ZO!

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OZZO

SELF SUFFICIENT DATA SYSTEMS

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ZO!

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1. Foreword

The city of Amsterdam has committed to reduce its CO_2 emissions by 40% in 2025 compared to 1990 levels. The IT sector in Amsterdam has endorsed this challenging objective and is backing it with its own ambitions, creativity and actions in both public and private areas. The city environment Alderman, Mrs. Marijke Vos, stimulated these public-private collaborations and endorsed end of 2008 the Green IT Initiative Region Amsterdam. This public-private collaboration led to the formation of the Green IT Consortium Amsterdam, founded on the 8th of June of this year as a platform for all Green initiatives in the Amsterdam region.

From the very beginning, OZZO was clearly the type of projects the foundation wanted to get on board, as a prime example of what we want to achieve with the Green IT platform. The Green IT consortium members participate within the consortium framework of programs to specific projects in which they invest time, resources and knowledge to collectively and pre-competitively identify, develop and pursue Green IT business opportunities. Green IT projects are intended to enable the region to achieve its objectives in the areas of energy savings and CO_2 emission reductions on the one hand, and benefit from ICT innovation in a fast-growing green economy on the other.

Because of the present issues surrounding CO_2 emissions and energy shortage, it is particularly encouraging to discover how a good fit the OZZO concept is. Our high expectations are based on the progressive way in which the OZZO project is being dealt with, on the top-down conceptual approach adopted, on the dedication, contribution and creativity that was not inhibited by present technical limitations, and on the surprising options and expected environmental benefits and energy savings that OZZO already shows we can reach in our computing and datacenters of the future.

OZZO supports Green-IT's vision that interdisciplinary knowledge sharing boosts creative problem-solving. "Greening IT" cannot happen without the knowledge and participation from various other stake holders in particular from the energy and building sectors. Innovation in local energy generation, smart grids, building design and use of materials, and combining datacenter services with other functions such as agriculture or urban heating, will lead to total, truly sustainable solutions.

On the economic front, the OZZO project shows that we can keep state-of-the-art datacenter technology and knowledge development in The Netherlands rather than seeing it depart to countries like Canada, Iceland or Norway, where sustainable energy sources are abundant and greening IT is not as challenging as in the rest of the world. Datacenters are crucial for developing the knowledge economy and form the backbone of the IT sector. It is therefore very important to tackle the sustainability issues of the future and not to "export" the problem elsewhere.
The Green IT Consortium will continue to push the development of the Dutch green economy along this path, and OZZO definitely has a place in that movement, starting in 2015 with the opening of the world's first Energy Self Sufficient data center, of course in the Amsterdam Metropolitan Area.

Anwar Osseyran
(Chairman of the OZZO advisory board and Chairman of the Green IT Consortium Amsterdam)

2. Introduction

This white paper presents the first findings of the OZZO project. It outlines possibilities for making data centers astonishingly more energy-efficient than the greenest of them currently are, simply by applying relevant, feasible techniques in a coherent, holistic way. It shows by a few examples which elegant appearances and environmental roles data centers can take when nature inspires architecture at the level of technology, not just aesthetics. And it tells a bit about the OZZO project itself.

After the introduction (section 2), this paper describes how, in answer to the challenge of 'greening' data centers (3), the OZZO project was launched (4). So far, OZZO analysed the power loss chain in data centers (5) and identified solutions (6), which in combination appear to add up to truly dramatic energy savings (7). Energy and data solutions form a grid (8) with nodes (9), which can materialize in various ways. These findings deserve further research and development in the near future (10).

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The visions presented and the conclusions drawn in this white paper do not necessarily reflect the views of the consulted experts and/or their companies.

3. Skies and Limits

With data centers expanding in numbers and capacity in attempt to keep pace with uncontrolled exponential growth of online data, the industry faces challenges similar to those of civil aviation. Like the latter, the former becomes more and more notorious for huge energy consumption, doubling every five years, and a corresponding CO2 emission. Data centers add to the greenhouse effect and use up resources that are becoming scarce and unpredictably expensive. People aware of their carbon footprint cannot but feel uneasy about flying. They are beginning to do so about surfing.

It is not hard to predict that public and business demand for environmentally responsible data centers will only grow in the near future. But this will not prevent the demand for processing power and storage from growing even faster. How to meet these seemingly incompatible demands?

The industry is already working to realize 'green' data centers. But are they green enough, and do they make the most of what is possible?

Here OZZO comes in.

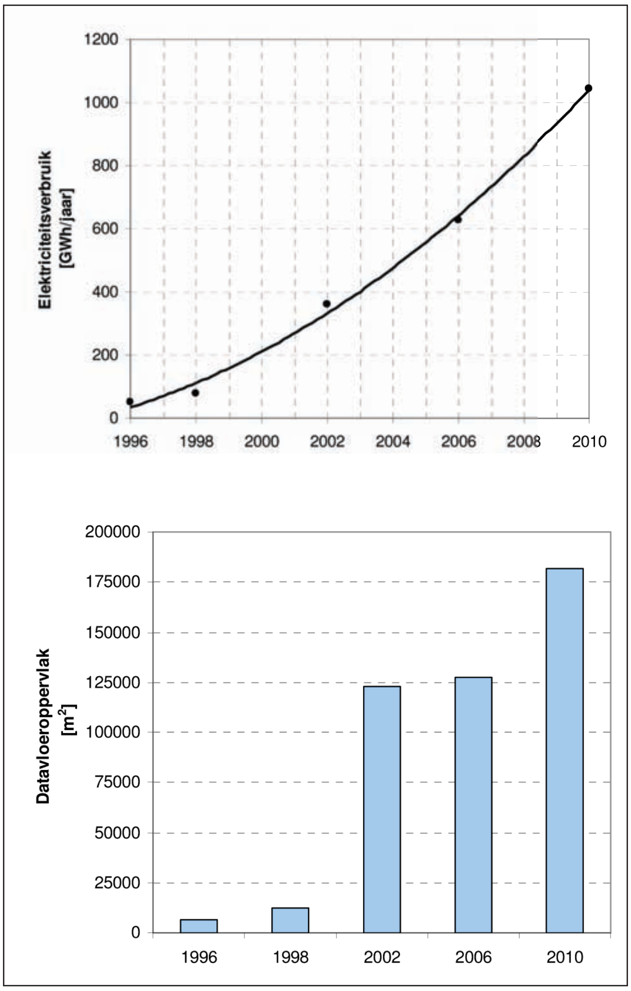


Figure 1. Electricity use (GWh/year) and surface area (m2) of data centers in The Netherlands between 1996 and 2010 (Tebodin/Meijer, 2007).

