Energy efficient IT-technology for data centers and server rooms: case studies, procurement guidelines and educational experience from the PrimeEnergyIT European project

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Abstract

As the overall costs of supplying power, and resources increase, IT managers are starting to examine their data center infrastructures more closely and determine where they can be more reliable, as well as more cost-effective and energy efficient. There are ways to achieve acceptable levels of performance and reliability without sacrificing the efficiency that environmentally responsible data centers require.

For the Western Europe the energy consumption of data centers was estimated to be 56 TWh/year 2007[1] which represented about to 1,5 % of the EU electricity consumption. It is project that this value increases to 104 TWh until 2020. With the continuous increase of data traffic and of the use of network services, the increase in the energy consumption is very likely to increase sharply in the next years.

This Intelligent Energy Europe PrimeEnergyIT project was proposed to further enhance market development for energy efficient central IT equipment with a focus on IT hardware, including servers, storage and network equipment as well as new power management technologies.

Although the energy saving potential for IT equipment is well known, the practical implementation is mostly in an early stage, particularly in small and medium size data centres which need guidance for the planning and procurement of efficient data center solutions. The project collected several best practice examples, developed public procurement guidelines and training materials. As part of the project about 500 IT experts were trained in workshops all over the participating countries as an active measure to enhance energy efficiency in the field of data center.

This paper presents two of the most successful best practice examples collected and is also focused on the energy efficiency procurement guidelines for public procurement and education and training workshops for central IT hardware and infrastructure managers.

1. P. Bertoldi: "The European Programme for Energy Efficiency in Data Centres: The Code of Conduct", Presentation at DC Stakeholder Meeting, DG JRC European Commission, London, November 2010.

Introduction

Data centers are dense and complex environments that house a wide variety of energy consuming equipment. The increasing use of powerful IT services in all public and private service sectors as for example administration, health services and entertainment has led to a growing energy demand for centralized IT equipment in data centers and central IT units of companies. Energy consumption of hardware and infrastructure has been continuously growing in the recent years. For the Western Europe the energy consumption of data centers was calculated to be around 56 TWh/year for 2007 and its projected to reach 104 TWh in 2020 (Bertoldi, P. 2010). According to International Energy Agency (IEA) assessments, on a global scale, ICT-related (networks, infrastructure, end-use appliances) is currently representing more than 5 % of total final global electricity consumption and is projected to increase three-fold by 2030[2].

2. IEA (2009) Gadgets and Gigawatts: Policies for Energy Efficient Electronics.

The number of data center IT devices has proliferated dramatically. The necessity to collect, transmit and store data is growing every day following the growth of ICT service providers. Globally, in 2011, it represented about of 1,8 trillion gigabytes of data, which doubles every eighteen months (McKinsey 2011). Data centers will continue to grow in proportion with the growth of network services: following a 9,9 % per annum rate of increase, 122 million servers will already be in place within eight years[3].

In the US, between 2000 and 2006, electricity demand for data centers has more than doubled to 61 TWh, representing about 1,6 % of total electricity sales. In 2008, this value increased to approximately 69 TWh (1,8 % of 2008 total U.S. electricity sales) (IEEE 2011). A recent publication suggests that it may be technically feasible to reduce this demand by up to 80 % (to 13 TWh) through aggressive pursuit of energy efficiency measures (IEEE 2011).

Electricity used in global data centers in 2010 likely accounted for between 1,1 % and 1,5 % of total electricity use, respectively. For the US that number was between 1,7 and 2,2 % (Koomey, J. 2011).

While Google is a high profile user of computer servers with about 900,000 servers in 2010, less than 1 % of electricity used by data centers worldwide was attributable to that company's data center operations (Google and (Koomey, J. 2011)).

