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Swiss Federal Institute of Technology Zurich

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Centre for Energy Policy and Economics
Department of Management, Technology and Economics

Energy Star Label für Rechenzentren – auch in der Schweiz?

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2. Anwendung und Grenzen von DCiE / PUE
3. Energy Star Label für Rechenzentren
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1. EEff in RZ: Indikatoren und Messkonzepte

1. Energie pro Dienstleistung eines RZ (Hardware + Software + Algorithmen)
2. Energieeffizienz der IT-Geräte (nicht System)
3. Energieeffizienz der Infrastruktur (System) eines RZ

Energie pro Dienstleistung

Energieproduktivität eines RZ = Data Center Energy Productivity

$$\text{DCeP} = \frac{\text{useful work produced in a data center}}{\text{total energy consumed in the data center to produce that work}}$$

Problem: wie Dienstleistung (useful work) messen?

- Anzahl Transaktionen (Bank)
- Anzahl Zugriffe („Google")
- Anzahl Rechenoperationen (Forschung)
- ???

Eine Definition für alle Bereiche?

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Mass für die Dienstleistung eines RZ?

The Green Grid
www.thegreengrid.org

PROXY PROPOSALS FOR MEASURING DATA CENTER PRODUCTIVITY

→ Haas et al, 2009

PROXY NAME	PROXY FORMULA	VARIABLE DESCRIPTION
Proxy #1 – Useful Work Self-Assessment and Reporting	$\frac{\sum_{i=1}^{n}(N_i * W_i)}{E_{DC}}$	n is the number of instrumented applications running during the assessment window. N_i is a normalization factor for each software application. W_i is the number of units of useful work reported by a particular instrumented application.
Proxy #2 – DCeP Subset by Productivity Link	$\frac{\left(\frac{N_{DC}}{N_{subset}}\right) * \sum_{i=1}^{n} W_i}{E_{DC}}$	N_{DC} is the total number of servers in the data center. N_{subset} is the number of servers in the subset. n is the number of instrumented applications running during the assessment window. W_i is the number of units of useful work reported by an instrumented application.
Proxy #3 - DCeP Subset by Sample Workload	$\frac{\left(\frac{N_{DC}}{N_{subset}}\right) * W_{subset}}{E_{DC}}$	N_{DC} is the total number of servers in the data center. N_{subset} is the number of servers in the subset. W_{subset} is the useful work number produced by instrumented software running on a server subset.
Proxy #4 - Bits per Kilowatt-hour	$\frac{\sum_{i=1}^{k} b_i}{E_{DC}}$	k is the total number of outbound routers. b_i is the total number of bits coming out of the ith router during the assessment window.
Proxy #5 - Weighted CPU Utilization – SPECint_rate	$\frac{T * \sum_{i=1}^{n}\left(U_{AVG}CPU_i * B_i * \left(\frac{Clk\_CPU_i}{Clk\_B_i}\right)\right)}{E_{DC}}$	T is the length of the assessment window. n is the number of servers being measured. $UAVGCPU_i$ is the average CPU utilization for the ith server. B_i is the benchmark result for the ith server. Clk_CPU_i is the nominal clock speed of the CPU in the ith server. Clk_B_i is the clock speed of the CPU that was used to establish B_i.
Proxy #6 – Weighted CPU Utilization - SPECpower	$\frac{T * \sum_{i=1}^{n}\left(U_{AVG}CPU_i * S_i * \left(\frac{Clk\_CPU_i}{Clk\_B_i}\right)\right)}{E_{DC}}$	T is the length of the assessment window. n is the number of servers in the data center. $UAVGCPU_i$ is the average CPU utilization for the ith server. S_i is the SPECpower ssj_ops/sec at 100% server utilization for the ith server. Clk_CPU_i is the nominal clock speed of the CPU in the ith server. Clk_B_i is the clock speed of the CPU that was used to establish B_i.
Proxy #7 – Compute Units per Second Trend Curve	$\frac{T * \sum_{i=m}^{n}\left(7^{\left(\frac{i-2000}{5}\right)} * Num_i * Util_i\right)}{E_{DC}}$	T is the length of the assessment window. m is the year of purchase of the oldest server in the data center. n is the year of purchase of the newest server in the data center. Num_i = number of servers in data center that were purchased in year i. $Util_i$ = average server utilization during the assessment window of the servers in the data center purchased in year i.
Proxy #8 - OS Workload Efficiency	$\frac{Count_{OS}}{P_{DC}}$	$Count_{OS}$ is the total OS instance count.