(NL) Elektriciteitsverbruik en oppervlakte van de datacenters in Nederland in de periode 1996 tot 2010. Bron: Tebodin & Meyer "ICT STROOMT DOOR: Inventariserend onderzoek naar het elektriciteitsverbruik van de ICT-sector & ICT-apparatuur (Opdrachtgever: Ministerie van Economische Zaken, 2007)

4. Constraints and Challenges

The OZZO Project's mission

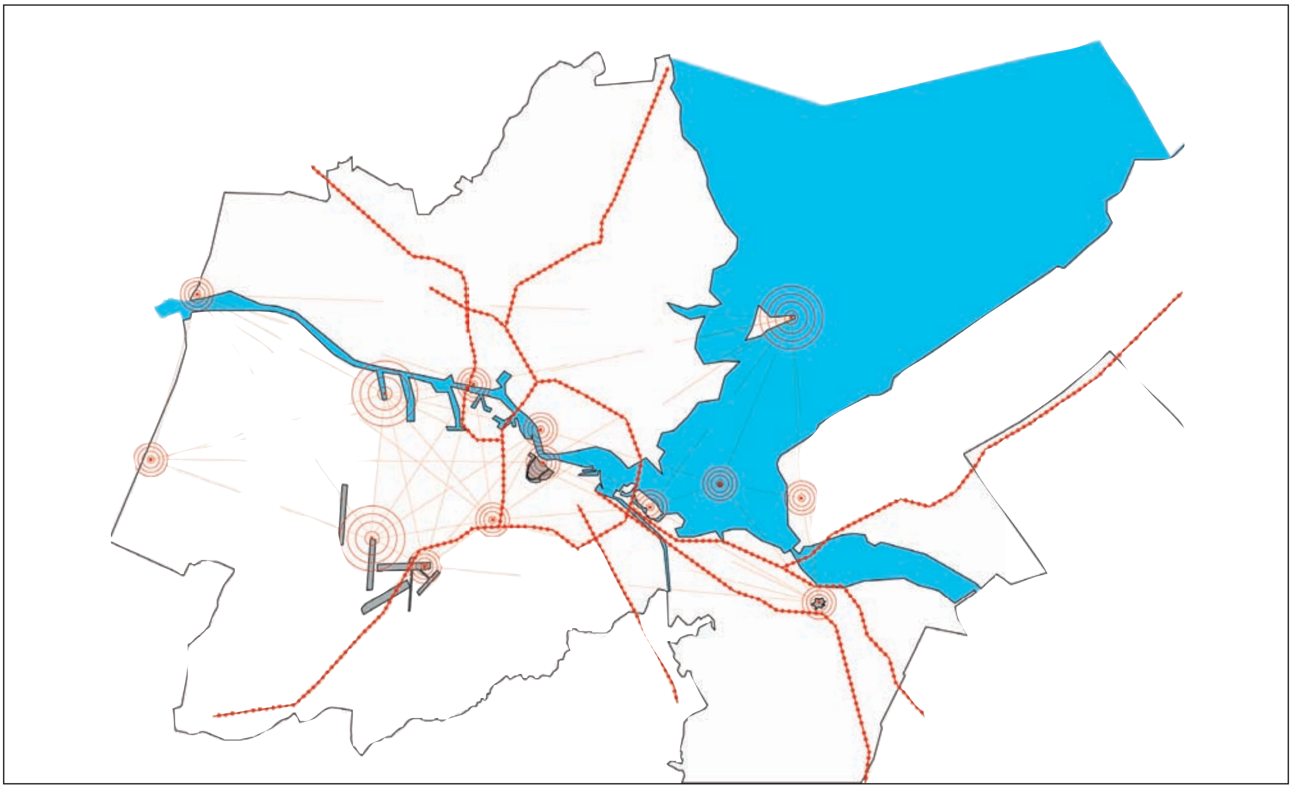
'Let's build an energy-neutral data center in the Amsterdam Metropolitan Area before the end of 2015. This data center produces by itself all the energy it needs, with neither CO2 emission nor nuclear power.'

Thus the challenge for the OZZO project. Started early 2010 in order to help speed up developments in Green IT, it took a Formula-1 approach: using maximum constraints to reach optimum performance. OZZO aims at realizing a data center that meets the highest standards in sustainability without sacrificing performance, reliability, and features. The result must be technically feasible, socially acceptable, and marketable using competitive SLAs. Amsterdam, not coincidentally the WCIT 2010 venue, was chosen for its high data traffic density and ditto ambitions.

OZZO goes beyond mere cherry picking from state-of-the-art components, current best practices, or near-future developments. OZZO connects innovative people, leading market partners, and knowledge institutions in various fields of expertise, combining different frames of reference. In a series of themed round tables during the spring of 2010, principles and ideas have been brought together to create something truly new.

By the end of May 2010, at WCIT, OZZO is ready to present its first results in the form of a 3D model and this white paper.

