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10

WHITE PAPER

An energy-efficient data centre using the EN 50600

By Niek van der Pas

Summary

EN 50600

According to the EN 50600, the following pillars together determine the quality of a data centre: **energy-efficiency, availability and security**. At an early stage, it is possible to estimate costs for, for example, a certain energy- efficiency. The standard provides guidelines for determining which level is desired in these areas.

PART ONE OF THE WHITE PAPER

White paper 10 "An energy-efficient data centre using the EN 50600" discusses the pillar **energy-efficiency**. This white paper will guide you through the different parts of this standard and will highlight aspects of energy-efficiency such as setting goals, designed PUE, best practices and measuring and managing energy-efficiency.

PART TWO OF THE WHITE PAPER

Part two of white paper 10 deals with energy-efficiency aspects of all the components in the data centre and relates these to the recommended practices and other relevant parts in the EN 50600. We will roughly follow the sequence of the consecutive parts of the EN 50600 and link the recommended practices. You will also find more details on the energy-efficiency properties of the corresponding Minkels, Legrand and Raritan products.

PART THREE OF THE WHITE PAPER

The third part of the white paper will discuss how to use European and country-specific programs which give incentives to implement energy-efficient solutions.

CONTENTS

Introduction

EN 50600

According to the EN 50600, three pillars together determine the quality of a data centre: energy-efficiency, availability and security. At an early stage, it is possible to estimate costs for, for example, a certain energy- efficiency. The standard provides guidelines for determining which level is desired in these three areas.

QUOTE FROM THE EN 50600-1

Introduction
"Data centres need to provide modular, scalable and flexible facilities and infrastructures to easily accommodate the rapidly changing requirements of the market. In addition, energy consumption of data centres has become critical both from an environmental point of view (reduction of carbon footprint) and with respect to economical considerations (cost of energy) for the data centre operator."

Scope: EN 50600-1
" d) specifies a classification system, based upon the key criteria of "availability", "security" and "energy-efficiency" over the planned lifetime of the data centre, for the provision of effective facilities and infrastructure; "

This is only a quote from the EN 50600. If you are interested in reading the entire standard, request this document online (www.nen.nl).

ENERGY-EFFICIENCY

In this white paper, the EN 50600 is used as a guide for the approach of energy-efficiency in a data centre. The EN 50600 provides a framework for designing and operating a data centre. The design is divided into 5 different sections:

- building construction
- power distribution
- environmental control
- telecommunication cabling
- security systems

In each of these sections, energy-efficiency goals can influence design choices.

We refer to several reports in this white paper.
You find a complete overview of the references on page 44.

HISTORY

In the past, the energy-efficiency of a data centre was not a variable with which could be experimented during the construction of a data centre. Availability, on the other hand, has always been very important as a key criterium.

EXAMPLE
PART 1

ENIAC

One of the first general purpose computers – the ENIAC with the size of a current data centre – had a MTBF of 7 minutes in IT incubation period. The reliability was increased to one tube failure every 2 days. To shorten the Mean Time To Repair the 18.000 vacuum tubes, they were placed on a removable chassis which could be exchanged in seconds. Diagnosing and finding the broken tube could be done in 15 minutes. The forced air-cooled machine had an energy consumption of about 150kW[1].

[1] Randall 5th, 2006

CURRENT CHOICES

It is very interesting to see that the key parameters that controlled the developments in those early days are very similar to the current choices. Energy-efficiency can now be a **design choice**, much like availability. Both are dependent on existing techniques, as showed in the above example.

EXAMPLE
PART 2

ENIAC

The (un)reliability of the vacuum tubes was solved with the invention of transistors and integrated circuits. And with the use of redundant components and path concepts in the infrastructure of a data centre, the reliability impacts were better understood. This led to the introduction of Tier/Class differentiations in the design.

The energy-efficiency of a data centre is also a choice. With the introduction of the key performance indicator (KPI) Power Usage Effectiveness (PUE), a great tool was introduced to understand energy-efficiency in the data centre.

PUE

The EN 50600 introduces the concept of energy-efficiency enablement and defines it as "The ability to measure the energy consumption". The ability to measure energy consumption at the place where it is used, gives the opportunity to optimise it. The PUE can be a very useful KPI in the design process of the data centre. The standardised PUE derivative designed PUE is tailored to be used in the early phase of the design process.

EXAMPLE

PUE

If – let's say – the goal is a PUE of 1,2, a subdivision can be made towards the different non-IT energy consumers. The example in the PUE standard divides them into 5 different groups. The result might be that the maximum partialPUE of the UPS shall not exceed 1,05. With this design goal different UPS concepts can be evaluated and compared. Similarly, the partialPUE of all the other systems of the data centre, such as the cooling system, can be calculated. The CLC/TR 50600-99-1 gives over 150 recommend practices in creating energy-efficient data centres.

Part 1: Energy-efficiency

1.1 STRATEGY AND OBJECTIVES

Cost

Cost is always a parameter which is closely related to energy-efficiency. The energy you don't use, you don't have to buy or generate. If the energy-efficient solution comes with a higher capital cost, a Return on Investment (ROI) calculation can help in making a balanced decision. If the business model of the data centre operator has a high number of long term uncertainties, it is very tempting to go for the short-term results. The consequences of not investing in energy-efficient solutions gives an instant relief but could lead to serious long term operational problems and high operational costs.

Corporate Social Responsibility

As the use of energy has a big impact on the global environment, Corporate Social Responsibility (CSR) can be of importance in choosing the right goals. Reports like "Clicking clean" of Greenpeace (Greenpeace Gary Cook, 2017) can influence the desired objectives. A growing number of customers, both internal and external, has a strong preference for energy-efficient solutions. The Greenpeace report uses a default PUE of 1.5 if no public data is available.

Energy-efficiency practices

The EU is now in the process of creating "Best Environmental Management Practices For The Telecommunications And ICT Services Sector" (Paolo Canfora, 2016) and will refer to energy-efficiency practices to improve the environmental impact of data centres.

1.2 BUSINESS RISK ANALYSIS AND AVAILABILITY

Redundancy class

The first Part, the EN 56000-1 General concepts, discusses the Business risk analysis in clause 6 and the different aspects involved in evaluating the risks. Energy-efficiency choices like type of cooling should be an integral part of the considerations. Availability requirements result in the choice of a redundancy class (i.e. the highest class 4 results in an overall 2N design, both on cooling and on energy distribution).

2N design

With a 2N design, the electric load per path will be halved. The distribution of the electric load over 2 paths also halves the current per path and has a very positive effect on the transportation losses. The thermal losses of the electrical distribution path are part of the overall losses. This so-called Joule heating is proportional to the square of the current.

For an ohmic load, the formula $P=I^2.R$ can be used. The power loss (P) is equivalent to the square of the current (I) and proportional to the resistance (R) of the conductor. The cable/busbar losses in a 2N design will be one fourth of a 1N design. To realise this, both the paths should be energised and balanced. Unbalanced paths will result in higher currents in one path and – due to the quadratic dependence – the extra loss in one path will not be compensated by the other path. Yet another reason to measure power balance in a multi-path system to minimise the losses. The reduction in current seems to have a positive effect on the minimising of the losses in the distribution system but this is not the case with all the components. Most UPSes reach the maximum efficiency at 80-90% of the maximum load. In a 2N design, the load is halved and the UPS operates at less than 50%. As operating a data centre at a 100% load is not realistic, the actual maximum load will be less than 40%. A high efficient UPS at partial load, less than 40%, will be a prerequisite for achieving an efficient solution.

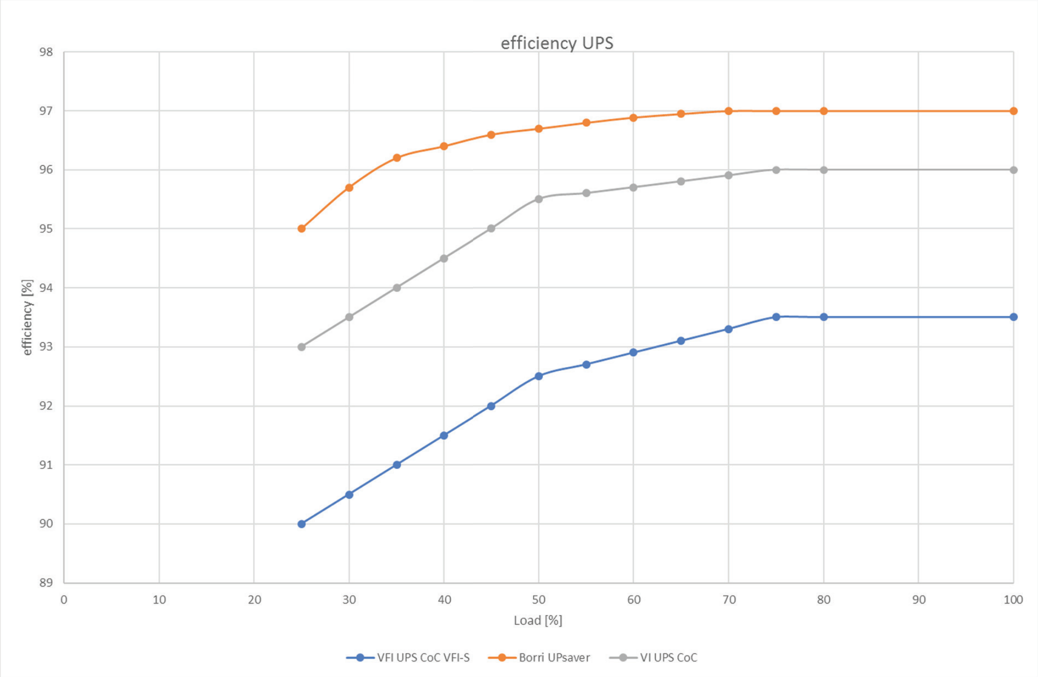


Figure 1: Energy efficiency of a Borri UPSaver (orange) as function of the load of the UPS compared to the minimal performance according to the IEC 62040-3 for a VFI-S (Voltage Frequency Independent- Sinusoidal) UPS with a rating ≥ 200kVA (blue line) and VI (Voltage Independent) UPS see EU Uninterruptible Power Systems Code of Conduct - Version 2.0

Improving availability

The availability can be improved by using a modular N+1 UPS design. For energy-efficiency, this modular setup gives the advantage and the possibility to scale the UPS to the actual power demand, thus preventing overdimensioning of the UPS. This overdimensioning is very often done to anticipate to future growth. But – as explained before – the consequence might be an inefficient design. A modern designed modular UPS has a load based module shutdown capability. The UPS shuts down unused capacity modules to prevent losses at light load conditions but has the capacity to ramp up in milliseconds to respond to dynamic load. The result is a double conversion VFI (Voltage and Frequency Independent) UPS mode with a very high efficiency with low loads. All these consequences of the design will have a direct impact on the energy efficiency, and it is possible to implement a solution which combines best of both worlds maximum protection and energy efficiency.

QUOTE FROM THE
EN 50600-1

6.4 Energy-efficiency enablement

6.4.1 General

The ability to measure the energy consumption and to allow calculation and reporting of energy-efficiency of the various facilities and infrastructures supporting the operation of a data centre is critical to the achievement of any energy-efficiency objectives.

Three levels of granularity are defined:
a) Level 1: a measurement regime providing simple global information for the data centre as a whole;
b) Level 2: a measurement regime providing detailed information for specific facilities and infrastructures within the data centre;
c) Level 3: a measurement regime providing granular data for elements within the spaces of the data centre.
Moving from one complexity level to a higher level requires an increased level of measurement / monitoring infrastructure.

The data centre owner/user shall define the appropriate energy-efficiency enablement level prior to the data centre design.

The desired energy-efficiency enablement level may be determined by:
1) an operating cost analysis;
2) external regulatory or legislative requirements;
3) user defined rules.

1.3 RESOURCE EFFICIENCY AND AVAILABILITY CHOICES

Selecting a cooling system
One of the big impacts on the energy-efficiency is the choice of cooling system. Minkels' White paper 2 (downloadable at www.minkels.com/whitepaper) can be of great help for selecting the right system. In white paper 2 (paragraph 6.2), it is explained how the reduction of complexity can be a good way to improve the performance of the data centre cooling system. The simplest way of cooling is using direct fresh air. However, the use of outside air introduces different new risks. The level of air contamination is an important factor in evaluating this solution.

Fresh air cooling
To understand all the ins and outs of fresh air cooling, W. Timmers of the Eindhoven University of Technology TU/e and Minkels conducted a study entitled "Fresh air cooling for data centres – energy-efficiency and particle contamination" (Timmers, 2013). The conclusion of the research was that it is possible to design a very energy-efficient solution but the contamination restrictions should be managed well with the correct filter choice and air path design.

