



FACULTEIT INGENIEURSWETENSCHAPPEN

Estimating and mitigating the energy footprint of ICTs

W. Vereecken, D. Colle, B. Vermeulen, M. Pickavet, B. Dhoedt, P. Demeester

1999, Marc Mills, 'The internet begins with coal'

*“... It now seems reasonable to forecast that in the foreseeable future, certainly within two decades, **30 to 50 percent** of the nation’s electric supply will be required to meet the direct and indirect needs of the Internet. ...”*

2002, Walter Baer et al., ‘Electricity requirements for a digital society’

*“... ICT networks, computers, and office equipment ... In none of our 2021 scenarios does this percentage exceed **5.5 percent** of the national electricity total. ...”*

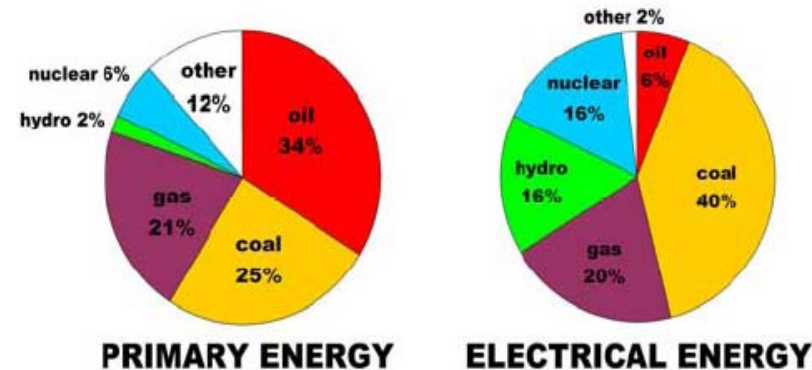
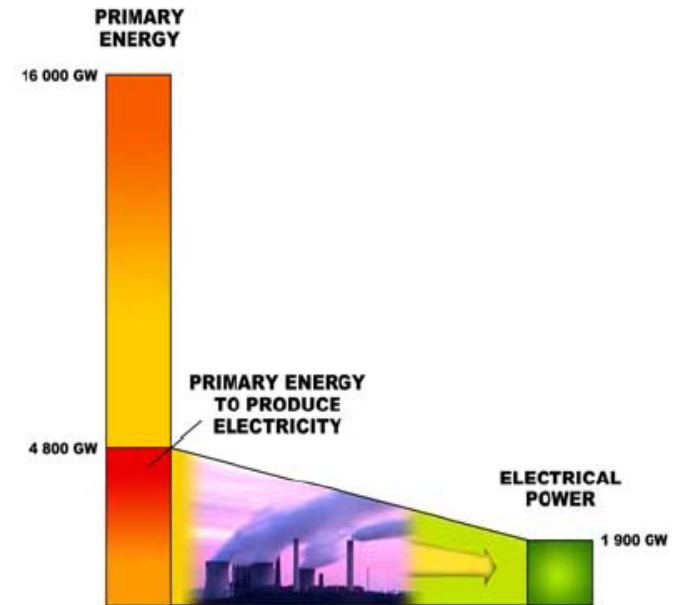
2007, Justin Mann, TechSpot.com

*“Server power **doubled** over the past 5 years...”*

2008, The Climate Group, 'Smart 2020 report'

*“... in 2020 ... specific ICT opportunities identified in this report **can** lead to emission reductions **five** times the size of the sector’s own footprint”*

- Average energy production 2007
- 16000 GW
- 30% electrical power production.
- Electrical Power Production has a yield factor of 40%
- Primary Energy growth rate of 2% p.a.
- Electrical Power growth rate of 3% p.a.



■ Data center

- Servers, storage, cooling, UPS, ...

■ PCs

- Desktop, Laptop, Screen, ...

