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Energy-Efficient ICT for SMEs, the Administration and the Home – IT2Green

A Technology Programme by the German Federal Ministry for Economic Affairs and Energy

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Content

Foreword

Information and communication technology (ICT) has become indispensable for Germany. Ever more ICT is being employed. Considerable amounts of energy are, therefore, needed to cope with growing use of ICT. The relevance of 'energy-efficient ICT' has, therefore, not diminished at all since the IT2Green programme started in 2011. That is why, in the last few years, we – together with the business sector – have invested around €60 billion in the technology programme entitled 'IT2Green – Energy-Efficient ICT for SMEs, the Administration and the Home'.

The research projects in the IT2Green programme are already enjoying significant successes. For example, in the field of telecommunications and data centres, energy savings of up to 30% have been achieved. The approaches adopted here optimise in particular the needs-based supply of IT resources while maintaining the usual performance for users. The efficient use of renewable energy also plays a crucial role here.

At the same time, the lT2Green programme demonstrates that energy efficiency in the ICT sector is an ongoing task. Especially because ICT is experiencing very dynamic development, efficient systems require regular adjustments to be made to them. As an essential component of the energy transition, the issue of energy-efficient ICT must be promoted in the future too, because 'GreenIT' is an important key to a sustainably designed information society. And ICT can only perfectly evolve as key innovation driver for increased productivity and energy efficiency in the economy as a whole when it is itself energy efficient.

The results of the lT2Green research programme show that we are on the right track. What is now essential is that we put the new findings into practice in order to support the end users, the public administrations and the economy in their aim to save energy and resources. Let's tackle this task together – it's well worth it!

Sigmar Gabriel
Federal Minister for Economic Affairs and Energy

Saving Energy and Resources

Why Green IT Should Have a High Priority in Practice

Source: © vovan - Fotolia.com

The economic benefits of information and communication technology (ICT) are immense. With their control and monitoring functions, ICT supports productivity in industry, makes smart grids possible and thus enables a more effective power supply. In addition, ICT can replace physical goods by digitising media and services. Examples of this are electronic news, books and video conferencing. But the number of products and their uses are growing disproportionately precisely because these applications are so easy and convenient. Although information and communication technology is becoming ever more efficient thanks to miniaturisation, the demand for energy will continue to rise due to increasing use.

The electricity demand of ICT, including infrastructure and terminals, was about 55 to 60 TWh in 2010 – more than 10% of Germany's total electricity demand. A further increase is to be expected. What is remarkable is that data centres and telecommunication networks already account for about 20 TWh – and the figure is rising. One major reason for this is that there are more and more network-enabled devices and Internet-based applications. Technology and product development is extremely dynamic in this area. Internet and cloud computing services are booming. This is causing a growing need for server and storage capacities in data centres as well as powerful telecommunications infrastructures.[1]

The Federal Ministry for Economic Affairs and Energy initiated the 'IT2Green – Energy-Efficient ICT for SMEs, the Administration and the Home' technology programme in 2011. In this programme, a total of ten collaborative projects receive €30 million in funding until 2014.

A holistic approach to efficiency is paramount for IT2Green. The model projects funded investigate, develop and test system-wide solutions to increase the energy efficiency of ICT. One important goal is the consolidation of ICT resources in data centres and office environments as well as the tailor-made connection and disconnection of equipment in the telecommunications sector. IT2Green demonstrates solutions for ICT that are sustainable and environmentally conscious in the long term. The results support our economy and administration through the targeted saving of energy and resources. Green IT is an important issue that must always be considered when designing our economy and society so that it is forward-looking and sustainable.

[1] Study: Fraunhofer Institute for Reliability and Microintegration IZM and the Fraunhofer Institute for Systems and Innovation Research ISI (2009): Estimating the energy requirements of information society's ongoing development, on behalf of the Federal Ministry for Economic Affairs and Energy

Funded Projects

Ten Collaborative Projects Are Researching Energy-Efficient ICT Solutions

24 companies and 24 public institutions, including universities and research institutes, are working together in ten cooperative projects as part of the IT2Greeen funding programme. Together, the project partners are exploring the energy efficiency of IT systems in different areas of application of information and communication technology. The focus is not on the energy savings of individual ICT devices, but on reducing the energy demanded by the ICT system as a whole.

Improving energy efficiency in the ICT sector is a complex challenge. On a technical level, the range of tasks embraces the development of new hardware and software along with the intelligent coordination and control of individual system components. At the same time, economic and legal framework conditions are crucial factors to be considered in an overall optimisation of ICT systems. So far, this has only rarely been the case. That is why the IT2Green joint projects are pursuing integral solutions that exemplify the new principles of energy optimisation in ICT.

One overarching optimisation approach is, for example, the needs-based provision of IT resources. The idea is simple: ICT systems should only be available when they are needed and should automatically switch over to low-power operating modes when not required. This technical approach requires an extended system view. The research projects are backing an intelligent combination of existing sensor technology for the active switching off and on of user systems on the one hand and, on the other, tools that gather and evaluate a variety of data and use them to forecast demand.

Another approach is the deliberate increase in the utilisation of existing IT resources. In contrast to existing technologies such as virtualisation, IT2Green research projects focus on more complex load shifting processes that take into account a variety of technical and economic factors – because, in practice, no ICT system resembles the other. The optimum operating point of data centres needs, therefore, to be individually readjusted at regular intervals. Customer-defined performance parameters (performance) and QoS (Quality of Service) influence this process significantly and represent essential boundary conditions. The solution approaches in the IT2Green research programme pick up on this advanced system view and, in the process, take into particular account load shifting concepts that exploit locally favourable conditions. Thus, the migration of IT applications between geographically separate data centres is examined, tested and optimised.

The research projects are always aimed at improving energy efficiency overall. Correctly measuring any improvement in energy efficiency is a vital task. The research projects are approaching this subject by, for example, developing relevant indicators. Extensive measurements taken in data centres and office buildings have also shown that the software-based consolidation and analysis of measurement data from various 'subsections' – such as the climate control and power supply infrastructure or ICT devices – involves a lot of 'manual work' and reveals where there is considerable room for improvement.

Finally, the research projects focus on the specific conditions and needs of ICT users in the areas of SMEs and the administration as well as in the home. Interdisciplinary research teams and regional networks were formed for the purpose of the development and testing of energy efficient ICT systems in realistic settings. The professional exchange of information and the close cooperation between research, industry and users are what enable such model projects, in which exemplary solutions are developed for a broad-based use.

IT2Green comprises a total of ten funded projects relating to the following clusters:

- **Telecommunication Networks**
- **Data Centres and Clouds**
- **Monitoring and Management**

Source: © VRD Fotolia.com

Cluster: Telecommunication Networks

Load-Dependent Operation of Telecommunications Technology

Approaches for the load-dependent operation of telecommunications technology are studied and tested in the cluster 'Telecommunication Networks'. The central objective is to switch individual network elements into energy-saving operating modes when low data traffic is expected – without the customer experiencing any loss in the quality of service. In this case, coordinated energy management must be applied at multiple network levels.

The energy demand of telecommunications networks is increasing due to the ceaseless and rapid growth in the volume of data. According to a forecast issued by Cisco (VNI Forecast 2013), between 2012 and 2017, IP-based data traffic in Germany will double to about 2.8 exabytes per month. This trend is being accelerated by Internet-based services with high data volumes, such as IPTV and video-on-demand. But the increasing exchange of photos and videos on social networking sites and the constant availability of online services are causing the data traffic on telecommunications networks to swell. The fastest growth has been in the mobile phone industry. Although data transfer rates are much lower here than with fixed network, mobile data transmission is significantly less energy-efficient – and mobile communications account for a similarly high proportion of total electricity consumption.

The telecommunications industry is responding to the growing data rates and increasing power consumption with a plan to update telecommunications technology that is designed to take place over the medium-term. The new network equipment and associated network architectures are not only more powerful than the old systems, but also many times more energy efficient. At the same time, however, owing to existing customer contracts, older technologies must be operated in parallel. In order to make it possible to save energy, diverse telecommunications systems need to be intelligently controlled. The problem consists of, on the one hand, ensuring high quality of service, i.e. safeguarding availability for customers at any place and at any time, and, on the other hand, switching network elements that are not being used much over to energy-saving modes. If they are then needed, these network elements must be quickly available so that the user does not experience any loss of service. Above all, the next generation of mobile networks must be designed to cope with a high number of terminals and highly variable load situations at the same time. One solution that leads to better coverage and availability for the end user is hierarchical network structures that, with many small transmitting cells, offer customised wireless access on corporate premises and in buildings.

In order to achieve maximum energy efficiency in mobile and landline networks, complex control mechanisms need to be developed. The IT2Green research projects are, therefore, investigating and developing methods that allow future traffic to be forecast on the basis of historical load curves and other data sources so as to control network capacity in a context-sensitive way. Particularly in the day-night-cycle, such a scheme saves considerable amounts of electrical power. In addition, new technologies for mobile communications systems are being developed, which can de- and reactivate individual radio cells, depending on utilisation, or dynamically adjust the signal strength and orientation of individual antennas. Tests have shown that these measures can reduce the power consumption of individual network elements by up to 30%.

