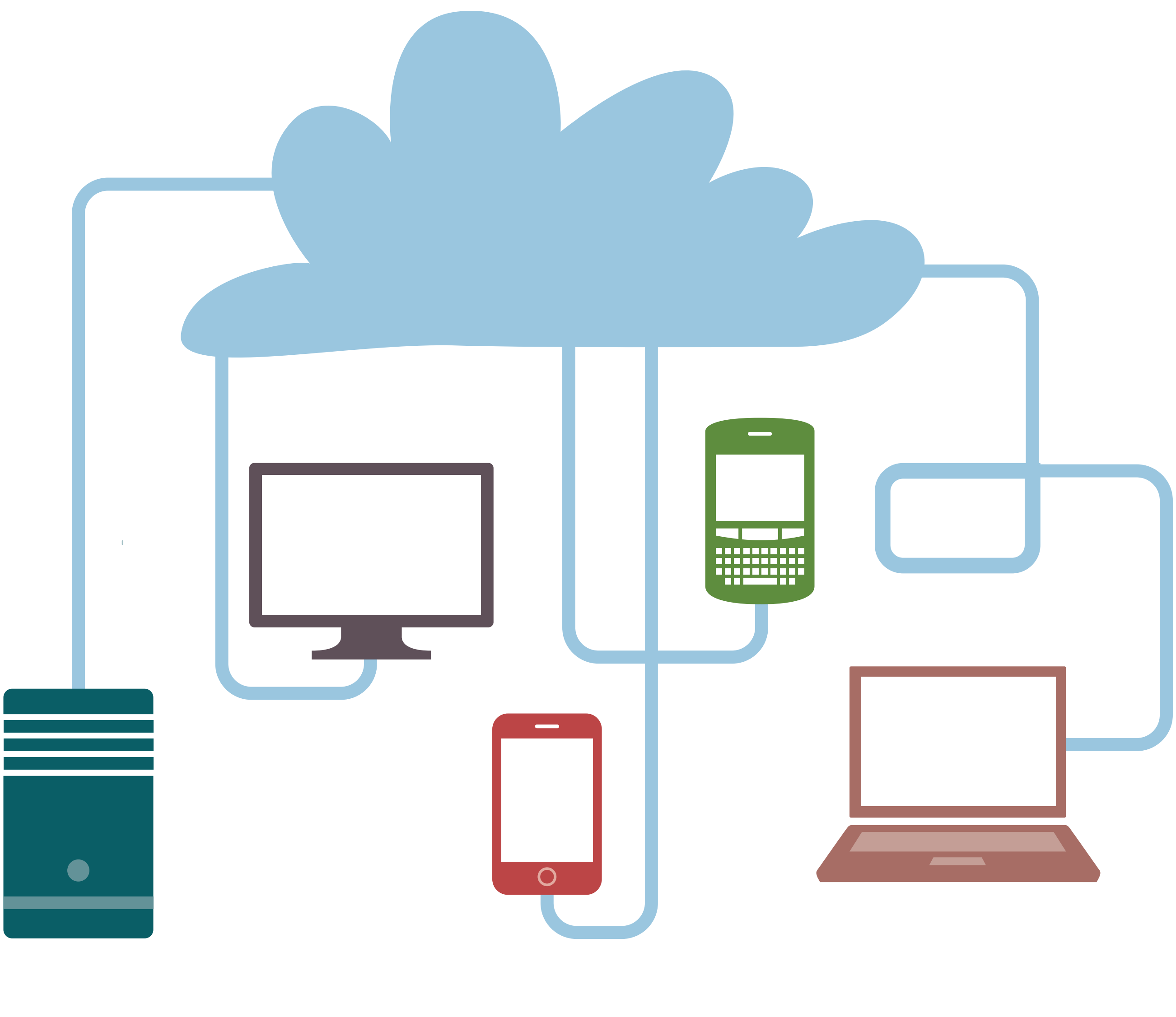
Carbon Disclosure Project Study 2011
Cloud Computing – The IT Solution for the 21st Century



Study produced for
Carbon Disclosure Project by:

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Foreword

Cloud Computing – The IT Solution for the 21st Century

It is with great pleasure that I introduce this significant and timely study on the nascent technology of cloud computing and the important role it can play in both increasing business efficiency and reducing greenhouse gas emissions.

If the 19th century was the agricultural century, and the 20th century was the century of manufacturing, then the 21st century is surely the communications century.

Hundreds of millions of people are being pulled from poverty around the world – in particular in China and India. As we pass this milestone of fundamental human development we can turn to higher aspirations and goals beyond basic human needs and enrich our society through development of Information Technology. This will deliver increasing luxury in entertainment, education, information and communications. The physical goods industries lay the foundations of our modern economy; now Information and Communications Technology (ICT) and cloud computing can help enable the full flowering of human potential.

A large percentage of global GDP is reliant on ICT – this is a critical issue as we strive to decouple economic growth from emissions growth. The carbon emissions reducing potential of cloud computing is a thrilling breakthrough, allowing companies to maximize performance, drive down costs, reduce inefficiency and minimize energy use – and therefore carbon emissions – all at the same time.

The early days of the computer revolution saw a great deal of money invested into ICT – one of the most important economic sectors in the world. There was enormous growth without sufficient thought regarding energy consumption. Now, we at CDP are delighted to be associated with new leadership in the ICT sector in recognizing and responding to the genius of science and design through energy efficiency.

We can experience a great move forward in this exciting time of technological development with ICT making a decisive contribution in reducing greenhouse gases and driving down emissions from business, increasing efficiency in operations and providing the network intelligence vital to reducing energy use and thereby combating climate change.

We are seeing an exciting proliferation of digital products including newspapers, music and movies and a growing range of products and services.

As we learn to live within the finite physical resources of this world, the future of our expenditure will naturally migrate towards the luxuries of the mind because these sectors of the economy have few limits. Business use of cloud services can play a vital part in making this dream a reality.

Paul Dickinson
Executive Chairman
Carbon Disclosure Project

Executive summary

Introduction

The sustainability agenda of many firms is increasingly seen as a core strategic priority. Executives are looking across the entire business to understand ways in which they can operate more sustainably and thereby increase their competitive edge.

ICT is seen as a key area of focus for achieving sustainability goals. Computing requirements have accelerated rapidly over the last ten years. Back in 2006, the Environmental Protection Agency (EPA) estimated data centers consumed 1.5% of total US electricity[1] and they suggested this was double the consumption in 2000. With data center growth continuing, the Department of Energy believes data centers may be consuming up to 3% of total US electricity today.

Businesses are aware this level of electricity usage comes at a cost in both financial and carbon terms. The adoption of cloud computing allows firms to deliver on sustainability while reducing costs. Executives are coming to view cloud computing as a way to transition to a lower carbon business model while increasing the efficiency and effectiveness of business operations.

"Cloud computing is a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g. networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction."[2]

Key findings

This study, produced by independent analyst firm Verdantix, used detailed case study evidence from 11 global firms that have been using cloud computing for at least two years. The information was used to build a forecast model[3] which assesses the financial benefits and carbon reductions for a firm opting for a particular cloud computing service[4]. The analysis also demonstrates how projected cloud computing adoption would drive economy-wide business benefits from a financial and carbon reduction perspective in the US[5].

Cloud computing can avoid millions of metric tons of CO_2

- A typical food & beverage firm transitioning its human resources (HR) application from dedicated IT to a public cloud can reduce CO_2 emissions by **30,000 metric tons** over five years. These reductions are equivalent to the annual emissions from 5,900 passenger vehicles[6].
- The same food & beverage firm transitioning its HR application from dedicated IT to a private internal cloud can reduce CO_2 emissions by **25,000 metric tons** over five years. These reductions are equivalent to the annual emissions from 4,900 passenger vehicles.
- From an economy-wide standpoint, US businesses with annual revenues of more than $1 billion can cut CO_2 emissions by **85.7 million metric tons annually** by 2020 as a result of spending 69% of infrastructure, platform and software budgets on cloud services.

