



Sustainable *ICT* systems for a green world

Keynote, CELTIC-NEXT Day, December 2, 2020

Dr. Klaus Grobe, Dir. Global Sustainability, ADVA Optical Networking

Anyone who believes exponential growth can go on forever in a finite world is either a madman or an economist.

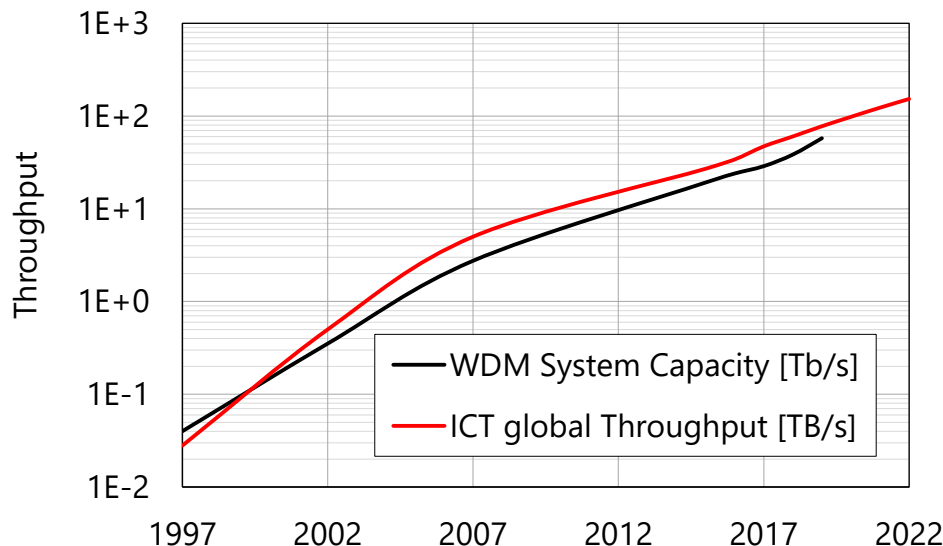
Kenneth E. Boulding, 1910-1993, English-born American economist, educator, interdisciplinary philosopher, and inventor of the Circular Economy concept

Overview / content

- Green ICT – where are we...?
- Cradle-to-cradle (lifecycle) view
- Consequences and way out
- Take-aways

Green ICT – where are we...?

ICT bandwidth growth and WDM development

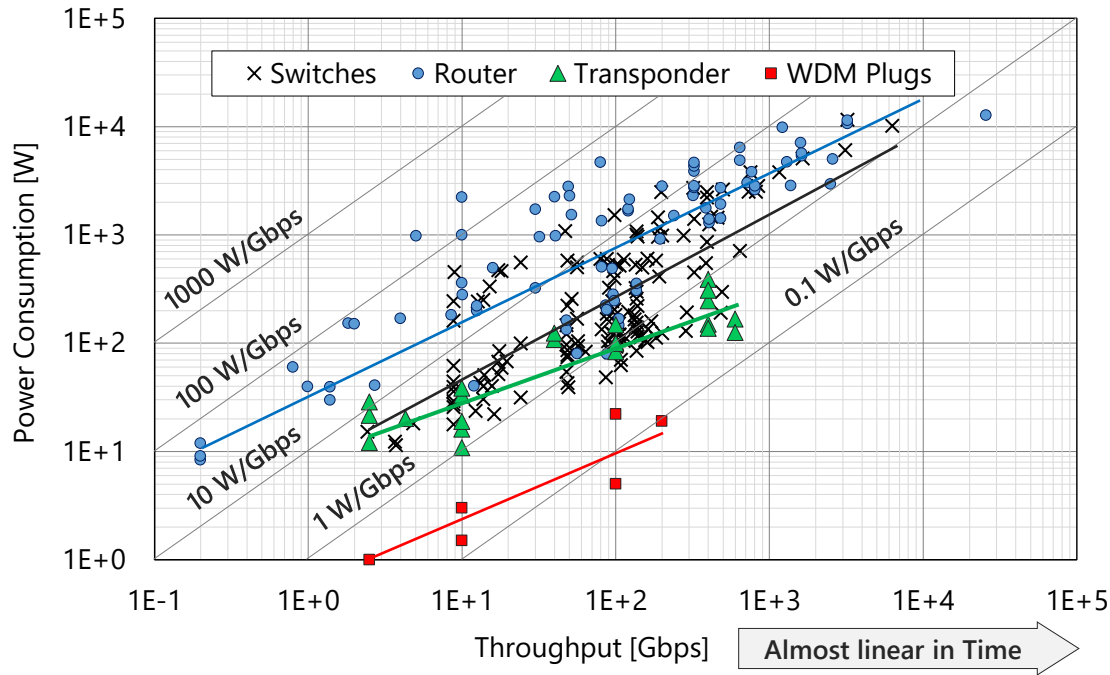


- According to Cisco VNI 2018-2022, the Internet throughput has a **CAGR \approx 26%**
- Further growth is forecasted (6G, IoT, Industry 4.0, Big Data, ...)
- Our WDM system capacity closely followed the development of the Internet throughput

