Internet

Climate Killer or Climate Saver?

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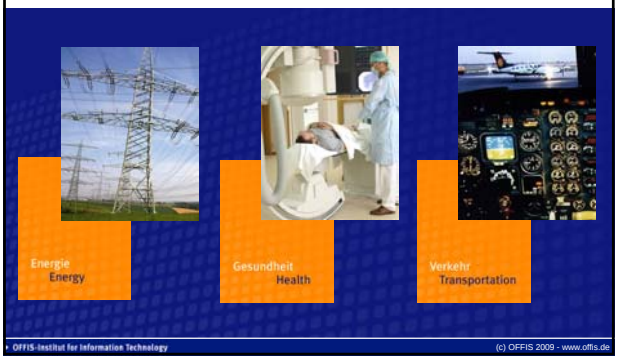
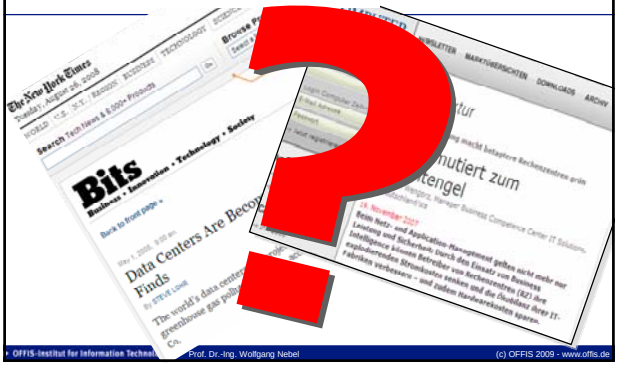
OFFIS - Institute for Information Technology

Success Through Innovation and Transfer



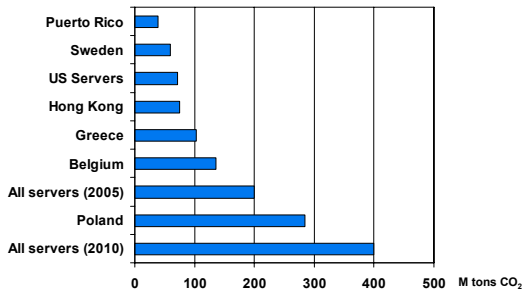
Internet – Climate Killer or Climate Saver?



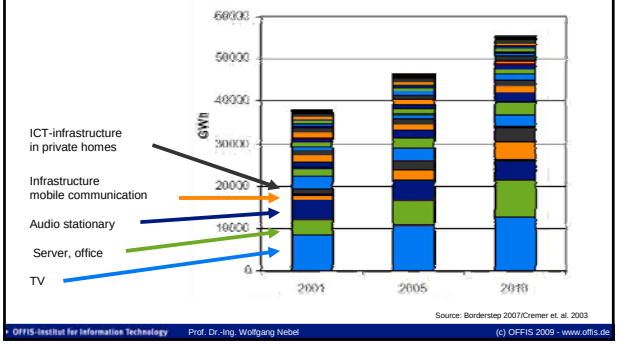
Energy Consumption, Climate Protection, Costs

- **Power Consumption of ICT (End Devices and Infrastructure) in Germany** (Source: Cremer et al. 2003)
  - 2001: 38 TWh (8% of power consumption)
  - Compared to 10.7 TWh generated from wind energy (Source: Bundesverband Windenergie)
  - 2010: 55 TWh (11% of power consumption)
- **CO_2-Emissions 2004 in Germany**
  - ICT: 28 Mio. t CO_2 (due to power consumption)
  - Compared to complete aircraft traffic of 22 Mio. t CO_2
- **Increase especially in ICT-Infrastructure** (UMTS-Network, Servers, Routers etc.)
  - The highest electricity consumers are data centers
  - Servers: 123 TWh in 2005 relate to 12 nuclear power plants worldwide
  - 80% of all servers are located in data centers

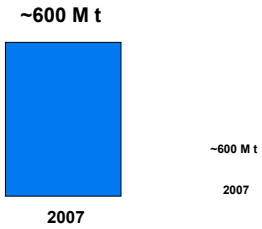
The IT Emission Race



Energy Consumption of ICT in Germany

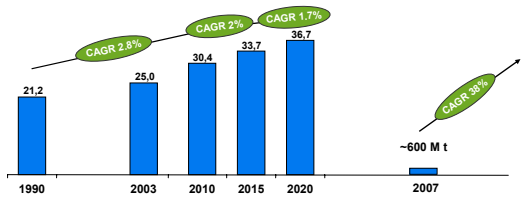


ICT CO_2 Emissions



Source: Eul: Von Green IT zu Green Business. A.T. Kearney,Report, Febr. 2008

Why Bother Its Just 2% Out of 98 %



Forecast worldwide CO_2 emission (Billion t)