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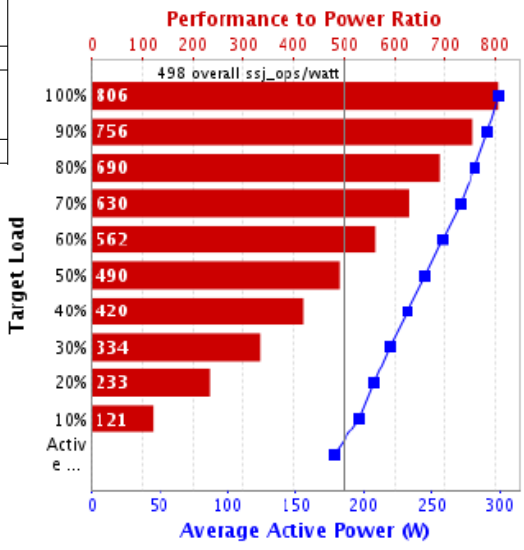
Energieeffizienz eines Servers

Existierende Spezifikationen (Fanara et al., 2009)

Data Center Workload Category	Available Benchmarks
High performance computing (HPC)	LINPACK, Green 500*, SPEC_CPU2006
Web services or other accessed services	SPECpower_ssj2008*, SPECweb2009*, TPC-App
Email services	SPECmail2009
Database management	NNA Server Power Efficiency*, NNA Server Transaction Throughput Benchmark, TPC-C, TPC-E, TPC-H
Shared file services	SPECsfs2008

In Entwicklung: Energy Star Servers Version 2.0 mit Anforderungen für Energieeffizienz im Betrieb (EPA, 2010)

→ SPECpower_ssj2008 (SPEC, 2008)

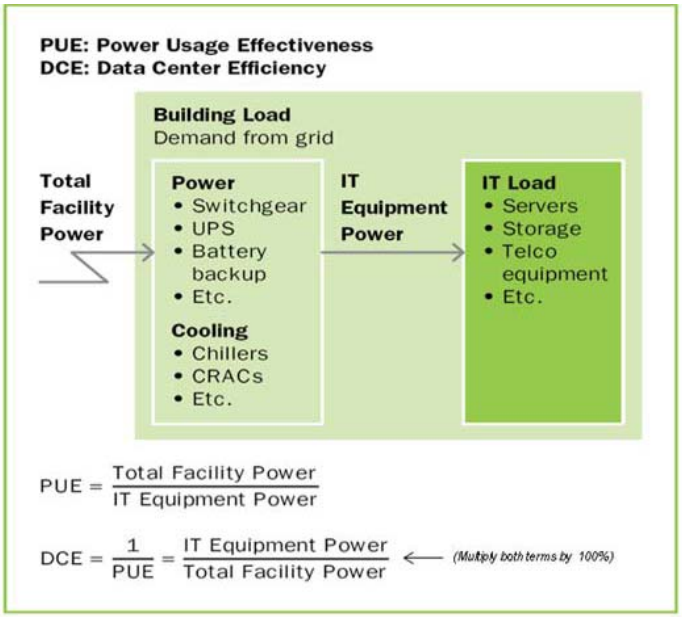


Energieeffizienz der (zentralen) Infrastruktur

Indikator: DCiE = 1/PUE
hat sich international durchgesetzt

- ERFA RZ (CH, 1980/90)
- …
- Kanton Genf (CH, 2003)
- …
- DoE, EPA (US)
- Green Grid (global, US)
- CoC (EU)

