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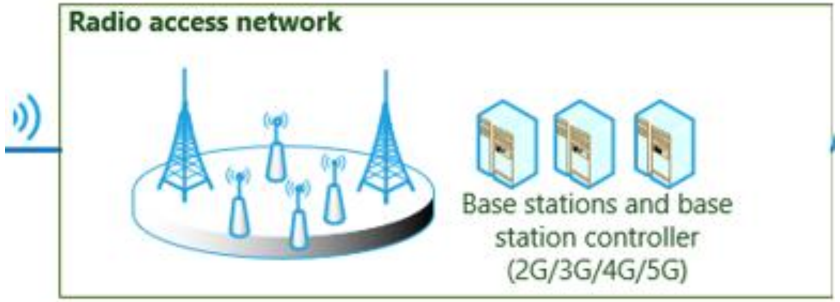
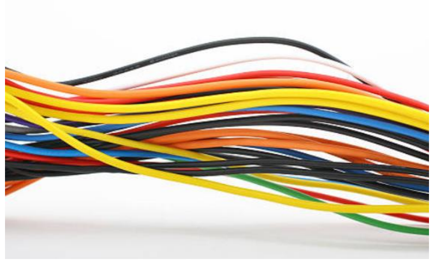
Environmental impacts of **software applications**: Digital basic resources and the automated environmental evaluation of **digital services**



ECO DIGIT



Dirk Bunke; Ran Liu; Felix Behrens; Jens Gröger   Öko-Institut e.V.

ETSI and ITU Symposium on ICT Sustainability

Geneva, 11 December 2024

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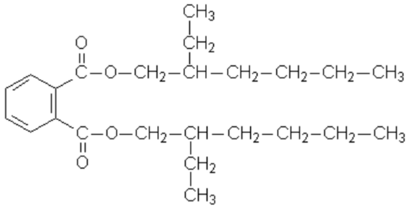
What is it about?

ECO:DIGIT

- **The question:** How to assess (and optimize) the ecological footprint of digital services?

- **The project ECO:DIGIT**
- **Main elements of the approach:**
  - Digital supply chains
  - Digital basic resources
  - LCA and supplements: MEG equivalents + the SVHC Score
  - The test bench.



-1- The project

ECO DIGIT

Enabling green COmputing and DIGItal Transformation

- funded by the Federal Ministry for Economic Affairs and Climate Protection (BMWK)
- Timeline: 01.05.2023 - 30.04.2026
- Project team:

GESELLSCHAFT FÜR INFORMATIK | adesso | Öko-Institut e.V. Institut für angewandte Ökologie Institute for Applied Ecology | plusserver

ScaleUp Technologies | SIEMENS | OSB Open Source Business ALLIANCE Bundesverband für digitale Souveränität e.V.

- https://ecodigit.de/en/home

-1- The project ECO DIGIT

Main Goal:

- To evaluate the **environmental impacts** of software applications by using a **transparent and standardized method**

↓

- Develop, validate, and provide an automated evaluation environment (**test bench**) that transparently discloses **key figures** (e.g. power consumption, the use of hardware resources, data transferred).
- The test bench considers software applications operating in four **deployment scenarios: mobile networks, end devices, cloud platforms, and edge computing.**

Key questions and steps for software developers / supplier:

- How is your software distributed on data centers and end devices?
- On which hardware does your software run?
- What are the environmental impacts of manufacture, software, power? (We can give estimates, if needed).
- Run your software on the test bench.
- We measure digital basic resources with performance counters.
- Get the environmental impact of your application!

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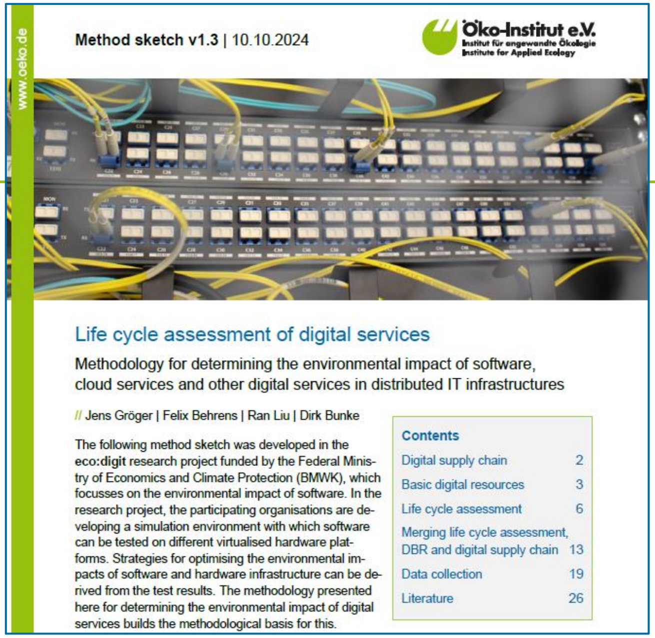
The approach in detail:


Method sketch v1.3 | 10.10.2024

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Life cycle assessment of digital services

