

# Total Consumer Power Consumption Forecast

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the Nordic Digital Business Summit,  
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# Introduction

There are conflicting messages regarding the path to sustainability:

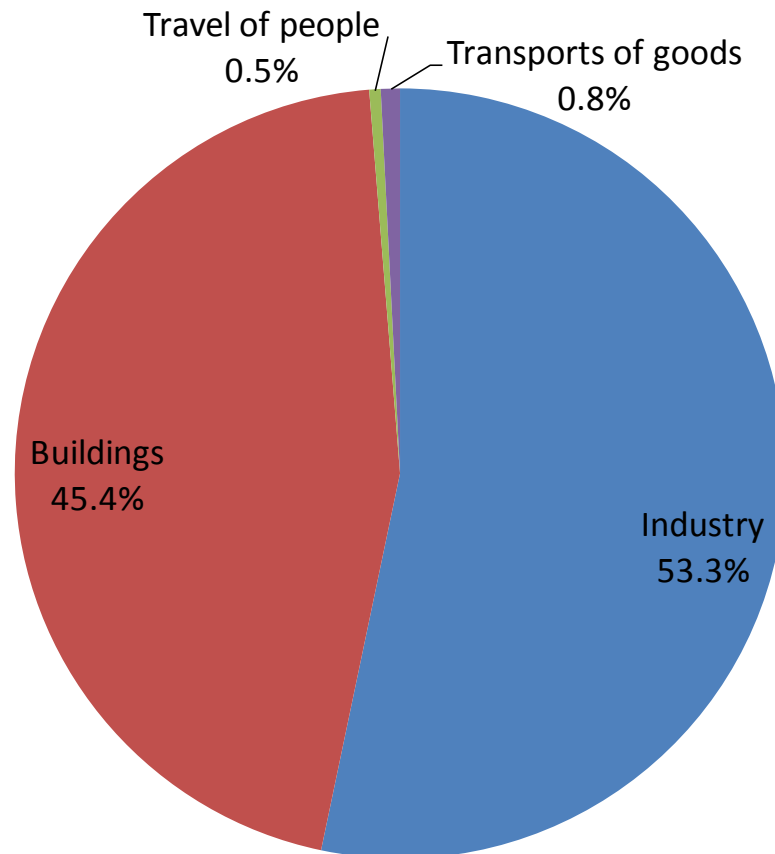
- ❑ -different ways to measure
- ❑ -different statistics
- ❑ -we got to prepare ourselves for a truth about the environment we may not like?
- ❑ -we might enter the YottaByte ( $10^{24}$  Byte) era in the next decade – if so, can the effect on power consumption be understood?

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

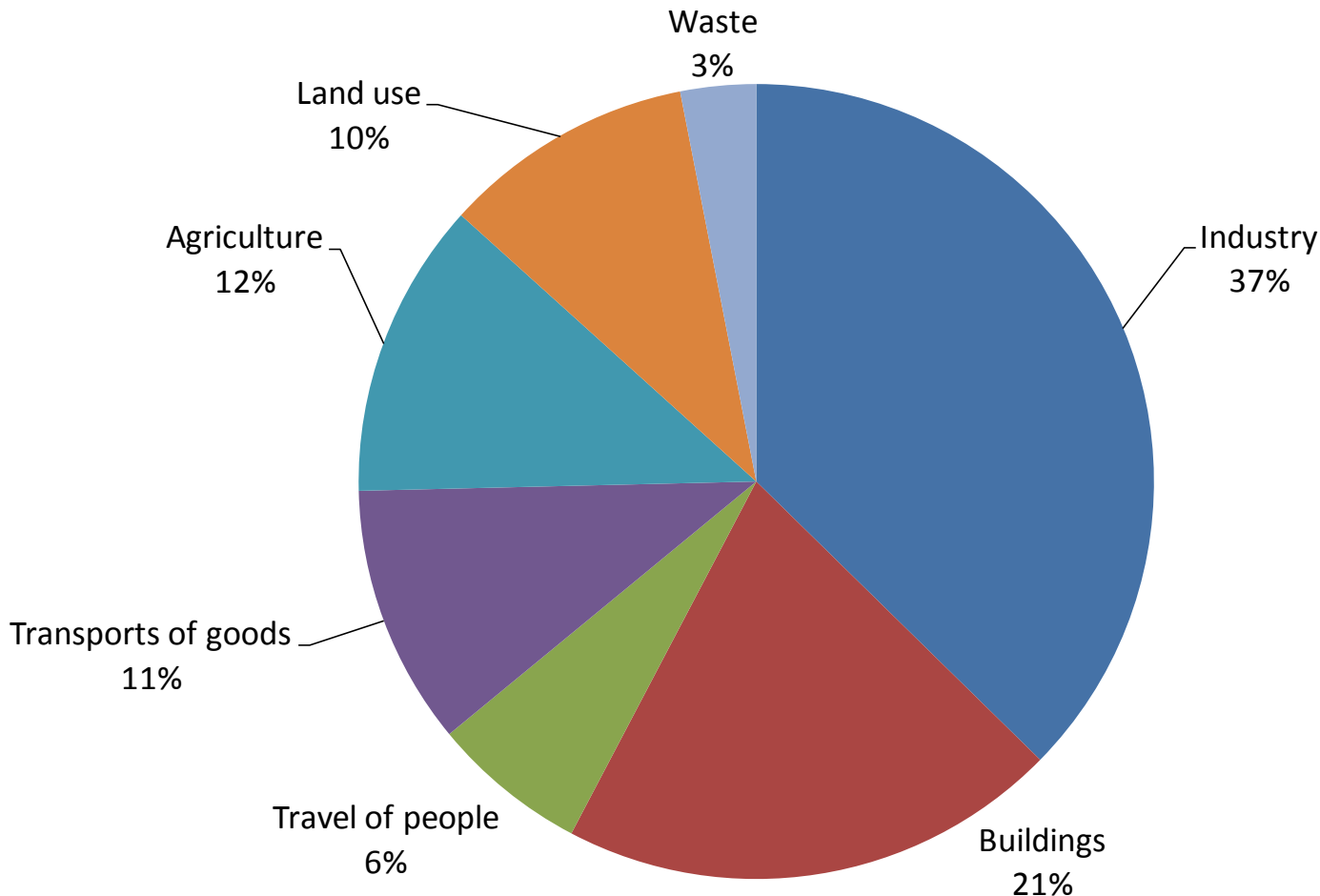
Electricity use in the world in 2015,  $\approx 22000$  TWh, ICT is  $\approx 1700$  TWh spread in different Sectors



# Introduction – ICTs share of the big picture for GHG

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

**Greenhouse gas emission in 2015 by Sector, ≈52 Gigatonnes, ICT is 1 Gt spread in different Sectors**



# 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.

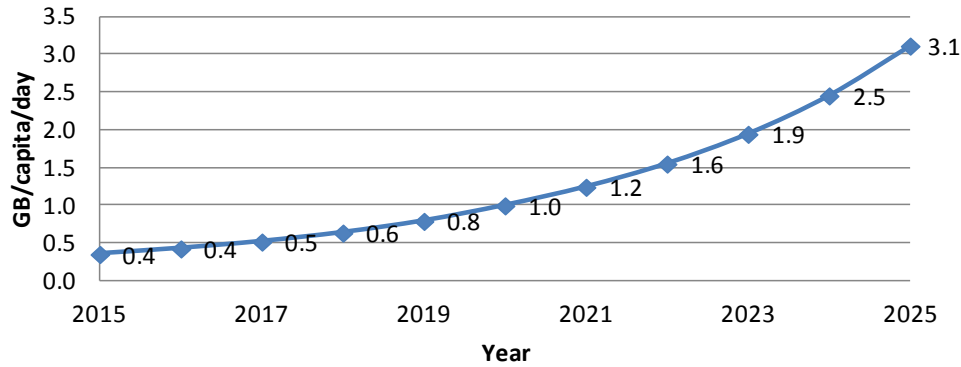
Optimizing for energy efficiency (EE) will be essential going forward.

