

Back to the Future – Waves of rising energy use in data centers

Dr. Bernard Aebischer, CEPE/ETH Zurich

EETD Seminars, LBNL, Berkeley, 20. 4. 2009

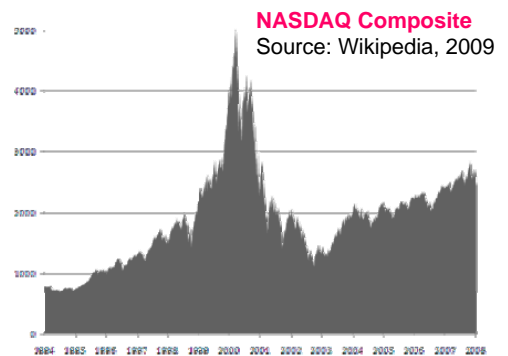
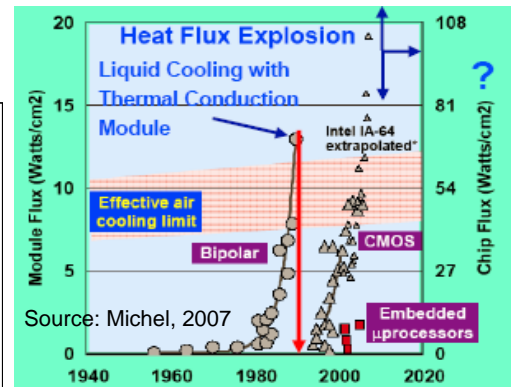
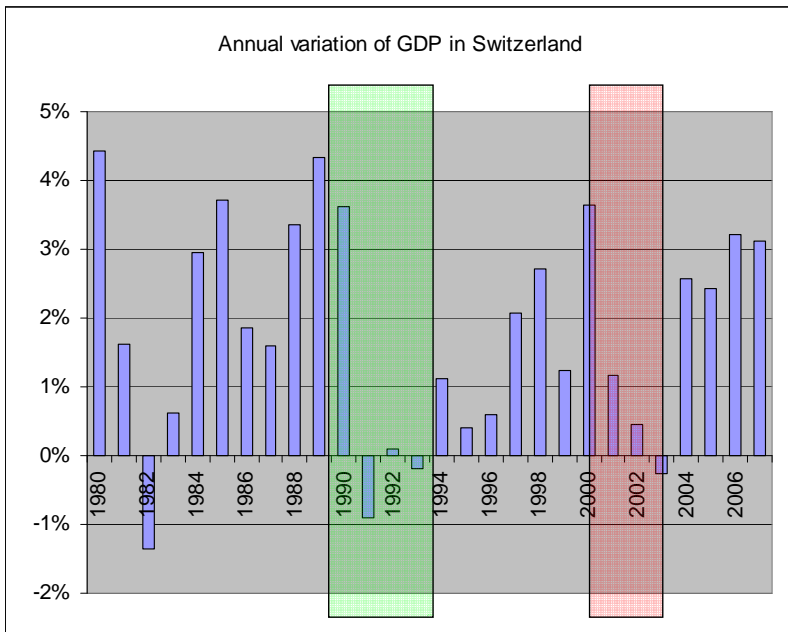


History and Future^S

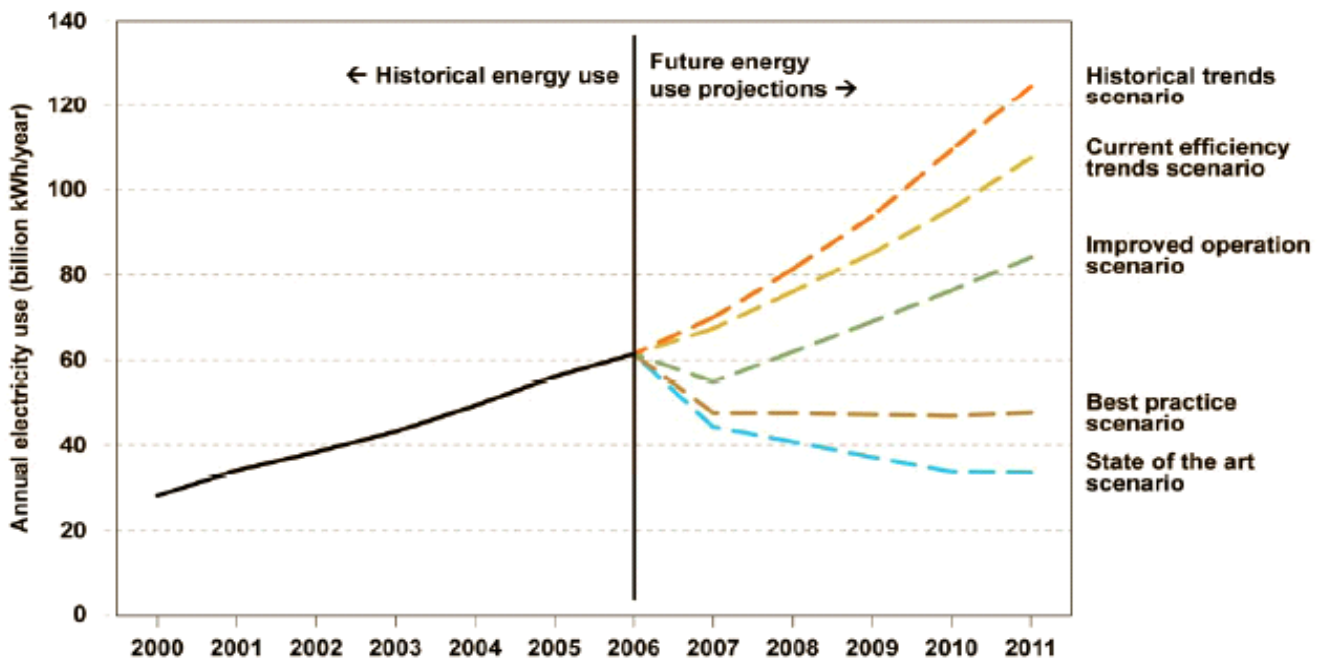
- 1985-1995: fast increase of energy in main frames and taming of main frame computers by new technologies
- 1995-2005: fast diffusion of internet and dotcom bubble interrupts fast growth of server farms
- 2005- : fast increase of energy costs and specific heat load → “green IT” → ?

