BLUE ANGEL

The Environmental Label

Energy Efficient Data Center Operation

DE-UZ 161

Basic Award Criteria

Edition February 2015

Version 2

The Environmental Label is supported by the following four institutions:

Federal Ministry
for the Environment, Nature Conservation
and Nuclear Safety

The Federal Ministry for the Environment, Nature Conservation and Nuclear Safety is the owner of the label. It regularly provides information on the decisions taken by the Environmental Label Jury.

Umwelt Bundesamt

The German Environmental Agency with its specialist department for "Ecodesign, Eco-Labelling and Environmentally friendly Procurement" acts as office of the Environmental Label Jury and develops the technical criteria of the Basic Criteria for Award of the Blue Angel.

Jury Umweltzeichen

The Environmental Label Jury is the independent, decision-making body for the Blue Angel and includes representatives from environmental and consumer associations, trade unions, industry, the trade, crafts, local authorities, academia, the media, churches, young people and the German federal states.

RAL gGmbH

The RAL gGmbH is the awarding body for the Environmental Label. It organises the process for developing the relevant award criteria in independent expert hearings – which involve all relevant interest groups.

If you require further information please contact:
RAL gGmbH
RAL UMWELT
Fränkische Straße 7
53229 Bonn
Tel: +49 (0) 228 / 6 88 95 - 0
E-Mail: umweltzeichen@ral.de
www.blauer-engel.de

Version 1 (02/2015): First Edition, Expiry date: December 31, 2018
Version 2 (01/2018): Prolongation without any change for 1 year, until 31.12.2019

Table of contents

This document is a translation of a German original. In case of dispute, the original document should be taken as authoritative.

1 Introduction

1.1 Preface

In cooperation with the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety, the German Environmental Agency and considering the results of the expert hearings conducted by RAL gGmbH, the Environmental Label Jury has set up these Basic Criteria for the Award of the Environmental Label. RAL gGmbH has been tasked with awarding the Environmental Label.
Upon application to RAL gGmbH and on the basis of a Contract on the Use of the Environmental Label to be concluded with RAL gGmbH, the permission to use the Environmental Label may be granted to all products, provided that they comply with the requirements as specified hereinafter.
The product must comply with all the legal requirements in the country in which it is to be marketed. The applicant shall declare that the product meets this requirement.

1.2 Background

Electricity consumption of data centers in Europe was around 52 TWh[1] in 2011, this corresponds to approx. 2.6 % of the entire electricity consumption in Europe and is set to increase to 70 TWh in 2020.

Following experience gained in pilot projects and based on examples of good practice, it can be assumed that there is great energy savings potential of between 40-50% in the area of data centers. Data center operators believe that there is particularly great potential for saving energy in the areas of air conditioning and waste heat recovery, the use of energy-efficient servers and storage systems, as well as in the generation and distribution of electricity (Borderstep 2014).

In its Digital Agenda 2014-2017, the German federal government decided to step up its efforts within the framework of the federal Green IT Initiative. This includes reducing the consumption of energy and resources in ICT, orientating public purchasing along sustainable criteria and implementing Green IT in the economy. In this context, the Blue Angel ecolabel for data centers provides data center operators with guidance on how to better exploit the enormous potential for making energy and cost savings.

1.3 Objective of the environmental label

The Blue Angel ecolabel for "Energy Efficient Data Center Operation" (DE-UZ 161) utilises an interdisciplinary approach covering all areas of a data center and its infrastructure. This system-based approach not only focuses on the energy efficiency of individual components but, in particular, also on the overall environmentally-conscious management of the data center. This includes the competent planning of the data center with the goal of achieving the best possible utilisation of existing information technology and ensuring the durability of the hardware with the aim of reducing the consumption of resources.

[1] Öko-Institut/IZM Study on the practical application of the new framework methodology for measuring the environmental impact of ICT - cost/benefit analysis (SMART 2012/0064)

In concrete terms, this means that the existing potential for efficiency in the data center has been fully exploited and thus the existing hardware resources are being optimally utilised and also that ambitious environmental criteria are observed when making new investments. The objective of the environmental label is also to provide operators with more transparency about the hardware resources used so that they can respond in an efficient manner to changes in the framework conditions at an early stage.

The environmental label for energy efficient data center operation can be awarded to those data centers in which the operators have made special efforts to:

- operate their data centers in an energy efficient and resource-conserving manner
- develop and successfully implement a long-term strategy for increasing the energy and resource efficiency in relation to the IT services required

The labelling of these data centers provides customers and public or private procurers of data center services with an informative tool that enables them to consciously select energy and resource efficient data center services.

Therefore, following benefits for the environment and health are stated in the explanatory box:

1.4 Compliance with legal requirements

These Basic Award Criteria have been developed with due consideration to the current German legal requirements, especially the Electrical and Electronic Equipment Act (ElektroG)[2], which implemented EU directives 2002/96/EC[3] and 2011/65/EC[4] into German law and governs the collection, treatment, disposal and pollutant content of electrical and electronic equipment. The user of the Blue Angel ecolabel must comply with these legal requirements.

1.5 Definitions

- **Central Processing Unit (CPU)** – This is the central component of a computer. Important key data for the CPU are the clock speed, width of the data bus, number of processing cores and the number of threads that can be carried out simultaneously.

---

[2] Law for the sale, return and environmental disposal of electrical and electronic equipment, BGBl, 2005, Part I, No. 17 (23 May 2005)

[3] Directive on Waste from Electrical and Electronic Equipment, Directive 2002/96/EC of the European Parliament and of the Council of 27/01/2003 on waste electrical and electronic equipment

[4] Directive 2011/65/EC of the European Parliament and of the Council of 8 June 2011 on the restriction of the use of certain hazardous substances in electrical and electronic equipment (revised version).

- **Energy Usage Effectiveness (EUE)** – A measure of how efficiently the data center infrastructure uses energy. It describes the ratio of the annual energy demand of the entire data center to the energy demand of the IT equipment.
- **Energy Efficiency Ratio (EER)** – This describes the ratio of the annual cooling load for the cooling system to the total electrical energy input into the entire cooling system.
- **Power Distribution Unit (PDU**) – This is the distribution unit within a server room that distributes the low voltage electricity to the individual IT components. In order to enable sophisticated monitoring of energy consumption, so-called "intelligent PDUs" including devices that measure the performance values and energy consumption of the individually connected devices are fitted. The measurement values are transferred to a central monitoring system via a signal bus (e.g. LAN network).
- **Random Access Memory (RAM)** – This is the working memory of a computer or server. It is characterised by quick read and write speeds. RAM is generally provided in the form of volatile semiconductor memory and this characteristic means that it is not suitable for the permanent archiving of data.
- **Server** - This is a computer that is connected to the computer network and provides it with software services. In a data center, servers are generally installed in shared server racks and represent one of the central IT components in the data center.
- **Storage** - This is used for permanently saving large volumes of data. It is generally provided in the form of rotating hard drives (Hard Disk Drive - HDD), tape memory or flash memory (Solid State Disk - SSD).
- **Uninterruptible Power Supply (UPS)** – This is an apparatus within the energy supply system for the data center that increases the reliability of the energy supply. The UPS bridges short-term interruptions to the electricity supply grid using batteries and ensures that the servers and storage systems can be properly shut down in the event of a prolonged power failure.
- **Virtualization** – This describes the use of the hardware of a single "physical" server for multiple parallel runtime environments (so-called "virtual servers") that are emulated using software. The virtual servers can be operated independently of one another and without any mutual interference and thus increase the utilisation of the physical server. The degree of virtualization describes the ratio of virtual to physical servers.

