ECODESIGN TECHNICAL ASSISTANCE STUDY FOR THE PRODUCT GROUP “DG ENTR LOT 9”

Standardised Test Method Gap Analysis on Enterprise Servers and Enterprise Data Storage Interim Report

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1 Introduction

The Ecodesign Technical Assistance Study on Standards for Enterprise Servers and Data Storage (DG ENTR Lot 9) is a European Commission study, led by Intertek.

The study aims to provide technical assistance to support standardisation-related tasks for equipment under the scope of the DG ENTR Lot 9 (namely enterprise servers and data storage). The focus of this project is upon the provision of technical assistance to facilitate the establishment of the foundation standards (or, when necessary, transitional methods) that will be necessary for implementing measures addressing Lot 9 products, should the Commission decide to proceed with such measures. Standardised approaches to measurement are necessary in order that manufacturers can assess their compliance with any requirements that may be defined in regulation, and so that national bodies can assess market compliance of products on their markets.

The study methodology centres upon an assessment of the need for standards – identifying parameters and existing standards and identifying gaps. The priority is to facilitate work towards:

- A robust, durable standardised method for measuring the energy efficiency of servers (especially rack servers but also blade servers)
- A robust, durable standardised method for measuring the energy efficiency of data storage devices

The study includes interaction with the relevant standardisation processes and a consideration of how metrics might be built upon the identified standards. This second component includes testing of rating tools and measurement approaches in order to provide recommendations to the standardisation processes underway to ensure repeatability, consistency and robustness.

This document presents the results of an initial gap analysis into standardised test methods for measurement and calculation, which could be used to support the implementation of a potential future EU Ecodesign Regulation on servers and storage equipment. It considers the parameters that could be described in Annex II of a Regulation, explores how these would need to be supported by standardised test methods and considers the potential basis for metrics.

2 Policy Context

2.1 European initiatives

The Ecodesign Directive is a key European Union (EU) sustainability policy, addressing both competitiveness and sustainable development in line with Europe’s 2020 Strategy. The directive aims to improve upon environmental performance of energy related products across the EU, by establishing a framework to set ecodesign requirements or to encourage manufacturer voluntary agreements.

DG Growth and DG Energy are responsible for the Ecodesign directive. The first step toward an ecodesign regulation is the identification of a product on the ecodesign working plan - an indicative list of product groups that are considered as priorities for

the adoption of implementing measures. This is followed by a preparatory study which explores the options to improve the environmental performance of the product and provides the necessary information to prepare for the next phases in the policy process such as the impact assessment, the consultation forum, and the possible draft implementing measures or voluntary agreement.

The Working Plan for 2012-2014 identified Enterprise servers and data storage as a key product area to be addressed, with initial estimated potential savings of 135 PJ/year as of 2030. As a result, the preparatory study "DG ENTR Lot 9" covering enterprise servers, data storage and ancillary equipment was initiated.

At the time of writing, the Lot 9 preparatory study has progressed to the point of publishing a draft Task 7 report. The study was completed in September 2015, and the publication of the final report will follow within November 2015.

The Commission has already regulated some aspects of servers through the Commission Regulation (EU) No 617/2013 of 26 June 2013, implementing Directive 2009/125/EC of the European Parliament and of the Council with regard to ecodesign requirements for computers and computer servers. This regulation only addresses efficiency requirements for power supply units in a sub-set of servers. The Commission is due to review the Ecodesign Regulation on computers towards the end of 2015.

Other overarching EU policy initiatives of relevance not addressed in further in this study include:

- The Waste Electrical and Electronic Equipment (WEEE) Directive (2012/19/EU)
- The REACH Regulation (No 1907/2006)
- The Restriction of Hazardous Substances (RoHS) Directive (2011/65/EU)
- The Electromagnetic Compatibility Directive (2004/108/EC)
- Low Voltage Directive (2006/95/EC)
- Regulation (EU) No 1275/2008 on standby and off mode electric power consumption of electrical and electronic household and office equipment

2.2 International and industry initiatives

International voluntary policy initiatives which have begun to establish measurement methods and standards include:

The voluntary ENERGY STAR® label (United States (US) Environmental Protection Agency (EPA) and European Commission): Addresses data centre products such as enterprise servers, data storage and large network equipment. ENERGY STAR programme requirements for servers v2.0 was implemented in the US on the 16th December 2013. The US EPA is currently starting to develop the v3.0 specification - primarily concentrating on improvements to the SERT rating tool and new criteria for data storage are in development.

ENERGY STAR has previously developed a testing methodology and performance standard for server idle power. This is limited to 1-2 socket servers which covers the largest sector of the server market.

The EU Code of Conduct for Data Centres (European Commission Joint Research Centre): Takes a holistic approach to the operation and selection of equipment for use in data centres, providing a means of outlining energy efficient best practice and putting in place voluntary targets for signatories to meet. The Code of Conduct does not specify test methods for IT equipment, but encourages selection tailored to the specific data centre application, and references ENERGY STAR for Servers as a possible solution for procuring efficient IT equipment.

Blue Angel (The Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety): This eco-label claims to provide the demand side (public sector or industry) with a reliable means of including ecological criteria in procurement contracts for external data centre services. The Blue Angel eco-label for data centre services was implemented in July 2012 and includes both technical and information disclosure requirements, as well as recommendations on further energy saving opportunities.

Triple E programme (The Sustainable Energy Authority of Ireland): The Triple E is a searchable listing of energy efficient equipment that meet minimum criteria listed under the programme. The programme covers a range of server and storage products used in data centres with the most recent specifications developed in 2010.

Certified Energy Efficient Data Centre Award (CEEDA) (Datacenter Dynamics Ltd): CEEDA provides an audited and certified assessment of the implementation of energy efficiency best practices within a data centre. It delivers an operational and deployment roadmap for further improving performance and enables demonstration of conformance to a benchmark. Most of the current best practices are derived from the European Code of Conduct for Data Centres, with metrics included developed by The Green Grid, which depending on the assessment type may include: Power usage effectiveness (PUE); carbon usage effectiveness (CUE); water usage effectiveness (WUE) and energy reuse effectiveness (ERE).

