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

DG ENTR Lot 9 - Enterprise servers and data equipment

Task 7: Scenarios

July 2015 – Final report

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Table of Contents

List of Figures

List of Tables

Glossary

ACPI	Advanced Configuration and Power Interface
ASHRAE	American Society of Heating, Refrigerating, and Air-Conditioning Engineers.
B2B	Business-to-business
BAT	Best Available Technologies
BC	Base-Case
CAPEX	Capital expenditure
COM	Capacity Optimisation Method
GER	Gross Energy Requirements
HDD	Hard Disk Drive
I/O	Input/Output
IEEE	Institute of Electrical and Electronics Engineers
JRC	Joint Research Centre
LCC	Life Cycle Cost
LLCC	Least Life Cycle Cost
MEErP	Methodology for Ecodesign of Energy-related Products
NSF	The Public Health and Safety Organization (formerly National Sanitation Foundation)
OPEX	Operating expense
PEF Pilot	Product Environmental Footprint
PFC	Power Factor Correction
PSU	Power Supply Unit
RAID	Redundant Array of Independent Disks
RAM	Random Access Memory
SERT	Server Efficiency Rating Tool
SLA	Service Level Agreements
SNIA	Storage Networking Industry Association
SPEC	Standard Performance Evaluation Corporation SPEC
SSD	Solid State Drive
SSJ	Server-Side Java
TWh	Terawatt-hour

Introduction

This task summarises the outcomes of all previous tasks and has the goal to identify suitable policy options, which will allow achieving reduction of environmental impacts with consideration to energy savings, material aspects and reduction in Life Cycle Cost (LCC). Some scenarios analyses allow examining and quantifying the energy and cost savings for the period of 2015-2030.

Although Tasks 1-6 set the foundations for future work to be carried out by the European Commission, Task 7 presents a summary of policies that the authors of the report believe to be of use in order to achieve the desired reduction of the environmental impacts of products covered by the Lot 9 study. A sensitivity analysis is carried out on some of the key parameters in order to examine the robustness of the results.

Note that the preliminary policy discussions are the opinions of the consultants and do not reflect the views of the European Commission.

1.Policy analysis

The purpose of Task 7 is to suggest the most beneficial policy on the products studied. In this section, policy options are identified considering the outcomes of all previous tasks. They are based on the definition of the product, according to Task 1 and modified/confirmed by the other tasks. Specific recommendations to the equipment covered by the Lot 9 study are detailed in the following sub-sections. While Task 7 tries to give as much quantitative indication as possible, the project team was limited to data provided by stakeholders and literature review.

1.1. Stakeholder consultation during the preparatory study

Throughout the entire project, the Lot 9 team was in direct and regular exchanges with different experts and stakeholders such as industry representatives, associations, environmental groups, citizens' organisations, national authorities and researchers. Furthermore, regular exchanges with different established programs such as ENERGY STAR, the Green Electronics Council, and others were maintained throughout the study.

A study website (www.ecodesign-servers.eu) was set up allowing centralised dissemination of documents and the creation of an email-list through voluntary registration. More than 160 stakeholders were registered and received regular updates concerning the study as well as invitations to participate in questionnaires or meetings.

The project team collaborated with other teams working on ongoing studies on enterprise servers (JRC - Environmental Footprint and Material Efficiency Support for Product Policy) and storage equipment (PEF Pilot on IT Equipment).

Consultations were organised through specific individual inquiries and meetings as well as three questionnaires which were addressed to all stakeholders. The first questionnaire was related to the scope, market segmentation and environmental considerations and stakeholders were asked to provide feedback by 4th November 2013. The second questionnaire concerned data collection, such as bills of materials, metrics, etc. and was due to 13th June 2014. Finally, the third questionnaire, due to 7th November 2014, concerned data and information collection on Best Available Technologies (BAT).

1.2. Opportunities and barriers for improvements of environmental impacts

1.2.1. Opportunities for improvements of environmental impacts

It was shown in Task 5 that energy consumption in the use phase is with about 90% of total environmental impact absolutely predominant. The domination of the use phase was also confirmed through a parallel study conducted by the JRC-IES[1], using almost the same bill of materials for a rack server, but another LCA methodology.

The Lot 9 preparatory study estimates that in 2015, data centres[2] consume around 78 TWh of electricity per year (see Figure 1), a significant share of total electricity consumption in the EU (ca. 2.5% of EU-28[3]).

Global data centre IP traffic is considered to keep increasing at a very fast pace in the years to come, particularly driven by the cloud (see Figure 2[4]). IDC expects that the total number of data centres deployed worldwide will reach 8.6 million in 2017 and that total worldwide data centre space will continue to increase from 1.58 billion square feet (146 km²) in 2013 to 1.94 billion square feet (180 km²) in 2018 (+23%)[5]. Growth in data storage is being pulled by social media, machine data, and transactional data.

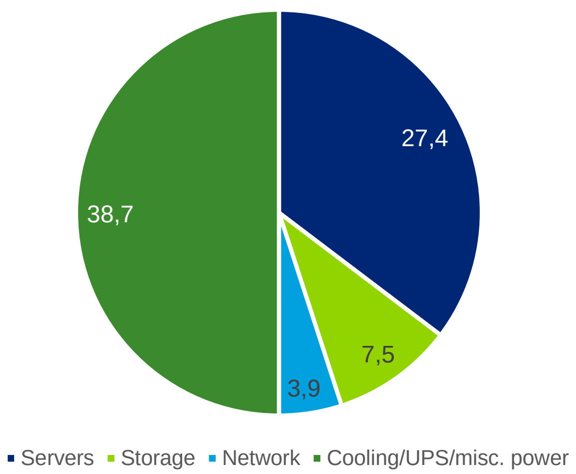

Figure 1: Electricity consumption in EU-28 (TWh) by product group in 2015

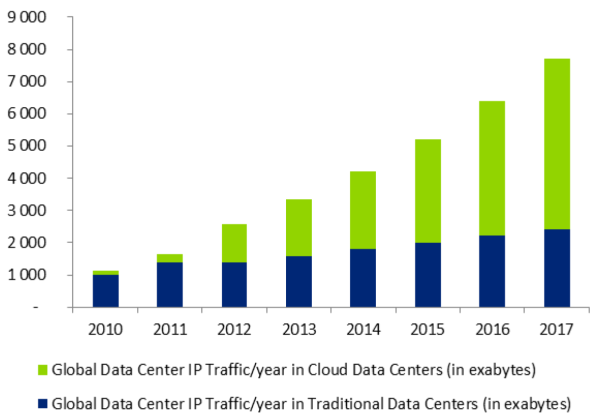

Figure 2: Global Data Center IP Traffic/year

While technological change (e.g. virtualisation) is going to mitigate the impact of the data increase to a certain extent, this dynamic development can still lead data centre managers to run into serious resource limits on electrical power, cooling, and space.

Ground space is scarce and in general one of the most important economic limitations in Europe. IDC predicts that "in the next two years, 25% of all large and mid-sized businesses will confront significant power/cooling facilities mismatches with new IT systems, limiting them to using less than 75% of their physical data centre space"[5]. In this respect, higher energy density is a central aspect related to ecodesign.

More performance per space (consolidation) means better space use and economic as well as environmental advantages. Ground space is also one of the most considerable cost factors in data centre operations (real estate expenses). Important opportunities of ecodesign measures that will lead to hardware consolidation and significant energy, space and cost savings are among others related to:

[1] JRC-IES (2015). Environmental Footprint and Material Efficiency Support for product policy - Analysis of material efficiency requirements for enterprise servers, Draft report.

[2] Servers, Storage and Network equipment with overhead

[3] Latest electricity generation data on the EU level (2013) was considered: http://ec.europa.eu/eurostat/statistics-explained/index.php/Electricity_production,_consumption_and_market_overview#Electricity_generation

[4] Source : Cisco Global Cloud Index: Forecast and Methodology, 2012-2017 (2013)

[5] https://www.idc.com/getdoc.jsp?containerId=prUS25237514

a) Improving energy efficiency and thermal management through conscious selection of efficient components (PSU, fans, CPUs, RAM, storage, etc.) and product configurations (for intended use based on benchmarks e.g. SERT),
b) Increasing utilization rate by means of virtualization and load balancing,
c) Higher operating temperature allowances (e.g. ASHRAE A1, A2 or higher),
d) Load-conscious power management (if applicable under SLAs),

In 2015, Moore's law turned 50 and might still continue for 3 or 4 chip generations before it gets slowed down by rising cost of the photo-lithography equipment needed to fabricate ever-smaller integrated circuits. From an innovation perspective, Ecodesign requirements such as low power consumption can have a positive impact on the continuous improvement efforts of the semiconductor industry (3D chips, quantum computing, etc.).

Since energy efficiency can contribute to reduce total electricity consumption, it is playing a key role for the decision where to locate big data centres[6]. Ecodesign can therefore help to keep the industry in Europe. However, given the relatively concentrated market structure with a few global players, the implementation of appropriate Ecodesign measures is very likely to have an impact that goes far beyond the EU-28 market.

Today's businesses are driven by cyber-physical systems, the Internet of Things, the Internet of Services (Industry 4.0), Big Data or Cloud Computing and need to be more efficient and more flexible. Load-adaptivness and virtualization are important ways to use scarce resources optimally and in a flexible manner.

Europe's target is to become a resource efficient circular economy. In the past, Ecodesign efforts have much concentrated on reducing energy consumption during the use phase of electrical and electronic products. What has been done for energy can also be done for resource use and in this respect, reuse and recycling of Lot 9 product components are key aspects with important potential to be considered in an adequate manner.

1.2.2. Barriers for improvements of environmental impacts

While the fast technological development (Moore's law) contributes significantly to the reduction of environmental impacts (e.g. by replacing inefficient technologies), it comes also with the directly related policy challenge to establish reference values and to set minimum requirements. In a recent paper on setting minimum efficiency performance standards, Siderius concluded that "policy makers should be cautious in preparing measures for products with a policy action window shorter than three years, unless of course other arguments exist."[7]

In applications and use environments with high availability and security requirements which are defined by service level agreements, it is more difficult to implement a consequent power management (influencing latency) or reduce redundancy (influencing power performance benchmarks).

The location, structural conditions, and given support infrastructure of an actual data centre will determine the physical system design, network architecture, and operating conditions (settings). Quite often, legacy equipment is still in use for very special purposes.

On average, IT equipment is renewed every 3 to 5 years, but the infrastructure has a lifetime that is typically two or three times longer. This time discrepancy needs to be considered and balanced in an optimal way. As an example, if higher inlet temperatures are considered, all the equipment in rack level including power distribution units (PDU), network and monitoring equipment need to be capable of handling these temperatures in a reliable manner.

Another general barrier that needs to be verified case by case can be seen in related costs, which e.g. could be the case for SSDs, software and interfaces.

[6] http://www.areadevelopment.com/data-centers/Data-Centers-Q1-2015/data-center-location-decision-parameters-46734866.shtml
[7] H.-P. Siderius / Energy Policy 70 (2014) 1-13

1.3. Definitions of the product group enterprise servers and storage

The study proposes to use definitions already used in other EU regulations, such as the Regulation (EU) No 617/2013 on Ecodesign requirements for computers and computer servers in order to guarantee a harmonized approach. For those products that are not yet defined (e.g. many storage products), it is recommended to align the definitions to the most recent ENERGY STAR® specifications for Enterprise Servers (Enterprise Servers Specification Version 2.0[8]) and Data Centre Storage (Product Specification for Data Centre Storage Eligibility Criteria Version 1.0[9]).

1.4. Scope of the product group enterprise servers and storage

According to the ENTR Lot 9 call for tender, the initial formal scope was entitled "enterprise servers and data equipment". The Ecodesign Working Plan considered the relatively vague product categories: "enterprise servers, data storage and ancillary equipment". During the Lot 9 kick-off meeting, servers, data storage, and network equipment that is professionally used and typically installed in server rooms or data centres was fixed as the basis for the scope by the European Commission representative.

During the first tasks of the preparatory study (Tasks 1-4) it was shown that networking equipment is an important product group, but that the complexity of these products made it unfeasible for the Lot 9 study to cover them in an adequate manner. For this reason it is suggested to conduct a separate preparatory study on networking equipment, based on preliminary information provided in Tasks 1-4 of the Lot 9 study.

The following subchapters summarize the scope of the product groups "enterprise servers" and "enterprise storage".

1.4.1. Scope of the product group "enterprise servers"

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

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

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

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

The ENTR Lot 9 preparatory study is not excluding at this point specific types of enterprise servers such as mainframes high performance computer systems, resilient servers or server appliances from the scope. However, it is strongly recommended to check the technical, economical and operational feasibility of particular ecodesign measures for these products due to the fact that they could be custom made and utilized for high available or mission critical computing processes. These functional or operational requirements have priority over environmental performance. It might be necessary to check feasibility of ecodesign measures case by case.

1.4.2. Scope of the product group "enterprise storage"

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

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

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

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

The ENTR Lot 9 preparatory study is not excluding at this point specific types of enterprise storage equipment such as Online 5 or 6 from the overall scope. However, here again, it is strongly recommended to check the technical, economical and operational feasibility of particular ecodesign measures for these products due to

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[8] http://www.energystar.gov/products/spec/enterprise_servers_specification_version_2_0_pd

[9] http://www.energystar.gov/ia/partners/product_specs/program_reqs/StorageV1.0_Program_Requirements.pdf?cb43-b421

the fact that they are often custom made and utilized for very specific purposes. Functional or operational requirements have clear priority over environmental performance. It might be necessary to check feasibility of ecodesign measures case by case.

1.5. Selection of policy measures for further analysis

According to the results of the study, the primary environmental impact of enterprise servers and storage equipment is related to the energy consumption in the use phase. The analysis in the previous tasks showed that yearly electricity consumption related to the use of enterprise servers and storage equipment in Europe is highly significant.

Although material aspects become more and more important and should definitely be addressed in an adequate manner, it is very likely that the electricity consumption during the use phase will continue dominating the life cycle impacts in the next decade (see also Figure 2). For this reason, it is important to give priority to measures that contribute to the reduction of total electricity consumption during the use phase.