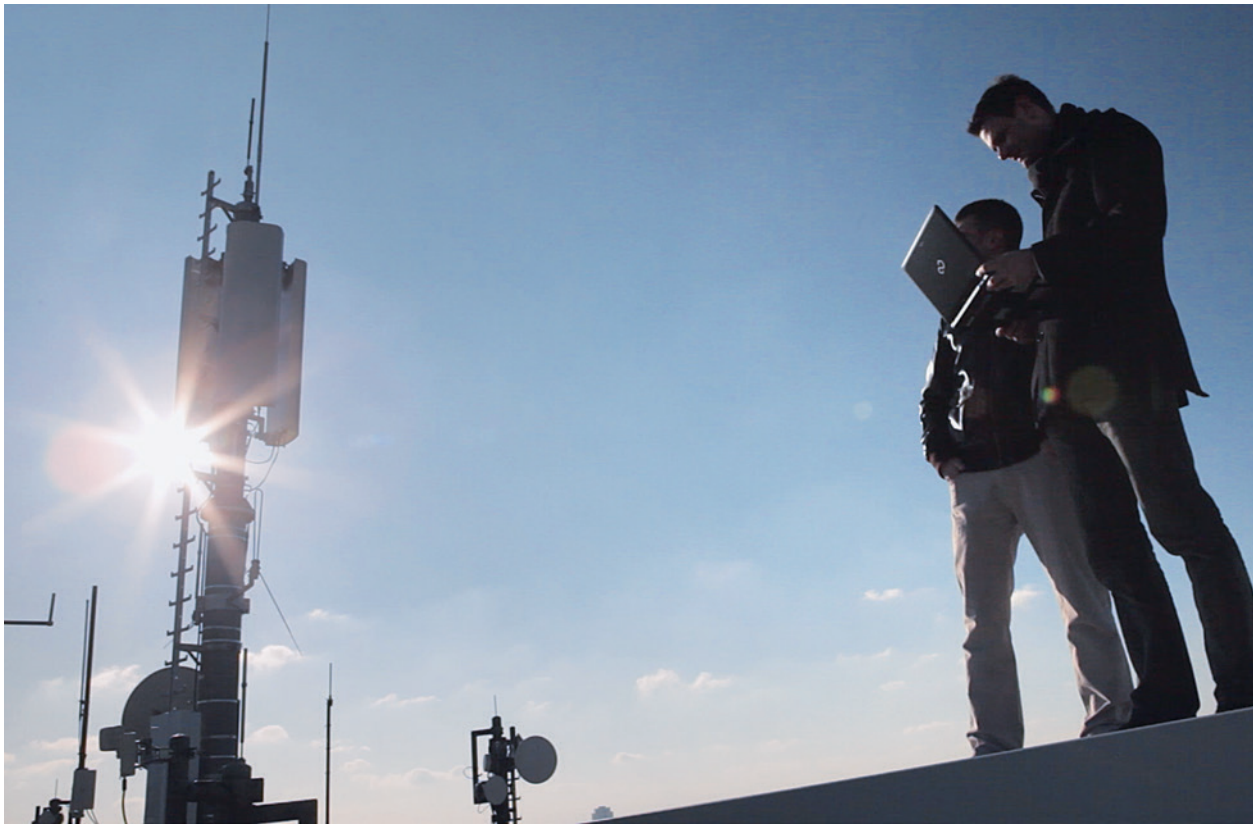
A further objective of the IT2Green projects is intelligent load shifting in the core network by means of energy-conscious routing. To achieve this, the energy demands of individual network elements in relation to data traffic are analysed, on the one hand, and algorithms for energy-based management are developed on the other. Since the uninterruptible power supply for the network technology at individual sites has large battery capacity, a more active use of energy storage to relieve the conventional power supply is also being investigated. Furthermore, the research also focuses on the development of procedures to effectively integrate renewable energies in the power supply of telecommunications equipment.

The projects in the cluster 'Telecommunication Networks' are:

- **ComGreen**
- **DESI**
- **IntelliSpektrum**

Mobile Radio Networks to Get a Sleep Mode

ComGreen – Communicate Green



Source: IT2Green

Mobile phone base stations are always awake, seven days a week, 24 hours a day. For nationwide mobile phone reception, base stations always transmit at peak performance – regardless of whether one or 1,000 users access the network. In order to save energy precisely in this area, the ComGreen project has developed methods for the selective shutdown of network resources. Optimisation processes that can be combined together identify the nodes that ensure adequate quality of service and consume the least energy. To do so, the many often unused base stations in diverse networks are analysed, and the hierarchical structures of the macro, micro and pico cells taken into account. Radio access technology, with whose support mobile phones can determine the quality of reception of broadcast cells, is also used.

The basis for deploying these methods is information from the network which is analysed with the aid of a context manager and the OpenMobileNetwork. This information is processed by terminal equipment and enriched with contextual information from the system. This way, any unneeded capacity can be switched off via bandwidth expansion and carrier sleep mode, and power consumption in mobile communications systems can be reduced by 30% to 40%.

ComGreen also has measured and investigated the energy consumption of the core and transport networks and found that the power consumption of these components is 90% independent of the amount of data transported. Studies carried out on real networks have revealed that the majority of network nodes are used to capacity for only a few hours during the week, although they are constantly switched on. That is why ComGreen is calling for a change to be made to hardware and software, so that the systems without load consume no more than 30% of the maximum energy available. And so that the systems can be completely switched off during periods of low utilisation, an intelligent method predicts demand and intelligently controls traffic routes. According to calculations, savings of up to 40% could be realised, depending on the subsystem.

COMGREEN
Communicate. Green.

Initial Situation:
"With the growing number of smartphones, the amount of energy consumed by mobile networks is increasing. What is even more important are intelligent processes by which consumption can be controlled and reduced."

Result:
"ComGreen has developed procedures which can cut the energy consumption of mobile base stations and transport networks by 30% to 40%."

Steffen Bretzke, Project Manager

The Project at a Glance

In order to offer mobile phone customers faster downloads with increasing bandwidth, nearly 150,000 base stations in Germany are in continual operation in four mobile networks 24 hours a day. ComGreen's advanced concepts can lower the high energy consumption of continuously available networks. A new architecture ensures that network properties adapt themselves to demand. When choosing the optimal network parameters, information flows in from all components. Different radio technologies, as well as the system-wide control of the radio and transport networks are modified so that each cell holds in store only the transmission capacity actually required at that time. This work has resulted in new methods and protocols that are realistically tested in a testbed and with demonstrators.

Source: ComGreen

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- Deutsche Telekom AG, Bonn

Duration: 1.1.2011 – 30.4.2014

Fit for Smart Grid

DESI – End-to-End Energy-Sensitive ICT Production

Source: © Fotolyse - Fotolia.com

Modern information and communication technology (ICT) is rarely visible. When the Internet TV is switched on or when a video call is in progress, a highly complex process is taking place in the background. The functions of many technical devices contribute to their smooth running and each of them consumes energy. This energy consumption is continually rising because of ever more new Internet applications. The 'DESI – End-to-End Energy-Sensitive ICT Production' project has set itself the task of optimising this energy consumption overall on the one hand, but also of adapting it to the needs of the smart grid on the other.

In order to do so, the DESI project has developed a 'load-dependent operation' as a demonstration. In this grid operation, as much data transport capacity as is actually demanded by the applications is always provided. The DESI demonstrator shows how newly developed control functions for network elements from the optical transport layer and in customer networks can be used in conjunction with the logical layer of the Internet Protocol in order to save energy. Researchers involved in the DESI project have developed a means of controlling the storage capacity of electrical power in the ICT grid for ensuring availability. The entire network thus ultimately becomes an energy consumer, whose load behaviour can be adapted, to some extent, to the requirements of the smart grid. In DESI, the battery storage facility of a real network node was, therefore, provided with a controller solution and a remote control connection. Depending on the market prices at the EEX power exchange, the electrical load of the on-site ICT and the battery control, a battery schedule is calculated and implemented.

Saving energy the DESI way is not simple – complex mathematical methods have been applied to optimise the interaction of all components of the ICT network and energy storage units. The DESI visualisation solution is designed to present and explain this interaction in a comprehensible way.

DESI Durchgängig Energiesensible IKT-Produktion

Initial Situation:
"The ICT network is a huge energy consumer. Economical use of energy is more necessary than ever before. What's even better, however, is if the network is able to offer the smart grid flexibility and responsiveness."

Result:
"The DESI solution enables common energy savings in all parts of the ICT supply chain and the ability to respond to signals emanating from the smart grid."

Heiko Lehmann, Project Manager

The Project at a Glance

DESI aims to lower the end-to-end energy consumption of ICT services. The object targeted by this optimisation is not just the energy consumption of the devices but also traffic management. Moreover, the ICT network is made suitable for the smart grid: the energy storage units in the network enable it to respond to the availability of wind or solar power, to shift loads to different times and thus stabilise the overall system. At the same time, the DESI project aims to establish the adaptability of ICT components, to integrate them across the entire supply chain and to ultimately develop a unified control system for ICT and energy elements. In the DESI project, a demonstrator was developed that – spread over four locations in Germany – exemplifies the holistic DESI solution for ICT and memory control.