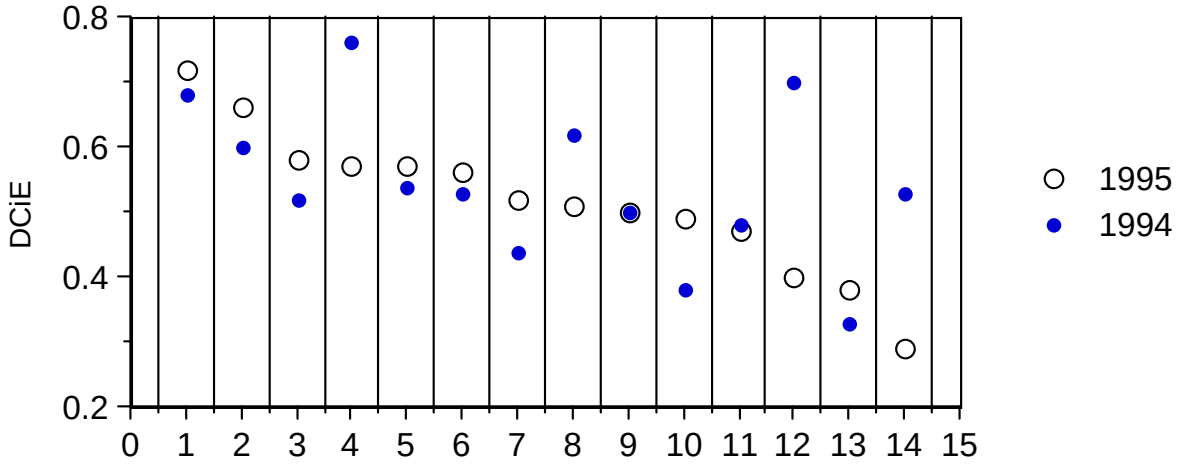
→ (7x24 Exchange, 2010)



Source: The Green Grid

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

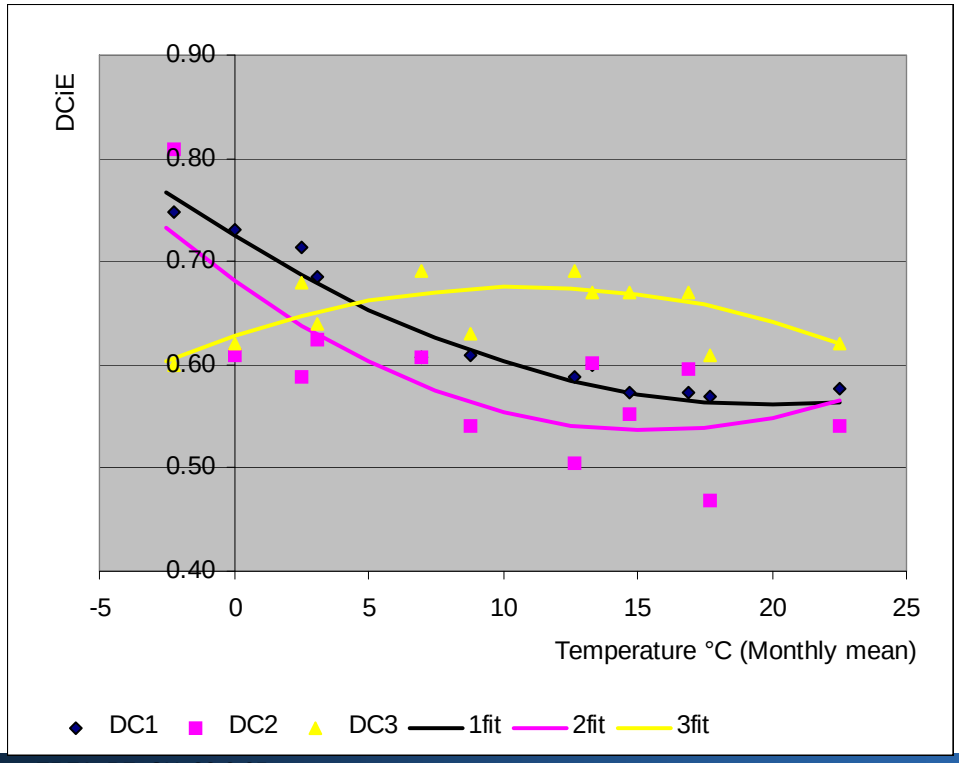
… but a good enough **measurement concept** – with energy and not power to be measured - is essential



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

Measuring concept/protocol Geneva

- Energy - not power!
- Reporting frequency at least monthly
- Precise enough defined measuring points

