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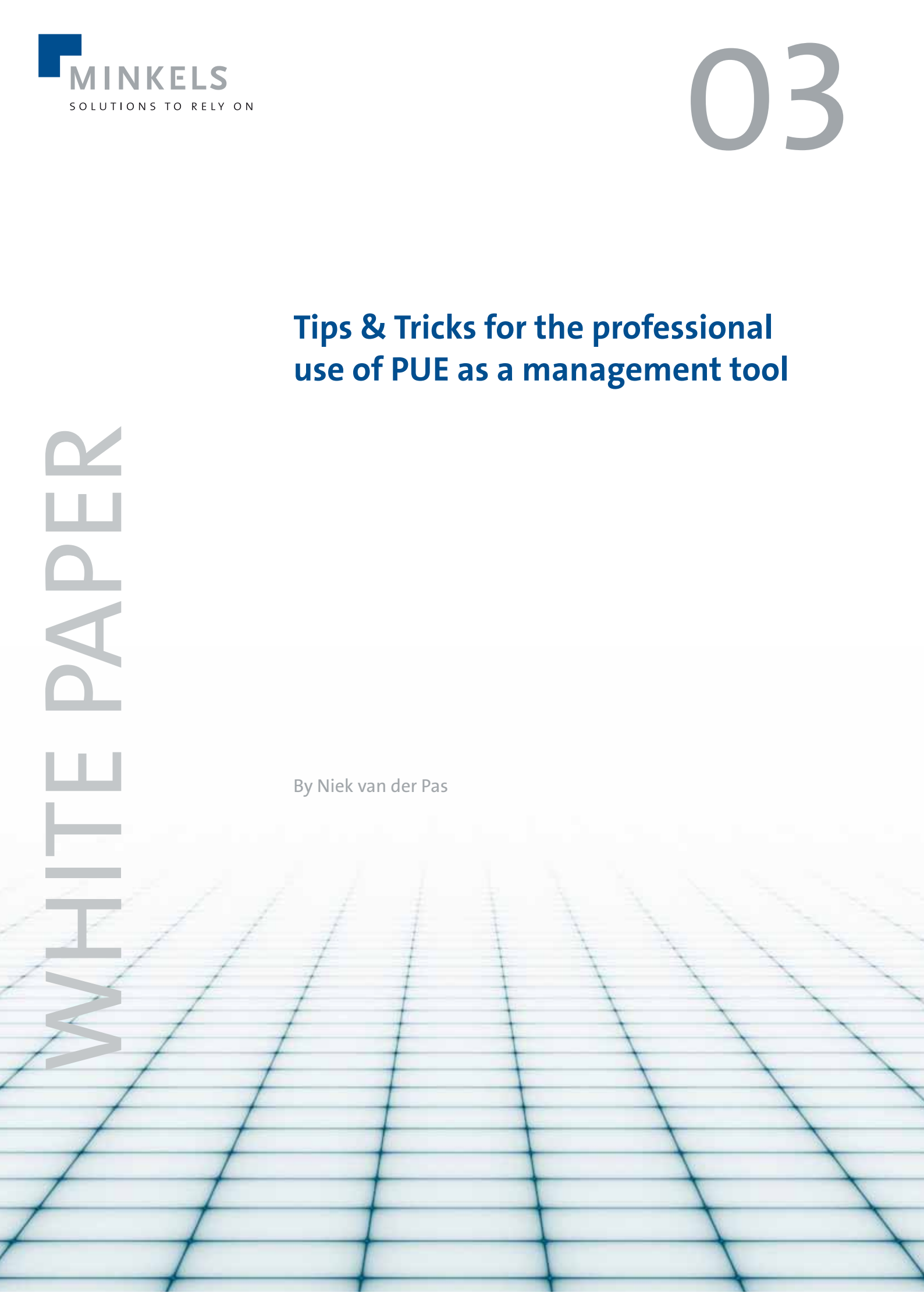
03

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

WHITE PAPER

By Niek van der Pas



In this whitepaper PUE specialist Niek van der Pas, working at the R&D department of Minkels, will share his knowledge. He will point out tips and tricks for the correct use of a PUE metric, in order to reach a certain level of operational excellence within your own data centre environment. This whitepaper is intended for use at the level of corporate computer rooms as well as commercial data centre level.

Throughout the years, Minkels' employees have acquired considerable knowledge and experience in the field of data centre infrastructure solutions. Therefore, Minkels was approached by the European Commission's Joint Research Centre (EU-JRC) in 2008, to assist in the process of drafting the EU Code of Conduct for Data Centres. Niek van der Pas represents the NEN standardization committee for Data Centres in The ISO/IEC Study group on Energy Efficient Data Centres (SG-EEDC). One of the goals of this group is to create an ISO / IEC standard for PUE.

Introduction

Energy efficiency will become a major issue within data centre environments. Setting up a new computer room or refurbishing an existing one without taking into consideration the operational energy consumption most likely means the set-up is not future proof. Having profound knowledge of the PUE (Power Usage Effectiveness) of a server room or data centre is a must for making energy-efficiency corrections and a prerequisite for a professional approach towards energy efficient data centre management. A good understanding of PUE will help you move forward in a quest for Operational Excellence in your data centre environment.

Current developments in IT infrastructure are strongly driving the need for operationally excellent and therefore energy efficient lay-outs of data centre design. Consolidation of existing IT infrastructures is one of those drivers, a very important one. Virtualization and cloud computing are the facilitators of consolidated infrastructures. Contemporaneously it implies an increased use of medium and high density computing. That, combined with the continuous rise of electricity prices, makes energy consumption a significant and still growing part of the Total Cost of Ownership (TCO) of a server room.

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Chapter 1: Basic principles of PUE

The Power Usage Effectiveness (PUE) of a data centre is a metric that is used by engineers and project managers of data centre supplier Minkels to define the energy efficiency of a data centre (over time) and to specify in what areas and through the use of which technologies certain improvements to the energy efficiency could be made.

Although a mature level of PUE information gathering is preferable in the end (see paragraph 4c about Master PUE), one could easily start off with Basic PUE principles (see paragraph 4a) and gradually move towards an Advanced PUE (see paragraph 4b) and then a Master PUE level. Basic PUE monitoring principles can be implemented using simple tools that are low on initial investments, for example with an instrument like a Current Clamp Meter, which is just a general electrician tool (see paragraph 5a).

