Study for the review of Commission Regulation 2019/424 (Ecodesign of servers and data storage products)

Task 1 Scope – Definitions, Standards & Legislation for Ecodesign – DRAFT v4

June 2024

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Task 1 Scope – Definitions, Standards and Legislation for Ecodesign – Draft version 4

A report submitted by ICF S.A.

Date: June 2024

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Document Control

Document Title	Task 1 Scope – Definitions, Standards and Legislation for Ecodesign – Draft version 3
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Date	June 2024

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1 Introduction to Task 1 Scope

The aim of Task 1 is to classify and define the products covered by the review of Commission Regulation (EU) 2019/424. The classification and definitions shall be in line with European Union (EU) product harmonisation legislation as well as from a technical, functional, economic, and environmental viewpoint. This classification and definition will be used as the basis for the review study.

The general scope of Regulation (EU) 2019/424 has been defined by the European Commission to cover servers and data storage products The objective of this chapter is to determine the product groups that are within Regulation (EU) 2019/424. In the following sections product scope, measurement and test standards and current legislation relating to Regulation (EU) 2019/424 will be discussed in detail. The project team intends to define this basic product scope with a focus on the environmental and economic aspects of servers and data storage products.

1.1 Product Scope

1.1.1 Product Classification

The product classification and definitions should be based on those provided within relevant Union harmonisation legislation, PRODCOM categories, other categories according to EN or ISO standards or other product specific categories drawn from labelling or sector specific categories, if not already defined by the above.

1.1.2 Prodcom categories (Eurostat)

There are seven categories defined by PRODCOM that cover servers and data storage products[1]. PRODCOM classifies servers and data storage products in the categories:

- NACE 26.20 “Manufacture of computers and peripheral equipment” and
- NACE 26.30 “Manufacture of communication equipment”[2].

The products covered under these categories which are relevant to this study, are presented below separated out by product type:

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

[1] https://ec.europa.eu/eurostat/web/main/home

[2] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32017R2119

and WANs and sound, video, network and similar cards for automatic data processing machines);

- **26202200** - Solid-state, non-volatile data storage devices for recording data from an external source (flash memory cards or flash electronic storage cards), unrecorded

Servers 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 a wide range of products, and it is not clear exactly which devices each category covers, as the aggregation level of data remains relatively high. There are some concerns when using the PRODCOM data, where the codes and their scope are not completely clear:

- The scope of 26.20.14.00 code is not completely clear but is more likely to be coding for computer mainframes.
- The scope of 26.20.15.00 code is not completely clear but is more likely to be coding for computer servers.
- 26.20.21.00 storage units may not apply to data storage devices as intended in the study. This is because it is possible the code is covering units such external hard drives, or USB keys.

1.1.3 Definitions

1.1.3.1 Servers, Data storage & Network equipment

Ecodesign Regulation 617/2013 for computers and computers servers

Previously, servers were captured within the Ecodesign Regulation 617/2013 for computers and computer servers [3]. This regulation introduced the following definitions: computer server, small-scale severs, blade system and components, server appliance, multi-node server, dual-mode server and computer servers with more than four processor sockets.

Ecodesign Regulation 2019/424 for servers and data storage products

Previous regulations only captured computer servers and no definitions were provided for data storage products. The Ecodesign Regulation 2019/424[4] covers servers and data storage products. The regulation provides the following definitions:

- '**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 telephones, smartphones, tablets, tele-communication, automated systems or other servers, primarily

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

[4] EUR-Lex - 32019R0424 - EN - EUR-Lex (europa.eu)

accessed via network connections, and not through direct user input devices, such as a keyboard or a mouse and with the following characteristics:

  - it is designed to support server operating systems (OS) and/or hypervisors, and targeted to run user-installed enterprise applications;
  - it supports error-correcting code and/or buffered memory (including both buffered dual in-line memory modules and buffered on board configurations);
  - all processors have access to shared system memory and are independently visible to a single OS or hypervisor.

- '**server with more than four processor sockets'** means a server containing more than four interfaces designed for the installation of a processor. For multi-node servers, this term refers to a server having more than four processor sockets in each server node.
- '**server appliance'** means a server that is not intended to execute user-supplied software, delivers services through one or more networks, is typically managed through a web or command line interface and is bundled with a pre-installed OS and application software that is used to perform a dedicated function or set of tightly coupled functions
- **'resilient server'** means a server designed with extensive reliability, availability, serviceability and scalability features integrated in the micro architecture of the system, central processing unit (CPU) and chipset.
- '**multi-node server'** means a server that is designed with two or more independent server nodes that share a single enclosure and one or more power supply units. In a multi-node server, power is distributed to all nodes through shared power supply units. Server nodes in a multi-node server are not designed to be hot-swappable.
- **'network server'** means a network product which contains the same components as a server in addition to more than 11 network ports with a total line rate throughput of 12 Gb/s or more, the capability to dynamically reconfigure ports and speed and support for a virtualized network environment through a software defined network
- '**fully fault tolerant server'** means a server that is designed with complete hardware redundancy (to simultaneously and repetitively run a single workload for continuous availability in mission critical applications), 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);
- **'server product family'** means a high-level description referring to a group of servers sharing one chassis and motherboard combination that may contain more hardware and software configurations. All configurations within a server product family must share the following common attributes:
  - a) be from the same model line or machine type;
  - b) either share the same form factor (i.e., rack-mounted, blade, pedestal) or share the same mechanical and electrical designs with only superficial mechanical differences to enable a design to support multiple form factors;
  - c) either share processors from a single defined processor series or share processors that plug into a common socket type;

  - d) share the power supply unit(s);
  - e) have the same number of available processor sockets and number of available processor sockets populated;

- **'High Performance Computing (HPC) server'** means a server which is designed and optimized to execute highly parallel applications, for higher performance computing or deep learning artificial intelligence applications. HPC servers must meet all the following criteria:
  - a) they consist of multiple computing nodes, clustered primarily to increase computational capability;
  - b) they include high speed inter-processing interconnections between nodes;
- **'data storage product'** means 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 data storage product architecture (e.g., to provide internal communications between controllers and disks) are considered to be part of the data 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 storage area network) are not considered to be part of the data storage product. A data storage product may be composed of integrated storage controllers, data storage devices, embedded network elements, software, and other devices.
- '**data storage device'** means a device providing non-volatile data storage, with the exception of aggregating storage elements such as subsystems of redundant arrays of independent disks, robotic tape libraries, filers, and file servers and storage devices which are not directly accessible by end-user application programs, and are instead employed as a form of internal cache;
- **'online data storage product'** means a data storage product designed for online, random-access of data, accessible in a random or sequential pattern, with a maximum time to first data of less than 80 milliseconds;
- '**active state efficiency'** (Eff_{server}) means the numerical value for server efficiency as measured and calculated according to Annex III point 3 of the Regulation.
- **'Idle state'** means the operational state in which the OS and other software have completed loading, the server is capable of completing workload transactions, but no active workload transactions are requested or pending by the system (i.e., the server is operational, but not performing any useful work). For servers where Advanced Configuration and Power Interface standards are applicable, idle state corresponds only to System Level S0;
- '**Active state'** means the operational state in which the server is carrying out work in response to prior or concurrent external requests (e.g., instruction over the network). Active state includes both active processing and data seeking/retrieval from memory, cache, or internal/external storage while awaiting further input over the network;
- **'server performance'** means the number of transactions per unit of time performed by the server under standardised testing of discrete system components (e.g. processors, memory and storage) and subsystems (e.g. RAM and CPU);

- '**maximum power'** (P_{max}) means the highest power, in Watts, recorded on the eleven worklet scores according to the standard;
- '**CPU performance (PerfCPU)**' means the number of transactions per unit of time performed by the server under standardised testing of the CPU subsystem;
- **'power supply unit' (PSU)** means a device that converts alternate current (AC) or direct current (DC) input power to one or more DC power outputs for the purpose of powering a server or a data storage product. A server or data storage product PSU must be self-contained and physically separable from the motherboard and must connect to the system via a removable or hard-wired electrical connection;
- **'direct current server'** means a server that is designed solely to operate on a DC power source;
- **'direct current data storage product'** means a data storage product that is designed solely to operate on a DC power source;
- '**Auxiliary Processing Accelerator' (APA)** means a specialized processor and associated subsystem that provide an increase in computing capacity such as graphical processing units or field programmable gate arrays. An APA cannot operate in a server without a CPU. APAs can be installed in a server either on Graphics or Extension add-in cards installed in general-purpose add-in expansion slots or integrated into a server component such as the motherboard;
- '**Expansion APA'** means an APA that is on an add-in card installed in an add-in expansion slot. An expansion APA add-in card may include one or more APAs and/or separate, dedicated removable switches;
- '**Integrated APA'** means an APA that is integrated into the motherboard or CPU package;

Definitions are also provided for disassembly, secure data deletion and firmware but were not included here because these will be discussed in greater detail by the project team in Task 3 and Task 4.

The following products are not currently covered by the Ecodesign Regulation for servers and data storage products:

a) servers intended for embedded applications;
b) servers classified as small scale servers in terms of Regulation (EU) No 617/2013;
c) servers with more than four processor sockets;
d) server appliances;
e) large servers;
f) fully fault tolerant servers;
g) network servers;
h) small data storage products;
i) large data storage products.

U.S. Environmental Protection Agency's (EPA) ENERGY STAR Program

Definitions in version 4.0 ENERGY STAR® specification for computer servers

The current specification[5] provides a comprehensive set of definitions for types of server products, server form factors, server components, other data centre equipment, operational aspects and power states, product families and their testing configurations and a list of key terms. The definitions covered by ENERGY STAR are very similar to those covered by the Regulation 2019/424.

The ENERGY STAR® specification for computer servers captures a broad taxonomy of useful definitions of server types and subcategories which will be useful for this review study:

- **'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 centers 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 […]" The ENERGY STAR certification specifies in detail the characteristics of a computer server, this is provided in A1.1.1.
- **'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". The ENERGY STAR certification specifies in detail the characteristics of a resilient server, this is provided in A1.1.1.
- **'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".
- **'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 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".

[5] https://www.energystar.gov/sites/default/files/asset/document/ENERGY%20STAR%20Version%204.0%20Computer%20Servers%20Final%20Specification.pdf

- **'Storage Heavy Server'**: "A computer server with greater storage capacity than a standard computer server. As shipped, these computer servers support 30 or more internal storage devices. These servers differ from Storage Products in that they run computer server operating systems and software stacks".
- **'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";
- **Hyperconverged Server**: Hyperconverged Server: A highly integrated server which contains the additional features of large network equipment and storage products.
- '**High Performance Computing (HPC) System'**: A computing system which is designed, marketed, sold, and optimized to execute highly parallel applications for high performance, deep learning, or artificial intelligence applications. HPC systems consist of multiple clustered computer servers, primarily for increased computational capability, high speed nter-processing interconnects, large and high bandwidth memory capability and often auxiliary processing accelerators. HPC systems may be purposely built, or assembled from more commonly available computer servers.

Full definitions are provided in 0 of this document. The specification also defines sub-categories according to components, form factor, other key terms relating to servers, common product family attributes and product family tested configurations. The definitions are the result of a complex and long stakeholder process, making them current and sensible.

The following products scope is eligible under Version 4.0: "*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)".*

The following products are explicitly excluded from Version 4.0:

1. Computer Servers shipped with Integrated APAs;
2. Computer Servers which are only shipped with at least one APA;
3. Fully Fault Tolerant Servers;
4. Server Appliances;
5. High Performance Computing Systems;
6. Large Servers;
7. Hyperconverged Servers;
8. Storage Products including Blade Storage; and
9. Large Network Equipment.

Definitions in v2.1 ENERGY STAR® specification for data centre storage equipment

The Version 2.1 ENERGY STAR® Specification for Data Centre Storage[6] took effect on March 15, 2021. It belongs to the suite of data centre equipment specifications, which currently includes Computer Server, Uninterruptible Power Supply, and Large Network Equipment specifications.

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 2.1 Specification requires all products to test and submit data using the Storage Networking Industry Association (SNIA) Emerald Power Efficiency Measurement Specification V4.0.0.

The specification provides the following useful definitions relating to data storage products:

- **'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 center 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."
- **'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."
- **'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)."
- **'Direct-attached Storage (DAS)':** One or more dedicated storage devices that are physically connected to one or more servers.
- **'Network Attached Storage (NAS)':** One or more dedicated storage devices that connect to a network and provide file access services (File I/O) to remote computer systems.
- **'Storage Area Network (SAN)':** A network whose primary purpose is the transfer of data between computer systems and storage products. A SAN consists of a communication infrastructure, which provides physical connections, and a management layer, which organizes the connections,

[6] ENERGY STAR Data Center Storage Version 2.1 Final Specification

storage controllers / devices, and computer systems so that data transfer is secure and robust. The term SAN is usually (but not necessarily) identified with block I/O services rather than file access services.

- **'Capacity Optimising Methods (COMs)':** The reduction of actual data stored on storage devices through a combination of hardware and / or software.
- **'Non-volatile Solid State (NVSS) Set Disk Access 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 NVSS Set Disk Access Online storage must be accessible MaxTTFD ≤ 80 ms, unless the storage product is in a Deep Idle state. NVSS Set Disk Access Online storage is typically comprised of one or more SSDs and a storage controller and provides primary data storage to supplement a Computer Server's internal memory.
- **'NVSS Set Memory Access 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 NVSS Set Memory Access Online storage must be accessible MaxTTFD ≤ 80 ms, unless the storage product is in a Deep Idle state. NVSS Set Memory Access Online storage is typically comprised of one or more banks of Solid State Storage devices and a storage controller and provides primary data storage to supplement a Computer Server's internal memory.
- **'Ready Idle'**: "The state in which a storage product is able to respond to arbitrary I/O requests within the MaxTTFD limits for its taxonomy category but is not receiving external I/O requests. The storage product may perform routine housekeeping tasks during Ready Idle, provided such operations do not compromise the product's ability to meet MaxTTFD requirements".
- **'Deep idle'**: "A state in which one or more storage product components or subsystems have been placed into a low-power state for purpose of conserving energy. A storage product in Deep Idle may not be able to respond to I/O requests within the MaxTTFD limits for its taxonomy category and may need to perform a managed 'wake-up' function in order to return to a Ready Idle or Active State. Deep Idle capability must be a user-selected, optional feature of the storage product."
- '**Power Supply Unit (PSU**)': "A device that converts ac or dc input power to one or more dc power outputs for the purpose of powering a storage product. A storage PSU must be self-contained and physically separable from the system and must connect to the system via a removable or hard-wired electrical connection. Note: Storage PSUs may be Field Replaceable Units (FRUs), but in some cases may be further integrated with the storage product."
- **'Ac-dc Power Supply'**: "A PSU that converts line-voltage ac input power into one or more dc power outputs."
- **'Dc-dc Power Supply'**: "A PSU that converts line-voltage dc input power to one or more dc power outputs. For purposes of this specification, a dc-dc converter (also known as a voltage regulator) that is internal to a storage product and is used to convert a low voltage dc (e.g., 12 V dc) into other dc power outputs for use by storage product components is not considered a dc-dc power supply."