## MAJOR TRENDS:

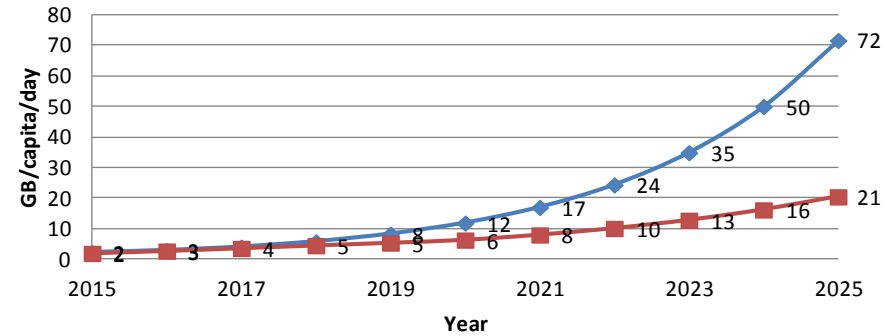
- ❑ IoT
- ❑ Artificial Intelligence
- ❑ Augmented Reality
- ❑ Virtual Reality
- ❑ Fog computing, SDN, Virtualization
- ❑ Mobile Edge Computing to increase battery life of mobile phones
- ❑ High-frequency EE antennae, for example GAPWAVES
- ❑ 35% annual increase of the average peak data rate from 2G →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

# Global Data trends

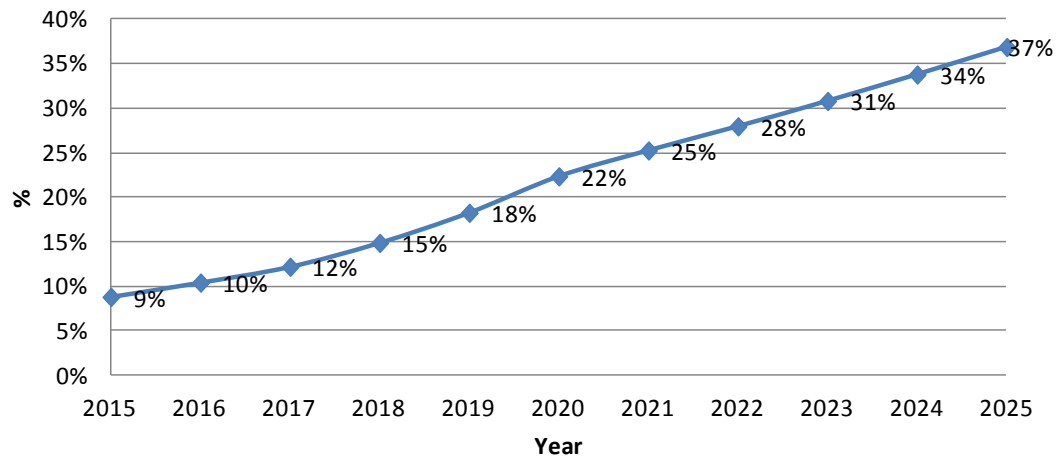
## Daily communication (GB) per capita 2015-2025, "data center to user=access"



## Daily data generation (GB) per capita 2015-2025, "within, between+access"



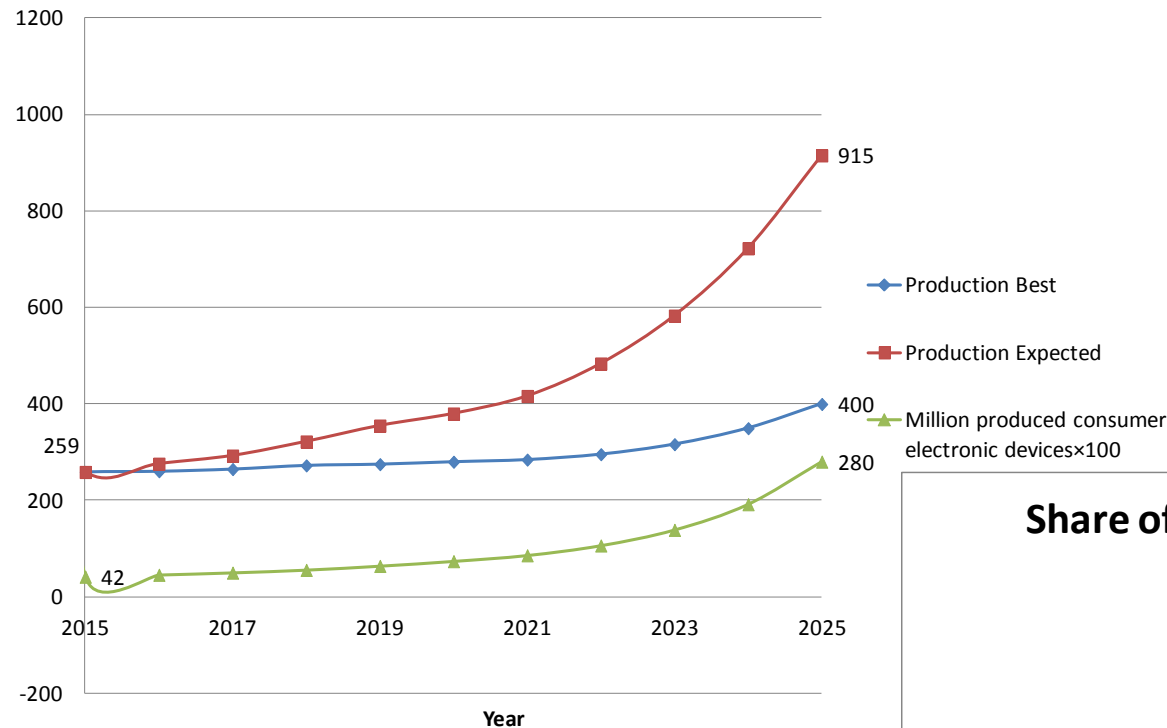
## Share of mobile communication of daily communication 2015-2025





# Emerging trends in global electricity use of production of hardware

Electricity usage (TWh) of Production 2015-2025



Smart home devices, Wearable devices, and AR/VR devices increase the electricity use of production by  $\approx 5-10\%$ .

The share of the Production of Data Center Hardware and Network Hardware is expected to rise.

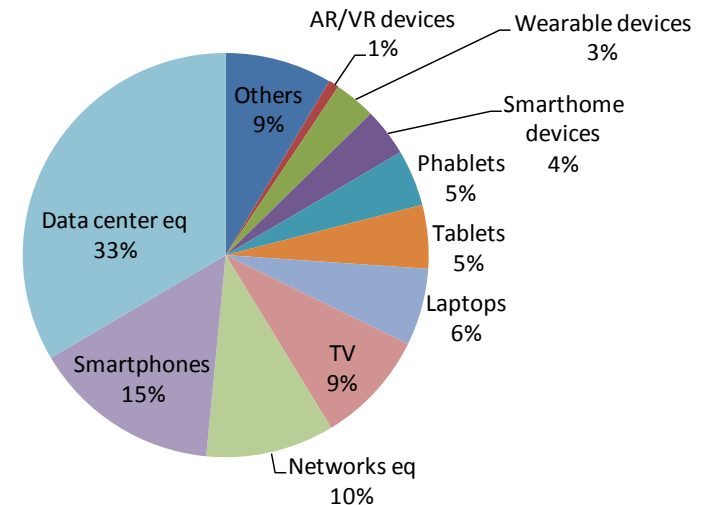
## Best case assumptions:

