

Laboratory of
ecosystem management

Life Cycle Environmental Impacts of Internet

Yves Loerincik, Olivier Jolliet, Greg Norris

This study

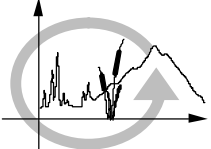
1. The Internet infrastructure has been assessed in two cases:

- The Swiss Federal Institute of Technology (EPFL)
- The US

2. The Internet infrastructure has been assessed using:

- **A Process LCA (PLCA)**
- **An Input-Output LCA (IO LCA)** (A few slides on the theory on IO LCA are available at the end of the presentation for those interested)

1. To point out where are the main impacts related to the Internet infrastructure
2. To be able to take into account the Internet infrastructure when evaluating services like e-business, e-banking etc...
3. To compare the **Process LCA** (PLCA) and the **Input-Output LCA** (IO LCA)



Laboratory of
ecosystem management

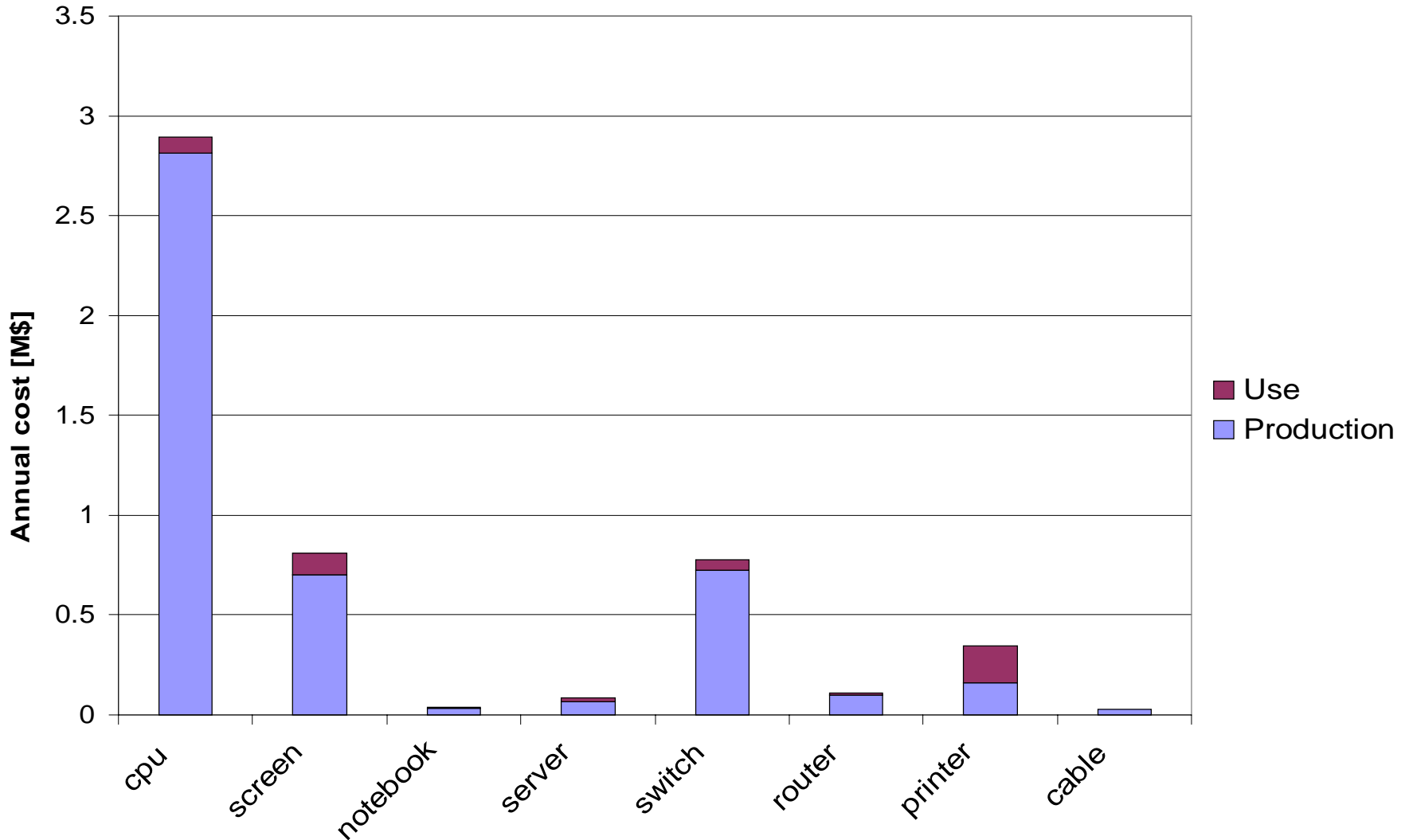
The case study of the Swiss Federal Institute of Technology (EPFL) Internet infrastructure

Step 1: Inventory of the necessary equipment for the Internet infrastructure at the EPFL

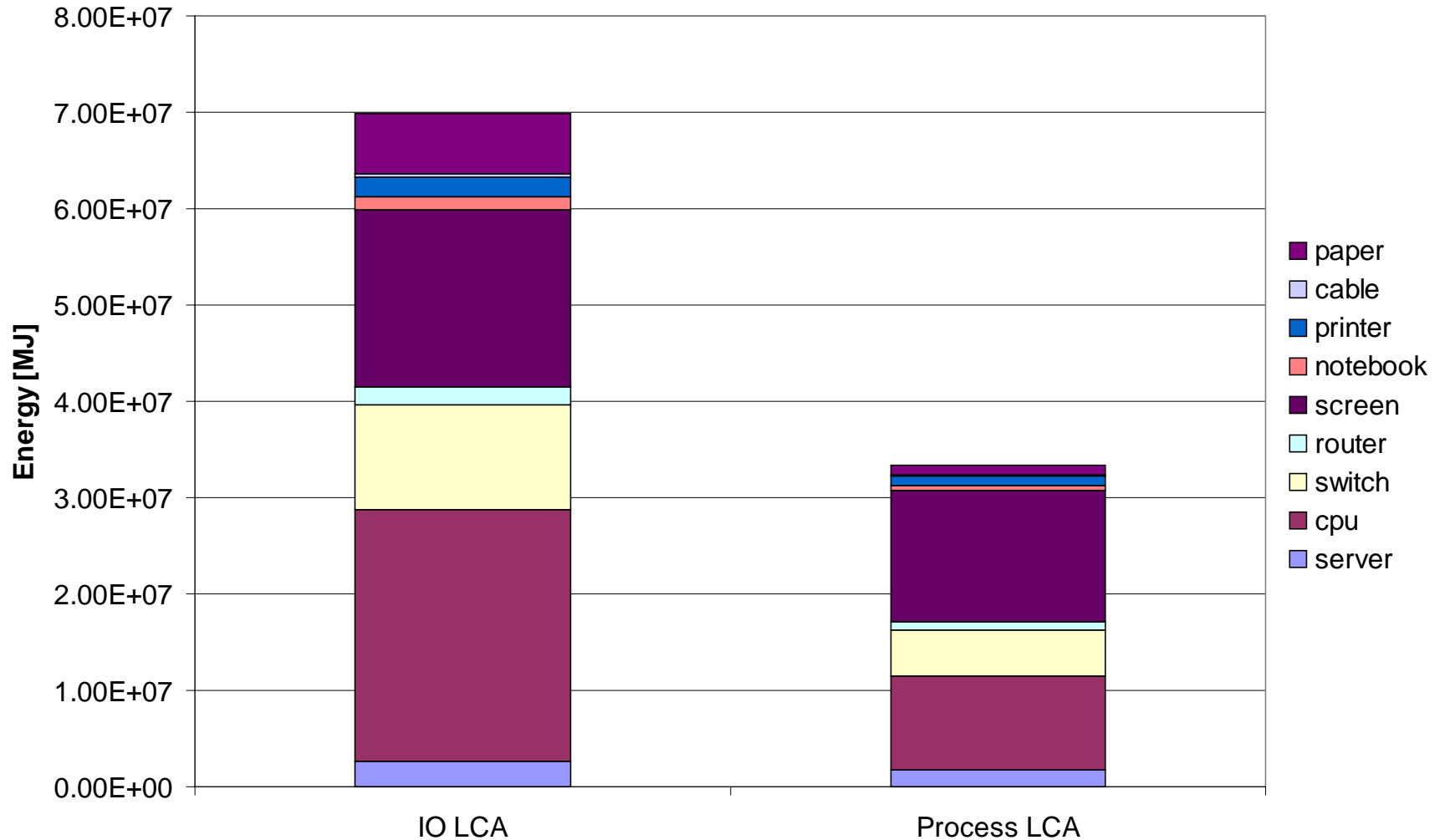
The functional unit = Internet infrastructure during one year