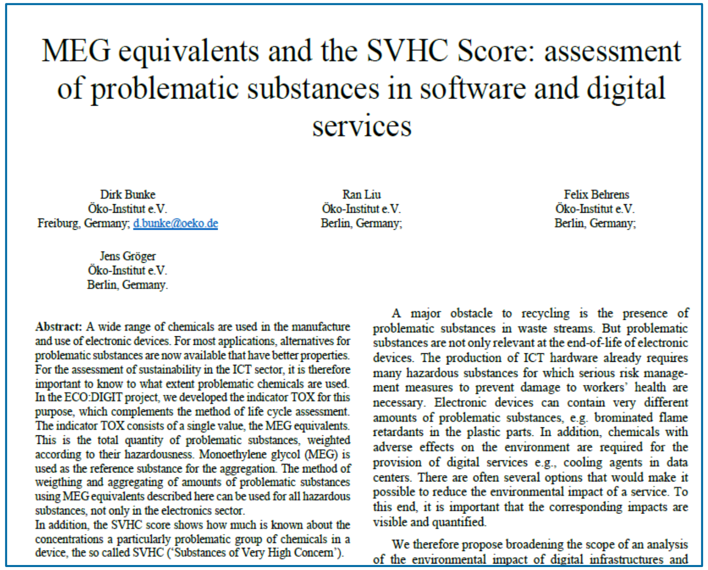
Methodology for determining the environmental impact of software, cloud services and other digital services in distributed IT infrastructures

// Jens Gröger | Felix Behrens | Ran Liu | Dirk Bunke

The following method sketch was developed in the eco:digit research project funded by the Federal Ministry of Economics and Climate Protection (BMWK), which focusses on the environmental impact of software. In the research project, the participating organisations are developing a simulation environment with which software can be tested on different virtualised hardware platforms. Strategies for optimising the environmental impacts of software and hardware infrastructure can be derived from the test results. The methodology presented here for determining the environmental impact of digital services builds the methodological basis for this.

Contents

- Assessing the ecological
  impacts of digital services:


MEG equivalents and the SVHC Score: assessment of problematic substances in software and digital services

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Berlin, Germany.

Abstract: A wide range of chemicals are used in the manufacture and use of electronic devices. For most applications, alternatives for problematic substances are now available that have better properties. For the assessment of sustainability in the ICT sector, it is therefore important to know to what extent problematic chemicals are used. In the ECO:DIGIT project, we developed the indicator TOX for this purpose, which complements the method of life cycle assessment. The indicator TOX consists of a single value, the MEG equivalents. This is the total quantity of problematic substances, weighted according to their hazardousness. Monoethylene glycol (MEG) is used as the reference substance for the aggregation. The method of weighting and aggregating of amounts of problematic substances using MEG equivalents described here can be used for all hazardous substances, not only in the electronics sector.
In addition, the SVHC score shows how much is known about the concentrations a particularly problematic group of chemicals in a device, the so called SVHC ('Substances of Very High Concern').

A major obstacle to recycling is the presence of problematic substances in waste streams. But problematic substances are not only relevant at the end-of-life of electronic devices. The production of ICT hardware already requires many hazardous substances for which serious risk management measures to prevent damage to workers' health are necessary. Electronic devices can contain very different amounts of problematic substances, e.g. brominated flame retardants in the plastic parts. In addition, chemicals with adverse effects on the environment are required for the provision of digital services e.g., cooling agents in data centers. There are often several options that would make it possible to reduce the environmental impact of a service. To this end, it is important that the corresponding impacts are visible and quantified.

We therefore propose broadening the scope of an analysis of the environmental impact of digital infrastructures and

- Assessing hazardous substances:
  MEG equivalents and the SVHC Score

https://ecodigit.de/en/home/publications
https://www.oeko.de/en/publications/meg-equivalents-and-the-svhc-score-assessment-of-problematic-substances-in-software-and-digital-services/

- Now: Focus on some key elements

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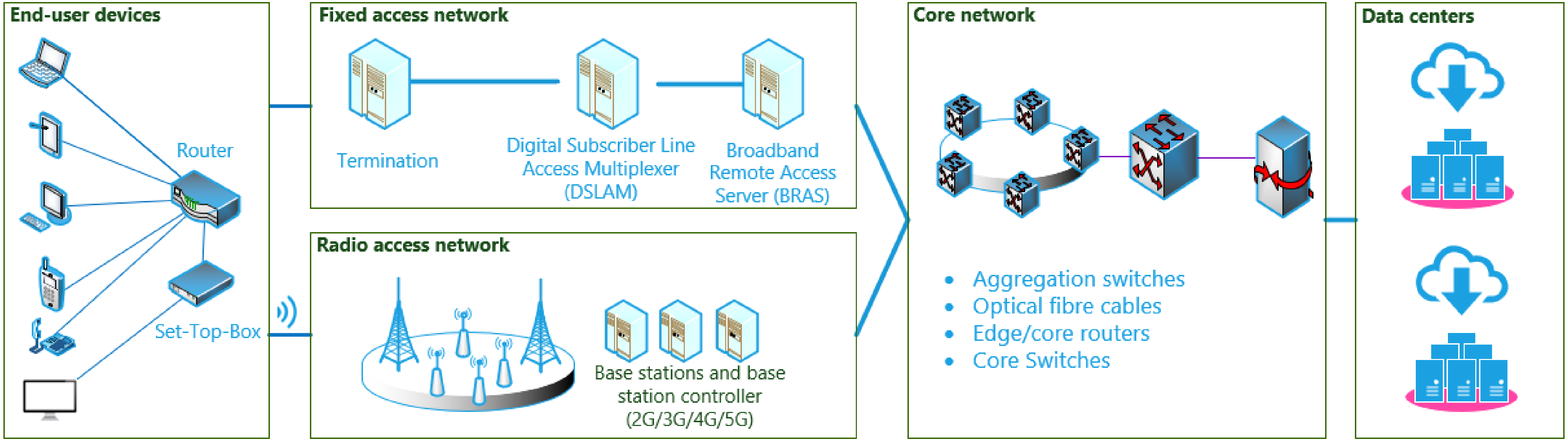
-2- What is needed to perform the digital service ?