The vast majority of the servers in data centers are "volume server" (about 90 to 95 % of USA market, that should not be much different than the EU market), which have an average value of input power of about 200 W. This volume server category includes new and more compact blade servers, which are an important factor in the growth of servers (one blade is counted as one server). The "midrange server" class represents about 5–10 % of the market. The "high-end server" represents just a small fraction of the market. Mid- and high-range servers classes are usually designed to undertake more sophisticated computing functions (Koomey, J. 2007).

With the continuous growth of data traffic and of the use of network services, the energy consumption is very likely to increase sharply in the next years. In spite of better energy efficiency due to new technologies, data centers need more energy than ever before. In many data centers power supply and cooling is already a limiting factor so that the challenges to cope with are huge. However energy saving technologies are already at hand. Depending on project types investment costs can be moderate and payback time may be short especially if measures are included in standard renewal or maintenance cycles for equipment and infrastructure.

Since infrastructure and energy costs in data centers have become a central factor in facility and IT management, a range of technologies has been developed to increase energy efficiency. According to some EU and US studies this trend will continue unless energy efficient technology and efficient operation of equipment is broadly implemented. Business-as-usual would lead to a doubling of energy consumption within a few years thereby also significantly increasing energy costs in data centers. The implementation of energy efficient technologies and optimized hardware operation however allows significant energy and cost savings.

In the past the focus of energy saving measures has been on efficient solutions for power supply and cooling. More recently also measures addressing IT hardware efficiency are considered. Current studies show that efficiency measures already lead to a significant reduction of energy demand compared to a business as usual scenario (Koomey, J. 2011 and Hintemann, R., Fichter, K. 2012). Nevertheless, the remaining energy saving potential is still large and new technologies allow even more effective deployment of saving options.

New hardware and power management options support energy saving strategies but need to be properly disseminated in order to be properly implemented. The PrimeEnergyIT project provided training to about 500 experts and developed brochures with case studies, technology assessment and public procurement guidelines.

The PrimeEnergyIT Project

The effective exploitation of the saving potentials for IT hardware and infrastructure requires concerted action at international level. Compared to many other areas strategies for sustainable solutions are relatively new and have to be further strengthened.

The international initiative PrimeEnergyIT[4] supported the market development and demand for energy efficient central IT hardware and infrastructure.

The project outcomes included tools and services for IT and infrastructure managers, consultants and other experts, covering:

- Hardware and service based energy efficiency criteria and metrics;
- Guidelines on energy efficient equipment and best practice;
- Education and training of IT and infrastructure managers and experts;
- Guidelines and criteria for procurement and management.

The PrimeEnergyIT initiative was operated by an international consortium of national agencies and research institutions in cooperation with a number of associate partners from industry. The project was supported by the EU programme Intelligent Energy Europe.

Case Studies

The case studies collection carried out during the project covers different sizes of data center and server rooms, in different sectors, both public and private institutions. It covered rooms from a few to more than 500 servers, requiring 50 to 1,500 kW power and 20 to 1,800 m² ground space.

In the past the most promising measures for energy efficiency were focused at the infrastructure level: cooling efficiency and power supply chain. In the last years were developed different approaches, involving a more holistic view of a data center:

3. Smart 2020: Enabling the Low Carbon Economy in the Information Age, The Climate Group (2008).

4. www.efficient-datacenter.eu

the capacity planning and management tools combined the efficient IT appliances opportunities with the reliability and availability requests. On the other hand the increasing prices of energy inspired several solutions involving renewable energy sources, passive or low energy techniques for cooling and advanced integrated management systems.

The case studies presented here represents a small but significant selection: public administrations, typically subject to budget constraints, are increasing their efficiency at central IT level with both technical and management solutions.

THE POLITECNICO DI MILANO DATA CENTER EVOLUTION

Politecnico di Milano is a scientific-technological university which trains more than 38,000 engineers, architects and industrial designers. The University has always focused on the quality and innovation of its teaching and research developing a fruitful relationship with business and productive world by means of experimental research and technological transfer.