Equipment	Number
server	68
switches	90
router	22
PC	6745
notebook	355
printer	400
cable	121225 meter

Corresponding annual costs (necessary to perform the IO LCA)



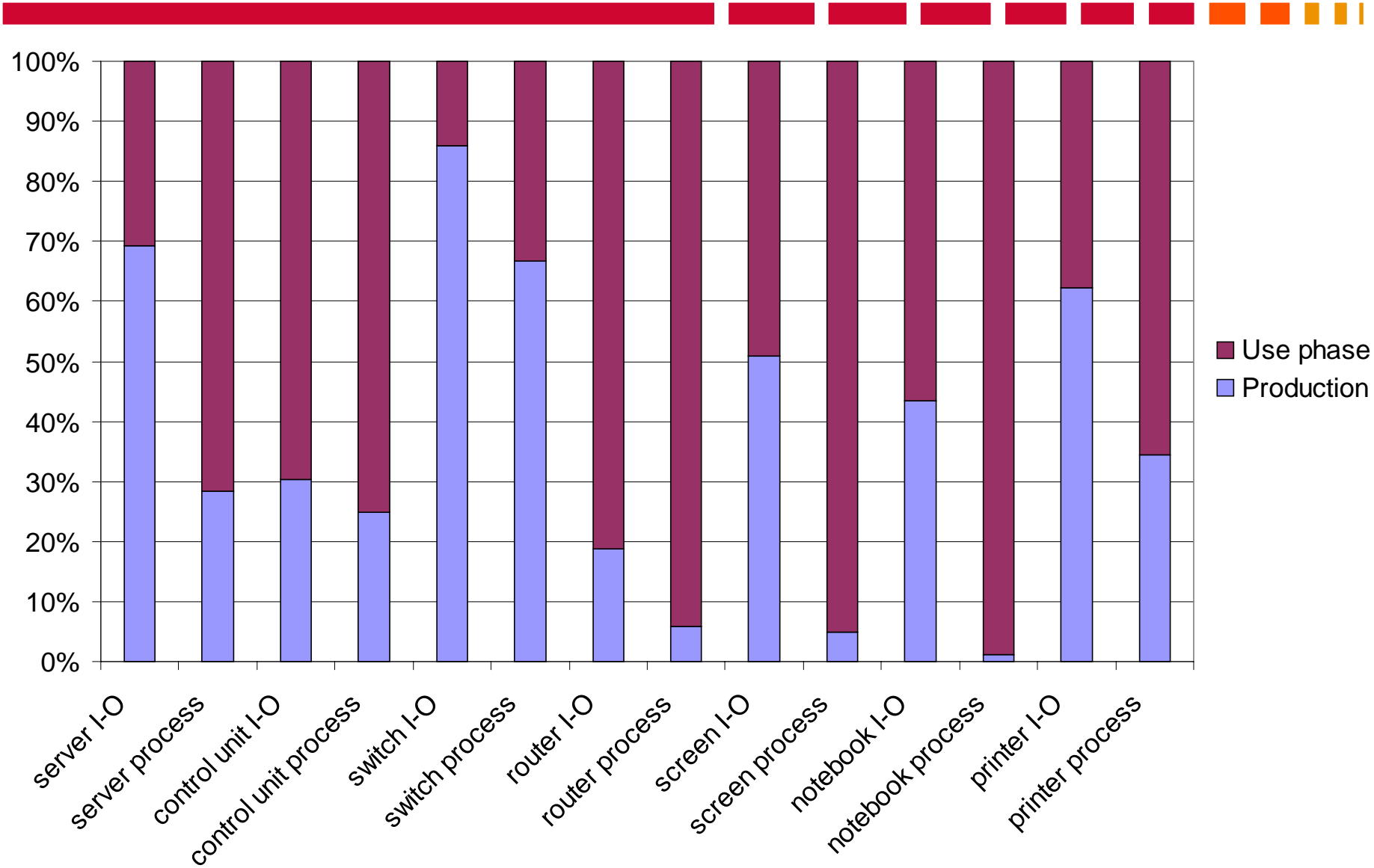
Results: the non-renewable primary embodied energy (use phase and production)



cpu = control unit

1. PCs are dominating (control unit (cpu) + screen)
2. Contribution of the switches and servers are significant
3. IO LCA value is two times the PLCA result