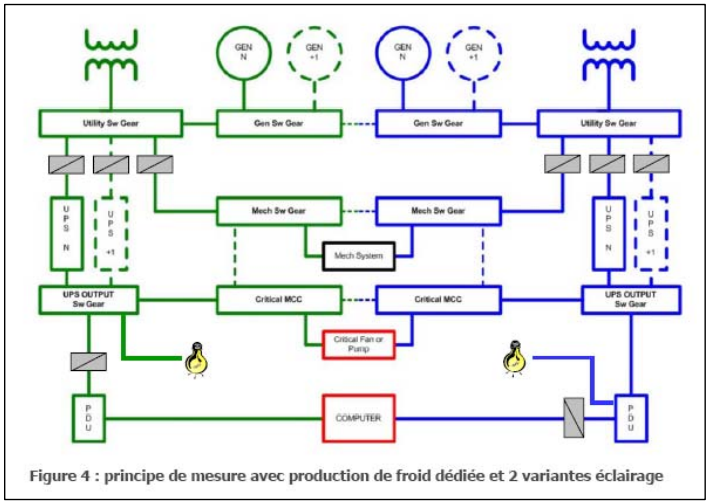


Figure 4 : principe de mesure avec production de froid dédiée et 2 variantes éclairage

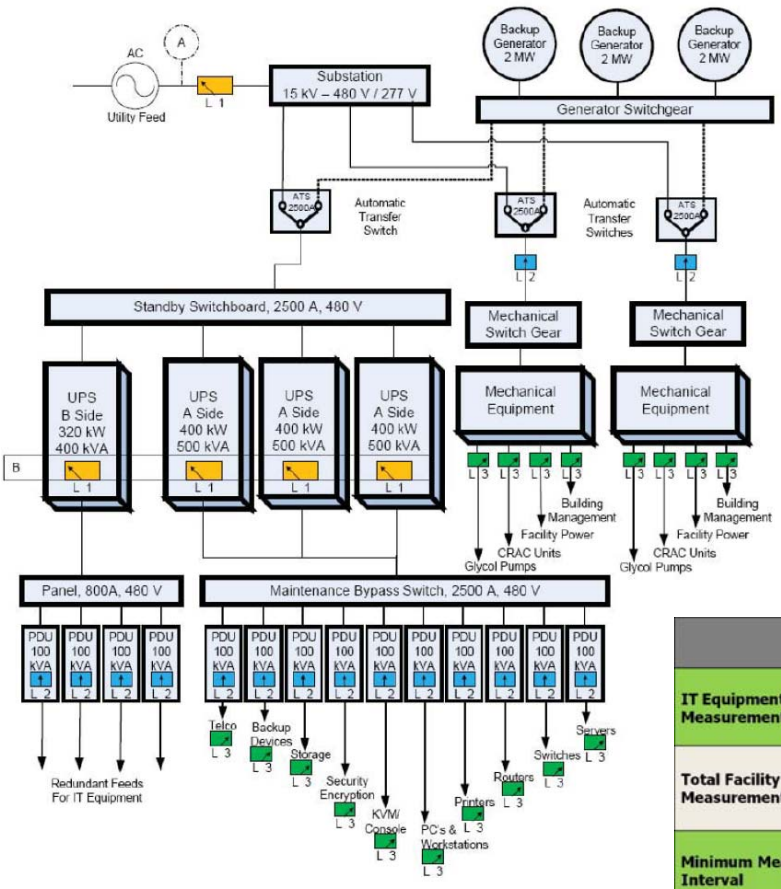
measuring points for tier IV DC with proper/own cold production

Source: Uptime Institute, 2006 and Maucoronel/Duc/Willers, 2008

Messkonzept Green Grid (→ CoC)

- „Power“ → „average power“ (für Reporting)
- Präzise (aber nicht einheitliche) Messstellen: UPS oder PDU oder Geräte
- Mindestens monatlich → kontinuierlich

→ Green Grid, 2009



Quelle: Green Grid, 2009

	Level 1 (Basic)	Level 2 (Intermediate)	Level 3 (Advanced)
IT Equipment Power Measurement From...	UPS	PDU	Server,...
Total Facility Power Measurement From...	Data Center input power	Data Center input less shared HVAC	Data Center input less shared HVAC plus building lighting, security...
Minimum Measurement Interval	Monthly/ Weekly	Daily	Continuous

0.45 $DCiE_{L1,--}$	Single DCiE measurement (0.45) taken using a Level 1 meter placement
0.51 $DCiE_{L1,YM}$	Yearly average DCiE (0.51), using data points gathered monthly with a Level 1 meter placement
1.6 $PUE_{L1,MW}$	Monthly average PUE (1.6) using data points gathered weekly with a Level 1 meter placement
0.43 $DCiE_{L1,WD}$	Weekly average DCiE (0.43), using data points gathered daily with a Level 1 meter placement
1.8 $PUE_{L2,WC}$	Weekly average PUE using data points gathered continuously with a Level 2 meter placement.
2.1 $PUE_{L3,YC}$	Yearly average PUE (2.1) using continuous measurements with a Level 3 meter placement.