80 PLUS certification (Ecova): 80 PLUS is an electric utility-funded incentive programme to integrate more energy-efficient power supplies into desktop computers and servers. The performance specification requires power supplies of 80% or greater energy-efficiency.

Top Runner Program in Japan (Energy Conservation Center Japan): The Top Runner Programme was introduced in 1999 to reduce energy consumption in Japan. The programme includes energy efficiency requirements for a range of different products types including servers. The range of servers covered is very wide, including mainframes, blade and 1-4 socket rack servers. The same metric is used across all computing products and is based on theoretical maximum central processing Unit (CPU) performance (CTP), idle power and standby power. It does not consider Random Access Memory (RAM) or hard drives.

These relatively recent policies continue to mature as knowledge builds and industry responds to demand for greater efficiency. Almost all of the efforts to date have been focussed on energy efficiency as it is considered the highest lifecycle impact of these products, which are under continuous use in relatively high power consumption modes over their entire lifetime. This means that other environmental parameters

such as hazardous chemical, and recyclability have mostly gone unaddressed. However, it should be noted that the NSF International (US Green Electronics Council) and Institute of Electrical and Electronics Engineers (IEEE) standards are seeking to address some of the wider environmental cycle impacts associated with servers in order to feed into an EPEAT specification for green procurement.

In addition, industry associations and partnerships such as The Green Grid work to encourage greater efficiency within data centres and provide a means of recognition for those who achieve the specified levels.

3 Standardisation context

3.1 Basic principles

The concept of a standard is well established. Recognised definitions of standards are shown below:

ISO website: A standard is a document, established by a consensus of subject matter experts and approved by a recognised body that provides guidance on the design, use or performance of materials, products, processes, services, systems or persons.
Formal definition of a Standard (ISO/IEC Guide 2): Document, established by consensus and approved by a recognised body, that provides, for common and repeated use, rules, guidelines or characteristics for activities or their results, aimed at the achievement of the optimum degree of order in a given context.
Definition from regulation 1025/2012 on standardisation: 'standard' means a technical specification, adopted by a recognised standardisation body, for repeated or continuous application, with which compliance is not compulsory, and which is one of the following:
(a) 'international standard' means a standard adopted by an international standardisation body;
(b) 'European standard' means a standard adopted by a European standardisation organisation;
(c) 'harmonised standard' means a European standard adopted on the basis of a request made by the Commission for the application of Union harmonisation legislation;
(d) 'national standard' means a standard adopted by a national standardisation body;

Standards are not the same as regulations. They are voluntary but are often necessary to support the implementation of regulation in that they describe how attributes of products should be measured in a clear and reproducible manner.
Implementing measures require clear, robust and appropriately harmonised measurement standards (or draft transitional methods – explained later) fairly applied to all products in scope. Without the foundation of standards, enforcement of regulation becomes impossible and laws have no force behind them.

Priorities in the creation of standards are:

- Robustness
- Clarity
- Applicability
- Avoidance of loopholes

- Coherence with other standards
- Complementary to legal requirements.

3.2 Entities involved

There are various different bodies involved in standardisation:

Type	Examples
Government organisations	Codex, IMO, UN/ECE.
National standardisation bodies	BSI, DIN, AFNOR
European standardisation organisations (ESOs)	CEN, CENELEC and ETSI
International standardisation bodies	ISO, IEC and ITU
Industry consortia	Symbian, UDDI, etc. (about 400, by European statistics)

Table 1 - Entities involved in standardisation

In the European Union, only standards developed by the ESOs (see Table 2) are recognised as 'European Standards'. The ESOs closely cooperate in the interest of European harmonisation, creating both standards requested by the market and harmonised standards in support of European legislation.

ESO	CEN	CENELEC	ETSI
Description	European Committee for Standardisation. The main body for developing standards in Europe in all areas except telecommunications (ETSI) and electrotechnical (CENELEC).	European Committee for Electrotechnical Standardisation. CENELEC coordinates closely with CEN via the CEN-CENELEC Management Centre (CCMC) on strategic matters of common interests.	European Telecommunications Standards Institute. Produces globally-applicable standards for Information and Communications Technologies (ICT), including fixed, mobile, radio, converged, broadcast and internet technologies.
International equivalent	ISO (the International Organization for Standardisation)	IEC (the International Electrotechnical Commission)	ITU-T (the International Telecommunication Union and telecommunication standardisation sector)

Table 2 - Standardisation organisations

There are agreements to recognise international standards against the particular needs within the EU for standards where a need has not been recognised or prioritised at the international level. Many CEN and CENELEC standards are identical to ISO and IEC standards – around 31% of CEN standards are identical to ISO due to the Vienna Agreement[1], and around 60% of the CENELEC standards are substantially identical to IEC due to the Dresden agreement[2].

3.3 The standardisation process

The standardisation process within ecodesign usually involves the European Commission making a formal standardisation request (SR) to ESOs to develop product-specific standards relevant to aspects of performance in accordance with Regulation (EU) No 1025/2012 on European standardisation[3]. This directive, one of the foundations of the single market act[4], has the goal of modernising the European standards process to enable more standards to be produced, faster and with greater inclusivity. It provides the general framework for European standardisation policy and places obligations on the recognised European Standardisation Organisations to meet the standardisation principles of transparency, openness, impartiality and consensus, effectiveness and relevance, coherence, and development dimension. Standardisation requests are created for each new implementing measure under the Ecodesign Directive.

Implementing measures will usually reference a product-specific "harmonised" standard, meaning a specification adopted by a recognised standards body under a mandate from the Commission[5]. A harmonised standard is deemed to exist when ESO members have formally presented the standards produced or identified conformity with the mandate.

Where a harmonised standard does not exist, transitional measuring methods and verification procedures can be detailed in a separate communication in the Official Journal of the European Union (OJEC), which can then be referenced in Commission guidance to accompany ecodesign directives for products. Such a communication would typically list out test methods in tabular form for each directive requirement. Transitional methods would ultimately be replaced by harmonised standards, which would also be published in the OJEC in accordance with Articles 9 and 10 of Directive 2009/125/EC.