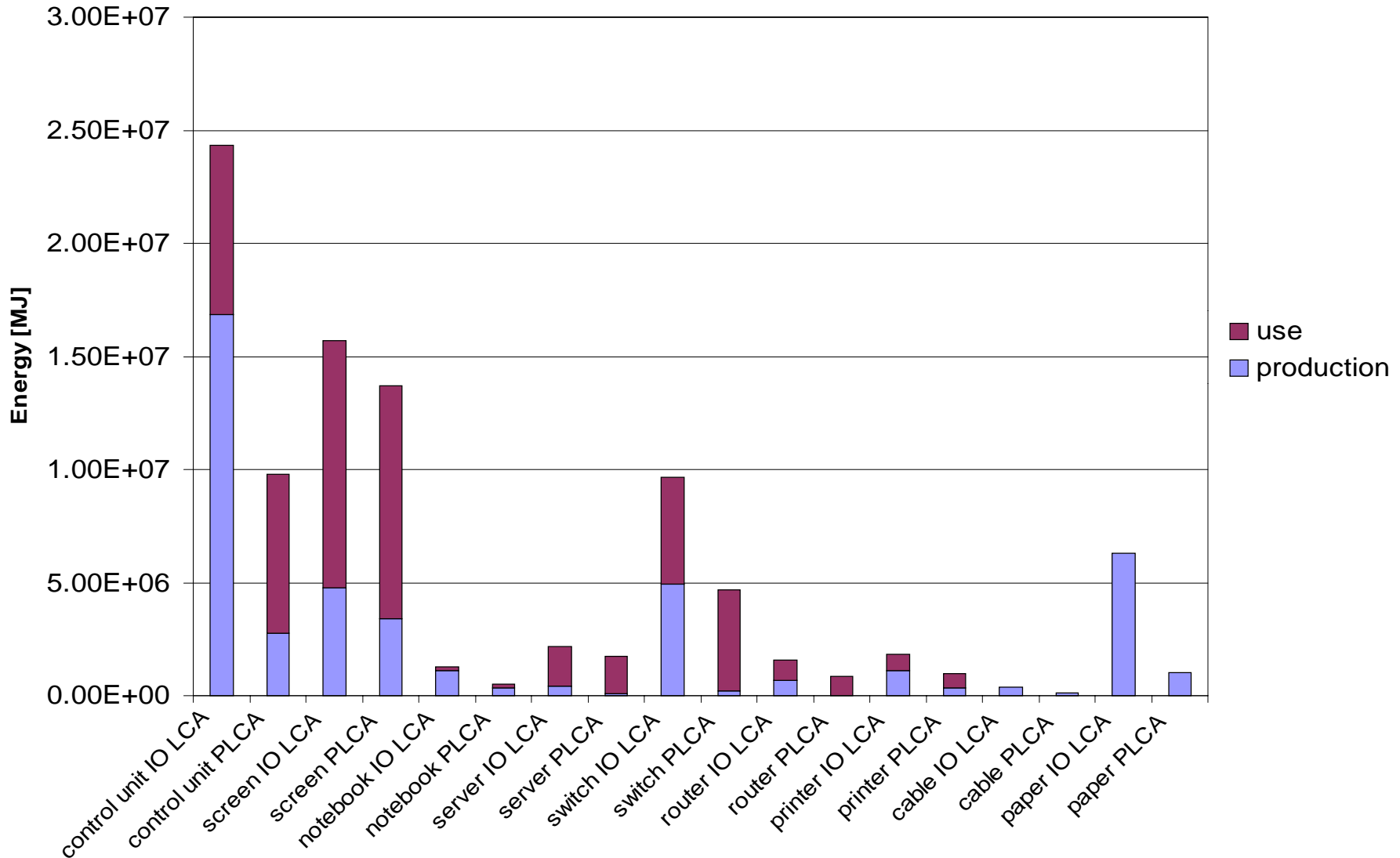
Non-renewable embodied primary energy, comparison between use and production phase (relative value)



Remarks

1. Use phase is in most of the cases dominating
2. The embodied energy during production is significant

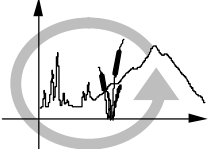
Non-renewable embodied primary energy, comparison between use and production phase (absolute value)



1. Use phase is more important in PLCA than in IO LCA (in relative values)

2. Results for the production is much higher with the IO LCA

Key parameter = the electricity and equipment prices (use to perform the IO LCA)