The following products are specifically excluded from certification under this specification:

I. Personal / Portable Data Storage Products;
II. Computer Servers;
III. Blade Storage Products;
IV. Direct Attached Storage Products
V. Storage Products capable of only object-based storage; Storage devices in the following categories of the taxonomy: Disk Set Near-Online, RVML Set Removable Media Library, RNML Set Virtual Media Library and NVSS Set Memory Access.

Definitions in v1.1 ENERGY STAR® specification for large networking equipment

The Version 1.1 ENERGY STAR® Specification for Large Network Equipment[7] took effect on March 1, 2016. The Version 1.1 specification provides the following useful definitions:

- **Network Equipment**: "A device whose primary function is to pass Internet Protocol traffic among various network interfaces/ports."
- **Large Network Equipment (LNE)**: "Network Equipment that is mountable in a Standard Equipment Rack, supports network management protocols (e.g. SNMP) and contains at least one of the following features:
  - Contains more than eleven (11) Physical Network Ports.
  - Total aggregate port throughput of the product is greater than 12 Gb/s"
- **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:

I. Designed for stationary operation ENERGY STAR Program Requirements for Large Network Equipment – Eligibility Criteria Page 3 of 10
II. Contains no more than eleven (11) wired Physical Network Ports; and
III. Primary configuration for operation outside of standard equipment racks

The products explicitly excluded from Version 1.1 include the following:

- Products that contain greater than four Physical Network Ports that have 100 Gb/s or higher link rate capability.

The following products are not eligible for certification under the ENERGY STAR Program:

- Small Network Equipment;
- Computer Servers, including blade switches sold within a Blade Server configuration;
- Storage Products, including Blade Storage; iv. Storage Networking Products;
- Security Appliances;
- Access Point Controllers;
- DSLAM/CMTS equipment;
- Network Caching Devices; and

[7] ENERGY STAR LNE Final Version 1.1 Specification

- Load Balancing Devices.

Storage Networking Industry Association (SNIA)

Version 4.0.0 of the SNIA Emerald™ Power Efficiency Measurement Specification[8] was released in July 2020. This specification has defined storage products in terms of their operational profiles and supported features. It provides a method for assessing the energy efficiency of commercial storage products in active and idle states.

In 2019, ISO published the international standard, ISO/ IEC 24091:2019 Information Technology – Power Efficiency Measurements Specification for data centre storage[9]. This converted the SNIA standard into an international standard which describes an internationally standardised methos to assess the energy efficiency of data storage products.

The SNIA Green Storage TWG Taxonomy makes the distinction of six product group categories with differing operational profiles:

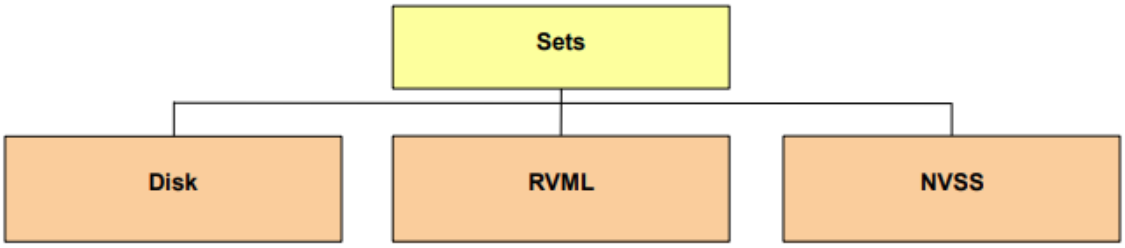
- **Disk Set Online**: Storage system for very fast random or sequential I/O request. The main distinction type is the maximum TTFD of <80ms.
- **Disk Set Near-Online:** Storage system for moderate random or sequential I/O request. The main distinction type is the maximum TTFD of >80ms.
- **RVML Set Removable Media Library:** System for sequential I/O request with a long response time (maximum TTFD <5 min). This is an automated or manual media loader such as a tape or optical library.
- **RVML Set Virtual Media Library**: System for very fast sequential I/O request with maximum TTFD of <80ms. The media are not removeable and are for long term data storage.
- **NVSS Set Disk Access**: Storage system for very fast random or sequential I/O request with a maximum TTFD of <80ms. Defines the features and functionalities for an online, random access, Solid State Storage-based disk access storage product. Offers disk access if it provides data access using storage paradigm. Products provide any combination of block, file or object interfaces.
- **NVSS Set Memory Access:** Storage system for very fast random I/O request with a maximum TTFD of <80ms. Defines the features and functionalities for an online, random-access, Solid-State Storage-based memory access storage product. Offers memory access if it provides host access to storage using memory primitives. Products provide a memory interface.

SNIA also define a broad set of groupings of storage products. Figure 1.1 below gives more information on these grouping which all share a similar system of characteristics. Products within different sets are generally not comparable in performance or power efficiency characteristics.

[8] SNIA Emerald™ Power Efficiency Measurement Specification

[9] ISO/IEC 24091:2019 - Information technology — Power efficiency measurement specification for data center storage

Figure 1.1 Taxonomy Overview defining the grouping of storage products[10]



Top-Runner Program (Japan)

The Japanese Top-Runner-Program currently covers Computer and Magnetic Disk Units[11]. This legislation has been in place since 2007 with no revisions conducted on this technology since then. There is also a legislation for Small Routers & L2 Switches, this was published in 2008 and has not been revised since[12].

Definition of Server Computers and classification

The following relevant definitions for servers are provided within Top Runner:

- 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 classified and distinguished by the CPU type and number of I/O slots.
- 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.
- 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.

Definition of data storage Hard Disk Drives

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.

[10] SNIA Emerald™ Power Efficiency Measurement Specification

[11] tr_computers_magneticdiscunits_dec2009.pdf (eccj.or.jp)

[12] https://www.eccj.or.jp/top_runner/pdf/tr_small_routers-apr_2008.pdf

- 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.).

Definition from the Small Router

The following definition of relevance to this study is provided in the Top Runner Legislation for small routers and L2 switches:

- Small routers: Targeted routers are all of those intended mainly to relay network data using the third layer (network layer), among models whose communication function is structured in layers based on OSI (Open System Interconnection) established by ISO (International Organization for Standardization). To be specific, they are products which relay network data referring to IP addresses. Here, this relay operation means that a router counts TTL of IP address header information backward and relays data to other data links. Among routers defined in the above, small routers are those with effective transmission rate of 200 Mbit/s or below (100 Mbit/s or below for wireless routers).

1.1.4 Preliminary product scope and definitions

Regulation 2019/424 scope covers servers and data storage products, which encompasses a broad range of products. As per Article 8 of 2019/424 the Commission shall assess this regulation, presenting the results of the assessment and if appropriate suggest draft revisions. Effective from March 2020, the Lot 9 regulation introduced minimum requirements for servers and data storage products on the EU market. From January 2023 the requirements for applicable power supply efficiency and power factor limits were made more stringent.

1.1.4.1 Product scope criteria

Servers and data storage products are understood as professional equipment which are marketed and sold through enterprise channels in a business-to-business environment. Servers and data storage products are comprised of a minimum hardware and software configuration. The 19-inch computer rack cabinet is the most widely used way to mount servers, data storage products and network equipment.

The preliminary criteria used in the last preparatory study to specify in more detail the scope of Regulation 2019/424 were reassessed and are still applicable under this review, therefore more detail is presented in the following section.

Operating location

- This considers where the equipment is operated and by whom. Often servers and data storage products are collated in large number fulfilling their intended service within the same room. Collectively this is known as a data centre. Data centres often have a customised infrastructure for power distribution, air conditioning, monitoring, safety, and administration. The Regulation 2019/424 primarily targets servers and data storage products in a professional environment (server rooms or data centres).

Product vs. system approach

- The Ecodesign Directive (2009/125/EC) implements a product approach. Thus, all implementing measures address single products only and not

interactive systems or complete installations. Consequently, Regulation 2019/424 covered fully functional singular products and not complete installations, such as a data centre. Servers and data storage products despite their interdependencies will be analysed at the product level during this study.

System performance considerations are discussed in greater detail within the Phase 1 report, see Section 2.10. A system in this case is considered the server and the Data Centre. The Phase 1 report considers two parameters which affect the energy consumption of data centres. These parameters include reducing the energy consumption of servers and the operating conditions of the servers themselves.

Volume vs. custom made products

- Currently on the EU market original equipment manufacturers (OEM) offer different product types and configurations for various purposes. Allowing the purchaser to choose a configuration that is best suited to their requirements. OEMs can customise product solutions according to the specification of the purchaser and their service level agreement (SLA) requirements. Since the EE Directive primarily focuses on products with significant sales and market impacts and that it is not practical to implement custom made products within the current Regulation. The Regulation will focus on typical volume products.

  The Phase 1 report highlights the issue of custom-made products within items c, e and f, this is covered in Section 2.2 of the report. It was recommended that custom made products remain exempt from the Regulation's energy efficiency information and criteria. However, a definition for custom servers should be added to the Regulation. This ensures that server configurations are not inappropriately deemed as ‘custom made’.

B2B-market

- This considers the market channels through which servers and data storage products are sold and purchased. Regulation 2019/424 targets professional servers and data storage products with small scale servers explicitly excluded from the regulation. Therefore, these products are sold in a Business-to-Business environment.

Quality of service:

- The legal framework and service condition under which servers and data storage products operate within are considered within the scope of the Regulation.

1.1.4.2 Servers

Preliminary product definition and scope

Regulation 2019/424 provides the definitions for servers as a computing product that provides services and manages networked resources for client devices. They include products that have the following characteristics:

- Servers are designed to support server operating systems and/or hypervisors, and targeted to run user-installed enterprise applications.
- Support error-correcting code and/or buffered memory
- All processor have access to share system memory and are independently visible to a single OS or hypervisor.

Server appliances, large servers, fully fault tolerant servers and network servers were exempt from the scope of the regulation.

Resilient servers, High Performance Computing (HPC) servers and servers with integrated APA were exempt from the energy efficiency requirements of active efficiency and idle state power consumption, which are set out in Annex II point 2.1 and point 2.2 of Regulation 2019/424.

Recommendations from the Phase 1 report

Section 2.2 of the Phase 1 report covers the recommendations put forward for updating the definitions for servers.

To ensure clarity and harmonisation, it is recommended to align product definitions with Energy Star, EPEAT, ISO/IEC 21836:2020 and ETSO EN 303 470. In particular, an update should be considered for the definitions of resiliency under the resilient server definition and the High-Performance Computing (HPC) servers as these do not align with ENERGY STAR. Furthermore, definitions specifically for resilient servers' recovery section and HPC servers should be updated to align with the latest industry standard. We also recommend the inclusion of the following definitions:

- Storage heavy servers: A computer server with greater storage capacity than a standard computer server. As shipped, these computer servers support 30 or more internal storage devices. These servers differ from Storage Products in that they run computer server operating systems and software stacks.
- Hyperconverged Server: Hyperconverged Server: A highly integrated server which contains the additional features of large network equipment and storage products.
- For large servers, we recommend for their exclusion from the regulation to be maintained.

We recommend the inclusion of fully fault tolerant servers, and hyperconverged servers into the regulation, with an exemption granted for energy efficiency requirements set out in Annex II point 2.1 and point 2.2, where these products are not yet in the test standard scope.

For custom servers, we recommend creating a definition within the regulation in order to ensure that server configurations are not inappropriately deemed as "custom made". The regulation has an exemption for the provision of energy efficiency information for custom made servers, the same exemption should be extended for energy efficiency criteria as these devices are not in scope for the SERT testing standard. The definition for custom made servers needs to be careful not to allow for market loopholes.

With regards to server appliances, these are out of scope of both SPEC SERT tool and ISO/IEC 21836:2020 standard which makes their inclusion into energy efficiency criteria difficult. Our recommendation is to include server appliances into the regulation, with specific exclusions for energy efficiency requirements set out in Annex II point 2.1 and point 2.2 of Regulation 2019/424.

As networks servers may be better defined as large network equipment, they are not in scope for the SERT test standard. They can therefore not be included in the active efficiency and idle score metrics, and that exemption should be maintained. We recommend investigating if network servers can be included into a regulation for network equipment in order for them to be measured under the ATIS test method.

As resilient servers are included in the scope of SPEC SERT, we recommend removing their exemption from the energy efficiency criteria. Research can be done to consider accommodations with regards to their higher uptime availability.

We recommend maintaining the exclusions on energy efficiency metrics (from annex II point 2.1 and point 2.2) granted to High Performance Computing (HPC) servers and servers with integrated APA as these devices are out of scope of the testing standards SPEC SERT tool and the ISO/IEC 21836.2020. The definition of servers with integrated APAs should be updated for clarity.

SPEC has shared that SERT V3 will be developed over the next two years, which should address HPC servers and those with many types of integrated APAs. The commission could look to include HPC servers and servers with integrated APAs into the regulation after SERT has updated the standard.

Section 2.11 of the Phase 1 report is recommending developing definitions for liquid cooled servers. The following definitions are recommended by the study team:

- liquid cooled servers are defined as servers where cooling liquid is in direct thermal contact with server components.

For indirect cooling systems applying to the rack, these are simple and cost effective, but are sold as separate equipment to the server and are therefore out of scope of the Ecodesign regulation. In addition, liquid cooling to the chips is largely limited to HPC systems, which are also out of scope of the Regulation. Therefore, no definitions are required for either of these

Regulated server products are currently tested under SERT in an air-cooled configuration. As the implementation of liquid cooling onto those servers is likely to increase efficiency and their low market share, no action is required on this front at this time. However, this technology should be monitored to ensure that if market share grows, the next Ecodesign revision may need to review regulatory action. A definition for liquid-cooled servers is needed, to ensure that servers that are only manufactured in liquid cooled versions are exempt from energy efficiency criteria of the regulation.

Functional unit

Servers contain hardware and software elements that provide computing services or task specific applications via a network. The design and configuration of a server is defined by the functionality and performance, the scalability and form factor, and the configuration for a specific service level.

