacentre level server and storage connectivity (e.g. network equipment such as LAN or FC switches and respective cabling) however remains in scope of the ENTR Lot 9 Study for subsequent tasks, which will provide further assessment and conclusions on the possibility and relevance of potential ecodesign measures for this product category.

Furthermore, **Lot 9 primarily targets equipment, which is installed in a professional environment (separated server rooms, or data centres,** i.e. Class A devices as far as network equipment are concerned. Definitions of Class A and Class B products are given in (CENELEC) EN 55022:2010 "Information Technology Equipment - Radio disturbance characteristics - Limits and methods of measurement"[8]:

- Class A products are intended for use in non-residential/non-domestic environments. Warning: In domestic environment, this product may cause radio interference in which case the user may be required to take adequate measures.
- Class B products are intended for use in residential/domestic environments but may also be used in non-residential/non-domestic environments.

2.2.4.2.Functional unit

Similarly to servers and storage products, for the purpose of this study, a “general functional unit” that reflects the material composition and energy consumption of an enterprise network product over its standardised lifecycle will be used (see Task 3 report regarding use pattern).

[8] Similarly, the Federal Communications Commission (FCC) defines in PART 15 — Radio Frequency Devices (Subpart A – General (h, i)) Class A and Class B digital devices as follows:
- Class A digital device: a digital device that is marketed for use in a commercial, industrial or business environment, exclusive of a device which is marketed for use by the general public or is intended to be used in the home.
- Class B digital device: a digital device that is marketed for use in a residential environment notwithstanding use in commercial, business and industrial environments. Examples of such devices include, but are not limited to, personal computers, calculators, and similar electronic devices that are marketed for use by the general public.

3. Test standards (EU, Member State and third country level)

This section identifies and describes the existing test standards, specifically addressing ENTR Lot 9 products and regarding the test procedures for:

- Primary and secondary functional performance parameters
- Resources use (energy and materials, incl. waste) and emissions
- Safety (flame retardancy, electric safety, EMC, stability, etc.)
- Noise and vibrations (if applicable)
- Other product-specific test procedures possibly posing barriers for Ecodesign measures.

3.1. EN-, ISO-, IEC- test standards

ISO/IEC JTC 1/SC 39 has started to develop key performance parameters (KPI) for IT equipment used in computer rooms and data centres in the ISO/IEC 30134 series. This includes the KPIs “IT Equipment Energy Efficiency for Servers (ITEEsv)” and the “IT Equipment Utilisation for Servers (ITEUsv)”.

The goal of the ITEEsv is to support data centre operators to optimise the energy efficiency of their servers. The user has to choose an adequate benchmark which fits his workloads. He is then able to compare the performance of his different servers and to identify the inefficient ones. The indicator is defined as the ratio of the sum of total processing power in the individual servers to the sum of the electric power in all servers in the data centre. The indicator is calculated according to the following formula.

$$ITEE_{SV} = \frac{\sum Maximum\ Server\ Performance}{\sum Power\ @\ Maximum\ Performance}$$

The ITEUsv has the objective to support data centre operators to optimise the utilisation of its servers. It can identify underutilized servers and increase energy efficiency by turning servers off. Furthermore, by weighting with the ITEE value, a lower utilisation of high-performance servers has a higher impact. It is calculated as the ratio of the sum of the actual cumulative server workloads divided by the sum of maximum server workloads, as shown in the following formula: $ITEU_{SV} = \frac{\sum Actual\ Cumulative\ Server\ Workload}{\sum Maximum\ Server\ Workload}$

The ITEUsv requires processing a considerable amount of data from the system management and practical experiences are still lacking.

3.2. Mandates issued by the EC to the European Standardisation Organisations (ESOs)

There is currently a standardisation mandate from the Commission to the ESOs, whose title is: "M/462-Standardisation mandate addressed to CEN, CENELEC and ETSI in the field of ICT to enable efficient energy use in fixed and mobile information and communication networks". Phase 1 of the Mandate has been concluded with a “Framework document for the ESO response to EU-Mandate M/462”. In particular, CLC/TC 215 is developing the EN 50600 series of standards on data centres and facilities under this Mandate (with 3 ENs published and 4 ENs under development at various stages).

Harmonisation of test procedures such as SERT, SNIA Emerald and TEER on an EU standard level is highly recommended. It is also recommended to extend the energy-performance testing procedure for server, storage and network products with respect to the temperature conditions under which the test occurs. At present, products are typically tested at around 23 °C inlet temperature. It seems feasible to also consider a testing environment with, for example, 32°C inlet temperature in order to assess the energy trade-off between the possible increase in IT power consumption versus a decrease cooling infrastructure power consumption (the basic concept behind free cooling solutions).

Despite energy consumption and respective testing, material and resource consumption is a considerable environmental aspect which can be assessed with a life cycle assessment (LCA) or a more simplified product

carbon footprint (PCF). There are few developments in conjunction with the greenhouse gas protocol that define general product category rules (PCR) for ICT products. However, there are no standard available yet. We therefore recommend developing specific PCR in support of life cycle assessments for server, storage and network products.

3.3. Test standards in individual Member States

3.3.1. PAS 141:2011 - Reuse of used and waste electrical and electronic equipment

PAS 141[9] is a standard developed by the Department for Business, Innovation and Skills (BIS) in the UK. It sets out the requirements to successfully manage the process of preparing used and waste electrical and electronic equipment for reuse. Giving practical advice, the standard helps to reduce costs and ensure that these recycled parts and products are of the highest quality. The standard also covers the preparation process for the reuse of electronic equipment and components. It applies to all organisations that deal with the preparation of equipment for reuse. Companies can ask that a UKAS accredited certification body certifies the implementation of the standard best practices. PAS 141 is being presented to the EU Standards Committee as the basis for a European-wide standard for re-use, following the recent update of the EU WEEE Directive.

Other test standards in individual Member States related to ENTR Lot 9 are not known to date.

3.4. Third country test standards

Third country test standards related to ENTR Lot 9 are not known to date.

3.5. Industry-based specifications

3.5.1. Standard Performance Evaluation Corporation (SPEC)

The System Performance Evaluation Cooperative, now named the Standard Performance Evaluation Corporation (SPEC)[10], was founded in 1988 by a small number of workstation vendors who realised that the marketplace was in need of realistic, standardised performance tests. The key realisation was that an ounce of reliable data was worth more than a pound of marketing hype. The goal of SPEC is to ensure that the marketplace has a fair and useful set of metrics to differentiate candidate systems. The path chosen is an attempt to balance requiring strict compliance and allowing vendors to demonstrate their advantages.

SPEC is structured into four working groups. Under the Open Systems Group (OSG) falls the subcommittee Power.

3.5.1.1.SPECpower

The Power committee developed SPECpower_ssj2008[11], the first benchmark for evaluating the power and performance characteristics of volume server class and multi-node class computers at varying workloads. The SPECpower benchmark was designed to address CPU oriented energy efficiency of standard rack servers but did not cover I/O oriented efficiency.

Based on the understanding that the power consumption profile of a server system is non-linear with respect to the workload (and respective performance), the SPECpower benchmark is varying the workload of the SPEC Java Business Benchmark (SPECjbb). According to SPEC, this benchmark provides a means to measure power (at the AC input) in conjunction with a performance metric. The initial benchmark addresses only one subset of server workloads: the performance of server side Java. It exercises the CPUs, caches, memory hierarchy and the scalability of shared memory processors (SMPs) as well as the implementations of the JVM (Java Virtual Machine), JIT (Just-In-Time) compiler, garbage collection, threads and some aspects of the operating system. The benchmark runs on a wide variety of operating systems and hardware architectures and should not require extensive client or storage infrastructure. Additional workloads are planned.

The latest SPECpower_ssj2008 V1.12 was released on July 26th, 2012. This is a point release which includes several enhancements, including added reporter support for large numbers of JVMs, PTDaemon update to version 1.4.2, and support for a new analyser (Newtons4th PPA15x0). A new version of PTDaemon v1.6.1,

[9] http://shop.bsigroup.com/en/ProductDetail/?pid=000000000030245346
[10] http://www.spec.org/spec/
[11] http://www.spec.org/power_ssj2008/

was released on July 24th, 2013. Use of v1.6.0 was temporarily accepted for SPECpower_ssj2008 submissions until midnight January 14th, 2014, and submissions made with v1.5.0 were accepted until midnight September 18th, 2013. All SPECpower_ssj2008 submissions on or after January 14th, 2014 must be made with v1.6.1 of PTDaemon.

3.5.1.2.SPEC SERT

SPEC is also developing the Server Efficiency Rating Tool (SERT), at the request of the US Environmental Protection Agency. It is intended to measure server energy efficiency, initially as part of the **version 2.0 of the ENERGY STAR® for Computer Servers specification**.

Designed to be simple to configure and use via a comprehensive graphical user interface, the SERT uses a set of synthetic worklets to test discrete system components such as processors, memory and storage, providing detailed power consumption data at different load levels. Results are provided in both machine- and human-readable forms, enabling automatic submission to government-sponsored certification programs as well as both summary and detail reports for use by potential customers. SERT can test both x86 and IBM Power servers with up to eight processors, as well as multi-node servers. SPEC hopes to expand the tool soon to include ARM- and Sparc-based servers.

Characteristics of SERT include:

- Synthetic worklets that test discrete system components such as memory and storage, providing detailed power consumption data at different load levels.
- Automatic collection of system configuration data with a graphical user interface to review and edit the information.
- Automatic validation of results at both runtime and upon completion of testing.
- Multi-threading and multiple-system runs, providing scalability across a wide range of servers.
- Portability to various computing platforms.
- Run-time behaviour that can be changed for research purposes.
- Results available in both machine- and human-readable forms, enabling automatic submission to government-sponsored certification programs.

In comparison to SPECpower_ssj2008, SERT does not provide comparative scores. SERT is designed to test server systems without the previous tuning. This “tuning” of products in order to achieve high scores has been a point of critique with respect to SPECpower.

There exist limitations of SPECPower and SERT with regards to comparability of data from more populated configurations and the impact of adding components that add power without adding performance. The testing results are dependent on the product categories or server types and the configuration dependency.

3.5.2. SNIA Emerald™ Power Efficiency Measurement Specification

The purpose of the SNIA (Storage Networking Industry Association) Emerald™ Program[12] is to provide public access to storage system power usage and efficiency through the use of a well-defined testing procedure, and additional information related to system power. The measurement procedure, the SNIA Emerald™ Power Efficiency Measurement Specification, was developed and released, and is maintained by the Green Storage Technical Working Group under the guidance of the Green Storage Initiative (GSI) of the SNIA.

The SNIA Emerald Program is sponsored, operated, and promoted by the SNIA GSI. The SNIA is a non-profit, international organisation of manufacturers, systems integrators, developers, systems vendors, industry professionals, and end users. The GSI is responsible for managing the SNIA Emerald Program, providing input and guidance to the Green Storage TWG, and general marketing of energy efficiency activities within the SNIA and the storage networking industry.