Reactive contamination monitoring
The gaseous contamination risk can and should be monitored when using fresh air, but this can only be done in a reactive way. This requires risk mitigation strategies which might influence the initial investment and the energy-efficiency of the design. Reactive contamination monitoring

is achieved using copper and silver strips. The weight of these strips is checked periodically to determine changes due to corrosion.

Reactive measuring with a continuous output
A good improvement is reactive measuring with a continuous output according to the ANSI/ISA Standard 71.04-2013. These meters continuously record the corrosion impact by registering the weight increase which is converted to thickness increase. When the severity level stays within the G1 boundary of copper corrosion (meaning: < 300 Angstroms/30 days and Silver corrosion < 2000 Angstroms/30 days) it can be assumed that the gaseous environment is safe. With these meters, continuous monitoring can be accomplished and the impact of pollution increase can be anticipated.

In-depth cooling system evaluation
For an in-depth evaluation of the best cooling system, a British Computer Society report entitled "IT environmental range and data centre cooling analysis" (Newcombe, 2011) can be of great help. It shows that with the choice of indirect free cooling, both with air and liquid, in almost any place in the world cooling of the data centre can be done in a very efficient way.

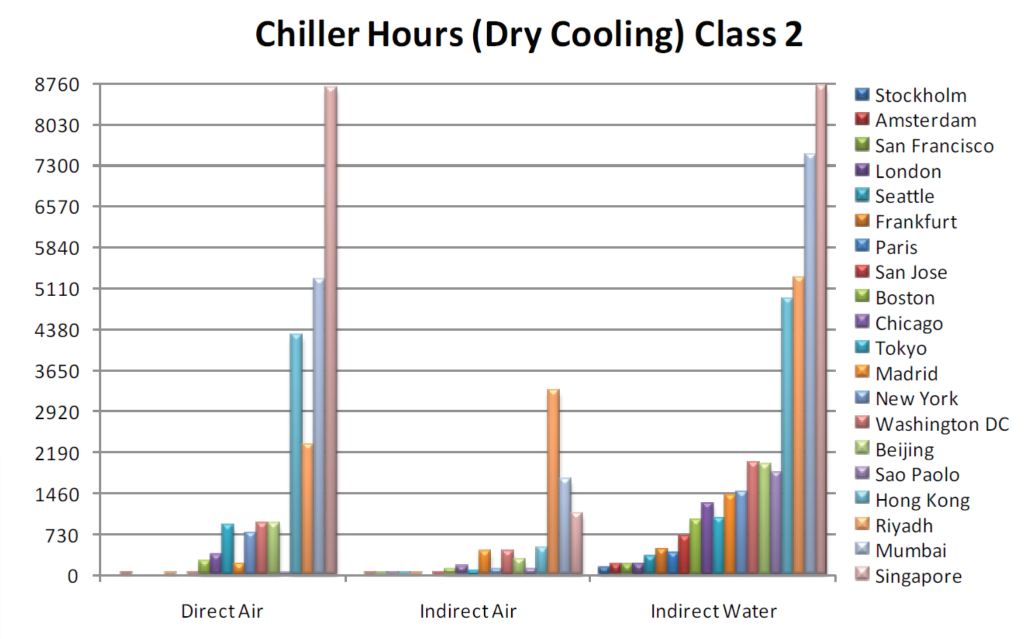


Figure 2: Annual world chiller hours for ASHRAE Class 2 (up to 35°C and 80% relative humidity or 21°C dew point) range - Dry cooling [Source: BCS, IT environmental range and data centre cooling analysis, Newcombe 2011]

Scale computing
The use of direct free air cooling by large IT companies like Yahoo and Facebook in their data centres can result in a good PUE and a very cost-effective design but can only be done when the complete IT stack is controlled by the same owner. One very distinctive aspect of scale computing is that in most cases the same company owns and operates the application software, the operating system, the network, the IT hardware, the IT infrastructure, the data centre building

and the lot on which the data centre is build. Even the WAN network to which the data centre is connected is often adjusted to the data centres demands. The scale computer data centres often service continental sized areas. Due to these conditions, they have the freedom to choose a location with favourable climatic conditions and can even consider the rate of air contamination at this location. Due to the fast-evolving demands for performance of the IT and network gear, the scale computing companies have a very high refresh rate of the equipment. Possible corrosion is less likely in this short time span. It is therefore not just to copy-paste these direct free cooling designs to any other place and expect to get, with the anticipated business risk, the same PUE and investment level.

Submerged cooling or water-cooling

Like fresh air cooling, the use of submerged cooling or water-cooled servers both seem very attractive for reducing energy use in the data centre. With both technologies, server fans become obsolete (or for water cooled servers: are almost obsolete) and therefore don't use energy. Although the elimination of fans will likely have a positive effect on the overall energy consumption of the data centre, it will not lower the PUE. The server fan power is calculated as IT power and therefore at the "wrong" side of the PUE equation. Criticasters on the use of PUE as the holy grail for data centre improvement are right: PUE fails here as the best KPI and should be valuated with this short coming. A 2012 study performed by AHRAE TC9.0 (ASHRAE Technical Committee (TC) 9.9 Mission Critical Facilities, Technology Spaces, and Electronic Equipment, 2012) showed that typical IT fan power overhead could be less than 5%. Therefore, a direct liquid cooled system must be optimally designed to prevent the extra needed pumps from consuming too much energy. The use of submerged and water-cooled IT equipment limits the choice of hardware vendors, IT product lines and asks for extra skills and challenges for maintenance. Scale and cloud computing, with its more uniform equipment, seems to be a good candidate for this type of cooling. The lack of standards for the uniform application of these techniques appears to be hindering its progress.

In the next paragraph, some techniques – part of the EN 50600 – which can be used in evaluating the energy-efficiency impact of a design are explained.

Availability classes

The EN 50600 defines 4 different availability classes:

- low
- medium
- high
- very high

Each class prescribes a typical minimal path and redundancy for power distribution cooling and data cabling:

- single path for Class 1
- single path with redundancy for Class 2
- multiple path and concurrent repair/operating solution for Class 3
- multiple path and fault tolerant for Class 4

As explained earlier, these redundancy setups can have:

- a negative impact on the energy consumption
- a positive impact on the energy consumption
- hardly any effect (in some cases)

Impact
For data cabling the energy impact is limited. Not obstructing airflows and avoiding air leakage are the main considerations. For power distribution and cooling design, the availability demands have a more profound impact on the energy consumption but most important is making balanced design choices and setting a realistic time horizon. It is very tempting to choose low capital costs solutions to achieve short term gains and limited investment risks but with a balanced design and realistic total cost of ownership calculations, a much better result can be reached. A variable speed fan or pump not only uses less energy but also creates a far more controllable environment.

EN 50600-1 clause 7.4 "Energy-efficiency enablement" states:

"The desired energy-efficiency enablement level may be determined by:
a) an operating cost analysis;"

1.4 USING KPI'S IN DESIGNING A DATA CENTRE

This paragraph explains how Key Performance Indicators (KPI) can help in analysing the operational costs.

The EN 50600 series requires design choices due to availability but is less restrictive in the field of energy-efficiency. The CLC/TR 50600-99-1 "Recommended practices for energy management" is the document that guides you through all the different options in this area.

KPI's
The EN 50600-4-X part of the standard deals with key performance indicators. The current indicators are all energy related. Minkels Whitepaper 3 "Tips and Tricks for a professional use of PUE as a management tool" deals with a lot of aspects of the use of one of these KPI's: the PUE.

MINKELS WHITE PAPER 3:

Tips & Tricks for the professional use of PUE as a management tool

www.minkels.com/whitepapers

The formula is: PUE = E_{DC}/E_{IT}
Where:
E_{DC} = total data centre energy consumption (annual) in kWh
E_{IT} = IT equipment energy consumption (annual) in kWh

PUE
During design and planning the main focus is on EDC - EIT = the facility power to run the data centre. Although the EIT part is the main chunk, this part is mainly seen as the requirement for which the data centre is build. But as explained later this is the very important and often underestimated denominator of the equation.

QUOTE FROM THE EN EN 50600-4-2

C.4 Designed PUE
The energy-efficiency of a data centre can be predicted at the design stage based on:
a) the scenario for growth or expectation of occupancy
b) the timeline for increases and/or decreases in energy consumption

Table C.1 shows an example, for a containerized data centre, of such predictions using expected loads based on target occupation of a data centre leading to a designed PUE (dPUE) for each stage – and resulting in an annualized value of dPUE of 1,20.

Month		IT equipment		Cooling/ventilation/ humidification		Power distribution	UPS	Lighting	Remaining support	Total data centre in	
Nr	Dura-tion	Average load	Energy used [a]	Average load [a]	Energyused	Energy used	Energy used	Energy used	Energy used	Energy used	idPUE
#	Days	kW	kWh	kW	kWh	kWh	kWh	kWh	kWh	kWh	
1	31	50	37 200	6	4 464	221	3 720	248	744	46 597	1,25
2	28	100	67 200	10	6 720	769	4 704	224	672	80 289	1,19
3	31	125	93 000	11	8 184	1 301	5 580	248	744	109 057	1,17
4	30	135	97 200	14	10 080	1 511	5 832	240	720	115 583	1,19
5	31	140	104 160	18	13 392	1 756	5 729	248	744	126 029	1,21
6	30	140	100 800	19	13 680	1 720	5 544	240	720	122 704	1,22
7	31	140	104 160	20	14 880	1 800	5 729	248	744	127 561	1,22
8	31	160	119 040	25	18 600	2 407	5 952	248	744	146 991	1,23
9	30	160	115 200	24	17 280	2 304	5 760	240	720	141 504	1,23
10	31	160	119 040	20	14 880	2 278	5 952	248	744	143 142	1,20
11	30	160	115 200	16	11 520	2 108	5 760	240	720	135 548	1,18
12	31	160	119 040	15	11 160	2 154	5 952	248	744	139 298	1,17
□											dPUE
Σ	365		1 191 240		144 840	20 329	66 214	2 920	8 760	1 434 303	1,20

[a] Forecasted use or estimate.

Table 1: C.1 - Example of dPUE calculation *Source: EN 50600-4-2*

Designed PUE : EN50600-4-2 Power Usage Effectiveness
PUE has different derivatives, for zoning, reporting and a very useful PUE derivative during planning: the "designed PUE" or dPUE. dPUE gives a standardised method for comparing the energy-efficiency of different designs. As with PUE, dPUE is calculated on an annual basis. By doing so, all four seasons (or wet and dry for the tropics) are taken into account for calculating the energy needed to climatise the data centre. The second very important methodology described in this derivative is "the scenario for growth or expectation of occupancy". This one sentence in the standard can have a huge impact on the design. It asks for creating a realistic scenario of what the expected IT equipment power demand will be during the lifetime under consideration of the data centre.

To illustrate the consequences of not using designed PUE in the correct way, check out an example of "Datacenter Universitair Medisch Centrum Groningen" (Rijksdienst voor Ondernemend Nederland, 2018) - (Dutch report).

EXAMPLE

Datacenter Universitair Medisch Centrum Groningen
“Datacenter Universitair Medisch Centrum Groningen” was built with the ambition of a PUE better than 1.3. The designer calculated an expected PUE of 1.12 which was far beyond the initial expectation. After one year of operation the measured PUE was 1.4. Quite a difference. What went wrong? The evaluation showed that the actual IT load of 97 kW – which is only 20% of the max design load – results in this bad performance. However: the real cause of this bad performance actually lies in a design with incorrect assumptions of the IT load. (Rijksdienst voor Ondernemend Nederland, 2018)

Professionalisation of future IT loads estimate
The overestimation of presumed IT load is a very often heard problem with new data centres. One solution is the professionalisation of the way future IT loads are estimated. The standard asks for “resource capacity forecast”. The closely related ISO/IEC PUE standard 30134-2 refers to the ISO/IEC 20000-1:2011, 6.5 as a source for methods of this forecast. To extract the expected IT load out of this “resource capacity forecast”, a very detailed analysis of the deployed hardware should be done. This goes down to the amount and the actual energy consumption of servers, network equipment etc. Very often this data is not available or hard to collect. As seen in the example, this is not always possible, plausible or desirable.

PUE not dependent on the IT load
A very good alternative is to make a design where the PUE is not dependent on the IT load. This sounds very logical but it is an often overlooked insight. Common practice – as seen in the example – is a PUE optimisation at max design load instead of at variable IT load. The solution of creating an IT load-independent PUE design is done with a modular and scalable strategy. Rather than one big cooling wheel with a 10 kW threshold loss, as was used in the UMC Groningen example, a segmented modular design would be preferable. Only the facility capacity that is needed shall be deployed. The dPUE standard gives a table based example of a calculation method. This exercise can easily be done in a spreadsheet program. By making the spreadsheet adaptive and intelligent, different IT load scenarios can be evaluated so the energy-efficiency behaviour of the data centre under these different scenarios becomes clear. The spreadsheet method for calculating PUE was, following usage at Minkels, introduced in the Dutch NEN Best practice guide NPR 5313 “Computerruimten en datacenters” in 2014 and later on became part of the European and Global ISO/IEC PUE standard.

