Early Replacement of Notebooks Considering Environmental Impacts

- Study commissioned by the German Federal Environment Agency (UBA)

Siddharth Prakash, Öko-Institut e.V.

Ran Liu, Öko-Institut e.V.

Dr. Lutz Stobbe, IZM

Karsten Schischke, IZM

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About Öko-Institut e.V.

- **Öko-Institut is a leading European research and consultancy institute working for a sustainable future.**
- **Founded in 1977, non-profit association**
- **More than 130 staff, including 85 researchers**
- **Offices in Freiburg, Darmstadt and Berlin**

About Öko-Institut e.V.

- Clients: European Union, ministries, industrial companies, non-governmental organizations
- Annual turnover: some 12 million Euros

Our Issues

- Energy and Climate Protection
- Nuclear Engineering and Facility Safety
- Sustainability in Consumption, Mobility, Resource Management and Industry
- Law, Policy and Governance
- Emission and Ambient Pollution Control
- Chemicals Management and Technology Assessment
- Agriculture and Biodiversity

Background

- Production of notebooks is highly material and energy intensive
- Empirical evidence suggests that actual life-time of notebooks is getting shorter

Public authorities and private consumers lack information on the ecologically optimum time period for the replacement of notebooks

- Wide variations in the life-cycle assessment of notebooks

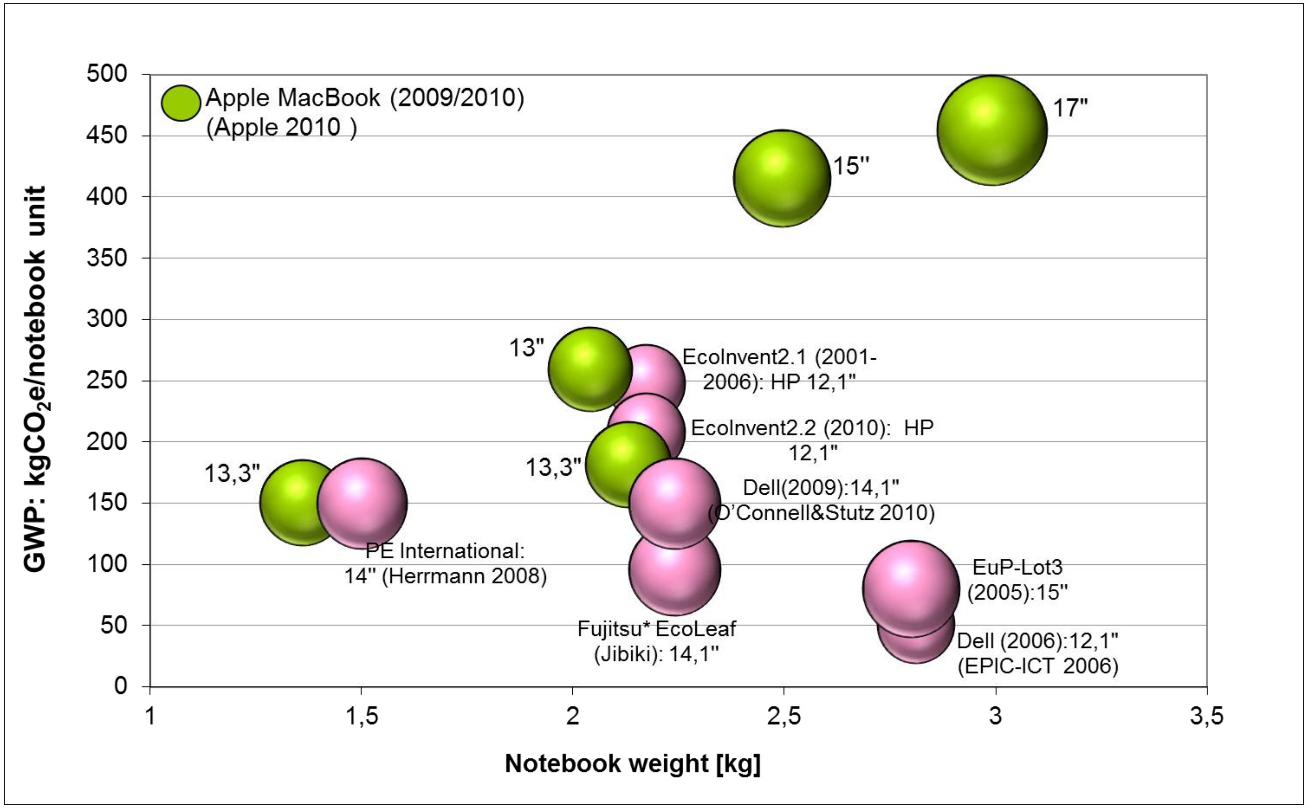


Figure 1: Global Warming Potential (CO_2e) in the production phase of selected notebooks