Measurement concept

User groups



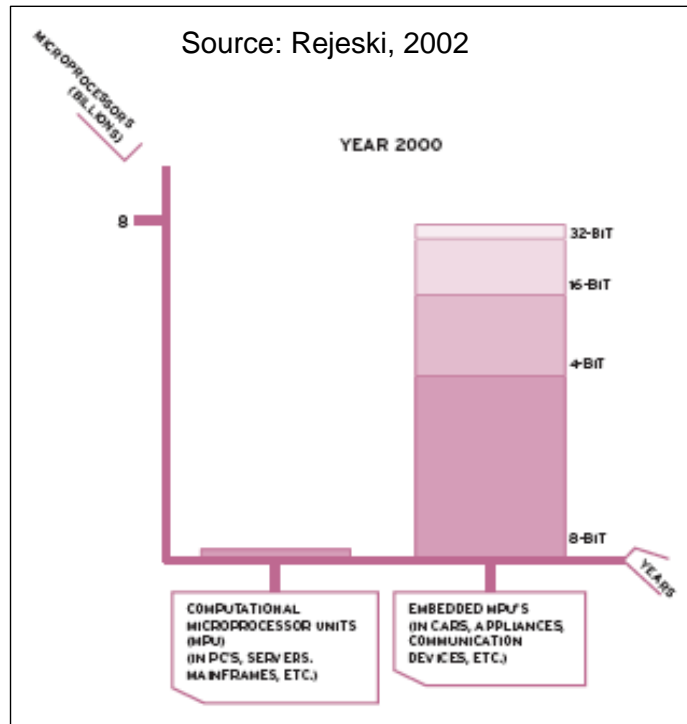
Summary: History 2 = FutureS



Source: EPA, 2007, Figure ES-1

Extension 1 on FutureS: What is included in ICT?

- There could be as many as 10,000 telemetric devices per person in the industrialized countries by 2010.
- Within a decade more things will be using the Internet than people (Michel Mayer, head of IBM Pervasive Computing)



Extension 2 on FutureS: Energy impact of ICT?

- Investments or capital stock in ICT = major indicator in “macro analysis”, but not specified **what ICT is used for.**
- ICT usually used to increase (labor) productivity only and not for a more rational use of natural resources
→ Spreng’s triangle: substitution of time and energy (Spreng, 1993)

Source: Aebischer, 2008)

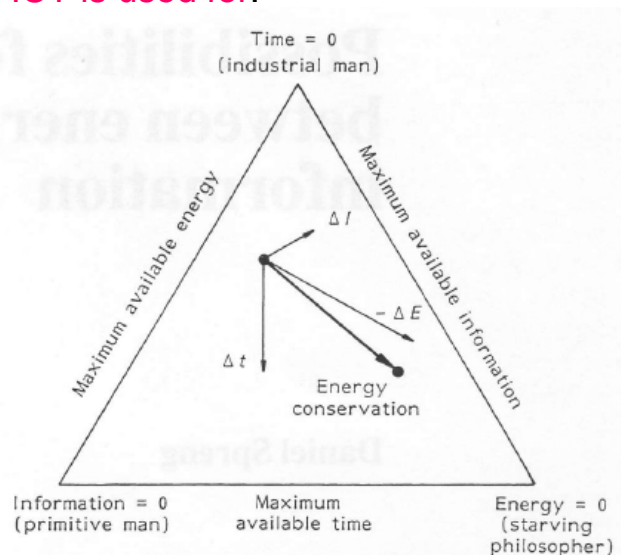


Figure 3. The time–energy–information triangle.^a

History: 1985-1995 (1)

Fast increase of electricity demand by large computer centres in the financial sector (1985-1990)

Energy analysis at ETH Zürich

- **Power flow** in large computer centres (Spreng/Aebischer, 1990)

Formation program RAVEL (1992, p. 67)