Research has always been linked to didactics and is a priority commitment which has allowed Politecnico di Milano to achieve high quality results at an international level as to join the university to the business world. Research activity moreover constitutes a parallel path to that formed by cooperation and alliances with the industrial system. Knowing the world in which you are going to work is a vital requirement for training students.

ICT services in the university

The University has today two data center rooms in which are hosted all the main centralized IT infrastructures: the main site (Zone 1) and the disaster recovery (Zone 2). The services provided are primarily for the central administration of the university (admin and students services, email), students (computer rooms) and services for the departments (hosting of web sites, housing).

Both rooms are connected with dedicated broadband optical fibre, from the logical point of view are a single data center space. The storage system, distributed in both sites, has a total capacity of about 100 TB.

Regarding the networking, in both data centers are installed primarily high density enclosures (blade servers), with integrated network devices, linked directly and redundantly with the core devices. The internet access is provided by GARR, through an optical ring system with redundant devices.

Both rooms are served by UPS (Uninterruptible Power Supply) systems in redundant configuration (2N), served by additional power generator.[5]

The cooling system has a typical layout, with an underfloor air distribution, served by a DX system located on a shadowed roof space. All the racks with a specific power installed higher than 6 kW – high density racks – are equipped with perforated doors connected with a ducted air plenum for a separate exhaust hot air.

5. The Power Usage Effectiveness (PUE), developed by The Green Grid consortium, is defined as the ratio between the total facility power consumption and the IT equipment power consumption.

Virtualization process

Virtualization is one of the most powerful technologies for reducing energy demand in data centers and server rooms. Consolidation of server hardware by concentrating workload on a lower number of physical servers often allows energy savings of 40 % to 80 % and sometimes more, depending on the specific case. Current technology provides the possibility to implement virtualization with consolidation factors of at least 10–20, depending on the specific systems and requirements.

Overall virtualization offers a number of advantages for the effective design of IT systems in server rooms and data centers, as for example the reduction of hardware and space requirements via deployment of virtual machines (VMs) that can be run safely on shared hardware, increasing server utilisation from 5–15 % to 60–80 %. This technique optimize also the test and development phase, rapidly provisioning test and development servers by reusing pre-configured systems enhancing developer collaboration and standardizing development environments. The reduction of costs and complexity of business continuity (high availability and disaster recovery solutions) is reached by encapsulating entire systems into single files that can be replicated and restored on any target server.

In Politecnico di Milano the virtualization and consolidation process started in 2006. During the last five years the virtualized services reached the 80 % of the total, reducing the number of physical servers.

Success factors for the Politecnico

The primary success factor is the broad interest for efficiency and improved operation of the whole ICT area personnel. Both rooms' facilities are controlled via a management system tool that provides information on power distribution system, building mechanical and cooling, IT room, and security. The software acts upon user-set thresholds by alarming, logging, or even controlling physical devices. It includes management for power, environmental control, security subsystems. Thanks to the interaction with the server management tools is possible, in case of failure/lack of power or coolant power, hardware overloading or overheating, maintenance or substitution operations, to migrate workloads between racks/servers/rooms.

The server rack standardization, the convergence between physical electrical infrastructure and IT devices (Integration UPS-Cooling-Server) and a good monitoring system for power continuity and temperatures contributed to the optimization process of energy consumption.

The introduction of blade systems and the virtualization process supported the strategies of energy conservation. Table 3 shows that the power consumption remains unchanged in the last 7 years, despite the fast growth of services and the doubling of servers.

CITY OF MARBURG HIGH TECH COOLING (GERMANY)

The city of Marburg is located in the state of Hessen, Germany. The municipality of Marburg is responsible for 19 city districts and approximately 80,656 inhabitants. The 6 municipality departments are connected via one server room. A second server room works as backup solution. Therefore, the small data center forms the backbone for the administration service of Marburg's municipality.

Table 1. Summary of characteristics for the two data center rooms.

