Reorganizing computer rooms and data centers in an energy efficient way

may 2014

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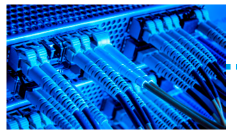
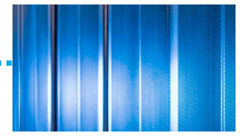
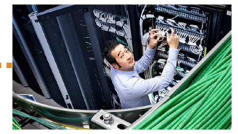


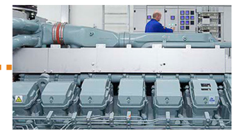












Preface

The aim of Green Deals is to contribute to a more sustainable society. To attain optimal creativity, entrepreneurship and innovation, public-private partnerships have been chosen to this end. With this in mind, the government, the City of Amsterdam, and the companies in the Consortium Green-IT of the Amsterdam Region have cooperated and succeeded in overcoming certain barriers, exploiting sustainable opportunities, and accelerating innovation development and adoption.

The Green Deal: ICT/data centers are made to comply with the Energy Strategy 2040 of the City of Amsterdam: a CO2 reduction of 40% in 2025 compared to the level of 1990. Recognizing the value of a fast-growing data center capacity in Amsterdam for ICT, financial and scientific sectors in the Netherlands, the aim is to preserve the “level playing field” for establishment conditions of data centers in the Netherlands. Finally, the high market efforts of this sector of industry contribute to the creation of a real Green Data Port in the Amsterdam region.

Part of this Green Deal are the efforts of the municipality of Amsterdam to attain a national performance standard for existing data centers based on the best achievable performance for existing data centers, and based on best available techniques for new data centers.

Green IT Amsterdam aims to scale up these technologies and innovations. This study offers assistance that will be useful for 80% of the data centers in the Netherlands.

For data centers that want to go to the implementation phase, we suggest to give a look to the Green IT Energy Solutions website, that is being created as a result of the lessons learned from this Green Deal!

JOHN POST *is director of the Amsterdam Region Green IT Consortium. Among other things, he is a board member of TKI SWITCH2SmartGrids and chairman of the Netherlands ECP Open Data Platform. Post has in-depth knowledge of information technology and a lot of experience in this field (since 1970). He has always had a special interest in the social aspects related to the interaction between technology and people. Natural leadership and team spirit are much more important to him than directive action.*

Worldview

**The global rise of the use of ICT products and services is accompanied by a growing demand for data centers. Data centers use a lot of energy. In 2010 they were responsible for about 1.5 percent of the total electricity consumption. Ten years ago this was only 0.5 percent.
By the continual digitizing of Western society and emerging economies such as China and Brazil, this percentage could reach as much as 10 percent in 2020.**

IMPACT

As fossil fuels become scarcer, energy prices rise. There is also an increasing interest in the impact of fuels on our environment, such as global warming. Moreover, our energy infrastructure cannot handle the ever-increasing demand for energy.
If we do nothing, energy prices will rise explosively, reliability will decrease and dependency will increase. Saving energy and going green are important steps to counter these effects.

PRIMARY ENERGY
Is energy as it is found in the original energy source, such as coal, oil, natural gas and uranium.

The current situation within the energy sector has a direct impact on the affordability and reliability of ICT services. The ICT sector is aware that the energy supply and the availability of materials will look different in a few decades.

CONTRIBUTION

The ICT sector itself is able to provide an important contribution to reliable and affordable energy supply in the future. This is stated in the Roadmap ICT 2030 ("Routekaart ICT"), prepared by the ICT sector as part of the multi-year agreements (MJA3). This is possible if the ICT services are used for greening other sectors (greening by ICT) and if they deal in a more efficient and green way with energy themselves (greening of ICT). The challenge will be to improve the energy efficiency of existing datacenters.

Amsterdam is an important region for the ICT sector in the Netherlands and Europe. One of the reasons being that Amsterdam has one of the largest Internet nodes in the world (AMS-IX).

'If we do nothing, energy prices will rise explosively, reliability will decrease and dependency will increase.'

This is why, around 2000, many data centers were built in the Amsterdam region and the number continues to grow.
At that time it was important to ICT companies to make their data center quickly operational so as to have the competitive advantage. Energy still played a minor role.

Introduction

Amsterdam is important for the ICT sector in the Netherlands and Europe. The city has one of the largest Internet nodes in the world (AMS - IX). Around the year 2000, many data centers were built in the region. In order to stay ahead of the competition it was of great importance for ICT companies to make their new data center quickly operational. Energy played a subordinate role. The number of ICT companies in the Amsterdam region is still growing.

'We did have room for the ICT equipment we wanted to install, but the energy supply was not sufficient. We therefore needed to install a new cooling system.'
Willem Oepkes, Delta Lloyd

DEVELOPMENTS

Developments are fast. For example, ICT equipment has become much more compact, which makes it possible to provide more services or to accommodate more customers per square meter of floor area.
By increasing the number of servers per floor, (older) data centers encounter the following problem: it is impossible to deliver sufficient electricity and/or cooling. In addition, many of these data centers are faced with installations that are near the end of their lifecycle, such as cooling systems and emergency power supplies. To maintain the reliability of their services, improve their competitiveness and respond to the ever-growing market of ICT services, many existing data centers need to be upgraded.

'A complete renovation process is required to achieve reliability, competitive position and growth'

DIGITIZATION

Since 2000, many offices have their own server rooms, initially for the internal network, but now, because of digitization of documents and e-mail also for data storage and services. Digitization in the industry is steadily increasing. Some companies now work completely without paper. With developments in relation to the "New Way of Working" and the so-called virtualized desktop computers, the demand for server capacity in offices has grown significantly. Many server rooms in companies are not designed for these developments. Here also, renovation is necessary in order to continue to provide reliable services.

WHY THIS PUBLICATION?

Renovation is a natural moment to examine if the energy consumption of a data center or server room can be reduced. Energy saving leads to a greener image and this is something that customers find important. It also gives rise to a lower energy bill and thus to a better competitive position. For data centers that run up against the limits of energy supply so that any plans of expansion are hampered, energy saving is also a solution, since leeway is created for the extension of ICT services.

GREEN DEAL

The Consortium Green IT Amsterdam Region aims to contribute to a stronger ICT sector in the Amsterdam region. It has taken the initiative for a Green Deal with the Dutch government: Green Data Ports. One of the objectives is to identify and make available proven scalable and affordable solutions to make (older) data centers sustainable. The emphasis is on sharing knowledge and experience of existing data centers and server rooms that have already achieved sustainability.

WHO IS THE TARGET AUDIENCE?

This publication is primarily intended for administrators and managers of data centers and server rooms. It is a source of inspiration and motivation to combine the renovation of data center and server rooms with the improvement of their energy efficiency.
The content is also interesting for stakeholders who deal with data centers and server rooms, such as suppliers of ICT and implementation services, policy makers and enforcers. Reading this

PROCESSORS AND ELECTRICITY

Of all primary energy a data center needs, only about 0.5 percent ends up in the processors of ICT equipment. The rest of the energy disappears in the entire chain by, among other things, conversion losses, transmission losses and facilities like cooling and power supply.
Source: British Computer Society

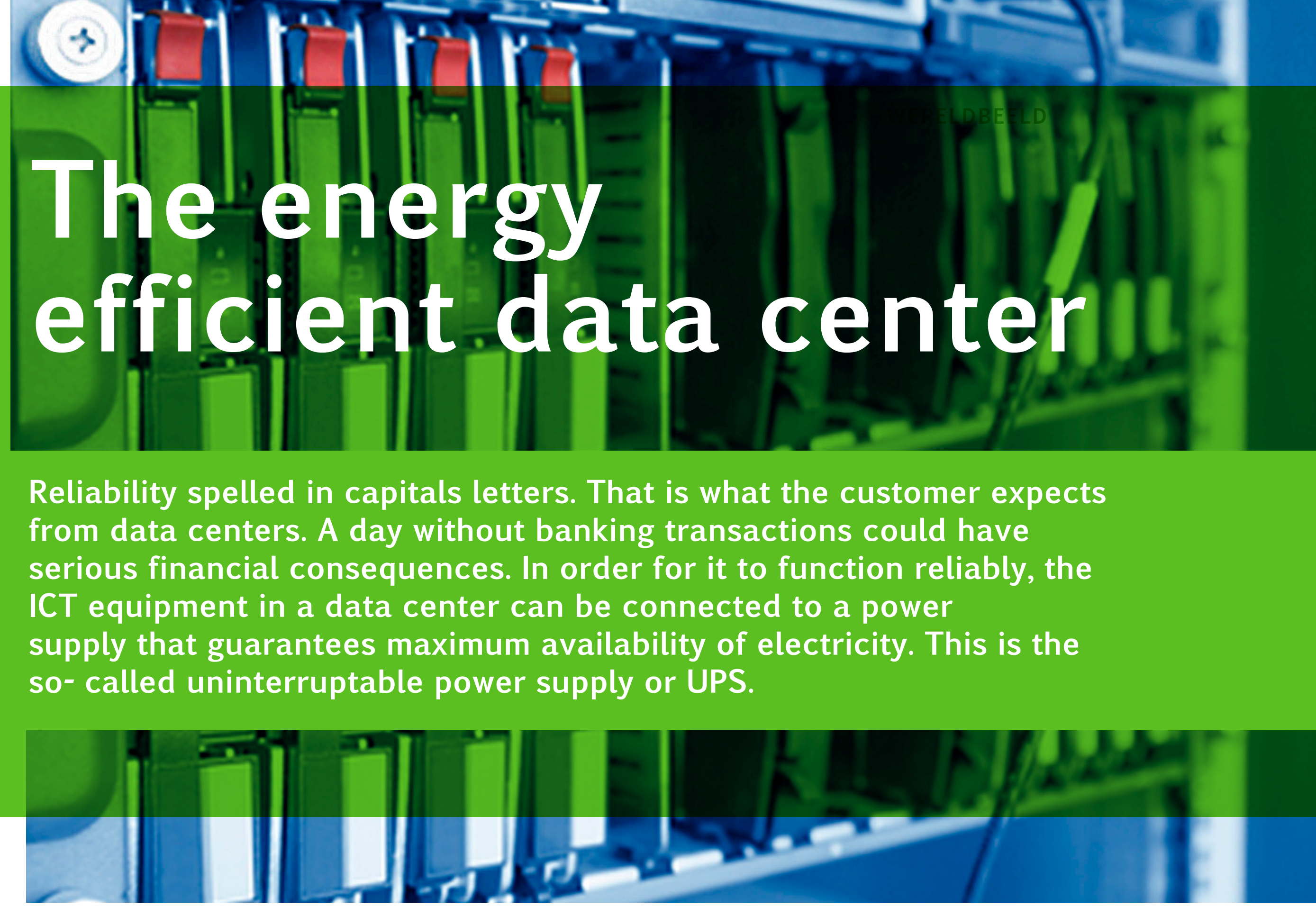
publication will give them a good idea of the possibilities for the sustainability of data centers and server rooms. They can also get ideas on how to make their own contribution.

OVERVIEW

The first part of this publication is about the reasons why energy-efficient renovations are necessary, along with strategies to implement them successfully.

In the second part, four major companies share their practical experience on the subject of sustainable data centers and computer rooms.

In the third and final part several energy saving measures are technically explained. Also, four fictitious business cases are presented, based on practical experience. Focus lies on energy cost reduction, investment costs and experience of data centers and suppliers. The underpinnings and calculations of the business cases can be obtained from the following link: http://www.greenitamsterdam.nl/green-deal-datacenter-business-cases



The energy efficient data center

Reliability spelled in capitals letters. That is what the customer expects from data centers. A day without banking transactions could have serious financial consequences. In order for it to function reliably, the ICT equipment in a data center can be connected to a power supply that guarantees maximum availability of electricity. This is the so- called uninterruptable power supply or UPS.

In addition, the servers are cooled to prevent overheating. Both the power and cooling equipment need a lot of energy. Things like the lighting or monitoring system also need energy.

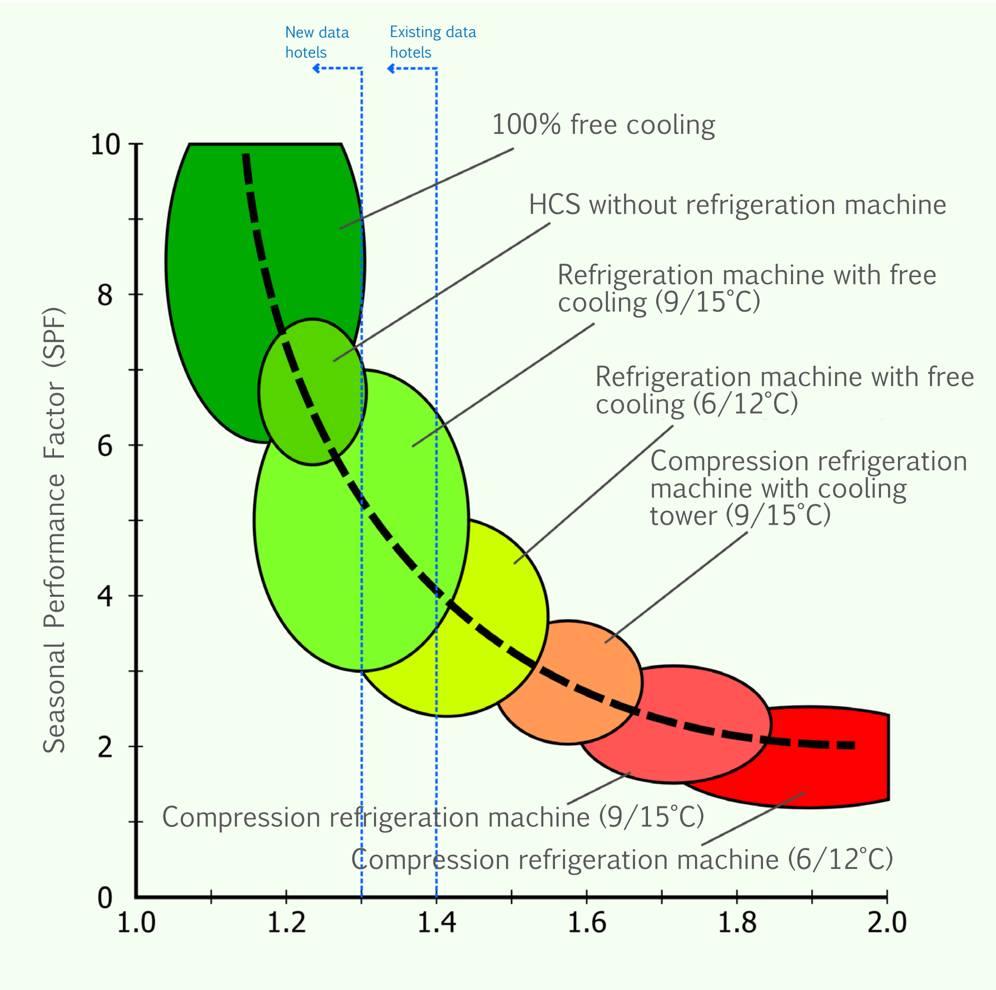
ENERGY USAGE EFFECTIVENESS

One of the most well-known indicators used to express the energy efficiency of a data center is the EUE. The EUE stands for ‘Energy Usage Effectiveness’ and indicates the ratio of the energy used by the ICT equipment itself compared to the total amount of energy that goes into the data center (or computer room):

For example, at an EUE of 1.5, for every 100 units of energy that are used by ICT, another 50 units will be used by the other facilities. The higher the EUE, the more energy the support facilities will need.