The parameters that are used to characterise servers are provided below Table 1.1.

Table 1.1 Server characterisation parameters

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

The energy consumption and product performance over its lifetime is defined by the configuration and utilisation aspects. Due to heterogenous nature of server configurations and actual utilisation, it is not possible to define specific functional units that are based on certain performance parameters.

1.1.4.3 Data Storage Products

Product definition and preliminary scope

Regulation 2019/424 provides the definitions for data storge products as a fully functional storage system that supplies data storage services to clients and devices either directly or through a network. The components and subsystems that are an integral part of the data storage product architecture are considered to be part of the data storage product. Whereas components that are not associated with a storage environment at the data centre level are not considered to be part of the data storage product. A data storage product may be composed of integrated storage controllers, data storage devices, embedded network elements, software and other devices.

Recommendations from the Phase 1 report

Phase 1 report, Section 2.2, covers the recommendations put forward for updating the definitions for data storage products. It is recommended that all definitions are updated so they align with the definitions provided in ENERGY STAR, EPEAT, ISO/ IEC 21836:2020, ETSI EN 303 470 and SNIA Emerald. For data storage products it is recommended that definition are to be updated in line with SNIA Emerald taxonomy.

The SNIA Emerald benchmark provides valuable data on energy efficiency in storage systems. This can inform the creation of new active levels and can be designed to match the workload requirements of storage devices more accurately, allowing for more efficient power management. Given the smaller size of the storage market and limited number of unique models, care should be taken not to create requirements as aggressive as may be developed for servers which are far greater in number and variety.

The Ecodesign PSU requirement applies to both servers and data storage products. For servers, the PSU maximum efficiency has been reached. We recommend keeping the power supply efficiency requirements for storage products as they are to align with servers.

Energy consumption of storage products in data centres is primarily driven by the number of physical storage devices present (HDDs, SDDs, etc.), which can be reduced by using higher capacity devices and implementing capacity optimisation methods. It is recommended to require the availability of capacity optimisation methods data, specifically related to deduplication and data compression.

Additionally, the Commission should provide users/operators with information on the benefits of utilising these methods. Educating consumers about the benefits of energy-efficient storage products and providing guidance on selecting and using such products can drive demand for energy-efficient options.

Functional unit

The design and configuration of a data storage products is defined by the provided functionality and performance, storage media, scalability and form factor, as well as service level. Typically, data storage products are free standing (pedestal) or in a cabinet (rack-mounted) and are usually installed in a data centre. The characterisation parameters are specified below in Table 1.2.

Table 1.2 Data Storage Products 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-optimised (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

Like servers the energy and resource consumption of a data storage product over its lifetime is determined by the specific configuration and utilisation aspects. In addition, due to the large variability with respect to data storage products configuration and actual utilisation, it is not viable to define the functional units of each of these.

1.1.4.4 Network Equipment

Network equipment are devices that provide connectivity and passes data through a wired or wireless network interface. It can work based on physical layer (OSI layer 1), on data link layer (OSI layer 2), or on network layer (OSI layer 3).

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. The following aspects should be considered with regards to the definition of network equipment:

- The type of network equipment it is. There are many different types of network equipment which can make one definition very difficult. These include devices the apply different transmission technologies (wired, wireless) and work on the physical, data link or network layer (transmitting, switching, routing, etc.,)
- Often the same type of networking equipment will be operated in different networks under different operative conditions and quality of service requirements.
- Network equipment by nature does not operate independently and usually interacts with one or multiple links. This makes it difficult to measure the performance because this must be judged based on the performance of the overall network system.

Product definition and preliminary scope

The scope of the initial preparatory study in 2014 also included network equipment. However due to the complexity and variability of network equipment, establishing a regulation that would define and set standards for these devices was deemed difficult. However, there is interest to review if there may be simple measures which could be applied to improve sustainability of network equipment devices, notably with regards to material efficiency requirements.

Recommendations from the Phase 1 report

Within the Phase 1 report, item c covers the recommendations put forward for updating the definitions for network equipment. For more information, please see Section 2.2 of the Phase 1 report.

Auxiliary Processing Accelerators (APAs)

Servers with integrated APAs are still waiting for SERT to develop a new test standard, and therefore should be maintained in this exemption. However, it is noted that the technology is developing quickly, such newer CPU designs with accelerator blocks may be confused under the current EU regulation server with integrated APA definition. This definition therefore needs to be updated. The Energy Star Version 4 definition can be taken as a first definition update.

ENERGY STAR Version 4.0 for computer servers defines APAs in the following way:

'They are additional compute device installed in the computer server that handles parallelised workloads in place of the CPU. This includes, but is not limited to, General Purpose Graphics Processing Units (GPGPUs) and Field Programmable Gate Array (FPGA) chips. There are two specific types of APAs used in servers:

- Expansion APA: An APA that is an add-in card installed in an add-in expansion slot (e.g., GPGPUs installed in a PCI slot). An expansion APA add-in card may include one or more APAs and/or separate, dedicated removeable switches.
- Integrated APA: An APA that is integrated into the motherboard or CPU package.'

Recommendations from the Phase 1 report

Within the Phase 1 report, item c covers the recommendations put forward for updating the definitions for APA's. The Phase 1 report has recommended that the exclusions on energy efficiency metrics granted to servers with integrated APA's is maintained. This is because these devices are out of scope of the testing standards SPEC SERT tool and the ISO/IEC 21836.2020. The definition of servers with integrated APAs should be updated for clarity, to align with the definition given by Energy Star above.

1.2 Measurement & Test Standards

This sub-task identifies relevant measurement and test standards for servers and data storage products and is comprised of a description of each of the identified standards together with a comparative analysis.

This section identifies and describes the existing test standards and test procedures, specifically addressing the EU Regulation 2019/424:

- 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.

1.2.1 Identification and Description of Relevant Standards

EN-, ISO-, IEC- test standards Commission Regulation 2019/424 lays down the Ecodesign requirements for servers and data storage products[13]. This regulation was the first to specifically cover different types of servers and data storage products. There has been a large number of ENs published or being developed by CENELEC in support of European Legislation as laid down in the WEEE, RoHS, EMC and LVD Directives and the REACH Regulation. With some of these relevant to servers and data storage products. For example, the Technical Committee CENELEC TC 215 has transposed the ISO/IEC standards developed into EN standards for electrotechnical aspects of telecommunication equipment[14]. This covers the energy consumption of servers and data equipment. In 2015 the Commission issued mandate M543 to the European Standardisation Organisations requesting standards to support requirements on material efficiency aspects of energy related products. M543 was initially rejected by ESO, CEN and CENELEC, however, it was eventually accepted. The Technical Committee CEN-CENELEC TC10 was responsible for producing the standards which resulted from mandate M543. CENELEC published these standards in April 2020. These standards are discussed in more detail within Section 1.2.1.3.

1.2.1.1 EN-, ISO-, IEC- test standards developed at product level

ISO/IEC has recently adopted international standards for both SPEC SERT and SNIA Emerald. These standards are:

- SNIA Emerald was adopted as **ISO/ IEC 24091: 2019**
- SPEC SERT was adopted as **ISO/ IEC 21836: 2020**

The Phase 1 report provides more information on why it has recommended that these test standards are used within the Regulation for servers and data storage products. Items a and b of Section 2.1 of the Phase 1 report lays out the recommendations for using SPEC SERT, which serves as the foundation for ISO/IEC 21836:2020, as the benchmark or server requirements.

In addition, Item i of Section 2.3 of the Phase 1 report provides more information on why the study team wishes to introduce the use of SNIA Emerald under the ISO/

[13] https://eur-lex.europa.eu/legal content/EN/TXT/?uri=CELEX%3A32019R0424#:~:text=Commission%20Regulation%20(EU)%202019%2F,(Text%20with%20EEA%20relevance.)

[14] https://standards.iteh.ai/catalog/tc/clc/d8429a65-36a6-4cc7-9a70-a9aa104350d9/clc-tc-215

IEC 24091: 2019 standard to calculate the energy and performance efficiencies for data storage products.

ISO/ IEC 24091: 2019

ISO/ IEC 24091:2019 was developed from the SNIA Emerald industry test standard. ISO/ IEC adopted V3.0.3 of the SNIA Emerald power efficiency measurement specification in 2019. The standard provides a recognised method to assess the energy efficiency of data storage products. The resulting power efficiency metrics are defined as ratios of idle capacity or active operations during selected stable measurement intervals to the average measurement power[15].

The purpose of the ISO/ IEC 24091:2019 is to provide public access to storage system power usage and efficiency. This is achieved 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 ISO/ IEC 24091:2019 benchmark provides valuable data on energy efficiency in storage systems. This can inform the creation of new active levels and can be designed to match the workload requirements of storage devices more accurately, allowing for more efficient power management. A discussion on adopting ISO/ IEC 24091: 2019 in the legislation has been discussed in Section 2.3 of the Phase 1 report.

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.

ISO/ IEC 21836:2020

ISO/ IEC 21836:2020 collects measurements and efficiency metrics to assess a servers energy efficiency for the ENERGY STAR®. SPEC SERT became ISO 21836 compliant in 2020, with international agencies standardising the SERT 2 suite for measuring server efficiency on a global scale. The SERT 2 suite utilises the SPECpower Committee's modular architecture, which allows integration of the latest version of the Chauffeur benchmark harness and the PTDaemon Interface. This new method helps to reduce the time required for developing future workloads[16]. Ultimately, this next generation measurement standard enables the energy efficiency of single and multi-node servers across the latest server architectures and processors.

It was designed to be simple to configure and use via a comprehensive graphical user interface, ISO/ IEC 21836: 2020 is organised around eleven worklets which fall under three categories: CPU based, memory based and storage based. The results from the tested worklets are aggregated into a single score with a weighting of 65%

[15] https://www.iso.org/obp/ui/#iso:std:iso-iec:24091:ed-1:v1:en

[16] https://aithority.com/it-and-devops/cloud/spec-releases-new-iso-iec-21836-compliant-sert-suite/

for CPU, 30% for memory, and 5% for storage worklets[17]. The power demand of these worklets at idle and several other utilisation levels are also captured.

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. ISO/IEC 21836:2020 can test both x86 and IBM Power servers with up to eight processors, as well as multi-node servers. It 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.

A discussion on adopting ISO/ IEC 21836: 2020 in the legislation has been discussed in Section 2.3 of the Phase 1 report.

1.2.1.2 EN-, ISO-, IEC- test standards developed at system level

ISO/IEC JTC 1/SC 39 has developed a suite of effective key performance indicators (KPI) in relation to the ISO/ IEC 30134 series on IT equipment. In order to determine the overall effectiveness or efficiency of data centre these KPIs provide. This includes the following KPIs:

- ISO/IEC 30134-1: Part 1 - Overview and general requirements
- ISO/IEC 30134-2: Part 2 - Power usage effectiveness (PUE)
- ISO/IEC 30134-3: Part 3 - Renewable energy factor (RES)
- ISO/IEC 30134-4: Part 4 - IT equipment energy efficiency for servers (ITEE)
- ISO/IEC 30134-5: Part 5 - IT equipment utilisation for servers (ITEU_SV)
- ISO/IEC 30134-6: Part 6 - Energy reuse factor (ERF)

The objective of Part 2 of ISO/ IEC 30134 series is to support data centre operators by defining the power usage effectiveness of a data centre[18]. The PUE can be used to determine improvements of the operational efficiency, designs and processes of the data centre.

Part 3 of ISO/ IEC 30134 series aims to support data centre operators by defining the renewable energy factor (REF) of a data centre[19]. According to Part 3 "*The REF provides a quantitative metric for the actual use of renewable energy in the form of*

[17] https://www.energystar.gov/products/ask-the-experts/how-to-measure-server-efficiency-with-sert-

electricity in a data centre". Thus, providing an assessment of the mitigation of carbon emissions that originated from the data centre and is useful in improving the sustainability of data centres by enhancing the use of renewable energy.

The objective of Part 4 is to support data centre operators to optimise the energy efficiency of their servers[20]. This series quantifies the energy efficiency characteristics of servers in data centre. IT equipment energy efficiency for servers (ITEEsv) helps users improve energy effectiveness of their servers by providing a measure of work performed per unit of power consumed[21]. This will allow the user to compare the performance of their servers, identifying the inefficient ones. ITEEsv is intended for self-improvement of a data centre and not for comparison of other data centres.

Part 5 has the objective to support data centre operators to optimise the utilisation of its servers[22]. IT equipment utilisation for servers (ITEUsv) describes the utilisation of servers in operational conditions. This was developed with the knowledge that server energy efficiency tends to be greater with higher utilisation[23]. ITEUsv consider the utilisation and power management aspects of the server. It can identify underutilized servers and increase energy efficiency by turning servers off.

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

1.2.1.3 Mandates issued by the EC to the European Standardisation Organisations

Mandate M/573

In 2021 the Commission issued mandate M573 to the European Standardisation Organisations (CEN, CENELEC and ETSI) requesting to support Regulation (EU) 2019/424 as regards ecodesign requirements for servers and data storage products[24]. In August 2021, ETSI accepted the mandate.

The requirements of the specific standards to be adopted involve:

- Measurement and calculations of the power supply unit efficiency, the power factor, and its rated power output.
- The calculation of energy efficiency measurements and metrics for servers.
- Measurement and calculation of the opening condition class.
- A way to verify the compliance of products with the requirement on the secure data deletion functionality for servers and data storage products.
- Ensuring verification of compliance with the requirements for the availability of firmware and of security updates to firmware.
- Verifying the compliance of a server with the requirements of the supply of information on the weight range of critical raw materials
- Ensure that servers verify the compliance with requirements on its ability to be disassembled
- A deliverable on the assessment of the efficiency, performance, and power demand of data storage products.

[20] https://www.iso.org/standard/66191.html

[21] https://www.ictfootprint.eu/en/isoiec-30134-00-factsheet

[22] https://www.iso.org/standard/66934.html

[23] https://www.ictfootprint.eu/en/isoiec-30134-00-factsheet

[24] https://ec.europa.eu/growth/tools-databases/mandates/index.cfm?fuseaction=search.detail&id=597

The Commission requested that the output of the mandate be adopted by the end of January 2023. The technical body EE EEPS is responsible for producing the standard resulting from the mandate. Since the Commission issued mandate M573 to the European Standardisation Organisations in 2021, all seven standards are yet to be published. Table 1.3 features the complete lists of standards under the mandate progress against which is published on the ETSI website[25].