The SNIA Emerald Power Efficiency Measurement Specification is used in the V1.0 ENERGY STAR® Data Centre Storage specification. GSI and the Green Storage TWG have been strongly involved with the EPA in creating the EPA's specification. SNIA defined workload tests can be found in the “SNIA EmeraldTM Power Efficiency Measurement Specification” Version 2.0.2.

[12] http://snia.org/emerald

3.5.3. Telecommunications Energy Efficiency Ratio (TEER)

The TEER standard was developed by the Alliance for Telecommunications Industry Solutions (ATIS) to provide telecommunication equipment manufacturers and service providers with a methodology to calculate the energy efficiency of individual equipment and network configurations. It is a useful tool for benchmarking similar equipment. TEER is the ratio of useful work (workload) over power (energy consumption):

TEER = Useful Work / Power

A higher TEER value expresses a higher energy efficiency level. The TEER standard specifies equipment classes according to the number of ports and throughput parameters. The standard also specifies the *useful work* and *power* measurement procedures in supplementary documents. It is interesting to note that *useful work* can be expressed by a variety of aspects including data rate, throughput, processes per second, etc.

The enhanced TEER considers three different data utilisation states (0%, 50%, and 100%) with associated power levels. The metric further differentiates utilisation aspects by additional weighting of power modes according to the different load rates:

$$P_{\text{TEER\_CERT}} = \sum_{j=1}^{m} \left(\frac{P_{0j}}{3} + \frac{P_{50j}}{3} + \frac{P_{100j}}{3} \right)$$

3.5.4. Energy Consumption Rating (ECR Initiative 2010)

The original ECR[13] (Energy Consumption Rating) is a peak metric and intended for a general description of network efficiency:

ECR = E / T, where

- *E* represents the energy consumption (in watts),
- *T* represents the effective maximum system throughput (in bits per second).

ECR is normally expressed in W/Gbps. The ECR peak metric only reflects the energy efficiency in correlation to the highest performance capacity of the device. However, the power consumption of current network devices typically adapts according to the actual work load. In order to get a more accurate understanding of the energy efficiency of modern network equipment, a load variable testing of the devices is necessary.

The enhanced ECR-VL (Energy Consumption Rating Variable Load) is a variable load metric and intended to differentiate energy efficiency under various workload conditions.

$ECR\text{-}VL = (\alpha * E_{100} + \beta * E_{50} + \gamma * E_{30} + \delta * E_{10} + \varepsilon * E_i) / (\alpha * T_f + \beta * T_{50} + \gamma * T_{30} + \delta * T_{10})$, where

T_f = maximum throughput (Gbps) achieved in the measurement cycle,

$T_{50} = T_f * 0.5$,

$T_{30} = T_f * 0.3$,

$T_{10} = T_f * 0.1$,

E_{100} = energy consumption (watts) under highest load,

E_{50} = energy consumption (watts) under fifty percent offered load,

E_{30} = energy consumption (watts) under thirty percent offered load,

E_{10} = energy consumption (watts) under ten percent offered load,

E_i = energy consumption (watts) measured under idle run (removes the load and runs for another 1200 seconds),

$\alpha, \beta, \gamma, \delta, \varepsilon$ are weight coefficients selected such as $(\alpha + \beta + \gamma + \delta + \varepsilon) = 1$.

Finally, a last metric, ECR-EX (extended-idle), can be used as an average energy rating in a reference network, where non-real time (extended) energy savings capabilities are enabled.

[13] http://www.ecrinitiative.org

3.6. Comparative analysis for overlapping test standards on performance, resources use and/or emissions

The existing standardised benchmarks and tests for assessing the functional performance and respective energy consumption of a server, storage or network products include developments solely from industry initiatives including SPEC, SNIA, and ATIS.

The SPECpower test standard is widely used since its introduction in the year 2007, but has been criticised recently for being not very realistic. The main point of criticism is the possible tuning of the product under test, meaning a reduction of its hardware configuration to an absolute minimum. This results in comparably low power consumption when running the performance benchmark.

In order to overcome this situation SERT was developed, providing multiple (more realistic) configuration options for a number of applications and performance aspects. The resulting power consumption is considerably higher (diverse) when running the different worklets (benchmarks). At the moment, the industry is assessing these first results of SERT testing. According to U.S. EPA and industry sources, this process will continue at least until 2015. However, certain industry stakeholders are already promoting SERT, since it provides much more realistic power consumption and performance data and therefore helps customers in their procurement decisions.

With respect to SNIA Emerald and ATIS TEER, the study could not confirm to date the reliability and acceptance of these two energy-performance test standards due to missing information and data sets of test results.

4. Legislation and voluntary agreements

No mandatory legislation or scheme currently exists specifically for enterprise servers and storage equipment in any country, except the Top Runner Program in Japan covering servers. However, there is a great number of voluntary industry initiatives with respect to energy efficiency and sustainability of servers and data centres currently active.

4.1. Legislation and Agreements at European Union Level

4.1.1. The WEEE Directive (2012/19/EU)

The Waste Electrical and Electronic Equipment (WEEE) Directive[14] is a European Directives that implements the principle of "extended producer responsibility". Under this principle, producers are expected to take responsibility for the environmental impact of their products, especially when they become waste. The WEEE Directive applies this in relation to electrical and electronic equipment (EEE).

The broad aims of the WEEE Directive are to address the environmental impacts of electrical and electronic equipment and to encourage its separate collection, and subsequent treatment, reuse, recovery, recycling and environmentally sound disposal.

The WEEE Directive seeks to improve the environmental performance of all operators involved in the life cycle of EEE, especially those dealing with the end of life of EEE. Accordingly, it sets certain requirements related to the separate collection WEEE, standards for its treatment at permitted facilities, and requires its recycling and recovery to target levels. It makes producers responsible for financing the majority of these activities. Distributors have responsibilities in terms of the provision of facilities to enable the free take-back of WEEE by consumers and the provision of certain information EEE consumers.

Options for ecodesign measures might include those that contribute to the WEEE implementation in contributing to waste prevention, in reducing materials use, when possible, and in introducing e.g. easier disassembly, which will make reuse and recycling of energy using products easier.

The product must meet the following three main criteria to be within the WEEE legislation scope:

- Main power source is electricity (including batteries);
- Less than 1 000 V AC or 1 500 V DC; and
- Electricity is needed for primary function.

Enterprise servers and data equipment meet these criteria and belong to the following product categories defined by the Directive:

- 3. IT and telecommunications equipment in Annex I, from 13 August 2012 to 14 August 2018 (transitional period); and
- 4. Large equipment (any external dimension more than 50 cm), and
- 6. Small IT and telecommunication equipment (no external dimension more than 50 cm) in Annex III, from 15 August 2018.

4.1.2. The REACH Regulation (No 1907/2006)

The Regulation on the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH) aims at improving the protection of human health and the environment through better and earlier identification of the intrinsic properties of chemical substances. It places greater responsibility on industry to manage the risks from chemicals and to provide safety information on the substances. In particular, manufacturers and importers have to gather information on the properties of their chemical substances and to register the information in a central database. REACH provides criteria to identify “substances of very high concern” (SVHC) included on

[14] Available here : http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2012:197:0038:0071:EN:PDF

the candidate list[15], which then need to be subject to an authorisation to be used or put on the market after they have been included in a "List of Substances subject To Authorisation"[16]. In particular, substances with the following hazardous properties may be identified as SVHCs:

- Substances meeting the criteria for classification as carcinogenic, mutagenic or toxic for reproduction category 1A or 1B in accordance with Commission Regulation (EC) No 1272/2008 (CMR substances);
- Substances which are persistent, bioaccumulative and toxic (PBT) or very persistent and very bioaccumulative (vPvB) according to REACH (Annex XIII);
- Substances identified on a case-by-case basis, for which there is scientific evidence of probable serious effects that cause an equivalent level of concern as with CMR or PBT/vPvB substances.

REACH thus promotes the progressive substitution of the most dangerous chemicals when suitable alternatives have been identified.

4.1.3. The RoHS Directive (2011/65/EU)

The Restrictions of the use of Hazardous Substances in electrical and electronic equipment (RoHS) Directive[17] bans the putting on the EU market of new EEE containing more than the permitted levels of certain substances listed in Annex II (lead, mercury, cadmium, hexavalent chromium, polybrominated biphenyls (PBBs) and polybrominated diphenylethers (PBDEs)), with the possibility for exemptions given in Annex III, when their use in certain applications is justified/necessary. In particular, exemption 7(b) concerns "lead in solders for servers, storage and storage array systems, network infrastructure equipment for switching, signalling, transmission, and network management for telecommunications".

Therefore, to put products on the EU market, manufacturers must ensure that their products comply with the RoHS Directives requirements. Enterprise servers and data equipment are in the scope of the RoHS Directive as they meet the two main criteria, given in the EEE definition:

- Electricity is needed for at least one intended function; and
- Less than 1 000 V AC or 1 500 V DC.

They belong to category 3: "IT and telecommunications equipment", defined in Annex I. Options for ecodesign measures might include those that contribute to the RoHS implementation in contributing to the reduction of the use of hazardous substances in new products, and this may lead to indirect effects such as an easier disassembly, recycling, and end-of-life treatment.

4.1.4. The Electromagnetic Compatibility Directive (2004/108/EC)

The Electromagnetic Compatibility Directive (EMC) Directive[18] on the approximation of the laws of Member States regulates the electromagnetic compatibility of both apparatus and fixed installations. The directive applies to most electrical and electronic apparatuses including enterprise servers and data equipment, which are finished products and systems that include electrical and electronic equipment that may generate or be affected by electromagnetic disturbance.

The main objective of the EMC Directive, thus, is to regulate the compatibility of equipment regarding EMC. In order to achieve this objective, provisions have been put in place so that equipment needs to comply with the requirements of the EMC Directive when it is placed on the market and/or taken into service. On the one hand, it has to be ensured that the electromagnetic emissions of this equipment in its intended use do not disturb radio and telecommunication, as well as other equipment. On the other hand, the Directive also governs the immunity of such equipment to interference and seeks to ensure that this equipment is not disturbed by radio emissions when normally used as intended.