■ Network Equipment

- Datacom and Telecom infrastructure, User Premises Equipment
- Not: Data Center Network Equipment, Built-in network interface in PC

■ TVs

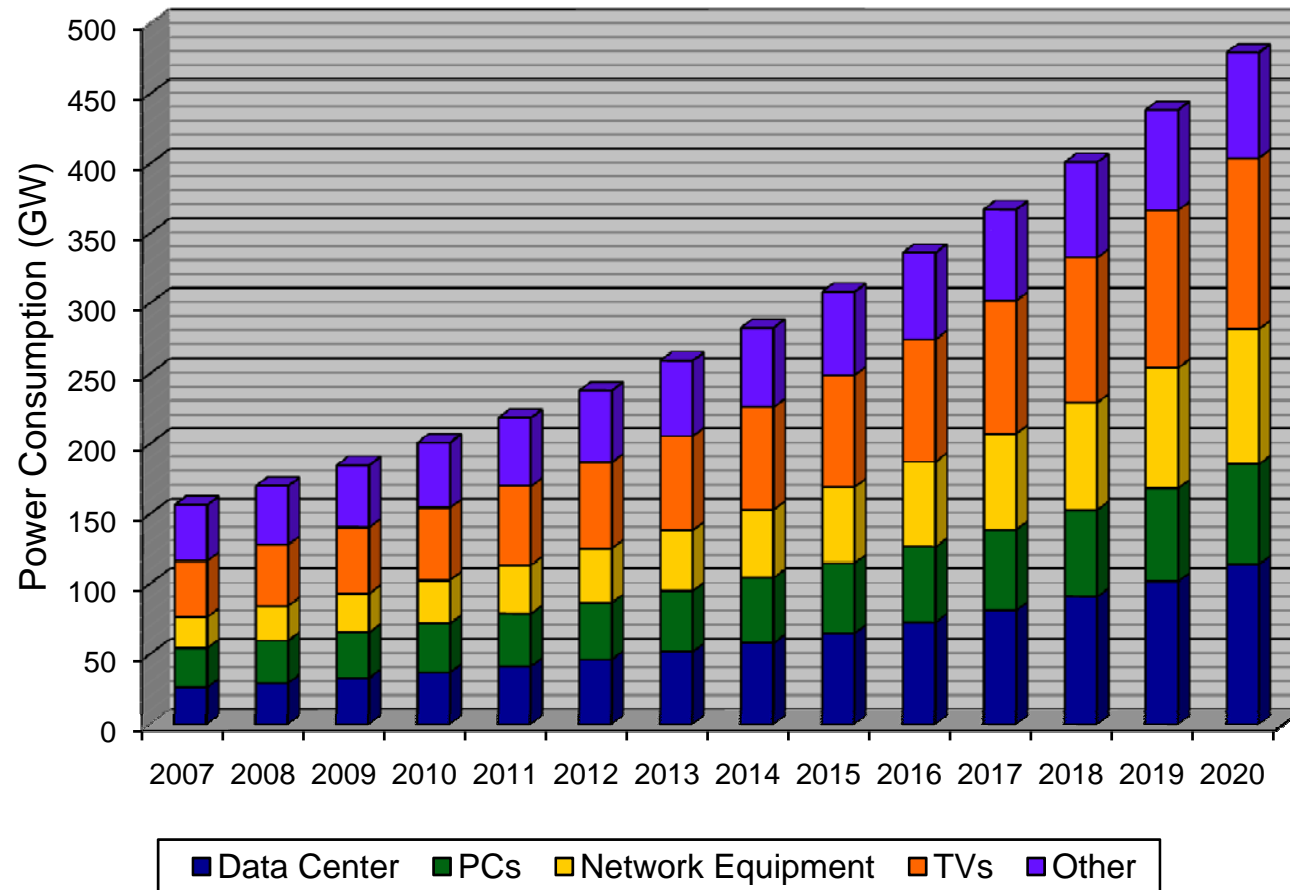
- TV, DVD player, Decoder, ...

