Hur påverkar Internet & IT i vårt vardagsliv klimatet?

LCA (livscykelanalys) av IT/telecom
Hur stort är "fotavtrycket" av IT/telecom?
Hur mycket el drar dess olika delar?
Vad gör vi på Ericsson?
LCA av en smartphone
Lite "korrigering" av en del "fakta" man hittar på nätet
Hur halverar vi utsläppen till 2030
och hur kan ICT hjälpa till

Jens Malmodin Ericsson Research 2019-11-07

Global warming

- Law of nature:

More CO_2e
=
More heat

It gets hotter…

Global carbon footprint

1988
James Hansen in US Congress
CO_2 level in atmosphere passed 350 ppm, labeled as *safe* noting *it may be less*

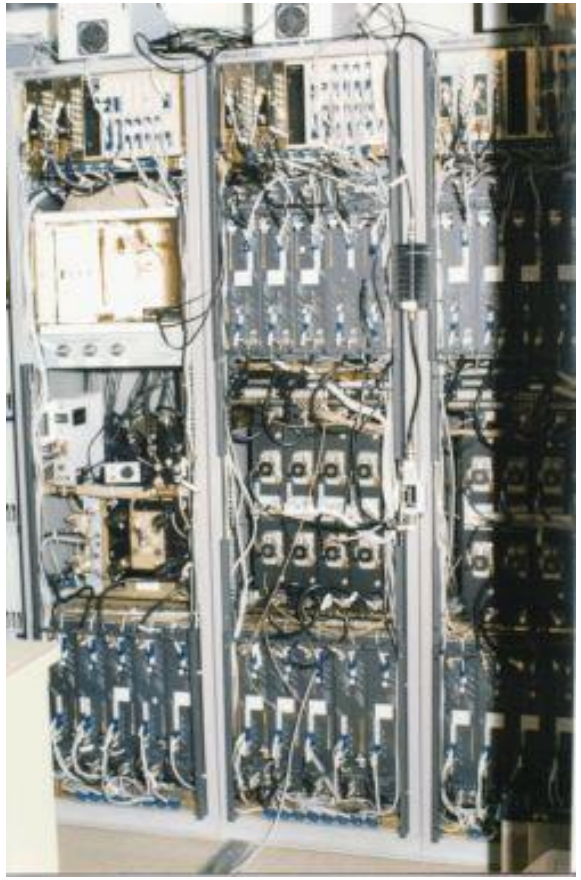
2019:
~ 56 billion ton CO_2e / year
~ 410 ppm (~ 470 ppm for all GHG's)

We need to halve emissions in the next decade to have a chance to stay below 1.5°C

First LCA on a "radio base station" (RBS) 1994-1995

Conclusions from first LCA study:

- Electricity consumption major environmental impact due to how electricity is produced around the world
  1994: coal 37%, gas & oil 25%
  2018: coal 37%, gas & oil 26%
- Fossil fuels: CO_2, NO_X/SO_X, particulate matter (energy resource depletion)
- Rare metals (gold, silver and copper) second
- More work (LCA) is needed!



First LCA on a "radio base station" (RBS) 1994-1995

Conclusions from first LCA study:

— Electricity consumption major environmental impact due to how electricity is produced around the world
1994: coal 37%, gas & oil 25%
2018: coal 37%, gas & oil 26%

— Fossil fuels: CO_2, NO_X/SO_X, particulate matter (energy resource depletion)

— Rare metals (gold, silver and copper) second

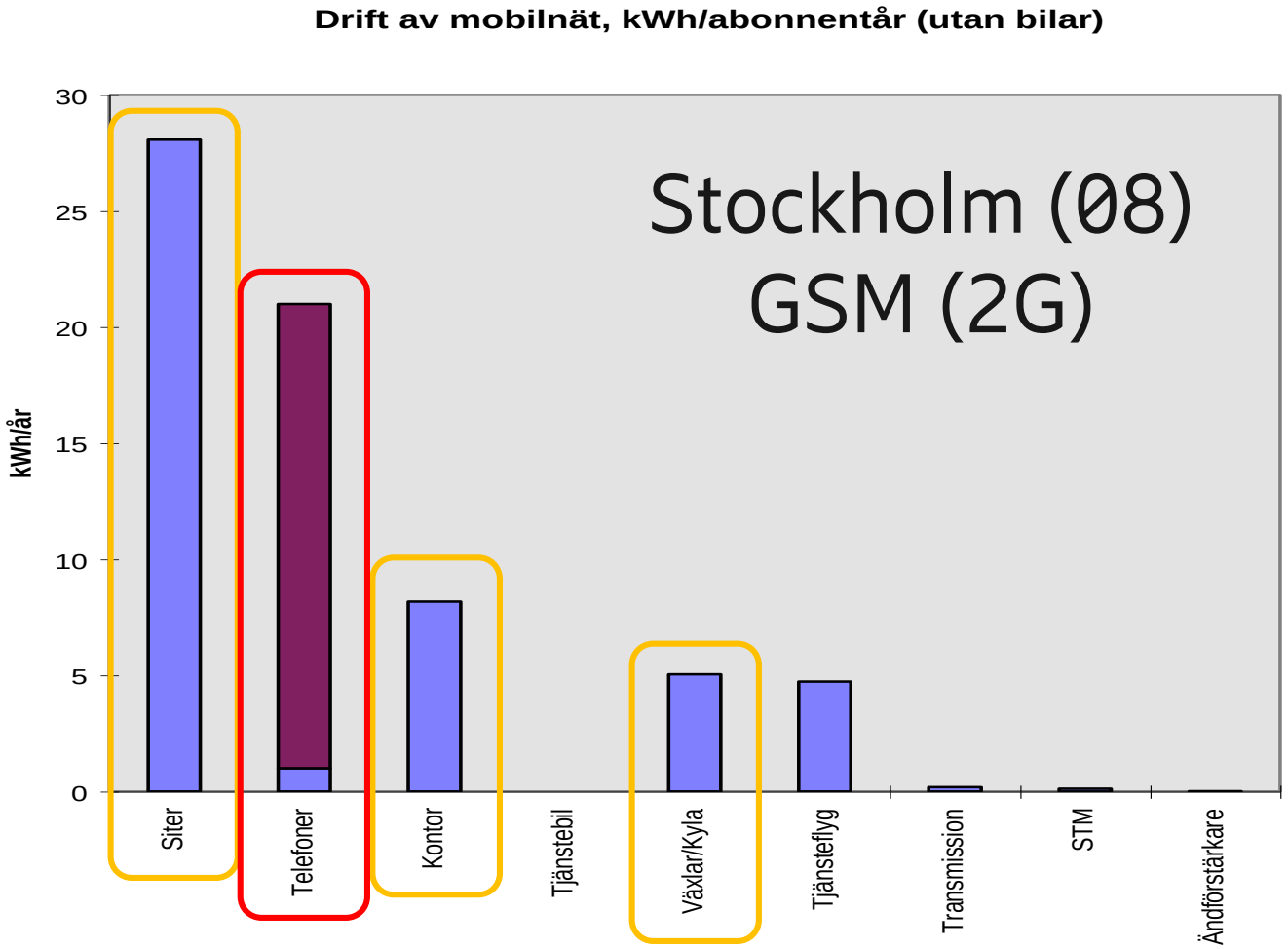
— More work (LCA) is needed!

