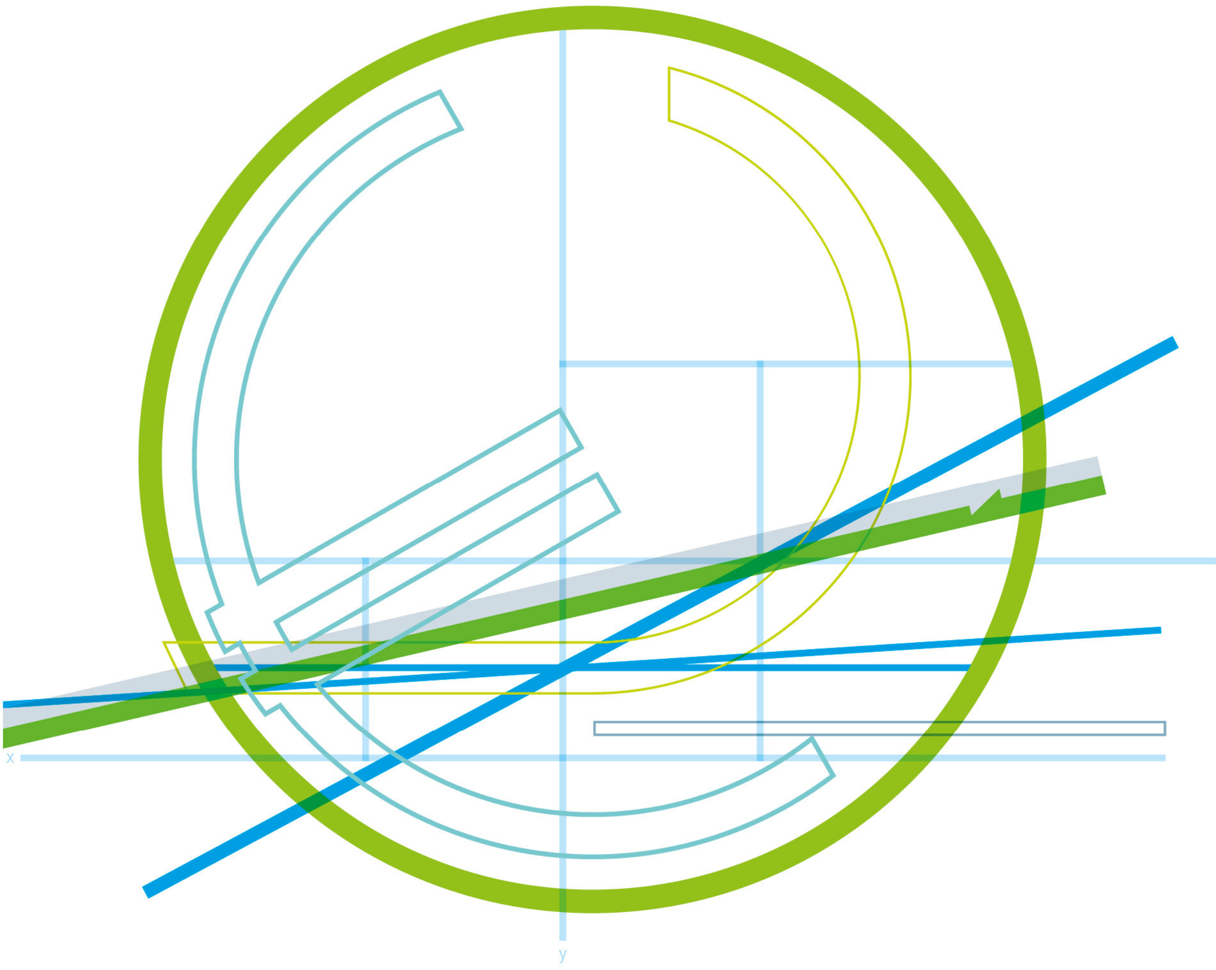
# Blue Globe Foresight

**Studie** #11/2013

## CLOUD-PIONEER

## Cloud Powered IT as an Energy Efficiency Enabler: A feasibility Study for Austrian public sector



**Amirreza Tahamtan**

# VORWORT

Die Publikationsreihe BLUE GLOBE REPORT macht die Kompetenz und Vielfalt, mit der die österreichische Industrie und Forschung für die Lösung der zentralen Zukunftsaufgaben arbeiten, sichtbar. Strategie des Klima- und Energiefonds ist, mit langfristig ausgerichteten Förderprogrammen gezielt Impulse zu setzen. Impulse, die heimischen Unternehmen und Institutionen im internationalen Wettbewerb eine ausgezeichnete Ausgangsposition verschaffen.