These ecodesign measures include:

1. **Product information before and during the operation** – Information are important for selecting or configuring the right product for the intended use. A condition for this information requirement are power-performance benchmarks that allow product comparison. Furthermore, sensor based (continuous) monitoring of operation conditions (power, temperature, performance, etc.) is essential in order to detect suboptimal power performance and to adjust the operational parameters for bringing the system back into the efficiency zone.
2. **Product hardware components and configuration** – This is addressing the use of highly efficient PSUs, fans, and other main electronic components for data processing and storage. Again, benchmarks such as SPEC SERT indicate energy performance for certain applications (13 worklets) and should be utilized.
3. **Product software components and configuration** – This includes software that supports virtualization, load balancing, appropriate power management and interoperability, capacity optimization options for storage, etc. Software requirements are difficult to address separately from hardware (and vice versa) – therefore tests and benchmark are useful indicators.
4. **Product operating conditions and energy management** – This aspect relates to the ASHRAE A1 and A2 allowances and follows the idea to reduce “extended system cooling on data centre room level” by conditioning the IT equipment for higher operating temperatures. Power management and load balancing is supporting the efficiency and reliability of this ecodesign approach. A new aspect is the “reuse of exhaust heat” – the higher the outlet temperature the better the reuse options.
5. **Resource efficiency requirements** – This requires modular designs e.g. for easy dismantling of useful components such as RAM, CPU, network controllers and storage capacity. It also addresses technologies for erasing storage media permanently and without physical damage, functional testing of used components (remaining lifetime diagnostic) as well as re-packaging / system integrating technologies. With respect to materials, there is a good chance to recover valuable materials from Lot 9 products due to its relatively high concentration of electronic components (e.g. on the populated printed circuit boards and storage media).
6. **Energy labelling** – Midterm target, requires considerable standardization for testing and evaluating the energy performance of products across the whole spectrum of Lot 9 equipment. A combination value integrating aspects such as dynamic range, specific worklets (functionality) and necessary configuration (redundancy) should be developed and considered in order to provide a fair comparison fundament.

1.5.1. Product information before and during the operation

1.5.1.1.Active State Information Criteria

A specific configuration might be optimal for one purpose (application) but not for another. This is why for instance the SPEC Server Efficiency Rating Tool (SERT) is testing different performance requirements (worklets). On an individual level, such tests provide useful information in conjunction with procurement processes where performance data for specific product configurations are needed.

It needs to be clear which kind of information can help the customer to select the most energy efficient configuration for the intended application of the server or storage unit. For this purpose, SPEC SERT, SNIA Emerald™ Power Efficiency Measurement Specifications or other kind of power and configuration benchmark data are key. It is widely accepted that performance measurement per Watt is the best way to measure energy efficiency.

The Lot 9 preparatory study recommends information requirements for active state efficiency criteria for enterprise servers and storage which should be published on the producer's website as defined by the different ENERGY STAR specifications presented in Table 1 and Table 2:

Table 1: ENERGY STAR Active State Efficiency Reporting for enterprise servers[10]

To qualify for ENERGY STAR, a Computer Server or Computer Server Product Family must be submitted for qualification with the following information disclosed in full and in the context of the complete Active State efficiency rating test report:

i. Final SERT rating tool results, which include the results files (both html and text format) and all results-chart png files; and

ii. Intermediate SERT rating tool results over the entire test run, which include the results-details files (both html and text format) and all results-details-chart png files.

Table 2: ENERGY STAR Active State Efficiency Reporting for enterprise storage[11]

The Active state performance shall be measured according to the SNIA Emerald™ Power Efficiency Measurement Specification Version 2.0.2: Section 7.4.3: Online Active Test.

1.5.1.2.Idle State Informaiton Criteria

The same argument that holds for active state information is also true for the idle state. On an individual level, tests like SPEC SERT or SNIA Emerald™ provide important information for procurement processes where performance data for specific product configurations are needed.

The Lot 9 study recommends that the idle state power of enterprise servers shall be measured and reported as required in the ENERGY STAR Program Requirements for Computer Servers Version 2.0 (Section 6.1 Idle State Testing).

As far as storage equipment is concerned, the Ready Idle state performance of storage equipment should be measured and reported as required in the ENERGY STAR Program Requirements for Data Centre Storage Version 1.0, according to the SNIA Emerald Power Efficiency Measurement Specification Version 2.0.2: Section 7.4.4: Online Ready Idle Test.

[10] Source : ENERGY STAR® Program Requirements Product Specification for Computer Servers Eligibility Criteria Version 2.0
[11] Source : ENERGY STAR® Program Requirements Product Specification for Data Center Storage Eligibility Criteria Version 1.0

1.5.1.3.Energy proportional design / Dynamic Range

Energy proportional design means that servers and storage equipment consume energy in proportion to the amount of work (load) performed. The system should have a low idle power, since no active workload is handled and should proportionally increase power consumption in conjunction with the work-load. In general, a good product has a larger dynamic range, meaning that the ratio between idle and max power is large. As the system is loaded, power consumption should gradually increase.

Below figure shows exemplary performance to power ratios for an older Intel Xeon-based HP ProLiant DL160 (2007)[12] where the dynamic range is about 1.6 and a more recent Fujitsu PRIMERGY RX300 S7 (2012)[13] where the factor is around 5[14].

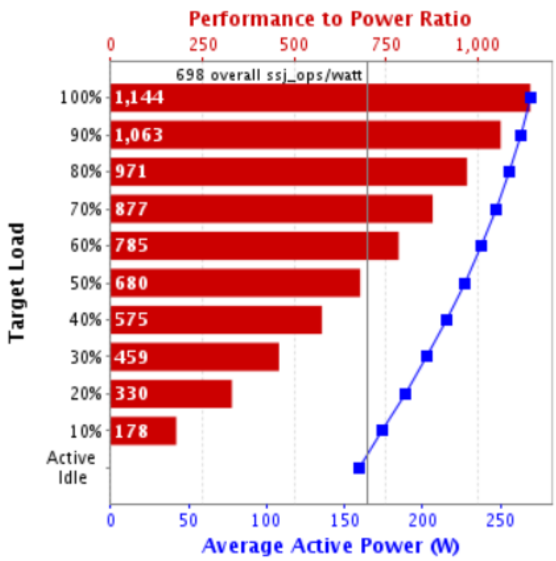

Figure 3 : Performance to Power Ratio for an exemplary server in 2008

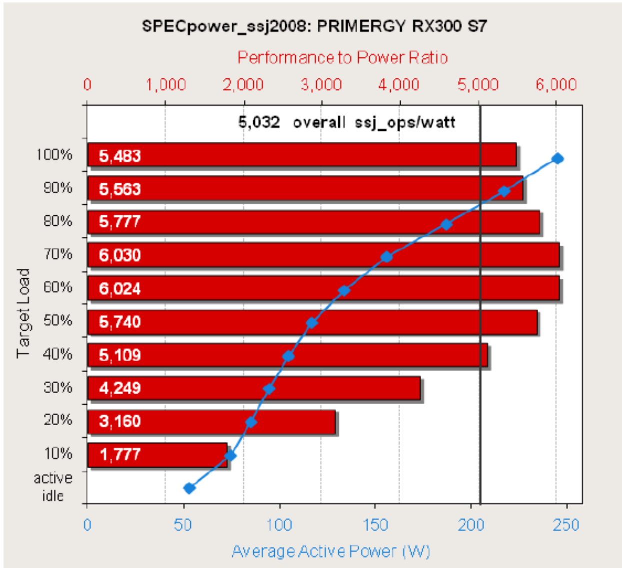

Figure 4: Performance to Power Ratio for an exemplary server in 2012

The low utilisation comes in first place from non-proportional energy consumption of different components like PSUs, memory, disks or network interfaces. Some of these components have a relatively low dynamic range of max power consumption as compared to idle power.

The performance/power relationship can be optimized at different points for different worklet types. E.g. CPU worklets show their best performance with an optimal amount of memory and storage. Furthermore, the best memory worklet scores can be found at the high end of GB capacity for a given machine type. The best storage scores depend to a large extent on an optimal number of drives matched to the capabilities of the processors. The performance and power use of a server are highly dependent on the specific mix of components such as technologies, number of threads, interface speeds, etc[15].

Overprovisioning has long been seen a required element of data centre architecture to ensure performance, availability and capacity. With increasing rack space scarcity and pressure on data centres to reduce their power consumption, overprovisioning can no longer be seen as a best practice.

It has been shown in Task 6 that overprovisioning can lead to significantly higher life-cycle costs and environmental impacts. The increasingly virtualized data centres need purpose-built storage solutions which are able to support a large number of Virtual Machines without wasting capacity.

For this reason, configurations which consume more energy but do not have higher performance should be avoided and precise hardware should be used for precise needs.

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[12] http://searchdatacenter.techtarget.com/news/1286006/SPEC-benchmark-measures-servers-performance-to-power-ratio

[13] http://globalsp.ts.fujitsu.com/dmsp/Publications/public/wp-performance-report-primergy-rx300-s7-ww-en.pdf

[14] Note that there are other aspects to be considered such as the 20% to 50% partial loads have been optimized – this aspect is typically not correctly covered by the dynamic range indicator

[15] https://www.energystar.gov/sites/default/files/specs/ITI%20Analysis%20of%20SERT%20Data.pdf

Defining application categories and respective hardware or software requirements would be helpful, but is a rather complex task (could not be done in the framework of the Lot 9 study). Next to the task of defining applications is the task to define (or describe) compute capacities and product configurations[16].

SERT Data complexity in the face of server configuration complexity illustrates that any performance/power metric for servers will have limitations in how it is used[17]. Overall operations-per-watt information is useful for a general comparison of the performance and power between different servers. However, this metric might be too broad when considering specific application scenarios or utilization levels. E.g. if the user knows that a server will be used in a heavily loaded environment, it is more important to compare the performance-to-power ratios of the server at higher utilizations and not focus as much on the overall performance–per-watt value. Furthermore, a simple dynamic range metric could provide a perverse incentive for manufacturers to increase max power rather than reduce minimum power, which would result in higher energy consumption. For this reason, dynamic range by itself may not be a sufficient indicator of product efficiency for both product information and product labelling.

The Lot 9 study recommends to consider elaborated requirements for a dynamic range that would be a reliable indicator for load-adaptiveness and a more efficient product. These requirements could be information requirements in a first step and would need to be further developed.

1.5.2. Product hardware components and configuration

1.5.2.1.Power Supply Efficiency

The efficiency of PSUs and particularly higher capacity PSUs has been improved during the past years to typical levels of over 85% and up to 90%.

The 80 PLUS certification enables manufacturers and their customers to compare and contrast different PSUs based on established criteria from ENERGY STAR and the Climate Savers Computing Initiative[18]. It differentiates five levels of efficiency, including Bronze, Silver, Gold, Platinum, and Titanium. In 2012, Dell became the first to achieve 80 PLUS Titanium-certification for a server power supply[19]. **Error! Reference source not found.** shows a summary of what is 80 PLUS certified.

[16] In one comment DIGITALEUROPE noted that “the concept of compute capacity is changing rapidly as processor cores are likely to become heterogeneous across a single processor, GPUs and/or other compute devices. In general, work per core will change and improve significantly from one generation to the next. GPUs and other compute devices will be used more extensively to augment specific compute operations. Any performance/power metric will need to consider compute capacity and the definition of compute capacity will need to be flexible so that it can encompass the impending expansion of processor capabilities.”

[17] In another comment DIGITALEUROPE stated that the “applicability of dynamic range highly depends on configuration, latency, response time and SLA requirements. It would require significant further study before being considered as an ErP product requirement. If the data is to be reported, it is important to clearly define which configuration(s) are to be used for reporting and to designate how to select the maximum power use from the results of the 12 SERT worklets. DIGITALEUROPE recommends the use of the 100% load level power measurement from the highest value of the 7 CPU worklets and the Hybrid_ssj worklet for servers and the maximum power use measured by the SNIA Emerald test specific to the storage system type (transaction, sequential or capacity). Where measurement data is not available, companies should be allowed to provide idle and maximum power estimates using power calculators or other, similar tools they offer to their customers.”

[18] http://www.thegreengrid.org/~/media/TechForumPresentations2010/TGG%20Tech%20Forum%20Presentation%20CSCI%20Final%20for%20posting.pdf?lang=en

[19] http://en.community.dell.com/dell-blogs/direct2dell/b/direct2dell/archive/2012/02/22/dell-first-to-achieve-80-plus-titanium-psu-energy-efficiency

Table 3: 80 PLUS certifications[20]

80 PLUS Certification	115V Internal Non-Redundant				115V Industrial			
% of Rated Load	10%	20%	50%	100%	10%	25%	50%	100%
80 PLUS	---	80%	80%	80% / PFC .90	---			
80 PLUS Bronze	---	82%	85% / PFC .90	82%	---			
80 PLUS Silver	---	85%	88% / PFC .90	85%	80%	85% / PFC .90	88%	85%
80 PLUS Gold	---	87%	90% / PFC .90	87%	82%	87% / PFC .90	90%	87%
80 PLUS Platinum	---	90%	92% / PFC .95	89%	85%	90% / PFC .95	92%	90%
80 PLUS Titanium	90%	92% / PFC .95	94%	90%	---			

80 PLUS Certification	230V EU Internal Non-Redundant				230V Internal Redundant			
% of Rated Load	10%	20%	50%	100%	10%	20%	50%	100%
80 PLUS	---	82%	85% / PFC .90	82%	---			
80 PLUS Bronze	---	85%	88% / PFC .90	85%	---	81%	85% / PFC .90	81%
80 PLUS Silver	---	87%	90% / PFC .90	87%	---	85%	89% / PFC .90	85%
80 PLUS Gold	---	90%	92% / PFC .90	89%	---	88%	92% / PFC .90	88%
80 PLUS Platinum	---	92%	94% / PFC .90	90%	---	90%	94% / PFC .95	91%
80 PLUS Titanium	90%	94% / PFC .95	96%	94%	90%	94% / PFC .95	96%	91%

[20] Source: http://www.plugloadsolutions.com/80pluspowersupplies.aspx#

It was shown in Task 6 that a switch from Silver to Gold, Platinum or Titanium can result in significant improvements in energy efficiency without impacting overall life cycle costs very much.

Specific efficiency requirements for power supply units are already part of the existing Regulation (EU) No 617/2013 on Ecodesign requirements for computers and computer servers. While blade systems, server appliances, multi-node servers and computer servers with more than four processor sockets are explicitly excluded from this Regulation, other computer servers (rack, tower, etc.) are concerned. The following tables show the PSU requirements as stated in Regulation (EU) 617/2013.

Table 4: Internal power supply efficiency requirements for computer servers as of Regulation 617/2013

Power Supply Type	Related Output Power	10% Load	20% Load	50% Load	100% Load
Multi-output (AC/DC)	All	NA	82%	85%	82%
Single-output (AC/DC)	<500W	70%	82%	89%	85%
	500W<X<1000W	75%	85%	89%	85%
	>1000W	80%	88%	92%	88%

Table 5: Power Factor Requirements for computer server PSUs according to Regulation 617/2013:

Power Supply Type	Related Output Power	10% Load	20% Load	50% Load	100% Load
Multi-output (AC/DC)	All	NA	0.80	0.90	0.95
Single-output (AC/DC)	<500W	NA	0.80	0.90	0.95
	500W<X<1000W	0.65	0.80	0.90	0.95
	>1000W	0.80	0.90	0.90	0.95

For comparison purposes, the following tables summarize the power supply requirements (efficiency and power factor) as formulated in the ENERGY STAR® Program Requirements for Computer Servers V2.0.