1.6 Overview of possible future requirements

As a result of a lack of measurement methods and benchmarks, these Basic Award Criteria for the environmental label do not specify any target values for evaluating the energy efficiency of memory systems and network components. These points will be examined again during the next revision and minimum requirements may be set for these components.

1.7 Information on submitting an application and compliance verification

The requirements for energy efficient data center operation formulated in these Basic Award Criteria are valid at both the time the application is submitted and also during the use of the environmental label. Compliance with these requirements must be verified before the environmental label is awarded and also during the term of the contract on an annual basis. The requirements stated in Paragraph 3 are split into the following subparagraphs:

- 3.1 Requirements at the time of application
- 3.2 Requirements during the period of the contract
- 3.3 Checking the requirements

When submitting an application, all of the compliance verifications stated in Paragraph 3.1 must be provided. The central document for verifying compliance with the requirements at the time of the application is the Energy Efficiency Report, which comprises general information on the data center, the IT and building technology utilised and the results of the energy and IT monitoring.

This Energy Efficiency Report must be audited and confirmed by a designated testing institution. For this purpose, RAL gGmbH, with the support of the Federal Environmental Agency, has designated testing institutions (see Annex 3) that are permitted to approve auditors for the completion of these audits on behalf of the testing institution. The approval of the auditors guarantees that the testing of the report is carried out independently and with a high level of professional qualifications. The auditors can support the applicant in the creation of the energy efficiency reports by providing, for example, online tools or questionnaires that the operator of the data center has to complete and continuously update.

During the term of the Contract on the Use of the Environmental Label, the data center must be operated in an energy efficient manner and energy efficiency criteria must be taken into account when acquiring new equipment for the air conditioning system or data center. In this context, the requirements stated in Paragraph 3.2 must be observed.

Compliance with the requirements and the results of the monitoring are to be documented in an Annual Energy Efficiency Report and submitted to RAL gGmbH in the form stated in Paragraph 3.3. This Annual Energy Efficiency Report must also be audited and confirmed by a designated testing institution.

2 Scope

Within the scope of these Basic Award Criteria, a data center is defined as follows:
A data center is capable of securely, permanently and centrally processing large amounts of data over a long period of time. In the process, the data center shall still possess these capabilities even when individual capabilities are not being used e.g. operation over a long period of time. The required capabilities are described in concrete terms below:

a) **Data processing** includes e.g. the collection, transfer, calculation or storage of data.
b) **Secure** data processing is described, in technological terms, as the "minimum level of security" required for a "controlled shutdown of the computers without any loss of data in the event of damage to the supply units".
c) The term **large amount** of processed data is relative to the technical capabilities of current state-of-the-art systems and thus represents a dynamic factor over time.
d) Operation of the data center **permanently over a long period of time** requires measures to control those influences that may have critical effects beyond a certain period of time such as heat, humidity or dust.

Operators and/or service providers of data centers who have an influence over all areas and systems of a data center that is covered by the requirements specified in these Basic Award Criteria are eligible to apply for the environmental label. The environmental label is awarded to the entire building that houses the data center (including the technical building equipment) that is defined by a fixed location and a unique name or designation. If a company operates multiple data centers[5] that are distributed over a variety of locations and/or operated independently of one another, each one represents a stand-alone data center for which it is necessary to apply for a separate environmental label.

3 Requirements

3.1 Requirements at the time of application

Verification of compliance with the requirements stated in Paragraph 3.1 must be submitted at the time of application. The Contract on the Use of the Environmental Label will be issued on this basis. The other requirements (Paragraph 3.2) must be observed during the term of the contract and this must be regularly verified in the form of an Annual Energy Efficiency Report (Paragraph 3.3).

3.1.1 Energy Efficiency Report at the time of application

An Energy Efficiency Report must be submitted at the time of application that provides information on the current technical status of the data center. In addition, the Energy Efficiency Report must document compliance with all of the requirements that are valid at the time of application according to Paragraphs 3.1.2 to 3.1.10. The information required for the award of the environmental label is listed in the document template in Annex 2.
The Energy Efficiency Report must be audited by the designated testing institution (see Paragraph 1.7) The testing institution must confirm in the form of an audit report that the information requested in Annex 2 has been provided in full and is highly plausible.

Compliance verification

The applicant shall submit a fully completed Energy Efficiency Report as Annex 2 to the Contract. The Energy Efficiency Report can be provided by the applicant either using the document template in Annex 2 to the Basic Award Criteria or in another suitable form, such as a printout from an online tool or a spreadsheet program. However, the report must contain the structure (Paragraph headings) and the information requested in Annex 2 to the Basic Award Criteria.
The applicant shall declare compliance with the requirement in Annex 1 to the Contract and submit an audit report as Annex 4 to the Contract from the testing institution designated in Annex 3 that confirms that the applicant has provided at least the required information in full and with a high level of plausibility.

3.1.2 Energy Usage Effectiveness (EUE)

Energy Usage Effectiveness (EUE) is a measure of the energy efficiency of the data center's infrastructure. In order to determine the EUE value, a measurement concept must be implemented in the data center in accordance with Appendix A: Measurement concept. Based

[5] IT system dependencies are not relevant.

on the measured energy consumption values, the EUE value must be determined in accordance with the calculation guidelines described in Appendix A.

The applicant must specify the Energy Usage Effectiveness (EUE) of the data center over a period of twelve months and document this value in the Energy Efficiency Report. At the time of application, the end of the measurement period for the EUE must not be more than three months ago.
Depending on the date at which the data center was commissioned in relation to the date the application is submitted (Δt), the Energy Usage Effectiveness (EUE) of the data center must not exceed the following values:

Commissioning of the data center	EUE
up to a maximum of 12 months ago ($\Delta t \leq 12$ months)	EUE ≤ 1.4
more than 12 months ago and less than 5 years ago (12 months < Δt < 60 months)	EUE ≤ 1.6
5 years ago or more ($\Delta t \geq 60$ months)	EUE ≤ 1.8

Exemption: New data centers, which were commissioned less than twelve months ago at the time of the application, are exempt from the requirement that the EUE value must be calculated over a measurement period of twelve months. The expected EUE value for these data centers must be calculated as follows:

- Either based on planning data from a qualified specialist planner (planning according to DIN EN 50600 or comparable), in which the calculation of the EUE value reflects the expected status of the data center twelve months after it has been commissioned.
- Or on the basis of a load test, where the expected status of the data center after twelve months is simulated using load banks and then used to calculate the annual energy consumption of the data centre and the IT equipment.