Jährlich stehen dem Klima- und Energiefonds bis zu 150 Mio. Euro für die Förderung von nachhaltigen Energie- und Verkehrsprojekten im Sinne des Klimaschutzes zur Verfügung. Mit diesem Geld unterstützt der Klima- und Energiefonds Ideen, Konzepte und Projekte in den Bereichen Forschung, Mobilität und Marktdurchdringung.

Mit dem BLUE GLOBE REPORT informiert der Klima- und Energiefonds über Projektergebnisse und unterstützt so die Anwendungen von Innovation in der Praxis. Neben technologischen Innovationen im Energie- und Verkehrsbereich werden gesellschaftliche Fragestellung und wissenschaftliche Grundlagen für politische Planungsprozesse präsentiert. Der BLUE GLOBE REPORT wird der interessierten Öffentlichkeit über die Homepage www.klimafonds.gv.at zugänglich gemacht und lädt zur kritischen Diskussion ein.

Der vorliegende Bericht dokumentiert die Ergebnisse eines Projekts aus dem Forschungs- und Technologieprogramm „Neue Energien 2020". Mit diesem Programm verfolgt der Klima- und Energiefonds das Ziel, durch Innovationen und technischen Fortschritt den Übergang zu einem nachhaltigen Energiesystem voranzutreiben.

Wer die nachhaltige Zukunft mitgestalten will, ist bei uns richtig: Der Klima- und Energiefonds fördert innovative Lösungen für die Zukunft!

Theresia Vogel
Geschäftsführerin, Klima- und Energiefonds

Ingmar Höbarth
Geschäftsführer, Klima- und Energiefonds

# 1 Inhaltsverzeichnis

# 2 Einleitung

**Aufgabenstellung**

It is estimated that global emissions will be approximately 53 billion tones carbon dioxide equivalent (GtCO2e) in 2020 [IPCC, Gartner]. The grand technological challenge of our time is tackling climate change with its ecological, economic, social and political consequences. Tackling climate change affects all of us, 7 or 8 billion people.

According to analysts [Smart2020] the direct footprint of Information and Communication Technology (ICT) is around 2%-3% of total emissions. However, ICT's footprint sets to grow at 6% annually. ICT is responsible for 10% of emissions in OECD-countries, almost equal to the emissions caused by air traffic. ICT has a critical role for both reduction of its own $CO_2$ footprint and for optimization of processes of other sectors. ICT is a key player for standardization, monitoring, accounting, optimization and providing new business models. However, ICT is not the only player. It requires help of industry and governments, policy support and financing research and development both in terms of staff and infrastructure. Lord Stern, the former UK government and World Bank chief economist, revised his targets for safe levels of greenhouse gas emissions reductions to 2 tons per capita by 2050. The ICT-enabled solutions would make possible savings of 1 tone per capita in 2020, a huge step. The role of ICT for $CO_2$-emission reduction has been recognized by scientific community, international bodies such as OECD and United Nations and national and international policy makers such as the European Commission and US Government. OECD demands policies and initiatives to improve environmental performance of ICTs, and to apply ICTs across the economy to tackle the challenges of global warming and environmental degradation [OECD]. A Focus group on impact of ICT on the environment at the International Telecommunications Union (ITU), a United Nations agency, demands the ICT industry to take steps now to curb and ultimately reduce its carbon emissions [UN]. The European Commission in addressing the challenge of energy efficiency through information and communication technologies, requires to provide a cost-effective means of improving energy efficiency across industry and broader civil society [EUCOMa].

