InterNetX

GREEN PAPER

WHITEPAPER

HOW GREEN CAN DATA CENTERS BE?

INTERNETX.GREEN

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ENERGY CONSUMPTION AND SUSTAINABILITY **IN DATA CENTERS**

For IT professionals, this is hardly news: data centers form the backbone of the IT industry. For decades, data centers have been judged by their performance, but many companies are now breaking new ground: Eco-friendly or "green" data centers are setting a new sustainable direction that some operators are already embarking on. Combining performance, energy efficiency and ecological goals is no longer a utopian vision: the future belongs to the green data centers.

According to Radicati Group's Email Statistics Report, **215 billion emails** are transported through the networks every day. In doing so, they pass at least two servers, are being forwarded from router to router and from switch to switch, before finally reaching the addressee. The number of web pages accessed exceeds the number of emails sent by far, keeping an even larger number of computers and network devices busy. These systems need to be produced, powered and cooled – **a tremendous environmental burden** that consumers are often unaware of. With increasing global efforts to relieve the environment, there also is growing awareness that, in addition to cars and coal-fired power plants, data centers also offer a surprisingly large potential for saving valuable resources.

As a matter of course, we look up the fastest travel route, buy smartphones and refrigerators online – without ever having to enter a shop – and watch streamed tv series in the best UHD quality from the comfort of our own living room. In addition to private aspects, the Internet is probably **the most important medium for the economy, research and finance sectors**. Most users are unaware about the technical effort being made to make these services and websites work.

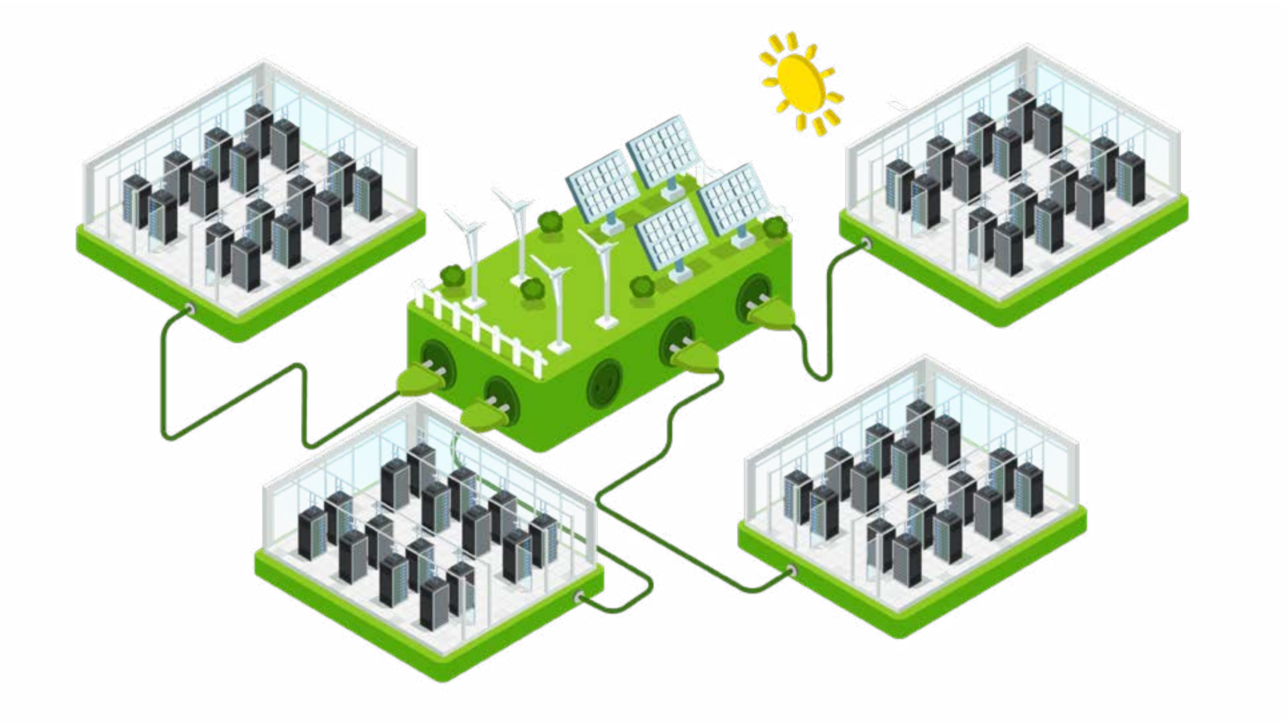
They focus on this topic only if they are about to launch their own website or if the press reported the inauguration of another large data center. Where data centers in the early days used to be rooms containing just a few servers, today's high-tech facilities are housing several thousand units and are many hectares in size. The need for computing capacity, disk space and data transfer is growing enormously – and the development of mobile services and the "Internet of Things" in companies is only just beginning.