Figure 2. Data center as an 'urban cloud'. Sketch of the AMA region with schematic (imaginary) fibre connections and specialised data/energy nodes. OZZO 2010



5. Losses and Possible Gains

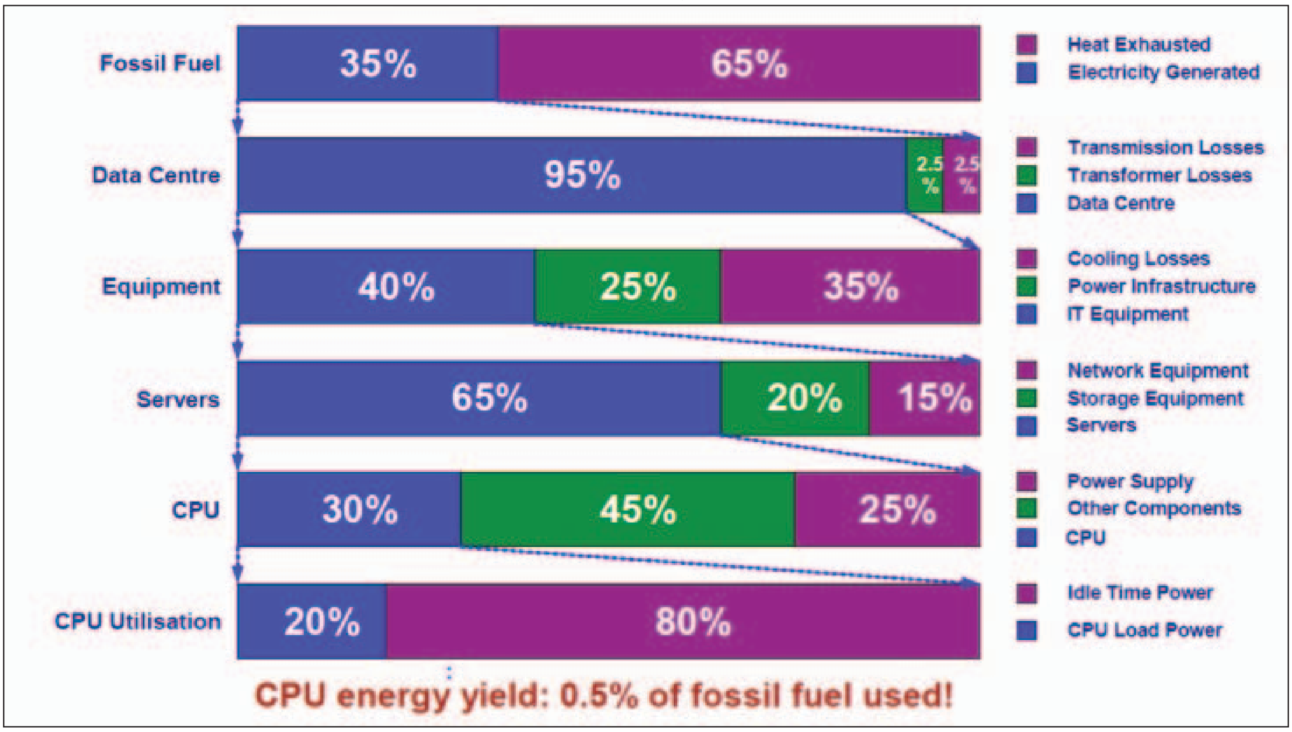
In current data centers typically less than 14% of energy even arrives at the rack: processing receives 9%, storage 3%, and routing a bit less than 2%. And even this is largely discarded. In the end, less than 1% of the energy contained in the fuel is converted to useful work at CPU level. Most is spent on facilities such as cooling, climate control, lighting, and – above all – power conversions, before it can enter its actual workspace: the chip, disk, or switch. There it is converted into heat with 100% effectiveness. But instead of reusing this energy, it is taken for granted that energy output – heat cooled away from the racks – disappears into thin air.
Not surprisingly, 'greening' data centers is now mainstream and many a data center is working to lower its PUE (Power Use Effectiveness) coefficient: spending less of the energy on facilities and more on IT. A PUE of 1.35 is now considered state-of-the art.
Rather surprisingly, however, PUE is not about in-rack losses, although those may amount to 90% of the input and have a multiplying effect on losses outside the racks.
By the way: energy costs during hardware lifetime almost equal economic write off.

As for energy reuse and supply, data centers are only beginning to be built in the vicinity of waste-heat consumers such as nursing homes or greenhouses, or, alternatively, close to producers of otherwise 'wasted cold' such as gas compression stations. Still, entirely 'greening' energy generation for data centers is problematic using current sustainable/renewable concepts. Current data centers typically calculate with an approximate 5kW per data-rack, or 65kWh per year. Thus, a single data rack would require an approximate 635m2 of commodity photovoltaics or 18.000m2 of biomass production.

Other links in the power loss chain are also seldom addressed. Data accumulation is answered with increased capacity, no questions asked. Over-dimensioning and redundant hardware and facilities, including backups, are common in data center design, resulting in efficiency losses. Guidelines for ambient temperature are on the safest possible side, demanding huge cooling efforts. Of course: day-to-day business continuity is top priority. But why not try to find synergy with energy efficiency?

Obviously, all current solutions address only part or parts of the challenge. Therefore, OZZO takes a holistic approach.

Figure 3. 'Greening the data center: *Power loss chain*', source: British Computer Society



Breaking Down Requirements

In order to make a data center sustainable and energy-neutral,

- internal energy demand and dissipation must be reduced as far as possible;
- the external energy input/output balance must be optimized, reusing heat produced within surrounding systems, while generating all of the energy needed from renewable resources, preferably on-site or within a smart green grid, with minimal carbon footprint;
- taking into account relevant economical, legal, and social parameters in the environment.

Converting constraints into performance, this means:

- processing more data using less energy;
- storing more data using less energy;
- getting the same useful work (processing and storage) using less overhead;
- reusing more of the waste heat;
- harvesting the remaining energy renewably while using as little of the Earth's precious surface as possible.

Unifying Metrics

It's easy to understand that fuel economy should not be compared between means of transport using 'kilometres per fuel tank': fuel tanks differ in size, as cars do from buses and planes. 'Passenger kilometres per litre of fuel' are compared instead. Yet popular measures of data center capacity and energy efficiency are woefully imprecise: e.g., 'watt per rack' and 'PUE'. These won't take us where we want to go.

Adequate and unambiguous metrics ensure that current, state-of-the-art, and possible future solutions can be sensibly assessed in comparison. As part of its holistic approach, OZZO uses unified metrics for four parameters: storage, processing, overhead, and energy balance. These metrics boil down data center performance to 'work per Joule' equivalents.

