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LEAN, CLEAN & GREEN

Deerns Consulting Engineers

Three Steps To Perfectly Green

By Wouter M. Kok, Manager, Cleanroom, Laboratory, and Data Center Department

Deerns leads the way in making data centers greener, by reducing the amount of energy needed for cooling by an impressive 80 percent.

It's a well-known fact: data centers use enormous amounts of energy. Apart from the energy used by computers, an almost equal amount is used by the infrastructure of the data center, particularly for cooling purposes. Often, this secondary energy use is over 90 percent compared with the primary energy used by the servers. In other words, an overall power usage efficiency (PUE) of 1.9.

As a first step, tuning the traditional data center infrastructure for free cooling and energy efficiency has led to some 25 percent less cooling energy usage, leading to a PUE of 1.7 or, in specific data centers, 1.5. Obviously, much more needs to be done to reach the goal of greener data centers.

Recently, Deerns has developed the second step by designing smart "add-ons" to the data center infrastructure. This has resulted in an additional 50 percent reduction in cooling energy, leading to PUEs of 1.35 to 1.26. Taking advantage of lower air temperatures that occur during nights and winters, Deerns designed a number of innovative systems such as aquifers and surface water to store this surplus cold.

Deerns has now identified a third step and is shaping the next generation of data centers. Deerns" GC-DC© (Green Cooling for Data Centers) system combines a number of advantages:

- Eliminating 80 percent of "standard" cooling infrastructure, leading to an additional 50 percent saving on cooling energy (as compared to step 2) and a PUE of 1.15
- Combining simple, proven technologies with this new concept leads to excellent reliability and availability
- Investment costs are below "traditional" data centers, leading to zero pay-back periods
- Modularization leads to increased phasing of the investments for the entire cooling infrastructure: pay-as-you-grow has been made possible, with short realization times
- Data centers no longer contain any liquids associated with cooling

Introduction

Some years ago, the IT sector was calling itself the most environmentally friendly branch in business. Since 2008, that statement is no longer heard. The IT sector, with a growth-rate of more than 20 percent per year, emits almost as much carbon dioxide ($CO_{2)}$ as the entire aviation sector. It is now time to turn the tide. Hence, everyone is talking about green data centers and what should be done.

Companies like AMD, Cisco, Microsoft, HP, Sun and Google have united in *The Green Grid*. One of the goals of this global organization is to promote energy-efficiency in data centers. In early 2008, *The Green Grid* reported that more than 150 organizations had already joined, including Deerns.

In this paper, Deerns elaborates on what has been done in recent years and what are the best options available for any data center developed in the near future. Deerns has identified three steps in the development towards the perfectly green data center.

The industry, however, is conservative when it comes to innovations that deviate from traditional infrastructure; operational reliability and safety are of paramount importance, just like the data center"s business model. Deerns fully acknowledges this and fulfills these demands: the "green improvements" improve reliability, safety, and the economics of a data center.

Three Steps To Green Data Centers

Deerns identifies three steps towards green data centers:

Step 1. Conventional data center infrastructure concepts, especially those for cooling, can be improved by tuning the infrastructure to minimize energy consumption through a total cost of ownership perspective. This generates a greener data center with less operational expenditures. The tuning to minimize energy consumption from a total cost of ownership perspective, basically optimizing the life cycle cost, is done integrally for the entire cooling system: the recirculation units, pumps, chillers, heat exchangers, and dry coolers or cooling towers. The improved energy consumption results in the ability to use higher outside air temperature for free cooling and a higher energy efficiency of individual components. (See Figure 1.)

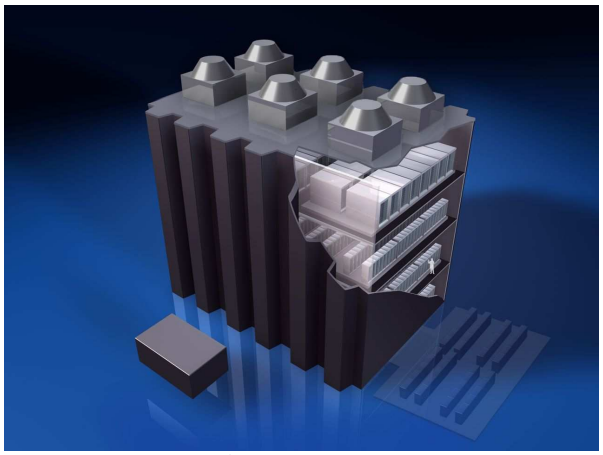

Figure 1. Conventional infrastructure

The total result is a reduction of 25 percent of the data center"s overall energy use: a PUE of approximately 1.7 to 1.5.[1] Step 1 thus leads to a small improvement in the total cost of ownership of the data center, while the reliability and availability remain unaffected.