- Free cooling, modular design, inlet temperature, metering

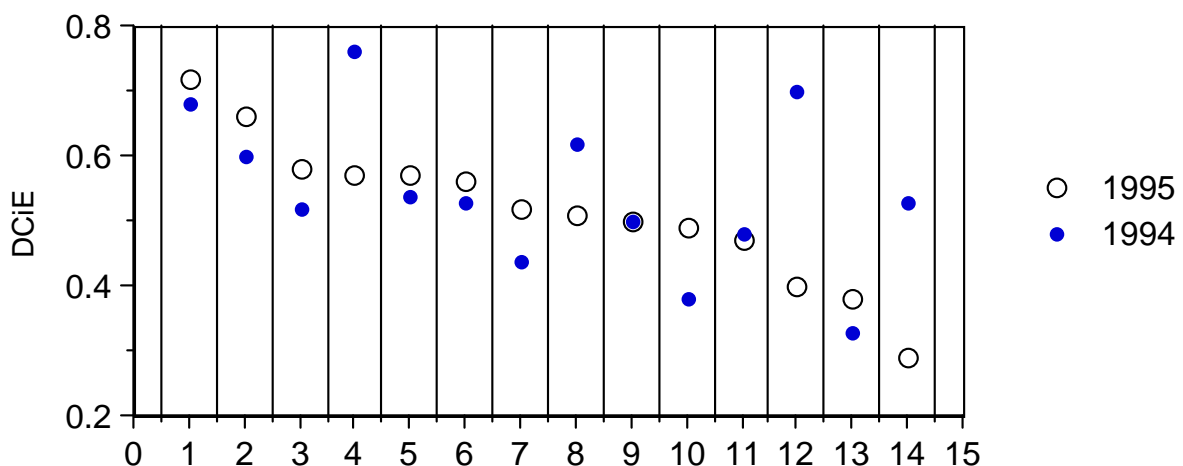
User group (ERFA RZ)

- Benchmarking of energy efficiency of infrastructure:

$$K = (\text{el. power IT rooms}) / (\text{total el. power}) = C1 = DCiE = 1/PUE$$

$K = C1 = DCiE = 1/PUE$ is a good indicator

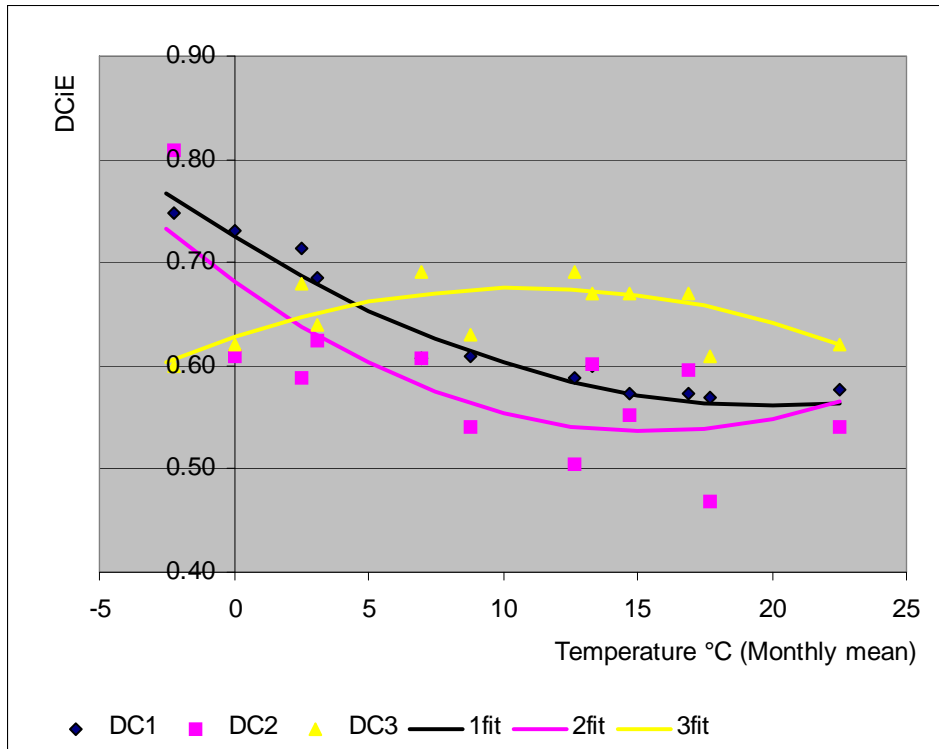
... but a good enough **measurement concept** – **with energy and not power to be measured** - is essential



DCiE in 1994 and 1995 in 14 computer centres in Switzerland

Source: Bänninger (1996) in Aebischer (1996)

DCiE (energy) in function of outdoor temperature



Source:

Swiss DCEE
Group, 2007;

Bänninger, 2007

History: 1985-1995 (2)

Fast increase of electricity demand by large computer centres in the financial sector (1985-1990)

Energy analysis at ETH Zürich

- *Power flow in large computer centres (Spreng/Aebischer, 1990)*

Formation program RAVEL (1992, p. 67)

- *Free cooling, modular design, inlet temperature, metering*

User group (ERFA RZ)