Processing: MIPS per watt

Processing is the transformation of information as discerned from mere storage, the two taken together being the data center's 'primary process'.

The number of Millions of Instructions executed Per Second (MIPS) quantifies processing. This number is compared to the power in watts needed to accomplish this number. The energy taken into account is that consumed by the CPU and the motherboard (including memory) to which the CPU is attached. The two are taken together because choosing a CPU automatically entails a certain overhead in the matching motherboard.

Storage: Terabytes per Watt

Storage is about storing data on appropriate media and fetching it whenever it is to be processed.

Storage volume is expressed in Terabytes (TB). Energy efficiency is expressed as the number of TB that can be kept in storage using 1 watt of power.

Overhead: data center Productivity versus Power Use Efficiency

A data center's overhead is most usually expressed in its PUE. A PUE of 2 means that 2 watts are needed to deliver 1 watt to the rack. However, this leaves in-rack losses and CPU, disk, and networking energy efficiency unaccounted for. A more accurate metric is data center Productivity (DCP), comparing useful work – measured in MIPS and TB – to total power usage.

Energy reuse: %

Relevant in energy reuse are the percentage of input energy that is harvested as output energy, and the percentage to which this output is effectively used inside or outside the data center.

Energy generation: Watts per M2

Sustainable energy generation is expressed in the amount of energy per unit of time (in watt) that can be extracted from the continuous natural processes that occur on the surface that is occupied for energy generation (in m2).

6. Choices and Combinations

Applied Principles

OZZO takes a holistic approach. In order to be able to build a truly energy-neutral data center, the project combines IT, energy, and integrative ecological architecture, uniting the latest developments and realistic year-2015 prognoses in these fields.
OZZO uses a set of principles in order to find out more about the synergetic returns at their points of intersection.

As for IT, including data center facilities, OZZO uses best-in-class, innovative (green) hardware, software, and concepts. The most important of these are:

- virtualization of processing;
- data management based on the HotColdFrozenData (HCFD) concept and dynamic, dedicated configuration;
- extrapolation of current developments like memory compressing, modularization, and on-chip liquid cooling;
- check of temperature regulations against technical, economical, as well as energetic considerations;
- a high-performance fiber/copper infrastructure;
- managed services as a precondition, as co-location jeopardizes optimum efficiency.

OZZO takes into account that the edge of the Internet (the consumer's end) is steadily gaining importance – HDoIP, HD YouTube, cloud computing, Internet caching providers – implying network concepts that can dynamically transfer processing power outwards. This suggests a node structure: a concept currently in rapid development. The data center should function within multiple smart grids: for data, electrical energy, and thermal energy. These are preconditions, as is full encryption of all data involved for security and privacy reasons. Energy is produced and reused using the most efficient sustainable methods, preferably on-site or in the adjacent area, or alternatively within the smart electricity grid.

Building and context are considered one system. Thus, proximity of energy production, reuse, and data processing is important, not only technically but also from a 'social' point of view: users identify with resources that are close by. The overall system within which the data center is developed is defined as the entire Amsterdam Metropolitan Area, with its energy needs and sustainable resources, and its data supply and demand. The data center is very unlikely to be confined to one physical site; nodes and components should be scalable and adaptable up to this metropolitan level, if necessary, balancing critical mass for optimization with maximum size for energy self-sufficiency. Modern sustainable architectural techniques enable for optimum low-energy climate control.

At the intersection points of the principles applied, OZZO identifies major possibilities for energy-neutral data center development.

HotColdFrozenData

Key to the HotColdFrozenData™ concept, developed by MDES, are intelligent distinctions between high-frequency use data and low-frequency use data. On average, offices and individuals use and change 11% of their data intensively, i.e., every day (hot); 15% is seldom accessed (cold); and 74% is practically never looked at any more (frozen).
Special software can classify data streams real-time. After classification and segmentation, data is deduplicated, consolidated, and stored separately on appropriate media. Data can change classifications from hot to cold to frozen, but frozen data can also become hot at times: e.g., when a forgotten singer becomes camp for a summer.

7. Techniques and Estimates

Results at Intersections

In OZZO's holistic approach not some but all of the relevant energy saving methods and techniques are applied. At the end of a chain of repetitive savings they all add up to truly astonishing results. Implementation is shown in the following section for each of the areas processing, storage, overhead, and energy balance.

A. How OZZO reduces processing energy

All power in data centers scales with storage and processing, with processing as the dominant partner, currently taking about three times more energy per m2 than storage.

OZZO dramatically reduces watts per MIPS by stacking the following approaches, derived from the principles outlined in the preceding section (Table A).

B. How OZZO reduces storage energy

As the processor consumes most of a data center's energy, storage is often overlooked in energy-efficiency programs. With the amount of data exploding, however, storage energy does become an issue and savings in this area will only become more substantial over time.

OZZO dramatically reduces watts by reducing TBs needed, as well as watts per TB, by stacking a number of approaches, derived from the principles outlined in the preceding section (Table B).

Table A. Expected reduction of processing energy

Measures/Expected result		
Virtualization (as applied in best-practice data centers): - Allocating tasks so processors work at 80% of capacity instead of 15-25%, switching off those not needed.		
Watts used before	Net power savings	Watts used after
12.4 (typical current data center)	**67%**	**4.0 (virtualized best practice)**
Hardware optimization: - reducing power loss at voltage regulators on motherboard; - processing data on hardware that is optimally energy-efficient considering the task at hand; - using a mix of regular (e.g., Xeon) and energy-efficient (e.g., Atom and ARM) servers on efficient motherboards (such as Google's 12V).		
Watts used before	Net power savings	Watts used after
4.0 (virtualized best practice)	**70%**	**1.0 (OZZO)**

Table B. Expected reduction of storage energy

Measures/Expected result		
Consolidation (SAN/NAS):		
Watts used before	Net power savings	Watts used after
24 (typical current data center)	**29%**	**17 (SAN/NAS)**
HotColdFrozenData: - managing and storing data on hardware that is optimally energy-efficient considering the type of data stored. - hot data (11%) is stored on 256GB SSD; - cold data (15%) on 2TB SATA disks; - frozen data (74%) on 2TB slow spinning disks.		
Watts used before	Net power savings	Watts used after
17 (SAN/NAS)	**94%**	**1.0 (OZZO)**

Notes:

Switching off parts of the CPU according to workload could bring non-virtualizible tasks, such as business-critical applications that massively address databases in real time, within the span of this approach.

