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Information technology — Data centres — Key performance indicators — Part 4: IT Equipment Energy Efficiency for Servers (ITEEsv)

Technologies de l'information -- Centres de traitement de données -- Indicateurs de performance clés -- Partie 4: Efficacité énergétique des appareils de technologies de l'information (TI)

Foreword

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This document was prepared by ISO/IEC JTC 1, *Information technology*, SC 39, *Sustainability for and by Information Technology.*

A list of all the parts in the ISO 30134- series can be found on the ISO website.

Introduction

The global economy is now reliant on information and communication technologies and the associated generation, transmission, dissemination, computation and storage of digital data. All markets have experienced exponential growth in that data, for social, educational and business sectors and, whilst the internet backbone carries the traffic there are a wide variety of data centres at nodes and hubs within both private enterprise and shared/collocation facilities.

The historical data generation growth rate exceeds the capacity growth rate of the information and communications technology hardware and, with less than half (in 2014) of the world's population having access to an internet connection, that growth in data can only accelerate. In addition, with many governments having ‘digital agendas‘ to provide both citizens and businesses with ever-faster broadband access, the very increase in network speed and capacity will, by itself, generate ever more usage (Jevons Paradox). Data generation and the consequential increase in data manipulation and storage are directly linked to increasing power consumption.

With this background it is clear that data centre growth, and power consumption in particular, is an inevitable consequence and that growth will demand increasing power consumption despite the most stringent energy efficiency strategies. This makes the need for Key Performance Indicators (KPIs) that cover the effective use of resources (including but not limited to energy) and the reduction of CO_2 emissions essential.

In order to determine the overall resource effectiveness or efficiency of a data centre, a holistic suite of metrics is required. For the resource effectiveness or efficiency of data centre infrastructure, power usage effectiveness (PUE) was defined as ISO/IEC 30134-2. PUE will be utilized to measure and improve energy efficiency of data centre infrastructure, such as cooling systems and power supply systems. For data centres which own not only infrastructure but also IT equipment, it is also necessary to measure and improve resource effectiveness or efficiency of IT equipment. A data centre, which provides only infrastructure to the customer, can be called a co-location data centre or housing service provider. For these data centres, PUE is essential. However, a data centre which owns and provides a server, storage, and network equipment is called a hosting or cloud service provider. These service providers can manage IT equipment and improve resource effectiveness or efficiency of a data centre by improving energy effectiveness or efficiency of IT equipment which they own. This document specifies the IT Equipment Energy Efficiency for servers (ITEEsv) in a data centre which specifies a method for measuring the energy effectiveness or efficiency of server equipment in a data centre. A data centre which owns servers can use this document to determine the energy effectiveness or efficiency of their current server equipment and to improve energy effectiveness or efficiency by including energy effectiveness or efficiency in their procurement requirements when replacing servers or expanding server capacity. IT equipment installed in a data centre consists of servers, storage systems, and network equipment. But it is difficult to calculate the summarized value of the energy effectiveness or efficiency among different types of IT equipment since the metrics for measuring their performance are different and simple addition or average is not an appropriate method for summarizing. ITEEsv defines the method to obtain average energy effectiveness or efficiency for servers.

This document is part of a series of International Standards for such KPIs and has been produced in accordance with ISO/IEC 30134-1, which defines common requirements for a holistic suite of KPIs for data centre resource usage effectiveness or efficiency.

The ISO/IEC 30134- series does not specify limits or targets for any KPI and does not describe or imply, unless specifically stated, any form of aggregation of individual KPIs into a combined nor an overall KPI for data centre resource usage effectiveness or efficiency.

Information Technology — Data Centres — Key Performance Indicators — Part 4: IT Equipment Energy Efficiency for Servers (ITEEsv)

1 Scope

This document specifies Information Technology Equipment Energy Efficiency for servers (ITEEsv), a key performance indicator (KPI) which quantifies the energy efficiency characteristics of servers in a data centre. ITEEsv can be calculated using a choice of pre-existing or context specific server performance benchmarks. ITEEsv intends to assist in improving the aggregate energy effectiveness of servers in a given data centre.