European standards can be split into two main types – prescriptive (state requirements) and non-prescriptive (provide advice or information). In the ESO

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[1] International Organization for Standardization (ISO) and European Committee for Standardization (CEN), agreement on technical co-operation between ISO and CEN (Vienna agreement), http://boss.cen.eu/ref/Vienna_Agreement.pdf

[2] IEC - CENELEC Agreement on common planning of new work and parallel voting, http://www.iec.ch/about/globalreach/partners/regional/iec_cenelec_agreement.htm

[3] paragraphs 1 and 2 of Article 10

[4] (SMA) COM 2011

[5] in accordance with the procedure laid down in Directive 98/34/EC of the European Parliament and of the Council of 22 June 1998 laying down a procedure for the provision of information in the field of technical standards and regulations (1), for the purpose of establishing a European requirement, compliance with which is not compulsory.

process, the full (EN) standard is the most prescriptive, and is usually what is referred to as a harmonised standard. It guarantees the commitment of national standards bodies (NSBs) who must adopt the standard at a national level and remove/modify any conflicting standards (even if the country voted against the draft). EN standards may take 2 to 4 years to develop and must be reviewed at the latest 5 years from publication.

4 Product Scope

The product scope for this gap analysis is limited to the scope published in the Task 7: Scenarios report[6] published as part of the Preparatory study for implementing measures of the Ecodesign Directive 2009/125/EC (DG ENTR Lot 9) - Enterprise servers and data equipment.

The Task 7 report defined the scope of the Preparatory study as limited to "enterprise servers" and "enterprise storage" products. Networking equipment was excluded.

4.1 Enterprise servers

The report specified "enterprise servers" as including products that are:

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

"Enterprise servers" were not considered to include products that are:

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

The report's authors did not explicitly remove from the scope enterprise server types such as mainframes, high performance computer systems, resilient servers or server appliances. However, they strongly recommended that the technical, economical and operational feasibility of ecodesign measures for these products should be reviewed in detail. In particular, these products could be difficult to as they could be highly customised and used for mission-critical computing processes in which functional or operational requirements take priority over environmental performance.

4.2 Enterprise storage

The Task 7 report specified "enterprise storage" as including products that are:

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

"Enterprise storage" was not considered to include products that are:

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

[6] Preparatory study for implementing measures of the Ecodesign Directive 2009/125/EC DG ENTR Lot 9 - Enterprise servers and data equipment (June 2015) Task 7 Draft report. available at www.ecodesign-servers.eu/

Whilst more specialist enterprise storage equipment such as Online 5 or 6 was not explicitly removed from the scope of the preparatory study, it was noted that due to the specialist nature of these product types, the environmental performance of these products may be of significantly less concern than operational performance.

4.3 Definitions

The Task 7 report proposed adopting the product definitions already used in other EU Regulations, such as the Ecodesign Regulation (EU) No 617/2013 on computers and computer servers in order to guarantee a harmonised approach. Where products are not defined in an existing Regulation, it was suggested that definitions be aligned with the relevant ENERGY STAR specification (Enterprise Servers Specification Version 2.06 and Data Centre Storage Eligibility Criteria Version 1.07)[7].

Whilst definitions could be based off the foundation of ENERGY STAR, it is likely that they would need to be refined in order to be sufficiently robust for the purposes of a standard supporting any regulation. Due to the voluntary nature of the ENERGY STAR programme, definitions are able to have a degree of flexibility. The language may be insufficiently detailed to ensure that i) all products covered under the scope meet the definition and ii) all product types intended to be outside scope are explicitly excluded.

Further definitions (not defined in the Task 7 report) would need to be developed for standardisation purposes to address factors such as:

- Excluded products
- Power modes
- Individual components where additional allowances may apply

[7] It should be noted that depending on the timing of any Ecodesign Regulation measures, reference to product definitions in newer ENERGY STAR specification may be more appropriate.

5 Performance parameters considered

It was necessary to select the key parameters for which standards needed to be identified.

Impact areas and individual parameters were elaborated using as the "Task 7: Scenarios" report of the preparatory study on DG ENTR Lot 9 products, built upon with a knowledge of wider standardisation initiatives where appropriate.

Impact area	Parameter	Product	Source / Explanation
Energy performance in operation [8]	Active State (power demand / rating)	ES, DS	Preparatory study task 7
	Idle State (power demand/ rating)	ES, DS	Preparatory study task 7
	Energy proportional operation (dynamic range)	ES, DS	Preparatory study task 7
	Overall energy performance (TEC type approach)	ES, DS	Preparatory study task 7
Product hardware / software / configuration	Power Supply Efficiency	ES, DS	Preparatory study task 7
	Power Supply Power Factor	ES, DS	Preparatory study task 7
	Capacity Optimizing Methods (COMs)	DS	Preparatory study task 7
	Reusability of components (Firmware availability)	ES, DS	Preparatory study task 7
Product operating conditions	Operating temperature	ES, DS	Preparatory study task 7
	Acoustic noise	ES, DS	Preparatory study task 7
Material efficiency	Removability of external enclosures, PCBs, processors, data storage devices and batteries with common tools	ES, DS	Preparatory study task 7
	Ease of dismantling, reuse and recycling at the end-of-life.	ES, DS	Preparatory study task 7
	Data sanitisation [9]	ES, DS	Preparatory study task 7
	Critical raw material (CRM) content	ES, DS	Preparatory study task 7
	Postconsumer recycled content of CRM	ES, DS	JRC Science and Policy Report, Environmental Footprint and Material Efficiency Support for product policy, Analysis of material efficiency requirements of enterprise servers
	Replacement components availability	ES, DS	JRC as previous
	Reduction of surplus parts by default	ES, DS	JRC as previous
	Hardware functionality testing software tools	ES, DS	JRC as previous

Table 3 – Parameters to assess for standards availability

[8] The energy performance of the server depends on the different components, including the PSU, motherboard, CPU, RAM, storage components, network and other I/O interfaces. The power demand of these varies in active state depending on the workload being applied. A full breakdown is not shown in Table 3 because there are potentially too many different components to cover.

[9] Data sanitisation is the complete removal or all data from a storage component or equipment to make it unrecoverable by forensic methods. Sanitisation can be destructive or non-destructive to the hardware equipment. While it is not a direct environmental aspect,

6 Relevant EC Standardisation Requests

6.1 Standardisation request related to the computer regulation

As previously mentioned, "Commission Regulation (EU) No 617/2013 of 26 June 2013 describing ecodesign requirements for computers and computer servers" addresses efficiency requirements for power supply units in a sub-set of servers.