Data center Zone 1 (Main site)	Data center Zone 2 (Disaster Recovery)
Floor area: 84 m^2	Floor area: 63 m^2
Number of physical and virtual servers: 119/470	Number of physical and virtual servers: 119/470
Related electrical load: 45 A	Related electrical load: 30 A
Set-point temp: 24 °C	Set-point temp: 23,5 °C
Period of implementation: 2003	Period of implementation: 2003
PUE: 1,5 (excluding switchboards)	PUE: 1,5 (excluding switchboards)

Figure 1. Data center zone 2.

A security check showed that the existing server racks did not fulfil today's fire protection, water protection and security requirements. Therefore, the decision was made to purchase hermetically sealed server racks from Rittal which meet the latest technical requirements. However, this closed rack system required the implementation of a new cooling solution. Due to the fact that the original cooling system could not be upgraded it was decided that a new cooling system is purchased with the focus on energy efficiency and cost effectiveness. During the market screening for a best practice cooling solutions fulfilling the technical requirements, the use of a CHP unit in combination with an adsorption chiller soon became the focus of interest.

Efficient cooling adoptions

According to current information, cooling technology can be responsible for up to 50 % of total energy consumption in server rooms. Therefore, the municipality of Marburg (Germany) invested in 2011 into a new highly efficient cooling technology for their existing server room. The installed combined heat, power (CHP) and cooling system provides the cooling power as well as the required electricity for the IT-equipment. Turning from standard cooling solutions towards a new integrated energy solution enables the municipality to save more than 70 % of total server room energy. This allows energy-cost savings up to €15,000 per annum.

The major challenge in the procurement of a new cooling system was to find an optimal ecological and economical solution. This case demonstrates that the growing importance of energy efficiency in data centers has also reached the attention of small public authorities. A recent survey shows that 58,9 % of companies asked, intend to setup data center projects to increase the energy efficiency (IT SME Index 2011 by Techconsult).

High availability and improvement of redundancy was the major design goal for the server room upgrade of Marburg's municipality. Additionally, the performance of the new cooling solution should be improved, so that less energy is required. Right dimensioning according to the actual needs and economic feasibility had to be taken into account. It was important to realize the improvements without affecting the security of service supply. Changing the basic cooling system including equipment parts of the heating system was a considerable investment and risk factor. Therefore, the procurement process was based on a long planning phase with a first concept in summer 2008. To ensure the commercial success of this measure, the municipality applied in 2009 for a demonstration project with financial support from the federal state and succeeded in autumn 2010. The energy consultancy Freischlad supported the magistrate with analyses of suitable technological solutions. Finally, it was decided to combine a cogeneration plant (CHP unit) with a cooling system from InvenSor.

As mentioned above, the most critical factor was system reliability. The key criterion for the procurement process was to ensure the reliable operation of over 700 connected computers in the public administration. The chosen cooling solution has the advantage of a second, grid independent power source which increases the overall reliability significantly. In addition, the new cooling system consumes less power and decreases the carbon dioxide emission for the infrastructure. The calculations in Table 4[6] demonstrate that the upgrade with the selected combination of CHP and chiller technology has environmental and also financial benefits.

The electrical consumption for server room is 70,000 kWh per year, the Senertec cogeneration plant is capable of 5,5 kW electric power and 12,5 kW heating power output (integrated condenser). The InvenSor adsorption chiller has a 9 kW coolant power, and is connected with a cold water buffer storage of 500 litres closed dry re-cooling. Additionally it could be integrated with a free cooling system for low external temperature periods.

The three server racks are hermetically sealed and equipped with an integrated air/water heat exchanger (Rittal Liquid Cooling Package).

Besides the main objective to save electrical energy for the servers the municipality also addressed the server room's and

6. CHPR: Combined Heat-Power-Refrigeration.

Table 2. Evolution of virtualized services in PoliMi data center, 2005–2011.