The LCA work continued!

— LCA of integrated circuits (ICs) and mobile phones

— Real network measurements → Whole networks

First LCA together with an operator 1997



- Mobile network (GSM), electricity consumption per subscriber and year (including offices, stores etc.):
  40 kWh/subyear

- Mobile phone charging, electricity consumption per subscriber and year:
  21 kWh/subyear
  Charger(s) plugged-in

Telia AB, 1997

LCA of whole mobile networks over time

1997

40 kWh/subyear

→ 24 kg CO_2e (globally)

21 kWh/subyear

→ 12 kg CO_2e (globally)

+ manufacturing:

15 kg CO_2e/subyear

~50 kg CO_2e/subyear

A few design changes,

a few lines of new code

2001

20 kWh/subyear

→ 12 kg CO_2e (globally)

3 kWh/subyear

→ 1.8 kg CO_2e (globally)

+ manufacturing:

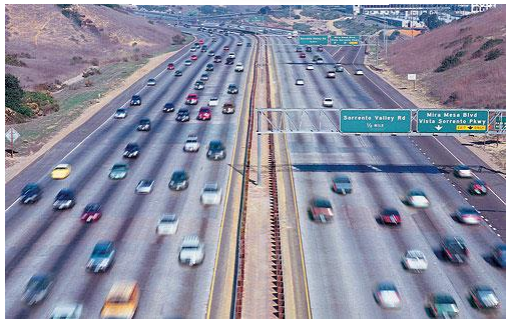
11 kg CO_2e/subyear

~25 kg CO_2e/subyear

one year

=

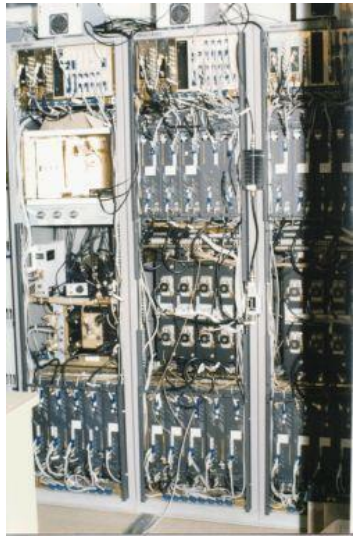
one hour



LCA of whole mobile networks over time

1997	2001	2018
40 kWh/subyear	**20 kWh**/subyear	**18 kWh**/subyear
→ 24 kg CO_2e (globally)	→ 12 kg CO_2e (globally)	→ 12 kg CO_2e (globally)
	A few design changes, a few lines of new code 	
21 kWh/subyear	**3 kWh**/subyear	**3 kWh**/subyear
→ 12 kg CO_2e (globally)	→ 1.8 kg CO_2e (globally)	→ 1.8 kg CO_2e (globally)
+ manufacturing:	+ manufacturing:	+ manufacturing:
15 kg CO_2e/subyear	11 kg CO_2e/subyear	~20 kg CO_2e/subyear
~50 kg CO_2e/subyear	**~25 kg CO_2e**/subyear	**~34 kg CO_2e**/subyear
		+ 6 kg for "Internet"