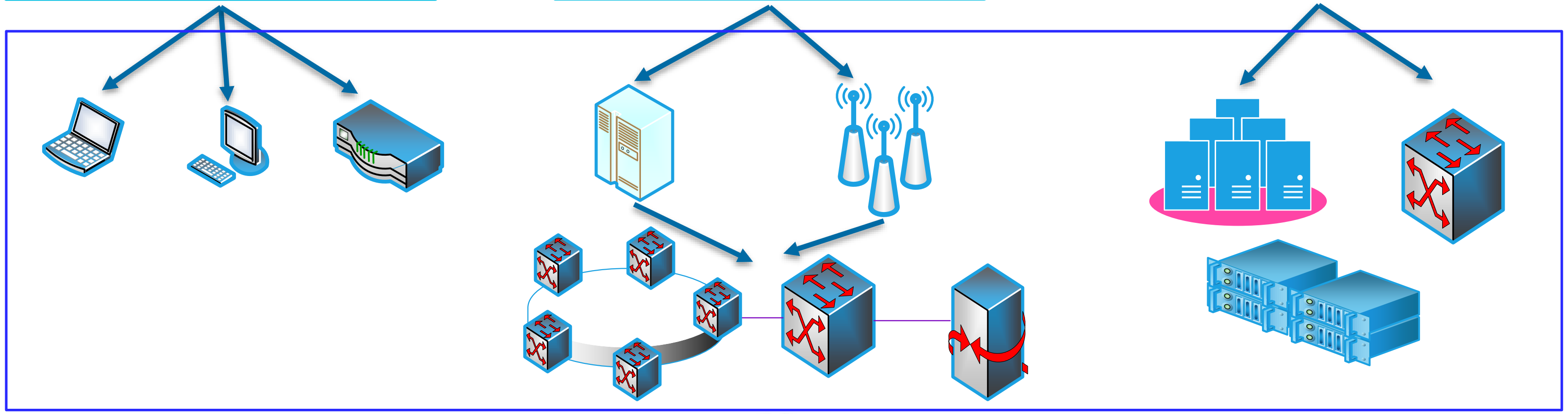
The digital supply chain: The backbone to deliver a digital service



- **Identify the components (hardware devices = „platforms“) involved to deliver the specific digital service**

-3- The common structural elements: Four digital basic resources (DBR)

End-user devices | Networks | Data centers



Digital basic resources

Compute	Store	Memorize	Transfer
CPU, GPU	HDD; SSD	RAM	Network-card

-3- Digital basic resources and digital work

Each hardware component: a specific amount of digital basic resources

- **Example: average digital resources provided by a platform**

Table 1: Exemplary basic digital resources of a platform

Hardware component	Abbreviation	Digital basic resource of the platform (DBR)	Exam-ple	Unit	Average capac-ity utilisation or occupancy (load coverage)	Average basic digital resource provided basic digital re-source (DBRa ver-age)
CPU	co (compute)	CPU frequency * bus width	128	GHz*bit	20%	25.6 GHz*bit
RAM	me (memorise)	Working memory space	8	Gigabyte	10%	0.8 gigabyte
Storage	st (store)	Hard disc space	4.000	Gigabyte	50%	2,000 gigabytes
Network	tr (transfer)	Maximum data transmission	100	Megabit/s	2%	2 megabit/s

Source: Öko-Institut

- **Multiplication with life expectancy and average load** → **digital work over the lifetime**

-4- Digital basic resources and their ecological impact

Assess the ecological impacts

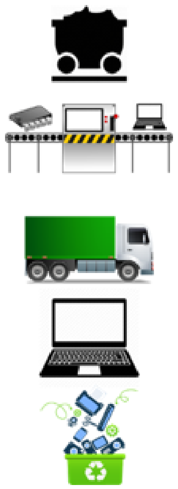
- for production of hardware
- for use of hardware.

Extraction from the environment

- Energy source (fossil, nuclear, renewable)
- Ores and other minerals (e.g. iron, alumin-ium, silicon)
- Water
- Organic re-sources
- Soil
- ...

Life phases

- Extraction of raw materials
- Production and assembly
- Transport
- Utilisation phase
- Waste disposal



Inputs into the environment

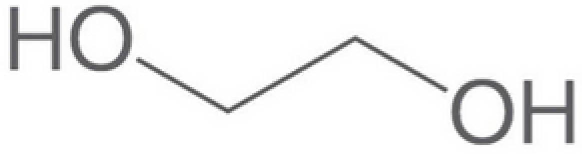
- Emissions into the air (e.g. greenhouse gas emissions)
- Solid waste from in-cineration
- Waste heat
- Contaminated water
- Deterioration of soil quality
- Electronic waste
- Land consumption for landfill sites
- Pollutants
- ...

Source: Öko-Institut

Recommendation: Go beyond CO2 and energy!