4.1.5. Low Voltage Directive (2006/95/EC)

The Low Voltage Directive (LVD)[19] seeks to ensure that electrical equipment within certain voltage limits both provides a high level of protection for European citizens and enjoys a Single Market in the European Union. The Directive requires electrical equipment to have protection against hazards that could arise from within the

[15] Available here: http://echa.europa.eu/web/guest/candidate-list-table
[16] Available here: http://echa.europa.eu/web/guest/addressing-chemicals-of-concern/authorisation/recommendation-for-inclusion-in-the-authorisation-list/authorisation-list
[17] Available here: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2011:174:0088:0110:EN:PDF
[18] Available here: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2004:390:0024:0037:en:PDF
[19] Available here: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2006:374:0010:0019:EN:PDF

electrical equipment itself or from external influences. The Directive covers all risks arising from the use of electrical equipment, including mechanical, chemical (such as, in particular, emission of aggressive substances). The LVD also covers noise and vibration, and ergonomic aspects, which could cause hazards within the scope of the Directive. The LVD covers electrical equipment designed for use with a voltage rating of between 50 V and 1000 V for alternating current and between 75 V and 1500 V for direct current. It should be noted that these voltage ratings refer to the voltage of the electrical input or output, not to voltages that may appear inside the equipment. Thus, enterprise servers and data equipment fall under the Low Voltage Directive.

4.1.6. Regulation (EU) No 617/2013 on ecodesign requirements for computers and computer servers

Regulation No 617/2013 on ecodesign requirements for computers and computer servers[20] implements the Ecodesign (2009/125/EC) Directive, following the preparatory study DG ENER Lot 3 on Personal Computers (desktops and laptops) and computer monitors.

The Regulation applies to, amongst others:

- Small-scale servers;
- Computer servers.

The following products are explicitly excluded from the scope:

- Blade system and components;
- Server appliances;
- Multi-node servers;
- Computer servers with more than four processor socket.

Implementing measures concerning small-scale servers and computer servers only concern:

- the internal power supply efficiency (efficiency and power factor) (see Table 5); and
- the provision of information in the technical documentation, especially on internal/external power supply efficiency, maximum power, idle state power, sleep mode power, off mode power, noise levels and the measurement methodology used to determine these information.

As a result, the scope of the regulation is partly overlapping with the scope of this preparatory study. Harmonisation regarding potential measures on internal power supply efficiency could be required depending on the outcomes of the study.

[20] Available here: http://new.eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32013R0617&from=EN

Table 5: Ecodesign requirements concerning server power supply efficiency in Regulation No 617/2013

Product group	Internal power supply efficiency requirements
Small-scale server	From 1 July 2014 All computer internal power supplies shall not perform at less than: (a) 85 % efficiency at 50 % of rated output power; (b) 82 % efficiency at 20 % and 100 % of rated output power; (c) power factor = 0.9 at 100 % of rated output power. Internal power supplies with a maximum rated output power of less than 75 W are exempt from the power factor requirement.
Computer servers	5.2. From 1 July 2014 5.2.1. All multi-output (AC-DC) power supplies shall not perform at less than: (a) 85 % efficiency at 50 % of rated output; (b) 82 % efficiency at 20 % and 100 % of rated output. 5.2.2. All multi-output (AC-DC) power supplies shall not perform at less than: (a) power factor 0.8 at 20 % of rated output; (b) power factor 0.9 at 50 % of rated output; (c) power factor 0.95 at 100 % of rated output. 5.2.3. All single output (AC-DC) power supplies with rated output of not more than 500 W shall not perform at less than: (a) 70 % efficiency at 10 % of rated output; (b) 82 % efficiency at 20 % of rated output; (c) 89 % efficiency at 50 % of rated output; (d) 85 % efficiency at 100 % of rated output. 5.2.4. All single output (AC-DC) power supplies with rated output of not more than 500 W shall not perform at less than: (a) power factor 0.8 at 20 % of rated output; (b) power factor 0.9 at 50 % of rated output; (c) power factor 0.95 at 100 % of rated output. 5.2.5. All single output (AC-DC) power supplies with rated output greater than 500 W but not more than 1 000 W shall not perform at less than: (a) 75 % efficiency at 10 % of rated output; (b) 85 % efficiency at 20 % and 100 % of rated output; (c) 89 % efficiency at 50 % of rated output. 5.2.6. All single output (AC-DC) power supplies with rated output greater than 500 W but not more than 1 000 W shall not perform at less than: (a) power factor 0.65 at 10 % of rated output; (b) power factor 0.8 at 20 % of rated output; (c) power factor 0.9 at 50 % of rated output; (d) power factor 0.95 at 100 % of rated output. 5.2.7. All single output (AC-DC) power supplies with rated output of more than 1 000 W shall not perform at less than: (a) 80 % efficiency at 10 % of rated output; (b) 88 % efficiency at 20 % and 100 % of rated output; (c) 92 % efficiency at 50 % of rated output. 5.2.8. All single output (AC-DC) power supplies with rated output of more than 1 000 W shall not perform at less than: (a) power factor 0.8 at 10 % of rated output; (b) power factor 0.9 at 20 % of rated output; (c) power factor 0.9 at 50 % of rated output; (d) power factor 0.95 at 100 % of rated output.

4.1.7. Regulation (EU) No 1275/2008 on standby and off mode electric power consumption of electrical and electronic household and office equipment

Regulation No 1275/2008 implements the Ecodesign Directive (2009/125/EC) with regard to ecodesign requirements for standby and off mode electric power consumption of electrical and electronic household and office equipment. According to Annex I, it covers "information technology equipment intended primarily for use in the domestic environment", i.e. Class B equipment, and it is at this stage not clear which types of Lot 9 equipment would fall under this scope but it is expected to be a minor share, if any.

Amendment 801/2013, which extends this Regulation with network standby mode implementing measures for networked electrical and electronic household and office equipment (equipment that can connect to a network and has one or more network ports), covers amongst others:

- Small-scale servers;
- Computer servers;
- and all other equipment potentially covered by Lot 9 (e.g. storage and network equipment).

Requirements include:

- Possibility of deactivating wireless network connection(s),
- Power management function,
- Compliance with standby mode(s) requirements when all network ports are deactivated,
- Product information requirements, as of 1 January 2015; and
- Compliance with standby mode(s) requirements when all wired network ports are disconnected and when all wireless network ports are deactivated, as of 1 January 2017.

The Regulation also sets maximum power consumption requirements in a condition providing networked standby. Small-scale servers and computers are specifically exempted for these requirements until 01/01/2019 (see Table 6). Other enterprise data equipment (storage and network equipment) should be covered by these requirements from 2015, under the high network availability equipment.

Table 6: Power consumption requirements in a condition providing networked standby

Equipment	Stage 1 (01/01/2015)	Stage 2 (01/01/2017)	Stage 3 (01/01/2019)
High Network Availability (HiNA) equipment	12 W	8 W	-
Equipment other than HiNA	6 W	3 W	2 W

4.1.8. Regulation (EU) No 278/2009 on ecodesign requirements for external power supplies

The Regulation No 278/2009 implements the Ecodesign Directive (2009/125/EC) with regard to ecodesign requirements for no-load condition electric power consumption and average active efficiency of external power supplies (EPS).

The Regulation applies to power supplies with an output of less than 250 W and supplying only one output voltage at a time. It applies only to external power supplies that are intended for use with electrical and electronic household and office equipment as referred to in Article 2(1) of Regulation (EC) No 1275/2008. Thus, regarding IT equipment, this Regulation only covers "information technology equipment intended primarily for use in the domestic environment", i.e. Class B equipment, and it is unclear at this stage which Lot 9 products may be covered by this scope, but it is expected to be a minor share, if any.

The main requirements of the Regulation focus upon no-load power consumption and average efficiency.

4.1.9. Regulation (EU) No 327/2011 on ecodesign requirements for fans driven by motors with an electric input power beween 125 W and 500 kW: Ventilation Fans

The Regulation No 327/2011 implements the Ecodesign Directive (2009/125/EC) with regard to ecodesign requirements for fans driven by motors with an electric input power between 125 W and 500 kW.

Final regulation for ventilation fans entered into force on 26 April 2011. The first tier of the minimum energy efficiency requirements is effective since 1 January 2013; the second will be effective on 1 January 2015.

A fan is defined as a rotary bladed machine that is used to maintain a flow of a gas, typically air, passing through it and whose work per unit mass does not exceed 25 kJ/kg. Furthermore it is designed for use with or equipped with an electrical motor with an electric input power between 125 W and 500 kW (≥ 125 W and ≤ 500 kW) to drive the impeller at its optimum energy efficiency point. It can be an axial fan, centrifugal fan, cross flow fan or mixed flow fan and may or may not be equipped with a motor when placed on the market or put into service.

The first tier of the ecodesign requirements only applies to "ventilation fans", which explicitly exclude fans used in 'information technology product', and thus all products under the scope of Lot 9 according to the FAQ[21].

However, the fans for such products are concerned by the second tier, according to articles 2 and 3, and the energy efficiency requirements shall become effective in 2015. These minimum energy efficiency requirements for all fans from 1 January 2015 are displayed in Table 7 below.

Table 7: Second tier minimum energy efficiency requirements (from 01/01/2015)

Fan Types	Measurement Category	Efficiency category	Power range P in kW	Target energy efficiency[22]	Efficiency grade (N)
Axial Fan	A,C	Static	0,125 ≤ P ≤ 10	$\eta_{target} = 2,74 \cdot \ln(P) - 6,33 + N$	40
			10 < P ≤ 500	$\eta_{target} = 0,78 \cdot \ln(P) - 1,88 + N$	
	B,D	Total	0,125 ≤ P ≤ 10	$\eta_{target} = 2,74 \cdot \ln(P) - 6,33 + N$	58
			10 < P ≤ 500	$\eta_{target} = 0,78 \cdot \ln(P) - 1,88 + N$	
Centrifugal forward curved fan and centrifugal radial bladed fan	A,C	Static	0,125 ≤ P ≤ 10	$\eta_{target} = 2,74 \cdot \ln(P) - 6,33 + N$	44
			10 < P ≤ 500	$\eta_{target} = 0,78 \cdot \ln(P) - 1,88 + N$	
	B,D	Total	0,125 ≤ P ≤ 10	$\eta_{target} = 2,74 \cdot \ln(P) - 6,33 + N$	49
			10 < P ≤ 500	$\eta_{target} = 0,78 \cdot \ln(P) - 1,88 + N$	
Centrifugal backward curved fan without housing	A,C	Static	0,125 ≤ P ≤ 10	$\eta_{target} = 4,56 \cdot \ln(P) - 10,5 + N$	62
			10 < P ≤ 500	$\eta_{target} = 1,1 \cdot \ln(P) - 2,6 + N$	
Centrifugal backward curved fan with housing	A,C	Static	0,125 ≤ P ≤ 10	$\eta_{target} = 4,56 \cdot \ln(P) - 10,5 + N$	61
			10 < P ≤ 500	$\eta_{target} = 1,1 \cdot \ln(P) - 2,6 + N$	
	B,D	Total	0,125 ≤ P ≤ 10	$\eta_{target} = 4,56 \cdot \ln(P) - 10,5 + N$	64
			10 < P ≤ 500	$\eta_{target} = 1,1 \cdot \ln(P) - 2,6 + N$	
Mixed flow fan	A,C	Static	0,125 ≤ P ≤ 10	$\eta_{target} = 4,56 \cdot \ln(P) - 10,5 + N$	50
			10 < P ≤ 500	$\eta_{target} = 1,1 \cdot \ln(P) - 2,6 + N$	
	B,D	Total	0,125 ≤ P ≤ 10	$\eta_{target} = 4,56 \cdot \ln(P) - 10,5 + N$	62
			10 < P ≤ 500	$\eta_{target} = 1,1 \cdot \ln(P) - 2,6 + N$	
Cross flow fan	B,D	Total	0,125 ≤ P ≤ 10	$\eta_{target} = 1,14 \cdot \ln(P) - 2,6 + N$	21
			10 < P ≤ 500	$\eta_{target} = N$	

The product information requirements on fans and how they must be displayed are as set out in Annex I, Section 3 of the Regulation. These requirements apply from 1 January 2013.