Different IT load scenarios and different designs
By running the spreadsheet with different IT load scenarios and different designs the most optimal solution can be chosen. The spreadsheet method can be used to evaluate the individual “Recommended practices for energy management” of the CLC/TR 50600-99-1."

High impact can be expected from:
- Frequency controlled pumps and fans
- The use of free cooling systems
- Modularisation of components with a high zero load consumption
- Use of systems which can respond to dynamic loads
- Oversized energy transport and fluid paths
- Separation of hot and cold air

As the Groningen example illustrates, it is important to not only design for a certain energy-efficiency level but to check the performance during operation.

Measuring and managing energy consumption
To measure and manage energy consumption, measuring equipment should be installed. For installing the correct measuring equipment at the right place, the PUE standard 50600-4-2 and the energy distribution part 2-2 give requirements. The general rules for optimal results are:

- Measure as close as possible to the energy user
- Measure every individual energy user
- Use the accuracies as mentioned in the standard

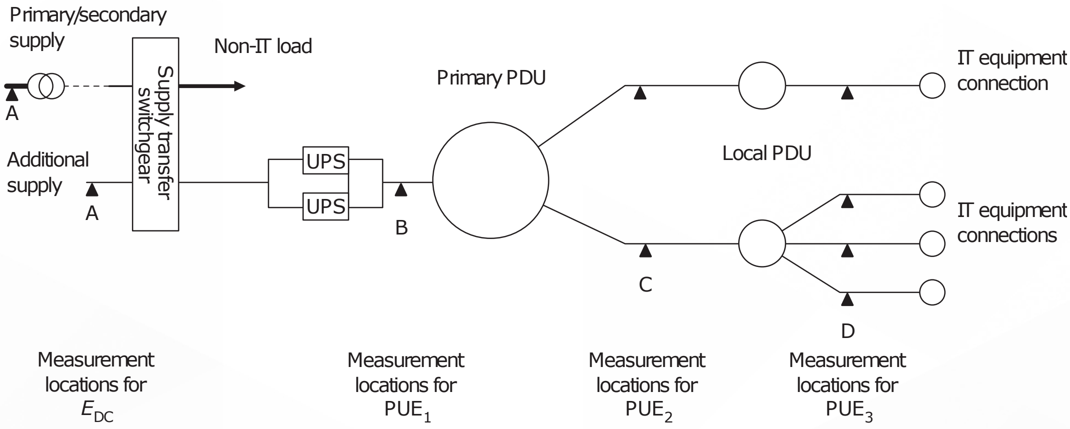


Figure 3: EN 50600-4-2 Power Usage Effectiveness - Measuring locations

3 categories
The PUE standard defines 3 categories:
- Basic
- Intermediate
- Advanced

The basic measurement category with IT power measurement only at the output of the UPS gives a PUE as a result but does not provide clues as to the location or equipment which is responsible for the losses. It is therefore not recommended to use this as a basis for energy management processes. Category 3 (Advanced) is much better. The IT equipment is individually measured and transportation losses are not accounted for as IT energy. But solely measuring IT equipment and EDC for PUE misses the insight in the location of the losses. It is better to use the EN 50600-2-2 for this.

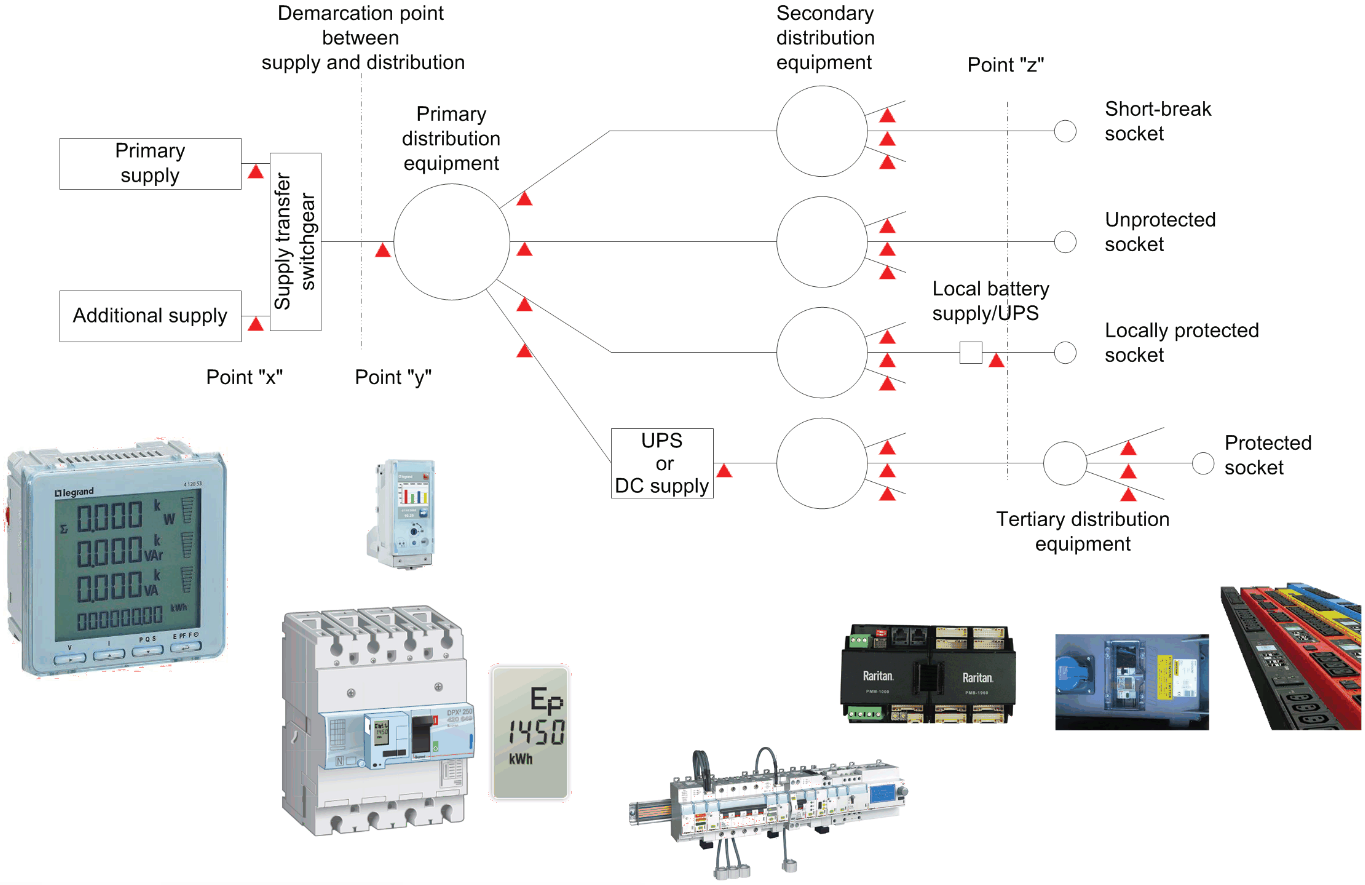


Figure 4: Instruments to measure energy consumption

1.5 ACCEPTANCE TESTING AND OPERATING THE DATA CENTRE WITH THE HELP OF THE STANDARD

In the next paragraphs, we will discuss what different standards have to say about energy-efficiency.

EN 50600-2-2 Power distribution

The EN 50600-2-2 requires the energy measurement of the whole distribution system including the non-IT equipment. With level 3 measurements, information of individual consumers can be pinned to the actual devices. The red triangles in figure 4 of the standard show the location of the measuring devices. With the use of load responding equipment like EC fans, it seems less necessary to measure its consumption. But just with the use of speed controlled equipment, the risk of incorrect behaviour increases. To understand and control its consumption, a fine granular measurement layout is essential, as the numbers give essential information. To use the output of all the different measuring equipment, a DCIM software package can be very useful.

EN 50600-3-1 Management and operational information

During the acceptance test of a new data centre – as stated in the EN 50600-3-1 in clause 6.6 and 6.7 – the energy-efficiency enablement tests shall be performed. This means that all the energy measurement equipment shall be assessed. Not only the equipment but also the software used for collecting and evaluating the energy consumption data, has to be tested. It is good practise to run different load scenarios and evaluate the energy-efficiency of the installation during these tests.

The behaviour of the cooling system in different annual outside conditions – like a summer or a winter day – cannot be assessed during the limited timespan of an acceptance test but at least the day and night performance should be tested. It is highly essential to test all the different modes and record the energy consumption of all the different components. If the cooling system has a free cooling mode, all the different settings have to be evaluated.

Establish thermal equilibration in every mode to record the correct consumption. All the building components like walls and roofs and the installed equipment have a certain heat capacity and heat transfer coefficients and it takes a while before a stable situation is established. Therefore, take enough time to do the energy-efficiency enablement test. It will most likely take multiple days to run all the tests, but this time investment will pay itself back. Before the actual tests are done, it is good to reserve time to check the behaviour of the system with different settings. It is best to test the system with IT load simulators (dummy servers) in configured aisle setups. If it is the case that UPSes with different energy-efficiency settings are used, then this is the time to perform all the efficiency tests under dummy load conditions. At this point there is no risk for downtime during failure. Take into account the energy cost while running all the tests. If UPS Eco modes are part of the intended operation modes, the acceptance test period is a good time in which to get used to the different modes and the consequences for the installation. Envision different test scenarios during the planning phase, if i.e. the UPS has to react on the power quality of the supply or on the power demand of the IT load, draw a test for each instance. It is essential to involve all the data centre personnel in both the planning and running of all the tests. In an interview, a maintenance engineer stated: "I always switch off Eco-mode, why would you buy an expensive double conversion UPS and not use it? Eco-mode is just a sales trick. Don't take the risk of failure, don't use it". In complex systems – which data centres are – it is a rewarding challenge to find the most efficient settings while still getting optimal availability, security with the lowest costs.

All procedures for selecting the most optimal energy-efficiency mode should be supported by everyone involved

After the start-up of the data centre, the design can proof if it can meet or surpass its expectations.

DesignedPUE can be the reference for the actual PUE monitoring. By comparing the monthly interim Power Usage Effectiveness (iPUE) and – even better – the interim partial Power Usage Effectiveness with the interim designed Power Usage Effectiveness, a check can be done: whether or not the systems are performing as expected. Use the energy consumption data of UPSes, coolers, pumps, fans etc. for this exercise.

A DCIM system in combination with a building management system pays off at this stage. With accurate organised data, it becomes easy to manage and predict the behaviour of the data centre.
www.sunbirddcim.com/what-dcim

■ EN 50600-4-3 Renewable Energy Factor

The EN 50600-4-3 standardises the renewable energy factor REF. The REF is defined as the ratio of renewable energy (RE) used in comparison with the total data centre energy consumption.

The formula is: REF = E_{ren} / E_{DC}

Where:
E_{ren} = is the RE in kWh owned and controlled by a data centre (i.e. any energy for which the data centre owns the legal right to the environmental attributes of renewable generation)
E_{DC} = is the total data centre energy consumption (annual) in kWh

DCIM software is a new class of software that gives data center operators the ability to run efficient data center operations and improve data center infrastructure planning and design. It typically replaces Excel, Visio, and home grown databases. DCIM software can bridge information across organizational domains – Data Center Ops, Facilities, and IT to maximize utilization of the data center.

QUOTE FROM THE TS 50600-99-1

1 Scope
This Technical Report is a compilation of recommended Practices for improving the energy management (i.e. reduction of energy consumption and/or increases in energy-efficiency) of data centres. It is aligned with the EU Code of Conduct for Data Centre Energy-efficiency (CoC) scheme operated by the Directorate-General Joint Research Centre (DG JRC) of the European Commission (EC).

REF is a KPI which can be used in reporting CSR goals. REF doesn't need any measurement equipment unless onsite renewable energy is used in running the data centre. These onsite usages could be solar panels, windmills, biodiesel or any other renewable.

Although REF is standardised for the use with data centres it can actually be used by any other industry or organisation. Replace EDC with the energy an organisation uses and the methodology standardised in this KPI is easily extended. The fact that the KPI was standardised by the IT infrastructure community signals the importance and leading position towards CSR and the use of sustainable processes in this industry. The ICT industry and specifically large data centres are the frontrunners in using renewable energy.

Applying renewable energy factor
Major internet companies' leadership has been a catalyst in driving a broader set of corporations to adopt 100% renewable goals, contributing to a dramatic increase in renewable deals in the U.S. signed directly by corporations. A total of 3.4GW of renewable deals were signed in 2015, with over two-thirds of this power from renewable deals by IT companies (Greenpeace Gary Cook, 2017).

EN 50600-4-6 Energy Reuse Factor

Currently ISO/IEC JTC1 SC 39 WG1 progresses on the development of the Energy Reuse Factor (ERF) KPI. It is intended that this KPI will be published as the EN 50600-4-6.

