Total Consumer Power Consumption Forecast

by Dr. Anders S.G. Andrae (Huawei) at the Nordic Digital Business Summit, Helsinki, Finland, October 5, 2017

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Introduction

The are conflicting messages regarding the path to sustainability:

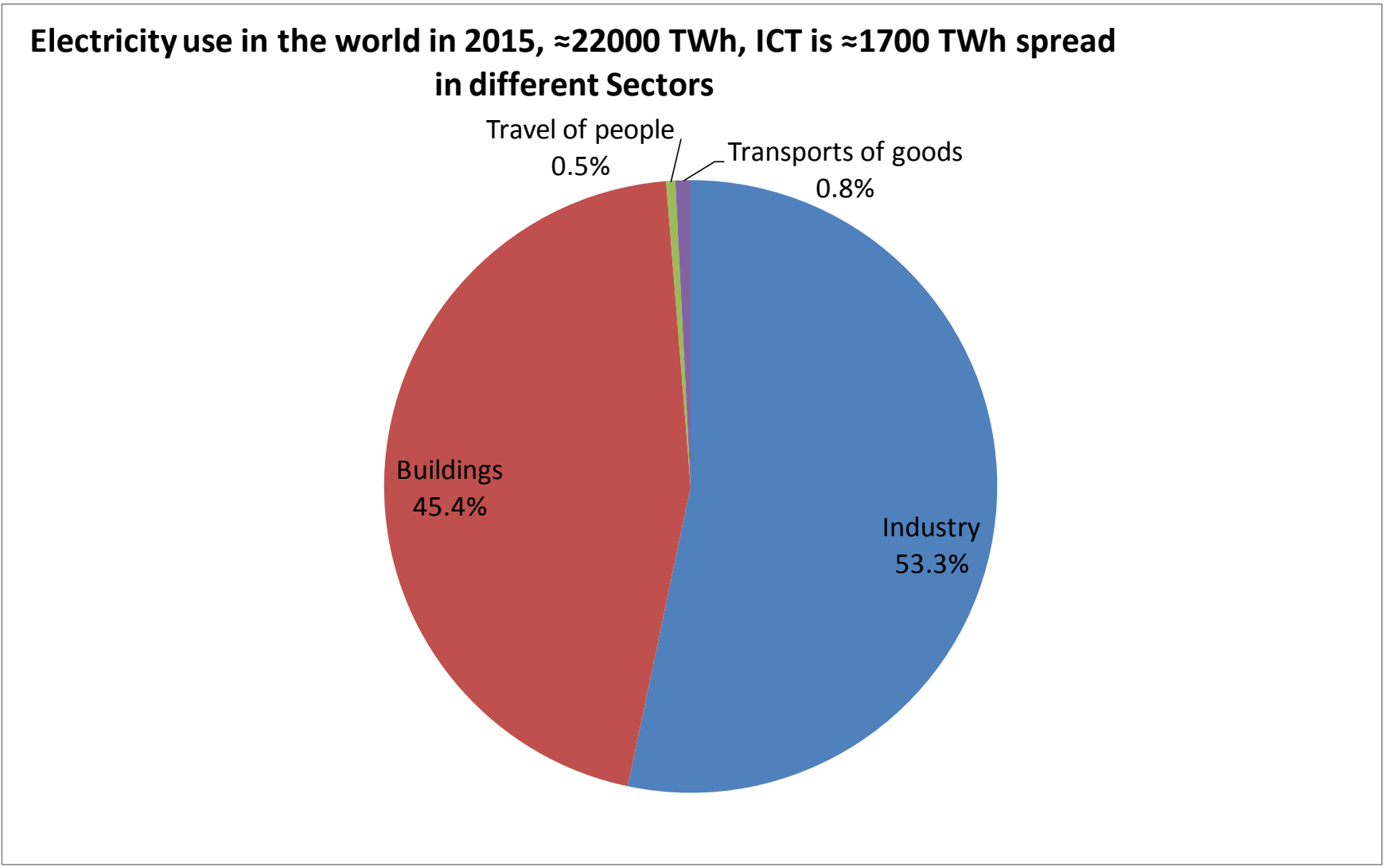
- -different ways to measure
- -different statistics
- -we got to prepare ourselves for a truth about the environment we may not like?
- -we might enter the YottaByte (10^{24} Byte) era in the next decade – if so, can the effect on power consumption be understood?

Problems with several existing ICT footprint investigations:

- -too limited (geographical and temporal) system boundary
- -overestimation of power saving potential in the *next* decade
- -assume that historical—low—power use can predict future *global* power use in the next decade with—foreseen—*unprecedented* data traffic growth
- -assume that Moore´s law relation to digital circuitry can continue "forever"
- -"wrong" slicing of the networks and thereby possible double counting of e.g. the core network

- Can future consumer ICT infrastructure actually slow its overall electricity use until 2025?
- Under which circumstances is the power consumption of ICT slowing?
- Under which circumstances is it rising?

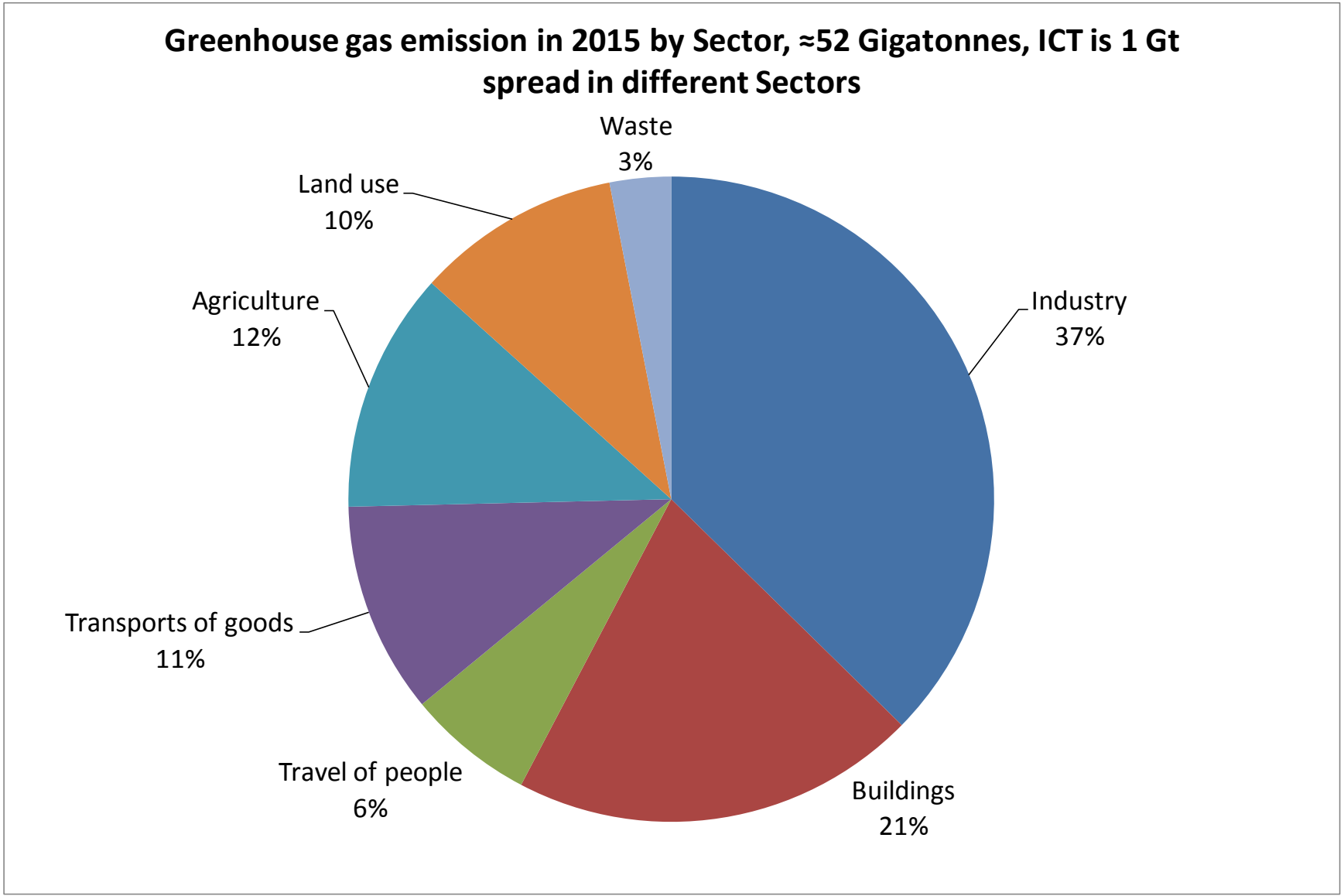
Introduction – ICTs share of the big picture for electricity



Sources: Adaptions of Malmodin, J., & Bergmark, P. (2015). and Andrae&Edler (2015).

Introduction – ICTs share of the big picture for GHG

Source: Adaptions of Malmodin, J., & Bergmark, P. (2015).



Methodological approach – Global Scope

1. Consumer ("client+TV") devices: *Desktops, Monitors, Laptops, Smartphones, Tablets, Ordinary Mobile Phones, Phablets, Mobile Broadband Modems, TVs, TV peripherals (Set Top Boxes and Game Consoles)+Smarthome devices+Wearable devices+AR/VR devices*

2. Wireless (mobile) Access Networks: *radio base stations, mobile switching*

3. Fixed Wired Access Networks: *Optical core wired access networks*

4. Fixed Wi-Fi Access networks: *Customer Premise Equipment+WLAN*

5. Data Centers: *Entire data centers including cooling*

6. Production of all: *Production from LCAs for devices, lifecycle ratio method for Networks and Data Centers*

Methodological approach – trends

Trends are more important than ”exact” use patterns and numbers, as we do not exactly know *how* and *which* devices will be used in the future.