[Cisco White Paper, "The Zettabyte Era: Trends and Analysis," June 2016], [Cisco White Paper, "The Zettabyte Era: Trends and Analysis," June 2017], [Thomas Barnett, Jr., et al., "Cisco Visual Networking Index (VNI) Complete Forecast Update, 2017–2022," Cisco Knowledge Network Presentation, Dec. 2018]

Exponential ICT traffic and WDM capacity growth

ICT equipment power consumption

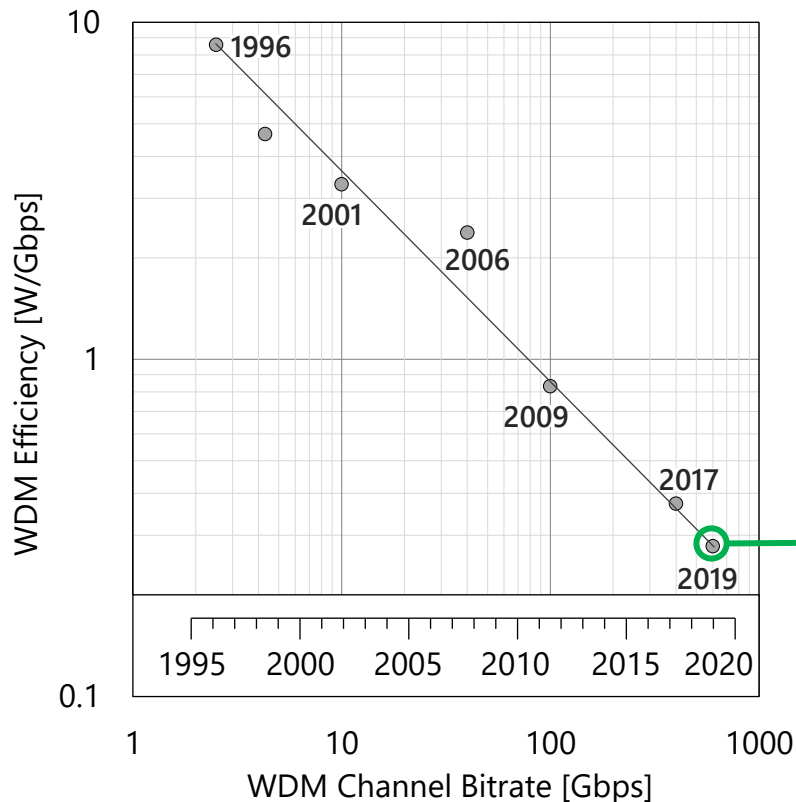


- Router, switch and WDM power consumption is exponentially increasing
- Energy efficiency gets better, but obviously cannot cope with bitrate increase

[Mellah, Sansò, June 2011, DOI: 10.1109/WoWMoM.2011.5986484], [Vereecken et al., IEEE COMMAG, Vol. 49, No. 6, 2011], [Tucker et al., ECOC 2008, based on METI, 2006, Nordman, 2007], [ADVA own research and WDM specifications]

Power consumption of all core-network equipment classes *increases*

WDM power-efficiency development (ADVA data)



- WDM power efficiency has a **CAGR** of ~14%
- ICT traffic increases faster
- Efficiency gain started to saturate