First we will share some basic PUE knowledge, with information about the metric and the specific values of it for your own organization. Later on in this whitepaper we will elaborate on how you can pave your own individual path towards Operational Excellence using PUE information. Also, we will give you some tips and tricks brought to you by Minkels engineers, including the picking of some low hanging PUE fruits (see paragraph 7d and 7e).

1a. Definition

A PUE is an index number. Generally speaking a traditional server room design will generate a PUE of about 2.0, sometimes even higher. The closer to 1.0 it gets, the more energy efficient a server room set-up will be. However, a result of 1.0 is hardly possible as it would imply an absence of overheads such as lighting and so on. An overall PUE figure can be subdivided into several location specific sub figures, so adequate and prioritized measurements can be taken in locations that need attention.

The definition of a PUE is as follows:

$$\text{PUE} = \frac{\text{Total Facility Power}}{\text{IT Equipment Power}}$$

1b. Initiated by The Green Grid

PUE has been introduced in the market by The Green Grid (www.thegreengrid.org). The Green Grid is a worldwide consortium of companies within the ICT sector, founded by Intel, AMD, VMware, Dell, HP, IBM, Sun Microsystems and Microsoft, amongst others. Since the foundation in 2007 quite a number of companies worldwide have joined the consortium. The aim of combined efforts is to seek energy efficiency maximization in server rooms and a significant reduction of energy use in the data centre environment. This is conducted by the exchange of knowledge and insights into energy efficiency issues.

Nowadays the PUE is a broadly and worldwide accepted metric that clearly visualizes the energy efficiency of a server room or data centre. For data centre managers, IT managers and general management executives it is not only an eye opener to the importance of energy consumption awareness. It also provides them with a detailed grip on the energy use in a server room and informs them how to manage server rooms in the most effective way.

DCiE (Data Center infrastructure Efficiency) is another metric launched by The Green Grid. It has the same purpose and characteristics as a PUE, only with a different conclusive figure and another way to judge it's outcome. The higher a DCiE figure is, the more efficient the facilities are. For a PUE the reverse is true. A low PUE figure will reflect high efficiency in a data centre. DCiE was launched to replace PUE, however PUE has since become widely accepted in the market as the preferred metric to show data centre efficiency.

Chapter 2: The value of a PUE

A PUE figure will not only give you detailed grip on the energy use in a server room. At the same time it is an important indicator for the level of professionalism and efficiency regarding your business and technical processes.

2a. Structuring of processes

A low PUE figure means that the business processes as well as the technical processes in your data centre operations are well organized. The lower your PUE gets, the better optimized your data centre operations will be. The reverse is also true. When there is no awareness and knowledge on how the processes in a data centre environment are established, then it will be very difficult to realize and maintain a good PUE figure.

Gathering information about the PUE of your data centre environment - whether it is a corporate server room or a commercial managed carrier neutral data centre - will be a good starting point for an operationally excellent approach towards the overall management of your server rooms. Provided that a PUE figure is used appropriately, then it will be a good management tool to judge the operational efficiency of a certain data centre design and to take managerial measures for improvement.

2b. Management tool for uptime

Even when it comes to the subject of availability, having profound knowledge of PUE will be a prerequisite to achieving the desired uptime of every data centre manager, namely around 99,999 to 100 percent. That's because a PUE figure will be able to give you information on the energy loads in your systems and to predict whether these loads are reaching their limits in certain locations. If they exceed certain parameters, failure of the server room or data centre as a whole would be the result.

Also, the cost-effectiveness of a specific data centre solution can be managed more easily if you know about your PUE and the processes within your operations. In that case it would be possible for example to even build certain parts of your data centre in a less redundant and less capital intensive way. Only because all the management info and information about peak loads are available to make such decisions, so risks of failure can be minimized. Furthermore, PUE data can be of interest to Service Level Agreements (SLA's) in contracts, depending on your business model of course.

In fact, using the PUE metric as a management tool in your data centre is one of the basic management principles to implement and maintain high levels of efficiency in your data centre design. As a data centre manager you have to know what is happening in your systems, otherwise you can't control and improve. PUE knowledge can help. It's is an integral part of the road towards Operational Excellence - with cost efficiency, high availability, flexibility and scalability as key ingredients - a goal every professional data centre manager should aspire to. A good PUE result is an indicator for good management and having the right knowledge about data centre processes at the right levels in your organization.

2c. Road towards operational excellence

The gathering of PUE data is an important and integral part of the road to Operational Excellence in data centre environments. The road towards Operational Excellence is actually a continuous process in which you'll have to determine step by step what actions are necessary to improve the PUE in your individual situation. If one parameter is under control you'll have to focus on the others one after another.

In case of brand new server room development, there is another basic management principle next to PUE improvement that might help you on the road towards Operational Excellence. It is called the Volumetric Dimension and it is described in a previous whitepaper from Minkels, called: "New dimensions in Data Centre Design - Professionalizing the data centre by striving for Operational Excellence."

The traditional approach, based on the number of square metres available, often leads to inappropriate choices during the initial phase, which unfortunately implies protracted implementation projects and an increased continuity risk during the life span of a data centre. The 'Volumetric Dimension', as explained in this whitepaper, is an approach devised by Minkels as one of the basic principles for the design and layout of 'Operationally Excellent' data centres and server rooms.

This previous whitepaper from Minkels is available in English from:
www.minkels.com/whitepaper

Chapter 3: The PUE components

To get the right outcome of your PUE definition it is important to have a good understanding of the varying components in the metrics.

3a. Total Facility Power

This is the PUE metric component which includes the total energy load or power consumption of a data centre facility or server room. A control room for purposes of data centre management should be seen as part of the Total Facility Power, but in a 'mixed use situation' the energy load of the IT equipment in the offices and the energy used for the offices should be subtracted.

To the data centre facilities as a whole one should consider things like Uninterruptable Power Supplies (UPS), chillers, pumps, CRACs, generators, stand by systems as well as lighting and for example elevators. In fact, all power distribution components and IT equipment should be part of the Total Facility Power metric.