Environmental impacts: Categories investigated in eco:digit

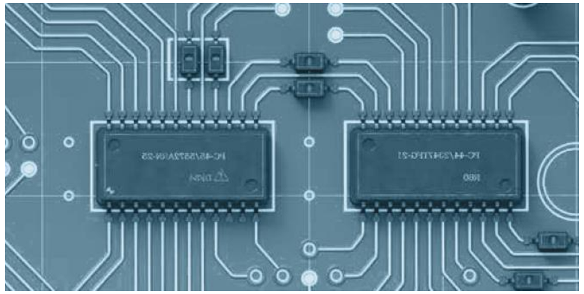
- **Global Warming** Potential (GWP)
- **Abiotic Resource Depletion** Potential (ADP)
- **Water Use** (WU)
- Cumulative **Energy Demand** (CED) of digital infrastructures.
- Total quantity of **Waste** Electrical and Electronic Equipment (WEEE) in kilograms
- **Problematic substances in the digital supply chain** (TOX) (in **MEG equivalents**) (3 aspects) + **SVHC Score**



TOX: Problematic substances within the digital supply chain
Element 1: Use of hazardous substances: production of ICT hardware

Table 1 **Inventory of chemicals used for the production of wafer, weigthing factors and MEG equivalents. Unit: g/cm2 wafer output.**

Substance	Amount		Weighting Human Health	MEG equivalents	
Sulfuric acid	6	g/cm^2	100	12	g/cm^2
Hydrogen peroxide	2	g/cm^2	100	4	g/cm^2
Hydrogene fluoride	0.5	g/cm^2	1,000	10	g/cm^2
Phosphorous acid	2.7	g/cm^2	100	5.4	g/cm^2
2-Propanol	2.3	g/cm^2	50	2.3	g/cm^2
Ammonium hydroxide	0.89	g/cm^2	100	1.78	g/cm^2



- Data from the LCA inventory
- Important information even independent from exposure situation

  Aggregation: MEG equivalents

  * Weighting: H phrases

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-5- Environmental impacts: Calculation specific to main components

Separate calculation of the environmental impacts in the manufacturing phase for

• Processors	Compute
• Main Memory	Store
• Permanent Memory	Memorize
• Network components	Transfer

- shared components (e.g. power supply, housing) = **“overhead”**

-6- How much does one unit of a specific DBR cost? / 2

Calculate effort / benefits ratios: e.g. for the utilisation phase / 1

$$EBR = effort\ benefit\ ratio = \frac{effort}{benefit}$$

- Environmental impact: depending on the emissions factors for energy
- e.g. **1 kWh electricity = 420 grams CO2 equivalents** (electricity mix Germany 2020)

Emission factors for electrical energy

Environmental impact category (EI)	Emission factor (EF)	Example value (electricity mix, DE, 2020)	Unit
CED	CED_{el}	8,37	[MJ/kWh_{el}]
GWP	GWP_{el}	0,421	[kg CO_2 e/kWh_{el}]
ADP	ADP_{el}	5,24 E-6	[kg Sb eq/kWh_{el}]
Water	$Water_{el}$	0,239	[m^3 world eq/kWh_{el}]
WEEE	$WEEE_{el}$	n.a.	[kg WEEE/kWh_{el}]
TOX	TOX_{el}	n.a.	[kg MEG eq/kWh_{el}]

Source: Öko-Institut (according to Ecoinvent 3.10) Legend: n.a. = not applicable

-6- How much does one unit of a specific DBR cost? / 3

Calculate effort / benefits ratios: e.g. for the utilisation phase / 2

$$EBR = effort\ benefit\ ratio = \frac{effort}{benefit}$$

- Example: personal computer, average power consumption specific for DBR „Compute“

Effort benefit ratios in utilisation phase (P_{el} in relation to DBR)

DBR abbreviation	$P_{average}$ (gross)	Average basic digital resource provided basic digital resource ($DBR_{average}$)	EBR_P = $P_{average}$/$DBR_{average}$
co (compute)	81,7 W	25.6 GHz*bit	3.1932 W/(GHz*bit)
me (memorise)	23,4 W	0.8 gigabyte	29.1946 W/Gigabyte
st (store)	11,7 W	2,000 gigabytes	0.0058 W/gigabyte
tr (transfer)	5,8 W	2 megabit/s	2.9195 W/(megabit/s)

Source: Öko-Institut

- 1 unit of the digital basis resource „Compute“ (**1 Ghz* bit**) → **3,2 W**

-7 - How much digital work has been needed for a digital service?

Example: Video stream, 1 h, data centre in Germany, delivered via internet to a private DSL router, displayed on a desktop computer

Digital work (DW) along the digital supply chain

Digital work	Desktop computer	Home router	Transmis-sion net-work	DC network switch	DC server	DC storage	Unit
DW_{co}	44.851	-	-	-	134.554	-	Gbit
DW_{me}	4.205	-	-	-	8.410	-	Gigabyte*s
DW_{st}	5.256.000	-	-	-	657.000	1.971.000	Gigabyte*s
DW_{tr}	21.024	21.024	21.024 *	21.024 *	31.536	10.512	Megabit

Source: Öko-Institut

* the data volumes in the transmission grid and data centre are likely to be higher than the data generated by the user. Corresponding factors still need to be worked out or measured.