This KPI will create a common base for evaluating and reporting on the reuse of energy produced in a data centre. All the electric energy used in a data centre will eventually be transformed to heat. By reusing this heat, the impact on consuming electric energy can be reduced. For large data centres to reuse its heat is quite challenging. The heat reuse implicates extra dependency on other processes. A data centre produces 24/7, year-round waste heat but not all demand for reusing this heat is in line with its production. Heat used for heating a building is season dependent and the surplus of heat in summer makes it harder to create a positive business case. The Yandex data centre in Mäntsälä, Finland is a positive exception.

EXAMPLE

Yandex
Yandex works closely together with the energy company of Mäntsälä. The exhaust air of the data centre is used for the local district-heat system. The Mäntsälä district-heating also provides hot tap water and therefore has a year-round heat demand. (Korhonen, 2018)

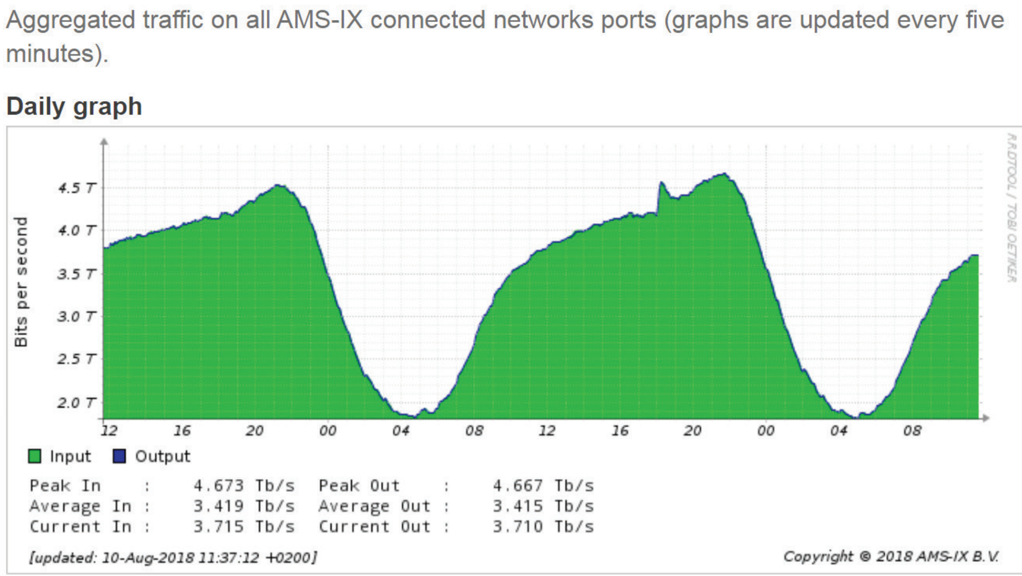


Figure 5: gives the graph of the network load of the Amsterdam Internet exchange AMS-IX

Most of the cases where data centre energy is reused involve liquid cooled systems. With the increase of immersive cooling and liquid cooled servers the temperature of the cooling media increases and the higher the temperature of the waste heat, the easier it is to create profitable use cases. The new initiative in IEC SC 48D to create a standard for liquid cooled 19" cabinets, could boost the use of direct liquid cooling in data centres. The existing technical specification IEC TS 62454 "Design guide: Interface dimensions and provisions for water cooling of electronic equipment within cabinets of the IEC 60297and IEC 60917 series" could be the bases for this standard.

■ EN 50600-4-X

The EN 50600-4 series is an evolving subset of KPI standards closely related to the KPIs created on ISO/IEC level by JTC1 SC 39. Two of the KPIs measure server efficiency and are too much out of scope to be discussed here but it is good to emphasize that PDU outlet monitoring can be used for ISO/IEC 30134-5 (ITEUsv) "IT equipment utilization for servers". This KPI relates the server utilisation to the energy consumed by the server. For the selection of energy-efficient servers, a new KPI is at its end phase of creation. This new ISO/IEC standard is called SEEM "Server Energy Effectiveness Metric" and is developed in close corporation with SPEC, the Standard Performance Evaluation Corporation, and uses its SERT™ tool to measure the energy use of servers in a standardised way. Again, in SERT results conjunction with PDU energy outlet metering the data from the SEEM metric can be used as the reference for the energy management of servers. If energy management on server level is an objective of a data centre, a DCIM software installation is essential.

■ EN 50600-4-X Candidates

The KPI Cooling Efficiency (CER) just started in the European standardisation process and Carbon Usage Effectiveness (CUE) is described by the green grid and awaits international standardisation. Another candidate for standardisation is a KPI which indicates the ability of the data centre to follow the dynamic load of the data centre.

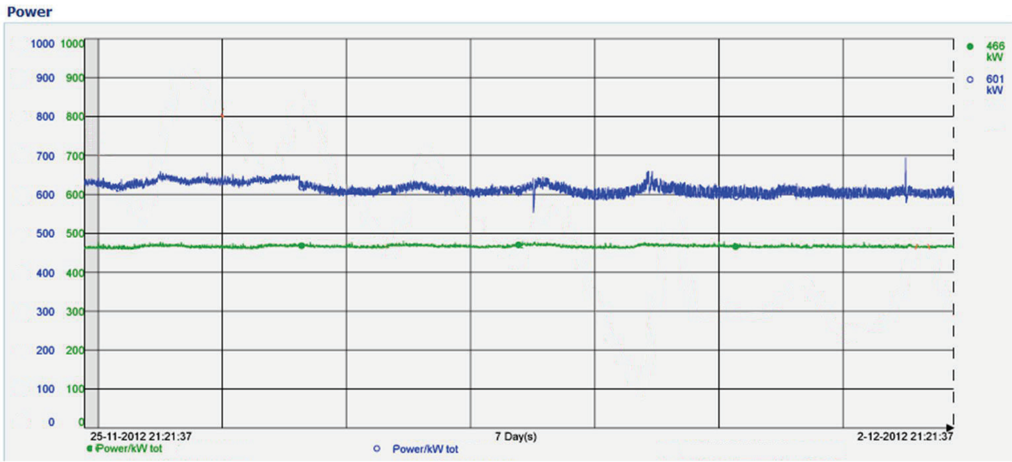


Figure 6: shows the power consumption of a typical data centre connected to the AMS-IX

EXAMPLE

Figure 5 and 6
Figure 5 gives the graph of the network load of the Amsterdam Internet exchange AMS-IX. As you can see, the daily load fluctuates with a factor of more than 2 between 1,9 and 4,6 Tb/s. But if you look at the power consumption of a typical data centre connected to the AMS-IX you will get a graph similar to figure 6 with a minimal consumption of 460 kW and a maximum consumption of 466 kW.

If you use the external network load as a proxy for work done, as proposed in The Green Grid white paper 17, in a data centre you might expect a power consumption with a fluctuation like the data fluctuation. There are a lot of reasons why this is not happening which has to do with the difference in external traffic and the actual work done but if we leave this for a separate analysis we can make a simple KPI which gives a power traffic ratio.

In formula form $PTR = \frac{(Pmin.Trmax)}{(Pmax.Trmin)}$ and for the above example this would give:

PTR = 460 *4,6/466*1,9=2,39. If the equipment in the data centre would use less power when the network traffic decreases and would follow the traffic line, the PTR would be 1. So, the ideal value is 1. A value below 1 is possible but gives also an indication for optimisation. In "Data centre Fixed to Variable Energy Ratio metric DC-FVER", (Newcombe, Liam, 2012) a publication of the data centre group of BCS, it is argued that the simplicity of a bit per watt or a bit per kWh could give false incentives, but very similar as for PUE the simplicity and therefore the usability and understandability might prevail over mathematical correctness.

The annual updated publication of the European Coordination Group on Green Data Centres gives a good overview of existing and upcoming standardisation publications related to energy-efficiency. "Standardisation landscape for the energy management and environmental viability of data centres" is available for free ((Joint Coordination Group Green Data, 2017)

CLC/TR 50600-99-1

This document finds its origin in the Best Practice Guidelines for the EU Code of Conduct on Data Centre Energy-efficiency. The content is similar but is reordered to bring it in line with standardisation requirements. As a TR (Technical Report), it currently follows the annual update cycle of its origin. As a result of its adaptation into part of a standard series it is now also available in French and German.

Minkels, Raritan and Server Technology are all endorsers of the EU code of Conduct and therefore involve the recommended practices in their design and promote the use of the code to customers.

The practices are divided into expected and optional practices. If a data centre company becomes a participant, it enrols in an application and annual reporting scheme. This participation involves the assessment of all the practices and an action plan in implementing the "Expected" practices.

The participating data centres will annually provide data to the EU. PUE reporting and progress on implementation of expected practices is part of that.

In the white paper you are reading right now (white paper 10), some of these over 150 practices will be discussed (see chapter 2). Although it seems quite challenging to evaluate all the practices, our over 10 years' experience in using them has learned that implementation will be rewarding, from easy takes as installing blanking plates to complex ones as "Consider the embodied energy in devices". But even with the latter, the manufacturer can be of great help. We offer a PEP EcoPassport for a wide range of products and embodied energy is one of the reporting items.

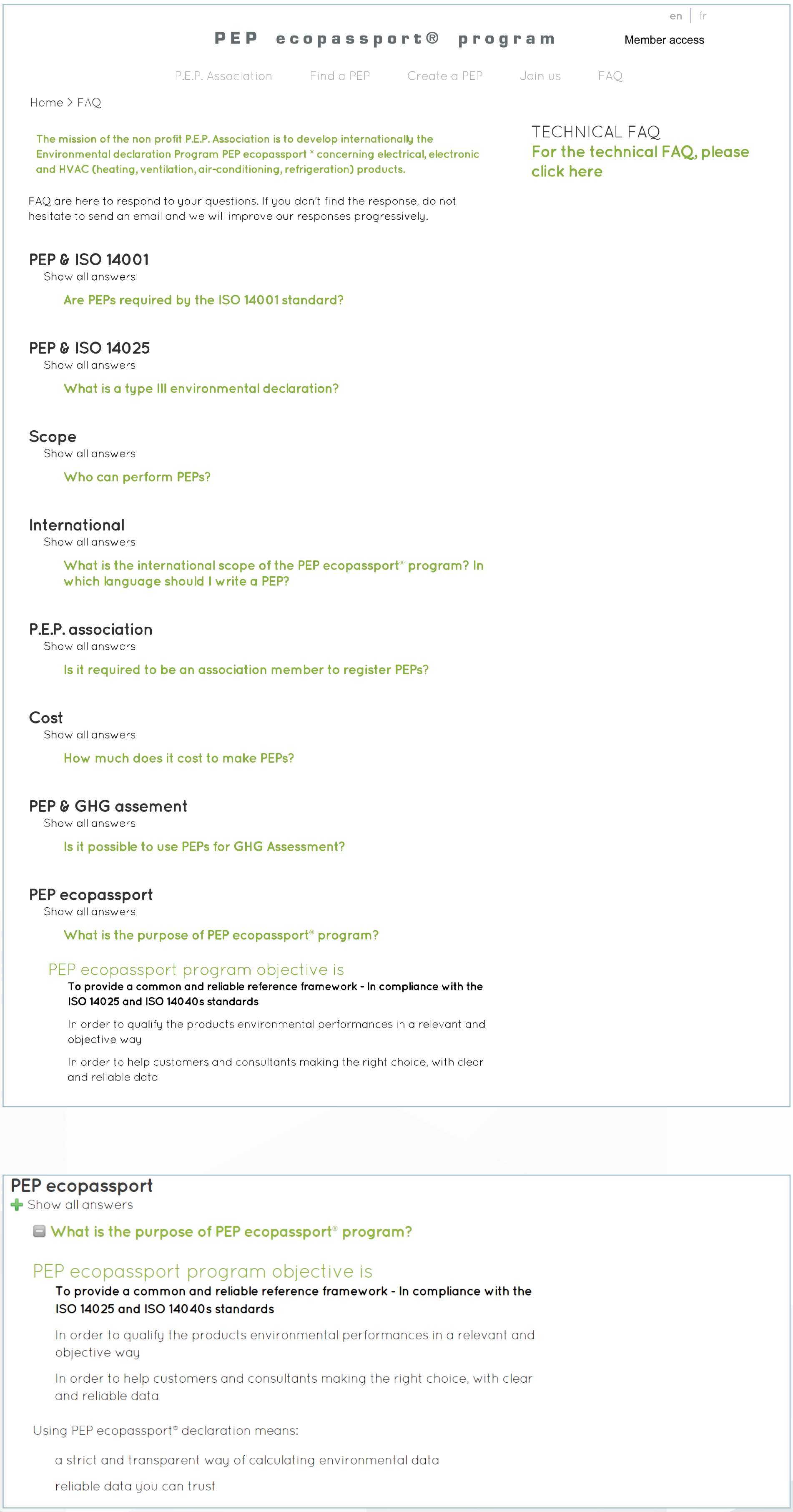


Figure 7: The PEP ecopasport program

The first practice is one of the most important ones: **Group involvement**. The practice asks for involvement of representatives of the following disciplines:

- Software
- ICT equipment
- Mechanical
- Electrical
- Procurement

The better a data centre masters the cooperation between all these departments, the better the result will be.