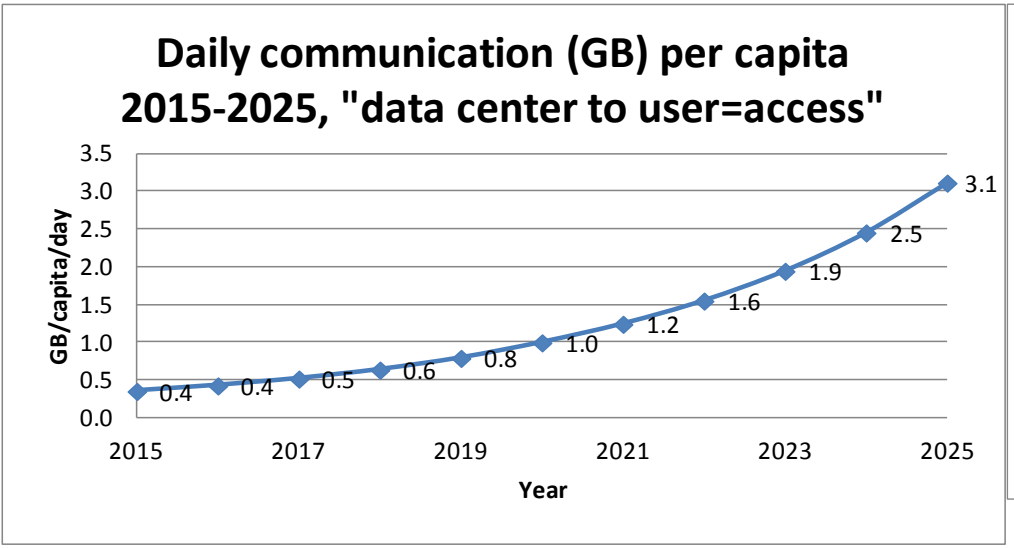
Fundamental conflict (for wireless mobile) between cost, bandwidth efficiency and energy efficiency.

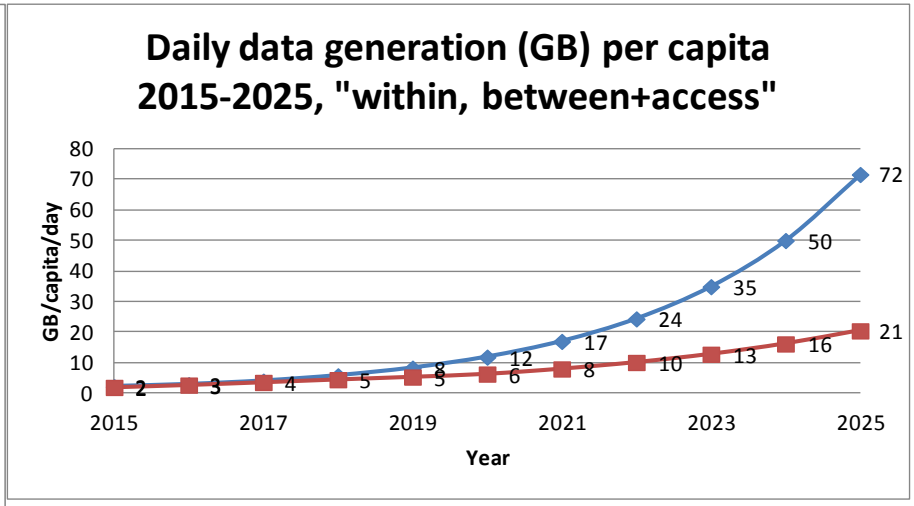
Optimizing for energy efficiency (EE) will be essential going forward.

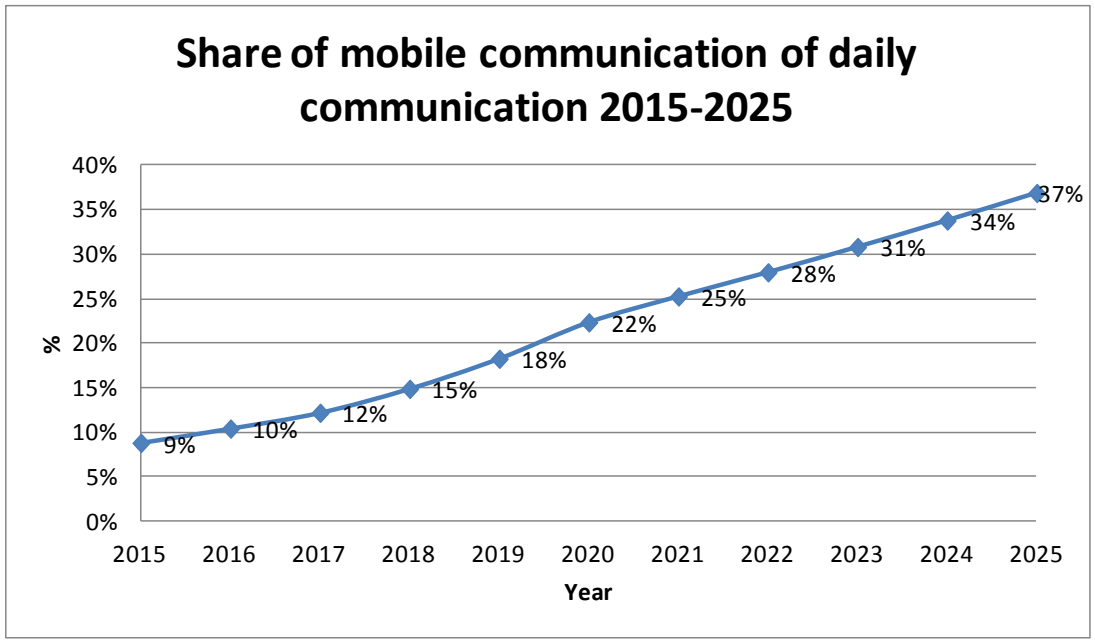
MAJOR TRENDS:

- IoT
- Artificial Intelligence
- Augumented Reality
- Virtual Reality
- Fog computing, SDN, Virtualization
- Mobile Edge Computing to increase battery life of mobile phones
- High-frequency EE antennae, for exampel GAPWAVES
- 35% annual increase of the average peak data rate from 2G → 5G and 6G (expected in 2030 with at least 80Gb/s), 20 times higher rates for each G.

