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# INNOVATIONS IN TECHNOLOGY: CLOUD COMPUTING AND ENERGY EFFICIENCY

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**ABSTRACT**
Tight budgets, rising costs of energy, and limited availability on electric power are hampering the ability of organisations information technology (IT) departments to meet the growing demand for IT services. IT suppliers and vendors are trying to meet these challenge by producing energy-efficient computer hardware, creating software that helps to improve the energy efficiency of IT operations, and improved operational efficiency through public and private cloud computing platforms and services.

Despite the wide availability of server virtualization and centralized PC power management solutions, only 25% of IT departments have a plan for optimization of use of IT resources, increasing energy efficiency, and reducing the waste generated by their IT operations. As a result, average server utilization remains at historically low levels, and in many organizations, desktop PCs waste as much as 75% of the electricity they consume.

Organizations can reduce their IT budgets by implementation of energy efficiency in areas such as system architecture, network architecture, hardware provisioning, software design and operations to respond more rapidly to demands for additional services, and their overall productivity and competitiveness.

**Keywords:** IT efficiency, public and private cloud computing platforms.

## Introduction

Information Technology (IT) is so deeply penetrated in our society that the way we interact with our friends and family, how organizations communicate and collaborate with their channel partners and customers. Online demand for IT services, including cloud computing continues to grow, it is important for organisations and decision makers to adapt and optimize their existing IT services to meet the demand. Due to financial constraints, rising cost of energy and Limited supply of electricity, grid and data centers of several organizations find it difficult toad new IT capacity. Now-a-day computer hardware and data center becoming more energy efficient, cooling performance and software solution improve energy efficiency including server virtualization and centralized power management. Even with these advancement traditional IT organisation struggle with high energy costs and growing demand as compare to both public and private cloud computing infrastructures.

Despite the wide spread implementation of server virtualization technologies, about two-thirds of organizations report that less than half of their production environment has been virtualized. Average server utilization is still at or below 15% to 20%, probably no better than it was a decade ago many organizations, including the U.S. government, report average server utilization rates of less than half. This is a huge waste of resources, especially considering that 15% of servers in large organizations are completely idle. There are two factor appear in the root of slowing down virtualization efforts.

- IT departments do not control all of their organization's IT assets.
- Traditional application designs make it difficult to optimize IT resource allocation.

As server performance and storage capacity increase, overall IT energy efficiency and resource utilization will continue to decline unless these factors are addressed. Underutilization of IT assets is a waste of money. Computer Manufacturing is a resource-intensive process, many of the materials and energy resources are damaging to the environment when extracted. In the client computing environment, many organizations have not implemented centralized PC power management which could reduce their PC energy use by up to 75%. Even when PC power is centrally managed, applications often inadvertently interfere with PC power management capabilities, preventing the machines from saving energy when they are not being used.

IT energy efficiency and resource utilization is achievable if hardware manufacturer, software vendors, consultants, software developers, and IT departments make it a priority.

### IT ENERGY PRODUCTIVITY

Unplanned disruptions due to hardware or software failures or system slowdowns caused by unexpected user demand produces overbuilding is a major cause of poor IT energy productivity. A typical data center consumes more than 30 times the energy that it uses to perform computations. Most of the remaining energy is wasted due to server underutilization.

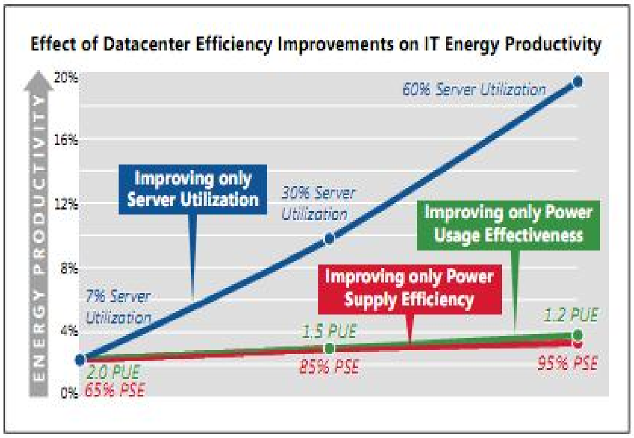


**Figure 1.** The effects of various data center efficiency measures

Increasing server utilization offers greater potential to improve a data center's overall IT energy productivity compared to PUE and PSE improvements—far greater than conventional wisdom has recognized. In fact, until average server utilization approaches 50%, improving server utilization offers the biggest gains in IT energy productivity because servers consume a significant amount of energy when idle—typically between 30% and 60% of the power they consume when fully utilized.