Understanding the code of conduct practices will pay off in the energy optimisation of an existing data centre – but the impact can be much bigger when they are used in the design phase. Group involvement can give good IT capacity planning etc. and by instructing the data centre designers to look at all the individual practices nothing will be missed.

Segregation of hot and cold air is discussed in different practices and is one of the basics of a good data centre design. One of the sections of the 50600-99-1 (with 6 practices), discusses "Airflow management and design".

An essential principle is to measure all the parameters which should be improved.

QUOTE FROM THE CLC/TR 50600-99-1

Clause 4.8 "Data centre monitoring"
a) Energy consumption and environmental measurement:
Many data centres currently have little or no monitoring of energy consumption or environmental conditions; some do not have separate utility metering or billing.
The ability to measure energy use and factors impacting energy use is a prerequisite to identifying and justifying improvements. It should also be noted that measurement and reporting of a parameter can also include alarms and exceptions if that parameter passes outside of the acceptable or expected operating range.

b) Energy consumption and environmental data collection and logging:
Once data on energy consumption and environmental (temperature and humidity) conditions is available through the installation of measurement devices it should be collected and logged.

c) Energy consumption and environmental reporting:
Energy consumption and environmental (temperature and humidity) condition data needs to be reported to be of use in managing the energy-efficiency of the facility.

d) ICT reporting:
Utilization of the ICT equipment is a key factor in optimising the energy-efficiency of the data centre."

SUMMARY CHAPTER 1

The above recommendations and practices require a large amount of planning during the design phase. The cost of installing measurement equipment and systems and software will be an integral part of the budgeting rounds. History teaches us that understanding and recognising the operational parameters aids in quantifying desired energy losses and lets us define the designed PUE. The standard supplies a choice of KPI's to support the intended CSR goals. With a scalable and modular design redundancy can be used in lowering energy losses. The cooling system has a big impact on both the use as well as the reuse opportunities. The initial focus on direct fresh air is transferring to a less risk full indirect fresh air system, with often even better performance. Liquid server cooling is the new star on the horizon with low losses and high temperatures as tempting properties but conformity and interfacing as a challenge.

To control and improve the efficiency of a data centre an energy measurement system has to be in place. A highly granular system can give deep insight in the individual consumption of components and can pinpoint problem components but only if supported by a good management sytem.

The next chapter deals with energy-efficiency aspects of all the components in the data centre and relates these to the recommended practices and other relevant parts in the EN 50600.

Part 2: Data centre components

2.1 INTRODUCTION

In the previous chapter, we reviewed how the EN 50600 can help in making data centre design choices – to build and operate an energy-efficient data centre in accordance with the intended goals. In this chapter, we will look at the components which are part of this design. When relevant, you will be referred to the corresponding recommended practice of CLC/TC 50600-99-1. We will roughly follow the sequence of the consecutive parts of the 50600 and link the recommended practices.

Building Construction

The EN 50600-2-1 deals with building construction. In Utility buildings, the type of construction has a big impact on its energy consumption footprint. For a data centre – with its very high power consumption per square meter – the relative impact of the building is far less. The performance of the building construction is closely related to the chosen cooling mechanism. Creating a predictable environment is one of its main functions. Whether e.g. the insulation of the outer walls contributes to the overall energy-efficiency depends on the cooling concept.

2.2 POWER

The EN 50600-2-2 is all about supply and power distribution.

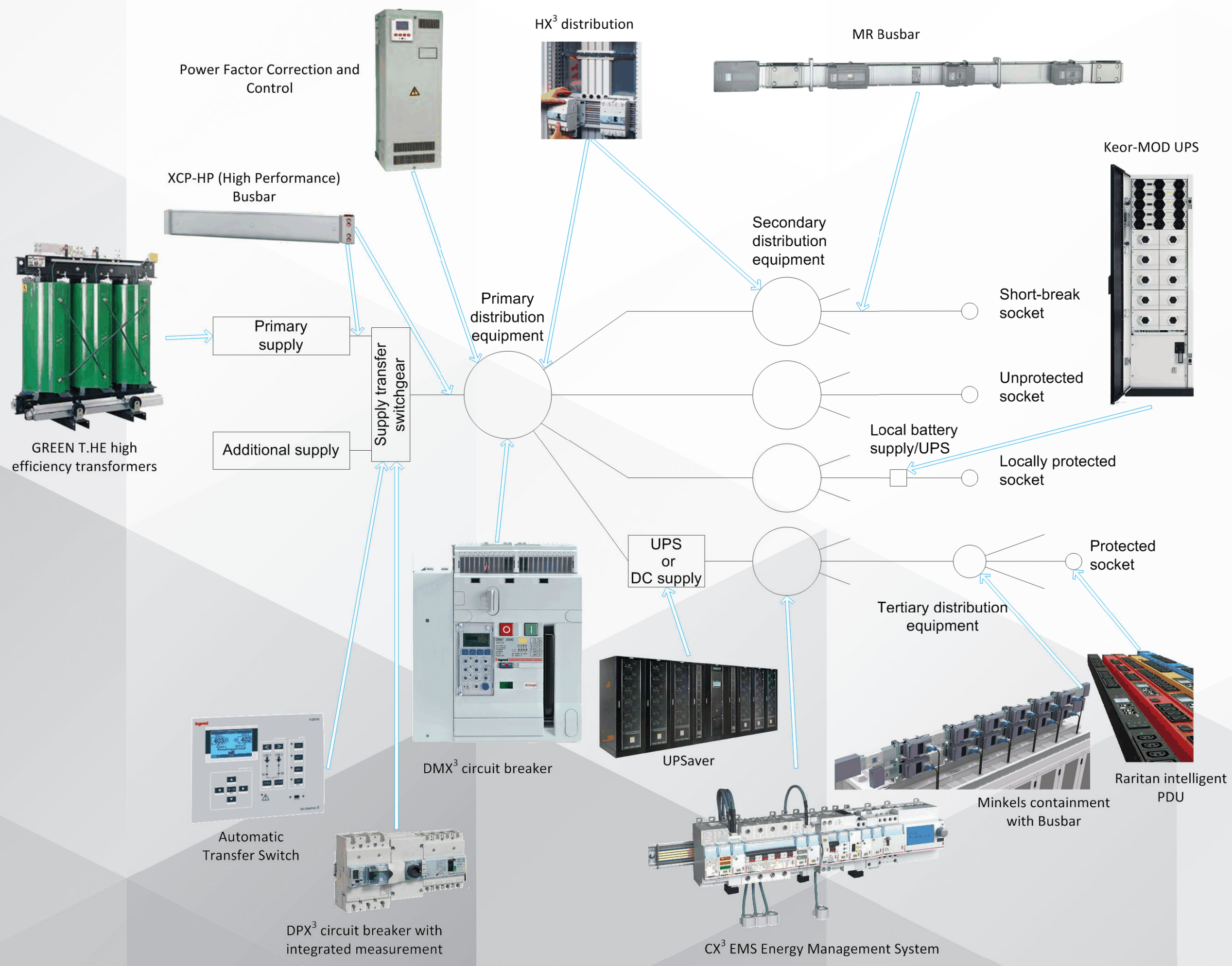


Figure 8: Components of the supply and distribution system

We will now run through a couple of components making up the supply and distribution.

Transformers
The power to the data centre often comes in at a medium voltage level. The further the transformation point can be brought into the data centre, the lower the losses will be. Medium to low voltage transformers are therefore often an integral part of large data centre designs. Use the EN 50588-1 for a specification of a Green Transformer with a desired level of energy-efficiency. Sub-clause 6.2.1.2.1 demands the user take the efficiency of the transformer in to consideration.

REQUIREMENTS

6.2.1.2.1 Requirements

The selection of components of the power supply system (e.g. transformers and generators within the premises shall:

a) allow a modular solution which takes into account the initial load and the maximum planned load while maintaining optimum efficiency;

In sub-clause 8.2.2., more details on energy-efficiency measurements of transformers can be found. Energy measurement at the supply of the transformer is crucial in evaluating its performance.

RECOMMENDATIONS

8.2.2 Recommendations

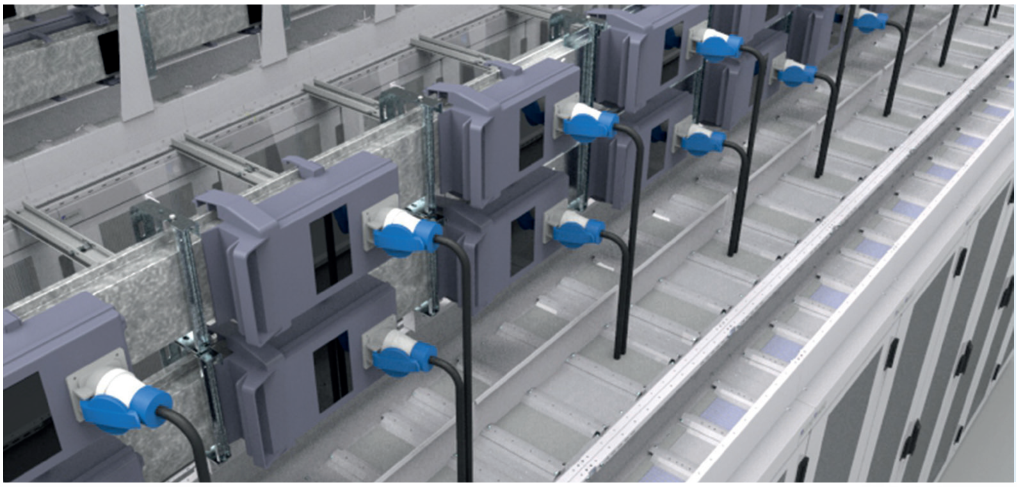
Where possible, the measurements should be made at the input to the primary and/or secondary supply transformers and, where relevant, the output of the additional supply (indicated as point A in figure 12, see next page). This will provide the optimum information in relation to energy efficiency objectives. Measurement at point B in Figure 12 represents a useful but non-ideal condition.

Note: Figure 12 mentioned above refers to the EN 50600-2-2.

Not to be overlooked is a detail in EN 50600-2-3 Environmental control in subclause 5.2.5 "Transformer Spaces":

Detail
Forced air cooling of the transformer should be considered at the design phase where this would represent an improvement in transformer efficiency.

It is good to study the effect of a slight over-dimensioning of the transformer. This might give the same result.



Busbars
Traditionally, the distribution of power is done with copper cables. Copper seems to give a good optimum between flexibility, cost and ease of installation. The unique properties of busbars are often not that well known to data centre designers and therefore overlooked. One very important aspect is the use of aluminium as a conductor in a busbar. Aluminium has less than one third of the density of copper and the conductivity of copper is only 60% better than aluminium. So, by using aluminium, a lower resistance connection can be made with the same weight. Legrand recently released a product line with "green" busbars contributing to an overall more energy-efficient design. The conductors in the busbars are – when necessary – specially coated to avoid corrosion risks. Although aluminium has its specific qualities, copper busbars can also be used to distribute power – all the way from the transformer to the tap-off box above the cabinet in the data room.

Switchgear
The selection of switchgear doesn't seem to be the first consideration when designing for energy-efficiency but it is important not to forget the current opportunities for integrating measuring capabilities into the switchgear. As can be seen in Figure 12 of EN 50600-2-2 the Legrand program offers different types of circuit breakers with all kinds of possibilities for monitoring energy consumption in real-time. You will also find panel meters with communication capabilities for directly connecting to a building management or DCIM system. When making the detailed switchgear design, it is crucial to incorporate space claims for things like measuring coils, meters, communication equipment and measurement cabling. When omitting these aspects in the initial stage, there might be a cost benefit but the penalty for not having the possibility to analyse and understand the data centre will likely backfire due to a lack of knowledge regarding the behaviour of the installation. Recommended practice 5.18.89 of the CLC/TR 50600-99-1* supports this pledge.

DATA CENTRE MONITORING: Energy consumption and environmental measurement *			
5.18.89	9.1.5	Distribution board level metering of energy consumption of mechanical and electrical equipment	Improve visibility and granularity of data centre infrastructure energy consumption

** CLC/TR 50600-99-1 Recommended practices for energy management*

Figure 12 of the EN 50600-2-2 is extended with some pictures of measuring equipment which should be deployed at the position of the red triangles.