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

Share of global ICT production electricity use by type in 2025

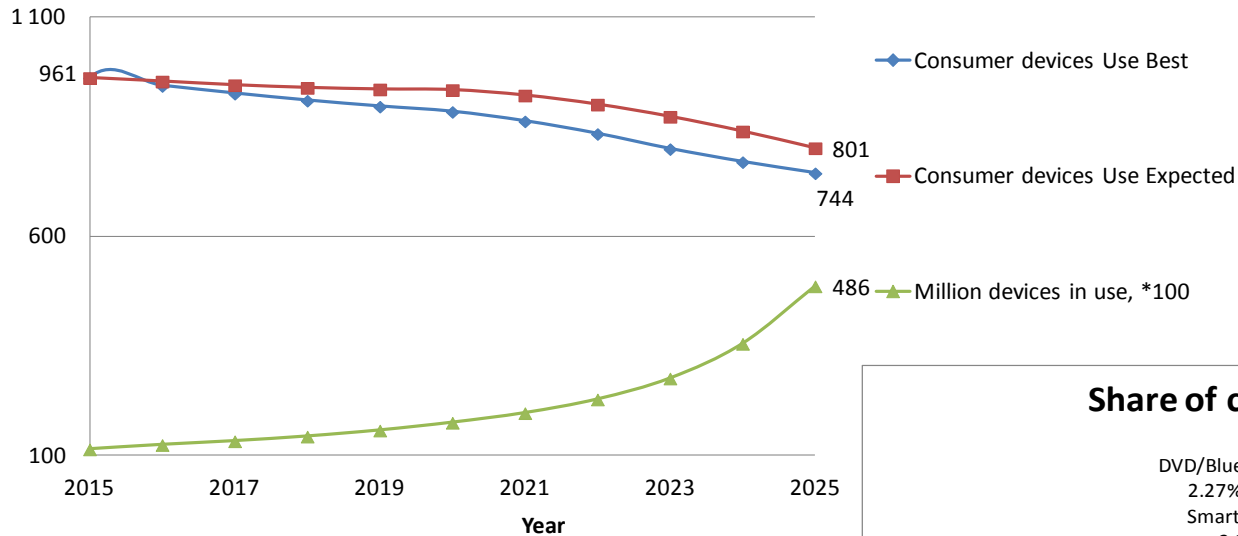


# Emerging trends in global electricity use of consumer devices

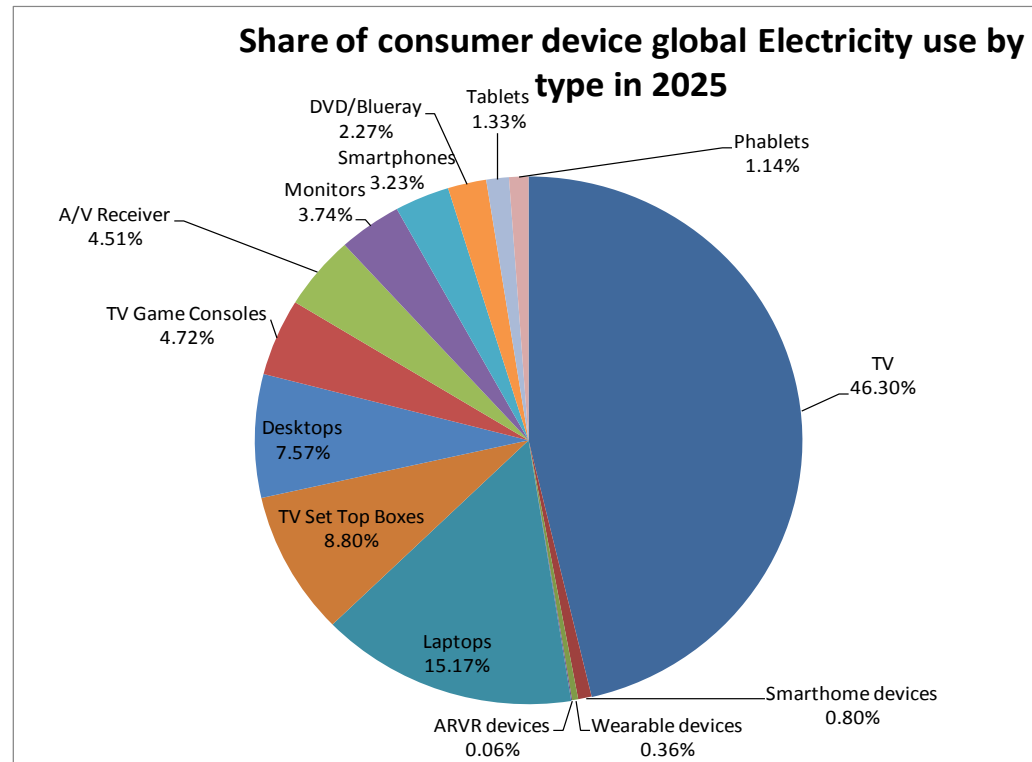
## Model includes:

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

Global Electricity usage (TWh) of Consumer Devices 2015-2025



Share of consumer device global Electricity use by type in 2025

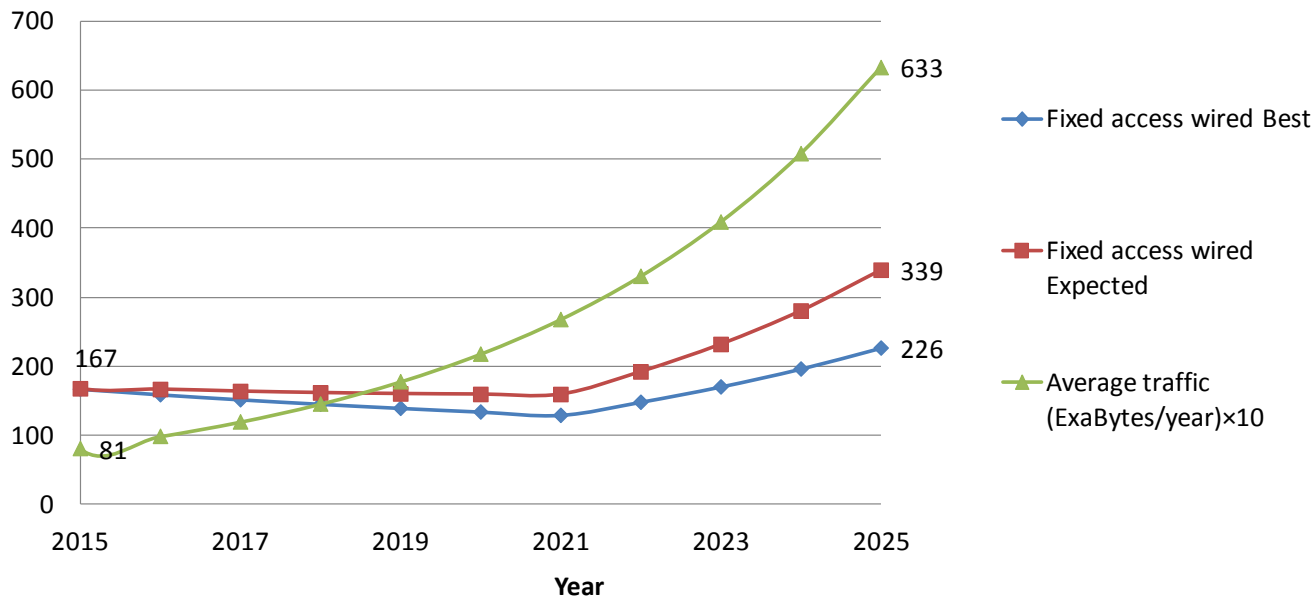


Source: Adaptations of Supplementary Materials of <http://www.mdpi.com/2078-1547/6/1/117>

- ❑ 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

Global Electricity usage (TWh) of Fixed access wired networks 2015-2025



## 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)

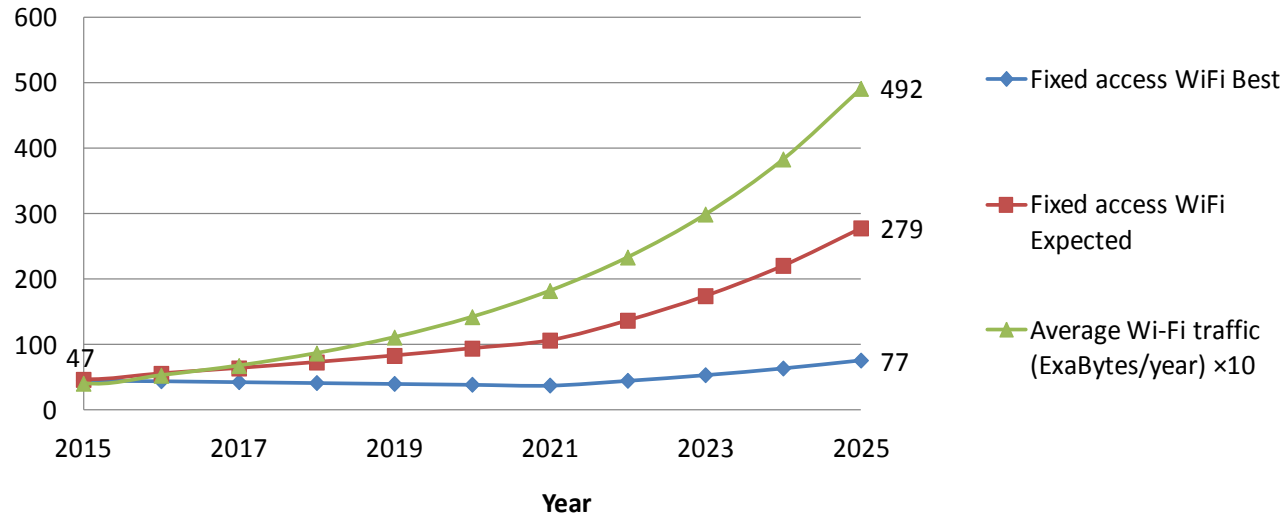
- From 2022, for EI only, 5% is assumed possible for both scenarios as I expect it will become more difficult to improve the EI via Moore's Law.