Potential financial benefits from cloud computing run into $ billions

- Through the forecast uptake of cloud computing, US businesses with annual revenues of more than $1 billion can achieve economy-wide savings in energy alone of $12.3 billion a year by 2020.

Cloud computing delivers a positive net present value (NPV)

- A typical food & beverage firm transitioning its HR application from dedicated IT to a public cloud can achieve a NPV of $10.1 million over five years with a payback period of under a year.
- A typical food & beverage firm transitioning its HR application from dedicated IT to a private internal cloud can achieve a NPV of $4.4 million over five years with the payback coming during year two.

Cloud computing brings business efficiency savings

- Significant non-monetary benefits are also achieved with cloud computing including business process efficiency and increased organizational flexibility.

1. http://www.energystar.gov/ia/partners/prod_development/downloads/EPA_Datacenter_Report_Congress_Final1.pdf
2. http://csrc.nist.gov/publications/drafts/800-145/Draft-SP-800-145_cloud-definition.pdf
3. See appendix
4. Forecast was limited to an individual firm due to the significant variations which exist in the IT estates of different firms
5. For firms generating $1 billion plus revenues in the US
6. Environmental Protection Agency – Green Power Equivalency Calculator http://www.epa.gov/greenpower/pubs/calcmeth.htm

Contents

Introduction

This study, commissioned by the Carbon Disclosure Project and conducted by the independent analyst firm Verdantix, provides detailed analysis of the financial and carbon benefits of cloud computing. With the aid of a detailed model and looking specifically at firms generating at least $1 billion of annual revenues in the US, we demonstrate how projected cloud computing adoption will drive economy wide benefits from both a financial and carbon perspective.

So what is cloud computing? It is a term which has been used in many different contexts but the definition we are using comes from The National Institute of Standards and Technology (NIST)[7]: "Cloud computing is a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g. networks, servers, storage, applications, and services that can be rapidly provisioned and released with minimal management effort or service provider interaction)."

Cloud computing is a multi-faceted concept and needs to be understood across three dimensions:

1. **Characteristics.** Server virtualization (where multiple server instances are created on one physical server machine) is a key element of the cloud, allowing for the rapid provisioning or de-provisioning of services (often referred to as elasticity). Self service is also a key component, allowing users to provision new or additional server capacity without requiring interaction from the service provider. The capabilities are available over a network and the services used can be measured accurately and charged for on a usage basis.
2. **Service delivery.** Three main types of cloud service have emerged. Infrastructure as a service (IaaS) provides the processing, storage and network capability to a user. Platform as a service (PaaS) provides users with a development platform for the design and test of custom applications. Software as a service (SaaS) provides applications to users through a centralized network allowing access over the internet or intranet.
3. **Deployment models.** Three main deployment models of cloud computing have developed. Public cloud describes when a third party is providing the cloud service and does so on a multi-tenant basis such that different firms share the same infrastructure, platform or instance of the software application. Private cloud describes a situation where the service is operated exclusively for one particular firm. This service can be provided either internally or externally, by a third party provider. Finally, hybrid clouds describe a situation where the service is delivered through a combination of both the public and private cloud models.

"First we saw the need to get infrastructure which allows us to create a virtualized environment. Following that, we felt we should partner with an IaaS provider to allow us to scale without having to build our own infrastructure."

Applied Materials,
Jay Kerley

Virtual private cloud

Internal and external private clouds have been discussed but it is also valuable to reference a subset of the external private cloud. Virtual private cloud (VPC) describes a situation whereby a cloud provider virtually partitions (rather than physically partitions which would be a standard external private cloud) a portion of a public cloud environment into an isolated environment for exclusive use by a single customer. The service is only accessible via a private network connection and not through the public internet. While our interviewees had not implemented any VPC services, this is an area which could grow alongside the wider growth in cloud computing.

7. http://csrc.nist.gov/publications/drafts/800-145/Draft-SP-800-145_cloud-definition.pdf

Cloud computing explained

“The cloud has enabled us to become a truly global firm.”

Aviva,
Matthew Dines

“With the cloud, firms get a variable pay-per-use model. This is metered down at the hourly level, rather than a fixed monthly rate.”

AT&T,
Jeff Shafer

“We see the cloud as reducing the administration and headache side of IT, allowing our leadership to focus on things that are critical to the business”

Aviva,
Matthew Dines

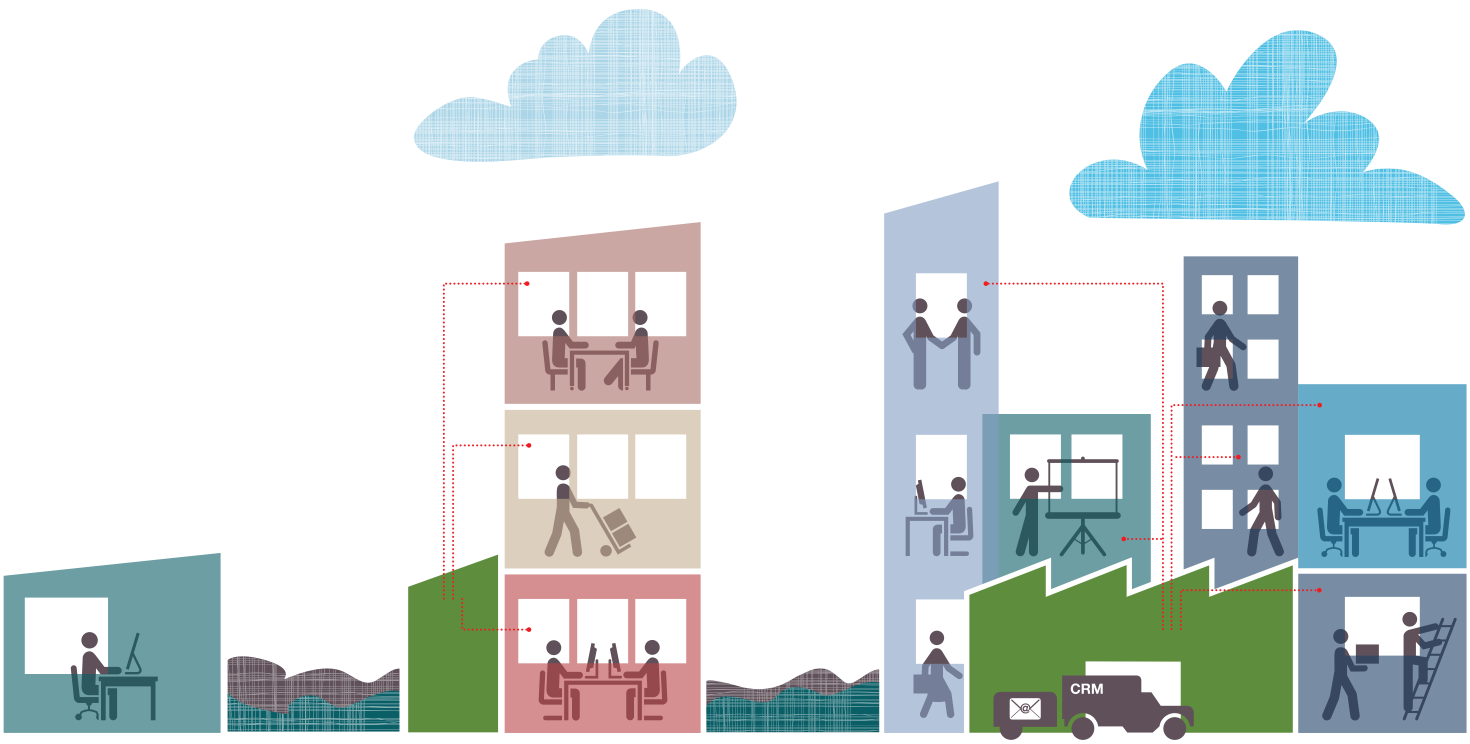
Cloud computing is a term with which most people will be familiar. It continues to receive a growing amount of media attention. Most people are already interacting with various types of cloud computing services but despite this, cloud computing continues to prove an impenetrable concept to many people. In essence it is all about where your computing resources reside, who manages them and how you access and pay for them.