Table 6: Efficiency Requirements for PSUs according to ENERGY STAR requirements for servers

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

Table 7: Power Factor Requirements for PSUs according to ENERGY STAR requirements for servers

Power Supply Type	Rated Output Power	10% Load	20% Load	50% Load	100% Load
Multi-output (AC/DC)	All Output Levels	N/A	0.80	0.90	0.95
Single-output (AC/DC)	<500W	N/A	0.80	0.90	0.95
	500W<X<1000W	0.65	0.80	0.90	0.95
	>1000W	0.80	0.90	0.90	0.95

While power factor requirements for PSUs are identical in Regulation (EU) 617/2013 to those in the ENERGY STAR requirements for servers, efficiency criteria show some differences. When compared to 80 PLUS certification criteria, requirements set by Regulation (EU) 617/2013 find themselves in the 80 PLUS or 80 PLUS Bronze category for lower output power levels (<1000W), whereas ENERGY STAR requirements are situated in slightly higher categories (dependent on load levels).

As far as storage equipment is concerned, the Data Centre Storage Eligibility Criteria (Version 1.0) of ENERGY STAR state that a storage product PSU shall meet power factor requirements as specified the following tables.

Table 8: Efficiency Requirements for PSUs according to ENERGY STAR requirements for storage products

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

Table 9: Power Factor Requirements for PSUs according to ENERGY STAR requirements for storage products

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

When compared to the 80 PLUS certification tables in **Error! Reference source not found.**, these values correspond to a large extend to the 80 PLUS Bronze category for the 230V EU Internal Non-Redundant PSUs and to the 80 PLUS Silver category for the 230V Internal Redundant PSUs.

The Lot 9 preparatory study recommends first seeking for harmonisation with the existing EU Regulation No 617/2013 on ecodesign requirements for computers and computer servers and as a second step requiring higher standards for PSUs, such as 80 PLUS Silver in Tier 1 and 80 PLUS Gold in Tier 2, for both enterprise servers and storage. The time line could be set to 2018 for Tier 1 and 2022 for Tier 2.

Higher categories could be envisaged for single-output power supplies which could require 80 PLUS Gold in Tier 1 and 80 PLUS Platinum in Tier 2.

1.5.2.2.Reduction of Idle Power

There are a large number of servers which are unused and others that are spending a considerable amount of time in idle mode waiting for transaction requests. Several studies, such as the most recent one conducted by Koomey and Taylor (June 2015)[21], have estimated that 30% of installed servers are "comatose", meaning that they have not delivered any information or computing services for six months or more. Other relevant studies showing similar findings were conducted by McKinsey[22] and the Uptime Institute[23].

According to stakeholders, memory is often responsible for the majority of consumption in idle mode. Using lower power memory and powering down some memory in idle could lead to significant energy reductions in idle mode.

However, there are some opposed forces in play when products should be designed for high utilization (which means a lot of RAM capacity, I/O capacity and parallel computing CPU) on the one hand and should at the same time also have low idle power. Idle power is the sum of the power draw of the individual hardware devices (components). The more a product features (for high performance and utilization), the higher will be the basic load in idle.

If idle power needs to be reduced, it is most of the time necessary to shut off devices (e.g. the way it is done through standards such as ACPI in the field of PCs)[24]. The reactivation and synchronization of many devices takes time and could increase the failure rate[25].

A low idle power limit could therefore be biased to servers with low power, low core count, and low frequency processors which have a relatively low compute capacity and workload capability. Server efficiency is a function of the compute capacity, the ability to proportion power use to workload demand, and the ability to maximize the output, functionality and/or utilization of the server or storage product over time. In some cases, servers with a higher idle power demand are able to do significantly more work per unit of energy consumed. Limiting the market to low power servers might therefore have unintended consequences, as it would result in the need for significantly more servers to perform the workload on a range of complex and compute intensive workloads.

If energy efficiency benchmarks should be required for server and storage products, then the threshold requirements would need to:

- Be based on a performance/watt metric, specifically SPEC SERT (servers) or SNIA (storage), to properly characterize the functional capabilities of the product. Particularities need to be considered carefully: e.g. the SNIA Emerald Test does not reflect the impact of COMS on idle time.
- Use the ENERGY STAR product categories to differentiate the product types under server and storage products. These product categories recognize specific differences in product performance capabilities and power profiles which affect the ability to compare the capabilities and energy consumption of the products.

The ENERGY STAR programme defines Idle State Efficiency Criteria for One-Socket (1S) and Two-Socket (2S) Servers (neither Blade nor Multi-Node) as well as for Three-Socket (3S) and Four-Socket (4S) Servers (neither Blade nor Multi-Node). Table 10 shows idle state efficiency criteria for one and two socket servers according to ENERGY STAR Enterprise Servers Specification Version 2.0).

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[21] http://anthesisgroup.com/30-of-servers-are-sitting-comatose/

[22] Kaplan, James M., William Forrest, and Noah Kindler. 2008. Revolutionizing Data Center Efficiency McKinsey and Company. http://www.mckinsey.com/clientservice/bto/pointofview/pdf/revolutionizing_data_center_efficiency.pdf

[23] https://uptimeinstitute.com/research-publications/asset/comatose-server-savings-calculator

[24] In a comment ECOS noted that "it is not necessary to shut off components completely, most components now offer low-power states with very rapid resume times (C7 states on CPUs, hybrid drives etc.). In addition, not all servers need to be instantaneously ready-to-respond all the time. For example, groups of load-sharing web servers are sized to be able to handle peak-traffic, but the majority of them can be put in low-power modes most of the time, only being ready-to-respond when traffic requires it. The power generation electricity has been using the concept of spinning and non-spinning reserves for decades, the data centre industry also uses it to some extent. Its use needs to be encouraged by ensuring that servers are designed to save energy when this technique is utilised".

[25] In another comment ECOS stated that "failures to wake up were a known issue a decade or more ago, but recent technology no longer has this problem. An NRDC communication with a data centre software company whose solution powers down servers when unused and powers them back up when needed, indicated that the company had not seen a single failure to restart servers that are 5 years old or less, out of tens of thousands of production servers. Remnants of a legacy concern should not be a reason to dismiss a promising energy efficiency solution."

Table 10: Idle State Efficiency Criteria for one and two socket servers according to ENERGY STAR (V 2.0)

Category (as used in ENERGY STAR)	Maximum Possible Number of Installed Processors (#P)	Managed Server	Required by ENERGY STAR, SERT measures (W)
A	1	No	47
B	1	Yes	57
C	2	No	92
D	2	Yes	142
Resilient	2	Yes	205

Furthermore, the ENERGY STAR Enterprise Servers Specification Version 2.0 defines additional Idle Power Allowances for extra components such as additional power supplies, additional hard drives (including SSDs), additional memory, additional I/O devices, etc.

The first version of the ENERGY STAR Enterprise Servers Specifications had already requirements for Idle State Efficiency Criteria, which were higher. Table 11 shows idle state efficiency criteria for one and two socket servers according to ENERGY STAR Enterprise Servers Specification Version 1.0.

Table 11: Idle State Efficiency Criteria for one and two socket servers according to ENERGY STAR (V 1.0)

Category (as used in ENERGY STAR)	Maximum Possible Number of Installed Processors (#)	Managed Server	Required by ENERGY STAR, SERT measures (W)
A	1	No	55
B	1	Yes	65
C	2	No	100
D	2	Yes	150

Setting specific idle power thresholds for different enterprise servers and storage in the context of ecodesign is a complex task that requires an own in-depth investigation to get accepted statistics. Additional idle power allowances for extra components such as additional power supplies, additional hard drives (including SSDs), additional memory, additional I/O devices, etc. would also need to be elaborated.

In the case of enterprise servers and storage equipment, the Lot 9 preparatory study recognizes that the reduction of idle power consumption is an important factor that needs to be considered. At the same time, the Lot 9 study emphasises the complexity of the product group and recommends to further investigate possible idle power thresholds and specific additional idle power allowances for extra components. Alignment could be sought to older versions of the ENERGY STAR, such as V 1.0 for servers.

1.5.3. Energy requirement on the overall energy performance

The Lot 9 study recommends that - in case reliable measurement methods will permit to provide a quantitative ranking between products in the future - specific requirements on the overall energy performance could be envisaged.

Any specific requirements based on overall energy performance as measured by SERT or Emerald will require an understanding of the impact of component choice and configuration on the metric results and insure that products are properly categorized to deliver reasonable comparisons.

1.5.4. Product software components and configuration

Software aspects play a very important role in reducing energy consumption in data centres and should be part of ecodesign. However, they are rather difficult to address with testable requirements.

Better utilization can lead to reduction of power, cooling, network infrastructure, storage infrastructure or real estate requirements, which can result in significant energy savings and a reduction of the environmental impacts of data centres. Important aspects are:

- Interoperability with the operating system and applications
- Thermo-sensors providing information about settings
- Highly virtualised systems bringing advantages for deduplication
- Standardised description of the software (support of load transfer)

Green storage technologies such as Capacity Optimizing Methods (COMS) improve storage use by shrinking stored data and lead to a falling power consumption. The reduction of actual data stored on storage devices is usually achieved through a combination of hardware and/or software. The following figure shows the effects of green storage technologies.

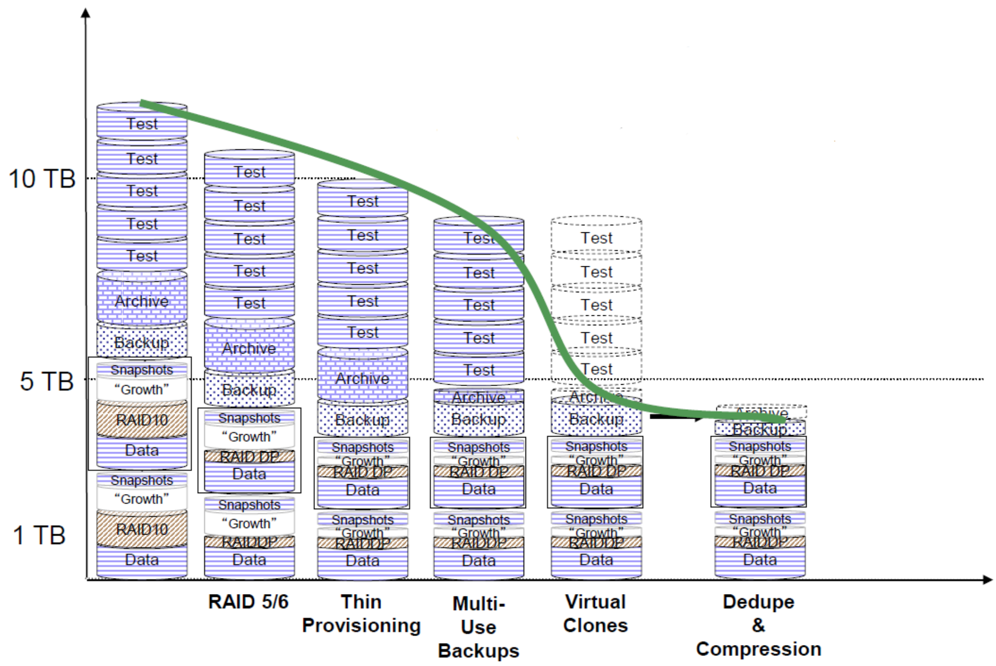

Figure 5: Effect of COM technologies[26]

It could be shown in Task 6 that Capacity Optimizing Methods (COMs) such as thin provisioning, data deduplication, compression, delta snapshots or parity RAID can lead to significant environmental improvements. Furthermore, every disk purchase that can be avoided, saves the operator both capital expenditure (equipment, footprint, conditioning and cooling) as well as operational expenditure (equipment power, conditioning and cooling power, storage management, service contract fees).

There exist already some ENERGY STAR requirements for Online 2, 3 and 4 systems. According to these requirements, a storage product should make available to the end user configurable or selectable features listed in Table 12 in quantities greater than or equal to those listed in Table 13.

[26] http://www.snia.org/sites/default/education/tutorials/2012/spring/green/AlanYoder_Green_Storage_Technologies.pdf

Table 12: Recognized COM Features

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

Table 13: COM requirements for Online 2, 3 and 4

Storage Product Category	Minimum number of COMs required to be made available
Online 2	0
Online 3	1
Online 4	1

Measurement guidelines for the SNIA verification test are available on the SNIA website[27].

Since potential ecodesign requirements would be set in several years after the completion of the preparatory study, the Lot 9 study recommends at this stage aligning ecodesign requirements to ENERGY STAR requirements as formulated in the ENERGY STAR Program Requirements Product Specification for Data Center Storage Eligibility Criteria Version 1.0 for Online 2, 3 and 4 systems. An important precondition for this measure is that these systems can be identified easily.

1.5.5. Product operating conditions and energy management

In the past, typical data centres were operated in a temperature range of 21°C to 24°C with a common notion of 'cold is better' in case of an internal cooling failure. Some of the main reasons for this behaviour could be found because of SLA's and warranties, legacy systems engineered to a certain temperature (e.g. 21°C) or over-engineered hot spot avoidance. Over the past years, data centre operators questioned the necessity for cooling the room temperature of the cold aisle to levels way below 27°C (max. recommended IT inlet temperature defined by ASHRAE). According to a data centre expert, data centre managers can save up to 4% in operational energy costs for every degree of upward change in the set point[28].

It was shown in Task 6 that significant environmental as well as cost savings can be possibly achieved by passing to a higher inlet temperature, such as ASHRAE Class A1 or A2.

While new servers and storage equipment are often already capable of working under ASHRAE A2 conditions (35°C inlet temperature), it has to be noted that these temperature and humidity specifications would affect all products in the data centre, including PDUs, network, storage and monitoring equipment. There are still potential reliability issues when storage equipment and storage media are run in the high end of the ASHRAE A2 limits. Nevertheless, as could be shown in a recent white paper by ASHRAE, most of the storage array products are able to handle temperatures higher than ASHRAE Class A1 equipment[29].

While all data centre equipment is nowadays normally able to run under ASHRAE A1 conditions without any restrictions, smaller adjustments might be necessary to pass on to Class A2 requirements. These adjustments could e.g. concern the design or the configuration of uninterruptible power supplies and power distribution units[30]. Furthermore, the implication on network equipment needs to be further investigated, although networking equipment is usually designed for telecommunications and outdoor situations and should therefore be able to handle these higher inlet temperatures. In its latest version, the Best Practices for the EU Code of Conduct on Data Centres recommend an ASHRAE Class A2 environment for the entire data centre[31].

The Lot 9 preparatory study recommends considering a higher inlet temperature, such as the ASHRAE Class A1 allowable temperature and humidity range. The possible timing for implementing the measure could be 2018. As a further step, the ASHRAE Class A2 allowable temperature and humidity range could be targeted in a Tier 2 around 2022.

Besides reliability issues, other factors such as the acoustical noise from higher fan speed, corrosion from higher temperature and humidity changes, possible performance loss due to inappropriate thermal management, etc. are influencing the data centre operating envelope and should be considered.