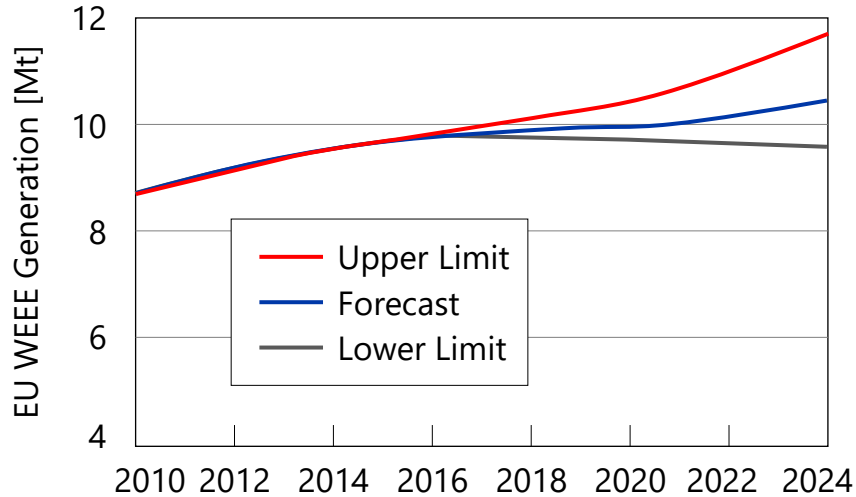


WDM power efficiency of ~0.25 W/Gbps

Efficiency calculated with the Ecology Guideline for the ICT Industry (Version 8.2), February, 2020, ICT Ecology Guideline Council, Japan.
www.tca.or.jp/information/pdf/ecoguideline/guideline_eng_8_2.pdf

Power efficiency increases, but this will saturate

WEEE, raw materials, ...



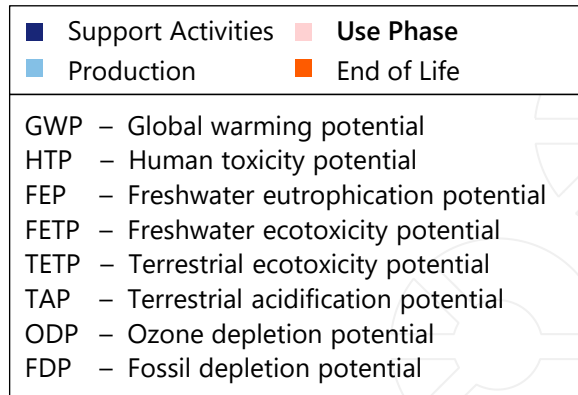
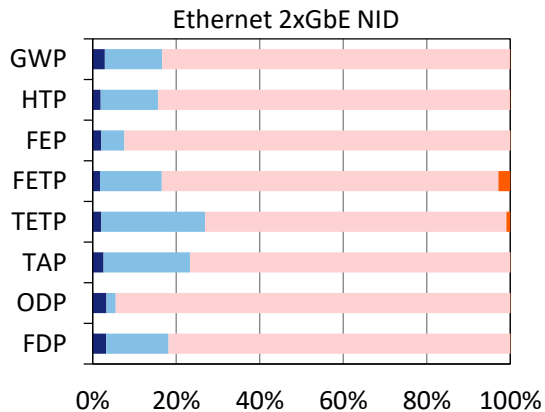
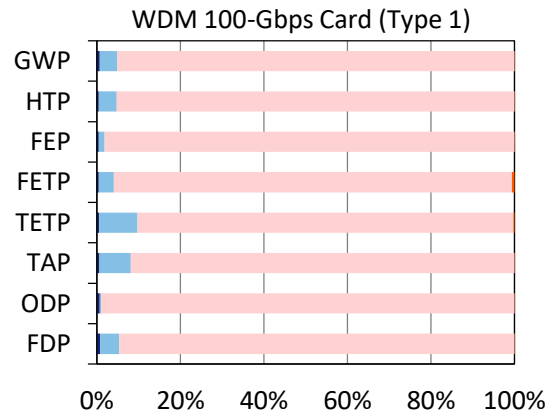
- The amount of waste electronic and electrical equipment (WEEE) is increasing
- *ICT requires critical raw material*
- *EU 2017 Critical Raw Materials list includes:*
Rare-Earth elements, Gallium, Germanium, Tantalum, Platinum-Group Metals, Indium, ...
- Moreover, efficiency in WEEE recycling is limited (partially due to very complex compounds)

[Magalini, F. et al. Study on Collection Rates of Waste Electrical and Electronic Equipment (WEEE), possible measures to be initiated by the Commission as required by Article 7(4), 7(5), 7(6) and 7(7) of Directive 2012/19/EU on Waste Electrical and Electronic Equipment (WEEE). Technical Report. 2016]