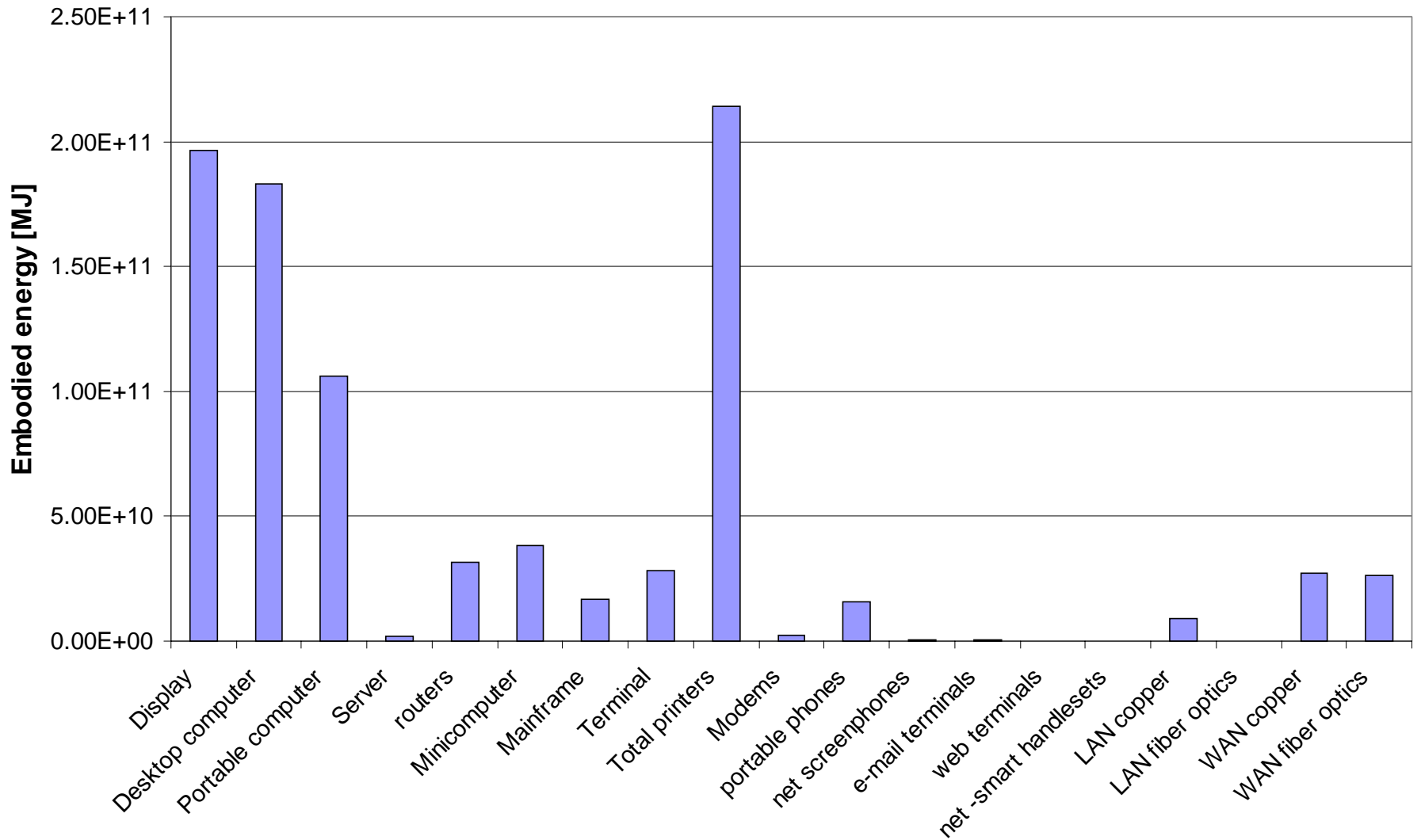


Laboratory of
ecosystem management

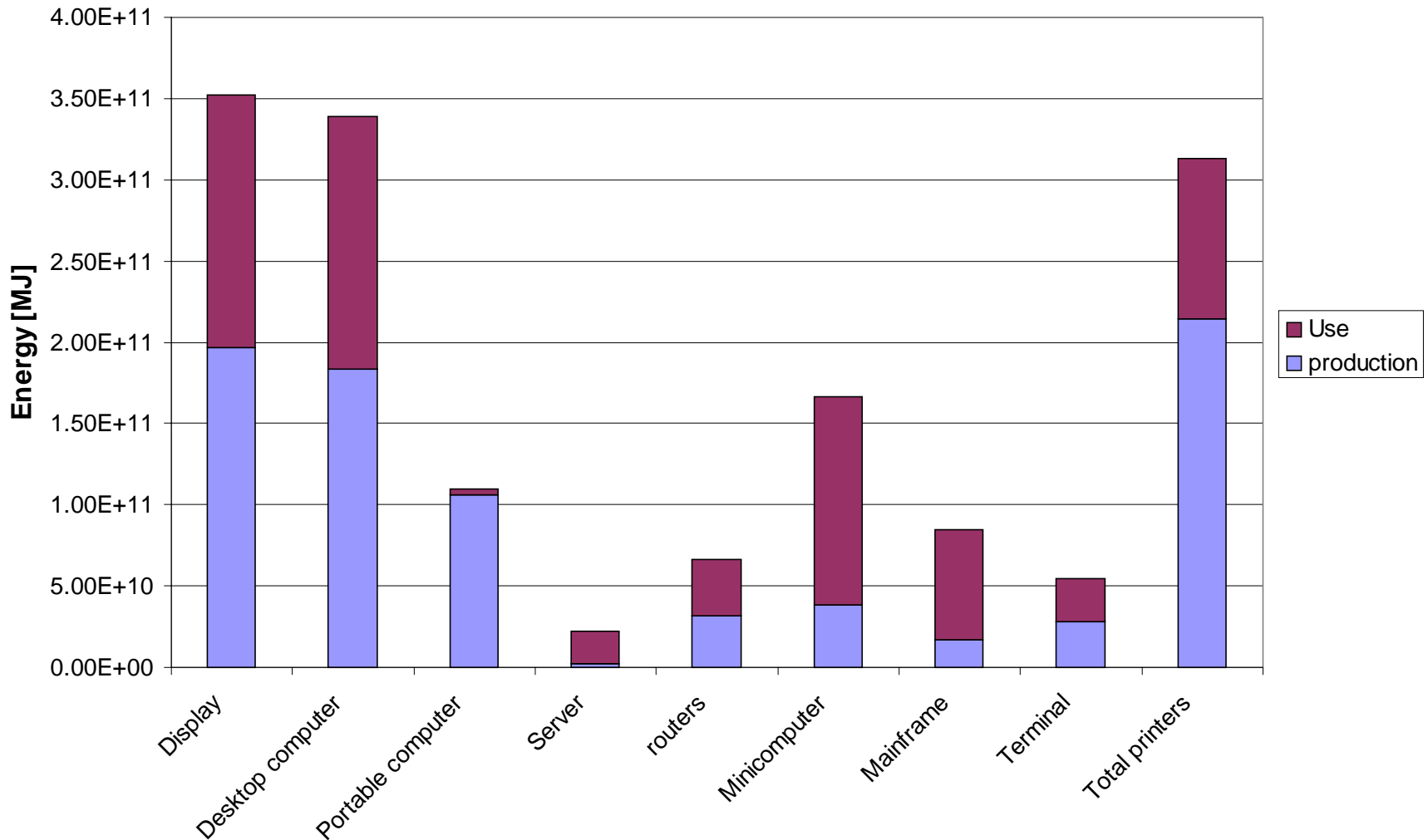
The case study of the United States Internet infrastructure

Filippo Della Croce, Olivier Jolliet, Greg
Norris, Yves Loerincik

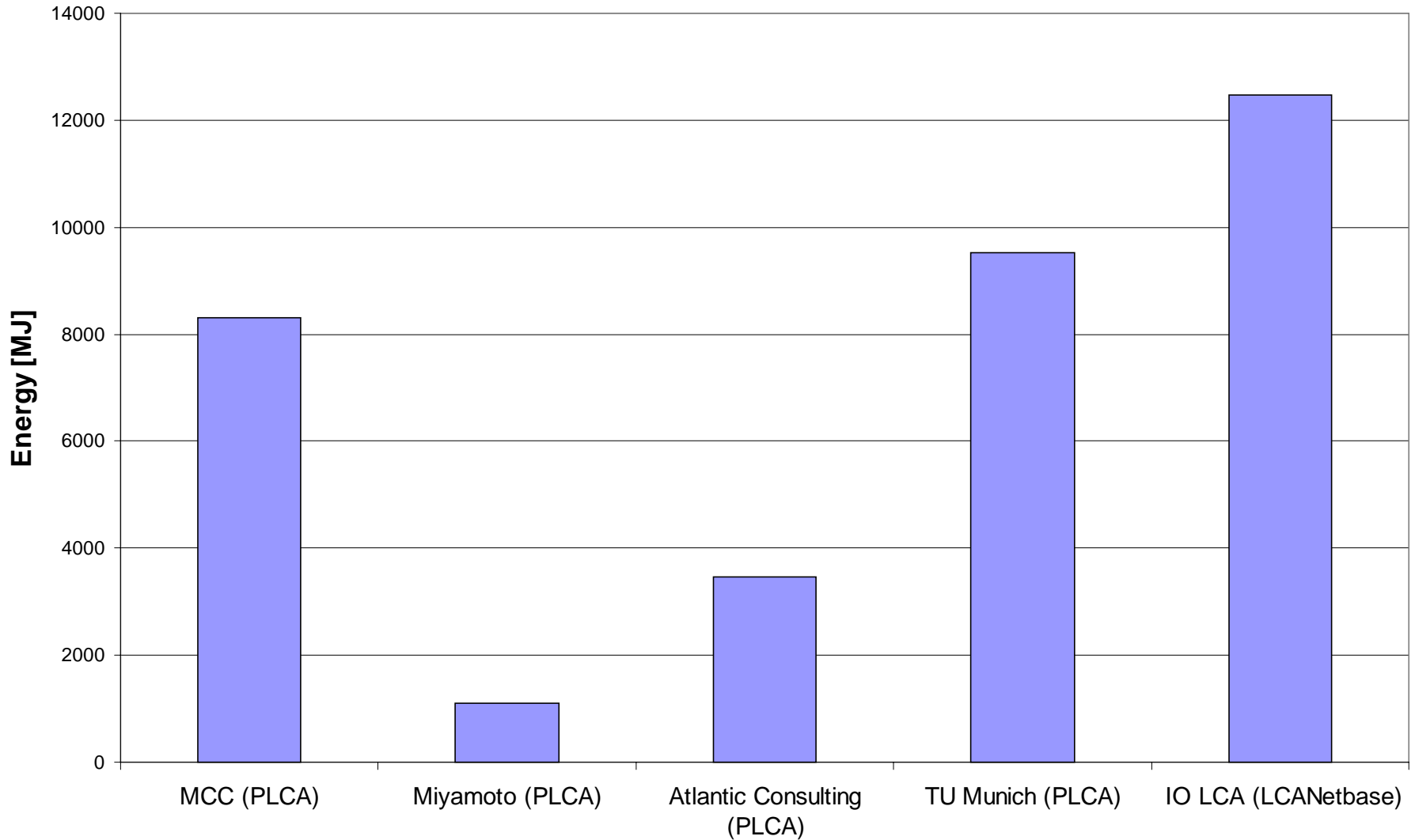
Non-renewable primary embodied energy of the Internet infrastructure in place in the USA in 1999 using PLCA