In the event that this exemption is utilised, the planning results or the results of the load test must be documented in the Energy Efficiency Report (see Paragraph 3.1.1)

Compliance verification

The applicant shall declare compliance with the requirement in Annex 1 to the Contract and document the calculation process and the EUE value in the Energy Efficiency Report as Annex 2 to the Contract.
In the event that the exemption has been utilised, the applicant shall demonstrate compliance with the requirement for Energy Usage Effectiveness (EUE) by submitting the planning data or a measurement report for the load test as a Appendix to the Energy Efficiency Report. The testing institution for the Energy Efficiency Report must verify the plausibility of the documentation.

3.1.3 Energy management system

The applicant confirms that he/she has implemented an energy management system. This should be based on DIN EN ISO 50001[6] or EMAS III[7]. The energy management system must comprise the following points:

- An energy strategy that has been set out in writing.
- Energy saving measures are considered and developed across all sectors (IT procurement, IT operation, building management, energy controlling, purchasing and, where relevant, sales).
- Responsibilities for optimising energy usage are clearly defined.
- A continuous improvement process for optimising energy usage has been established.
- There are defined efficiency improvement targets and their achievement is reviewed.

Compliance verification

The applicant shall declare compliance with the requirement in Annex 1 to the Contract and document the energy management system in the Energy Efficiency Report as Annex 2 to the Contract by providing information on the energy strategy of the company, efficiency improvement targets, optimisation measures, responsibilities and monitoring.

3.1.4 Electrical energy

The data center must cover most of its electricity demand, meaning over 50%, from renewable energies such as hydroelectric power, photovoltaic power, wind power, biomass power or from a combined heat and power plant.

The specific global warming potential of the electricity mix used must not exceed a value of 370 g of carbon dioxide equivalents per kilowatt hour (based on the electricity labelling data according to Article 42 of the German Energy Act (Energiewirtschaftsgesetz))

Exemption: Applicants that are themselves not contractual partners of an electricity supplier but rather receive their electricity via a third party (e.g. the operator of an administration building or a superordinate administrative unit of an authority or company) are exempt from this requirement. This exemption is only valid if the electricity ($Q_{el,DC,a}$)[8] used in the data center accounts for less than half of the total electricity supplied via the relevant electricity supply contract.

Compliance verification

The applicant shall declare compliance with the requirement in Annex 1 to the Contract and submit as Annex 5 to the Contract the electricity labelling data in accordance with Article 42 of the German Energy Act (Energiewirtschaftsgesetz) providing at least information on the CO_2

---

6 DIN EN ISO 50001: Energy management systems - Requirements with guidance for use

7 Regulation (EC) No. 1221/2009 of the European Parliament and of the Council of 25 November 2009 on the voluntary participation by organisations in a Community eco-management and audit scheme (EMAS): OJ EC No. L 342, P. 1, 22.12.2009

8 $Q_{el,DC,a}$ describes the amount of electricity used in the entire data center in [kWh/a] and thus includes, in accordance with Appendix A: Measurement concept, the electrical energy consumed by the IT equipment ($Q_{el,IT,a}$), the electrical energy losses due to the uninterruptible power supply ($Q_{el,UPS,a}$) and the energy distribution units ($Q_{PDU,a}$), the electrical energy for the cooling system ($Q_{el,CS,a}$) and the electrical energy for the operation of other consumers ($Q_{el,OC,a}$).

emissions [g/kWh] as well as the proportion of the electricity mix accounted for by renewable energies (subsidised according to the German Renewable Energies Act (EEG) and non-subsidised renewable energies). A specific verification based on the system used in the German Energy Act can be submitted for the share of the electricity accounted for by the data center's own systems for power generation.
In the event that the exemption has been utilised, the applicant shall demonstrate (for example in the form of electricity bills) who the contractual parter for the electricity supply contact is on the customer side and that the amount of electricity $Q_{el,DC,a}$ [kWh/a] used in the data center represents less than half of the total amount of electricity provided by the electricity supply contract or the company. This information is also to be submitted as Annex 5 to the Contract. The testing institution for the Energy Efficiency Report must verify the plausibility of the documentation.

3.1.5 Creation of an IT inventory list

The applicant shall submit an inventory list containing all of the IT components installed in the data center. This IT inventory list must include the following IT equipment as a minimum:

- Servers
- External memory systems
- Network equipment

Exemption: Equipment with a connected electrical rating of less than 10 Watts, of which a maximum of 5 identical pieces of equipment are utilised, do not need to be included in the IT inventory list.

Compliance verification

The applicant shall declare compliance with the requirement in Annex 1 to the Contract and document the IT inventory list in the Energy Efficiency Report as Annex 2a (servers), 2b (external storage systems) and 2c (network equipment) to the Contract.

3.1.6 Monitoring of the IT load

The data centre must have a monitoring system for the IT load, which continually records the load average for the servers, RAM memory and storage systems.
The following values from the monitoring of the IT load must be documented at least monthly for the past 12 months or, in the case of data centers that were commissioned less than 12 months ago, from the time the data center was commissioned:

- Load average for the CPUs [%]
- Load average for the RAM [%]
- Load average for the storage [%]

The calculation of the load average must be carried out in accordance with the method described in Appendix C: Calculation of the load average of the IT equipment by monitoring at least 90% of the relevant IT equipment (CPUs, RAM, storage).

Compliance verification

The applicant shall declare compliance with the requirement in Annex 1 to the Contract and document the monthly results of the monitoring for the past 12 months based on the time series in the Energy Efficiency Report in Annex 2e (Monitoring of the IT load).

3.1.7 Energy efficiency of the cooling system

The Energy Efficiency Ratio (EER) of the cooling system (CS) in a data center describes the ratio of the cooling load $Q_{th,DC,a}$ [MWh_{th}/a] in the data center that is handled by the cooling system within one year (12 months) to the total electrical energy input into the entire cooling system $Q_{el,CS,a}$ [MWh_{el}/a].

$$JAZ = \frac{Q_{th,RZ,a}}{Q_{el,KS,a}}$$

In cooling systems that are operated by means of electrically operated compression-type chillers, the Energy Efficiency Ratio must be determined by measurements carried out at the required measurement points in accordance with Appendix B: Determining the key values for the cooling system.

Depending on the date at which the cooling system was commissioned in relation to the date the application is submitted (Δt), the Energy Efficiency Ratio (EER) calculated in this way must not exceed the values stated in the following table:

Commissioning of the cooling system	EER
up to a maximum of 12 months ago ($\Delta t \leq 12$ months)	EER > 7
more than 12 months ago and less than 5 years ago (12 months < Δt < 60 months)	EER > 5
5 years ago or more ($\Delta t \geq 60$ months)	EER > 3.5

Exemption 1: New data centers, which were commissioned less than twelve months ago at the time of the application, are exempt from the requirement that the EER value must be calculated over a measurement period of twelve months. The expected EER value of these data centers must be calculated as follows:

- Either based on planning data from a qualified specialist planner, in which the calculation of the EER value reflects the expected status of the data center twelve months after it has been commissioned.
- Or on the basis of a load test, where the expected status of the data center after twelve months is simulated using load banks and then used to calculate the annual cooling load for the cooling system and the total electrical energy input into the entire cooling system.