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-7/3- Putting the pieces together…input data

-1- **Run the software application on the test bench**: a virtual digital supply chain

Suitable logging tools must be used within the test bench to record the following parameters:

Table 15: Measurement of the digital work used by a software product

- Service units: Number of utilisation units in the measurement period [no.]
- DW_{co} : CPU or GPU work calculated from full load seconds [Gbit/s*s]
- DW_{me} : RAM memory work [GByte seconds]
- DW_{st} : Permanent memory work [GByte seconds]
- DW_{tr} : Data transmission work [Mbit/s*s]

-2- Calculate automatically key figures: Cumulated Energy Demand, Global Warming Potential, Ressource Depletion, Water Demand, Electronic Waste, MEG equivalents

CONCLUSIONS AND OUTLOOK

- **ECO:DIGIT: What you can expect?**
  - **Test bench:** for **software applications**.
  - **Assessment method: Key indicators** for ecological impacts of **software and hardware**
    - **Check your application / your hardware: CO2e, resources, water, energy, E-waste, MEG equivalents and SVHC Score for problematic substances.**

  - **Track changes** in **environmental impacts** in an **automated and transparent way** .

  - **Optimize both**: **hardware and software!**

Your contacts

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Thank you for your attention! ? Questions are welcomed! !

You like to know more details beyond 12 mins?

- .
-

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7 Steps to evaulate the environmental impacts of a software application

- Draw the **digital supply chain** for the application
- Think in **digital basis resources (DBR)**
- Assess the **ecological impacts of hardware components**
- **Calculate the amount of digital work supplied by hardware components**
- **Split** the ecological impact and **allocate it to digital basis resources**
- **Run the software application on the test bench**
- **Determine the amount of work required from the application and calculate its footprint.**

Example: Global Warming Potential / Manufacture of a Personal Computer Allocation of environmental impacts to basic resources

Figures in kg CO2 equivalents

Hardware-components	Environmental impacts: kg CO2-equiv.	Allocation parameter for Overhead	Overhead	4 basic digital resources + Overhead	Allocation to the 4 basic digital resources
CPUs/GPUs	a = 150 kg	a/(a+b+c+d) = 48%	24	A = 174 kg	co (compute)
RAMs	b =100 kg	b/(a+b+c+d) = 32%	16	B = 116 kg	me (memorize)
SSDs/HDDs	50 kg	c/(a+b+c+d) = 16%	8	C = 58 kg	st (store)
Network-components	10 kg	d/(a+b+c+d) = 3%	2	D = 12 kg	tr (transfer)
remaining components (Overhead)	50	-	-	-	-
Total	Σ = 360 kg	100%	Σ = 50 kg	Σ = 360 kg	

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-6- How much does one unit of a specific DBR cost? / 1

Calculate effort / benefits ratios: e.g. for manufacture

$$EBR = effort\ benefit\ ratio = \frac{effort}{benefit}$$

- Input 1: Environmental impact for the manufacture of a hardware component (= platform)
- Input 2: Digital work provided by the platform

Example: Computer platform with a technical service life (lifetime) of 4 years

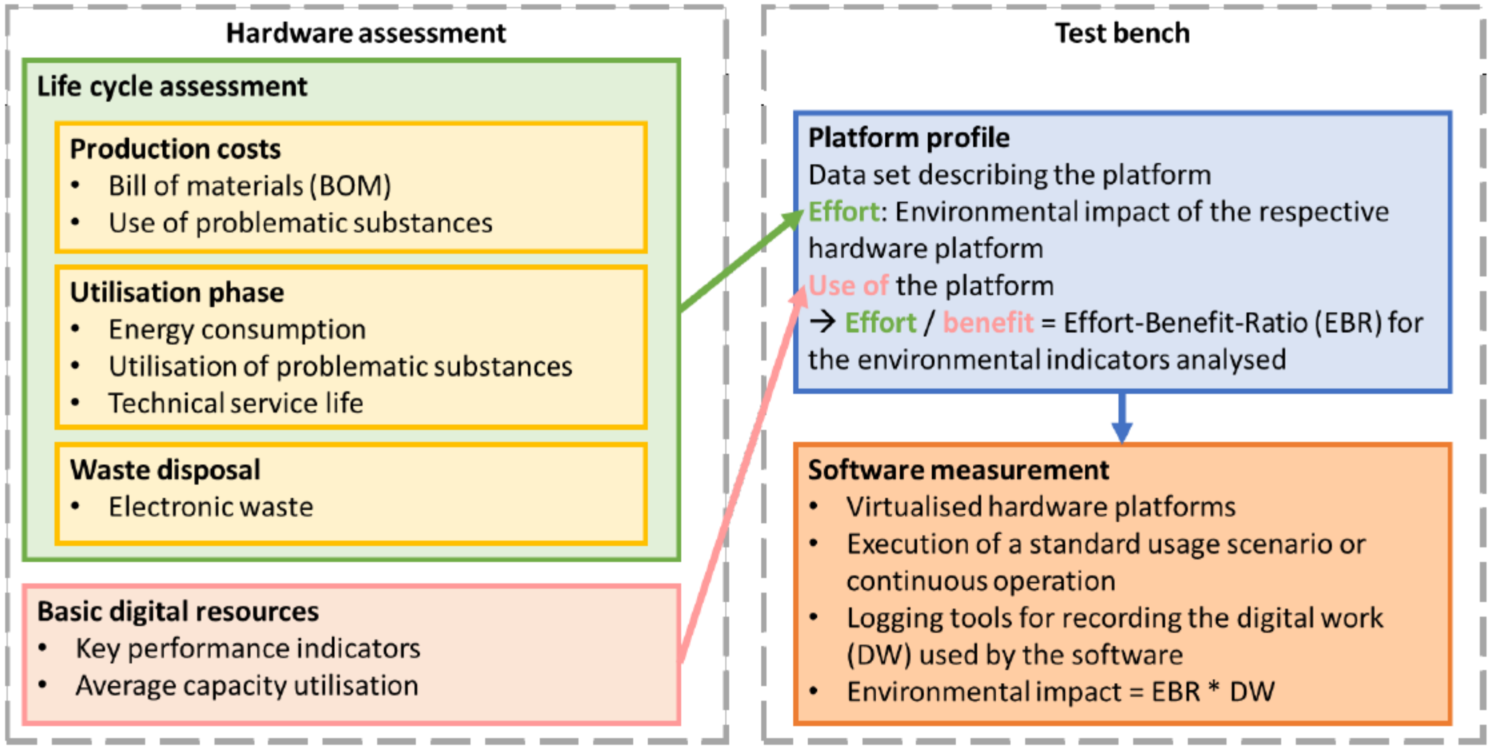
Example calculation of the effort benefit ratios EBR_EI_{DBR}

