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Information Technology — Data centres — Application Platform Energy Effectiveness (APEE)

Technologies de l'information — Centres de traitement de données — Efficacité énergétique des plateformes d'applications (APEE)

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Foreword

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This document was prepared by Joint Technical Committee ISO/IEC JTC 1, *Information technology*, Subcommittee SC 39, *Sustainability, IT & Data Centres*.

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Introduction

The growth of the Internet of Things (IoT) has resulted in the storage of increasingly large amounts of data in data centres and the increased utilization of this data by technologies such as artificial intelligence (AI). As a result, energy consumption of data centres is also increasing. In this recent utilization of large amounts of data by technologies such as AI, various kinds of data are combined and analysed, and processing requests for such combinations and analysis are also increasing. Middleware, such as a database management system (DBMS), is also becoming more important for this data utilization. The energy effectiveness of application platforms can be greatly improved through the selection of middleware.

In addition to improving the energy effectiveness of target IT equipment itself, it is necessary to improve application platform energy effectiveness by choosing an optimally energy-effective combination of target IT equipment, operating systems and middleware.

Although there are several KPIs for the energy effectiveness of target IT equipment itself (for example, ISO/IEC 30134-4, ISO/IEC 21836), there have previously been no KPIs for energy effectiveness to calculate the energy effectiveness of a combination of target IT equipment, operating systems and middleware. This document, therefore, introduces a KPI for the energy effectiveness of an entire application platform. A typical use case of application platform energy effectiveness (APEE) is a criterion for procuring an energy efficient application platform for an IT service.

This KPI provides assistance in selecting an optimal application platform for energy effectiveness. This KPI does not apply to the energy effectiveness of an entire data centre. The colloquial term of "efficiency" is commonly used in regional programmes and "effectiveness" can be referenced as "efficiency" in those programmes.

Information Technology — Data centres — Application Platform Energy Effectiveness (APEE)

1 Scope

This document specifies application platform energy effectiveness (APEE) as a Key Performance Indicator (KPI) which quantifies the energy effectiveness of an application platform for an IT service in data centres. This KPI evaluates the energy consumption of an application platform prior to deployment. The purpose of this KPI is to measure the energy effectiveness of a set of target IT equipment, operating systems and middleware, to enable the selection of an energy effective IT stack.

This document specifies a formula for calculating APEE and definitions of components of the formula.

This document specifies a measurement method for assessing and reporting the energy effectiveness of an application platform.

This document also specifies requirements for benchmarks to be used for APEE and requirements for reporting.

The following topics are outside of the scope of this document:

1) KPIs intended to solely evaluate the energy effectiveness of target IT equipment hardware,

2) energy effectiveness of data centre facilities.

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 21836:2020, *Information technology — Data centres — Server energy effectiveness metric*

ISO/IEC 21878, *Information technology — Security techniques — Security guidelines for design and implementation of virtualized servers*

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 21878 and the following apply.

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

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

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

3.1.1
application platform
platform composed of *target IT equipment* (3.1.4), operating systems, and *middleware* (3.1.3) with the purpose of providing an *IT service* (3.1.5)

Note 1 to entry: An application platform is an environment for executing *software applications* (3.1.2) such as ERP and CRM software. Therefore, a software application itself is not included as part of an application platform.

3.1.2
software application
computer program for implementing an *IT service* (3.1.5)

Note 1 to entry: A software application is usually developed independently for each IT service.

3.1.3
middleware
software layer between an operating system and the *software applications* (3.1.2)

Note 1 to entry: Examples of middleware include DBMS, web server software, application server software, transaction monitor.

Note 2 to entry: An operating system is the software directly managing the hardware, e.g. conventional operating system, hypervisor, etc.

[SOURCE: ISO/IEC/IEEE 24765:2017, 3.2459, modified – Notes 1 and 2 to entry have been added.]

3.1.4
target IT equipment
server, storage and network equipment that are components of an *application platform* (3.1.1)

3.1.5
IT service
service that provides an outcome to its users via information technology

3.1.6
application outcome
information provided by an *IT service* (3.1.5) to its users

Note 1 to entry: An example of an application outcome is a set of reports to support decision-making at retail outlets (such as sales analysis reports, and stock status reports).

3.1.7
measurement period
duration in which the benchmark performs the intended data processing

Note 1 to entry: Typically, the measurement period(s) is/are the only portion of the benchmark execution which is/are used to calculate the benchmark score.

Note 2 to entry: The intended data processing routine is a routine including the benchmark calculation.

Note 3 to entry: In the case of using TPC-H[1] , the measurement target of TPC-H is a performance for executing SQL queries, so a period of executing SQL queries is a measurement period. Other periods, such as a data loading, are not a measurement period.

3.1.8
benchmark identifier
string which identifies a specific benchmark, which consists of the name and the major *version* (3.1.9), when applicable

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1) TPC-H, TPC-E, and TPCx-IoT are trademarks of the Transaction Processing Performance Council. This information is given for the convenience of users of this document and does not constitute an endorsement by ISO/IEC of the product named. Equivalent products may be used if they can be shown to lead to the same results.

3.1.9
version
particular form or variation of a resource that differs from other instantiations of the resource in at least one aspect or item of information

Note 1 to entry: The first digit of a version is called the major version, and any numbers right of that digit is called a minor version.

Note 2 to entry: Example: in the version designated as "v1.2.3," the Major Version identification is "1", and the Minor Version identification is "2.3".

[SOURCE: ISO 24619:2011, 3.1.9, modified — Notes 1 and 2 to entry added.]

3.1.10
internal power supply
independent device that converts commercial AC power to DC power as required inside *target IT equipment* (~~3.1.4~~)

3.2 Abbreviated terms

AC	alternating current
AI	artificial intelligence
APEE	application platform energy effectiveness
CRM	customer relationship management
DBMS	database management system
DC	direct current
EAP	energy consumption of application platform during the measurement periods
ERP	enterprise resource planning
FC	fibre channel
IoT	Internet of Things
NoAO	number of application outcomes during an APEE measurement
OS	operating system
RDBMS	relational database management system

4 Relevance of APEE

Many kinds of IT services are provided by using data centres, and it is necessary to conserve the amount of energy used by these IT services. A lot of IT services use various technologies, such as AI, IoT and big data technologies. For each of these technologies, there are several combinations of target IT equipment, OSs and middleware that can be used to provide IT services. These combinations of target IT equipment, OSs and middleware are called an application platform.

Even if the results provided by an IT service are the same, if the application platform used to provide the IT service is different, the energy consumption is also different. For example, when the same query is executed on different DBMSs, because the processing method and processing time are different for each DBMS, energy consumption also differs.

In order to choose the optimum application platform for energy effectiveness, a KPI for measuring the energy effectiveness of an application platform is necessary. There are KPIs for measuring the energy effectiveness of target IT equipment only, and ISO/IEC 21836 is one of KPIs for a server. APEE is a KPI for measuring the energy effectiveness of an application platform. Use cases of APEE are described in ~~Annex A~~.