[21] http://ec.europa.eu/enterprise/policies/sustainable-business/documents/eco-design/guidance/files/faq-fans-327-2011_en.pdf

[22] Where η_{target} is the target energy efficiency, P is the electrical input power and N is the integer of the energy efficiency grade required.

4.1.10. Directives on electronic communications networks and services

The Commission periodically reviews the functioning of the five Directives comprising the existing regulatory framework for electronic communications networks and services (the Framework Directive and the Specific Directives) in order to determine the need for modifications in the light of technological and market developments. The Directives in question are the following:

- Directive 2002/19/EC of the European Parliament and of the Council of 7 March 2002 on access to, and interconnection of, electronic communications networks and associated facilities (Access Directive).
- Directive 2002/20/EC of the European Parliament and of the Council of 7 March 2002 on the authorization of electronic communications networks and services (Authorization Directive).
- Directive 2002/21/EC of the European Parliament and the Council of 7 March 2002 on a common regulatory framework for electronic communications networks and services (Framework Directive).
    - Regulation (EC) No 717/2007 on roaming on public mobile telephone networks within the Community amending Directive 2002/21/EC.
    - Regulation (EC) No 544/2009 amending Regulation (EC) No 717/2007 on roaming on public mobile telephone networks within the Community and Directive 2002/21/EC on a common regulatory framework for electronic communications networks and services.
    - Directive 2009/140 amending Directives 2002/21/EC on a common regulatory framework for electronic communications networks and services, 2002/19/EC on access to, and interconnection of, electronic communications networks and associated facilities, and 2002/20/EC on the authorisation of electronic communications networks and services.
- Directive 2002/22/EC (Universal Service Directive)
    - Amended by Directive 2009/136/EC on universal service and users' rights relating to electronic communications networks and services, Directive 2002/58/EC concerning the processing of personal data and the protection of privacy in the electronic communications sector and Regulation (EC) No 2006/2004 on cooperation between national authorities responsible for the enforcement of consumer protection laws.
- Directive 2002/58/EC (Directive on privacy and electronic communications)
    - Amended by Directive 2006/24/EC on the retention of data generated or processed in connection with the provision of publicly available electronic communications services or of public communications networks.
    - Amended by Directive 2009/136/EC.

The electronic communications sector thus underlies regulations with respect to different aspects such as competition, affordable accessibility, or security. A Directive that is affecting the equipment under consideration is the Directive on privacy and electronic communications (Directive 2002/58/EC), since it requires from providers very specific measures with respect to features such as safety, availability, serviceability, performance or capacity. It will therefore influence the choice of the providers of electronic communications networks and services with respect to the proper equipment.

It concerns the processing of personal data and the protection of privacy in the electronic communications sector, and regulates different issues like confidentiality of information, treatment of traffic data, spam and cookies. It takes also into account security concerns and requests e.g. from the provider of a publicly available electronic communications service to take appropriate technical and organizational measures to safeguard security of its services (Article 4). National legislations of the Member States have to ensure the confidentiality of communications and the related traffic data by means of a public communications network and publicly available electronic communications services.

Directive 2006/24/EC – also known as the Data Retention Directive – requires from Member States to store citizens' telecommunications data for retained for periods of not less than six months and not more than two years from the date of the communication. With respect to data protection and data security, this Directive builds up on Directives 95/46/EC and 2002/58/EC and requires from Member States that the retained data should have the same quality and be subject to the same security and protection as those data on the network. Furthermore, the data has to be subject to appropriate technical and organizational measures in order to protect the data against accidental or unlawful destruction, accidental loss or alteration, or unauthorized or

unlawful storage, processing, access or disclosure. The data shall underlie appropriate technical and organizational measures ensuring that they are accessed only by specially authorized persons and that the data is destroyed properly after the period of retention.

4.1.11. Code of conduct on data centres

The EU Code of Conduct (CoC) for data centres[23] was one of the first international approaches addressing energy efficiency management in data centres from 2008. It is a voluntary scheme that was developed by the Joint Research Centre (JRC), Institute for Energy and Transport (IET). Its objective is to inform and stimulate data centre operators and owners to reduce energy consumption in a cost-effective manner without hampering the mission critical function of data centres, by improving understanding of energy demand within the data centre, raising awareness, and recommending energy efficient best practice and targets.

The CoC is basically a voluntary commitment of companies that own or operate data centres to support a reduction of energy consumption in data centres by applying best practice. The core of the programme is a registration form, signed by the participants, in which they commit to:

- an initial energy measurement, and energy audit to identify the major energy saving opportunities.
- an Action Plan must be prepared and submitted, once the Action Plan is accepted the Participant status will be granted.
- implement the Action Plan according to the agreed timetable. Energy consumption must be monitored regularly, to see overtime progresses in the energy efficiency indicator related to the Data centre.

This initiative thus includes the typical elements of environmental management schemes including an energy efficiency strategy, energy efficiency monitoring and best practice measures. Progress reporting must be done on an annual basis to the responsible management body. However, the CoC partnership is issued for three years and the data centre is reassessed in a three years cycle.

The CoC approach is based on a comprehensive set of best practice measures, which are revised on a regular basis by the JRC. The IT load (consumption of the IT equipment in the data centre) is one of the focus areas. **Error! Reference source not found.** lists the best practices that are related to enterprise servers and data equipment. They include considerations mostly dealing with:

- Embedded energy/life cycle analysis;
- Energy efficiency and power management (including references to ENERGY STAR®);
- Influence from environment during usage (temperature, humidity, air flows);
- Resilience, quality of service; and
- Performance monitoring and reporting capabilities.

All these aspects may be relevant areas for potential Ecodesign measures.

[23] http://iet.jrc.ec.europa.eu/energyefficiency/ict-codes-conduct/data-centres-energy-efficiency

Table 8: CoC best practices related to the selection or use of individual IT (server, storage, and network) equipment (2013 Best Practices, Version 4.0.5)

No and Name	Description
3.2.1 Consider the embedded energy in devices	Carry out an audit of existing equipment to maximise any unused existing capability by ensuring that all areas of optimisation, consolidation and aggregation are identified prior to new material investment.
3.2.3 Lifecycle Analysis	Introduce a plan for Lifecycle Assessment (LCA) in accordance with emerging EU Guidelines and internationally standardised methodology (ISO 14040 ff)
4.1.1 IT hardware – Power	Include the Energy efficiency performance of the IT device as a high priority decision factor in the tender process. This may be through the use of ENERGY STAR® or SPECPower type standard metrics or through application or deployment specific user metrics more closely aligned to the target environment which may include service level or reliability components. The power consumption of the device at the expected utilisation or applied workload should be considered in addition to peak performance per Watt figures.
4.1.2 New IT hardware – Restricted (legacy) operating temperature and humidity range	Where no equipment of the type being procured meets the operating temperature and humidity range of practice 4.1.3, then equipment supporting at a minimum the restricted (legacy) range of 15°C - 32°C inlet temperature (59°F – 89.6°F) and humidity from 20% to 80% relative humidity and below 17°C maximum dew point (62.6°F) may be procured.
4.1.3 New IT hardware – Expected operating temperature and humidity range	Include the operating temperature and humidity ranges at the air intake of new equipment as high priority decision factors in the tender process. Equipment should be able to withstand and be within warranty for the full range of 10°C to 35°C inlet temperature (50°F to 95°F) and humidity within 20% relative humidity to 80% relative humidity or 21°C (69.8°F) dew point. This is defined by the ASHRAE Class A2 allowable temperature and humidity range.
4.1.4 Select equipment suitable for the data centre – Power density	Select and deploy equipment at the design power density (per rack or sq m) of the data centre to avoid running the cooling system outside design parameters.
4.1.5 Select equipment suitable for the data centre - Air flow direction	When selecting equipment for installation into racks ensure that the air flow direction matches the air flow design for that area. This is commonly front to rear or front to top.
4.1.6 Enable power management features	Formally, change the deployment process to include the enabling of power management features on IT hardware as it is deployed. This includes BIOS, operating system and driver settings.
4.1.7 Provision to the as configured power	Provision power and cooling only to the as configured power draw capability of the equipment, not the PSU or nameplate rating. Note that this may require changes to the provisioning if the IT equipment is upgraded internally.
4.1.8 ENERGY STAR® compliant hardware	The ENERGY STAR® Labelling programs for IT equipment should be used as a guide to server selection where and when available for that class of equipment. Operators who are able to determine the in use energy efficiency of hardware through more advanced or effective analysis should select the most efficient equipment for their scenario.
4.1.9 Energy & temperature reporting hardware	Select equipment with power and inlet temperature reporting capabilities, preferably reporting energy used as a counter in addition to power as a gauge. Where applicable, industry standard reporting approaches should be used such as IPMI, DCMI and SMASH.
4.1.10 Control of equipment energy use	Select equipment which provides mechanisms to allow the external control of its energy use. An example of this would be the ability to externally restrict a server's maximum energy use or trigger the shutdown of components, entire systems or sub-systems
4.1.11 Select free standing equipment suitable for the data centre – Air flow direction	When selecting equipment which is free standing or supplied in custom racks the air flow direction of the enclosures should match the air flow design in that area of the data centre. This is commonly front to rear or front to top.
4.1.12 Operating temperature range – Liquid cooled IT equipment	Devices whose primary cooling method is not air (directly liquid cooled) are not subject to the air environmental requirements specified in 4.1.3. These devices should be able to operate with supply coolant liquid temperatures equal to the air temperatures specified in 4.1.3 - 10°C to 35°C (50°F to 95°F)