DBR abbreviation	Environmental impact Gross $EI_{ei\_embedded}$ (e.g.: EI $)_{GWP}$	Digital work (DW_{DBR}) provided over the lifetime at average utilisation ($_{load}$ coverage)	effort benefit ratios for manufacturing EBR_EI_{DBR} = EI_{ei}_embedded/DW_{DBR} (Example: EBR_GWP $)_{DBR}$
co (compute)	174 kg CO_2 e	53,821,440 Gbit	**3.23 E-06 kg CO_2 e/Gbit**
me (memorise)	116 kg CO_2 e	1,681,920 gigabytes*s	6.90 E-05 kg CO_2 e/(gigabyte*s)
st (store)	58 kg CO_2 e	4,204,800,000 gigabytes*s	1.38 E-08 kg CO_2 e/(gigabyte*s)
tr (transfer)	12 kg CO_2 e	4,204,800 megabits	2.85 E-06 kg CO_2 e/megabit

- Digital work to compute 1 Gbit: 3,3 milligrams CO2-equivalents…
- Specific platform / average utilisation / LCA differentiated by components

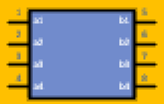
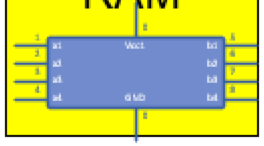
-7- Putting the pieces together…

Figure 4: Scheme of data collection



Source: Öko-Institut

Allocation to a specific digital application by using specific performance metrics

Environmental impacts of 4 basic digital resources	Effort-benefit-ratios		Specific performance associated with an individual software
CPU/GPU 	$\frac{Environmental\ impacts_{compute}}{Performance\ over\ lifetime_{compute}}$	X	Compute
RAM 	$\frac{Environmental\ impacts_{memorize}}{Performance\ over\ lifetime_{memorize}}$	X	Memorize
SSD/HDD 	$\frac{Environmental\ impacts_{store}}{Performance\ over\ lifetime_{store}}$	X	Store
Transfer 	$\frac{Environmental\ impacts_{transfer}}{Performance\ over\ lifetime_{transfer}}$	X	Transfer

$\sum$

CONCLUSIONS AND OUTLOOK

ECO DIGIT
Enabling green COmputing and DIGItal Transformation

- Categorizing hardware into **four basic digital resources** (Compute, Memorize, Store, Transfer) **:** Better understanding of different software applications, their varying demands on hardware, and their environmental impacts.
- **Needed: Key performance indicators** of these 4 basic digital resource. Investigations and real examples will be carried out during the project.
- Combination of the LCA method with **specific approaches for assessing problematic substances:**
  - **a more complete picture of the environmental impact** of digital services.
  - **MEG equivalents**, based on the hazard statements of chemicals: weight and aggregate quantities of chemicals **used or present** in digital devices.
  - **SVCH Score**: state of knowledge on substances of very high concern in hardware components.

Problematic substances within the digital supply chain
Substances of very high concern (SVHC) in ICT / 4

SCIP

Consumers: Right to know, REACH Art. 33

Producers/ importers of hard ware: Notification requirement to ECHA (European Chemicals Agency), SCIP (https://echa.europa.eu/de/scip-database database)

Substances of **C**oncern **I**n **P**roducts

- **Which score does your product have?**

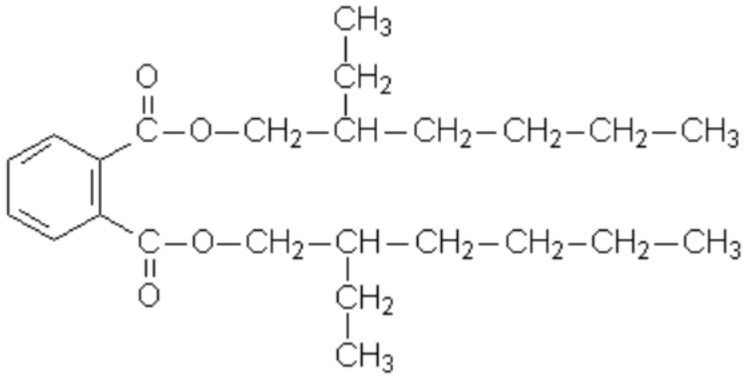
-The SVHC Score-

- SVHC Score 5: No information, no activity
- SVHC Score 4: Information requested
- SVHC Score 3: Information retrieved
- SVHC Score 2: SVHC identified (substances)
- SVHC Score 1: SVHC content clarified (name, concentration, location)

Supply chain, 4 elements: SVHC Score = sum (SVHC Score (El. 1-4)) / 4.