This document:

a) defines ITEEsv;

b) describes the purpose of ITEEsv;

c) describes how to use ITEEsv;

d) describes reporting of ITEEsv.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO/IEC 30134-1:2016, *Information technology — Data centres — Key performance indicators — Part 1: Overview and general requirements*

3 Terms, definitions and abbreviated terms

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO/IEC 30134-1 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— IEC Electropedia: available at http://www.electropedia.org/

— ISO Online browsing platform: available at http://www.iso.org/obp

3.1.1
Information Technology Equipment Energy Efficiency for servers
ITEEsv
maximum performance per kW of all servers or a group of servers in a data centre

3.1.2
server
functional unit that provides services to workstations, to personal computers or to other functional units in a computer network

Note 1 to entry: Services may be dedicated services or shared services.

[SOURCE: IEC 60050-732:2010, 732-01-12, modified: Note 2 deleted]

3.2 Abbreviated terms

For the purposes of this document the abbreviated terms given in ISO/IEC 30134-1 and the following apply:

CPU	Central Processing Unit
ITEEsv	IT Equipment Energy Efficiency for servers
SERT	Server Efficiency Rating Tool
SMPE	Server Maximum Performance
SMPO	Server Maximum Power

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4 Relevance of ITEEsv

ITEEsv is a KPI which describes the maximum performance per kW of all servers or a group of servers in the data centre based upon a specification or potential performance of these servers. ITEEsv reflects the energy effectiveness capability of servers, not the energy effectiveness at a real operating situation of the servers.

Server energy effectiveness or efficiency is a combination of

a) the capacity to do work per unit energy (capability);

b) the amount of time the server is actually doing work (utilization);

c) the ability of the server to reduce the energy use when the workload is reduced (power management).

ITEEsv accounts for capability [list item a)] and is used to quantify the effects of introducing servers which have high capability per unit energy. The other aspects are addressed in ISO/IEC 30134-5[1]. Data centres with larger ITEEsv values, indicate, on average, installation of servers with higher energy effectiveness or efficiency.

NOTE ITEEsv does not involve data centre infrastructure such as air conditioning, or operation of IT equipment. IT equipment in the data centre includes servers, storage systems, and network equipment. ITEEsv only addresses servers.

ITEEsv is a KPI intended for self-improvement of a given data centre or a part of a data centre, not for comparison among different data centres. ITEEsv should not be used to set regulation for a data centre or individual server.

5 Determination of ITEEsv

ITEEsv shall be determined and described by Formula (1).

$$\text{ITEEsv} = \frac{\sum_{i=1}^{n} SMPE_i}{\sum_{i=1}^{n} SMPO_i} \quad (1)$$

~~[1] To be published.~~

where

$SMPE_i$ is maximum performance of a server *i*,

The $SMPE_i$ value is the maximum or peak performance of a server *i*. $SMPE_i$ shall be obtained either from performance benchmark results provided by the manufacturer or from direct measurement where the benchmark meets the requirements of 6.2.

NOTE Options for the performance benchmark method are explained in A.2. The unit of $SMPE_i$ depends on a benchmark method applied.

$SMPO_i$ is maximum power consumption of a server *i* in kW.

~~(1)~~ The $SMPO_i$ value is the maximum power consumption of a server. $SMPO_i$ shall be obtained either from the use of a power consumption data provided by the manufacturer or from direct measurement. $SMPO_i$ shall represent the average power used during the benchmark execution which obtained its corresponding $SMPE_i$ value. Options for measurement of $SMPO_i$ are explained in A.3 and levels of ITEEsv by these options are explained in Annex B.

NOTE The maximum value of server energy effectiveness varies among CPU architectures and workloads, but is often achieved at high CPU load levels. However, only a few benchmarks, such as SERT and SPECpower, can find the approximate maximum server energy effectiveness. Most of the benchmark methods reveal the maximum performance (SMPE) and the maximum power consumption (SMPO) of a server. As an alternative indicator to real maximum server energy effectiveness, ITEEsv is calculated as maximum performance divided by maximum power consumption.

ITEEsv is an average of the energy effectiveness of all servers or a group of servers in a data centre. A higher ITEEsv value indicates higher processing capacity per unit of electric power (at maximum power). ITEEsv can be improved by utilizing servers with higher energy effectiveness.