Source: Alcatel-Lucent Deutschland AG

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- Cisco Systems GmbH, Kassel
- PASM Power and Air Condition Solution Management GmbH & Co. KG, München
- Konrad-Zuse-Zentrum für Informationstechnik Berlin

Duration: 1.6.2011 – 31.5.2014

Efficient Data Transport to Any Place at Any Time

IntelliSpektrum – Intelligent Spectrum Management for Energy-Efficient and Service-Optimised Access in Flexible Hierarchical Mobile Communication Networks

Source: IT2Green

Especially at concerts, football games, at Christmas and New Year or at major trade shows, the surge in mobile data traffic is huge. In order to transfer such large amounts of data, the mobile communications network has a large number of radio masts equipped with large transmitter cells. Each of them supplies continuous power for a large reception range, but with a power consumption of thousands of watts and usually irrespective of the actual demand, the amount of energy consumed by this is vast.

In order to better ensure energy efficiency and the performance of the mobile radio network, the IntelliSpektrum project has examined scenarios for a flexible, dynamic and heterogeneous mobile radio network. The concept envisages supplementing large transmitter cells with smaller and more energy-efficient pico- and femtocells: picocells have a power rating of less than 100 Watt and femtocells less than nine Watt depending on network utilisation, the small radio cells are activated or deactivated using an intelligent control system. For this purpose, the project partners have developed a flexible, dynamic and self-optimising transmitter for base stations which relieves the central control unit. The new transmission cell uses gallium nitride circuits. They allow a higher transmission frequency at a lower energy consumption level than the commonly used silicon circuits. Two other important components have been developed for the new energy-efficient transmission cells: a multi-band transmission amplifier and a low-noise receiver amplifier. The project also focused on the methods of flexible network management: studies have examined how, if necessary, data traffic can be concentrated on smaller, more efficient cells and how transmission cells can be intelligently and flexibly switched on and turned off.

Also, the end-user device itself can help to save energy: the project has developed an energy-profiler tool that analyses the interaction between the mobile communications network and the end-user device. This enables the functions of mobile radio networks to be evaluated for their impact on energy consumption.

IntelliSpektrum

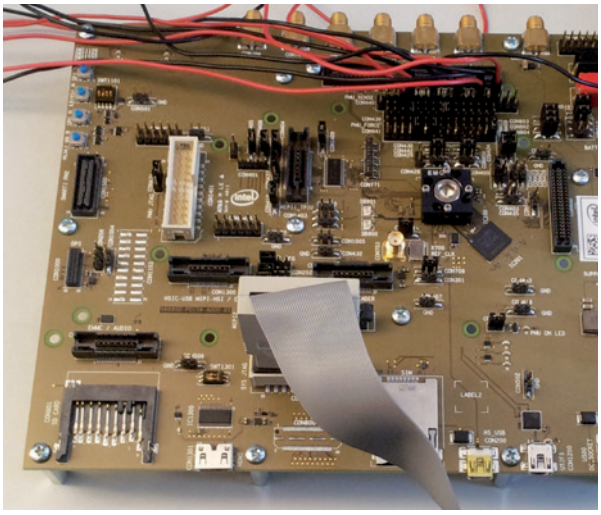
Initial Situation:
"Conventional mobile phone masts consume a lot of power because, with their large transmission cells, they're continuously transmitting at a high performance level – regardless of the actual demand."

Result:
"With the implementation of new network architectures, new hardware and associated innovative algorithms, energy savings in and also through powerful small cellular networks are possible."

Andreas Wich, Project Manager

The Project at a Glance

Around the world, more and more people are making use of mobile phones, Web-based services and data transfer or mobile access to high-definition video and TV broadcasts. That's why the next generation of mobile communication networks have to be designed to handle both a high number of end-user devices as well as greatly fluctuating load situations. The IntelliSpektrum project investigated how the energy consumption of mobile networks can be reined in despite increasing traffic. For this purpose, the project partners analysed energy-efficient, hierarchical networks and developed dynamic, highly efficient transmitters for base stations. Thanks to this approach, algorithms and the new components, the project has enabled the energy-efficient communication networks of tomorrow.



Source: Intel Mobile Communications

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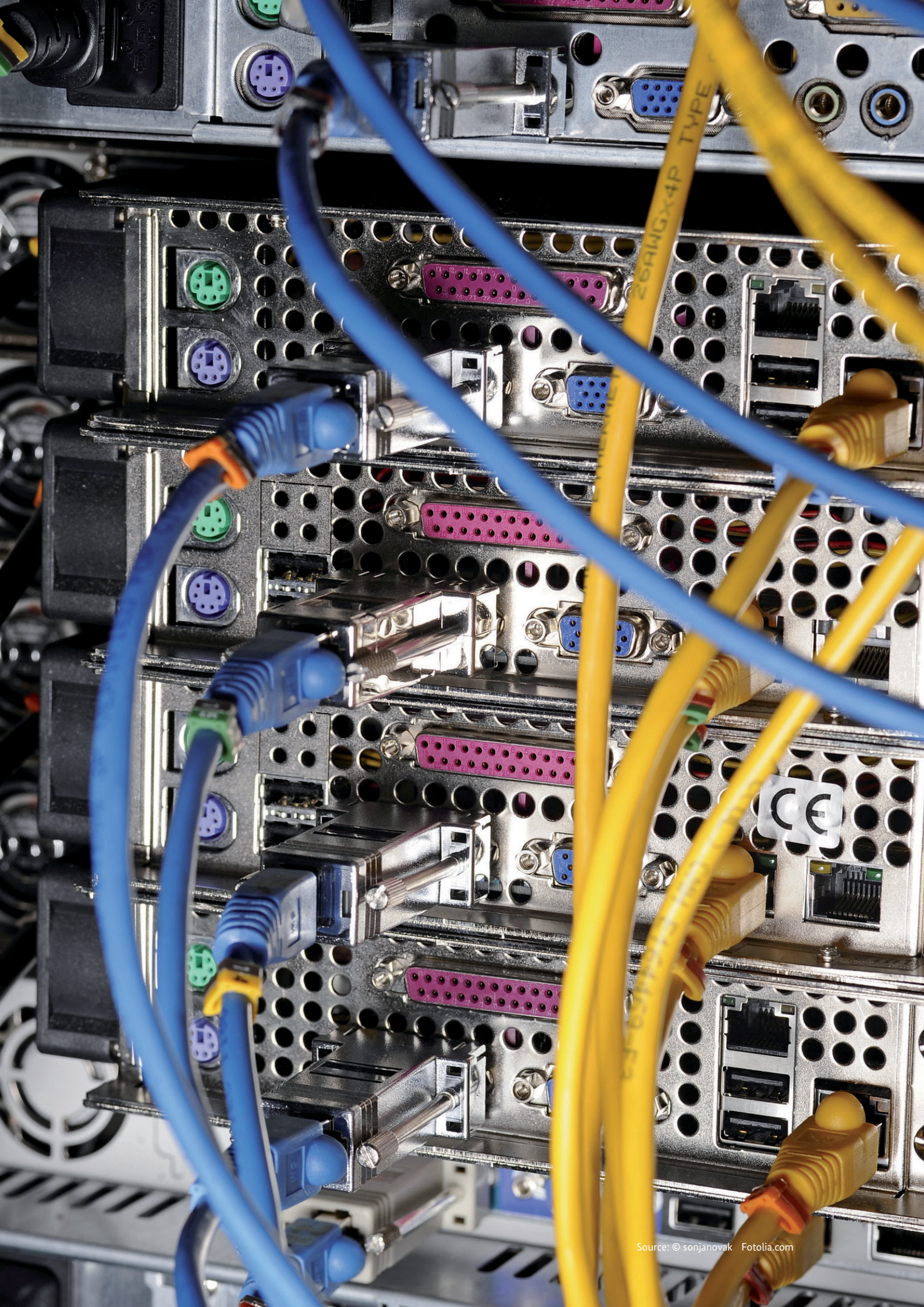
Duration: 1.4.2011 – 30.9.2014



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Cluster: Data Centres and Clouds

Energy-Based Load Shifting in Data Centres and the Cloud

With regard to the 'Data Centres and Clouds' cluster, methods and technologies are being developed that allow the utilisation of the IT systems of individual data centres or those working in combination to be increased. This is intended to allow energy-related locational advantages to be better utilised at any given time.

Increasing energy efficiency is a big challenge for large data centres, since electricity costs form a significant proportion of their overall running costs. That's why professional data centre operators have gone over to the energy-based optimisation of the data centres' operation while improving customer-oriented IT performance in relation to energy consumption and quality of service from end to end.

