# Nova dimenzija zelene ekonomije – Zeleni data centri

# New Dimension of Green Economy – Green Data Centers

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## APSTRAKT

Dostupnost i primena savremene tehnologije u privatnom životu, poslovnom okruženju, nauci i tehnici, kao i svim ostalim sferama ljudskog delovanja, generiše uvećavanje podataka po eksponencijalnoj stopi. Fotografije, muzika, filmovi, poslovna korespondencija, dokumenta, istraživački podaci ubrzano zauzimaju prostor na serverima. Dostupnost podacima, ali i njihova sigurnost predstavljaju veliki izazov za kompanije koje pružaju usluge bazirane na podacima. Data centri su tehnološka rešenja koja nude bezbedno okruženje za raznovrsne podatke. U njima su, bazično, smešteni računari (serveri) i telekomunikaciona oprema, ali i prateća infrastruktura koja obuhvata: sisteme za neprekidno napajanje (UPS, agregati), bezbednosne sisteme, sisteme za hlađenje, protivpožarne sisteme i sl. Funkcionisanje data centara, posebno u vlasništvu velikih kompanija, poput *Facebook* ili *Google*, imaju izrazit uticaj na okruženje, pre svega u kontekstu potrošnje energije i zagađenja koje nastaje kao rezultat hlađenja sistema. Zbog toga se ovaj rad bavi analizom koncepta zelenih data centara. Ova vrsta centara dizajnira se sa ciljem maksimiziranja energetske efikasnosti, uz minimiziranje uticaja na prirodno okruženje. U radu će biti opisana rešenja koja se primenjuju u zelenim data centrima i njihovi rezultati koji se mere pomoću dva indikatora: efikasnost infrastrukture data centra (DCiE) i efikasnost upotrebe električne energije (PUE).

**Ključne reči:** zeleni data centri, podaci, energetska efikasnost, zaštita prirodnog okruženja, ekologija

## Abstract

The accessibility and use of modern technology in private life, business environment, science and technology, as well as all other areas of human activity generate data by the exponential rate. Photos, music, movies, business correspondence, documents, research data rapidly take up space on the servers. The availability of data and their safety is a major challenge for companies that provide services based on the data. Data Centers are technological solutions that offer a safe environment for different types of data. They include computers (servers), telecommunication equipment, and supporting infrastructure which includes: systems for uninterruptible power supply (generators), security systems, cooling systems, fire protection systems etc. Functioning of Data Centers, especially of the big ones, like Facebook or Google, have a huge impact on the environment, in the context of power consumption and pollution as the result of system cooling. The paper analyzes the concept of Green Data Centers. This type of Data Centers has been designed with the aim of maximizing energy efficiency while minimizing the impact on the natural environment. We will describe solutions that are used in green data centers and their results measured by two indicators: data center infrastructure efficiency (DCiE), and the efficient use of electricity (PUE).

**Key words:** Green Data Centers, Data, Energetic Efficiency, Environment Protection, Ecology

## INTRODUCTION

The first decade of the XXI century have largely emphasized the alarming problem of environmental degradation. Our planet has a limited amount of resources, which have to be preserved and carefully used. A particular problem we are facing is the rapid rise in the cost of these resources as a result decrease of supply, with the constant growth of demand. In addition, we are also facing with increased pollution of the planet as a result of raised carbon dioxide emissions. Additionally, there is a growing problem of e-waste. The recycling process of electronic devices has very high costs because these devices are not initially constructed for recycling and in many cases contains toxic materials. Also, in many countries, there is not appropriate law for discarding electronics, so most of it goes to the landfill.

In this paper, we are dealing with these challenges from the perspective of data centers. We will present the methods they use to reduce bad influence of such occurrences through the concept of *Green Data Centers*.

## 1. CONTEMPORAY DATA CENTERS

Data Center or Datacenter (DC) is technological solutions that offer a safe environment for different types of data. Basically, it is a centralized repository which can ingest, store and disseminate data and information. In most cases Data Centers are organized in order to cover some particular subject or area (corporate data, government data, data generated from Internet-based service providers like Google or Facebook, etc.).