‘At KPN Datacenters the PUE (Power Usage Effectiveness) is measured in compliance with Green Grid L3/M and is validated by KEMA.’
Jan Huntelaar, KPN

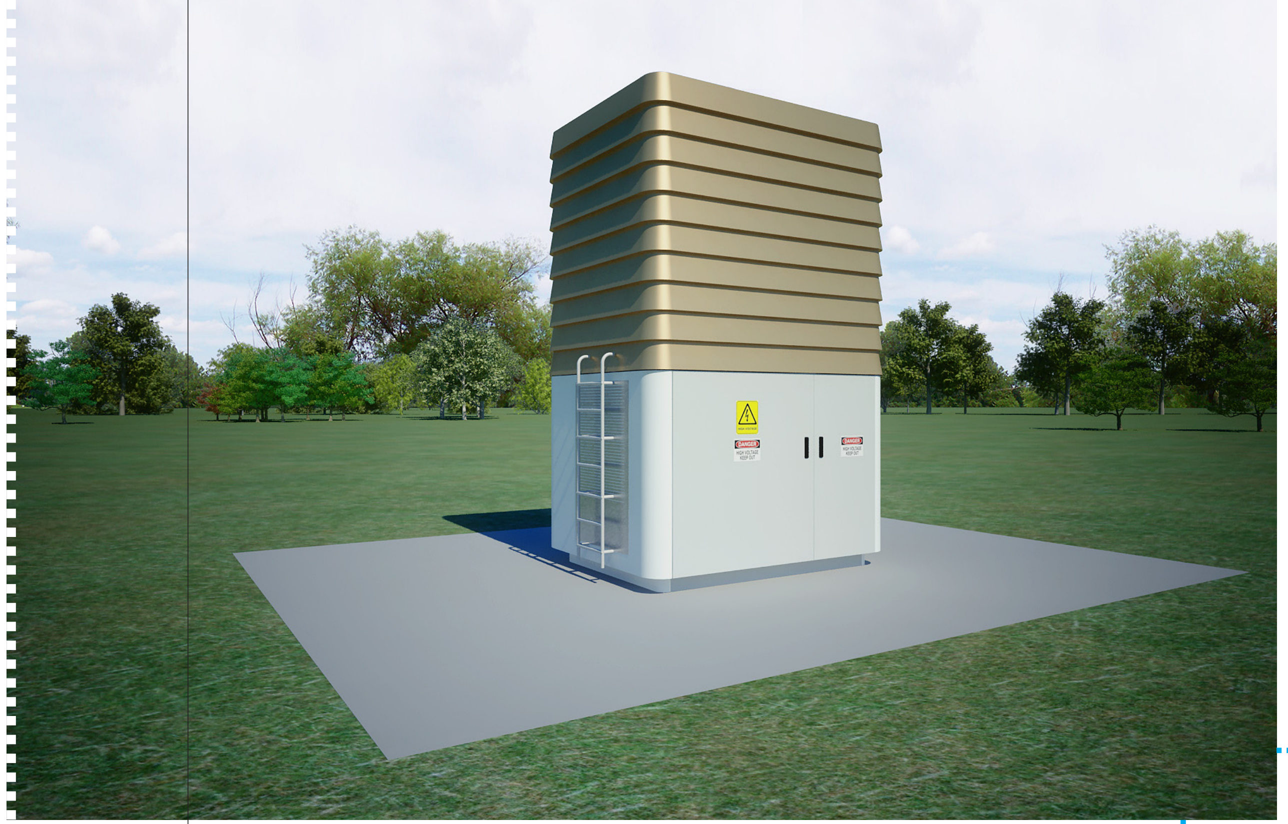
In an ideal energy efficient data center the EUE is 1.0. The energy consumption of the data center is completely attributable to the ICT equipment. Supporting facilities are not available or do not use energy. Of course this is an ideal situation, which, for the time being, is not yet feasible in practice. A number of data centers have already reported how close they can get to this ideal situation. Google, for example, achieved an average EUE of 1.12 in 2012. In general, energy-efficient data centers have a EUE lower than 1.4, while the average in the Netherlands at the moment is about 1.8.

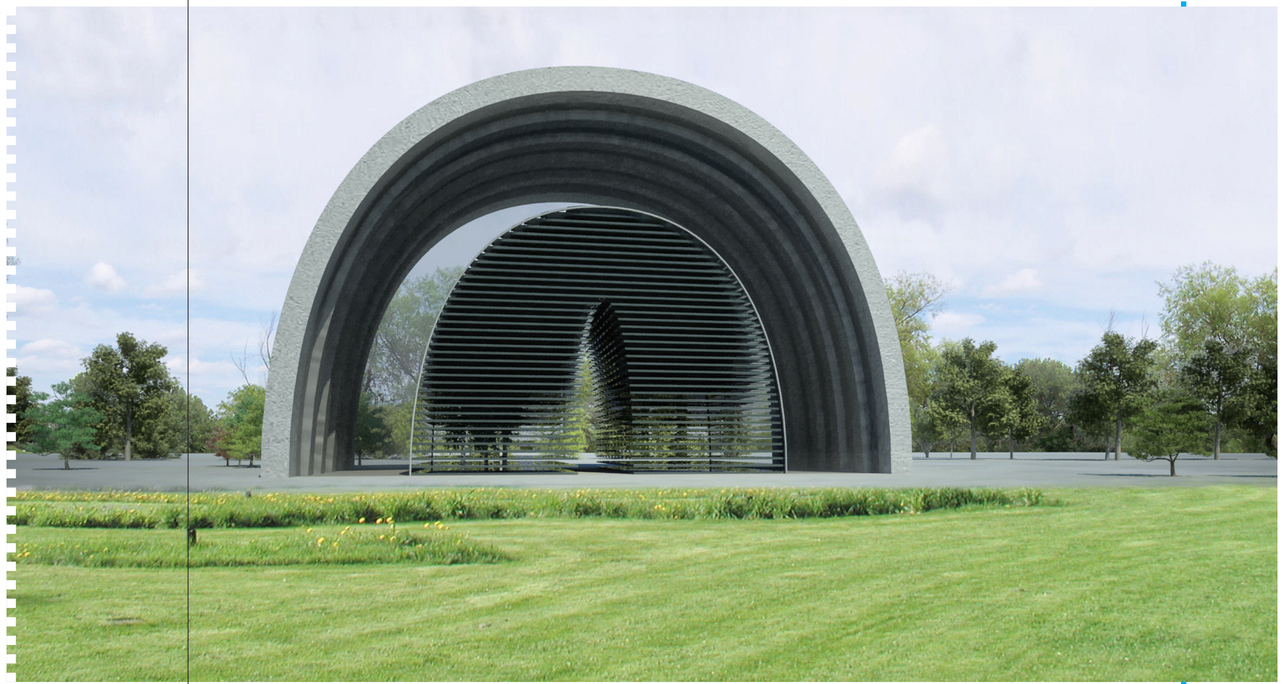


RELATIONSHIP BETWEEN COOLING AND EUE

The fact that the cooling system has a significant influence on the energy efficiency of a data center will be clear. This figure shows us the seasonal performance factor (SPF) of several types of cooling systems and how they affect the EUE.

Source: ECN





ENERGY SELF SUFFICIENT DATA CENTER CONCEPT

What is distinctive of this concept is that the data are processed and stored in a network of loose nodes: a swarm of data centers that function as one system. All nodes are optimized as a function of the type of data, compliant with the HotCold-FrozenData ® methodology of MDES, the available locally generated CO2-free energy and the capability to recycle the energy. Shown here are a Hot Data Node, a Cold Data Node and a Frozen Data Node. In the latter, rarely used data are concentrated on highly energy-efficient equipment.

Source: http://www.ozzodata.com

PHOTOGRAPHS:
RAU ARCHITECTS ©

Beyond the EUE

Although the EUE is a useful indicator to gain a quick insight into the efficiency within the data center, it also has its limits. The biggest missing factor being the ICT equipment itself. In recent years, computer hardware has become faster and more efficient.

Because of the wide variety of servers and their various components (processor, memory, storage), it is difficult to devise an indicator to express the efficiency of a server. An organization doing research in this area is the SPEC (Standard Performance Evaluation Corporation), with their Server Efficiency Rating Tool (SERT).

BETTER

A distinctive characteristic of all servers is that the energy usage is not linear with the size of the ICT workload processed by a server. Idle servers are liable to use 50 to 75 percent of the energy consumption at full load. From an energy perspective, it is therefore better to load one server at 100 percent rather than two servers at 50 percent.

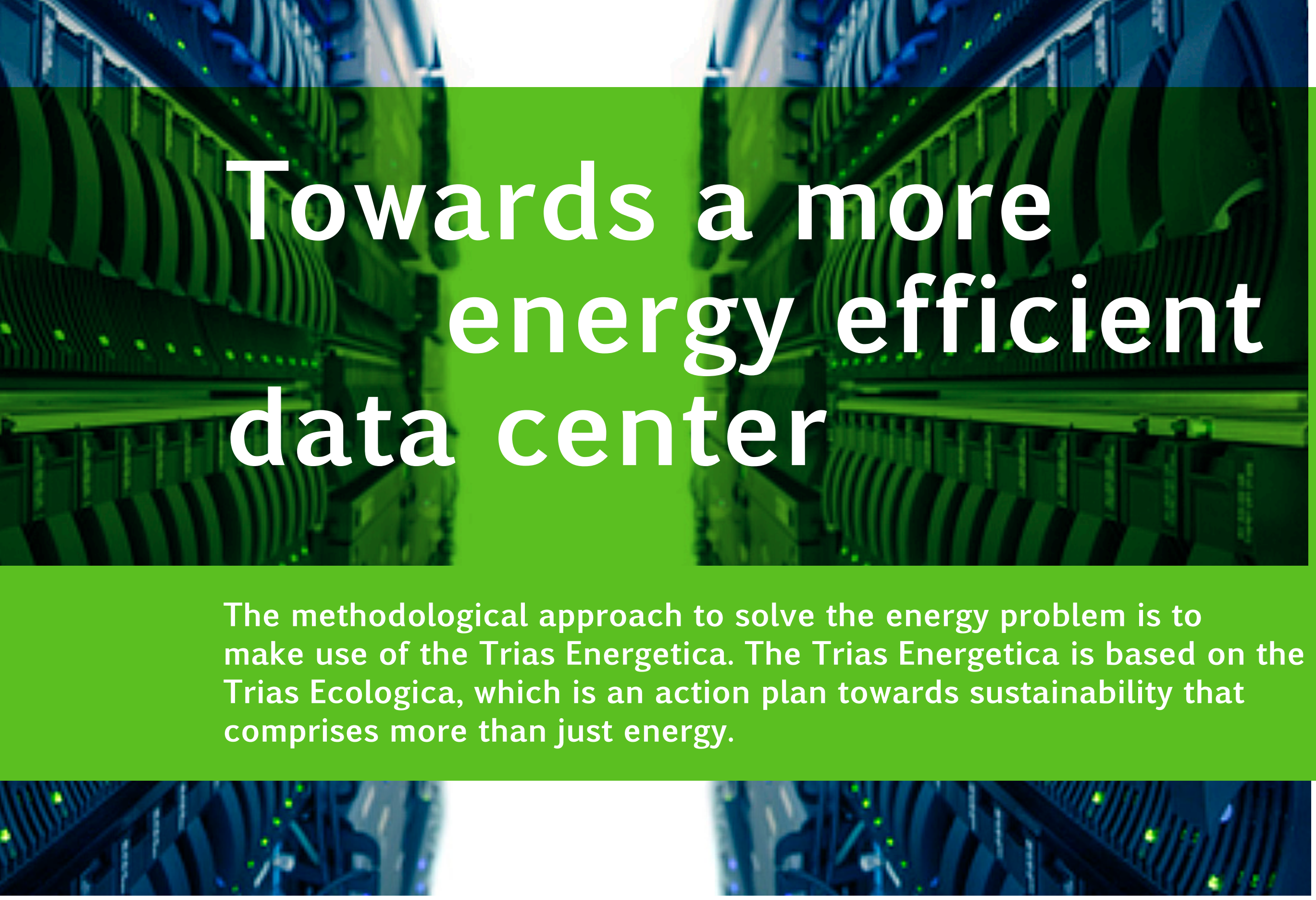
There are also environment-related measures that affect the energy efficiency of a data center and its surroundings but that do not affect the EUE. For instance, using waste heat from a data center in order to heat an office, but also generating one's own (sustainable) energy, i.e. by installing solar panels.

OPTIMAL ENERGY EFFICIENCY

An energy efficient data center is characterized by:

- **an energy usage efficiency (EUE) of 1.0**
- **100% load of the ICT hardware**
- **100% recycling of exhaust heat from the data center**
- **100% own renewable energy**

The closer a data center gets to this ideal situation, the better the energy management.

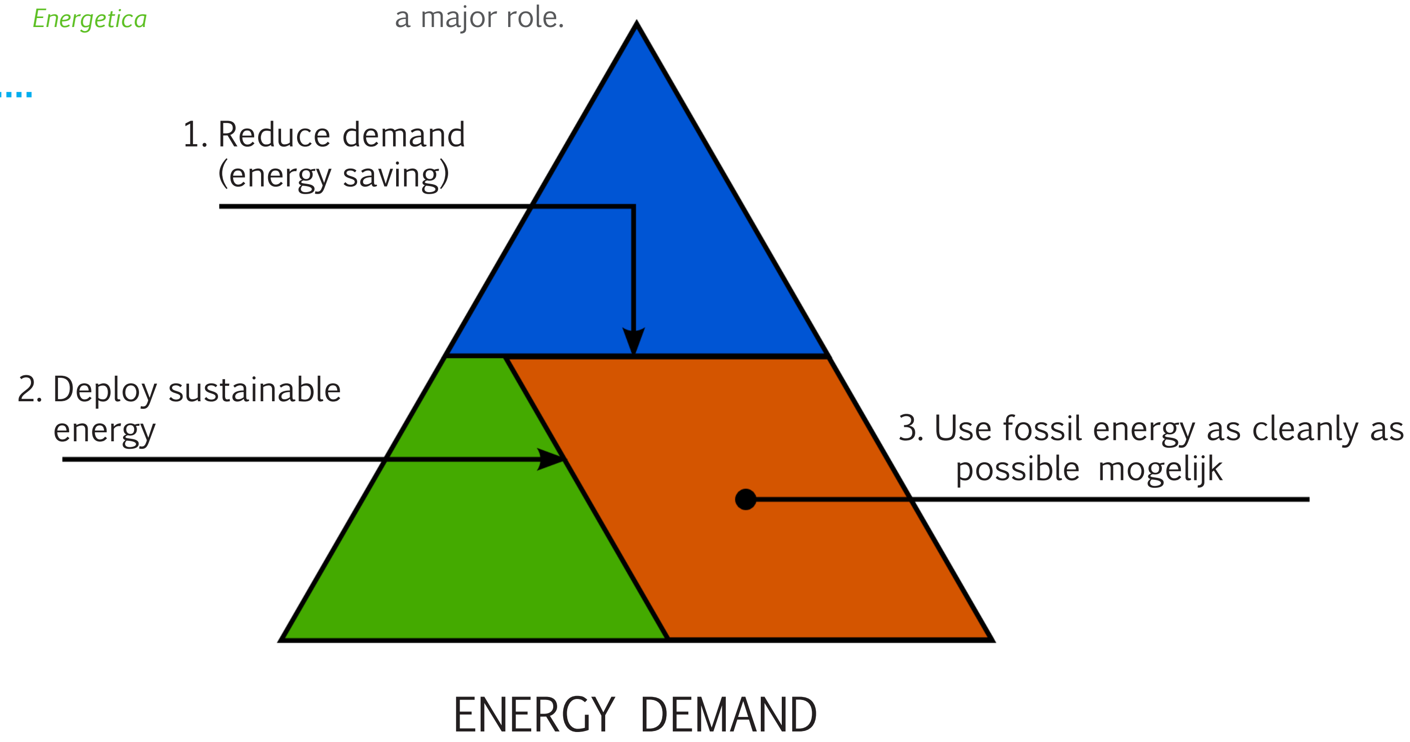


Towards a more energy efficient data center

The methodological approach to solve the energy problem is to make use of the Trias Energetica. The Trias Energetica is based on the Trias Ecologica, which is an action plan towards sustainability that comprises more than just energy.

The Trias Energetica focuses on the most sustainable way to meet the energy demand. The first step is to reduce the demand for energy as much as possible. Step two is to meet the remaining demand with renewable energy such as solar energy, wind energy and/or environment energy (soil, water, and air). Following this step, any remaining energy demand will be met in the most efficient and clean manner possible, using finite energy sources such as natural gas, coal or petrol. Smart adjustment, energy storage and reuse of waste streams are interwoven in the different steps of the Trias Energetica. The Trias Energetica is an iterative process in which quality control plays a major role.