One major approach being taken is the continuous updating of the IT systems, since the ratio of computing power to energy consumption has significantly improved, particularly in the servers of recent years. One important reason for this is the technical progress made in the semiconductor industry. Particularly in the area of processors, technology development is still following the miniaturisation paradigm laid down by Gordon Moore 40 years ago, which postulates that, given the same surface area, the number of transistors doubles approximately every 18 months. Although this trend has slowed down somewhat, the potential for innovation in the semiconductor industry remains extremely high and forms the basis of the growing energy efficiency of IT systems in data centres. Besides the periodically increasing number of transistors, processors are also becoming more modular in design and are being equipped with multiple cores. With this new processor design, the semiconductor industry supports a second vital measure to improve resource efficiency – that of virtualisation.

The progressive implementation of virtualisation and dynamic load balancing thus increase the previously low utilisation rate of servers. Only 10% or 20% of the capacity of the servers in today's data centres are often actually used. Through virtualisation, utilisation can be increased to between 60% and 70%, which can ultimately lead to a reduction in the hardware required. Such consolidation is possible for both servers as well as data storage units and network technologies.

Other measures for the end-to-end improvement of the energy efficiency of data centres relate to redesigning and customising the data centre infrastructure so as to make it compatible with the actual needs of the IT systems. This primarily includes the design of an effective and, at the same time, low-loss electrical power supply. All elements in the power supply are subject to energetic losses, which can be analysed through measurements and then optimised. Energy measurements and thermal analyses are also highly significant for optimising cooling and air conditioning. Many projects, including those in the context of the German Data Center Award, vividly demonstrate that the appropriate design and operation of the air-conditioning system can save up to 30% of data centre energy costs. That is why particularly efficient air-conditioning concepts generally make use of locational advantages. This shows that no data centre is like another and there are many ways to approach the issue of optimisation.

The IT2Green research projects build on these positive developments. The projects take into account the specific conditions in which small and medium-sized businesses, government agencies and universities operate. The specific research topics are diverse and range from the needs-based provision of IT resources to dynamic load shifting between multiple data centres based on local energy efficiency indicators via regular load forecasts. In the process, specific customer requirements and legal frameworks are consistently taken into consideration which is of great importance to, for example, IT applications in government agencies. Another focus is the use of renewable energy to operate data centres.

The following research projects are grouped under the thematic cluster of 'Data Centres and Clouds':

- **AC4DC**
- **GGC-Lab**
- **GreenPAD**
- **MIGRATE!**

Building Bridges with Algorithms

AC4DC – Adaptive Computing for Green Data Centres

Source: © djama - Fotolia.com

The aim of the project 'AC4DC – Adaptive Computing for Green Data Centres' is the sustainable reduction in the energy consumption of data centres. To achieve this, intelligent forms of load, infrastructure and data management were explored within a data centre and also across data centres. The developed concepts are implemented as prototypes and operated in the test data centres of the project partners so that the possible saving potentials of the solutions can be evaluated.

Intelligent load and power management of servers enabled up to 50% of energy to be saved. In addition, the joint control of all air components allows a significant improvement in PUE (Power Usage Effectiveness). Thus, a typical SME data centre with a maximum IT load of 60 kW will see, on average, an improvement in its PUE rating from 1.5 to 1.3. This corresponds to an annual saving of 29.8 tons of CO_2. The exploitation of unused storage space in desktop computers as a combined intranet cloud backup solution for backing up file servers also increases the added value of existing resources. At the same time, using this backup solution removes the need for any dedicated backup hardware in the data centre.

The targeted and early integration of data centre operators guarantees that the project is demand-oriented. On this basis, powerful business models were developed during the project, and energy and material savings calculated. Moreover, a patent has been filed for a number of innovations. Furthermore, research results outside the funding framework were developed and applied to specific products and solutions. One example of this is the new air-conditioning concept in the modular, standardised data centre 'RiMatrix S' belonging to the Rittal company, which was displayed at CeBIT 2013 for the first time.

Initial Situation:
"The optimised interaction of all data centre components – such as cooling and power protection, servers and storage units, operating systems and services – is intended to sustainably increase energy efficiency."

Result:
"The holistic approach demonstrates that a data centre can save up to 50% of the energy it uses – and thus also contributes to cutting CO_2 emissions."

Bernd Hanstein, Project Manager

The Project at a Glance

The AC4DC project aims to sustainably reduce the energy consumed by data centres. The focus here is on taking a holistic view of the data centre, since the areas of infrastructure, servers and the operating systems and services running on them can only currently be considered independently of each other and without taking into account user behaviour. On the basis of previously identified user needs, new optimisation algorithms can form a bridge between these data centre subsystems, while, in the process, exploiting, for the purpose of optimisation, important factors such as user behaviour, economic requirements – e.g. the local price of electricity – and site-specific parameters, such as the outdoor temperature for the use of free cooling.

Source: Rittal GmbH & Co. KG

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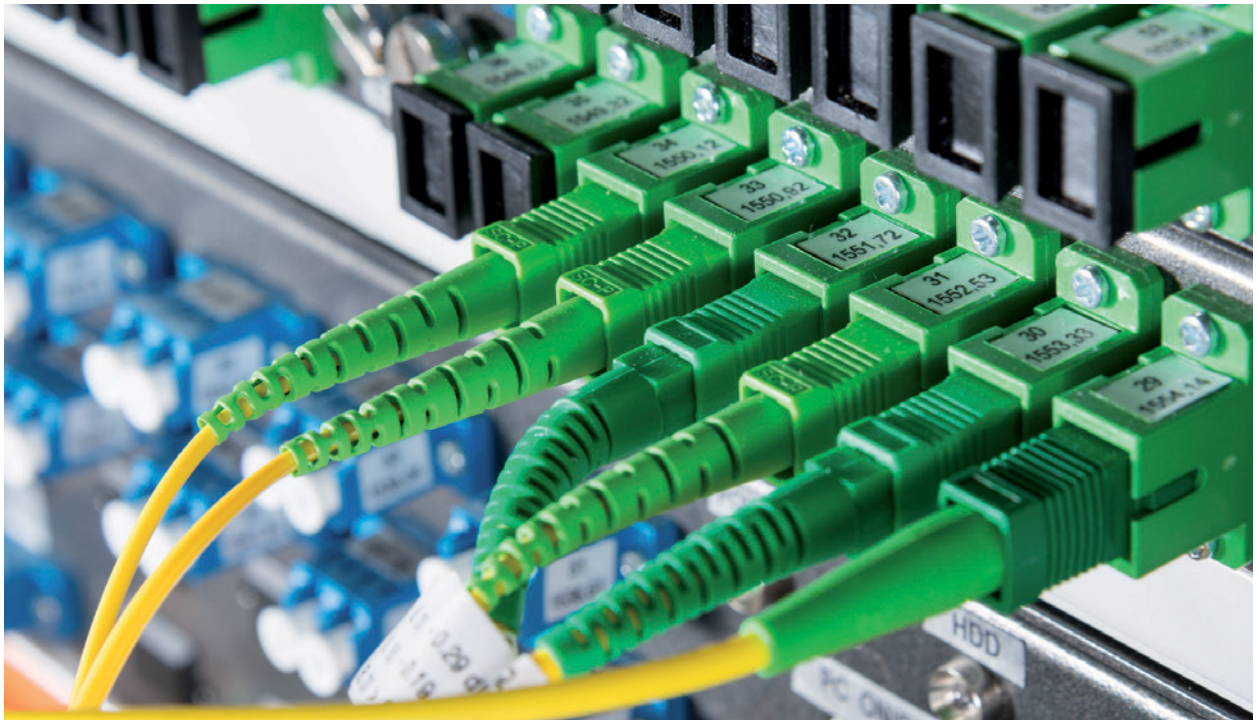
- OFFIS Institut für Informatik, Oldenburg
- Universität Paderborn
- Borderstep Institut für Innovation und Nachhaltigkeit gemeinnützige GmbH, Berlin

Duration: 1.5.2011 – 30.4.2014

A Cloud for Public Administration

GGC-Lab – Government Green Cloud Laboratory



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Day after day, the demand for IT computing capacity is increasing in public administrations. For this purpose, local authorities have large data centres at their disposal whose IT resources are designed to cope with occasional peak loads. Due to fluctuations throughout the day, only 30% of their capacity is typically used – but the energy demand remains almost constant. The GGC-Lab project means that, for the first time ever, a cloud infrastructure for business applications extended across data centres has been built, which should increase the utilisation rate to 60%. The cloud will also make it possible to carry out specialised applications where energy efficiency is high and the price of electricity low.

At the start of the project, the interactions along the value chain of a community cloud were analysed. The results are models that can be transferred to roles, processes and organisational structures. At the same time, demands made on the IT infrastructure, specialist applications and the mechanisms for load management were determined and the specific market conditions examined. Thus, specialist applications offering huge potential were selected for the test operation and the legal challenges identified. The result is a catalogue of requirements and a model of how to proceed to ensure potential candidates have easy access to the GGC-Lab. It became clear that legal provisions, along with the architectures and licensing models of today's professional applications, severely restrict the application scenarios of cloud computing.