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[27] http://snia.org/sites/default/files/UserGuide_Emerald_Power_Efficiency_Measurement_Spec_V_2_0_r3_0.pdf

[28] http://www.datacenterknowledge.com/archives/2008/10/14/google-raise-your-data-center-temperature/

[29] ASHRAE TC9.9 Data Center Storage Equipment – Thermal Guidelines, Issues, and Best Practices Whitepaper prepared by ASHRAE Technical Committee (TC) 9.9 Mission Critical Facilities, Data Centers, Technology Spaces, and Electronic Equipment available at http://tc99.ashraetcs.org/documents/ASHRAE_Storage_White_Paper_2015.pdf, see page 28.

[30] Since e.g. temperature sensors and fuses for fire prevention are sometimes set to 40°C which might create hot spots.

[31] http://iet.jrc.ec.europa.eu/energyefficiency/sites/energyefficiency/files/best_practices_v4_0_5-r1.pdf

1.5.6. Resource efficiency requirements

Reuse and recycling play a crucial part in the EU's strategy towards a circular economy. Although the Ecoreport outcomes showed that the environmental impact of server and storage equipment is mainly determined by the power consumption in the use phase, the end-of-life phase plays an important role. End-of-life aspects for servers and storage equipment are strongly linked to the modular design of the equipment, enabling relatively easy dismantling of useful components such as RAM, CPU, network controllers and storage capacity.

Since enterprise servers and storage equipment are B2B products and leasing as well as take back programs are often in place, several best practices like (colour) coding of replaceable components (hot swapping) or instructions for decomposition already exist for most of the products on a broader scale.

Original equipment manufacturers (OEM) of enterprise server and storage are aware of the economic value of their products and have developed their own end-of-life policies to optimise reuse of components and waste reduction.

1.5.6.1. Requirements on dismantling, re-use and recycling

In their study, using almost the same bill of materials as the Lot 9 preparatory study, the JRC-IES showed that several server components such as main boards, processors, memory cards and data storage devices such as HDDs generate the major part of the environmental impact during the manufacturing phase[32]. As compared to the Lot 9 study, the JRC study also considered batteries in their bill of materials. Although not significant from a total environmental impact point of view, batteries underlie existing EU regulations which require their extraction.

Another important re-use aspect addresses data deletion of data storage equipment. Technologies for erasing storage media permanently and without any physical damage are already available and are called "Data Sanitization Methods"[33]. Reuse of storage media needs procedures that ensure the complete deletion while overcoming security issues. The existence of personal data on storage devices and the difficulties to safely transfer and/or delete such data is considered to be an important obstacle for more widespread reuse and refurbishment.

Functional testing of used components (remaining lifetime diagnostic) as well as re-packaging and system integrating technologies could positively contribute to the reduction of environmental impacts of Lot 9 products.

The Lot 9 study recommends that manufacturers should make sure that external enclosures of enterprise servers and storage should be removable by hand or with commonly available tools.

Furthermore, manufacturers should ensure that printed circuit boards (including main boards and memory cards), processors, data storage devices (such as HDD or SSD) and batteries should be accessible and removable by hand or with commonly available tools.

The deletion of data shall be ensured by standardised formatting procedures which guarantee data security.

1.5.6.2. Requirements for technical documentation

The simple provision of technical information can lead to resource savings at reuse and recycling. In this respect one of the main aspects concerns the location of precious metals such as copper, silver, gold or critical raw materials.

The Lot 9 study recommends that manufacturers and/or importers in the EU shall provide a report on resource efficiency which should contain relevant information addressing dismantling, reuse and recycling at the end-of-life of the product.

The report should be available on a website, be free of charge and come without restriction of access. It should contain at least an exploded-view drawing of the product, allowing to locate components and materials with special handling as well as a documentation of the dismantling operations.

[32] JRC-IES (2015). Environmental Footprint and Material Efficiency Support for product policy - Analysis of material efficiency requirements for enterprise servers, Draft report.

[33] Fisher, T. (2015) "Data Sanitization Methods. A List of Software Based Data Sanitization Methods."

In order to guarantee maintenance and upgrading, the latest version of firmware to test the functionality and compatibility between diverse components shall be available to companies dealing with maintenance, reuse and upgrading of servers (including brokers, spare parts repairer, spare parts provider and third party maintenance) through normal channels.

1.5.6.3. Critical raw material (CRM) voluntary declaration

As far as materials are concerned, there is a good chance to recover valuable materials from Lot 9 products due to its relatively high concentration of electronic components (e.g. on the populated printed circuit boards and storage media).

As has been shown in Task 5, products in scope of the Lot 9 preparatory study contain several critical raw materials such as Neodymium, Silicon Metal, Antimony or Cobalt. The main critical raw materials are located in HDD, diverse PCBs and connectors as well as in batteries. The most important weight of CRM is coming from Neodymium in the magnets of the HDD, followed by Silicon Metal in the die of integrated circuits and Cobalt in batteries. An example for material declaration concerning CRM is the Draft Regulation for electronic displays which includes the voluntary provision of the average amount of Indium contained in electronic displays.

The Lot 9 preparatory study recommends that manufacturers should provide voluntarily information about the location of critical raw materials (according to the EC list), in particular rare earths. Depending on the advancement in CRM research, this requirement could be made mandatory in the future.

1.5.6.4. Energy consumption of servers and storage with reused components

According to the European Waste Framework Directive, reuse is at the highest level of the waste hierarchy[34] and should also be promoted for servers and storage products. One possibility to do so would be through a bonus system that gives bonus points to products with reused parts in the calculation of e.g. energy efficiency indexes or in the assignment of potential energy labels.

The Lot 9 study recommends promoting the reuse of different components in enterprise servers and storage by a standardized incentive scheme. Such a scheme could consist in a bonus system which attributes bonus points to servers and storage equipment that contain reused components.

1.5.7. Energy labelling

Energy labelling could be considered as a midterm target, since it requires that standardization for testing (e.g. SERT) and evaluating the energy performance of products across the whole spectrum of Lot 9 equipment is in an advanced state.

For this purpose, a combined value which integrates different aspects such as the dynamic range, specific worklets (functionality) and necessary configuration (redundancy) has to be developed and should be considered in order to provide a fair fundament for comparison.

Major opportunities for energy labelling are that metrics such as SPEC SERT are available and that ENERGY STAR Program Requirements for Computer Servers and Storage already exist and continue to progress. Furthermore, standards such as the NSF *Environmental Leadership Standards for Servers* and IEEE P1680.4 *Standard for Environmental Assessment of Servers* are under development.

Challenges with respect to energy labelling can be seen in the time that is needed to set up the label, which might require several server generations, making it difficult to keep pace with technological change.

[34] Directive 2008/98/EC on waste, European Parliament, 2008

2.Scenario analysis

Disclaimer: Projections were estimated until 2030, as required by the Methodology for the Ecodesign of Energy-related Products (MEErP). However, one has to keep in mind that the equipment under consideration is undergoing very fast technological changes and that long-term projections are subject to high uncertainties and should therefore be considered with caution.

In order to study possible effects on energy consumption and expenditures during the period 2015 – 2030, six different scenarios were modelled:

- Worst case scenario with no technological improvement (FREEZE)
- Ambitious Business as Usual Scenario (BAU_Amb)
- Conservative Business as Usual Scenario (BAU_Con)
- Least Life Cycle Cost Scenario (LLCC_2015)
- Best Available Technology Scenario (BAT_2015)
- Policy Scenario (Policy)

Inputs related to the stock, sales, replacement and lifetimes were taken from Task 2. Information on energy consumption, product prices and operating costs for each design option are extracted from Task 6.

The FREEZE scenario represents the worst case scenario and is based on the hypothesis that the Base Cases remain unchanged and that no efficiency improvements through technological progress will occur in the future. The BAU_Amb scenario assumes that the PUE decreases continuously from 2.0 (BAU assumption) to 1.5 in 2030. BAU_Con scenario assumes that the PUE decreases continuously to 1.8 in 2030 (see Figure 6).

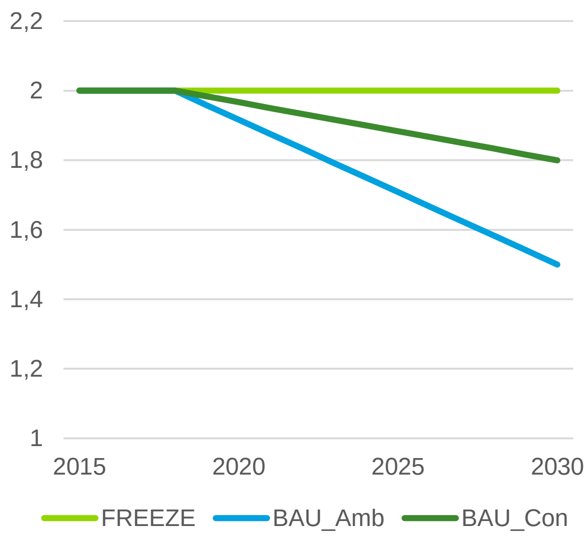

Figure 6: PUE Assumptions for FREEZE & BAU

The Least Life Cycle Cost (LLCC_2015) scenario takes up the design option with the least cost throughout the whole life cycle, taking into account both purchase costs and discounted operating costs. This scenario does not undergo any technological improvements in time. The Best Available Technology (BAT_2015) scenario is a combination of different design options, where total energy savings are not the simple sum of the different design options, but result from their interaction. Like the LLCC_2015 scenario, this scenario does not undergo any improvements in time[35].

For the Policy scenario, two different points in time were considered for the introduction of sequential policies: Tier 1 in 2018 and Tier 2 in 2022. Tier 1 was set according to the estimated time needed after the preparatory study to finalise an eventual Regulation. Tier 2 was estimated with respect to the product design cycles, but should be adapted accordingly during the Regulation process, to reflect technological advancements. The following table summarizes the assumptions for the different Base Cases:

[35] The _2015 affix means that these scenarios do not take into account efficiency improvements that occur in time.

Table 14: Policy Scenario for the different Base Cases

	PSU		ASHRAE		COMS	
	Tier 1 (2018)	Tier 2 (2022)	Tier 1 (2018)	Tier 2 (2022)	Tier 1 (2018)	Tier 2 (2022)
BC1 – Rack Server	Balanced Mode 80+ Silver	On/Standby Mode 80+ Gold	A1	A2	-	-
BC2 – Blade System	Balanced Mode 80+ Silver	On/Standby Mode 80+ Gold	A1	A2	-	-
BC3 – Storage	Balanced Mode 80+ Silver	Balanced Mode 80+ Gold	A1	A2	X	X

2.1. Analysis on the 2015-2030 horizon

This section shows the different outputs of the scenario analysis for the horizon 2015-2030:

2.1.1. Base Case 1 (Rack Server)

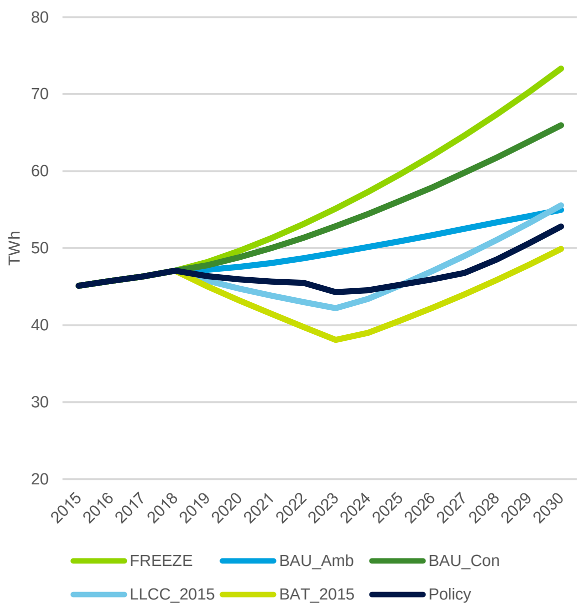

Figure 7 : Total electricity consumption for Base Case 1 (Rack Server) in TWh

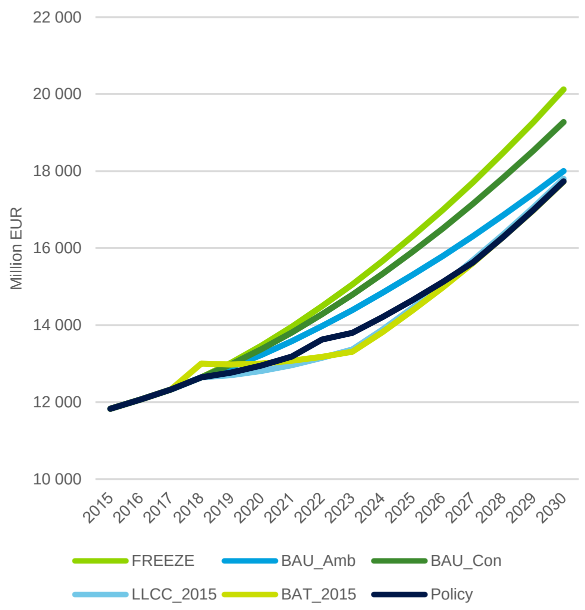

Figure 8 : Total expenditure for Base Case 1 (Rack Server) in M EUR

The analysis shows that an annual electricity consumption of around 45 TWh can be attributed to Base Case 1 (Rack Server) in 2015. The FREEZE scenario suggests that in case of no improvement in energy efficiency, this amount will increase significantly in the next years, reaching a level of 73 TWh by 2030 (+62%). The two BAU scenarios follow the simplifying hypothesis that until 2018 there are no energy efficiency gains through technological improvements and that from 2018 on, the PUE decreases steadily to 1.5 in 2030 in the ambitious scenario and to 1.8 in the conservative scenario.

The BAT and LLCC scenarios show that total energy consumption decreases significantly after 2018, since the rising consumption from the continuously increasing stock can be compensated by more efficient equipment that is substituting the old one. After a lifetime of around 4 years this substitution process stops, since all non-BAT or non-LLCC equipment has been replaced. From 2022/23 total electricity consumption rises again, driven by continuously increasing demand.

The Policy measures are able to compensate the increasing electricity consumption from rising demand for the first and second lifecycle (until 2022/23 and 2026/27, based on a 4 year lifecycle assumption). After 2026/27, meaning as soon as all 'less efficient equipment' has been substituted by 'more efficient equipment', electricity consumption takes up again as a consequence from increasing demand.

Comparing the Policy scenario to the BAU_Con and BAU_Amb scenarios in the following table shows the differences in electricity consumption for the years 2020, 2025 and 2030.

Table 15: Comparison between the BAU Scenarios and the Policy Scenario (in TWh) for BC-1

Year	Policy Scenario	BAU_Con	∆ Policy-BAU_Con	% Policy-BAU_Con	BAU_Amb	∆ Policy-BAU_Amb	% Policy-BAU_Amb
2020	45.9	48.8	-2.9	-6%	47.6	-1.6	-3%
2025	45.2	56.1	-10.9	-19%	50.9	-5.7	-11%
2030	52.8	66	-13.2	-20%	55	-2.2	-4%

Electricity savings related to the Policy scenario as compared to the two BAU scenarios can vary between 3% and 6% in 2020 and between 11% and 19% in 2025. The 2030 scenario is subject to high uncertainty and shows savings in the range of 4% and 20%. The following table shows the related monetary expenditures in million EUR.