Traditionally, each office would have its own **dedicated IT** systems with their own servers, software applications (e.g. email system) and development platforms (e.g. website development platform). These have to be paid for, managed and maintained internally. There are high capital expenditures associated with purchasing the hardware and it can be time intensive updating and maintaining these systems. Also these systems are often underutilized as they must have the capacity to cope with the highest levels of traffic – this may only happen once a month or once a year.

Some large businesses have adopted a **private cloud** approach which means that they have consolidated all their disparate servers and applications into one company wide system which is maintained behind their firewall and can be accessed across their intranet i.e. they are sharing their resources between the different offices and business units. This means that they can make better, more efficient use of their resources because they are being shared by more people. It also means that their systems are uniform across the company.

Then there are **public clouds**. Instead of owning and managing your own IT systems and hardware you buy the service from specialist cloud providers and you access them from anywhere via the internet. Your customer relationship management systems may be run by one company and the information stored in the provider’s data centers and your email by another company. There are huge economies of scale associated with this model and therefore these providers can make more efficient use of their resources. These services can be provisioned remotely, quickly and in an on-demand, self provisioned manner and you pay only for what you need. This means that less time is spent managing systems and the IT team can focus on innovation to meet their business objectives.

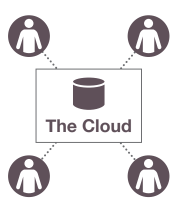
The diagram on the next page visualizes these approaches, using an isolated business, an office block and a business park as analogies.



Dedicated IT

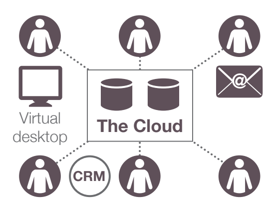
Corporations own and manage their own IT resources, each having their own servers, software and hardware.

Private Cloud



With a private cloud, IT resources are pooled and shared between different business units in the same organisation.

The Public Cloud



A public cloud delivers IT resources through specialist providers to different corporations. You only pay for the services that you use.

Research methodology

"Once public cloud providers are more confident with the security of their offering, they will take on more liability and allow firms to move more of their IT to the public cloud."

Boeing,
Jim Rubert

"Government legislation on sustainability and data protection means cloud computing, especially offshore, has to be monitored closely and managed proactively."

CloudApps,
Peter Grant

The purpose of this study is to get first hand accounts of companies' use of cloud computing and to quantify the potential financial and environmental benefits that can be attained from this technology. For energy and climate change policy-makers, the analysis explains how cloud computing can assist countries to reduce CO_2 emissions.

This research is based on:

1. In-depth case studies with 11 multi-national corporations, across a broad spectrum of industries, who have invested in cloud computing.
2. In-depth interviews with experts from three global cloud computing service providers.
3. A financial model built to calculate the NPV of cloud computing based on a set of specified assumptions.
4. A carbon reduction model built to calculate carbon reductions from cloud computing based on a series of parameters including the size of the firm, the number of servers, server utilization rates, data center power usage effectiveness (PUE), data transmission and embedded energy.
5. An economic model, based on financial data for over 1,800 global firms operating in the US that forecasts economy-wide financial and environmental benefits from cloud computing up until 2020.
6. The methodology used in this report aligns with the assessment methodology established by the Global e-Sustainability Initiative[8] (GeSI), a global not for profit association which brings together leading ICT companies and non-governmental organizations committed to achieving sustainability objectives through innovative technology.

We have shown that different deployment models exist for cloud computing (public, private and hybrid). For the purposes of this study, we analyzed cloud computing in terms of public and private cloud since that is how firms allocate spending (hybrid cloud merely describes a combination of these two approaches). We also included a 'dedicated IT' deployment model which can be defined as the traditional IT deployment approach. It is a non-cloud based model without virtualized servers and without any of the key characteristics associated with cloud computing.

Deployment models
This report analyzes three IT deployment models which are defined as follows:
Public cloud – A third party provides the cloud service on a multi-tenant basis such that different firms share the same infrastructure, platform or instance of the software application.
Private cloud – The firm builds its own cloud and makes the service available exclusively within the business (often referred to as a private internal cloud).
Dedicated IT – A non-cloud service without virtualized servers and without any of the key characteristics associated with cloud computing.

8. http://www.gesi.org/ReportsPublications/AssessmentMethodology.aspx

Table 1 – Industry interviews

Firm	Name	Role
Applied Materials	Jay Kerley	Corporate Vice President and Deputy Chief Innovation Officer
Aviva	Matthew Dines	Head Of Group IT Strategy & Architecture
Barclays Capital	Dave King	Director, IT Production Engineering
Boeing	Jim Rubert	Enterprise Technical Architect
Bouygues Telecom	Alain Moustard	Chief Innovation Officer
Citigroup	Paul Stemmler Michelle Erickson	Managing Director, Engineering and Integration, Citi Global Operations & Technology Initiative Director, Sustainability & Research, Citi Global Operations & Technology
Dell	John Pflueger	Principal Environmental Strategist
Deutsche Bank	Marc Banks	Lead Domain Architect Eco-Efficient IT
Juniper Networks	Dhritiman Dasgupta Masum Mir	Director, Product Marketing Senior Product Line Manager
Novartis	Juergen Basse-Welke	Lead Architect Infrastructure
State Street	Madge Meyer	Executive Vice President, Chief Innovation Officer and Technology Fellow, State Street Corporation

Table 2 – Expert interviews*

Firm	Name	Role
AT&T	Jeff Esposito Jeffrey Shafer	Associate Vice President, AT&T Managed Hosting & Cloud Services Director, AT&T Cloud Services
CloudApps	Peter Grant	Chief Executive Officer
IBM	Rich Lechner	Vice President, IT Optimization and System Software

*Written input was also provided by Hewlett Packard

Why firms invest in cloud computing

"The challenge for any institution is the time to market challenge. Three years ago, it would take six months to approve the installation of a new server. Today, a virtualized server can be created in two hours with a click of a button without the need for any further manual intervention"

Barclays Capital,
David King

We conducted in-depth interviews with multi-national firms in a diverse group of sectors: financial services, insurance, pharmaceuticals, technology and telecommunications. The firms interviewed had adopted cloud services to varying extents for at least two years.

Advantages of adopting a cloud model

Why do firms choose to adopt cloud computing and what benefits have they seen? Our detailed case studies revealed a range of factors encouraging adoption of the cloud. Among the findings:

- **Time to market.** Firms looking to develop and provide new services to their customers can do this far more effectively though a cloud computing model. Prior to adopting a cloud based model, firms indicated it could take two to three months to get new server capacity installed, but a cloud based model enables the creation of a new server instance in minutes.
- **Cost savings.** Many of the interviewed firms reported cost savings as a primary motivator. Anticipated cost reductions were as high as 40%-50% when implementing an internal private cloud (as opposed to dedicated IT). These savings would come from better use of hardware as well as a reduced support team.
- **Capex to opex.** Firms or departments can avoid costly up-front capital investments in infrastructure and can fund the purchased service through operational expenditure.
- **Flexibility.** Many firms run with a large amount of excess computing capacity for much of the time to enable them to handle the spikes in activity which can occur. Firms found

Case study: Boeing Information Technology

"Boeing sees cloud computing as an opportunity to transform its business and processes while improving customer and supply chain satisfaction. Boeing is implementing a hybrid deployment model of both private and secure public cloud services in an enterprise wide strategy which optimizes the business growth from these investments.

Boeing started out on its cloud transition in 2008 and saw immediate benefits from server virtualization in helping to drive energy efficiency and today, Boeing has over 8,000 virtualized servers. However, the most significant impact of the move towards a cloud based model has been the improvement in process efficiency. Previously, it could take up to three months to provision and install a new server in the data center. With the development of a private cloud for the firm's infrastructure, servers will be provisioned within minutes.