Step 2. Once the basic cooling system is tuned to minimize energy consumption, the next step is to search for improvements in the efficiency of the energy that is used. One method through which this can be accomplished is the storing of "cooling energy" (e.g., cold water), maximizing the utilization of cheap cold air or cold surface water in relation to daily or seasonal fluctuations. (See Figure 2.)

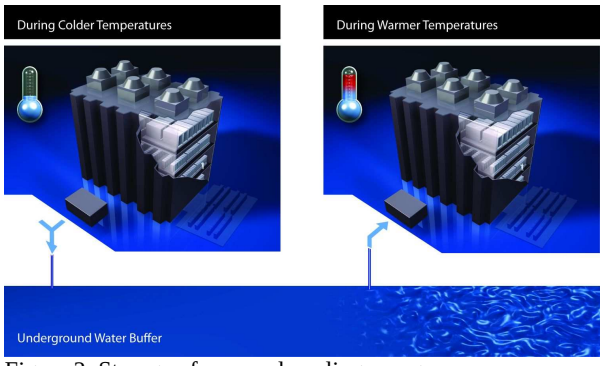

Figure 2: Storage of seasonal cooling energy

This has been done in a 6,500 m^2 (70,000 ft^2) data center for a corporate client in the Netherlands, using an aquifer to store cooling energy in winter and during the night in other seasons. Using this stored cold during warmer periods results in a reduction of the PUE to less than 1.35 (at full load, 1.26), and a substantial reduction of the operational expenditures and indeed, the total cost of ownership.

Step 3. With steps 1 and 2, the conventional cooling concept has been stretched to its limit in terms of energy efficiency. Thus, the next step is to rethink the cooling needs of a data center and how to best satisfy those needs. With this goal in mind, Deerns" data center specialists have developed the GC-DC© concept (Green Cooling for Data Centers, in collaboration with KyotoCooling© and Holland Conditioning), an innovative and intelligent new combination of existing, proven technologies. It is, however, a different and much more efficient way of "getting the heat outside."

Heat Emitted Directly Outside

Conventional data centers make use of recirculation units installed in the computer room. These units are force-cooled with water continually pumped through the pipework. In the GC-DC© concept, the traditional recirculation units in the computer room are replaced with compartments, which include a heat exchanger and coolers that are installed outside the computer room. With the aid of fans, the air in the computer room is recirculated while it is being cooled by the stationary heat exchanger. The heat is discharged directly outdoors - no direct contact, no mixture nor leakage of air from the computer room with the outside air. And no more cooling liquids anywhere in computer rooms. That is "Kyoto"-cooling for a data center. (See Figure 3.)

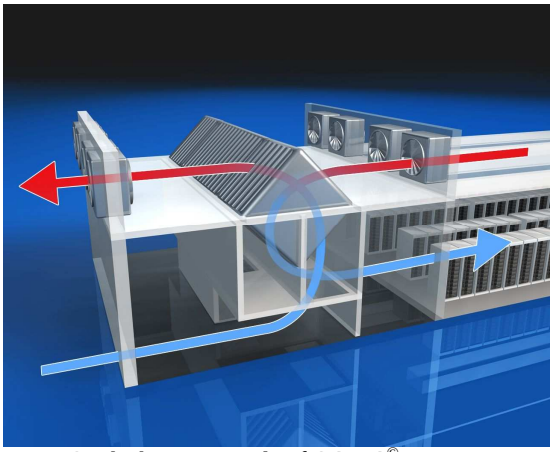

Figure 3: The basic principle of GC-DC©

[1] The reduction of 25 percent is calculated over the surplus energy compared to server energy, i.e., with a PUE of 1.9 for a conventional data center, a 90 percent surplus on the server energy is consumed by the infrastructure. A reduction of 25 percent leads to 90% x (100%- 25%) = 68%, leading to a PUE of approximately 1.7.