'M' = monthly, 'W' = weekly, 'D' = daily,
'C' = continuously (frequency one hour or less)

Quelle: Green Grid, 2009

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2. Anwendung und Grenzen von DCiE / PUE (1)

- Zeitliche Entwicklung in einem RZ
  - Prozesskontrolle, Monitoring
  - Evaluation einer Massnahme

→ **CoC, Green Grid**

- Vergleich von mehreren RZ
  - Benchmarking
  - Qualität
  - (Best practice)

→ **Energy Star**

- Vorgabe, Ziel
  - Planung, Neubau, Sanierung
  - Best practice

→ **Kanton Genf (?)**
(Aebischer et al., 2003)

2. Anwendung und Grenzen von DCiE / PUE (2)

- „Äussere“ Einflussfaktoren
  - ausserhalb RZ, z.B. Klima
  - ausserhalb „zentrale“ Infrastruktur, z.B. variable Auslastung RZ

  → „Korrektur“ Energy Star
- keine Erklärung
- keine Hinweise auf Verbesserungen/Massnahmen

  → spezifischere Indikatoren, z.B. Auslastung von Geräten/Anlagen, HVAC Performance Index
- Systemgrenze RZ

  → z.B. Nutzung der Abwärme mit ergänzendem Indikator berücksichtigt (im Moment!)

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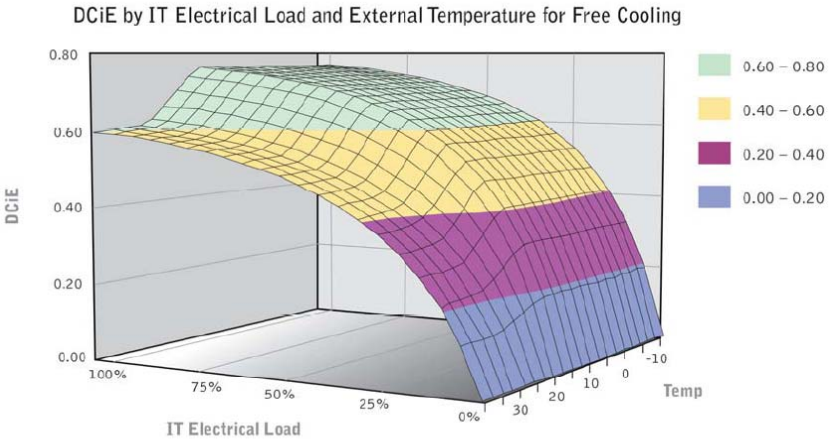


Figure 8-4 DCiE by IT electrical load and external temperature, fresh air cooling

Grenzen der Vergleichbarkeit, z.B. Klima und Auslastung

Effizienzverbesse-rungen bei IT kann zu schlechterem DCiE führen!

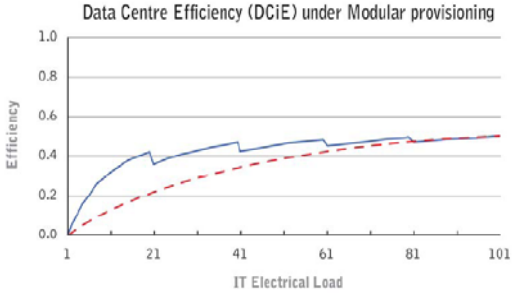
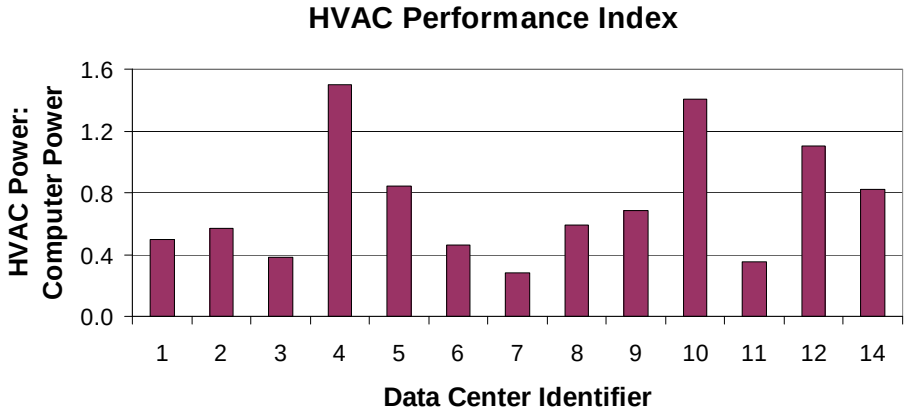