■ Other

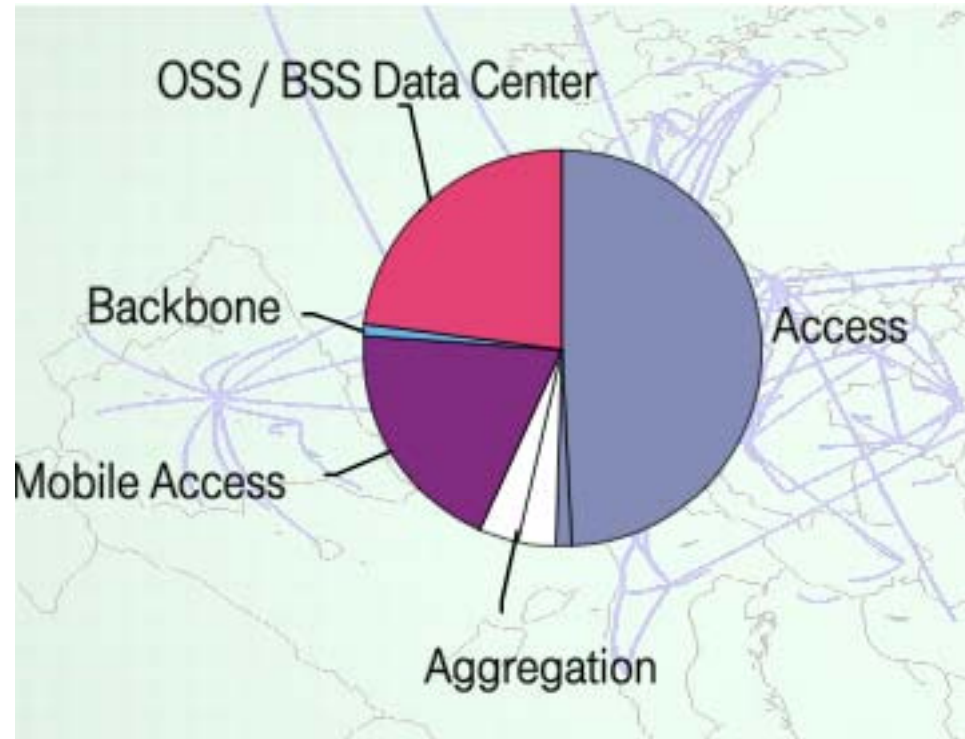
- Audio Equipment, Game Consoles, Telephones, ...

Equipment Type	Est. Consumption 2007 (GW)	Est. Annual growth rate
Data centers	26	12%
PCs	28	7.5%
Network Equipment	22	12%
TVs	40	9%
Others	40	5%
Total	156	

Yearly Power Consumption Forecast



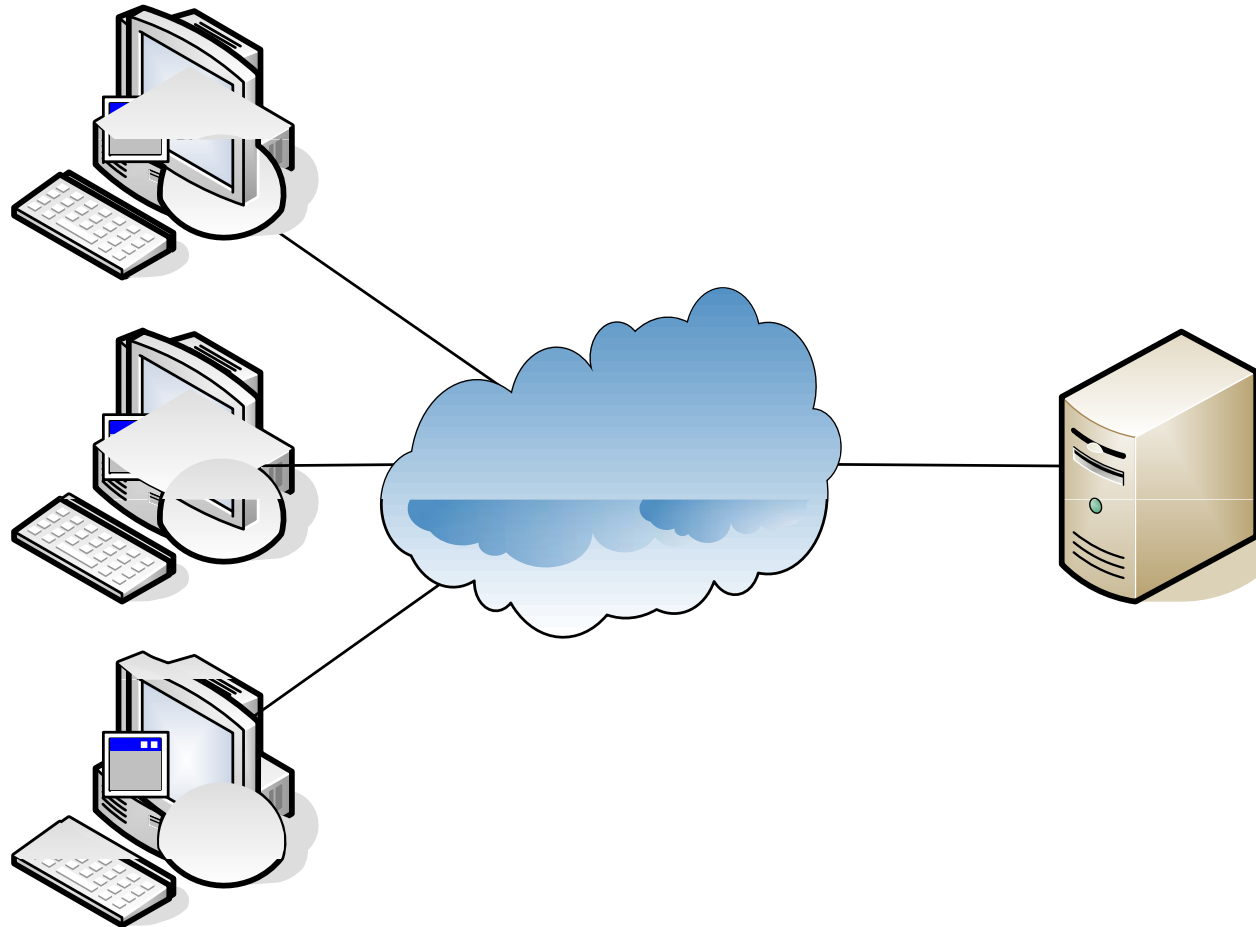
- **Network technology: 22 GW**
- **Base stations and backhaul networks: 6,85 GW**
- **30% of the network technology power consumption is due to mobile networks**

