

An Inconvenient Truth: Energy-Efficient Future Internet

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Some quotes...

2007, Justin Mann, TechSpot.com

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

Some quotes...

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. ...”*

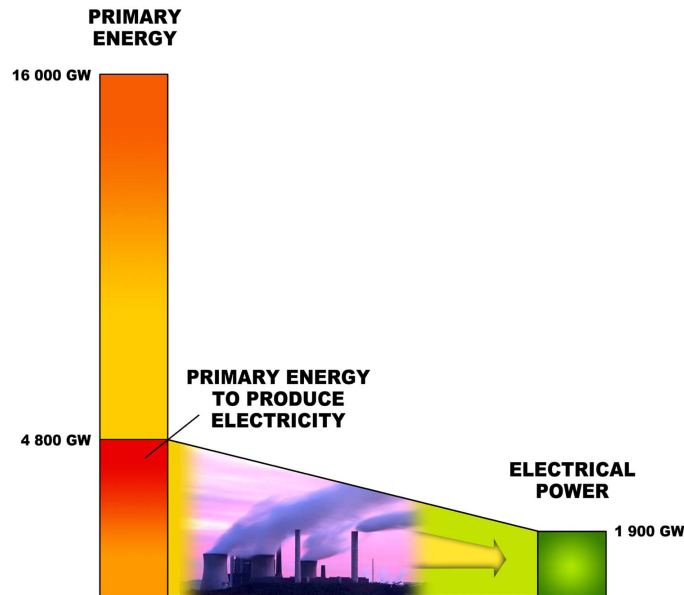
Some quotes...

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. ...”*

1. Realistic assessment

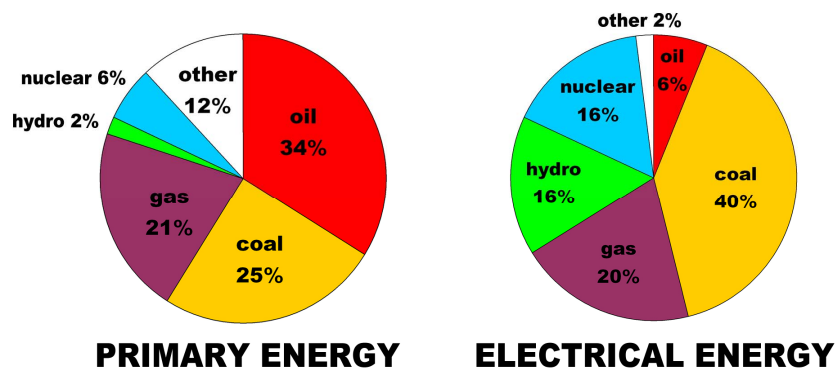
Energy worldwide today



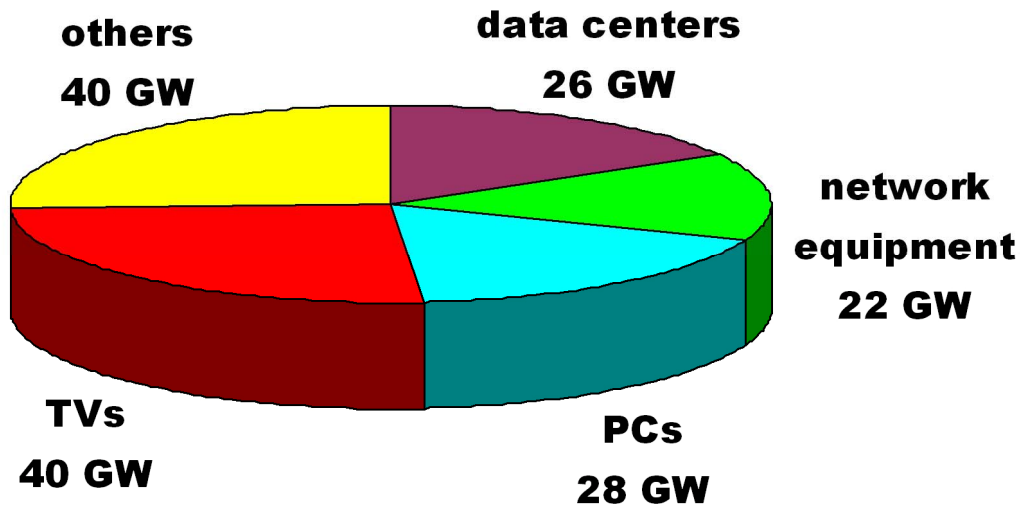
Some key conclusions:

- Electricity = 30% of energy
- In terms of CO₂ emissions:

1 W of electrical energy \approx 2.1 W of primary energy



ICT use phase: worldwide today



Conclusions:

- Total = 156 GW = 8% of global electricity consumption
- No dominating front, several fronts are important