WEEE generation and raw-material depletion are growing problems

Cradle-to-cradle (lifecycle) view

LCA examples for WDM modules and Ethernet NIDs



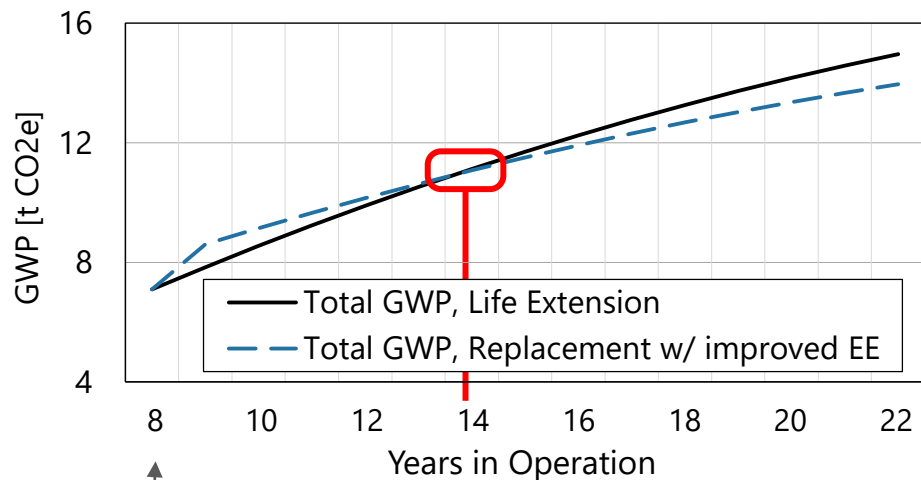
- Results are similar across the full portfolio of ICT core-network equipment
- Results confirmed for routers / switches, e.g., by Cisco

NID : Network Interface Device

ICT sold-products use-phase energy consumption dominates!

LCA: lifetime limitation for equipment w/ “always-on” mode

- How long should an old product's life be extended – ***until this is net-negative?***
- Successor product has better energy efficiency, but its production etc. cost CO₂



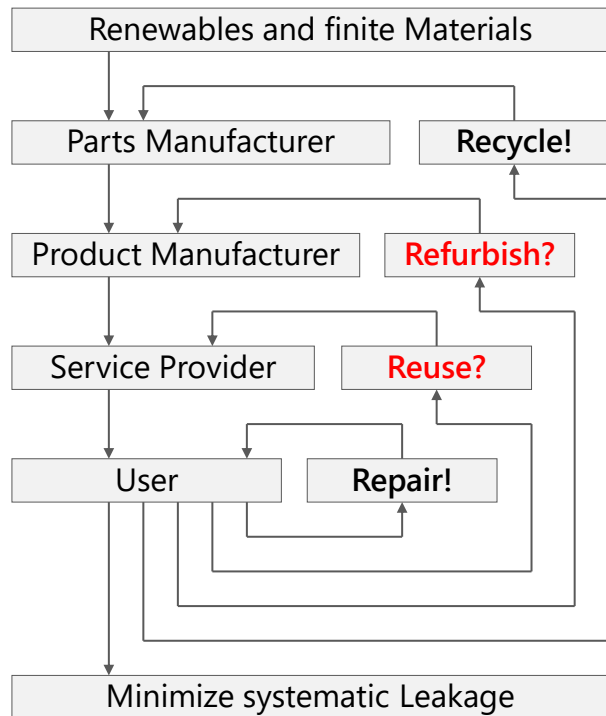
End of “regular” life, maximum of 6 years second life here

Data used

Emission factor (EU, 2017)	0.46 kgCO ₂ e/kWh
CO ₂ reduction in electricity until 2030 by 50%	
Point-to-point WDM configuration	
Power consumption	176.4 W
Use mode	24/7 always on
Successor available after	8 years
Next-Gen energy-efficiency improvement of 25%	

Arbitrary lifetime extension can lead to net-negative GWP!