In data centers that are unused for load balancing reasons, idle processors could be kept running for climate control purposes by putting them at the disposal of non-profit projects, such as SETI@home.

C. How OZZO reduces overhead

OZZO optimizes the power loss chain from processor and storage media level upwards, as savings at lower stages multiply higher up. Both the number of stages and the discharge at each one of them are reduced, combining a number of intelligent techniques and approaches, derived from the principles outlined in the preceding section.

- DC is used straight from photovoltaics or turbines throughout the chain, dismissing inverters needed with AC.
- Like at processor and disk level, hardware at server, rack, and node level is either used with over 80% efficiency, or (temporarily) switched off, wasting no energy on idle or even standby time.
- Virtualization ensures high availability, flexibility, and redundancy, reducing energy and hardware at all levels including network connections, saving the enormous investments needed for current over-dimensioned (hardware) designs.
- Hardware is separated physically and can even be distributed geographically, according to its energy profile and local IT demands. Each type has its own energy-optimized cooling regime.
- Water-cooling is applied at appropriate distances from heat-producing components. Expensive on-chip cooling is efficient only on hard-working processors; if less heat is produced cooling from a distance is better and cheaper.
- All nodes are logically and functionally monitored and managed using remote software, and only physically on-site.

Using these techniques, OZZO reduces data center overhead dramatically, as shown by the following estimated losses (Table C).

Table C. Expected overhead reduction			
Measure/Expected result			
Losses in data center of type:	Typical current	Best-practice	OZZO
Power lost on networking, on top of processing and storage	18%	15%	12%
In-rack losses due to PSU inefficiencies	33%	5%	2,5%
Power losses outside the racks	63%	8%	6%
Cooling losses on top of everything else	54%	13%	5%
Total data center overhead percentage according to definition	*75%*	*35%*	*15%*
(OZZO working hypothesis) Watts needed as overhead to make use of every single watt delivered to motherboard and storage media	**3.0**	**0.5**	**0.3**

D. How OZZO improves energy balance

Energy reuse

OZZO achieves the main gain in energy reuse by applying water-cooling as the principal heat harvesting technique throughout instead of air-cooling. Other techniques are used only supportively to accumulate heat with appropriate configurations.
Thus, instead of low-value energy in the form of hot air, the output is high-value energy in the form of hot water with a temperature of 40° and in some cases even 50-60°. The output can be directed to geothermal pumps or heat exchangers for reuse in the data center's surroundings.

Experiments in Zurich, Switzerland, show that water harvesting enables for returns of up to 64%. Exact output volume and the surroundings' needs are to be calculated in a later stage of the OZZO project. The inclusion of these returns would improve efficiency of OZZO even more, leading to a ERF(Energy Return Factor) of 0,5 meaning of every Watt invested in IT 50% is used and 50% is re-used. This however requires that such harvesting can be made benificial to the direct neighbourhood of the data node.

Energy generation

OZZO optimizes energy production in a number of ways, stacking the returns.

- Locating nodes on sites that provide for the most feasible sustainable/renewable resources within the delimiters of the defined geographical area.
- Scaling each node and its environmental system to an optimum balance.
- Using the most efficient technologies to harvest energy from the resources at hand.
- Using the harvested energy to the full by directing as much data as possible to nodes with high energy production at a given moment.
- Switching resources and thus moving data to other nodes before taking refuge to on-site energy buffering and/or the energy grid in case of local energy shortage.

CO_2 emission is zero, or neutral within the smallest possible system delimiters.

Data are based on the Round Tables discussions and additional desk research. All figures and their interrelations are preliminary and to be tested/validated during the design phase of the prototype(s).

8. The OZZO Grid

Data Follows Energy

Data centers are some kind of high-performance trucks: superfast and heavy, Ferraris crossed with Macks. So far, energy supply has been a huge outboard fuel tank, dragged behind a cargo of MIPS and TBs to be delivered at a given site. Energy reuse has not been more than an optional extra trailer yet – with other priorities at hand.

For OZZO, on the contrary, energy is rather a vehicle for IT. Its environment is a smart, three-layer grid – for data, electrical energy, and thermal energy. Possible and actual energy generation and reuse at a given point in the grid serve as drivers for data center or node allocation, size, capacity, and use. Processing and storage move fluidly over the grid in response to real-time local facility and energy intelligence, always looking for optimum efficiency.

This is how OZZO works. Data follows energy. Architecture is the link.

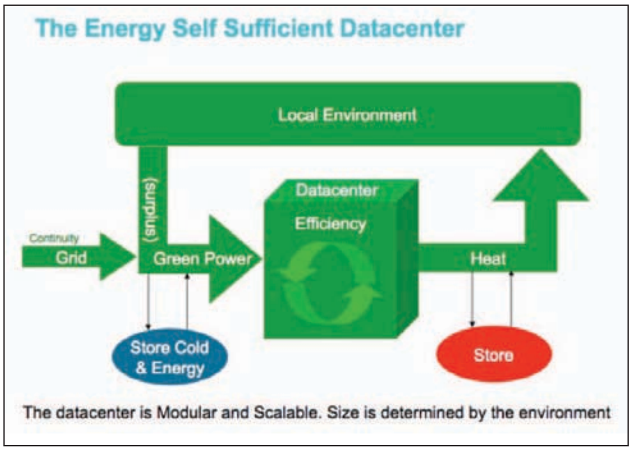


Figure 4. The data center as an integral part of the local environment. With thanks to IBM (Round Table 3, Almere)