NOTE APEE is a KPI for measuring the energy effectiveness of an application platform for a particular IT service, not the energy effectiveness of an entire data centre. Therefore, APEE is not suitable for use in regulations that apply to an entire data centre.

5 Determination of APEE

APEE shall be determined and described by ~~Formula (1)~~:

$$c = a / b \tag{1}$$

where

a is the number of application outcomes during an APEE measurement (NoAO) (see ~~Clause 6~~); is

b the energy consumption (kWh) of the application platform during the measurement periods (EAP) (see ~~Clause 6~~);

c is the APEE.

The unit dimension of APEE is (application outcome(s)/kWh). The APEE value should have at least 2 significant digits.

Reporting of data for APEE is described in ~~Clause 7~~.

An example of APEE calculation is given in ~~Annex B~~.

6 Determination of application outcome and energy consumption of the application platform for APEE

6.1 Prerequisites for the benchmark and application platform

The following prerequisites shall apply when measuring the APEE of an application platform that provides an IT service:

a) The measurer determines one benchmark to be used for the calculation of APEE. Benchmarks shall meet the following requirements. Examples of benchmarks that can be used for APEE measurement are given in ~~Annex D~~.

   1) The benchmark is representative of the target IT service.

   2) The start and the end of the execution of the benchmark are clear.

   3) All iterations of the benchmark run produce comparable results.

   4) An application outcome defined by the benchmark is identical regardless of how many times it is executed on any application platform.

      NOTE 1 In the case of TPC-H as an example of an application outcome, it defines a set of results of business-oriented ad-hoc queries as an application outcome of the execution. A performance metric such as throughput and processing time is not an application outcome.

EXAMPLE 1 A benchmark that executes transactions while increasing the multiplicity until the system cannot keep the specified response time in order to obtain maximum multiplicity is not applicable because the processes of measurement target for these benchmarks have the potential to change from run to run.

5) Start date and time, and end date and time of all the measurement period(s) are clear.

NOTE 2 Some benchmarks have multiple measurement periods in one benchmark execution.

EXAMPLE 2 (Example of clarification) A benchmark has warmup and cooldown phases which do not effort a benchmark performance score. It records start date and time and end date and time of these phases in a log file, so these phases are distinguishable from measurement period(s).

6) Measurement period start and stop time are measured in seconds or higher precision.

7) To ensure that the result is verifiable, the benchmark is made publicly available.

b) The measurer determines the target IT equipment, OSs and middleware that are to serve as the elements of the application platform. The application platform shall meet the following requirements:

1) The application platform contains all of the target IT equipment necessary to execute the benchmark.

2) Every target IT equipment component can be measured for energy consumption.

6.2 Determination of application outcome

For the determination of application outcome, the following terms are introduced:

— One application outcome is defined as one valid execution of the benchmark.

The following requirements for measurement shall be met:

a) The benchmark is executed at least one time. If the benchmark is executed multiple times, the number of benchmark executions is a positive integer.

NOTE The tester can interact with the server between benchmark iterations, typically to calculate the total measured time for benchmarks which include unmeasured periods.

b) If the total time of the whole measurement period is less than one hour, the benchmark is repeatedly executed until the total time of the whole measurement period exceeds one hour.

c) If the benchmark has a setting for official or valid or reportable results for publication or use in comparisons, this mode shall be used for APEE comparisons.

6.3 Determination of energy consumption of the application platform

6.3.1 Requirements for obtaining energy consumption of the application platform

Energy consumption of the application platform shall be obtained by the sum of energy consumption (kWh) of all the target IT equipment in the application platform during all benchmark measurement period(s) of the APEE measurement. Non-benchmark software should be minimal during the measurement period(s). Execution of non-benchmark software on the application platform shall not invalidate energy results. Energy measurements during benchmark execution shall not be adjusted to remove the effects of non-benchmark software.

NOTE The application platform is usually used solely by the benchmark during the measuring period for accuracy.

The energy consumption of each item of target IT equipment in the application platform is obtained by the measurement method. Details of this method are given in ~~6.3.2~~.

6.3.2 Requirements for the measurement method for obtaining energy consumption

The measurement method shall meet the following requirements. The measurer shall replace "SEEM" or "SERTv2" with "APEE" and "SUT" with "application platform" in the text of the SEEM referenced below and apply.

a) Environment

   1) ISO/IEC 21836:2020, 7.2 applies for measurement environment.
   2) ISO/IEC 21836:2020, 7.4 applies for power requirements.

b) Power measurement

   1) One or more power analysers shall be used to measure the entire energy consumption of the application platform.
   2) Maximum sampling interval of the power analysers shall be at least one sample per second.
   3) ISO/IEC 21836:2020, 7.3 and 9.2.2.2 apply for power analyser requirements.
   4) Power analysers shall comply with ISO/IEC 21836:2020, 9.2.2.3 and 9.2.2.4.
   5) The following requirements shall be preferentially followed over the above ISO/IEC 21836 requirements.
      i) The energy consumption shall be measured by using one or more power analysers.
      ii) All clocks of all power analysers and target IT equipment shall be synchronized such that time stamps are aligned within 1 second.

      NOTE This requirement is intended to support measurements of the energy consumption of multiple target IT equipment. ISO/IEC 21836 targets a server, but this document targets multiple target IT equipment.

c) Temperature measurement

   1) The instantaneous temperature of an inlet of one typical element of the application platform shall be measured by a temperature sensor both within 1 minute of the start time of the benchmark execution and within 1 minute of the end time of the benchmark execution.
   2) ISO/IEC 21836:2020, 9.2.3 applies for temperature sensor requirements.

d) Approved measuring instrument

   1) ISO/IEC 21836:2020, Annex B, Table 4 and Table 5 apply for pre-approved power analysers and temperature sensors.

7 Reporting of APEE

7.1 Requirements

When presenting an APEE, both the benchmark identifier and the APEE value shall be presented, and the benchmark identifier shall be written in parentheses as follows:

APEE(benchmark identifier)

For all benchmarks which include version numbers, the corresponding benchmark identifier shall include the benchmark's major version number.

EXAMPLE APEE is written as APEE(TPC-H v2) when TPC-H version 2.17.3 is used as the benchmark.

When presenting APEE, APEE shall be presented along with a report or link to a report. The report shall include at least the following information:

a) APEE value

b) NoAO value and EAP value

c) start date and time of measurement, and end date and time of measurement

d) start date and time of each measurement period, and end date and time of each measurement period

e) target IT service

f) details of the selected application platform:

   1) vendor names and model names of target IT equipment;

   2) vendor names, model names, and version numbers of operating systems and middleware;

   3) system configuration diagram of the target IT equipment, operating systems, and middleware;

      NOTE 1 For an example of a configuration diagram, see ~~Annex C~~.

   4) all target IT equipment configuration and software settings that affect NoAO and EAP values or are required to reproduce the results shall be documented, including load range, power management settings, and virtualization resource allocation configuration.

