DataCenter 2020
von T-Systems and Intel
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The test lab with approx. 70 sqm is equipped with 180 server in racks and as well as the latest energy, climate, measurement and control technology. Approx. 50 sensors measures data like humidity, room temperature, temperature difference supply and return temperature, processor load or fan speed. The most important tool is the electric meter – which should run as slow as possible. In the raised floor of the test lab is in addition a smoke generator, which visualizes the air flow. The produced fog makes the flow direction and the speed of the air visible; at the same time the engineers can identify so called flow short circuits, i.e. find leakages and areas, where air shouldn't steam out.

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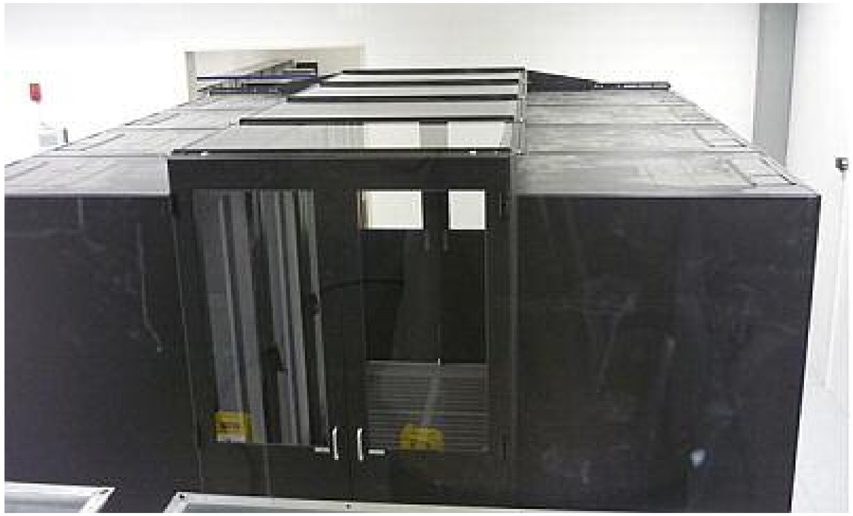

The whole construction has one primary ambition: to figure out which solution in what terms will bring the optimum energy efficiency in a data center. In the process the engineers views the complete process chain from the power generation to the energy consumption. Besides an improved air conditioning the use of energy-saving IT components is focused, for example with the server and processor technology.

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DataCenter 2020

First results for energy-optimization at existing data centers

Introduction

Environmentally friendly and sustainable IT is a hot topic given the current climate change and ecological challenges. The objective is to use energy resources more efficiently while also reducing CO_2 emissions. Much focus lies on achieving maximum energy efficiency – that is, to optimize the amount of energy used by each unit of output.

The most important tool for combating power consumption and improving the climate footprint of the data centers is higher energy efficiency. This poses the question: How can the existing infrastructure (cooling, power, space etc.) use new technology with maximum efficiency – that is, how can the best possible ratio of power consumption to required performance be achieved?

The two technology partners Intel and T-Systems are working together on solutions for the industrialization and automation of ICT services. Their aim is to make these market-ready with maximum efficiency and cost effectiveness. The nucleus of this collaboration for energy efficiency is a test laboratory at the Euroindustriepark in Munich.

DataCenter 2020: The test lab at Munich’s Euroindustriepark

The test lab is equipped with around 180 rack servers, as well as the latest in energy, air-conditioning, measuring and control technology. Approximately 1800 data points record parameters such as humidity, room temperature, temperature difference between the incoming and outgoing air, processor load, and fan speeds. The most important instrument is the electricity meter. To simulate data centers with different ceiling heights, the test lab employs a lift slab with a variable height of between 2.5 and 3.7 meters.