Circular-economy loops and challenges



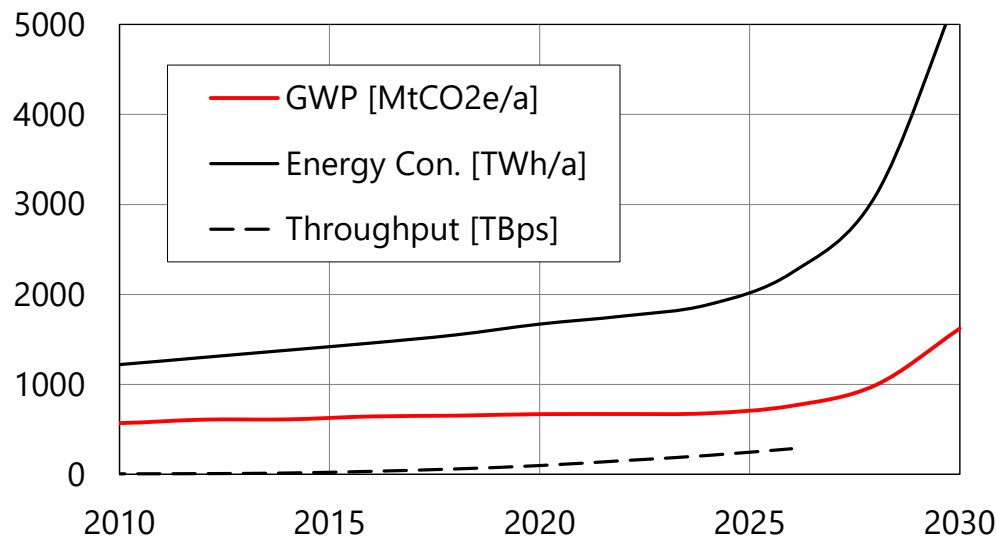
[Ellen MacArthur Foundation, CE systems diagram, 2019]

- ICT network equipment typically has **long lifetime**
 - Limited by energy efficiency and functional obsolescence
 - *Therefore, strictly limited reuse, including parts reuse*
- *Therefore, recycling as primary end-of-life path, but ...*
 - Complex material compounds
 - Regionally scattered equipment (complex reverse logistics)
 - **Recycling must be further improved**

Core-network ICT equipment does not have a substantial second life

Consequences and way out

Global ICT environmental impact



- Global ICT power consumption is forecasted to grow massively
- GWP will grow, but less due to improving electricity emission factors (kgCO₂e/kWh)
- *Is the Internet becoming the biggest emissions-generating machine...?*

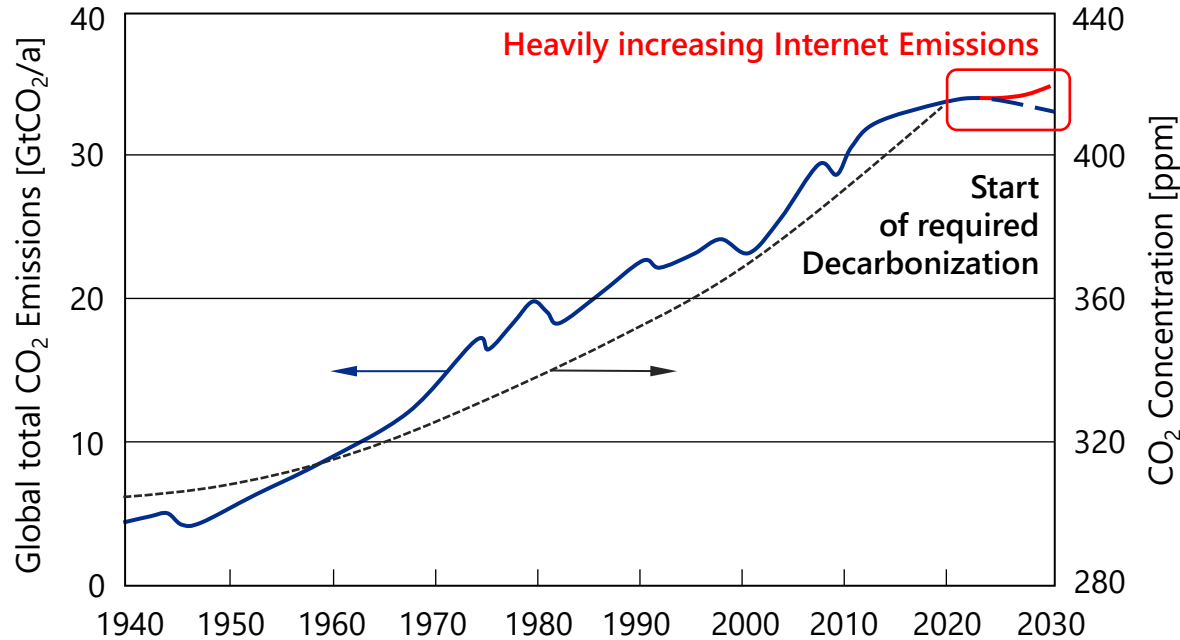
GWP : Global Warming Potential in [kgCO₂ equivalents]

[A.S.G. Andrae, Int. J. Science and Engineering Investigations Vol. 8, Issue 86, March 2019]

[GWP calculated w/ emission factors known till 2018 and predicted till 2030], [Cisco VNI, extrapolated beyond 2022]

Global ICT carbon emissions may further increase

Global carbon emissions...



