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Institut für angewandte Ökologie
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Environmental assessment of cloud services in data centers

Methodological challenges

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Digital transformation: LCA of digital services, multifunctional devices and cloud computing

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Project Framework

Client: Federal Environment Agency

Umwelt Bundesamt

Title: Life cycle-based data collection on environmental impacts of cloud computing (DE: “Lebenszyklusbasierte Datenerhebung zu Umweltwirkungen des Cloud-Computing“)

Short title: Green Cloud Computing

UFOPLAN Research code: 3717 34 348 0

Project period: September 2017 – April 2020

Research team:

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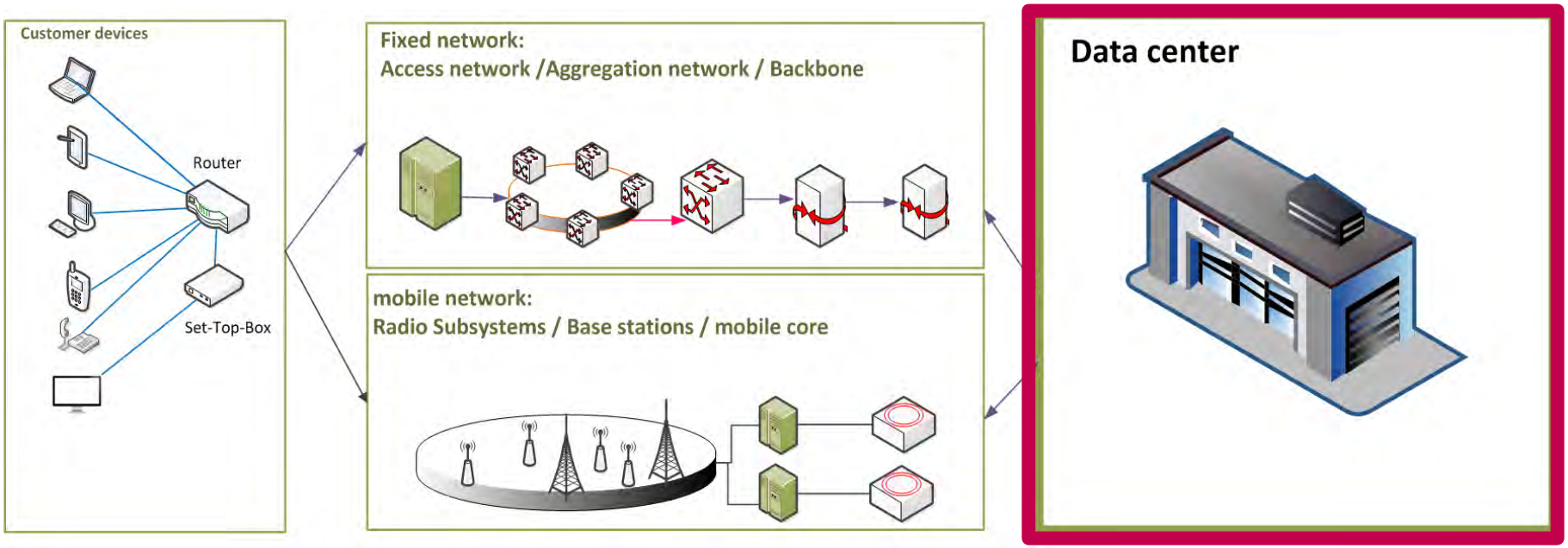
Fraunhofer IZM

tippingpoints
agentur für nachhaltige kommunikation

Project „Green Cloud Computing“

- Aim: data center operators are able to evaluate environmental impact of cloud services provided by means of the tool developed, in order to optimize their data centers.