Background

- UBA R&D Project UFOPLAN (2009): Creation of a database for determination of the environmental impacts of ICT products

No.	Dataset name in ProBas	Reference unit	Notes
1.	Display module production	1 TFT LCD module	With upstream chains
2.	Silicon wafer production	1 cm^2 polished silicon wafer	Partly with upstream chains. The upstream chains of hydrogen chloride, graphite and electrical energy are not included
3.	IC fabrication front-end process \ “wafer out”	1 cm^2 finished wafer out	Without upstream chain. However, the additional input factors for the production of high-purity process chemicals are characterised.
4.	IC fabrication front-end process \ “good die out”	1 cm^2 defect-free die out	Without upstream chain. However, the additional input factors for the production of high-purity process chemicals are characterised.
5.	IC fabrication back-end process	1 memory IC	Without upstream chain

Objectives

What is the share of different life cycle phases in the total greenhouse gas emissions of a notebook?

When are the environmental impacts, which are associated with the production, distribution and disposal of a new notebook, compensated as a result of energy efficiency gains in the use-phase of the new notebook?

Which energy efficiency gains should be possessed by a new notebook, if the replacement of the older and less energy efficient notebook can be justified under the consideration of environmental concerns?

Methodology

- Measurement of greenhouse gas emissions of a notebook on the basis of three different data sources

- EuP Lot 3
- EcoInvent 2.2
- UBA R&D Project, UFOPLAN 2009

Table 1: Overview of data sources and assumptions for the scenarios studied[9]

Scena-rio No.	Production	Transport (distribution to wholesalers + to retailers)	Shopping trip	Use	End-of-life
1	Calculated following EuP Lot 3	Calculated following EuP Lot 3	Assumptions: 10 km round trip by car	In accordance with the utilisation profile of Energy Star Version 5.0	Calculated following EuP Lot 3
2	Calculated in accordance with data from EcoInvent 2.2	Assumptions: 1) Production sites -> airport: truck: 500 km 2) Flight: Shanghai -> Warsaw: 8000 km 3) Distribution to retailers: truck: 1000 km			Business-as-usual
3	Calculated in accordance with data from UBA R&D project (UFOPLAN 2009) (for display module and ICs) + EcoInvent 2.2 (other components)[10]				Business-as-usual
4	Calculated in accordance with data from UBA R&D project (UFOPLAN 2009) (for display module and ICs) + EcoInvent 2.2 (other components)[8]				Best practice

Methodology

Function und functional unit – 1 Notebook with a life-time of 5 years

Table 2: Notebook specifications in EuP Lot 3, EcoInvent 2.2 and UBA R&D project (UFOPLAN 2009)

	EcoInvent 2.2	EuP Lot 3	UBA R&D project (UFOPLAN 2009)
CPU	Pentium 3, 600 MHz	1.7 GHz	Pentium 3, 600MHz[12]
HDD	10 GB HDD	60 GB HDD	10 GB HDD[9]
Memory IC	128 MB RAM	512 MB RAM	8 GB
Display size	12.1"	15"	15.4"
Weight	3.15 kg (with packaging) 2.17kg (without packaging)	3.7 kg (with packaging) 2.8 kg (without packaging)	3.3 (with packaging) 2.4 (without packaging)[13]
Reference year	2005	2005	2000-2010

- Goal of the study was not to produce a comparative LCA of different notebooks
- The procedure adopted for this LCA study still follows ISO 14040/44, but only examines one impact category, namely Global Warming Potential (GWP)

Methodology

Use Phase based on data bank of Energy Star Version 5.0 for Computers

Table 17: Weighting of the operational states of a notebook (Energy Star® Version 5.0)

Operational state	Proportion
T-Off	60%
T-Sleep	10%
T-Idle	30%

Table 18: TEC values (kWh/a) of the notebooks[32], as of August 2010 (Energy Star® Version 5.0)

	Category A[33]	Category B	Category C
Number of models measured, base configuration (n)	1190	264	9
TEC: Annual average electricity consumption	30.1 kWh	40.2 kWh	68.5 kWh
TEC: Annual average over the three categories		46.3 kWh	
Average electricity consumption over a period of 5 years (according to assumed lifetime)		231.3 kWh	

Methodology

Umwelt Bundes Amt – Für Mensch und Umwelt
Fraunhofer IZM
Öko-Institut e.V. – Institut für angewandte Ökologie – Institute for Applied Ecology