## THE HIDDEN IMPACTS OF UNDERUTILIZATION

The cost of powering underutilized IT equipment can be a significant percentage of an organization's energy bill, and it greatly contributes to data center capacity constraints. These constraints include

- Limits on available utility power,
- limited power and cooling capacity within the building,
- lack of physical space for computers

The manufacturing of computers that will be underutilized also wastes a significant amount of energy, water, and raw materials. Such equipment becomes e-waste within just a few years. When this e-waste is dismantled it contaminate the surrounding land, air, and water with toxic metals and chemical compounds, harming the health of unprotected workers and others in the surrounding areas.

## GOVERNMENT OVERSIGHT AND IT INDUSTRY LEADERSHIP

Many Computer hardware manufacture especially PCs and monitors are aiming to meet Energy Star standard and disposal process more environment friendly. A growing number of software solutions manage computer energy use and improve hardware utilization through centralized power management, virtualization, and other capabilities. Cloud computing also has an important role to play in improving IT energy efficiency. All size public cloud computing platform can free up valuable server and power capacity in an organization's data center and reduce the need to invest in IT infrastructure that will be likely be underutilized and reduces energy use and carbon emissions up to 30%. Many governments and regulatory bodies are taking action to address the environmental impact of growing IT energy use.

## OPERATING IT AS A SERVICE

Most large IT departments have been trying to improve server utilization for some years through the use of server virtualization technology. But many of these efforts have stalled due to financial constraints, organizational politics, and a shortage of sufficiently skilled IT staff. Building a consolidated IT infrastructure often requires a heavy investment of time and money,

In 2010, only one in four IT departments had a plan for further optimizing IT resource use, increasing energy efficiency, and minimizing waste generated by their operations, according to a report by Forrester Research. Improving IT infrastructure energy efficiency was a critical priority for just 12% of companies.

"IT as a Service" can be used through centralized computation-and-storage services hosted in private or public clouds. Operating IT in this manner can dramatically improve equipment utilization and energy efficiency, as well as significantly reduce IT costs across the entire organization.

Centralized computation-and-storage services are at the heart of public and private clouds. Public clouds consist of IT infrastructure that is shared among many organizations and improves energy efficiency through

- Economies of scale,
- Multi-tenancy, and
- The motivation of the cloud provider to improve its bottom line without sacrificing reliability or security.

Public cloud computing from a reputable vendor, provides most secure, reliable, and cost-effective IT services. Private clouds are installed in their premises and operated exclusively by single organization. Private clouds are less energy efficient than public clouds due to their smaller scale. Private clouds do have one important advantage over public clouds as migrating data and applications (such as virtual machines) is much faster and easier given the physical proximity between the existing IT infrastructure and the private cloud.

Using IT services from a cloud enables business organisation to pay for only what they use, is more cost effective and energy efficient way.

IT departments that focus on energy efficiency as a core practice can stretch their budgets and respond more rapidly to demands for additional services, thereby improving their organization's productivity and competitiveness. By embracing IT energy efficiency in areas such as system architecture, hardware provisioning, software design, and operations, organizations will almost certainly realize significant energy and cost savings up and down the IT stack.

## APPLICATIONS: THE GAP

Traditionally IT energy efficiency efforts have focused on physical infrastructure like energy-efficient computer hardware and cooling systems, operating system power management features, and reducing the number of servers in the data centers through hardware virtualization.

But a significant gap in amount of IT energy inefficiency stems from how applications are designed and operated. Virtualization can help improve hardware utilization to a certain degree, Applications in virtualized servers are often just as idle as they were when they ran on dedicated infra-structure because their use of IT resources is not scaled dynamically. Application designer and developer think twice to reduce uncertainty in running the application on dedicated infrastructure as well as dynamically. Some of the gap areas are as

**Reduce uncertainty**

Developers can reduce uncertainty significantly by instrumenting their applications to expose usage and performance metrics that can be used to assign and withdraw IT resources dynamically.

