Server room guide helps energy managers reduce server consumption

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Abstract

About 1.1–1.5 % of the global electricity consumption is consumed by servers and data centres[1]. In the European Union (EU) the total electricity consumed in data centres, including enterprise servers, ICT equipment and cooling equipment is estimated at 56 TWh per year in 2007[2] corresponding to about 1.9 % of EU total electricity consumption. The consumption is projected to increase to 104 TWh per year in 2020[2].

Actions are needed in order to reduce the environmental impact of the projected increase in energy consumption. Solutions exist. A study[3] showed significant potential – up to 55 % – for efficient technologies and practices to improve the energy efficiency of servers and data centres. Cases collected by the author showed savings up to 80 %.

The Danish Energy Agency (and previously the Danish Electricity Saving Trust and the Danish Energy Saving Trust) has had focus on servers' importance on the electricity consumption during a decade. Already in 2003 they launched activities for energy savings in servers and datacentres. Since then, many activities have been carried out such as demonstration projects, procurement requirements, dialogue and cooperation with the industry, reach out activities, information activities etc. Furthermore, Danish Energy Agency supports international activities such as the EU Code of Conduct on Data Centres and the Green Grid.

One main information and reach out activity is a server room guide. It has been updated and extended over the recent years. In beginning of 2013, it was again updated and extended.

The paper describes as an introduction why the energy consumption in data centres is important followed by the nature of the energy consumption, saving opportunities and a market analysis among IT managers. This is followed by a presentation of the contents of the server room guide and the process of preparing the guide. Finally, a conclusion is provided.

Viegand Maagøe assists the Danish Energy Authority in the server activities.

Energy Consumption in Server Rooms and Saving Opportunities

EQUIPMENT AND ENERGY CONSUMPTION

The server room equipment is typically composed by:

- Critical (basic) IT (Information Technology) equipment: Servers, storage, switches and UPS.
- Cooling system.
- Miscellaneous consumption such as lighting and non-critical IT equipment.

1. "My new study of data center electricity use in 2010". Jonathan G. Koomey. 2011. www.koomey.com/post/8323374335

2. "Code of Conduct on Data Centres Energy Efficiency Version 2.0. Participant Guidelines and Registration Form. Valid as from 1.1.2010". European Commission Joint Research Centre, Ispra.

3. "Report to Congress on Server and Data Center Energy Efficiency Public Law 109-431". U.S. Environmental Protection Agency ENERGY STAR Program. August 2, 2007

Measurements of Danish server rooms by Danish Electricity Saving Trust[4] resulted in the following breakdown of the electricity consumption:

- Critical IT: 60 %.
- Cooling: 30 %.
- Other IT equipment: 10 %.

In less efficient server rooms cooling and other IT equipment takes a larger proportion (50 % or more), while in very efficient server rooms with use of free cooling, the proportion could be as low as 10 %[5]. The amount of cooling naturally also depends on the climatic location and other conditions of the data centre.

The critical (basic) IT equipment in data centres and server rooms comprises:

- Servers: The main data processing is taking place in servers. These are typically rack servers and blade servers. Blade servers consist of cabinets with several servers (called blades) built in. These servers share a common power supply, network cards, fans for internal air distribution etc.
- Storage: In data centres the data storage typically takes place in separate and common storage systems for many servers. The storage systems are network connected to the servers. There are many different kinds of storage systems dependent on their functionality.
- Switches and other network equipment: The switches connect the various IT equipment in the data centre and – in case of enterprise server rooms – in the building being served by the data centre.
- UPS systems: These are uninterruptible power supplies and they work as a temporary emergency power supply for the IT equipment in case of power outages. These are in function until the power comes up again or until an alternative power generator takes over the power supply. In smaller server rooms without an alternative power generator, the UPS systems will safely close down the IT systems. UPS systems also function as correction of common utility power problems such as voltage spikes, reduction in input voltage, noise, instability of the frequency and harmonic distortion.

The terms "data centres" and "server rooms" cover a broad range of facilities with servers: From a non-cooled small room in e.g. an office building with a few servers up to very large professional data centres such as Google's and Facebook's data centres and such as colocators, where the data centre organisation provides the infrastructural services, while the servers belong to the data centre clients.

SAVING OPPORTUNITIES

Main saving opportunities include:

- Consolidate several server rooms into one or fewer server rooms.
- Virtualise servers and consolidate them into fewer physical servers.
- Purchase efficient IT equipment.
- Design the server room and data centre efficiently.
- Choose an efficient cooling solution, which include free cooling, if possible, and an efficient cooling machine.
- Use excess heat to heating purposes with the use of heat pumps.

Market analysis of IT managers

Danish Energy Saving Trust previously carried out a market analysis among about 300 IT managers in Denmark[6]. The objective of the market analysis was to get more knowledge on the situation at the IT managers as an input for all of the efficient server activities including the server room guide.