ICT complete life cycle

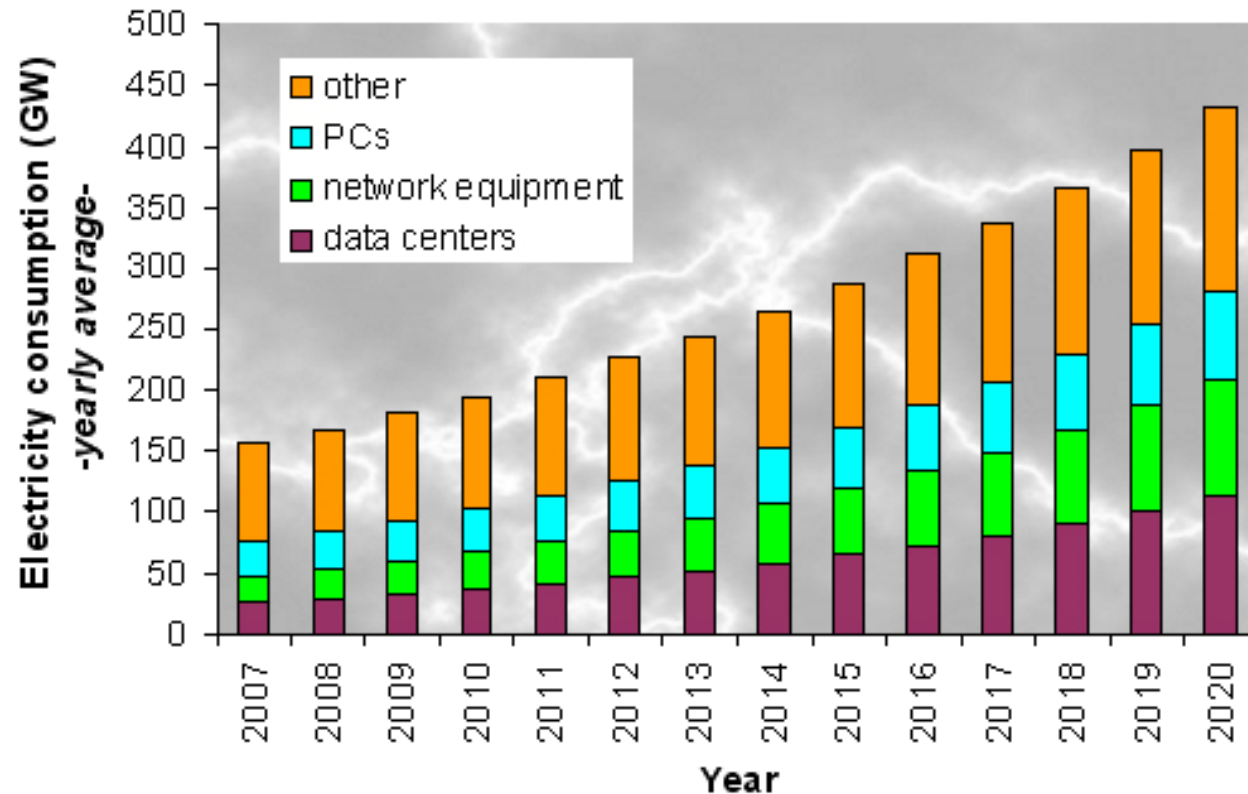
■ Example*: typical PC with CRT screen (2000)

- Manufacturing phase:
 - ◆ Electrical: 1550 MJ → 3875 MJ primary energy
 - ◆ Non-electrical: 4850 MJ primary energy
- Use phase:
 - ◆ Electrical: 3500 MJ → 8800 MJ primary energy
- Disposal phase:
 - ◆ Highly depending on recycling/landfill/...

■ Conclusions:

- Manufacturing phase and use phase: same order of magnitude
 - longer life cycle is key challenge
- ◆ * E. Williams, “Energy Intensity of Computer Manufacturing: Hybrid Assessment Combining Process and Economic Input-Output Methods”, Environmental Science & Technology, Vol. 38, No. 2, November 2004, p. 6166-6174

Future estimations



Conclusions:

- 1/7th of electricity goes to ICT use phase in 2020
- Power efficiency key research topic !!!

2. Directions for improvement

Key Issues

- **Build a holistic view of ICT energy consumption**
- **Subproblem optimizations and innovative global solutions**
- **Increase ICT equipment lifetime by appropriate functional decomposition**
- **Advanced technologies for more energy efficient data handling/storage and computing resource usage**

Hardware improvements

■ 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
- Energy labels
- 'Green' as marketing factor

Software optimizations

■ 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

New network paradigms

■ Initiatives today:

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

■ Clean slate approaches

E.g. EENet (Energy Efficient Future Networks)

- ◆ **Terminals: only I/O**
- ◆ **Content: reduction of #copies**
- ◆ **Energy-efficiency key driver**

4. Conclusions

Main conclusions

■ Is ICT green ?

- About 4% of primary energy today
- About 8% of primary energy by 2020 ?

■ Is the situation hopeless ?

- Much room for improvement
- More research initiatives to be taken
- Pioneering role for Europe !