Boeing sees opportunities to move some of its IT estate to the public cloud but the majority of the cloud services are private internal clouds. Boeing classifies all of its data and for the lower sensitivity data, a public cloud service may be applicable. However, a significant portion of the data which Boeing deals with is classified as highly sensitive and public cloud providers today are generally not willing to take on the levels of liability necessary to prompt Boeing to utilize their services."

Jim Rubert,
Enterprise Technical Architect,
Boeing Information Technology

that using a cloud model allows them to pay for that excess capacity only when it is required, resulting in reduced overall costs.
- **Automation.** The self-service and increased automation associated with the cloud is found to drive process efficiencies with many of the firms we spoke with since it eliminates the need to go through a server provisioning team.

Barriers to adopting a cloud model

While a series of cloud computing benefits were outlined through the course of the interviews, firms also revealed reasons why they are hesitant to adopt a cloud model. Among the findings:

- **Perceived security concerns.** This was the area most frequently referenced with respect to restricting cloud computing investment. Many firms remain reluctant to move any of their services to a public cloud environment since they prefer to keep their data behind their own firewalls. This situation is only likely to change if cloud service providers accept liability for the data, removing the litigation risk which currently sits with the customer regarding data loss or leakage.
- **Service reliability.** This has been brought into sharp focus with the April 2011 multi-day outage of Amazon Web Services. This outage resulted in the slow-down and in some cases, shut-down, of prominent internet sites such as Quora and Reddit. Many firms cannot countenance a similar outage across their IT estate.
- **Vendor lock-in.** Firms are concerned about moving to a public cloud deployment model since they fear becoming dependent on the provider's service and exposed to any future price increases in the subscription.
- **Lack of clarity in the business case.** While firms can understand the subscription-based costs associated with a public cloud service, understanding how this compares to the costs of the existing operations proves challenging since it is necessary to identify and calculate the costs of the hardware and people that support the existing operations.

Industry variations in cloud adoption

The interviews also revealed variations by industry in terms of cloud computing adoption. The principle trends were:

Financial services firms feel restricted by data security legislation. All the financial services firms interviewed were unwilling to use a public cloud provider to support any operations which involved client data. These firms in particular are governed by extremely strict legislation (e.g. Gramm-Leach-Bliley Act) concerning the security of the data and they considered a public cloud provider unable to provide the necessary guarantees.

Technology and pharmaceutical firms prefer direct control of their intellectual property (IP). In these sectors in particular, competitive advantage is established mainly through the development of IP through their research and development operations. Firms in these industry areas remain hesitant to allow this data to sit outside their firewalls in a public cloud.

Telecommunication firms demonstrate support for their own cloud solutions. Cloud computing services have emerged as a fundamental offering for telecoms providers. As a result, telecommunication firms are early

"If clients have workloads that only need to run once a week or month, they can leverage a cloud service and the cost savings can be immense."

AT&T,
Jeff Shafer

"Cloud computing offers faster time to value and the ability to quickly scale,"

IBM,
Rich Lechner

"With an internal private cloud, we expect to reduce costs in terms of total cost of ownership (TCO) by 40-50%. 10-15% of that saving will come from better usage of hardware and the rest from improved operations basically introducing a self-provisioning portal that requires minimal human intervention."

Novartis,
Juergen Basse-Welke

"We are experiencing significant reuse, and hence carbon reduction, in our internal private cloud environment. Fully 1/3 of all of the virtual servers requested in the internal private cloud are recycled each month."

Citigroup,
Paul Stemmler

large-scale adopters of private cloud solutions since they wish to demonstrate confidence in their own cloud services to their customers.

The financial and business case for cloud computing

The complexity of the term 'cloud computing' was outlined in the initial section with its variations in delivery methods and deployment models. Added to this, each organization has a unique IT estate (the entire suite of information technology which supports the business) and will seek to leverage cloud services in different ways. The amount paid for a particular software license or cloud service subscription will also vary by firm. As a result, the business case for cloud computing is typically a company specific exercise, and in this report a business case has been generated for a hypothetical food & beverage firm.

The environmental case for cloud computing

Cloud computing has the potential to reduce firms' carbon emissions. Through virtualization and running servers at higher utilization rates, the total energy required to support a given service is reduced, which results in lower carbon emissions. Added to this is the fact that for public clouds in particular, providers focus on the efficiency of the data center as a whole (data center PUE) and generally run data centers at lower PUEs.

The critical inputs into our analysis to calculate carbon reductions from cloud computing are[9]:

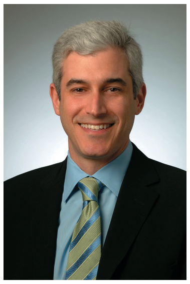
- Number of servers
- Server utilization rate
- Maximum and idle server power ratings
- Network and storage utilization rate
- Data center PUEs
- Embedded server energy
- Energy for data transmission
- Size of firm (by revenue)

Data center PUE

Power usage effectiveness (PUE) is a data center efficiency measure and calculates the ratio of total power consumed by a data center against the total power consumed by the IT equipment. This measure has attracted a certain level of criticism due to variations in interpretation over what should be included in the total data center power consumption calculation as well as questions around temporal variations in the measure. Attempts to provide greater standardization around this measure have been made by the Green Grid in a May 2011 publication[10]. For the purposes of this report, average PUE values were applied to public cloud, private cloud and dedicated IT deployment environments and were based on data obtained through the study interviews and extensive additional research.

9. The model schematic and key assumptions used in the model can be found in the appendix
10. http://www.thegreengrid.org/~/media/WhitePapers/Data%20Center%20Metrics%20Task%20Force%20Recommendations%20V2%205-17-2011.ashx?lang=en

Sustainability perspective



Andrew Winston – A leading expert on sustainable business and author of 'Green to Gold' and 'Green Recovery' gives his view on the role cloud computing can play in sustainability business strategy.
http://www.andrewwinston.com/

Cloud computing is all the rage. In its simplest terms, it means centralizing your company's information technology (IT), from data and storage to software. All the servers and applications sit elsewhere in the Internet "cloud", but more literally in a data center or centers. You can request these additional resources when you need them and you only pay for what you use.

This report shows that US companies are set to increase their adoption of cloud computing over the next decade from 10% to 70% of their IT spend. The predicted adoption could save 85.7 million tons of carbon in 2020, a 50% reduction versus no cloud at all. The energy savings would be more than $12 billion per year by 2020.

With analysis like this showing dramatic energy reductions, I am optimistic about the role that the cloud can play in a low carbon economy – it makes business and environmental sense. It can help companies decrease their carbon emissions, improve operational efficiency and decrease capex on IT resources.

So the move to more cloud provisioning is good news. IT is one of the fastest growing energy hogs, accounting for at least two percent of global energy use and is set to more than double over this decade (Smart 2020). In my last book, Green Recovery, I focused on IT as one of five operational areas where green initiatives help companies save money quickly (the others were facilities, distribution, telework, and waste).

While the IT world has gotten a lot more efficient lately, there's still much room for improvement and the results of this and other studies strongly suggest that moving some of your applications to the cloud can help immensely.

Data centers can lose up to 96% of the energy coming into the building, losing efficiency in three key areas: cooling the room, cooling the servers, and keeping servers idle (utilization rates as low as 10 to 20 percent)[11]. Using the cloud can help in all these areas. Modern data center design tackles room and server cooling and "virtualization" techniques, used at scale, can address the absurd waste, in percentage terms, from server underutilization.

In essence, large scale centers serving many clients are more efficient, especially for smaller enterprises seeking cloud support, and allow for better resource planning. But I'd offer a few points worth thinking about, and one note of caution.