3b. IT Equipment Power

This is the metric component that represents the energy consumption of all the IT equipment inside your server room or data centre. One should not only take into account the energy consumption of server equipment for general computing purposes. Also, the energy loads of storage and networking equipment (including routers, switches and load balancers) are part of this metric, along with peripheral equipment like monitors, laptops and workstations, plus all kinds of rack gear like KVM switches.

3c. Where to measure

Generally speaking, Total Facility Power can be measured at - or close to - the utility meter of a facility. Of course this should be a relatively easy job for a commercial data centre, whereas for a corporate server room possible adjustments in the outcome figure might have to be made. For example when it comes to shared CRACs and/or chillers in the office buildings.

The right place to measure IT Equipment Power, again - generally speaking - would be at the output of the Power Distribution Unit (PDU) at cabinet level in your server room. At this point tasks such as switching and power conversion are completed already. After this point power consumption applies specifically to your IT equipment.

To these general assertions at Master PUE level of measurement, various deviations could be defined in line with different levels of maturity in PUE measurement or type of businesses. For these deviations, also have a look at chapter 4.

Chapter 4: PUE measuring: from Basic to Master level

It is quite easy to get started measuring the PUE of your facilities. By taking into account three levels of ascending granularity, you can just start with a basic level and develop the right level of granularity in measurement instrumentation at your own pace regarding time and cost investments. Having profound knowledge of the PUE of your facilities will become an indispensable instrument in managing your server room in the near future. The more you measure the greater the effect. A phased implementation of PUE measurement however will provide space for creating organizational support and a spreading of necessary PUE investments.

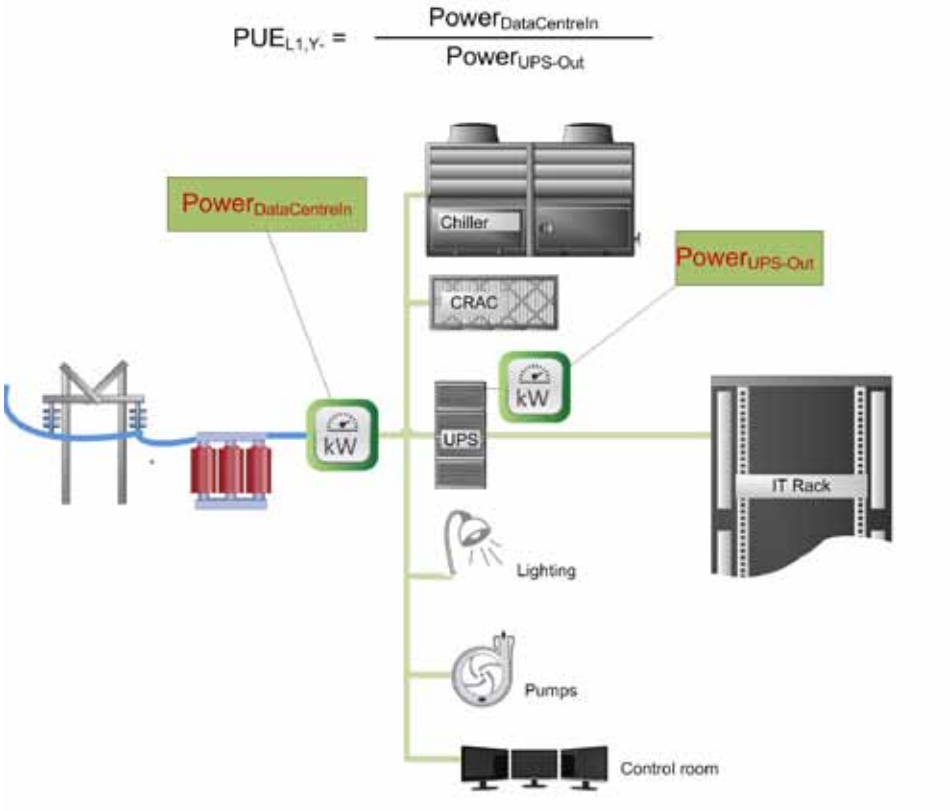
4a. Basic PUE

A basic PUE can be measured at the levels of your UPS output (IT Equipment Power) and data centre input power (Total Facility Power). This would result in a snapshot measurement of your electric demand at one specific point in time. Therefore, the energy consumption in this metric is measured in kW, not kWh (kilowatt-hour) as is the case with a Master PUE measurement.

Positive: a Basic PUE could be a good starting point for facility managers, IT managers and general managers of a data centre facility, mainly for the sake of creating PUE awareness within the own organization. It also gives you a very broad idea of how good or bad your data centre is achieving in terms of energy consumption.

Negative: the outcome of a Basic PUE measurement is not so reliable. It's just a snapshot in time. It doesn't give you insight into PUE development over time, neither does it give you the right information for developing effective directions of improvement. For example, it still doesn't give you a clue whether it is your UPSs, your CRACs, or other facility or IT equipment that's wasting energy and spoiling a good PUE outcome. Also, a snapshot measurement can be misleading due to seasonal differences in PUE outcome (in case of Free Cooling being used). And you still won't know whether or not having your main cooling compressor or humidifier in operation at the time of measurement could make a big difference in the PUE end results.

Figure 1: Basic PUE



4b. Advanced PUE

Within an Advanced PUE the IT load (IT Equipment Power) can be measured at UPS output level as well, just the same as with a Basic PUE. The energy consumption measurement of your data centre facility as a whole can be done at data centre input power level (Total Facility Power). In this case the energy consumption is measured in kWh (kilowatt-hour), because it is a continuous measurement on a periodical basis .

Continuous measurement of PUE periodically, monthly or weekly, will require some investments. Only a small number of UPS's currently available are capable of continuous measuring at output level. In case you do have a UPS with such capabilities, even then it is not certain that the UPS will deliver you the right figures. The quality of measurement by those UPS's differ, but large deviations are not uncommon.

To build in a more reliable way of continuous measurement one should install a separate kWh (kilowatt-hour) electricity meter in a cabinet behind the UPS and connect it to the switchboard.