Visualization of the Trias Energetica



1. LIMIT THE ENERGY DEMAND

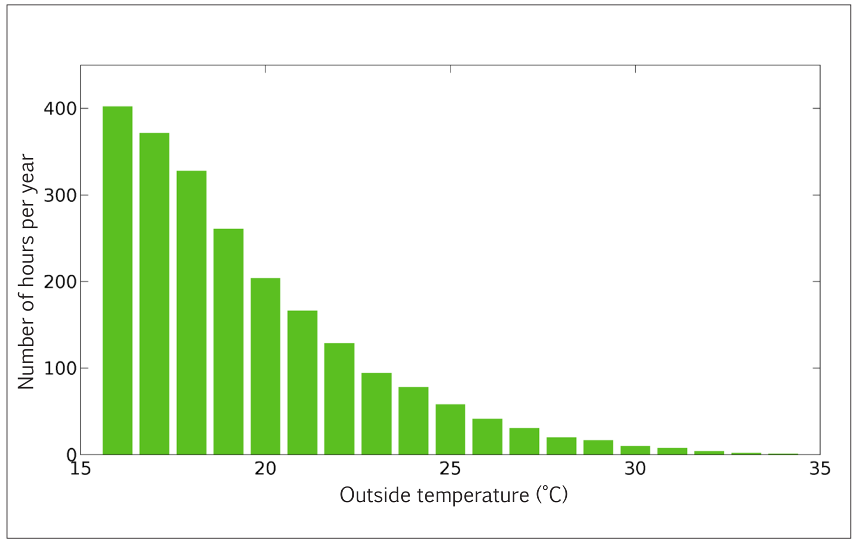
The first step of the Trias Energetica is to reduce the energy demand as much as possible. This means omitting servers, lighting and installations that devour energy. Determining the remaining annual energy demand pattern in relation to 'smart' control and/or demand management is also part of this step. Demand management can be done using sophisticated techniques that allow large scale on/off switching of electrical appliances. This is coupled with the available supply of (intermittent) renewable energy sources in combination with the necessary energy techniques. The proper adjustment of existing installations (including optimization of airflows) is also included in this first step.

User behavior is just as important. Attention must be paid to the consequences of their (own) energy behavior and the resulting energy bill. By using domotica (motion detection) and a continuous supply of information, users regularly receive incentives that will automatically lead to energy saving behavior.

2. USE SUSTAINABLE ENERGY AS AS MUCH AS POSSIBLE

The second step of the Trias Energetica is to meet the demand pattern determined in step one in the best possible way with infinite energy sources. This will be combined with smart control of energy demand and sustainable supply and the use of residual heat and energy storage technologies on an industry, district and/or building level.

We know from experience that the temperature of the air supplying cooling to the servers can be 25° C or even higher. The outside temperature in the Netherlands is generally much lower than 25° C. As a result, it is very often possible to use outside air to cool the servers through free cooling. The great advantage being that outside air is (almost) available for free.



ASHRAE

The American Society for Heating, Refrigerating and Air-conditioning Engineers (ASHRAE) provides guidelines for the design of technical facilities for computer rooms and data centers. They recommend that the temperature of the air blown in for cooling lies between 18°C and 27°C and indicate that any temperature between 15°C and 32°C is permissible.

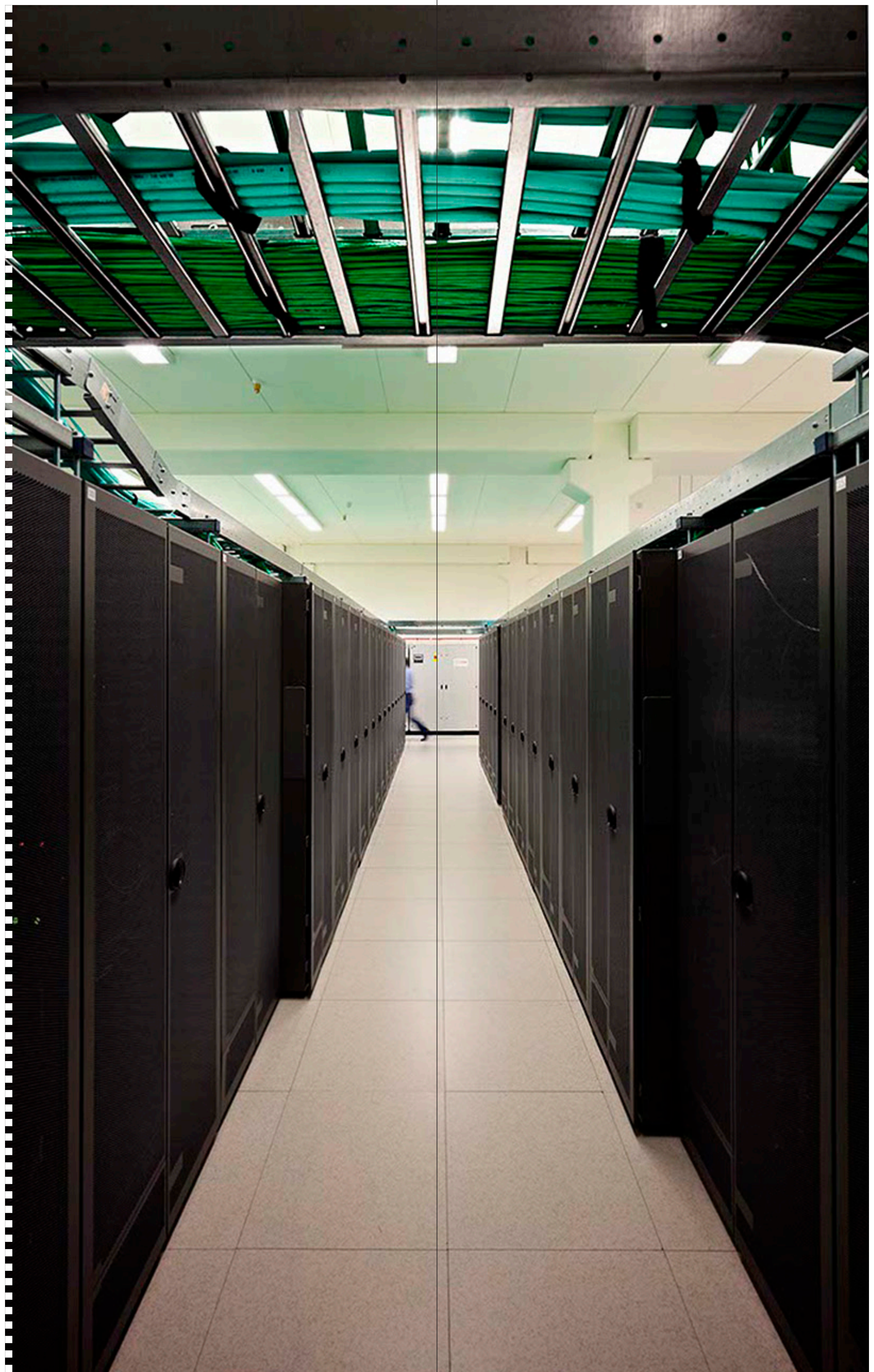
Renovation of a data center or server room is a natural time to start making maximum use of the potential of free cooling. This can be achieved with outside air but also with water, while ensuring the reliability and continuity of the data center. Data centers use large amounts of electricity and also have large roof surface areas, which provide a perfect opportunity for the placement of solar panels. Solar panels convert sunlight directly into electricity, and they contribute to corporate social responsibility. Their deployment does not affect the EUE.

3. USE GENERATED ENERGY AS EFFICIENTLY AS POSSIBLE

The remaining energy demand (mostly cold) is met in the third step of the Trias Energetica, with energy technologies that use finite resources in the most efficient and clean manner possible. For example: efficient coolers, use of residual heat, green energy purchasing or compensation with green certificates. Green purchasing and compensation contribute to corporate social responsibility. The application does not affect the EUE.

Server rooms are usually part of an office building, so the heat can be used internally during the heating season. This reduces the energy bill considerably. Conversely, there is also a benefit. In some cases, the server room can still be perfectly well cooled with residual cold from air conditioning systems in office buildings.

Large data centers themselves usually don't require any heating. Areas adjacent to a data center, like, for example a large office building, an industrial complex or a swimming pool, do need heat. Supplying heating to the direct environment can be interesting for both parties. In the Netherlands, this has not yet been widely implemented. However, residual heat has a lot of potential. This is why "Agentschap NL" is investigating the opportunities.



TOWARDS A MORE ENERGY
EFFICIENT DATA CENTER

DATA CENTER MATURITY MANAGEMENT

The first steps of the energy renovation process are iterative. These steps are usually required in the first phase when the necessary improvements are defined. A well-known method for setting up the renovation process is the DMAIC improvement method.

DMAIC stands for Define -Measure - Analyze - Improve- Control. DMAIC is part of "Six Sigma". Six Sigma is a quality management approach to improve operational performance of a company by identifying and improving process deficiencies.

The DMAIC steps can best be described as follows:

Define: *defining the problem and aligning the project organization*
Measure: *understanding the current performance of a process, i.e. determining the current baseline*
Analyze: *analyzing and determining the causes of the problem*
Improve: *designing and selecting solution(s), i.e. determining process optimization*
Control: *implementing and securing the improvements*

For the stepwise implementation of a sustainable data center, the Data Center Management Maturity (DCMM) action plan can be used. This tool can be downloaded from the following website: **thegreengrid.org**

www.thegreengrid.org/Global/Content/Tools/~/media/Tools/DataCenterMaturityModelv1.ashx

INTERVIEWS

KPN

In the Netherlands, KPN is widely known as a telecommunications company, but KPN also has eight large data centers in the Netherlands, which makes it an important organization within this sector. In recent years it has committed itself to the creation of energy-efficient data centers. Jan Huntelaar, KPN: 'At the end of 2012, we managed to improve the average PUE (Power Usage Effectiveness) by 30.4 percent compared to 2005.'

HOW DOES KPN ENGAGE IN SUSTAINABILITY FOR ITS DATA CENTERS?

'Each site manager receives an annual target for the PUE and energy reduction to be achieved. At an occupancy rate of over 20 percent per data center, the PUE is included in the overall average of all locations. The PUE improvement is included in the achieved energy reduction calculation, which we report in our annual Corporate Responsibility Report in the section Energy efficiency improvement datacenters.'

'Energy efficiency is a joint effort of KPN, customers and hardware suppliers'

WHY ARE DATA CENTERS WITH AN OCCUPANCY OF LESS THAN 20 PERCENT DISREGARDED?

'This is in line with the position of the Green Grid. When the occupancy of a site is too low, this indicates a PUE deviation that is too large in relation to other locations. What you then get is a misrepresentation of the average and you can't demonstrate and benchmark successfully realized energy saving projects in other locations anymore.'

HOW DID KPN REDUCE ENERGY CONSUMPTION IN ITS DATA CENTERS?

'KPN has data centers both for hosting (own servers) and for housing (servers of customers). In recent years, we have raised the temperatures and relative humidity in the computer rooms of all data centers. In the case of server housing, KPN adjusted existing contracts accordingly, in consultation with its customers. In years to come, this will be a repetitive process because ASHRAE* continuously broaden their norms, in consideration of the social energy efficiency issue.
The success of energy reduction in our data centers does not just depend on our own efforts, but rather on the joint effort of KPN, the customers and the (hardware) suppliers.'

kpn

** ASHRAE: American society for Heating, Refrigerating and Air-conditioning Engineers*

Delta Lloyd

Delta Lloyd has incorporated sustainability in its policy. This intrinsic motivation, in combination with the 'common sense' of the IT stakeholders, led to an energy-efficient data center. Spokesman William Oepkes: 'The renovation took several years, but it was successful and we managed to maintain continuity.'

WHY DID DELTA LLOYD RENOVATE ITS DATA CENTER?

'Before 2009, the data center of five hundred square meters was physically full. There was no room for new servers in the server racks. Following the IT outsourcing construction employed by Delta Lloyd at the time, it was decided that part of the servers had to be moved to another data center. In 2009, the outsourcing was stopped and we decided to host all servers in our own data center again.'

HOW WAS THE PROBLEM OF THE FULL SERVER RACKS SOLVED?

'Thanks to the rapid developments in hardware, we were able to choose less bulky but still powerful servers and storage devices. This allowed us to accommodate all our ICT requirements within the existing floor space.'

WERE THERE ANY OTHER CHALLENGES THAT NEEDED TO BE ADDRESSED?

'Because we were able to place more servers in our data center, both the electricity and the cooling demand were higher than the installations could handle. We developed a concept that allowed us to divide the data center into three TIER classes (0, I and IV).
The highest TIER-class has a redundant power supply and an emergency chiller. The TIER I-section is only equipped with an emergency generator and TIER 0 has no emergency facilities whatsoever.'

WHAT ABOUT THE COOLING LOAD?

'The data center obtains its cooling from the NUON hot/cold net (WenK). In addition, the data center is in an area sheltered from the wind, so the use of free cooling was not possible. That's why we are installing a hot aisle/cold aisle system.'

DOES THIS MEAN THAT THE WHOLE DATA CENTER WAS DOWN FOR A LONG PERIOD OF TIME?

'Absolutely not! By inventing creative and down-to-earth solutions it has not been necessary to close the data center. We have been renovating rack by rack. In our own data center we had a new server ready at the new location. We then transferred the data over the network. Depending on the importance of the server, this was done overnight or during the day, without the users noticing anything. The former server was left empty in the old data center. Old servers were removed. Recent servers were physically moved for use in a future relocation. In addition, the rows in the existing data center had to be rotated by a quarter turn to be able to use the hot/cold aisles appropriately in combination with the new cooling units. Most of the time the racks were rotated empty on the spot, but sometimes it was done in the evenings with the servers still in them.'

Thanks to creative and down-to-earth solutions, users haven't noticed anything of the renovation

ROTATING RACKS CONTAINING SERVERS? THAT SOUNDS TRICKY!

'It was a matter of placing a few straps around the racks and making them rotate by a quarter turn with some lifting equipment and a lot of muscle. We were lucky that the wiring had enough slack, especially from above, so that rotation was possible. There was a lot of copper cabling, but during the renovation a transition was made to mostly glass fiber, so that has also been improved.'

Interxion

**With its 32 carrier neutral colocation data centers in Europe, Interxion is a major player in the market. More than 1,200 customers have placed their own hardware in the data centers of the company.
One of the most advanced Interxion data centers is the AMS 5 in Schiphol-Rijk. Service Delivery Manager Rice van Gompel: 'Interxion managed to achieve substantial energy reduction in its data centers without sacrificing reliability.'**

'Interxion pays a lot of attention to improving the airflow in its data centers. Measurements and calculations in this area are done by Interxion itself, so that knowledge on how to save energy is acquired. Thus, a saving of up to 20 percent of the cooling energy has already been achieved in a number of large computer rooms.'

WHAT ARE YOUR MAIN DAILY TASKS?

'As a Service Delivery Manager I am responsible for the cost effective energy efficiency management of all seven Interxion data centers in the Netherlands. In a five-member management team I am, among other things, responsible for energy measurements, in which aspects such as information management, ISO, KPI's and of course the LTA play a role. I also deal with the innovation processes within Interxion.'

CONCERNING ENERGY, WHAT IS MEASURED IN YOUR DATA CENTERS?

'We measure all technical installations in the data center, such as the cooling and the emergency power system. In addition, the energy consumption of the ICT equipment is also measured at the rack level. We use a Site Management System, so we can see at a glance the status of the installations and how they are functioning. In this way, our system is always optimally tuned.'

WHAT IS BEING OPTIMIZED?

'We focus primarily on the airflow within a data center. At Interxion we have one person who is responsible for optimizing airflows. Extensive use is made of computational fluid dynamics (CFD) simulations, complemented by practical tests. One of the studies is aimed at finding the optimal pressure of the air blown into the data center.'

DID THIS RESEARCH YIELD ANY RESULTS?

'The optimization has led to a reduction of 20 percent of the energy required for the airflow. In addition, the temperatures of the air blown in were raised, allowing longer free cooling. We have also experienced that blade servers can create underpressure by the built-in fans, which causes the airflow to get out of balance. Through CFD research, we have been able to solve this within Interxion.'

TECHNICAL DATA AMS5

Built: *2008*
Surface area: *6000 m²*
Redundancy: *2N*
Green Energy: *100%*

HOW DO YOU SET UP AN ENERGY SAVING PROCESS?

'An energy saving measure must meet three conditions before Interxion will proceed with implementation. By far the most important is operational safety. In addition, the obtainable savings in relation to the cost are important. Finally, we also look at the potential impact on the environment.'

'Optimization of airflow leads to a reduction of 20 per cent of the required energy.'

WHICH CHALLENGES AND BARRIERS CAN BE EXPECTED DURING JOURNEYS LIKE THIS?

'It has turned out to be very difficult to assess the impact of the measures, because often little or nothing is known about the reference situation. Old premises, where little to no sustainability seems possible, require extra attention. Especially in relation to the enforcement processes that may be required by the municipality of Amsterdam.'

WHAT IS IN YOUR OPINION THE BEST SOLUTION FOR COOLING A DATA CENTER?