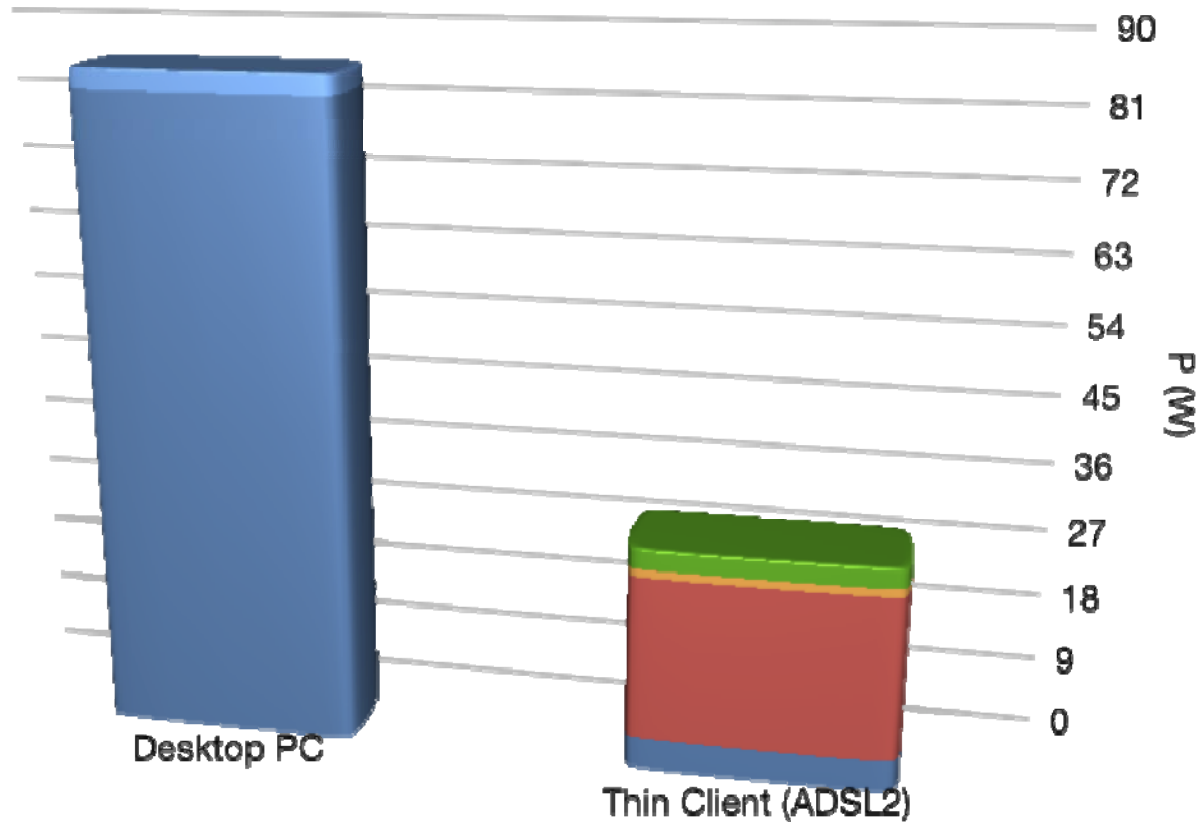


Source: T-Systems

2G Networks			3G Networks		
Equipment	Power	Share	Equipment	Power	Share
BTS	1200 W	97 %	Node B	6000 W	98%
BSC	500 W	2,2 %	RNC	2500 W	1,5%
MSC	4000 W	0,8 %	UMSC	4000 W	0,5%