Radio base station development



1G

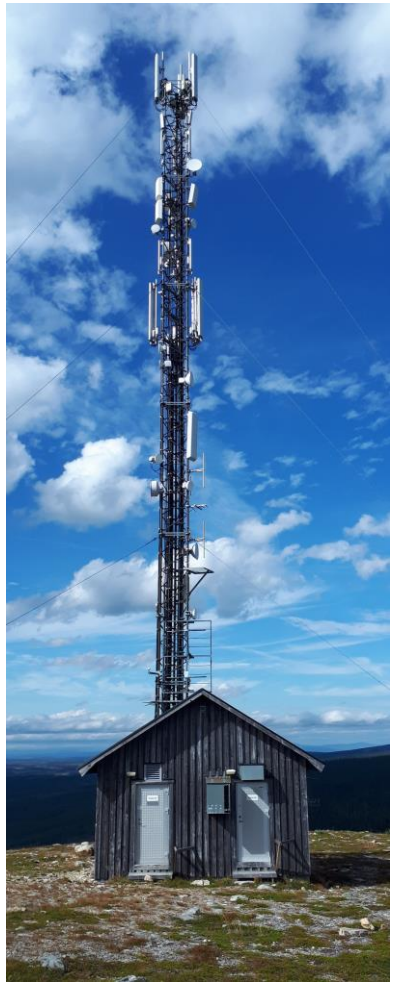
4 cabinets
800 kg
4 kW
21 voice calls
200 → 50 kWh
per subyear

2G

2 cabinets
350 kg
2 → 1 → 0.5 kW
69 voice calls
0.014 → 0.24 Mbps
50 → 10 kWh

3G

1 cabinet
150 kg
1.4 → 0.5 kW
~100 voice calls
0.4 → 42 Mbps
50 → 10 kWh



4G

Main-Remote
85 kg
1.2 kW → 0.8 kW
50 → 300 Mbps
50 → 10 kWh

How do we define "ICT"?

ICT

Information (IT) and Communication (telecom) Technology

Mobile devices

Networks

PCs

Data centers

Trend

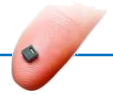
E&M

Entertainment (music, film) and Media (TV, paper)

Other EEE

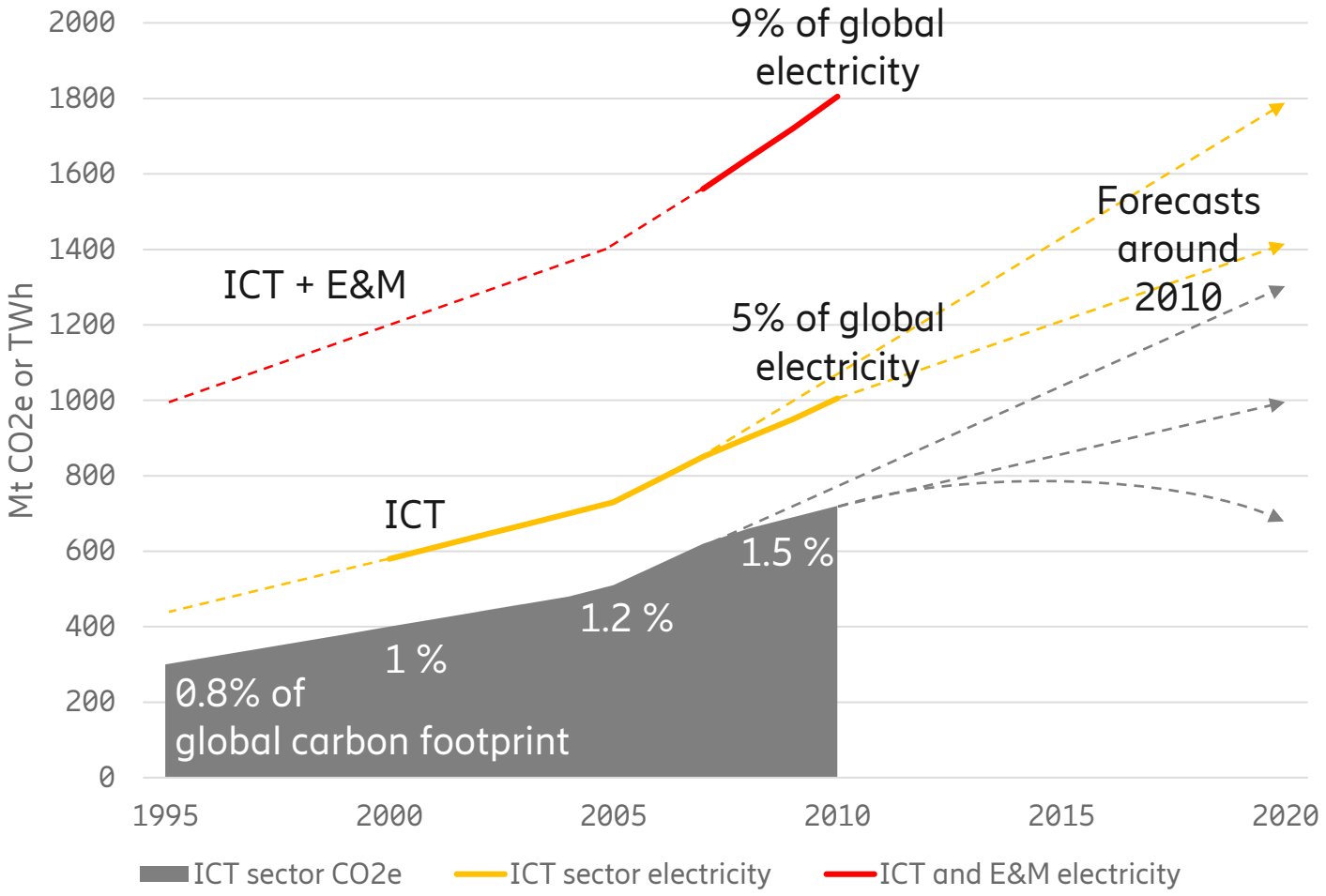
Other electrical and electronics equipemnt