The aspect of environmental friendliness is not new at this point: For 25 years, computer hardware has been equipped with logos and certificates that are intended to suggest to buyers that they are economical devices. The "Energy Star" is one example that still pops up for a moment on monitors today when powering them on. It signals that a device consumes less power in standby than it does during operation, and that it automatically enters that mode after some time of inactivity.

In order to market their energy and environmental properties, manufacturers use their own logos, which show less comparable values and describe only the general company philosophy. The value of these logos only becomes clear upon closer inspection. Besides the many general and rather nebulous promises, there are indeed clearly defined principles that focus on environmental protection and demonstrate verifiable and sustainable measures.

Previously, large figures were the most important marketing tool for data centers: Higher clock speeds, more memory, larger hard drives and faster transfers for ever less money were more important than an environmentally friendly manufacturing process or savings on energy consumption. For some time now, however, there has been a change in priorities. **Customers now value low energy consumption, longevity and environmentally conscious processes when choosing their manufacturers and operators**. Ecologically thought-out concepts are no longer a bonus, but elementary features of products that are demanded by the customer and therefore need to be implemented and promoted.

THE ESSENTIAL QUESTION
CAN HARDWARE BE GREEN?



Most data centers use commonly accessible hardware. Depending on the setting and preferences of the operator, there are differences in form and design, but in the end the hardware used is quite similar: standard CPUs from Intel or AMD in addition to standard memory bars on standard boards of more or less well-known mass manufactures.

Selecting these components alone can mean a difference of 50 watts, given the same computing power. Differences of this scope quickly add up to more than 400 kilowatt hours per year – for each individual server, mind you. With these 400 kWh a person could take warm showers for a whole year.

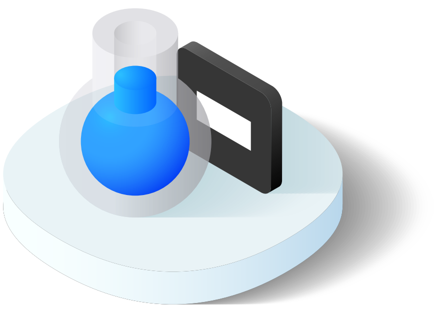
InterNetX uses Dell EMC servers that have a much longer life span than those of comparable providers.
Hard disks and SSDs have less headroom, but contribute significantly to the energy balance of a device. Hard drives require more power and cooling than SSDs, but are cheaper, store significantly more data and reach a long service life depending on how they are used. Furthermore, modern components are much less temperature-sensitive and can be operated stably in warmer environments. This reduces not only the direct internal consumption but also the need for cooling capacity.

For the efficient operation of a data center, it is essential to **use state-of-the-art hardware**. Old, inefficient components should be identified and replaced with new ones that are more ernery efficient – a continuous process which ensures that energy is not unnecessarily wasted.

Old hardware should not simply be disposed of, because the life expectancy often is an underestimated part of the overall balance. Hard-to-obtain “rare earths” are needed for the production of memory, processors or other system components, in addition to low-cost materials such as silicon – and sheer incredible amounts of water and energy. When a system can no longer be used efficiently as a server, it makes sense to allocate it to other tasks that are less burdensome. The internal reuse or recycling after an energy audit is therefore quite reasonable from an ecological and economic point of view.

HEAT AND HUMIDITY
ENEMIES OF THE SERVER

A computer center houses hundreds or thousands of devices whose waste heat must be dissipated reliably and as environmentally friendly as possible. It is important to find the balance between heat transport and energy expenditure. The higher the ambient temperature in which a server is operated, the higher the probability of a defect. For a long lifespan and good profitability, the temperature must stay within a defined range, ideally room temperature. The further the temperature of a room has to be lowered, the more energy needs to be expended.