No. Services / Year	2005	2006	2007	2008	2009	2010	2011
Total server	232	256	380	325	373	425	471
Physical servers	144	142	217	145	119	119	119
Virtualized servers	88	114	163	180	254	306	352
ESX nodes	8	8	12	12	16	23	23
% virtualization	39%	46%	44%	58%	71%	76%	79%

Table 3. Average power consumption, years 2005–2011, in kW.

Year	2005	2006	2007	2008	2009	2010	2011
Zone 1 – Main site	30,9	30,3	32,3	30,3	29,3	29,6	29,6
Zone 2 – Disaster recovery	21,1	20,4	22,4	21,7	20,1	20,4	19,7

Table 4. Efficient cooling results – energy and cost savings.

	Initial situation		CHP with cooling adsorption	
	Energy (kWh)	Expenses	Energy (kWh)	Expenses
Gas consumption for building	335000	18458 €	402871	22198 €
Electricity procurement for building	177000	37878 €	92000	19688 €
Maintenance and repair costs		400 €		2512 €
Revenues for CHPR bonus		–		- 2248 €
Revenues for tax on oil and gas		–		- 999 €
Total costs p.a.		56736 €		41150 €
Energy cost savings p.a.				+ 15585 €
One-off funding of from state of Hessen				32000 €
Static amortization of CHPR system				3,08 years

adjacent office building's carbon footprint. The carbon dioxide emission of data centers is defined as emitted CO_2 during operation time. In this case the CO_2 emissions are related to the power consumption of the IT and thermal energy used in the building infrastructure.

With respect to the combined CO_2 reduction focus for server room and office building, different time and planning frameworks apply and needed to be considered. A typical data center or server room is – compared to a typical office building – more energy intensive. However, the office building has an additional energy overhead for heating during wintertime. Furthermore data centers operate on very different life cycles (data center: 10 years, office building: 50 years). According to this, investments for office building have a much longer amortization period compared to data center investments.

The selected solution is in many ways interesting. Not only was an effective reduction in electricity consumption achieved, the slightly higher utilization of gas improved the overall carbon footprint. The new cooling and heating system saves about 47 % (34 t per year) of carbon emissions. Additional yearly savings of 4 t CO_2 emissions are possible by utilizing the waste heat of the CHP unit for the heating system during winter time.

Figure 2. City of Marburg data center.

Success factors

This best practice case demonstrates impressively that an innovative new power and cooling concept not only improves the energy efficiency of the data centers but the overall carbon

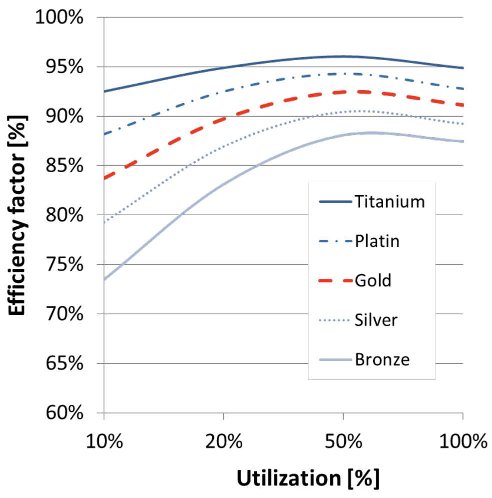

Figure 3. SPECpower diagram.

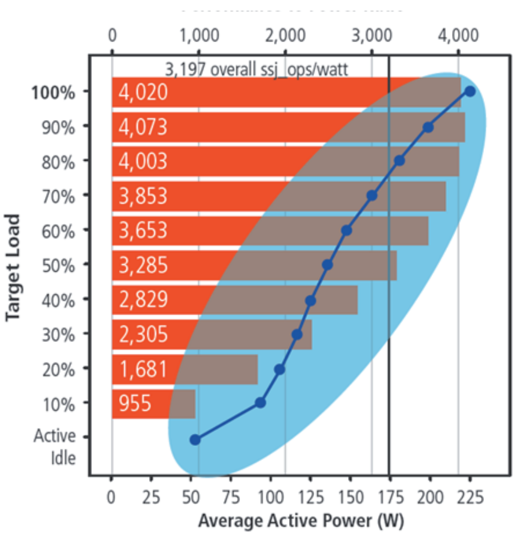

Figure 4. 80plus certified power supply units based on 80plus.org.