1. The centralization of computing power should look familiar. I recently spoke with Mark Monroe, the new Executive Director of Green Grid, an organization dedicated to making IT more energy and carbon efficient. He compares the cloud to the electric grid, citing Nicholas Carr's book, The Big Switch, which Monroe says "compares utility computing development to the emergence of centralized electrical generation in the early 20th century." Like electric plants, Monroe says, central computing "utilities" benefit from scale and high utilization.
2. We are talking about "servicizing," or turning a product into a service offering. In theory, a service provider will strive to keep its costs down, thus using as little energy and resources as possible. Cloud computing fits this model well (and fits a general transition to helping customers use less). As Monroe says, "Cloud providers want to provide an hour of CPU time, a Gigabyte-month of storage, a CRM transaction, an email, or a web page for as little cost and as high a margin as possible. That just has to lead to higher efficiency than someone focused on delivering a feature internally."
3. But, keep one thing in mind when moving to a service based energy-using function: the footprint is still yours. Technically, a company's main footprint includes only its own facilities (in wonky terms, that's "Scope 1 emissions"). But I believe that anyone doing contract work for you – which is not really the same as traditional suppliers – should count toward your footprint.

In short, finding providers and partners that can take some of your energy-using operations to scale, and manage them in a shared capacity, is good for both a business' carbon footprint and its bottom line. The sustainability agenda of many firms is increasingly seen as a core strategic priority. The adoption of cloud computing allows firms to deliver on sustainability while reducing costs. Executives should view cloud computing as a way to transition to a low carbon business model while increasing the efficiency and effectiveness of business operations.

11. Cited in The Green Recovery

How cloud computing delivers economy-wide financial benefits and carbon reductions

Our interviews demonstrate the financial benefits firms have achieved from cloud computing and the potential for significant associated emissions reductions. In this section, we explain how evidence of financial benefits and carbon reductions achieved by cloud computing will translate into economy-wide benefits and emissions reductions.

Business case scenarios

The 11 global firms interviewed provided the data and insight necessary to build two scenarios to analyze the business case for cloud computing. The scenarios have been analyzed for the following hypothetical firm[12]:

Firm profile

- Sector: Food & Beverage (selected since it was identified as a sector with highly uniform IT requirements which could be most accurately modeled)
- Annual revenues: $10 billion
- Employees: 60,000
- Global penetration: Operations in 30 countries

The firm is in a situation whereby it will lose operational support for its HR application within one year. We modeled the transition and operational costs associated with the following two scenarios over a five year period and compared them to the costs of simply upgrading to the latest version of the application:

Scenario 1
The firm moves to an HR application in the public cloud.

Scenario 2
The firm moves an HR application in the the private (internal) cloud.

Scenario 1

Moving your HR application to the public cloud could save you $12 million over five years and cut CO_2 emissions by 30,000 metric tons which is equivalent[13] to taking 5,900 cars off the road for a year

Building on the data gathered through the interviews, we created a model to analyze the financial benefits and carbon reductions associated with a $10 billion global food & beverage firm moving its HR application from a dedicated IT environment to the public cloud. More detailed information on the model can be found in the appendix. This analysis finds that:

- The total lifetime cost of implementing and operating the public cloud solution over five years is $12.3 million. This compares to $24.6 million to upgrade and operate a dedicated IT solution over the same time frame.
- The investment in the public cloud solution pays back within the first year and has a NPV of $10.1 million over five years.
- CO_2 emissions are reduced by 30,000 metric tons over five years as a result of more efficient use of hardware and more efficient data centers.

Scenario 2

Moving your HR application to the private cloud could save you $5 million over five years and cut CO_2 emissions by 25,000 metric tons which is equivalent[13] to taking 4,900 cars off the road for a year

The same $10 billion global food & beverage firm was also analyzed in terms of moving its HR application from a dedicated IT environment to a private cloud. This analysis finds that:

- The total lifetime cost of implementing and operating the private cloud solution over five years is $20 million (this compares to $12.3 million for public cloud. The additional costs relate to a greater implementation effort required for a private cloud as well as a higher number of employees to support the private cloud service). This compares to $24.6 million to upgrade and operate a dedicated IT solution over the same time frame.
- The investment in the private cloud solution pays back within year two and has a NPV of $4.4 million over five years.
- CO_2 emissions are reduced by 25,000 metric tons over five years as a result of more efficient use of hardware and more efficient data centers.

12. See appendix for the key inputs to the business case
13. Environmental Protection Agency – Green Power Equivalency Calculator http://www.epa.gov/greenpower/pubs/calcmeth.htm

US cloud computing adoption forecast shows a big economic saving – $12.3 billion a year by 2020

Firms interviewed as part of this study confirm economic savings have been achieved from switching to a cloud based model. But what does this mean for the wider US economy? To understand the impact, we built a cloud computing adoption forecast model based on the interviews conducted.

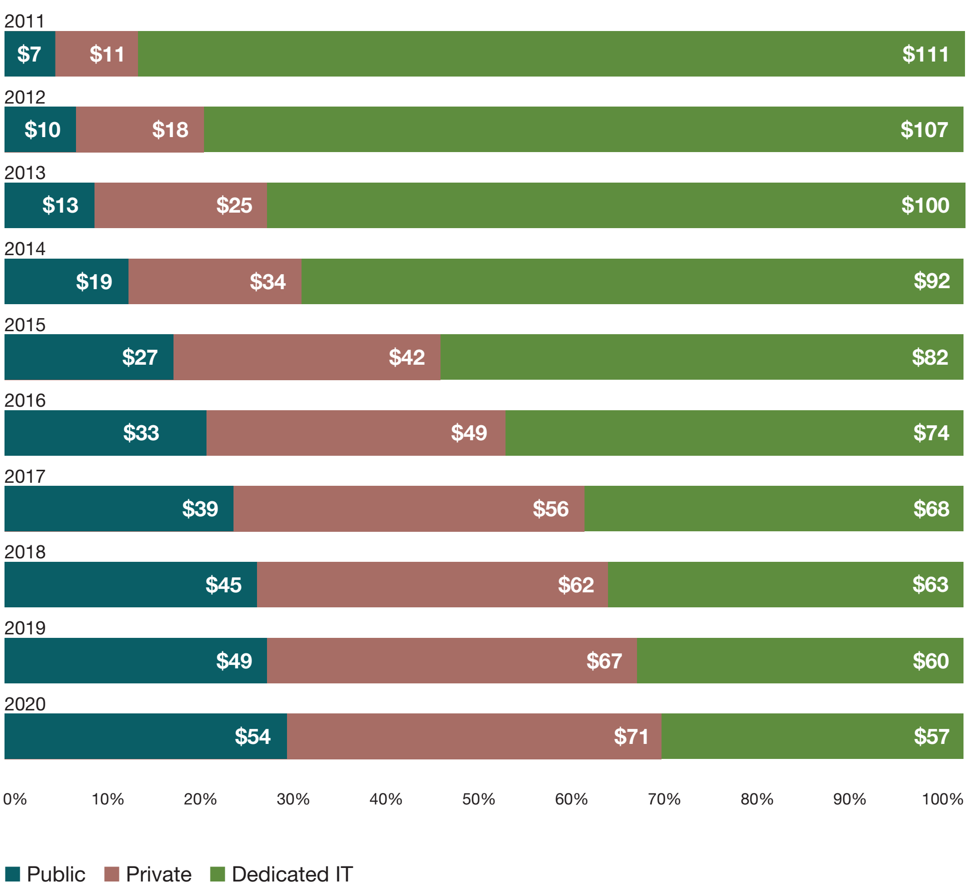
It consisted of:

- An algorithm that forecasts the adoption of cloud computing by business customers.
- Assumptions about the rate of adoption of cloud computing in different industries and the maximum penetration rate of this solution (see appendix).
- Financial data for 2,653[14] global firms with annual revenues in the US above $1 billion.

> "Carbon reduction is one driver, but not the primary driver. The primary driver is time to market. Developers used to take 45 days to get new servers, but in our virtualized private cloud environment, it takes just a couple of minutes."
>
> **Citigroup,**
> Paul Stemmler

> "Not only can firms perform more rapid application development but a firm can also realize savings across the application lifecycle, moving costs from capex to opex."
>
> **IBM,**
> Richard Lechner

Figure 1. Model derived percentage spend of US multi billion dollar revenue firms on IT deployment solutions 2011-2020.