Regardless of the size, DCs have common structure and each DC contains:

- Numerous of computers (servers) or sometimes called “farm of servers” with appropriate software. Nowadays the efficiency of servers have been improved by the virtualization. Without virtualization, each server can host only one application, but with it, server hosts one or more applications at the same time, or even one application can run on multiple servers. This option reduces the susceptibility to interference, as well as the probability of critical events. It also makes free space in the DC and in its cabinets. Also, it reduces the number of required server licenses. Virtualization results in significant savings in hardware investments but increases the complexity of the system.
- Storage devices are keep data and usually occupy a lot of space (storage sylos).
- Telecommunications equipment. American National Standard (ANS) quality standard *Telecommunications Infrastructure Standard for Data Centers* (ANSI/TIA-942-A) contains minimum requirements for DC, regardless it is single tenant DC or multi-tenant Internet hosting DC. It requires structured cabling system, wide range of applications (LAN, WAN, SAN, channels, consoles), etc. (http://www.tia-942.org/content/161/283).

- Supporting systems which include:
  - Backup systems for data security;
  - Power supply systems;
  - Colling facilities;
  - Surveillance and security systems and
  - Fire-protection systems.

Estimation of the core equipment in DCs shows that 60% are computers, 15% is telecommunication and 25% is storage (Greenberg, et.al, 2009). Nevertheless, Data Centers are facing the challenge of a relatively short life time of servers (apx. 3 years) and whole DC (apx. 10 years). The main problem is technological obsolescence of computers.

Today, as a result of fast Internet connection DCs can be and usually are physically dislocated from the users. It is important that they have to be in the environment with good energy infrastructure and good cooling conditions i.e. climate with lower year average temperature.

## 2. CHALLENGES IN DATA CENTERS FUNCTIONING

Based on Moore's Law (Moore, 1965), computer science claims that in mathematical terms, server computes performance has been increasing by a factor of three every two years while energy efficiency is only doubling in the same period (Brill, 2007). Having in mind the basic economic logic of supply and demand, we can understand that if demand increases while supply decreases, prices tend to rise.

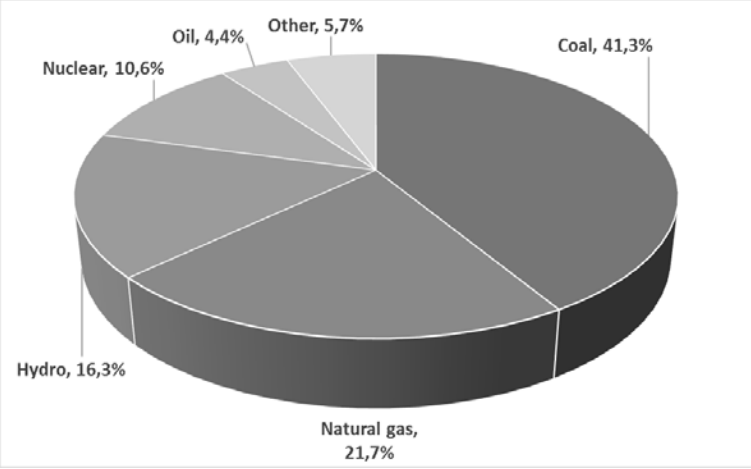


*Figure 1 World electricity generation by energy sources in 2013*
*Source: http://www.statista.com/statistics/269811/world-electricity-production-by-energy-source/*

As an illustration of this tendency Figure 1 presents world electricity generation by energy sources in 2013, and the main problem is that natural gas prices increased 300% since 1999, coal spot market prices increased 100% since 2003, oil prices for electric

generators increased 50% from 2003 to 2005 and nuclear uranium prices increased 40% since 2001 (Dupuy, 2007). As a result of this trend, DCs are facing the challenge of more electricity demand in the situation of price growth. Large data centers are industrial scale operations using as much electricity as a small town (Glantz, 2012).