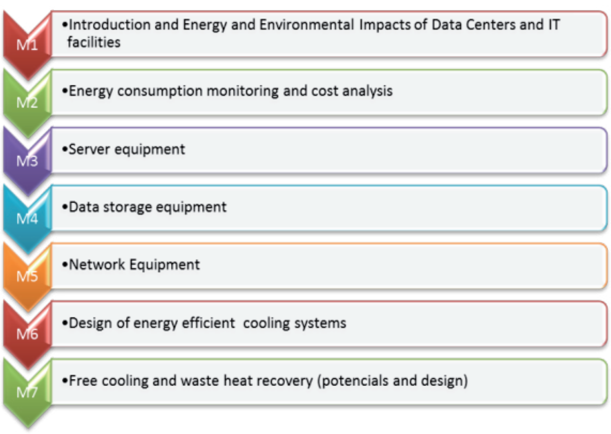

Figure 5. Different training modules developed for the training events.

footprint of the office building as well. The implementation measures resulted in substantial electricity savings of 78 %. Furthermore, the improved cooling system allowed up to 47 % less CO_2 emissions. The decisive advantage here is that with a combination of CHP unit and adsorption chiller the cooling electricity was reduced to a minimum.

The use of CHP unit as an additional independent power source for the server room increased the service redundancy significantly compared to traditional solutions with UPS as emergency backup.

Due to the fact that the combined heat and electricity generation approximately saves up to 40 % primary energy, the German energy law "EEWärmeG" treats the generated electricity 100 % equally to renewable resources. Feeding the excess power into the public grid has thereby also economic benefits. As additional environmental improvement, the cooling process uses only water without any greenhouse gas relevant additives.

This best practice case has shown that the used cooling solution is economically feasible within the extended framework of the server room and office building infrastructure. The lesson learned here is the necessity for extending the focus of the improvement, incorporating adjacent areas such as the office building as well as calculating the improvement in a holistic manner, e.g. overall carbon footprint.

Although the concept phase was an extremely time consuming process, the final trade-off was worth the effort. The greatest challenge was the integration of all responsible departments in order to plan the integrated solution.

Public Procurement Guidelines

The provision of public services is more and more based on information technology. Therefore, this sector is heavily affected by the grown computation power for data centers which is also reflected by the case studies above. In addition, current ICT including data centers play a vital role to drive the transition of public services that are interoperable, scalable and in line with the needs of a mobile generation. The needs for improved service performance such as improved security, user-friendliness and full electronic public services is reflect by the increased data center capacity of public authorities. The public sector is the largest buyer of IT services in Europe. (EC, 2012) Therefore, public authorities have a role to play in forging on energy efficient data centers in Europe. The procurement weight should be used to promote and stimulate the development and implementation of highly energy efficient solutions based on best available technologies.

The most significant environmental impact of data centers is extensive energy consumption during their use phase. The optimal efficiency is strongly related to an overall system design. At the same time, it's a complex topic to define general measures for efficient data centers. Although governments and public institutions have a strong demand on energy related information and procurement guidance this topic so far has not been covered due to lack of widely accepted criteria.

At this point PrimeEnergyIT has developed a guideline for the procurement of central IT equipment like server, storage and network equipment. The hardware approach has been selected as a first important step to improve the efficiency which should be followed by system-based approach.