4.1.13 IT equipment power against inlet temperature	When selecting new IT equipment require the vendor to supply at minimum; Either the total system power or cooling fan power for temperatures covering the full allowable inlet temperature range for the equipment under 100% load on a specified benchmark such as SPECPower (http://www.spec.org/power_ssj2008/). Data should be provided for 5°C or smaller steps of inlet temperature Optional but recommended; Total system power covering the full allowable inlet temperature range under 0% and 50% load on the selected benchmark
4.1.14 New IT hardware – Extended operating temperature and humidity range	Include the operating temperature and humidity ranges at the air intake of new equipment as high priority decision factors in the tender process. Consider equipment which operates under a wider range of intake temperature and humidity such as that defined in ASHRAE Class A4 or ETSI EN 3.1
4.2.1 Deploy using Grid and Virtualisation technologies	Processes should be put in place to require senior business approval for any new service that requires dedicated hardware and will not run on a resource sharing platform. This applies to servers, storage and networking aspects of the service.
4.2.2 Reduce IT hardware resilience level	Determine the business impact of service incidents for each deployed service and deploy only the level of hardware resilience actually justified.
4.2.3 Reduce hot / cold standby equipment	Determine the business impact of service incidents for each IT service and deploy only the level of Business Continuity / Disaster Recovery standby IT equipment and resilience that is actually justified by the business impact.
9.4.1 Server Utilisation	Logging and internal reporting of the processor utilisation of the overall or grouped by service/location IT server estate. Whilst effective metrics and reporting mechanisms are still under development a basic level of reporting can be highly informative.
9.4.2 Network Utilisation	Logging and internal reporting of the proportion of the overall or grouped by service / location network capacity utilised. Whilst effective metrics and reporting mechanisms are still under development a basic level of reporting can be highly informative.
9.4.3 Storage Utilisation	Logging and internal reporting of the proportion of the overall or grouped by service / location storage capacity and performance utilised. Whilst effective metrics and reporting mechanisms are still under development a basic level of reporting can be highly informative. The meaning of utilisation can vary depending on what is considered available capacity (e.g., ports, raw v. usable data storage) and what is considered used (e.g., allocation versus active usage). Ensure the definition used in these reports is clear and consistent. Note that mixed incentives are possible here through the use of technologies such as deduplication.

4.1.12. EU Ecolabel

The European Ecolabel[24] is a voluntary scheme, established in 1992 to encourage businesses to market products and services that are environmentally friendly. Products and services awarded the Ecolabel carry the flower logo, allowing consumers - including public and private purchasers - to identify them easily. The environmental benefits of any EU eco-labelled product can be measured throughout its life cycle, from the extraction of raw material to disposal. The benefits are therefore translated in terms of lower consumption of energy, water and raw material as well as reduced impact on air quality, global warming, and biodiversity. Some EEE are covered by the Ecolabel, for instance personal computers and portable computers, and the following criteria apply:

- The product consumes less energy during use and standby;
- It contains less substances that are dangerous for health and the environment;
- The product can be taken back free of charge by the manufacturer after use;
- It can be easily dismantled and recycled; and
- The product durability is increased through up-grades.

Enterprise servers and data equipment are not covered by the scheme - or under development - to date.

[24] www.ecolabel.eu

4.1.13. ENERGY STAR® programme

Initially, ENERGY STAR® is a joint voluntary labelling program of the U.S. Environmental Protection Agency and the U.S. Department of Energy supporting energy efficient products and practices, launched in 1992[25]. Products that comply with the performance criteria set by ENERGY STAR® may use the ENERGY STAR® certification mark (after the manufacturer became an ENERGY STAR® partner, which comes along with some further, however not product specific requirements). The ENERGY STAR® specification criteria only deal with energy efficiency of products during their use phase.

The EU ENERGY STAR® programme for IT and office equipment results from an agreement between the US government and the European Commission. In 2001, the European Union signed an Agreement with US EPA to introduce the ENERGY STAR® in Europe as well (only for IT and office equipment), thereby recognising each other as Partner in the ENERGY STAR® programme. This allows potential partners in the European Union to sign up through the European Commission, who is responsible for the EU ENERGY STAR Programme.

In particular, the ENERGY STAR® specifications are used as compulsory public procurement requirements in the EU-28 for the EC and Member States (central governments), as stated in Article 6 of the European Regulation 106/2008[26] on a Community energy-efficiency labelling programme for office equipment and in Article 6 of Directive 2012/27/EU on energy efficiency.

To date, due to some delays on the adoption of specifications in the EU for products relevant for Lot 9, computer servers version 2.0 and small-scale servers (through computer equipment specifications v 5.0) are implemented in the EU scheme[27] through Computer Equipment specifications v 5.0. Given the definition, "a computer that typically uses desktop components in a desktop form factor, but is designed primarily to be a storage host for other computers", products in scope of this study are not concerned by this product group.

However, ENERGY STAR® recently finalised **Version 2.0 specification for Computer Servers**[28] (took effect on 16 December 2013 and was adopted on 20 March 2014), **Version 1.0 specification for Data Centre Storage**[29] (took effect on 2 December 2013), and **Version 1.0 specification for Small Network Equipment**[30] (took effect on 3 September 2013). The EU scheme should cover servers soon through the associated specification, according to a draft version of Annex C of a revision of the agreement between the Government of the United States of America and the European Union on the coordination of energy-efficiency labelling programs for office equipment. The adoption of storage equipment specifications based on Version 1.0 specification for Data Centre Storage within ENERGY STAR® is also expected at a later stage. These three specifications are briefly presented below.

Finally, a specification for large network equipment is also currently under development[31].

4.1.13.1. Specification for Computer Servers

The specification for Computer Servers **covers blade-, multi-node, rack-mounted, or pedestal form factor computer servers with no more than four processor sockets in the computer server** (or per blade or node in the case of blade or multi-node servers)[32]. Fully fault tolerant servers, server appliances, high performance computing systems, and large servers are explicitly excluded from the scope. The qualification criteria include (criteria on documentation/ information provision are not all listed below):

- Power supply efficiency criteria (Table 9) and power factor criteria (Table 10) for all Power Supply Units: based on the Generalized Internal Power Supply Efficiency Test Protocol, Rev. 6.6 (available at www.efficientpowersupplies.org)

[25] www.energystar.gov
[26] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2008:039:0001:0007:EN:PDF
[27] http://www.eu-energystar.org/downloads/legislation/20090624/L161_16_20090624_en.pdf
[28] https://www.energystar.gov/products/specs/node/142
[29] http://www.energystar.gov/products/specs/node/144
[30] http://www.energystar.gov/products/specs/small_network_equipment_specification_version_1_0_pd
[31] https://www.energystar.gov/products/specs/node/413
[32] Detailed definitions used with the specification have been presented in section 2.1.

Table 9: ENERGY STAR® Efficiency Requirements for PSUs (Version 2.0 specification for Computer Servers)

Power Supply Type	Rated Output Power	10% Load	20% Load	50% Load	100% Load
Multi-output (AC-DC)	All Output Levels	N/A	85%	88%	85%
Single-output (AC-DC)	All Output Levels	80%	88%	92%	88%

Table 10: ENERGY STAR® Power Factor Requirements for PSUs (Version 2.0 specification for Computer Servers)

Power Supply Type	Rated Output Power	10% Load	20% Load	50% Load	100% Load
Multi-output (AC-DC)	All Output Levels	N/A	0.80	0.90	0.95
Single-output (AC-DC)	Output Rating ≤ 500 W	N/A	0.80	0.90	0.95
	Output Rating > 500 W and Output Rating ≤ 1,000 W	0.65	0.80	0.90	0.95
	Output Rating > 1,000 W	0.80	0.90	0.90	0.95

- Power management requirements: enabled by default at processor and supervisor levels (when pre-installed).
- Thermal management and monitoring for blade and multi-node systems: Real-time inlet temperature monitoring and fan speed management capability enabled by default.
- Idle State Efficiency Criteria: Idle State power shall be measured and reported for all types of products covered (for blades and multi-node servers, reporting shall be done at both the system and the blade/node levels), while minimum efficiency requirements apply only to one-socket and two-socket servers (neither blade nor multi-node), based on the following formula:

$$P_{IDLE\_MAX} = P_{BASE} + \sum_{i=1}^{n} P_{ADDL\_i}$$, where

P_{IDLE_MAX} is the maximum idle state power requirement, to be compared to the measured value,

P_{BASE} is the base idle power allowance, which depends on the maximum possible number of installed processors, whether the server is managed or not, whether it is resilient or not,

P_{ADDL_i} is the idle state power allowance for additional components, depending on the number of additional power supplies, hard drives, additional memory, additional buffered DDR channel and additional I/O devices.

- Active State Efficiency Reporting: for all types of servers, according to the SPEC SERT rating tool.

Amongst the considerations for future revisions of the specification, active state efficiency criteria (for all computer server categories in which EPA has enough SERT data to adequately differentiate products) are stated.

Server products are complex, given the range and choices of component types and performance as well as the range of configurations which can be purchased under a given machine type.

4.1.13.2.Specification for data centre storage

Regarding the data centre storage specification, it **covers storage products defined the following way**: "*A fully-functional storage system that supplies data storage services to clients and devices attached directly or through a network. Components and subsystems that are an integral part of the storage product architecture (e.g., to provide internal communications between controllers and disks) are considered to be part of the storage product. In contrast, components that are normally associated with a storage environment at the data centre level (e.g., devices required for operation of an external SAN) are not considered to be part of the*

storage product. A storage product may be composed of integrated storage controllers, storage devices, embedded network elements, software, and other devices. For purposes of this specification, a storage product is a unique configuration of one or more SKUs, sold and marketed to the end user as a Storage Product". Moreover, products in scope shall contain a controller with advanced data recovery capability, support Block I/O storage functions either entirely or as an additional capability, and implement scale-up or scale-out storage. In particular, the **specification does not apply to** personal / portable data storage products, computer servers, blade storage products, direct attached storage products, network attached storage products that cannot perform block I/O, storage products capable of object based storage, and storage devices in the following categories of the taxonomy: Near-online, Removable Media Library, Virtual Media Library, Adjunct Storage Products, and Interconnect Elements.

The qualification criteria introduces an approach to product families that allows both homogenous and heterogeneous storage device configurations to be certified. They include (criteria on documentation/ information provision are not all listed below):

Power supply efficiency and power factor requirements: Embedded PSUs that power primary components of the components of the storage product, including controllers and drawers, must meet the requirements in Table 11 and

- Table 12, tested using the EPRI Generalized Internal Power Supply Efficiency Test Protocol, Rev. 6.6.

