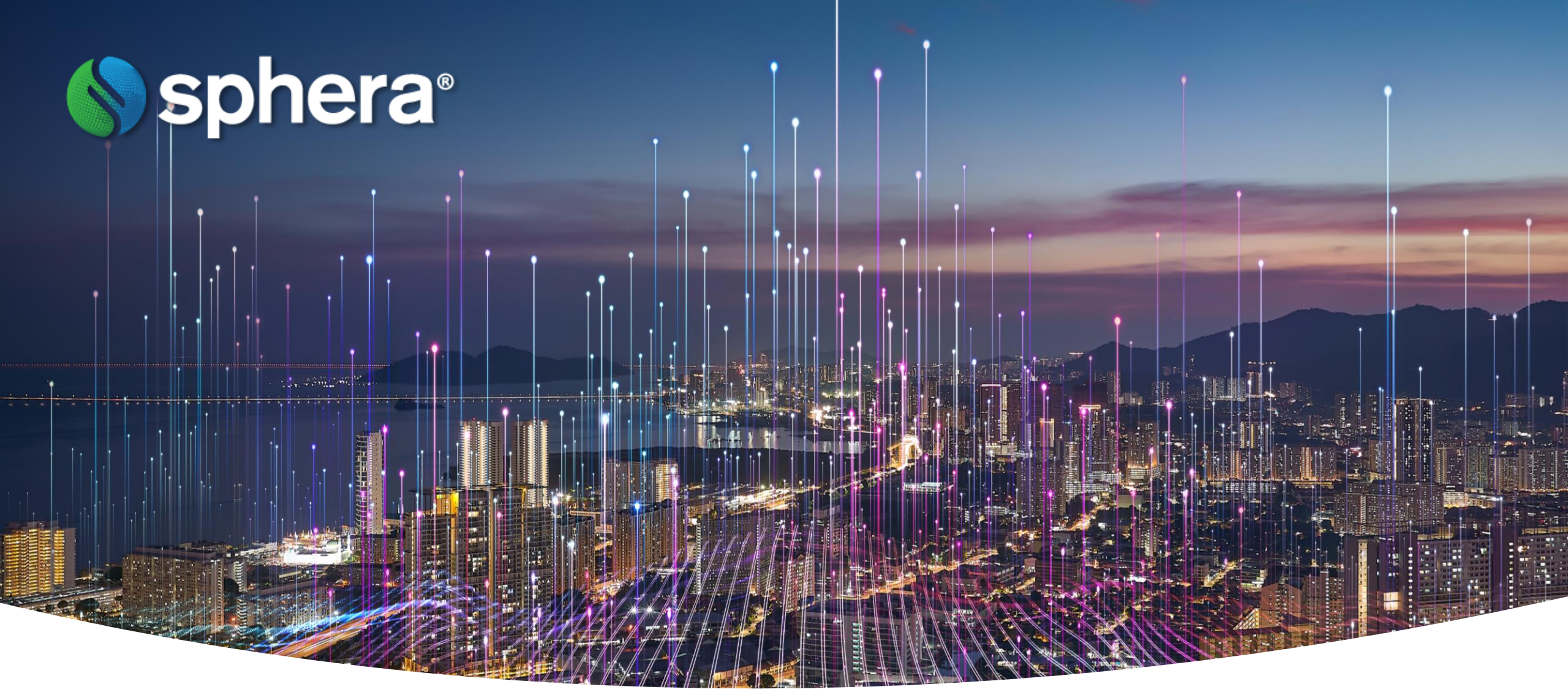

Umweltauswirkungen vernetzter digitaler Systeme: Wie lässt sich der CO_2-Fußabdruck von Data Traffic berechnen?

DIV 2023 – Speaker: Dr. Constantin Herrmann – Director Sustainability Consulting @ Sphera Solutions GmbH

Our Mission

Sphera is a leading global provider of Environmental, Social and Governance (ESG) performance and risk management software, data and consulting services with a focus on **Environment, Health, Safety & Sustainability (EHS&S), Operational Risk Management** and **Product Stewardship**.

Environment, Health, Safety & Sustainability

Operational Risk Management

Product Stewardship

To create **a safer, more sustainable** & **productive world**.