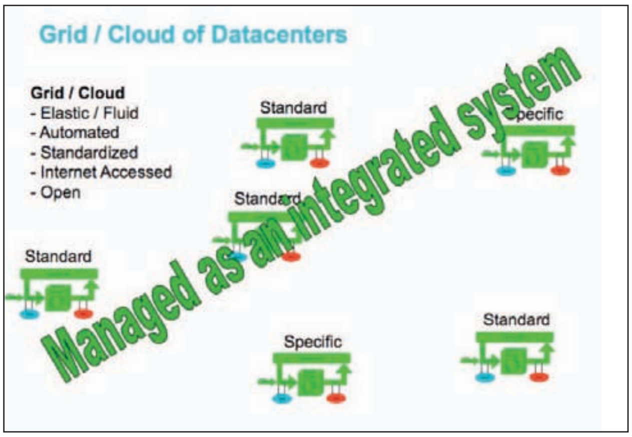


Figure 5. De-central data centers managed as an integrated system. With thanks to IBM (Round Table 3, Almere)

The Beehive Analogy

Nature provides data center architects with a powerful analogy to draw lessons from: the beehive. Hardware in data center racks provides for data processing, just like bees in their hived honeycombs produce honey.

The bee swarm is a cloud taking from, and giving to, its environment. It follows highly effective mechanisms to distribute itself and its processes in accordance with available resources and other factors within the delimiters of the system it makes part of. Architects can set up data centers analogously to have data follow energy over the grid. But there is more.

Within the hive, bees maintain a constant temperature needed for their processes, wasting minimal energy. They achieve this by using algorithms on position, scale, and activity. Heat accumulates within the insulating envelope of the hive. The surplus dissipates through adiabatic cooling, helped by natural air flow between combs and, if necessary, wing movement. By contrast, the type of building typically used for data centers – even with rack configuration optimized – is kept at a constant temperature only to the cost of lots of energy: mostly electrical energy, which is in fact too high-value not to be spent on the primary process. Using water cooling helped by natural air convection instead is not only more effective. It also creates high-value heat output for reuse in systems outside the actual data center.

Distributed data center IT design

As a result of developing the possibilities at the intersections of the principles applied, the OZZO data center takes the form of a grid of nodes of various sizes.

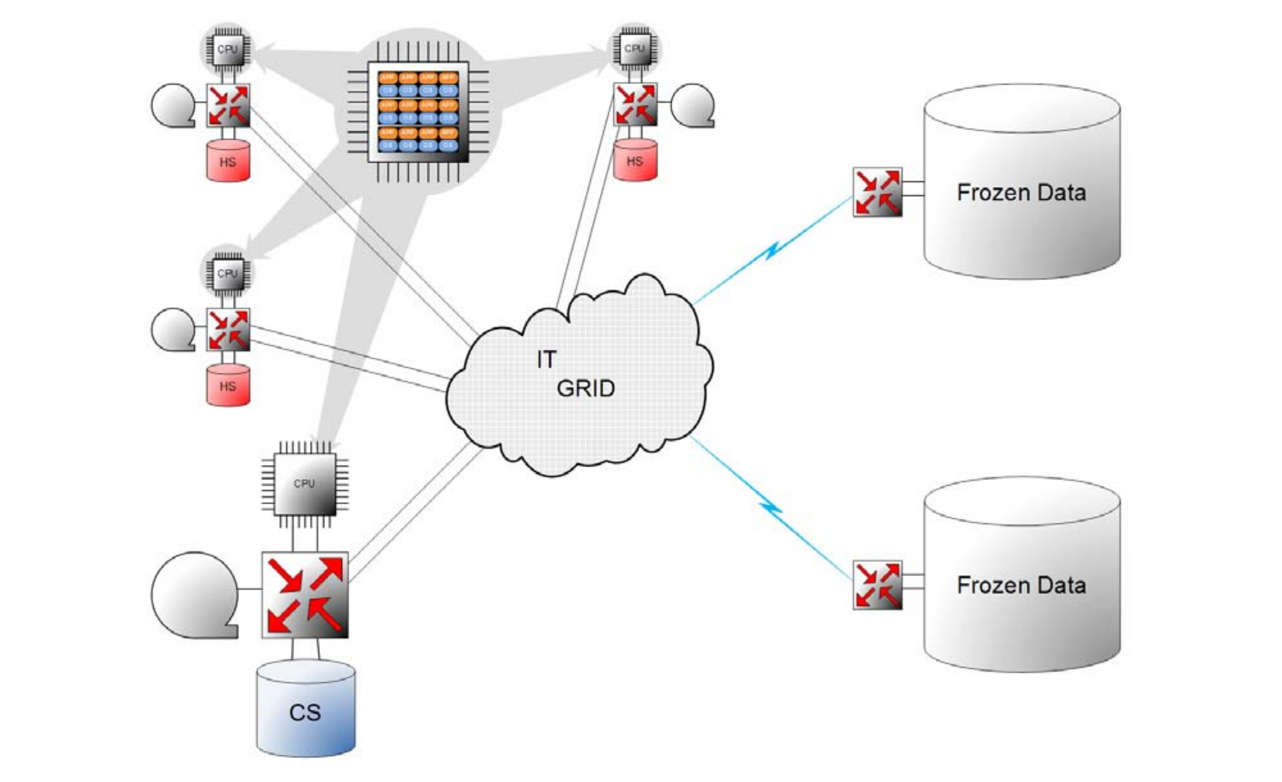


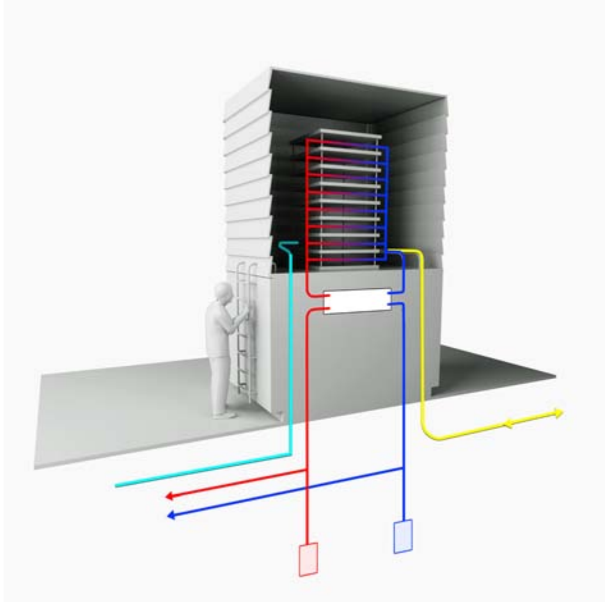
Figure 6. Typical OZZO grid configuration, with thanks to MDES

Processing capacity is fully occupied continuously by applied virtualisation techniques. The HotColdFrozenData concept determines the nodes' characteristics, roughly according to the following typology. Each node handles routing. Using Fiber over IP, fewer switches are involved and less heat is produced. Network components are dimensioned according to performance required. For safety and security reasons, encryption is applied throughout the grid.