Table 11: ENERGY STAR® Efficiency Requirements for PSUs (Version 1.0 specification for Data Centre Storage)

PSU Type	Rated Output Power	20% Load	50% Load	100% Load
Redundant and Non-redundant capable PSU	All Output Levels	85%	89%	85%

Table 12: ENERGY STAR® Power Factor Requirements for PSUs (Version 1.0 specification for Data Centre Storage)

PSU Type	Rated Output Power	20% Load	50% Load	100% Load
Redundant and Non-redundant capable PSU	All Output Levels	0.80	0.90	0.95

- Power Modelling tool: for systems that qualify using modelled data, a power modelling tool characterizing the storage product will be made available to manufacturer qualified purchasers of the product.
- Energy Efficiency Feature Requirements: storage products must contain adaptive active cooling features that reduce the energy consumed by the cooling technology in proportion to the current cooling needs to the storage product. The storage product shall also make available to the end user configurable / selectable features (thin provisioning, data deduplication, compression or delta snapshots) in minimum quantities than depend upon its category: 0 feature for Online 2; 1 feature for Online 3 and Online 4.
- Active and Idle State Efficiency Disclosure: for 6 different workloads, according to the SNIA Emerald™ Power Efficiency Measurement Specification Version 2.0.2.

Storage products are very complex. Because of the modularity and variety of configurations possible for storage products, the testing process defines some "extreme" configurations to be tested. The specification allows for variations within product families to incorporate newer storage devices and other system improvements over the life of the storage product, striking a balance between additional testing burden and representative test data: for instance, manufacturers may replace storage devices that were used during qualification with storage devices that have similar energy efficiency (performance/watt) compared to the device being replaced after qualification. In the considerations for future revisions, EPA includes the expansion of the scope, as well as active and idle state efficiency criteria for storage products in which it has enough data to adequately differentiate products.

4.1.13.3.Specification for Small Network Equipment

The specification applies to broadband modems (Cable, DSL), optical network termination device (ONT), integrated access device (IAD), router, switches and access points, meeting the definition of “small network equipment” provided (see section 2.1.3.3). In particular, it does not apply to:

- Network equipment capable of accepting interchangeable modules, such as line cards or additional power supplies;
- Network equipment with one or more network ports using pluggable or modular media adapters such as Gigabit Interface Convertor (GBIC) or Small Form-factor Pluggable (SFP) modules. This does not include USB ports;;
- Network equipment whose primary wireless capability is not IEEE 802.11 (Wi-Fi);
- Network equipment that receive direct DC power (PoE, USB) or provide power through PoE;
- Large network equipment; and
- Network equipment that is marketed and sold as enterprise network equipment and can be controlled and configured for operation by an external controller.

The qualification criteria include:

- **External Power Supply (EPS) Requirements**: Single- and Multiple-voltage EPSs shall meet the Level V performance requirements under the International Efficiency Marking Protocol when tested according to the Uniform Test Method for Measuring the Energy Consumption of External Power Supplies, Appendix Z to 10 CFR Part 430.
- **Efficiency criteria**: Calculated Average Power P_{AVG} = Average [P_{WAN_TEST},N_TEST,$P_{WIRELESS\_TEST}$] shall be less than or equal to P_{AVG_MAX}, where P_{AVG_MAX} is given by: $P_{AVG\_MAX} = P_{BASE} + \Sigma P_{ADDi.}$ The base power and additional allowances are presented in Table 13 and Table 14. P_{WAN_TEST}, P_{LAN_TEST}, and $P_{WIRELESS\_TEST}$ shall be determined according to a specific ENERGY STAR test method for small network equipment.

Table 13 : Base Power Allowances

Product Type	P_{BASE} (watts)
Broadband Modem – Cable	5.7
Broadband Modem – ADSL	4.0
ONT	4.4
IAD - Cable	6.1
IAD - ADSL	5.5
IAD - VDSL	7.5
Router	3.1
Switch	0.6
Access Point	2.0

Table 14 : Additional Functional Adders

Feature	Power Allowance (P_{ADD}) in watts	Notes
Fast Ethernet (100Base-T)	0.1	Allowance applied once per port present in the UUT.
Gigabit Ethernet (1000Base-T)	0.3	Allowance applied once per port present in the UUT.
Wi-Fi (802.11a/b/g/n)	0.7	Allowance applied once for the UUT for availability of Wi-Fi connectivity.
802.11n per Receive Spatial Stream	0.2	Allowance applied to total number of 2.4 GHz and 5.0 GHz 802.11n receive spatial streams. Only applicable for products that ship with simultaneous dual band Wi-Fi enabled.
802.11ac per Receive Spatial Stream	1.3	Allowance applied to 5.0 GHz 802.11ac receive spatial streams only. Only applicable for products that ship with simultaneous dual band Wi-Fi enabled.
Plain Old Telephone Service (RJ11/RJ14)	0.5	Allowance applied once per port, up to a maximum of two ports.

4.1.14. TCO Certification

The TCO Certification is a combined energy usage and ergonomics rating from the Swedish Confederation of Professional Employees (TCO). The TCO labelling system specifically targets IT and office equipment that is designed for the benefit of both the user and the environment. The label takes legislation as well as voluntary agreements into consideration.

No product group related to enterprise servers and data equipment is currently considered by the scheme.

4.2. Member State legislation and agreements

4.2.1. Germany

4.2.1.1. Blue Angel

The German ecolabel Blue Angel[33] defined award criteria for the “Energy-Conscious Data Centres” product group in 2011, for operators of data centres and/or providers of data centre services. The criteria were however revised in July 2012 since no datacentre was awarded with the initial version. Some of the criteria deal with management and monitoring at the datacentre level which are not presented below since they are not relevant for the product approach followed in this study. The criteria that directly concern datacentre equipment (servers, storage or network) are provided in Table 15 and Table 16.

[33] www.blauer-engel.de

Table 15: Description of the Blue Angel binding criteria dealing with individual IT equipment in data centres (RAL-UZ 161)

Criteria	Description
Energy Conscious Procurement	The applicant undertakes to perform a life cycle cost calculation over the period of use (investment costs, maintenance and energy costs) when buying new equipment and devices and to take these costs into consideration for offer evaluation.
Acquisition of New Servers	When buying new servers during the term of the Contract on the Use of the Environmental Label the total energy efficiency of the servers (Σssj_ops/ Σpower) shall be determined using the SPECpower_ssj2008 methodology and shall be, at a minimum, 2,000 ssj_ops/W. High performance computers shall be exempt from this requirement. The ratio of performance (ssj_ops) to electrical power consumption (W) shall be given for loads between 10% and 100% in increments of 10 percent.
Virtualization of Servers	Servers must be virtualised. The average level of virtualization (number of virtual servers per physical server in the entire data centre) must be greater than 2.
Energy Efficient Power Supplies	The minimum efficiency (at 20%, 50% and 100% load) of newly acquired power supplies installed in new IT equipment shall meet the requirements of the 80 PLUS GOLD efficiency standard11. The power supplies of existing IT equipment shall also meet the 80 PLUS GOLD efficiency standard.
Monitoring of the IT Load	The monitoring of the IT load shall be introduced following the award of the eco-label at the latest. Server workload (CPU workload [%], RAM workload [%]), memory (storage/disk space workload [%]) and network (bandwidth workload [%]) shall be continuously monitored.

Table 16: Energy-saving recommendations dealing with individual IT equipment in data centres (RAL-UZ 161)

Criteria	Description
IT servers	• The purpose of all servers is known and documented • The data centre uses dynamic power-saving technologies which automatically control the frequency and voltage of processors depending on the workload • Hardware consolidation
IT storage	• The power consumption or electricity consumption of the storage (per unit) is known • The data centre uses storage virtualisation • The data centre uses Information Life Cycle Management (ILM) • Unnecessary/aged data is regularly deleted and an archiving system is implemented • Tapes are used for archiving data • Hard drives are automatically turned off when not in use • The storage has already been consolidated for the purpose of increasing efficiency
IT network	• The power consumption or electricity consumption of the network is known • The network is regularly revised
Power Supplies – Server, Storage, Network	• Each server, storage and network unit is actively supplied with electricity by only one power supply unit. In the case of redundant power supply units the redundant power supply unit only provides power in the event of a failure of the main power supply unit.

It can be argued that a single static requirement for servers based on SPECpower is not appropriate since SPECpower values vary depending on the performance of a server. They have been changing over time due to technological developments.

Product groups “External hard disks”, “Small Network Attached Storage Systems” and “Routers” are also covered by the scheme (respectively criteria RAL-UZ 162, RAL-UZ 186, RAL-UZ 160) but these groups are intended to cover household products and are not expected to be used as enterprise data equipment.

4.2.1.2.Future Thinking initiative

The data centre initiative Future Thinking was established in 2010 and has three main objectives: to enhance innovation, knowledge transfer and networking. This exchange platform promotes energy efficient thinking and sustainable resource use. Furthermore, the German Data Centre Price was introduced in 2011 in order to further incentivize innovative thinking.

4.2.2. Ireland

4.2.2.1.Triple E programme

The Sustainable Energy Authority of Ireland (SEAI) is responsible for a searchable listing of energy equipment entitled Triple E[34]. Triple E is setting minimum criteria that different products have to meet in order to be listed. These criteria are updated on a regular base with the goal that only the top 10-15% of the most energy efficient products in any technology are listed. For the time being, the Triple E includes 52 technologies and is based on the existing Accelerated Capital Allowance (ACA) list of eligible products and eligibility criteria. The ACA is a tax incentive aiming to encourage enterprises to invest in energy saving technologies, allowing them to write off 100% of the purchase value of qualifying energy efficient equipment against their profit in the year of purchase.

Concerning the Lot 9 scope, this Triple E list covers Rack Mounted Servers, Enterprise Storage Equipment, Blade Servers and enterprise communication equipment. The ACA sets the following eligibility criteria (which must be all met) for these technologies.

- **Rack-mounted servers**

Table 17: ACA Rack Mounted Server Eligibility Criteria

No.	Condition	Supporting Documentation Requirement
1.	Marketed and sold as an enterprise Rack Mounted Server.	Official and published manufacturer's technical data sheet or brochure that demonstrates compliance with the requirements of the condition.
2.	Designed for, and listed as, supporting enterprise Server operating Systems and/or hypervisors, and targeted to run user-installed enterprise applications.	
3.	Be capable of remote power-down.	
4.	Meet the relevant minimum performance to power ratios in the table below.	Test report completed according to the Standard Performance Evaluation Corporation (SPEC) industry standard benchmark performance test, SPECpower_ssj2008. Test reports must be of the format as required by SPECpower and published on the SPECpower website.
5.	Be supplied with a software management system which renders the server virtualisation capable.	Official and published manufacturer's technical data sheet or brochure that demonstrates compliance with the requirements of the condition.

Table 18: ACA minimum server performance to power ratios, for rack mounted servers

Server application	Minimum Ratio
Performance at low utilization of less than or equal to 30%.	> 700
Performance at moderate utilization of greater than 30%, but less than 70%.	> 1650
Performance at high utilisation of greater than or equal to 70%.	> 2150

The Performance to Power Ratio is based on the SPEC industry standard benchmark performance test, SPECpower_ssj2008.