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Background

CO_2-Footprint / LCA of Data Traffic

Exemplary Results

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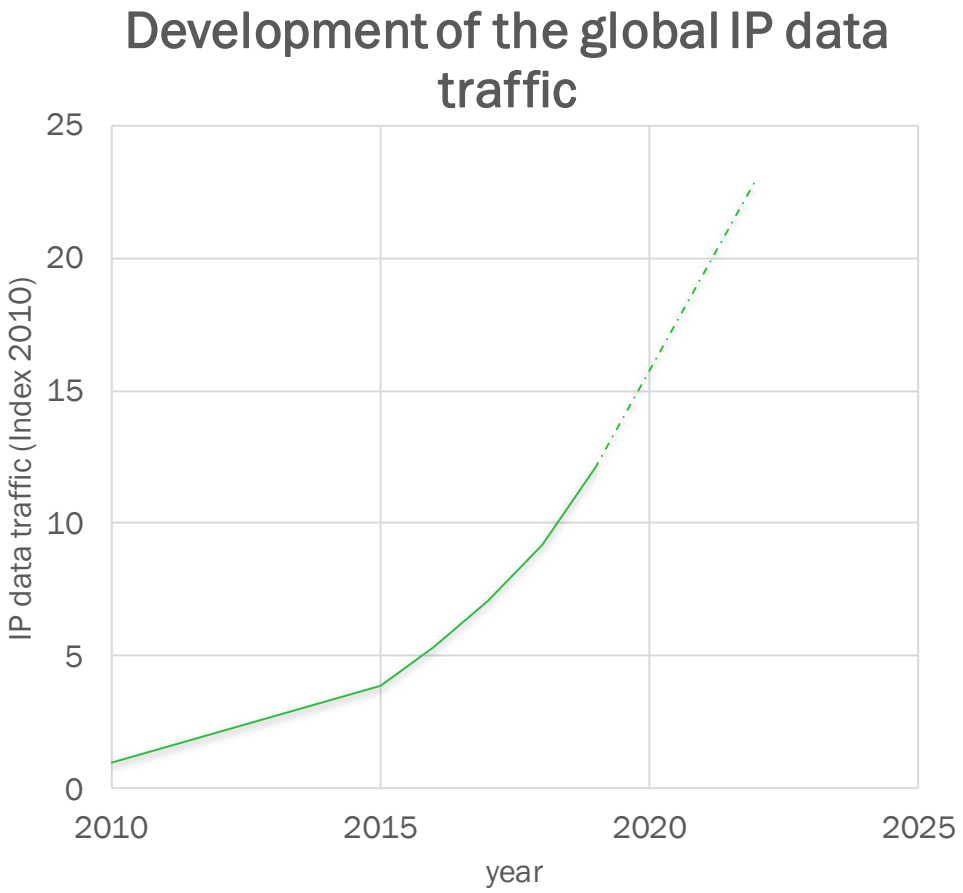
The Rise of IP Data Traffic



Main drivers:

- More people with internet access
- More devices
- New product concepts

  (i.e., smart home applications)
- Remote work

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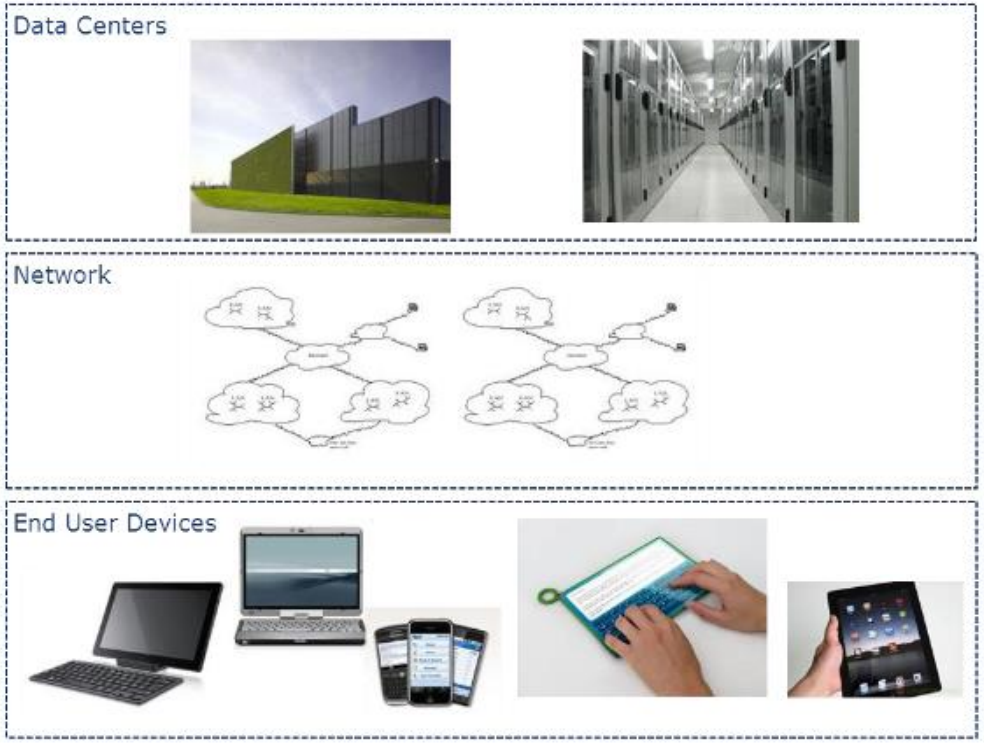
Environmental Impacts of Information and Communications Technology (ICT)

2-3% on the global carbon footprint

→ Energy demand of e.g., data centers has stabilized

? Future: Green by IT?

High level structure of ICT



% on ICT emissions 2020

~30%

~29%

~41%

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Future Development of the CF

Chances:

- Server virtualizations,
- Moore's law (just for now?)
- Data center cooling technologies
- AI in energy management
- Larger data centers
- "From plasma TV to smartphones"

Challenges:

- Heat up microprocessors
- Smart devices
- Number of devices
- Increased workload (!)

A

Assumptions about efficiency	Assumptions about demand for ICT: increases less than or in line with efficiency	Assumptions about demand for ICT: increases more than efficiency
continues	'Efficiency saves ICT' Emissions decline or stabilise *e.g. Malmodin, Masanet*	'Jevons Paradox' Emissions increase *e.g. Hilty, Galvin, Magee*
stops	'Jevons stalled' Emissions stabilise	'Growth without efficiency' Emissions increase rapidly *e.g. Andrae, Belkhir*

Who is right?

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Standards & Guidance for Organizations

- ICT Sector Guidance built on the GHG protocol (2017)
  - Developed by GeSi & carbon trust
  - Defines general principles (relevance, completeness, consistency, transparency, accuracy)
  - Requirements for functional units (basis of a calculation)
  - Examples of functional units and system boundaries

- ITU-T L.1410 (2014)
  - Great similarities to ICT sector guidance of the GHG protocol

Product or Service (examples)	*Functional unit description (examples)*		
	Magnitude	*Duration*	*Quality*
Phone call using a telecommunications network	A minute of voice call over a single carrier's network	One minute phone call	• Listening – e.g., narrow / wideband Mean Opinion Score (MOS) limits • Conversational – e.g., echo / latency limits • Transmission – ITU E-model rating limit
Data transfer using a telecommunications network	• Transfer of 1 megabyte of data • Packet-switched data over a single carrier's network	Extent of time necessary to transfer 1 megabyte of data	• Physical layer net bit rate –10 megabits per second (Mbps) • Includes data link and higher layer overhead
Desktop Managed Service	• 5,000 users (with geographical and service breakdown)	Five year contract	• Service level agreement (SLA), specifying support response times and geographical locations

Both standards help define the starting points of an environmental analysis, but they do not provide information on how to calculate impacts.