      NOTE 2 Examples of load range in DBMS are database size and transaction throughput.

g) information about the selected benchmark:

   1) name and version;

   2) reference to the specifications of the benchmark;

   3) benchmark settings descriptions and values used for all benchmark settings that affect NoAO and EAP values.

h) power supply information (e.g. power supply mode, power supplies 80 plus rating, AC/DC, voltage, frequency, and phase)

i) instantaneous temperatures of the inlet at start and end of benchmark execution, and location of the temperature sensor

j) information about the measurement method:

   1) vendor names and model names of the selected power analysers;

   2) physical locations of the power analyser(s) between the power source and the measured systems, including servers, storage, and network equipment;

   3) any deviations from the measurement procedure and any unusual features observed.

k) number, publication year, and title of this document, i.e. ISO/IEC 23544:2021, Information Technology — Data centres — Application Platform Energy Effectiveness (APEE)

7.2 Recommendations

The report should include the following information:

a) purpose of measuring of the APEE value;

b) reason for selecting the benchmark.

Annex A
(informative)

Use cases of APEE

A.1 Introduction

The life cycle of an IT service consists of the following phases:

a) planning,

b) procurement,

c) operation,

d) update,

e) disposal.

APEE can be effectively used in the procurement phase. This annex provides two use cases for the procurement phase, from the perspective of the party procuring the IT service and from the perspective of the party proposing the IT service. These parties fulfil the following roles in the use cases described in this annex. The following description of characters is used only in this ~~Annex A~~.

— IT service provider: entity that provides IT services to end users.

— System integrator: entity that builds an IT system that implements IT services by combining target IT equipment and software.

A.2 Use cases

This annex provides the following two use cases.

Use case 1: Procurement of an IT service — A case where the IT service provider uses APEE as a criterion for energy effectiveness when narrowing down candidates from among multiple system integrator proposals.

a) The service provider chooses one benchmark, which is representative of the IT service in question, and informs multiple system integrators of this benchmark, as shown in ~~Annex D~~.

b) Each system integrator specifies the middleware and builds an application platform.

c) On their respective application platforms, each system integrator executes the benchmark selected by the service provider.

d) The system integrator measures the energy consumption of the application platform, and calculates the APEE value.

e) Each system integrator informs the service provider of the APEE value.

f) The service provider receives the APEE value from the multiple system integrators, and uses the APEE value, as an expression of energy effectiveness, to narrow down candidates from among multiple system integrator proposals.

Use case 2: Promoting sales of an application platform — A case where the system integrator uses APEE to appeal to customers regarding the energy effectiveness of the system integrator's application platform.

a) The system integrator clearly identifies the target IT service and the target customer of the system integrator, and determines the benchmark based on the workload type of the IT service, as described in ~~Annex D~~.

b) The system integrator builds an application platform that can implement the IT service in an energy-efficient manner.

c) The system integrator measures the APEE value for the application platform and the selected benchmark, and uses this value to help sell the application platform to the target customer.

Annex B
(informative)

Example of APEE calculation

This annex provides an example of APEE calculation.

TPC-H version 2.17.3 is used as the benchmark in this example. The benchmark is executed 2 times, and the total execution time of the benchmark is 1,32 h, which is a value exceeding 1 hour. The energy consumption of the application platform is 0,901 kWh during these 1,32 h.

The procedure for measuring energy consumption is as follows:

1) Synchronize the time between the power analysers and the server of the application platform.
2) Start measuring energy consumption.
3) Run the benchmark twice.
4) Stop measuring energy consumption.
5) Obtain the start time and end time of each measurement period from the benchmark execution log.
6) Based on these times, obtain the energy consumption value from the power analyser log.

Obtain the value of NoAO by the number of benchmark executions, as follows:

a = 2 application outcomes

where

a is the NoAO value.

Obtain the value of EAP by the energy consumption of the application platform during the benchmark executions, as follows:

b = 0,901 kWh

where

b is the value of EAP.

Calculate the value of APEE(TPC-H v2) as follows:

$c_1 = a / b = 2 / 0{,}901 = 2{,}22$

where

c_1 is the value of APEE(TPC-H v2).

An example report of this calculation example is shown in ~~Annex C~~.

NOTE The entire benchmark run period is used in the measured performance, so post-processing the data for measured periods is not necessary in this measurement.

Annex C

(informative)

Example of an APEE report

C.1 Exampleof an APEE report using TPC-H as benchmark

This annex provides an example of an APEE report (~~Table C.1~~) for APEE(TPC-H v2) = 2,22[2] .

Table C.1 — Example of an APEE report

No.#	Item	Value
1	APEE(TPC-H v2)	2,22
2	NoAO value	2 application outcomes
3	EAP value	0,901 kWh
4	Start date and time of measurement, and end date and time of measurement	27 March 2019, 15:46:44 – 17:06:12
5	Start date and time of each measurement period, and end date and time of each measurement period	1 st measurement period of 1stbenchmark execution: 27 March 2019, 15:50:27 – 16:27:03 1st measurement period of 2 benchmark execution: 27 March 2019, 16:30:44 – 17:06:12
6	Target IT service	Decision support system for the supermarket
7	Details of the selected application platform	Server: Vendor name: Hitachi, Ltd. Model name: HA8000 RS220AN2 CPU: Intel Xeon E5-2699v4 x 2 slots Cores per CPU: 22 Threads per Core: 2 CPU Frequency: 2.20GHz Memory: 192GB Memory Type: 16GB DDR4-2400MHz Registered DIMM Frequency Number of DIMMs: 12 Internal storage: SAS 1,2TB (Hitachi GQ-UH71200BB1EX)x 5 disks (4D1P) + 1 spare disk (Hitachi GQ-UH71200B-B1RX) DVD Drive: Hitachi GQ-UV5100EX FC HBA: Hitachi GQ-CC7F21EX Internal power supply: 80 Plus Platinum x 2 units

2) Products mentioned in this annex are examples of suitable products that are available commercially. This information is given for the convenience of users of this document and does not constitute an endorsement of these products by ISO/IEC.