Lighting
Home appliances
Tools
Vehicles
Health care
Security
Industry (motors)
Finance
Aerospace
Military



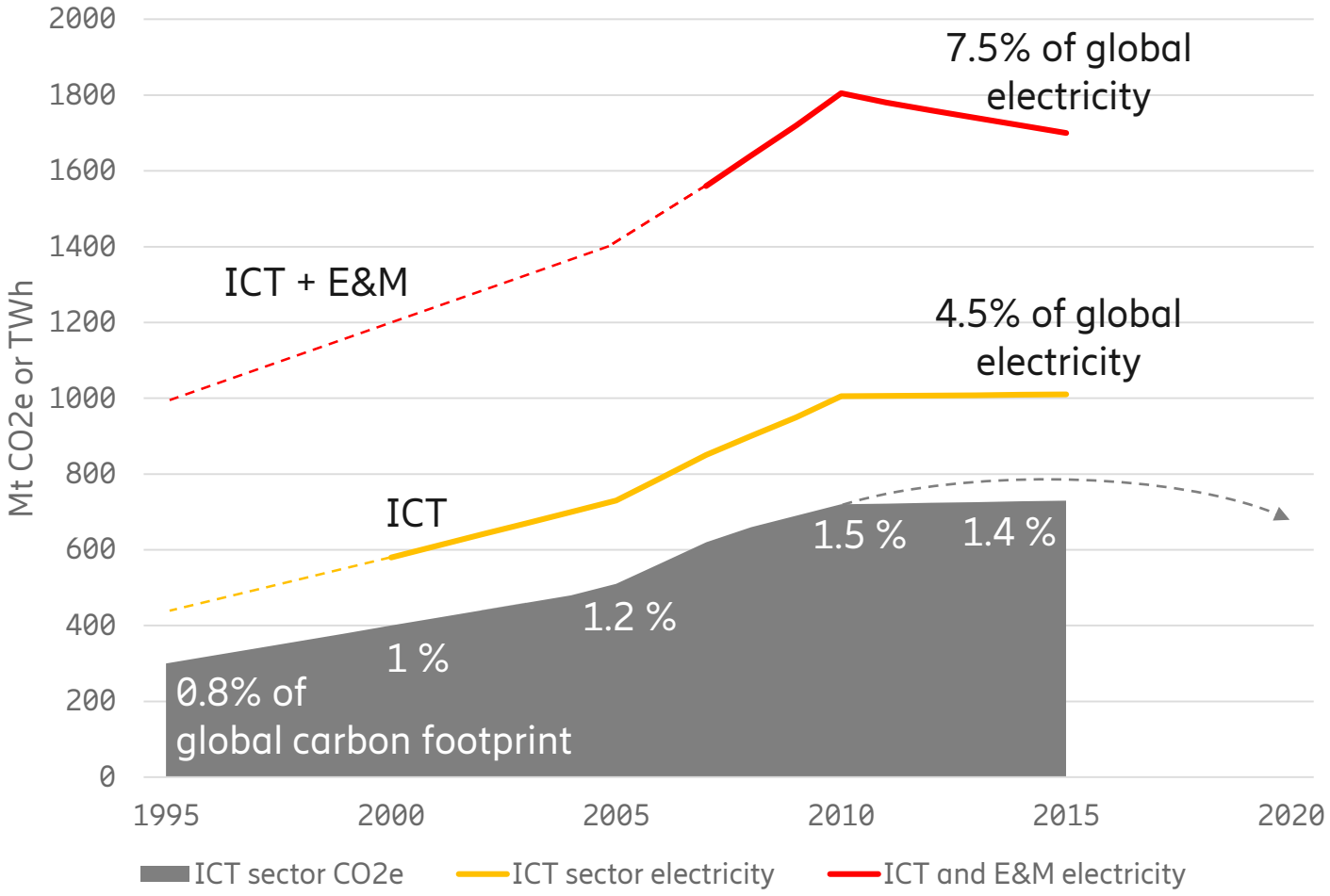
Other trend

ICT and E&M sector "footprints" to 2010



- Relative fast growth to 2010, especially 2005-2010 due to PCs
- ICT sector's carbon footprint 2010: 720 Mt CO2e
  1.5% of the global total (including all manufacturing)
- Nearly all forecasts estimated a continuing growth to 2020
- ...but not this one:
  "All households can have laptop PCs and all people mobile devices in 2020 with the same footprint as today.
  - Ericsson @OECD 2008