Table 1.3 Status of Ecodesign Requirement Standards for M573

Reference	Title	Draft
DEN/ EE-EEPS44	Energy efficiency metrics and measurements for data storage equipment.	✓
DEN/ EE-EEPS47-5	Server and data storage product disassembly and disassembly instruction	✓
DEN/ EE-EEPS47-4	Server and data storage product critical raw materials	✓
DEN/ EE-EEPS47-3	Server and data storage product availability of firmware and of security updates to firmware	✓
DEN/ EE-EEPS47-2	Server and data storage product secure data deletion functionality	✓
DEN/ EE-EEPS47-1	General for server and data storage products	✓
REN/ EE-EEPS42	Energy efficiency measurement methodology and metrics for servers	✓

Since this mandate was issued by the Commission ETSI have planned a separate deliverable for CPU power management. In addition, the critical raw material requirements that were originally to be included in ETSI standard will instead be included in CEN-CLC EN 45558 standard as a Z-annex.

Item l of the Phase 1 report covers the recommendations put forward by this review for including the standards originating from M/573 within the scope of the Regulation. Section 2.8 of the Phase 1 report provides more information on the recommendations put forward by the study team.

Mandate M/543

In 2015 the Commission issued mandate M543 to the European Standardisation Organisations (CEN, CENELEC and ETSI) requesting standards to support Ecodesign requirements on material efficiency aspects for energy-related products[26]. In January 2016, the ESOs, CEN and CENELEC accepted the mandate – which had previously been rejected[27]. This mandate aims to ensure the mandatory regulation of these practices across the EU, as the EU pushes to achieve the targets set out by the Circular Economy Action Plan of 2015.

The standardisation request relates to the following three material efficiency aspects:

- Extending product lifetime;

[25] Work Programme - EWP on the Web - Query Result (etsi.org)

[26] http://ec.europa.eu/growth/tools-databases/mandates/index.cfm?fuseaction=select_attachments.download&doc_id=1611

[27] http://www.endseurope.com/article/44907/green-light-for-resource-efficiency-standards?utm_source=07/01/2016&utm_medium=email&utm_campaign=ENDS%20Europe%20editorial%20bulletin?utm_source=07/01/2016&utm_medium=email&utm_campaign=ENDS%20Europe%20editorial%20bulletin

- The ability to re-use components or recycle materials from products at end-of-life; and
- The use of re-used components and/or recycled materials in products

The Commission has requested that the outputs from the mandate deal with the following topics:

- The definition of parameters and methods relevant for assessing durability, upgradability and ability to repair, re-use and re-manufacture of products;
- Provision of guidance on how standardisation deliverables for assessing durability, upgradability and ability to repair and re-manufacture of products can be applied to product-specific standards;
- Ability to access or remove certain components, consumables or assemblies from products to facilitate repair or remanufacture or reuse;
- Reusability/recyclability/recoverability (RRR) indexes or criteria, preferably taking into account the likely evolution of recycling methods and techniques over time;
- Ability to access or remove certain components or assemblies from products to facilitate their extraction at the end-of-life for ease of treatment and recycling;
- Method to assess the proportion of re-used components and/or recycled materials in products;
- Use and recyclability of Critical Raw Materials to the EU, listed by the European Commission;
- Documentation and/or marking regarding information relating to material efficiency of the product taking into account the intended audience (consumers, professionals or market surveillance authorities).

Table 1.4 features the complete list of standards under the mandate, progress against which is published on their committee website[28]. All standards are now published as of April 2020, with the exception of 45551 which has been discontinued.

Table 1.4 Status of Material Efficiency Standards

Reference	Title	Published
45550	Definitions related to material efficiency	CLC/ TR 45550:2020
45551	Guide on how to use generic material efficiency standards when writing ErP product specific deliverables	Discontinued
45552	Method to assess durability of ErPs	EN 45552: 2020
45553	Method to assess ability to remanufacture ErPs	EN 45553: 2020
45554	Method to assess ability to repair, reuse and upgrade ErPs	EN 45554: 2020
45555	Method to assess the recyclability and recoverability of ErPs	EN 45555: 2019
45556	Method to assess proportion of reused components in ErPs	EN 45556: 2019

[28] https://www.cenelec.eu/dyn/www/f?p=104:22:1183738753089601::::FSP_ORG_ID,FSP_LANG_ID:2240017,25

Reference	Title	Published
45557	Method to assess proportion of recycled content in ErPs	EN 45557: 2020
45558	Method to declare use of critical raw materials in ErPs	EN 45558: 2019
45559	Method to provide information on material efficiency of ErPs	EN 45559: 2019

Of particular interest to this review study is the recent adoption of M/543 within the recently drafted Smartphone and Tablets Ecodesign requirements. This is the first-time material efficiency has been adopted by an Ecodesign Regulation and this adoption will be used to support this part of the review study. Thus, ensuring that servers and data storage products successfully adopt these horizontal standards. Accelerating the development of standards on various aspects of material efficiency.

Item j a) of the Phase 1 report covers the recommendations put forward by this review for including the standards originating from M/543 within the scope of the Regulation. Section 2.8 of the Phase 1 report provides more information on the recommendations put forward by the study team.

Mandate M/462

In addition to M/543, the Commission has issued the standardisation mandate 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"[29]. The standardisation is not only limited to networks but extends to data centres and other ICT nodes with broadband deployment[30]. It provides standards for measurement, monitoring, and definitions of energy efficient KPIs. The actions requested by the commission include:

- **Action 1:** Definition of Global KPIs for Energy Management of Fixed and Mobile access, and Core networks.
- **Action 2:** Guidelines for the use of Global KPIs for Data Centres.
- **Action 3:** Definition of Global KPIs for Data Services.
- **Action 4:** Guidelines for the definition of Green Data Services.
- **Action 5:** Definition and guidelines of KPIs for ICT networks.
- **Action 6:** SDOs to identify needs and develop standards to support UN SDGs, in particular KPI for both synergies and conflicts in Digital transformation and Green transition projects.
- **Action 7:** ETSI, in collaboration with the EGDC, to consider possible paths for ITU L.1480 and L.1333 to be made available for European standardisation to meet EU policy objectives.

[29] https://portal.etsi.org/portals/0/tbpages/ee/docs/eso%20response%20to%20m462%20phase%201%20.pdf

[30] https://joinup.ec.europa.eu/collection/rolling-plan-ict-standardisation/ict-environmental-impact-0

1.2.2 Industry-Based Specifications

1.2.2.1 Standard Performance Evaluation Corporation (SPEC)

The Standard Performance Evaluation Corporation (SPEC) was founded in 1988 by workstation vendors who realised that the marketplace needed realistic, standardised performance tests[31]. 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.

Under the Open System Group (OSG), SPEC is structured into six working groups: Cloud, CPU, Java, Power, Storage and Virtualization. Relevant to this study is the subcommittees, Power.

SPEC SERT

SPEC developed the Server Efficiency Rating Tool (SERT)[32], in collaboration with the US Environmental Protection Agency. SERT is also adopted within the EU Lot 9 Ecodesign regulation and Japan's Top Runner program for computer servers, creating a harmonised way to evaluate server efficiency in different geographies[33]. Additionally, they are required for cloud service providers deployments in the EU. The China National Institute of Standardisation (CNIS) is also considering SERT for inclusion in its upcoming mandatory server energy regulations.

ISO 21836:2020 was developed as an international test standard from the industrial test method SPEC Server Efficiency Rating Tool (SERT)[34]. For more information on the SPEC test standard please see Section 1.2.1.1.

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.

SPECpower

Since this measurement standard was not utilised in Regulation 2019/424, it will not be included within this section of the report. It was not included in the previous Regulation because SPEC SERT was used instead, which also included an idle measurement. Thus, SPECpower was made redundant. The SPECpower overview has been included in the Annex A1.1.2.

[31] https://www.spec.org/

[32] https://www.spec.org/sert/docs/SERT-Design_Document.pdf

[33] https://www.energystar.gov/products/ask-the-experts/how-to-measure-server-efficiency-with-sert-

[34] https://www.spec.org/sert/docs/SERT-Design_Document.pdf

1.2.2.2 SNIA Emerald™ Power Efficiency Measurement Specification

SNIA (Storage Networking Industry Association) Emerald™ Program[35] provides public access to storage system power usage and efficiency. With international agencies standardising the Emerald power efficiency measurement specification V3.0.3. 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 Power Efficiency Measurement Specification is used in the V2.1 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 Emerald™ Power Efficiency Measurement Specification" Version 4.0.0. In addition, the definitions for data storage products within the EU Lot 9 Ecodesign regulation were developed by SNIA. In particular, the definitions for small data storage products and large data storage products[36].

ISO 24091:2019 was developed as an international test standard from the industrial test method SNIA Emerald. For more information on the SNIA Emerald test standard please see Section 1.2.1.1.

1.2.2.3 Energy Consumption Rating (ECR Initiative 2010)

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

$$ECR = Ef / Tf,$$

Where:

- *Ef* represents the energy consumption (Watts),
- *Tf* represents the effective maximum system throughput (Gbps).

ECR is normalised to W/Gbps and has a physical meaning of energy consumption to move one Gigabit worth of line-level data per second[37]. It reflects the best possible platform for a fully equipped system with a chosen application. However, the power consumption of current network devices typically adapts according to the actual work load. 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,
- $T_{50} = T_f * 0.5$,
- $T_{30} = T_f * 0.3$,

[35] https://www.snia.org/technology-focus/power-efficiency

[36] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32019R0424

[37] final LATEST ENERGY EFFICIENCY22MARCH.pdf (tec.gov.in)

- $T_{10} = T_f * 0.1$,
- 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),
- α, β, γ, δ, ε are weight coefficients selected such as (α + β + γ + δ + ε) = 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.

1.2.2.4 Third country Test Standards

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

PAS 141 is a standard developed by the UK's Department for Business, Innovation and Skills (BIS) now the Department for Energy Security and Net Zero, in 2011. It sets out the requirements to successfully manage the process of preparing used and waste electrical and electronic equipment for reuse. By managing electrical waste, it is aiming to reduce the generation of waste by encouraging reuse and properly treating the waste by recycling and recovery decreasing the amount to landfill.

IEC TR 62635:2012 – Guidelines for end-of-life information provided by manufacturer and recyclers and for recyclability rate calculation of electrical and electronic equipment.

This standard provides a methodology for information exchange involving manufacturers and recyclers, and for calculating the recyclability and recoverability rates[38]. In addition, it provides a description of the end-of-life principles of electrical and electronic waste, including the scope, terms and definitions and description of a generic treatment process of electronic waste[39].

The standard also provides a calculation which helps to describe the method of recyclability and recoverability rates of each part:

$$Rcyc = \frac{sum\ of\ recyclable\ masses\ of\ each\ part}{total\ product\ mass} \times 100\% = \Sigma\ (m(i) \times RCR\ (i)\ MEEE\ \times 100\%$$

Where:

- m(i): the mass of part i.
- RCR: recycling rate of the i^{th} part in corresponding end of life treatment scenario
- MEEE: total product mass.
- Included within standard is a list of recyclability and recoverability rates.

[38] https://webstore.iec.ch/publication/7292

[39] https://webstore.iec.ch/publication/7292

NSF/ ANSI 426-2017: Environmental Leadership and Corporate Social Responsibility Assessment of Servers.

This standard defines environmental and corporate social responsibility performance criteria for computer servers as defined in the ENERGY STAR Server specification[40]. Providing performance objectives which consider the energy and material efficiencies to reduce the environmental impact of servers[41]. It establishes a set of criteria on environmental leadership and corporate social responsibility throughout the products life cycle, these relate to:

- Energy efficiency;
- management of substances;
- preferable materials use;
- product packaging;
- design for repair;
- reuse and recycling;
- product longevity;
- responsible end of life management;
- corporate responsibility

ITU-T Standards

The international Telecommunications Union provide standards to improve the circular economy of ICT equipment. The ITU standards are carried out by technical study groups in the past they have published standards that are focused on power supply series, e-waste management and recycling of rare metals in ICT. Since 2017 Study Group 5 has developed standards regarding the environmental impacts, end of life impacts and circular economy structures[42].

1.2.3 Comparative Analysis of Relevant Test Standards

One of the major driving forces behind improved efficiency of serves in the last decade has been from the use of SPEC. Other industry initiatives including SNIA and ATIS have also developed benchmarks and test for assessing the functional performance of the energy consumption of a server, storage or network product. Due to their recognition as accurate ways to measure the energy performance of servers, these benchmarks have been adopted by ENERGY STAR, Ecodesign and Japan's Top Runner program.

The SPECpower test standard is widely used since its introduction in the year 2008 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. To overcome this issue SPEC SERT was developed alongside the US Environmental Protection Agency. SERT is able to provide a much more realistic power consumption and performance data and therefore helps customers in their procurement decisions.

[40] https://webstore.ansi.org/standards/nsf/nsfansi4262017

[41] A SITUATIONAL ANALYSIS OF A CIRCULAR ECONOMY IN THE DATA CENTRE INDUSTRY (weloop.org)

[42] https://www.itu.int/en/Pages/default.aspx

1.2.4 New Standards Under Development

The study team conducted extensive research to discover if there were any new standards under development in the EU and in third party countries. It was concluded that no new standards were under development at the time of writing this report.

1.3 Existing Legislation

This section identifies existing legislation that may affect servers and data storage products. This is considered at the European and Member State level as well as Third Countries (e.g. UK and USA).

1.3.1 Legislation at European Union Level

1.3.1.1 Commission Regulation 2019/424 for Servers and Data storage Products

Ecodesign Regulation 2019/424 establishes the requirements for servers and online data storage products placed on the EU market. This regulation was published on 18th March 2019, with the first set of requirements coming into effect from 1st March 2020 for servers and data storage products. These requirements were then uplifted for on the 1st March 2021 and then again on the 1st March 2023.

The scope of Regulation 2019/424 does not include server appliances, large servers, fully fault tolerant servers and network servers. While resilient servers, High Performance Computing (HPC) servers and servers with integrated APA are exempt from the energy efficiency requirements of active efficiency and idle state power consumption, which are set out in Annex II point 2.1 and point 2.2 of Regulation 2019/424. In addition, the initial preparatory study had included networking equipment within its scope. However, due to the complexity and variability of network equipment, establishing a regulation that would define and set standards for these devices was deemed difficult.

Within this review study we have provided our recommendations for the scope of the Regulation within Section 2.2 of the Phase 1, Task 1 report.