Another issue for DCs is a need for continuous cooling of each part of computer room (servers and disk storage systems, workstations – standalone, tape storage systems and communication equipment - frames).

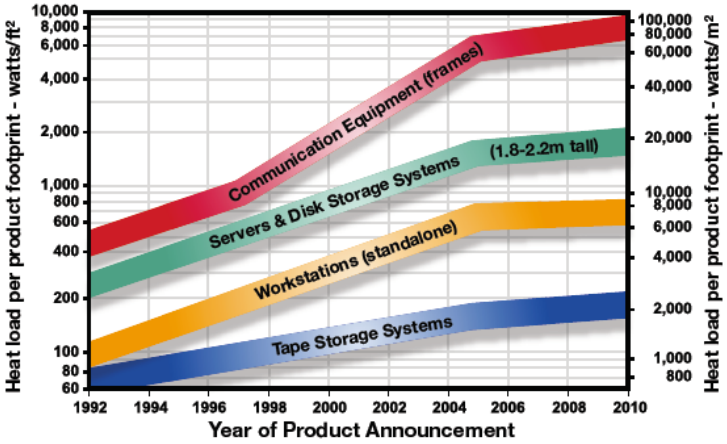


*Figure 2 Product heat density projections in period 2000-2010*
*Source: (Menuet, et.al, 2006, p. 2)*

Figure 2 presents product heat density projections in period 2000-2010. The authors (Menuet, et.al, 2006) use a logarithmic scale for Y axis, because if they use linear scale growth will be presented as a vertical line. Based on presented data we can conclude that heat load per product footprint is rising extremely fast and that DCs must invest in the appropriate cooling systems.

## 3. GREEN DATA CENTERS

With the intent to exceed above challenges, lot of data centers attempt to be energy efficient and responsible toward the environment. Also, they try to decrease the power consumption for computer and cooling systems, to increase utilization of servers and storage devices and to improve overall DC space, with constant monitoring of energy consumption. These DC can be classified as Green DC.

Green DCs have three dimensions of benefits: financial, operational and environmental. In financial dimension, Green DCs are trying to operate in conditions of constant growth of energy prices conducting ongoing accurate analysis of energy cost. Also, they are trying to make cost savings from more efficient energy use. From operational perspective Green DCs are trying to get hardware with dominant performance, to shirt from energy -> cool to energy -> operate ratio with intent to have equipment with longer duration time. Finally, these DC are trying to be responsible to the environment (to reduce carbon pollution) and to create a pleasant ambiance for employees.

In order to measure the level of greenness, DCs can apply some standardized indicators. The most important are indicators which can assess facilities, i.e. DC infrastructure efficiency: data center infrastructure efficiency (DCiE) and power usage effectiveness (PUE). Total facility power is calculated as the total of IT equipment and supporting equipment, like power supply, switches, generators, cooling system parts, storage devices, etc.

$$DCiE = \frac{IT\ equipment\ power}{Total\ facility\ power} x100 \qquad PUE = \frac{Total\ facility\ power}{IT\ equipment\ power} x100$$

DCiE indicates the percentage of the energy that is used by IT equipment compared to the total energy drawn. For example, if we have DCiA value of 20% that means that IT equipment use 20% of all power resources in DC.

Figure 3 presents two main strategies for energy efficiency. Due to limited space we choose this figure with an intention to present all aspects of these strategies, because it contains all relevant points of DC improvement.