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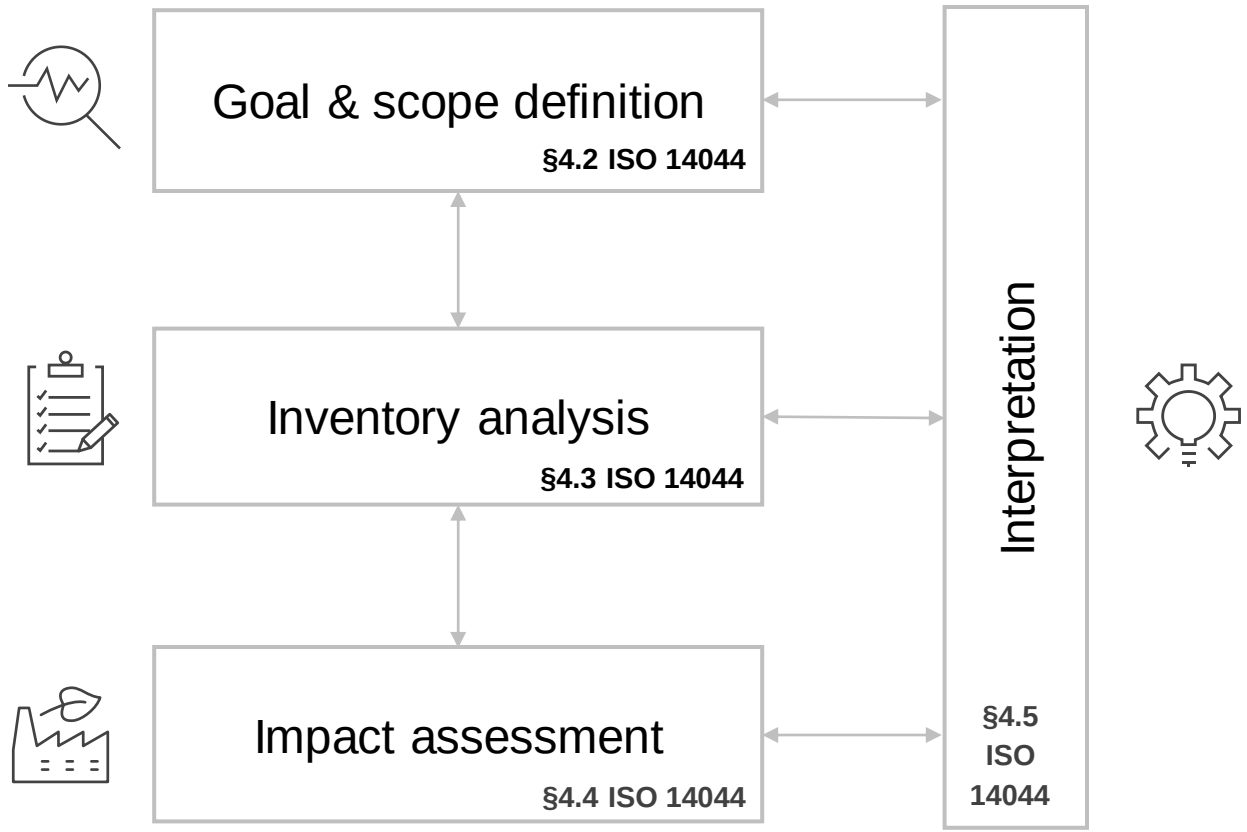
Life Cycle Assessment According to ISO 14040 and 14044

Following the standard ensures clear scope, functional unit and thus reliable results, ready for evaluation or comparison



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Existing Approaches

Several studies focus on the resource intensity of the Internet and use different approaches, methods and system boundaries

- Approaches: Top-down, bottom-up or mixed
- Methods: Experiments, annual energy stats, models, etc.
- System boundaries: E.g., inclusion of data centers

Reference year	Study	Approach	System boundaries			Energy intensity (kWh/GB)
			User device	Data transmission	Data center	
2014	(Coroama et al. 2015)	Bottom-up		x		–
2015	(Malmodin and Lundén 2018)	Mixed	x	x	x	0.88
2015	(Andrae 2019)	Top-down		x	x	0.11
2015	(Malmodin and Lundén 2016)	Mixed	x	x	x	–
2016	(Pärssinen et al. 2018)	Mixed	x	x	x	0.92
2020	(Andrae 2020)	Top-down		x	x	0.265
2020	(Ficher et al. 2021)	Bottom-up		x		0.002–0.007

The existing approaches
… mainly focus on energy consumption exclusively
… do not provide enough insights to understand the results
… can not applied on specific applications directly