Many organizations however don't have a data centre solution in place in which PUE measuring is such a clearly defined operation as mentioned. In practice lots of deviant situations are possible, especially when it comes to corporate data centre environments. For example, one can have CRACs behind a UPS. Sometimes also water cooling solutions are situated behind a UPS, or even the lighting of a data centre. In that case additional

electricity meters have to be installed for the equipment that doesn't belong to the IT load. If you don't, then the PUE outcome will be an incorrect figure. The results of these separate measurements have to be deducted from the IT load in order to get a detailed and reliable PUE figure.

Positive: continuous measuring will give you a more reliable PUE outcome than an ad hoc and individual figure. It will give you an average of PUE measuring over time. A one year measurement will give you an accurate insight in the energy consumption

Negative: although an Advanced PUE is far better than a Basic PUE regarding the reliability of your PUE figure, the outcome will not be as detailed and segmented as is needed for composing solid energy efficiency plans. For that you need to opt for a Master PUE. With an Advanced PUE it is still not possible to define a detailed plan of improvement. Efficiency improvements still have to be made subjectively rather than based on hard facts, because the information feed is not yet complete.

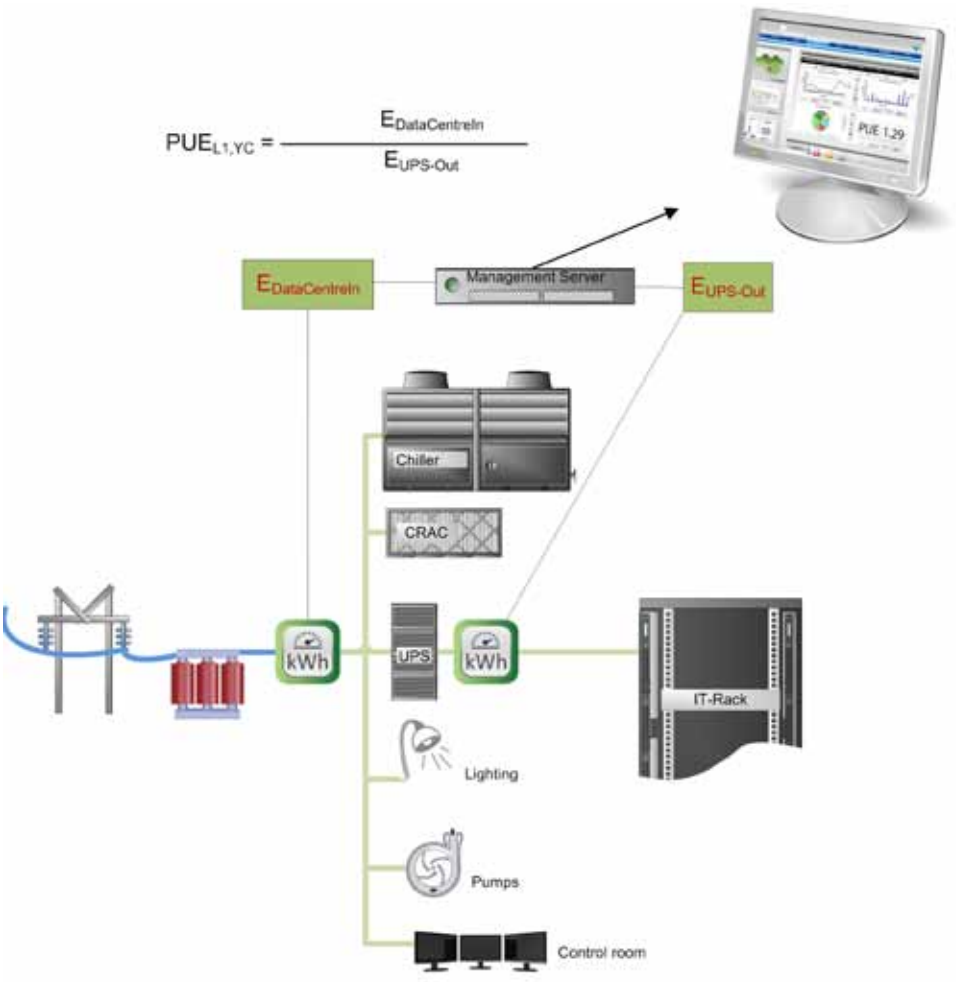


Figure 2: Advanced PUE

4c. Master PUE

When your organization is ready to go for an implementation of the most comprehensive level of PUE measurement, in terms of time and costs that's involved but also the maturity of your organizational processes and data analyzing power, a Master PUE is what you should strive for. A Master PUE requires a set up of several instrumentation points, at the level of a cabinet. Depending on the size of your data centre this could be quite a step to take.A Master PUE can be measured at the levels of your Power Distribution Unit (PDU) output of a cabinet (IT Equipment Power) and data centre input power (Total Facility Power).

Depending on your business model, whether you're an ISP, a managed services provider or a corporate organization, you can choose a measuring point either inside or outside a cabinet (e.g. on a Busbar). It would literally be only a cable length difference, so there shouldn't be a difference in the effectiveness or reliability between these types of measurement. If you don't have a Busbar system, then measuring rack load on an individual basis in the server room PDU board - the power distribution panel where the rack feeds are centred - would be an option. In case you do have a Busbar system in place, then measuring at cabinet level either at or near the Busbar system should be the location for installing PUE sensors. If you're an ISP for example, with no access to the cabinet, then power monitoring in the Busbar Take off boxes is the best option. If rack access is an option, rack PDU's with monitoring can be installed.

Generally speaking, in an optimum situation, PUE information should be gathered as close as possible to the power consuming equipment. On the other hand it is wise to create independency in acquiring data from possible fast changing parameters in the data centre infrastructure. Therefore, gathering PUE information at server (or network equipment) level might be not the best option to go for. Of course this could be handy to trace hotspots in a very detailed manner, but summing the power readings of servers could also mean high risk for disrupting and unavailable power data in case of changes in the server operating system. Not to mention incompatible operating systems or inaccessible systems because of security or availability reasons. Also, don't underestimate the extra effort which is needed to match the load with the correct outlet per server, especially when the servers are A/B fed and both feeds are energized If you don't match all this data you might end with an inaccurate result.