It is the responsibility of technology developers to increase the ICT energy efficiency by innovative methods. As 75% of ICT's emissions are caused by its use and only 25% by its production, obviously the potential for reducing emissions lies in usage optimization. The European Commission also underscored the untapped potential for the ICT sector to focus on systemic improvements to its own processes, including operations, manufacturing, service delivery and supply chain management and considers the setting of ambitious targets by the ICT sector for improving the energy and environmental performance of its processes of the utmost importance [EUCOMb].

One of the main consumers of energy are servers in data centers. According to current studies the annual energy consumption of servers in the US is of the same order of magnitude as for television sets. In Europe servers are currently the second largest energy consumer among IT equipment following TV sets. The worldwide energy consumption of servers amounts to roughly 123 TWh/year [KOOM]. According to forecasts for the German market the electricity consumption of servers will increase by 50% between 2005 and 2010 [FHG]. It is expected that energy costs for the operation of servers will exceed the costs for server hardware by 2015. The energy consumption of the servers (not the ICT in total) is doubling almost every five years [Koom].

The key enabling technology for stopping this cycle and energy efficiency and resource optimization is Cloud computing. This paradigm due to its potentials has recently received a lot of interest from both academia and industry. According to the definition of the American National Institute of Standards and Technology (NIST) [NIST] , Cloud computing is a model for enabling 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. This Cloud model promotes availability and is composed of essential characteristics, deployment models, and various service models.

In order to illustrate the current situation in ICT industry and how Cloud computing helps to improve energy efficiency and to understand its environmental impact, we use an analogy. Imagine a family with different transportation needs. This family may need a van for family travels, two cars for parents going daily to work, motorcycles for teenagers visiting friends and a pickup for transporting furniture. The family purchases all the vehicles, let them run and consume energy for most of the day and produce $CO_2$-emissions, just in case the family needs one of the vehicles, it can be used immediately. The smarter way, both economic and ecological, would be using public transportation, buying one or two cars and renting a pickup when the family moves to a new apartment. Organizations and companies act in the same expensive and environmental unfriendly way as the imaginary family in this example. For example the Austrian federal ministry of finance operates a big number of servers to meet the requirements at peak time once a year when the deadline for annual tax declaration approaches. The situation in private sector is not different. A web retailer company sets up a data center to be equipped for two annual peak times around Christmas and Eastern holidays. The rest of the year, servers are underutilized and consume a high amount of energy. According to a study conducted by McKinsey [McKa] server utilization rarely exceeds 6% and facility utilization can be as low as 50%. According to Vivek Kundra [KUNa, KUNb] the chief information officer of the Obama administration in his address at the Brookings Institute, US federal servers are utilized around 7%. In the Austrian Public Sector we face the same situation. Some servers are underutilized as low as 4%. This is where Cloud Computing can play a key role for energy efficiency and reducing $CO_2$-emissions.

Clouds are a large pool of easily usable and accessible virtualized resources (such as hardware, development platforms and/or services). These resources can be dynamically reconfigured to adjust to a variable load (scale), allowing also for an optimum resource utilization. This pool of resources is typically exploited by a pay-per-use model in which guarantees are offered by the infrastructure provider [VRC+08]. The underlying Cloud technologies such as virtualization enable optimum resource utilization and energy efficiency. Virtualization refers to presenting a single physical computer as many logical computers. One of the major causes of energy inefficiency in data centers is the idle power wasted when servers run at low utilization. Even at a very low load power consumed is 50%-70% of the peak power [CHL+08]. According to a study conducted by HP, Uptime Inst. this figure is even higher and is around 60%-70%. In other words a fully utilized server replaces more than16 servers with 6% utilization and

consumes only the energy of two of these servers. The other 14 servers can be switched off. Because of the high ICT penetration rate in Austria, the energy saving potential is tremendous. According to “Statistik Austria”, 98% of companies and 81% of households in 2013 used computers and internet. Energy efficiency of Clouds and Green IT in general are emerging as some of the most critical environmental challenges to be faced, because of the increasing yet unprecedented trend in digitization of business processes such as online banking, e-government, e-health and digital entertainment. As an example, worldwide data centers $CO_2$-emissions achieve about half of the overall airlines’ ones, and are overall greater than both the Argentina and the Netherlands emissions. Virtualization represents a radical rethinking of how to deliver the services of data centers, pooling resources that are underutilized and could reduce emissions by 27% – equivalent to 111 MtCO2e [McKb].
The energy saving potentials of Cloud computing has been confirmed both in theory e.g. [BGG+09] and practice e.g. [GS]. The energy savings through the use of Cloud services offered by [GS] is estimated to be approx. 595 million kilowatt hours. This results in a reduction of greenhouse gas emissions by more than 423,000 metric tons of carbon dioxide per year, the equivalent of:

- $CO_2$ emissions produced by the consumption of more than 181 million liters of gasoline
- $CO_2$ emissions produced by the consumption of approximately 985,000 barrels of oil
- And the yearly pollution caused by more than 77,000 automobiles.

Another incentive for entering Cloud is the fast development rate of energy-efficient Cloud technologies. Due to this fact, it is estimated that despite the massive use and proliferation of Cloud centers till 2020, we have no increase in their net energy consumption [Smart2020]. In other words, the net energy consumption of Clouds remains the same and the energy consumption of individual consumers decreases. The scope of this project is increasing energy efficiency and decreasing the $CO_2$ through Cloud computing.

**Schwerpunkte des Projektes**

The issue that we specifically address in this project is energy efficiency through an optimized use of ICT for the Austrian public sector. We decided to choose the public sector because of the following reasons:
(i) In Austria as well as many other countries public sector is a big part of the economy and therefore it offers a big potential for energy savings. Federal ministries, provincial government authorities, federal authorities, health insurances, accident insurances, pension insurances and municipalities, among others, are candidates for energy saving.
(ii) Public sector has a role model and other sectors will follow.
(iii) The requirements of public sector such as data privacy and security, service availability and business continuity is also present in other sectors. Hence the results and experiences in the public sector can be applied to other sectors as well and the energy saving potentials can be leveraged.
(iv) According to the Austrian ICT-Factbook, although Austria’s e-government comes in the first ranking in the European Union, these services are used only by 27% of the population [ICT]. It means the servers are severely underutilized and a vast amount of energy can be saved.
The European Network and Information Security Agency (ENISA) as well recommends Cloud computing and e-governance as high-priority research fields.
Table 1 shows in a concrete example the energy saving potentials of Cloud vs. data centers.

We assume a data center consisting of 200 servers of the type HP Bladesystem c7000 utilizing at 7%. The organization instead of running the data center can use Cloud services and the Cloud is utilized at 80%. (We do not assume full utilization, rather a realistic value of 80% which is achieved by other implementations e.g. Intel's internal Cloud). For the sake of comparability we assume that both Cloud and data centers use the same servers. 200 servers utilized at 7% are equal to 18 servers utilized at 80%. Because servers in the Cloud are utilized at a higher rate, we assume the peak power consumption for the servers in the Cloud. The calculated $CO_2$-emission value is based on the information provided by "Wien Energie", 80,61 g/kWh $CO_2$-Emission. The energy saving potential for Austria is much more considering ministries, federal and provincial authorities and insurances. This project has the potential to serve as a basis for migration of Enterprise IT to Cloud. Considering the number of companies in Austria, according to Statistik Austria 311.073, the energy saving potentials are substantial

| | **Data Center** | **Cloud** |
|---|---|---|
| **Type of Server** | HP Bladesystem c7000 | HP Bladesystem c7000 |
| **Utilization Rate** | 7% | 80% |
| **Number of Servers** | 200 | 18 |
| **Server and Cooling Power Consumption (kWh)** | 149,37 | 333,42 |
| **Total Consumption/year** | 261.696.240 | 52.573.665,6 |
| **Net Energy Saving/year** | 209.122.574,4 | |
| **Net Saving $CO_2$-Emission/year** | 16.857 tons of $co_2$-emissions | |

**Table 1:** Possible energy and $CO_2$-emissions saving by Cloud implementation for only 1 data center per year

**Einordnung in das Programm**

The project CLOUD-PIONEER addresses energy efficiency issues. The main focus of the project is energy efficiency in the public sector. But requirements of the public sector are similar to other sectors such as finance and health. Therefore the energy efficiency results can be leveraged.