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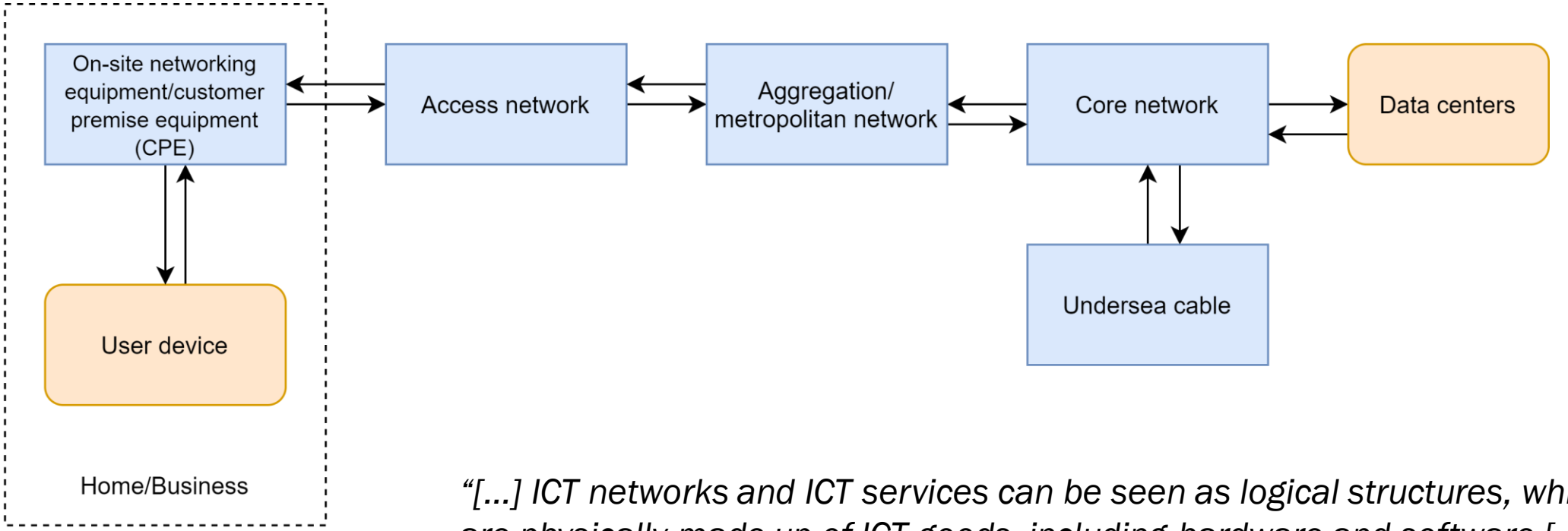
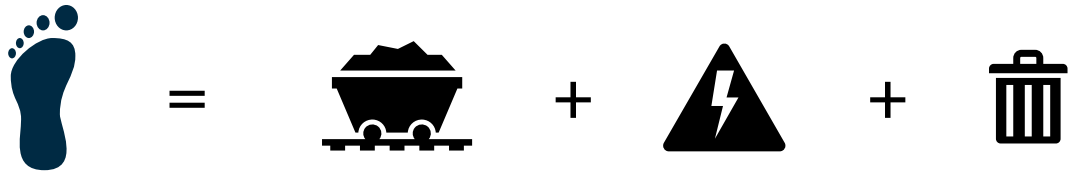
The Internet – Network of the Networks



"[...] ICT networks and ICT services can be seen as logical structures, which are physically made up of ICT goods, including hardware and software [...]."
– ITU-T L.1410