Positive: a Master PUE will continuously give you very detailed and segmented information about the energy efficiency of your data centre or server room. On the basis of this information possible energy inefficiencies can be identified and one can develop an overall plan of improvement and make targeted modifications to the data centre environment.

Negative: in the beginning, a Master PUE will require quite some investments in time and money. In the end however it will definitely pay off. It's good to know that PUE measurement can be automated to the fullest, so after your first investments the measurement of your PUE should be quite an easy task.

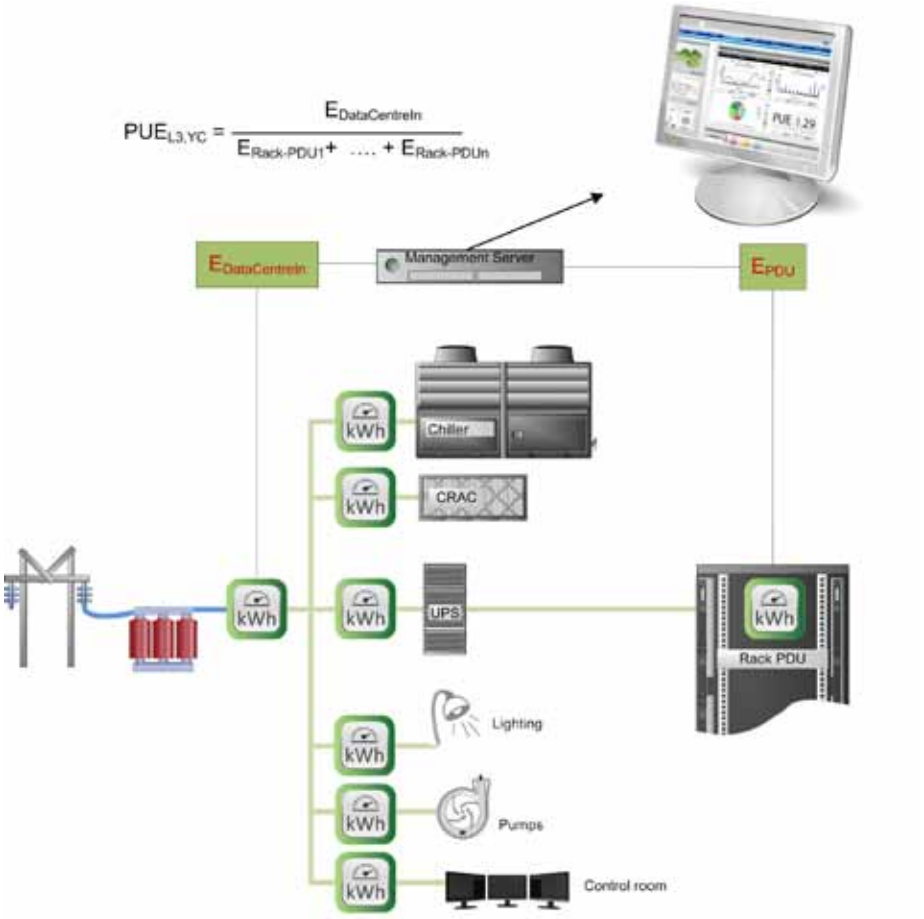


Figure 3: Master PUE

Chapter 5: Using the right measuring equipment

Gathering PUE data inside your data centre facilities will require the use of some basic PUE equipment. Here we shall mention the ones that you will probably need most.

5a. Current Clamp Meter (general electrician tool)

This is a quite handy tool for everyone who's involved in day-to-day operations of a data centre or server room. An RMS Current Clamp meter can be used for individual and mobile electricity measurement. This hand held clamp meter is very useful for indicative energy efficiency surveys and targeted efficiency analysis.

This is a tool that should be available in every Data Centre and is of low cost In fact, this instrument should be a standard tool in the tool box of every electrician.

This product is a particularly good solution to be used in retrofit situations, in existing data centre environments (this product is suitable to start with PUE measuring right away, without infrastructural modifications).

On the other hand it could also be a handy instrument to be used in the latest designs of next generation server rooms, for individual and targeted electricity measuring. A Current Clamp Meter is very useful for indicative energy efficiency surveys and targeted efficiency analysis during the process of PUE efficiency improvement.

Current Clamp Meters have their drawbacks. Only skilled personnel can work with them because of the necessity of working in open switch boards. Also, it is not possible to measure current on a standard power cord. The magnetic fields of the phase and neutral line will cancel out so no reading can be accomplished. With a Current meter no voltage or power factor is being measured. The result will therefore give you an indication, not an absolute result.

If available, an alternative tool like the Fluke 430 or the LEM Analyst3P can also help to measure the PUE. Both are hand held tools that can give you accurate power measurement reporting.

5b. Current Transformer (CT)

This tool is meant for electricity measuring at PDU level outside the rack. This is an energy monitoring system which may be installed into a live data centre environment.

- **Minkels product**

Minkels has a CT measuring tool available, it is called Varicontrol-C . Varicontrol-C is a stand-alone monitoring and reporting application which provides kWh, W, V, A, and pf, and the possibility to transfer alarm-condition alerts via e-mail server, or via SNMP traps to a network management system. This system includes voltages and power factor measurement and will give you very accurate results.

Varicontrol-C can be integrated to the Minkels Varicontrol Data Centre Infrastructure Management (Varicontrol DCIM) platform (see also 7b), an overall software suite that is able to manage all the data (PUE data, amongst other data) gathered in your data centre.

5c. Intelligent Rack PDU

Depending on your business model, it could be possible that you have full access to the equipment in data centre racks. If that is the case, like in corporate business environments, it is possible and desirable to install intelligent Rack PDU's to measure electricity consumption inside the cabinets.

- **Minkels product**

For this purpose Minkels has developed a product called Varicontrol-P. These are intelligent PDU's which are able to deliver you the PUE data needed.

A rack PDU can be connected to the Minkels Varicontrol data centre infrastructure management platform (see also 7b), an overall and vendor independent software suite (based on open source) that is able to manage all the data (PUE data, amongst other data) gathered in your data centre.

Chapter 6: Embedding PUE in your organization

The nature of your business model has quite a lot of influence on the type of PUE measuring you are able to choose.