ICT CO_2 emission

Source: Eul: Von Green IT zu Green Business. A.T. Kearney,Report, Febr. 2008 (CAGR Germany)

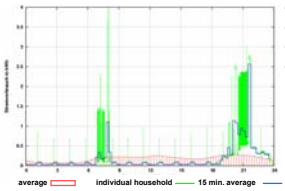
Telepresence or Business Trip?

- Energy consumed per GB transferred: ~ 1.1 kWh
- Data volume per h video presence @ 1 Mb/s ~ 3.6 GB
- Energy hour tele presence ~ 3.9 kWh

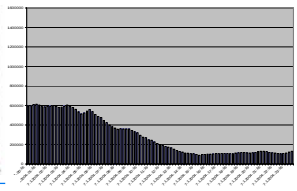
- CO_2 per hour telepresence (intercontinental) ~ 2.45 kg
- CO_2 footprint of roundtrip Frankfurt – New York 4,168 kg*

Source: TU-Berlin http://user.cs.tu-berlin.de/~roland/flug/flug.cgi - Lufthansa published comparable figures Cisco estimated equivalence of 1 intercontinental flight and 98 hour of telepresence. This seems far too low.

Usage Profile of Renewable Energy

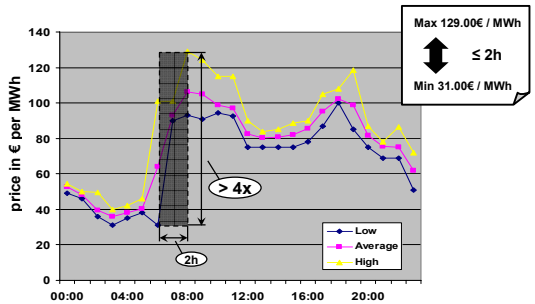


energy demand of single household



available wind energy

Electricity Spot Market – Jan 14th, 2009



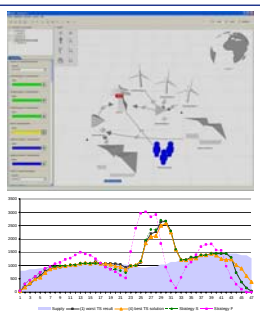
Quelle: European Energy Source 2009

Example Decentralized Management of Energy Grid

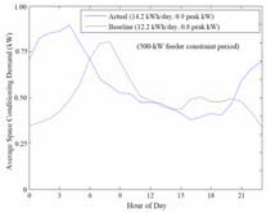
- **Objectives:**
  - Increase share of renewable energy
  - Ensure stable energy grid in presence of dispersed providers of (renewable) energy
  - Cost efficient utilization of energy supply
- **Means:**
  - Utilize energy storages, e.g.
    - Thermo energy: hot water (house, pools), chill (freezer, refrigerator)
    - Electrical energy: eMobility
  - Improve match demand and supply of energy by load shifting
- **ICT Challenges:**
  - Demand and supply prediction
  - Communicate pricing information to users and devices
  - Intelligent metering
  - Standardize information flow in energy grid
  - Control means for grid stability

Shift of Energy Demand by Real-Time Pricing

Simulator by OFFIS

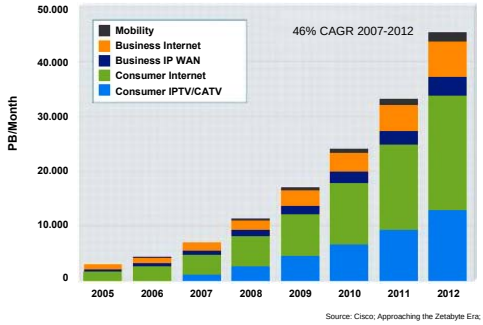


Result from Olympic Peninsula Project



Source: D.J. Hammerstrom; Pacific Northwest GridWise Testbed Demonstartion - Projects. Pacific Northwest National Laboratory, 2007

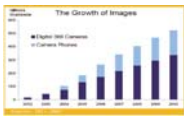
Forecast Development of Data Volume



Source: Cisco; Approaching the Zetabyte Era; June 2008

What Demand Causes this Growth?