What is currently still being examined are the gains in efficiency that are possible in the cloud. On the one hand, by shifting the peak loads of one data centre into one with free resources, the capacity held available can be better utilised; on the other hand, load shifting takes into account the energy efficiency of the IT and building technology as well as the electricity prices and mixes. The task of controlling load management is undertaken by decentralised resource controllers with the aid of configurable control systems and key data measures in real time. A system-wide monitoring system has been developed to furnish these key figures. Initial simulations confirm that green cloud computing relieves the IT budgets of public administration, with manageable risks, and reduces the negative impact of the growing use of IT.

GGC-Lab
Government GreenCloud Laboratory

Initial Situation:
"Cloud computing offers public administrations new ways of countering the negative impact of rising demand for centralised IT services through a more efficient use of IT infrastructures."

Result:
"GGC-Lab illustrates that, with cloud computing concepts and corresponding general conditions, economic and ecological efficiency potentials can be realised, despite the special risks and requirements that arise when operating specialist municipal applications."

Bernhard Barz, Project Manager

The Project at a Glance

The GGC-Lab project examines the potential of cloud computing for typical application scenarios for municipal administrations. The overall aim of the project is to serve the growing demand of public administrations for centralised IT services with the aid of cloud computing in a way that conserves resources. For this purpose, an expandable community cloud infrastructure for municipal applications are being set up and tested in four data centres spread across the German federal states, while at the same time taking into account the specific operational and security requirements of the public sector. Efficient load management extended across data centres should, above all, lower costs and reduce climate-polluting effects.

Source: IT2Green

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- StoneOne AG, Berlin
- Technische Universität Berlin

Duration:: 1.6.2011 – 31.5.2014

Computing When the Wind Blows

GreenPAD – Energy-Optimised ICT for Regional Economic and Knowledge Clusters

Source: MEV Verlag

Information and communication technologies are essential for exchanging information and knowledge. With growing data volumes, the energy consumed by data centres is also steadily swelling. It is, therefore, all the more important that energy-savings potentials along the entire IT value chain are exploited – from the procurement of energy-efficient hardware components to resource-use by the user via the targeted control of the operation.

The GreenPAD project has developed an energy-efficient ICT infrastructure model for regional business and science parks. The model envisages uniting many small, decentralised and underutilised data centres to form a single large data centre. With the aid of a central controller, which combines the variety of IT applications and building automation to ensure a style of operation that conserves resources, the infrastructure of data centres can be controlled in an energy-efficient way from start to finish. At the same time, a smart grid has been set up by means of a local wind farm. The idea behind the so-called smart grid is to match the data centre's current power consumption with the current availability of renewable energy. Larger amounts of data should be processed "when the wind blows". The project was able to demonstrate, in an exemplary way, that data centres can respond flexibly to a fluctuating power supply and react to provide relief and thus save costs. With a final consumption analysis of the entire ICT infrastructure, the project also identified numerous opportunities for further energy savings. For example, redundant ICT components were identified and power-hungry desktop computers replaced by low-power notebooks. The loss of computing power was compensated with a cloud computing solution.

The project's results are combined into a 'Best Practice Code' for energy-efficient cloud computing operation. In the process, the standards for privacy and data security are taken into account on the basis of guidelines for IT baseline protection issued by the Federal Office for Information Security.

GreenPAD

Initial Situation:
"In many business parks in Germany, numerous small server rooms result in a relatively large amount of energy being consumed. This is mainly caused by a variety of heating, air-conditioning and ventilation infrastructures."

Result:
"The GreenPAD project shows that with a centralised and energy-optimised data centre, one can not only consume significantly less, but it is also possible to use 'ecologically clean' electricity."

Thomas Dyroff, Project Manager

The Project at a Glance

The GreenPAD project demonstrates the development, testing and transfer of an energy-optimised ICT infrastructure model for regional economic and scientific clusters, using the example of the collaboration between a technology park and the University of Paderborn. This cluster can bundle the ICT infrastructure of the region into a single shared data centre operation, thus reducing energy consumption and CO_2 emissions caused by ICT. Efficiency potentials along the supply chain are tapped. The remaining consumption is coupled to the direct supply of renewable energies by means of a smart grid. Incentives that promote the migration of decentralised structures and reward energy-saving behaviour are created. The standards relating to data protection and security are respected.

Source: Adelheid Rutenburges, Universität Paderborn

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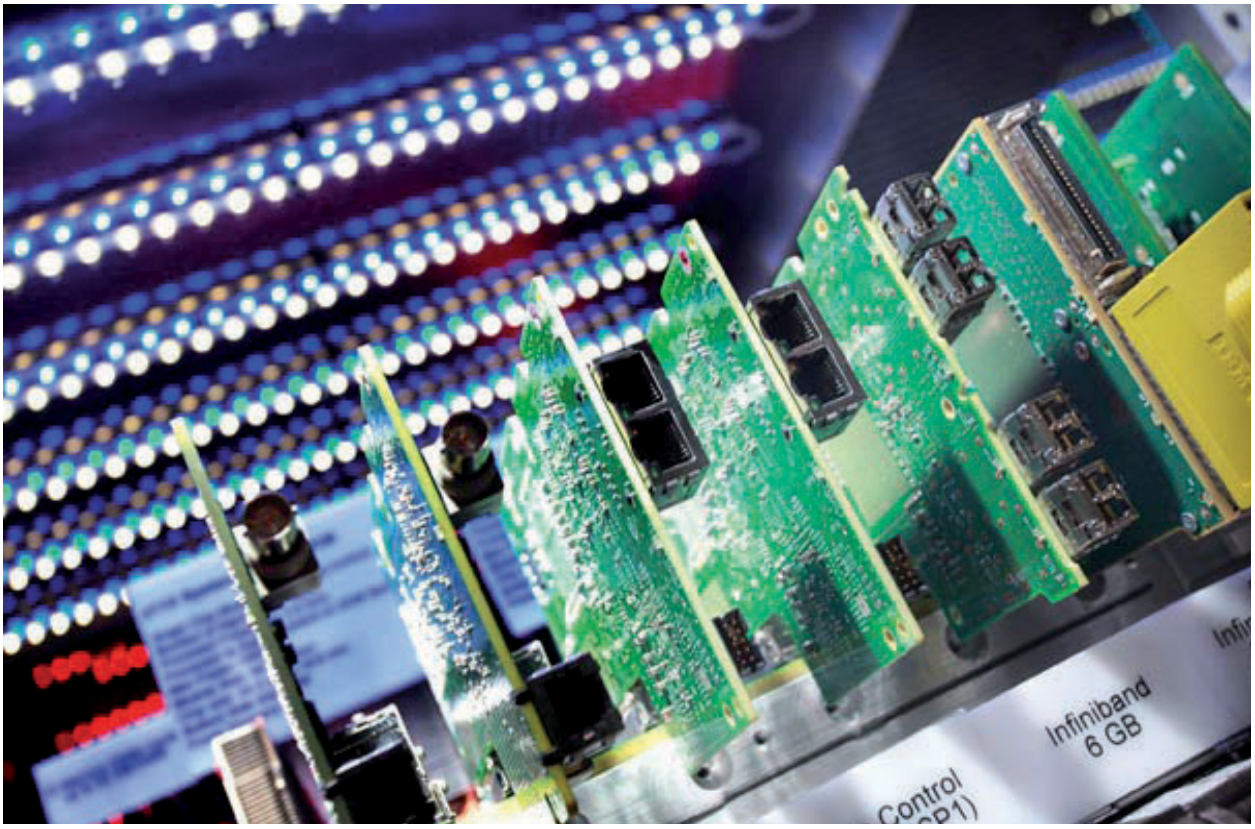
Duration: 1.6.2011 – 31.5.2014

Saving Power with a Cloud

MIGRATE! – Models, Methods and Tools for the Migration to Cloud-based, Energy-Optimized User Infrastructures and their Management



Source: IBM Deutschland GmbH

Cloud computing promises a more efficient use of ICT resources. However, many things remain a puzzle to users: which ICT systems should be migrated to clouds? What impact do cloud solutions have on energy efficiency and costs? And how can the migration of ICT systems be performed efficiently? The project MIGRATE! investigated precisely these issues. In order to do so, methods and tools were developed to assist IT decision-makers throughout the migration process.

Users' ICT infrastructure is often characterised by complexity, heterogeneity and different IT maturity levels. Only occasionally are appropriate data on the energy efficiency of infrastructure and its components available. The MIGRATE! model showing how to proceed with cloud migration takes this situation into account. On the basis of a few components and parameters, the actual infrastructure is adequately recorded to ensure that the decision to migrate is sufficiently well founded. A migration portfolio is thus created, from which migration scenarios can be derived. The analysis integrates commonly used methods, such as the total cost of ownership and a feasibility study. During system operation, any actual data that arise are played back into the output models to carry out target/actual comparisons.

Cloud migration projects are very specific to each individual application and require special expertise. So that the gains in efficiency are not pitted against high migration costs, methods have been developed to automate software migration: today's applications are described in formal models in such a way that they can be made directly available at the cloud provider. This cloud automation is also the goal of the TOSCA standard (Topology and Orchestration Specification for Cloud Applications), in whose development leading software companies are involved. The MIGRATE! methods are already implementing the TOSCA standard and providing TOSCA-compatible, customisable energy savings plans (policies) that are carried out on the premises of the cloud provider.