In relation to this regulation, the Commission has already issued:

- A Commission Communication on transitional methods for measurement.
- A standardisation request for the ESOs to develop harmonised standards which will incorporate relevant measurement and calculation methods.

The standardisation request includes standards to enable the measurement of power supply efficiency.

6.2 Mandate M/462 on telecommunications infrastructure

6.2.1 Activities requested

The European Commission recognised that further action was needed in order to improve the energy efficiency and offset the growth of the telecommunications infrastructure. Therefore, in 2010, the Commission published the EU standardisation request M/462 addressed to CEN, CENELEC and ETSI. The standardisation request called for two distinct phases of work:

In Phase 1 of the standardisation request, the European standardisation organisations CEN, CENELEC and ETSI, in cooperation with other relevant standards organisations, were invited:

- To analyse the economic environment and the political context for efficient energy use,
- To identify the potential role of ICT standardisation in achieving efficient energy use,
- To identify existing and/or ongoing standardisation and consensus-building activities on the issue within national, regional and international standardisation organisations, formal or otherwise, and to assess their relevance for achieving European policy objectives in this domain,
- To identify consistencies, relations, dependencies, hierarchy (taxonomy), overlaps and gaps in ICT standardisation work related to efficient energy use,
- To establish a standardisation work programme with a view to filling the gaps, taking into account relevant regulatory initiatives, R&D projects or standardisation activities carried out by relevant fora and consortia.

In Phase 2, the work programme is agreed and the standardisation activities are launched following consultation of the Member States on the results of Phase 1.

In 2011 the ESO’s published the “Framework Document for ESO Response to EU Mandate M/462”, which aimed to respond to the Phase 1 standardisation request requirements and provide a gap-analysis of the relevant existing and ongoing standardisation activities.

6.2.2 Organisation of standardisation work

The Joint Coordination Group established between CEN, CENELEC and ETSI in response to Mandate M/462 is coordinating the standardisation work for this request. In addition, they will also coordinate with the CEN, CENELEC and ETSI "Green Data Centres" group (CG GDC), as a first step in focussing on energy efficiency. ETSI's Technical Committee "Environmental Engineering" (TC EE) is responsible for defining the environmental and infrastructural aspects for telecommunication equipment in various types of installations. They are therefore involved in engineering aspects of standards such environmental conditions (climatic, thermal, acoustic, etc.), equipment (physical requirements of racks, sub-racks and cabinets including thermal matters), power supply requirements, and eco-environmental matters (energy efficiency, environmental impact analysis, alternative energy sources). The key activities of TC EE addressing eco-environmental matters are:

- reduction of power consumption of telecommunication equipment and related infrastructure;
- determination of the environmental impact of telecommunication equipment.

Cooperation of TC EE with other Technical Bodies and with external organizations is managed within ETSI through the Operational Co-ordination Group (OCG). Several external liaisons have been established with standardisation bodies including IEC, CENELEC and the ITU-T, and other organisations / research projects. CENELEC supports the ETSI standardisation activity by producing standards in the energy efficiency field for components, infrastructure designs and infrastructure installation which are applicable to the delivery of ICT within customer premises (which may also be applicable to the needs of operator's sites). An example of this is the development of the EN 50600 series which, in part, addresses the installation of appropriate infrastructure to enable the energy efficiency of data centres to be measured and monitored. CEN is not actively involved as the most relevant CEN activities (development of standards addressing life cycle assessment) lie outside the direct focus of operational energy efficiency defined by the Mandate M.462.

6.2.3 Review of standardisation activities

The ESO review of standardisation activities relevant to Mandate M/462 includes those at a European and an international level, covering relevant documentation being produced by ESOs and other standards organisations, fora and consortia. Of particular relevance is the CEN-CLC-ETSI established Coordination Group to develop standards for Energy Efficiency within Data Centres and associated infrastructure.

The table in Appendix 1 highlights those documents identified by the ESOs as being of relevance to the server and data centre storage areas[10]. It should be noted that the table was created in 2011, and there has been significant further activity in standardisation since that time. As such, it provided a starting point for the gap analysis, which was then expanded with up to date insights on standards (see Section 7):

[10] “Framework Document for ESO Response to EU Mandate M/462”, Version 3.0.0 Dec 2011, ETSI https://portal.etsi.org/Portals/0/TBpages/ee/Docs/ESO%20response%20to%20M462%20phase%201%20.pdf

6.2.4 Standardisation workplan

The standardisation workplan put forward by the ESOs is not broken down to the level of specific areas or standards, but states a general ambition to have published European Standards (ENs) covering each of the subject areas ("Operation", "Test" and "KPI") for areas including:

- Network operator sites / Facilities / Data centres
- IT Equipment / Servers and storage

In particular, in relation to KPIs, the following activities have been since highlighted by ESOs as necessary for ecodesign purposes:

- Measurement Process for Energy Efficiency KPI for Servers
- Measurement method and Process for Energy Efficiency KPI for Storage equipment[11]

The original objective of ESO's was to produce the required standards within 3 years from the approval of the standardisation program (around 2014), but it is likely that this deadline has now been delayed as some of the standardisation work is still underway.

[11] http://docbox.etsi.org/Workshop/2015/201506_EEWORKSHOP/SESSION01_Setting_the_Scene/Mandate_462_RodolpheWouters_EC.pdf

7 Status of test standards and metrics

This section summarises the results of the 2015 gap analysis. Key standards were examined to determine which relevant parameters they addressed, what the current status of each standard was, the degree of harmonisation, and how relevant it was to supporting ecodesign for Lot 9 products.

An overview of the status of the standards and initiatives assessed is shown in Table 4.