End-Of-Life

-EcoInvent 2.2 - „*Disposal, Laptop Computer, in E-Scrap-Processing*“

-BUSINESS-AS-USUAL

Table 21: Recycling rates for business-as-usual scenario

Precious metals	Business-as-usual	Source
Ag	40%	Personal communication[35]
Au	40%	Chancerel 2010
Pd	40%	Chancerel 2010

-BEST PRACTICE

Table 22: Recycling rates for best practice[36]

Precious metal	Best practice	Source
Ag	87%	Prakash and Manhart 2010
Au	93%	Prakash and Manhart 2010
Pd	91%	Prakash and Manhart 2010

Methodology

End-Of-Life

-EcoInvent 2.2 - „*Disposal, Laptop Computer, in E-Scrap-Processing*“

Table 20: Estimated Ag, Au and Pd proportions in the notebook

Precious metal	EuP Lot 3 (excl. printed wiring board)	Gref et al. 2008 (only printed wiring board)	Total (EuP Lot 3; Gref et al.)	Gmünder 2007
Ag	0.01%	0.005%	0.015% 360 mg	0.017%
Au	0%	0.010%	0.010% 240 mg	0.003%
Pd	no data	no data	no data	0.001% 24 mg

Methodology

Amortisation calculation

- Assumptions
  - New notebook more energy efficient than the old notebook
  - Energy efficiency improvements of the new notebooks in 10% intervals (10%, 20%, 30%.........70%)
  - Measurement of the saving potential of the new notebook

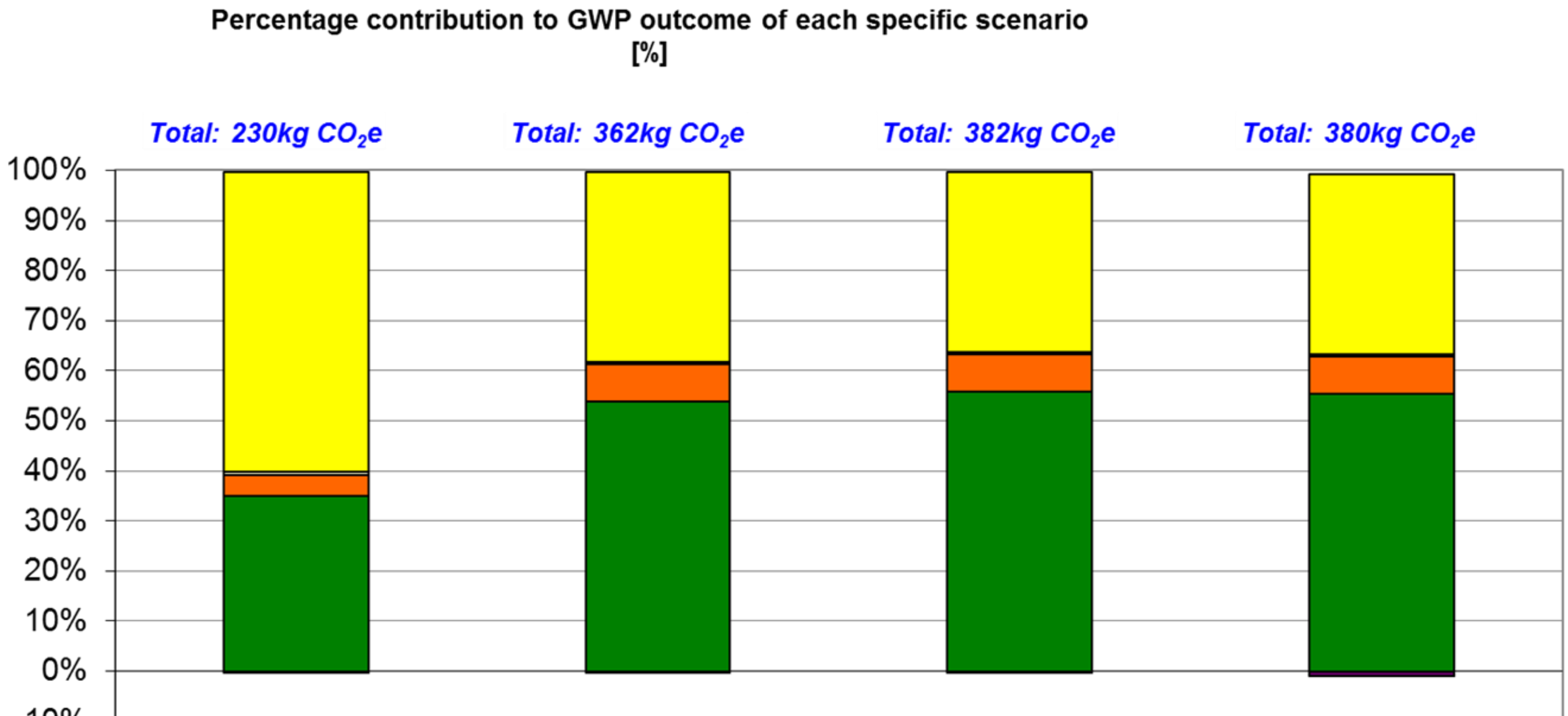
$$GWP_{\text{Saving potential}} = GWP\_{}_{\text{Use}}\ [kg\ CO_2e/year/notebook] * x[\%])$$