Footprint Production Use End of life

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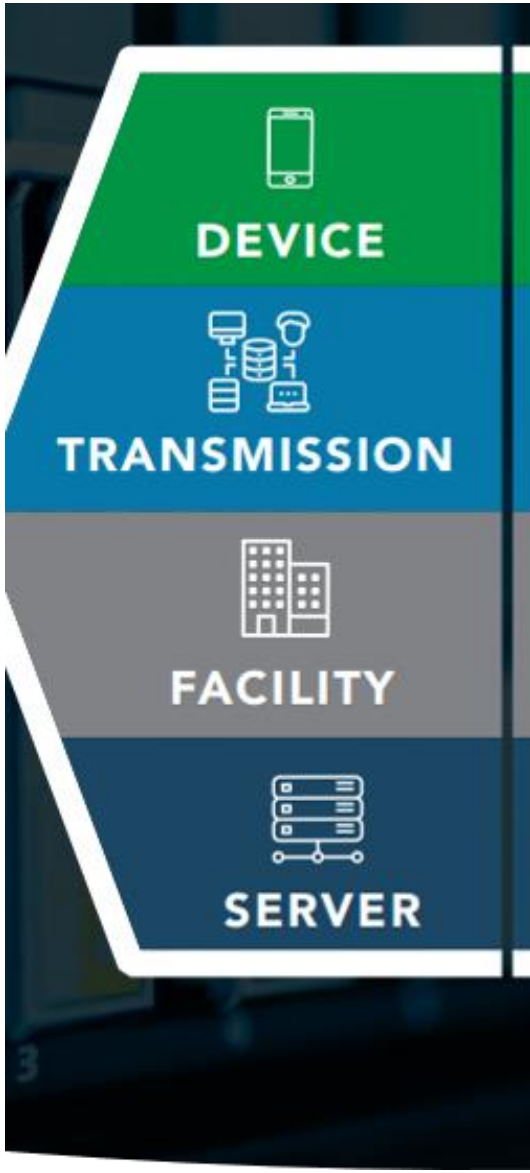
Sphera's Solution

- We provide a holistic mixed-method (mainly bottom-up) approach to quantify the impacts of internet services
  - Bottom-up necessary to gain insights and model infrastructure
  - Combines knowledge of the scientific community **(meta-model)**

Inputs necessary to create specific analyses

- Definition of functional unit (applications incl. reference unit e.g., GB)
- Access technologies in use
- Server & client location
- Definition of user devices
- Data center information (PUE, etc.)
- Number of passed network nodes
- Av. bandwidth (depending on the use case



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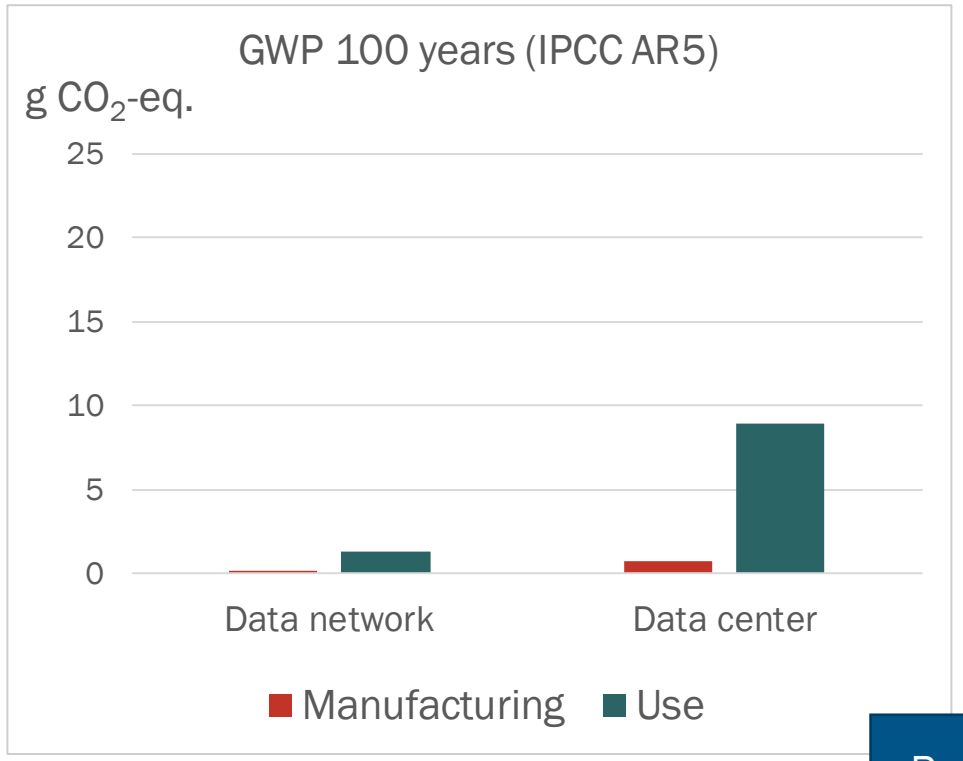
Exemplary Application