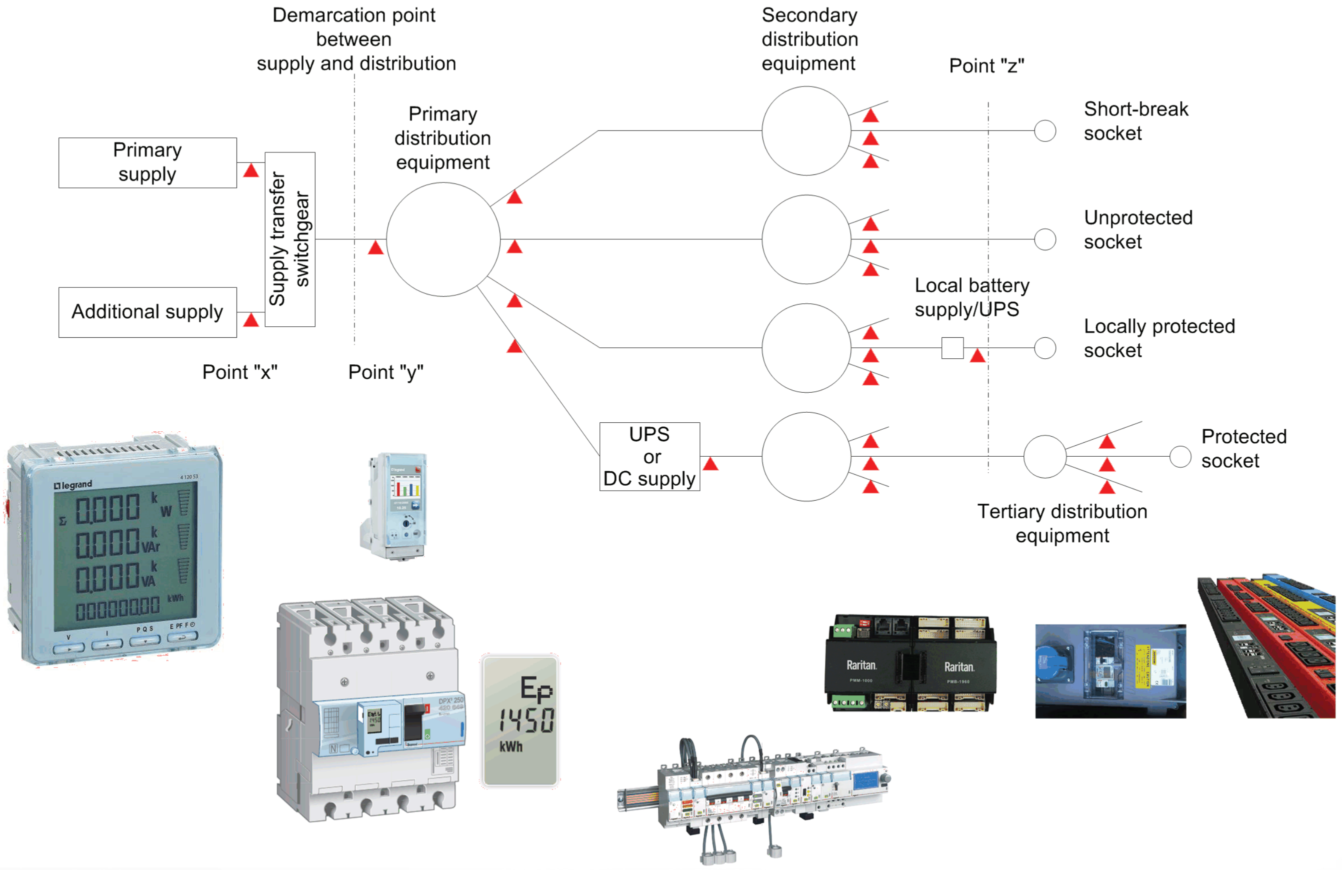


Figure 9: One of the figures of the EN 50600-2-2 is extended with some pictures of measuring equipment which should be deployed at the position of the red triangles

With the choice of the meters, it is good to take the accuracy demands of the 50600-2-2 into account. The different granularity levels require a defined minimal accuracy. Use the product specification sheets to make the right choice.

Power quality improvement equipment
Consider the use of power quality improvement equipment to control the electrical network quality. Practice 6.18.20 deals with this subject.

DATA CENTRE POWER EQUIPMENT: Management of existing power equipment *				
6.18.20	6.2.2	Power Factor Correction	Monitor the power factor of power supplied to the ICT, mechanical and electrical within the data centre. Consider the use of power factor correction where appropriate. *Note Poor power factor management can lead to higher cable losses and also introduce significant risk to the continuity of power supply. Low cost power supplies often have very poor power factors with little or no correction. These can build up to introduce electrical inefficiency and risk.*	2

Variable speed motors for pumps, fans, compressors etc. are crucial components in building an energy-efficient solution. They do have a side effect: they can have a very negative effect on the power quality, resulting in higher losses. It is best to constantly monitor the power quality and – if necessary – take measures to improve it. This can be done with active and passive equipment. Expertise on this complex subject is crucial to make the right decisions – both during design and operation. Legrand Data Center Solutions can assist in making informed decisions.

UPSes
UPSes have two major tasks in a data centre. Firstly, they provide power in case of a supply failure (often a power interruption of the mains); secondly, they provide high quality power to the connected equipment. Most static UPSes convert AC to a buffered DC stage and then back from DC to the demanded AC. This double conversion can only be done with the loss of energy and that is why UPSes can have a big impact on the overall efficiency of a data centre. The buffering of energy might be not that efficient but as this first task requires – in most cases – such limited time (when the mains fail or the generator is not yet ready), this is not taken in to account. The second task is the part to consider. An important design choice is the sizing. The simplest and easiest way is to look at the maximum required power and dimension the UPS accordingly. The pitfall is that the efficiency curve of the UPS is not a flat line at every load condition. This means that the specified max efficiency is not the value during actual operation. A typical Class 3 or Class 4 data centre has an A and a B feed with less than 40% UPS load during normal operation when the data centre would be fully utilised. To avoid low efficiencies at partial design load, it is essential to use a modular UPS (Practice 5.18.75). The example in chapter one illustrates the consequences with a monolithic design. To avoid big impact at partial load, choose a UPS with a high efficiency under these conditions (5.18.76). And last but not least: use energy-efficiency modes with much higher efficiencies than plain double conversion (VFI Voltage Frequency Independent IEC 62040-3). However, if more efficient modes are used, it is best to do it with a UPS capable of selecting its efficiency mode by analysing the power quality and acting accordingly. To run safe and understand what the effects are, it is best to use power quality metering parallel to the UPS to monitor and evaluate its behaviour. Subclause 6.2.3 "Power quality" of the EN 50600-2-2 shows the requirements of these meters. Legrand offers a wide range of modular energy-efficient UPSes and power quality meters.

** CLC/TR 50600-99-1 Recommended practices for energy management*

RECOMMENDATIONS

6.3.1.2.2. Recommendations

UPS systems should be loaded to optimise their efficiency in accordance with manufacturer's instructions. Modularity should be balanced with reliability by ensuring that the component count is not increased to the detriment of reliability or availability.

CLC/TR 50600-99-1 Recommended practices for energy management

DATA CENTRE POWER EQUIPMENT: Selection and deployment of new power equipment *			
5.18.75	6.1.1	Modular UPS deployment	Specify and deploy modular (scalable) UPS systems. *Note Physical infrastructure such as switches, transformers and cabling can be designed and installed to meet the maximum electrical load of the facility but the sources of inefficiency (such as UPS units and batteries) are installed, as required, in modular units. This substantially reduces both the capital cost and the fixed overhead losses of these systems. In low power environments these might be frames with plug in modules whilst in larger installations these are more likely to be entire UPS units.*

DATA CENTRE POWER EQUIPMENT: Selection and deployment of new power equipment *			
5.18.76	6.1.2	High efficiency UPS	Select high efficiency UPS systems *Note These can be of any technology including chemical battery, compressed gas or stored inertia to meet both site limitations and business expectations.* This Practice should be implemented with reference to the EN 62040 series of standards for UPS systems.

DATA CENTRE POWER EQUIPMENT: Selection and deployment of new power equipment *			
5.18.77	6.1.3	Use efficient UPS operating modes	Deploy UPS units in their most efficient operating modes where appropriate. Use of alternative UPS technologies such as rotary or direct current systems can be considered. The comparison and evaluation of the technologies shall be based on latest and non-biased information about available products in the market. Some UPS systems can have technologies allowing energy optimization at partial load levels and these shall be taken into account as appropriate for the application. This might also be particularly relevant for any UPS system feeding mechanical loas e.g. CRAC/CRAH fans.

** CLC/TR 50600-99-1 Recommended practices for energy management*

PDU's

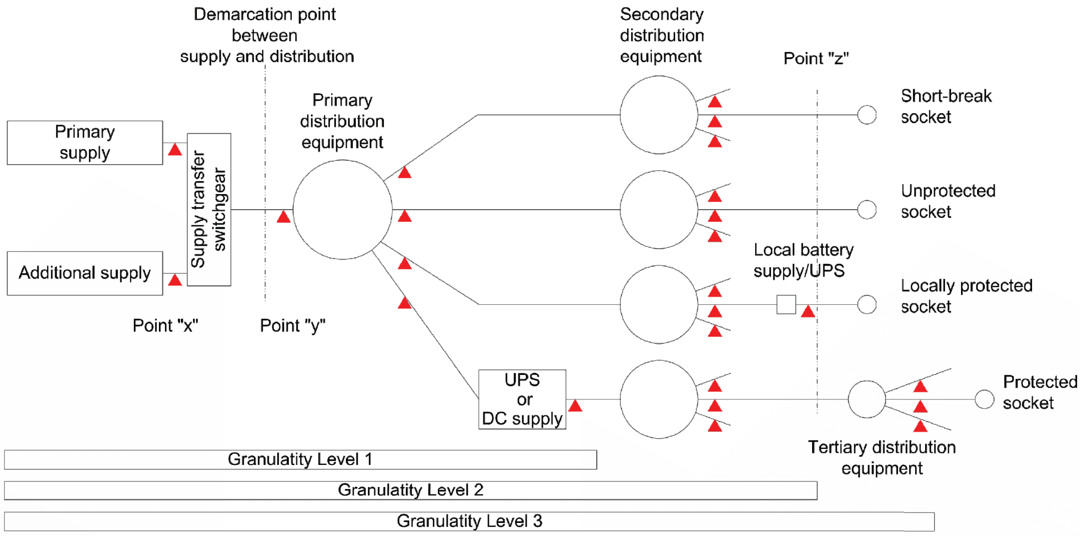


Figure 10: EN 50600-2-2 Level 3 measurement

The primary function of the rack PDU is distributing power to the attached IT equipment. Efficiency gains can be achieved by using sufficient thickness of the conductors in the feeding cables. Use 2,5 mm2 instead of 1,5 mm2 for 16A and 6mm2 instead of 4 mm2 for 32 A.

With measuring outlet energy, the level three requirement of 50600-2-2 is perfectly met. In the rightmost part of the figure representing the measurement locations, the red triangles indicate the position of the meters. Measuring at individual IT equipment level gives perfect insight in the actual consumption. As explained in the previous chapter, in the discussion about power traffic ratio, insight in the energy consumption of individual equipment can help in pinpointing energy use where no actual work is done. Recommendation 5.18.35 asks for the enabling of power management features of ICT equipment. Outlet metered PDUs are capable of verifying the use of these features. If the energy consumption is flat and the IT load is not, the features are not enabled. By reporting this to the IT system administrators, action can be taken. If PDUs are equipped with outlet switching, it is important to use bi-stable relays. These relays only use energy during switching and not continuously during the activated state.

Level 3 measurements for KPI's like PUE at Rack PDU level

DATA CENTRE MONITORING: Energy consumption and environmental measurement *			
5.18.24	9.1.2	ICT energy consumption meterin	Install metering equipment capable of measuring the total energy consumed by ICT equipment within the computer room space(s) to support the reporting of data as described in Practice 5.18.35. *Note This includes all power feeds i.e. where non-UPS protected power is delivered to the ICT equipment.*

ICT EQUIPMENT AND SERVICES: Selection and deployment of new ICT equipment *			
5.18.35	4.1.8	Enable power management features	Enable power management features on ICT equipment as it is deployed. This includes BIOS, operating system and driver settings. Ensure that this policy is documented in the ICT equipment deployment process.

2.3 MONITORING

DCIM

Controlling and monitoring a data centre is not a simple task. Different examples in this white paper illustrate the necessity to understand the behaviour of all the systems. Monitoring energy consumption and interpreting the behaviour can best be done with an application dedicated to data centres. A building management system is capable of controlling a building but is not designed for all the specific tasks like improving energy-efficiency. A well implemented DCIM system can be used to get an advanced understanding of all the energy-consuming processes and can straight forward produce reports and insight as recommended by the 50600-99-1.