Amortisation time:

$$= \frac{GWP_{\text{Production distribution, disposal}}}{GWP_{\text{Saving potential}}}$$

Results

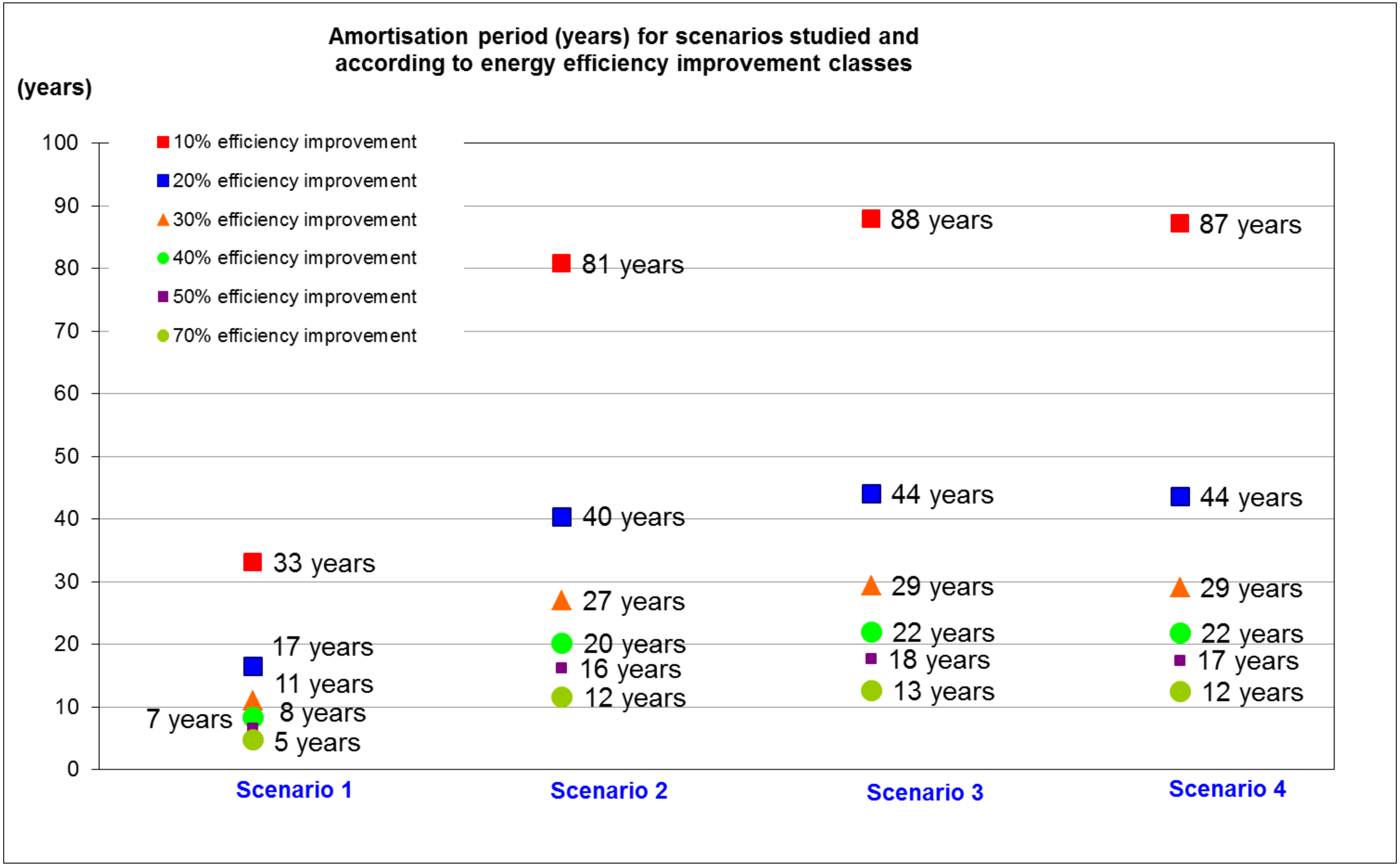
Absolute GWP emissions outcome for all scenarios studied (kg CO_2e/notebook)