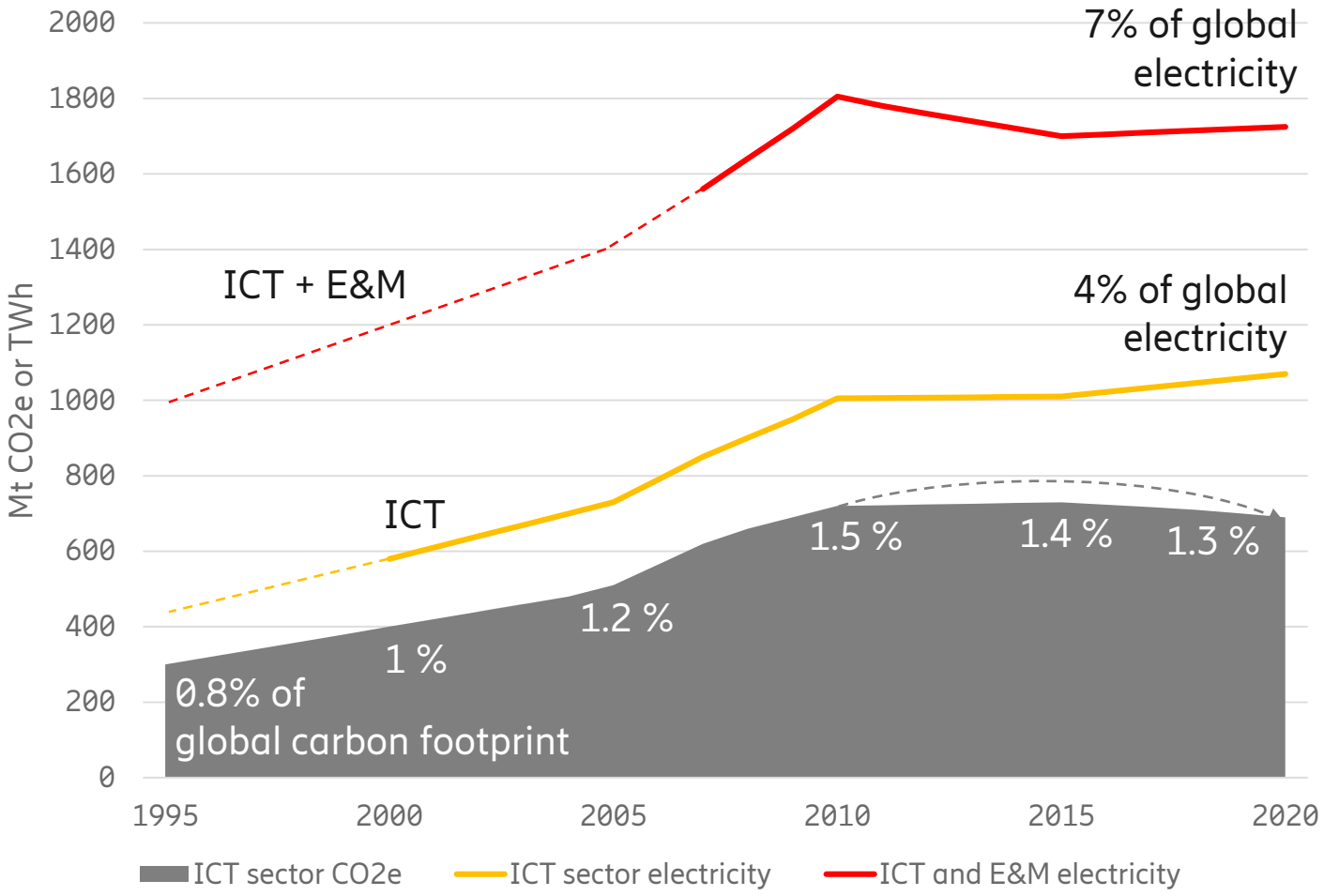
ICT and E&M sector "footprints" to 2015



— Major trend shift!

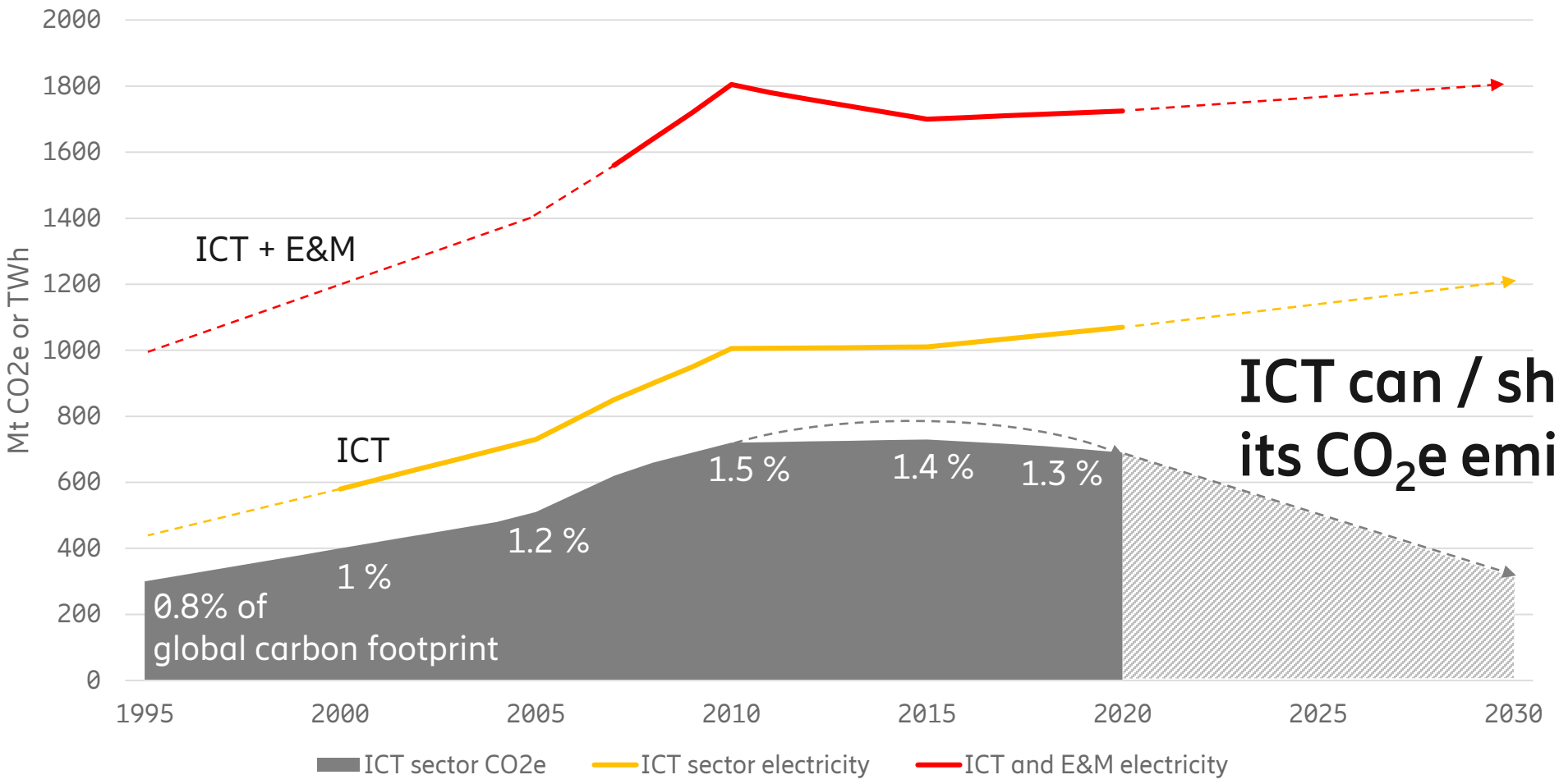
- — Both PC and TV sales peaked around 2010 and has since then declined
- — Nearly all forecasts made around 2010 was wrong by a large margin (but not all…)
- — New energy efficient display technologies played an important role
- — Use "moved" from E&M devices to ICT devices and paper media "moved" online