'The optimal system takes a stepwise approach. First of all, free cooling is used. If this is no longer sufficient, cold will be extracted from the soil (HCS). Finally, you can use energy efficient compression refrigeration machines to ensure that the servers will always be cooled. We have adopted this tiered system in our newest AMS6 data center. However, this system is usually only applicable to new sites.'

RICE VAN GOMPEL

Rice van Gompel has a long history in the ICT sector. Having started in managerial positions at various companies, he progressed to positions with a more strategic content and has acquired extensive experience in the field of energy and environment in data centers. Since early 2012, Rice van Gompel is Service Delivery Manager at Interxion and his responsibilities include the energy and cost efficient management of all Dutch Interxion data centers.

interxion™

UNET

The office of UNET, formerly a branch of IBM, is in Almere. At the time of writing this publication UNET is renovating and expanding its data center. We visit their office and speak with director and co-owner Ger Bakker.

UNET

Now manages over 3,000 kilometers of fiber optic cable in the Netherlands and thus offers several services for the government, businesses, the food service industry, healthcare, educational institutions, retail and security. The organization comprises approximately 50 FTE.

WHY IS UNET EXPANDING ITS EXISTING DATA CENTER AND CHANGING ITS COOLING SYSTEM?

'When UNET took over the office building from IBM, the data center set-up was rather traditional. Because more computer equipment of our customers was brought into the server space, the energy consumption intensified and the traditional cooling system didn't suffice any more. The existing space became full. We needed to set up a new one to serve new customers. It was also frustrating to us that we were cooling exhaust heat, while the outside air was often much cooler. This led us to explore how we could use the outside air at times when it was colder than the exhaust air from the data center.'

WHAT DID THE OLD TRADITIONAL COOLING SYSTEM LOOK LIKE?

'It consisted of air handling units that were connected to the traditional cold generator which also provided cooling to the office section. There were also some separate compressor driven cooling units installed in the data center.'

WHICH OPTIONS WERE CONSIDERED FOR THE EXPANSION AND MODIFICATIONS?

'A system with and without free cooling. In both cases, the "old" traditional coolers have been used as a back-up facility. Existing and new rooms have windows. The glass of some of the windows has been replaced by grates, through which air can be drawn in. By applying an air handling unit, which can draw in outside air directly and which switches on a refrigeration machine when temperatures get too high, the best use is made of cold outside air.'

HOW DID YOU REACH A DECISION ABOUT WHICH CONCEPT TO USE?

In terms of investment, free cooling turned out to be about 30 percent more expensive, but could be financially recuperated within two years. Along with the use of the existing installation (reuse), free cooling seemed like a good choice.

'Measuring is knowing'

HOW DO YOU KNOW IF THE SYSTEMS ARE WORKING WELL?

'Measuring is knowing. Our NOC (Network Operation Centre) monitors the everyday running of our networks and systems. In emergencies we can therefore be on site very quickly. Our own data center is included in this as well. In the data center itself we also do manual measurements. This way we can identify customers who create hot spots. In most cases these are caused by improper rack wiring, which prevents the air from flowing sufficiently through the units. We point this out to our customers and ask them to fix it. After all, reducing the air resistance allows higher temperatures for the air that is blown in, which enables more free cooling, thus helping us to reduce the energy bill.

Technical measures

This section elaborates various aspects of the measures that can be introduced to reduce energy consumption in data centers and computer rooms. Based on these measures, three business cases will be presented at the end of the section, for a computer room, a small data center, and a large data center. These business cases are based on real situations and have been tested in the industry.

Reducing energy consumption in (and by) existing data centers can be achieved at different levels by taking technical measures. Three measures in particular, namely:

Saving energy begins with limiting the energy demand

1. **ICT hardware and software**
2. **Housekeeping**
3. **Environment**

On the following pages these will be discussed in more detail.

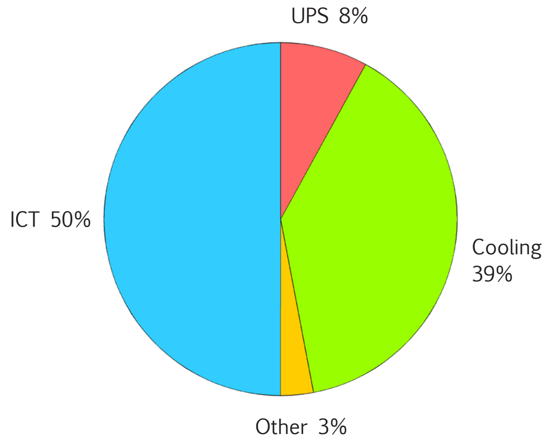
1. ICT HARDWARE AND SOFTWARE

According to the Trias Energetica, saving energy starts with the limitation of the energy demand. That means using energy efficient software and hardware and optimizing the capacity of computer equipment, for example through virtualization.

'Certifications are essential for distinctive capabilities and quality assurance: ISO 14001, ISO 27001, ISO 9001, PCI DSS, and a Code of Conduct are currently in place.'
Jan Huntelaar, KPN

The choice of specific ICT hardware and software can only be influenced by the owner of that equipment. Data centers that provide only housing will have to discuss the options with the customer who owns the ICT hardware and software. The fact that KPN has increased the room temperature in consultation with its customers proves that this is not impossible. It is an aspect that directly affects the hardware.

Data centers that provide ICT services themselves, which is called hosting, often manage their own hardware. That way it is easier to make decisions about replacing hardware or changing the set-up. Virtualization may, for example, be a case in point. In data centers and server rooms, the hardware consumes most of the energy (see Figure 3).



Distribution of energy in an existing data center, with a PUE of 2.

In recent years there have been significant developments in energy-efficient hardware. Today's processors are faster than their predecessors and at the same time use less energy. Fans with a larger diameter are not only quieter, but also more energy-efficient. In addition, some components of a server do not need to be always on. Hard drives and RAM strips that are not used can be switched off.

Furthermore, a server's energy consumption is relatively high when it is idle: it is on, but doesn't do anything. By arranging ICT services in a smarter way, and by disassociating software applications from a server ('virtualization' of servers/applications), the number of servers can be reduced. These servers run more productive hours and jointly use less energy.

'These last 4 years we have achieved about 25 percent of energy savings through extensive virtualization. (At the beginning of 2009 UPS load was 95-100 percent, today about 70 percent). With our new server room with free cooling and heat recovery we hope to save another 30. Our current PUE of 2.24 should then be reduced to 1.2.'*
Martin Kuijl,
Province of Noord-Brabant

**Uninterruptable Power Supply*

2. HOUSEKEEPING

Housekeeping comprises measures that relate to the technical equipment in a data center. For instance installations that provide power and cooling.

POWER SUPPLY

Power Quality is the quality of the voltage and the electric current. The quality can be affected by the implementation of all kinds of equipment, such as power electronics (e.g. LED), frequency inverters and the servers themselves. Examples are reactive current and harmonic pollution. These result in unwanted voltages and currents in the network with the possible consequences of a less reliable data center, more wear and tear on equipment and higher energy bills. Modern UPS systems filter a large portion of this type of contamination so that the power quality is maintained.

However, maintaining and improving the power quality throughout the lifecycle of the data center remains imperative. Thus, avoiding power consumption (UPS) during partial load is very important. Applying energy-efficient modular UPS is a solution.

WIRING

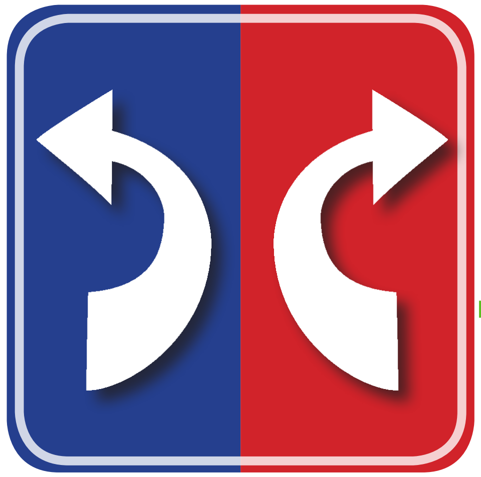
Transporting power and data through cables causes energy losses and therefore additional cooling loads. It is important to choose an infrastructure that avoids cable losses, by not using unnecessarily long cables. Repositioning computer equipment can also be an option.

COOLING

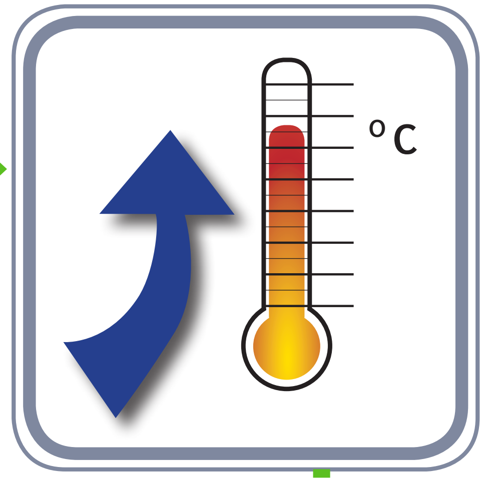
The benefits of cooling with outside air (free cooling) and the measures to make maximum use of it are already widely applied in data centers.

TECHNICAL MEASURES

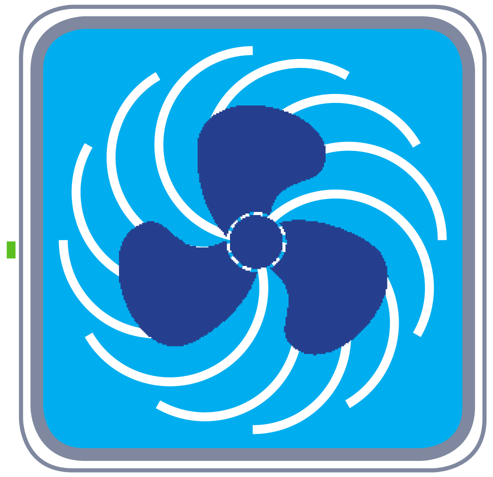
The measures and the strategy for efficient cooling are as follows:



1. Ensure that hot and cold air in the computer room are separated.

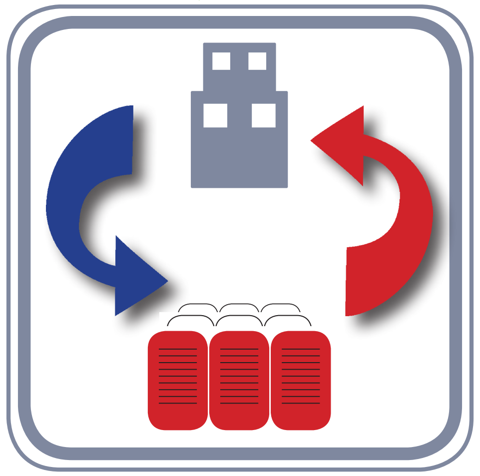


2. Blow cooled air in as at the warmest possible temperature.

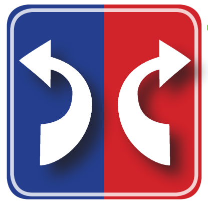


3. Direct the airflow in an energy efficient way (as little resistance as possible in the air flow path and well controlled efficient fans).

4. Use cold outside air (free cooling) so that the cooling machine compressors use less energy or none at all.



5. Use heat (air, water or refrigerant) from the data center for use elsewhere (heating of offices).

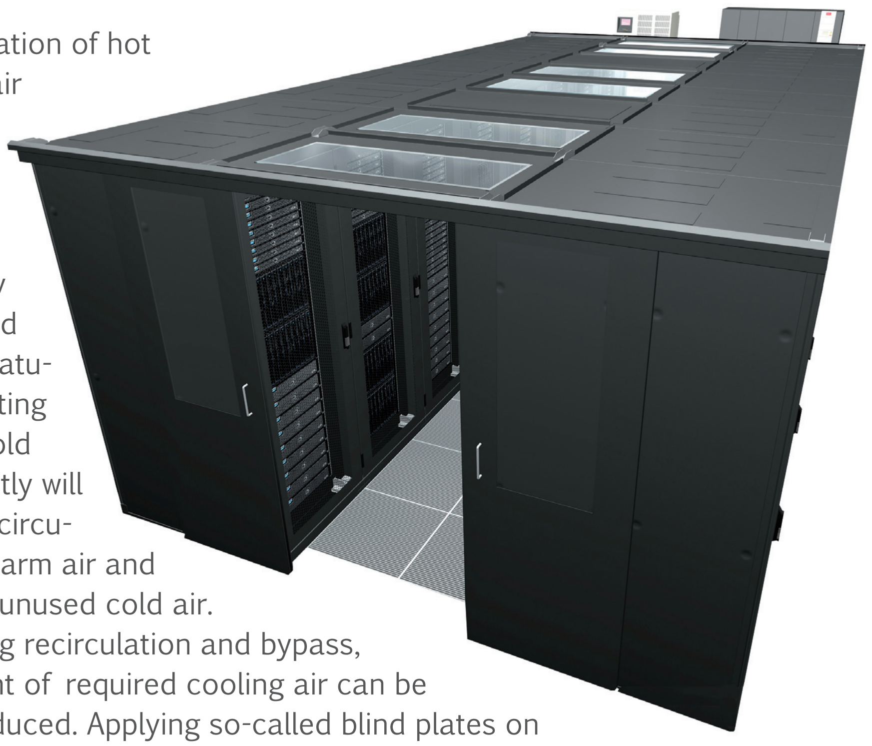


SEPARATION OF HOT AND COLD AIR FLOWS

The separation of hot and cold air is already widely applied. The optimal situation is achieved by so-called closed aisles, in which the server racks are placed in rows, side by side and opposite each other, forming a closed space. The aisle between the server racks forms the channel for taking in cooled air or releasing the heated air. This depends, among others, on whether access to the servers is obtained through the cabinet or through the outer area and also on the existing infrastructure, like raised floors for air supply.

'In six months' time, we have created hot and cold aisles by rotating the server racks in a 500 square meter data center without the users being affected by it.'
Willem Oepkes, Delta Lloyd

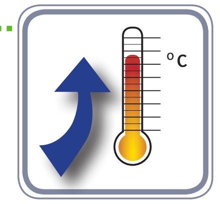
If the installation of a closed aisle is not feasible, a compromise can be reached by placing the server racks in such a way that hot air from the rear is blown in the same direction. Please bear in mind that this may affect your cabling layout, but any changes can be carried out step by step.



The separation of hot and cold air helps to achieve sufficient cooling at a relatively high cooled air temperature. Separating hot and cold air efficiently will prevent recirculation of warm air and bypass of unused cold air. By avoiding recirculation and bypass, the amount of required cooling air can be greatly reduced. Applying so-called blind plates on open slots in a server cabinet will also contribute to this.

PHOTOGRAPHS: MINKELS

Since the required fan capacity increases with the cube of the speed of the fan, small reductions in air leakage will already have a major impact on energy efficiency. Why this saves energy will be explained later. Creating enclosed hot and cold aisles in existing computer rooms requires clever use of available space. Thus the part of the computer room where no racks are installed can be prepared for closed hot and cold aisles.



LETTING IN COOLED AIR

WARMEST POSSIBLE TEMPERATURE

By blowing in cooled air at the warmest possible temperature, the cooling water temperature of the chilling machines can be raised, thereby increasing the efficiency of the chillers and diminishing their electricity consumption. With free cooling, raising the temperature means that more outside air can be used for cooling so that the compressors of the chillers don't need to be operational. This will lead to considerable reduction in energy use for cooling, as free cooling costs about 7 to 12 times less energy than compression chillers. Another advantage of blowing in air at a higher temperature is its effect on the relative humidity. In conventional systems, air is usually cooled with water at 6°C. At this temperature, water vapor condenses in the air so that the relative humidity falls in the server room. This is undesirable because of static electricity, which is why in traditional situations the room will often be humidified. This uses a lot of unnecessary energy. With a raised air intake temperature, the air is not dehumidified, so the relative humidity can be controlled much more easily, without using a lot of energy. In the case of data centers and server rooms with in-house hardware (including hosting companies), increasing the air intake temperature is usually not a problem and takes minimal effort.

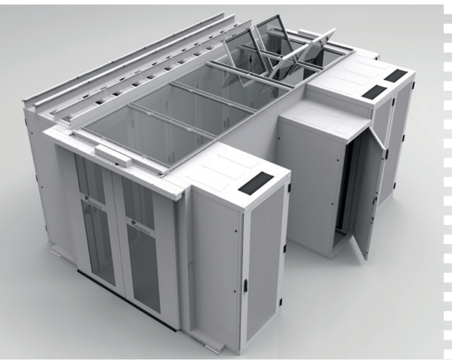
SAFETY LEGISLATION

The Occupational Health and Safety Act stipulates that the temperature in the workplace must not be harmful to the health of the employees. Although no specific temperatures are mentioned, it does state that employers must do everything in their power to prevent health problems and hazards.