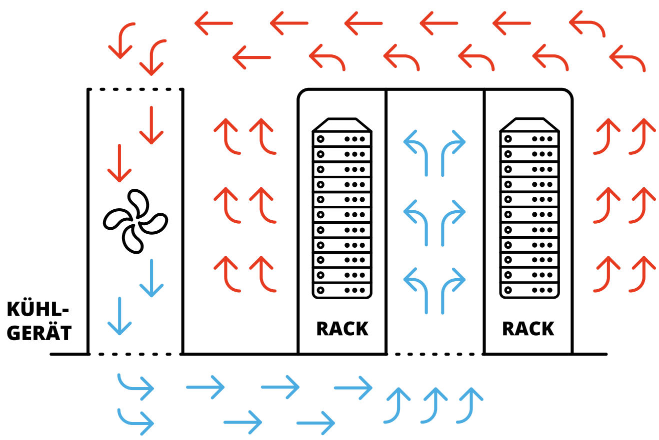
Conventional **cooling units** use coolants and compressors to create cool air that is pumped into the server rooms – amazingly efficient these days. This is made possible by sophisticated refrigerants that replace the previously used CFCs. These modern refrigerants no longer have ozone layer-hostile properties, but they still cause greenhouse gases that contribute to global warming.

Structural measures can significantly increase the effectiveness of an air conditioning system. Positioning the walls, pipes and server cabinets intelligently, ensures short distances through which the heat has to be transported. Water carries heat much better than air, which is why "open pipes" in server rooms are not uncommon. What works well in a home-built gaming PC also boosts cooling performance in the server rack, so server cabinets are often equipped with a network of water hoses and heat exchangers.

The **architecture of a data center** and the **building materials** used are also helpful in deriving heat from rooms with as little effort as possible. According to the chimney principle, an air flow is generated and the warm air is replaced by fresh air with very little energy input. However, not all environmentally friendly concepts of modern house construction can be applied to a computer center. Clay bricks contribute to a good indoor climate and are helpful in cooling, but stand in the way of fulfilling other important requirements for a secure server environment. Open windows certainly help with air conditioning, but are a bad argument when it comes to dust, humidity, insects, criminals and other things hostile to computers.

Lowering the temperature requires significantly more energy than keeping it constant at a low level. In addition, the devices work better if the environmental conditions do not change. Modern cooling concepts provide for the separation of areas with cooled and non-cooled air, so that only the inside of the server racks is actually air-conditioned and not the rooms in which they stand.

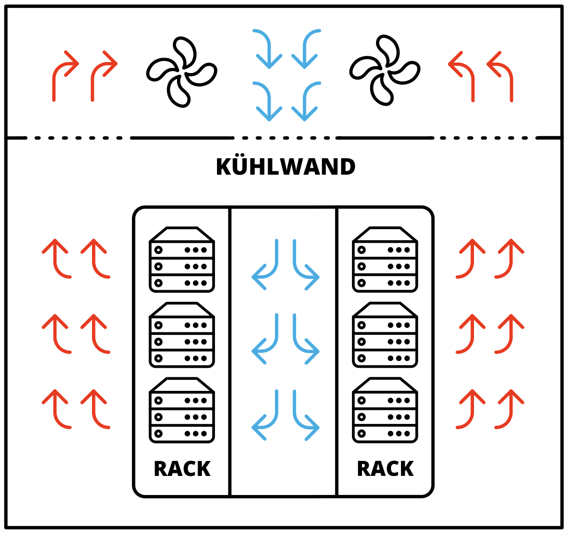
So, it is not quite as cold in the InterNetX data center as one might expect. The concept of **cold aisle containment** means that the cold air flows through the servers, constantly cooling and ejecting waste heat into the data center. The air volume that needs to be cooled drops dramatically and temperature fluctuations in the air have almost no influence on the cooled systems. This also saves energy because the area that needs to be cooled is significantly smaller.



Cold Aisle Containment (cross-section)

But heat is not the only energy problem: in addition to the **temperature**, **humidity** has an influence on the operation and the life expectancy of devices. Wherever mechanical things move, such as the myriad of small fans, dust also plays a role. Depending on the requirements, the cleanliness has to be kept at laboratory levels. Moisture and dust are removed from the air through air conditioning and filter systems. The best and simplest strategy to minimize this effort is to keep the air as dry and dust-free as possible from the outset. Therefore, **airlocks** and similar structural measures are instrumental in not wasting energy to get rid of heat, moisture and dust brought in by people entering.