Recommendation 5.18.28 "Written Report", 6.18.25 "Automated daily readings", 6.18.26 "Automated hourly readings", 6.18.27 "Energy and environmental reporting console", 6.18.28 "Create an integrated ICT, mechanical and electrical equipment energy and environmental reporting console" and 6.18.32 "Business relevant dashboard" are best resolved by using a DCIM software package.

DATA CENTRE MONITORING: Energy use and environmental reporting *			
5.18.28	9.3.1	Written Report	Report periodically, as a minimum (via written or automated means), the following: • energy consumption; • Power Usage Effectiveness (PUE) in accordance with EN 50600-4-2 or Data centre Infrastructure Efficiency (DCIE) - see NOTE; • environmental ranges *Note DCIE is the inverse of PUE expressed as a percentage.*

** CLC/TR 50600-99-1 Recommended practices for energy management*

DATA CENTRE MONITORING: Energy consumption and environmental collection and logging *				
6.18.25	9.2.2	Automated daily readings	Implement automated daily readings of energy usage and environmental conditions. *Note This enables more effective management of energy use and supersedes periodic manual readings Practice 5.18.33.*	4
6.18.26	9.2.3	Automated hourly readings	Implement automated hourly readings of ICT energy consumption. *Note This enables effective assessment of how ICT energy use varies with ICT workload and supersedes periodic manual readings Practice 5.18.33) and automated daily readings Practice 6.18.25*	4

DATA CENTRE MONITORING: Energy consumption and environmental reporting *				
6.18.27	9.3.2	Energy and environ-mental reporting console	Provide an automated energy and environmental reporting console. Report PUE (according to EN 50600-4-2) or DCIE. See NOTE in Practice 5.18.28 with regard to method of reporting. *Note This allows mechanical and electrical staff to monitor the energy use and efficiency of the facility and provides enhanced capability. This supersedes the "Written Report"in Practice 5.18.34.*	4

DATA CENTRE MONITORING: ICT reporting *				
6.18.32	9.4.4	Business relevant dashboard	Define and report upon appropriate and relevant business specific metrics relating to data centre services. Consider representing these metrics on a dashboard to accurately reflect, highlight, manage and ideally reduce the overall energy usage required to deliver the ICT services defined by specific business requirements. *Note 1 This goes beyond Practice 6.18.28 and the metrics chosen as relevant will vary between different businesses.* Consider reporting aggregated data relevant to specific internal business needs. *Note 2 This Practice will remain optional while effective open metrics and reporting mechanisms remain under development.*	3

** CLC/TR 50600-99-1 Recommended practices for energy management*

DATA CENTRE MONITORING: Energy consumption and environmental reporting *				
6.18.28	9.3.3	Create an integrated ICT mechanical and electrical equipment energy and environmental reporting console	Provide an integrated energy and environmental reporting capability in the main ICT reporting console. Report PUE (according to EN 50600-4-2) or DCIE and relate to ICT workload. See NOTE in Practice 5.18.34 with regard to method of reporting. *Note This allows integrated management of energy use and comparison of ICT workload with energy use. It supersedes Written Report and Energy and environmental reporting console. This reporting can be enhanced by the integration of effective physical and logical asset and configuration data.*	4

Figure 11: DCIM dashboard

** CLC/TR 50600-99-1 Recommended practices for energy management*

Sensors
Environment sensors are an easy to install, cost-effective way to reduce energy costs, improve reliability, and increase capacity for future data centre growth. By using environmental sensors, you can optimize your data centre ecosystem to ensure that you are meeting equipment guidelines, reducing operational costs, deferring capital investments, and improving your power usage effectiveness (PUE). Minkels' White Paper 04 "Rack airflow optimisation" and 08 "ROI Calculation Tool" give extensive explanation on how to measure and where improvements can be made (www.minkels.com/whitepapers)

50600-99-1 Recommendation 5.18.25 "Room level monitoring of supply air temperature and humidity", 5.18.26 "CRAC/CRAH unit level metering of supply or return air temperature" and 5.18.27 "Periodic manual readings" are all important for understanding and improving the EE of the data centre.

DATA CENTRE MONITORING: Energy consumption and environmental measurement *				
5.18.25	9.1.3	Room level monitoring of supply air temperature and humidity	Install monitoring equipment at room level capable of indicating the supply air temperature and humidity for the ICT equipment.	2

DATA CENTRE MONITORING: Energy consumption and environmental measurement *				
5.18.26	9.1.4	CRAC/CRAH unit level metering of supply or return air temperature	Collect data from CRAC/CRAH units on supply and return (dependent upon operating mode) air temperature	3

DATA CENTRE MONITORING: Energy consumption and environmental collection and logging *				
5.18.27	9.2.1	Periodic manual readings	Undertake manual measurements at regular intervals (ideally at peak load) and record following: • energy consumption; • temperature and humidity (dry bulb temperature, relative humidity and dew point temperature). *Note Automated readings (see 6.18.25) are considered to be a replacement for this Practice..*	3

** CLC/TR 50600-99-1 Recommended practices for energy management*

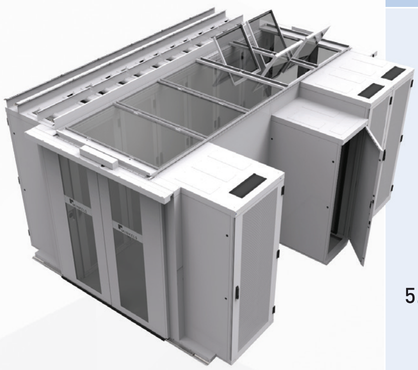
2.4 ENCLOSURES

Light coloured cabinets and aisle containment
A very simple, free of charge and instant ROI is the use of light coloured cabinets, aisle containment and cable ducting. A lower light intensity is needed and work circumstances are improved.

OTHER DATA CENTRE EQUIPMENT: General Practices *				
5.18.82	7.1.2	Pale coloured fixtures and fittings	Use pale/light colours on walls, floors fixtures and fittings including cabinets, etc. to reduce the amount of lighting required to illuminate a computer room and therefore the energy consumed for lighting. *Note This will also ensure good levels of visibility both throughout the hall and within cabinets.*	3

2.5 COOLING

Aisle containment
Aisle containment systems are the solution to the challenge that data centres have faced from the very start: how to optimise cooling and energy-efficiency through the optimum separation of warm and cold airflows. Servers are installed in insulated corridors, cold air is supplied into these corridors (aisles) to cool the servers. The warm air produced by the servers is extracted at the back. White paper 04 and 08 give all the details.



DATA CENTRE COOLING: Airflow management and design *				
5.18.55	5.1.2	Contained hot or cold air	Utilize floor layout and equipment deployment design concepts whose basic intent is to contain and separate the cold air from the heated return air in the computer room. *Note 1 Examples of these concepts include:* *• hot aisle containment;* *• cold aisle containment;* *• contained supply, room return;* *• room supply, contained return, (inc. cabinet chimneys);* *• contained supply, contained return.* *Note 2 Failure to contain airflow results in both a reduction in achievable cooling efficiency and an increase in risk. Changes in ICT equipment and management tools mean that the airflow and heat output of ICT equipment might vary rapidly due to power management and workload re-allocation. This might result in rapid changes to computer room airflow pattern and ICT equipment intake temperature which cannot be easily predicted or prevented.*	3

** CLC/TR 50600-99-1 Recommended practices for energy management*

Airtight cabinets and air ducting accessories
Airtightness can be reached with the use of server and network racks with an airflow management package. These packages keep the loss of air to a minimum, which improves energy-efficiency.

DATA CENTRE COOLING: Airflow management and design

DATA CENTRE COOLING: Airflow management and design *				
5.18.56	5.1.5	Cabinet/ rack airflow management	Install aperture brushes (draught excluders) or cover plates and panels to minimize all air leakage in each cabinet/rack and across raised floor areas when a raised floor is used as a cooling air supply plenum. *Note 1 This includes floor openings at the base of the cabinet/rack and gaps at the sides, top and bottom of the rack between equipment or mounting rails and the perimeter of the cabinet.* *Note 2 This is in addition to Practice 5.18.10.*	3

CLC/TR 50600-99-1 Recommended practices for energy management

Cooling equipment and Free cooling equipment
Traditional computer room air conditioners are equipped with an on/off compressor. Energy-efficiency gains can be made by using an inverter-controlled compressor. The compressor speed can then be controlled, and the efficiency of the system increases. When the outside air temperature is below the demanded air inlet temperature of the equipment in the data centre, a free cooling system can be used. If the data centre uses a water based cooling system, the water can be cooled (through a heat exchanger) by the outside air. Due to system losses, the free cooling can be used up to a few degrees below the desired IT inlet temperature. Only pumps and fans – and not the compressor – use energy.

Over-dimensioning is a proven way to reduce cooling losses. Fans use 1/8 of the power if the speed is halved. In Minkels White paper 02 in Paragraph 6.1 "The volumetric dimension" this phenomenon is explained.

DATA CENTRE COOLING: Selection of cooling system: High efficiency cooling system *				
5.18.63	5.4.2.1	Select chillers with high Coefficient of Performance	Select chillers based upon their predicted or specified Coefficient of Performance (CoP) in accordance with the EN 14511 series throughout their likely working range. This is a key decision factor during procurement when mechanical refrigeration is to be installed.	3
5.18.64	5.4.2.3	Efficient part load operation	Design the cooling system infrastructure to maximize its efficient under partial load conditions.. *Note For example, exploit the heat exchange area, reduce fan energy consumption, sequence chillers and operate cooling towers with shared load.*	3
5.18.65	5.4.2.4	Variable speed drives for compressors, pumps and fans	Utilize variable speed (or frequency) controls to optimize energy consumption during changing load conditions. Consider new or retrofit of electrically commutated motors which are significantly more energy efficient. In addition to installing variable speed drives it is critical to include the ability to properly control the speed according to demand. It is of limited value to install drives which are manually set at a constant speed or have limited control adjustment.	2

** CLC/TR 50600-99-1 Recommended practices for energy management*

DATA CENTRE COOLING: Selection of cooling system: High efficiency cooling system *				
5.18.66	5.4.2.5	Select systems which facilitate the use of economizers	Select cooling designs and solutions which facilitate the use of cooling economizers to maximize the use of "Free Cooling" based on site constraints, local climatic or regulatory conditions that might be applicable. *Note In some data centres it might be possible to use air-side economizers. Others might not have sufficient available space and might require a chilled liquid cooling system to allow the effective use of cooling economizers.*	5

2.6 ENERGY-EFFICIENCY DEMONSTRATOR TOOL

EE Demonstrator is a tool that estimates the energy saving potential for all Legrand energy-efficiency solutions. Calculations are based on rules specified in standards. For each solution it:

- determines the energy saving level in local currency and kWh
- estimates the simple payback time
- calculates the project economic data (NPV, IRR and Savings on TCO)
- gives the scoring for Environmental Rating Systems (LEED BREEAM or HQE)

The EE demonstrator is a piece of software which can be requested from the Legrand agency staff by filling in the "Request form" – available on their website. You will then be contacted directly by Legrand. For more information, please visit the dedicated page on http://elene-program.legrand.com.

The EE Demonstrator is part of the Legrand ELENE (ELectrical ENergie Efficiency) program. More information on the whole Legrand product range in this area can be found in the Solutions For Energy Efficiency In Buildings (ELENE, 2017) Brochure, www.legrand.co.uk/media/80424/legrand-solutions-for-energy-efficiency-in-buildings.pdf.

SUMMARY CHAPTER 2

This chapter discusses the different components making up the power source and power distribution as well as the cooling, enclosures, containment, measurement and monitoring system of the data centre. It links these products to the relevant recommended practices of the TS 50600-99-1. Giving an easy link understanding of the products and the recommended practices.

** CLC/TR 50600-99-1 Recommended practices for energy management*

Part 3: European and country-specific programs

3.1 INTRODUCTION

Third part of the white paper
The third part of the white paper will handle how to use European and country specific programs that give incentives to implement energy-efficient solutions.

Programs
To stimulate the use of energy-efficient solutions in data centres, there are several authorities that run programs to reach this effect. In- and outside of Europe, the EU code of conduct on energy-efficient data centres and the best practices within this code, have been the reference for local programs. It is outside the scope of this white paper to discuss all of the existing programs, but for two examples we will look at the situation in the Netherlands and in the UK.

3.2 THE NETHERLANDS

Scheme: EIA
The Dutch government has a tax scheme which provides favourable fiscal conditions for energy-efficient technology and durable energy. This Energy Investment Allowance (EIA) is not specific to data centres but gives income tax deductions for clearly defined investments. There is an annual adjusted Energy List (2018) available online (www.rvo.nl/subsidies-regelingen/energie-investeringsaftrek-eia/energielijst/energielijst-2018). At least the next four investments should be considered:

- 220219 "Free cooling of server rooms or existing data centres"
- 220221 "Energy-efficient rack cooling"
- 220222 "Energy-efficient cooling of server rooms up to and including 100 m2"
- 220912 "Energy-efficient UPS"

The Minkels publication "EIA 2018 Minkels" gives more information on the EIA related to data centres (www.minkels.com).