Table D. OZZO data center nodes profiles

Node size	**Small, 1-5m2**	**Medium, 5-20m2**	**Large, 2,000m2**
Number of nodes	Many	Medium	Few
Node-user distance	Close by	Medium distance	Remote
Data type	**Processing + hot storage**	**Cold storage**	**Frozen storage**
Performance driver	Fast hardware + data grid	Fast hardware	Acceptable hardware performance
Energy intensity	High	Medium	Low
Cooling	On-chip	In/off-rack	At node level
Energy reuse	District heating	t.b.d.	t.b.d.
Main scalability type	Increasing number of nodes	Increasing capacity, then number of nodes	Increasing node capacity
Redundancy and 24/7 availability	By peers in grid + real-time dynamic data flow	By peers in grid	Data backup
Energy resource	Photovoltaics	Wind turbine	Biomass
Model shown at WCIT 2010	**Power distribution substation extension**	**Data backbone bridge**	**Data hive**

9. Node models



Data centers and nodes within OZZO can take various appearances. Integrative architecture is leading in the design: for each location, the building and its environment are taken as one system. Dimensions, forms, and materials enable the structure to optimally function within the three-layer data, electrical energy, and thermal energy grid. A few design examples can show the potential of this approach.

Power Distribution Substation Top

A typical 'hot' node is located in the midst of a housing estate, covering its data demand, drawing electric energy from it, and providing it with reusable thermal energy. To this end, an available existing power distribution substation can be topped with a 'data cube' providing the surrounding households with processing power and storage. The houses serviced are covered with photovoltaics, which deliver their power to the node using the available cable grid.

On-chip cooling produces heated water, which is led through a heat exchanger, geothermal pump or district heating. The architectural envelope doesn't need to have thermal characteristics and can be designed entirely for weather protection, data security, and aesthetic appeal.

Table E. Model A: Power distribution substation top

Node configuration:			
Energy input	9.700 W	PV (Solar)	1.000 m2
Processing	6.400 W	32x Xeon	0,4 rack
Storage	788 W	17 TB	0,05 rack
Routing	800 W	80 ports	0,2 rack