The ultimate goal of the project is enabling energy efficiency through an efficient use of ICT across the economy. Our vision is illustrated in figure 1. Our concrete goal in this project was to perform a feasibility study of using Cloud technology for public sector and give decision makers a framework to evaluate its potential impacts. The feasibility study can be seen as a pre-stage and enabler of adaptation of Cloud technology for public sector in Austria. The public sector has requirements such as data privacy and security, availability, reliability that are also present in other sectors. In other words the results of the feasibility study for public sector can also (partially) serve as a basis for a paradigm shift in order to achieve energy efficiency in other sectors.

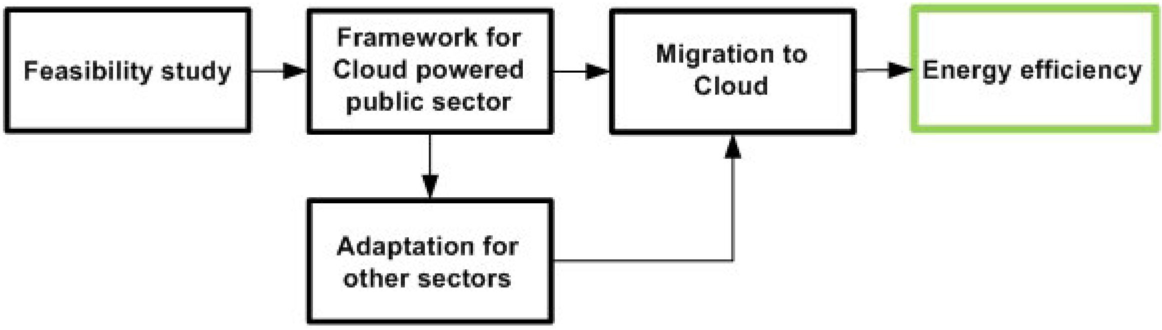



Fig 1: Project goals

**Verwendete Methoden**

The methodology can be summarized as follows:

(i) Which technologies are in use: This task analyzes the current situation and identifies the used technologies and systems. The main goal was to determine if software and applications can be migrated directly to Cloud or any conversion is needed. E.g. are applications web applications, are applications .NET or another technology and if the Cloud supports this technology. Other aspects such as usage pattern and traffic are also assessed in this task.

(ii) Which kind of Cloud services or a combination of Cloud services and deployment model can best serve the used technologies: The second step consisted of identifying which kinds of Cloud services are required for a given system and what is the best deployment model. This has been done first by creating an ontology of Cloud services and consequently mapping the used technology onto the Cloud service ontology. In this step we can determine for example if storage services or application hosting services are needed. Finally we evaluated the different deployment models: are private government clouds necessary or can public clouds or a combination of both be used?

(iii) What are the stakeholder's requirements: Migration of applications to Cloud does not eliminate the responsibility of the organization to remain legally compliant. It must be ensured that no applicable law or regulation is violated. For example a European regulation requires data to be stored within the borders of the European Union. In addition, it must be ensured that used Cloud services are in line with organizational policy.

(iv) Which Cloud providers offer the required types of services: This identifies the list of concrete service providers by a market study. For example what companies provide storage as a service.

(v) What is the cost of using specific Cloud providers: This step studied economic aspects of using Cloud by consideration of operational costs and saving potentials. This is done by analyzing the usage pattern of the system and the cost model of the Cloud.

(vi) Which kind of risks the organization may face by using services of specific Cloud providers: This step analyzes the risk of using services of the specific Cloud providers: will the provider allow audits, does the provider have certification on security standards, is interoperability with other Clouds supported, etc.
Figure 2 depicts our overall approach.