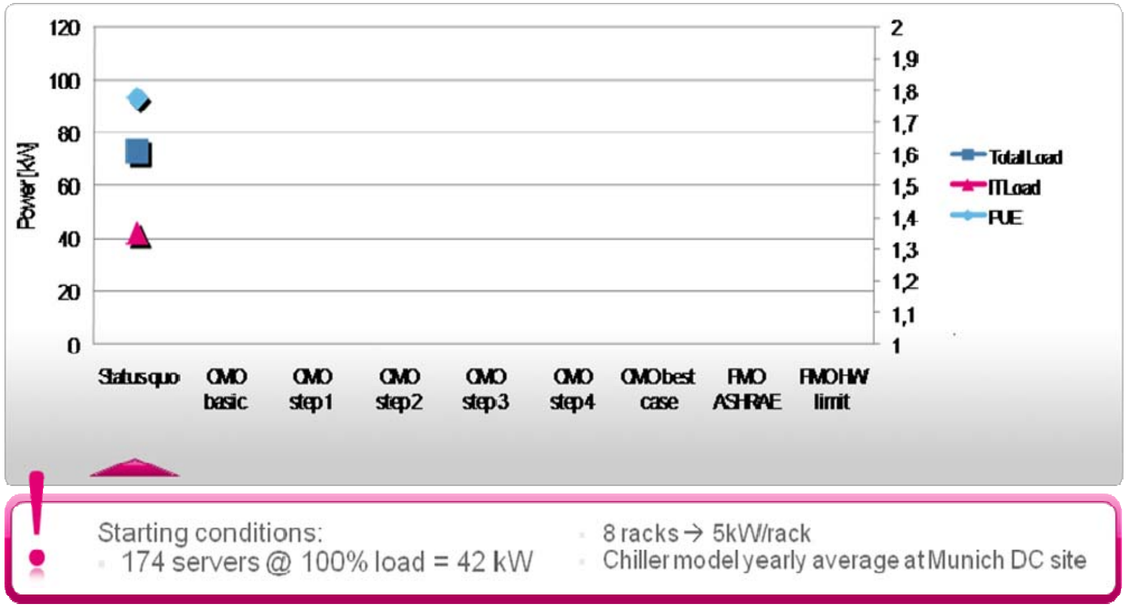
At the data center, airflow plays a vital part in climate control. The engineers carry out various tests and examine both the cold aisle containment and warm aisle containment.

PUE value as a measurement for energy efficiency

To measure energy efficiency at DataCenter 2020, T-Systems and Intel use the Power Usage Effectiveness (PUE) industry standard defined by the Green Grid organization – that is, the efficiency of energy consumption. This value measures how much consumed energy is actually converted to processing power. PUE is the ratio of total facility power consumption to IT equipment power consumption. At present, the average PUE value at existing data centers is 1.9.

Starting point: Today's standard data center

In conventionally designed data centers, the server cooling system eats up around half of all the energy needed. At DataCenter 2020, the researchers from Intel and T-Systems produced their first measurements by simulating the conditions at current up-and-running data centers with all their inefficiencies. The PUE value resulting from this environment was approximately 1.8. The following conditions were defined for the measurements.



1. Leakage in the raised floor, racks and cable feedthroughs causes thermal short circuits.

2. The speed of the forced air cooling devices is set to the maximum (100 percent) to ensure that, despite leakages in the raised floor, enough air reaches the servers in the cold aisle.

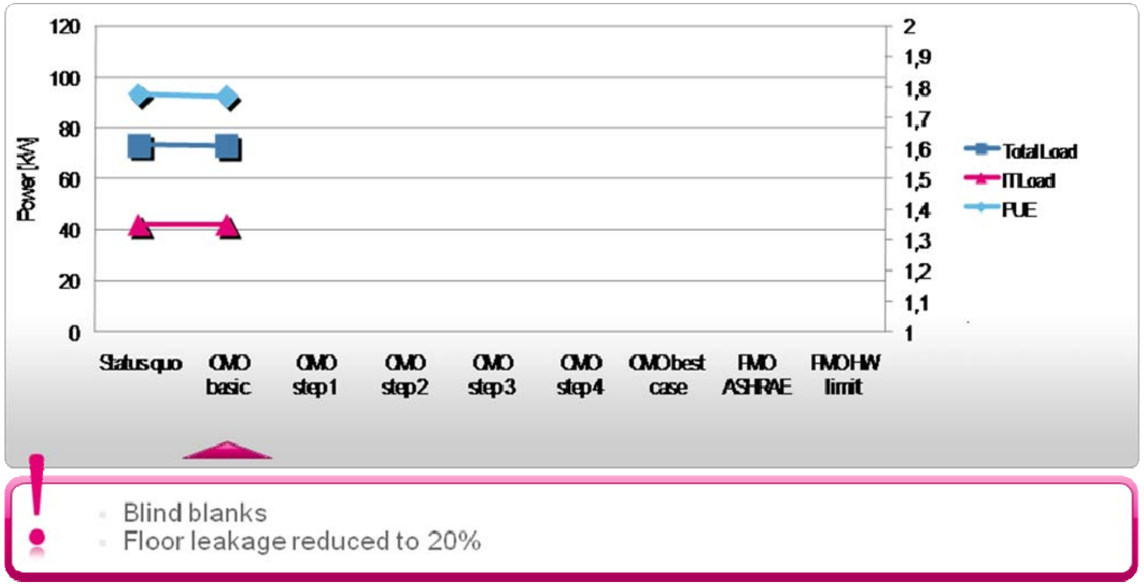
3. The IT load is limited to approx. 5 kW/rack (8 racks with a total of 174 servers are in use) or 2 kW/m².