The guideline "Procurement guidance for energy efficient server room and data center equipment" (Clement S. et al. 2012) provides purchasing recommendations for public authorities and data center requisitioners in the European Union. The core elements focus the replacement and refurbishment of server room and data center equipment such as:

- Servers.
- Storage devices.
- Network equipment (network access equipment, gateways, switches and routers).
- Cooling equipment.
- Monitoring equipment.

The procurement criteria were specifically designed to cover the broad diversity of procurement scenarios. The guideline is subdivided into two major sections. The preparation section covers functional and performance specifications as well as the energy related aspects during the market screening. A key element during the preparation phase is the total cost of ownership (TCO) approach which allows an equipment comparison based on acquisition costs to operating costs. Since the TCO approach is increasingly employed within procurement decisions and a number of suitable tools are already available.

The equipment section contains mandatory criteria, award criteria and contractual conditions for each of the above listed product groups. Mandatory criteria are basically technical specifications such as:

- Power supply efficiency (Energy Star/80plus)
- Temperature requirements (ASHRAE thermal guidelines).

Figure 3 represents the efficiency level of 80plus standard: the PrimeEnergyIT guideline recommends the gold-level for server.

The award criteria are more comprehensive to cover the individual preferences of procurers. The guidance recommends a relative weighting for each of the award criteria. The award criteria for server comprise:

- SpecPower;
- Ratio between SPECpowerIdle/SPECpower100%;
- Power supply dimensioning;
- Power supply redundancy;
- Power management features (power monitoring, power management on component and system level).

Most public authorities rely to some extent on contracted IT service providers to manage and maintain their IT software and hardware arrangements. This may also include responsibility for procuring IT hardware. In such cases, energy efficiency criteria can be made a compulsory element of the service contract. Concerning the criteria for server it is recommended that suppliers must provide a traing for the correct application of power management features. Furthermore, the publication provides first thoughts for monitoring and evaluation of performance and calls for the need of ecolabels and specific benchmark systems that would allow public procurers to more effectively apply green public procurement principles in tenders for server room and data center equipment.

In addition PrimeEnergyIT carried out trainings and GPP workshops to provide the information required by purchasers that take into account energy related considerations.

Education Events

The effectiveness of the training events in each partner of the consortium required a strong cooperation with experts or companies who were already established in the market. An important task was to identify and select suitable co-operation partners or platforms either at international or at national level.

The main objective of the training events was to educate and motivate all chain of professionals involved in the ICT systems, into alter their decisions towards an effective improvement of the systems energy efficiency.

The project partners followed different approaches some used all modules in one single event others preferred to implement small events of 2 to 4 hours with selected modules. Before implementation, all approaches were evaluated taking into consideration the past experiences and trying to predict what would be the target group expectation.

In each module specific attention was taken to ICT related issues regarding Energy Efficiency.

The training materials consisted on presentations and technical supporting scripts for each of the developed modules. Each lecture within the modules included also literature recommendations, best practice and questions to create more interactivity. Training material have been made available through the PrimeEnergyIT website.

OBJECTIVES AND TARGET GROUPS

The main objective of the Education/Training events was to educate and motivate all chain of professionals involved in the ICT systems, into alter their decisions towards improved energy efficiency.

After successful completion of the events, participants should have consciousness about:

- Development of energy efficient ICT systems;
- Energy-efficient procurement;
- Energy life-cycle analysis of an ICT system;
- Analysing energetic gaps of existing ICT hardware and infrastructures and develop plans aiming their improvement;
- Responsibility towards improvement of energy performance.

The events should also raise awareness of energy efficiency value by those involved in the development, management and use.

Usually "IT managers" do not consider energy efficiency in their procurement and management activities because they don't actually benefit from it. The "Infrastructure managers" should always consider efficiency in their equipment acquisition and management processes, but often do not. "Building energy managers" usually are very concerned with energy bills, but sometimes don't have the necessary "tools" to achieve their goals: lack of information about more energy efficient equipment and processes, deficient access to qualified staff that could change processes, etc. … So, all the "chain" that contributes to non-efficient ICT systems needed to be addressed in the education events.