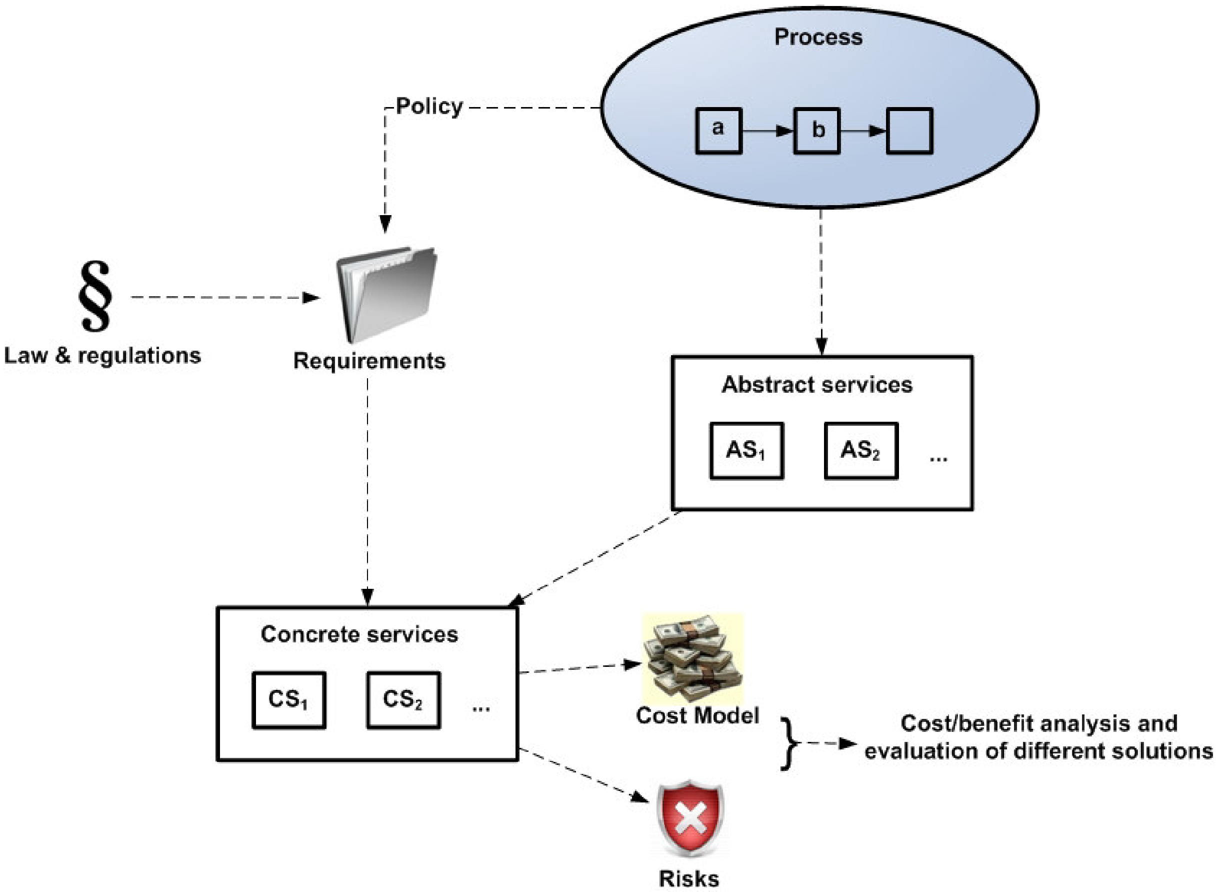



Fig 2: The overall approach

**Aufbau der Arbeit**

In this project a study of different aspects has been provided:

- Technology and System Feasebility
- Requirement Analysis
- Market Study
- Energy Saving Analysis
- Risk Analysis
- Cost/Benefit Analysis

# 3 Inhaltliche Darstellung

As first step the current state has been evaluated. The goal was to understand which stack of technologies are in use. This is important because it must be known what is being transferred and its technological aspects, e.g. what database types are in use. To evaluate the current state, ministries and organizations in the Austrian public sector have been interviewed including: Office of the Chancellor

(Bundeskanzleramt), Federal Ministry for Justice (Justizministerium), Federal Ministry for Transport, Innovation and Technology (Bundesministerium für Verkehr, Innovation und Technologie), Federal Ministry for European and International Affairs (Außenministerium), Federal Ministry for Education, the Arts and Culture (Bundesministerium für unterricht kunst und Kultur), Federal Ministry of Health (Gesundheistministerium), The city of Vienna (Stadt Wien) and Federal Computing Center (Bundesrechenzentrum). In addition, based on the different business process function frameworks [BFO, eTOM] different business processes and functions which may be used in an organization have been identified and classified. The goal was to identify all different kind of organizational processes such that energy inefficiency of in-house solutions can be minimized.
The second step consisted of creation of an ontology of Cloud services and consequently finding a mapping from used technology onto ontology of Cloud services. The proposed ontology captures the required business services in an organization and provides a mapping between business functions and the offered services in the Cloud landscape. It closes the gap between on premise and Cloud services. Moreover, it includes the essential characteristics of Cloud providers.