However, things are different in data centers with customer hardware in the server racks (housing). Data centers have contracts with their customers that contain conditions for the environment in computer rooms (temperature and relative humidity). This means that the contracts with customers need to be considered before the temperature can be raised. For example, the customer might benefit from the energy load reduction by offsetting the gains in the rental rate.
The increase of the temperature in the data center obviously affects the working conditions of the employees as well. However, general health and safety legislation does not set a maximum temperature for server rooms. Working on computer racks from the 'cool' side is also a possibility. When server rooms are fully cooled with outside air it is recommended to lower the air intake temperature during cold periods. This avoids having to heat the air before it is blown into the computer rooms.

ENERGY EFFICIENT AIR TREATMENT

Servers are usually still cooled with air. The air is drawn out of the warm aisles and blown back into the cold aisle by an air-handling unit, via a heat exchanger. It is important that there



is minimal air resistance during this process, otherwise the engines that power the fans use too much energy. It is also important to use efficient fans with speeds that can be changed according to the required quantity of air and the current airflow resistance. Such systems can be placed between the server racks but also as standalone air handling units.
In both cases, the quantity of circulating air has to match the cooling demand. Often in existing situations neither the chiller nor the air conditioning system are adjusted to the actual cooling demand. Some approaches work without air handling units. Structural modifications are often required to be able to transfer the enormous quantities of air that are required.

USING FREE COOLING

In new data centers free cooling is now standard. When free cooling is used optimally, little or no compression refrigeration is required. Only in case the free cooling breaks down completely or in conditions of extreme heat, will the compression refrigeration need to be switched on. This is why in addition to free cooling a compression system is often installed in order to ensure continuity. In the Netherlands, systems without compression cooling, which fully rely on free cooling, are already being applied as well. Data centers can obtain an eco-certificate for this type of cooling system.

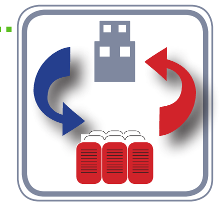
For example, if the desired temperature of intake air in the server room is 25°C, during the average Dutch summer it's only too hot outside for 65 hours a year. During this time a different system will have to provide active cooling. The implementation of free cooling in existing data centers can sometimes be very simple, but also very difficult. Renovation carried out at a former datacenter of PinkRoccade-Getronics (now owned by KPN) shows what engineers can accomplish.

This large data center switched to a concept whereby outside air is cooled indirectly by means of so-called Kyoto wheels. Holes were made in the roof of the building on which large air handling units were installed. The energy savings obtained as a result of the renovation were way ahead of their time. The system is now still running successfully and the concept has been further developed by KPN. Installing free cooling can also be relatively simple. Turn-key systems with all the necessary guarantees are now for sale that can easily be connected to existing cooling systems. The existing system can then be (incrementally) disabled and removed or used as a back-up facility.

ECO-LABEL

Since 2012 it is possible for data centers to acquire an eco-label for sustainable cooling. One of the conditions is that traditional compression refrigeration is no longer applied (http://www.smk.nl).

3. ENVIRONMENT

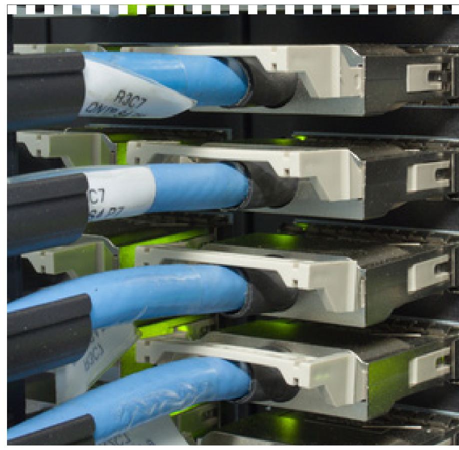


REUSE OF (WASTE) HEAT OR COLD

When the temperature of the heated air, the water or the coolant from the data center is warm enough (> 40 ° C), it can be used for recycling. This is especially true for server rooms in office buildings that can use the exhaust heat for heating the building. A data center is nothing other than a thermal plant. So why not use it? The challenge lies in the relatively low temperature of the waste heat. Initially, this can be reused locally for low temperature heating (e.g. swimming pools, greenhouses, low temperature heating in the utility). An alternative is to use heat pumps to increase the water temperature for further use or transport. It is also possible to use heat cold storage (HCS) in containers or in the ground. Unlike utility buildings, data centers produce year-round heat and will therefore need cooling all through the year. In winter however, considerably less energy is needed for the production of chilled water than in summer. An HCS can then still be used as a cold buffer.

'A data center is a heat plant'

Also, large data centers can give warmth to their neighbors or their neighborhood so they can make use of the heat. Currently a study commissioned by the "AgentschapNL" is being carried out to form a better assessment of these opportunities.



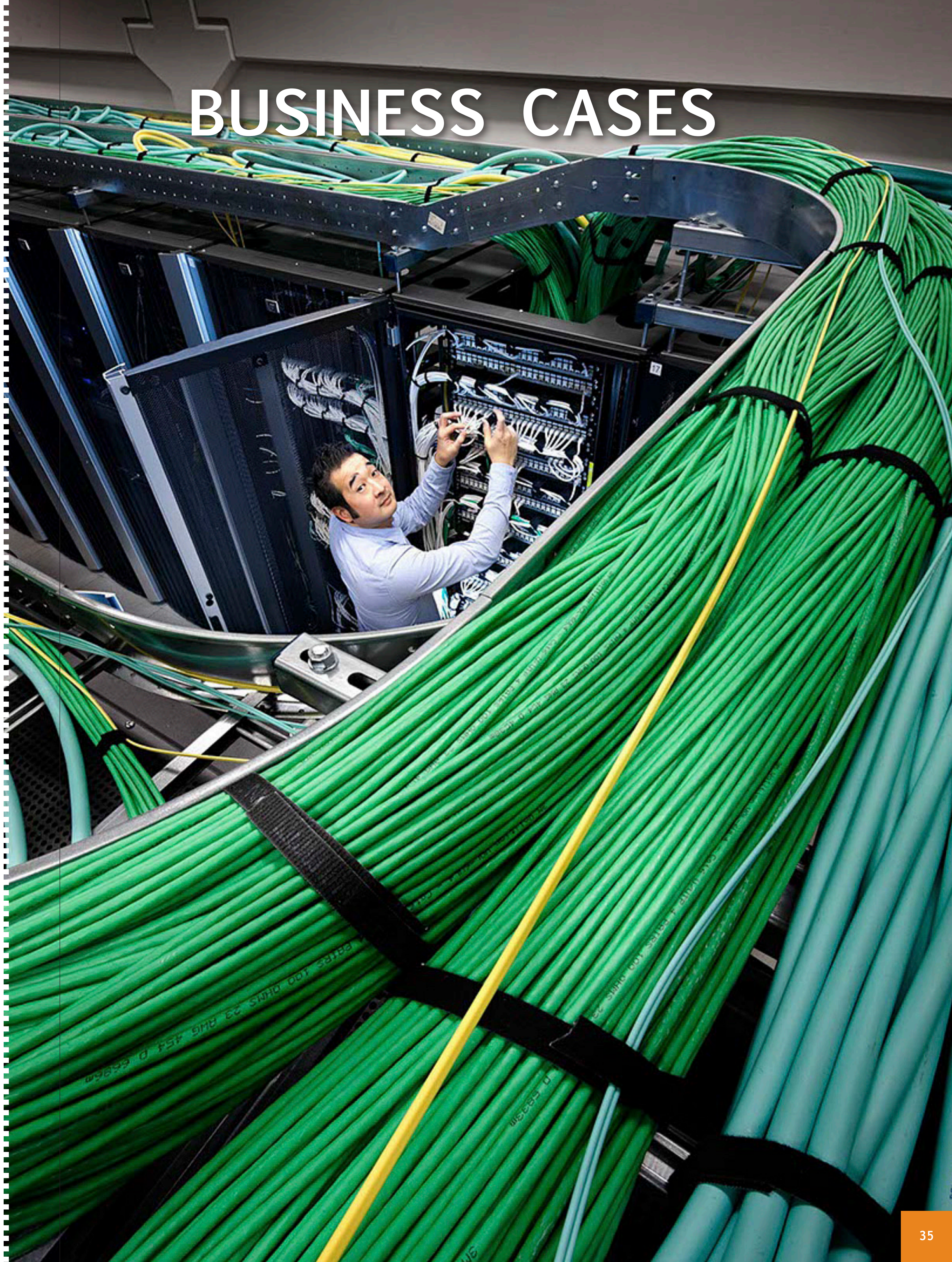
GENERATE SUSTAINABLE ENERGY

Sustainable electricity can, for example, be generated by wind turbines, solar panels on roofs and in fields, biomass CHP (Combined Heat and Power) and deep geothermal energy in combination with CHP. Sustainable cold can be generated using ambient heat (air, water and soil). One example is Google's data center in Hamilla, Finland. Google uses seawater from the Bay of Finland for cooling. Another example of the use of ambient energy is the use of the outside air for free cooling.

SUMMARY

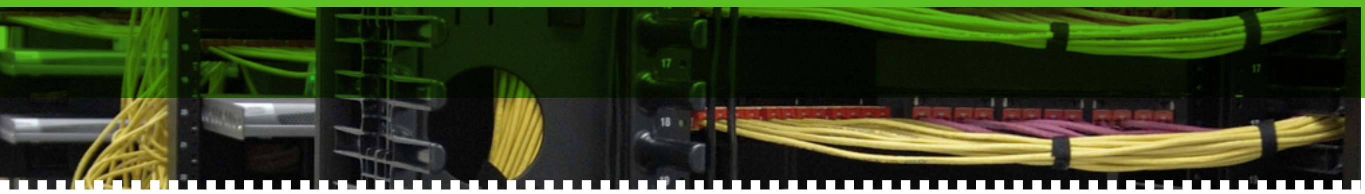
MEASURE	POINTS OF CONCERN DURING IMPLEMENTATION
Hot and cold aisles without covers (rotating racks)	Pay attention to cabling. Avoid open slots in the server racks.
Hot and cold aisles with cover (cabinets)	Use modular deployment when renovating.
Raise air intake temperature	Pay attention to customer contracts, both standard temperatures and margins. Temperatures > 25 °C are already being applied.
Low pressure air treatment	Avoid unnecessary obstruction to the air flow (think of computer floor tiles). Make sure that a good separation between warm and cold air is maintained.
Efficient fans and motors	DC motors and appropriate controls along with efficient fans are widely available on the market.
In-Row cooling	Placing air treatment between the racks allows easy, scalable renovation.
Recycling of waste heat	The supply of heat to the environment (neighboring sites) calls for attention to availability of heat, costs, technology and organization.
Reuse of residual cold (climate installation in the building)	Existing cooling systems in buildings can also still be used for cooling server rooms by reuse of cold (the refrigerant/chilled water is often still cold enough to cool the air in a server room to 25 °C).
Using free cooling	The moment of switching from the old to the new situation demands attention. By doing this incrementally and beginning the implementation with the existing system running in parallel, the old system can be phased out gradually.
Virtualization	Customer contracts.
Lighting	Current and voltage quality when applying LED lighting.
Modular UPS systems	Avoid partial load charges of these systems.
Continuous energy care	A measurement system that continuously monitors the energy performance of the data center or computer room provides insight. It is a way of checking if the system is working optimally and if behaviors are changing.

BUSINESS CASES



Business case: Server room

Service organizations like banks and insurance companies usually have a large amount of centralized data, which is managed on their own servers in an on-premise server room. Companies applying the New Way of Working, also need to maintain relatively large centralized ICT systems. The heat generated by this ICT hardware is often vented into the outside air, while the office heating system is working overtime in winter.



'Using ICT warmth for office heating'

SITUATION OVERVIEW

A bank/insurance company of 90 FTE has its own office building of 3,000 square meters with a server room on-premise of 150 square meters. The office building, together with the server space, went into operation about 10 years ago and has not changed since.
The installations in and around the server room are soon to be replaced to ensure continuity for the coming years. The office building itself has a D label and uses about 27,000 cubic meters of gas per year for heating.

The ICT equipment in the server room requires an average of 40 kW of electricity and operates under TIER III conditions. For this purpose 2 UPS systems are in operation, each operating at 50 kVA. The cooling system consists of two 10 year old compression refrigeration machines without free cooling. The annual average SPF (Seasonal Performance Factor) of these machines is 1.8.The server room has no hot and cold aisles. The servers are placed in rows, all oriented in the same direction.
The server room uses a total of almost 700,000 kWh of electricity a year. Of this amount, 50 percent is attributable to the ICT equipment itself, 39 percent to the cooling and air treatment, 8 percent to losses in the UPS and 3 percent to other issues such as lighting. The resulting EUE of this server space on 2.0. The energy prices this bank/insurance company is paying are € 0.09 per kWh and € 0.45 per m^3.

THE RENOVATION

The server room is to be completely renovated, by introducing the following measures:

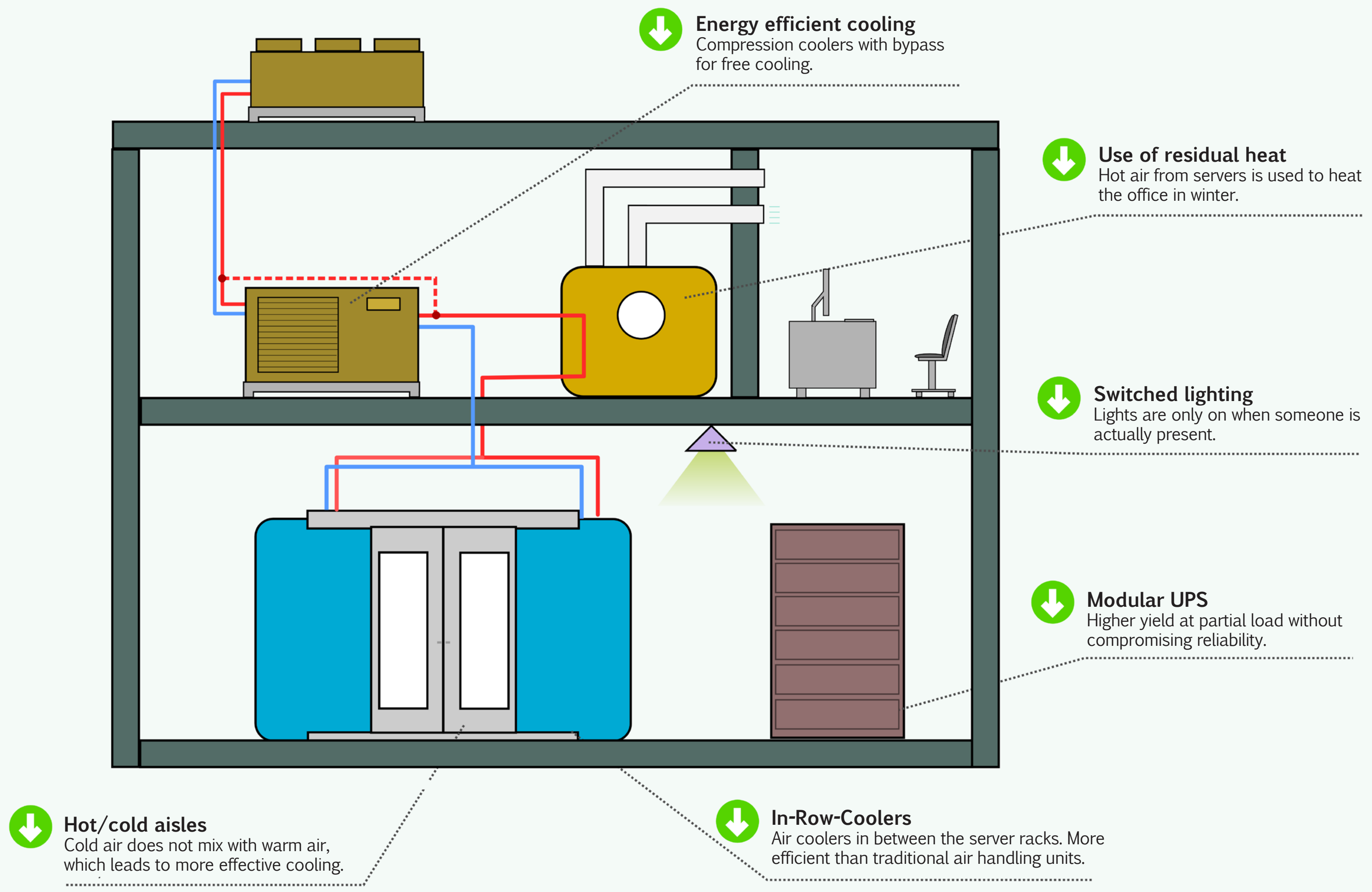
- Modern compression refrigeration machines with free cooling will replace the old chillers. Free cooling will be used 60 percent of the time with an SPF of 10. The compressors are used for the remaining 40 percent and have an SPF of 2.5 during the summer months that they are in use.
- The air-handling unit will be replaced by a similar but more modern version.
- The UPS systems are replaced by a state of the art modular variant with high yield at partial load.