In the event that this exemption is utilised, the planning results or the results of the load test must be documented in the Energy Efficiency Report (see Paragraph 3.1.1)

Exemption 2: In the event that absorption chillers are utilised, the EER value does not need to be calculated as described above. Instead, the specific greenhouse gas emissions [kg_{CO2e}/kWh_{th}] associated with the cooling output must be calculated and the value documented in the Energy Efficiency Report. It is not permitted for the specific greenhouse gas emissions to exceed the requirements described above for greenhouse gas emissions from electrically operated compression-type chillers. In order to determine the specific greenhouse

emissions, the calculation guidelines described in Appendix B: Determining the key values for the cooling system must be followed.

Compliance verification

The applicant shall declare compliance with the requirement in Annex 1 to the Contract and document the amount of energy ($Q_{th,DC,a}$ and $Q_{el,CS,a}$) and the Energy Efficiency Ratio (EER) in the Energy Efficiency Report in Annex 2 to the Contract.
In the event that Exemption 1 has been utilised, the applicant shall demonstrate compliance with the requirement for the Energy Efficiency Ratio (EER) by submitting the planning data or a measurement report for the load test as an Appendix to the Energy Efficiency Report.
If absorption chillers are installed in the cooling system, the applicant shall calculate the specific greenhouse gas emissions (FATC) for the cooling output in accordance with Exemption 2 and document this value in a Appendix to the Energy Efficiency Report (Annex 2). If one of the exemptions has been utilised, the testing institution for the Energy Efficiency Report must verify the plausibility of the calculations.

3.1.8 Refrigerants

Only chlorine-free refrigerant may be used in the cooling system for cooling the data center.
In those cooling systems that entered into operation after the 1 January 2013, only halogen-free refrigerants may be used.

Exemption: Data centers with a maximum cooling requirement of 50 kW_{th} are exempt (corresponds to the connected electrical rating of the data center components to be cooled. The use of refrigerants containing halogens must be justified in these cases.

Compliance verification

The applicant shall declare compliance with the requirements in Annex 1 to the Contract and name the refrigerant and the quantity of refrigerant used in the Energy Efficiency Report (Annex 2).

3.1.9 Uninterruptible Power Supply (UPS)

The efficiency of the uninterruptible power supply (UPS) must not be lower than:

- 90% at an electrical output of 100% of the nominal output
- 85 % at an electrical output of 75 % of the nominal output
- 80 % at an electrical output of 50 % of the nominal output
- 80 % at an electrical output of 25 % of the nominal output

Compliance verification

The applicant shall declare compliance with the requirements in Annex 1 to the Contract and document the efficiency of the uninterruptible power supply in the Energy Efficiency Report in Annex 2. In addition, the applicant shall submit a measurement report in accordance with DIN EN 62040 (or the valid measurement standard at the time the UPS system is installed) from the manufacturer of the UPS system or from a testing institution accredited according to DIN EN ISO/IEC 17025 as Annex 6 to the Contract, which documents compliance with the requirement using relevant data (here: efficiency depending on the electrical output).

3.1.10 Virtualization of servers

Server virtualization must be used. The average degree of virtualization (number of virtual servers per physical server in the entire data center) must be greater than two.

$$\text{Degree of virtualization} > 2$$

Exemption: If server virtualization is not possible or not sensible based on the IT service provided by the data center, it is permitted to deviate from this requirement. The degree of virtualization must nevertheless be documented in the Energy Efficiency Report and justification provided for the deviation from this requirement.

Compliance verification

The applicant shall declare compliance with the requirement in Annex 1 to the Contract and document the degree of visualisation of the servers in the Energy Efficiency Report (Annex 2 to the Contract).

In the event that the exemption has been utilised, the applicant shall document the degree of virtualization of the servers in the Energy Efficiency Report and provide justification for the deviation from the minimum value in a Appendix to the Energy Efficiency Report (Annex 2) The testing institution for the Energy Efficiency Report must verify the plausibility of the reason provided.

3.2 Requirements during the period of the contract

The requirements for the energy efficient operation of data centers and the energy efficient acquisition of new IT components are described in Paragraph 3.2. These requirements must be complied with by the holders of the environmental label during the period of the contract. Compliance with the requirements according to Paragraph 3.2 must be verified in the form of an Annual Energy Efficiency Report (Paragraph 3.3) at the latest 14 months after the label has been awarded and then subsequently on an annual basis.

3.2.1 Progress report about the energy management system

The holder of the environmental label must report on the progress that he/she has made with the energy management system (see Paragraph 3.1.3). The progress report is part of the Annual Energy Efficiency Report (see Paragraph 3.3) and must contain the following points as a minimum:

- Progress in the implementation of the energy strategy in the company
- The optimisation measures taken
- The increases in efficiency achieved

Compliance verification

The holder of the environmental label shall document their progress in the implementation of the energy strategy in the company, the optimisation measures taken and the increases in efficiency achieved in the Annual Energy Efficiency Report (see Paragraph 3.3).

3.2.2 Monitoring of the electrical energy and IT load

Monitoring must be carried out in which measurements of the electrical output and the energy consumption of the important components of the data center, the server load and the storage system load are recorded and evaluated continuously throughout the whole year. For this purpose, the measurement points in accordance with Appendix A, as well as further measurement points for determining the Energy Efficiency Ratio (EER) of the cooling system, must be set up as a minimum and measurements taken on a regular basis.

The following values must be determined through this energy monitoring on at least an annual basis:

- Energy Usage Effectiveness (EUE) (see Paragraph 3.1.2)
- Energy Efficiency Ratio (EER) of the cooling system (see Paragraph 3.1.6)

The following values must be determined through this energy monitoring on at least a monthly basis (see Appendix A: Measurement concept):

- Electricity demand of the entire DC (MP_{DC} + MP_{OSG}) [kWh_{el}]
- Peak load of the entire DC (MP_{DC} + MP_{OSG}) [kW_{el}]
- Electricity demand of the IT equipment (MP_{IT2}) [kWh_{el}]
- Peak load of the IT equipment (MP_{IT2}) [kW_{el}]
- Electricity demand of the cooling system (MP_{CS}) [kWh_{el}]
- Peak load of the cooling system (MP_{CS}) [kW_{el}]
- Electricity demand of the UPS (losses) (MP_{UPS} - MP_{IT1}) [kWh_{el}]
- Electricity demand of the PDUs (losses) (MP_{IT1} - MP_{IT2}) [kWh_{el}]
- Electricity demand of other consumers (MP_{OC}) [kWh_{el}]
- Cooling load of the entire DC [kWh_{th}]

The following values must be determined through the monitoring of the IT load for at least 90% of the relevant IT components (CPUs, RAM. storage) on a monthly basis (see Appendix C: Calculation of the load average of the IT equipment):

- Load average for the CPUs [%]
- Load average for the RAM [%]
- Load average for the storage [%]

Compliance verification

The holder of the environmental label shall document the most important results of the monitoring in the Annual Energy Efficiency Report (see Paragraph 3.3). The documentation shall include, as a minimum, those values that must be determined on a monthly basis according to the requirements as a time series for the past 12 months. In addition, the annual values for the electricity demand of the entire DC, electricity demand of the IT equipment, EUE and EER shall be documented in the Energy Efficiency Report as Annex 2e (Monitoring of the electrical energy and IT load) as a time series for the period since the application back to the previous year.