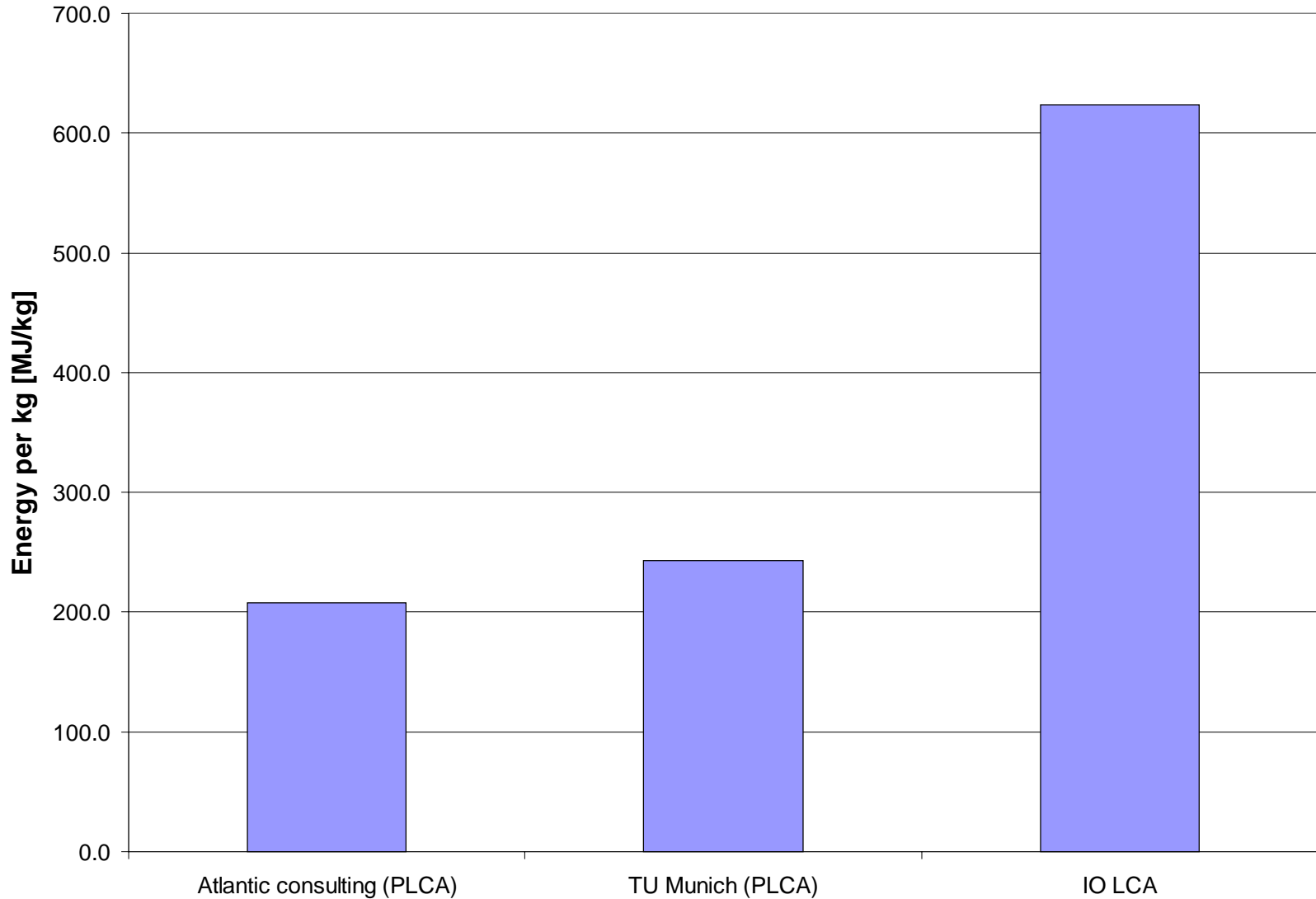
Non-renewable primary embodied energy and use phase energy of the Internet Infrastructure in place in the USA in 1999



Comparison of various case study for the non-renewable primary embodied energy of computers



Comparison of IO and process LCA for computers on a per kg basis



The higher value of the Input-Output LCA can be due to:

- Different **energy efficiencies** of US and Europe
- Different **levels of comprehensiveness** of the two methods
- Level of accuracy

Different levels of comprehensiveness

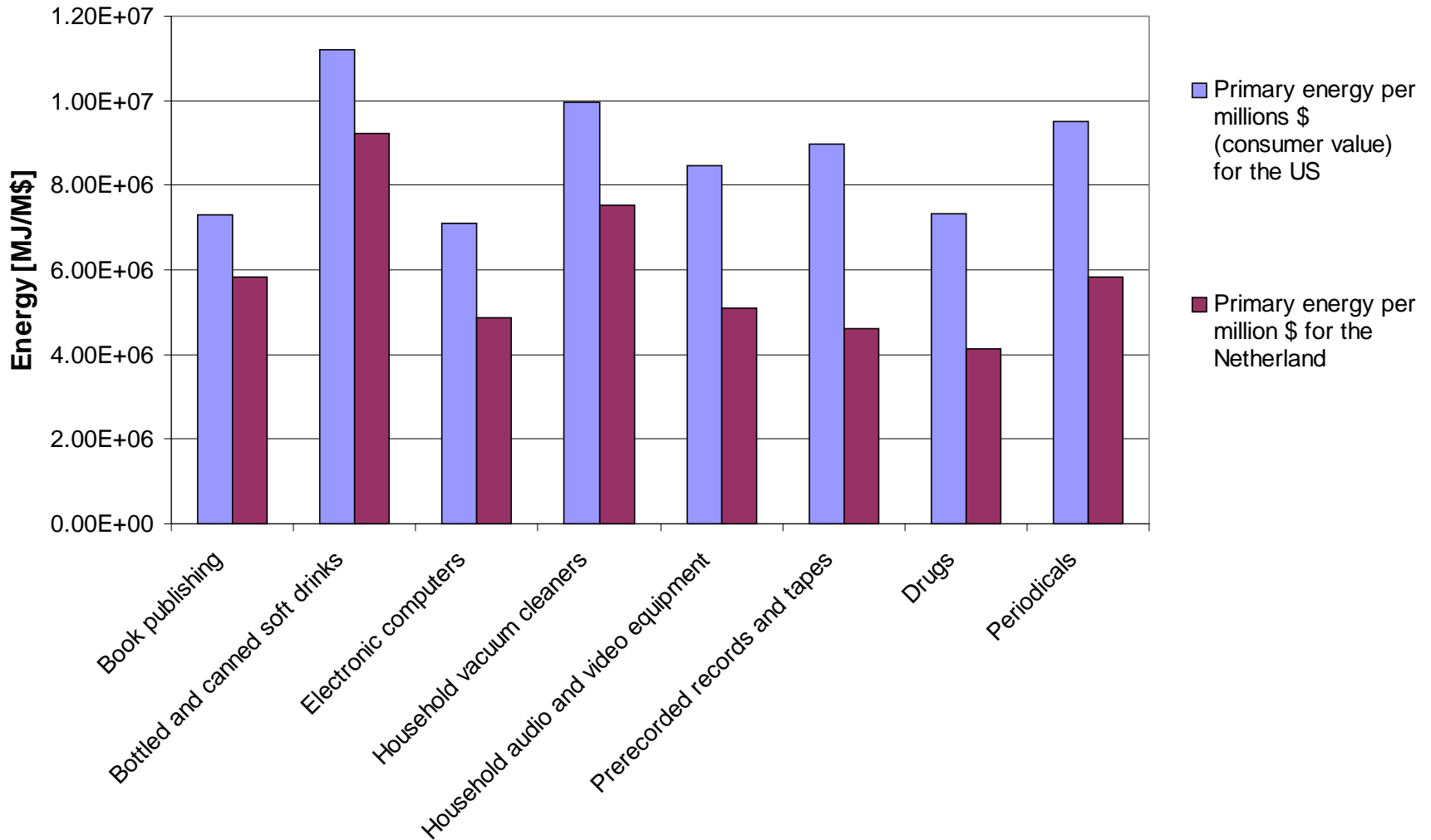
In an IO LCA all the sectors of the economy are described, therefore all the contributions are taken into account. For example (see next slide): the air transportation, the hotels and lodging place and the automotive rental are normally not considered in a PLCA