- Scope:



Cloud services

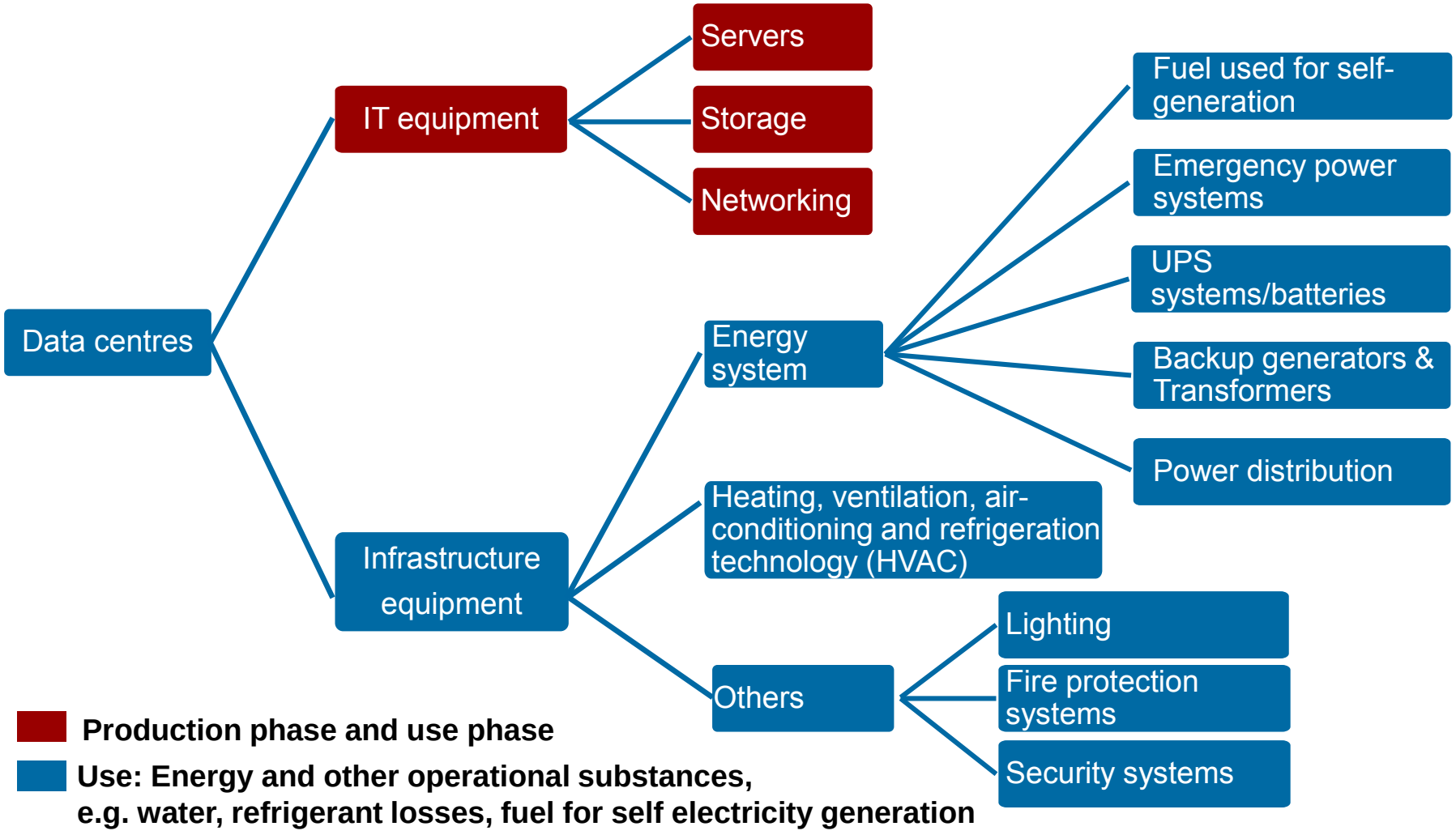
Case studies:

- Online storage
- Video streaming
- Virtual desktop
- Email service

Impact categories:

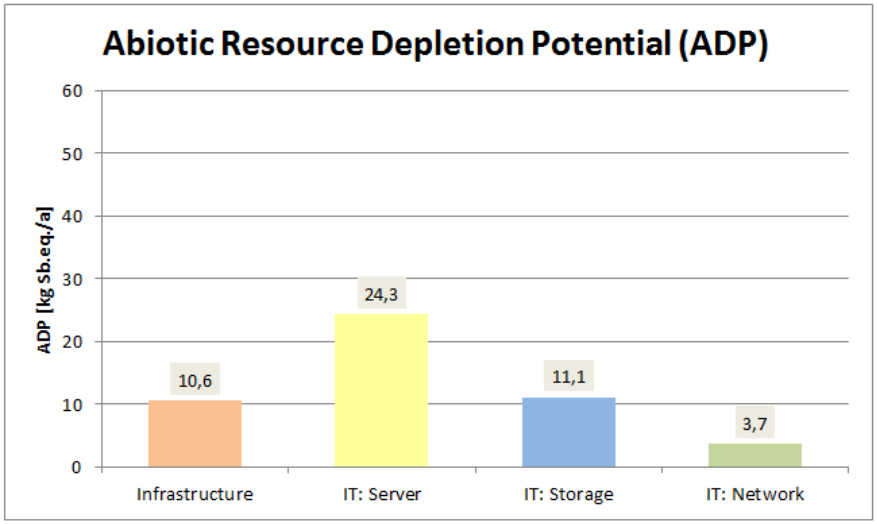
- GWP (Global Warming Potential)
- CED (Cumulative Energy Demand)
- ADP (abiotic resource depletion)
- Water consumption only in the use phase

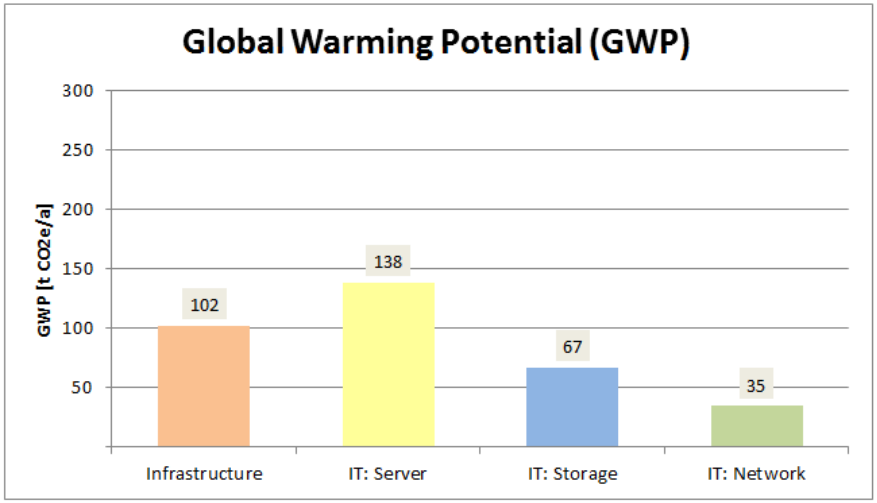
Cloud-Computing: System boundaries



Fictitious example: Step 1: calculation of impacts of the entire data center

- Server
  - 54 Rack-Server, 216 cores
- Storage
  - 20 Controller Enclosures
  - 148 HDD à 600 MB (= 88,8 TB)
- Network
  - 40 Network Switches (2080 Gbps)
- Energy Consumption
  - 490 TWh/a
- Environmental impacts
  - Σ ADP: 50 kg Sb.eq./a
  - Σ CED: 5,8 TJ/a
  - Σ GWP: 342 t CO_2e/a
  - Σ Water: 524 m³/a





Step 2: allocation

A DC delivers 3 cloud computing services (CloudS)

- CloudS 1: Video-Streaming
- CloudS 2: Online storage
- CloudS 3: Office 365
- CloudS 4: emails