The Regulation sets requirements for the following parameters: PSU efficiency (%), power factor, idle state power and maximum power, and active state efficiency and performance in active state. In addition, there are a material efficiency requirements required in the Regulation. These requirements will be described in the following text.

Since January 2023 servers and data storage products have had to reach the PSU efficiency requirements values set in Table 1.5. These requirements are measured at 10%, 20%, 50% and 100% of the rated load level and power factor at 50% of the rated load level. Direct current server and data storage products are exempts from the requirements.

Table 1.5 Minimum PSU efficiency and power factor requirements for servers.

	Minimum PSU Efficiency				Minimum Power factor
% of Rated Load	10%	20%	50%	100%	50%
Multi-output	-	90%	94%	91%	0.95
Single Output	90%	94%	96%	91%	0.95

Regulation 2019/424 provides specific requirements for servers. From March 2020, the idle state power (P_{idle}) of servers (excluding resilient servers, HPC servers and servers with integrated APA), are required to be calculated using the following equation.

$$P_{idle} = P_{base} + \Sigma P_{add\_i}$$

Where:

- P_{base} is the basic idle state power allowance, as determined below by Table 1.6
- ΣP_{add_i} is the sum of idle state power allowance for applicable and additional components as determined below by Table 1.7.

Table 1.6 Basic Idle State Power Allowance

Product Type	Basic Idle Power Allowance P_{base} (W)
1-socket servers (neither blade nor multi-node servers)	25
2-socket servers (neither blade nor multi-node servers)	38
Blade or multi-node servers	40

Table 1.7 Additional Idle Power Allowances for Extra Components

System Characteristics	Applies to	Additional idle power allowance
CPU Performance	All servers	1 socket: 10 x $Perf_{cpu}$ W 2 socket: 7 x $Perf_{CPU}$ W
Additional PSU	PSU installed explicitly	10 W per PSU
HDD or SDD	Per installed HDD or SDD	5.0 per HDD or SDD
Additional Memory	Installed memory greater than 4 GB	0.18 W per GB
Additional buffered DDR channel	Installed buffered DDR channels greater than 8 channels	4.0 W per buffered DDR channel
Additional I/O devices	Installed devices greater than two ports of ≥ 1 Gbit, on board Ethernet	< 1 Gb/s: No Allowance
		= 1 Gb/s: 2.0 W/ Active Port
		> 1 GB/s and < 10 Gb/s: 4.0 W/ Active Port
		≥ 10 Gb/s and < 25 Gb/s: 15.0 W Active Port
		≥ 25 Gb/s and < 50 Gb/s: 20.0 W Active Port
		≥ 50 Gb/s: 26.0 W Active Port

Active state efficiencies (Eff_{server}) for servers have been in enforced by the regulation since March 2020. Servers, with the exception of resilient servers, HPC servers and servers with integrated APA, shall have an active state efficiency value no lower than the values in Table 1.8.

Table 1.8 Active state efficiency requirements

Product type	Minimum active state efficiency
1-socket servers	9.0
2-socket servers	9.5
Blade or multi-node servers	8.0

The Regulation also requires manufacturers to provide information regarding the material efficiency of servers and data storage products. These requirements have been enforced since March 2020. Manufacturers are required to ensure that the joining, fastening, or sealing techniques used on their product do not prevent the repair or reuse of the following components:

- Data storage devices
- Memory
- Processor (CPU)
- Motherboard
- Expansion card/ graphic card
- PSU
- Chassis
- Batteries

In addition, the regulation required data storage products to have a function to delete all secure data contained within it, to allow for the safe reuse of products. This was enforced from March 2020.

From March 2021, the latest version of the firmware shall be made available from two years after first being placed on the market. From this point the firmware should be available free of charge or at a fair transparent and non-discriminatory cost, for a minimum of eight years after placing on the market. Similarly, for security updates the firmware, these should be made available, free of charge, until at least eight years after first being placed on the market.

Furthermore, the Regulation includes general information requirements that have been enforced since March 2020. Within Annex II, Section 3.1 there is a list of the type of product information that must be included in the server's instruction manuals for installers and end users. This information should also be made available on a free access website. This information must be accessible for at least eight years after the product is placed on the market. It should be noted that this does not apply to custom made servers. Within Annex II, Section 3.2 of the Regulation there is also list of the information requirements for the instruction manuals for data storage products. Again, this excludes custom built data storage products. Within Section 3.1 and 3.2 of Annex II, the Regulation requires manufacturers to declare the operating conditions inm which the product was tested at. The products must be tested within the boundaries of the operating conditions displayed in Table 1.9 in order to comply with the Regulation.

Table 1.9 Operating Condition Classes defined by EU Regulation 2019/424

	Dry bulb temperature °C		Humidity range, non-condensing			
Operating condition class	Allowable range	Recommended range	Allowable range	Recommended range	Max dew point (°C)	Maximum rate of change (°C/ hr)
A1	15-32	18-27	-12 °C DP* and 8% RH** to 17 °C DP and 80% RH	-9 °C DP to 15 °C DP and 60% RH	17	5/20
A2	10-35	18-27	-12 °C DP and 8% RH to 21 °C DP and 80% RH	Same as A1	21	5/20
A3	5-40	18-27	-12 °C DP and 8% RH to 24 °C DP and 85% RH	Same as A1	24	5/20
A4	5-45	18-27	-12 °C DP and 8% RH to 24 °C DP and 90% RH	Same as A1	24	5/20

**DP = dew point, **RH = relative humidity.*

There are additional production information requirements for servers and online data storage products. The following information shall be made available from the time the product is on the market until at least eight years after. The manufacturers authorised representatives and importers to third parties who deal with repair, reuse, recycling and upgrading of servers (including brokers, spare parts repairers, spare parts providers, recyclers and third-party maintenance). Must be provided with the following information regarding servers and online data storage products placed on the market from March 2020:

- indicative weight range (less than 5 g, between 5 g and 25 g, above 25 g) at component level, of the following critical raw materials:
  - Cobalt in batteries
  - Neodymium in the HDDs
- instructions on the disassembly operations referred to in point 1.2.1 of Annex II, including, for each necessary operation and component:
  - The type of operation
  - The type and number of fastening technique(s) to be unlocked
  - The tool (s) required

For servers if a product model is part of a server product family, the production information displayed above shall be reported for either the product model or alternatively, the low end and high end configurations of the server product family.

1.3.1.2 Ecodesign and Energy Labelling Working Plan (2022-2024)

The European Commission adopted the Ecodesign and Energy Labelling Working Plan 2022-2024 on 30th March 2022. This working plan will act as a bridge to future 'sustainable product policy initiatives'[43]. The main aim of the working plan is to increase the ambitions of existing Ecodesign and energy label regulations covering energy-related products.

Servers and data storage products are within the scope of the workplan, the deadline for the review was the 31st March 2022. In addition, the Working Plan emphasises work on the following standards which are of high interest:

- The Commissions' standardisation request M/543
- EN 45554: 2020
- Methodology of Ecodesign for Energy-related Products.

Mandate M/543 will play a significant role in ensuring that servers can become more sustainable and reduce their life-cycle environmental impact. Hence, with the Working Plan putting a stronger emphasis on achieving a circular economy in the EU this is likely to have a significant impact on severs and data storage products in the near future.

1.3.1.3 **Energy Efficiency Directive** (2012/27/EU) and recast (2023)

The European Union has prioritized energy savings and efficiency in its strategy, aiming to enhance security, reduce emissions, and ensure affordable transitions. The Energy Efficiency Directive (EED) strengthens the legal framework for achieving the objectives of the "Fit for 55 package" and "REPowerEU" plan.

The Energy Savings Obligation (ESO) is the central pillar of the EED and, more broadly, a key element of the whole EU energy efficiency framework. Since 2021, Member States must achieve each year 0.8% new end-use energy savings. The 2023 EED recast introduces a progressive increase in ambition with an annual rate of 1.3% from 1 January 2024 to 31 December 2025, 1.5% from 1 January 2026 to 31 December 2027 and 1.9% from 1 January 2028 to 31 December 2030 (EED Art. 8.1).33 This progressive increase corresponds to a constant annual rate of 1.49% over the period 2024-2030, which is almost a doubling of the 0.8% current annual objective.34 The 1.9% savings rate will be maintained for the next obligation periods, starting with 2031-2040 (EED Art. 8.13)[44]. As of September 2023 the updates to the Directive have now been published[45].

The Ecodesign Regulation for servers and data storage products, works alongside the overarching and parallel perspective of the EED while contributes in the achievement of those targets. The two should work in parallel and this study is taking this into account.

[43] https://eurovent.eu/?q=articles/ecodesign-and-energy-labelling-working-plan-2020-2024-gen-113900

[44] The-new-2023-EED-Guidance-for-national-planning-and-implementation.pdf (energycoalition.eu)

[45] Directive - 2023/1791 - EN - EUR-Lex (europa.eu)

Reporting requirements on the energy performance and sustainability of data centres for the Energy Efficiency Directive

With regards to the sustainable development in the ICT sector, the recast proposal of the EED[46] asks data centres to make information about their energy performance publicly available as well as report it to the Commission. These reporting requirements would apply to all Data Centres, old and new, that have a significant energy consumption.

A study was undertaken for the European Commission, DG ENER, that proposes 'Reporting requirements on the energy performance and sustainability of data centres for the Energy Efficiency Directive'[47]. The report proposes definitions, classification, and scope of reporting obligations. The latter include the demand for a available information on IT power demand for data centres with installed IT power demand equal to or greater than 100kW (including colocation data centres). Other information obligations proposed are relevant to building information, reporting organisation domain of control, operation and Key Performance Indicators (KPIs). Reporting KPIs aims to later establishing a set of "data centre sustainability indicators". Indicators proposed for reporting purposes are Total DC energy consumption and data functions and ICT equipment energy consumption compared to total DC energy consumption. Additionally, other indicators include ICT equipment capacity and ICT equipment utilisation. Ancillary metrics are also taken into account such as indicators on water usage, energy/heat reuse, renewable energy and server age.

Task B of the report[48] explores the introduction of an EU-wide labelling scheme for the sustainability of data centres and/or the introduction of minimum performance standards for data centres, especially new and significantly refurbished ones.

1.3.1.4 The WEEE Directive (2012/19/EU)

The objective of the waste electric and electronic equipment (WEEE) Directive is to promote the collection of waste electrical and electronic equipment and recovery, recycling, and preparation for reuse of this waste[49]. Servers are within the scope of the WEEE Directive. Due to the ever-increasing quantity of WEEE waste there are serious concerns about environmental and health risks caused by the incorrect disposal of WEEE waste due to the hazardous components contained within them. Furthermore, the collection, treatment, and recycling of WEEE is essential to improve environmental management and its contribution to circular economy and enhancing resource recycling efficiency.

The WEEE set a collection target of 65% collection by 2019 in the EU. It is estimated that only Bulgaria, Croatia and Poland have achieved that target in the EU. However, once collected, electronic waste under the scheme is estimated to be recovered/recycled at 80% rate[50].

[46] European Commission (2021). Directive of the European Parliament and of the Council on energy efficiency (recast). COM(2021) 558 final

[47] Reporting requirements on the energy performance and sustainability of data centres for the Energy Efficiency Directive, Task A and B, Viegand Maagøe and COWI, February 2023

[48] Reporting requirements on the energy performance and sustainability of data centres for the Energy Efficiency Directive, Task A and B, Viegand Maagøe and COWI, February 2023

[49] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:02012L0019-20180704

[50] Waste statistics - electrical and electronic equipment - Statistics Explained (europa.eu)

The product must meet the following three main criteria to be within the scope of 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.

Since 2019, all EEE are classified within 6 product categories set out in Annex III of the Directive. Servers and data storage products meet the criteria of the following product categories defined by the directive:

- Large equipment (any external dimension more than 50 cm);
- Small equipment (no external dimension more than 50 cm);
- Small IT and telecommunication equipment (no external dimension more than 50 cm)

Alongside the high energy use of servers and data storage products, the replacement of IT equipment every three to five years results in a large amount of post-consumer plastic waste, all with an embodied impact. Despite this, increasing the lifespan of a server is not encouraged because the operational phase energy consumption of older products heavily outweighs the standard such that extending the life of servers has a net negative impact, because of the generational improvements in the efficiency of severs. Thus, highlighting the importance of effective decommissioning and the re-using of materials found in servers. At present the end-of-life processing is inadequate due to the complexities of management routes required to effectively manage the recycling and decommissioning routes

1.3.1.5 The REACH Regulation (No 1907/2006)

The regulation of the Registration, Evaluation, Authorisation and Restriction (REACH) of chemicals purpose is to ensure high level protection of human health and the environment[51]. This is achieved through better and earlier identification of the intrinsic properties of chemical substances. The regulation places greater responsibility on industry to manage the risks of the chemical substances found within products. While also enhancing competitiveness and innovation including the development of alternative methods for the assessment of hazards.

REACH provides criteria to identify “substances of very high concern” (SVHC) included on the candidate list, which are then subject to an authorisation procedure to be used or put on the market after they have been included in a “List of Substances subject To Authorisation”.

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);

[51] https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2007:136:0003:0280:en:PDF

- 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.

1.3.1.6 The RoHS Directive (2011/65/EU)

The Restriction of Hazardous Substances (RoHS) Directive was developed by the EU in 2011[52]. It places restriction on the use of hazardous substances in electrical and electronic equipment. These restrictions include ensuring all new EEE contain 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. Of particular interest for servers is exemption 7(b). This exemption concerns *"lead in solders for servers, storage and storage array systems, network infrastructure equipment for switching, signalling, transmission, and network management for telecommunications"*[53].

The objective is to contribute to the protection of the human health and the environment, which involves the environmentally sound recovery and disposal of electrical and electronic waste. It applies to any business in the EU selling electric and electronic equipment that contains any of the 10 restricted substances.

Servers and data storage products are within the scope of the RoHS Directive because 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.

Servers and data storage products belong to Category 3 defined in Annex I. This category covers "IT and telecommunications equipment". For Ecodesign RoHS will assist in the delivery of providing information for recycling and disassemblability for products in the EU.

1.3.1.7 The Electromagnetic Compatibility Directive (EMC) (2014/30/EU)

The Electromagnetic Compatibility Directive limits the electromagnetic emission from equipment to ensure that when in use the equipment does not interfere with radio and telecommunications equipment[54]. It also ensures that there is sufficient immunity of such equipment to interference to ensure that the equipment is not disturbed by radio emissions. The directive applies to severs and data storage products, as they meet the criteria of being a finished product and system that includes electrical and electronic equipment that may generate or be affected by electromagnetic disturbance.