**Focus on business value rather than on the complexities**

Breaking down applications into fine-grained units of service delivery enables far more effective IT resource usage and control than is typically possible with large, monolithic application components and services. Developers should focus on business value rather than on the complexities of scaling and reliability.

**Better managed of operating costs**

Demand for many applications is initially unknown and unpredictable, developers should implementing administrator controls to limit the number of simultaneous users that dynamically degrade the fidelity of the application experience if IT resources are limited. In this way, operating costs can be better managed, and active users of an application will have a predictable experience rather than experiencing random slowdowns.

**Noncritical work should be separated**

Applications such as batch processing and other maintenance tasks when specified by the IT operator provide unanticipated spikes in demand. It will also provide additional options for IT departments to temporarily reduce power use.

**Disaster Recovery**

Applications should operate in degraded or partially recovered states during disaster recovery situations and do not need to have dedicated capacity to sustain service during maintenance events.

**Reduce the costs of maintenance**

All applications should be tested to ensure that they do not waste energy while performing little or no useful work. IT resources should be claimed and released as required, keeping the costs of maintenance events to a minimum. Application that are used rarely or experimental in nature must be reduced.

## ENERGY EFFICIENCY IN PERSPECTIVE

Energy efficiency is important, it doesn't pay if it significantly reduces productivity, performance, and reliability. IT pros are highly cautious and will advise against operational practices that introduce real or perceived risk. Most of the applications are not going to harm significantly if they are oversubscribed or not available for short periods of time.

If energy efficiency of resource is the key criteria for the design of application, reliability is likely to be better than it would be when using traditional IT resource provisioning practices, which are prone to error and uncertainty.

Applications that report their performance dynamically and adjust to constraints should be much easier to keep in compliance with their service level agreement (SLA) as compared to applications whose performance and availability requirements are only expressed on paper.

## END USER COMPUTING ENVIRONMENTS

End user computing environments waste significant amount of energy which is higher than cooling costs office building due to lack of control over IT department.

Organizations with large numbers of PCs and monitors should transparently reflect the cost of space, cooling, and direct energy use by employee equipment through charge-backs to their business units.

IT departments can also ensure that employees choose energy-efficient PCs, and optimized power management capabilities. Organizations with large numbers of users who need computing capacity beyond their primary device should also consider using server-based computing technology.

## A VISION OF IT ENERGY EFFICIENCY AND CLOUD

If "Energy efficiency by design" becomes a fundamental IT ideology, then decision makers can better meets the need to organisation by demanding new IT services quickly and cost effectively. Imagine this future scenario:

- IT departments in large organizations have achieved significant operational flexibility and energy efficiency by running IT as a service, using public cloud computing platforms for line-of-business applications and commodity services such as email, as well as their own private clouds for applications that must remain on premises for compliance or technical reasons.
- IT departments of smaller organizations mostly use applications run on a public cloud, having retired all of their servers except those running legacy applications that must run on premises.
- The vast majority of new applications are developed and deployed directly on public and private clouds. Most legacy applications that were not designed with the cloud in mind have been migrated to private or public clouds as virtual machines.
- Departments outside of IT rent cloud computation-and-storage capacity through the IT department and are not allowed to buy servers to be housed in the data center.
- The IT department helps determine where the application should reside (private or public cloud) based on technical and regulatory constraints, and it passes the operating costs to the application owner.
- Owners of applications that are deployed in a private cloud provide periodic usage forecasts to the IT department to help determine the quantity of IT hardware needed to adequately support demand. Usage trend reporting and instrumentation in new applications makes this forecasting easier.
- Application owners pay for computing resources on a frequent (e.g., hourly) basis, they have an incentive to

ensure that their applications can be dynamically scaled based on demand and to implement throttling mechanisms for applications with unpredictable demand.

- Many applications provide mechanisms to postpone noncritical work to provide additional “virtual” capacity for critical application services if there is a shortfall in IT resources or if power is constrained.
- Applications designed specifically for the private cloud can extend into the public cloud (in a process known as cloud bursting) if additional capacity is required.
- Because the IT department buys, owns, and controls all of the IT hardware within the organization, it determines when the hardware will be deployed, powered on and off, refreshed, or decommissioned to maximize energy efficiency and productivity.
- Server configurations are right-sized and balanced to optimize utilization by the application portfolio.
- Excess capacity can be temporarily turned off until it is needed, but it is ideally made available on a spot market.
- The data centers themselves are constructed with energy-efficient components and a minimal environmental footprint.