Table C.1 *(continued)*

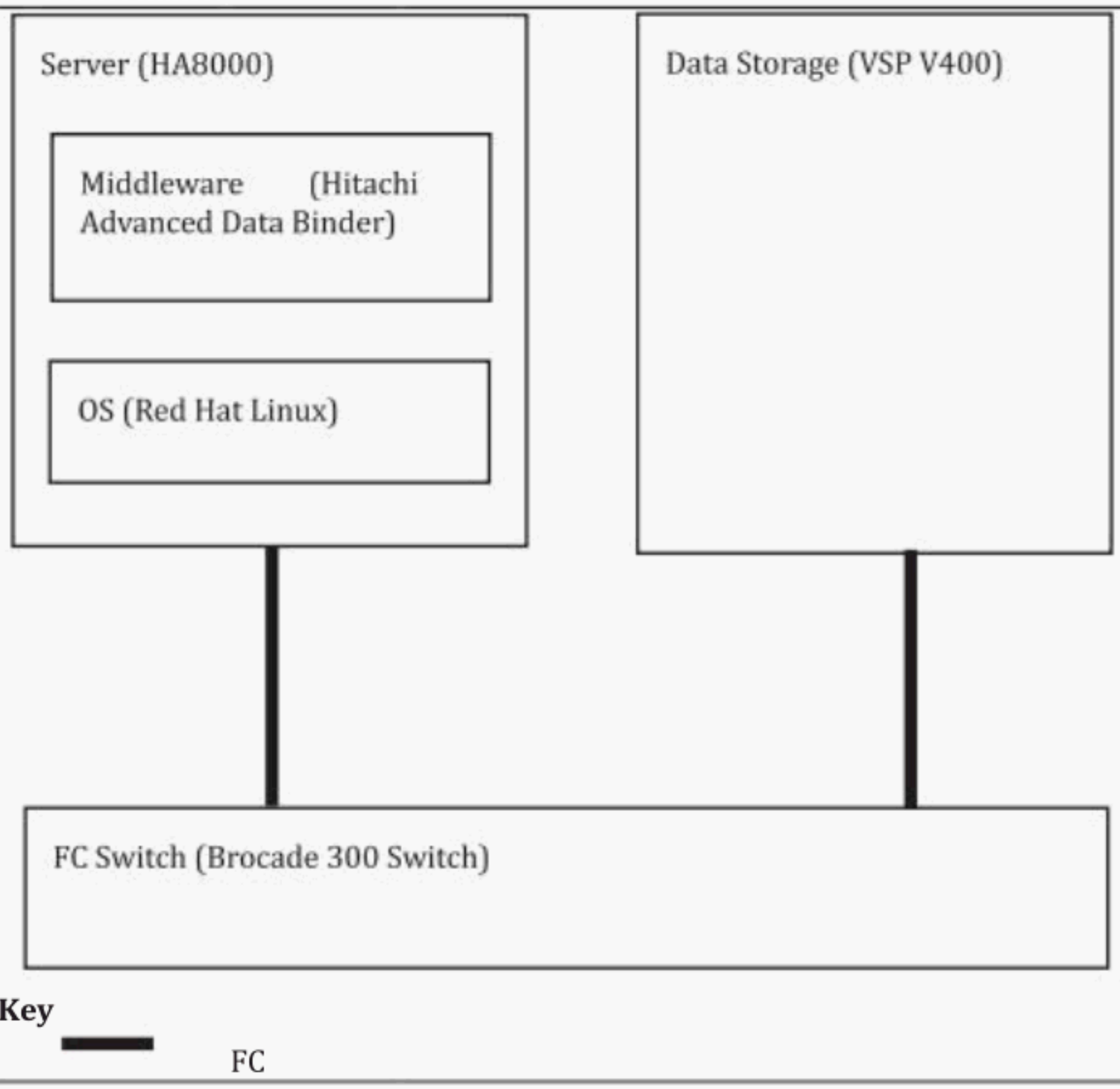
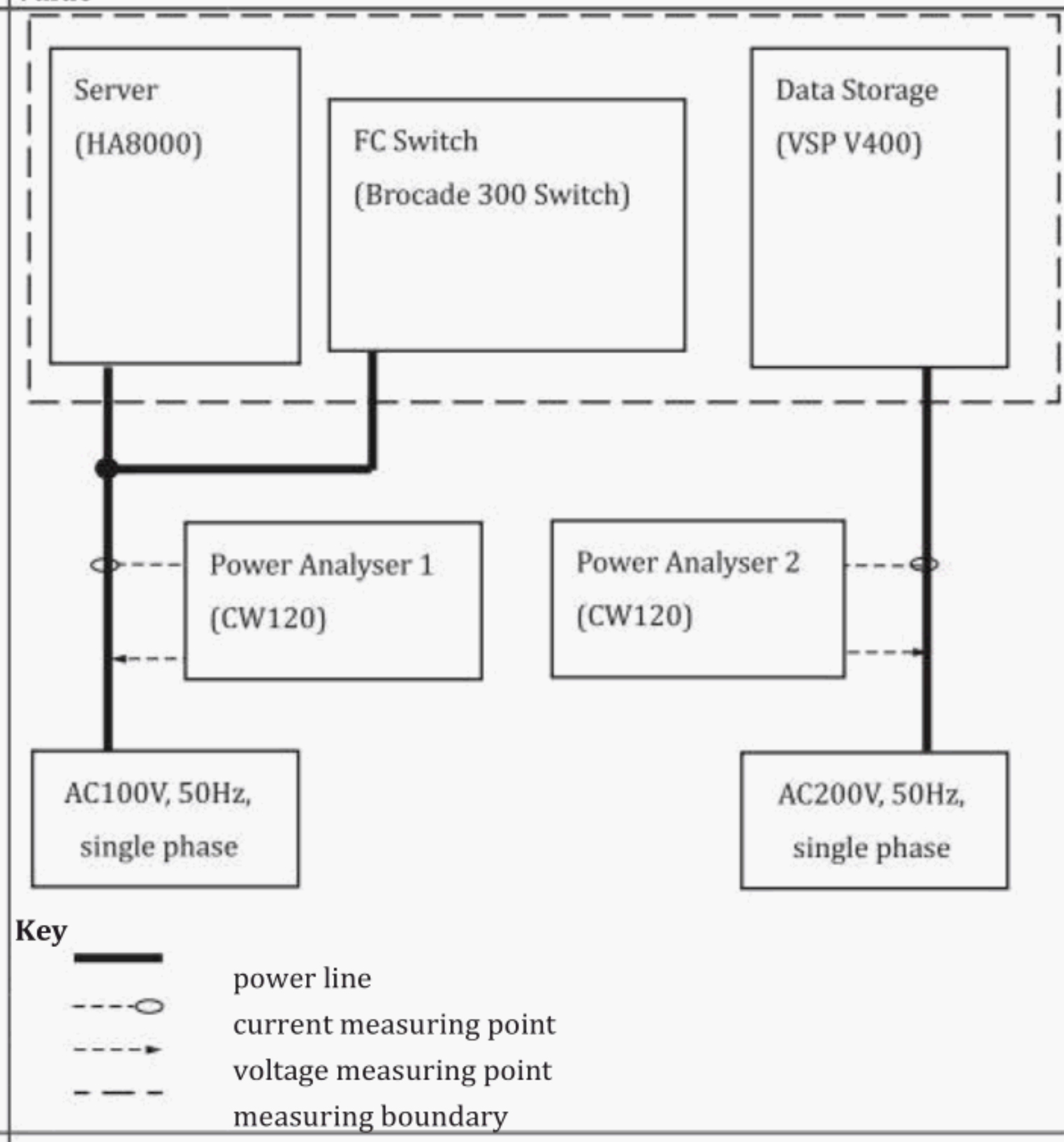
No.#	Item	Value
		Data storage: Vendor name: Hitachi, Ltd. Model name: VSP F400 Drive: Flash module drive 6,2TB x 16 disks (7D1P x 2) FC switch: Vendor name: Brocade Model name: Brocade 300 Switch Port: 8Gbps x 24 ports OS: Vendor name: Red hat Model name: Red hat Linux Version number: 7.4 Middleware: Vendor name: Hitachi, Ltd. Model name: Hitachi Advanced Data Database Version number: 4.3 Buffer size: Power 150GB
8	Details of the selected power analysers	Analyser 1 & 2: Vendor name: Yokogawa Test & Measurement Corporation Model name: CW120
9	Details of the selected application platform - configuration diagram	