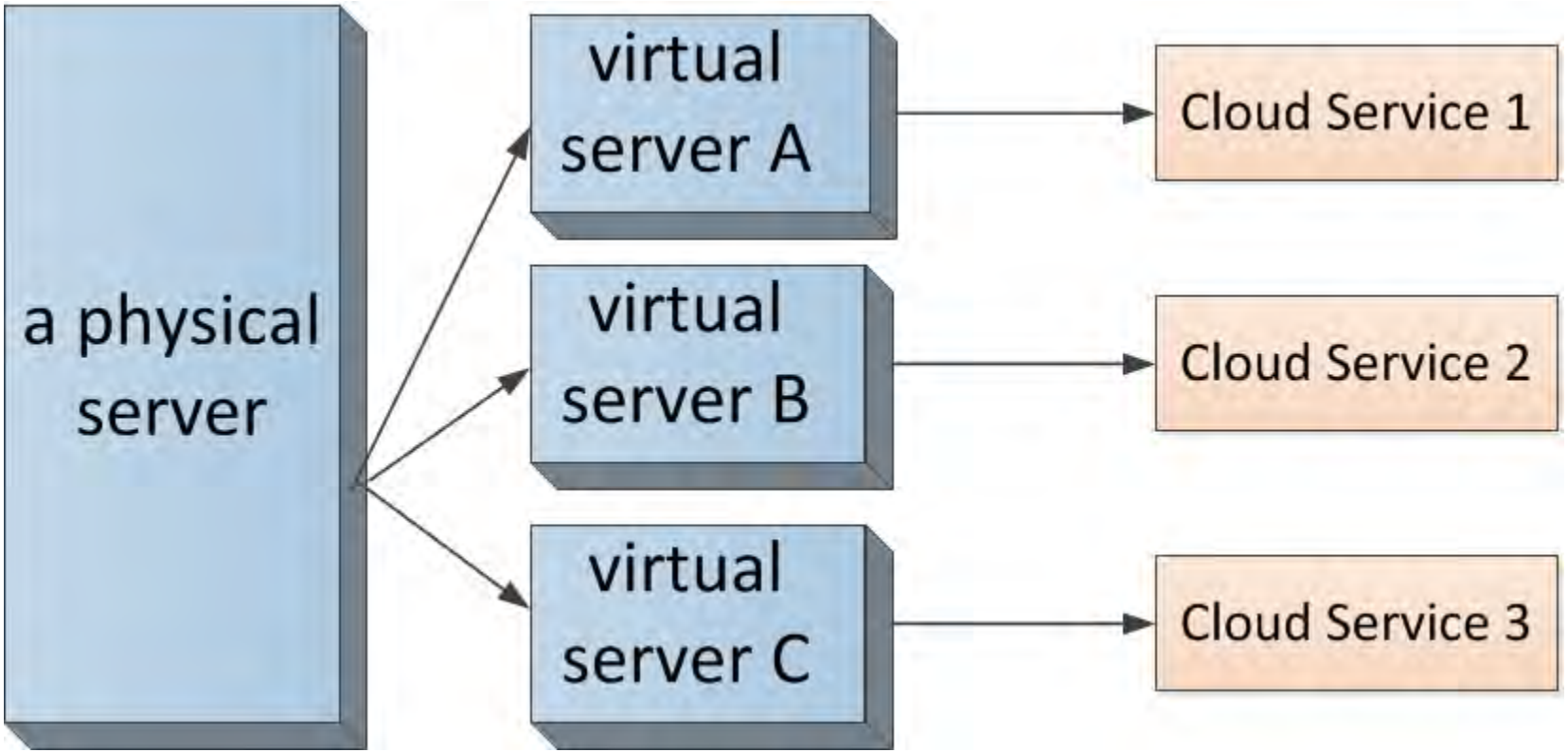
One of the methodological challenges in the environmental assessment of cloud services: **allocation**

- Calculation of impacts for cloud services:

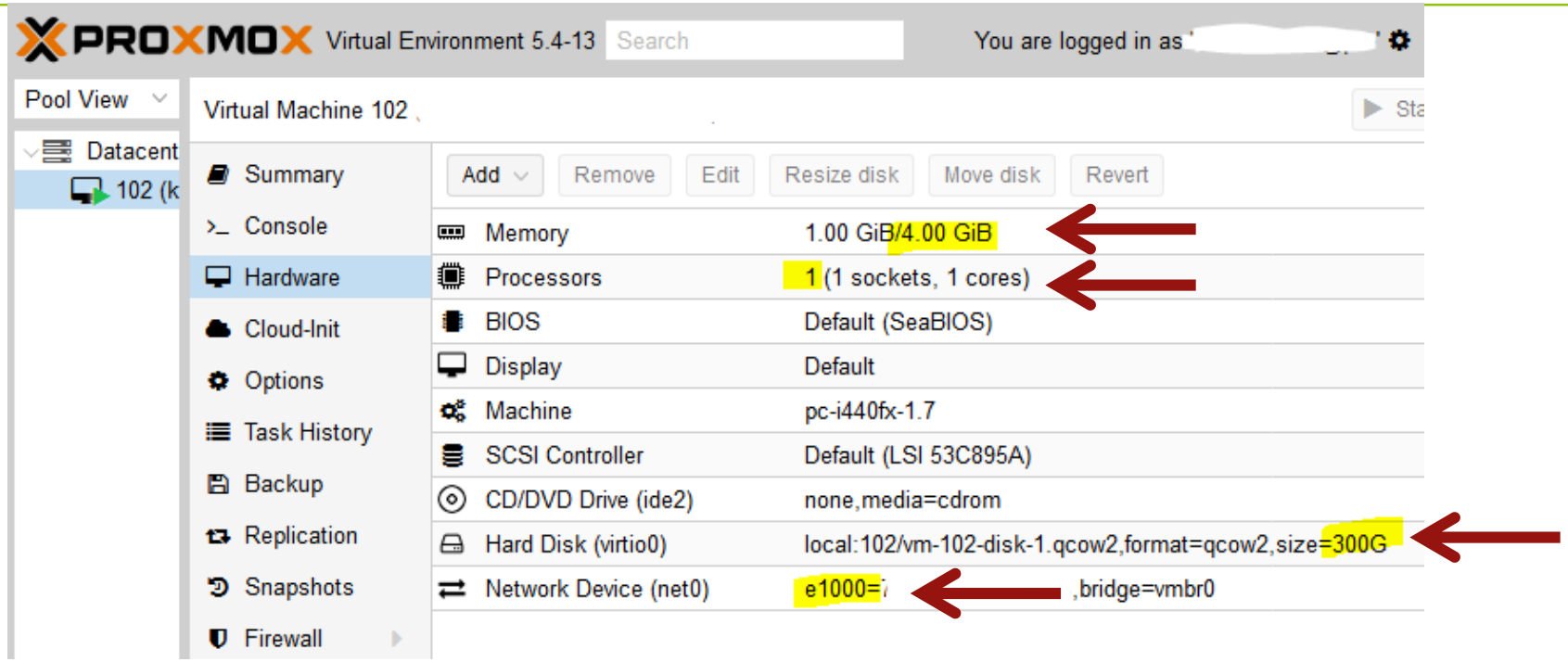
$$\text{Impact of an individual cloud service} = \frac{\text{Impacts of a DC (servers, storage, networking)}}{\text{Allocation parameter of cloud service}}$$

Allocation by virtual servers (VSs) / virtual machines (VMs)

Individual cloud services can be directly assigned to VMs. virtual hardware resources are assigned centrally via the VS management interface.



Example for virtual server configuration



- For each service the virtual resources can be determinded
  - This example: 4 GB RAM, 1 CPU core, 300 GB HDD, 1 MBit/s network

Allocation by virtual server resources (example DC)

	Data center physical resources	VM1: Cloud Service 1	VM2: Cloud Service 2	VM3: Cloud Service 3	Sum of virtual resources
Cores of CPUs	**216**	108	216	108	**432**
HDD	**88,8 TB**	44,4 TB	88,8 TB	22,2 TB	**155,4 TB**
Network	**2.880 Gbps**	1.440 Gbps	1.440 Gbps	1.440 Gbps	**4.320 Gbps**

Allocation Ratio Server (Cores)	-	**25%**	**50%**	**25%**	**100%**
Allocation Ratio Storage (HDD)	-	**29%**	**57%**	**14%**	100%
Allocation Ratio Network	-	**33%**	**33%**	**33%**	100%

ADP [kg Sb.eq./a]	**50**	**13**	**25**	**11**	
Servers	31	8	15	8	
storage	14	4	8	2	
network	5	2	2	2	

Thank you for your attention!

Do you have any questions?