Values in $billion

14. This is the total number of firms generating more than $1 billion of revenue in the US

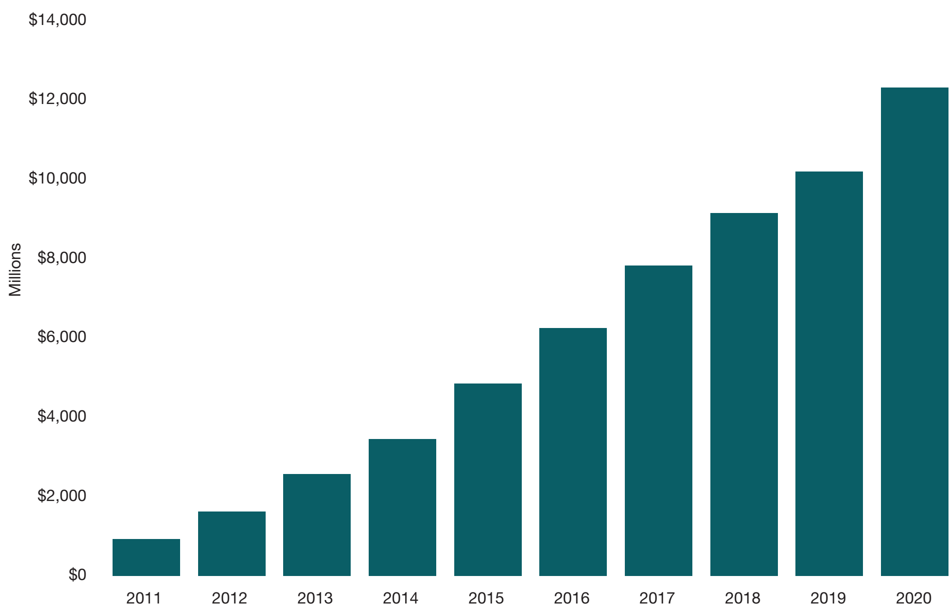
"At one location, we took 400 development servers and consolidated them into 8-10 physical servers to achieve significant savings."

State Street,
Madge Meyer

"To increase the utilization of hardware and power efficiency from a sustainability view, you need to have elasticity and flexibility and ability to move applications around between servers."

Deutsche Bank,
Marc Banks

Figure 2. Model derived net energy savings 2011-2020.



The business case model makes a number of assumptions around license costs, subscription costs and the complexity of existing deployment models which are highly firm specific and it would not be credible to roll these figures up to try to provide a US perspective.

What we can do is convert the cloud adoption forecast into financial savings through reduction in electricity usage. In this respect, key financial findings from the analysis are:

- By 2020, firms with annual US revenues of more than $1 billion will be spending 69% of their infrastructure, platform and software budget on cloud based solutions (Figure 1). Segmenting this further, 39% of the spend will be on private cloud computing while 30% will be on public cloud services (Figure 1).
- Annual net financial benefits associated with the energy saving from cloud computing are forecast to reach $824 million by 2011, rising to **$12.3 billion by 2020** for the 2,653 global firms with annual revenues in the US above $1 billion (Figure 2).

Potential carbon reductions of 85.7 million metric tons per year by 2020, equivalent to the annual emissions from 16.8 million passenger vehicles.[15]

Alongside the financial benefits from cloud computing come the potential carbon reductions. Our forecast for the 2,653 global firms operating in the US identifies the potential to cut CO_2 emissions with cloud computing as follows:

- CO_2 reductions in 2011 of 5.7 million metric tons for global usage of cloud computing in 2011.
- Annual reduction of CO_2 of 85.7 million metric tons by 2020 for multi billion dollar US firms (Figure 3).
- A reduction of 50% in CO_2 emissions by 2020 compared to a scenario where there is no cloud computing (but a real increase of 36% in CO_2 emissions as compared to 2011) (Figure 4) (Figure 5).

Figure 3. Model derived net CO_2 savings 2011-2020.

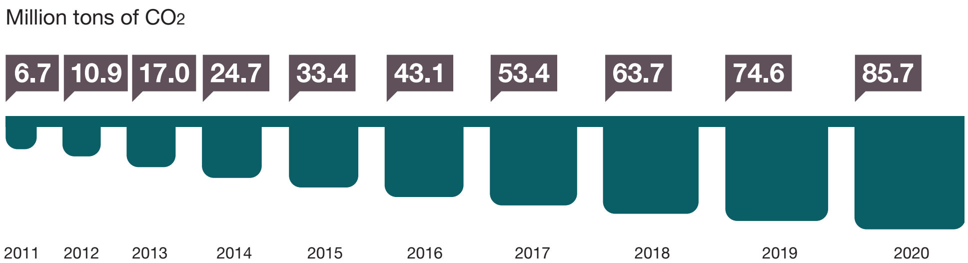


Figure 4. Model derived percentage CO_2 savings of cloud computing compared to no cloud computing 2011-2020.

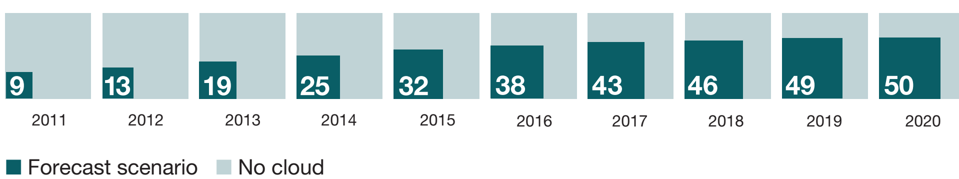
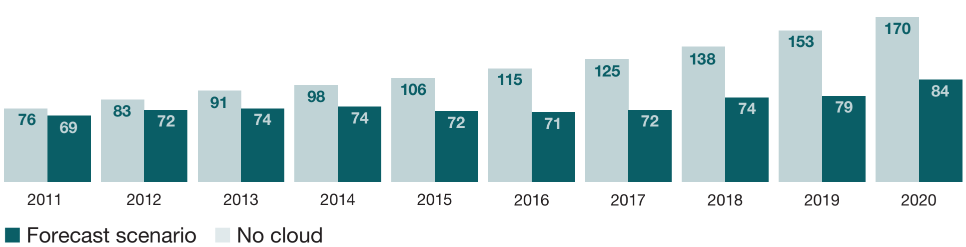


Figure 5. Model derived percentage rise of CO_2 emissions of forecasted scenario compared to non adoption of cloud computing.



Data center energy sources and efficiency

Two elements to be considered in evaluating the carbon impact of the cloud computing strategies of specific firms are the source of the energy being used to power the data center and energy efficiency efforts. A recent Greenpeace report[16] focused on exactly these issues and made the point that while significant advances in data center energy efficiency have been achieved, this has not been matched by efforts to source lower carbon energy to power them. PUE calculation tools, developed by the likes of The Green Grid[17], have helped in driving efficiencies in the data center but increasing IT demand serves to offset progress in energy efficiency. Many companies are seeking to use renewable energy such as hydropower to power their data centers whilst increasing energy efficiency levels. Overall, in looking to de-carbonize your data center it is important to look at the source of the power as well as the efficiency of the data center itself.