3.2.3 Continued use of the IT inventory list

In the event of the new acquisition of servers, external storage systems, network equipment and intelligent power distribution units (PDUs), the holder of the environmental label must

continue to use the IT inventory list described under 3.1.5 and document the current status at the time the annual report is submitted. Newly acquired components whose commissioning dates lie within the reporting period must be suitably marked.

Compliance verification

The holder of the environmental label shall document their continued use of the IT inventory list to describe the current status of the servers, external storage systems and network equipment in the Annual Energy Efficiency Report in Annexes 2a to 2d (see Paragraph 3.3).

3.2.4 Taking into account life cycle costs when making acquisitions

The applicant obligates themselves to carry out a calculation of the life cycle costs for the planned period of use (e.g. investment costs, maintenance and energy costs, disposal costs) when acquiring new equipment and systems and to take this into account when evaluating quotations.

Compliance verification

The applicant shall declare compliance with the requirement in Annex 1 to the Contract.

3.2.5 Acquisition of new servers

When acquiring new servers, the total energy efficiency of the server (Σssj_ops/Σpower) determined in accordance with the SPECpower_ssj2008[9] methodology must be calculated by the holder of the environmental label or provided by the manufacturer of the server.
The total energy efficiency of the newly acquired server must be at least **5,000 ssj_ops/W**.

Exemption: Deviations from this requirement are permitted in justified cases. Such cases include, for example, server architecture that is not applicable for the SPECpower_ssj2008 methodology or for which the deviating efficiency level has been consciously accepted. These servers must also be documented in the Energy Efficiency Report and the deviation from the requirement justified.

Compliance verification

The holder of the environmental label shall provide information about the manufacturer, model, nominal power output and total energy efficiency of the server (Σssj_ops/Σpower) in accordance with the SPECpower_ssj2008 methodology in the Annual Energy Efficiency Report (see Paragraph 3.3).
In the event that the exemption has been utilised, the applicant shall provide justification for why this server is exempt from this requirement in the Energy Efficiency Report.

3.2.6 Acquisition of new energy efficient external power supplies

Newly acquired external power supplies and power supplies built into newly acquired IT components, which are not subject to the EC Regulation No. 278/2009[10], must correspond at

---

[9] Method according to the Standard Performance Evaluation Corporation; http://www.spec.org/power_ssj2008/

[10] Commission Regulation (EC) No. 278/2009 of 06 April 2009 implementing Directive 2005/125/EC of the European Parliament and of the Council with regard to ecodesign requirements for no-load condition electric power consumption and average active efficiency of external power supplies

least to the requirements of the energy efficiency standard 80 PLUS GOLD[11] when it comes to their energy efficiency.

Compliance verification

The holder of the environmental label shall document the efficiency of those newly acquired external power supplies that fall outside of the validity of the EC Regulation No. 278/2009 at 20%, 50% and 100% of their nominal output in the Energy Efficiency Report (see Paragraph 3.3) and verify compliance with the required energy efficiency standards.

3.2.7 Acquisition of new cooling systems

In the case of newly acquired cooling systems, no halogenated hydrocarbons may be used as a refrigerant.

Exemption: Data centers with a maximum cooling requirement of 50 kW_{th} are exempt (corresponds to the connected electrical rating of the data center components to be cooled. The use of refrigerants containing halogens must be justified in these cases.

The requirements placed on the energy efficiency of cooling systems in accordance with Paragraph 3.1.7 Energy efficiency of the cooling system must also be complied with when acquiring new cooling systems. The Energy Efficiency Ratio (EER) of the cooling system must be determined and documented in accordance with the rules defined in the relevant paragraph.

Compliance verification

The holder of the environmental label shall document the newly installed cooling system in the Annual Energy Efficiency Report (see Paragraph 3.3) and state the refrigerant and the quantity of refrigerant used, as well as the Energy Efficiency Ratio (EER) of the cooling system.

In the event that the exemption described in Paragraph 3.1.7 has been utilised, verification in accordance with the verification requirements in Paragraph 3.1.7 shall be submitted.

If refrigerants containing halogens are used in newly installed systems in data centers with a maximum cooling requirement of 50 kW, the holder of the environmental label shall submit a justification for its use.

3.2.8 Acquisition of new Uninterruptible Power Supply (UPS) systems

In the case of newly acquired uninterruptible power supply systems, the following minimum requirements for their efficiency must be fulfilled. The efficiency of the uninterruptible power supply must not be lower than:

- 92 % at an electrical output of 100 % of the nominal output
- 93 % at an electrical output of 75 % of the nominal output
- 92 % at an electrical output of 50 % of the nominal output
- 90 % at an electrical output of 25 % of the nominal output

Compliance verification

The holder of the environmental label shall document the newly acquired UPS systems and state their efficiency levels in the Annual Energy Efficiency Report (see Paragraph 3.3). In addition, the applicant shall submit a measurement report in accordance with DIN EN 62040 (or the valid measurement standard at the time the UPS system is installed) from the manufacturer of the UPS system or from a testing institution accredited according to

[11] 80 PLUS Certified Power Supplies; http://www.plugloadsolutions.com/80PlusPowerSupplies.aspx

DIN EN ISO/IEC 17025 as an Appendix to Annex 6 to the Contract, which documents compliance with the requirement using relevant data (here: efficiency depending on the electrical output).

3.2.9 Acquisition of new intelligent power distribution units (PDUs)

The power loss from newly acquired intelligent power distribution units (PDUs, see Paragraph 1.5 Definitions) must not be greater than 0.5W per available power outlet (power socket or connection terminal). Newly acquired intelligent PDUs and their power losses must be documented in the IT inventory list (see Paragraph 3.2.3)

Compliance verification

The holder of the environmental label shall document the newly acquired intelligent PDUs in the Annual Energy Efficiency Report (see Paragraph3.3) in Annex 2d (Acquisition of new intelligent PDUs) and state the number of available power outlets and their power losses. The measurement of the power losses must be carried out in accordance with DIN EN 50564 or IEC 62301 and can be carried out on individual PDUs and then extrapolated for the total number of units. The power outlets on the PDUs must be activated for the measurements, meaning all relays or switching equipment that may exist must be active.

3.3 Checking the requirements with the Annual Energy Efficiency Report

The holder of the environmental label must submit an Annual Energy Efficiency Report to RAL gGmbH at the latest 14 months after the label has been successfully awarded and at a regular interval of every twelve months (annually) in subsequent years, in which he/she documents their activities for energy efficient data center operation.
The Annual Energy Efficiency Report can be provided as a continuation and update of the Energy Efficiency Report submitted at the time of application (see Paragraph 3.1.1). The report must correspond to the structure and content of Annex 2 to the Basic Award Criteria and must be Appendixed to include the information that is required by Paragraph 3.2 Requirements during the period of the contract.
The Energy Efficiency Report must be audited by a designated testing institution (see Paragraph 1.6) The testing institution must confirm in the form of an audit report that the information requested in Annex 2 and Paragraph 3.2 has been provided in full and is highly plausible.
If the holder of the environmental label does not fulfil his/her obligation to submit an Annual Energy Efficiency Report or the report documents that the requirements placed on the data center or the operation of the data center have not been observed, this represents an infringement of the Contract on the Use of the Environmental Label (see Paragraph 5.3) and can be sanctioned by RAL gGmbH with the removal of permission to use the environmental label.