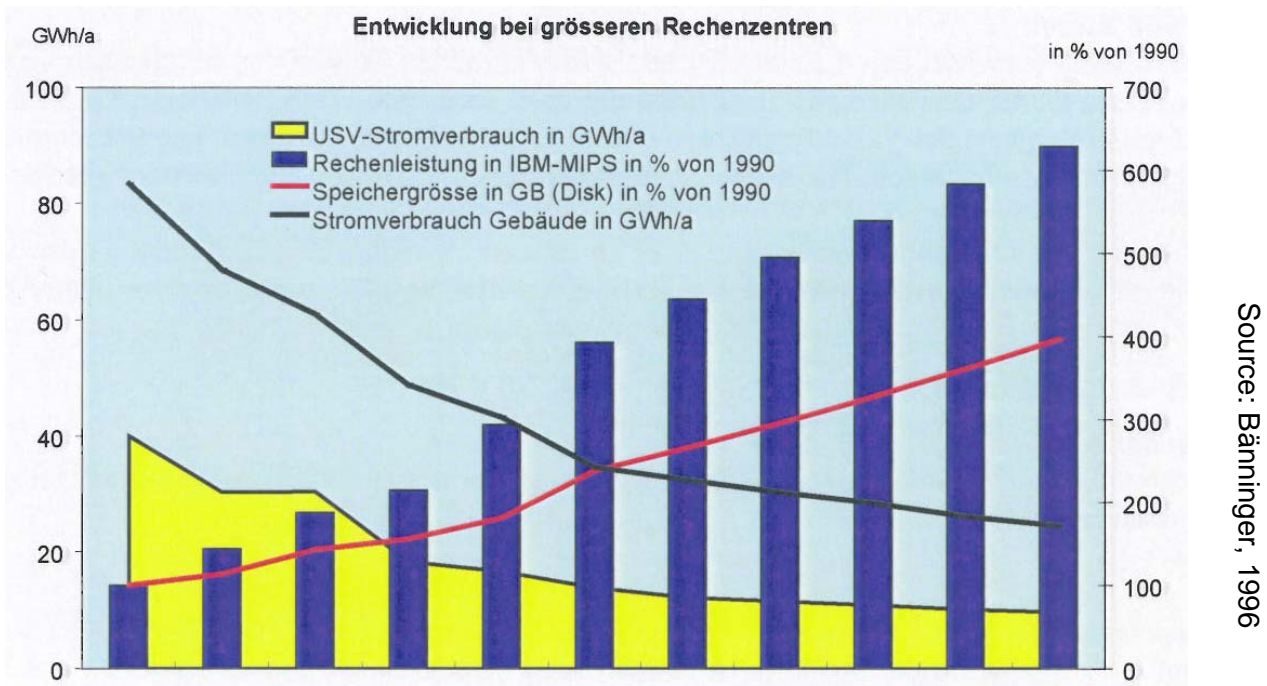
- *Benchmarking of energy efficiency of infrastructure:*

$$K = (\text{el. power IT rooms}) / (\text{total el. power}) = C1 = DCiE = 1/PUE$$

Technology breakthrough (CMOS, architecture, software)

- *Decrease of electricity demand in large computer centres (1990-1995)*
- *→ Other priorities!*

Computing capacity and electricity consumption 1990-2000



EETD Seminars, LBNL, Berkeley, 20. 4. 2009

Dr. Bernard Aebischer, CEPE/ETHZ

11

History: 1995-2005 (1)

Diffusion of use and applications of Internet → server farms, collocation sites

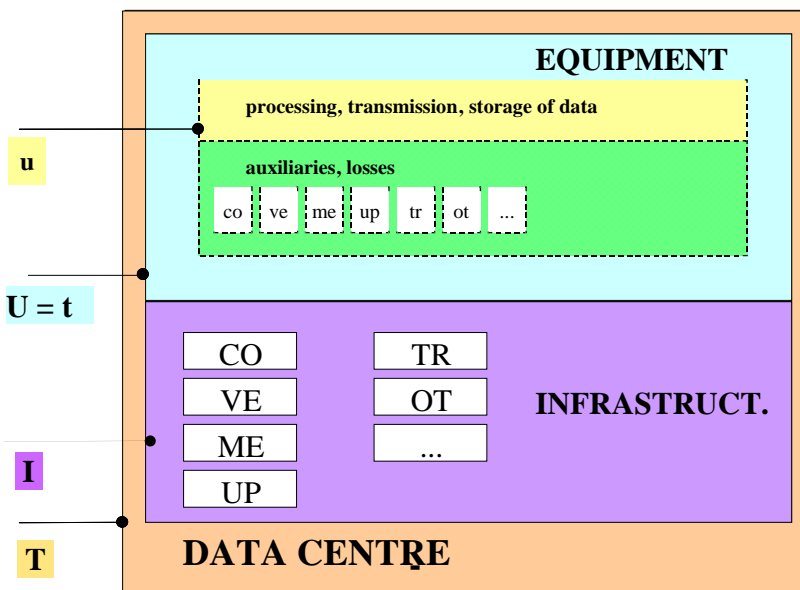
Projects with locally potential huge increases of power and energy demand

- Geneva: +(10-20)% of total electricity demand.

Study: indicators and target values for energy efficiency in data centres

→ voluntary agreements or legal requirements (Aebischer et al. 2003)

Efficiency indicators for Geneva: $CEE = C1 * c2$



Indicator for over-all energy efficiency:

$$CEE = u/T$$

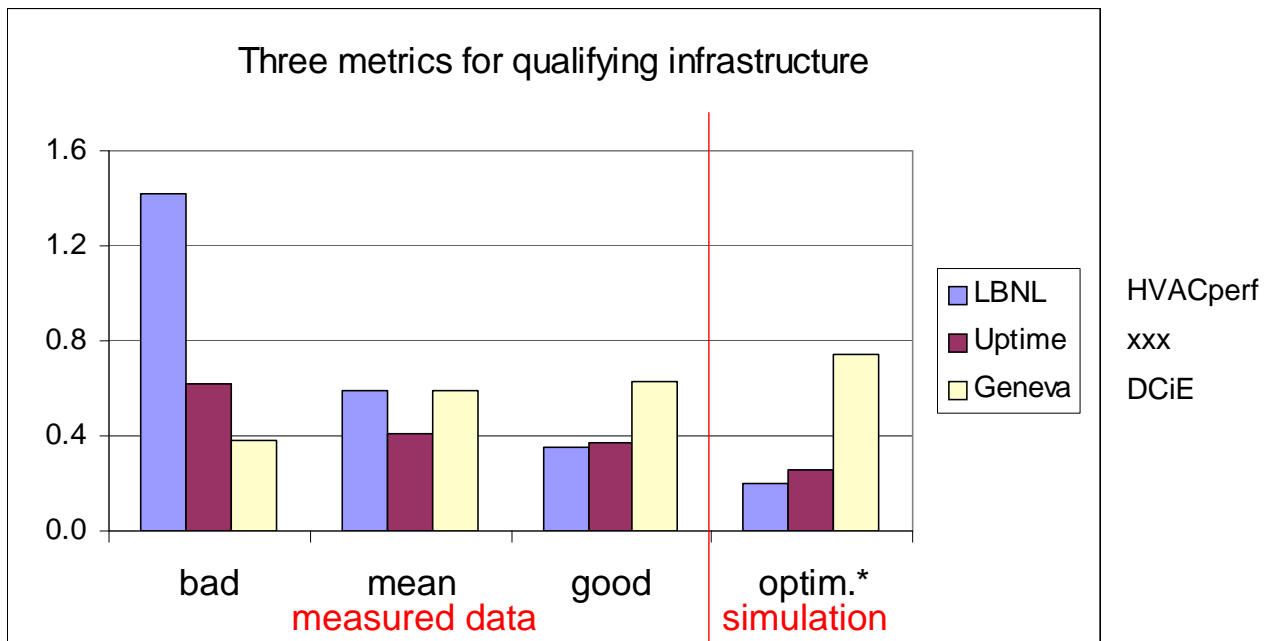
$$= U/T * u/t$$

$$= C1 * c2$$

- C1 = indicator for energy efficiency of central infrastr. = **DCiE**
- c2 = indicator for energy efficiency of ICT-equipment : **nok**

Source: Aebischer et al., 2003

Different metrics for energy efficiency of DC central infrastr.



Source: Aebischer/Eubank/Tschudi, 2004 (presentation at conference)

History: 1995-2005 (2)

Diffusion of use and applications of Internet → server farms, collocation sites

Projects with locally potential huge increases of power and energy demand

- *Geneva: +(10-20)% of total electricity demand.
Study: indicators and target values for energy efficiency in data centres
→ voluntary agreements or legal requirements (Aebischer et al. 2003)*

*Case study of efficiency improvements in existing data centre:
(Altenburger, 2004)*

Dotcom bubble bursts after 2000

- *Geneva: very little built → other priorities!*

History: 2005 -

Data flow increases faster than technical progress → new data centre capacities

Oil price increase → electricity price

W/m² increase → problems heat evacuation (no technological breakthrough in view)

Climate change discussion

→ worldwide “green IT initiatives”

More than a hype ?

→ 3rd wave !?

Green IT in Switzerland (1)

Geneva goes towards “standard” for data centres

- Benchmarking to define minimal requirement for DCiE
- Standardised measurement concept needed

Measurement concept for DCiE

- Energy consumption
- Well defined measurement points
- Read out at least once a month

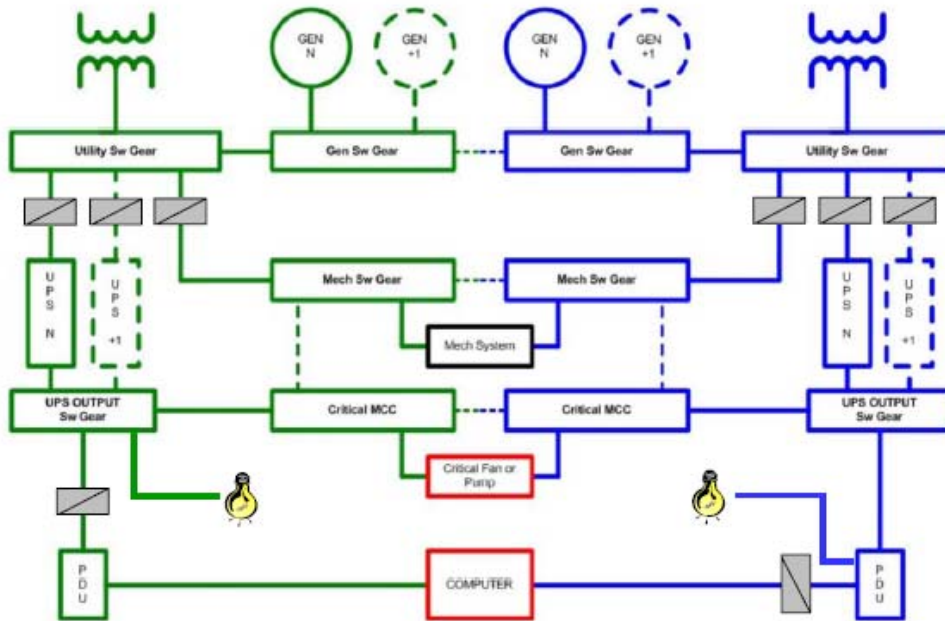
Following two characteristics of data centres:

1. Reliability: Tier levels I – IV defined by Uptime Institute
2. Cooling by equipment
 - dedicated to data centre
 - used for the whole (office) building

→ Maucoronel et al., 2008

http://www.biblioite.ethz.ch/downloads/Measurement-concept_DCiE_10-2-09.pdf

Measurement concept for Tier IV with dedicated cooling



Source:
Uptime Institute,
2006
and
Maucoronel et al.,
2008

Figure 4 : principe de mesure avec production de froid dédiée et 2 variantes éclairage

History: 2005 -

Green IT in Switzerland (2)

Geneva goes towards "standard" for data centres

- Benchmarking to define minimal requirement for DCiE
- Standardised measurement concept needed

ERFA RZ → policy process: SwissEnergy Programme

User groups (old)

ERFA RZ participating in Swiss policy projects:

- Grossverbrauchermodell (Canton of Zürich)
- Energie-Modell Schweiz (Switzerland)

Voluntary agreements between cantonal/federal governments and large companies to reduce energy consumption and CO₂-emissions by well defined measures – e.g. in data centres.