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.

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

Global Electricity usage (TWh) of Fixed access Wi-Fi networks 2015-2025



## Model includes:

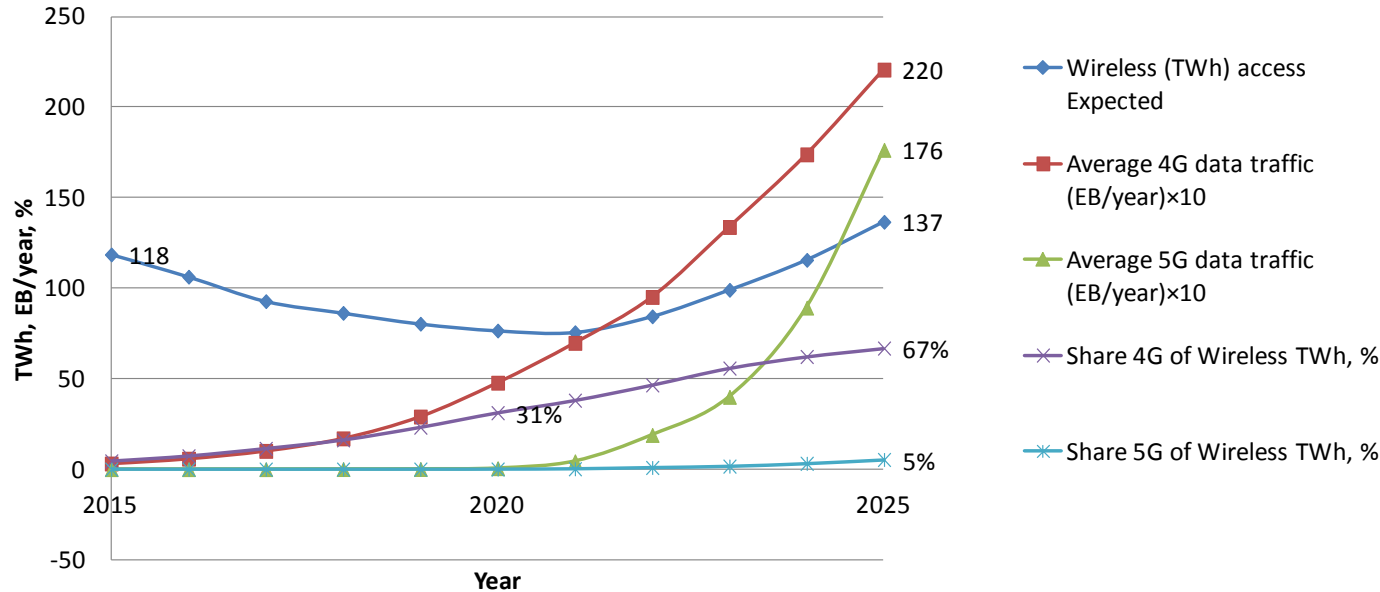
- Global electricity usage of CPE (46 TWh) in 2011 and 2012 (51 TWh)
- Fixed access Wi-Fi data traffic in 2011 (154 EB/y) and 2012 (200 EB/y) and so on..
- Annual electricity intensity improvement (EI) 22.5% p.a. (best) and 15% p.a. (expected)

- 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.

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

Wireless access electricity consumption from 2015 to 2025



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.**

I currently **expect a reduction until around 2021** in global WAN due to replacements (“swapping”).

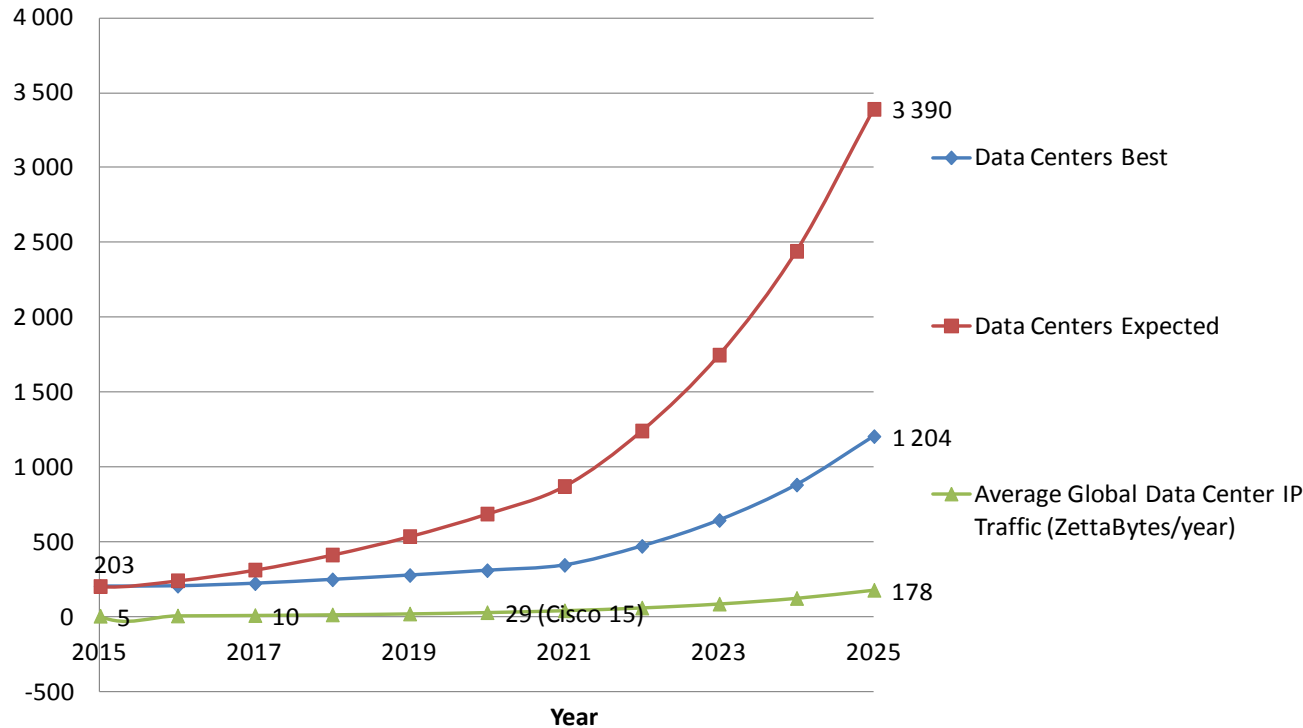
**After 2022 I foresee an increase of the electricity use.**

**22% p.a. 2015-2021, 5% p.a. from 2022-2025**

**Should the breakthrough of the energy efficient “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

Electricity usage (TWh) of Data Centers 2015-2025



## Model includes:

- Global electricity usage in Data Centers in 2010 ( $\approx 189$  TWh) and 2011 ( $\approx 193$  TWh).

- Global Data Center IP traffic in 2010 ( $\approx 1.4$  ZB) and 2011 ( $\approx 1.8$  ZB).