Downloading a file with a size of 1 GB

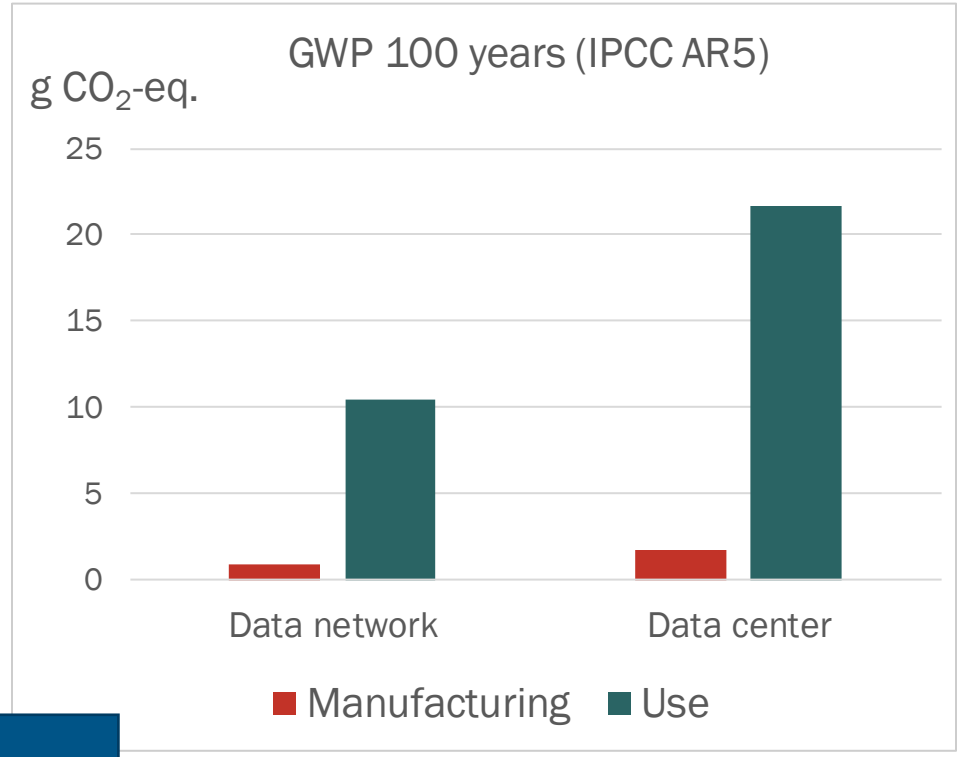
Assumptions: VDSL, av. downstream rate 47.7 Mbps



Total: 11g CO_2-eq.

Streaming a video for 1 hour on 1080p

Assumptions: VDSL, streaming intensity 2.35 GB/hr



Total: 35g CO_2-eq.