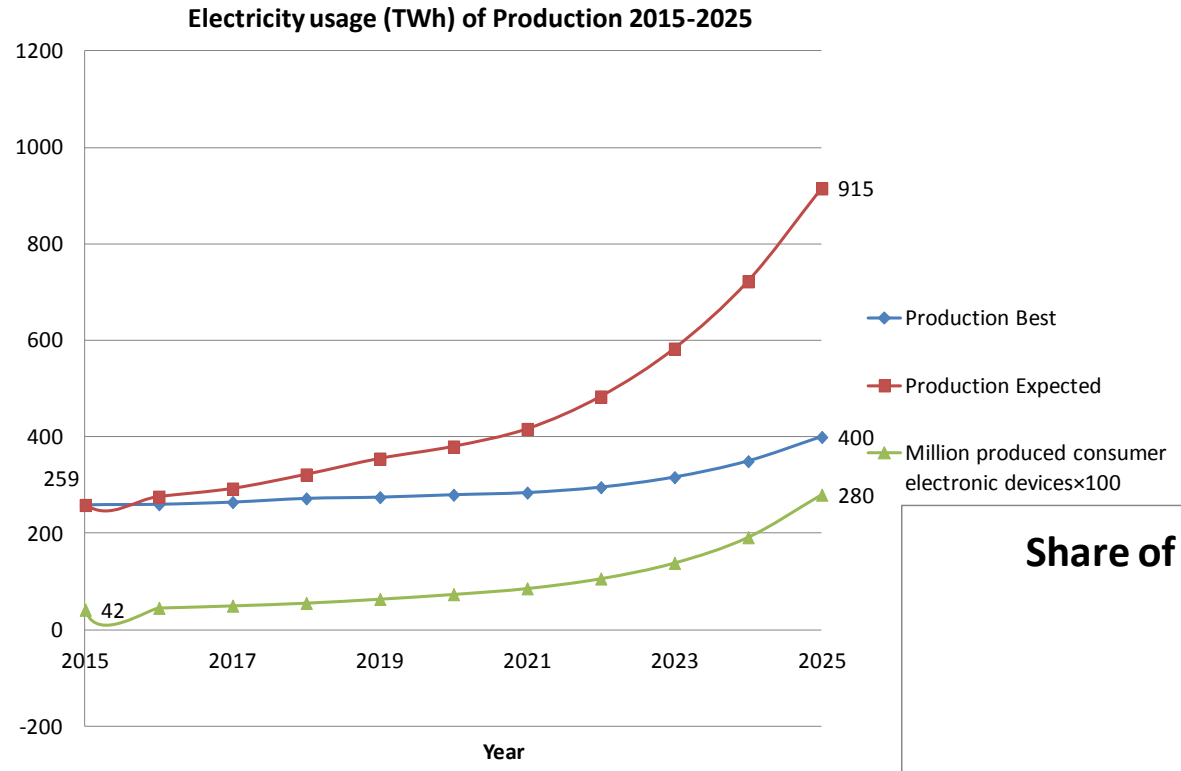
Global Data trends







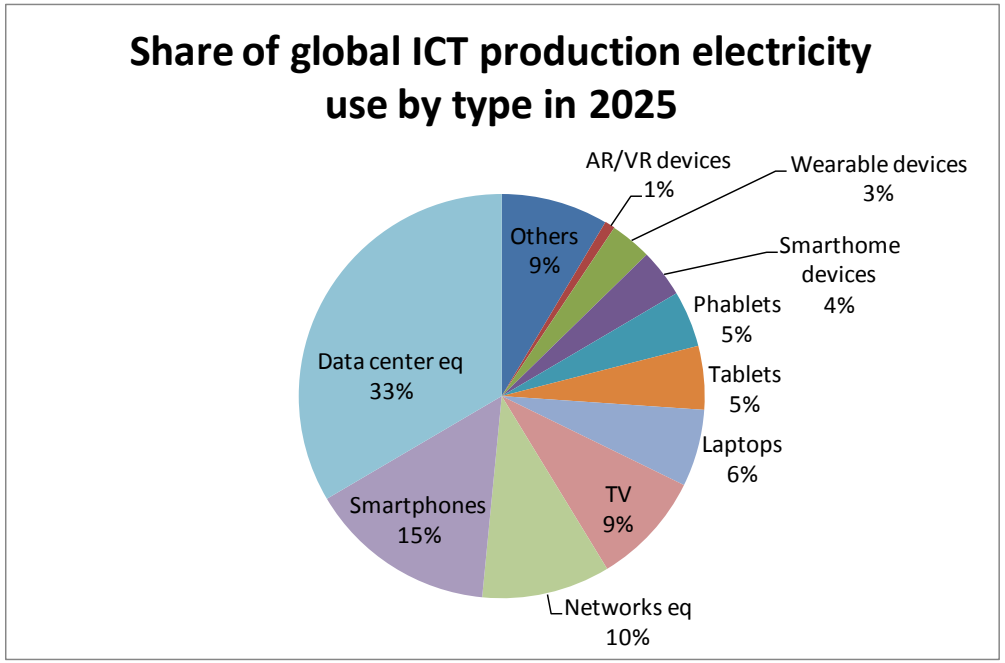
Emerging trends in global electricity use of production of hardware



Best case assumptions:
Lowest upstream LCA value for production in 2010,
5% annual improvement of productivity, lowest value (10%) found for share of manufacturing electricity, Networks and Data Centers 10%

Expected case assumptions: 3% improvement, 15% share of manufacturing

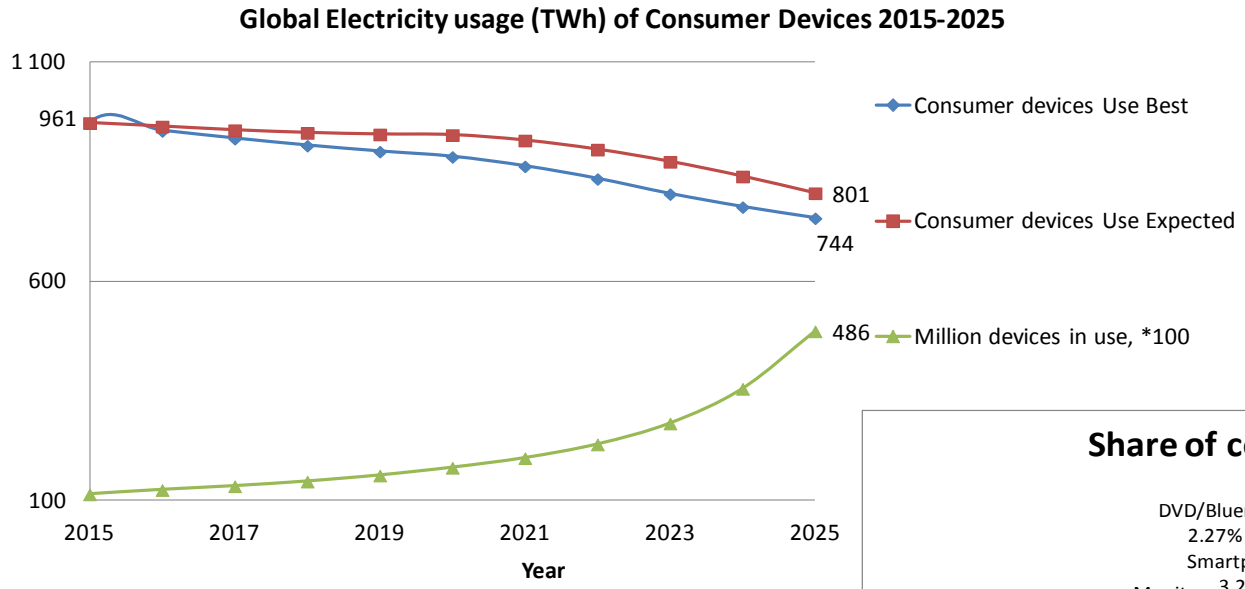
- Smarthome devices, Wearable devices, and AR/VR devices increase the electricity use of production by ≈5-10% .
- The share of the Production of Data Center Hardware and Network Hardware is expected to rise.

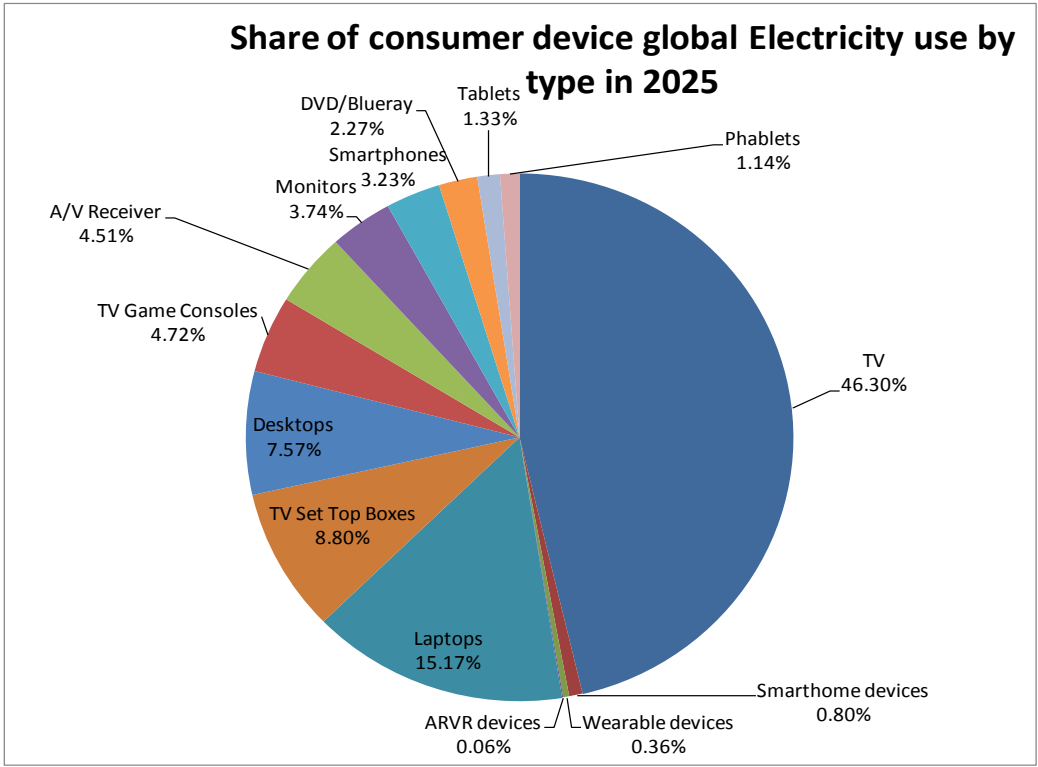


Source: Adaptions of the Supplementary Materials of http://www.mdpi.com/2078-1547/6/1/117

Emerging trends in global electricity use of consumer devices

Model includes:
- Lifetimes
- Units produced/year
- Average electricity used/unit/year
- Annual reduction of electricity (%)

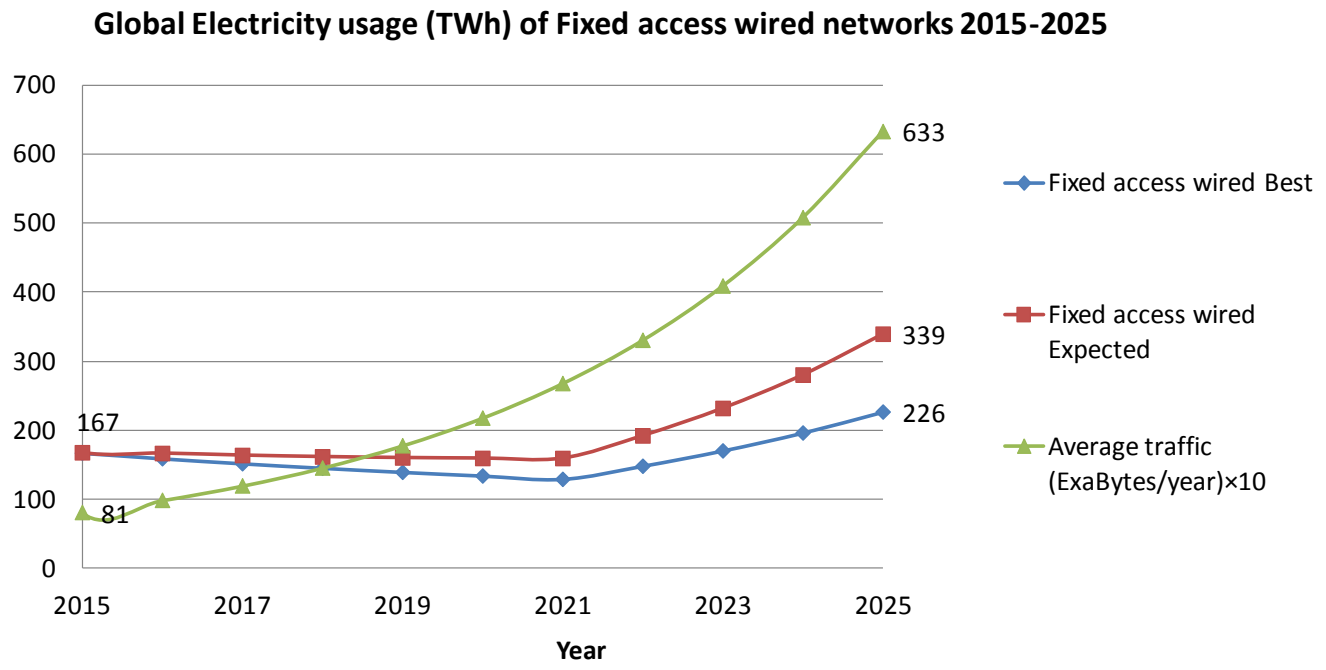




Source: Adaptations of Supplementary Materials of http://www.mdpi.com/2078-1547/6/1/117

- The client device power use is dominated by processing and displays.
- Current downward trend is expected to continue.
- Power saving (architectures, management, technologies) will allow improvements.
- Smarthome devices, wearables and AR/VR seem to be ≈1% of total in 2025. TVs&peripherals >60%.