More about problematic substances:

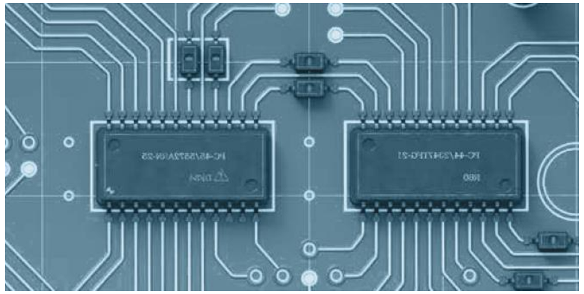
MEG equivalents and the SVHC Score



TOX-E: Problematic substances within the digital supply chain
Element 1: Use of hazardous substances: production of ICT hardware

Table 1 **Inventory of chemicals used for the production of wafer, weigthing factors and MEG equivalents. Unit: g/cm2 wafer output.**

Substance	Amount		Weighting Human Health	MEG equivalents	
Sulfuric acid	6	g/cm²	100	12	g/cm²
Hydrogen peroxide	2	g/cm²	100	4	g/cm²
Hydrogene fluoride	0.5	g/cm²	1,000	10	g/cm²
Phosphorous acid	2.7	g/cm²	100	5.4	g/cm²
2-Propanol	2.3	g/cm²	50	2.3	g/cm²
Ammonium hydroxide	0.89	g/cm²	100	1.78	g/cm²



- Data from the LCA inventory
- Important information even indepen-dent from exposure situation

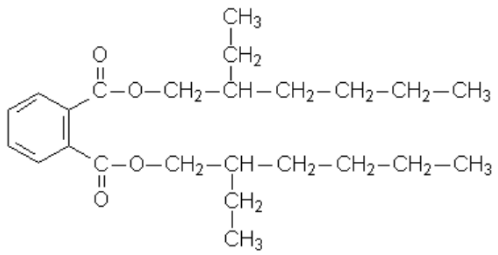
Aggregation: MEG equivalents

* Weighting: H phrases

TOX-E: Problematic substances within the digital supply chain
Element 2: Content of hazardous substances in ICT hardware

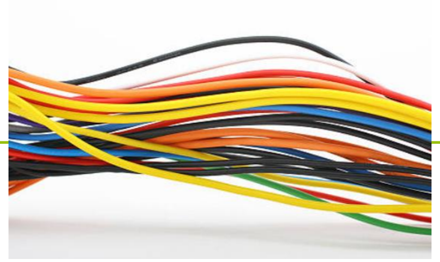
Table 2 **Concentrations of flame retardants and metals in plastics of waste from electronic devices (plastic fraction with small particles with a maximum size of 25 mm). Unit: mg/ kg plastics.**

Substance	Concen-tration		Substance	Concen-tration	
Flame retardants			**Metals**		
TBBPA	1,700	mg/kg	Antimony	1,400	mg/kg
DecaBB	14	mg/kg	Cadmium	36	mg/kg
TBP	50	mg/kg	Lead	1,400	mg/kg
BTBPE	360	mg/kg	Mercury	0.3	mg/kg
DBDPE	1,100	mg/kg	Nickel	270	mg/kg
DDC-CO	66	kg/kg			



- Flame retardants
- Softeners
- Fluorinated anti-dripping agents
- Heavy metals

Large differences between products and basic resources !



TOX-E: Problematic substances within the digital supply chain
Element 3: Problematic substances: use phase of ICT

Table 3 Chemical identity, formula and global warming potentials (GWPs) of cooling agents used in data centers. (GWP from production and intrinsic potential of the substance).

Name	Substance	GWP	
R 134a	C2H2F4	1,446	kg CO_2 equivalents/kg
R 290	C2H8 (Propane)	4	kg CO_2 equivalents/kg
R 32	CH2F2	983	kg CO_2 equivalents/kg
R 717	NH_3 (Ammonia)	2	kg CO_2 equivalents/kg
R 718	H_2O (Water)	0	kg CO_2 equivalents/kg
R 744	CO_2 (Kohlendioxid)	1.8	kg CO_2 equivalents/kg

- Cooling agents
- Cleaning agents
- Fire protection foams

Large differences between products and basic resources !

1 MW cooling capacity, loss of 16 kg R 134a / year

463 kg MEG equivalents ! Allocation to the digital servives provided by the data center.