Due to the much more direct transfer of the heat developed in the computer racks to the outdoor air, free cooling can be used for a much greater part of the year. When the outdoor temperature becomes too high (greater than ca. 21°C / 70°F),[2] the system is aided by a compression cooling unit located outside the computer room. The overall system is built in modular compartments or "cooling cells" that are totally independent of one another, so full cooling system failures are no longer possible and no water-bearing systems for cooling are located in the computer room: better availability and reliability through simplicity. Because of the modular nature of the system, investment costs for the entire cooling infrastructure can be postponed in line with the growth of energy demand during the operational —pay-as-you-grow. (See Figure 4.)

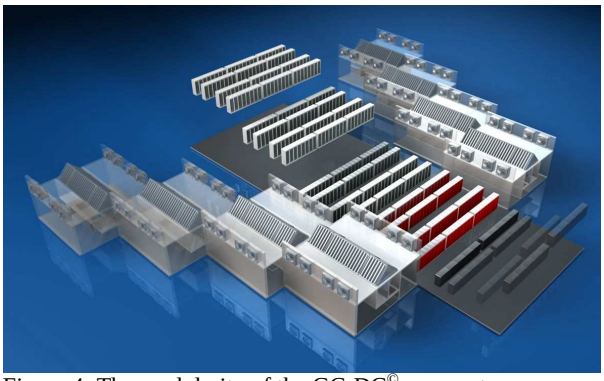

Figure 4: The modularity of the GC-DC© concept

Compared to a conventional system, the GC-DC© concept reduces the demand for cooling energy by 80 percent; the resulting overall PUE of the data center is approximately 1.15. Even in a hot climate like Phoenix, Arizona, the reduction in cooling energy is approximately 30 percent, with an overall PUE of 1.38. (See Figure 5.)

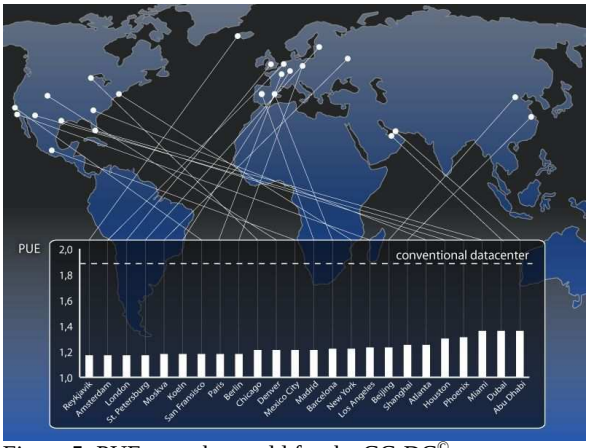

Figure 5: PUE over the world for the GC-DC© concept

The system not only leads to huge savings on cooling costs, but also improves availability and reliability with the same level of investment. (See Table 1.)

2,000 m², 2.5 kW/m² TIER III	Today	GC-DC©
Investment	25,000,000 Euro	24,000,000 Euro
DC IT Power	5 MW	5 MW
Cooling Power Average per year	50% 2.5 MW	10% 0.5 MW
Cooling Energy Consumption per Year	21.9 GWh	4.4 GWh
Cooling Energy Costs	100 kEuro/GWh 2,190,000 Euro	100 kEuro/GWh 440,000 Euro
Saving per year Saving p.a. % investment		1,750,000 Euro/a 7.3 %

Table 1: Financial information on the GC-DC© concept

The Bigger Picture

If the philosophy behind GC-DC© is projected to the surroundings of the data center, one not only gets an opportunity to reuse the waste heat of the data center, but an entire sustainable Internet valley can be created. The Lockerbie Data Centres project in Scotland seeks to pursue just this: a sustainable development of the energy chain around the data center. This project combines multiple sustainable power resources with a collection of greenhouses, residential areas and commercial real estate to reuse the heat. In realizing this philosophy, the carbon footprint of the data center and its surroundings is diminished. (See Figure 6.)