Emerging trends in global traffic and electricity use of fixed wired access networks



Source: Adaptations of http://www.mdpi.com/2078-1547/6/1/117

The large energy saving improvements from phasing out copper are already included →Future improvement rate will eventually not mitigate traffic growth. Still, the average EI could be improved ≈5 times between 2015 and 2025.

Model includes:

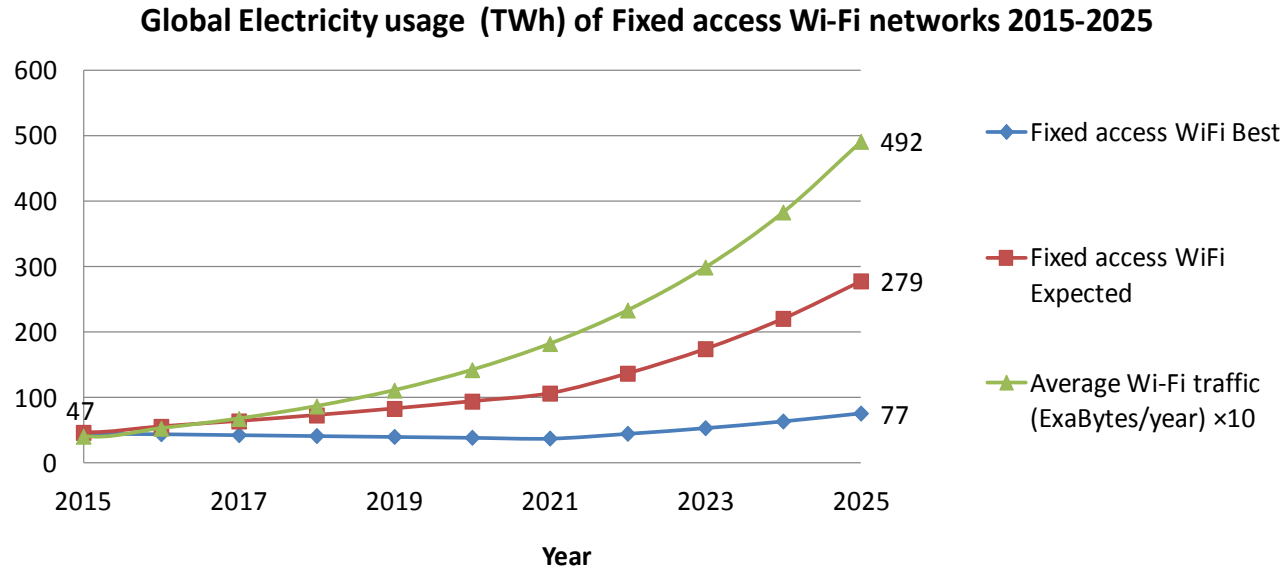
❑Global electricity usage in 2011 (178 TWh) and 2012 (196 TWh)

❑Fixed access wired + fixed access Wi-Fi data traffic in 2011 (390 EB/y) and 2012 (470 EB/y) and so on…

❑Annual electricity intensity improvement (EI), 22% (best) and 15% p.a. (expected)

❑From 2022, for EI only, 5% is assumed possible for both scenarios as I expect it will become more difficult to improve the EI via Moore's Law.

Emerging trends in global traffic and electricity use of fixed Wi-Fi access networks



Model includes:

❑Global electricity usage of CPE (46 TWh) in 2011 and 2012 (51 TWh)

❑Fixed access Wi-Fi data traffic in 2011 (154 EB/y) and 2012 (200 EB/y) and so on..

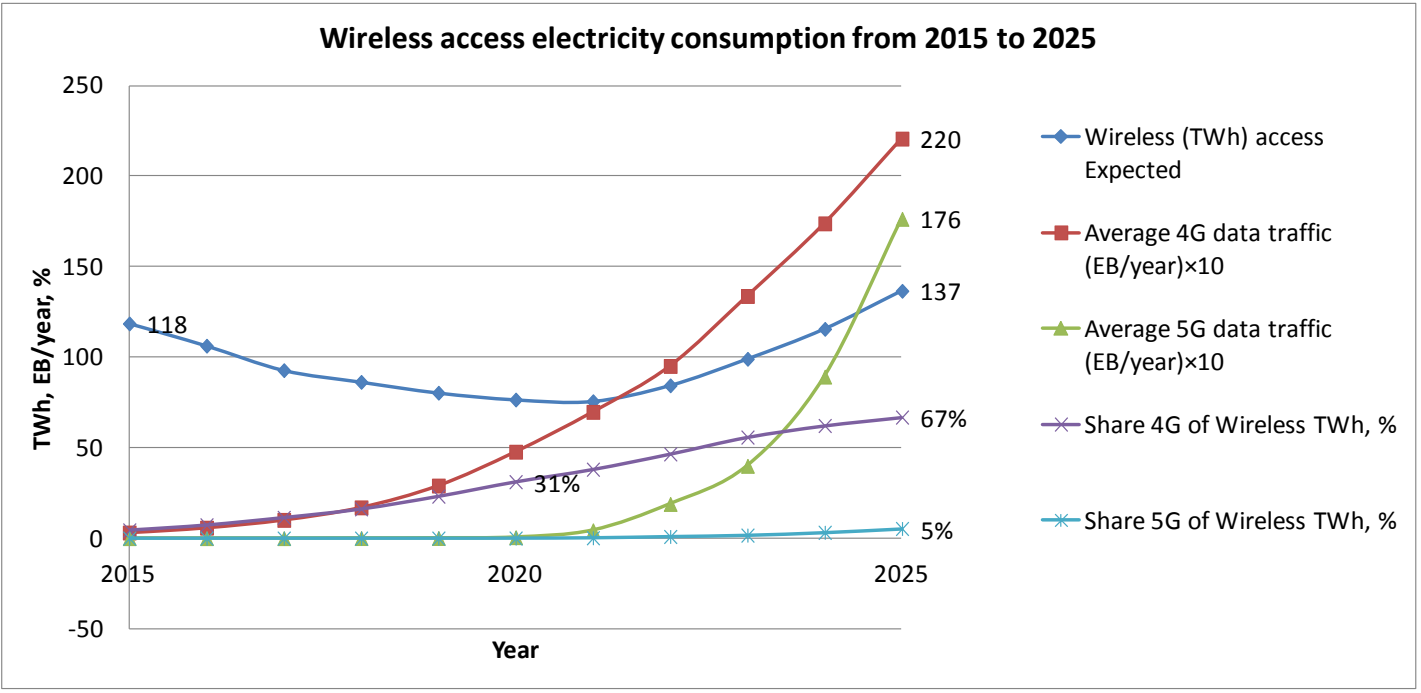
❑Annual electricity intensity improvement (EI) 22.5% p.a. (best) and 15% p.a. (expected)

❑From 2022, for EI only, 5% is assumed possible for both scenarios.

CPEs (modems, gateways, ONTs) are improving their energy efficiency, but the numbers are growing assumingly along the traffic. The Wi-Fi backhaul infrastructure (included here) is also expected to keep growing.

Source: http://www.mdpi.com/2078-1547/6/1/117

Emerging trends in global traffic and electricity use of wireless (mobile) networks



Source: http://www.mdpi.com/2078-1547/6/1/117

KPN, between 2010 and 2015:

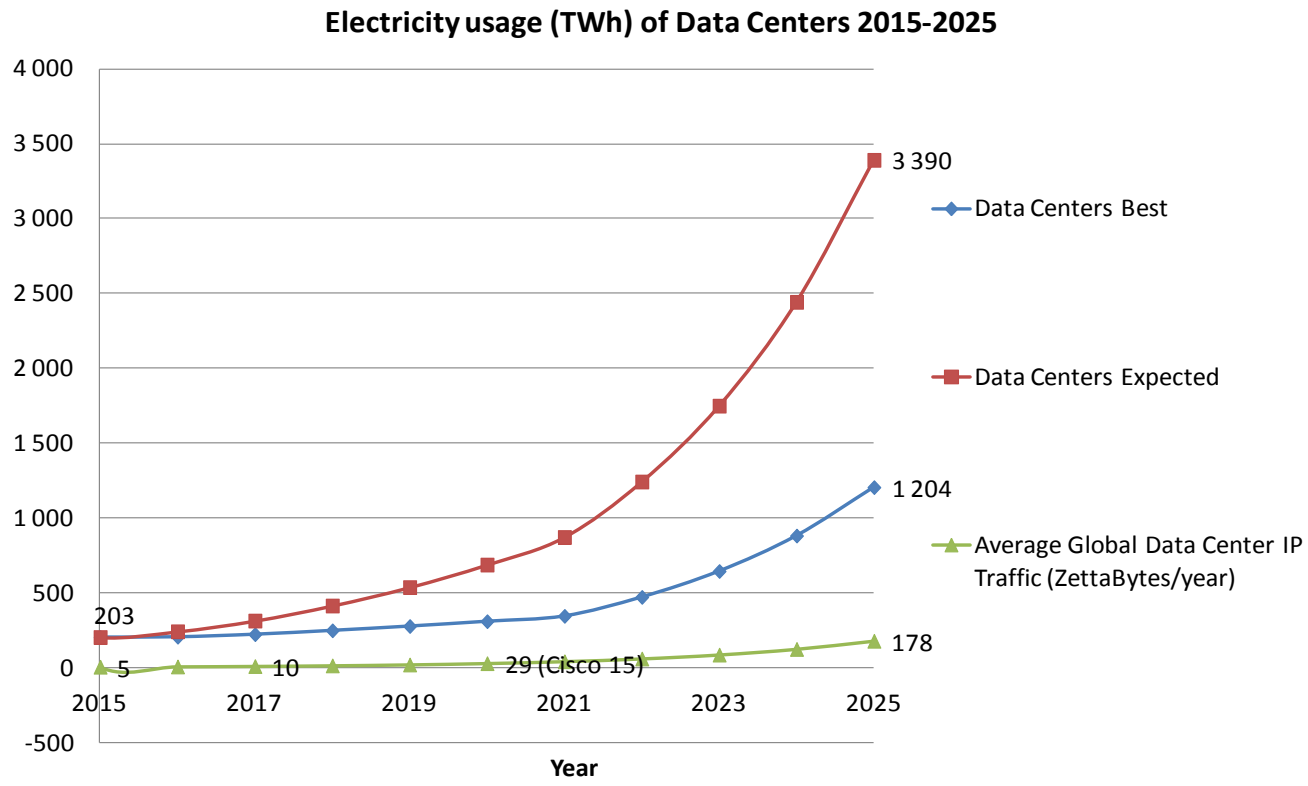
- ❑decreased their Network power consumption by 12%
- ❑ improved their energy efficiency [GWh/Gbps] by 30% per year for wireless and fixed networks.