We also evaluated the possible deployment models. The deployment models include: private Cloud, public Cloud, community Cloud and hybrid Cloud. Each of the deployment models are suitable for a set of specific uses cases.

In order to have a better understanding, stakeholders requirements have been collected and analyzed. The goals was not only to capture the technical view but also other formal and informal policies. Organizations not only must be legally compliant but also need the Cloud migration strategy to reflect their organizational and political requirements. Some of the policies supported the Cloud adaptation whilst some other can slow down the process.

In addition an overview on the current legal framework on Cloud computing is provided. There is no Cloud computing law rather other applicable laws that affect the choice of Cloud providers such as “Datenschutzgesetz” and “E-Commerce-Gesetz”. The framework reflects the organizational perspective. The provided framework identifies and analyzes the applicable laws that must be considered before deciding for specific Cloud providers. In other words which cloud providers with which characteristics may be chosen such that the organization is legally compliant.

In the next step a comprehensive market study has been performed. The result of this market study demonstrates which Cloud providers offer specific functions and services that an organization may need. In addition we have developed a tool that assists organization to find the suitable Cloud provider for their specific organizational needs. The tool serves as a Cloud repository with querying Capabilities. In other words, organizations can enter their technical requirements (e.g. supported programming language, etc.) and non-technical requirements (location of the server, security mechanisms, etc.) and the tool finds the Cloud providers that satisfy such needs. The tool is extendable that means by changing the requirements and/or Cloud providers it can still be used.

The energy saving analysis was also included in this project. The goal was to estimate how much energy can be saved using Cloud computing and if Cloud computing is the greener Choice for the task and application at hand. A model for calculating the required energy which does not only consider energy used for processing and storing but also other factors such as data transport, clients, PUE of the Cloud providers, etc is provided. The model for energy saving analysis is divided in two parts: processing in the

Cloud and transportation. In other words how green the Cloud operates, what are the metrics for green cloud and how much per bit of energy is consumed for data transportation to and from the cloud. Using the model it can be calculated if private clouds (e.g. Bundesrechenzentrum) or a public Cloud (e.g. Amazon Web Services) is a greener choice and how much energy can be saved.
The energy usage and energy efficiency of data centers have been studied and analyzed and different specifications and standards for choosing the green cloud providers have been provided such as: Green Grid Power Efficiency Metrics including Power Usage Effectiveness (PUE) [PAR10], Data Center Productivity (DCP) [DJK+09], etc. In order to be able to calculate the total energy used it is not enough to consider only operations in the data center [SV09, LZL+09, BH07] but also the energy used for data transportation to and from Cloud [BAH+10] must be calculated.

It must be also understood what risks Cloud computing poses. This study also provides a list of general risks associated with Cloud computing. These include also a list of questions an organization need to answer before entering the Cloud. Risk analysis of Cloud providers is very much dependent on the task and application at hand. This project also provide a framework that helps CIOs to identify the Cloud ready applications based on different criteria such as business value, risk exposure and technological fitment. After identification of the task, using the tool developed in this project, suitable Cloud providers can be identified. In the consequent step risk analysis of specific Cloud providers can be analyzed.