6 Determination of SMPE and SMPO for ITEEsv

6.1 General

When using the benchmark method to determine SMPE and SMPO, the benchmark should represent the application of the servers being tested. For ITEEsv calculation, one benchmark method should be applied for all servers, and benchmark methods shall not be mixed. If one benchmark method is not appropriate for all servers due to a difference in server type, configurations, or intended loads, then servers should be grouped so that one benchmark method can be applied. Then the ITEEsv of the servers in a group shall be calculated. ITEEsv should not be added among these groups. If SMPE and SMPO cannot be accurately determined for any particular servers in a group, those servers shall not be included in the calculation of ITEEsv. When comparing historical ITEEsv values of a given data centre, the same benchmark method shall be used every time ITEEsv is measured.

Data centre owners/operators are advised to appropriately and carefully choose the benchmark method based on the following criteria according to the situation in the data centre they operate. When a benchmark method is used to calculate ITEEsv, the selected benchmark shall meet the requirements in 6.2 and should meet the recommendations in 6.3.

NOTE Calculation examples of ITEEsv are shown in Annex C.

6.2 ITEEsv benchmark method selection requirements

Benchmarks used to calculate ITEEsv shall have:

— an SMPO that is collected using a precise and highly reproducible power and performance measurement methodology such as those referenced in A.3;

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— a run to run variation of effectiveness score of ≤ 5%;

— workloads with a high correlation to server power consumption;

— a benchmark that measures and reports power and performance during execution of included workloads;

— a benchmark that is a generally accepted tool or its results are used for the class of server being tested.

6.3 ITEEsv benchmark method selection recommendations

Benchmarks used to calculate ITEEsv should:

— be portable across major hardware architectures and operating systems;

— have an execution time of a full run of less than six hours;

— measure or represent real world workloads;

— include end-to-end automation;

— specify and automatically collect configuration details needed to reproduce results;

— provide run rules and software infrastructure for precise performance and power measurement;

— be publically available worldwide;

— include developers committed to providing timely support and updates for the foreseeable future;

— include a level of tamper protection and a log file for audit purposes;

— have open and transparent design guidelines, implementation, and result calculations;

— have full documentation available to enable unfamiliar parties to collect accurate results;

— not require extensive optimization expertise to obtain optimal results;

— perform output validation to ensure all systems are performing the same amount of work;

— include documentation in at least several major languages.

7 Direction for use of ITEEsv

ITEEsv can assist stakeholders with improving the energy effectiveness of their servers by providing a measure of work performed per unit of power consumed. ITEEsv should be calculated for existing servers and data centres for use as a baseline. When a server is replaced, the ITEEsv of the new equipment should be greater than that of the old equipment. When additional servers are added to increase capacity, the impact of the new equipment on ITEEsv should be determined. Likewise, when a data centre is reconfigured, the design ITEEsv should be an improvement over the baseline calculation. The data centre owner can check whether an ITEEsv of a newly introduced server is larger than the current ITEEsv, which is the average energy effectiveness of existing servers in a data centre. Alternatively, when replacing servers, the data centre owner can check

whether the ITEEsv of the newly introduced server is larger than the replaced server. Then, the data centre owner can calculate the expected value of the ITEEsv and compare it to the current ITEEsv to know the improvement of overall energy effectiveness. The data centre owner can define any server group according to its needs for energy effectiveness analysis as long as a single benchmark method is applied to all servers in the group. By defining a group by an application system, the data centre owner can analyse the energy effectiveness of the target application system.

To determine ITEEsv for the common group of servers, a single system shall be sufficient to represent the capacity per group. This value is the modulo for capacity planning of that server model. The total capacity is the multiplication of the number of servers to that modulo. Conversely, the compute capacity for a provisioned amount of power would be provisioned power multiplied by the modulo.

The SMPE and the SMPO can be self-determined or provided by the system manufacturer. To communicate common values, the tool used shall be identified and be an industry-wide used tool such as those in Annex A. Reported ITEEsv values shall be based upon benchmarks which satisfy the selection criteria stated in 6.2.

Typically, data centre planning requires establishing what capabilities exist compared to what is required. The assessment methods of new systems were previously listed. Older systems may be assessed with either the latest or the majority configuration of the existing stock. Older systems should be grouped as closely as possible with respect to generation of server and/or similar modulo. To assess the aggregate capacity and power level, the performance capacity and energy shall be added separately across groups of servers which use the same benchmarks. The resulting ITEEsv of the existing server base can be compared against the ITEEsv of new servers to determine capacity plans and optimization opportunities, such as supporting future needs within the same data centre infrastructure.