ICT and E&M sector "footprints" to 2020



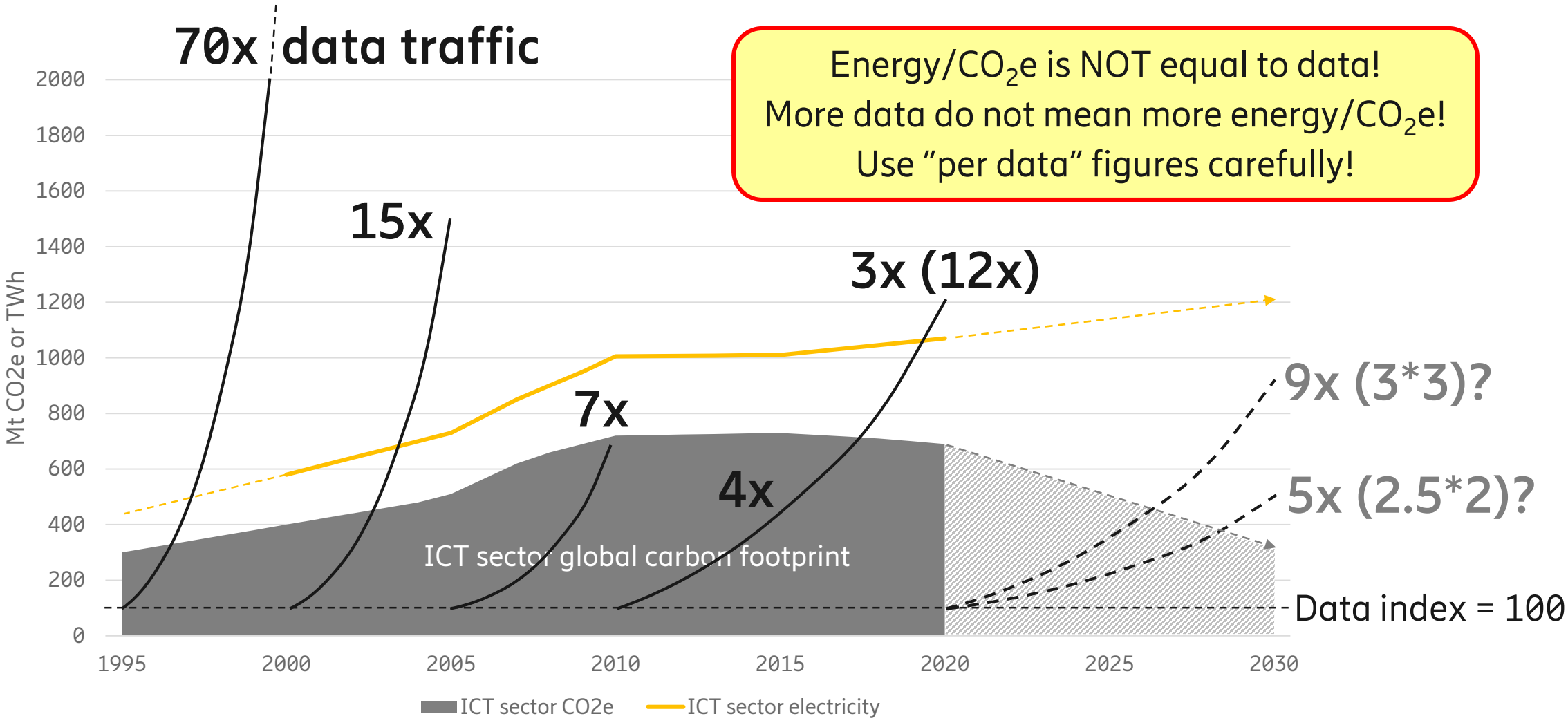
- The trends continue
- ICT's electricity consumption increases slightly due to the continuing expansion of mobile and fixed broadband
- ICT's carbon footprint has on the other hand decreased slightly as a result of investments in renewable electricity
- E&M continue to decrease but slower after 2015
- Most new M2M/IoT has a very small footprint

ICT and E&M sector "footprints" to 2030



ICT can / should halve its CO_2e emissions!