[34] http://www.seai.ie/Your_Business/Triple_E_Product_Register/About/

- **Blade Servers**

Table 19: ACA Blade Server Eligibility Criteria

No.	Condition	Supporting Documentation Requirement
1.	Marketed and sold as an enterprise Blade Mounted Server.	Official and published manufacturer's technical data sheet or brochure that demonstrates compliance with the requirements of the condition.
2.	Designed for, and listed as, supporting Blade Server operating Systems and/or hypervisors, and targeted to run user-installed enterprise applications.	
3.	Be capable of remote power-down.	
4.	Meet the relevant minimum performance to power ratios in the table below.	Test report completed according to the Standard Performance Evaluation Corporation (SPEC) industry standard benchmark performance test, SPECpower_ssj2008. Test reports must be of the format as required by SPECpower and published on the SPECpower website.
5.	Be supplied with a software management system which renders the server virtualisation capable.	Official and published manufacturer's technical data sheet or brochure that demonstrates compliance with the requirements of the condition.

Table 20: ACA minimum server performance to power ratios, for blade servers

Server application	Minimum Ratio
Performance at low utilization of less than or equal to 30%.	> 900
Performance at moderate utilization of greater than 30%, but less than 70%.	> 1900
Performance at high utilisation of greater than or equal to 70%.	> 2500

The Performance to Power Ratio is based on the SPEC industry standard benchmark performance test, SPECpower_ssj2008 V1.10.

- **Enterprise Storage Equipment**

Table 21: ACA Enterprise storage general Eligibility Criteria

No.	Condition	Supporting Documentation Requirement
1.	Be supplied with management software capable of two of the following: A. Data de-duplication, data compression or single instancing B. Thin/Virtual Provisioning C. Array Virtualisation	Official and published manufacturer's technical data sheet or brochure that demonstrates compliance with the requirements of the condition.
2.	Must form part of one of the following enterprise storage solutions: A. Storage Area Network (SAN) B. Direct Attached Storage (DAS) C. Network Attached Storage (NAS)	

Additionally, criteria are added at the storage device level. Solid State Drives must be designed to form part of an enterprise storage solution and have a minimum storage capacity of 120 Gb. Disk Drives, when idle, must be capable of intelligent power-down and drive spin-down or slow spin (MAID 2/IPM), and must have a disk tiering strategy capable of supporting storage media with multiple power / capacity points with a factor of at least 2X between the slowest and fastest.

- **Enterprise Communication Equipment**

Enterprise Communication Equipment is considered to include network routers, network switches, network firewalls, and optical transmission equipment.

No.	Condition
General Eligibility Criteria (applicable to all Enterprise Communication Equipment):	
1.	Internal power supplies must achieve an 80 PLUS gold standard or scientific equivalent.
2.	External power supplies must be ENERGY STAR®-compliant or scientific equivalent.
Network Router – specific eligibility criteria (to be met in addition to the general eligibility criteria)	
3.	Must achieve an ECR–VL energy consumption rating with variable load of less than or equal to 10 W/Gbps.
4.	Must have variable-load energy-management capabilities.
Network Switch – specific eligibility criteria (to be met in addition to the general eligibility criteria)	
5.	Must achieve an ECR–VL energy consumption rating with variable load of less than or equal to the values as set out in the table below.
6.	Must have variable-load energy-management capabilities.
Network Firewall – specific eligibility criteria (to be met in addition to the general eligibility criteria)	
7.	Must achieve an ECR energy consumption rating of less than or equal to 3W/Gbps.
8.	Must have variable-load energy-management capabilities.
Optical Transmission Equipment – specific eligibility criteria (to be met in addition to the general eligibility criteria)	
9.	Must achieve an ECR energy consumption rating with variable load of less than or equal to 3W/Gbps
10.	Must have variable-load energy-management capabilities

Table 23: Maximum energy consumption values for Network Switches

Switch Type	Energy Consumption rating (W/Gbps)
Stackable fixed port switches – Layer 2	≤3
Modular Chassis switches – Layer 2	≤7.5
Modular Chassis switches – Layer 3	≤11

4.2.3. UK

4.2.3.1.BCS – Certified Energy Efficient Data Centre Award

The Certified Energy Efficient Data Centre Award (CEEDA), is an assessment and certification program which is ratified by BCS (the Chartered Institute for IT).

CEEDA applies an assessment framework based on energy efficiency best practices in: M&E and IT infrastructure; operational management; the management of IT services and software. These best practices are principally those obtained from the EUCoC. CEEDA also validates the method of measurement and calculated values for a set of energy efficiency performance metrics, primarily those defined by the Green Grid, such as PUE, WUE (source, onsite) or ERE.

Assessments are performed by BCS-approved assessors and the assessment reports are audited by BCS-approved auditors.

CEEDA assessment and certification process occurs in three phases: first, data is gathered which represent evidence of best practice implementation and provide the basis for measurement of performance metrics. Second, a site visit by the assessor, where personnel in the data centre team are interviewed and the evidence submitted is reviewed against the actual data centre; third, compilation of an assessment report by the assessor. The assessment report contains a performance gap analysis, set of recommendations for further improvement and a recommendation of certification level. This report is then audited and, after a period of consultation, a certification level is conferred.

The certification period is of two years' duration and includes a follow-up assessment one year after the certification date. The purpose of the follow-up assessment is to determine the impact of any implemented recommendations from the gap analysis and roadmap and any significant changes in the facility, services provisioned, operational management or IT infrastructure.

Although the assessment framework aims to appraise the overall, holistic energy efficiency performance of the facility against currently available best practice, performance at the levels of algorithm, component, server, management/optimisation of IT infrastructure and software is assessed. Examples include: tender/development of energy efficient software/algorithms, ENERGY STAR® compliance or equivalent in acquisition of IT hardware; extent of virtualisation; IT device level temperature metering.

4.2.3.2. UK Data Centers Climate Change Agreement

In the UK, a recent climate change agreement for data centres is expected to encourage energy efficiency at the system level. As of January 2015 about 100 data centres have been approved to be exempt almost entirely (90%) from paying an extra tax on energy use. In exchange the operators have to commit to increase energy efficiency of the facilities.[35]

4.3.Third country legislation and agreements

4.3.1. EPEAT

The Electronic Product Environmental Assessment Tool (EPEAT)[36] is a global rating system for electronics equipment which covers the complete lifecycle and thus combines comprehensive criteria for design, production, energy use and recycling with ongoing independent verification of manufacturer claims. It is managed by the Green Electronics Council in the USA. It is used by multiple governments around the world (such as US, Canada, UK, France, Poland, Australia, New Zealand, Singapore) and awards more than 3 000 products from more than 50 manufacturers registered in 43 countries.

It rates products Bronze, Silver or Gold, based on how many of the optional criteria they meet (while meeting all required criteria) and products on the EPEAT registry are subject to unannounced audits at any time, with results publicly reported. In particular, requirements of the ENERGY STAR® programme are considered in the criteria.

The EPEAT registry currently includes ratings for Personal Computer Products & Displays, Televisions, and Imaging Equipment (printers, copiers, scanners). EPEAT will soon include servers (computer servers as defined in the ENERGY STAR® Server specifications, including managed servers and blade servers), as work is in progress to develop criteria. These criteria will deal with reduction or elimination of environmentally sensitive materials, materials selection, design for end of life, lifecycle extension, energy conservation, end of life management, corporate performance, and packaging.

The IEEE 1680.4 Standard for Environmental Assessment of Servers standard for servers - currently under development - is part of the EPEAT family of standards.

4.3.2. 80 PLUS certification

The 80 PLUS programme[37] is a voluntary certification programme launched by Ecos Consulting (now Ecova) in 2004, to promote energy efficiency of power supply units. The 80 PLUS performance specification requires power supplies in computers and servers to be 80% or greater energy efficient at 20%, 50% and 100% of rated load with a true power factor of 0.9 or greater. This makes an 80 PLUS certified power supply substantially more efficient than typical power supplies. The programme differentiates further levels of high

[35] http://www.datacenterknowledge.com/archives/2015/01/16/nearly-100-data-centers-qualify-for-uks-climate-change-tax-break/
[36] www.epeat.net
[37] http://www.plugloadsolutions.com/80PlusPowerSupplies.aspx

efficiency, through the Bronze, Silver, Gold, Platinum and Titanium awards. Table 24 presents the efficiency and power factor requirements for the different certification levels of the programme.

Table 24: Efficiency level requirements of the 80 PLUS programme

80 PLUS Certification	115V Internal Non-Redundant				230V Internal Redundant*			
% of Rated Load	10%	20%	50%	100%	10%	20%	50%	100%
80 PLUS	-	80%	80%	80% / PFC 0.90	-	-	-	-
80 PLUS Bronze	-	82%	85% / PFC 0.90	82%	-	81%	85% / PFC 0.90	81%
80 PLUS Silver	-	85%	88% / PFC 0.90	85%	-	85%	89% / PFC 0.90	85%
80 PLUS Gold	-	87%	90% / PFC 0.90	87%	-	88%	92% / PFC 0.90	88%
80 PLUS Platinum	-	90%	92% / PFC 0.95	89%	-	90%	94% / PFC 0.95	91%
80 PLUS Titanium	-	-	-	-	90%	94% / PFC 0.95	96%	91%

*Typically for datacentre applications

4.3.3. Top Runner Program in Japan

The Japanese Top Runner Program is a mandatory policy instrument that targets the energy consumption during the use phase through market transformation. The scope and targets for each product range are regularly revised. The basic principle is that the product with the highest energy efficiency on the market (the Top Runner) sets the standard, and all other appliances are required to reach that level within an agreed time scale (2-3 years). If the required level is achieved or surpassed by the manufacturers and importers before the deadline, the process starts again, starting a new cycle. If targets are not met, the government makes recommendations, which can be enforced in the event of further non-compliance. The necessity of meeting the Top Runner Program provides the companies with an incentive to use those technologies, which they may otherwise would have waited to commercialise.

It currently covers servers under the specifications of "Computers and hard disk drives"[38]. The product definition reads: Server computers refer to a computer that is designed to operate 24 hours a day and provide services on a network, and which can be accessed only via a network.

A few items are excluded, like products with a composite theoretical performance of 200,000 mega calculations or more per second, products capable of performing calculations using an arithmetic processing unit composed of more than 256 processors, etc. The specifications include energy efficiency, as well as labelling requirements.

The following targets were set for FY2011 (see Table 25). The energy efficiency is defined as:

$$E = [(W1 + W2) / 2] / Q, \text{ where}$$

- E: Energy efficiency (units: Watts/giga calculations)
- (W1 + W2) / 2: Power consumption (units: Watts)

[38] http://www.eccj.or.jp/top_runner/pdf/tr_computers_magneticdiscunits_dec2009.pdf

- W1: Power consumption in idle state (units: Watts): indicates the power consumption when the main power is energized, in a state when operation is possible without resetting the initial program, and in a state before transitioning to a low-power mode such as the standby mode or suspend mode described in ACPI standards[39].
- W2: Power consumption in low-power mode (units: Watts): low-power mode defined in ACPI standards as a standby mode, suspended mode, or similar mode. (However this is limited to modes in which the programs and data are retained in the main memory device.) For server computers and client computers which do not have a low-power mode, use the same value as W1 for W2.
- Q: Composite theoretical performance (CTP) (units: giga calculations).