I expect >50 times improvement of average EI globally.

Source: KPN Integrated Annual Report 2015 Tables 2 and 6 in Appendix

- ❑**I currently expect a reduction until around 2021 in global WAN due to replacements (”swapping”).**
- ❑**After 2022 I foresee an increase of the electricity use.**
- ❑**22% p.a. 2015-2021, 5% p.a. from 2022-2025**
- ❑**Should the breakthrough of the energy efficienct ”5G” be delayed five years (1% 2025 instead of 1% 2020), an extra 47 TWh could be used by WAN globally.**

Emerging trends in global traffic and electricity use of data centers



Between 2010 and 2015, KPNs data centers <u>increased</u> their power consumption by 9%.

Source: KPN Integrated Annual Report 2015 Table 2 in Appendix

Model includes:

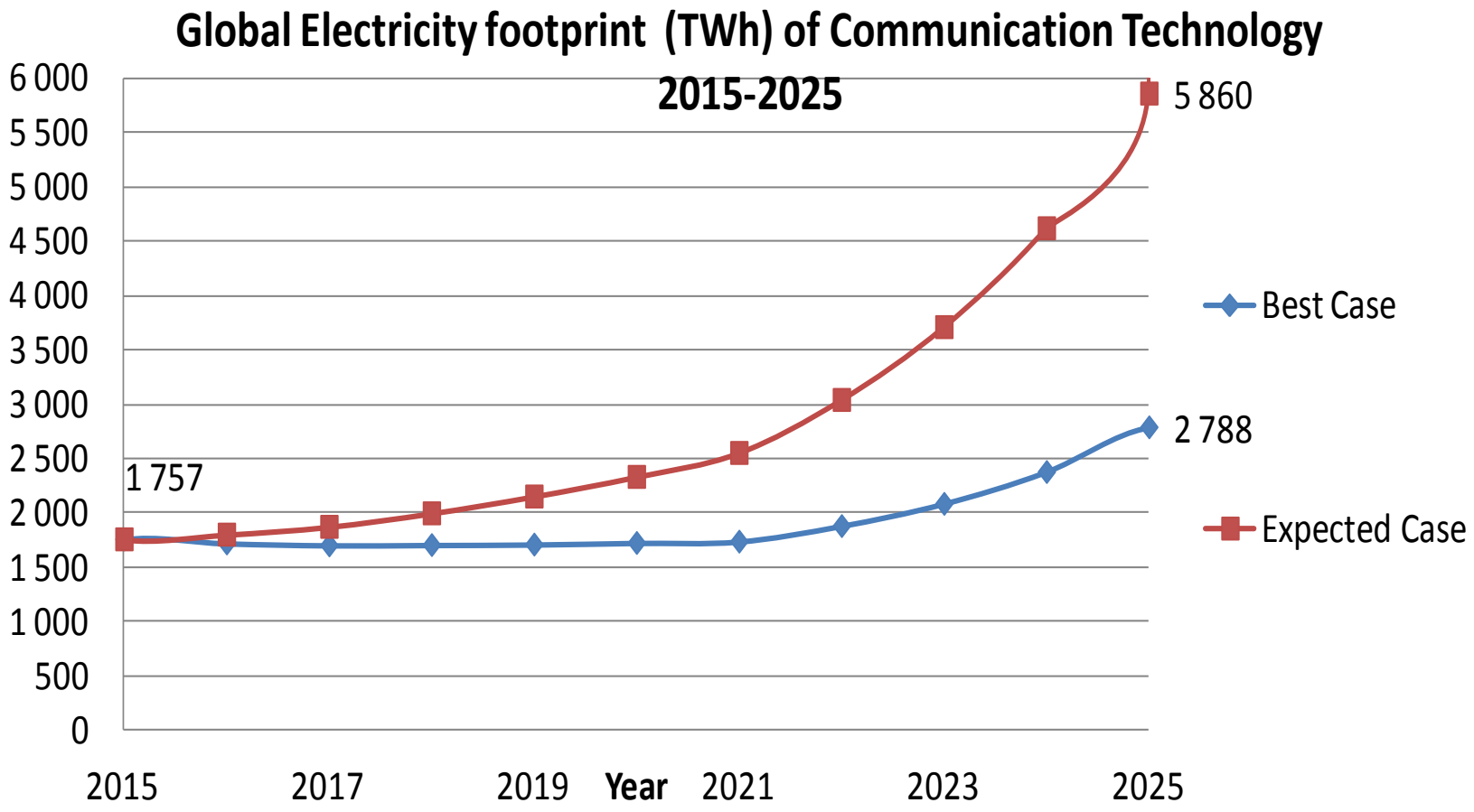
❑Global electricity usage in Data Centers in 2010 (≈189 TWh) and 2011 (≈193 TWh).

❑Global Data Center IP traffic in 2010 (≈1.4ZB) and 2011 (≈1.8ZB).

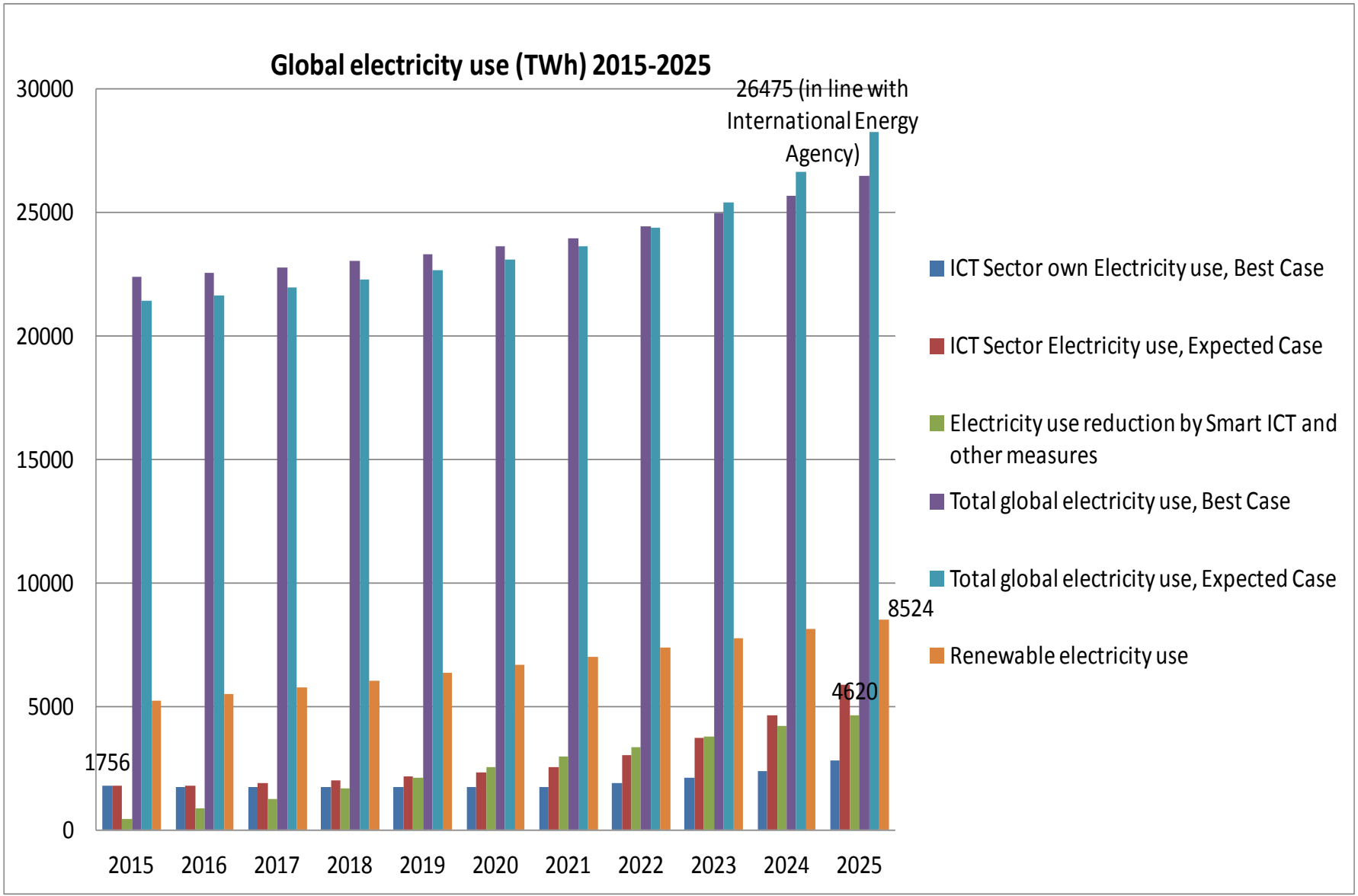
❑Annual electricity intensity improvement (EI), 22.5% p.a. (best), 15% p.a. (expected).