- One generation: 5 x power consumption
- Roughly 10 years between generations
- Growth rate = 20 % p.a. (rough estimate)
- Shrinking cell size has not been accounted for

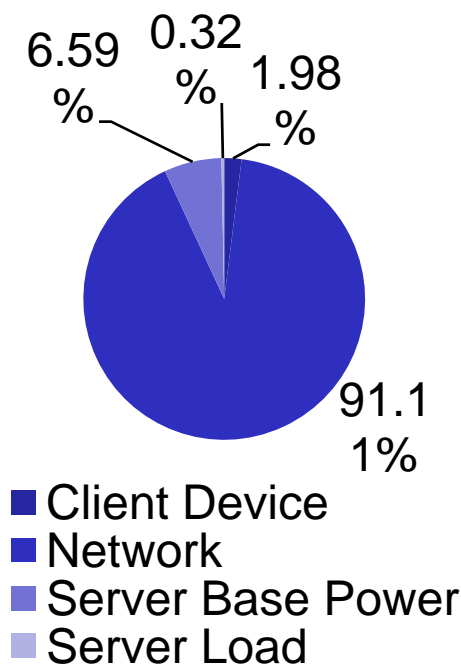




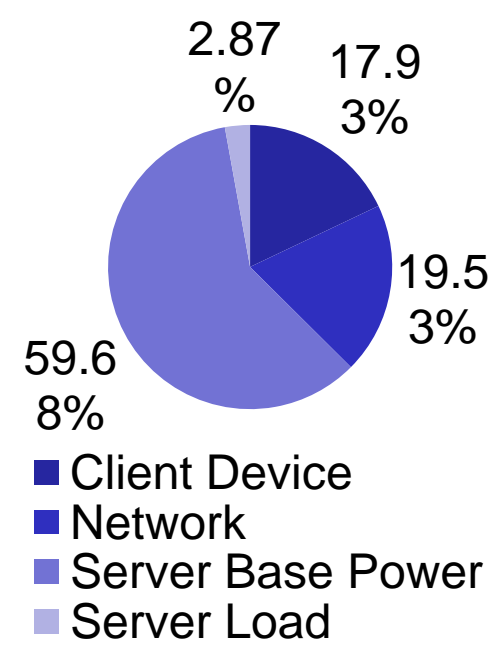
■ PC / Terminal Base Power
■ Server Base Power
■ Network

■ CPU load (local)
■ CPU load (server)

UMTS 329W



WIFI 36W



■ Production of a PC

- 4850 MJ non-electrical energy
- 1550 MJ electrical energy
- ⇒ 8700 MJ primary energy