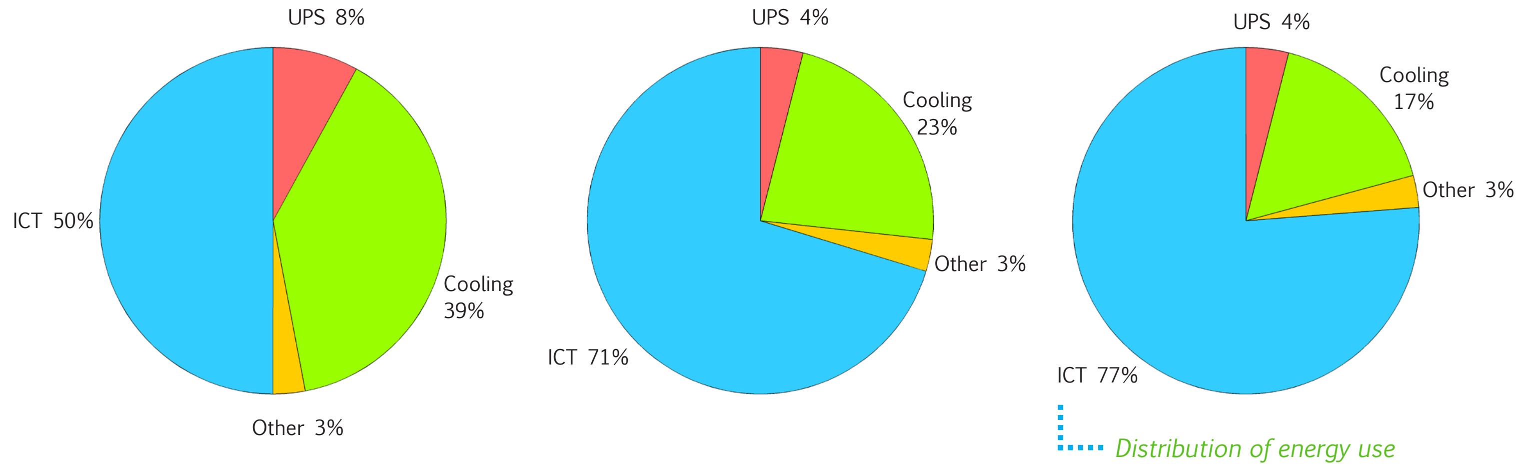
The investment costs for these measures amount to approximately € 125,000.
This renovation is necessary because the old installations are in need of replacement. The above measures can be considered as standard procedure in the industry. The energy consumption of the server room will be reduced by 30 percent as a result of this renovation.
This corresponds to energy savings of around € 18,000 per year. Because the cooling and UPS use significantly less energy, the EUE drops to 1.41, which amounts to a considerable reduction.

THE BUSINESS CASE

The measures outlined above are necessary to keep the server room operational for the next decade. However, with some additional investments it is possible is to be even more energy efficient and make considerable gains without compromising reliability. An important step is to separate the cold and warm air. As a result, existing systems can work more efficiently, but it also creates potential for new applications: the hot air is perfect for heating the office building in winter. This requires the following measures:

- The server racks are positioned in such a way that hot and cold aisles can be introduced. Additionally, In-Row-Coolers are used, so that the central air-handling unit is no longer needed. This increases the percentage of free cooling from 60 percent to 90 percent, because cooling can be obtained at a higher air temperature.

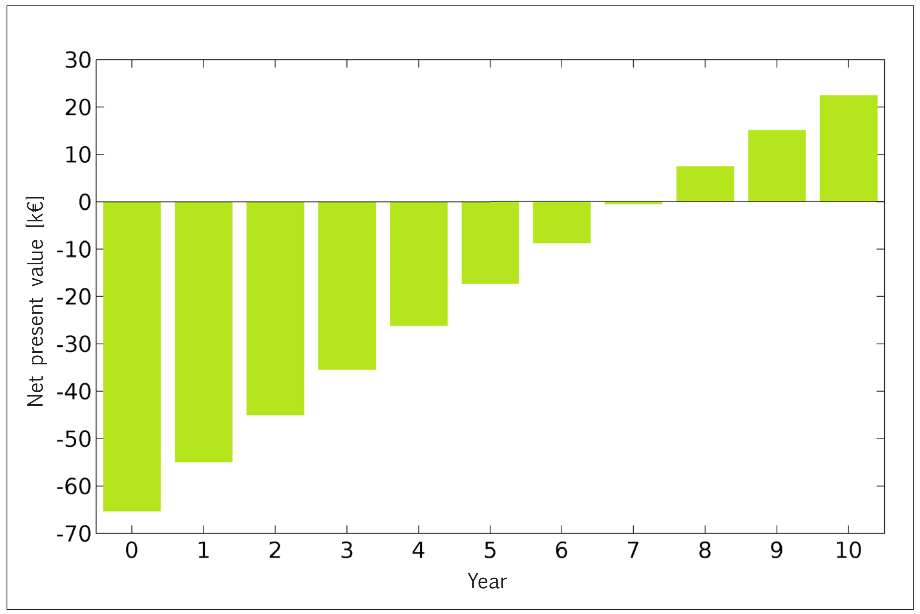




Distribution of energy use in the old situation (left), after renovation (center) and after applying the business case (right).

- The heat extracted from the hot aisle is diverted to the climate system of the offices. With this heat the ventilation air can be preheated for 150 days per year (heating season).

The measures require an additional investment of € 65,000, but create another 8 percent savings on electricity and 65 percent savings on gas consumption for the office area. Energy costs are thus decreased by another € 11,000 per year. The EUE drops to 1.30. The net present value of this business case with a lifespan of 10 years is € 22,500, at an energy price inflation rate of 4 percent per year and an internal rate of return of 8 percent.



Net present value of the business case.

Business case: Data center (small) in office building

As service companies expand their services, their server rooms may gradually evolve into data centers, which will house customer hardware in addition to their own machines. This increases electricity use, which means that the installation that provides power and cooling has to be modified. Often, extra space is also needed in order to accommodate new equipment.

'Reuse of existing installation components is possible'

SITUATIONAL OVERVIEW

About five years ago, an owner and operator of a fiber optic network moved to a new office because of the growth of the company. The new office building looked promising to the company. Not only because of the increasing number of workplaces the company needed to accommodate, but also because of its expansion plans for the data center. In the meantime, the growth of the company has resulted in maximum capacity utilization of the installations that provide the data center with cooling and power and their data center is now full. To enable expansion with a second data center, extra floor space is required. The expansion of the data center will be used as an opportunity to adapt the current refrigeration equipment.

Currently there are 50 racks in the data center with an ICT power output of approximately 50 kW, TIER II/III, which requires a UPS system of 80 kW. In the data center, there are four air-handling units (crack units) that receive cold water through the central cooling system of the building. The cold water is produced by an approximately ten-year-old compression cooler, which has no provision for free cooling. This system also provides cooling for the office building. The annual average SPF (Seasonal Performance Factor) of this machine is 2. Furthermore, the existing data center is not equipped with enclosed hot and cold aisles.

The data center uses approximately 850,000 kWh per year in electricity. Of this amount, 52 percent is attributable to the IT equipment itself, 37 percent to refrigeration and air conditioning, 8 percent to losses in the UPS and 3 percent to other issues such as lighting. The EUE of the data center thus comes to 1.93. The electricity costs for the data center are 0,09 €/kWh so the annual bill for the data center is over € 76,000 or € 760 per square meter of the data center per year.

THE RENOVATION

The current data center is nearing the limits of the maximum cooling and electrical capacity. The whole floor space is used up as well. It is obvious that the facilities need to be extended and updated.

The facilities in the existing data center will be renovated or replaced and a second, identical space will be added. This renovation will lead to a doubling of the cooling capacity and power supply. The following measures will be introduced:

- Two separate traditional chillers are to be purchased, but without free cooling. Each machine has sufficient capacity to supply cooling to one area of the data center. In the event of a calamity, the existing cold generation of the office (N +1) can be used. The new chillers have an SPF of 2.5.
- The existing air handling units are reused and new, modern air handling units are purchased for the new space.
- For the extension a new modern UPS system is installed, with high efficiency at partial load.
- The current racks are recycled and 50 new racks are purchased for the new space. Separated hot/cold aisles are also created in this space.

The investment costs for these measures amount to approximately € 270,000. These are necessary investments to keep the current space in operation and at the same time double the floor surface and, hence, the capacity. The above measures are the minimum steps required to achieve these improvements. Continuing the business on tha basis of the current situation would endanger

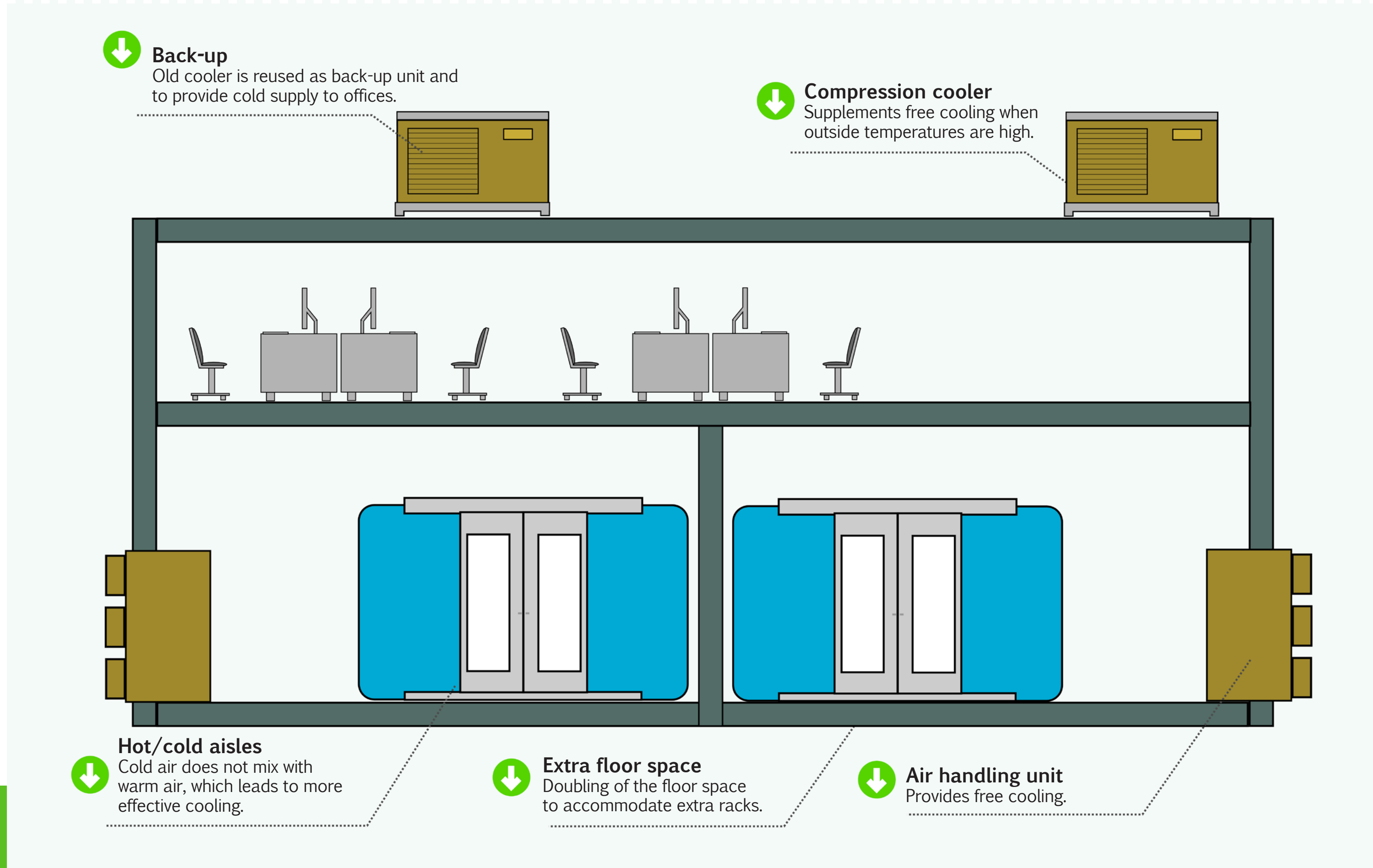
PHOTOGRAPHS:
ICT-ROOM

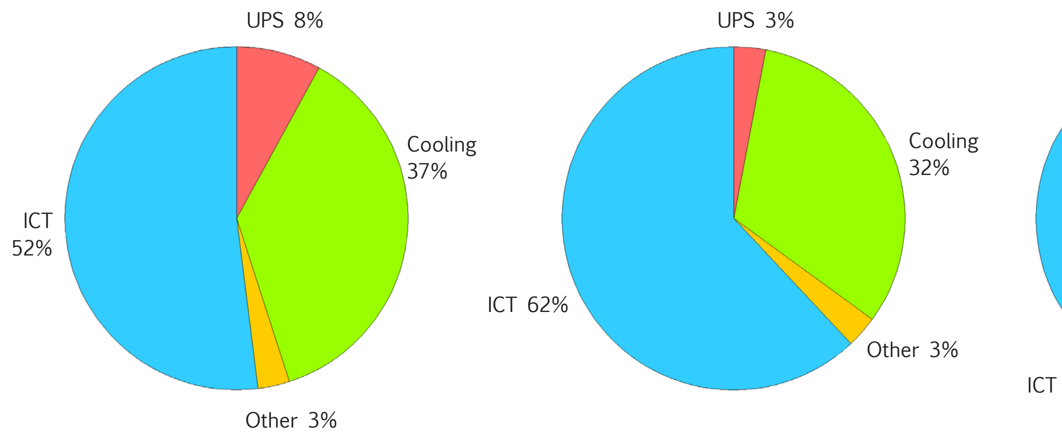
business operations. In comparison with a situation in which the second data center would have an installation similar to the current one, the above measures would result in an energy cost reduction of approximately € 25.000 per year - a savings rate of more than 32 percent compared to the existing situation. The renewed cooling, air handling units and UPS will reduce the EUE from 1.93 to 1.62.

THE BUSINESS CASE

The above measures are the minimum required for the business to be able to continue to grow in the coming years. However, with some additional investments, a lot more energy can be saved without compromising reliability. The use of free cooling is the starting point. Both of the areas where the servers are installed have an advantage: they are adjacent to the outside air.

This makes it possible to place integrated air-handling units (=air handlers that also provide the cold supply) along the outer walls of the room. These air handling units use cold outside air for cooling when the outdoor temperature is low enough. When it gets warmer, a compression cooler in the unit will supplement the cooling requirement, and at very high outside temperatures it will take over the cooling task completely. This will, however, require structural modifications. Some of the windows will have to be removed and provided with grids so that outside air can be drawn in and blown out.





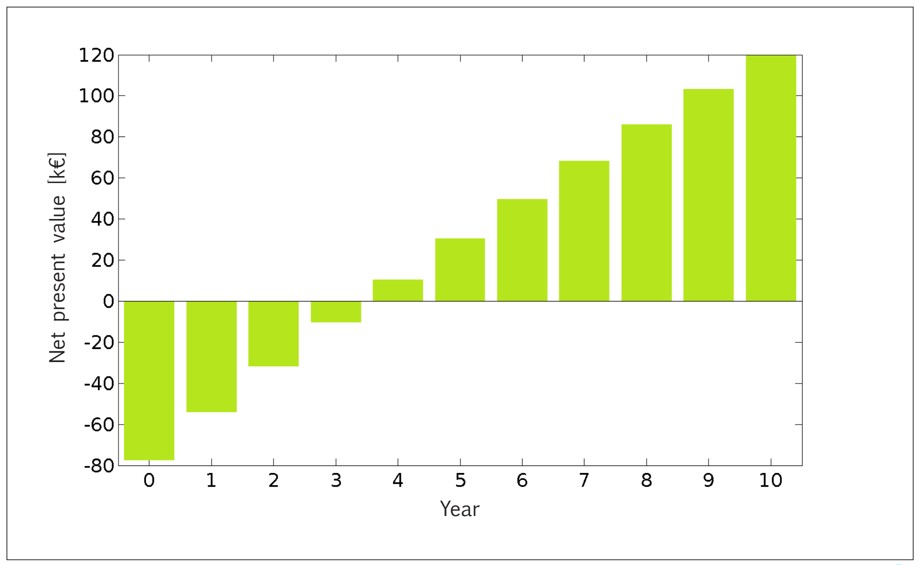
Distribution of energy use in the old situation (left), after renovation (center) and after applying the business case (right).