The main objective of the directive is to regulate the compatibility of equipment regarding the EMC. In order to meet this objective, equipment must comply with EMC requirements when places on the market and/ or taken out of service. For fixed installations such as servers, the application of good engineering practice is

[52] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32014L0030

[53] Directive 2011/65/EU of the European Parliament and of the Council of 8 June 2011 on the restriction of the use of certain hazardous substances in electrical and electronic equipmentText with EEA relevance (europa.eu)

[54] https://single-market-economy.ec.europa.eu/sectors/electrical-and-electronic-engineering-industries-eei/electromagnetic-compatibility-emc-directive_en

required, with the possibility that EU member states may impose measure in instances of non-compliance.

1.3.1.8 Low Voltage Directive (2014/35/EU)

The Low Voltage Directive (LVD) ensures that electrical equipment within certain voltage limits, reducing the risk to human health[55]. The Directive requires ensure that electrical equipment has protection against hazards that could arise within the electrical equipment itself or from external sources. This encompasses all risks including mechanical and chemical (emission of aggressive substance). The LVD covers the risks on electrical equipment operating with an input or output voltage between:

- 50 and 1000 V for alternating current
- 75 and 1500 V for direct current

Since these voltages ratings refer to the voltage of the electric input or output and not to voltages that appear inside the equipment, this Directive scope encompasses servers and data storage products.

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

Regulation (EU) 327/ 2011 sets the minimum energy efficiency requirements for industrial fans in the EU[56]. The regulation covers fans that are equipped with an electric motor with an electrical input power between 125 W and 500 kW, which is used to drive an impeller. The fan must be either an axial fan, centrifugal fan, cross flow fan or mixed flow fan.

Initially when this ecodesign Regulation came into effect it only applied to 'ventilation fans', which explicitly excluded fans used in IT. Thus, excluding all products under the scope of Lot 9. From January 2015, the second tier of regulation requirements were released. The regulation now encompasses all fans. Requiring all fans to meet the energy efficiency requirements displayed in Table 1.10 below from January 2015.

Table 1.10 Energy Efficiency Requirements for all Fans from Regulation (EU) 327/2011

Fan Types	Measurement Category (A-D)	Efficiency category (static or total)	Power rating range in P in kW	Target energy efficiency	Efficiency Grade (N)
Axial Fans	A, C	Static	0.125 ≤ P ≤ 10	$\eta_{target} = 2.74 \cdot \ln(P) - 6.33 + N$	40
			10 < P ≤ 500	$\eta_{target} = 0{,}78 \cdot \ln(P) - 1.88 + N$	

[55] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32014L0035

[56] https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1521113646166&uri=CELEX:32011R0327

Fan Types	Measurement Category (A-D)	Efficiency category (static or total)	Power rating range in P in kW	Target energy efficiency	Efficiency Grade (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	$\eta_{target} = N$	

1.3.1.10 Directives on electronic communications networks and services

The Electronic Communications Framework is a regulatory framework that applies to all transmission and services for electronic communications[57]. It originally consisted of the following EU Directives and regulations:

- the Framework Directive (2002/21/EC) - (Directive 2002/21/EC on a common regulatory framework for electronic communication networks and services);
- the Access Directive (2002/19/EC) - (Directive 2002/19/EC on access, to and interconnection of, electronic communication networks and associated facilities);
- the Authorisation Directive (2002/20/EC) - (Directive 2002/20/EC on the authorisation of electronic communication networks and services);
- the Universal Service Directive (2002/22/EC) - (Directive 2002/22/EC on universal service and users' rights relating to electronic communications networks and services);
- the E-Privacy Directive (2002/58/EC) - (Directive 2002/58/EC concerning the processing of personal data and the protection of privacy in the electronic communications sector); and,
- the BEREC Regulation - (Regulation (EC) No 1211/2009 establishing the Body of European Regulators for Electronic Communications (BEREC) and the Office).

The objective of the Framework is to harmonise the regulation of electronic communications services across the whole EU. It aims to achieve this by strengthening competition in the electronic communication section; stimulate investment and foster freedom of choice for customers.

To ensure that the Framework continues to meet these objectives and keeps up to pace with the technological development within the electronic communication sector and changing market dynamics. The Framework contains an Article with the provision for regular review.

In November 2007 the EC published a series of legislative proposals for updating the framework. These proposals were contained within the "Citizens' Rights" amending Directive and the "Better Regulation" amending Directive. The EU Regulation 1211/2009 was established called the Body of European Regulators in Electronic Communications (BEREC)[58]. The revisions that were put forward in this Framework were adopted in 2009. These revisions brought new rights and protections for consumers and citizens in the EU.

Based on the review conducted in 2009, the 2002/21/EC Framework Directive was amended by Directive 2009/240/EC[59].

In September 2016, the Directive was revised again. The EC proposed the establishment of a European Electronic Communications code (EECC) and a proposal for a Regulation on the BEREC, to ensure the EU was prepared for its digital future[60]. On this basis, the EU Directive 2018/1972 was established in

[57] Official Journal L 337/2009 (europa.eu)

[58] https://www.ofcom.org.uk/cymru/about-ofcom/international/telecoms/framework-review

[59] https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:337:0011:0036:en:PDF

[60] https://denmark.dlapiper.com/en/news/electronic-communication-networks-and-services#_ftn1

December 2018, also known as the EECC Directive[61]. This came into force in December 2020, meaning member states have to ensure that their telecommunications regulation is in accordance with the EECC Directive.

Overall, the EECC Directive maintains the objectives set in 2002, with the Directive ensuring that it keeps up to pace with technological advancement. For example, it now aims to stimulate competition and investments in high-capacity networks, especially 5G[62]. It comprises both traditional telecommunications companies and over-the-top provides such as WhatsApp and Facebook.

The Directive thus underlies regulations with respect to different aspects such as competition, affordable accessibility, or security. 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.

An additional related Directive is the Data Retention Directive 2006/24/EC[63]. It requires EU members to store citizens' telecommunications data for retained periods of not less than six months and not more than 2 years. However, in 2014 the Court of Justice of the EU decaled this Directive invalid. The court ruled that, "*despite the Directive's legitimate purpose of fighting against serious crime and the protection of public security, it does not meet the principle of proportionality and should provide more safeguards regarding the protection of fundamental rights such as respect for private life and the protection of personal data*"[64].

1.3.1.11 Other Regulations in the European Union

There are several other regulations in Europe that support the increased energy efficiency of data centres and are focused on extending the lifetime of products[65]. These include the following list of regulations with a description of what they target provided as well:

- Medium Combustion Plant Directive, 2015 – Energy efficiency
- Industrial Emissions Directive, 2010 – Energy efficiency
- European Parliament resolution on a longer lifetime for products: benefits for consumers and companies (2016/2272(INI)) – Extended lifetime.

[61] https://eur-lex.europa.eu/eli/dir/2018/1972/oj#:~:text=Directive%20(EU)%202018%2F1972,Recast)Text%20with%20EEA%20relevance.

[62] https://denmark.dlapiper.com/en/news/electronic-communication-networks-and-services#_ftn1

[63] LexUriServ.do (europa.eu)

[64] https://curia.europa.eu/jcms/upload/docs/application/pdf/2014-04/cp140054en.pdf

[65] A SITUATIONAL ANALYSIS OF A CIRCULAR ECONOMY IN THE DATA CENTRE INDUSTRY (weloop.org)

1.4 Voluntary Agreements

1.4.1 Voluntary Agreements at the European Union Level

1.4.1.1 The EU Code of Conduct on data centres

The EU Code of Conduct (CoC) for data centres is a voluntary scheme developed by the Joint Research Centre in 2008[66]. It was created to help reduce the environmental, economic and energy security impacts of data centres. The main 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 growing the understanding of the energy demand of data centres, raising awareness, and recommending energy efficient best practices the CoC hopes to reduce the energy consumption of data centres.

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 includes the typical elements of environmental management schemes. Progress reporting is required to 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 energy saving focus of the Code of Conduct covers two main areas:

A. **IT Load** - this relates to the consumption of the IT equipment in the data centre.

Facilities Load - this relates to the mechanical and electrical systems that support the IT electrical load.

These practices are relevant to both servers and data storage products.

1.4.1.2 Report on Critical Raw Materials and the Circular Economy

The EU has defined 27 materials as CRMs under the economic importance and supply risk criteria[67]. The report was produced in 2018 under the Action Plan on Circular Economy. These materials are regarded as important electrical equipment including servers with the table below highlighting in bold the CRMs relevant to servers.

[66] https://joint-research-centre.ec.europa.eu/scientific-activities-z/energy-efficiency/energy-efficiency-products/code-conduct-ict/code-conduct-energy-efficiency-data-centres_en#:~:text=The%20European%20Code%20of%20Conduct,100%20TWh%20in%20year%202020).

[67] https://op.europa.eu/en/publication-detail/-/publication/d1be1b43-e18f-11e8-b690-01aa75ed71a1

Table 1.11 List of CRMs defined by the EU in 2018[68]

Critical Raw Materials (CRMs)			
Antimony	Fluorspar	**LREEs***	Phosphorus
Baryte	Gallium	Magnesium	Scandium
Beryllium	Germanium	Natural graphite	Silicon metal
Bismuth	Hafnium	Natural rubber	Tantalum
Borate	Helium	Niobium	Tungsten
Cobalt	HREEs**	PGMs***	Vanadium
Coking coal	Indium	Phosphate rock	

**LREE = Light Rare Earth Elements (this includes neodymium), **HREEs = Heavy Rare Earth Elements, ***PGMs = Platinum Group Metals.*

Within the Phase 1 report, item j b). analyses the benefits of the information requirement for CRMs such as cobalt and neodymium. Section 2.8 of the Phase 1 report also provides the study team's recommendations. This includes keeping the current requirement for cobalt and neodymium, while also expanding the list of CRMs reported to include germanium, silicon, tantalum, gold and dysprosium. In addition, it is recommended that the indicative weight of these materials are provided, to facilitate recovery and recycling activities of these CRMs.

1.4.2 Voluntary Agreements at Member State Level

1.4.2.1 Blue Angel (Germany)

The German ecolabel Blue Angel[69] has developed an award criteria for "Servers and Data Storage Products" called DE-UZ 213. The award criteria were published in March 2022[70]. This ecolabel closely aligns with the requirements of the current Ecodesign legislation. The new Blue Angel eco-label for servers and data storage products sets a standard for ecological and energy-efficient top-of-the-range products in this area.

The Award Criteria for the Blue Angel apply to servers and data storage products that are designed for use in server rooms or data centres[71]. The basic requirements to achieve the Award Criteria for Blue Angel require the applicant must declare that the product meet the following relevant standards:

- 2019/ 424 (EU) Ecodesign for Servers and Data Storage Products
- V4.0 ENERGY STAR for Computer Servers
- V2.1 ENERGY STAR for Data Center Storage.

The energy efficiency requirements for servers in active state must be determined according to the most recent SERT version. Servers must comply with the requirements referred to in Table 1.12 to achieve the Blue Angel:

[68] https://op.europa.eu/en/publication-detail/-/publication/d1be1b43-e18f-11e8-b690-01aa75ed71a1 -p6

[69] https://www.blauer-engel.de/en

[70] Blue Angel eco-label for servers and data storage products | Federal Environment Agency (umweltbundesamt.de)

[71] DE-UZ 213-202001-en-criteria-V3.pdf

Table 1.12 SERT Requirements in Blue Angel criteria

Number of CPU Sockets	Energy Efficiency in Active state
1-socket server	$Eff_{ACTIVE} \geq 15$
2-socket server	$Eff_{ACTIVE} \geq 25$
4-socket server or more	$Eff_{ACTIVE} \geq 27$

Blue Angel looks at the following specifications to measure the energy efficiency of servers and data storage products:

- **Power supply units**: For all internal and external power supply units that are designed to convert AC voltage from mains power supply to DC voltage for supplying the power to the device, the power supply unit (PSU) efficiency and power factor must be measure the same as defined in Regulation 2019/424.
- **For data storage products** the energy efficiency of these products must be determined in accordance with SNIA Emerald Power Efficiency Measurement Specification.
- **Monitoring data interface:** server and data storage products must provide the following data in real time:
  - power consumption (W),
  - inlet temperature of cooling medium (e.g. air/water) (°C)
  - data transfer via the network interface (Mbit/s)
  - for servers: Load state for every logical CPU (%)

Blue Angel looks at the following specifications to assess material requirements of servers and data storage products. This includes restricting the contents of certain substances within the plastic used in the housing and housing parts. The properties of these components include:

- Substances which are identified as particularly alarming under the European Chemicals Regulation REACH (1907/2006/EC) and which have been incorporated into the list drawn up in accordance with Article 59, Paragraph 1 of the REACH Regulation#
- Substances that according to the CLP Regulation have been classified in the following hazard categories or which meet the criteria for such classification
  - carcinogenic in categories Carc. 1A or Carc. 1B
  - germ cell mutagenic in categories Muta. 1A or Muta. 1B
  - reprotoxic (teratogenic) in categories Repr. 1A or Repr. 1B

In addition, there are restrictions on halogenated polymers in the housing and housing parts.

Other requirements that are involved in the Blue Angel criteria include:

- Product Durability
  - Availability of spare parts
  - Resetting capability for reuse
- Product documentation
- Applicants and parties involved
- Use of the Environmental Label

1.4.2.2 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.

1.4.2.3 Triple E programme (Ireland)

The Sustainable Energy Authority of Ireland (SEAI) is responsible for the list of energy equipment entitled Triple E34[72]. Triple E sets the 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. The Triple E includes 52 technologies containing nearly 31,000 products on the register.

Concerning the Lot 9 scope, this Triple E list covers Rack Mounted Servers, Enterprise Storage Equipment, Blade Servers and ICT communication equipment. The Triple E programme is based on the existing Accelerated Capital Allowance (ACA) list of eligible products and eligibility criteria. The ACA is a tax incentive to encourage enterprises to invest in more energy efficiency technologies. It allows purchasers to write off 100% of the purchase value of the qualifying equipment against their profit for the year. The ACA sets the following eligibility criteria (which must be all met) for these technologies.

Rack Mounted Servers[73]

Table 1.13 ACA Rack Mounted Servers Eligibility Criteria

No	Condition	Supporting Documentation Requirements
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 Table 1.14	Test report completed according to the 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.

[72] Categories & Criteria | Triple E Register for Products | SEAI

[73] Enhanced Capital Allowances (seai.ie)

Table 1.14 Minimum server performance to power ratios

Server Application	Minimum Ratio
Performance at low utilisation of less than or equal to 30%.	> 700
Performance at moderate utilisation 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.