	Published standard in use by industry addressing most aspects of a parameter	Standard in draft that may be suitable to address a parameter	Shortlisted standards not suitable.	Total
European Standards	0	0	4	4
International Standards	2	1	0	3
National standards/initiatives	5	1	1	7
Industry standards/ International initiatives	5	2	1	8
Total	14	4	6	22

Table 4 – Coverage and status of key standards / initiatives for enterprise servers (ES) and data storage

A detailed breakdown of the standards available and what parameters they address is contained in appendix 2. Whilst 10 standards have already been identified that could address most aspects of a parameter, some parameters are better covered than others, and there are substantial gaps in some areas. These gaps are highlighted in the blank cells in the table below:

Parameter	Published standard in use by industry addressing most aspects of a parameter	Standard in draft that may be suitable to address a parameter	Shortlisted standards not suitable.	Ability to verify via test
Server active state power **Server idle state power**	ENERGY STAR servers v2.0 SERT V1.1.0	ENERGY STAR servers v3.0 (est 2016) ISO/IEC 30134-4 (est 2016)	SPECpower_ssj2008	Yes
Server overall energy performance (TEC)	ENERGY STAR servers v2.0 SERT V1.1.0	ENERGY STAR servers v3.0 (est 2016)	SPECpower_ssj2008	Yes but not fully validated for regulatory purposes
Data storage active state power **Data storage idle state power**	SNIA Emerald V2.x	ENERGY STAR storage v2.0	ENERGY STAR	Yes but complex and

Data storage overall energy performance (TEC)		(no timeline)	storage v1.0 EN 50600	test standard revisions not all compatible
Energy proportional operation	SERT V1.1.0		EN 62018	Yes – servers only
Data storage COMs	ENERGY STAR storage v1.0 SNIA Emerald V2.x			Yes
Power Supply Efficiency	EPRI protocol v 6.7		EN 300 132-3	Yes
Power Supply Power Factor	EPRI protocol v 6.7			Yes
Firmware availability		NSF/ANSI 426		Limited. Verification procedures included in standard.
Operating temperature	ASHRAE guidelines 3rd edition table 2.3		EN 300 019-1	Yes
Acoustic noise	ISO 7779:2010 ECMA 74		EN 62075	Yes
Removability of external enclosures, PCBs, processors, data storage devices and batteries with common tools	IEC TR 62635:2012 PAS 141:2011	NSF/ANSI 426 (est 2016)	EN 62075	Limited. Verification procedures included in standard.
Ease of dismantling, reuse and recycling at the end-of-life.	IEC TR 62635:2012 PAS 141:2011	NSF/ANSI 426 (est 2016)	EN 62075	Limited. Verification procedures included in standard.
Data sanitisation	NIST 800-88 rev1 CESG various PAS 141:2011		EN 62075	Yes
CRM content		NSF/ANSI 426 (est 2016)	EN 62075	Limited. Verification procedures included in standard.
Postconsumer recycled content of CRM				
Replacement components availability				
Reduction of surplus parts by default				
Hardware functionality testing software tools				

Table 5 – Summary of standards gaps for enterprise servers (ES) and data storage

The gap analysis has highlighted the following considerations:

- For both enterprise servers and data centre storage, the critical area of focus is the ability to assess and rate energy performance. Whilst some standards exist that could support these areas to some degree, further necessary work is underway to improve upon these approaches. In particular, it is necessary to ensure that the existing standards meet the priorities for creating a standard (robustness clarity etc described in Section 3.1) and that sufficient data is available to validate the applicability of the test method over the range of server configurations and form the basis of a meaningful efficiency metric.
- Test approaches for power supply efficiency and power factor are relatively well established although not harmonised.
- Test approaches for material efficiency aspects, are for the most part not well-defined, but not a key priority at this stage. However, data sanitisation is relatively well supported.

Further information on the status of the most relevant standards is contained in the following section. Background on explaining why certain European (EN) standards

highlighted under mandate M/462and some industry standards have been discounted as less relevant is contained in Appendix 3.

7.1 Relevant European standards (EN)

7.1.1 CENELEC (CLC TC 215): EN 50600 Series

CENELEC is establishing a set of standards on data centres (DC), under the EN 50600 series. The standards are designed to be fair, consistent and comparable. The target audience is the average Small and medium enterprise (SME) DCs that might not have the high level of expertise compared to a large data centre and therefore benefit from design and operation guidelines.

The intention is to address the complexities of DC in a holistic form compared to previous work which has already covered discrete components and systems such as cabling, UPS, fire systems and access control.
The Activities are built on three pillars:

1. Design – building, power, environmental control, IT cabling and security.
2. Operation and Management
3. KPIs – to assess resource and energy efficiency including subsystems and possibly components which will be linked to the EU CoC for DCs.

The first two pillars are almost finished and activities are now concentrated on the KPIs for pillar 3 in close cooperation with ISO/IEC JTC 1/SC39 WG who are developing ISO/IEC 30134-4. Standards should be available in 2016 and will include PUE which has been handed over from The Green Grid. They have been working to formalise and correct the insufficiently clear guidance in the existing white paper[12] and rewrite it in a clear and consistent manner suited for an international standard.

7.2 Relevant international standards

7.2.1 ISO/IEC 30134-4 SO/IEC 30134-5 (ITEE and ITEU for servers)

ISO/IEC 30134-4 is a project under the ISO/IEC Joint Technical Committee (JTC) 1/SC 39 addressing ITEE (IT energy efficiency) and ISO/IEC 30134-5 addresses ITEU (IT Energy Utilisation) KPIs for servers. Utilisation is not a relevant parameter for the product since it will depend on the application by the end-user. The work is being led by the Japanese and Korean representatives in the working group.

It is still in early stages of addressing some of the complex issues in the area. Whilst the first internal committee draft report was completed in spring 2015, further work is necessary to take this forward and transform the findings into KPIs.

The current draft defines KPIs and describes application but leaves it to the user to pick the test. There is no focus on any particular testing tool as there are so many different options covering different use cases and architecture (Linpack, SERT etc), however, the current focus is on the efficiency at maximum performance. This may

[12] http://www.thegreengrid.org/Global/Content/white-papers/The-Green-Grid-Data-Center-Power-Efficiency-Metrics-PUE-and-DCiE

present a problem because peak efficiency does not occur at maximum performance and servers are almost never used at this load level.

One possible long term solution is to arrive at a well-defined testing approach combining a number of different workloads to provide a representative picture of energy performance, however, there has been no final decision made regarding this. Such a deliverable would likely be developed iteratively and would not be expected for a few years or in the first edition.