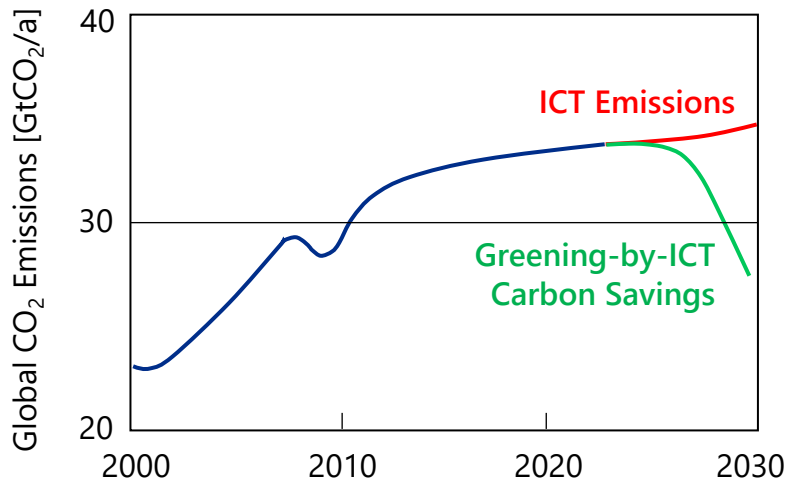
- Here, the ICT emissions are added to the global carbon emissions beyond 2020
- The increasing ICT emissions may interfere with the start of the required decarbonization

[Scripps Institution of Oceanology, Keeling Curve, online: scripps.ucsd.edu/programs/keelingcurve/wp-content/plugins/sio-luemoon/graphs/mlo_full_record.pdf]
[H. Ritchie, M. Roser, "CO₂ and Greenhouse Gas Emissions," 2020, Retrieved from: ourworldindata.org/co2-and-other-greenhouse-gas-emissions]

Is ICT increasing global warming?

ICT is the key enabler to decarbonize our lifestyle

- Some of the positive *Greening-by-ICT* effects:
 - *Dematerialization* – less travel, less transport, ...
 - *Efficiency gains* – traffic, energy grids, buildings, ...
- Covid-19 made some of these pretty clear



Global ICT-enabled CO ₂ Reduction 2030	
Sector	GtCO ₂ e
Manufacturing	2.7
Energy	1.8
Buildings	2.0
Mobility	3.6
Agriculture	2.0
Total global	12.1
Global ICT Emissions 2030	1.25
Saving Factor	9.7
[GeSI Smarter2030]	

ICT can massively enable decarbonization in *other* sectors

ICT helps climate-change mitigation and adaptation...

- **Greening-by-ICT** is a very strong enabler of climate-change mitigation / adaptation actions
 - Primarily holds for mitigation, see example sectors on previous slide
 - Also very beneficial in adaptation actions, e.g., early-warning systems for extreme-weather conditions
 - *Need to investigate and develop more Greening-by-ICT enabling actions*
- It needs to be complemented by **Greening-of-ICT**
 - Continue / strengthen power-efficiency improvements (particularly, given saturation effects)
 - Tackle the raw-material / WEEE problem – further analyze and implement ICT Circular Economy

Green ICT enables global decarbonization

Take-aways

Conclusions

- ICT is subject to exponential growth – bitrates, even power consumption
- Leads to the main environmental impact – emissions, critical raw materials
- However, ICT has a **very strong climate-change mitigation & adaptation enabling potential**
- *Recommendations for the future*
 - *Further improve power-efficiency, against saturation effects*
 - *Further improve Circular Economy in ICT, against the main challenges (use-phase dominance)*
 - *Further investigate in Greening-by-ICT services*

Green ICT is needed for greening the planet



Thank you

KGrobe@ADVA.com



IMPORTANT NOTICE

The content of this presentation is strictly confidential. ADVA Optical Networking is the exclusive owner or licensee of the content, material, and information in this presentation. Any reproduction, publication or reprint, in whole or in part, is strictly prohibited.

The information in this presentation may not be accurate, complete or up to date, and is provided without warranties or representations of any kind, either express or implied. ADVA Optical Networking shall not be responsible for and disclaims any liability for any loss or damages, including without limitation, direct, indirect, incidental, consequential and special damages, alleged to have been caused by or in connection with using and/or relying on the information contained in this presentation.

Copyright © for the entire content of this presentation: ADVA Optical Networking.