❑From 2022, for EI only, 5% is assumed possible for all scenarios.

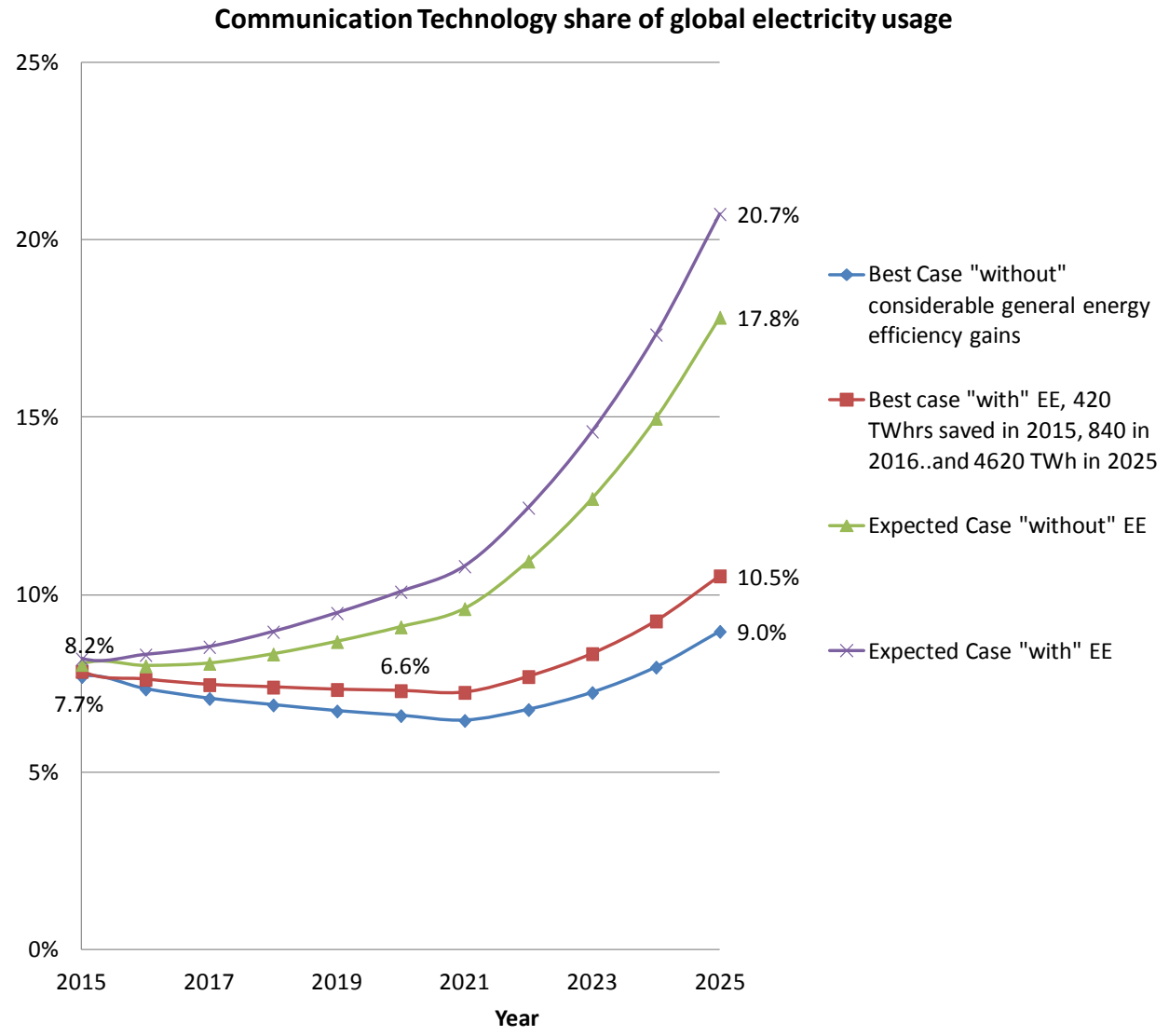
Synthesis: The global power trend for ICT 2015 to 2025



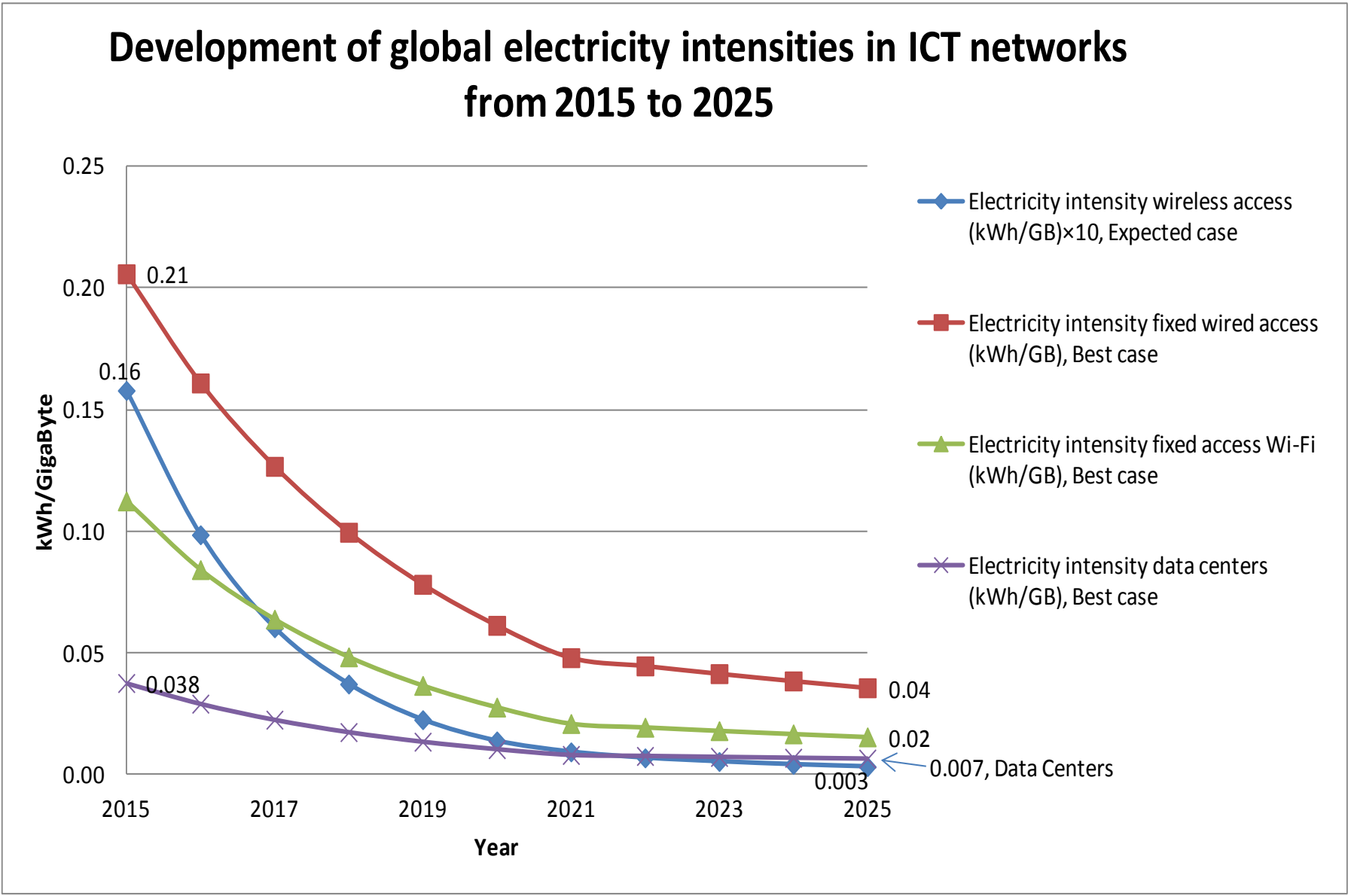
Increasing energy efficiency including enabling effect of SMART ICT Solutions