MIGRATE

Initial Situation:
"When it comes to cloud migrations, cutting costs and increasing flexibility have so far taken centre stage – energy efficiency gains are a side-effect that is not carefully planned, but one which we are delighted with."

Result:
"In the MIGRATE! project, we have demonstrated, by means of four very different cloud migrations, how energy efficiency can become a solid target figure and how migration can also be accelerated at the same time."

Stefan Kirn, Project Manager

The Project at a Glance

While cloud computing holds out the prospect of a more efficient use of ICT resources, there is still uncertainty among users regarding the 'what' and 'how' of cloud migration. Together with four users of complex, heterogeneous ICT infrastructures (an airport, a hospital, a building society and a regional government administration), methods and tools have been designed to help IT decision-makers throughout the migration process. In the process, the MIGRATE! model of how to proceed structures the migration process. On the basis of fewer components and parameters, infrastructures are recorded in such a way that sufficiently substantiated migration decisions can be made. The software migration itself will be largely automated, thanks to applications being described in machine-executable models. To achieve this, MIGRATE! will rely on the new TOSCA standard.

Source: IBM Deutschland GmbH

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- Brandenburgischer IT-Dienstleister, Potsdam
- Universität Stuttgart
- Bosch Gesellschaft für medizinische Forschung mbH, Stuttgart
- Flughafen Stuttgart GmbH, Stuttgart

Duration: 1.10.2011 – 30.9.2014

Source: © Christian Müller Fotolia.com

Cluster: Monitoring and Management

User-Sensitive Provision of IT Resources

In the thematic cluster of 'Monitoring and Management', intelligent controls for the needs-based supply of IT resources are developed at the office workplace. The aim is to let the ICT devices only run at full power if the user is present – when the user leaves the office workplace, the IT resources are automatically switched to idle mode.

Even if all ICT devices such as personal computers and printers now have energy-saving modes, and the legal requirements regarding energy efficiency are increasing, research in this field nevertheless remains important. Again and again, practice shows that significant energy savings in the office have failed to materialise – although the end-user devices comply with the European Ecodesign Directive (ErP) and eco-labels such as the Energy Star or Blue Angel.

One major reason for this is inefficient user behaviour: on the one hand, many users disable power management to prevent alleged loss of comfort and slightly longer reactivation times and, on the other hand, the default settings set by the system administrators are often not ideal for all applications and device configurations. Conflicts between the availability of the mains or server and the power management of the client computer may thus arise. These everyday examples are reason enough to develop alternative control mechanisms that focus on the user and adjust the power management to suit the individual behaviour of the user.

Through monitoring, user recognition and individual management that builds on this, the aspects of energy efficiency and user-friendliness are perfectly matched. The projects develop and test new measurement and control technologies that help not only ICT end-user devices, but also building services engineering, such as lighting, heating and blinds, to be operated in a demand-oriented manner. For this purpose, existing sensors and network options of mobile phones, such as Bluetooth, can be used to detect the user's approach to the workplace. The user's departure from the workplace can also be logged and the terminals can thus be directly switched into sleep mode. The software systems developed in the IT2Green projects also allow a targeted evaluation of resource booking systems.

This permits an extremely effective provision of resources in, for example, meeting rooms that are not in constant use.

Another research topic is the dynamic adaptation of the IT resource utilisation in the data centre to suit users' actual needs. In practice, far more IT resources than required for sporadically used services are often maintained. This circumstance leads to the continuous power consumption of almost unused servers. By modelling and analysing IT processes, user interaction with data centre resources can be simulated as repetitive load profiles. These simulations are then sent as samples to the data centre in order to measure the response time. Comparing these values with the IT resources and the associated power consumption allows optimisation rules to be drawn up and applied.

As the IT2Green projects demonstrate, intelligent monitoring without evaluating personal data is also possible and suitable for closed-loop control. One important finding is that both the energy-related measurement data of the IT systems used as well as the data relating to IT performance and quality of service must be measured simultaneously and promptly evaluated. However, previous research results also show that any appropriate control of the ICT system as a whole is difficult under the present conditions since they are influenced by a variety of proprietary measurement systems and protocols. Besides harmonising interfaces, one solution lies in end-to-end IP-based systems.

The following research projects are part of the thematic cluster of 'Monitoring and Management':

- **Adaptive Sense**
- **GreenIT Cockpit**
- **pinta**

Intelligent PCs, Printers and Phones

Adaptive Sense – Adaptive Sensors for the Energy-Efficient Control of Distributed Systems

Source: MEV Verlag

At present, ICT applications use only 55% of the available hardware resources – which means that 45% of the hardware is left unused. The aim of 'Adaptive Sense' was to develop an energy management system for energy efficiency in the workplace. Intelligent sensors that detect and adapt the status of users, applications and the related ecosystem facilitate this gain in efficiency. For this purpose, a requirements analysis, the analysis of the potential savings and the associated consideration of the business case were carried out first. The design and implementation of the prototype then followed.

The technical realisation of the adaptive recognition is based on a wide area network of sensors based on an IPv6 (Internet Protocol Version 6). The analysis and optimisation are carried out on a central service platform. The heart of the sensor network consists of a network transceiver and an operating system from the Zentrum Microelectronics Dresden AG company. The cloud portal and the resulting application of the measuring and switching of energy flows are provided by the TU Dresden. The associated cloud applications were developed by T-Systems Multimedia Solutions GmbH, especially for the roles of employee and energy manager. DREWAG – Stadtwerke Dresden GmbH was in charge of managing the pilot projects. After identifying possible energy efficiency strategies to reduce ICT-related energy consumption in the workplace, the project planning of various strategies in DREWAG's central depot and on the premises of the Johanniter-Unfall-Hilfe e.V. then ensued.

The studies have shown that, with presence-controlled automation, the potential savings can be exploited to the utmost. By configuring the rule-based strategy of 'Adaptive Sense' on the premises of Kiwigrid GmbH, the wrong ICT operation mode can be significantly reduced in the adaptive and non-adaptive area. As a result, saving potentials are fully exploited and energy consumption reduced.

Adaptive Sense

Initial Situation:
"Modern workplaces are flexible, and a lot happens at the same time: computers, printers, phones and, of course, the heating and lights are in constant use. But how can we save energy if all the resources have to be available at all times – and constantly consume energy?"

Result:
"In the Adaptive Sense project, we faced up to this problem. With the help of our energy management system, we were able to demonstrate energy savings of up to 62% in the pilot phase."

Juliane Steinhauf, Project Manager

The Project at a Glance

Within the context of the 'Adaptive Sense' project, a sensor-based energy management system for the workplace was developed with the primary aim of saving large amounts of electric and thermal energy – and thus of increasing the energy efficiency of ICT systems. The gain in efficiency results from the analysis of the measured utilisation of PC hardware, devices and the network as well as from the associated recognition of user statuses and application benefits. These analyses and the optimisation of status information are performed on a central service platform which has been developed as a cloud computing system. Even during the pilot phase, possible energy savings of up to 62% were confirmed.

Source: TU Dresden

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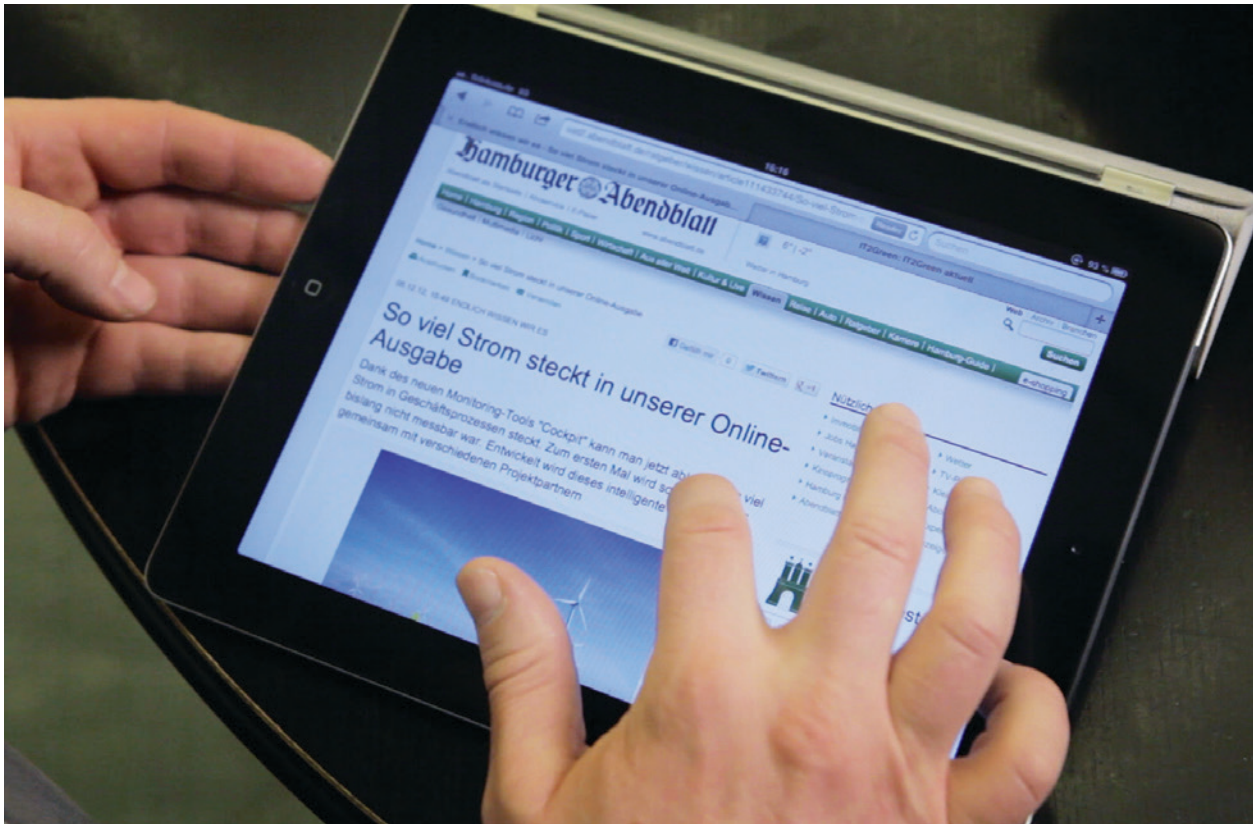
Duration: 1.10.2011 – 30.9.2013