Table 16: Comparison between the BAU Scenarios and the Policy Scenario (in M EUR) for BC-1

Year	Policy Scenario	BAU_Con	∆ Policy-BAU_Con	% Policy-BAU_Con	BAU_Amb	∆ Policy-BAU_Amb	% Policy-BAU_Amb
2020	13 027.7	13 372.8	-345.1	-3%	13 229.3	-201.6	-2%
2025	14 795.1	15 908.4	-1 113.3	-7%	15 305.1	-510.0	-3%
2030	17 923.0	19 276.5	-1 353.5	-7%	18 004.6	-81.6	0%

2.1.2. Base Case 2 (Blade System)

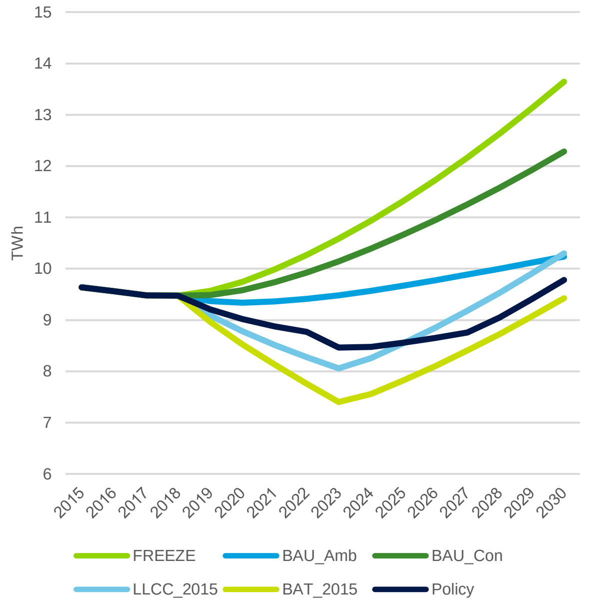

Figure 9 : Total electricity consumption for Base Case 2 (Blade System) in TWh

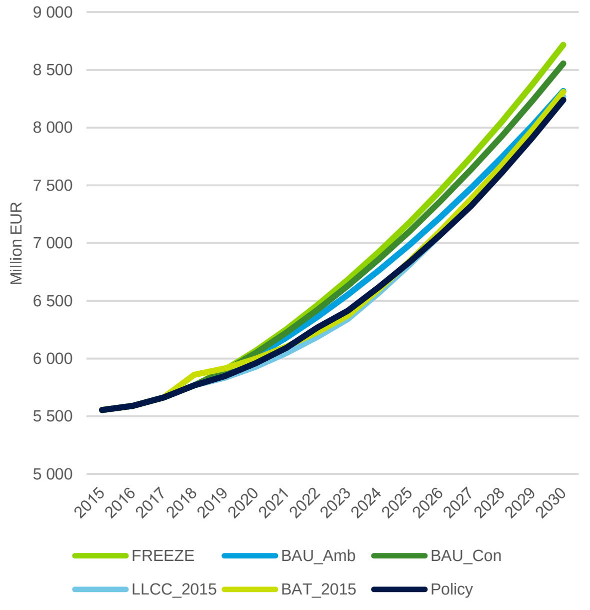

Figure 10 : Total expenditure for Base Case 2 (Blade System) in M EUR

The scenario analysis of the second Base Case (Blade System) shows that around 9.6 TWh of annual electricity consumption can be attributed to this product group in 2015. Total expenditures amount to around EUR 5.5 bn per year.

Again, the BAT and LLCC scenarios show that total energy consumption decreases significantly after 2018, as a result from the replacement by more efficient equipment. After a lifetime of around 4 years this process fades, when all non-BAT or non-LLCC equipment has been substituted. From 2022/23 total electricity consumption rises again, driven by continuously increasing demand.

The Policy measures again compensate increasing electricity consumption from rising demand for the first and second lifecycle (until 2022/23 and 2026/27, based on a 4 year lifecycle assumption). After 2026/27 electricity consumption takes up due to increasing demand.

Comparing the Policy scenario to the BAU_Con and BAU_Amb scenarios in the following table shows the differences in electricity consumption for the years 2020, 2025 and 2030:

Table 17: Comparison between the BAU Scenarios and the Policy Scenario (in Twh) for BC-2

Year	Policy Scenario	BAU_Con	∆ Policy-BAU_Con	% Policy-BAU_Con	BAU_Amb	∆ Policy-BAU_Amb	% Policy-BAU_Amb
2020	9.0	9.6	-0.6	-6%	9.3	-0.3	-3%
2025	8.6	10.7	-2.1	-20%	9.7	-1.1	-12%
2030	9.8	12.3	-2.5	-20%	10.2	-0.5	-4%

Electricity savings related to the Policy scenario as compared to the two BAU scenarios can vary between 3% and 6% in 2020 and between 4% and 20% in 2030 due to increasing uncertainties. The following table shows the respective annual monetary expenditures in million EUR.

Table 18: Comparison between the BAU Scenarios and the Policy Scenario (in M EUR) for BC-2

Year	Policy Scenario	BAU_Con	∆ Policy-BAU_Con	% Policy-BAU_Con	BAU_Amb	∆ Policy-BAU_Amb	% Policy-BAU_Amb
2020	5 980.7	6 049.0	-68.2	-1%	6 020.3	-39.6	-1%
2025	6 874.5	7 103.4	-228.9	-3%	6 986.9	-112.4	-2%
2030	8 283.5	8 556.6	-273.1	-3%	8 315.9	-32.4	0%

2.1.3. Base Case 3 (Storage)

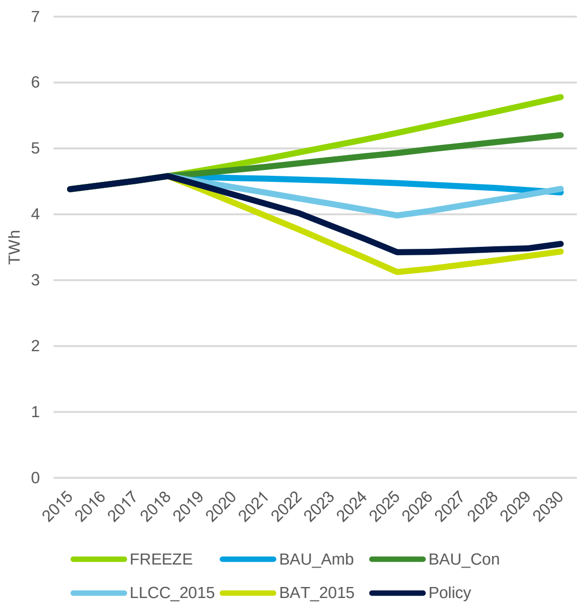

Figure 11 : Total electricity consumption for Base Case 3 (Storage) in TWh

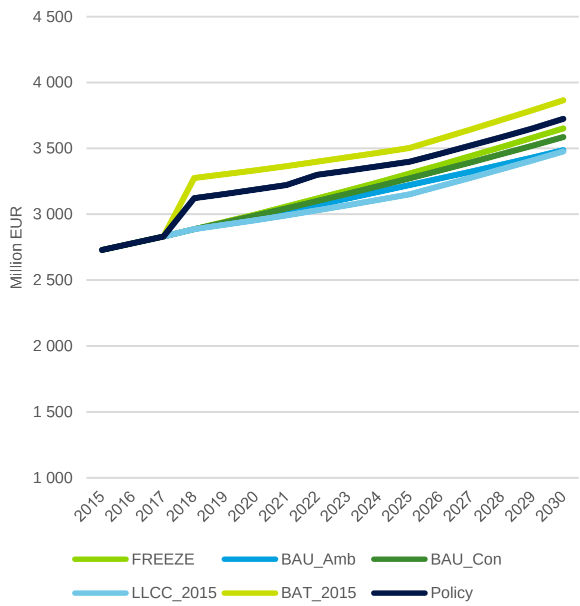

Figure 12 : Total expenditure for Base Case 3 (Storage) in M EUR

The electricity consumption of the storage Base Case is estimated at around 4.3 TWh per year in 2015 and to reach almost 6 TWh in 2030 in the FREEZE scenario. Cost are estimated to rise in the Policy and BAT scenario, but necessary initial expenditures (CAPEX) like in the Policy scenario can almost be compensated in the mid-term by reduced operating expenses (OPEX).

Energy consumption decreases again significantly after 2018 in the BAT and LLCC scenarios until equipment is substituted after around 6 years (lifetime of storage equipment). From 2024/25 total electricity consumption rises again in those scenarios, driven by continuously increasing demand.

The Policy measures compensate increasing electricity consumption from rising demand for the first lifecycle (until 2024/25, based on a 6 year lifecycle assumption). After 2026/27 electricity consumption takes up slowly.

Comparing the Policy scenario to the BAU_Con and BAU_Amb scenarios in the following table shows the differences in electricity consumption for the years 2020, 2025 and 2030.

Table 19: Comparison of savings between the BAU Scenarios and the Policy Scenario (in TWh) for BC-3

Year	Policy Scenario	BAU_Con	∆ Policy-BAU_Con	% Policy-BAU_Con	BAU_Amb	∆ Policy-BAU_Amb	% Policy-BAU_Amb
2020	4.2	4.6	-0.4	-9%	4.5	-0.3	-7%
2025	3.3	4.8	-1.5	-31%	4.4	-1.0	-25%
2030	3.5	5.1	-1.6	-31%	4.2	-0.8	-17%

Electricity savings related to the Policy scenario as compared to the two BAU scenarios can vary between 7% and 9% in 2020 and between 17% and 31% in 2030, due to increasing uncertainties. The following table shows the related monetary expenditures in million EUR.

Table 20: Comparison of savings between the BAU Scenarios and the Policy Scenario (in M EUR) for BC-3

Year	Policy Scenario	BAU_Con	∆ Policy-BAU_Con	% Policy-BAU_Con	BAU_Amb	∆ Policy-BAU_Amb	% Policy-BAU_Amb
2020	3 180.6	2 980.4	200.1	7%	2 967.0	213.6	7%
2025	3 395.4	3 262.7	132.7	4%	3 210.9	184.5	6%
2030	3 722.4	3 573.6	148.8	4%	3 475.6	246.8	7%

It was argued from the industry that the chosen base case might be not representative for most of the storage systems used in (large) data centres and that this base case excludes high end OL-3 systems which will have more than two drawers of devices and all OL-4 systems which have much higher storage media counts and dual controllers and power supplies. It is likely that especially larger OL-3 products and OL-4 products are much more complex than the proposed base case (which is rather a virtual average Online-2/Online-3 product) and have different power profiles, since they are application specific. However, the idea behind a base case is not to represent a real life product, but rather a theoretical product that can be used to evaluate the overall environmental impact.

The Base Case was constructed based on market data provided to the project team by the industry during the consultation process. Data for 2012 (Base Case) is recalled in the following table:

Table 21 : Storage Capacity Sold In Europe in 2012 (Source: DIGITALEUROPE)

Storage Class	TB Capacity	Unit Sales	Average TB/Unit
Online 1&2	3,369,851	125,624	26.8
Online 3	1,555,820	38,836	40.1
Online 4	660,240	5,004	131.9
Online 5&6	905,632	2,817	321.5

The main focus of the project team was on volume products, which are represented by Online 2 and Online 3 products, since Online 1 products are considered to cover consumer components. As can be seen in the table, in 2012 an Online 3 unit had an average capacity of around 40 TB, which is also the case of the chosen Base Case. While smaller entry level systems have the highest unit count and percentage of sales, their power consumption is a smaller percentage of the total power use for storage products. The considered Base Case covers around 54% of total market sales, but might only cover around 30% of total electricity consumption. **For this reason, the total electricity consumption related to storage equipment can be estimated to around 15 TWh in EU-28.**

2.1.4. Base Cases 1+2+3

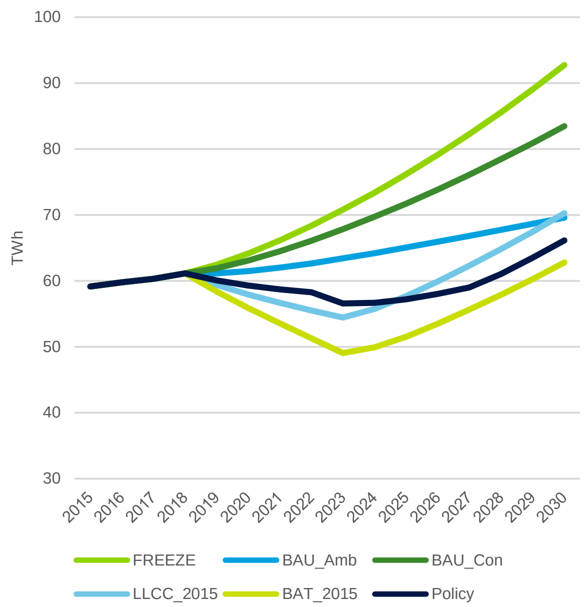

Figure 13 : Total electricity consumption for Base Cases 1+2+3 in TWh

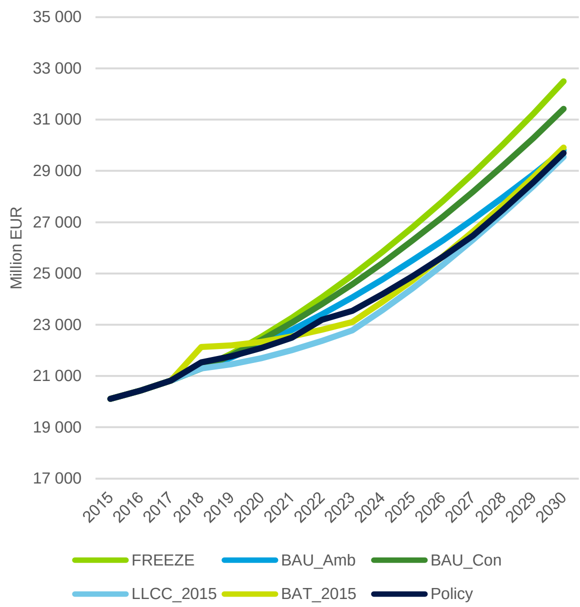

Figure 14 : Total expenditure for Base Cases 1+2+3 in M EUR

Estimated 60 TWh are consumed by the three combined Base Cases in EU-28 in 2015. This consumption is projected to increase to more than 90 TWh in 2030 (+30%) in the FREEZE scenario. The different scenarios suggest, that significant energy as well as cost savings are possible.

The BAT and LLCC scenarios show that total energy consumption decreases quickly after its introduction in 2018, since the soaring consumption from the continuously increasing stock can be compensated by more efficient equipment through the substitution process. After a lifetime of 4-6 years (depending on the equipment) this substitution process comes to an end, since all non-BAT or non-LLCC equipment has been replaced. From 2022/23 total electricity consumption rises again, driven by continuously increasing demand.