7.2.2 IEC TR 62635:2012

The IEC Technical Report (TR) provides a methodology for information exchange involving electronic and electrical equipment manufacturers and recyclers. The report also identifies how recyclability and recoverability rates should be calculated in order to provide accurate information to recyclers. It is envisaged that this information enables appropriate and optimized end of life (EoL) treatment operations, provides sufficient information to characterize activities at EoL treatment facilities.

7.2.3 ISO 7779:2010

The ISO 7779 standard specifies procedures for measuring and reporting the noise emission of information technology and telecommunications equipment.

7.3 Relevant national standards / initiatives

Note: The EU (voluntary) Code of Conduct on Data Centres and the EPA ENERGY STAR® Program Requirements for Computer Servers v2.0/v3.0 are not detailed further in this section as they have already been addressed in section 2.2.

7.3.1 United Kingdom: British Standards Institute ZZ/1 Publicly Available Specification (PAS) 141:2011

PAS 141 is a process management specification for the re-use of used and waste electrical and electronic equipment (UEEE and WEEE). The specification was developed by industry experts working with the UK Department for Business, Innovation and Skills (BIS).

The main aims of PAS 141 are to:

- Improve the standards for the re-use and refurbishment of electrical and electronic equipment that has reached the end of its first useful life in the UK; and
- Address the demand from consumers for assurance that the used electrical products they buy are electrically safe to use and functionally fit for purpose.

PAS 141 provides the following.

- A framework for the testing, treatment and provision of re-use electrical and electronic equipment in the UK;
- Reassurance that used equipment is electrically safe to use and functionally fit for purpose;
- A method of differentiating legitimate exports from illegal exports of WEEE under the guise of being sent abroad for re-use.

A PAS 141 Certification Scheme was launched on the 27th February 2013.

7.3.2 United States: NSF/ANSI 426

The NSF 426 standard development process is a USA based initiative to develop a set of environmental criteria for servers which address multiple environmental impact categories. The final standard will be American National Standards Institute (ANSI) accredited.

The purpose of the NSF standard for servers is to establish product environmental performance criteria and corporate performance metrics that exemplify environmental leadership in the market. The scope of the standard is limited to “servers” that are covered under the ENERGY STAR Program Requirements for Computer Servers Version 2.0.

The standard provides a framework and consistent set of performance objectives for manufacturers in the design and manufacture of servers and server components. The standard establishes measurable criteria across multiple environmental impact categories including energy efficiency, management of substances, preferable materials use, product packaging, design for repair, reuse, and recycling, product longevity, responsible end-of-service/end-of-life management, life cycle assessments, and corporate responsibility.

The NSF standard is likely to be referenced by the EPEAT scheme although discussions are underway on whether this standard and the IEEE 1680.4 standard will be merged.

7.3.3 United States: NIST Special Publication 800-88

The NIST document aims to assist in the development of effective media sanitization programmes with proper and applicable techniques and controls for sanitization and disposal decisions based on different levels of data security required.

The publication assists with decision making when media require disposal or reuse. It also provides guidance for information disposition, sanitization, and control decisions. The publication provides reference to applicable techniques and controls for data sanitisation based on different levels of data security needs.

7.3.4 United Kingdom CESG standards on data sanitation

CESG is the Information Security arm of the UK Government Communications Headquarters (GCHQ), and the National Technical Authority for Information Assurance within the UK. Their main role is to provide technical assistance concerning Information Security in Government.

There are three main standards the CESG is responsible for in the area of data sanitisation. These are:

- CPA Security Characteristics for Data Sanitisation - Flash Based Storage
- CAS Sanitisation Requirements Version 2.0 Nov 2014
- HMG Information Assurance (IA) Standard No. 5 - Secure Sanitisation Version 5.0

The Her Majesty’s Government (HMG) IA Standard No. 5 identifies how to destroy data depending on its sensitivity, where it is located and the media on which it is stored. The CAS Sanitisation Requirements Version 2.0 is a certification scheme to which commercial sanitisation services may subscribe, therefore demonstrating compliance with HMG IA Standard No. 5 when serving Government customers. The CPA Security Characteristics for Data Sanitisation - Flash Based Storage document includes requirements for sanitisation of all Flash-based storage media (e.g. solid state hard drives).

Note there are a number of other national initiatives addressing data sanitisation. These are not discussed in detail, as the NIST Publication 800-88 document provides a good overview of data sanitisation methods and procedures.

7.4 Relevant industry standards and international initiatives

There are already a number of measurement methods available for servers, storage and other equipment to measure and report energy use in an accurate and reproducible manner. However, there are large gaps in coverage and many are still not finalised. Regardless, their development to date has established a technical expertise in the industry that can be called upon in the formal development of transitional and harmonised standards.

7.4.1 SPEC: SPECpower_ssj2008

SPECpower is the initial rating tool developed by the SPEC group. It was earmarked for use in the first server specification, but unresolved complexities meant that SPEC recommended on delaying on its inclusion. Efforts subsequently shifted to development of the SERT tool. SPECpower only measures efficiency under a very limited conditions of the SPEC ssj_2008 test which only tests the CPU and RAM. The power is measured at different server utilisation levels, from 0 to 100% and gives a power consumption level and performance rating at each level

The SPECpower tool was previously referenced in ENERGY STAR (although not required) and is referenced in the Irish Triple E program. This aggregates the performance and power for low (10-30%), mid (40-60%) and high (70-100%) utilisation levels and produces three performance/power ratio. The specifications set minimum ratios for each utilisation level.

7.4.2 SPEC: SERT V1.1.0

The Server Efficiency Rating Tool (SERT tool) is a tool intended to measure server energy efficiency which can run on the full range of server specifications and configurations. The compatible server architectures continues to expand. It was created by the Standard Performance Evaluation Corporation (SPEC). SPEC is a non-profit organisation open to all parties but requires membership fees. SPEC has over 50 members which includes almost all the main ICT hardware manufacturers and a number of software and internet companies. There are also SPEC Associates and a Research Group which include approximately 100 other organisations, in particular universities in USA, Japan and Germany.