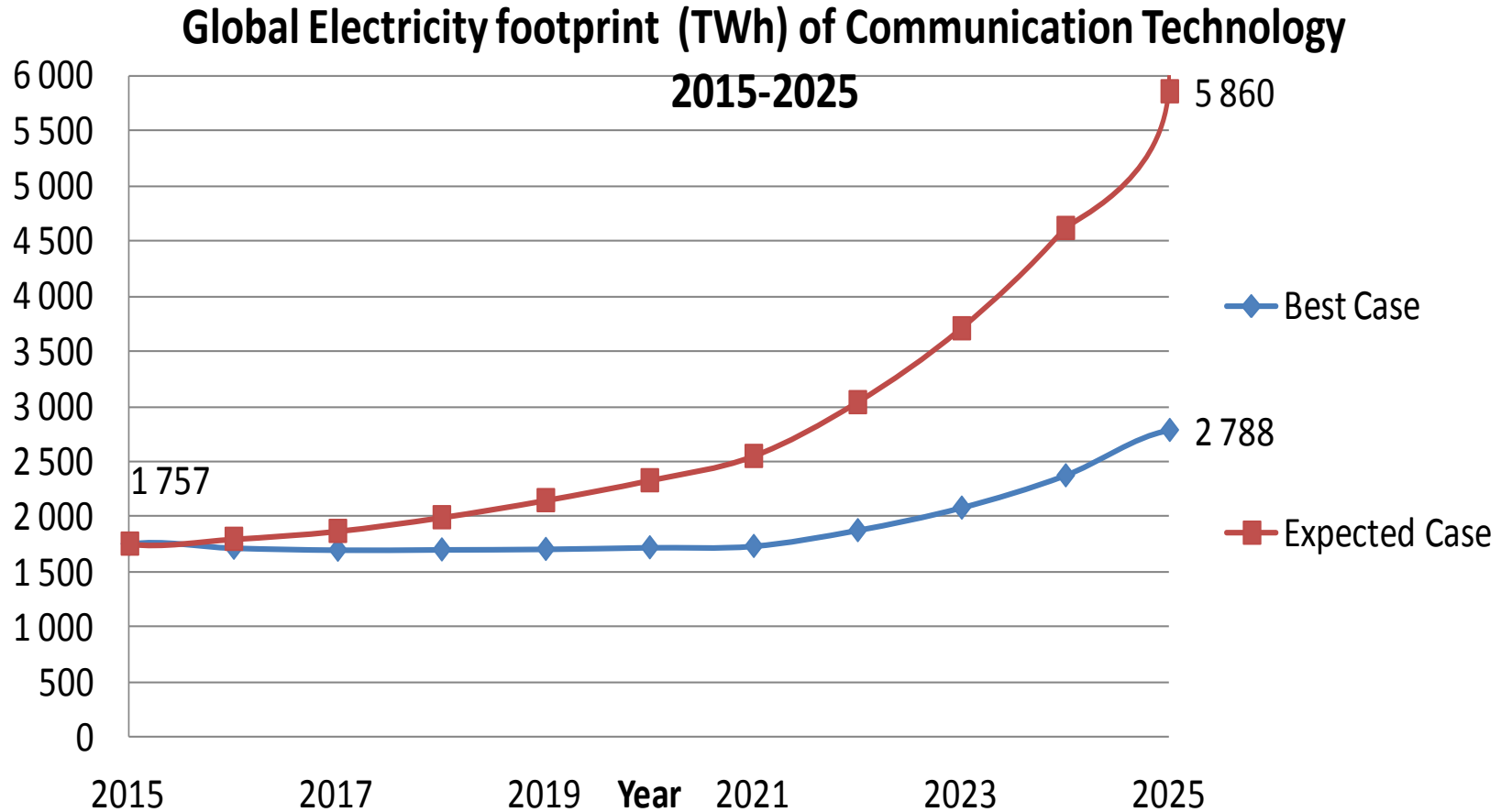
- Annual electricity intensity improvement (EI), 22.5% p.a. (best), 15% p.a. (expected).

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

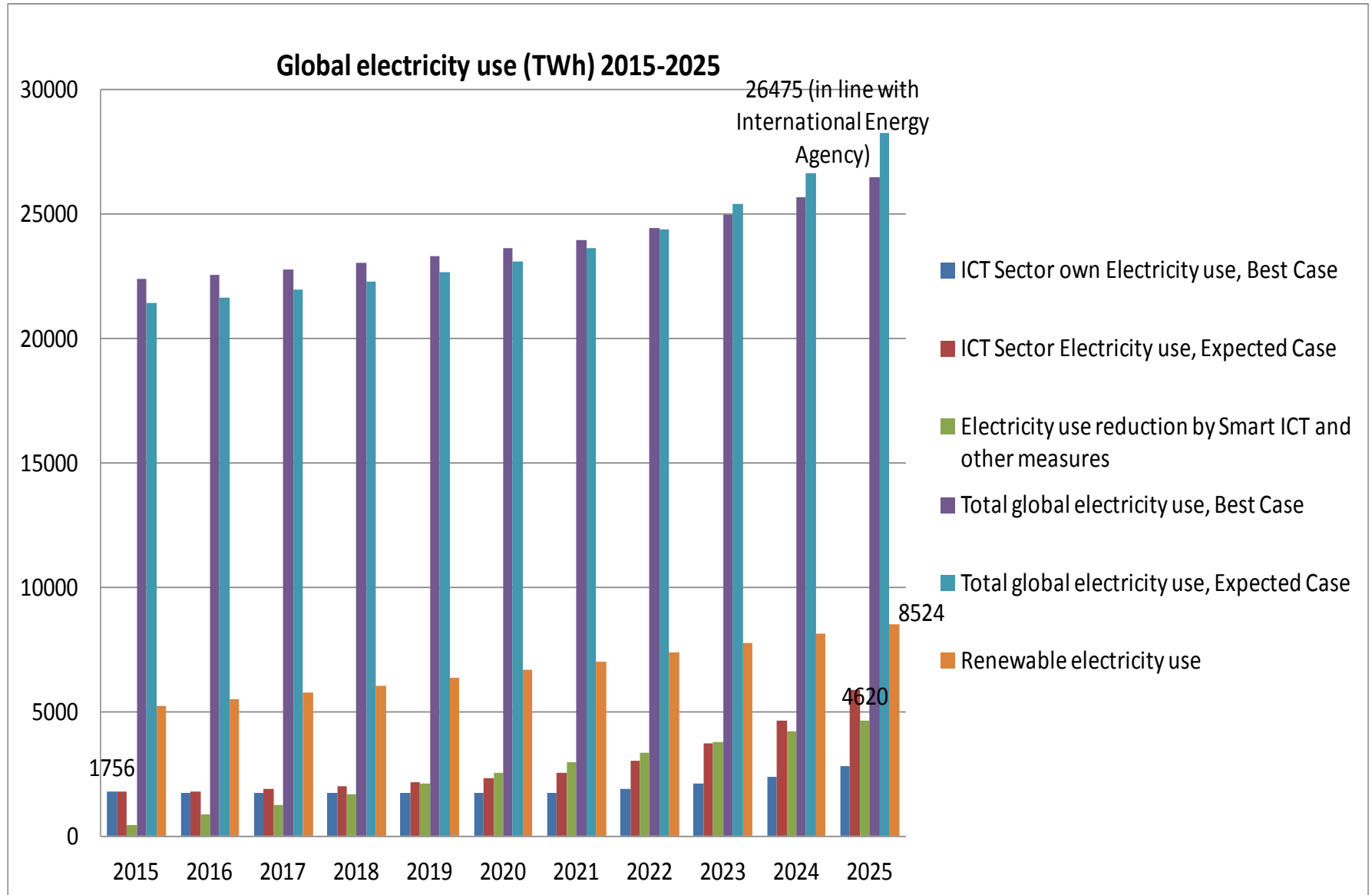
Between 2010 and 2015, KPNs data centers increased their power consumption by 9%.