Table C.1 *(continued)*

No.#	Item	Value
10	Power supply information and connection location of power analysers	
11	Inlet temperatures and location of the selected application platform at start and end of measurement	Start temperature: 22,3 °C at 27 March 2019, 15:47:00 End temperature: 22,5 °C at 27 March 2019, 17:06:00 Location: an inlet of the server(Server1)
12	Information of the selected benchmark	TPC-H, version 2.17.3, scale factor = 10, throughput test and power test using Q1 – Q22 http://www.tpc.org/TPC_Documents_Current_Versions/pdf/tpc-h_v2.17.3.pdf Scale factor is a parameter of the database size specified by the measurer, and the unit is gigabyte(GB).
13	Standard number, publication year, and title of the standard when the APEE value was measured	ISO/IEC 23544:2021, *Information Technology — Data centres — Application Platform Energy Effectiveness (APEE)*

TPC-H has a scale factor representing the size of the database, and the execution time of the benchmark varies depending on the value of the scale factor. Therefore, the scale factor is reported.

In this RDBMS, the execution time of the benchmark changes depending on the value of the buffer size specified by the measurer. Therefore, the buffer size is reported.

C.2 Measurement example on two application platforms with different middleware

C.2.1 General

This subclause provides an example in which the hardware of two application platforms is the same, but software is different, so that the energy effectiveness of the application platforms is different[3] .

~~Table C.2~~ shows the results of APEE measurement of two application platforms with different middleware (RDBMS). This measurement assumes a decision support system as an IT service and uses TPC-H as a benchmark. ~~C.2.2~~ and ~~C.2.3~~ show reports of these APEE measurement.

Table C.2 — APEE value of two application platforms that differ only in middleware

Application Platform	Middleware	APEE value
application platform A	RDBMS A	1,94
application platform B	RDBMS B	0,734

As shown in ~~Table C.2~~, by replacing the middleware that composes the application platform, the energy effectiveness of the application platform when used in the target IT service differs.

C.2.2 Example of an APEE report for application platform A

~~Table C.3~~ shows an example of an APEE report for application platform A.

3) Products mentioned in this annex are examples of suitable products that are available commercially. This information is given for the convenience of users of this document and does not constitute an endorsement of these products by ISO/IEC.

Table C.3 — Example of an APEE report for application platform A

No.	Item	Value
1	APEE(TPC-H v2)	1,94
2	NoAO value	6 application outcomes
3	EAP value	3,101 kWh
4	Start date and time of measurement, and end date and time of measurement	30 January 2020, 12:09:08 – 13:12:14
5	Start date and time of each measurement period, and end date and time of each measurement period	1st measurement period of 1st benchmark execution: 30 January 2020, 12:09:08 - 12:12:16 1st measurement period of 2nd benchmark execution: 30 January 2020, 12:12:18 - 12:19:30 2nd measurement period of 1st benchmark execution: 30 January 2020, 12:19:40 - 12:22:50 2nd measurement period of 2nd benchmark execution: 30 January 2020, 12:22:54 - 12:30:02 3rd measurement period of 1st benchmark execution: 30 January 2020, 12:30:14 - 12:33:32 3rd measurement period of 2nd benchmark execution: 30 January 2020, 12:33:34 - 12:40:44 4th measurement period of 1st benchmark execution: 30 January 2020, 12:40:54 - 12:44:04 4th measurement period of 2nd benchmark execution: 30 January 2020, 12:44:08 - 12:51:28 5th measurement period of 1st benchmark execution: 30 January 2020, 12:51:38 - 12:54:46 5th measurement period of 2nd benchmark execution: 30 January 2020, 12:54:50 - 13:02:00 6th measurement period of 1st benchmark execution: 30 January 2020, 13:02:10 - 13:05:20 6th measurement period of 2nd benchmark execution: 30 January 2020, 13:05:24 - 13:12:14
6	Target IT service	Decision support system for the supermarket
7	Details of the selected application platform	Server: Vendor name: Hitachi, Ltd. Model name: BS500 A1 (GG-SRE3A1TBN1) CPU: Intel Xeon E7-8880v2 x 2 slots Cores per CPU: 15 Threads per Core: 2 CPU Frequency: 2,50GHz Memory: 512GB Memory Type: 16GB DDR3 Registered DIMM Number of DIMMs: 32 Internal storage: SAS 900GB (Hitachi GG-UH39001N6EX) x 2 disks FC HBA: Hitachi GG-CC3M162N1EX x 2 Internal power supply: 80PLUS PLATINUM (GG-BP3PWS1N1BX) x 3