Measuring the Power Consumption of Business Processes

GreenIT Cockpit – Business-Oriented Management Cockpit for Energy-Efficient ICT Throughout an Organisation



Source: IT2Green

The 'Green IT Cockpit' project has developed a management tool to optimise the energy-efficient use of information and communication technologies in enterprises and public administrations. To achieve this, the 'green' cockpit first determines the energy consumption of all computer, storage and network systems that are essential for daily business processes and that are running in the data centre. In a second step, the energy consumption of individual system components, such as scanners, Internet browsers and e-mail programmes, is summarised and assigned to the various business processes. Then the system services actually called on by the users are compared with the energy used. Data on the energy efficiency of the entire ICT system can thus be ultimately determined.

Subsequently, all the information on the efficiency of the ICT systems and their components is collected and processed in the user interface in a simple and easily interpretable form. Doing this can thus improve the strategic planning of government agencies and companies with regard to ICT-related energy efficiency. The cockpit's content and user interface are customisable and permit the detailed scrutiny of cause-effect relationships besides key data analysis.

A set of energy-efficiency indicators determines which business processes are particularly inefficient. The key data, also known as key performance indicators (KPIs) are incorporated into the implementation of the GreenIT Cockpit and adapted to the demands of the industry partners. In one test project with Axel Springer AG, for example, an online reaction process with all the ICT systems involved was examined with regard to its efficiency. Besides server utilisation, the GreenIT Cockpit also displayed the working hours of the overall system in terms of the actual services requested by the editorial office.

Initial Situation:
"The ICT-related energy costs of business processes are currently largely unknown in businesses and public authorities."

Result:
"With the GreenIT Cockpit, we now have a tool that gathers data relating to the energy consumed by the business processes and presents it clearly."

Thomas Leitert, Project Manager

The Project at a Glance

How can we make more use of energy-efficient information and communication technologies in business and government – and optimise their usage? With the GreenIT Cockpit, the project partners have developed a tool with which ICT-related power consumption can be determined and made more efficient. To achieve this, key indicators and scenarios for an energy-saving approach to ICT systems were developed in the process and value chains of businesses and public administrations. The cockpit's task is to bundle and display all the data relating to the energy-efficient use of ICT systems in a divisional and business-process-oriented way. As industry partners, Axel Springer AG, TimeKontor AG and the Federal Environment Agency support the GreenIT Cockpit project.

Source: IT2Green

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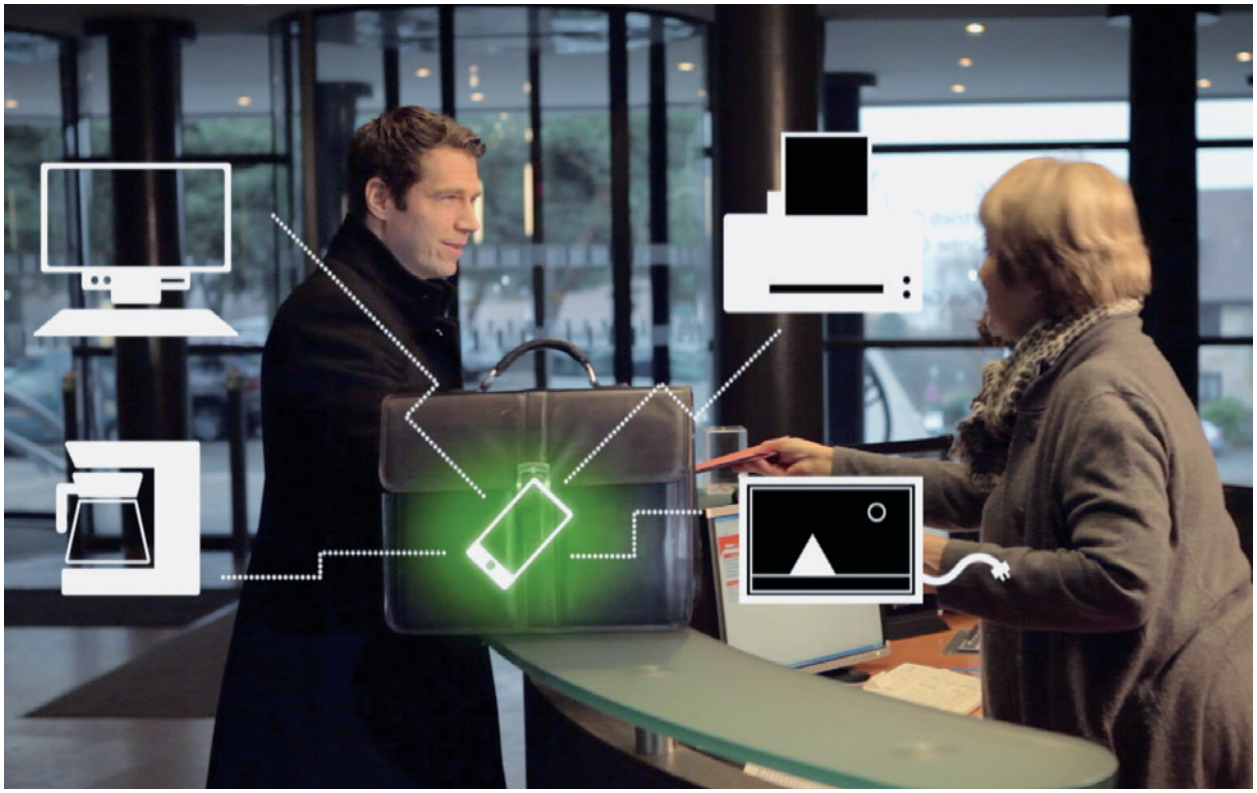
Duration: 1.4.2011 – 30.9.2014

Smartphones Operate Devices

pinta – Pervasive Energy via Internet-Based Telecommunications Services



Source: IT2Green

A major part of the energy in Germany is consumed in and by buildings. Heating, cooling, hot water and the operation of electrical equipment – particularly computers and other ICT devices – are among the biggest consumers. In the 'pinta' project, a digital platform has now been developed with which IT equipment, heaters and office lighting for the individual workplaces can be controlled in an energy-efficient and cost-saving way. The idea behind this automatic control is simple: energy should only be consumed when it is needed by employees. With the help of mobile devices such as smartphones and sensors in the office, the pinta system automatically recognises when, for example, the PC screen or desk lighting should be switched on or off.

Already at the beginning of the project, an analysis had shown that, with such control software, savings of up to 30% are possible – depending on user behaviour. This was confirmed by several tests conducted in a municipal building and on the project partners' premises.

At the same time, the studies revealed that the automatic control of appliances and lighting as well as automatic temperature regulation significantly increase user comfort.

The pinta platform is at the heart of this controlling. In addition, there is an app that, besides visualising the surrounding properties, enables people to personally control the settings of their office space and electrical devices. Context and presence detection is thus carried out with the aid of GPS, WiFi and Bluetooth solutions, sensors and other technologies. Several context sources can thereby directly react to the state of the building in question. The 'Open Gateway Energy Management Alliance – OGEMA' software served as the basic technology of pinta-platform. With it, the electricity price trend can be observed and energy consumption automatically shifted to low-cost times. This allowed new software requirements to be identified that will now be incorporated in the development of the impending OGEMA 2.0.

pinta

Pervasive Energie durch internetbasierte Telekommunikationsdienste

Initial Situation:
"Today, buildings account for about 40% of primary energy use – a powerful lever for savings. And pinta sets it in motion."

Result:
"The pinta system controls energy consumers in the office, based on ambient information and user behaviour. This can not only cut the energy used by up to 30%, but also increase user comfort."