The InterNetX data center can save even more energy by using a room height almost three-times the average: The waste heat rises and can be drained from there without it affecting the devices on the ground. In addition, maintenance work on the cooling system does not require maintenance on the data center area. **Cooling units**, which are located in the so-called "**CoolWalls®**", cool the air, which is then routed back down to the servers.



CoolW@ll® (top view)

In so-called **serverhousing**, often known as **colocation**, the data center provides only the space and the technical connection, while the customer operates his own hardware and uses only the premises of the data center. This is particularly interesting for customers who use very specialized servers – Macs for example – or for those who want to have full control over the hardware for security reasons. For this reason, separate areas are often provided for server housing. Here a more flexible climate control is operated, but at the expense of a higher energy expenditure.

THE SOFTWARE SHOULD ALSO **BE EXAMINED MORE CLOSELY**

Probably the most effective way to save energy for cooling is not to consume it in the form of heat in the first place. That computer hardware generates heat when operating is a side effect of the built-in transistors. The more these switch between their states, the more energy is consumed on the one hand for the desired calculations and on the other hand in the form of unwanted heat.

A high **clock frequency** therefore always entails a high loss of energy due to unwanted heat. In order for the transistors in chips to operate reliably at high clock frequencies, the applied voltage must also continue to rise, which in turn leads to an increased heat output.

In special laboratory environments, clock speeds of 10 GHz and more can be achieved with the help of complex cooling systems. While the computing power grows linearly, doubling at twice the clock frequency, the loss in the form of heat and electricity grows exponentially. From an ecological point of view, it is devastating.

The clock frequency is a good measure of how fast a processor can perform its calculations. But it does not express how efficiently one or all of the calculations are carried out. Many tasks consist of countless smaller subtasks that can be done independently. This is why in recent years chips have been developed and used that apply several slower processing units instead of a single one that is extremely fast. These CPU cores are complete processors that share the remaining resources in the server.

This “trick” ensures that both performance and losses grow in a linear fashion. In addition, parallel tasks are indeed processed in parallel, so the actual achieved speed can be even faster depending on the program running.

Whether a few very fast CPU cores or several slower ones form the optimal basis depends on the specific requirements of the hardware. Customers do not always know these backgrounds or cannot estimate the technical requirements well enough. Advance consultation helps to determine the most technically suitable solution for the client with the greatest possible environmental compatibility. This does not only leave the customer with a good feeling – the environment will be grateful as well.

For programs to benefit from the concept of multiple CPU cores, they must be specially designed with them in mind. This is a challenging task for programmers. **Updates to software packages** and **operating systems** often include improvements in handling the cores and the remaining system resources. From an ecological point of view, it therefore makes sense to always use up-to-date software.

But there are other reasons for taking a closer look at the software used. Computers have the ability to decelerate or even shut down some components when they are not or rarely needed. As a server waits for the next task, large portions of the CPU, memory, and the data storage are turned off. These power-saving mechanisms are designed so that the components can either be reactivated quickly or consume almost no energy. If a device is powered down too deeply, it consumes no energy, but takes a long time to get back to the operating mode. It is the task of the **operating system** and **the firmware** of the hardware to find the right balance. Old software that may not even have been designed with the power-saving features of the hardware in mind, will waste valuable processing power as well as energy.

THE OPTIMAL UTILIZATION AND CONTAINER **AS PART OF THE SOLUTION**

The utilization of servers is subject to large temporal fluctuations. For example, during the daytime, a company's email server handles messages almost uninterruptedly, while at night it has virtually nothing to do. In addition, different subsystems have different requirements: Some require more memory, others more processing power.

To optimally utilize existing hardware, the concept of **containers** is being applied. A server runs several independent environments. These can belong to different customers or fulfill different tasks. This utilizes the existing hardware better, because the work of two or more servers is done on one device. On the other hand, these containers can be quickly moved to more powerful hardware when needed. If the requirement of a container increases, it can be run on a more powerful machine for the period of greater demand. Alternatively, several instances of the same container can be started, which can then be switched off again as soon as the load drops.