Some important results were:

- Only 3 % of the IT departments actually pay the energy consumption from their own budget.
- Only 12 % of the server rooms have installed power meters.
- Only 11 % have established energy management.
- 42 % have plans to virtualize servers, but not carried out the plans.
- 45 % do not know the cooling temperatures. Of the remainder, about 46 % use too low temperatures.
- 40 % are interested in making the server rooms more energy efficient and additionally 31 % are considering it.

Summarized, the challenges are: Because very few IT departments are responsible for the power consumption budget, most do not have a direct interest in energy savings unless some targets are set by the management. The basis in knowing what the energy is used for is very weak due to the limited amount of server rooms with power meters and energy management. Many IT managers do not know the cooling temperature, which is a very important parameter for energy consumption. Fortunately, there is a general interest in energy efficiency.

These facts have been taken into account when selecting the topics and contents of the server room guide.

The Server Room Guide

AIMS AND TARGET GROUPS

The long term aim of the guide is to reduce the energy consumption in server rooms without jeopardising the delivery of secure and reliable IT services.

The short term aim is to provide a tool with the following functions:

- Stimulate the end-users to start or continue energy efficiency activities.

4. "Electricity Consumption in Server Rooms". Technological Institute for Danish Electricity Saving Trust. 2003. In Danish.

5. Own calculations.

6. "IT Manager Server Analysis" Danish Energy Saving Trust. 2010. Unpublished. In Danish.

- Provide specific knowledge to the end-users about energy efficiency opportunities and ways of prioritising.
- Provide the industry and consultants with the state-of-art knowledge and standards on efficient data centre technology.
- Provide the industry and consultants with best practice material that they can use in marketing of efficient solutions.

The primary target groups are the following end-users:

- Smaller enterprises and institutions with no dedicated IT manager and energy manager.
- Medium sized and large enterprises and institutions with a dedicated IT manager and energy manager.
- Professional data centres selling IT server solutions.

The secondary target groups are:

- IT hardware industry and suppliers.
- Cooling industry and suppliers.
- Consultants in data centre design and other consultants.

CONTENT OF THE GUIDE

In the following we present briefly the content of the guide.

The server room guide comprises all important issues for low energy consumption when designing server rooms and data centres and maintaining them. The topics for the guide are: Electricity consumption and management, server hotels, cloud computing, consolidation, virtualisation, storage, UPS, surveillance systems, design, temperatures, humidity, heat recovery and cooling.

Target group specific sections

There is a section for each of the three primary target groups:

- Smaller enterprises and institutions.
- Medium sized and large enterprises and institutions.
- Professional data centres.

The objective of these three sections is to stimulate the various target groups to start the activities and help them in selecting the most relevant activities to perform. The section structure is the same independently of target group, however, the content is highly adapted to the situation for each of the target groups.

The content is structured around:

- Organisation: Involvement of the management, involvement of IT and energy managers and setting up a steering committee.
- Coordination of electricity and IT hardware purchases: Often these purchases are not thought together and IT equipment is purchased, which is not financially optimal, when looking at both the electricity bill for IT equipment and the purchase cost. The recommendation is to let the same department or person be responsible for both costs.
- Energy management: The user should set a target for the energy consumption by assessing the consumption and the potential improvement options. An energy plan should be established with steps to reach the target.
- Key figures: The section presents most relevant key figures to use for server rooms. The most typically key figure in a global perspective and with a standard calculation method is PUE (Power Usage Effectiveness)[7]. This shows how efficiently auxiliary power (UPS, cooling, other equipment) is used by comparing the total electricity consumption to the consumption of servers, storage and network equipment. PUE can be supplemented with own key figures, where the total consumption is related to the most important server functions. For a server room for an office building this is typical the number of office employees.
- Check list for saving measures: This is a list with maximum 10 most important saving measures.
- Start saving: This is a highlighted box with three to five steps for starting the activities.

Electricity consumption in server rooms

The objective of this section is to provide knowledge about the main components in a server room (both IT equipment and cooling equipment) and their impact on the power consumption.

The section is structured around a detailed illustration of the server room components.

Surveillance of equipment and power consumption

The objective of this section is to create awareness on the relevance of keeping track of all the equipment and of measuring the power consumption.

The concept Data Centre Infrastructure Management (DCIM) is described and how to implement it. Furthermore is described installation of power meters at various component levels.

Finally is described how to identify equipment, which is no longer in use and can be removed and equipment, which is rarely used and can be switched off most of the time.

Key figures

The objective of this section is to provide a detailed understanding of establishing key energy figures and how to use them in the energy management work. The section is more comprehensive compared to the description in the target group specific sections.

The key figures are PUE (Power Usage Effectiveness), NPUE (Net Power Usage Effectiveness), where heat recovery is included, and productivity indexes, where the power consumption is related to the useful work provided by the servers[8].

Robustness and redundancy

The objective of this section is to provide knowledge on how the chosen level of robustness and redundancy influences the energy consumption.

7. "White Paper #49-PUE: A Comprehensive Examination of the Metric". The Green Grid. 2012.

8. "Measuring Data Center Energy Productivity Through Productivity Proxies". The Green Grid. 2012.