Different levels of comprehensiveness

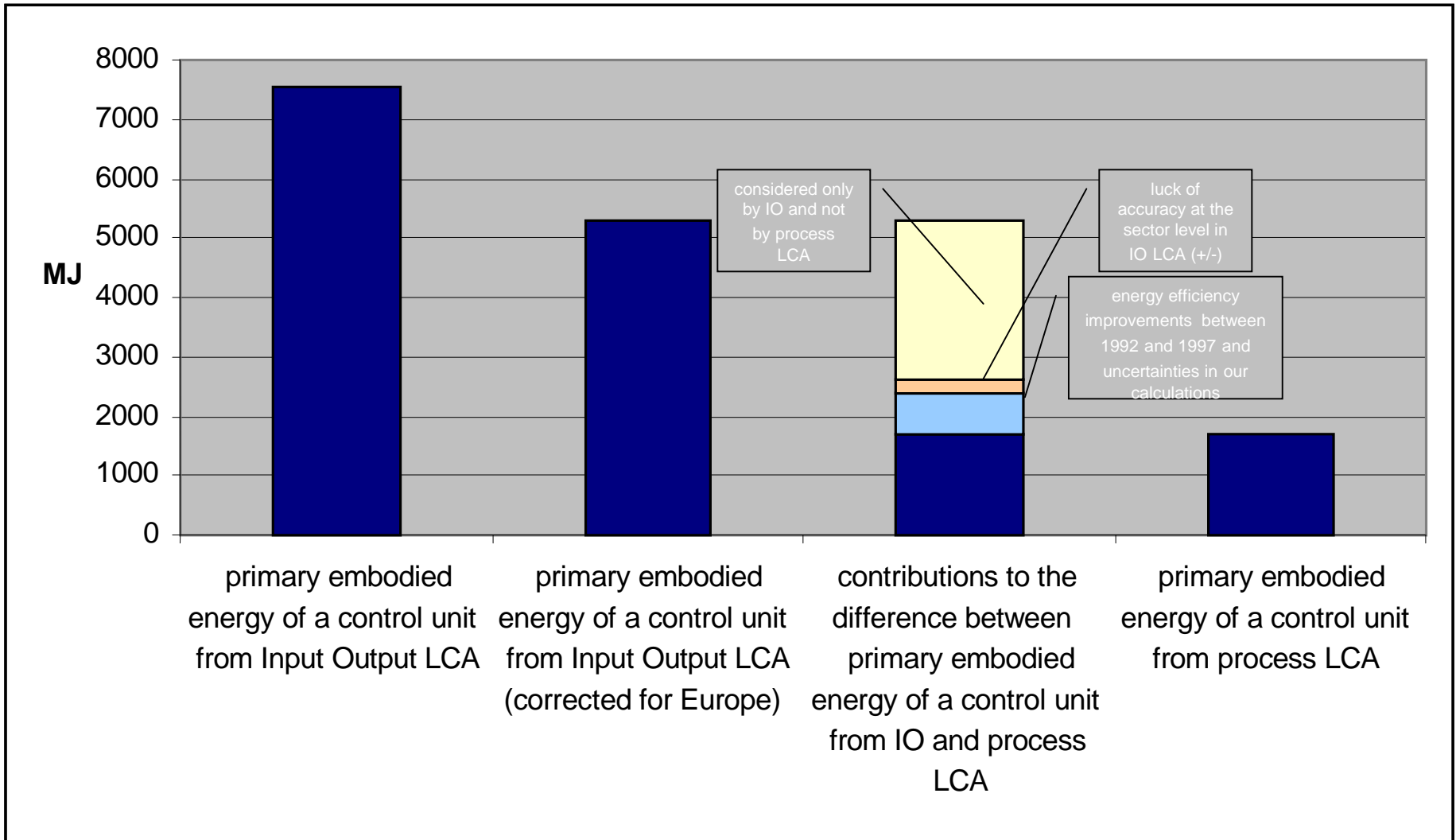
	% to total upstream embodied energy	cumulative %
Air transportation	12%	12%
Electric services (utilities)	12%	24%
Computer peripheral equipment	10%	34%
Wholesale trade	10%	43%
Semiconductors and related devices	9%	53%
Petroleum refining	6%	59%
Other electronic components	5%	64%
Miscellaneous plastics products, n.e.c.	4%	68%
Relays and industrial controls	3%	71%
Gas production and distribution (utilities)	3%	74%
Automotive rental and leasing, without drivers	2%	76%
Hotels and lodging places	2%	78%
Telephone and telegraph apparatus	2%	80%
Aluminum rolling and drawing	2%	81%
Motors and generators	1%	83%
Blast furnaces and steel mills	1%	84%
Sheet metal work	1%	85%
Electron tubes	1%	85%
Nonferrous wiredrawing and insulating	1%	86%
Fabricated metal products, n.e.c.	1%	87%
Legal services	1%	87%
Paperboard containers and boxes	1%	88%
Motor freight transportation and warehousing	1%	89%
Power, distribution, and specialty transformers	1%	89%
Gaskets, packing, and sealing devices	1%	90%
Metal stampings, n.e.c.	1%	91%
Real estate agents, managers, operators, and lessors	1%	91%
Banking	1%	92%
Eating and drinking places	1%	92%
Management and consulting services, testing and research labs	1%	93%