ICT sector "footprints" and data traffic



Total sector figures 2018

ICT

Information (IT) and Communication (telecom) Technology

4.3% of electricity

~2% of energy*

1.3% of CO2-eq

Including manufacturing and overhead (offices, stores etc.)

6 Mt (0.2%)

Products & packaging (+20 Mt for infrastructure)

E&M

Entertainment (music, film etc.) and Media (TV, paper etc.) Focus on electronics

2.9% / 2.6%

~1.3% / ~1.2%

1.1% / 0.7%

With and without paper

Including manuf./overhead

130 Mt / 8 Mt

With and without paper

Other EEE

Other electrical and electronics equipemnt

72% of electricity

Excluding large scale industrial and non-residential building use which is about 21% (about 1% is allocated to ICT and E&M manufacturing & overhead)

95 Mt

Primary data from companies (100+)

Data centers:

— Google: 10.1 TWh
— Amazon: 9.5 TWh
— Microsoft: 7.6 TWh
— Facebook: 3.4 TWh
— Apple: 2.2 TWh
— Oracle: 1.3 TWh

Alibaba, Tencent, Baidu,
JD.com, Ant FSG: no data...

34+10+X = 230 TWh
(incl. 15 TWh offices, stores etc.)
+25 TWh for Enterprise networks
19% primary data

Networks:

— China Mobile: 24.5 TWh
— China Telecom: 17.1 TWh
— AT&T: 14.2 TWh
— China Unicom: 14.2 TWh
— Verizon: 9 TWh
— NTT: 8.3 TWh
— DT: 7.9 TWh
— Telefonica: 6.7 TWh
— America Móvil: 6 TWh

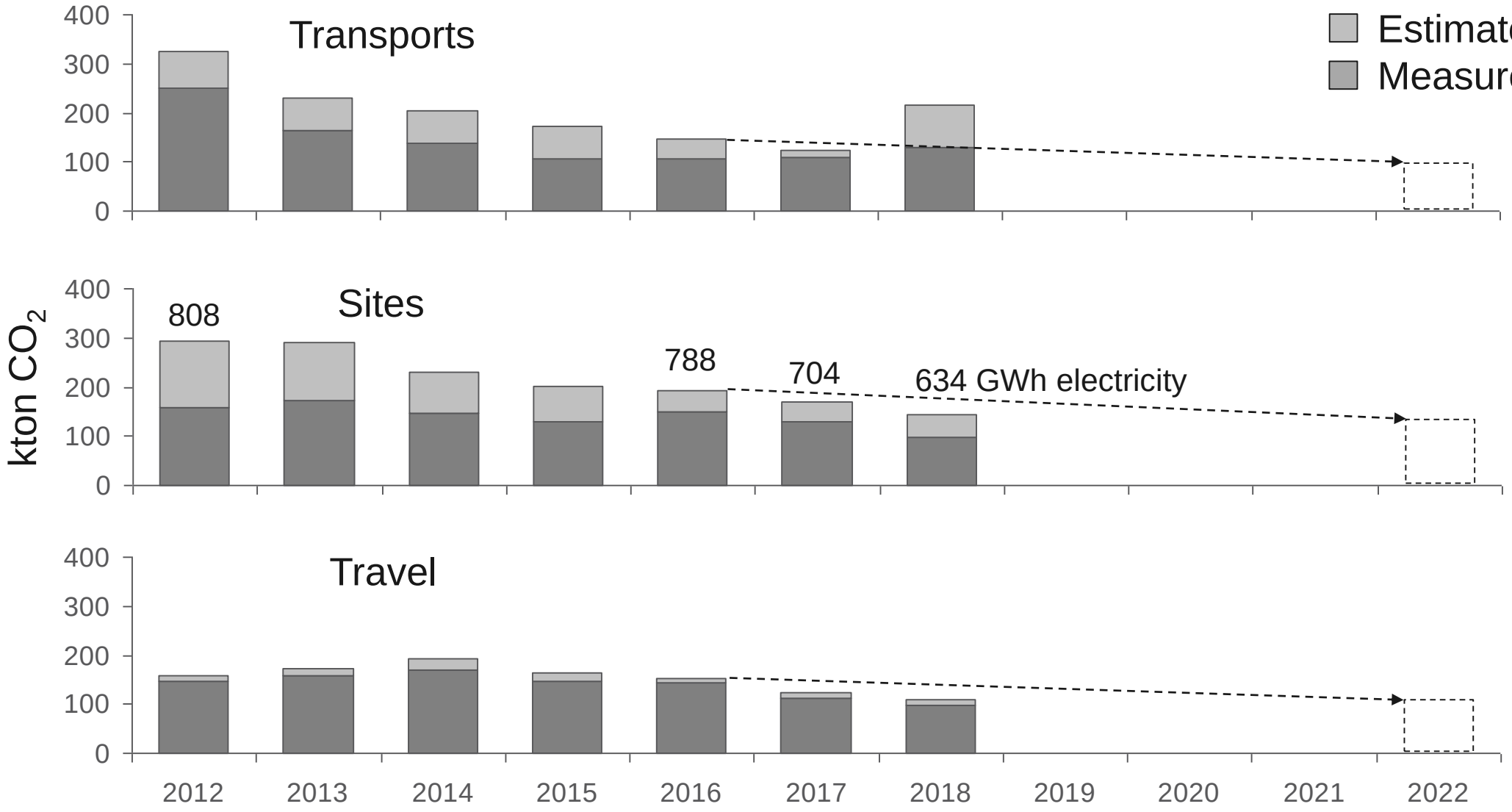
108+56+Y = 245 TWh
(incl. 20 TWh offices, stores etc.)
67% primary data