Table 25: Target standard values for server computers[40] in the Japan Top Runner Programme

CPU Type	No. of I/O slots	No. of CPU sockets	Provisional classification	Target standard value (W/GTOPS)
Dedicated CISC	Less than 32	-	A	**1.950**
	32 or more	-	B	**2.620**
RISC	Less than 8	-	C	**13.0**
	8 to less than 40	-	D	**31.0**
	40 or more	-	E	**140.0**
IA64	Less than 10	-	F	**6.2**
	10 or more	-	G	**22.0**
IA32	0	-	H	**1.3**
	1 to less than 7	Less than 2	I	**1.2**
		2 to less than 4	J	**1.9**
		4 or more	K	**6.7**
	7 or more	-	L	**7.4**

For hard disk drives, requirements are set at the individual device level, and not at the storage product level considered in this study; they are therefore not presented in detail here. The Japanese Ministry of Economy, Trade and Industry (METI) is currently revising the program for servers, storage and PCs, and a new cycle will start from 2015 that may take into account the recent development by ENERGY STAR® to set the target standard values and method[41].

The Top Runner Programme also covers small routers[42], which are however not expected to enter the scope of this study as enterprise data equipment.

4.3.4. Australian Ecolabel Program

The Good Environmental Choice Australia Standard for computers[43] issued in 2008 provides specifications for the Australian Ecolabel Program, and servers are included in the scope of this standard. The criteria concerning servers include:

[39] ACPI (Advanced Configuration and Power Interface) is an open industry specification that establishes industry-standard interfaces enabling OS-directed configuration, power management, and thermal management of mobile, desktop, and server platforms. More information at: http://acpi.info/

[40] Defined as a computer that is designed to operate 24 hours a day and provide services on a network, and which can be accessed only via the network

[41] http://www.meti.go.jp/english/press/2011/0124_01.html

[42] http://www.eccj.or.jp/top_runner/pdf/tr_small_routers-apr_2008.pdf

[43] http://www.geca.org.au/media/medialibrary/2012/08/GECA_24-2007_Computers_current_May_2012.pdf

- Material requirements for plastics and heavy metals;
- Power management: servers and units with a power supply with a maximum continuous power output greater than 400 W shall have a sleep mode power consumption of less than 5 % of the maximum continuous power consumption and a default power management sleep present time of less than 30 minutes;
- Spare parts, product take back and information provision.

4.3.5. Voluntary Product Certification in China

A Voluntary Product Certification scheme in China (CQC mark certification) is implemented by the China Environmental United Certification Centre.[44] The products shall be verified to conform to the requirements of the standards of quality, safety, environment and performance defined in the different rules. In particular, the scheme defines rules and criteria for servers (CQC3135-2011)[45]. The scope includes tower-type and rack-mounted servers using power supply from 220V/50Hz power grid, with 1 and 2 processor slots while blade servers and multi-node servers are excluded from the scheme. Requirements concern the idle-state consumption:

- 1 socket server: ≤ 65 W
- 2 sockets server: ≤ 150 W

With some allowance:

- 2 W per additional GB
- 20 W for a power supply module
- 8 W per hard disk drive
- 2 W per network port

[44] http://www.sepacec.com/cecen/cdm1/About/201009/t20100917_194692.htm
[45] http://www.cqc.com.cn/chinese/rootfiles/2011/09/27/1313600447699352-1317056536935197.pdf

Annex 1. ENERGY STAR® definitions

Version 2.0 ENERGY STAR® specification for computer servers

- Computer Server: A computer that provides services and manages networked resources for client devices (e.g., desktop computers, notebook computers, thin clients, wireless devices, PDAs, IP telephones, other computer servers, or other network devices). A computer server is sold through enterprise channels for use in data centres and office/corporate environments. A computer server is primarily accessed via network connections, versus directly-connected user input devices such as a keyboard or mouse. For purposes of this specification, a computer server must meet all of the following criteria:
    - A. is marketed and sold as a Computer Server;
    - B. is designed for and listed as supporting one or more computer server operating systems (OS) and/or hypervisors;
    - C. is targeted to run user-installed applications typically, but not exclusively, enterprise in nature;
    - D. provides support for error-correcting code (ECC) and/or buffered memory (including both buffered dual in-line memory modules (DIMMs) and buffered on board (BOB) configurations).
    - E. is packaged and sold with one or more ac-dc or dc-dc power supplies; and
    - F. is designed such that all processors have access to shared system memory and are visible to a single OS or hypervisor.
- Managed Server: A computer server that is designed for a high level of availability in a highly managed environment. For purposes of this specification, a managed server must meet all of the following criteria:
    - A. is designed to be configured with redundant power supplies; and
    - B. contains an installed dedicated management controller (e.g., service processor).
- Blade System: A system comprised of a blade chassis and one or more removable blade servers and/or other units (e.g., blade storage, blade network equipment). Blade systems provide a scalable means for combining multiple blade server or storage units in a single enclosure, and are designed to allow service technicians to easily add or replace (hot-swap) blades in the field.
    - A. Blade Server: A computer server that is designed for use in a blade chassis. A blade server is a high-density device that functions as an independent computer server and includes at least one processor and system memory, but is dependent upon shared blade chassis resources (e.g., power supplies, cooling) for operation. A processor or memory module that is intended to scale up a standalone server is not considered a Blade Server.
        - (1) Multi-bay Blade Server: A blade server requiring more than one bay for installation in a blade chassis.
        - (2) Single-wide Blade Server: A blade server requiring the width of a standard blade server bay.
        - (3) Double-wide Blade Server: A blade server requiring twice the width of a standard blade server bay.
        - (4) Half-height Blade Server: A blade server requiring one half the height of a standard blade server bay.
        - (5) Quarter-height Blade Server: A blade server requiring one quarter the height of a standard server bay.
        - (6) Multi-Node Blade Server: A blade server which has multiple nodes. The blade server itself is hot swappable, but the individual nodes are not.
    - B. Blade Chassis: An enclosure that contains shared resources for the operation of blade servers, blade storage, and other blade form-factor devices. Shared resources provided by a chassis may include power supplies, data storage, and hardware for DC power distribution, thermal management, system management, and network services.

    - C. Blade Storage: A storage device that is designed for use in a blade chassis. A blade storage device is dependent upon shared blade chassis resources (e.g., power supplies, cooling) for operation.
- Fully Fault Tolerant Server: A computer server that is designed with complete hardware redundancy, in which every computing component is replicated between two nodes running identical and concurrent workloads (i.e., if one node fails or needs repair, the second node can run the workload alone to avoid downtime). A fully fault tolerant server uses two systems to simultaneously and repetitively run a single workload for continuous availability in a mission critical application.
- Resilient Server: A computer server designed with extensive Reliability, Availability, Serviceability (RAS) and scalability features integrated in the micro architecture of the system, CPU and chipset. For purposes of ENERGY STAR® qualification under this specification, a Resilient Server shall have the characteristics as described in Appendix B of this specification.
- Multi-node Server: A computer server that is designed with two or more independent server nodes that share a single enclosure and one or more power supplies. In a multi-node server, power is distributed to all nodes through shared power supplies. Server nodes in a multi-node server are not designed to be hot-swappable.
    - A. Dual-node Server: A common multi-node server configuration consisting of two server nodes.
- Server Appliance: A computer server that is bundled with a pre-installed OS and application software that is used to perform a dedicated function or set of tightly coupled functions. Server appliances deliver services through one or more networks (e.g., IP or SAN), and are typically managed through a web or command line interface. Server appliance hardware and software configurations are customized by the vendor to perform a specific task (e.g., name services, firewall services, authentication services, encryption services, and voice-over-IP (VoIP) services), and are not intended to execute user-supplied software.
- High Performance Computing (HPC) System: A computing system which is designed and optimized to execute highly parallel applications. HPC systems feature a large number of clustered homogeneous nodes often featuring high speed inter-processing interconnects as well as large memory capability and bandwidth. HPC systems may be purposely built, or assembled from more commonly available computer servers. HPC systems must meet ALL the following criteria:
    - A. Marketed and sold as a Computer Server optimized for higher performance computing applications;
    - B. Designed (or assembled) and optimized to execute highly parallel applications;
    - C. Consist of a number of typically homogeneous computing nodes, clustered primarily to increase computational capability;
    - D. Includes high speed inter-processing interconnections between nodes.
- Direct Current (DC) Server: A computer server that is designed solely to operate on a dc power source.
- Large Server: A resilient/scalable server which ships as a pre-integrated/pre-tested system housed in one or more full frames or racks and that includes a high connectivity I/O subsystem with a minimum of 32 dedicated I/O slots.

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Storage Taxonomy: A categorization scheme for use in segmenting the data centre storage market by end-use application and key product characteristics. The major categories of the taxonomy that are referenced in this document are as follows:

- 1) Online Storage: Storage products that are intended to service a mixture of Random and Sequential I/O requests with a short response time. All data stored in Online storage must be accessible MaxTTFD ≤ 80 ms, unless the storage product is in a Deep Idle state. Online storage is typically comprised of one or more HDDs or SSDs and a storage controller, and provides primary data storage to supplement a Computer Server's internal memory.
- 2) Near-online Storage: Storage products that are intended to service a mixture of Random and Sequential I/O requests with a short to moderate response time. Near-online storage products offer an asymmetrical response; a portion of data may be accessible MaxTTFD ≤ 80 milliseconds, while other data may be accessible MaxTTFD > 80 milliseconds.

- 3) Virtual Media Library: Storage products that are intended to service primarily Sequential I/O, with a short response time. The media in a Virtual Media Library (e.g., HDD, optical disk) is not designed to be physically removed from the system. All data stored in the Virtual Media Library must be assessable MaxTTFD ≤ 80 ms, unless the storage product is in a deep idle state. Virtual Medial Libraries are intended primarily for moderate and long term data storage.
- 4) Removable Media Library: Storage products that are intended to service primarily Sequential I/O, with a moderate to long response time. The media (e.g., tape cartridge, optical disk) in a Removable Media Library is designed to be physically removed from the storage product. Removable Media Libraries are intended primarily for long term data archiving.
- 5) Adjunct Storage Products: Products which closely support storage devices by adding in real time value or additional control capabilities not present in the storage device(s) itself. Examples include SAN based virtualization controllers, NAS gateways, or other storage services. A key feature of these products is that no end user data is primarily stored on Adjunct Storage products, though data may be held in cache or other working buffers.

6) Interconnect Element: Devices which provide for interconnection functionality within a storage area network. Examples include SAN Switches, etc.