- For large companies: targets in % per year reduction of specific variable;
- For data centres: planned/realised savings/reductions in absolute terms.

History: 2005 -

Green IT in Switzerland (3)

Geneva goes towards “standard” for data centres

- *Benchmarking to define minimal requirement for DCiE*
- *Standardised measurement concept needed*

ERFA RZ → policy process: SwissEnergy Programme

Swiss DCEE (data centre energy efficiency) Group

- Shares information
- elaborates tools (e.g. „Stromeffiziente Rechenzentren durch Sensibilisierung über eine transparente Kostenrechnung“ with support of SFOE)
- makes assessments (e.g. new data centre of the city of Zurich)

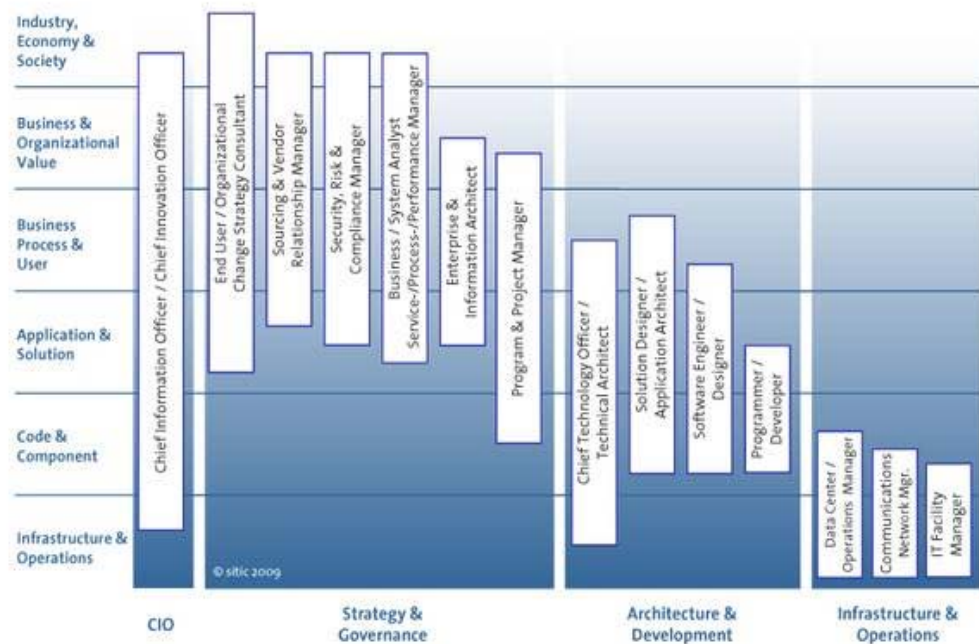
SWKI (Swiss Society of Heating and Air-Conditioning Engineers): adaptation of ASHRAE recommendations for data centres (temperature and humidity)

Demonstration: 100% free cooling in telecommunications centres (Singy, 2005)

Sitic (Swiss IT Intelligence Community) www.sitic.ch

- The Swiss IT Intelligence Community sitic is a vendor-independent peer-to-peer network. It fosters the sharing of ideas and best practices among IT departments of Swiss-based companies.
- Sitic is composed by a number of communities covering different aspects of IT in the companies.
- The **Infrastructure & Operations Community** is a new sitic community with focus on operations aspects of IT. It addresses Data Center Managers, Environmental and Green IT officers as logistics managers.
- The Swiss DCEE Group participated at the kick-off meeting of the Infrastructure & Operations Community and is willing to share their experience and tools.

“Infrastructure & Operations” and the other communities;
<http://www.sitic.ch/community.html>