Table C.3 *(continued)*

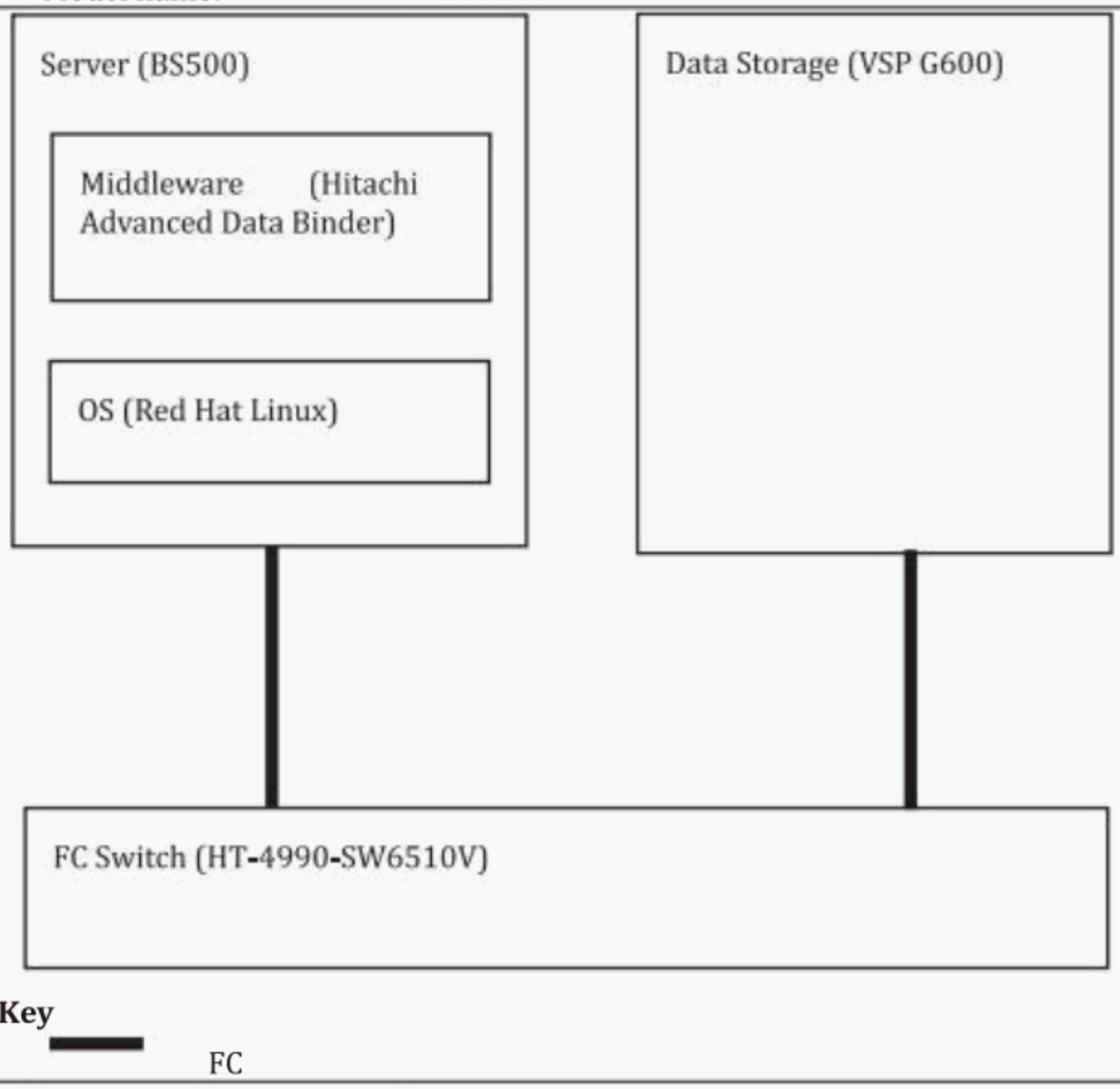
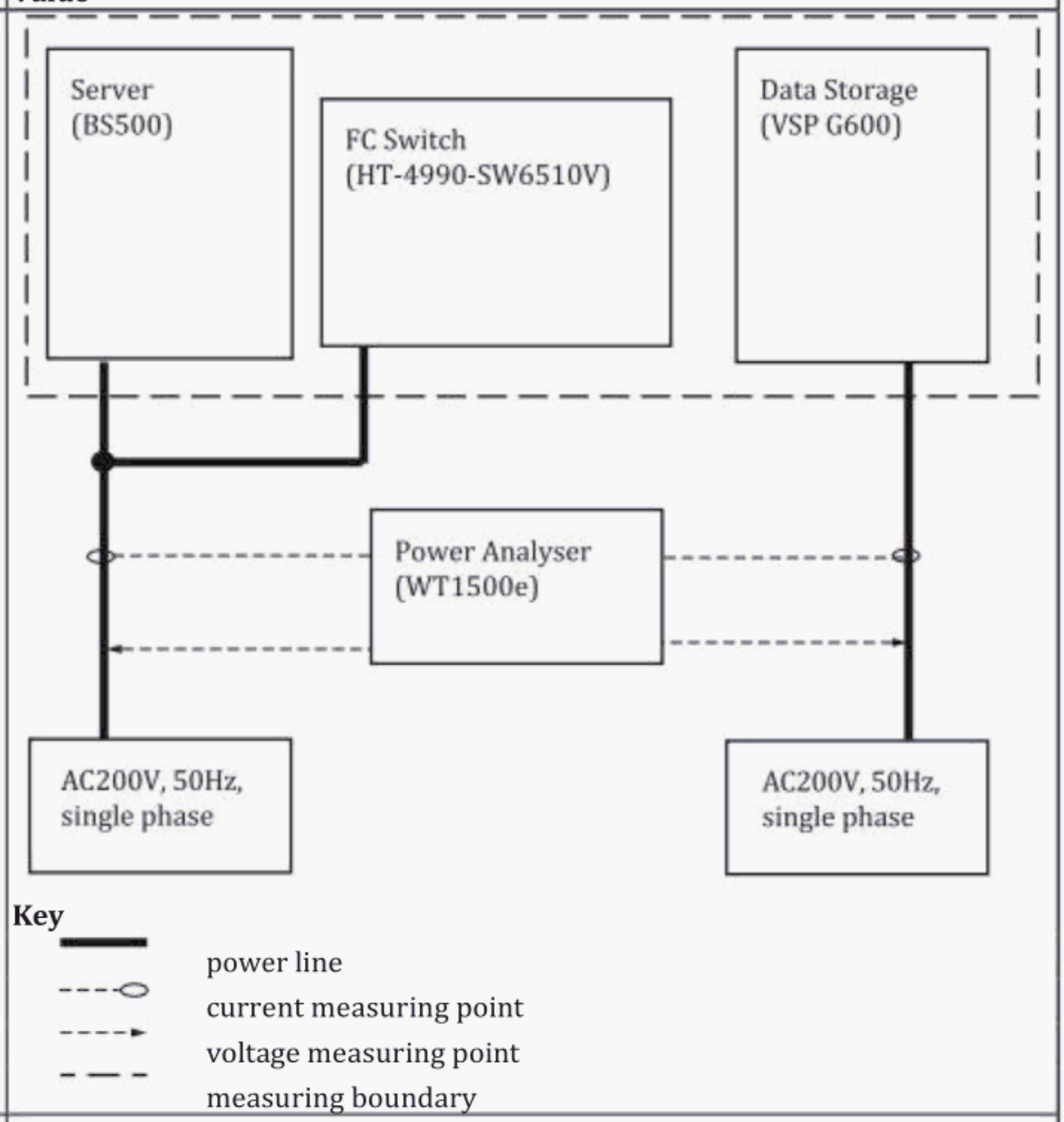
No.	Item	Value
		Data storage: Vendor name: Hitachi, Ltd. Model name: VSP G600 Drive: HT-F40SC-3R2FM (3.1TB) x 12 disks FC switch: Vendor name: Hitachi Model name: HT-4990-SW6510V Port: 16Gbps x 24 ports OS: Vendor name: Red Hat, Inc. Model name: Red Hat Enterprise Linux Version number: 7.4 Middleware: Vendor name: Hitachi, Ltd. Model name: Hitachi Advanced Data Database Version number: 05-00 Buffer size: 150GB
8	Details of the selected power analysers	Power Analyser: Vendor name: Yokogawa Test & Measurement Corporation Model name: WT1500e
9	Details of the selected application platform - configuration diagram	

Table C.3 *(continued)*

No.	Item	Value
10	Power supply information and connection location of power analysers	 **Key** power line; current measuring point; voltage measuring point; measuring boundary
11	Inlet temperatures and location of the selected application platform at start and end of measurement	Start temperature: 23,5 °C at 30 January 2020, 12:10:00 End temperature: 23,5 °C at 30 January 2020, 13:10:00 Location: an inlet of the server(Server)
12	Information of the selected benchmark	TPC-H, version 2.17.3, scale factor = 10, throughput test and power test using Q1 – Q22 http://www.tpc.org/TPC_Documents_Current_Versions/pdf/tpc-h_v2.17.3.pdf Scale factor is a parameter of the database size specified by the measurer, and the unit is gigabyte (GB).
13	Standard number, publication year, and title of the standard when the APEE value was measured	ISO/IEC 23544:2021, *Information Technology — Data centres — Application Platform Energy Effectiveness (APEE)*

C.2.3 Example of an APEE report of application platform B

Table C.2.3.1 shows an example of an APEE report of application platform B.