Enterprise Storage Equipment[74]

Enterprise storage equipment is considered to include one or both of the following: solid state drive storage and disk drive storage.

Table 1.15 ACA Enterprise Storage Equipment's general Eligibility Criteria

No	Condition	Supporting Documentation Requirements
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)	

In addition, a criteria has been developed at storage level. In order to meet this criteria Solid State Storage Drives must:

- Be designed to form part of an enterprise storage solution and have a minimum storage capacity of 120 Gb.

Disk Drive Storage must meet the following eligibility requirement:

- When idle be capable of intelligent power down and drive spin down or slow spin (MAID 2/IPM)
- 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

[74] https://www.seai.ie/publications/Enterprise_storage.pdf

***Blade Servers*[75]**

Table 1.16 ACA Blade Server Eligibility Criteria

No	Condition	Supporting Documentation Requirements
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 Table 1.17	Test report completed according to the 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 1.17 Minimum server performance to power ratios

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

***ICT Communications Equipment*[76]**

ICT Communications Equipment is considered to include the following: network routers, network switches, network firewalls and optical transmission equipment. Therefore, it does not fall within the scope of Lot 9.

1.5 Third Country Legislation & Voluntary Measures

1.5.1.1 ENERGY STAR® programme (U.S)

Launched in 1992, ENERGY STAR was originally a voluntary labelling program controlled by the U.S EPA and the U.S Department of Energy which supported energy efficiency products and practices. The blue ENERGY STAR label indicates that products comply with the performance criteria set

[75] https://www.seai.ie/publications/Blade_servers.pdf

[76] https://www.seai.ie/publications/ICT_Communications.pdf

by ENERGY STAR. It provides simple, credible, and unbiased information that consumers and businesses rely on to make informed decisions[77].

In 2001, the EU signed an Agreement with the US EPA to introduce the ENERGY STAR in Europe for IT and office equipment. This allowed potential partners in the European Union to sign up through the European Commission, who were responsible for the EU ENERGY STAR Programme. However, in 2018 the agreement between the U.S and the EU lapsed. This meant that the ENERGY STAR logo cannot be used on any EU products apart from those in stock already[78].

There are separate ENERGY STAR requirements documents for server and storage systems. ENERGY STAR server V4 specifies submission of SERT data, among other criteria, for the certification of server systems. The Data Center Storage requirements were published on March 15th of 2021 and are titled "Version 2.1 ENERGY STAR Data Center Storage Specification.

Version 4.0 ENERGY STAR® specification for computer servers was published in April 2023 and will take effect from January 12, 2024 and aims to differentiate energy efficient computer servers in order to support a more environmental-oriented procurement of products. Version 4.0 is a considerable enhancement of the previous 3 versions (2009, 2013, 2018) and reflects the deep analysis and development work that has been done by the U.S. Environmental Protection Agency (EPA). 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 Regulation (EU) 2019/424 study.

The current ENERGY STAR requirements for servers, storage systems and networking equipment are listed below. These include:

- Version 4.0 ENERGY STAR® specification for computer servers was published in April 2023 and will take effect from January 12, 2024.
- Version 2.1 ENERGY STAR Data Center Storage specification was published on March 15th of 2021.
- Version 1.1 ENERGY STAR® specification for Large Network Equipment[79] took effect on March 1, 2016.

1.5.1.2 Specification for Version 4.0 Computer Servers

The specification for computers servers covers: Blade, Multi-node, Rack-mounted, or Pedestal form factor computer servers with no more than four processor sockets in the computer server. The qualifications criteria include:

- Power supply efficiency criteria (Table 1.18) and power supply factor criteria (Table 1.19) for all power supply units. These units must meet the following

[77] https://www.energystar.gov/about

[78] https://www.greenbiz.com/article/scrapping-energy-star-labels-leaves-vacuum-europe

[79] ENERGY STAR LNE Final Version 1.1 Specification

the requirements when tested using the *Generalised Internal Power Supply Efficiency Test Protocol, Rev. 6.7*[80].

Table 1.18 ENERGY STAR Efficiency Requirements for PSUs

Power Supply Type	Rated Output Power (W)	10% Load	20% Load	50% Load	100% Load
Multi-output (Ac-Dc)	750 watts or greater	N/A	90%	92%	89%
Multi-output (Ac-Dc)	Less than 750 watts	N/A	87%	90%	87%
Single-output (Ac-Dc)	750 watts or greater	90%	94%	96%	91%
Single-output (Ac-Dc)	Less than 750 watts	83%	90%	94%	91%

Table 1.19 ENERGY STAR Power Factor Requirements for PSUs

Power Supply Type	Rated Output Power (W)	10% Load	20% Load	50% Load	100% Load
Ac-Dc Multi-output	All Output Ratings	N/A	0.80	0.90	0.95
Ac-Dc Single-output	Output Rating ≤ 500 W	N/A	0.80	0.95	0.95
	Output Rating ≥ 500 W and Output Rating ≤ 1000 W	0.65	0.80	0.95	0.95
	Output Rating ≥ 1000 W	0.80	0.90	0.95	0.95

- Power Management Requirements: Computers server must offer processor power management that is enabled by default in the BIOS and/or through management controller, service processor and/or the operating system shipped with the computer server.
- Supervisor Power Management: products which offer a pre-installed supervisor system must offer supervisor system power management that is enabled by default.
- Power Management Reporting: all power management techniques must be detailed in certification submission.
- Blade and Multi-node Thermal Management and Monitoring: real-time chassis or blade/node inlet temperature monitoring and fan speed management capability that is enabled by default.
- Blade and Multi-node Server Shipping Documentation: one that is shipped to a customer independent of the chassis must be accompanies with documentation to inform the customer that the blade or multi-node server is ENERGY STAR qualified only if installed in chassis meeting requirements set out in Section 3.4.1 of V4 Computers Servers specification.

[80] http://www.efficientpowersupplies.org/

- Active State Efficiency Criteria: Products must be submitted with the following information disclosed in full in context of the complete Active State efficiency rating test report:
  - Final SERT rating tool results, which include the result files and all result charts; and
  - Intermediate SERT rating tool results over the entire test run, including the results-details files

Calculate Active State efficiency requirements shall be greater than or equal to the minimum Active State efficiency thresholds listed below in Table 1.20.

Table 1.20 Active State Efficiency Thresholds for all non-SHS Computer Servers

Product Type	Minimum Eff_{ACTIVE}
One Installed Processor	
Rack	26.4
Tower	24.4
Resilient	6.6
Two Installed Processor	
Rack	30.4
Tower	26.5
Blade or Multi-Node	29.1
Resilient	6.0
Greater Than Two Installed Processors	
Rack	31.9
Blade or Multi-Node	26.8

- Idle State Efficiency Criteria: Idle State power shall be measured and reported for all computer server types. In addition, for blade and multi-node products, $P_{TOT\_BLADE\_SYS}$ and $P_{TOT\_NODE\_SYS}$ shall also be reported respectively. Calculation of single blade power shall be done by:

$$P_{NODE} = \frac{P_{TOT\_BLADE\_SYS}}{N_{INST\_BLADE\_SRV}}$$

Where:

- P_{NODE} - is the per-Node Server Power.
- $P_{TOT\_NODE\_SYS}$ - is total measured power of the Multi-Node Server,
- $N_{INST\_NODE\_SRV}$ - is the number of installed Multi-Node Servers in the tested Multi-Node Chassis.

1.5.1.3 Specification for Version 2.1 Date Center Storage

The ENERGY STAR defines a for data centre storage product as one a “a fully-functional storage system that supplies data storage services to clients and devices attached directly or through a network” the full definition can be found in Definitions in v2.1 ENERGY STAR® specification for data centre storage equipment. This type of data centre storage systems fits within the EU Lot 9 scope. The qualification criteria for data centre storage products looks at power supply requirements, energy efficiency feature requirements and information requirements.

Power supply units (PSU) which are used in storage products are able to qualify for ENERGY STAR if they meet the following requirements when tested using EPRI Generalised Internal Power Supply Efficiency Test Protocol.

The efficiency and power factor in primary embedded equipment requirement include: embedded PSUs that power components of the storage product, including controllers and drawers, must meet the requirements set forth in Table 1.21 and Table 1.22.

Table 1.21 Efficiency Requirements for PSUs

Power Supply Type	Rated Power Output	20% Load	50% Load	100% Load
Multi-output (Ac-Dc)	All Output Levels	88%	92%	88%
Single-output (Ac-Dc)	All Output Levels	90%	94%	91%

Table 1.22 Power Factor Requirements for PSUs

PSU Type	Rated Power Output	20% Load	50% Load	100% Load
Single and Multi-Output PSU	All Output Levels	0.80	0.90	0.95

To certify the optimal configuration point submitted for a block I/O storage product or storage product family must meet the following active state requirements in Table 1.23.

Table 1.23 Active State Requirements for Block I/O Storage Products

Workload Type	Specific Workload Test	Minimum Performance/ Watt Ratio	Applicable Units of Ratio
Transaction	Hot Band	28.0	IOPS/watt
Streaming	Sequential Read	2.3	MiBS/watt
Streaming	Sequential Write	1.5	MiBS/watt

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 listed in Table 1.24 and in quantities great than or equal to those listed in Table 1.25.

Table 1.24 Recognised COM features.

Feature	Verification Requirements
COM: Thin Provisioning	SNIA Verification test
COM: Data Deduplication	SNIA Verification test
COM: Compression	SNIA Verification test
COM: Delta Snapshots	SNIA Verification test

Table 1.25 COM Requirements for Disk Set and NVSS Set Access Online Systems

Storage Product Category	Minimum number of COMS required to be made available
Online 2	1
Online 3	2
Online 4	3

Included within the data centre ENERGY STAR specification is an extensive set of information requirements which covers the following:

- Active and idle state efficiency disclosure: all products are requires to state the test results based on workloads listed in section 3.5 of Version 2.1 Data Center Storage specification[81]. There are 6 different workloads for block I/O configurations and 5 different workloads for file I/O configurations.
- Workload weighting requirements: the weighted percentages presented according to the Optical workload ratings provided in section 3.5.2 of Version 2.1 Data Center Storage specification.
- Testing data requirements for all scale-up storage products must be submitted for certification.
- Testing data requirements for all scale-out storage products must be submitted for certification.

1.5.1.4 Specification for Version 2.1 Large Network Equipment

This specification applies to large network equipment which is mountable in a standard equipment rack, supports network management protocols and contains either more than 11 physical network port or a total aggregate port throughput greater than 12 Gb/s[82].

The qualification criteria includes power supply requirements, energy efficiency feature requirements and active state efficiency.

The Power Supply Requirements include:

- Power supply efficiency criteria: power supplies used in products that are eligible for the specification must meet the requirements set out in Table 1.26.

Table 1.26 Efficiency Requirements for PSUs

PSU Type	Rated Power Output	10% Load	20% Load	50% Load	100% Load
Multi-output	All Output Levels	N/A	85%	88%	85%
Single-output	All Output Levels	80%	88%	92%	88%

- Power supply power factor criteria: Ac-Dc power supplies used in the large networking equipment must meet the requirements set out in Table 1.27.
- **Fixed large networking** equipment and **modular large networking** equipment should meet the all the Ac-Dc PSUs requirements set out in Table

[81] ENERGY STAR Data Center Storage Version 2.1 Final Specification -p10

[82] ENERGY STAR LNE Final Version 1.1 Specification

1.27 prior to shipment under all loading conditions when output power is greater than or equal to 75 Watts.

Table 1.27 Power factor requirements for Ac-Dc PSUs

PSU Type	Rated Power Output	10% Load	20% Load	50% Load	100% Load
Multi-output	All Output Levels	N/A	0.80	0.90	0.95
Single output	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

The energy efficiency feature requirements for large networking equipment requires these products to have the following features:

- Remote port administration
- Adaptive active cooling
- Energy efficient ethernet

In addition, ENERGY STAR has looked into providing a set of active state efficiency criteria for all large networking equipment. ENERGY STAR are current pursuing an approach to encourage further testing of the energy efficiency of large networking equipment. Currently ENERGY STAR requests that active state data is reporting in order for it gain certification.

1.5.1.5 The Certified Energy Efficient Data Centre Award – BCS (UK)

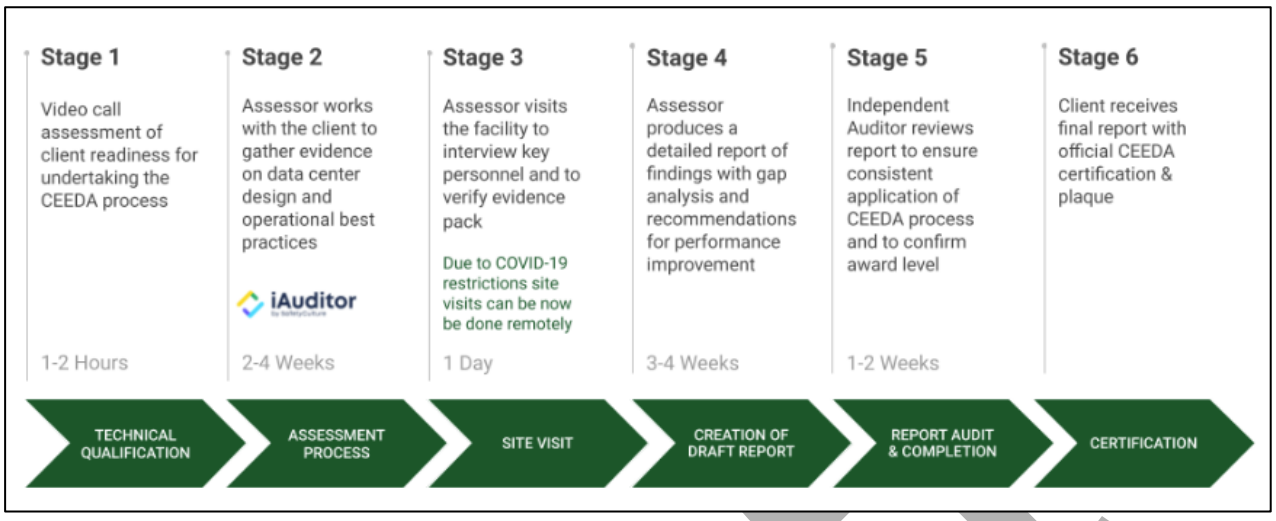
The Certified Energy Efficient Data Centre Award (CEEDA) is an assessment and certification program which is ratified by the BCS (the Chartered Institute for IT)[83]. CEEDA is an independently evaluated global certification program designed to recognise the implementation of energy efficiency best practices in data centres.