Compliance verification

The applicant shall declare compliance with the requirements in Annex 1 to the Contract. The holder of the environmental label shall submit an Energy Efficiency Report as a Appendix to Annex 2 of the Contract and an audit report as a Appendix to Annex 4 to the Contract from a testing institution designated in Annex 3 at the latest 14 months after the label has been awarded and then subsequently on an annual basis. The audit report shall confirm that the

holder of the environmental label has provided at least the required information in full and with a high level of plausibility.
Energy Efficiency Report can be provided by the applicant either using the document template in Annex 2 to the Basic Award Criteria or in another suitable form, such as a printout from an online tool or a spreadsheet program. However, the report must contain the structure (Paragraph headings) and the requested information in Annex 2 to the Basic Award Criteria, as well as the information requested in Paragraph 3.2.

4 Applicants and Parties Involved

Operators of data centers or providers of data center services according to Paragraph 2 shall be eligible for application.

Parties involved in the award process are:
- RAL gGmbH to award the Blue Angel Environmental Label,
- the federal state being home to the applicant's production site,
- Umweltbundesamt (German Environmental Agency) which after the signing of the contract receives all data and documents submitted in applications for the Blue Angel in order to be able to further develop the Basic Award Criteria.

5 Use of the Environmental Label

The use of the Environmental Label by the applicant is governed by a contract on the use of the Environmental Label concluded with RAL gGmbH.

Within the scope of such contract, the applicant undertakes to comply with the requirements under Paragraph 3 while using the Environmental Label.

Contracts on the Use of the Environmental Label are concluded to fix the terms for the certification of products under Paragraph 2. Such contracts shall run until December 31, 2019.
They shall be extended by periods of one year each, unless terminated in writing by March 31, 2019 or March 31 of the respective year of extension.
After the expiry of the contract, the Environmental Label may neither be used for labelling nor for advertising purposes. This regulation shall not affect products being still in the market.

The applicant (manufacturer) shall be entitled to apply to RAL gGmbH for an extension of the right to use the ecolabel on the product entitled to the label if it is to be marketed under another brand/trade name and/or other marketing organisations.

The Contract on the Use of the Environmental Label shall specify:
- Applicant (Owner/Operator of the data center)
- Brand/trade name, product description
- Distributor (label user), i.e. the above-mentioned marketing organisations.

Appendix A Measurement concept

The installation of measurement technology creates the prerequisites for the continuous measurement of the electrical output and energy consumption of the most important components of the data center. This requires the implementation of a measurement concept comprising at least the following measurement points. In this process, the individual measurement points can be realised using multiple measurement locations or reference measurements that enable the relevant measurement results to be calculated.

- MP_{DC}: Measurement point for the total energy in the data center: electrical power and electrical work for supplying the entire data center
- MP_{OSG}: Measurement point for own systems of power generation: electrical power and electrical work for the data center's own systems for power generation (if available)
- MP_{CS}: Measurement point for the cooling system: electrical power and electrical work for the cooling system (cooling plants, free cooling / heat exchanger, humidifier/dehumidifier, pumps and valves)
- MP_{UPS}: Measurement point for UPS: electrical power and electrical work input into the uninterruptible power supply
- MP_{IT1}: Measurement point for IT 1: electrical power and electrical work output from the uninterruptible power supply
- MP_{IT2}: Measurement point for IT 2: electrical power and electrical work for supplying the ICT system
- MP_{OC}: Measurement point for energy consumers: electrical power and electrical work for the other energy consumers (e.g. measurement, management and control technology, lighting, small consumers, fire and hazard protection equipment)

The following schematic diagram shows the arrangement of the measurement points:

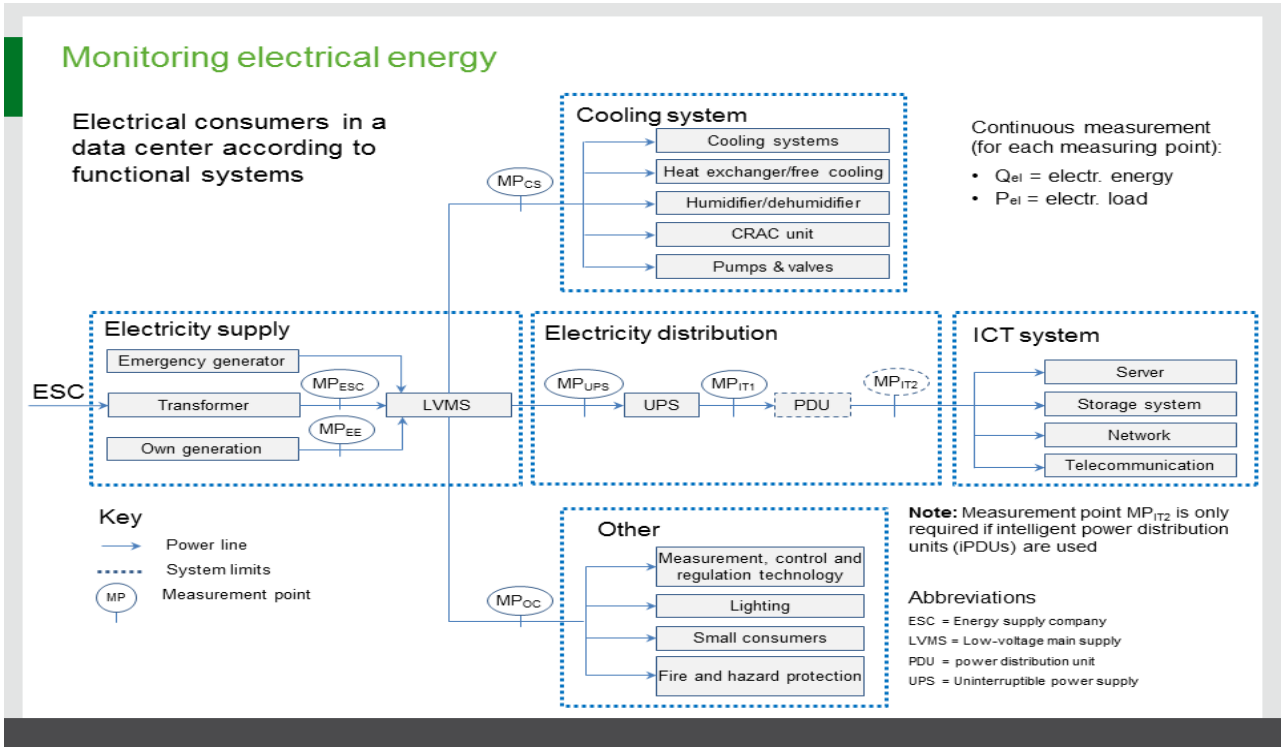

Figure 1: Measurement of the main components of a data center (source: TU Berlin FG IKM)