Despite all the benefits Cloud computing may offer an Organization, moving to Cloud is always a question of financial viability, if moving to the Cloud save costs or produce a financial overhead. A framework for cost/benefit analysis of Cloud computing has been developed. This framework compares cost model of both in-house and Cloud solutions and gives organizations a handy tool to analyze costs and cost saving potentials. We have included different kind of direct costs (such as hardware and software costs) and indirect costs (such as downtimes and hidden end user costs). The framework has been applied on the use case “Bundeskanzleramt”

# 4 Ergebnisse und Schlussfolgerungen

The Austrian public sector can be viewed as a huge enterprise with a heterogeneous set of requirements and technologies. We could identify a general set of requirements and applications which are in common in all organizations and shared by all of them. But there are also many domain specific applications with a limited number of users such as “Heimtierdatenbank” run by the federal ministry of Health.

Several Committees and working groups in the Austrian public sector are involved with Cloud computing. Such as “E-Government Plattform Digitales Österreich“ and „Kompetenzzentrum Internetgesellschaft (KIG)“. These working groups generally work in parallel even though they have some partial positive effects on each other. An overall Cloud computing strategy for the whole public sector is missing. One issue is diverse interests of different stakeholders in these working groups. For example federal states are not willing to shut down their own dedicated data center in favor of a shared federal data center.

Many of the applications are good candidates for Cloud migration with huge energy and cost saving potentials. In addition to a governmental private Cloud (Bundesrechenzentrum is such a Cloud) other Cloud models are interesting options. Public cloud can be used for publicly available data. Community Cloud shared between several organizations with the same set of requirements is also a suitable option for many use cases.
The most important factor for adaptation of Cloud is still data security and privacy. The Austrian data privacy law is quite restrictive regarding the personal data. Due to this reason, organizations handling personal data are very reluctant to use Cloud services. A viable option would be use of anonymization and encryption techniques such that data cannot be viewed by Cloud providers. However, this option needs more in-depth analysis if use of such technologies do not produce a overhead and additional costs such that these solutions become economically unfeasible.

The reasons organizations are not willing to enter the Cloud is as follows (according to importance):

- Data security and privacy
- Vendor lock-in
- Loss of control over data
- Lack of inter-operability
- Lack of market transparency
- Availability
- Lack of control over required upgrades
- Organizational difficulty in changing the business as usual
- Costs
- Compliance
- Resistance by IT-departments as they fear job loss
- Fast change of Cloud market for long term planning in the public sector

Other obstacles are organization dependent. Organizations with a high IT-budget generally do not prefer to enter Cloud as they have more than enough hardware, software and staff available but the others who are forced to cut the budget are more willing to consider this option. Staffing is also another problem. Due to the fact that job cuts and reduction of staff is not very easy in the public sector, paying cloud providers and at the same time paying the IT-staff in the organization makes the cloud option unviable.

In general it can be said that adaptation to Cloud computing is much easier in newly formed organizations than existing ones. The established organizational policies and traditions are a challenge for change in the working culture of the organization. Cloud computing can be considered as a strategy for planned organizations.

Moreover it came to our conclusion that identified requirements during this study is not specific to the public sector. The organizations in the public sector face similar questions and challenges regarding the Cloud computing. The results of this study can be used by enterprises in other sectors such as banks, hospitals and even small and medium sized enterprises. A community Cloud shared by hospitals with highest standards on security of highly sensitive health data offers on the one hand more security and privacy and on the other hand cost reductions and energy saving potentials compared to local solutions available in each hospital.

# 5 Ausblick und Empfehlungen

Entering the Cloud is a complex, time consuming and costly process for organizations, both in private and public sector. Simplifying this process would increase the readiness of organizations to consider the Cloud option. Another important factor is making the benefits in terms of cost reduction and energy saving potentials visible and quantifiable. A software that on the one hand calculates the cost benefits and energy saving potentials based on the user's IT requirements and at the same time automates or simplifies the decision making process would be a great advantage.

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# IMPRESSUM

**Verfasser**
TU-Wien, Institut für Softwaretechnik und interaktive Systeme

Amirreza Tahamtan
Favoritenstrasse 9-11/188
Tel: 58801-18862
Fax: 58801-18899
E-Mail: tahamtan@ifs.tuwien.ac.at
Web: www.ifs.tuwien.ac.at

**Eigentümer, Herausgeber und Medieninhaber**
Klima- und Energiefonds
Gumpendorfer Straße 5/22
1060 Wien
office@klimafonds.gv.at
www.klimafonds.gv.at



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