15. Environmental Protection Agency – Green Power Equivalency Calculator http://www.epa.gov/greenpower/pubs/calcmeth.htm
16. http://www.greenpeace.org/international/en/news/features/New-Greenpeace-report-digs-up-the-dirt-on-Internet-data-centres/
17. http://www.thegreengrid.org/en/Global/Content/Tools/PUEE

Recommendations to maximize environmental cloud computing benefits

"The drivers for cloud computing can be summarized as cost, resiliency and efficiency"

Juniper Networks,
Dhritiman Dasgupta

"One of the difficulties of using old dedicated IT infrastructure is owning legacy servers which are fixed to applications. The cloud de-couples operating systems from hardware"

Deutsche Bank,
Marc Banks

Cloud computing offers firms the potential to combine financial savings with environmental benefits. Drawing on the detailed interviews as well as the financial and carbon reduction models developed for this study, the following recommendations can help maximize the cloud computing investments:

- **Develop enterprise-wide strategy.** Firms which have demonstrated greatest success in moving to a cloud based model have integrated cloud computing into the overall IT strategy. By taking a holistic approach, investments are appropriately targeted and rather than establishing an un co-ordinated mix of various cloud and non-cloud based solutions, targeted solutions are deployed which increase the efficiency of the business.
- **Understand the IT estate.** Creating a business case for cloud computing demands an understanding of the costs of supporting the different elements of the existing IT model. In looking at an IT application, the license fee may be highly transparent but the cost of the supporting infrastructure and the number of full time equivalents (FTEs) involved in the maintenance of the application may be less obvious, as well as the electricity cost of powering this application.
- **Investigate business processes.** One of the characteristics and benefits of cloud computing is its elasticity which allows for the rapid provisioning or de-provisioning of services. Many firms have particularly high computing demands at month end, quarter end or year end. Where a firm experiences these spikes in demand, adopting a cloud model allows the firm to rapidly scale up and down as required rather than spending money maintaining servers all year round to accommodate these occasional spikes.
- **Identify non business critical applications.** Firms repeatedly indicate they would not consider a public cloud software solution where business critical data would be stored. At the same time, firms did confirm that a public cloud solution would be feasible for less critical applications. Firms should understand applications which are non business critical and investigate a public cloud solution.
- **Harmonize employee behavior.** Developers have traditionally used their own tools to develop new IT applications. This is not conducive to using a cloud based development platform which demands consistency in the tools used. Firms should determine if it is possible to harmonize developer behavior so they all use the same tools thus facilitating a move to a cloud based platform.

Glossary

Cloud computing
A model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g. networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction (The National Institute of Standards and Technology [NIST]).

Dedicated IT
A non-cloud based environment with non-virtualized servers and without any of the key characteristics associated with cloud computing.

Hybrid cloud
The delivery of a cloud service through a combination of both the public and private cloud model.

Infrastructure as a service (IaaS)
Provides the processing, storage and capability to a user.

IT estate
The entire suite of information technology which supports the business.

Platform as a service (PaaS)
Provides a development platform for the design and test of custom applications.

Private cloud
A service operated exclusively for one firm. This service can be provided either internally or externally by a third party provider (for the purposes of the analysis in this report, the private cloud was assumed to be provided internally rather than by a third party. The data collected through the interviews indicated this was the dominant scenario).

Public cloud
When a third party is providing the cloud service and does so on a multi-tenant basis such that different firms share the same infrastructure, platform or instance of the software application.

PUE
Power usage effectiveness is a data center efficiency measure and calculates the ratio of total power consumed by a data center against the total power consumed by the IT equipment.

Server utilization rate
This denotes the percentage of maximum power which is being used by the server.

Server virtualization
The creation of multiple server instances on one physical server machine.

Software as a service (SaaS)
Provides applications through a centralized network allowing access over the internet or intranet.

Virtual private cloud (VPC)
A cloud service that is only accessible via a private network connection and not through the public internet.

Appendix

Business case model

The business case was developed for a hypothetical food & beverage firm with $10 billion of annual revenues, 60,000 employees and operations in over 30 countries. Five years is the typical lifespan of an HR application so the business case is evaluated over this time period. Implementation as well as operational costs are considered and this includes the costs of running the legacy dedicated IT model in 'Year 1' while the cloud service is being implemented. License fees still apply in the private cloud model since it is an internal private cloud where the firm is still required to buy the license and then set up the cloud service independently.

	Scenario 1	Scenario 2
Scenario definition	The HR application is currently deployed on dedicated IT and will lose operational support within one year.	
	This scenario looks at the business case for switching from an HR application deployed on dedicated IT to an HR system in the public cloud.	This scenario looks at the business case for switching from an HR application deployed on dedicated IT to an HR system in the private (internal) cloud.
Upfront investment costs		
Hardware purchase	Hardware owned and managed by cloud provider so no purchase necessary	No upfront investment in hardware as existing servers can be virtualized
Implementation	Costs relate to data migration and training	Costs relate to data migration, system customisation, server virtualization and training
Headcount reduction	75% of the FTEs supporting the application no longer required	25% of the FTEs supporting the application no longer required
Cloud costs		
Capital costs	None	License for software & ongoing server replacement program
Operational costs	Annual subscription fee and limited FTE support	Electricity bills and FTE support
Cost savings		
Capital costs	No license fee required or ongoing server replacement program. No system customizations necessary which would be expected from an upgrade to the latest HR system deployed on a dedicated IT environment	Reduced server replacement program due to virtualization of servers
Operational costs	No electricity payments and reduced FTE support costs	Reduced FTE costs and electricity payments (as a result of reduced number of servers)

Scenario 1 – Switching HR from dedicated IT to public SaaS

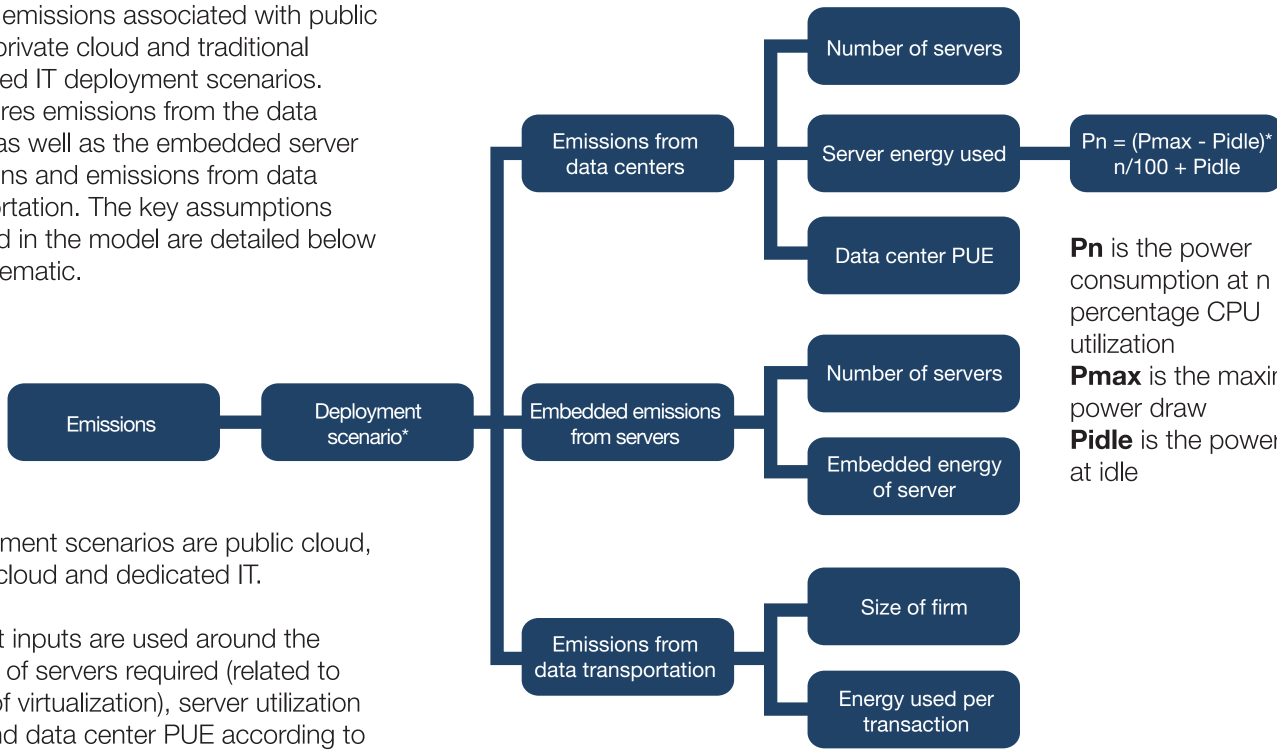
Example firm, food & beverage, $10b revenue, 60,000 employees, 30 countries		**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**
Cost of switching						
Implementation costs						
Hardware purchase		$0	$0	$0	$0	$0
Data migration		$0	$0	$0	$0	$0
	# of FTE consultants	25	0	0	0	0
	FTE rate	$90,000	$90,000	$90,000	$90,000	$90,000
	Total cost	$2,250,000	$0	$0	$0	$0
System customization	# of FTE consultants	0	0	0	0	0
	FTE rate	$90,000	$90,000	$90,000	$90,000	$90,000
	Total cost	$0	$0	$0	$0	$0
Server virtualization	# of FTE consultants	0	0	0	0	0
	FTE rate	$90,000	$90,000	$90,000	$90,000	$90,000
	Total cost	$0	$0	$0	$0	$0
Training	# of FTE consultants	14	0	0	0	0
	FTE rate	$60,000	$60,000	$60,000	$60,000	$60,000
	Total cost	$840,000	$0	$0	$0	$0
Headcount reduction	# of FTE	15	0	0	0	0
	FTE rate	$70,000	$70,000	$70,000	$70,000	$70,000
	Redundancy percentage	50%	50%	50%	50%	50%
	Total headcount reduction cost	**$525,000**	$0	$0	$0	$0
	Total implementation cost	**$3,615,000**	$0	$0	$0	$0
Public cloud costs						
Capital costs		$0	$0	$0	$0	$0
Operational costs	Subscription fee	$0	$1,100,000	$1,166,000	$1,235,960	$1,310,118
	Hardware purchase	$0	$0	$0	$0	$0
	Electricity	$0	$0	$0	$0	$0
Support	# of FTE	0	5	5	5	5
	FTE rate	$70,000	$70,000	$70,000	$70,000	$70,000
	Total support cost	$0	$350,000	$350,000	$350,000	$350,000
	Total cost of ownership	$0	$1,450,000	$1,516,000	$1,585,960	$1,660,118
Legacy solution		$2,579,134				
Total lifetime cost		**$12,406,212**				
Dedicated IT costs						
Capital costs						
License fee		$5,000,000	$0	$0	$0	$0
Hardware purchase		$0	$0	$0	$0	$0
Implementation		$0	$0	$0	$0	$0
	# of FTE consultants	50	15	0	0	0
	FTE rate	$90,000	$90,000	$90,000	$90,000	$90,000
	Total cost	$4,500,000	$1,350,000	$0	$0	$0
Operational costs						
License fee		$0	$0	$0	$0	$0
Hardware purchase		$200,000	$200,000	$200,000	$200,000	$200,000
Electricity		$979,134	$1,076,753	$1,176,271	$1,273,244	$1,364,588
Support	# of FTE consultants	20	20	20	20	20
	FTE rate	$70,000	$70,000	$70,000	$70,000	$70,000
	Total support cost	$1,400,000	$1,400,000	$1,400,000	$1,400,000	$1,400,000
	Total cost of ownership	$12,079,134	$4,026,753	$2,776,271	$2,873,244	$2,964,588