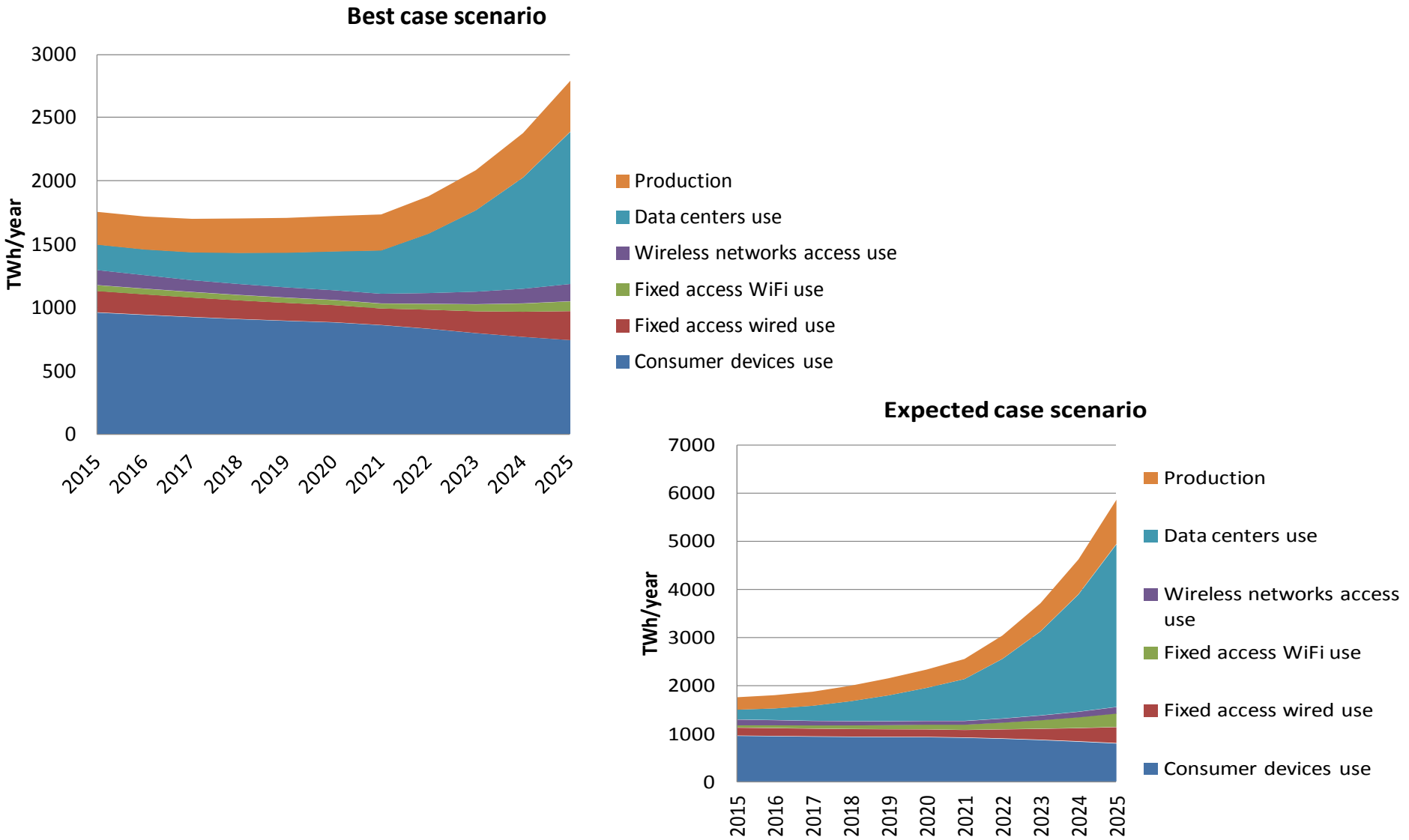
The share of ICT of global electricity usage: 2015 to 2025 with and without high global energy efficiency gains



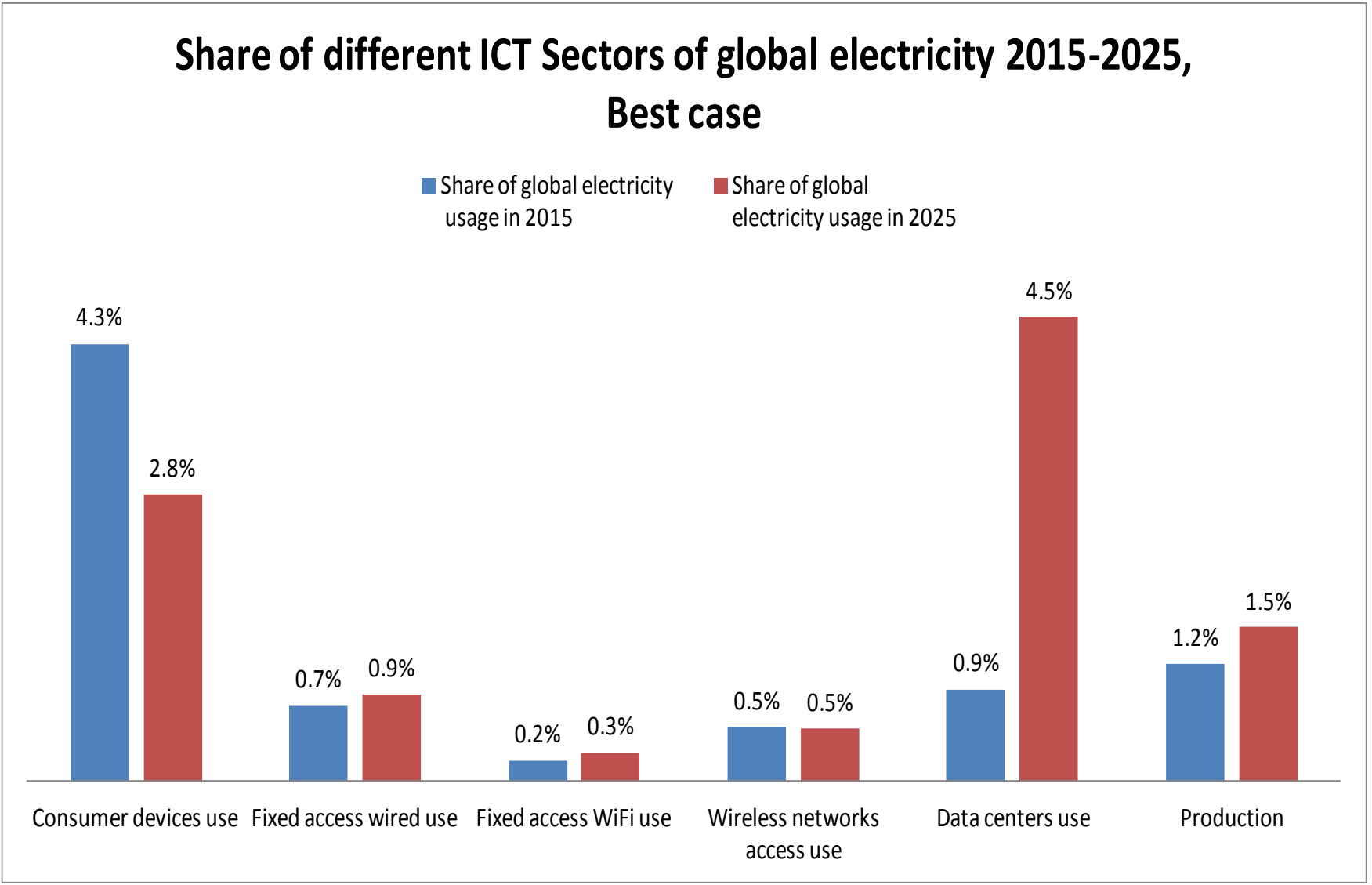
The global trends for ICT electricity intensities 2015 to 2025



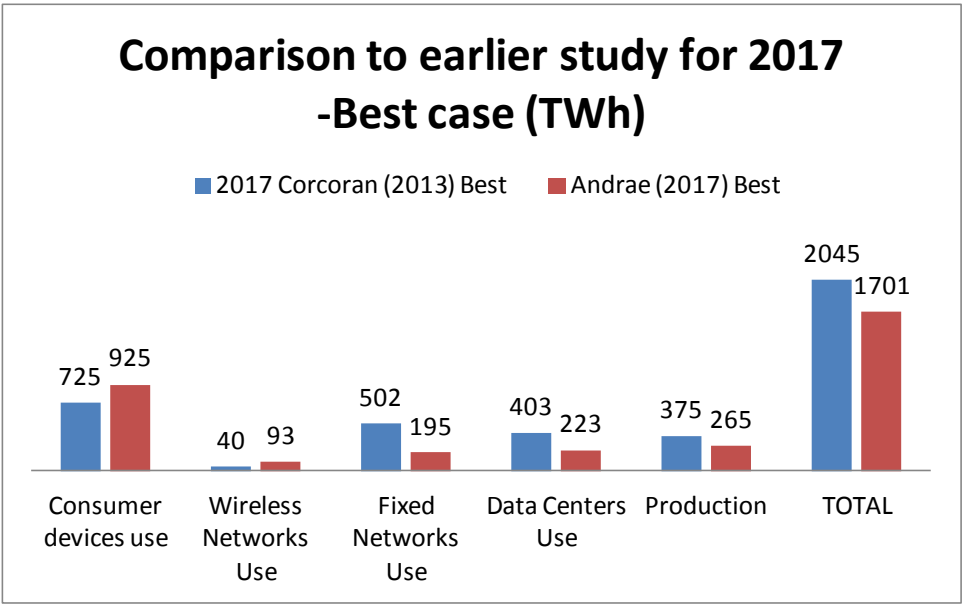
The global power repartition trends for ICT between 2015 and 2025

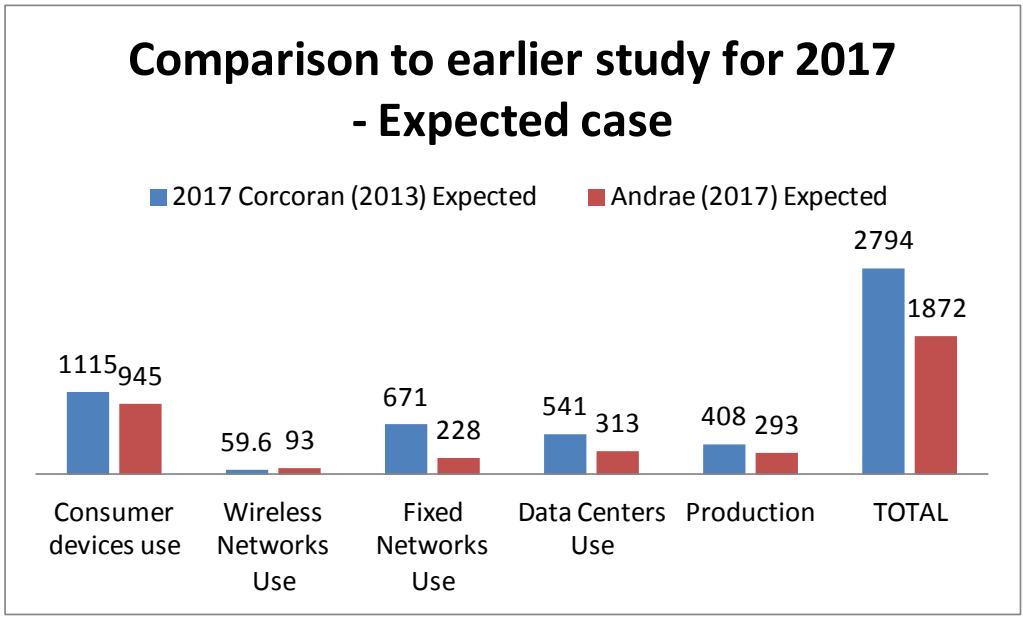


The share of different sections of ICT of global electricity use in 2015 and 2025