The organization’s client computing infrastructure is similarly energy efficient. The power settings of desktop PCs are centrally managed; the PCs automatically sleep when idle but can be woken (even remotely) by the end user or system administrator. IT pros ensure that applications running on mobile and desktop PCs are energy- smart and don’t keep the devices awake when they are not in use. Users who temporarily need additional computers can “check out” virtual machines running on servers to avoid buying an additional PC that will likely be underutilized over the long term.

Corporate IT hardware purchasing policies require that all hardware—servers, clients, displays, storage, networking, and peripherals—meets strict energy efficiency and IT resource consumption criteria.

IT departments that operate in this way can be dramatically more responsive to their organization’s needs and significantly reduce the amount spent on IT across the organization.

**OPPORTUNITIES FOR IT ENERGY EFFICIENCY**

There are many opportunities to improve energy efficiency at all layers of the IT stack that do not require a wholesale re-engineering of how an organization runs IT. Operating IT as a Service—IT energy efficiency can be improved significantly

- By the use of components that require less power to run,
- By managing components so they do not need to run continuously at the same power levels,
- By reducing the amount of hardware needed to do the job.

The layers in the IT stack are interdependent, and their boundaries are not entirely distinct. For an organization with multiple data centers, the Management Infrastructure layer will likely extend into the Building layer to allow for management of applications across multiple data centers.

1. **Silicon Layer**
   - **Variable power component:** In conjunction with operating system, a component like CPU and Hard disk drives can lower their power, when they are idle.
   - **Lower power component:** With solid state technology, component like Hard disk drives and RAM uses less power even in normal operational load.
2. **Operating System Layer**
   With the use of operating system power management system and usage pattern, it helps hardware components to reduce energy use.

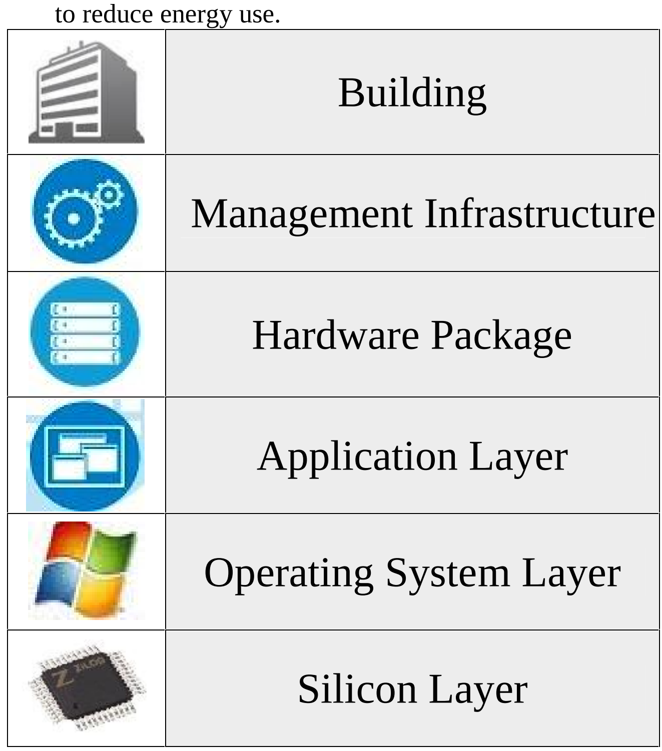


Figure.2 Stack of IT Layers

3. **Applications**
   - **Energy Smart Application:**
     Applications are design in such a way to work with power management system and ensure that servers and PCs save energy and do not affect the productivity when critical task is running.
   - **Dynamically scaled Application:**
     Server applications are designed to save energy and scale dynamically. They are also resistant to sudden Hardware failure.
   - **Postpone noncritical Task:**
     Applications are able to suspend their noncritical task when energy resources are constraints.
4. **Hardware Package:**
   - **Balance hardware subsystems**
     It ensure that hardware subsystem are neither “starved” due to bottlenecks in other systems nor overbuilt and mostly idle. It reduces overall cost and power draw.