Table C.2.3.1 — Example of an APEE report of application platform B

No.	Item	Value
1	APEE(TPC-H v2)	0,734

Table C.2.3.1 *(continued)*

No.	Item	Value
2	NoAO value	3 application outcomes
3	EAP value	4,087 kWh
4	Start date and time of measurement, and end date and time of measurement	4 February 2020, 11:08:46 – 12:34:04
5	Start date and time of each measurement period, and end date and time of each measurement period	1st measurement period of 1st benchmark execution: 4 February 2020, 11:08:46 - 11:30:50 1st measurement period of 2nd benchmark execution: 4 February 2020, 11:30:52 – 11:36:54 2nd measurement period of 1st benchmark execution: 4 February 2020, 11:37:08 – 11:59:28 2nd measurement period of 2nd benchmark execution: 4 February 2020, 11:59:30 – 12:05:44 3rd measurement period of 1st benchmark execution: 4 February 2020, 12:05:58 – 12:27:58 3rd measurement period of 2nd benchmark execution: 4 February 2020, 12:28:00 – 12:34:04
6	Target IT service	Decision support system for the supermarket
7	Details of the selected application platform	Server: Vendor name: Hitachi, Ltd. Model name: BS500 A1 (GG-SRE3A1TBN1) CPU: Intel Xeon E7-8880v2 x 2 slots Cores per CPU: 15 Threads per Core: 2 CPU Frequency: 2.50GHz Memory: 512GB Memory Type: 16GB DDR3 Registered DIMM Number of DIMMs: 32 Internal storage: SAS 900GB (Hitachi GG-UH39001N6EX) x 2 disks FC HBA: Hitachi GG-CC3M162N1EX x 2 Internal power supply: 80PLUS PLATINUM (GG-BP3PWS1N1BX) x 3 Data storage: Vendor name: Hitachi, Ltd. Model name: VSP G600 Drive: HT-F40SC-3R2FM (3.1TB) x 12 disks FC switch: Vendor name: Hitachi Model name: HT-4990-SW6510V Port: 16Gbps x 24 ports OS: Vendor name: Red Hat, Inc. Model name: Red Hat Enterprise Linux Version number: 7.4

Table C.2.3.1 *(continued)*

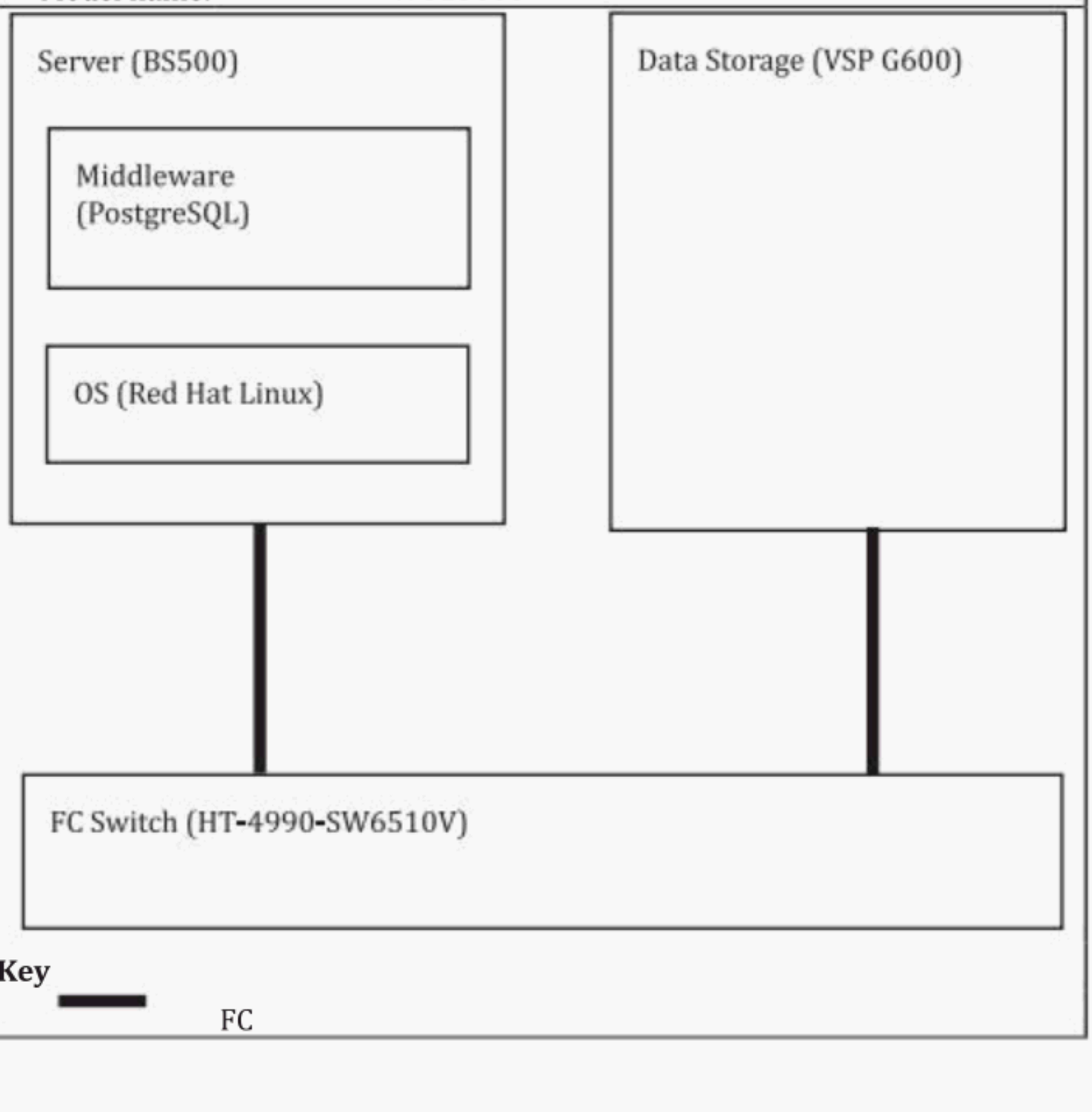
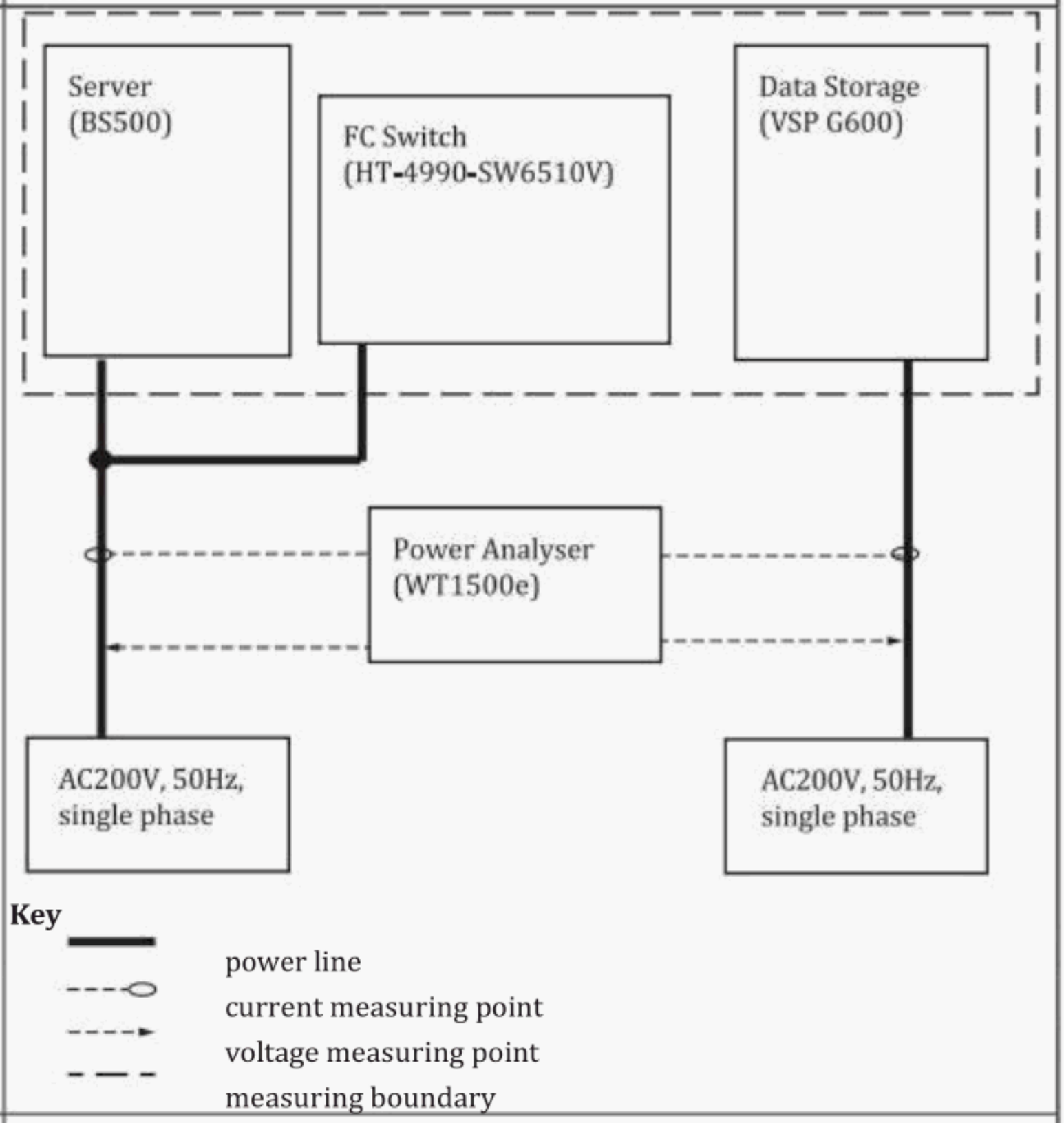
No.	Item	Value
		Middleware: Vendor name: PostgreSQL Global Development Group Model name: PostgreSQL Version number: 11 Buffer size: shared_buffers = 128GB work_mem = 1GB maintenance_work_mem = 24GB
8	Details of the selected power analysers	Power Analyser: Vendor name: Yokogawa Test & Measurement Corporation Model name: WT1500e
9	Details of the selected application platform - configuration diagram	