6a. Influence of business model on measurement options

As previously stated, PUE information should be gathered as close as possible to the power consuming equipment. But you also need to create independency in acquiring data from possible fast changing parameters in the data centre infrastructure. Plus your business model will dictate to you on which levels you should measure and on which level you are able to gather PUE data.

The level of granularity should match the business needs of a specific data centre. For a large data centre facility very detailed information about a cooling system is more valuable than would be the case with a relatively small corporate server room. Information about which part of the cooling system (including pumps) is using what part of the energy supply could be very informative PUE data for a large data centre. Such data can only be quantified by installing individual power metering devices at pump level.

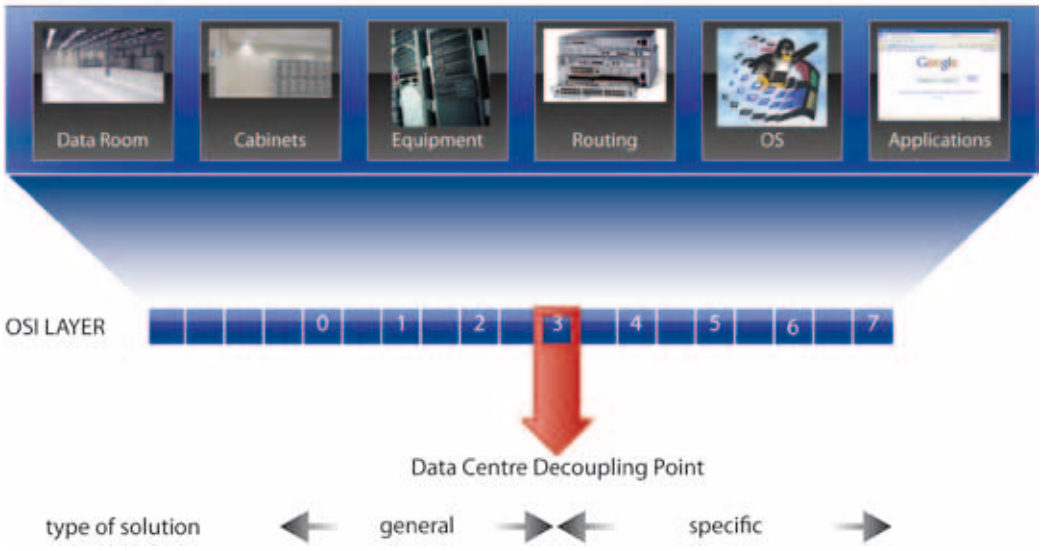
6b. Data Centre Decoupling Point (DCDP)

A good starting point in investigating which measurement options you have in your own data centre environment, is to determine what your specific Data Centre Decoupling Point

(DCDP) is. Determining your DCDP is a first step in understanding the level of influence you have on the final PUE measurement layout. To learn about this subject, please have a look at our previous whitepaper: "New dimensions in Data Centre design; Professionalising the Data Centre by striving for Operational Excellence", written by Patrick Timmer, business development engineer with Minkels.

The following scheme will give you an impression of your unique DCDP, the instrumentation points for PUE data gathering and the products Minkels has available for that.

Figure 4: Data Centre Decoupling Point



6c. Distribution of PUE information

Electricity measurement and electricity data monitoring used to be something only for technical people. Not anymore. With the urge at management level to improve energy efficiency and the availability of modern web based management software (see 7b), all the stakeholders in data centres can get access to this information.

With the higher level of use of PUE information and more segmentation in usage (general management, data centre management, server room management, floor management), data filtering and the way PUE data is represented at technical level as well as lower and higher management levels becomes more and more desirable.

The higher in an organization chart the PUE data should be analysed, the less technically detailed this information needs to be. A general manager probably wants to know about the overall PUE and have some arguments for investments to improve the PUE in the future. A facility manager probably will need more detailed information to do his job, like the PUE of a cooling system, the PUE of a UPS and the PUE of power distribution, to name a few. A data hall manager on the other hand will need PUE information at rack level. Therefore, it is necessary to subdivide an overall PUE in several decentralized PUE figures. A good PUE management system will help you out (see 7b).

6d. Incorporating PUE in quest for Operational Excellence

Operational excellence within your data centre environment is a very important goal to strive for. Not only for purposes of energy-efficiency, but also when it comes to having your data centre processes well organized. This of course will improve the uptime and reliability of your IT infrastructure.

6e. Practical examples PUE measuring

The gathering of PUE information is an important tool to improve your processes and trying to approach a situation of Operational Excellence. The next two practical examples will illustrate how PUE information can help you with this.

These examples describe the individual approaches of two organizations towards a situation of Operational Excellence, that is to say, an optimum use of their resources for (energy) efficient day-to-day data centre operations.

- **Example 1**

A data centre striving for Operational Excellence is using an energy-efficient concept in which hot and cold air is separated and outside air is being used for direct cooling of the equipment inside, both on account of creating energy efficiency. It seems that the implemented systems are functioning well. For the sake of PUE measurement several PUE measuring tools are being installed. The PUE information however shows that the PUE result figure is higher than initially expected. After having the systems analyzed it appears that the cooling equipment is sucking back the blown warm air flows. Adding an air separator turned out to be the solution to fix this problem. So PUE information laid the foundation for fixing this issue, helping this data centre get one step further in its quest for Operational Excellence.

- **Example 2**

7. An organization has multiple data centres on several locations. This organization at one time decides to implement PUE gathering tools in all of the premises in order to make its first steps in the direction of Operational Excellence. By doing this it is suddenly possible for the organization to compare and explain differences and analogies in computer room issues and to share best practices. PUE in this case is a tool to create an overall KPI (Key Performance Indicator), to speak the same language in different computer rooms and to analyze and judge improvements being made in a structured manner. A completely different situation than the first example, but again PUE is also helping this organization to

take the next step in optimizing the use of its resources for (energy) efficient day-to-day data centre operations.