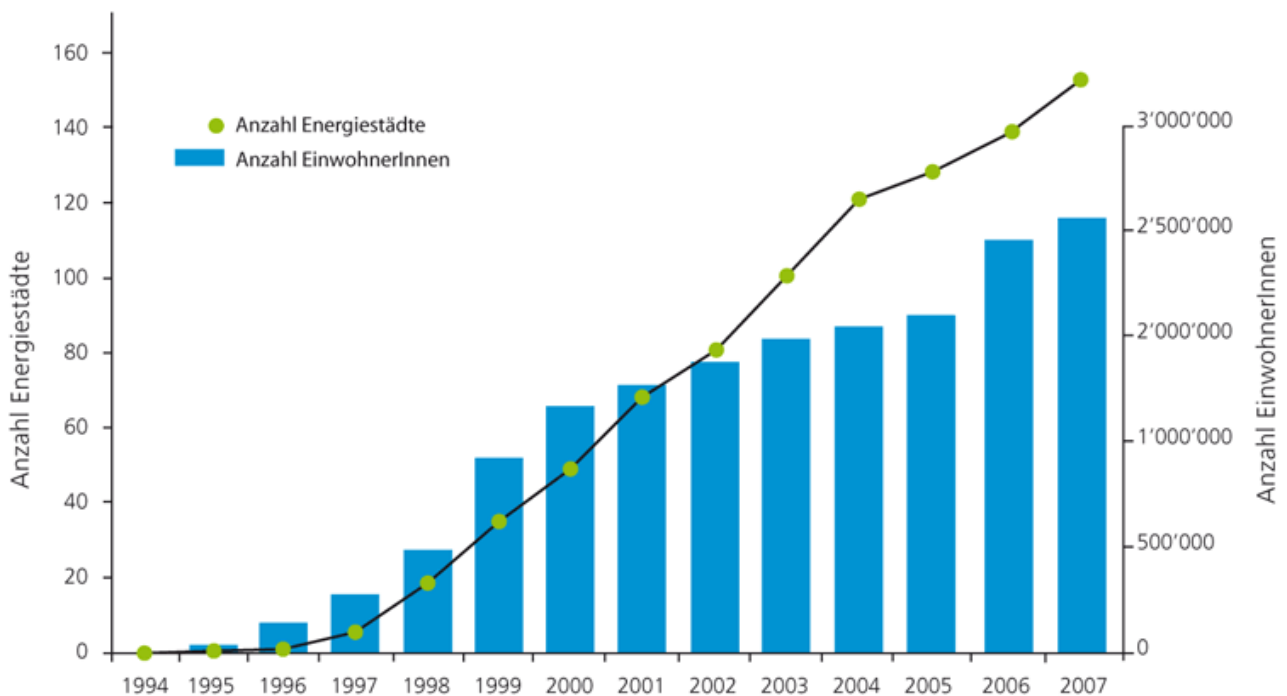


User groups (planned 1)

Integration of SME in “green data centres” movement

- 1st interested target group: data centres of cities/communities (Energienstadt / cité de l'énergie)
- Use experience and output of sitic user group
- Use experience of “Lernende Netzwerke” in Germany (Jochem/Gruber, 2007; Jochem, 2007; Weissenbach, 2008)

Energy cities in Switzerland



User groups (planned 2)

Integration of SME in “green data centres” movement

- *1st interested target group: data centres of cities/communities (Energistadt / cité de l'énergie)*
- *Use experience and output of sitic user group*
- *Use experience of “Lernende Netzwerke” in Germany (Jochem/Gruber, 2007; Jochem, 2007; Weissenbach, 2008)*

Data centres in Geneva

- Benchmarking process in order to define minimal requirements and/or target values for DCiE in new and existing data centres

Conclusions

History

- 2005-2015 : “green IT” more than a hype ?
→ 3rd wave !? Or even more than a (temporary) wave ?

Measurement concept

- Metering **ENERGY** (not power) is essential

Local user groups

- **THE** way for diffusion of energy efficient solutions

References/literature/websites (1)

- Aebischer B., 2008. ICT and energy: methodological issues and Spreng's triangle. In "The European e-Business Report 2008", S. 265. http://www.ebusiness-watch.org/key_reports/documents/EBR08.pdf
- Aebischer B., 2007. Quoi de neuf dans le domaine de l'efficacité énergétique des data centres? Eléments d'actualisation du rapport relatif à l'efficacité énergétique des data centres commandé par le ScanE en 2001. http://www.cepe.ethz.ch/publications/Aebischer_Data-Centre_ScanE_26-10-07.pdf
- Aebischer B., Eubank H. and Tschudi W., 2004. Energy Efficiency Indicators for Data Centers, Proceedings of the International Conference on "Improving Energy Efficiency in Commercial Buildings, IEECB'04", Frankfurt, 21 – 22 April. http://www.cepe.ethz.ch/download/staff/bernard/Aebischer_IEECB04_final.pdf
- Aebischer B., R. Frischknecht, Ch. Genoud, A. Huser, F. Varone, 2003. Energy- and Eco-Efficiency of Data Centres. Report commissioned by the Canton of Geneva, Geneva, Switzerland http://www.cepe.ch/research/projects/datacentres/data_centres_final_report_05012003.pdf
- Aebischer B., 1996 Rationellere Energieverwendung beim Einsatz von Computern. Proceedings der Fachtagung SIWORK '96 "Workstations und ihre Anwendungen". Zürich 14.-15. Mai 1996. vdf-Verlag (ISBN: 3 7281 2342 0)
- Altenburger A., 2004. Energieeffizientes Kühlen von IT-Räumen. Bundesamt für Energie, Ittigen. <http://www.bfe.admin.ch/php/modules/enet/streamfile.php?file=000000008975.pdf&name=000000240169.pdf>
- Baenninger, M., 2007. Energy consumption of large data centres in the financial sector in Zurich. Internal working paper.
- Bänninger M., 1996. Mitteilung, SBG, Zürich

References/literature/websites (2)

- EnAW Energie-Modell (Switzerland) <http://www.enaw.ch/webexplorer.cfm?id=5&tlid=1>
- Energiestadt / cité de l'énergie www.energiestadt.ch
- Grossverbrauchermodell (Canton of Zürich) <http://www.energie.zh.ch/internet/bd/awel/energie/de/Fachinfo/grossverbraucher-doku.html>
- EPA, 2007. Report to Congress on Server and Data Center Energy Efficiency. Public Law 109-431. U.S. Environmental Protection Agency. ENERGY STAR Program. Washington, August http://www.energystar.gov/ia/partners/prod_development/downloads/EPA_Datacenter_Report_Congress_Final1.pdf
- Jochem et al., 2007. Lernende Netzwerke – einer der Schlüssel zur schnellen Energiekostonenkung. ENERGIEWIRTSCHAFTLICHE TAGESFRAGEN 57. Jg. (2007) Heft 3
- Jochem E., E. Gruber, 2007. Local learning-networks on energy efficiency in industry – Successful initiative in Germany. Applied Energy 84 (2007) 806–816 http://www.sciencedirect.com/science?_ob=MIimg&_imagekey=B6V1T-4ND71HT-17&_cdi=5683&_user=3216521&_orig=search&_coverDate=08%2F31%2F2007&_sk=999159992&_view=c&_wchp=dGLbVlb-zSkWb&_md5=4abca5bd00bbcaed9d5e243ee573d957&_ie=/sdarticle.pdf
- Maucoronel C., P.-J. Duc, J. Willers, 2008. Standardized energy measurement concept for data centers and their infrastructures. Elaborated on behalf of the Canton of Geneva by Amstein+Walthert and Willers Engineering. http://www.biblioite.ethz.ch/downloads/Measurement-concept_DCiE_10-2-09.pdf