It is designed to be simple to configure via a comprehensive graphical user interface. The SERT tool uses a set of synthetic worklets to test discrete system components

(e.g. processors, memory and storage) and subsystems (e.g. RAM and CPU), providing detailed power demand data at different load levels. SERT does not include network I/O worklets due to the difficulty in validating external equipment which must be connected at the other end of the network and the low power consumption of the networking components relative to the whole server. Instead it recommends an energy allowance is applied to idle/active power for additional and faster network interfaces.

Results are provided in both machine and human readable forms, accompanied by summary and detail reports. It is thoroughly tested in-house, but internal test results for development purposes would not be shared externally. Purchase price for the SPEC software ranges from $900 (not for profit reduced rate) to $3,000. Charges are to cover the costs of providing support on the tool.

Via the current worklet approach, SERT provides results representative of real working environments. One of these worklets is the ssj_2008 test from SPECpower. Each worklet provides a numerical output which can then be combined and interpreted into an overall pass/fail conclusion in relation to the requirements of a particular policy. Manufacturers are discouraged from quoting numerical values for specific worklets in isolation for marketing purposes as taken in isolation these values can be misrepresentative.

As previously referenced, there is an ISO standard under development which recognises but does not endorse the SERT tool as a possible option to measure efficiency. In addition, SERT has been used as a foundation standardised testing tool to support policy measures on server energy efficiency. Current policy interest in SERT includes the United States (US EPA / ENERGY STAR), Korea, China, and Australia / New Zealand. SPEC are working closely with ENERGY STAR toward the revision of the server specification. Approaches are likely to be well-defined by end 2015. Usually, the policy maker gathers the data, does the analysis and defines their approach and metric, and then SPEC can customise the tool accordingly.

The tool includes features to avoid favourable “gaming” of results - for example, any divergence from standard settings is possible, but renders the output test results invalid.

New SERT versions have a development cycle of around 4 years, and can remain in place for between 2 and 8 years. The next version could potentially be introduced 2 to 3 years, or up to 5 years from now (2017/2018). New versions must be re-purchased. SPEC aim to halt support to previous versions of the tool, as soon as possible, but would work with policy makers to ensure this fitted with their timelines.

For each version there are updates, which are included in the initial purchase price. There have been 3 updates in the last 2 years. These include necessary enhancements for usability / performance or new hardware capabilities, but do not change the results. Regardless of updates, test results from a specific version should be comparable. There are no updates currently in development.

Test results from different versions would not be comparable.

7.4.3 SNIA Emerald™ Power Efficiency Measurement Specification

Storage Networking Industry Association (SNIA) Emerald is a test method specification for storage equipment. It measures the power consumption under a variety of use cases to give an overall efficiency metric. Due to the large differences in storage equipment design compared to servers with no clear market sector to focus on, the metric has a very detailed classification system based on the designed size and use of the storage system.

Emerald is designed to allow comparison of products within the same classification. Where applicable, five main tests are performed using vdbench, the first 'four corners' are designed to test the extremes of performance under small random data accesses and streaming data. The results report power, data throughout rate and latency.

The fifth test is called the hot band which simulates more realistic usage where a variety of data accesses are performed but concentrated around bands of frequently accessed data. This requires a lot of set up and as a result testing can be very complex and take days.

In addition, idle power is measured as well as tests to check for the presence of COMs, but not their effectiveness. While the test measurement covers all use cases, some of these may not be relevant for the product be used.

Emerald does not produce as much test result data compared to SERT, and therefore there are fewer variables to consider. However, the test report template requires in depth description of the system configuration since this can affect performance. There is currently not enough data to analyse fully and determine how detailed a metric can be developed based on performance, latency, throughout etc. which also fairly treats various configurations such as capacity. Results across different classes of products cannot be compared.

SNIA Emerald is developed and maintained by SNIA, a non-profit, international organisation of manufacturers, systems integrators, developers, systems vendors, industry professionals, and end users.

SNIA is being used by ENERGY STAR to develop specifications, however, the lack of data and difficulty in testing has meant progress so far has been slower than servers.

7.4.4 EPRI & Ecova: Generalized Test Protocol for Calculating the Energy Efficiency of Internal Ac-Dc and Dc-Dc Power Supplies Revision 6.7

The Electric Power Research Institute (EPRI) is a widely used testing method for internal power supplies which is used in 80plus scheme, ENERGY STAR and other efficiency policies. This protocol was established in 2004 but has integrated the Server Test Protocol since 2008, including test methods for direct current (DC-DC) power supplies. It includes instructions to measure the power supply efficiency and power factor at various load levels.

7.4.5 ASHRAE TC 9.9 2011: Thermal Guidelines for Data Processing Environments, 3rd Edition, in Table 2.3

The American Society of Heating, Refrigerating, and Air-conditioning Engineers (ASHRAE) defines a range of humidity and temperature operating conditions which many data centre and IT equipment manufacturers adhere to. Since data centres will often contain a very mixed range of IT equipment types and brands, this helps ensure the entire system interoperates reliability. The operating ranges were expanded widely in 2008 and have not been revised since 2011. The ranges are set by committee including data centre operators and equipment manufacturers.

The temperature range has an impact on the design and energy consumption of the server, particularly the internal cooling system such as the heatsink and fans. A larger range can reduce the data centre cooling costs but since the internal computing components are often unchanged and the same amount of heat produced must still removed, it can shift the energy consumption into the server, and require larger, more energy consuming fans as well as larger, heavier heatsinks which may impact the overall lifecycle. This aspect, however, was already analysed in the Lot9 preparatory study, with particular regards to servers; it was concluded that the overall energy saving is significantly positive (see in particular Task 6).

7.4.6 ECMA: ECMA-74 13th edition (June 2015) (based on ISO 3741, ISO 3744, ISO 3745, ISO 11201)

This Ecma Standard specifies procedures for measuring and reporting the noise emission of information technology and telecommunications equipment. Densely installed server equipment in a data centre can emit high levels of noise. Best practice requires that a data centre (which is often considered to be an industrial space) should only be occupied for service and maintenance purposes, however, this may not always be true for SMEs.

7.4.7 IEEE 1680.4 Servers

The IEEE 1680 series are a USA based series of standards which focus on IT products and which include environmental performance criteria across multiple environmental impact categories. The standard defines environmental performance criteria for computer servers as defined in the Energy Star Server specifications, including managed servers and blade servers, relating to reduction or elimination of environmentally sensitive materials, materials selection, design for end of life, lifecycle extension, energy conservation, end of life management, corporate performance, and packaging.