The topics covered include server over-capacity, UPS redundancy and data centre tier levels (1–4)[9].

Server hotels and cloud computing

The objective of this section is to provide an overview of the possibilities of using external server hosts for part or all of the server services.

The external server hosts can provide all or part of the server functionality needed. Examples of functions provided include web sites, e-mails, backup, telephone system and webinar facility.

Consolidation and virtualisation

The objective of this section is to provide knowledge on the concepts, the impact on the power consumption and how to start an implementation.

By consolidation is meant to consolidate several server rooms into fewer server rooms and to consolidate the content of several physical servers into fewer servers.

By virtualisation is meant to convert the content of a physical server to a virtual server, which can run at a larger physical server together with more virtual servers, typically 20 to 40 units.

The advantages of consolidation and virtualisation are very large both in terms of a better run server room and much reduced energy consumption.

Storage, servers, UPS systems and switches

The objective of this section is to provide advices how to select the most efficient products, which comply with the technical requirements.

Design and retrofitting

The objective of this section is to describe how the server rooms should be designed and retrofitted to minimize the power consumption and cooling needs and how to carry through the process.

The main areas covered are:

- Cold and hot isles: The cold air should not be mixed with the warm air from the servers and therefore the air distribution should be separated into cold isles, where the cold air is supplied to the ventilation inlet of the servers and hot isles, where the warm air coming from the servers is transported to the cooling system.
- Air flows in server racks: The cold air should go through only the servers and not through e.g. empty spaces in the server racks.
- In row cooling: In row cooling is an efficient way of cooling the racks by having the cooling units in the rack rows.
- Direct cooling in racks: Cooling units can be placed directly in the racks, which is also an efficient cooling concept.
- Location of UPS, network equipment and power distribution systems: Some of the equipment can – if the space allows it – be placed outside the cooled area, which will reduce the cooling load.

Temperature and humidity

The objective of this section is to provide a good understanding of the requirements for temperature and humidity and their impact on the power consumption. The section provides the recommended ranges, which are recommended by ASHRAE[10].

Heat recovery

The objective of this section is to describe the conditions for which heat recovery could be a feasible option and how to carry out the implementation process.

The section provides specific cases, which includes economic calculations.

Cooling

The objective of this section is to provide knowledge on the basic principles of cooling system and their impact on the energy consumption.

The systems covered are:

- Mechanical cooling: The entire heat load is removed through a cooling system with compressor.
- Indirect free cooling: Part of the heat load is removed through free cooling and the remainder by compressor cooling. Indirect cooling use typically a water circuit transferring the cooling from outside to the server room.
- Direct free cooling: The cold air from outside is used directly after filtering to cool the server room.

Free cooling signifies that cold ambient air or water (ground water, lake water, sea water) is used for cooling the server room.

Cases

The objective of this section is to provide the reader with examples of the savings for an optimised server room compared to an average not optimised server room.

The cases are based on calculations of enterprise server rooms.

DEVELOPMENT

The guide has been developed in cooperation and with input from a group comprising about 15 suppliers, consultants and users of server rooms. This is valuable in order to have hands-on experience on the user needs, the market etc. and also for the dissemination.

DISSEMINATION

The Danish Energy Agency has put much weight on a prober, easy to understand and nice-looking appearance by using a technical text writer and using an advertising agency for the layout, illustrations etc. It is available in both a printed and electronic version. The guide contains 60 pages in A4 format.

The printed version is sent directly by post to some thousands organisations in the target groups just. Furthermore, various communication activities take place such as a press release to relevant media, news and other information on the

9. "Telecommunications Infrastructure Standard Data Centers TIA-942". Telecommunications Industry Association. 2010.

10. "Thermal Guidelines for Data Processing Environments" ASHRAE. 2012.

Danish Energy Agency web site, information to industry organisations etc.

Additionally, the industry (suppliers, consultants etc.) often use it as part of their marketing of energy efficient systems and products.

Conclusion

The guide has been very well received by energy and IT managers. This has been indicated by the group of suppliers, consultants and users of server rooms, which has been involved in the preparation of the guide and by direct communication to the Danish Energy Agency.

Danish Energy Agency believes that the reasons are:

- A broad range of companies from the IT industry has been involved in the preparation. Companies include hardware suppliers, consultants, electricity utilities, refrigeration equipment suppliers etc. These partners provide valuable technical input to the guide and are also important for promotion of the guide.
- The content covers the most important topics related to the energy efficiency of server rooms is considered as a main reference for design, retrofitting and maintenance of server rooms.
- The guide has been sent by direct mail to a broad range of energy and IT managers.
- Several PR activities are carried out towards relevant IT and energy magazines when distributing the guide and additional over the year. For the PR activities cases with organisations following the advices in the guide have been selected and offered to the media.
- The guide has been promoted on the web.

The Danish Energy Agency has not measured or estimated the impact of the guide on a national level, however, they have been involved in design of a government data centre, where the energy efficient principles from the guide has been implemented. The energy consumption was reduced from 5.408 MWh to 3.075 MWh corresponding to 43 % savings[11].

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