[2] Assuming a cold aisle temperature of 25°C / 77°F

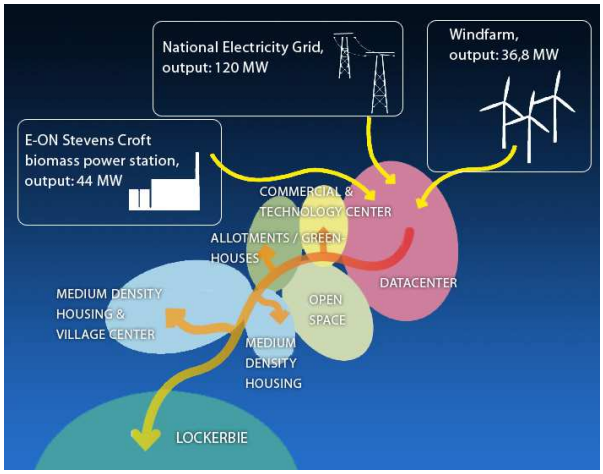

Figure 6: The Green Internet Valley of the Lockerbie Data Centres

Conclusion

In recent years, a reduction of about 60 percent of cooling energy consumption has been achieved by tuning the system design with respect to energy consumption and by incorporating add-on features for increased efficiency of the energy used. Today, a reduction of 80 percent of cooling energy consumption is possible with the Deerns GC-DC© concept. For tomorrow, Deerns is already developing the next step…

In summary, the GC-DC© concept features include

- a PUE of 1.15 and 100 percent free cooling up to 21°C / 70°F
- improved reliability and availability with no possibilities for total cooling system failure
- a completely modular cooling system for improved phasing of the investment
- a simpler system with easier maintenance and operation.

Thus, a company that operates a green data center based on the GC-DC© concept has a major competitive advantage due to lower operational expenditures, even without taking into consideration the associated benefits from a social and environmental perspective. The improved phasing of the investment is a valuable asset, especially given the present uncertainties with project finance and sales projections. Basically, GC-DC© makes a greener data center the best value proposition for any data center host.

About the Author

Wouter M. Kok, MSc, MMC, is a Manager in the Cleanroom, Laboratory, and Datacenter Department of Deerns Consulting Engineers. After studying Aerospace Engineering at the Technical University in Delft and obtaining a postgraduate degree in Management Consultancy, both in the Netherlands, Wouter Kok began his career at

Deerns Consulting Engineers in 2003. At that time, he quickly proved to be an ambitious and competent consultant. Working on projects for several Dutch universities, Ministries and industries (including KPN Telecom and Equinix, among others), Wouter soon became the Manager of Deerns' Cleanroom, Laboratory, and Datacenter Department. One of his greatest achievements has been developing the GC-DC© concept (Green Cooling for Data Centers; patent pending). Wouter Kok successfully combines a high level technical background with a sharp mind to improve, innovate and realize data center infrastructures.

About Deerns Consulting Engineers

Deerns enables clients to recognize their goals of comfortable, safe and sustainable projects. In doing so, Deerns challenges itself and its clients to realize the greenest solutions possible. A highly innovative and cost effective example of this is Deerns' critically acclaimed "Green Cooling for Data Centers" (GC-DC©) concept, which has proven to reduce cooling energy consumption by 80 percent.

For more information on this whitepaper or Deerns Consulting Engineers, please write contact@deerns.nl

About the Uptime Institute

Uptime Institute is a leading global authority on data centers. Since 1993, it has provided education, consulting, knowledge networks, and expert advisory for data center Facilities and IT organizations interested in maximizing site infrastructure uptime availability. It has pioneered numerous industry innovations, including the Tier Classification System for data center availability, which serves as a de facto industry standard. Site Uptime Network is a private knowledge network with 100 global corporate and government members, mostly at the scale of Fortune 100-sized organizations in North America and EMEA. In 2008, the Institute launched an individual Institute

membership program. For the industry as a whole, the Institute certifies data center Tier level and site resiliency, provides site sustainability assessments, and assists data center owners in planning and justifying data center projects. It publishes papers and reports, offers seminars, and produces an annual Green Enterprise IT Symposium, the premier event in the field focused primarily on improving enterprise IT and data center computing energy efficiency. It also sponsors the annual Green Enterprise IT Awards and the Global Green 100 programs. The Institute conducts custom surveys, research and product certifications for industry manufacturers.

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