For this business case the following measures need to be introduced:

- Instead of two separate traditional chillers and air handling units, integrated air handling units are installed in both spaces. With these, free cooling can be achieved for 90 percent of the time. As a backup cooling system, the existing cooling system of the office building can be used.

These measures require an additional investment of approximately € 78,000 but will save another 20 percent of energy, which means an energy costs reduction of more than € 25.000 per year. The EUE will decrease to 1.3.

The net present value of this business case over a lifetime of 10 years is € 120,000, at an energy price inflation rate of 4 percent per year and an internal return rate of 8 percent.



Net present value of the business case.

Business case: Small data center

Renovations do not exclusively involve the installations around the ICT hardware. The hardware itself can also be made more energy efficient. Most of the time, much of the hardware is operating at partial load. For example, a website for Dutch customers is hardly visited during the night. The server has nothing to do, but is switched on and uses a lot of energy. Through virtualization, the number of servers, and consequently the energy bill, can be reduced.

'ICT hardware itself can also be made more energy efficient'

SITUATION OVERVIEW

A 4 year old medium sized data center that hosts its own services has done well for itself. The 160 server racks that take up 500 square meters of floor space, are packed with 1-unit servers, which brings the ICT capacity to approximately 6kVA per rack. The total ICT energy consumption is approximately 1 MW.

Because the data center is relatively up-to-date, a lot has already been done to save energy in the ICT supporting installations. Thanks to hot and cold aisles in combination with in-row coolers, the cooling demand is limited. Compression chillers provide free cooling but the compressors are only required 20 percent of the time. The UPS is a modern modular unit with an efficiency of 90 percent at the given partial load. All in all, this data center has a respectable EUE of 1.42. The installations are all modularly constructed and can scale with the ICT hardware demand.

The current electricity price at this data center is € 0.07 perkWh.

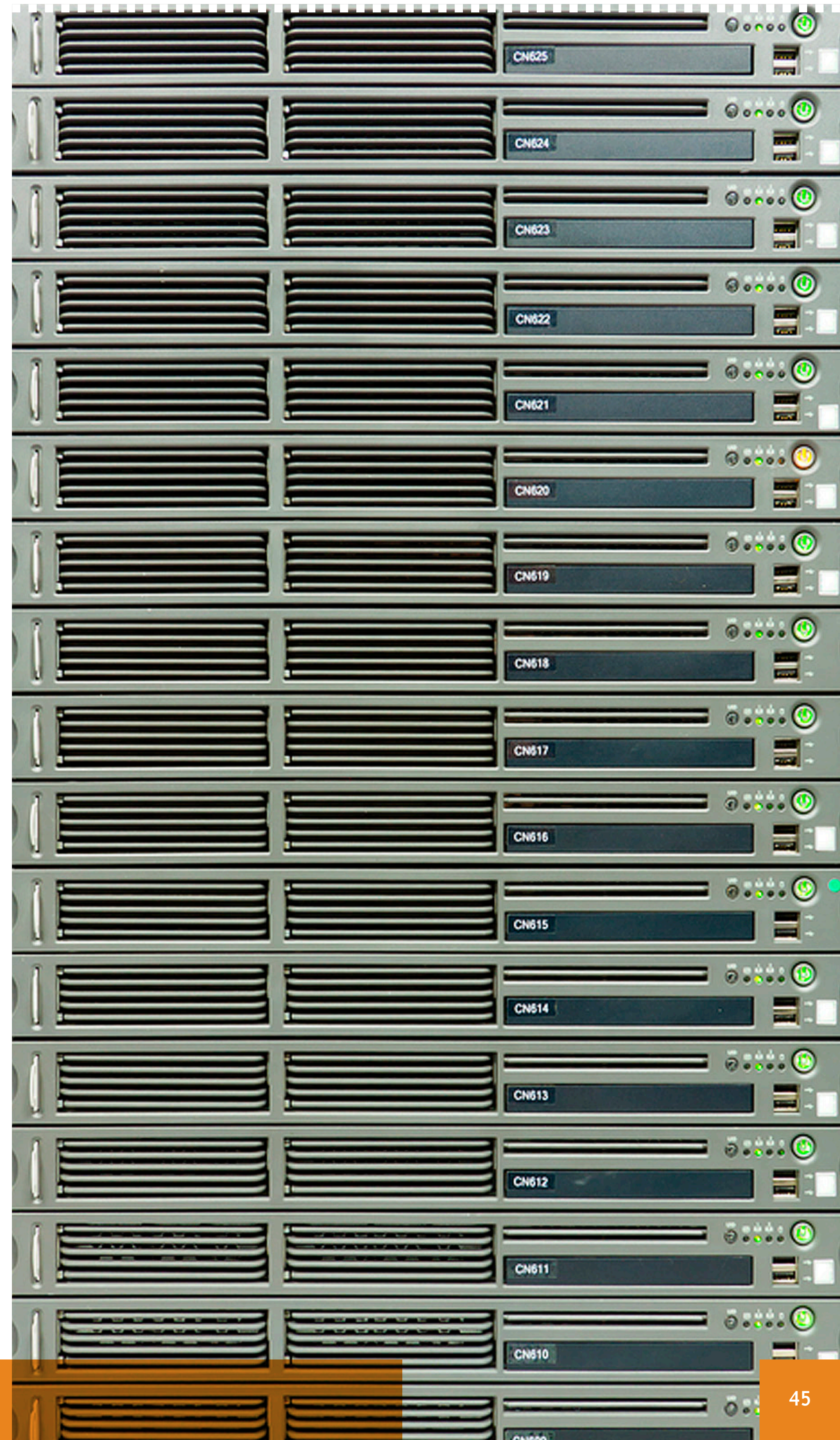
THE RENOVATION

The 4 year old servers are approaching the end of their life-cycle. Each rack contains 42 single unit servers, 40 of which are operational. The remaining 2 are used as backup. The cost of replacing all servers in one rack by equivalent hardware is € 63,000. Energy consumption will remain unchanged at about 150 watts per server.

THE BUSINESS CASE

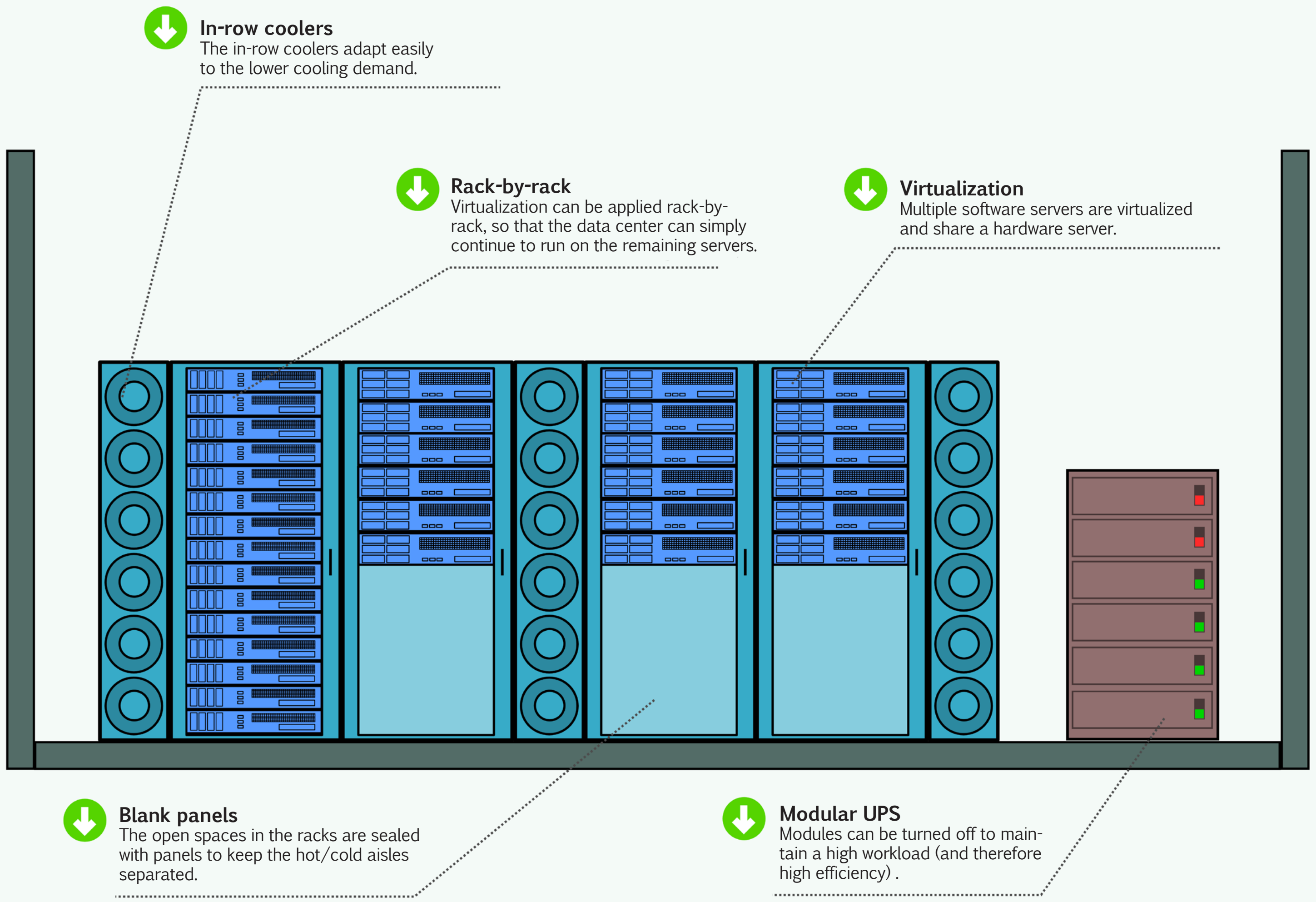
Much of the time the servers are running almost at minimal load. However, even when a server is idle, it still uses a lot of energy. When running completely idle, servers still use 140 watts each, while at maximum power the consumption is 190 watts per server. By no longer mapping one piece of hardware to each server but by making them share hardware, the number of hardware servers can be reduced. The virtualization of servers does not affect their functionality. The servers remain separate from each other, but share the same hardware. Everything is controlled by virtualization software.

This business case is based on the assumption that 8 1U-servers can run virtually on one more powerful 2U server. For one rack five new servers are needed, plus one extra as a spare. The more powerful server has a higher workload and an average consumption rate

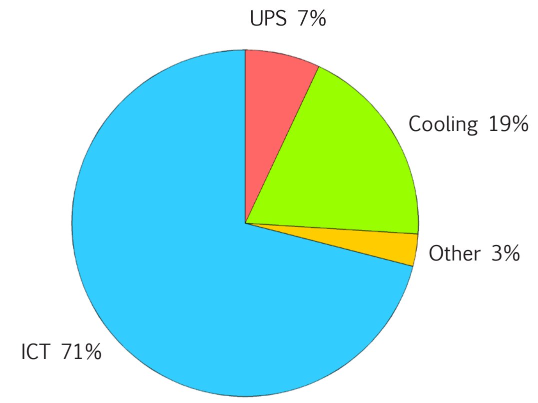


of about 375 watts. The six new servers together cost € 54,000. Furthermore, the licensing fee for the virtualization software is about € 15,000. This brings the total additional investment per rack to € 6,000.

In addition to the energy savings of 35,000 kWh/year per rack, there are proportional savings to be made in the amount of cooling, since less heat will need to be evacuated. A number of modules in the UPS will be turned off, which causes its efficiency to remain the same. Additionally, 30U will be available per rack for possible future expansion. As long as this open space is not yet filled with new servers, it is sealed with a panel to ensure optimal performance of the hot/cold aisles. Because all installations are proportionally scaled to the energy demand of the ICT equipment, the EUE remains unchanged at 1.42.

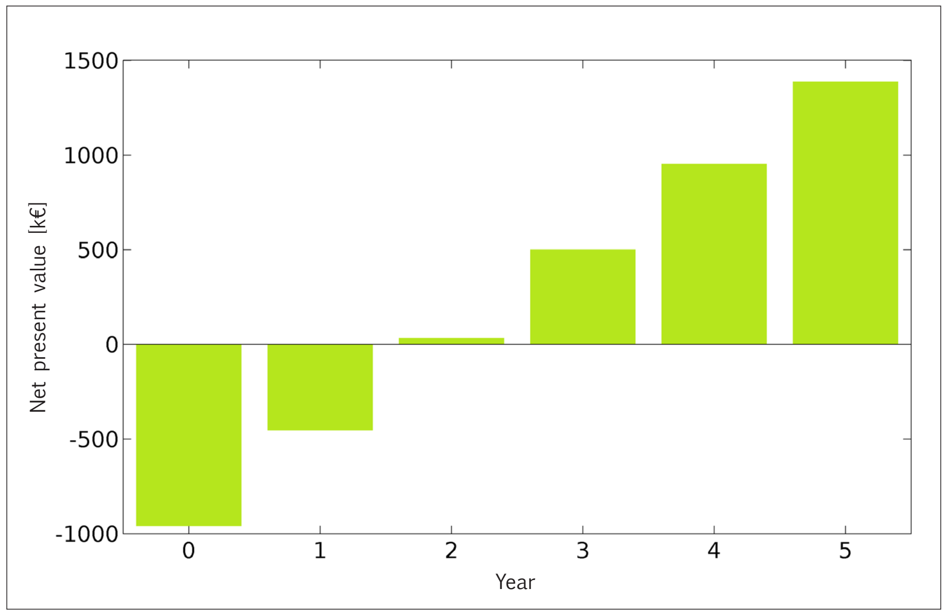


BUSINESS CASE
SMALL DATA CENTER

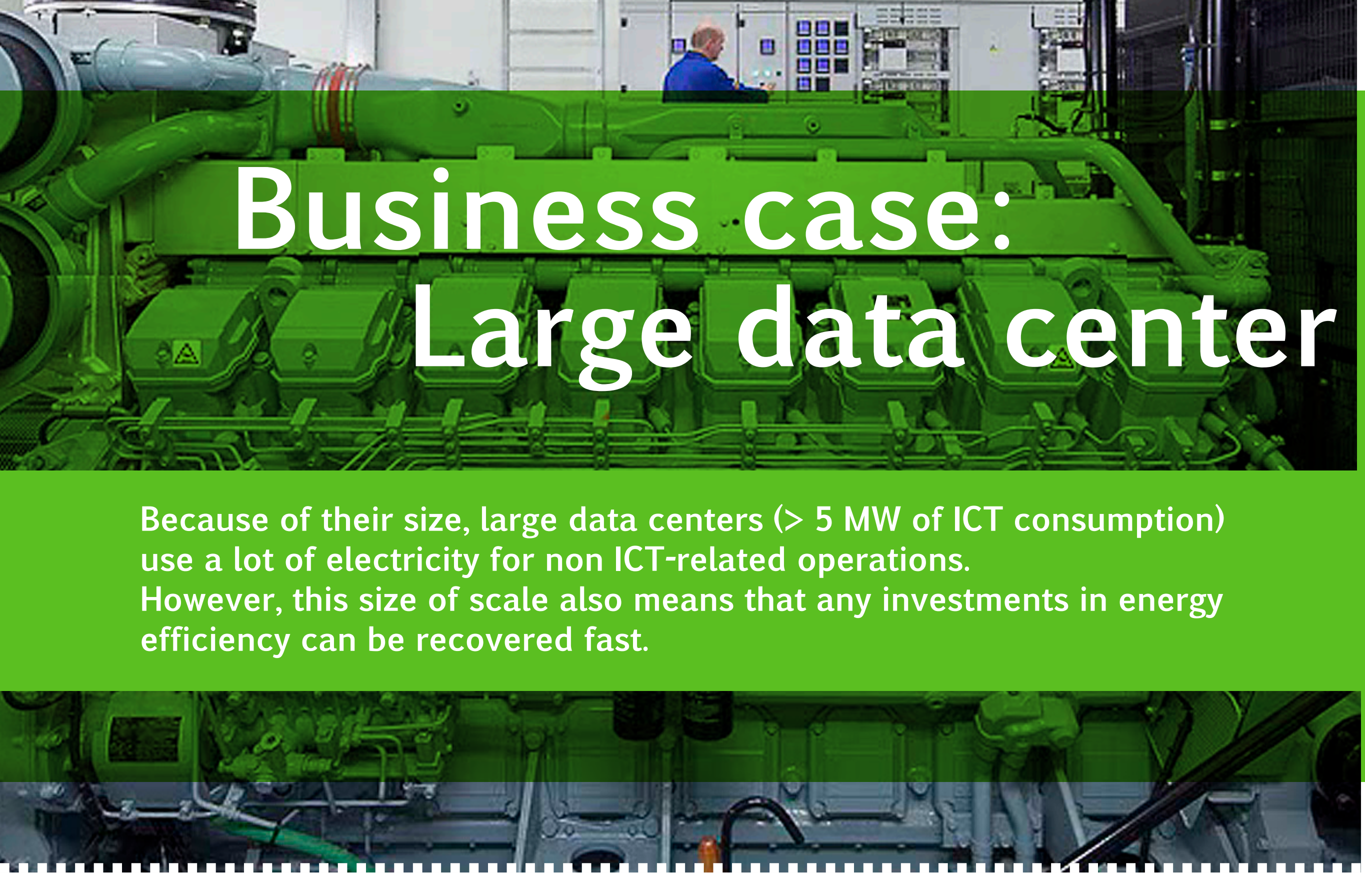


The percentage distribution of the energy consumption remains the same because the supporting installations are scaled to the reduction of the ICT energy demand.