4. The inlet temperature in the raised floor is set to 18°C. This results in a server intake temperature of around 22°C.

5. Since PUE represents an annual mean value, the experts at DataCenter 2020 developed a mathematical yearly model for the water chiller so as to eliminate non-representative snapshot readings. They also incorporated the average temperatures for the Munich area into the model. As a result, the temperature gradation can be used to forecast the potential for using indirect free cooling in the annual mean.

Optimization phase I: Separating cold and warm air

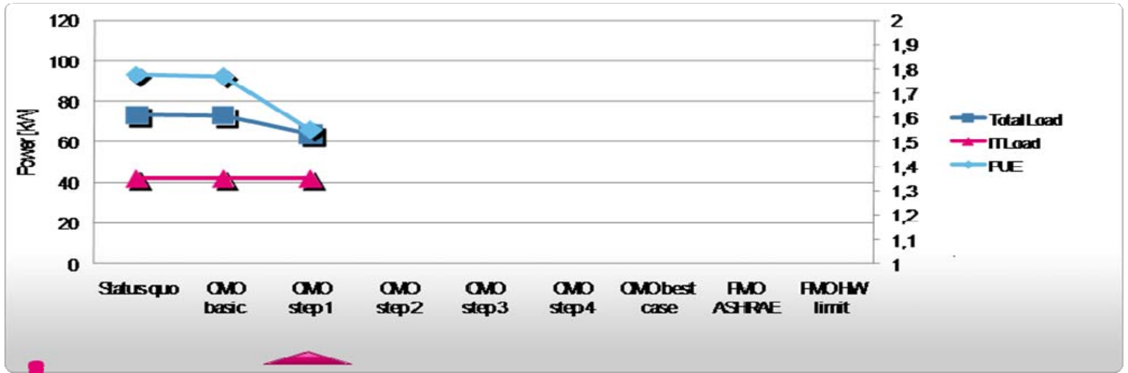
1. Sealing of leakages



The first step taken by the experts was to block air from escaping unnecessarily. They eliminated leakage air by sealing the raised floor (for example, where power cables were fed through) and by inserting dummy panels in the racks (between the rack units that house the servers).

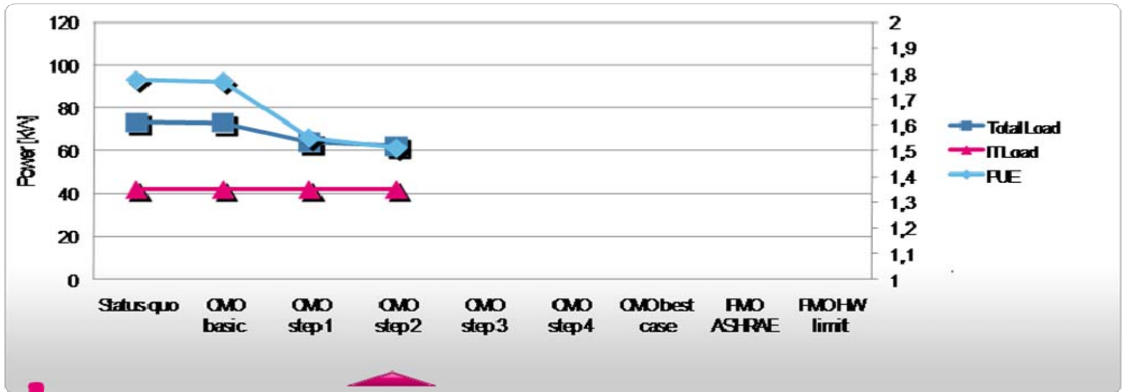
Sealing the leakages had no impact on the PUE, however, since all devices were still running in the same way. Indeed, the fact that air could no longer unnecessarily escape led to a considerable rise in air pressure within the raised floor. This forms the precondition for the next step.