	EuP Lot3	EcoInvent2.2	UBA R&D project (UFOPLAN 2009) + EcoInvent 2.2 (end-of-life business-as-usual)	UBA R&D project (UFOPLAN 2009) + EcoInvent 2.2 (end-of-life best practice)
End of life	-1,00	-1,05	-1,17	-3,42
Use	138,5	138,5	138,5	138,5
Shopping trip	1,4	1,4	1,4	1,4
Distribution	10,0	27,4	29,0	29,0
Production	81,0	195,8	214,2	214,2

Results

Amortisation period as a function of energy efficiency improvement in the use phase



Results

Sensitivity Analysis: Significance of life-time

Lifetime	Electricity consumption/lifetime	GWP values in the use phase
Base analysis (lifetime of 5 years)	231.3 kWh/5a	138.5 kg CO_2e/notebook within 5 years
Sensitivity analysis 6 (lifetime of 2.9 years)	134.2 kWh/2.9a	80.3 kg CO_2e/notebook within 2.9 years
Deviation from base analysis in %	-42%	-42%

Manufacturing phase contributes towards 76% of the total greenhouse gas emissions of a notebook, if the life-time is reduced to 2,9 years

Results

Sensitivity Analysis: Use phase according to EuP Lot 3

Table 31: Compilation of electricity consumption in the use phase of the base analysis and sensitivity analysis, according to different data sources

	Electricity consumption/ 5 years lifetime	GWP values in the use phase
Base analysis (after Energy Star® Version 5.0)	231.3 kWh	138.5 kg CO_2e/one notebook within 5 years
Sensitivity analysis 2 (after EuP Lot3)	486.7 kWh	291.4 kg CO_2e /one notebook within 5 years
Deviation from base analysis in %	+110.4%	+110.4%

Manufacturing phase contributes towards 46% of the total greenhouse gas emissions of a notebook, if use phase is modelled according to EuP Lot 3

Conclusions

Recycling: Low concentration of selected metals (Au, Ag and Pd) in Notebooks leads to a small reduction potential of 3 kg CO_2e per Notebook between Best-Practice und Business-as-Usual Scenario

Recycling: If recovery of a larger group of metals is considered, the reduction potential of greenhousegas emissions would be much higher, and, if other environmental impacts, such as acidification and eutrophication potential, are considered, reduction in the total environmental burden is more visible.

Production: The share of production phase is lowest with EuP Lot 3 (81 kg CO_2e; 35,2%) and highest with the data source of UBA R&D project (216 kg CO_2e; 56%)

Production: Production of the Motherboard causes 70 to 85 kg CO_2e;
Production of the display module causes 35 to 41 kg CO_2e

Use: Even if the energy consumption in the use-phase is doubled, environmental burden of production phase is quite substantial.

The MEEuP-method used within the framework of ecodesign directive underestimates the environmental burden of the production of electronic components

Extension of life-time of a notebook reduces the contribution of production phase towards total greenhouse gas emissions of a notebook

Conclusions

Proceeding from an assumed lifetime of 5 years, this means that a replacement of the notebook only pays in environmental terms if the EuP Lot 3 data are used, but even then only if energy efficiency is improved by 70%. Such an efficiency improvement between two notebook generations of similar configuration and functionality is unrealistic.

If we assume a realistic energy efficiency improvement of 10% between two notebook generations, the amortisation periods are between 33 and 88 years, while if energy efficiency improves by 20% the period is between 17 and 44 years, depending upon the data source used to analyse notebook production. Evidently no notebook has such a useful lifetime.

Amortisation calculation: The analysis of environmental amortisation periods has shown that the environmental impact associated with the production of a notebook is so great that it cannot be compensated in a realistic period of time by its improved energy efficiency during the use phase – regardless of which data source is used.

It therefore follows from this study that it is not environmentally purposeful (with regard to global warming potential) to purchase a new notebook after a period of only a few years, even if the assumed energy efficiency of the new device exploits the full scope of cutting-edge technology.

Conclusions

Focus of product design for ICT devices should be placed on the aspects that lead to an extension of device lifetimes

- Possibilities of hardware upgrading
- Modular construction
- Recycling-friendly design
- Availability of spare parts
- Standardisation of components
- Extension of minimum warranty periods

Thank you very much for your attention!

Contact Details:
Siddharth Prakash
Sustainable Products & Material Flows
Öko-Institut
Tel: +49-761-45295-244
E-Mail: s.prakash@oeko.de