- **Efficient power supplies**
  In Case of servers that are on nearly 24/7, an efficient power supply can significantly reduce the amount of energy consumed and more than pay for itself in energy savings.
- **Remove Unnecessary Component**
  Hardware component always draw power whether they are used or not, so Hardware components must be configure according to their use in system (eg. No sound card in servers) can reduce the server cost, electricity bill, associated environmental impact.

5. **Management Infrastructure**
   - **Improve server utilization**
     Server utilization can be increase by using new technologies like virtualization and virtual machine migration. It reduces the need of hardware in data center.
   - **Monitor and control power management in PCs**
     Modern operating systems are shipped with power management tool enable IT departments to ensure that power management is used and monitor its effectiveness. Users can easily reduce this feature's effectiveness by increasing timeouts or by disabling it altogether.
   - **Reduce data footprint**
     Storage management software can help significantly curb the growth of storage needs (and the associated energy consumption) through techniques such as data de-duplication, compression, and archiving.
6. **Building**
   - **Monitor and improve data center resource usage effectiveness**
     IT department also calculate and monitor the effectiveness of power uses in data center for its running purpose along with measuring the use of power in IT equipment and IT department. It also measure the ratio of water and carbon emissions to power consumed by the IT infrastructure.

## ENERGY EFFICIENCY PRINCIPLES

The best approach making IT operations more energy efficient and sustainable, Business organisation should follow some key principle for successful IT operation transition as IT utility

- Make IT more responsive to business demands.
- Improving IT energy efficiency will reduce the financial and environmental costs of running IT.
- Improvement of IT energy efficiency by increasing IT resource utilization in the most effective way.
- IT resource utilization can be increase by Central control of the IT infrastructure (local or cloud-based).
- Applications designed to optimize IT resource utilization are necessary to maximize the effectiveness of a centrally controlled IT infrastructure.

## ENERGY EFFICIENCY PRACTICES

The following practices support the above mentioned principles:

- Keep surveillance on, report, and set goals for IT resource utilization.
- Ensure that the costs of deploying and operating applications on dedicated hardware are fully reflected in the cost charged to the application owner—including energy use, allocated power, and data center space.
- Centralize the budget for server hardware capital expenditures, and decentralize the budget for server hardware operations.
- Use centralized computation-and-storage services (based in private and/or public clouds).
- Rent out capacity to business units (Hardware or software) to recover costs.
- Adopt application designs that enable dynamic resource allocation, cloud bursting, controlled deferral of noncritical work, and workload power efficiency.
- Ensure that power management is implemented on the desktop PCs, and applications function correctly.
- Mandate policies for procurement of energy-efficient hardware.

## IT ENERGY EFFICIENCY: PRESENT AND FUTURE

The integration of IT into almost every aspect of business and society is driving exponential demand of energy will strain the finances of many organization and limits the IT capabilities. There are several opportunity to improve IT energy efficiency but incentives and motivation are sometime low. Strategic level decision maker should ruminate the significant cost saving and productivity opportunities that improvement in IT energy efficiency and empower the IT department.

- Organizations that wish to ensure that their IT capabilities are not constrained over the long term should begin the transition to operating IT as a utility.
- Application developers need to ensure that their applications can scale dynamically with load and respond to constraints will have better performance and be more economical and reliable.
- IT energy efficiency extends far beyond the current needs of any individual organization and effective utilization of IT equipment can significantly reduce the growing volume of unrecycled e-waste that causes environmental and health risks.
- Regulations on pollution already increasing energy costs for data center operators in certain regions.
- Scarce water supplies are likely to threaten the cooling capabilities of many data centers in the future.

Like electricity, increased costs and regulations on water, e-waste, and other raw materials will substantially impact the bottom line of many data centers over time.

## CONCLUSION

Acceptance IT energy efficiency and improving utilization may be the only ways to ensure the viability of many IT operations in business organisation. Some people have expressed concern that advances in IT energy efficiency may, unexpectedly, increase the environmental footprint of IT services. As the cost of computation, data storage, and network bandwidth drops through performance and energy efficiency improvements, IT services and products might become even more widely used than already projected. However, if these more powerful and efficient computers are used effectively, it is feasible that much of the additional demand for IT services could be satisfied without a dramatic increase in the installed base of servers and data centers. The opportunity and the imperative are clear.

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