The IEEE series of standards (apart from IEEE 1680.4) are used to inform the development of EPEAT specifications. Discussions are currently underway about the potential to merge the draft IEEE 16890.4 and NSF 426 standards into a single multi-attribute environmental standard for servers.

7.4.8 ANSI ATIS: 060015.2013 (TEER)

This is a network efficiency test method used to determine the efficiency of the networking component of servers or networking equipment. It provides a measure of the data throughput per unit of power. Network interfaces have traditionally been poorly energy managed and historically consumed the same amount of energy regardless of how much data was passing through. While this is a small proportion of

server power for slower network interfaces, 10Gb ethernet interfaces can consume around 5W each.

The Telecommunications Energy Efficiency Ratio (TEER) is defined in the ANSI ATIS 060015.01.2014 standard. which addresses “Energy efficiency for telecommunication equipment: Methodology for measurement and reporting - Server requirements”. This standard references SPEC and specifies how to measure network efficiency only for a server, if TEER is requested. It does not cover server efficiency in general.

8 Metric development

A major consideration for servers is how standards and rating tools could enable an energy efficiency metric to be developed.

The broad objective of a metric is to provide an indicator to the server user of the energy efficiency and energy consumption of a particular model and configuration under normal use conditions. Because the users and use conditions are so varied for servers, and optimal efficiency is very dependent on configuration, it is preferable to focus where there is maximum potential for savings. These can be considered as:

- **Idle power / scaling with load level:** The current ENERGY STAR metric is based on the idle power rather than the active power. This simplifies the test method and metric development substantially. The main argument for this approach is that servers often run at low load levels, which is more similar to idle power. Therefore, a metric which encourages power consumption to scale with load level is an effective means to reduce energy consumption under real, common operating conditions.

- **SME workloads:** Similar to the reasoning of the CENELEC EN 50 600 standards development group, small and medium enterprise (SME) data centres and average users tend to have the least technical ability to understand and select efficient products. They are also less likely to have very specialist workloads such as high performance/ supercomputing type work. Server loads also tend to be lower. This means that a metric which is more representative of the typical workloads of this SME users could have the greatest energy saving impact.

The SERT tool provides an ideal starting point for metric development. Since SERT measures energy at various load levels as well as using different worklets to test different components and subsystems, it should be possible to weight the particular results which most strongly represent the most common types of work. A single metric or series of metrics could then be created to represent the workloads. Whether a single or series of metrics is needed depends on how much the efficiency varies between the workloads.

In the next stage of this project, the potential to develop metrics will be analysed in more detail. The approach to defining a metric would comprise the following stages:

1. Identify common workloads eg virtualization, database, webserver, file server
2. Understand how performance is influenced by server configuration and components

3. Analyse existing SERT worklet test results and develop workload metrics.

Such an approach is currently compatible with industry activities under Mandate M/462, CENELEC EN 50600 and IEC/ISO 30134-4 since it could be considered a subset of the test methods currently recognised under the draft ITEE KPI. However, it is possible that in another 3-5 years these initiatives may diverge as work moves forward on testing approaches and more data becomes available. The list of relevant test methods developed from this project would also need to be reassessed at that point.

9 Next steps

The next steps on this project are to engage more proactively with the most relevant standards identified, to further expand on the standardiation gap analysis, and to explore the potential for metrics for server energy efficiency to be developed.

10 Key issues to address going forward

There are a number of overarching issues to be further considered in the next stages of the project, including:

10.1 Referencing software in standards

It is not common that formal standards would reference software such as rating tools, but it has been done in specific cases – for example, the multimedia (MPEG) compression standard includes detailed technical specification and a reference software implementation, to avoid issues with bugs and to develop appropriate software. The most suitable approach appears to be the definition of a software specification for the task, rather than a reference to a specific software version. However, creating a full technical specification with sufficient detail to enable a third party to independently develop software and give identical results across multiple computer architectures is extremely challenging due to the number of variables which must be decided.

10.2 Version stability and availability of software referenced in standards

Any software specifically referenced must be widely available to all parties who wish to use it. Furthermore, the software must be available over a reasonably long period of time to ensure that tests conducted at one point in time can be fairly compared against previous or future testing.

10.3 Product scope of the test method

The test methods currently available are not suitable for every type of server and computer architecture. Therefore, the scope must be clearly defined

10.4 Taking into account timing and facilitating test standard development

Some standards may become available during this project, whilst others may not be available until after the project is complete. In the next stage the timing of delivery o

standards currently being drafted or refined will be taken into account in a prioritisation of possible standards references. Where possible, the project team will engage with key standards organisations to get a clearer understanding of timings and facilitate the development of standards.

10.5 Copyright Issues with Standards

Many of the parameters addressed above are included with copyrighted standards. As such, care needs to be taken to ensure that no copyright or other intellectual property rights are infringed when developing Ecodesign criteria on servers and storage equipment.

11 Conclusions

There is much standardisation activity currently underway in the area of server standards. Enterprise storage standards for energy efficiency measurement are not so advanced.

There is still further work to be done in the area of standardisation in order to fully address all the areas that may be of interest should it be decided to address these products under ecodesign. The major gaps identified for focus in the next stage of the project are shown in the table below:

Standardisation area	Observations	Key standards activities
Server idle / active metric approach	Team is actively engaging with SPEC and ENERGY STAR on their metric development	Server active power test methodology, SERT SPEC Server KPIs and ITEE in ISO 30314-4 and CENELEC EN 50600 ENERGY STAR Servers v3.0
Storage idle / active metric approach	Product complexity poses significant challenges to develop and finalise metrics.	SNIA Emerald ENERGY STAR Storage v2.0
Material efficiency considerations	Team is actively engaging with NSF on the standard development process.	NSF 426 Standard for Servers

This project is engaging on an ongoing basis with the various initiatives to gain a detailed understanding of developments and delivery timescales and where possible to facilitate the development of standards.

This report and its appendices will be revised throughout the project to ensure that they contain the latest information on the coverage of standards in this area.