Source: KPN Integrated Annual Report 2015 Table 2 in Appendix

# Synthesis: The global power trend for ICT 2015 to 2025

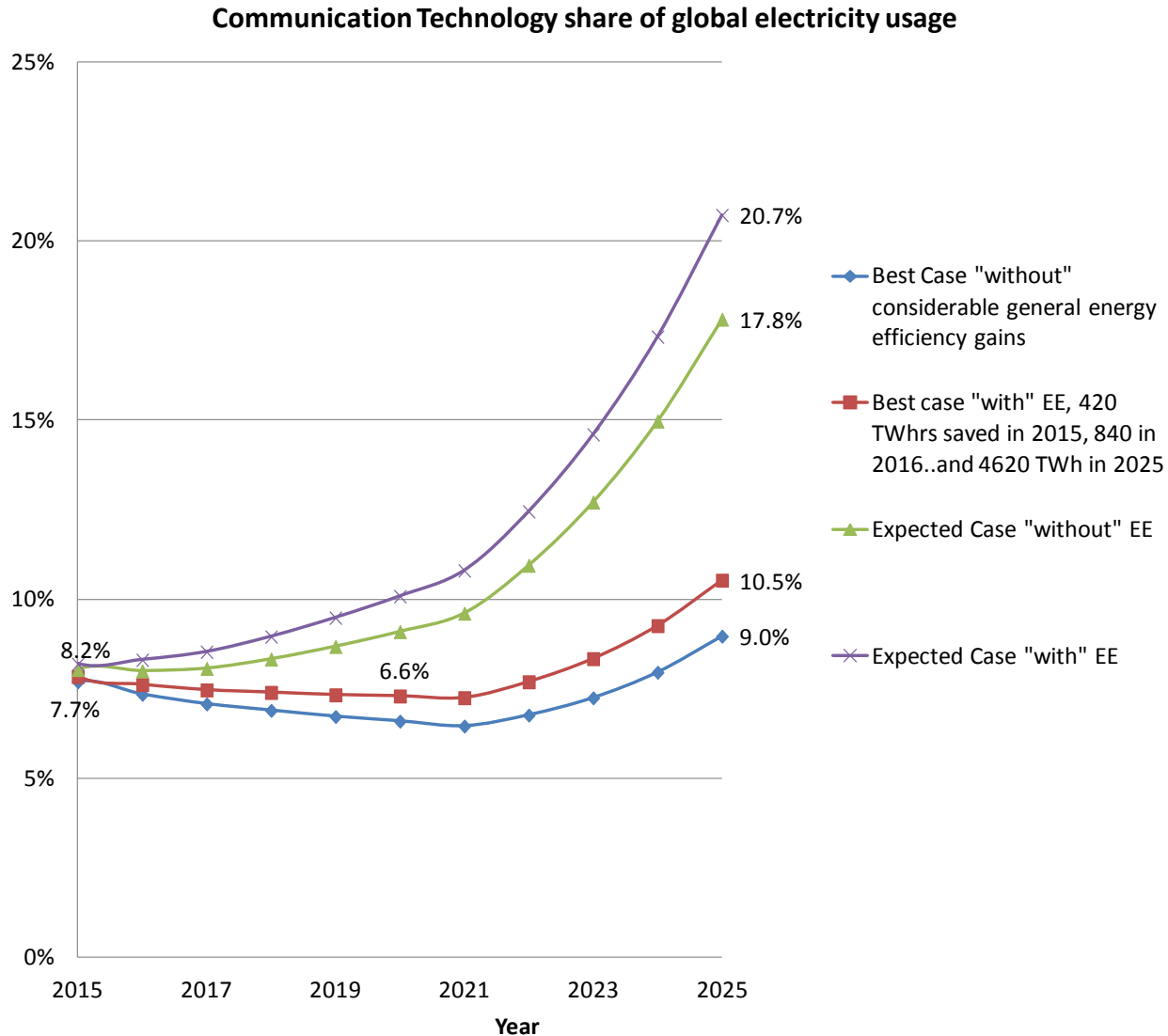


# Increasing energy efficiency including enabling effect of SMART ICT Solutions



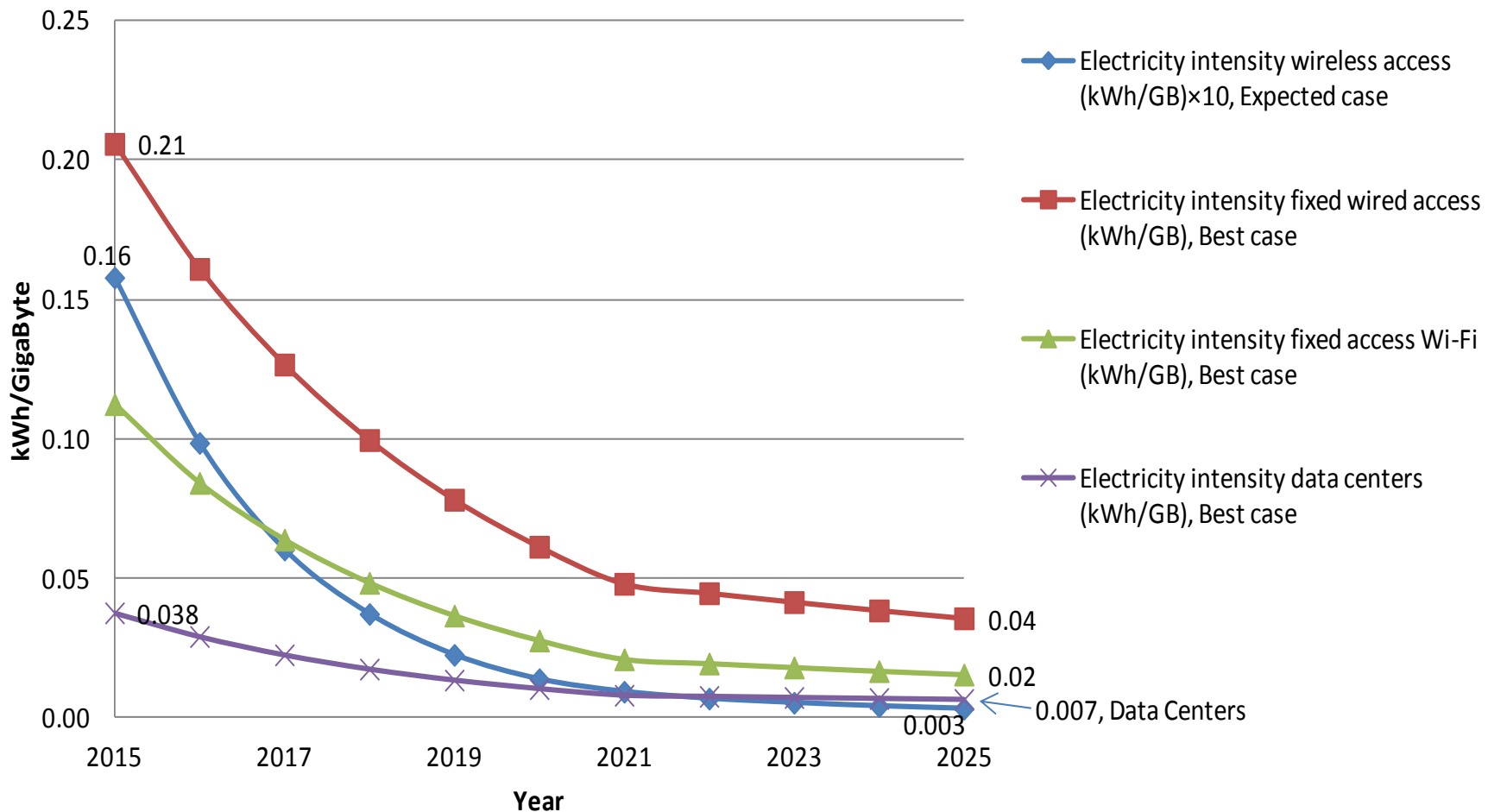


# The share of ICT of global electricity usage: 2015 to 2025 with and without high global energy efficiency gains



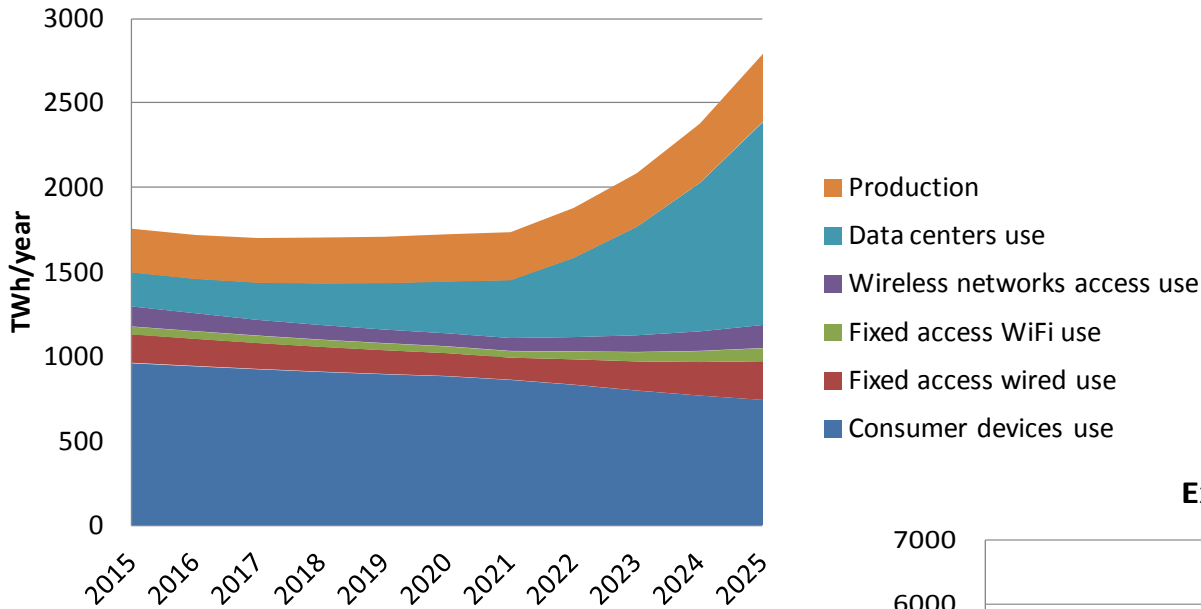
# The global trends for ICT electricity intensities 2015 to 2025