Figure 4-9 DCiE under modular provisioning

Quelle: Newcombe L., 2009.

Spezifischere Indikatoren

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



Quelle: Greenberg et al., 2006

3. Energy Star (1)

→ http://www.energystar.gov/index.cfm?c=prod_development.server_efficiency

- Datensammlung (2008-2009)
  → Data Collection Form
  http://www.energystar.gov/ia/partners/prod_development/downloads/data_collection_form.xls
- Erste Ergebnisse der Analyse von 108 DC → (**EPA, 2009/1, 2009/2**)
  - keine signifikante Abhängigkeit von Auslastung, Klima, free cooling!
  - Abhängig von IT-Stromverbrauch, …, leicht von Tier

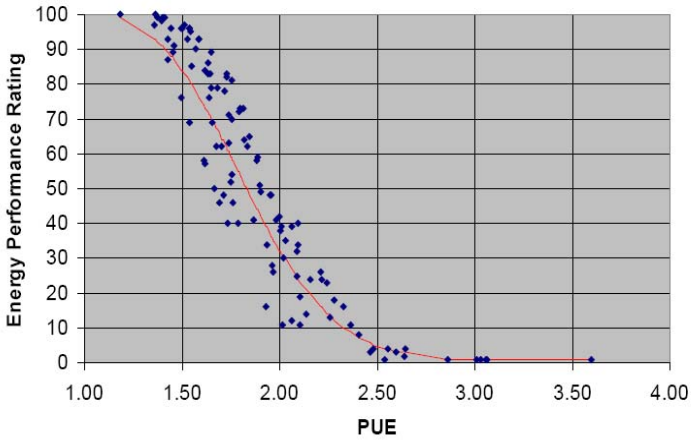
  Mögliche Erklärung:
  - Qualität der Daten
  - Konzeption und/oder Betrieb der technischen Anlagen
- → Kriterien Energy Star Label für Data Centres (Tier 1)

ohne „Korrektur" für Klima!, Tier?

3. Energy Star (2)

EnergyStar Label… (Tier 1): 25% tiefsten „korrigierten“ PUE

Rating vs. PUE



EPA

Quelle: EPA, 2009/2

22

> 25% = PUE < ~ 1.6

→ DCiE > ~ 0.63

(eigene Berechnung! Offizielle Ankündigung Juni 2010)

Zielwert (Standard) für Kanton Genf

- bestehende 0.55
- neue 0.65

(Aebischer, 2009)

4. E* – auch in CH?

- Wird im Juni in den USA eingeführt
- Einige 100 (?) RZ werden in 2011 Energy Star Label nutzen
- Wird EU nachziehen? Und die Schweiz?
- Und die Schweiz?
  - Die Schweiz ist Partner des US-Energy Star Programms www.energystar.ch
  - Kann Energy Star für Geräte/Anlagegruppen übernehmen
  - Bisher nur für IT-/Bürogeräte, aber z.B. nicht für Gebäude
  - Für IT-/Bürogeräte → Datenbank der EU
  - Für RZ → „Registrierung und Vergabe“ in der Schweiz? → Aufwand/Kosten
- Interesse bei Behörden, IT-Industrie, Firmen, RZ-Betreibern?
- Weiteres Vorgehen?

4. E* – auch in CH?

- Wie wertvoll ist Energy Star für …?
- Alternative Auszeichnungen?
  - CoC (kein Benchmarking!)
  - Zertifizierung (Labelsalat!)
- Proaktiv handeln?
- ENERGY SUPER STAR? (EPA, 2009/3)

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