Determining the Energy Usage Effectiveness (EUE)

Energy Usage Effectiveness (EUE) describes the ratio of the annual energy demand of the entire data center ($Q_{el,DC,a}$, [kWh_{el}/a]) to the energy demand of the IT equipment ($Q_{el,IT,a}$, [kWh_{el}/a]) over a period of one year.[12]

$$EUE = Q_{el,DC,a} / Q_{el,IT,a}$$

At the same time. the EUE is the average PUE (Power Usage Effectiveness) over a certain period of time, which is the past twelve months within the scope of these Basic Award Criteria. In order to measure the energy demand of the entire data center ($Q_{el,DC,a}$), a distinction is made between different classes of data center:

a) Data centers that exclusively source their energy from an energy supply company (ESC):

$$Q_{el,DC,a} = MP_{DC}$$

b) Data centers that have their own additional systems for power generation (e.g. via a combined heating and power plant or a solar power plant):

$$Q_{el,DC,a} = MP_{DC} + MP_{OSG}$$

In order to determine the energy demand of the entire IT equipment ($Q_{el,IT,a}$), it is also necessary to make a distinction between different classes:

a) **No** intelligent Power Distribution Units (PDUs) are used in the data center for distributing electricity:

$$Q_{el,IT,a} = MP_{IT1}$$

The measurement is taken directly downstream of the uninterruptible power supply (UPS)

b) Intelligent Power Distribution Units (PDUs) are used in the data center for distributing electricity, which also exhibit power losses:

$$Q_{el,IT,a} = MP_{IT2}$$

The measurement is taken downstream of the PDUs. Alternatively, the PDU losses can be subtracted from the energy measurements downstream of the UPS:

$$Q_{el,IT,a} = MP_{IT1} - Q_{el,PDU\text{-}losses,a}$$

[12] The EUE corresponds to PUE Category 2 according to "*Recommendations for Measuring and Reporting Overall Data Center Efficiency*". This guide was developed by a working group consisting of the following organisations: 7x24 Exchange, ASHRAE, The Green Grid, Silicon Valley Leadership Group, U.S. Department of Energy Save Energy Now Program, U.S. Environmental Protection Agency's ENERGY STAR Program, United States Green Building Council, and Uptime Institute. The guideline is available here: http://www.thegreengrid.org/Global/Content/Regulatory-Activities/RecommendationsForMeasuringandReportingOverallDataCenterEfficiencyVersion2.

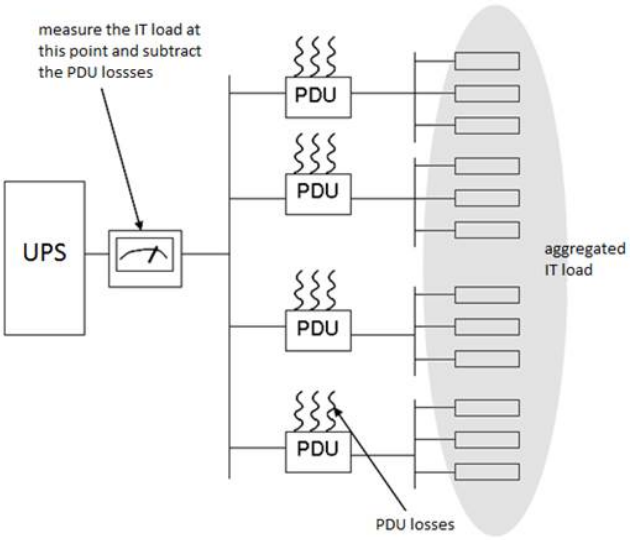

Figure 2: Measurement of the IT load

Further notes

The value for the annual energy demand of the entire data center ($Q_{el,DC,a}$) corresponds to the sum of the individual consumers being measured as follows:

$$Q_{el,DC,a} = Q_{el,IT,a} + Q_{el,UPS,a} + Q_{el,PDU\text{-}losses,a} + Q_{el,CS,a} + Q_{el,OC,a}$$

The assignment of the consumption values to the measurement locations is to be carried out as follows:

$Q_{el,DC,a} = MP_{DC} + MP_{OSG}$	(annual electricity demand of the entire data center)[13]
$Q_{el,IT,a} = MP_{IT}$	(annual electricity demand of the IT components)
$Q_{el,CS,a} = MP_{CS}$	(annual electricity demand of the cooling system)
$Q_{el,PDU\text{-}losses,a} = MP_{IT1} - MP_{IT2}$	(annual electricity demand of the PDUs)
$Q_{el,UPS,a} = MP_{UPS} - MP_{IT1}$	(annual electricity demand of the UPS)
$Q_{el,OC,a} = MP_{OC}$	(annual electricity demand of the other consumers)

Note about MPIT1: At the measurement point downstream of the UPS, it is only possible to measure the electricity demand of the entire IT equipment when the UPS exclusively secures the IT equipment. If other components, e.g. ventilation for the air circulation chambers, are secured by the UPS, these must be removed from the measurement values or the energy demand of the non-IT equipment must be specially determined using measurement technology.

In the calculations for the annual energy demand of the entire data center ($Q_{el,DC,a}$), the energy consumption of secondary consumers, which are not directly associated with the operation of the data center and are not included in Figure 1 (e.g. offices, canteen operation, lifts or car park lighting), is not taken into account.

[13] If the applicant does not have influence over the entire data center, he/she is nevertheless still obligated to request energy consumption data from his/her customers and to make this available as part of these Basic Award Criteria.

Appendix B Determining the key values for the cooling system

Determining the Energy Efficiency Ratio (EER)

The Energy Efficiency Ratio (EER) of the cooling system in a data center describes the ratio of the cooling load in the data center that is handled by the cooling system within one year (12 months) to the total electrical energy input into the entire cooling system.

The annual cooling load for the cooling system ($Q_{th,DC,a}$, [kWh/a]) is determined in accordance with VDI Guideline 2078 as the sum of all electrical losses in the rooms being cooled.

The total electrical energy supplied to the entire cooling system ($Q_{el,CS,a}$, [kWh/a]) is determined in accordance with the DIN V 18599 standard from the electrical energy input into all of the components in the entire cooling system (i.e. also including the operating power for fans, pumps, re-cooling systems or absorption chillers).

Both energy values must be determined through measurements in accordance with the measurement concept illustrated in Figure 1 over a time period of 12 months.

$$Q_{el,CS,a} = MP_{CS}$$

The Energy Efficiency Ratio (EER) is then calculated as follows:

$$EER = \frac{Q_{th,DC,a}}{Q_{el,CS,a}}$$

Determining the specific greenhouse gas emissions of absorption chillers

In the event that absorption chillers are utilised, the specific greenhouse gas emissions for the cooling output (F_{ATC}) must be calculated and documented annually.