## Development of global electricity intensities in ICT networks from 2015 to 2025

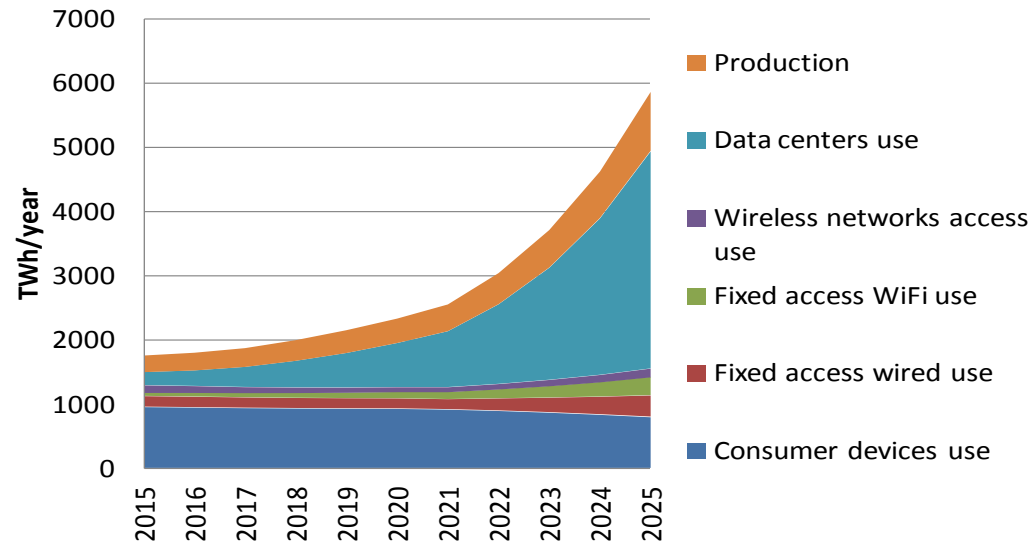


# The global power repartition trends for ICT between 2015 and 2025

Best case scenario

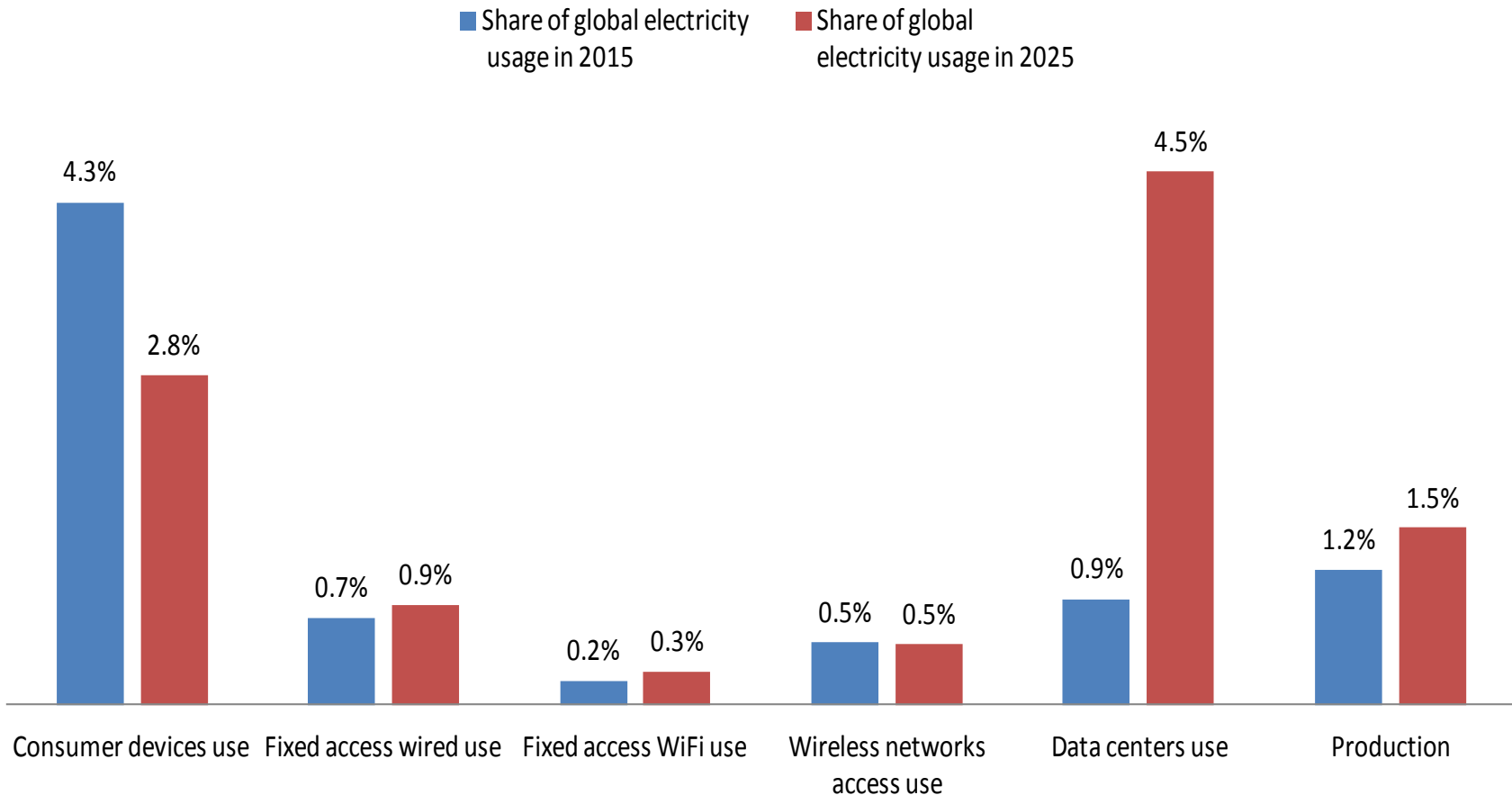


Expected case scenario



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

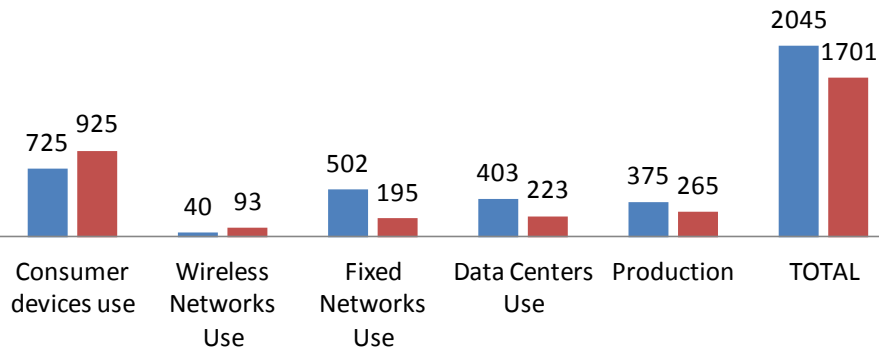
Share of different ICT Sectors of global electricity 2015-2025,  
Best case