Results highly sensitive to input information and use cases

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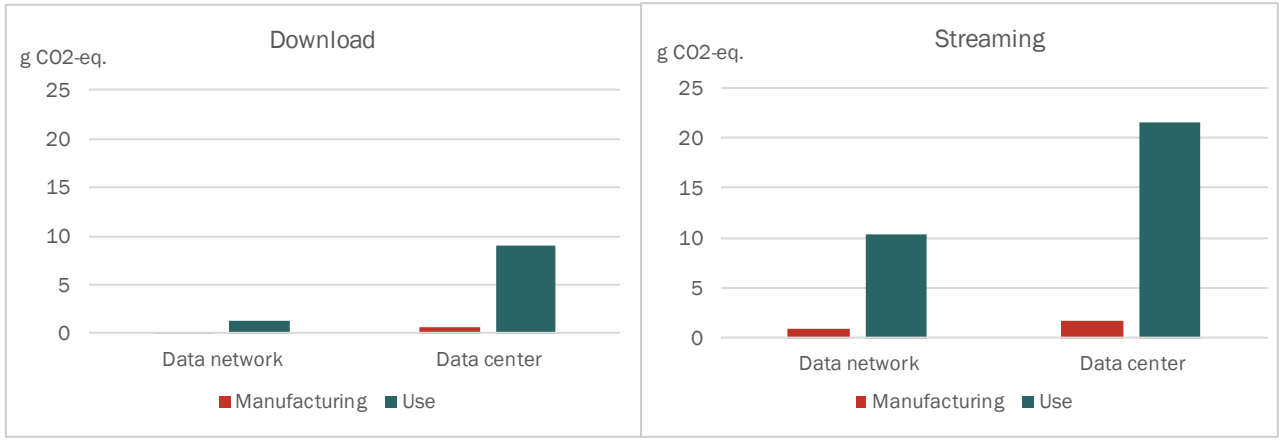
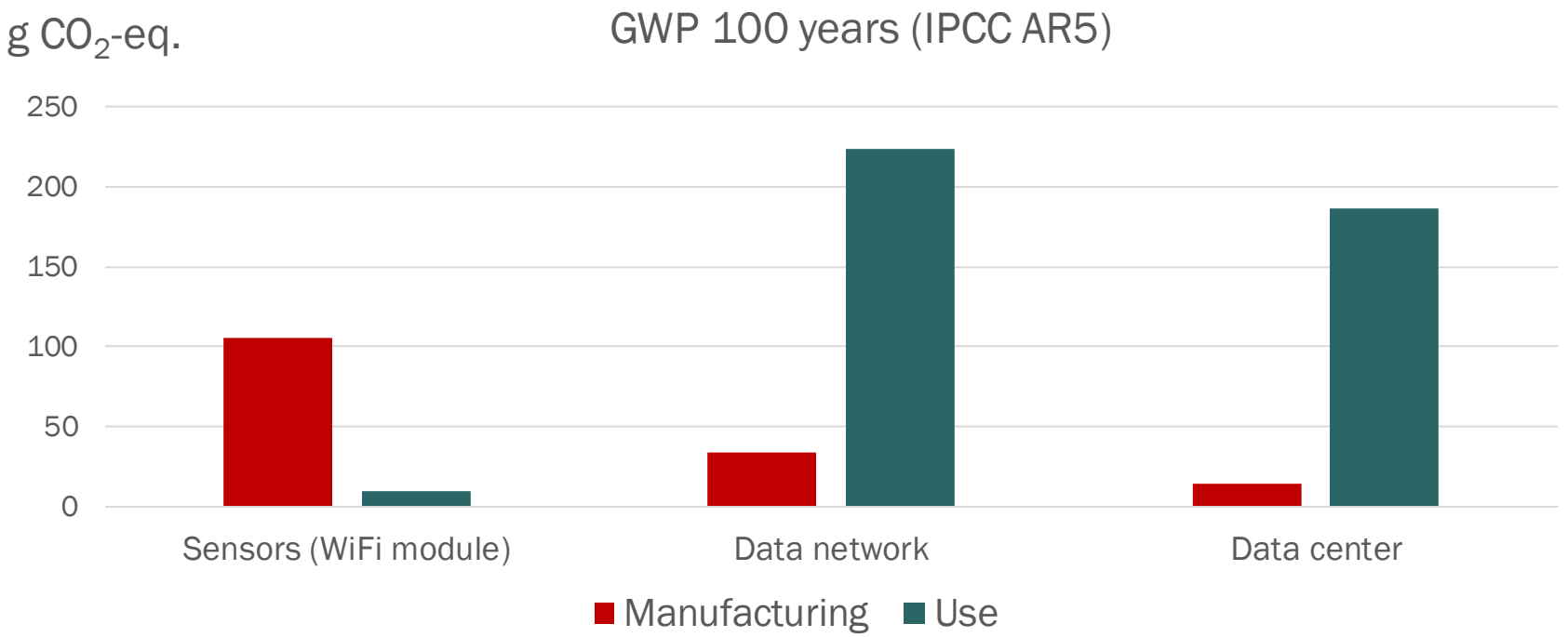
Exemplary Application



Sensor-based communication system for 1 hr

Assumptions: 25 acoustic sensors, GPON, 50% processed locally, 40.5 GB/hr



Total: 573g CO_2-eq.

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Conclusions

Carbon Footprint of digitalisation; Data Traffic as functional unit in product system

1. Don't forget the hardware
2. Life Cycle Assessment as tool for data-driven decisions
3. Define your use case & scope before you assess and conclude

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