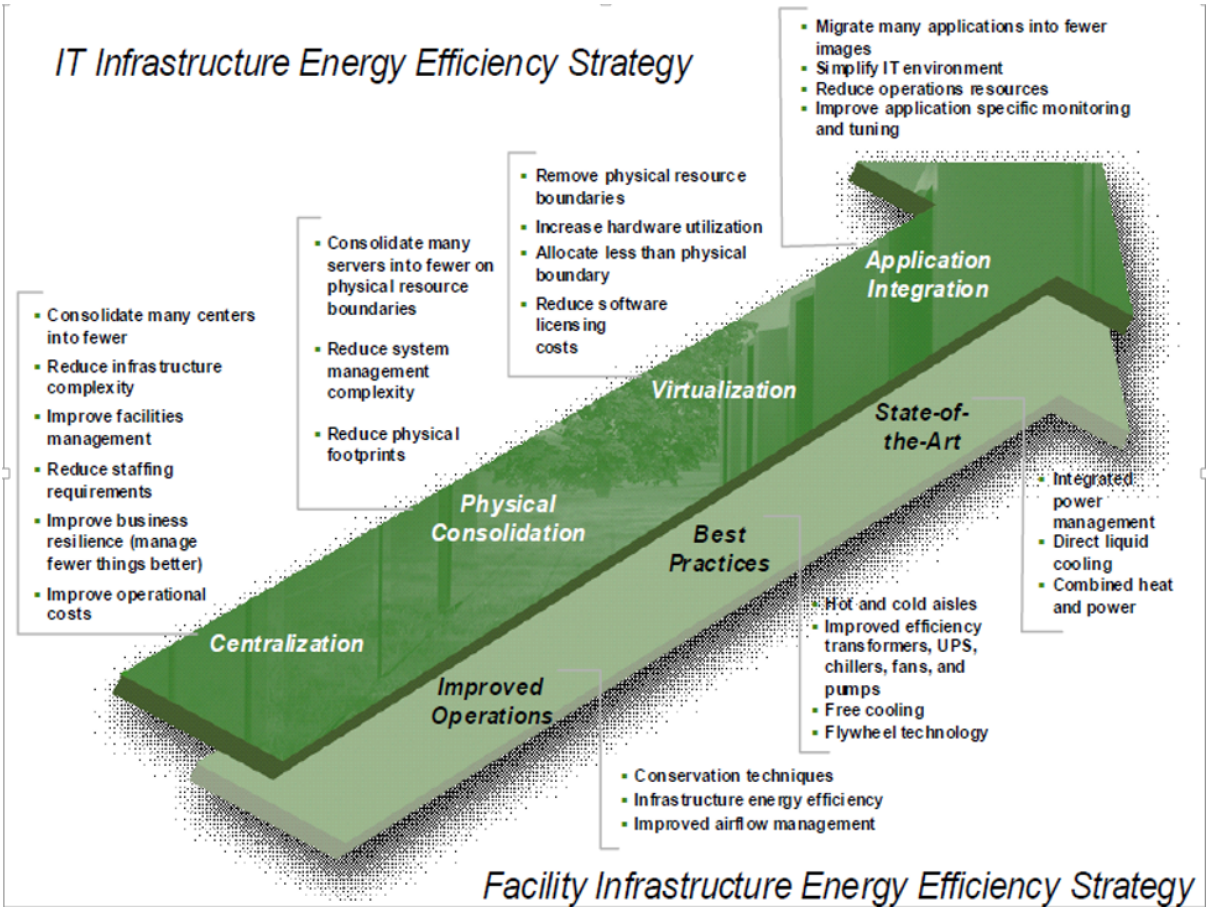


*Figure 3 Strategies for energy efficiency in DC*
*http://www.slideshare.net/RahulKaushal/green-data-centerrahul-ppt*

## CONCLUSION

Data centers, as separate unites, are one of the latest technical solutions as an effective and safe data storage. Some countries pay attention on the environmental impact of these centers and they implement the concept of Green data centers.

As a further step in this area we can expect consolidation of data centers and development of big data centers, which can include or interconnect smaller data centers. The big data center can more easily invest in technical improvements and based on that to achieve better performances, measured by two main indicators: data center infrastructure efficiency and power usage effectiveness.

In light of the increasingly used renewable energy, such as bio gas, the intersection of agriculture with other branches can also be useful.

For example, the product which is produced by means of bio-gas energy could be used for energy supply of the green data centers. In this way, the economy of production and energy consumption would be double.

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