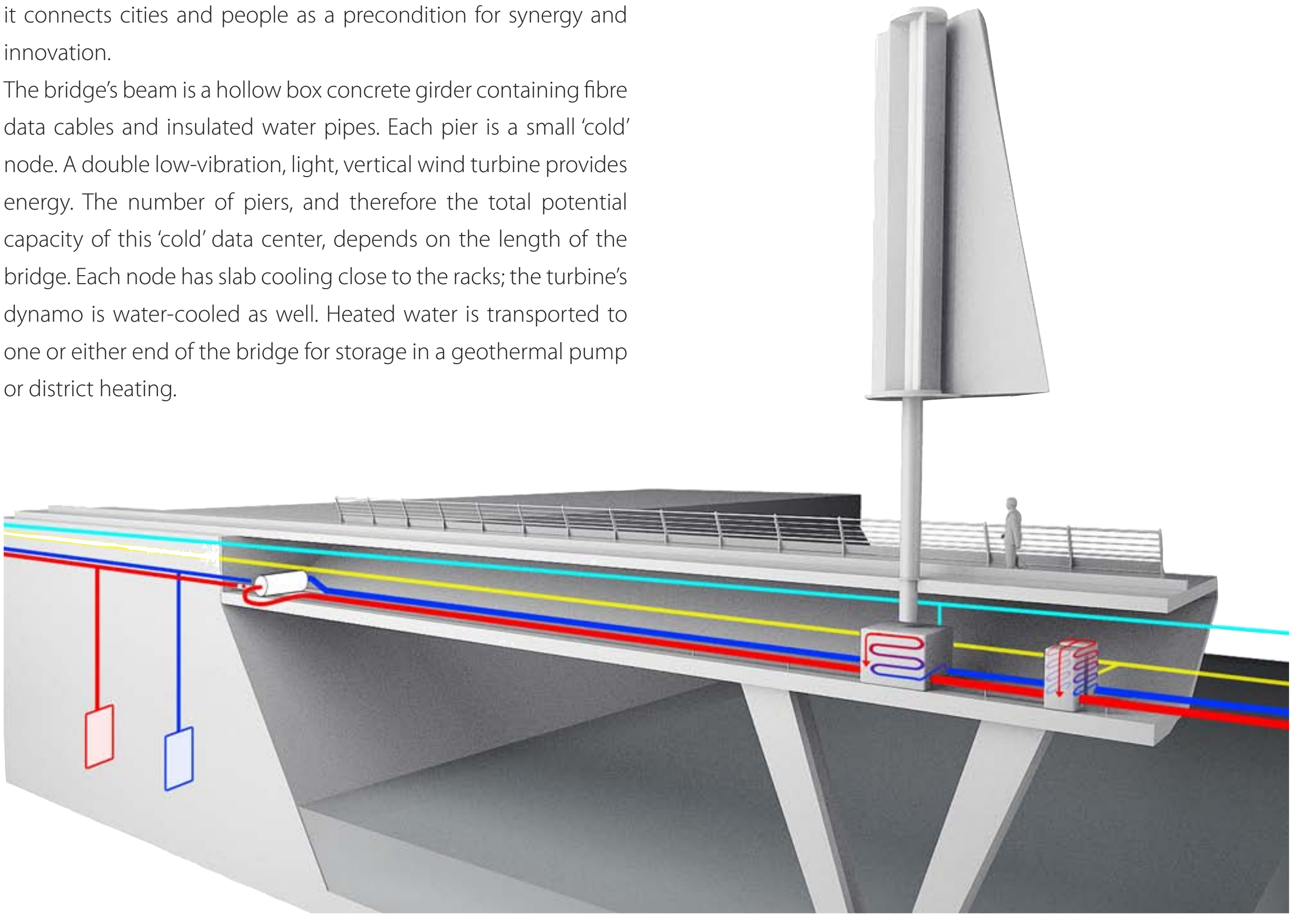
Data Backbone Bridge

As 'cold' nodes don't have to be close to users, locations can be chosen just outside housing estates or industry areas. They may take the form of a light pedestrians and bikers bridge, connecting two districts. Within AMA, this bridge could be located between Amsterdam and Almere at the very heart of the region. Apart from its landmark quality, such a civil structure has a symbolic value: it connects cities and people as a precondition for synergy and innovation.

The bridge's beam is a hollow box concrete girder containing fibre data cables and insulated water pipes. Each pier is a small 'cold' node. A double low-vibration, light, vertical wind turbine provides energy. The number of piers, and therefore the total potential capacity of this 'cold' data center, depends on the length of the bridge. Each node has slab cooling close to the racks; the turbine's dynamo is water-cooled as well. Heated water is transported to one or either end of the bridge for storage in a geothermal pump or district heating.

Table F. Model B: Data Backbone Bridge

Node configuration (15 combined into one civil structure):			
Energy input	92.000 W	Wind	15 turbines
Processing	64.000 W	320 Xeon	4 racks
Storage	11.400 W	1650 TB	5 racks
Routing	8000 W	80 ports	0,5 rack



Data hive

Nodes for 'frozen' data – by far the largest slice in the HotCold-FrozenData concept – are big, and better stay out of the way of 'warmer' data streams. But even a remote location can still have a useful relationship with its environment, as shown by the example of this datahive, located in an elephant grass field the same size with Lelystad (4.5x4.5km2) and supporting this city's heating grid. Inspired directly by the beehive, this data center is enclosed by a thick, insulating envelope. Inside, air convection transports and accumulates the heat from the racks to the roof, where it is cooled away adiabatically by a water grid. The resulting warm water is heated up by heat output of the biomass power plant, which generates the electrical energy needed to run IT and facilities. This datahive can serve as a real icon for green computing. Insulating glass at both sides allow it to proudly expose its interior – racks and installations – to passers-by.

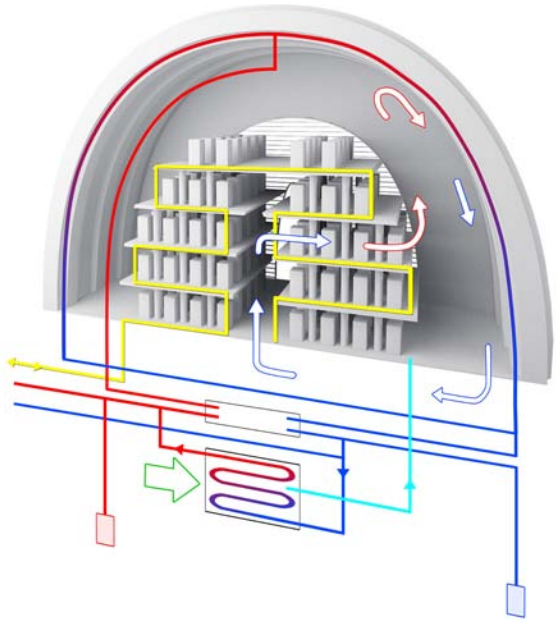


Table G. Model C: Data hive			
Node configuration:			
Energy input	40.000 W	Bio mass	100.000 m2
Processing	6.800 W	34x Xeon	0,4 rack
Storage	15.725 W	10.400 TB	16 racks
Routing	13.600 W	1.360 ports	0,9 rack

10. To (the) finish

SLA's in 2015

OZZO's WCIT 2010 presentation is only one project milestone. From May 2010 onwards, the OZZO team works to have the concept realized by 2015 as fluently and efficiently as possible.

To this end, technical issues have to be addressed such as: further exploration and integration of hardware developments; calculation of actual energy reuse options, based on output volumes and needs, e.g., in district heating, based on best practices; and cradle-to-cradle as an additional parameter of sustainability. Vendors, providers, investors, and sponsors will be invited to participate.

Obviously, economical aspects deserve further scrutiny. Cost and write off have not been taken into account yet, and for a reason: OZZO's challenge so far has been to stir the imagination and to show what is technically possible. Next stages will include market consultation so as to make inventories of needs, to develop product-market combinations, and business cases: aiming at innovative, attractive and competitive SLA's by 2015.

Prototypes in 2012

The pressure-cooker aproach has proven successful for the realisation of the overall concept and the scale models as presented on WCIT. Since we also enjoy it personnally, there is no reason to divert from this route.

Market consultation meetings have been planned throughout the summer. This will result in clarity on the various roles and positions for the realisation of the node prototypes. The target is to have three working 'nodes' ready in 2012, as a proof of concept and the first building blocks of the OZZO data center in the Amsterdam Metropolitan Area. They are likely to be built in a dedicated environment where we can put them to the test. In parrallel, we will work on the business modelling at the intersection of data and energy flows.

Thanks to the city of Almere and Amsterdam

The support and co-funding by the city of Almere and the city of Amsterdam have been crucial for the success of this first stage of the project. The initiators wish to thank both cities for their enthousiastic commitment. Thanks, guys.

This is a living document. Paul's version number is 1.35, its latest issue date is 26 July 2010.

Figure 7. Road Map for an Energy Self Sufficient data center in the Amsterdam Metropolitan Area project: ***Towards SLA's in 2015***. Current phase: development of prototype.