This has advantages for both the data center operator and the customer. The customer has flexible access to virtually unlimited performance, but only pays for the resources actually consumed. At the same time, the data center can ensure a balanced utilization of its resources. Colloquially, this concept is referred to as **cloud computing**: The internal structure of this "cloud" is not visible from the outside.

From an ecological point of view, **cloud computing** makes definitely sense. Rather than building an infrastructure consisting of servers, networks and services, an existing one is rented and then digitally tailored to your specific requirements. The most popular providers Amazon Web Services and Microsoft Azure represent virtually all imaginable services and together operate an estimated 2.5 million servers.

Although InterNetX does not quite reach this impressive number, it can provide individualized service, highest security standards and often more predictable costs.

SECURITY IN THE DATA CENTER
AN ABSOLUTE MUST-HAVE

If you compare the performance of today's computers with those of 20 years ago, you'd expect every task to be done in fractions of a second. Experience shows, however, that the perceived speed has not increased to the same degree. During the same period, the demands and data volumes have grown enormously as well. 20 years ago, a well visited web server might have delivered 20,000 page requests per day – today that's the burden of a moderately busy system in a single hour. In addition to the number of users, the type of data and how it is transported has changed dramatically.

Web pages are no longer static HTML files consisting of plain text and a few pictures. Rather, they are assembled with the help of databases, loaded content from other servers, images and videos transformed in real time and encrypted with SSL. Emails are no longer just plain text, but can contain images and complex presentations. The ease of access and the considerable gain in convenience offered by the use of digital devices also brings a number of problems.

Malware, formerly transmitted almost exclusively through passing on infected floppy disks, now spreads automatically over networks. The effort to identify and ward off such dangers has increased dramatically in recent years. In addition to **virus scanners**, which examine files transparently and automatically, emails must be scanned for dubious advertising offers.

The recent emergence of **denial-of-service attacks (DDoS)**, are causing a huge load on the targeted servers, which, in addition to the economic damage suffered by the operator, is reflected in an equally enormous waste of energy. The data center infrastructure therefore carries an ever-greater responsibility in the defense against such attacks.

On the one hand, effective protection is of course in the interest of the customer, who wants to know his servers in safety. On the other hand it lowers the costs of energy, cooling, data transport and unnecessary support – all expenses that should be avoided in terms of environmental protection. Of course, firewalls, intrusion detection systems and virus scanners also consume resources. However, it is much more efficient to do these tasks centrally for many servers at once, instead of thousands of times in many different places.
Protecting the transported data from being viewed by third parties is not only an important issue in the business environment. Ever since the leaks of Edward Snowden revealed that intelligence agencies can actually store and evaluate nearly every bit transmitted in unencrypted form, the importance of encrypting data has increased dramatically. But effective encryption is by no means an easy feat.

The generation of keys and the actual ciphering, despite relatively simple mathematical operations, is very expensive and increases the load on the processors. The quality of the protection depends mainly on the **length of the key** used. If it is too short, it can be "guessed" by trial and error, if it is too long, the effort becomes so great that even opening a website becomes a test of patience. A remedy at this point – at least partially – comes in the form of special circuits that are integrated into modern processors. They have important algorithms built in, such as **RSA** (attributed to Ron Rivest, Adi Shamir and Leonard Adleman) or **AES** (Advanced Encryption Standard) and do not have to use the much more universal but inefficient calculators.

Unfortunately, the protocols on which the Internet is based have been designed completely devoid of security mechanisms. IPv4 does not provide encryption or authentication – every form of such application has to be laboriously mapped through multiple layers of transmitted data. The new version of the protocol, **IPv6**, has this feature built in directly. **VPN connections** and other modern protocols such as **HTTP/2** use the existing resources significantly more economical.

MAKING DATA CENTER
GREENER WITH ECO POWER

Despite all the optimizations, data centers – including "green" ones – consume a lot of energy, of course. The simplest and most effective way to use electricity efficiently is for the data center operator to tackle the problem directly. Operators of green data centers sometimes use the possibility of supplying energy through self-produced solar power. Choosing the location based on the number of sunshine hours throughout the year plays an important role. Some energy concepts rely on the coupling of solar systems to electricity storage and thus partially on the decentralized energy supply. But the proportion of self-produced energy can only cover the power requirements partially.