TOX-E: Problematic substances within the digital supply chain
Element 4: Substances of very high concern (SVHC) in ICT / 1

The most hazardous substances, e.g. PFOA, PCBs, HBCD…

REACH Candidate List / 1

TOX-E: Problematic substances within the digital supply chain
Element 4: Substances of very high concern (SVHC) in ICT / 2

The most hazardous substances, e.g. PFOA, PCBs, HBCD…

REACH Candidate List / 2

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Substance name (expand / collapse)	EC No.	CAS No.	Date of inclusion	Reason for inclusion	Decision	IUCLID dataset	
Oligomerisation and alkylation reaction products of 2-phenylpropene and phenol Phenol, methylstyrenated EC No.: 270-966-8 | CAS No.: 68512-30-1	700-960-7	-	23-Jan-2024	vPvB (Article 57e)	D(2023)8585-DC		
Bumetrizole (UV-326)	223-445-4	3896-11-5	23-Jan-2024	vPvB (Article 57e)	D(2023)8585-DC		
2-(dimethylamino)-2-[(4-methylphenyl)methyl]-1-[4-(morpholin-4-yl)phenyl]butan-1-one	438-340-0	119344-86-4	23-Jan-2024	Toxic for reproduction (Article 57c)	D(2023)8585-DC		

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TOX-E: Problematic substances within the digital supply chain
Element 4: Substances of very high concern (SVHC) in ICT / 3

Fig.2 Substances of very high concern in a desktop PC. Information notified to the SCIP database at the European Chemicals Agency (ECHA).

OVERVIEW

For the safe use instruction of the article go to: **Safe use instruction**

CANDIDATE LIST SUBSTANCES

Substance name(s)	Reason for inclusion
2-methyl-1-(4-methylthiophenyl)-2-morpholinopropan-1-one	Toxic for reproduction (Article 57c)
1,3,5-Tris(oxiran-2-ylmethyl)-1,3,5-triazinane-2,4,6-trione (TGIC)	Mutagenic (Article 57b)
Lead titanium trioxide	Toxic for reproduction (Article 57c)
Lead titanium zirconium oxide	Toxic for reproduction (Article 57c)
Hexahydromethylphthalic anhydride	Respiratory sensitising properties (Article 57(f) - human health)
1, 2-dimethoxyethane; ethylene glycol dimethyl ether (EGDME)	Toxic for reproduction (Article 57c)
Diboron trioxide	Toxic for reproduction (Article 57c)

Source: ECHA 2024.

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Problematic substances within the digital supply chain
Substances of very high concern (SVHC) in ICT / 4

Consumers: Right to know, REACH Art. 33

Producers/ importers of hard ware: Notification requirement to ECHA (European Chemicals Agency), SCIP (https://echa.europa.eu/de/scip-database database)

Substances of **C**oncern **I**n **P**roducts

- **Which score does your product have?**

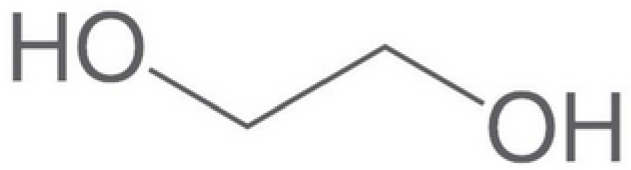
-The SVHC Score-

- SVHC Score 5: No information, no activity
- SVHC Score 4: Information requested
- SVHC Score 3: Information retrieved
- SVHC Score 2: SVHC identified (substances)
- SVHC Score 1: SVHC content clarified (name, concentration, location)

Supply chain, 4 elements: SVHC Score = sum (SVHC Score (El. 1-4)) / 4.

TOX-E: Problematic substances within the digital supply chain
MEG equivalents: Weighting and aggregation

Challenge: Thousands of chemicals…….



Reference substance: Monoethylenglycole

Weighting factors: based on

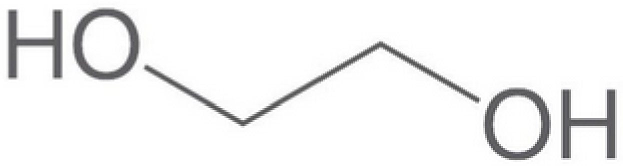
- hazard statements (H phrases) for substances classified as hazardous according to the Globally Harmonised System (GHS)
- Global Warming Potential

Unit: MEG equivalents (MEG eq.) (similiar to CO_2 equivalents)

TOX-E: Problematic substances within the digital supply chain
MEG equivalents: Weighting and aggregation

Monoethylenglycole (MEG) CAS (Chemical Abstracts Services) no.: 107-21-1





H phrases:

H 302 Harmful if swallowed Weighting factor: 10

H 373 May cause damage to organs through prolonged or repeated exposure
Weigthing factor: 50

Weigthing factor MEG = maximum weighting factor H phrases = 50

TOX-E: Problematic substances within the digital supply chain
MEG equivalents: Weighting factors / part 1

Global Harmonised System of Classification and Labelling of Chemicals

CLP Regulation: Classification, labelling and packaging of substances and mixtures

TRGS 600 Substitution

Adverse effects on human health	Weighting factor
H300: Fatal if swallowed	1,000
H301: Toxic if swallowed	100
H302: Harmful if swallowed	10
H303: May be harmful if swallowed	5
H304: May be fatal if swallowed and enters airways	1,000
H305: May be harmful if swallowed and enters airways	5

TOX-E: Problematic substances within the digital supply chain MEG equivalents: Weighting factors / part 2

Adverse effects on human health	Weighting factor
H334: May cause allergy or asthma symptoms or breathing difficulties if inhaled	500
H335: May cause respiratory irritation	5
H336: May cause drowsiness or dizziness	5
H340: May cause genetic defects	50,000
H341: Suspected of causing genetic defects	100
H350: May cause cancer	50,000