- YouTube: 50 PB per month in mid 2007 ~ 7 % US Internet traffic
- MSN Video Messenger in mid-2007 4 PB per month
- Second Life more than 11 million users, 50.000 concurrent
- 1 HD movie is about 10 GB
- IMAX at Home: 250 GB per movie
- UHDV (2016 in Japan): 360 GB per movie
- 2007: peer to peer file sharing > 500 Mio DVD
- 2007 Video is ¼ of consumer traffic
- 2012 Video will be 50% of consumer traffic



Source: Swanson, B.; Gilder, G.: Estimating the Exaflood. www.Discover.org Discovery Insitute, Jan. 2008
Cisco Visual Networking Index – Forecast and Methodology, 2007 – 2012. June 16 2008

Movie Download or Drive?

- Energy consumed per GB transferred: ~ 1 kWh
- Energy per DVD (movie of 4 GB) ~ 3.8 kWh
- Energy per BlueRay Disk (HDTV movie 25 GB) ~ 24.5 kWh

- CO_2 per DVD transfer ~2.5 kg
- That allows to drive with EU 2012 car (120 g/km) 20 km

Putting it together

- Global increase of CO_2 emission: 2 % per year
- Increase of Data Centre CO_2 emission (BAU) 15.8 % per year
- Increase in Internet traffic 46 % per year

CO_2 [Mio t]	2005	2010	2015	2020
Global	26437	30400	33700	36700
Data Centres	49	102	212	441
Data Traffic*	9	63	416	2759

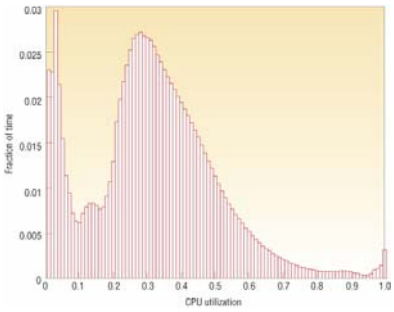
* Under the unrealistic assumption of no efficiency improvements

- Data Centres and data traffic could account for more than 8% of CO_2 emissions under a business as usual scenario compared to 0.2% in 2005.
- Data traffic will surpas data centres in CO_2 emission.
- This does not include local office equipment and consumer electronics.

So far the Symptoms – Now the Diagnosis

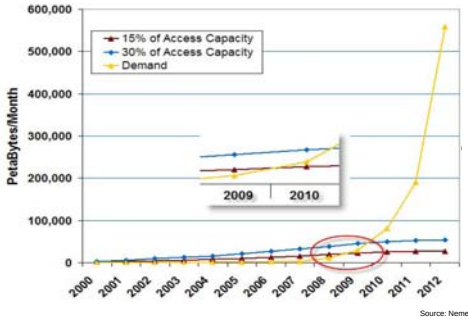
Example Utilization of Google Servers

Average utilization of today's servers (measured approx. 5,000 servers over a 6 month period)



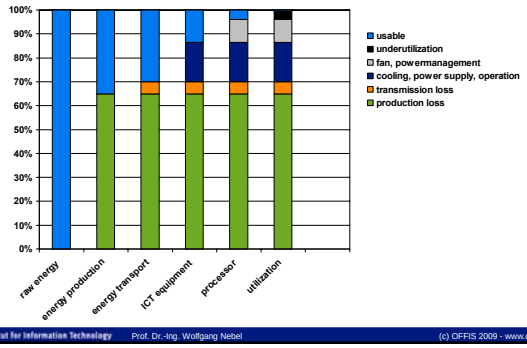
Source: Barroso, L.; Hölzle, U.: The Case for Energy-Proportional Computing. IEEE Computer, Dec. 2007

Utilization of Internet Ressources



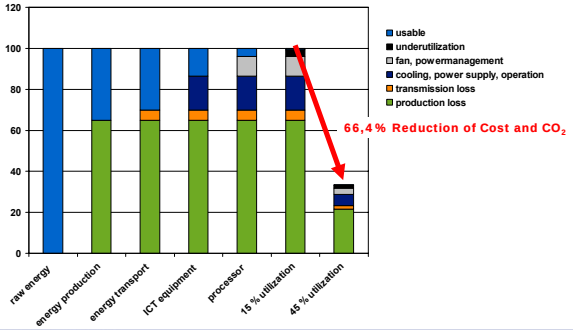
Source: Nemertes Research 2007

The Main Technical Cause is Inefficiency



So far the Analysis - Now Some Solutions

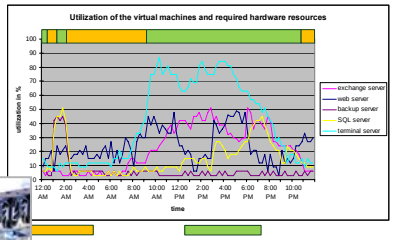
Increase Utilization by Virtualization, Load- and Powermanagement