The Policy measures are able to compensate increasing electricity consumption from rising demand for the first lifecycle (until 2022/23) as well as for the second lifecycle (until 2026). After 2026/27, meaning as soon as all equipment introduced after Tier 1 has been substituted by more efficient equipment introduced after Tier 2, electricity consumption takes up again as a consequence from increasing demand.

The Policy scenario suggests that in 2025 total electricity consumption can be reduced by 20% as compared to the BAU_Con and by 12% as compared to the BAU_Amb scenario. Comparing the Policy scenario to the BAU_Con and BAU_Amb scenarios in the following table shows the differences in electricity consumption for the years 2020, 2025 and 2030:

Table 22: Comparison of savings between the BAU Scenarios and the Policy Scenario (in TWh) for the three BC

Year	Policy Scenario	BAU_Con	∆ Policy-BAU_Con	% Policy-BAU_Con	BAU_Amb	∆ Policy-BAU_Amb	% Policy-BAU_Amb
2020	59.2	63.0	-3.8	-6%	61.4	-2.2	-4%
2025	57.1	71.6	-14.5	-20%	65.0	-7.9	-12%
2030	66.1	83.4	-17.3	-21%	69.5	-3.4	-5%

Electricity savings related to the Policy scenario as compared to the two BAU scenarios can vary between 4% and 6% in 2020 and between 12% and 20% in 2025. The 2030 scenario, which underlies high uncertainties shows possible savings between 5% and 21%. The following table provides the related monetary expenditures in million EUR, showing that the energy savings are accompanied by cost savings of up to 5%.

Table 23: Comparison of savings between the BAU and the Policy Scenario (in M EUR) for the three BC

Year	Policy Scenario	BAU_Con	∆ Policy-BAU_Con	% Policy-BAU_Con	BAU_Amb	∆ Policy-BAU_Amb	% Policy-BAU_Amb
2020	22 189.0	22 402	-213.2	-1.0%	22 217	-27.6	-0.1%
2025	25 065.0	26 274	-1 209.5	-4.6%	25 503	-437.9	-1.7%
2030	29 928.9	31 407	-1 477.7	-4.7%	29 796	132.9	0.4%

Based on overall findings and an extrapolation from the three analysed Base Cases, the Lot 9 study estimates that total electricity consumption of data centres in EU-28 amounts to around 78 TWh (servers, storage and network equipment combined) in 2015. Compared to an EU-28 electricity generation of 3101 TWh in 2013[36], this is equivalent to around 2.5%.

This order of magnitude can be supported by a recent study from NRDC which found that in 2013, U.S. data centres consumed an estimated 91 TWh of electricity[37]. In 2015, around 660 000 data centres existed in Western Europe, as compared to 740 000 in the US and 3.3 million worldwide[38]. According to Gartner, "Data centre systems spending is projected to reach $143 billion in 2015, a 1.8 percent increase from 2014"[39]. Considering that around 20% of the worldwide data centres are located in Europe, data centre system spending should be around $28.5 billion (=$143 billion * 20%; including servers, storage and networking) in the EU.

[36] http://ec.europa.eu/eurostat/statistics-explained/index.php/Electricity_production,_consumption_and_market_overview
[37] http://www.nrdc.org/energy/data-center-efficiency-assessment.asp
[38] Including Single, Rack/Computer Room, Midsize DC, Enterprise DC, Large DC (Source: Gartner Forecast: Data Centers, Worldwide, 2010-2018, 2Q14 Update)
[39] http://www.gartner.com/newsroom/id/2959717

3. Impact analysis industry and consumers

The Ecodesign Directive states that ecodesign requirements should not entail excessive costs nor undermine the competitiveness of enterprises and should not have a significant negative impact on consumers or other users. This will be studied in detail in an Impact Assessment which can be commissioned by the European Commission at a later stage in the policy-making process.

However, major impacts that are likely to occur as a consequence of introducing Ecodesign measures are identified in a preliminary step of the analysis. In particular, this preliminary assessment addresses impacts on manufacturers and consumers of enterprise servers and storage equipment as well as impacts on innovation and development.

The market for enterprise servers and storage equipment is relatively concentrated, since there exist only a few worldwide acting manufacturers. These producers sell both volume servers and custom-designed servers which need to meet very specific requirements (e.g. for banks, telecoms, etc.). The maximum achievable energy efficiency will depends to a large extent on specific applications.

The variety of these applications is difficult to capture by means of the MEErP, which is the basis of the ecodesign preparatory study. As there is much variation in the potentially available and already implemented designs, it is not straight forward to create representative base cases.

Consequently, the additional costs and potential energy savings calculated in the policy and impact analysis need to be interpreted as estimates for average values, keeping in mind that specific cost and energy reductions will vary considerably from one product to another.

The following subsections describe several key points to be taken into account for a possible impact assessment.

3.1. Impacts on manufacturers and competition

As described in Tasks 3 and Task 4, the necessary technologies for potential improvements are already available on the market. For this reason, the implementation of the policy options would be technically feasible for all manufacturers and no further R&D investments should be required to achieve the discussed ecodesign options.

80 PLUS Silver, Gold or higher rated PSUs are available on the market for several years now and can be used with enterprise servers and storage equipment without any restrictions[40]. The industry stated that new equipment is already capable to function under ASHRAE A1 and most of the time also under ASHRAE A2 (except for some storage equipment) temperature and humidity conditions.

Several standardisation processes are under development (e.g. NSF 426 - Environmental Leadership Standards for Servers, IEEE P1680.4) which define environmental performance criteria for computer servers and it is likely that product manufacturers will refer to these standards to earn recognition in the consumer market.

Overall, Ecodesign measures are likely to have positive impacts on manufacturers, since demand for more efficient equipment will rise, leading to higher sales and turnover.

3.2. Impacts on consumers

More and better information about the specific performance of the products will provide consumers with valuable knowledge, helping them to optimise their existing stock and to purchase new equipment which fits their specific requirements. It will reduce overprovisioning and underutilisation and lead to not only more efficient but also to more effective deployment of the equipment.

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[40] The full list of available 80 PLUS certified PSUs and their respective manufacturers is available online : http://www.plugloadsolutions.com/80pluspowersupplies.aspx

Changes on the IT level (e.g. higher energy density) have to be matched to some extend on the rack and room level of the data centre. This might affect power distribution, uninterruptible power supply, network and control equipment, cooling and fire safety equipment which will require initial capital expenditures at some point in time. However, the life time savings gained through less energy consumption over the total operating life time can largely surpass the required operating expenses (OPEX).

3.3. Impacts on innovation and development

Ecodesign measures are likely to have a positive impact on innovation by pushing manufacturers to develop more efficient equipment. In April 2015, Moore's law celebrated its 50th birthday and according to chipmakers, it can keep on going "for at least another ten years, eventually slimming its transistors down to 5nm, about the thickness of a cell membrane."[41] As an alternative to shrinking circuitry ever further, different producers have started to stack components, building 3D chips.

Fields like cyber-physical systems, the Internet of Things and the Internet of Services (Industry 4.0), Big Data or Cloud Computing are growing at a very fast pace and require more and more computing power and storage capacity.

Mature 3D technologies might allow more functionality to fit into smaller space. Quantum computers could change the way how operations on data will be performed and optical computing can lead to higher performance and less energy consumption. These are all potential technologies that can be enhanced by Ecodesign measures.

Ecodesign can also set incentives for better recycling and reuse, since it can define requirements that will lead to the creation of new markets (e.g. development of equipment to test for reuse-time).

[41] http://www.economist.com/news/business/21648683-microchip-pioneers-prediction-has-bit-more-life-left-it-ever-more-moore

4.Sensitvity analysis of the main parameters

In Task 2, average energy data was determined for the different Base Cases. Given the high uncertainty that is linked to the definition of “average” products, the sensitivity analysis will consider the following error margins:

- +/- 2% for the discount rate
- +/- 50% for the electricity prices, as proposed in MEErP
- +/-20% for the lifetime

The tested values are presented in the following table:

Table 24: Parameters of the sensitivity analysis

	Min	Reference value	Max
Discount rate range for sensitivity analysis			
BC1 – Rack Server BC2 – Blade System BC3 – Storage	2%	4%	6%
Electricity price range for sensitivity analysis			
BC1 – Rack Server BC2 – Blade System BC3 – Storage	0.06€/kWh	0.12€/kWh	0.18€/kWh
Lifetime range for sensitivity analysis (in years)			
BC1 – Rack Server	3.2	4	4.8
BC2 – Blade System	3.2	4	4.8
BC3 – Storage	4.8	6	7.2

With respect to the first two parameters (economic parameters), the sensitivity analysis was conducted only on the LCC, whereas the last also shows the effect of product lifetime additionally on overall energy consumption.

The results of this sensitivity analyses are presented below for each of the three Base Cases. Design Options are grouped according to their magnitude so as to facilitate legibility.

4.1. Base Case 1 (Rack Server)

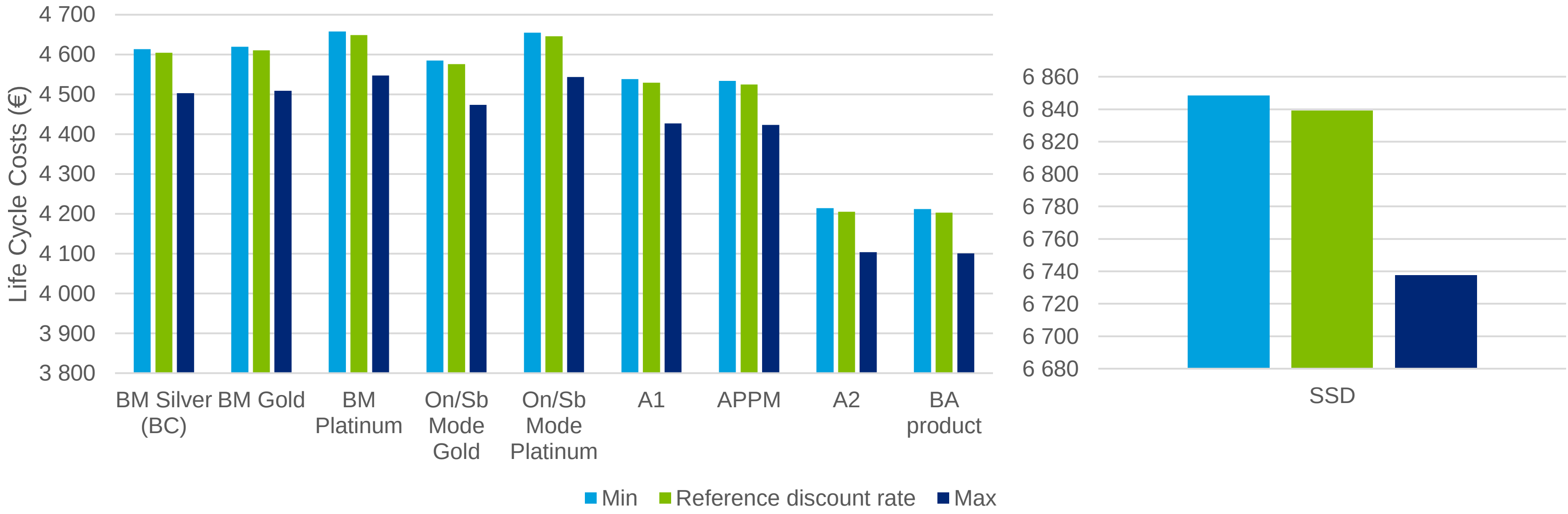

Figure 15: BC1 – Effect of a change in the discount rate on LCC

An increase in the discount rate to 6% leads to a drop in the present worth factor (PWF) and thus also to a decrease in LCC as can be seen from the figure above. The inverse is true for a decrease to 2% in the discount rate which, through the PWF, tends to increase the LCC of the product. However, the figures remain with around -2% for the increase in the discount rate and about 0.2% for the decrease negligible.

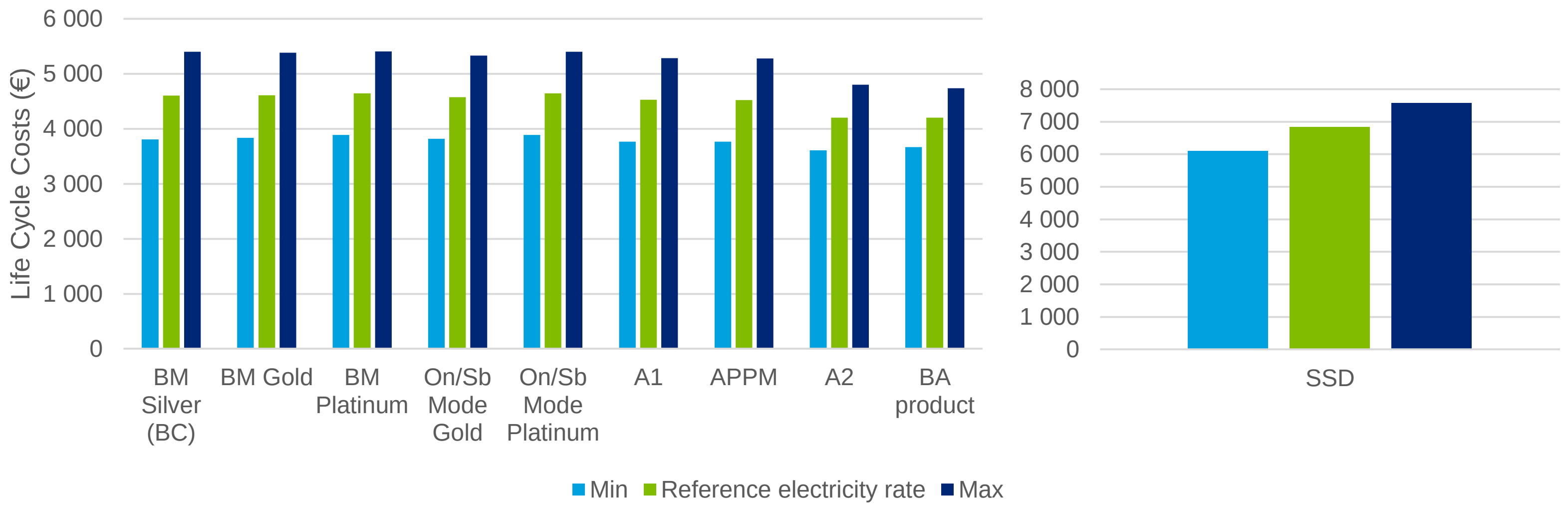

Figure 16: BC1 – Effect of a change in the electricity rate on LCC

A change in the electricity rate (+50%) results in a cost increase related to electricity consumption of 11-15%, while a 50% drop in the price of electricity results in LCC reductions (-15 to -21%).