Taking into account the main objective for the education events, the main target groups for the courses were:

- IT managers;
- Infrastructure managers;
- Building energy managers;
- Staff in consultancy, engineering, design companies, dealers/providers of energy saving technologies;
- Staff responsible for the procurement of IT equipment.

TRAINING MODULES

The Figure 5 shows the different training modules that were developed for the education and training events.

Due to partners countries social differences the appropriate concept for the training was selected together with the local education partners.

The several training approaches followed by each partner were different combinations of the modules showed before.

EVENT SUMMARY

Table 5 summarizes the different approaches followed by each project partner and the number of trainees for each event.

About 21 events were organized, with a total number of trainees of about 497. It was also possible to collect about 247 questionnaires correctly filled in, in order to give an overview about the feedback of the trainees.

For the feedback evaluation a standardised questionnaire was developed to be filled in by participants in all partners' events.

About 94 % of the trainees would recommend the PrimeEnergyIT training events and about 53 % recognized that the events have met their expectations. About 30 % and 57 % were respectively, "very satisfied" or "satisfied" with the training materials developed and about 86,4 % have intensions of using the recommendations presented in a near future.

Conclusions

In this time of innovative IT services solutions such as cloud computing and higher technological and communication needs, data centers and server rooms are increasingly becoming critical pieces of the overall IT services panorama. In this evolving context, and always considering that the main costs of running a server room go in parallel to its consumption of energy, the need to reorient the construction and renovation of data centers towards a more sustainable, environmental-friendly approach, becomes tangible. The "Green" data centers solutions does not only denote a significant reduction of monetary costs, but also offer a sustainable, innovative, safer and energy efficient computing solution.

The case studies collected by the partners of PrimeEnergyIT project show that significant energy savings can be achieved with proper investments in new technologies. The main effort should be in the IT personnel involvement in order to overcome all the economic and technical barriers.

The procurement guidelines developed will help public and also private authorities in enhance their efficient criteria on future procurement processes. The main technical aspects for improvement lie in purchasing energy efficient servers, data storage and network equipment as well as cooling equipment. In absence of type I environmental label, the purchasers still need to rely on data coming from measurements such as SPECpower and Ashrae cooling parameters. The proposed GPP criteria focus mainly on the following aspects:

- efficiency of the power supplies and power management,
- data storage energy efficiency according to SNIA Emerald Power Efficiency Measurement Specification Version 1.0,
- award criteria for the highest Telecommunications Energy Efficiency Ratio (TEER) for network equipment,
- cooling equipment minimum requirement: Eurovent class A.

The education events reached about 500 trainees from various target groups. The trainings have been able to raise awareness

Table 5. Event summary.

Partner	Country	Total Nº of training events	Total Nº of trainees	Questionnaires collected	Followed approach
ISR-UC	Portugal	3	149	104	Full day training workshops with all modules (except M5)
BEA	Germany	4	74	24	3 hours events, all together covering all modules
GAIA	Spain	3	28	28	Full day events with all modules
Seven	Czech Republic	2	37	14	8h30 to 15h00 event covering all modules
TUB	Germany	2	40	10	Half day events, covering all the modules after completing all 2 events
AEA	Austria	4	82	15	Half day events, covering all the modules
eERG	Italy	1	63	31	Full day events with all modules
BIOS	France	2	24	21	One event of 3 days with all modules and another event of one day with M1 and M2
Total		**21**	**497**	**247**	

for the subject of energy efficiency in server rooms and data centers and to provide practical help on how to implement these measures. Due to the rapid developments in the ICT sector, training will still be needed in the future. The training materials will need to be continuously updated.

The collaboration with the national implementation partners has proven to be quite successful for the dissemination and implementation of the events. Some of the implementation partners showed their interest in continuing participating on this kind of events.

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