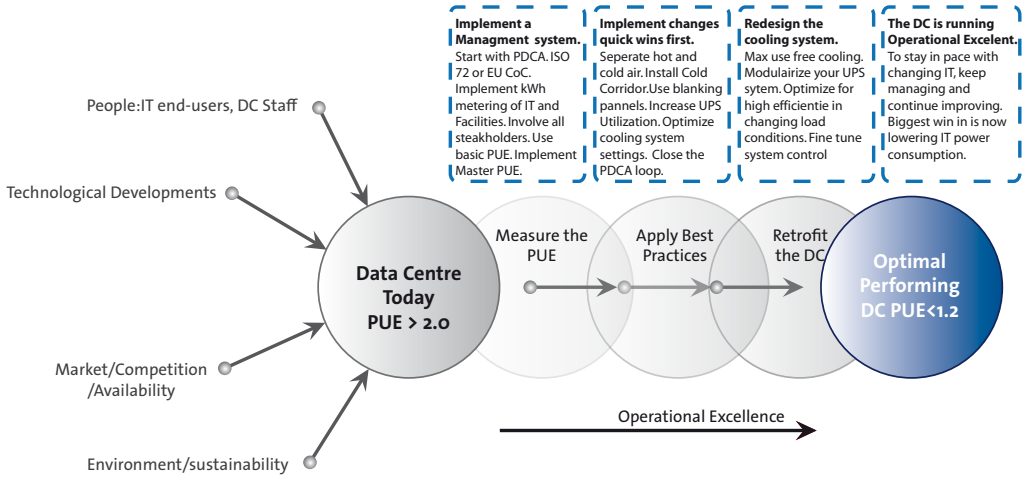


Figure 5: Path to an Operational Excellent Data Centre

Chapter 7: PUE recommendations by Minkels

A PUE can be measured with different types of granularity. Our advice is to do a PUE system implementation gradually, taking it step by step.

7a. Gradual implementation

Start off with a Basic PUE, to create awareness within your organization. By doing this you will be able to create a positive atmosphere towards the necessity of energy efficiency within your organization. Not only for environmental purposes, also regarding the level of availability of your server room(s), and reflection on the maturity of your processes and the cost saving options PUE data will bring.

After that you can go a bit further and opt for an Advanced PUE. It will ask for some more investments in terms of time and money, but your organization is convinced that PUE knowledge will pay off, so that hurdle is already being taken. The PUE data gathered is still not as detailed as you probably would have wanted, but it will give you enough data to fix some energy inefficiencies and improve your PUE by a fair amount.

The final step should be to go for a Master PUE. In this phase your PUE measurement system is measuring on a full continuous basis, with a level of granularity built in according to the type of your business. The overall PUE figure and subdivided PUE figures for different segments of your systems will give the different levels in your organization the specific PUE data they individually need. In this phase, with this information supply, you're able to make targeted modifications and improve your PUE figure to the fullest.

Keep in mind that a PUE-system implementation will cost some time and money in the start-up phase, but the gathering of PUE data can be a fully automated process in the end. So, PUE gathering on a continuous basis should finally be an easy task for every organization.

7b. PUE management software suite: Varicontrol DCIM

To have PUE data gathered continuously, analysed and distributed amongst the right persons within your organization, Minkels has a management platform available. The software product is called Minkels Varicontrol DCIM. This is a fully integrated, brand-independent data centre management system, which uses sensors in the data centre environment to measure, analyse and manage all different aspects in order to achieve and maintain maximum efficiency. Not only regarding your PUE, but also incorporating power consumption, cooling, environment and access control.

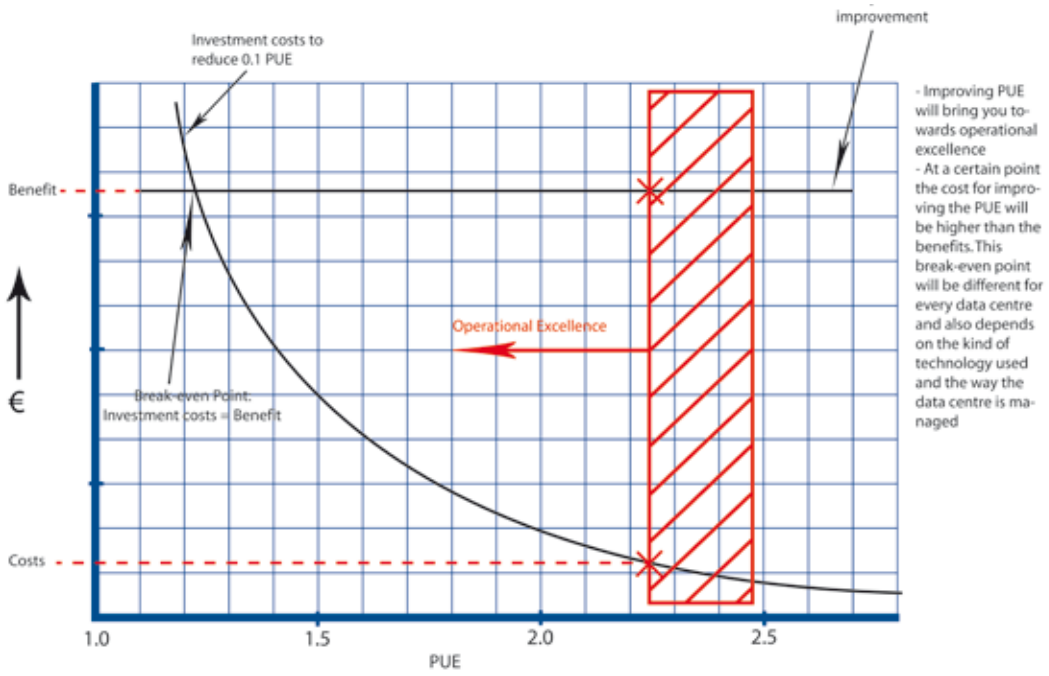
Minkels developed the data centre management system in cooperation with the University of Antwerp and leading customers. The monitoring system comprises all the Key Performance Indicators (KPIs) required to manage the entire infrastructure of a data centre environment cost-effectively and energy efficiently. The system accesses all the real-time data required from the various types of infrastructural equipment in a data centre, including PDUs, chillers, CRAC units, UPSs, coolers, cameras and fire detectors.

Thanks to the open source nature of the platform, it readily enables the integration of existing management software – such as an access control system, a Network Management System (NMS) and a building management system (BMS) – in Varicontrol DCIM.