The total additional investment for a virtualized server environment for 160 racks compared to standard 1U servers is about € 1 million. The annual energy savings amount to more than € 550,000. The net present value over a period of four years amounts to € 950,000, at an energy price increase of 4 percent per year and an internal interest rate of 8 per cent.



Net present value of the business case.



Business case: Large data center

Because of their size, large data centers (> 5 MW of ICT consumption) use a lot of electricity for non ICT-related operations. However, this size of scale also means that any investments in energy efficiency can be recovered fast.

'Hundred percent free cooling with hybrid dry cooler'

SITUATION OVERVIEW

A large TIER IV data center for housing (ICT hardware is owned by customers), covers an area of 9,000 square meters, containing 3.000 racks. The total ICT capacity is 7.2 MW. The data center is 8 years old and uses traditional compression cooling machines without free cooling. However, the positioning of the racks allowed hot and cold aisles to be created, which is why the average annual efficiency of the cooling machine has an SPF (Seasonal Performance Factor) of 2.5. The EUE of this data center is 1.79. The cooling and UPS systems are double redundant (2N). The current electricity price at this datacenter is € 0.06 per kWh.

THE RENOVATION

Both cooling and emergency power systems are approaching end of life and are being replaced in any case, to ensure the data center can remain operational for another 8 years. To this end, the most advanced and industry-accepted installations will be deployed:

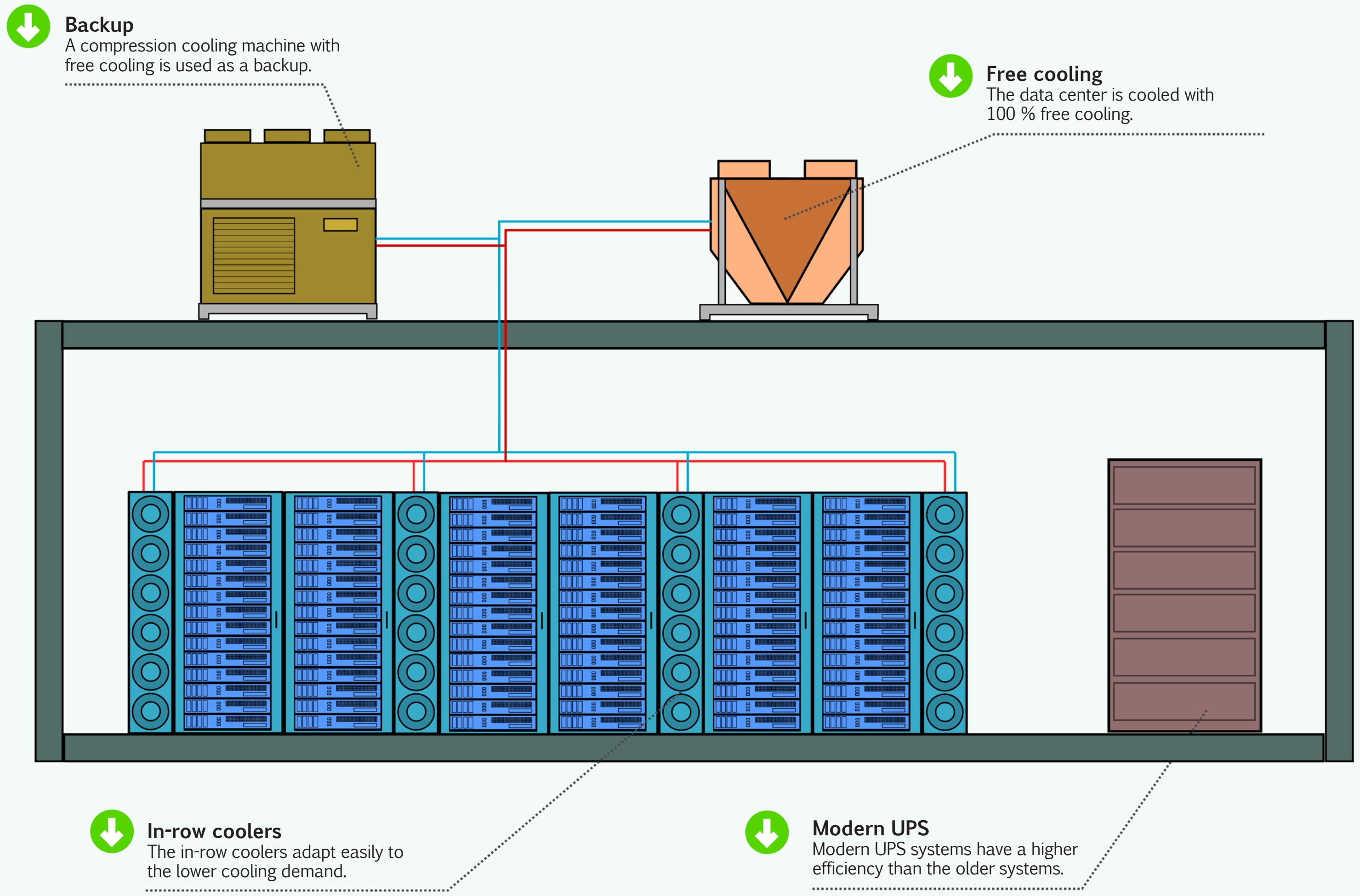
- Modern compression coolers with free cooling will replace the old cooling machines. 90 Percent of the time free cooling is used, with an SPF of 10. The compressors, which have an SPF of 2.5, are used for the remaining 10 percent.
- In-row coolers will be installed.

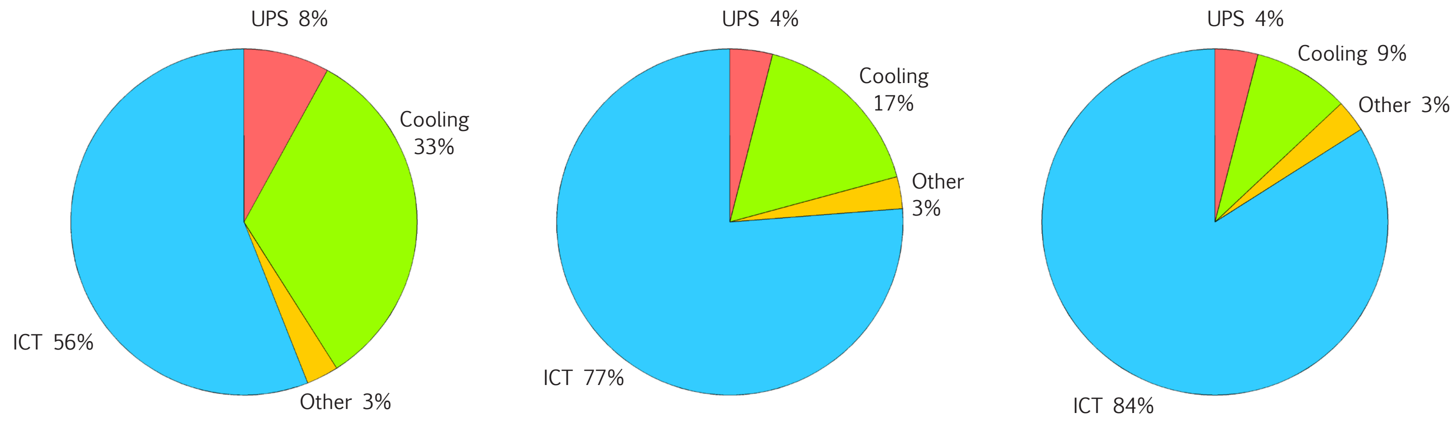
The UPS systems are replaced by an ultramodern modular variant with high efficiency at partial load.

The cost of the renovation is approximately € 18 million. As a result of the renovation, the energy consumption of the data center will, however, decrease by 16 percent. This means a cost reduction of about € 1.8 million per year. The EUE decreases to 1.30.

THE BUSINESS CASE

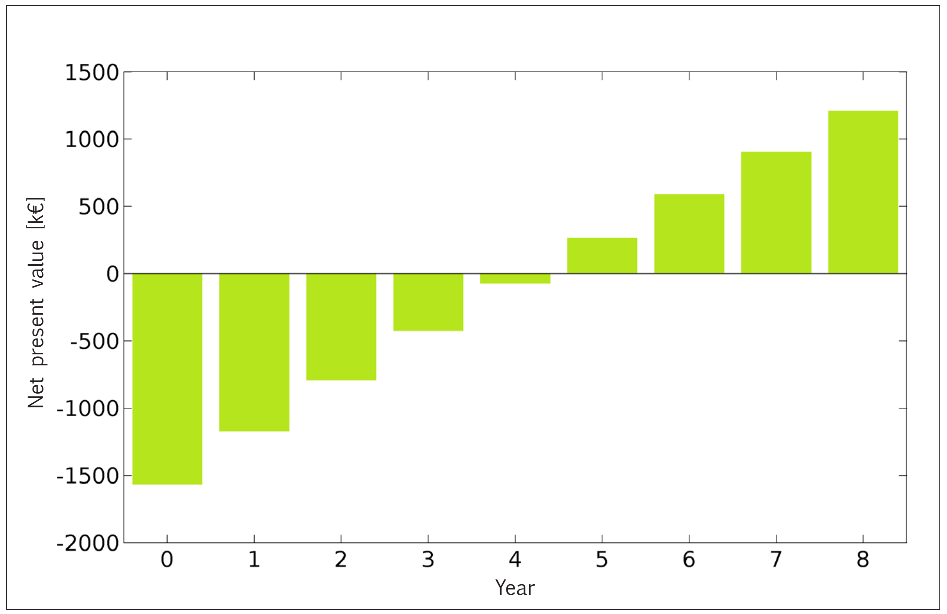
With an additional investment of approximately € 1.5 million, it is possible to use 98 percent of free cooling with a so-called hybrid dry cooler. This hybrid cooler has an SPF of about 28 and can run all year round. On hot summer days, water is vaporized to supply enough cool air. The number of compression cooling machines can therefore be halved. The remaining compression chiller is used as a backup.





Distribution of energy use in the old situation (left), after renovation (center) and after applying the business case (right).

This additional investment approximately provides another € 378,000 per year in electricity savings. The costs for the evaporation of water don't even amount to € 4,450 per year. The net present value over 8 years at 4 percent inflation and 8 percent internal rate of return is more than € 12 million. The EUE also decreases further to an impressive 1.2.



Net present value of the business case.

Consulted businesses, sources and initiatives

There are a lot of initiatives relating to the implementation of sustainable ICT and data centers. Both nationally and internationally, these initiatives are deployed by the ICT industry itself, by public authorities (including the EU) and by research agencies. Remarkably, many of these initiatives currently still focus on the sustainable design and construction of new buildings and we found no initiatives that focus solely on existing data centers and server rooms. Below is an overview of the key initiatives and sources that were used for this publication.

APPROACH

The research for this publication, and the publication itself, were carried out by EnergyGO at the request of the Consortium Green-IT Amsterdam Region. The EnergyGO team has extensive experience in the field of measurement systems in buildings and electric cars, the development and implementation of intelligent measurement and control strategies (Smart Grids) and independent energy consultation to governments and businesses. EnergyGO has broad expertise in the area of sustainability in the ICT sector.
The data and the documentation used for this publication include (parts of) various interviews and conversations held with representatives of data centers and equipment suppliers. In addition, several actual renovation projects of server rooms and data centers were investigated and used to support the business cases and the statistics referred to. Cost quotations or indications issued by providers and data centers have been made anonymous. Also, the case studies presented in this publication are based on real situations, but have been modified to ensure anonymity.

INFORMATION SOURCES

Code of Conduct
Initiative of the Joint Research Centre (EU). Code of conduct for ICT companies concerning energy and sustainability to which ICT companies can conform voluntarily. Aimed at data centers and power supply providers for ICT equipment.

Dutch Practice Guideline (NPR, NEN5313)
Initiative of the NEN, under development. Provides guidelines for the construction and installation of computer rooms and data centers.

ASHRAE (The American society for Heating, Refrigerating and Air-conditioning Engineers)
Provides guidelines for the design of technical facilities for computer rooms and data centers.

PrimeEnergyIT
PrimeEnergyIT supports the market-development of, and the demand for energy-efficient central ICT hardware and infrastructure.
www.efficientdatacenter.org

Eco-label for the cooling of Datacenters
Initiative from the industry and ICT sector to develop an Eco certificate for sustainable cooling of data centers.
The Eco-label ('Milieukeur') was launched in 2012. **www.smk.nl**

The Green Grid
Large joint international initiative with the purpose of sharing knowledge in a variety of areas including energy use and sustainability. **www.thegreengrid.org**

Sustainable cooling of data centers
AgentschapNL, 2012
Information about sustainable cooling systems for computer rooms and how to deploy them.

Breeam-NL Data centres
Quality label for sustainable real estate objects. Assessment guidelines for new data centers.

Techniques for energyefficient new-build data centres, Results of desk study
Desk study of CE Delft.

Data centers and server rooms
Interxion, Delta Lloyd, Province of Noord-Brabant, KPN, Level3, Gemeente Amsterdam, UNET

Suppliers
RC-group/Verhulst, Rittal, Jaeggi, Intelectric, Minkels, York, Datacenter-Koeling, ICT Room Company BV

Explanation of the calculation methodology used in thebusiness cases can be found in: 'Energy-efficient redistribution of data centers'
http://www.greenitamsterdam.nl/green-deal-datacenter-business-cases

Colophon

COMMISSIONING BODIES

Foundation Consortium Green IT Amsterdam, Service Area Planning - City of Amsterdam with financial aid from the Ministry of Economic Affairs (Green Deal initiative: ICT/data centers).

Greenit amsterdam region

Gemeente Amsterdam
Dienst Ruimtelijke Ordening

Ministerie van Economische Zaken

MANY THANKS TO THE STEERING COMMITTEE MEMBERS

John Post and **Jaak Vlasveld:** Consortium Green IT Amsterdam

Jeroen van der Tang: Nederland ICT

Frank Hartkamp: AgentschapNL

Stef Le Fèvre, Tjeerd Stam and **Patrick Teunissen:** Gemeente Amsterdam

ENERGYGO

IMPLEMENTATION

Niels Sijpheer, Marcel Elswijk, Bart Roossien: Research, texts, illustrations and interviews

C&M Media, duurzaam tekstbureau: Text editing

JoStudio: Design and illustrations

Carlos Sanchez: Translation

MANY THANKS TO

Interxion, Delta Lloyd, Province of Noord-Brabant, KPN, UNET, ICT Room Company BV and **Intelectric** for their cooperation with the interviews.

Remco Hiestand at **Level 3 Datacenters** and **René Baars & Pieter van den Burg** at **ICT Room Company BV** for testing the business cases.

Minkels and **ICT Room Company BV** for providing photographic materials.

Thijs Wolzak for the photographs used in this publication.

TRANSLATION

Funding for english translation **Amsterdam Smart City**.

amsmarterdam city