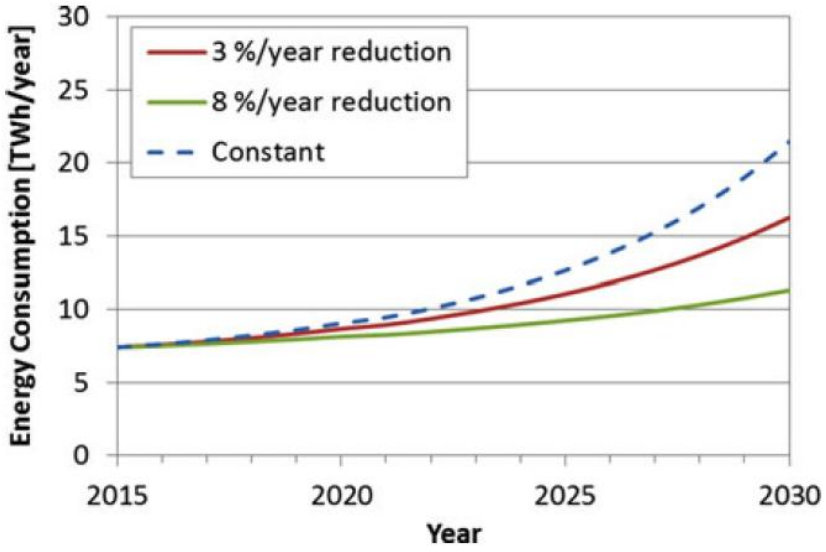


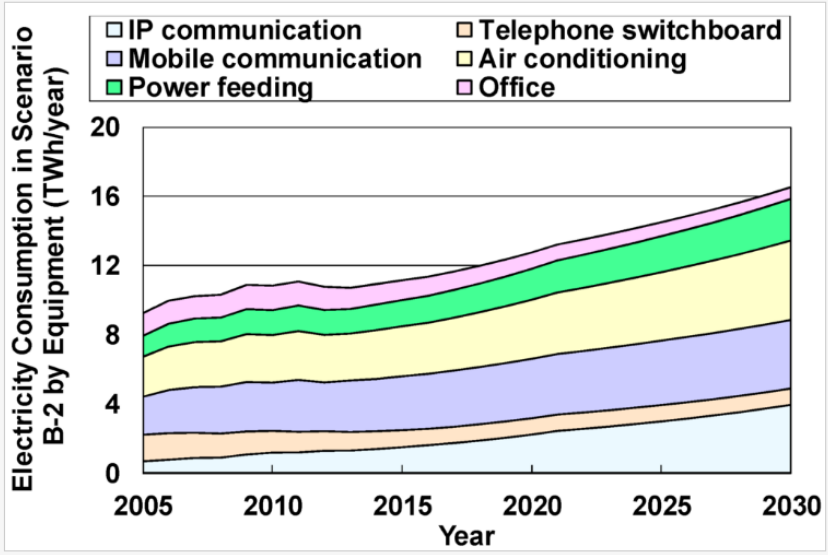
How does this study compare to 1st global study by Prof. Peter Corcoran in 2013?

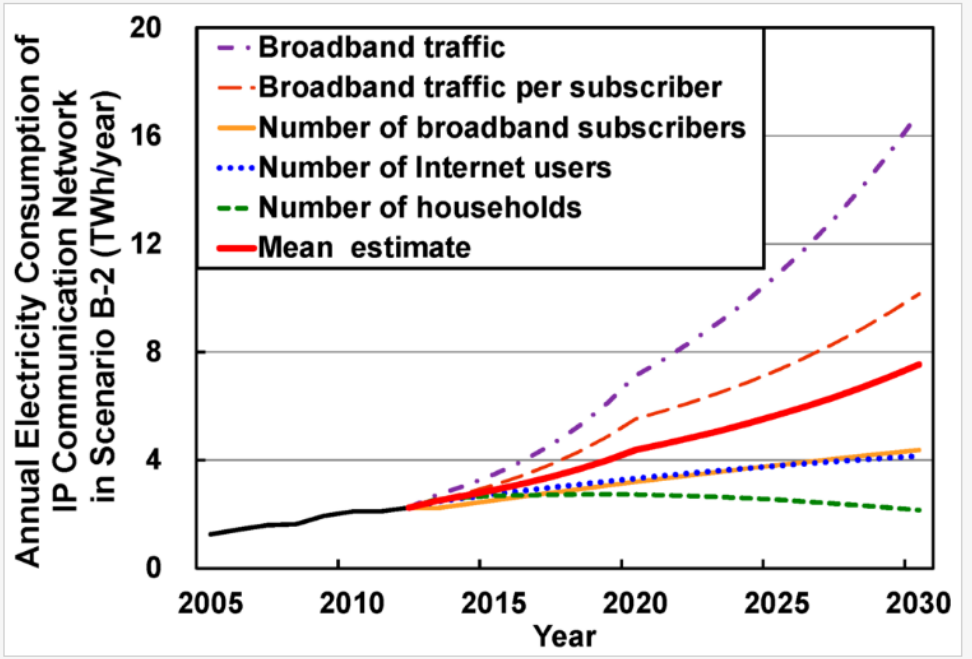




Other studies expected trends: Fixed and wireless electricity use in Japan







Increasing electricity use is expected in Japans telecom networks from now until 2030. Data centers, CPEs, production and client devices are not seemingly included.

Sources: Ishii, K.; Kurumida, J.; Sato, K.-i.; Kudoh, T.; Namiki, S. Unifying Top-Down and Bottom-Up Approaches to Evaluate Network Energy Consumption. *Journal of Lightwave Technology* **2015**, 33, 4395. Kishita, Y.; Yamaguchi, Y.; Umeda, Y.; Shimoda, Y.; Hara, M.; Sakurai, A.; Oka, H.; Tanaka, Y. Describing Long-Term Electricity Demand Scenarios in the Telecommunications Industry: A Case Study of Japan. *Sustainability* **2016**, *8*, 52.

Discussion

- The speed of electricity intensity reduction vs. the speed of data traffic increase.
- Highly variable outlooks for the future power consumptions depending on ”starting values” and percentual estimations of electricity intensity reductions and data traffic increase.
- Rebound effects – new consumption of goods and services
- “Ultra-efficient” Hong Kong's annual electricity consumption—and GHG emissions from electricity consumption—is predicted to increase by 2030

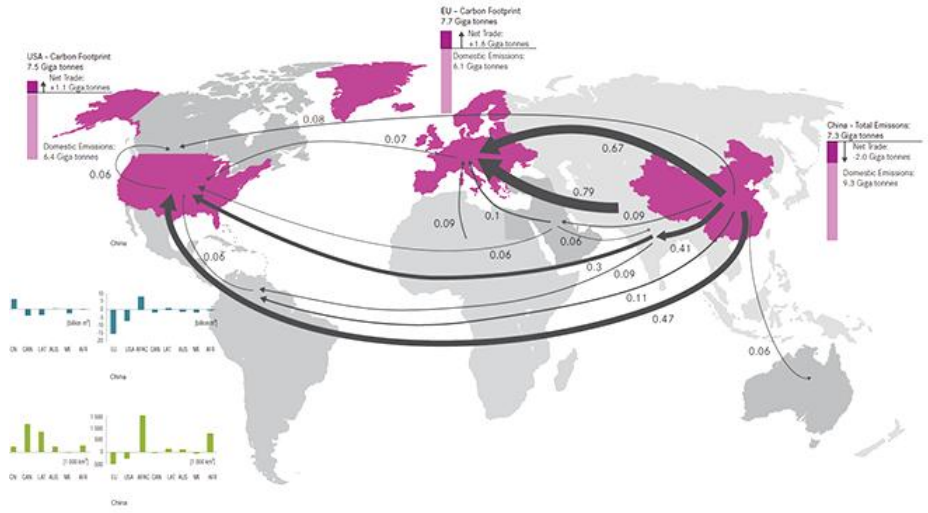
Concluding Remarks

Future consumer ICT infrastructure cannot slow its overall electricity use until 2025.

The electric power consumption of the present ICT scope will be very significant unless great efforts are put into power saving features.

It seems though that planned power saving measures and innovation will be able to keep the electricity consumption of ICT and the World under control.

Outlook



Source: http://www.exiobase.eu/

Different ”slicing” of the framework—

- Production of Networks hardware — number of servers, routers, base stations, modems,
- Production of consumer devices.
- Consumer devices use power,
- Core network use power,
- Access network use power,
- Private data center use power,
- Shared data center use power

—might lead to different absolute values and trends than my approach?

Widening the scope:

- EXIOBASE: Resource extractions and emissions related to the ICT industry.
- Sustainability risk estimations: EPS2015 for expressing the sustainability costs and savings.
  - *Land use change*
  - *Biodiversity*

Thanks for your attention!

anders.andrae@huawei.com

The global power repartition trends for ICT between 2015 and 2025 (II)