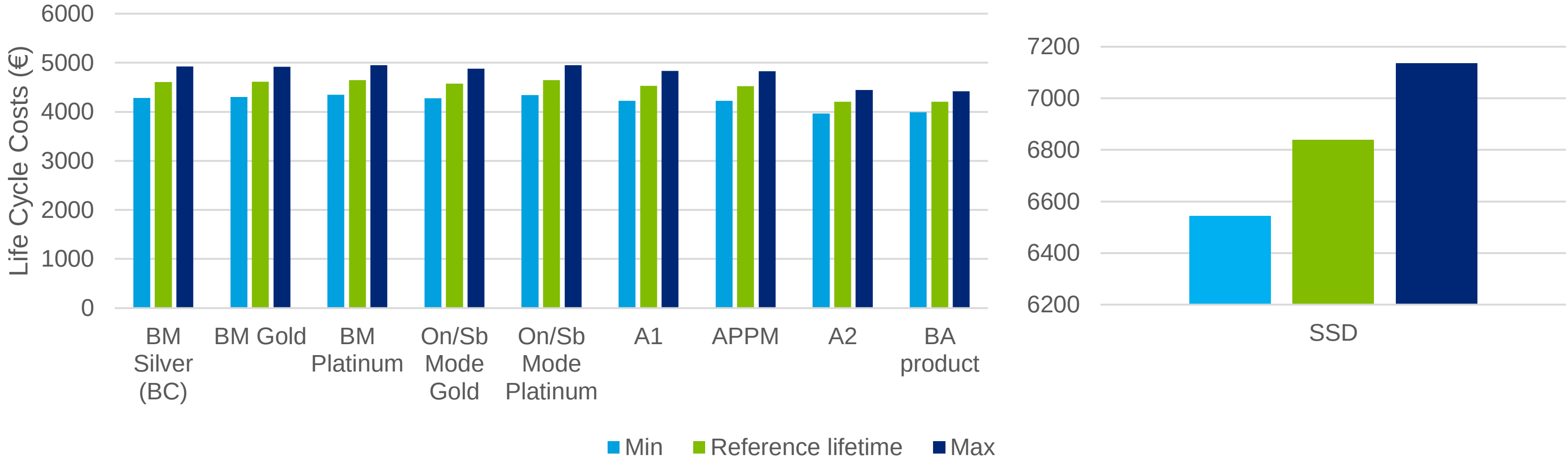

Figure 17: BC1 – Effect of a change in lifetime on LCC

A change of the lifetime of the product leads to a change in LCC in the same direction. Thus, a shorter lifetime results in reduced LCC (-5 to -7%), whereas an increase in the lifetime raises LCC by the same proportion of 5-6%.

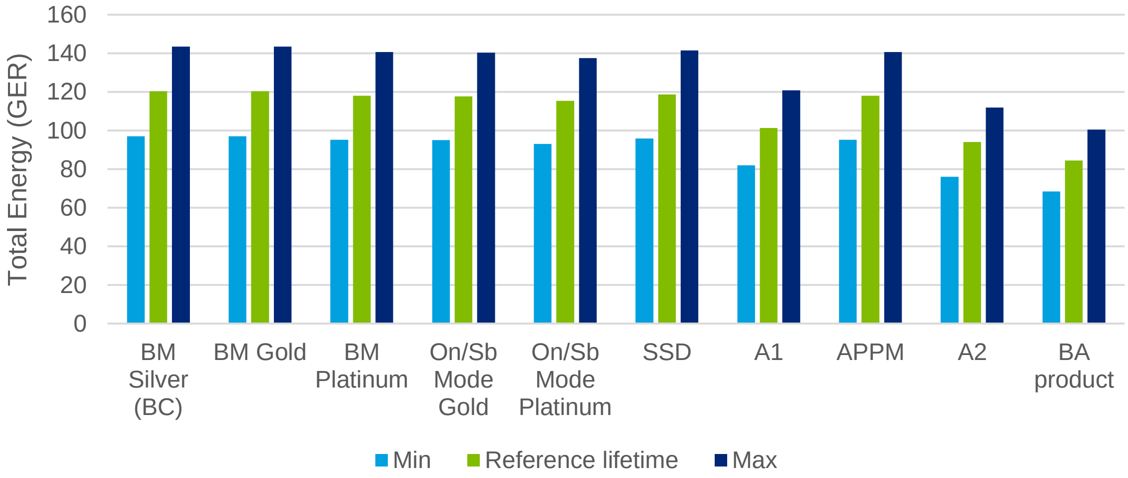

Figure 18: BC1 – Effect of a change in lifetime on total energy consumption (in GJ)

Figure 18 shows that an increase in the lifetime of the product (+20%) entails an increase in the total energy consumption (+16%), while a decrease induces a diminished energy consumption (-23 to -24% for the various design options) over the lifetime of the product.

4.2. Base Case 2 (Blade System)

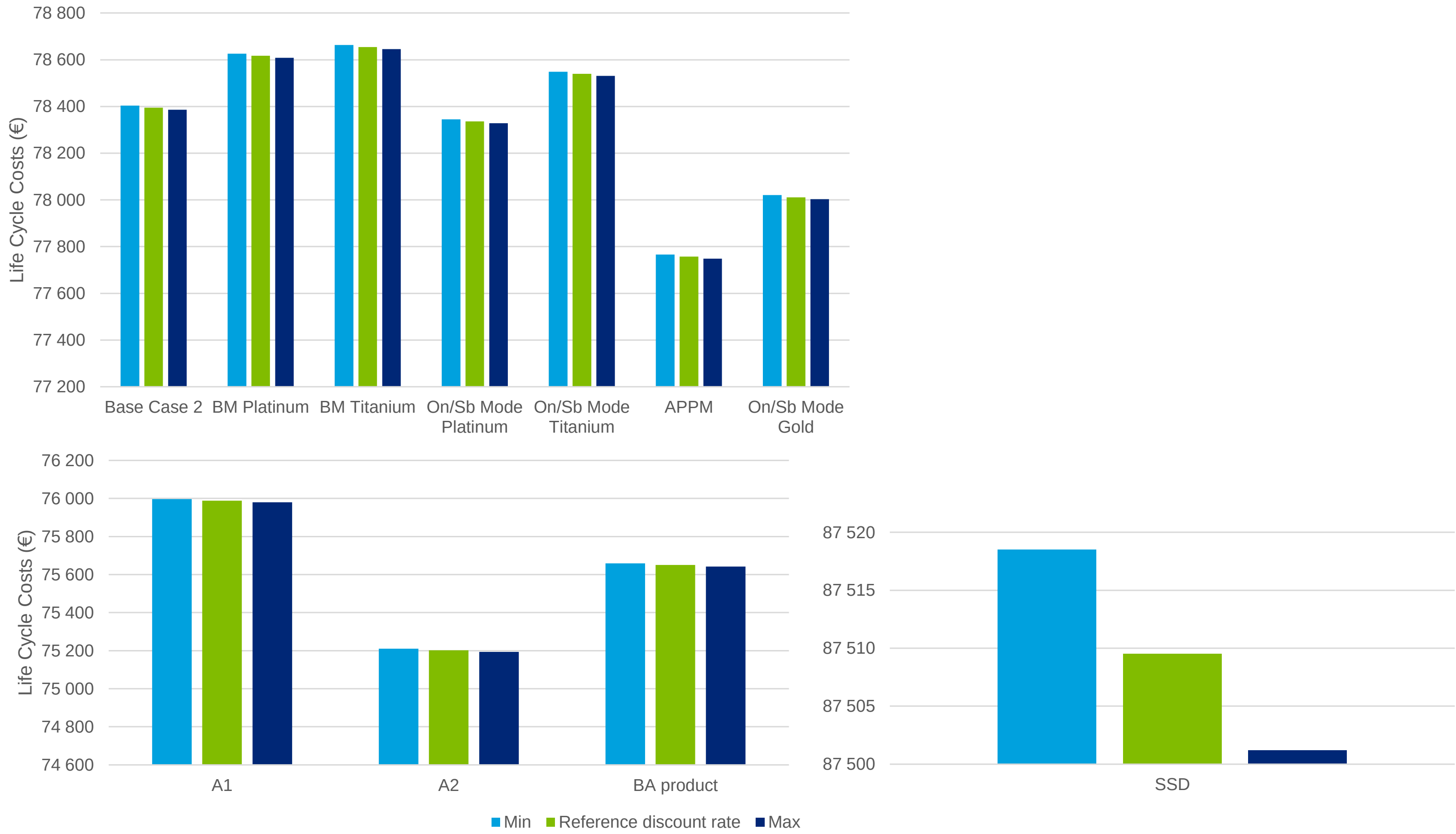

Figure 19: BC2 – Effect of a change in the discount rate on LCC

A rather important change in the discount rate entails once more negligible results of +/-0.01% for the 2 percentage point decrease/increase. This is due to the relatively short lifetime of the product considered that does not allow for the discount rate to exert a significant impact.

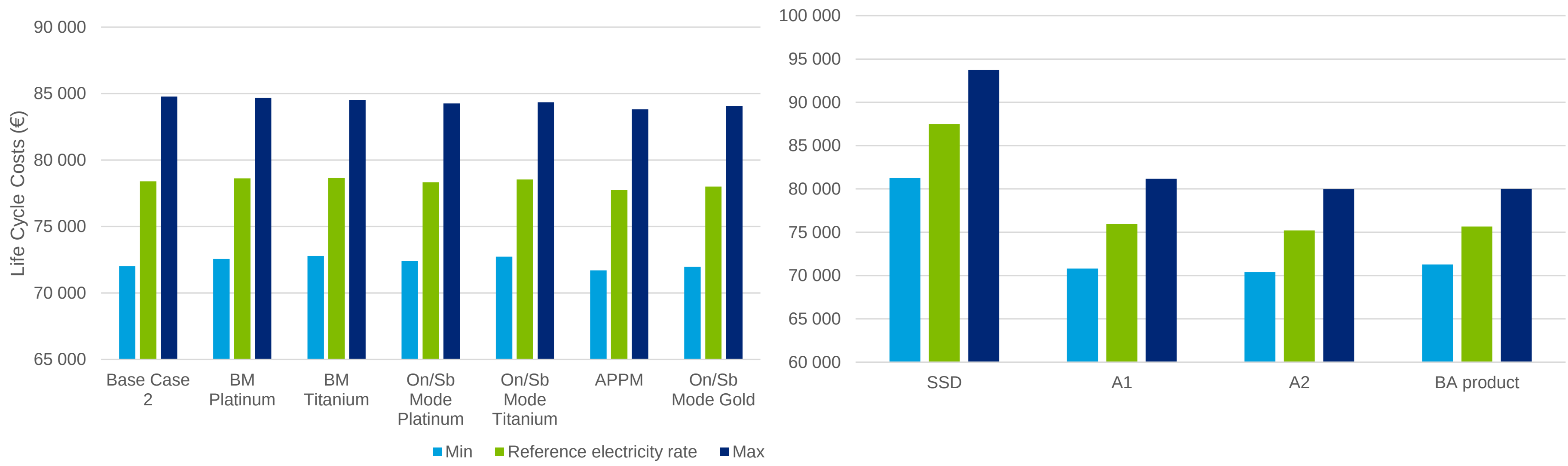

Figure 20: BC2 – Effect of a change in the electricity rate on LCC

A 50% increase in the electricity rate entails a 5-8% increase in the LCC of the product. The reduction in LCC resulting from a cut in electricity prices, on the other hand, is in the order with 6 to 9% slightly more accentuated.

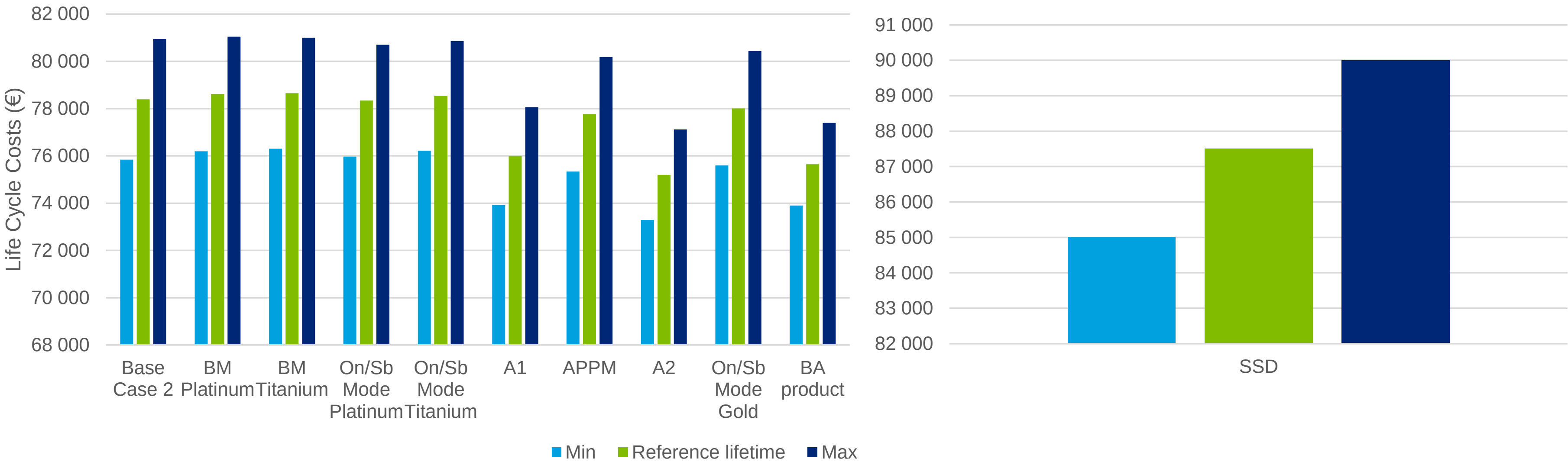

Figure 21: BC2 – Effect of a change in the lifetime on LCC

The change in the lifetime of the blade system from 4 to 4.8 years results in an increase of lifecycle costs by around 2-3%, while a reduced lifetime of 3.2 years is also of the same magnitude (- 2-3%).

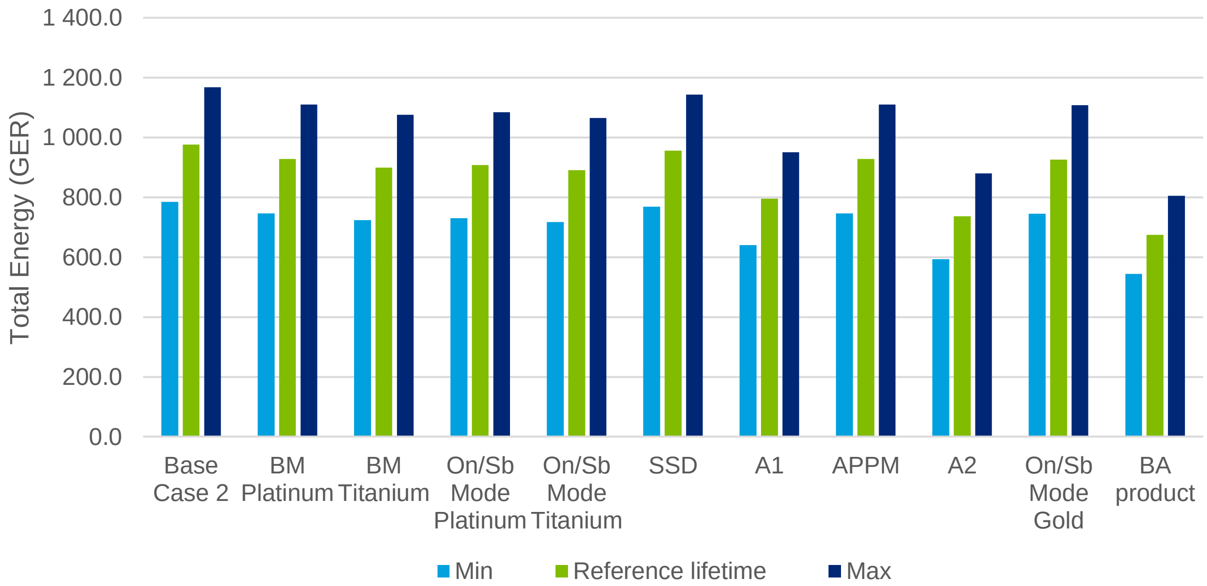

Figure 22: BC2 – Effect of a change in the lifetime on total energy consumption (in GJ)

The increase of the product lifetime also results in an increased energy consumption (+16% for all design options) and the change is even more important for a reduction in lifetime leading to an energy reduction of 24%.