# How does this study compare to 1<sup>st</sup> global study by Prof. Peter Corcoran in 2013?

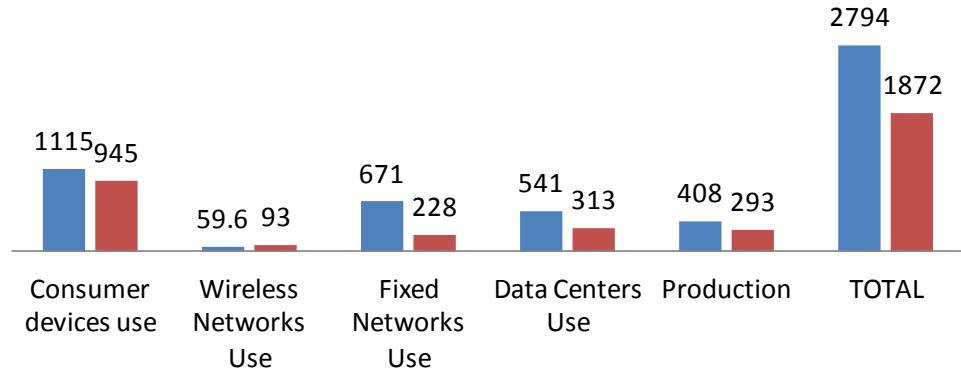
## Comparison to earlier study for 2017 -Best case (TWh)

■ 2017 Corcoran (2013) Best ■ Andrae (2017) Best

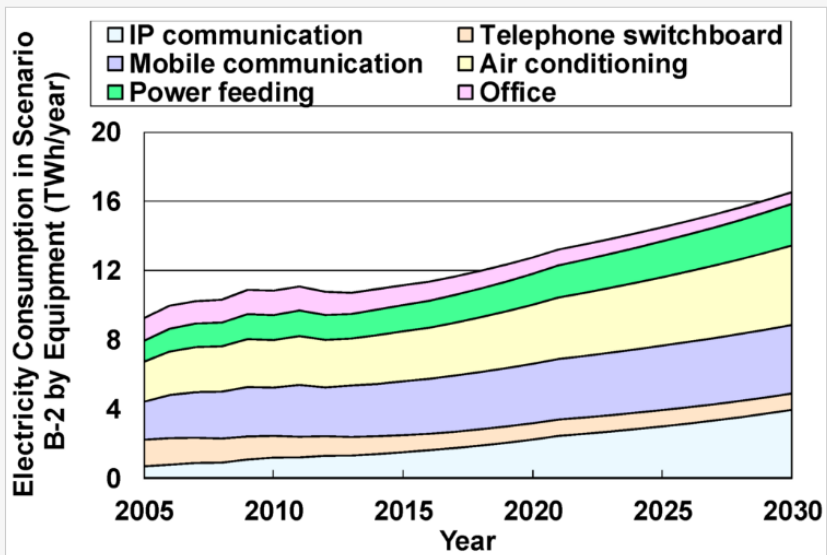
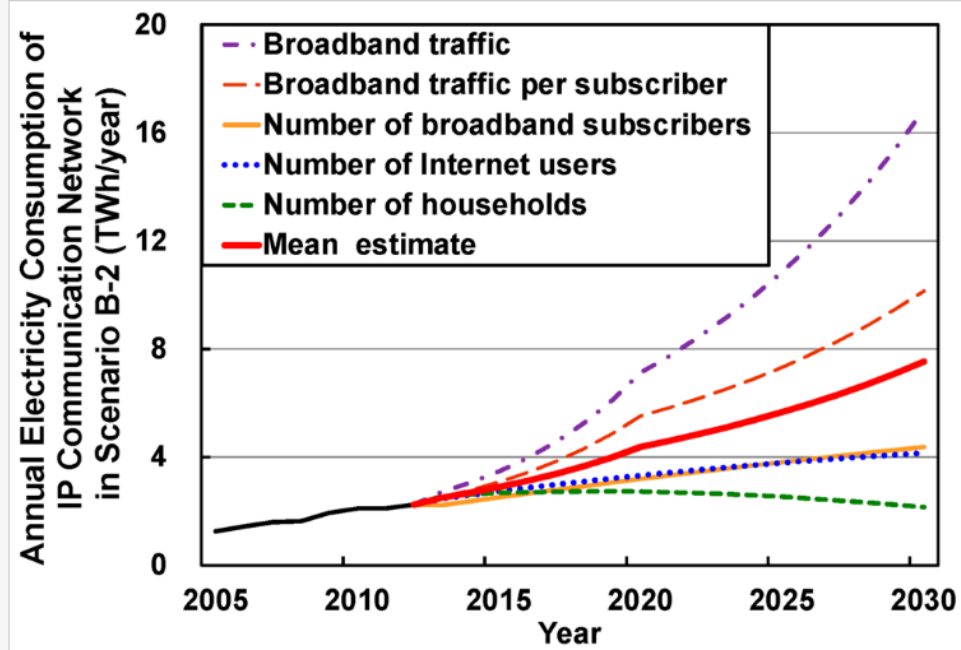
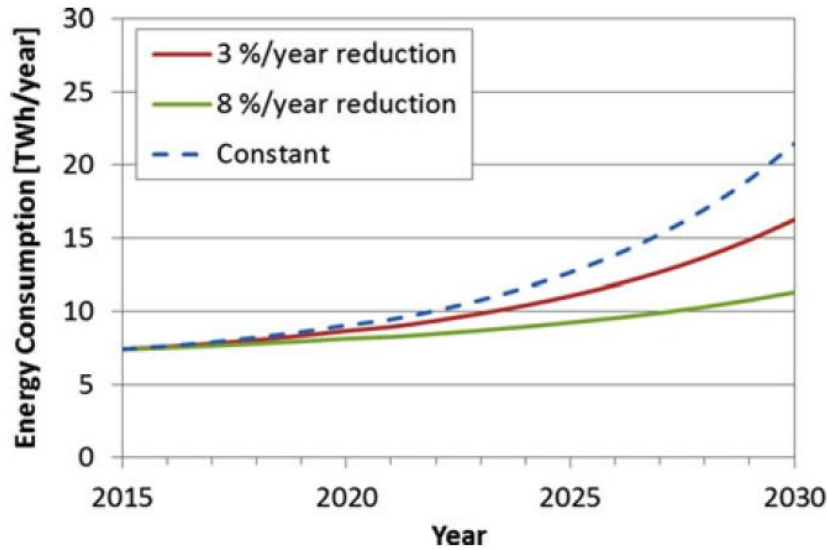


## Comparison to earlier study for 2017 - Expected case

■ 2017 Corcoran (2013) Expected ■ Andrae (2017) Expected



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



Increasing electricity use is expected in Japan's 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.





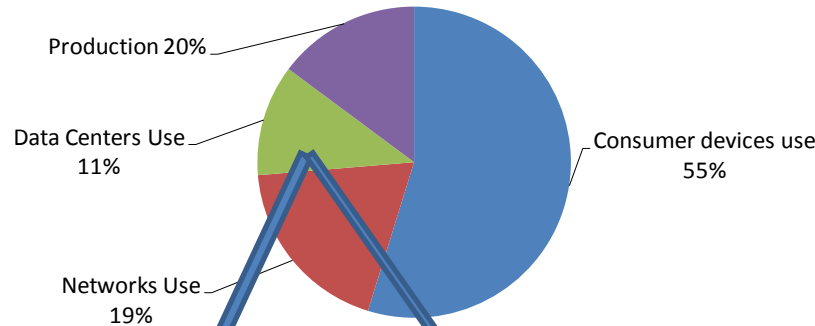
Thanks for your attention!

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

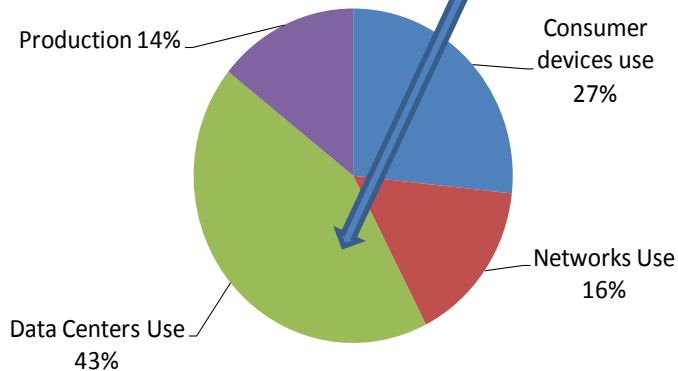
**Best&Expected Case Scenario 2015**

■ Consumer devices use ■ Networks Use ■ Data Centers Use ■ Production



**Best Case Scenario 2025**

■ Consumer devices use ■ Networks Use ■ Data Centers Use ■ Production



**Expected Case Scenario 2025**

■ Consumer devices use ■ Networks Use ■ Data Centers Use ■ Production