Yellow = not normally considered in a PLCA


Difference in the energy efficiency of US and Europe



Where does the difference between Process and IO-LCA come from



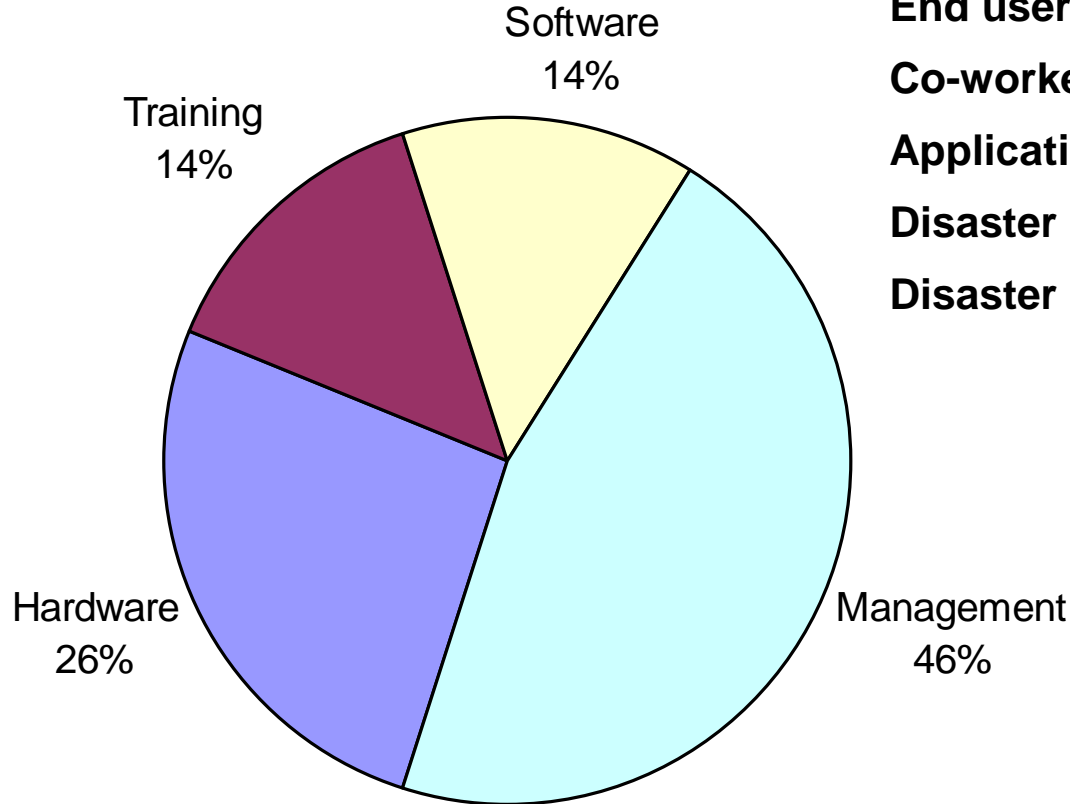
Remark



We only took into account the necessary physical equipment of the Internet infrastructure. But, if we have a closer look (see next slide), the main expenses related to a computer network come from other sectors than equipment (for example software, maintenance, management, etc...).

If the boundaries are extended

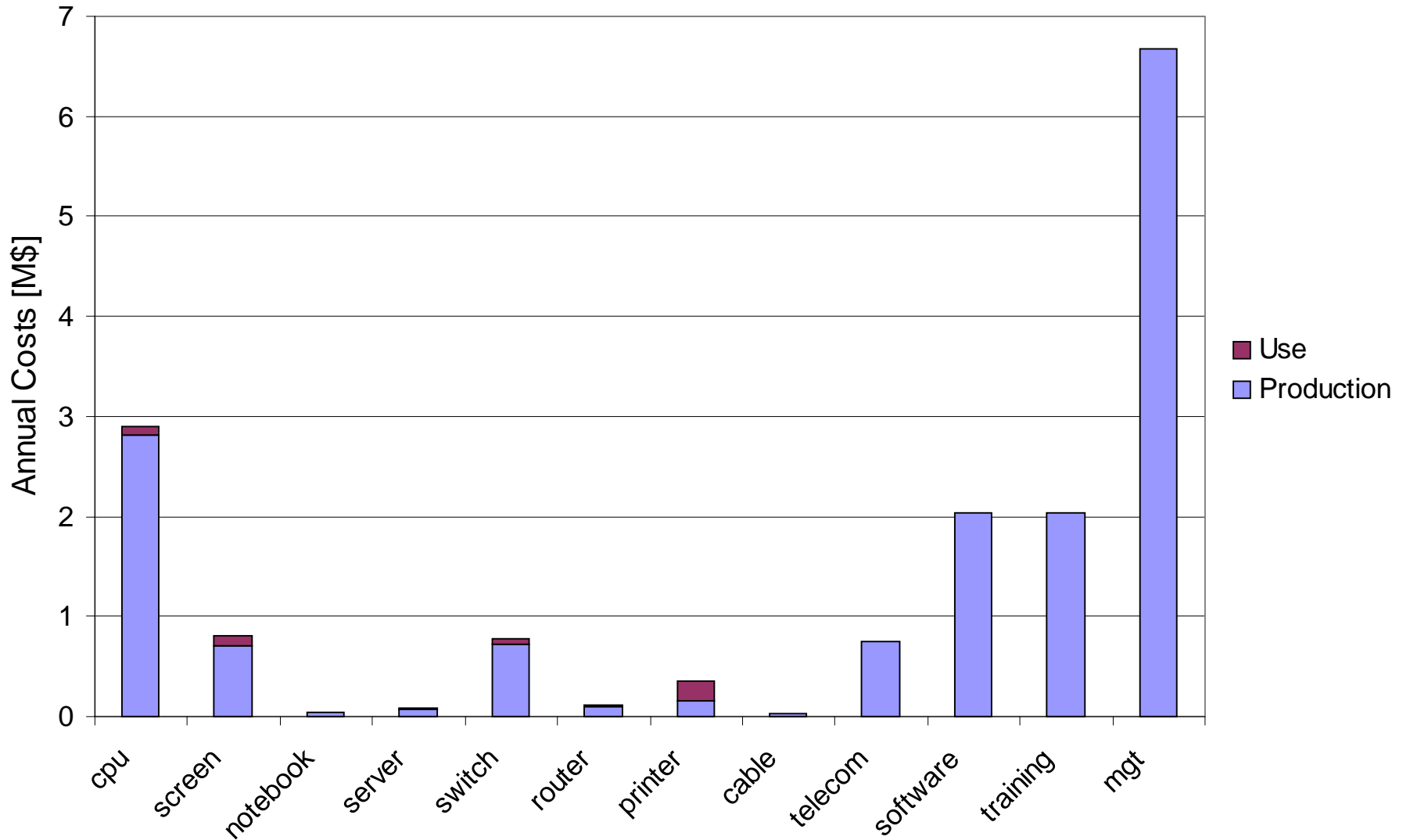
Total Cost of IT Ownership, Forrester Consultants, 1997



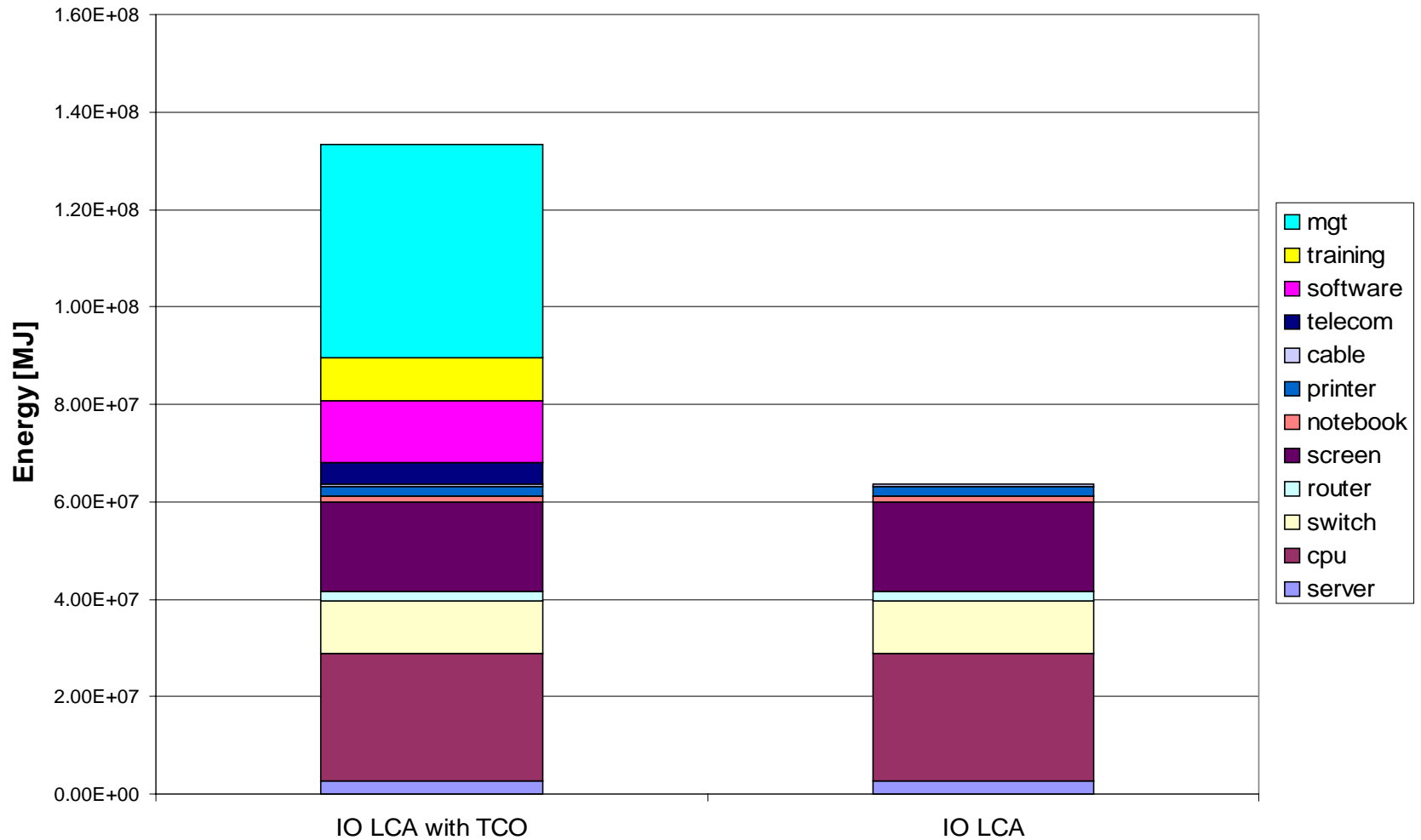
Management Costs:

Administration	34%
End user downtime	35%
Co-worker time	14%
Application developm't	14%
Disaster prevention	5%
Disaster recovery	12%

Annual Costs, EPFL Internet




Considering the other expenses and using an IO LCA



TCO = Total Cost of Ownership

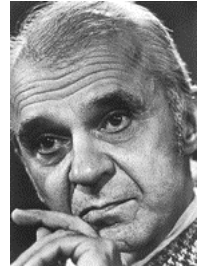
Future work

- Look at all the expenses related to the computer network (maintenance, software, buildings, security equipment, etc...) and evaluate their impacts.
- Use an hybrid approach to assess in more details the important contributions (PC, electricity, ?,...)



The next slides present very quickly
the Input-Output theory used to
perform the Input-Output Life Cycle
Assessment

- Original work done by Wassily Leontief (1906-1999) in the 60 's.
- Economic theory/model to assess the economic system.
- Combined with environmental data (for example to perform LCA).

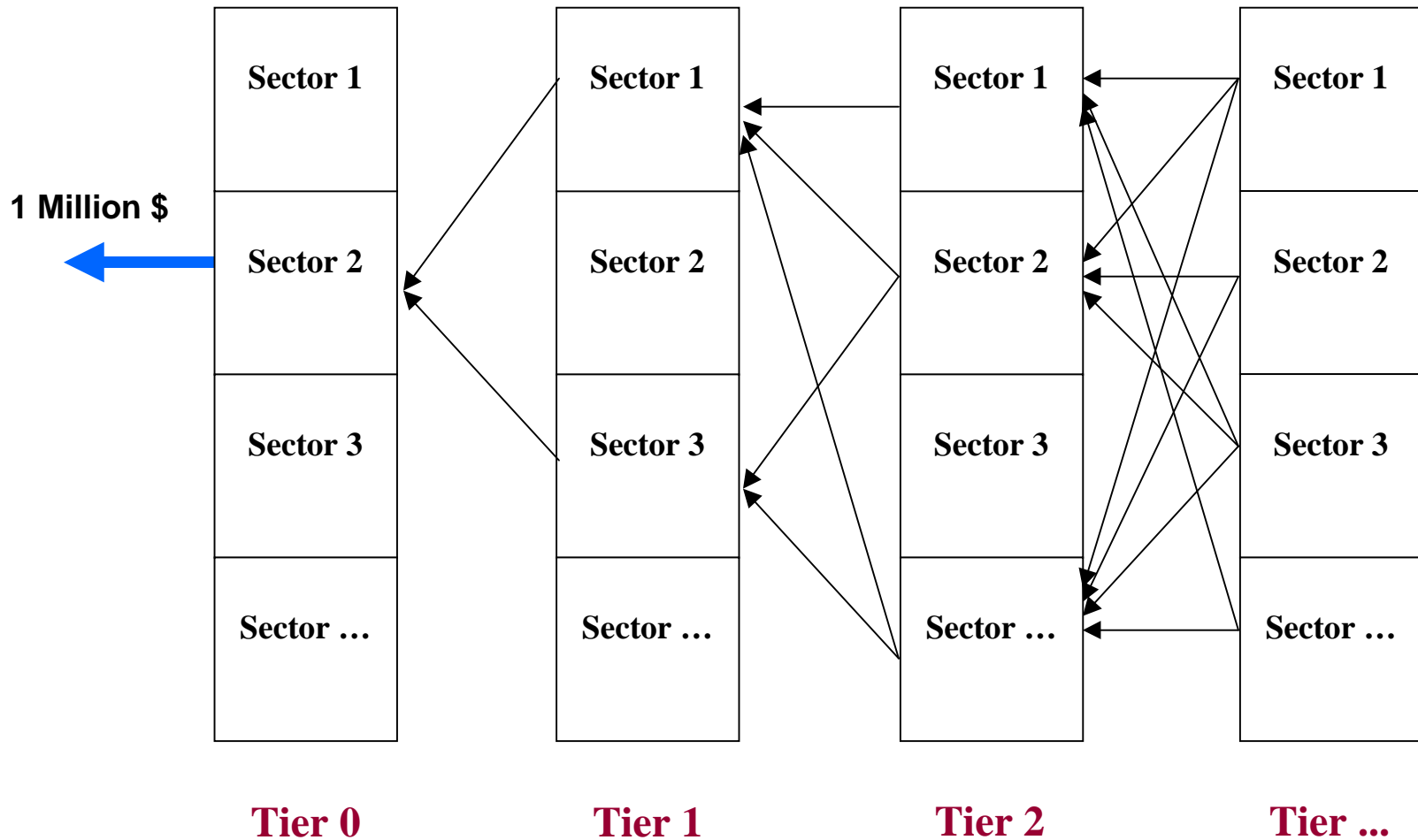


1) The economy is divided in sectors.

The US economy is divided in around 500 sectors
(Examples: poultry and eggs, cotton, crude petroleum
and natural gas, cookies and crackers, cigars, newspaper,
luggage, metal heat treating, water transportation,
hospitals, child day care service, etc...)

2) Statistical data on the monetary flows between these sectors are collected.

The structure of the economy



The Input-Output equation

$$\vec{X} = (\mathbf{I} - \mathbf{A})^{-1} \vec{Y}$$

Y = The final demand (for instance 5 \$ of aluminium)

X = The necessary output of all the sectors to produce
the 5 \$ of aluminium

The environmental equation

$$\vec{f} = F \cdot \vec{X} = F(I - A)^{-1} \vec{Y}$$

X = total output

F = matrix of environmental impacts

\vec{f} = total impact