2. Adjustment of fan speed in the forced air cooling device



! CRAC fan speed optimization (to be repeated in any of the following steps)

The experts at DataCenter 2020 were now able to reduce pressure in the raised floor to the minimum required, thereby ensuring that the intake temperature remained sufficient throughout the rack height. They achieved this by lowering the fan speed in the forced air cooling device. Since the fan was now rotating much more slowly and therefore using less energy, the PUE value decreased from 1.8 to 1.55.

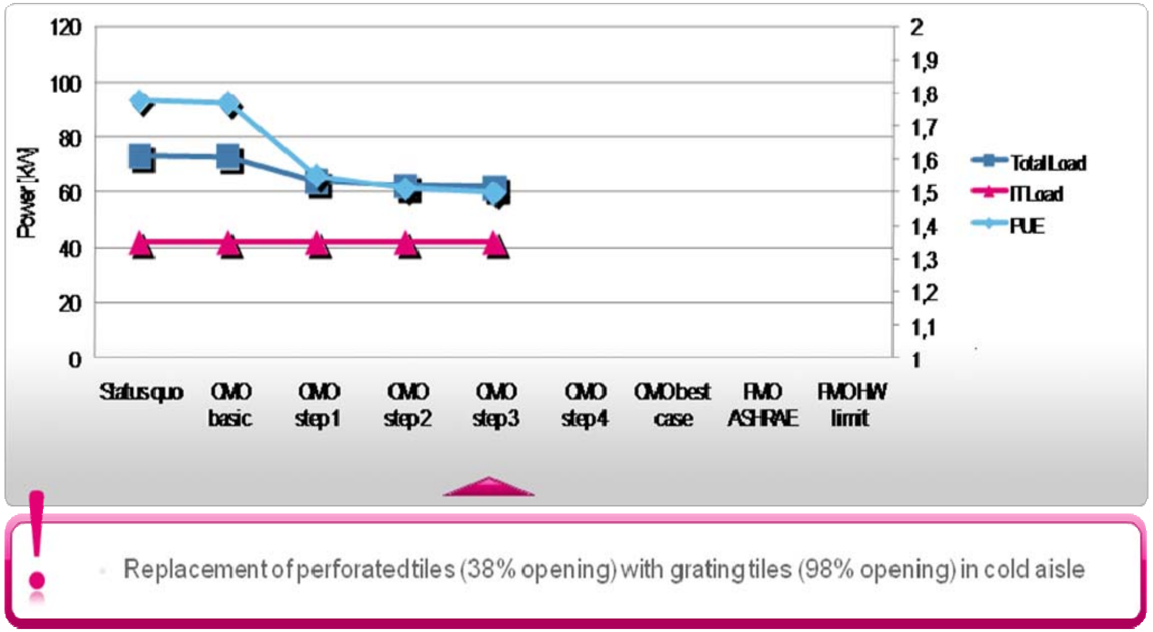


! Doors installed at end of the aisle (without ceiling)

Given that energy saving effects could only be achieved in this phase (separating the airflows) by adjusting the fan speed, this optimization step is repeated in all subsequent steps, even without specific reference.

3. Gradual improvement of the cold and warm air isolation

The strict separation of cold and warm air was applied in this step to future-proof against thermal short circuits. Doors were fitted at the ends of the aisles, preventing cold and warm air from mixing through the rack sides at the beginning and end of an aisle.