CeBIT OFFIS on CeBIT 2009
Hall 9 | Stand B22
Hall 8 | Stand B02

Evaluation Results

- Demonstrator
  - three Blade servers
  - five software server
  - XenServer Enterprise 4.1.0



- Gain
  - 11,5 % energy savings
  - potentially higher savings in larger applications

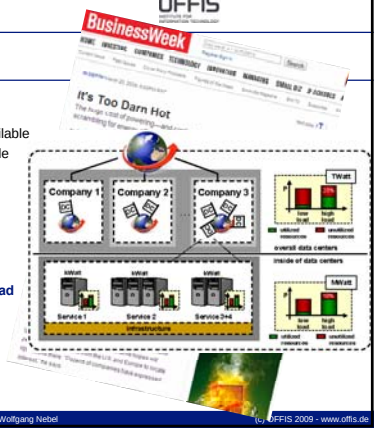
UPN on CeBIT 2009
Hall 9 | Stand B22

Example Powermanagement of PC and Notebook

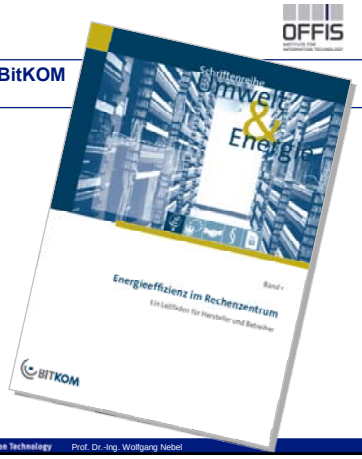
- **Problems of the Present Timeout**
  Based Power Managements
  - Idea: After some idle-time, the user is considered to be absent –> turn off device (e.g. display)
  - Error-prone (e.g. while user reads)
  - The chosen balance between saving energy and annoyance often is to the disadvantage of energy saving
- **Solution: Intelligent Power Management**
  - Adapt the power management to the pattern of use
  - Include learning and adaptation

Relocating Data Centres

- **An option iff**
  - power efficient data link available
  - renewable energy is available
  - cooling could be free
  - A cold and windy place!
- **Opens opportunity to global load management!**
  - Between data centers
  - Between providers



Guideline BitKOM

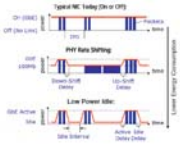


Guideline EU

presented Nov 19th 2008

Guidelines by ITU

- Next Generation Networks (NGN): The logical goal is the coming together of existing networks (fixed, mobile, Internet, broadcast etc.) into a unitary network architecture.
- Technical advancements:
  - Multiple power modes
  - Optical broadband access
  - Using only sufficient power to meet transport rate requirements
  - Reduction in the number of switching centres
- Behavioural advancements:
  - Teleconferencing, teleworking, e-learning, e-shopping
  - Virtual worlds: virtual newspapers, magazines, books etc.

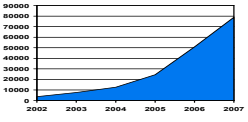


Source: Bennett 2008

Coutresy: Cisco

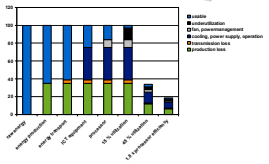
Conclusion (1)

- **ICT offers outstanding opportunities to reduce CO_2 emissions.**
  - E.g. Japan could almost meet their Kyoto commitments through ICT means.
- **ICT itself consumes substantial energy and is responsible for**
  - 2% of CO_2 emissions,
  - the same as the entire air traffic, more than wind energy can provide, …
- **Very good prerequisites for applying new technologies now, since**
  - environmentally and economically necessary,
  - technically required and feasible.



Conclusion (3C2)

- **Actions**
  - Raise cost awareness in decision makers (data centers and Telcos)
  - "Best practice" information on low hanging fruits
    - consolidation/virtualization,
    - increase utilization/load- and power management,
    - cooling.
  - Roadmap to coordinate suppliers towards market launch
  - Flagship initiatives (improving the state-of-the-art)
  - Energy-labels for the consumers market
  - Research initiatives for new holistic and sustainable solutions



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