7c. Deliverables on PUE investments

During the process of adjusting your data centre infrastructure and trying to lower your PUE figure, you will ultimately reach a point where the investments won't be fully offset by the financial benefits of a targetted PUE result. In other words, there is a break-even point within every achievement towards lowering your PUE figure. A break-even point differs from situation to situation. Basically, there are mainly three parameters with which you can determine your own personal break-even point.

Figure 6: PUE and ROI



These 3 parameters are:

- Level of PUE investment
- Benefits of lowering your energy cost
- Required payback time

The closer you get to the level of 'PUE=1.0', the more effort it will take to further improve your PUE results. The asymptotic effect means that you will eventually come to a break-even point where further investments in PUE improvement won't pay off anymore. Where the break-even point lays, is different for each and every situation. It also depends on the intended payback time. The longer this scheduled period is, the more investments you are able to make and the more chances you get to lower your PUE any further. Generally speaking, stretching the payback time a bit will pay off in terms of energy efficiency and energy cost reduction.

7d. Low hanging fruits

There are some quick wins you can make when it comes to lowering your PUE figure. These quick wins are relatively low on investment, potentially gaining high energy cost reduction. By making some quick wins it is possible to even lower your PUE from 2.0 to a figure of 1.6, with exact figure statements differing in each and every situation.

Monitoring first of all is a prerequisite to start lowering your PUE figure, otherwise you will never know where to start your quick win efforts and what results it will bring. After having a PUE monitoring system installed one can start picking the low hanging PUE fruits. Not every low hanging fruit will be applicable for every data centre in the market, but generally speaking the following actions could be taken to have some quick wins.

- **Installing Cold Corridors**

Complete separation of hot and cold airflows, achieved by enclosing the roof section between opposing data centre cabinets on the cold aisle with glass panels. Both ends of the cold aisle are sealed off using sliding doors to contain the air. Installing Cold Corridors together with other measures will lead to significant efficiency improvements.

- **Installing Free Cooling**

The use of Free Cooling is not applicable for every data centre environment. Especially within existing and full operational data centre environments installing Free Cooling would be a tough job to realize. For new data centre development however one should definitely have a look at this option. When Free Cooling is actually being installed it is very important to have the system tuned correctly. It happens quite often that Free Cooling is being installed but not tuned the way it should, with the result that the investment in Free Cooling doesn't pay off.

- **Reduce air leakage**

Cabinets within a Cold Corridor system can be easily equipped with blanking panels, so cooling air is not wasted at spots where no equipment is being installed yet. The use of blanking panels makes sure the only route for air flows is through the equipment. Another way to reduce leaks is by using air sealed racks.

- **Adjusting fan speed of cooling systems**

Especially when one is using Cold Corridors, the fan speed of cooling equipment can be set at lower levels than one is probably used to. That's because cool air is more equally and efficiently being divided within a Cold Corridor system. Fan power usage follows a 3th power curve with the airspeed. So reducing the fan speed by 25% will more than half the fan Power.

- **Allowing higher temperature set points will also lower your PUE figure**

Separation of hot and cold air avoids hotspots and therefor temperature set points can be higher without compromising the server inlet temperature.

Setting CRAC units at supply air temperature instead of return air temperature Before the introduction of hot and cold aisles data centre CRAC units were set at room temperature i.e. 22˚C. This is return (hot) air temperature. In a Cold Corridor DC the supply air temperature to the servers should be controlled, not the return air temperature. Get in contact with the CRAC unit manufacturer or Installer to check whether this is possible.

7e. Low hanging fruits – The next step

There are some other quick wins you can make, but these efforts will probably cost you a bit more energy and they'll ask for some intensive data centre engineering knowledge and experience. The following actions can probably help you taking the next step in picking some low hanging fruits in PUE improvement.

- Improve load efficiency of UPS
- Improve power factor of UPS
- Use clean air filters

7f. Conclusions

To conclude this whitepaper, I would like to stress that measuring your PUE, analyzing PUE data and using it for efficiency corrections in your data centre environment is always a continuous process that should be integrally embedded into your organization. Only continuous efforts in PUE measurement and efficiency corrections will help you optimise the use of your data centre resources, thus leading you towards a situation of Operational Excellence.

As a prominent contributor to drafting the EU Code of Conduct for Data Centres - for the European Commission's Joint Research Centre (EU-JRC) in 2008, Minkels hopes this whitepaper about the professional use of PUE as a management tool will foster a further professionalization of the data centre market. I also hope it will inspire your organization to take it to the next step and use PUE as a management tool for creating and maintaining data centre efficiency. The engineers of Minkels are always willing to assist you on this and give advice regarding PUE, efficiency improvements and server room solutions for specific situations.

ABOUT DATA CENTRE SUPPLIER MINKELS

Minkels B.V. (www.minkels.com) is a European manufacturer of total solutions for data centre infrastructure, whose headquarters, R&D department and assembly lines are in the Netherlands (Veghel). The firm also has branch offices in the UK, Switzerland, Belgium and France. Minkels' product portfolio is subdivided into cooling (Varicondition®), housing (Varicon®), and monitoring (Varicontrol®) solutions. The following are significant products in the Minkels portfolio: Data centre water-cooling solutions (Varicondition H2O); hybrid cooling solutions, using both air and water; and Cold Corridor systems, which are used to segregate hot and cold air flows in the data centre.

As a data centre supplier, Minkels has a client base which comprises prominent organisations, including Swisscom (Switzerland), Radboud University Nijmegen and EvoSwitch data centre (the Netherlands), as well as De Persgroep media firm (Belgium). In view of the considerable knowledge and experience Minkels has acquired throughout the years in the field of data centre infrastructure solutions.

Minkels is a subsidiary of the Aegide Group (www.aegide-group.com), a major European player in the field of integrated development, manufacturing and marketing of high-quality housing solutions for the ICT and high tech OEM industries. Minkels also won the 'Brabantse Economieprijs 2010' last year. This prize, which is awarded once every three years, was set up by the Dutch Province of Noord-Brabant with the intention of applauding the efforts of successful companies who dare to invest in innovation and innovative products, thereby providing dynamism and economic growth.

For more information on Minkels or some further help with the PUE metric in your specific business situation, please visit www.minkels.com, or contact one of our offices.

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