References/literature/websites (3)

Michel B., 2007. Kühlung / Wärmerückgewinnung / Energieweiternutzung mittels Flüssigkeitskühlung. Rechenzentrum
Thementag, 25. April, 2007, ETH.

RAVEL, 1992. Strom rationell nutzen. Umfassendes Grundlagewissen und praktischen Leitfadens zur rationellen
Verwendung von Elektrizität. Verlag der Fachvereine, Zürich <http://www.energie.ch/bfk/ravel/HANDBUCH.PDF>

Rejeski D., 2002. Anticipations. In „Sustainability at the speed of light“, Pamlin D. (Edit.). WWF, Sweden (ISBN 91-89272-
08-0) http://assets.panda.org/downloads/wwf_ic_1.pdf

Singy D., D. Többen, 2005. Energy and Cost Savings with fresh Air Cooling Systems. Comtec 06/05.

<http://www.swisscom-comtec.ch/pdf/comtec062005302.pdf> and

http://www.iec.org/events/2008/bbwf/conference/infovision/cat9_swisscom.asp

Sitic www.sitic.ch

Spreng D. und Aebischer B., 1990. Computer als Stromverbraucher. Schweizer Ingenieur und Architekt. Oktober

Spreng D., 1993. Possibility for Substitution between Energy, Time and Information Energy Policy, Vol. 21, Nr. 1, January

Swiss DCEE (data centre energy efficiency) Group, 2007. Internal working paper.

SWKI www.swki.ch

Uptime Institute, 2006. Tier Classifications Define Site Infrastructure Performance. White Paper. A new version was
published in 2008: [http://uptimeinstitute.org/wp_pdf/\(TUI3026E\)TierClassificationsDefineSiteInfrastructure.pdf](http://uptimeinstitute.org/wp_pdf/(TUI3026E)TierClassificationsDefineSiteInfrastructure.pdf) or
http://uptimeinstitute.org/cgi-bin/admin2/admin.pl?admin=wp_form&id_field=9

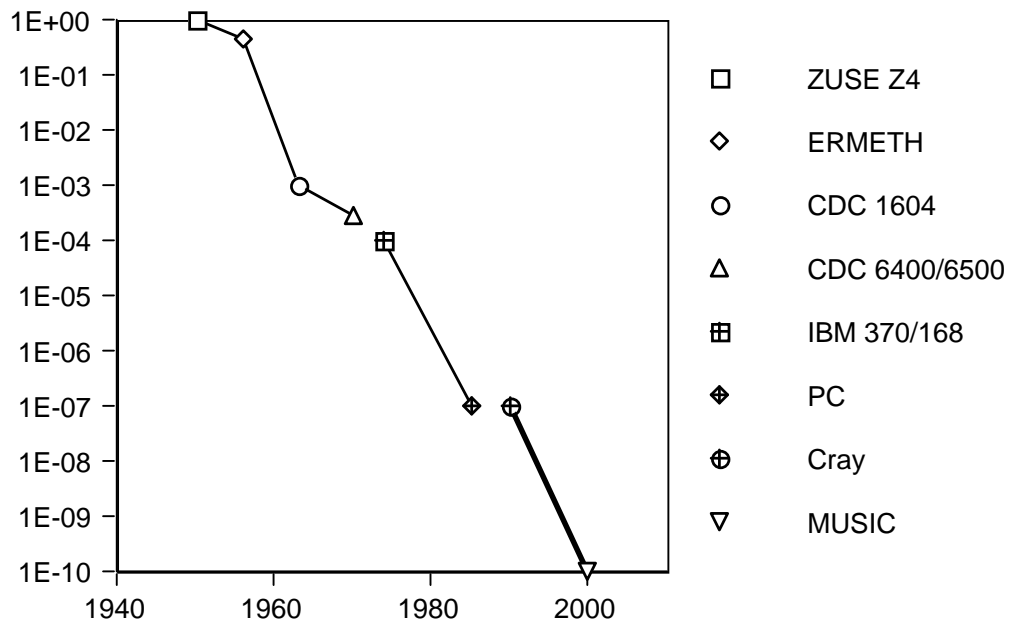
References/literature/websites (4)

Weissenbach K., 2008. Modell Hohenlohe e.V.: Vom EnergieEffizienz-Tisch zum Qualitäts- und Projektmanagement
System. Präsentation an Berliner Energietage 2008.

http://p4581.typo3server.info/fileadmin/Berliner_Energietage/2008/E7_Weissenbach_BET2008.pdf

Wikipedia, 2009. http://en.wikipedia.org/wiki/Dot-com_bubble

Relative Entwicklung des spezifischen Strombedarfs von Computergenerationen



Quelle: Aebischer/Mutzner/Spreng, 1994, und Aebischer/Bradke/Kaeslin, 2000

$$HVACperformanceindex(\%) = \frac{kW_{HVAC}}{kW_{UPSOutput}}$$

HVAC Performance Index