4.3. Base Case 3 (Storage)

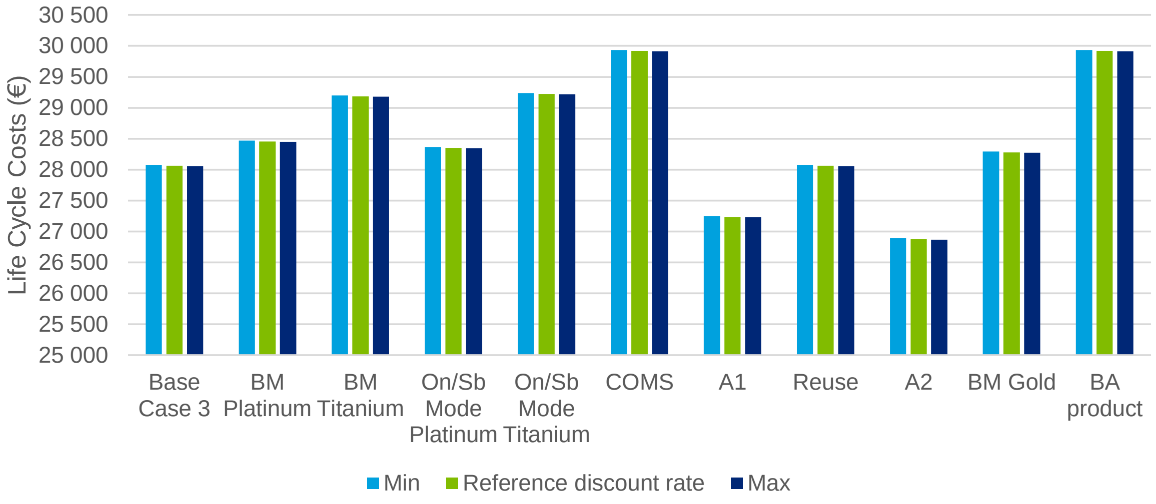

Figure 23: BC3 – Effect of a change in the discount rate on LCC

For the storage system Base Case the effect of a decrease or an increase in the discount rate on LCC is with 0.05% and -0.02% respectively negligible.

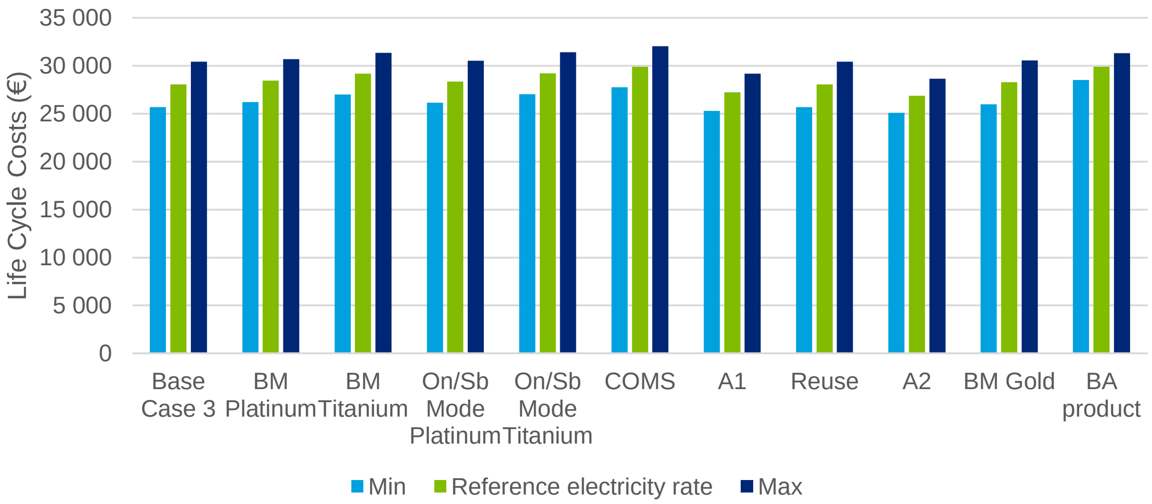

Figure 24: BC3 – Effect of a change in the electricity rate on LCC

The increase of the electricity rate by 50% results in a 4.5% to 7.8% increase in the LCC of the different Design Options; the increase being most important for BC3 and less important for the BA product.

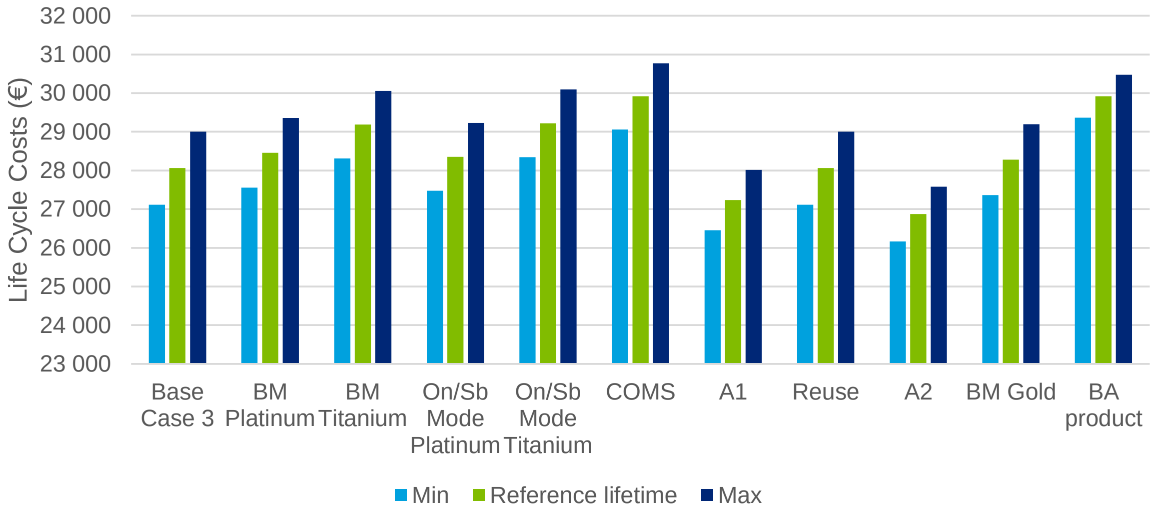

Figure 25: BC3 – Effect of a change in the lifetime on LCC

The effect of lifetime on the LCC of the blade server is of around 1.8-3.3% following an increase in the lifetime from 6 to 7.2 years. The LCC decreases by 1.9 to 3.5% if product lifetime gets reduced by 20%.

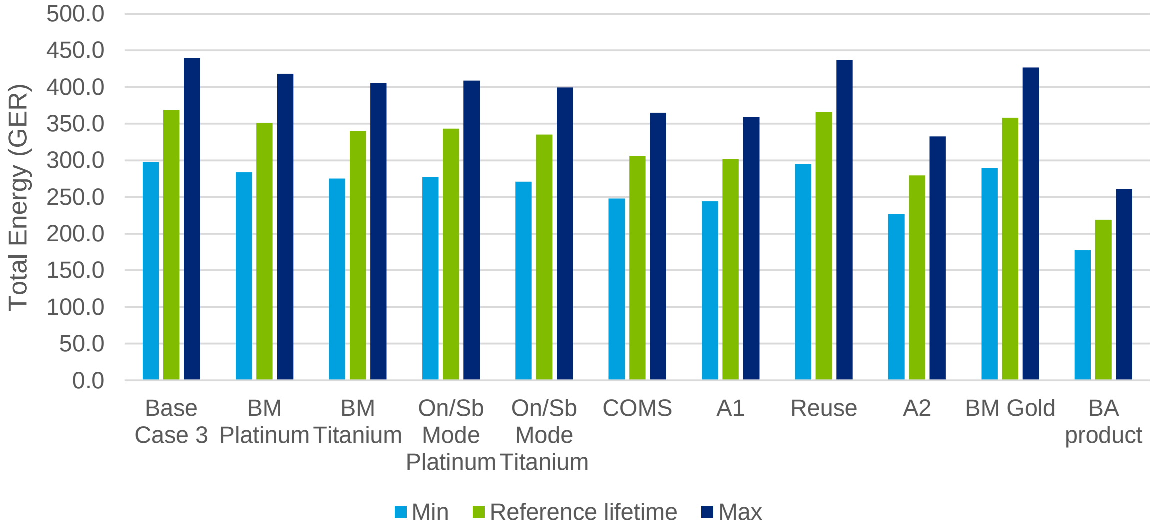

Figure 26: BC3 – Effect of a change in the lifetime on total energy consumption (in GJ)

The extension of the product lifetime by 20% leads to an increase in energy consumption of 16% depending on the design option, while its decrease results in an energy consumption which is reduced 24%.

Conclusion

The Lot 9 preparatory study showed that energy consumption in the use phase is with about 90% of total environmental impact predominant. It was estimated that servers, storage and network equipment consume a significant share of total electricity in the EU-28 (ca. 2.5%) and that a considerable savings potential exists for the analysed product groups (servers and storage equipment).

The study gives several recommendations for information requirements related to energy use and resource efficiency as well as energy efficiency requirements (efficient PSUs). Other recommendations concern product operating conditions or energy management.

In particular, the Lot 9 preparatory study gives the following recommendations:

Product information before and during the operation

- Information requirements should be established for active state efficiency criteria for enterprise servers and storage which should be published on the producer's website as defined by the different ENERGY STAR.
- The idle state power of enterprise servers shall be measured and reported as required in the ENERGY STAR Program Requirements for Computer Servers Version 2.0 (Section 6.1 Idle State Testing).
- Ready Idle state performance of storage equipment should be measured and reported as required in the ENERGY STAR Program Requirements for Data Centre Storage Version 1.0, according to the SNIA Emerald Power Efficiency Measurement Specification Version 2.0.2: Section 7.4.4: Online Ready Idle Test.
- Elaborated requirements for a dynamic range should be considered that would be a reliable indicator for load-adaptiveness and a more efficient product. These requirements could be information requirements in a first step and would need to be further developed.

Product hardware components and configuration

- Harmonisation with the existing EU Regulation No 617/2013 on ecodesign requirements for computers and computer servers should be sought in a first step and as a second step higher standards for PSUs, such as 80 PLUS Silver in Tier 1 and 80 PLUS Gold in Tier 2 should be required, for both enterprise servers and storage equipment. The suggested time line could be set to 2018 for Tier 1 and 2022 for Tier 2. Higher categories could be envisaged for single-output power supplies which could require 80 PLUS Gold in Tier 1 and 80 PLUS Platinum in Tier 2.
- The Lot 9 preparatory study recognizes that the reduction of idle power consumption is an important factor that needs to be considered. At the same time, the Lot 9 study emphasises the complexity of the product group and recommends to further investigate possible idle power thresholds and specific additional idle power allowances for extra components. Alignment could be sought to older versions of the ENERGY STAR, such as V 1.0 for servers.

Energy requirements on the overall energy performance

- In case reliable measurement methods will permit to provide a quantitative ranking between products in the future, specific requirements on the overall energy performance could be envisaged. Any specific requirements based on overall energy performance as measured by SERT or Emerald will require an understanding of the impact of component choice and configuration on the metric results and insure that products are properly categorized to deliver reasonable comparisons.

Product software components and configuration

- For Online 2, 3 and 4 systems, aligning ecodesign requirements to ENERGY STAR requirements as formulated in the ENERGY STAR Program Requirements Product Specification for Data Center Storage Eligibility Criteria Version 1.0. An important precondition for this measure is that these systems can be identified easily.

Product operating conditions and energy management

- Higher inlet temperatures, such as the ASHRAE Class A1 allowable temperature and humidity range should be considered. The possible timing for implementing the measure could be 2018. As a further step, the ASHRAE Class A2 allowable temperature and humidity range could be targeted in a Tier 2 around 2022.

Resource efficiency requirements

- Manufacturers should make sure that external enclosures of enterprise servers and storage should be removable by hand or with commonly available tools. Furthermore, manufacturers should ensure that printed circuit boards (including main boards and memory cards), processors, data storage devices (such as HDD or SSD) and batteries should be accessible and removable by hand or with commonly available tools.
- The deletion of data shall be ensured by standardised formatting procedures which guarantee data security.
- Manufacturers and/or importers in the EU shall provide a report on resource efficiency which should contain relevant information addressing dismantling, reuse and recycling at the end-of-life of the product. The report should be available on a website, be free of charge and come without restriction of access. It should contain at least an exploded-view drawing of the product, allowing to locate components and materials with special handling as well as a documentation of the dismantling operations.
- In order to guarantee maintenance and upgrading, the latest version of firmware to test the functionality and compatibility between diverse components shall be available to companies dealing with maintenance, reuse and upgrading of servers (including brokers, spare parts repairer, spare parts provider and third party maintenance) through normal channels.
- Manufacturers should provide voluntarily information about the location of critical raw materials (according to the EC list), in particular rare earths. Depending on the advancement in CRM research, this requirement could be made mandatory in the future.
- The reuse of different components in enterprise servers and storage should be promoted by a standardized incentive scheme. Such a scheme could consist in a bonus system which attributes bonus points to servers and storage equipment that contain reused components.

Energy labelling

- Energy labelling could be considered as a midterm target, since it requires that standardization for testing (e.g. SERT) and evaluating the energy performance of products across the whole spectrum of Lot 9 equipment is in an advanced state.

Form a forward looking perspective, it can be considered that global data centre IP traffic will keep increasing at a very fast pace in the years to come. The scenario analysis indicated that in the medium and long term, electricity consumption is likely to rise, even though technological change (virtualisation, consolidation, etc.) will be able to compensate some part of the increase. The Policy scenario showed that significant energy and cost savings are possible as compared to the BAU scenarios. The sensitivity analysis indicated that the results are robust for the three key parameters discount rate, electricity prices, and lifetime.

For these reasons, the project team considers that the product groups analysed within this study will stay highly relevant in the context of ecodesign for the next years and decades to come.