Table C.2.3.1 *(continued)*

No.	Item	Value
10	Power supply information and connection location of power analysers	
11	Inlet temperatures and location of the selected application platform at start and end of measurement	Start temperature: 23,5 °C at 4 February 2020, 11:09:00 End temperature: 24,5 °C at 4 February 2020, 12:34:00 Location: an inlet of the server(Server)
12	Information of the selected benchmark	TPC-H, version 2.17.3, scale factor = 10, throughput test and power test using Q1 – Q22 http://www.tpc.org/TPC_Documents_Current_Versions/pdf/tpc-h_v2.17.3.pdf Scale factor is a parameter of the database size specified by the measurer, and the unit is gigabyte (GB).
13	Standard number, publication year, and title of the standard when the APEE value was measured	ISO/IEC 23544:2021, *Information Technology — Data centres — Application Platform Energy Effectiveness (APEE)*

Annex D
(informative)

Examples of acceptable benchmarks

D.1 Introduction

This annex provides examples of benchmarks that can be used for APEE measurement.

D.2 Examples of benchmarks

~~Table D.1~~ shows the correspondence between workload types and benchmark names. Note that ~~Table D.1~~ contains only a sample of the possible workload types and does not cover all workload types.

Table D.1 — Correspondence table of workload types and benchmark names

Workload Type	Workload Type Sub Class	Example of typical IT Service	Benchmark Name	Includes non-measured period	Reference
Database transaction	OnLine Transaction Processing (OLTP)	IT system of a securities company	TPC-E [1]	No	~~http://www.tpc.org/tpce/~~
	OnLine Analytical Processing (OLAP)	Decision support	TPC-H	No	~~http://www.tpc.org/tpch/~~
HPCC	—	Scientific modelling	LINPACK	No	~~http://www.netlib.org/linpack/~~
IoT service	—	Analysis of sensor data from a power plant	TPCx-IoT [1]	No	~~http://www.tpc.org/tpcx-iot/~~
Compute	—	Compute and memory intensive server application	SPEC CPU® 2017 [a]	Yes (e.g. compiling benchmark programmes)	~~https://www.spec.org/cpu2017/~~
HPC Accelerated Compute	OpenCL, OpenACC, and OpenMP 4 Target Offload Applications	Server accelerated applications	SPEC ACCEL® [a]	Yes	https://www.spec.org/accel/
HPC Accelerated Compute	Server MPI Applications	Multi-threaded server applications	SPEC MPI® 2007 [a]	Yes	~~https://www.spec.org/mpi2007/~~

[a] SPEC, SPEC CPU, SPEC ACCEL, SPEC MPI, SPEC OMP, and SPECjvm are trademarks of the Standard Performance Evaluation Corporation. This information is given for the convenience of users of this document and does not constitute an endorsement by ISO/IEC.

Table D.1 *(continued)*

Workload Type	Workload Type Sub Class	Example of typical IT Service	Benchmark Name	Includes non-measured period	Reference
HPC Accelerated Compute	Server OpenMP 3.1 Applications	Multi-threaded server applications	SPEC OMP® 2012 [a]	Yes	~~https://www.spec.org/omp2012/~~
Java Application Performance	Java Runtime Environment (JRE)	Server java application	SPECjvm® 2008 [a]	Yes	~~https://www.spec.org/jvm2008/~~

[a] SPEC, SPEC CPU, SPEC ACCEL, SPEC MPI, SPEC OMP, and SPECjvm are trademarks of the Standard Performance Evaluation Corporation. This information is given for the convenience of users of this document and does not constitute an endorsement by ISO/IEC.

Bibliography

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

[2] ISO/IEC 30134-4, *Information technology — Data centres — Key performance indicators — Part 4: IT Equipment Energy Efficiency for servers (ITEEsv)*

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