The following calculation steps must be carried out:

- Calculation of the thermal Energy Efficiency Ratio for a cooling system with an absorption chiller (EER_{th}):

$$EER_{th} = \frac{Q_{th,DC,a}}{Q_{th,Input\_CS,a}}$$

- Calculation of the electrical Energy Efficiency Ratio for a cooling system with an absorption chiller (EER_{el}):

$$EER_{el} = \frac{Q_{th,DC,a}}{Q_{el,CS,a}}$$

- Calculation of the specific greenhouse gas emissions for the cooling supply:

$$F_{ATC} = \frac{Q_{el,CS,a} \times F_{el} + Q_{th,Input\_CS,a} \times F_{th}}{Q_{th,DC,a}} = \frac{F_{el}}{EER_{el}} + \frac{F_{th}}{EER_{th}}$$

[kg_{CO2e}/kWh_{th}]

Using the emissions factor for electricity from the German electricity mix (F_{el}) in 2013[14]:

F_{el} = 0.559 kg_{CO2e}/kWh_{el}

As an alternative to this value, the currently valid emission factors for the relevant electricity can be used.

The calculation also includes the emission factor for thermal energy (F_{th}) based on the energy source used. The source of the relevant emission factor must be documented for the calculation. In the following table, some energy sources are shown as examples:

Energy source	F_{th}
Heating oil HH/GHD	0.321 kg_{CO2e}/kWh_{th}
Natural gas HH/GHD	0.251 kg_{CO2e}/kWh_{th}
Liquefied gas HH/GHD	0.270 kg_{CO2e}/kWh_{th}
Wood pellets	0.023 kg_{CO2e}/kWh_{th}
Wood chips (forest)	0.022 kg_{CO2e}/kWh_{th}
Wood chips (SRF - poplar)	0.037 kg_{CO2e}/kWh_{th}

Examples for emission factors, source GEMIS 4.6[15]

For comparison with the cooling supply from a cooling system with electrically operated compression-type chillers, it is necessary to also calculate the specific greenhouse gas emissions with alternative compression-type chillers as follows:

$$F_{CTC} = \frac{F_{el}}{EER_{el\_CTC}} \times 1{,}1$$

[kg_{CO2e}/kWh_{th}]

The minimum requirements from the Basic Award Criteria (Paragraph 3.1.7) must also be applied for the Energy Efficiency Ratio for cooling systems with compression-type chillers (EER_{el_CTC}).

[14] Data source: UBA 2014, Development of the specific carbon monoxide emissions from the German electricity mix in the years 1990 to 2013, Internet: http://www.umweltbundesamt.de/publikationen/entwicklung-der-spezifischen-kohlendioxid-0

[15] Data source: Öko-Institut, GEMIS 4.6, March 2011, Scenario: Output: Heat - based on final energy 2010 [kWh]. HH = household, GHD = industry, trade and services, SRF = short rotation forestry

The factor 1.1 within the formula for calculating the specific greenhouse gas emissions for cooling systems with compression-type chillers (F_{CTC}) takes into account the impact on the climate caused by direct refrigerant emissions from the compression-type chillers.

In order to verify that the specific greenhouse gas emissions for the absorption chiller do not exceed the greenhouse gas emissions for the electrically operated compression-type chiller, the following conditions must be fulfilled:

$$F_{ATC} \leq F_{CTC} \quad [kg_{CO2e}/kWh_{th}]$$

The value for F_{ATC} must be documented in an annual time series. The comparative value F_{CTC} must be given in each case.

Appendix C Calculation of the load average of the IT equipment

For the monitoring of the IT load, the load average for the physical CPUs integrated into the physical servers, the RAM memory and the storage systems must be calculated and documented in the Energy Efficiency Report.

Load average for the CPUs

In order to calculate the load average for the individual CPUs (Load average for CPU_i), the arithmetic mean of the individual loads is determined during the measurement intervals. In this process, only those intervals in which the CPU was activated and thus consumed electricity are to be taken into account:

$$\text{Load average for } CPU_i\ [\%] = \frac{\sum_{n=1}^{measurement\ intervals} load\ CPU_i\ in\ measurement\ interval\ n}{total\ number\ of\ measurement\ intervals}$$

The load average for all CPUs used in the data center (Load average for the CPUs) is determined based on the weighting of the individual load averages based on the CPU performance as follows:

$$\text{Load average for the } CPU_s\ [\%] = \frac{\sum_{i=1}^{total\ number\ of\ CPUs} (CPU\ performance_i * load\ average\ CPU_i)}{\sum_{i=1}^{total\ number\ of\ CPUs} CPU\ performance_i}$$

The method for determining CPU performance can be freely selected and must be documented in the Energy Efficiency Report. A suitable method is, for example, the *Passmark CPU Mark*[16]. In simplified terms, the CPU performance per CPU can also be calculated as follows:

$$CPU\ Performance_i = clock\ speed_i * number\ of\ processor\ cores_i * number\ of\ threads_i$$

In order to ensure that the load average for the CPUs in the data center is determined with sufficient accuracy, at least 90% of all of the CPUs installed in the servers in the data center must be monitored and included in the calculations.

Load average for the RAM memory

The load average for the RAM memory must be initially determined based on the calculation of the load average for the individually monitored RAM memory units (Load average for RAM_i) as follows:

$$\text{Load average for } RAM_i\ [\%] = \frac{\sum_{n=1}^{measurement\ intervals} load\ RAM_i\ in\ measurement\ interval\ n}{total\ number\ of\ measurement\ intervals}$$

[16] Passmark CPU Mark: https://www.cpubenchmark.net/cpu_list.php

The load average for all of the RAM memory (Load average for the RAM) used in the data center is determined based on the weighting of the individual load averages based on the available RAM capacity in the data center as follows:

$$\text{Load average for the RAM [\%]} = \frac{\sum_{i=1}^{total\ number\ of\ RAM\ memory\ units} (RAM\ capacity_i * load\ average\ RAM_i)}{total\ capacity\ of\ RAM\ memory\ units}$$

In order to ensure that the load average for the RAM memory units in the data center is determined with sufficient accuracy, at least 90% of the total capacity of the RAM memory units must be monitored and included in the calculations.

Load average for the storage systems

Storage systems that must be covered by the monitoring include flash-based storage systems (SSD) and storage systems with rotating hard drives (HDD). Other storage systems (e.g. magnetic tape systems) do not need to be monitored for the calculation of the load average for the storage systems.

The method for determining the load average for the storage systems is the same as the method used for the RAM memory. The load average for the individual storage units (Load average for $storage_i$) is initially determined as follows:

$$\text{Load average for storage}_i\ [\%] = \frac{\sum_{n=1}^{measurement\ intervals} load\ storage_i\ in\ measurement\ interval\ n}{total\ number\ of\ measurement\ intervals}$$

The load average for all storage systems (Load average for the storage) used in the data center is determined based on the weighting of the individual load averages based on the available storage capacity in the data center as follows:

$$\text{Load average for the storage [\%]} = \frac{\sum_{i=1}^{total\ number\ of\ storage\ systems} (storage\ capacity_i * load\ average\ storage_i)}{total\ capacity\ storage}$$

In order to ensure that the load average for the storage systems in the data center is determined with sufficient accuracy, at least 90% of the total capacity of the storage systems must be monitored and included in the calculations.