■ Use phase of a PC

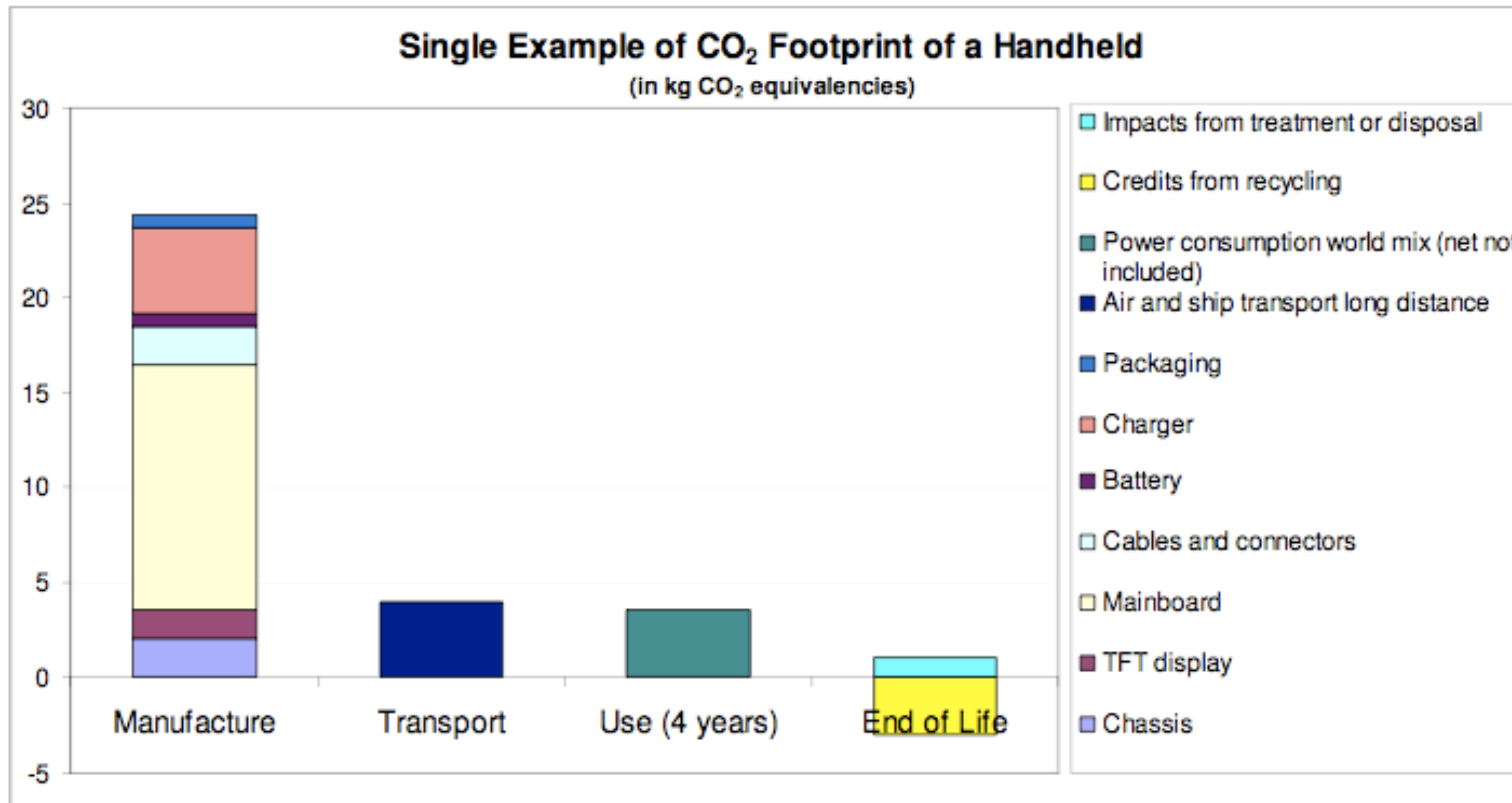
- Average use time of 4 years
- 28 W average power consumption
- ⇒ 8800 MJ primary energy

■ Production of a Mobile Phone

- 160 MJ primary energy

■ Use phase of a Mobile Phone

- Average use time of 1,5 years
- 0,5 W average power consumption
- \Rightarrow 60 MJ primary energy



Source: PE International

- **Currently 2.5 – 3% of worldwide energy consumption**
- **8% of the annual electricity production**
- **In 2020 approx. 14% of worldwide energy consumption**

- **All ICTs**
- **Only use phase!**

■ Individual Devices

- Optimize Hardware
- Optimize Software
- Easy to measure

■ New network paradigms

- Optimize use of network elements
- Eliminate redundant network elements

■ Policy Supporting Studies

- Standards for Power Consumption
- Energy Labels

■ Room for improvement ?

- Example 1: electricity use laptop vs. desktop: 1/4th
- Example 2: different TV technologies
- Standby power losses
- Efficiency of power supplies
- ...

■ Driving forces:

- Growing energy prices
- Governmental actions to reduce greenhouse gas emission
- Energy labels
- 'Green' as marketing factor

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- **Impact of operating system**
 - Electricity consumption
 - Lifetime
- **Intelligent power management of computers and screens**
- **Server parks**
 - Virtual server configurations
 - Switching off servers during quiet hours

■ ‘Incremental’ initiatives today:

- IEEE Study Group on Energy-Efficient Ethernet
- ADSL low power mode
- Low power access technologies
- ...

■ Clean slate approaches

- **Power consumption growth in ICTs is unsustainable.**
- **Mobile Networks are a large and rapidly increasing fraction**
- **When comparing to other sectors primary energy consumption needs to be calculated (\leftrightarrow electrical energy)**
- **Life Cycle Analysis needs to be taken into account**
- **Overall impact of new solutions must be taken into account**
- **When optimizing focus both on individual devices and network paradigms**



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Thank you for your attention