Scenario 2 – Switching HR from dedicated IT to private SaaS

Example firm, food & beverage, $10b revenue, 60,000 employees, 30 countries		**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**
Cost of switching						
Implementation costs						
Hardware purchase		$0	$0	$0	$0	$0
Data migration		$0	$0	$0	$0	$0
	# of FTE consultants	25	0	0	0	0
	FTE rate	$90,000	$90,000	$90,000	$90,000	$90,000
	Total cost	$2,250,000	$0	$0	$0	$0
System customization	# of FTE consultants	15	15	0	0	0
	FTE rate	$90,000	$90,000	$90,000	$90,000	$90,000
	Total cost	$1,350,000	$1,350,000	$0	$0	$0
Server virtualization	# of FTE consultants	8	0	0	0	0
	FTE rate	$90,000	$90,000	$90,000	$90,000	$90,000
	Total cost	$720,000	$0	$0	$0	$0
Training	# of FTE consultants	14	0	0	0	0
	FTE rate	$60,000	$60,000	$60,000	$60,000	$60,000
	Total cost	$840,000	$0	$0	$0	$0
Headcount reduction	# of FTE	5	0	0	0	0
	FTE rate	$70,000	$70,000	$70,000	$70,000	$70,000
	Redundancy percentage	50%	50%	50%	50%	50%
	Total headcount reduction cost	**$175,000**	**$0**	**$0**	**$0**	**$0**
	Total implementation cost	**$5,335,000**	**$1,350,000**	**$0**	**$0**	**$0**
Private cloud costs						
Capital costs		$0	$0	$0	$0	$0
	License fees	$5,000,000	$0	$0	$0	$0
Operational costs	Subscription fee	$0	$0	$0	$0	$0
	Hardware purchase	$50,000	$50,000	$50,000	$50,000	$50,000
	Electricity	$0	$296,345	$326,905	$359,347	$393,283
Support	# of FTE consultants	0	15	15	15	15
	FTE rate	$70,000	$70,000	$70,000	$70,000	$70,000
	Total support cost	$0	$1,050,000	$1,050,000	$1,050,000	$1,050,000
	Total cost of ownership	$5,050,000	$1,396,345	$1,426,905	$1,459,347	$1,493,283
Legacy solution		$2,573,134				
Total lifetime cost		**$20,090,013**				
Dedicated IT costs						
Capital costs						
Hardware purchase		$0	$0	$0	$0	$0
Implementation		$0	$0	$0	$0	$0
	# of FTE consultants	50	15	0	0	0
	FTE rate	$90,000	$90,000	$90,000	$90,000	$90,000
	Total cost	$4,500,000	$1,350,000	$0	$0	$0
Operational costs						
License fee		$5,000,000	$0	$0	$0	$0
Hardware purchase		$200,000	$200,000	$200,000	$200,000	$200,000
Electricity		$979,134	$1,076,753	$1,176,271	$1,273,244	$1,364,588
Support	# of FTE consultants	20	20	20	20	20
	FTE rate	$70,000	$70,000	$70,000	$70,000	$70,000
	Total support cost	$1,400,000	$1,400,000	$1,400,000	$1,400,000	$1,400,000
	Total cost of ownership	$12,079,134	$4,026,753	$2,776,271	$2,873,244	$2,964,588

Carbon emissions model

This model was created to calculate the carbon emissions associated with public cloud, private cloud and traditional dedicated IT deployment scenarios. It captures emissions from the data center as well as the embedded server emissions and emissions from data transportation. The key assumptions included in the model are detailed below the schematic.



*Deployment scenarios are public cloud, private cloud and dedicated IT.

Different inputs are used around the number of servers required (related to extent of virtualization), server utilization rates and data center PUE according to the deployment scenario.

Key assumptions in the carbon emissions model

Data center PUEs (Source: US EPA[18] and interviews)

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Public cloud	1.5	1.45	1.4	1.37	1.34	1.31	1.29	1.27	1.26	1.25
Private cloud	1.8	1.75	1.7	1.66	1.62	1.58	1.55	1.53	1.51	1.5
Dedicated IT	2	1.95	1.9	1.85	1.79	1.75	1.72	1.69	1.67	1.65

Server utilization rates (Source: Study interviews)
- Public cloud: 65%
- Private cloud: 40%
- Dedicated IT: 15%

Electricty price (Source: US Energy Information Administration[19])
- $0.099/kWh

Metric tons of CO_2 / kWh (Source: US EPA[20])
- 0.00069 tons of CO_2 / kWh

18. http://www.energystar.gov/ia/partners/prod_development/downloads/DataCenters_GreenGrid02042010.pdf
19. http://www.eia.gov/cneaf/electricity/epm/table5_6_a.html
20. http://www.epa.gov/cleanenergy/energy-resources/refs.html

Notes

About the Carbon Disclosure Project
The Carbon Disclosure Project (CDP) launched in 2000 to accelerate solutions to climate change by putting relevant information at the heart of business, policy and investment decisions. We further this mission by harnessing the collective power of corporations, investors and political leaders to accelerate unified action on climate change. 3,000 organizations in some 60 countries around the world now measure and disclose their greenhouse gas emissions and climate change strategies through CDP, in order that they can set reduction targets and make performance improvements. Data is made available for use by a wide audience including organizations, government bodies, academics and the public.
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