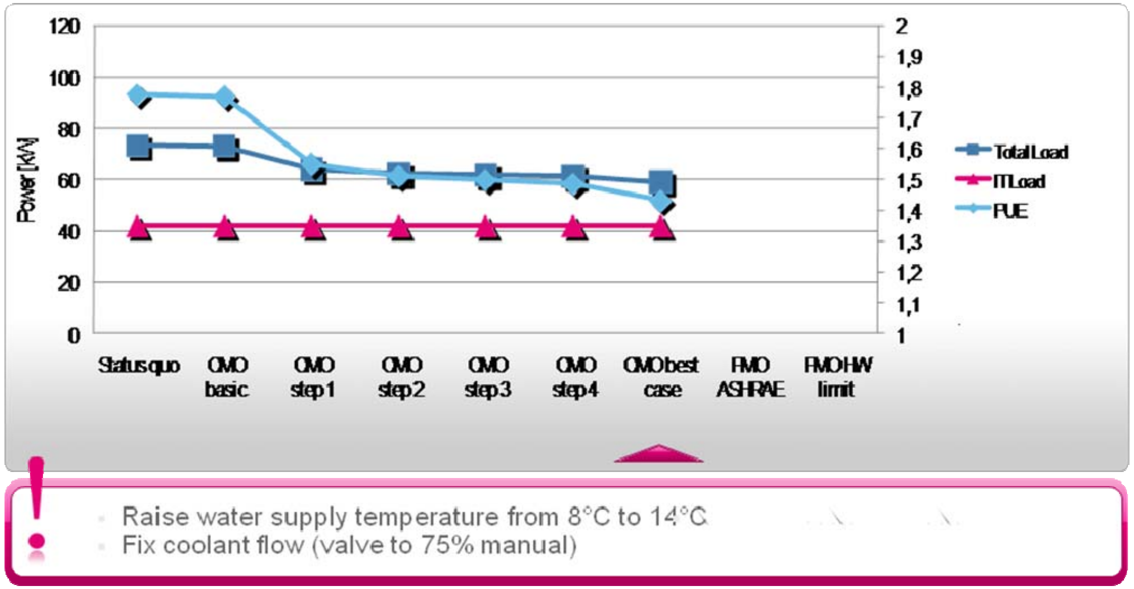


In addition, replacing the usual perforated tiles in the cold aisle with grating tiles achieved a reduction in aerodynamic resistance, since air flows through the larger openings with more ease. This allowed for a greater decrease in the fan speed of the forced air cooling device. Lastly, the cold air ceiling was closed to prevent the cold and warm air from mixing across the upper side of the rack. Following the third step of the first optimization phase, the PUE value sank once more, from 1.55 to 1.48.

Optimization phase II: Increasing the inlet temperature

The second optimization phase focused on increasing the inlet temperature. In principle: The ideal temperature range for humans is around 22°C, but the same does not apply for servers. However, many data centers fail to use energy efficiently because they are actually too cold. Today, many servers can tolerate ambient temperatures of 30 to 35 degrees Celsius, while the air intake temperature in most data centers is between 20 and 25 degrees Celsius. If the intake air does not need to be cooled as much, the air-conditioning system will use less energy.

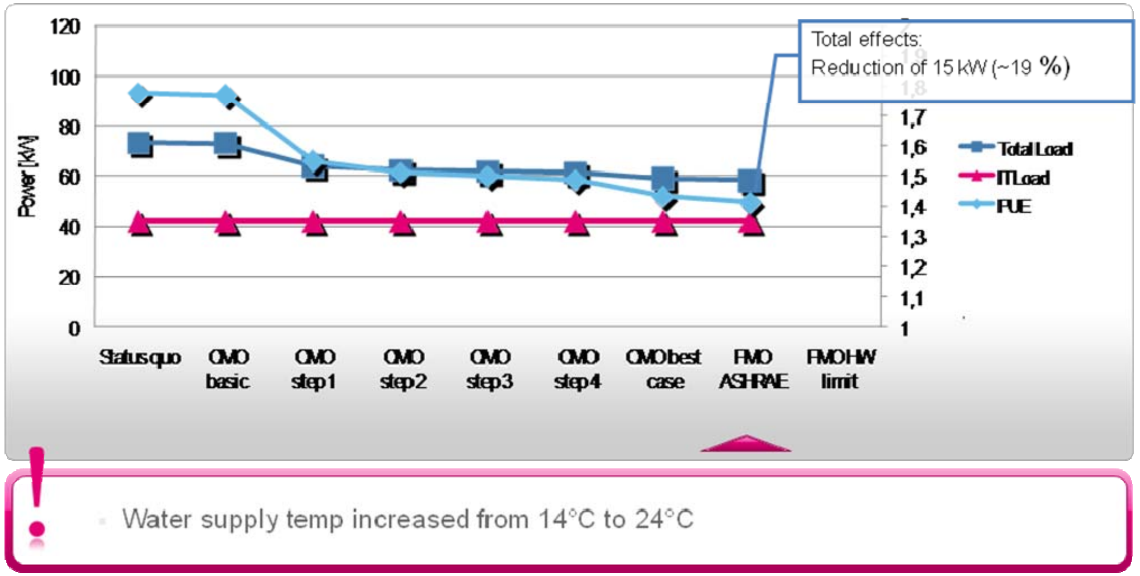
4. Reaching the limits of the existing cooling infrastructure



With standard chillers, the water supply temperature is limited to 14°C. However, an increase in this limit would see a drop in the need for forced cooling, and indirect free cooling would feature in the annual mean for longer. In a best case attempt, the experts at DataCenter 2020 introduced an air cooling device with an EC motor featuring a direct-current ventilator and raised the flow temperature to 14°C. EC motors require around 30 percent less power than conventional AC motors. This setup allowed the experts at DataCenter 2020 to again reduce the PUE value, from 1.48 to 1.43.