Jelena Mitic, Project Manager

The Project at a Glance

The research project pinta, 'Pervasive Energy via Internet-Based Telecommunications Services', has developed an energy management system which minimises the energy consumption of office workplaces. With the assistance of environmental information gathered using mobile devices and sensors, the system controls both ICT equipment and heating and lighting so that they comply with users' requirements. The aim is to consume energy only when it is actually needed. pinta thus automatically helps the user to save energy and money. pinta was designed specifically for PC workstations in offices, as found in many firms and public administrations. Tests have shown that energy savings of up to 30% are possible, depending on the specific behaviour of users.

Source: pinta

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- Fraunhofer-Institut für Windenergie und Systemtechnik IWES, Kassel
- E.ON Mitte AG, Kassel

Duration: 1.10.2011 – 31.3.2014

Source: © FotoDesignPP - Fotolia.com

Accompanying Research

Supporting, Evaluating and Defining Trends

The IT2Green programme addresses a complex set of issues in which technical and economic aspects are closely intertwined. The underlying conditions are changing dynamically as a result of continuous technical development and standardisation, but also on account of the constant regulation and deregulation of our markets.

That is why the systemic improvement of the energy efficiency of information and communication technology in the fields of telecommunications, data centres and end-user devices that is being striven towards by the IT2Green research programme presupposes a holistic understanding of cause and effect relationships and general conditions. The accompanying scientific research conducted at the Fraunhofer Institute for Reliability and Microintegration IZM (as the director of the accompanying research) and the Fraunhofer Institute for Systems and Innovation Research ISI supports the funding authority and the funded projects with respect to the successful realisation of the programme's objectives.

The central task of the accompanying research is the scientific support and evaluation of the ten funded research projects. The accompanying research is also intended to sift through cross-project research results and transform them into generalisable knowledge. For this purpose, three subject groups were established that meet every six months to discuss cross-cutting issues such as data protection issues or the measurement of energy efficiency. In this context, a so-called 'GreenIT dossier' has been compiled which clearly explains, among other things, energy efficiency indicators and measurement standards. These activities promote the exchange of information between IT2Green research projects. At the same time, important insights are summarised for the political clients, and potentials and the areas that need action are identified. The accompanying research of the VDI/VDE-IT ensures that the information and knowledge transfer is effectively transferred from the IT2Green programme to the general public.

Cross-Cutting Topics and Working Groups

The technical support for the projects is guided by a catalogue of questions that examines the research results for mechanisms and instruments in the context of energy-efficient solutions for ICT systems, services and business models:

- How is the ecological and economic potential of GreenIT measured? How is it clearly communicated to the customers?
- Which causal relationship exists between the size and efficiency of an ICT system? How is the optimum dimension identified?
- Which technical, economic and legal framework conditions are needed for an effective and sustainable implementation of Green IT innovations?

For a specific exchange of information and topic-oriented work in cooperation with the projects, the accompanying research has set up three working groups in which cross-cutting topics are discussed and recommendations developed. The working groups consist of project representatives and meet up twice a year, also with the participation of external experts; they are moderated by the accompanying research. The aim of these groups is to generate additional information for the IT2Green programme.

Measuring Energy Efficiency

In this working group, international activities regarding the measurement of energy efficiency in data centres and telecommunications are continuously monitored and analysed. The two goals are to develop an overview of the many initiatives in politics and industry and to contribute towards the harmonisation and useful application of effective measurement methods.

Besides the general measurement methods, the intended environmental improvements brought about by the projects were presented and the measurement and detection methods necessary for them discussed. The intended improvements were aimed mainly at three aspects:

- **Saving energy and increasing energy efficiency**
- **Increased use of renewable energy**
- **Reduction of hardware**

In addition, the projects presented their results, strategies and the difficulties they encountered when carrying out measurements, and derived best practice examples from the results of the monitoring.

New Networks and Technologies

How do telecommunication networks have to be designed so they can cope with growing data traffic in an energy-efficient way? What are advantages and disadvantages of the various technologies and network architectures? The topic dealt with by this working group is the description of mechanisms and aspects of an energy-efficient network de-

sign. Practical examples of the projects in the telecommunications cluster were presented and optimisation strategies discussed.

More extensive cooperation between the projects arose from the meetings of the working groups. The projects in the telecommunications cluster, for example, developed a joint network model for Germany.

Techno-Economic Competitive Factors

A balance between performance, quality of service, reliability, and energy demand has to be found for new business models that are aimed at energy efficiency. There is a debate, however, about which framework conditions are required to successfully implement such business models. The working group dealing with 'techno-economic factors of competition' discussed the recycling options and business models of the projects. What was analysed was whether the developed solutions were a matter of 'one-off effects' through, for example, new hardware solutions, or whether they were continuous improvement and monitoring solutions.

Besides the projects' best practice examples, the requisite reference calculations and possible technical, legal or economic barriers were discussed. One particularly important topic among all this is data protection, which was also discussed with external experts.

Practical Guide and GreenIT Dossier

With the support of the projects, the accompanying research has drawn up a practical guide and a GreenIT dossier.

Practical Guide

The practical guide is aimed at IT professionals and decision-makers in business and government and provides them with information and examples on how to implement GreenIT in the areas of office terminal equipment and data centres. In the process, those in charge are not only presented with concrete opportunities and examples, but are also given arguments to convince employees and directors to consistently put GreenIT into practice.

The guide provides information on planning, procurement, implementation and subsequent use optimisation, in each case substantiated with examples from the projects of the two clusters of 'Monitoring and Management' and 'Data Centres and Clouds'.

GreenIT Dossier

The GreenIT dossier is a collection of data on current trends and initiatives relating to the topic of GreenIT. It covers the entire spectrum of technology and applications from telecommunications to end-user devices via data centres.

The primary objective of the GreenIT dossier is the structured coverage of all the trends and activities – coverage that is as broad as possible. It therefore focuses more on a comprehensive compilation of information and less on a detailed description of individual trends. The document gives an overview of the GreenIT landscape at the time the dossier was completed in January 2013. It also provides an introduction to individual subject areas and offers readers the chance to get more information on the topics by providing them with references and links.

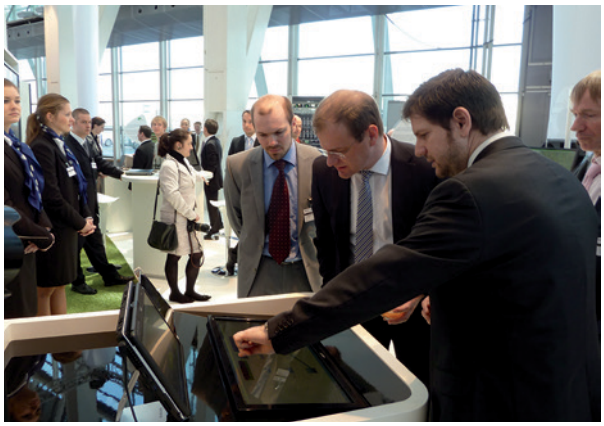
The detection systems for measuring the energy and resource efficiency of ICT that already exist or are under development form one focus. The initiatives in this field are quite diverse but, in part, also very transparent. The aim of the GreenIT dossier is to give the reader a structured overview and, beyond that to locate this topic in the context of regulatory and technical standardisation. Furthermore, the legal framework, market and technology developments as well as international research and funding activities are highlighted.

The GreenIT dossier is available for download on the IT2Green site:
www.it2green.de/de/1365.php (in German only)

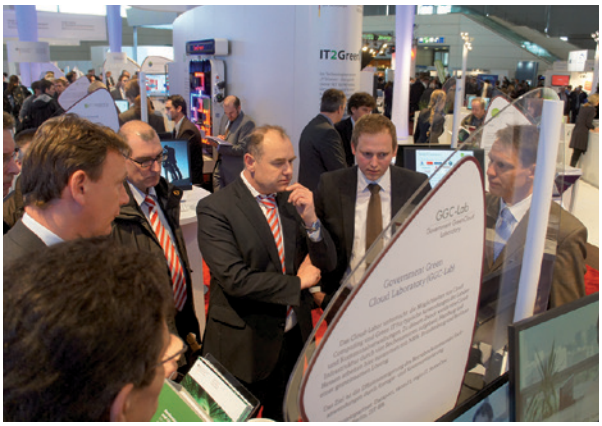
IT2Green in Pictures

Inaugural event in 2011: Ministerialrat Dr. Andreas Goerdeler (centre) gave the go-ahead for the ten funded projects of IT2Green.

2012 Annual Conference: Hans-Joachim Otto, Parliamentary State Secretary, opened the two-day meeting at which the various projects presented their interim results.



CeBIT 2012: Stefan Kapferer, State Secretary, finding out about IT2Green's current progress at the Federal Ministry's exhibition.



CeBIT 2013: the ICT-community were very interested in the IT2Green solutions developed for saving energy.

Twelve films inform professionals and lay people about IT2Green at trade shows, events and on the internet.

2013 Annual Meeting: in keynote speeches and on the podium, external experts involved in the IT2Green projects shed light on the issue of energy-efficient ICT.

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