8 Reporting of ITEEsv

8.1 Requirements

When reporting ITEEsv, the determination methods for SMPE and SMPO shall be disclosed in order to secure reproducibility of the reported results. In addition, the scope of measuring shall be presented and disclosed. The determination method shall be described in parentheses as arguments of ITEEsv as follows:

ITEEsv(determination method of SMPE).

Table 2 shows examples of ITEEsv with several determination methods for SMPE.

Table 2 — Description examples of ITEEsv

Determination method of SMPE	Description
SERT	ITEEsv(SERT)
SPECpower_ssj2008	ITEEsv(SPECpower_ssj2008)
LINPACK	ITEEsv(LINPACK)

The report shall include at least the following information

a) ITEEsv value;

b) benchmark chosen (benchmark method with its version number used for numerator and denominator);

c) in case the measurement was made in part of the data centre, the measured server group or system where the ITEEsv calculation is applied;

d) date of measurement;

e) data centre identification (e.g. name, address, owner/operator).

In case the published data were used instead of the actual measurements, these shall be referenced in the measuring method section.

In case a self-made measuring method was used, the method shall be described and published with at least the following information:

1) measuring method of SMPE;

2) measuring method of SMPO;

3) scope of the measuring method.

8.2 Recommendations

The report should include the following information:

a) purpose of reporting;

b) historically recorded data of ITEEsv;

c) reason for choice of benchmark method;

d) reference to this document, i.e. ISO/IEC 30134-4.

Annex A
(informative)

Options for determining SMPE and SMPO

A.1 Overview

Annex A provides several options for the benchmark method of measuring SMPE and SMPO, which meet the requirements in 6.2 (when direct measurement options are used, an explanation of those methods is required according to 8.1).

A.2 Measuring options for SMPE

A.2.1 General

SMPE is the maximum performance of a server. SMPE does not represent a maximum performance at running condition in a data centre. SMPE represents a maximum performance at an ideal condition. The data centre can obtain an SMPE value from the server manufacturer where the benchmark measurement was done or by measuring at their experimental condition using a benchmark performance tool. The performance and application of servers is diverse so it is impractical to specify a unified, standard workload to determine SMPE. To select servers relative to existing systems, published data provides a relative comparison between current available systems and those existing in the data centre. For those systems older than any published data, the oldest published data can be used as a minimum magnitude of efficiency that can be obtained in refreshing the server population. For example, a set of servers earlier than fiscal year 2000 does not have SPECpower information for comparison. The SPECpower values of the fiscal year 2004 model in lieu of the missing 2000 model should be used as the basis for comparison. To obtain the SMPE on an individual server, data centre operators should obtain these values from the server manufacturer. Alternatively, the data centre operator can perform the benchmark on their configuration prior to commissioning or selecting the server.

The data centre should choose an appropriate benchmark method considering the characteristics of application and servers to be tested. For example, a data centre targeted for high performance computing is likely to use LINPACK to represent the work capacity (SMPE) and the power impact (SMPO) for the data centre. Similarly, volume servers are likely to use SPECpower or SERT to determine SMPE and SMPO respectively. Server benchmarks which meet the requirements in 6.2 can be used to determine SMPE. For a historical comparison, a benchmark method should be consistent over the comparison period.

A.2.2 Server Efficiency Rating Tool (SERT)

The “normalized peak performance” of SERT can be used for the SMPE value. There are twelve types of worklet for different types of workload. The data centre owner should choose an appropriate type of worklet depending on the type of work done by the data centre. If the data centre performs a type of work, then an “ssj” worklet for a “hybrid” workload is appropriate.

SERT was created by the Standard Performance Evaluation Corporation (SPEC), at the request of the US Environmental Protection Agency (EPA). It is intended to measure server energy efficiency, initially as part of the second generation of the US EPA ENERGY STAR for Computer Servers program. Designed to be simple to configure and use via a comprehensive graphical user interface, the SERT uses a set of synthetic worklets to test discrete system components such as processors, memory and storage, providing detailed power consumption data at different load levels. Results are provided in both machine- and human-readable formats, enabling automatic submission to