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. The framework is base on a combination of standards from: ASHRAE, ENERGY STAR, ETSI, ISO, European Code of Conduct and the Green Grid metrics. 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.

The CEEDA assessment and certification process is summarised below by the diagram shown in Figure 1.2.

[83] https://www.datacenterdynamics.com/en/ceeda/

Figure 1.2 The 6-stage process from CEEDA Certification[84]



The certification period is two years' 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 note any significant changes in the facility, services provisioned, operational management or IT infrastructure.

1.5.1.6 UK Data Centres Climate Change Agreement

The UK's Data Centre Climate Change Agreement was started in 2015, with the aim to encourage energy efficiency at the system level[85]. Recently the agreement was revised in February 2022. As of 2020 it covers 129 facilities from 57 target units, representing 42 companies[86]. The total energy use by these facilities was 2.573 TWh p/a, all these facilities have a PUE of < 1.80. Being an approved data centre means exempts the facilities from paying an extra tax on energy use. In exchange the operators have to commit to increase energy efficiency of the facilities.

1.5.1.7 EPEAT

The Electronic Product Environmental Assessment Tool (EPEAT)[87] is a ISO 14021 Type-1 ecolabel for technology products, managed by the Global Electronics Council (GEC). It 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 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.

Products must meet certain requirements and optional EPEAT criteria to be considered EPEAT-registered. It rates products Bronze, Silver or Gold, based on how many of the optional criteria they meet (while meeting all required criteria). The Standard is a environmental leadership and corporate responsibility standard.

[84] https://www.datacenterdynamics.com/en/ceeda/about-ceeda/

[85] https://www.gov.uk/government/publications/climate-change-umbrella-agreement-for-the-data-centre-sector

[86] https://ukerc.ac.uk/news/uk-data-centres-carbon-neutral-by-2030

[87] https://www.epeat.net/

Therefore, approximately 25-35% of the products on the market are expected to qualify to the Bronze level and even fewer for Silver and Gold. Products registered as EPEAT products are subject to unannounced audits at any time, with results publicly reported. Requirements of the ENERGY STAR® programme are considered in the criteria. The EPEAT certified products are continuously monitored with last round of monitoring for servers and network equipment finishing in March 2023[88].

The EPEAT register currently includes ratings for Servers[89] (published in 2021) and Network equipment[90] (published in 2019). The EPEAT criteria cover the 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.

1.5.1.8 80 PLUS certification

The 80 PLUS programme is a voluntary certification programme launched by Ecos Consulting (now Ecova) in 2004, to promote energy efficiency technology products[91]. The 80 PLUS performance specification requires power supplies in computers and servers to be 80% or greater energy efficient at 10%, 20%, 50% and 100% of rated load. Additionally, It requires products to have a true power factor of greater than 0.9 at with a true power factor of 0.9 or greater 10%, 20%, 50% and 100% of rated load. This makes an 80 PLUS certified power supply substantially more efficient than typical power supplies. The programme differentiates further levels of high efficiency, through the Bronze, Silver, Gold, Platinum and Titanium awards.

Table 1.28 Efficiency Level Requirements of the 80 Plus Programme

80 Plus Certification	115V Internal Non-Redundant				115V Industrial			
% 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%	-			
80 PLUS Silver	-	85%	88% PFC ≥ 0.90	85%	80%	85% PFC ≥ 0.90	88%	85%
80 PLUS Gold	-	87%	90% PFC ≥ 0.90	87%	82%	87% PFC ≥ 0.90	90%	87%

[88] https://www.epeat.net/about-epeat#accessing-epeat-criteria

[89] https://globalelectronicscouncil.org/wp-content/uploads/NSF-426-2019.pdf

[90] https://globalelectronicscouncil.org/wp-content/uploads/EPEAT-Network-Equipment-Criteria_FINAL-April-2021.pdf

[91] https://www.clearesult.com/80plus/

80 Plus Certification	115V Internal Non-Redundant				115V Industrial			
% of Rated Load	10%	20%	50%	100%	10%	20%	50%	100%
80 PLUS Platinum	-	90%	92% PFC ≥ 0.95	89%	85%	90% PFC ≥ 0.95	92%	90%
80 PLUS Titanium	90%	92% PFC ≥ 0.95	94%	90%	-			

In addition, to the requirements displayed in Table 1.28 there are specific 80 Plus requirements for the following types of servers:

- 230V EU Internal Non-Redundant
- 230V EU Internal Redundant
- 380V DC Internal Redundant

These can be found on the 80 Plus website (Program Details | CLEAResult)

1.5.1.9 Top Runner Program in Japan

The Japanese Top Runner Program is managed by the Energy Conservation Center, Japan. It is a mandatory policy instrument that targets the energy consumption during the use phase through market transformation. The idea is that the product with the highest energy efficiency sets the standard and all other appliances are required to reach that level within an agreed time scale[92]. 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 aren't met the government will propose recommendations, which can be enforced in the event of further non-compliance.

There is currently only one Top Runner standard that fits within the EU Lot 9 scope. That is the standard for Computers & Magnetic Disk Units, with the most recent version of this standard dating back to 2009[93]. The standard provides the following definition for a computer server: ""*Server computer" refers 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 the network"*[94].

The following products are excluded from the legislation for computers in Top Runner are:

- Products with a composite theoretical performance of 200,000 mega calculations or more p/s.
- Products capable of performing calculations using arithmetic processing unit composed of more than 256 processors.
- Products with more than 512 or more I/O signal transmission lines

[92] https://www.asiaeec-col.eccj.or.jp/

[93] https://www.eccj.or.jp/top_runner/pdf/tr_computers_magneticdiscunits_dec2009.pdf

[94] https://www.eccj.or.jp/top_runner/pdf/tr_computers_magneticdiscunits_dec2009.pdf - p5

- Products with composite theoretical performance of less than 100 mega calculations per second.
- Products powered exclusively by an internal battery during use and never operate based on a power supply from a power line and do not contain a HDD.

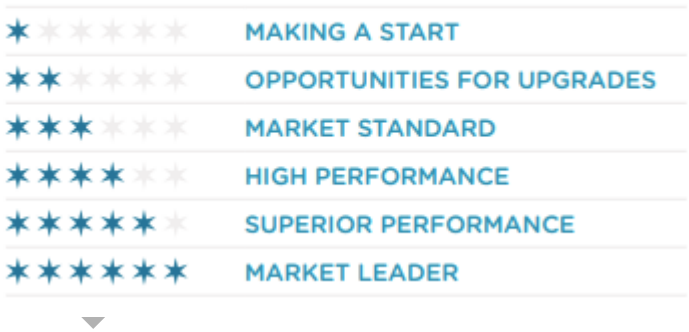
In 2019, Japan's Ministry of Economy, Trade and Industry (METI) indicated that they had accepted a change in the computer server energy conservation standard[95]. This update to the updated SERT suite version 2 now demonstrates the performance per watt of computer servers. This will further promote energy conservation by setting energy conservation standards based on energy consumption efficiency rates taking into account changing capabilities and environments. Previously the calculation method for efficiency was derived from a calculation based solely on the electricity consumption and performance of CPUs.

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 program has been looking into updating a new version of this standard however, it is not clear when.

1.5.1.10 The National Australian Built Environment System (NABERS) for Data Centres

The NABERS was developed to ensure that data centres operate efficient, assess where power is being consumed and to ensure that cooling capacity is correctly aligned to IT loads[96]. It aims to provide an indication of the operational energy efficiency and environmental impact of data centres in Australis. It scores data centres from one to six stars (see Figure 1.3) based on its power usage effectiveness (PUE) and is based on the facilities operational data, not design. With rating then used to help identify areas for operational improvement and cost savings, as well as to promote environmental credentials[97].

Figure 1.3 NABERS Star Rating Guide[98]



There are three different levels of rating streams these include:

- **IT Equipment** – This rating is for organisations who own or manage their IT equipment and don't control building amen such as A/C, lighting and security.

[95] New Energy Conservation Standards for Electronic Computers Formulated (meti.go.jp)

[96] https://www.energy.gov.au/business/equipment-and-technology-guides/data-centres

[97] https://www.nabers.gov.au/ratings/spaces-we-rate/data-centres

[98] Fact Sheet - Data Centres.pdf (nabers.gov.au)

- **Infrastructure** – This rating is for data centre owners and managers. It allows the self-determination of a facilities energy efficiency in supplying infrastructure to IT
- **Whole Facility** – This rating combines IT equipment and infrastructure tools. This is for organisations that managed and occupy their data centre or where internal metering arrangement don't permit separate IT equipment or infrastructure ratings.

1.5.1.11 Voluntary CQC Certification, China

The CQC certification is a voluntary product certification scheme implemented by the Chinese Environmental United Certification Centre[99]. Products that do not fall under scope of the mandatory China Compulsory Certification (CCC) can obtain a CQC certification on a voluntary basis. The aim is to provide an indication to the end user in China that the product meets the Chinese quality standards and corresponding GB standards.

The scheme defines rules and criteria for servers (CQC3135-2011)[100]. 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

1.5.1.12 The Swiss Datacentre Efficiency Association (SDEA)

The Swiss Datacenter Efficiency Association (SDEA) provides a measure of a datacentre's operational efficiency and environmental impact. It not only considers traditional elements such as PUE, but it also evaluates the IT infrastructure utilisation and heat recycling aspects of the datacentre. This Full-Stack Efficiency approach provides a comprehensive and quantifiable evaluation of operational efficiency and environmental impact[101]. The SDEA provide each datacentre that applies with a label to demonstrate their efficiency.

The baseline label encapsulates a datacentre's efficiency journey from energy intake to heat recycling and captures datacentre and IT infrastructure as well as workload utilisation and technology excellence. The premium variant of the label measure, the datacentres carbon emissions, factoring in emissions from imported energy sources. There are three grades which decipher how the datacentre performs, Gold, Silver and Bronze. The label thresholds are displayed below in Figure 1.4.

[99] https://www.china-certification.com/en/china-cqc-certification-ccap-certification/

[100] https://www.cqc.com.cn/www/chinese/c/2011-08-02/492857.shtml

[101] https://www.sdea.ch/

Figure 1.4 Label thresholds from the SDEA[102]

[102] https://www.sdea.ch/certification

Annex 1

A1.1 Energy Star Definitions

A1.1.1 Version 4.0 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 centers 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:

- is marketed and sold as a Computer Server;
- is designed for and listed as supporting one or more computer server operating systems (OS) and/or hypervisors;
- is targeted to run user-installed applications typically, but not exclusively, enterprise in nature;
- 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).
- is packaged and sold with one or more ac-dc or dc-dc power supplies; and
- is designed such that all processors have access to shared system memory and are visible to a single OS or hypervisor

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 certification under this specification, a Resilient Server shall have the following characteristics:

- Processor RAS: The processor must have capabilities to detect, correct, and contain data errors, as described by all of the following:
  - Error recovery by means of instruction retry for certain processor faults;
  - Error detection on L1 caches, directories, and address translation buffers using parity protection; and
  - Single bit error correction (or better) on caches that can contain modified data. Corrected data is delivered to the recipient as part of the request completion.
- System Recovery & Resiliency: No fewer than six of the following characteristics shall be present in the server:
  - Error recovery and containment by means of (a) data poison indication (tagging) and propagation which includes mechanism to notify the OS or hypervisor to contain the error, thereby reducing the need for system reboots and (b) containment of address/command errors by preventing possibly contaminated data from being committed to permanent storage;
  - The processor technology is designed to provide additional capability and functionality without additional chipsets, enabling it to be designed into systems with four or more processor sockets;
  - Memory Mirroring: A portion of available memory can be proactively partitioned such that a duplicate set may be utilized upon non-correctable memory errors. This can be implemented at the granularity of DIMMs or logical memory blocks;

  - Memory Sparing: A portion of available memory may be pre-allocated or re-purposed to a spare function such that data may be migrated to the spare upon a perceived impending failure;
  - Support for making additional resources available without the need for a system restart. This may be achieved either by processor (cores, memory, I/O) on-lining support, or by dynamic allocation/deallocation or processor cores, memory, and I/O to a partition;
  - Support of redundant I/O devices (storage controllers, networking controllers);
  - Has I/O adapters or storage devices that are hot-swappable;
  - Can identify failing processor-to-processor lane(s) and dynamically reduce the width of the link in order to use only non-failing lanes or provide a spare lane for failover without disruption;
  - Capability to partition the system such that it enables running instances of the OS or hypervisor in separate partitions. Partition isolation is enforced by the platform and/or hypervisor and each partition is capable of independently booting; or
  - Uses memory buffers for connection of higher speed processor-memory links to DIMMs attached to lower speed DDR channels. Memory buffer can be a separate, standalone buffer chip which is integrated on the system board or integrated on custom-built memory cards.

- Power Supply RAS: All power supplies installed or shipped with the server shall be redundant and concurrently maintainable. The redundant and repairable components may also be housed within a single physical power supply, but must be repairable without requiring the system to be powered down. Support must be present to operate the system in a degraded mode.
- Thermal and Cooling RAS: All active cooling components shall be redundant and concurrently maintainable. The processor complex must have mechanisms to allow it to be throttled under thermal emergencies. Support must be present to operate the system in a degraded mode when thermal emergencies are detected in the system components.

A1.1.2 SPECpower Overview

Following on from Section 1.2.2.1, please see below the overview for SPECpower.

The Power committee developed SPECpower_ssj2008, the first benchmark for evaluating the power and performance characteristics of single server and multi-node servers[103]. With power efficiency becoming a high-priority issues for the IT industry, computer manufacturers and governments due to increasing energy consumption. The SPECpower benchmark was designed to address these rising concerns across industry and governments.

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, the benchmark provides a means to measure power (at the AC input) in conjunction with a performance metric[104]. It measures the energy efficiency of volume server class computers by evaluating both the power and performance characteristics of the System Under Test (SUT)[105]. This contributes to the increased efficiency of data centres by considering power characteristics and other selection criteria. 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

[103] https://www.spec.org/power_ssj2008/

[104] https://www.spec.org/power_ssj2008/

[105] Benchmark Overview SPECpower_ssj2008 (fujitsu.com)

collection, threads and some aspects of the operating system[106]. The benchmark runs on a wide variety of operating systems and hardware architectures and should not require extensive client or storage infrastructure.

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

[106] https://www.spec.org/power_ssj2008/