5. Increasing the inlet temperature in line with current ASHRAE recommendations

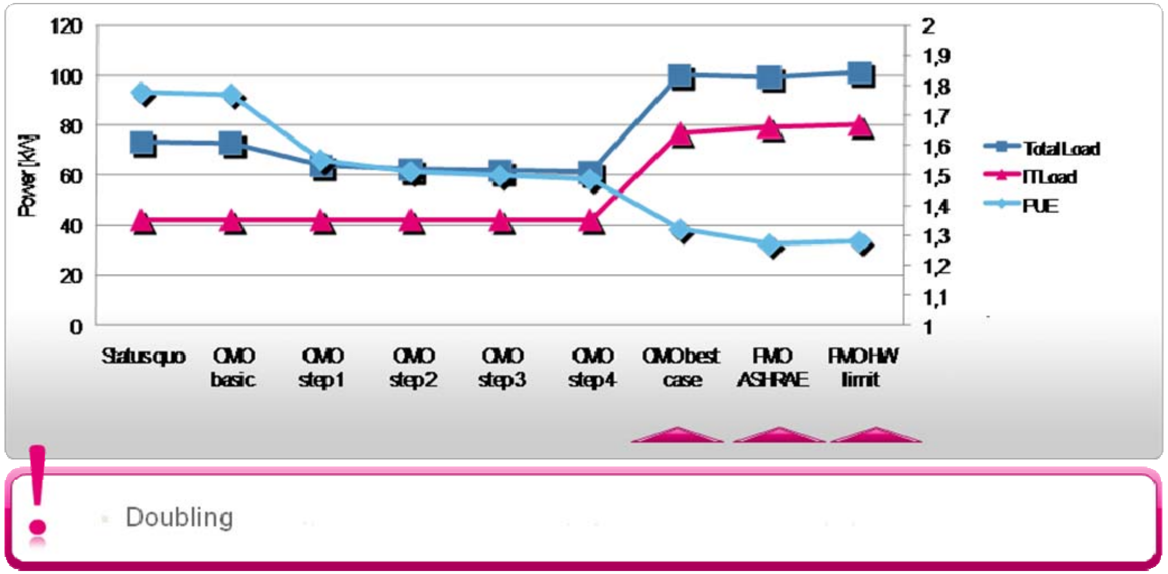
The next step taken by the DataCenter 2020 team was to raise the water supply temperature to 24°C as per the recommendations of ASHRAE (www.ashrae.org), corresponding to a server intake temperature of 27°C. The PUE value thus dropped to an optimal 1.4.



The researchers then raised the inlet temperature to 35°C. However, this made the server fans run faster, using more energy, and thus in this experiment the PUE value increased again slightly to 1.43.

6. Increasing the IT load to 10 kW/Rack or 4 kW/m²

In the last test, the experts at DataCenter 2020 doubled the IT load from around 5 kW/Rack or 2 kW/m^2 (= initial load) to around 10 kW/Rack or 4 kW/m². Since this doubles the IT Equipment Power from 40 kW to 80 kW, the Total Facility Power increases too. This experimental procedure achieved another improvement in efficiency and a PUE value of 1.3.



Summary

Energy consumption at data centers can be reduced using some fairly simple methods. The following two measures increase energy efficiency and decrease the PUE value at existing data centers:

1. The strict separation of cold and warm air and the resulting optimization of airflow, which allows for a reduction in the fan speed of the forced air cooling device. This result forms the basis for all further steps and must be implemented with comparatively cost-efficient measures.

2. Increasing the room temperature or inlet temperature. This measure shortens the time for forced cooling and lengthens the time for indirect free cooling. The experts achieved the best result at a server intake temperature of 27°C in accordance with ASHRAE's recommendations. This necessitates a detailed inspection of the existing infrastructure and buildings, so that they can be used as effectively as possible in line with design options. Location, power supply and customer focus are important criteria too for completing a holistic assessment of existing data centers.