Scheme: MJA3/MEE
A second important scheme is the MJA3/MEE. MJA3/MEE stands for "Meer Jaren Afspraak Energie-Efficiëntie" (or in English: Long-term Energy-Efficiency Agreement). The ICT branch joined this agreement in 2008 and in 2016 there were 34 companies participating in this agreement.

Figure 12: An overview of the companies participating in the MJA3/MEE agreement

In the reporting period 2009-2015, a process efficiency improvement of 24% was realised.

In 2015, 83% of the total used energy was delivered by renewables (MJA/MEE resultaten Brochure) (Dutch document).

Listed here are a number of aspects of the scheme (source: Nederland ICT "MJA-ICT-sector-v2016-12-NL"):

- Participants in the MJA3 draw up an Energy-Efficiency Plan (EEP) every 4 years
- Companies with multiple locations can draw up one EEP ('concern approach')
- Package measures with efficiency improvement of at least 8% (PE + KE + DE)
- The EEP applies, after approval by RVO and competent authority, for a period of 4 years
- This complies with energy saving "Wet milieubeheer en energie" audit EED (or in English: Environmental Protection and Energy Act
- Energy consumption and the implementation of measures are reported annually in e-mjv (Electronic environmental annual report - www.e-mjv.nl)
- Progress declaration for possible return of energy tax scale > 10 GWh
- MJA3 participants are meeting each other biannual on the MJA3-ICT business day
- MJA3 offers an effective network for consultation and knowledge sharing.

One of the major incentives is the energy tax deduction. To qualify for the program, the following measures have to be taken (follow link):
www.infomil.nl/onderwerpen/duurzaamheid-energie/energiebesparing/kennisbank/#&ajax=true&Activiteit=17043&Activiteit=17044&Bedrijfstak=17042
(only applicable for the Netherlands)

Facilities
- 4a-Efficient UPS system (efficiency, at double conversion, is 96% or higher)

Having a cooling installation in operation
- 1a-Completely separated cold and hot corridors (compartmentalisation)
- 2a-Blind plates
- 3a Speed controller (sensors and actuators) on existing fans
- 3b-New room coolers (CRAHs) fans with speed control
- 5a-Room coolers with high temperature cooling (as an indication: cooling water is at least 18°C)
- 6a-Dry cooler(s) via bypass
- 6b Evaporative cooler(s) via bypass
- 6c-Plastic cross-flow heat exchanger and evaporative cooler on the outside (indirect air / air cooling)
- 6d-Open cooling system (direct free air cooling) with additional indirect adiabatic cooling

The measures are periodically assessed and can be seen as a subset of the CLC/TC 506500-99-1 Recommended practices for energy management.

3.3 THE UK

In the UK, a climate change agreement is in place. Tech-UK is running the scheme and it is open to colocation data centres.

EXAMPLE

TECH-UK CCA

The following is an abstract of the Tech-UK CCA explanation:

“Climate change agreements (CCAs) are negotiated arrangements between government and energy intensive sectors. In return for a reduction in or exclusion from paying some carbon taxes (CCL and CRC), participants are given energy-efficiency targets. Data centre businesses providing colocation space (both wholesale and retail) are eligible. Tech-UK is administering the scheme.

What are the benefits?
If you pay CCL and CRC, the value of the CCA rebate is around £27 per tonne of carbon (CCL is around £10 per tonne and CRC is around £16 per tonne). This is made up of a 90% rebate on the CCL, (0.541 p per kWh of electricity from 1 April 2014), and the exclusion of energy captured under the CCA from CRC (equivalent to 0.867p per kWh from 1 April 2014). In normal language this means that the combined benefit is 1.35p per kWh of electricity.

Is it, like, free money?
No. A climate change tax concession can only be granted if energy-efficiency can be improved by alternative means. So you have to work towards efficiency targets. The sector target has been agreed as a 15% decrease in PUE by 2020 over a 2011 baseline. Individual site targets will be expressed as a 30% reduction in non-IT energy over the same period.”

PUE is an important part of the UK CCA scheme. Tech-UK asks for "a minimum of 12 months auditable PUE data for each participating site. If you haven't got the IT function sub-metered then you need to implement this."

3.4 THE EU

One of the first programs on energy-efficiency is the EU Code of Conduct for Energy-Efficiency in Data Centres. Every data centre can voluntary participate in this scheme. By measuring PUE and implementing and reporting best practices, one can become a participant. As part of the initial application, all the required and applicable best practices are reviewed and assessed. As the result of this self-assessment, a plan is formulated to improve the energy-efficiency of the data centre. The goal is not to reach a certain predefined level but to improve year over year, or keep the level of Energy efficiency if the data centre reached its maximum efficiency.

Currently 132 companies with 313 data centres are participating in the scheme of Conduct and support the manufactures commitment as requested in the "EU Code of Conduct on Data Centre Energy Efficiency Endorser Guidelines".

Over the past 10 years the code has shown its strength. During the annual stakeholder reviews the best practices has been adjusted to align with the latest insights and the code has been referred to in numerous other documents and programs. As explained in other parts of this document, the best practices are now an integral part of the EN 50600. To be clear the CLC/TR 50600-99-1 is not the EU Code of Conduct program replacement for participation or endorsement but only a translation in Standardisation language of the best practice guide so it fits in the EN 50600 series.

During the Development of the EU Green Public Procurement (GPP) Criteria for Data Centres it was strongly advised by multiple experts to use the EU CoC for EE DC's and its scheme as a way to meet the criteria.

SUMMARY CHAPTER 3

The Netherlands stimulates the use of energy efficient data centre designs with two schemes. The EIA Energy Investment Allowance gives a tax deduction based on a published list of energy efficient measures and the MJA/MEE a long-term Energy-Efficiency scheme signed by individual data centre and ICT companies.

The UK has a Climate Change Agreement with Carbon tax deduction for participating colocation operators. This scheme is administered by Tech-UK.

The EU has its Code of Conduct for Energy Efficiency in Data Centres program. Data centres can participate by implementing its over 150 best practices, which are the basis of the CLC/TR 50600-99-1 recommended practices. See chapter 2 for the treatise of these practices. Minkels is endorser of this program.

Conclusion

Energy-efficiency has become a standard part of the design of a data centre. The level of efficiency has become a design choice and is a result of the strategy. Although the availability of infrastructure and its services is the core requirement of the data centre, the realisation of an energy efficient data centre is not bound to the desired availability class. The EN 50600 gives a design structure and a wealth of recommended practices to choose from to reach this goal. Every data centre is different. The EN 50600 uses business risk analysis and risk analysis as methodology to create the deliberate and dedicated design. As discussed, the redundant solutions in the 1 to 4 class system of the standard doesn't impose inefficient designs but on the contrary can help in reducing energy consumption. With a scaled and modular design, redundancy can be used to reduce electric energy losses.

The way in which a data centre cools the IT equipment drives the layout of the data centre to a significant extent. The promising benefits of the simplicity of direct fresh air are tempered by the impact of contamination of the cooling medium. With filtering and monitoring it is possible to control the indoor environment but this is not a trivial case. Indirect fresh air cooling seems to be a better choice with a minimum to no chiller hours in moderate climates.

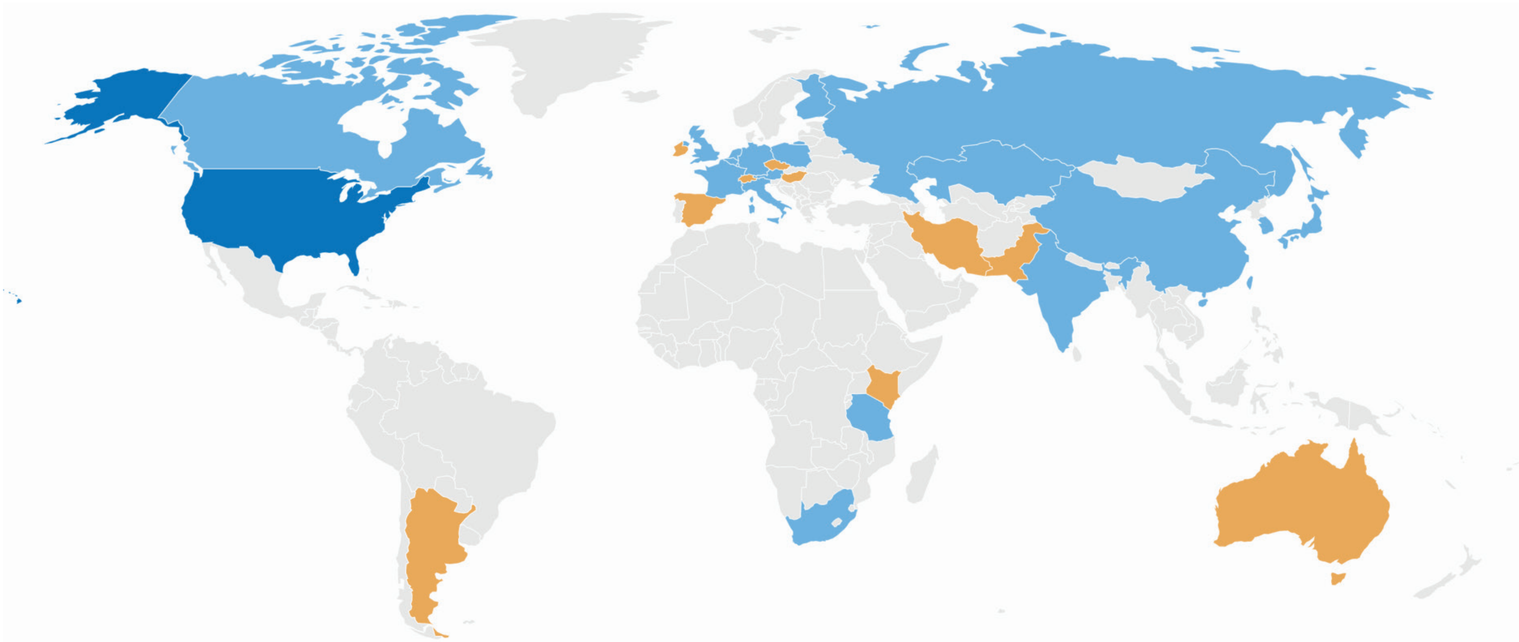
Using liquid for directly cooling the servers would greatly improve the reusability of the excess energy of data centres as the operating temperatures can be increased. These elevated temperatures widen applicability of systems that reuse the heat. Submerged cooling is a very interesting way to do this, but the lack of standards both for the housing and the immersed IT equipment seems to slow down an easy introduction.

With the presented designed PUE calculation method the efficiency is not only reached when the data centre is running on full capacity but with the right plan during its entire intended life.

PUE is the most renown KPI but not the only one. REF, Renewable Energy Factor, is a good KPI to report the source of the used data centre energy. This tool helps to report this CSR goal in a standardised way.

The products presented in this document support not only the design of an efficient solution but also support the operation of a data centre in an efficient way. The application of these product forms the base of the design and the use of measuring instruments are indispensable to control, verify and manage the performance. The metering and monitoring of the kWh's used at a high granular level drives the ability to understand the behaviour of the complete system. The recorded data provides the bases to make improvements or to verify the design intent. More and more local, national and international governments are becoming aware of the importance of data centres and see them as a highly valuable. To minimise the energy consumed by these data centres, programs are implemented to regulate and moreover stimulate measures to minimise losses. One of the programs run by the EU in close collaboration with a stakeholders community has resulted in the CLC-TR 50600-99-1 document – containing over 150 Recommended practices for energy management. The implementation examples in the EU, the United Kingdom and the Netherlands illustrate the willingness to use incentives to reward energy-efficient behaviour. The intensification and extension of these kind of programs to other countries will stimulate building and operating innovative and sustainable designs.

This white paper is the first in a series of three white papers on the EN 50600. The next two white papers will individually discuss the other two pillars of this standards series, namely: Availability and Security. It is the intention of these white papers to focus on these two main aspects of the standard which gain acknowledgement due to the extension of its domain through the work of ISO/IEC JTC SC 39. This global ISO/IEC committee currently transforms the EN 50600 into the Global ISO/IEC 22237 standard.



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About the White paper author

The author of this white paper - Niek van der Pas - contributed to the EU Code of Conduct, a Europe-wide best practices directive for energy-efficient data centre development. He is also active in ISO/IEC JTC 1/SC39 'Sustainability for and by Information Technology', where the new standard for Power Usage Effectiviness (PUE) has been established. As a representative of the NEN - the Dutch standardisation institute - the European Standard for Data Centres (EN 50600) has its full attention. Van der Pas is also chairman of the Dutch Standard Committee NEN 381039 'Computer Rooms and Data Centres'

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