However, data center operators must be able to guarantee their customers a stable power supply and usability and therefore have to rely on conventional electricity from the grid and other suppliers. Meanwhile, there are many cheap eco-electricity suppliers, which ensure a good balance of operations even with high power consumption.

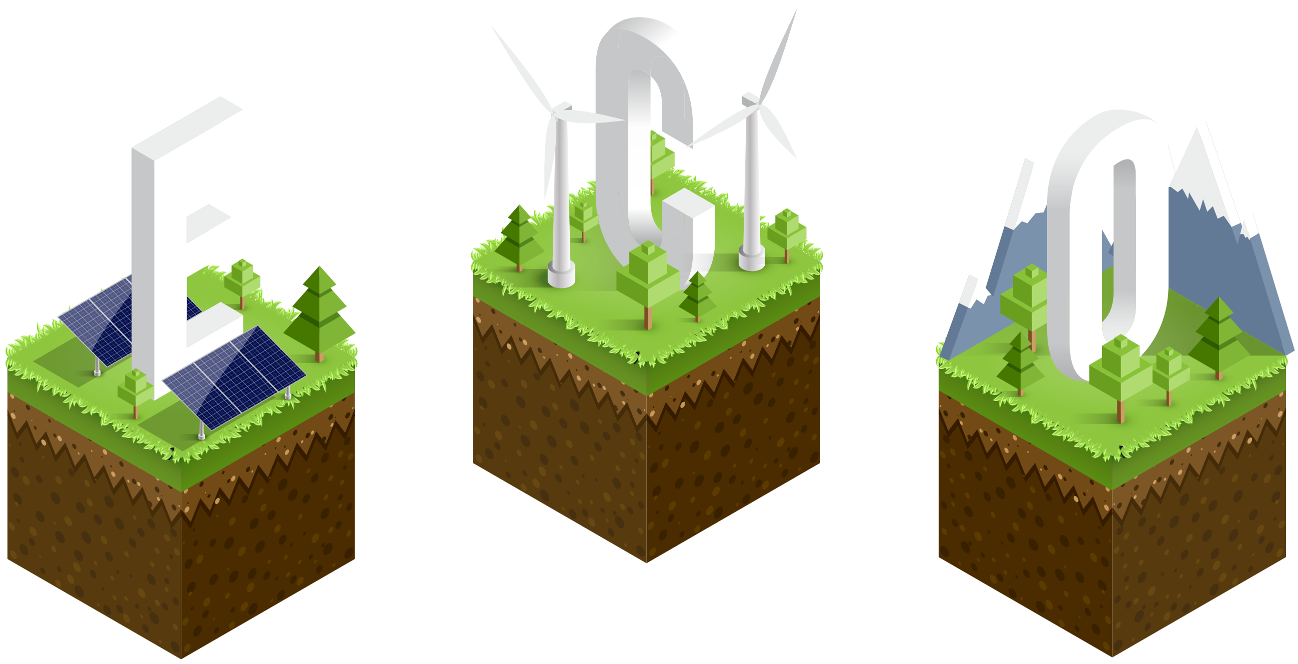
WHAT COULD THE FUTURE LOOK LIKE?

The need for green data centers, servers and computing capacity will continue to grow over the next few years, presenting many providers and businesses with new challenges. Customers and consumers see companies as responsible for actively promoting environmental protection. Moving to a green data center can not only help companies meet the needs of the market, but also have a positive impact on their brand and image.

The optimal design of a green data center, the maintenance of the servers and the efficient use of existing hardware can help to reduce consumption and environmental impact. In addition, the use of electricity from renewables is a new opportunity to improve the energy balance. As a company in a modern, future-oriented industry, it is also important to lead by example – despite some higher costs per kWh. Smart energy monitoring across all components and throughout the data center building can help recoup these costs.

In the future, data centers should use only green energy and systems should be designed to work in an environmentally friendly manner.

Let us create this future together.



THE INTERNETX DATA CENTER

Energy is generated on the roof of the data center during the 1,777 hours of sunshine per year.

The thermals on the roof of the data center are used to cool the equipment.

Additional energy needs are satisfied entirely from hydropower.

Thanks to cold-aisle containment the air volume that needs to be cooled decreases.

We use Dell EMC servers with a long service life.

Thanks to a threefold room height, the waste heat rises without affecting the devices.

ix.biz/datacenter

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