User devices (manufacturing):

— Samsung: 20.6 TWh
— TSMC: 12 TWh
— Foxconn: 8.9 TWh
— LG Display: 8.3 TWh
— SK Hynix: 8.2 TWh
— Intel: 6.7 TWh
— Micron: 5.6 TWh
— Innolux: 5.5 TWh
— AUO: 5.1 TWh

81+37+Z = 217 TWh
+ 324 TWh operation
54% primary data

Ericsson own activities (top 3)



2012: 778 kton
...
2016: 497 kton
2017: 422 kton
2018: 470 kton

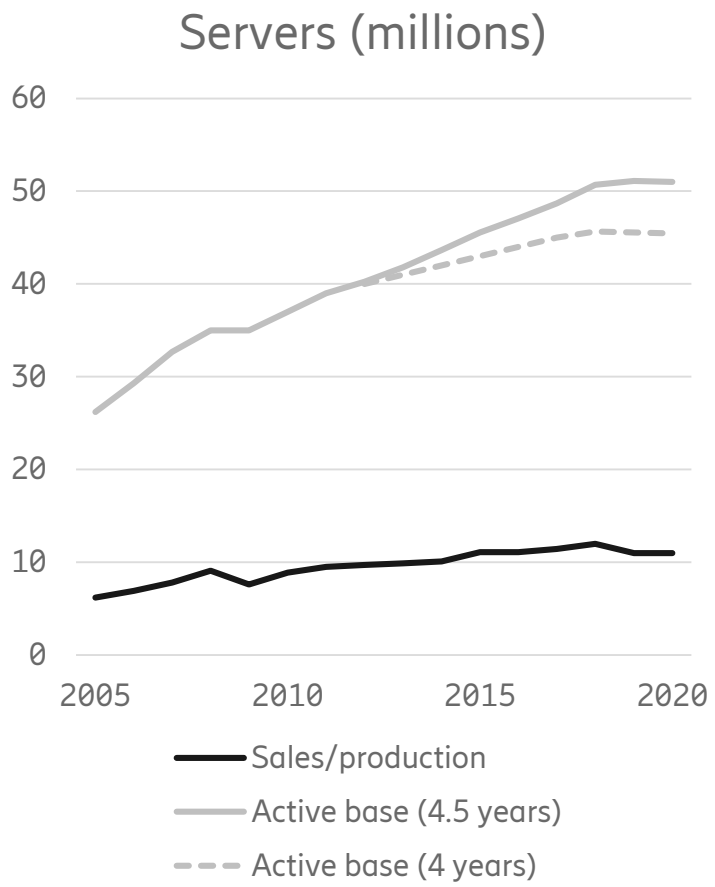
A reduction of
281 kton
2012 – 2016
(-36%)
...and now
-40% in 2018

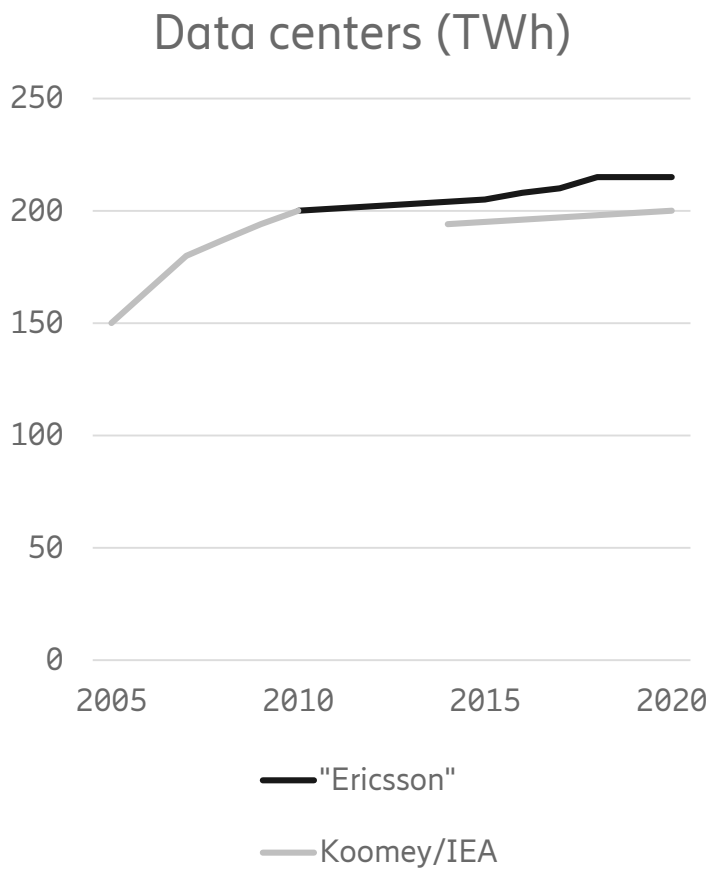
Ericsson data centers

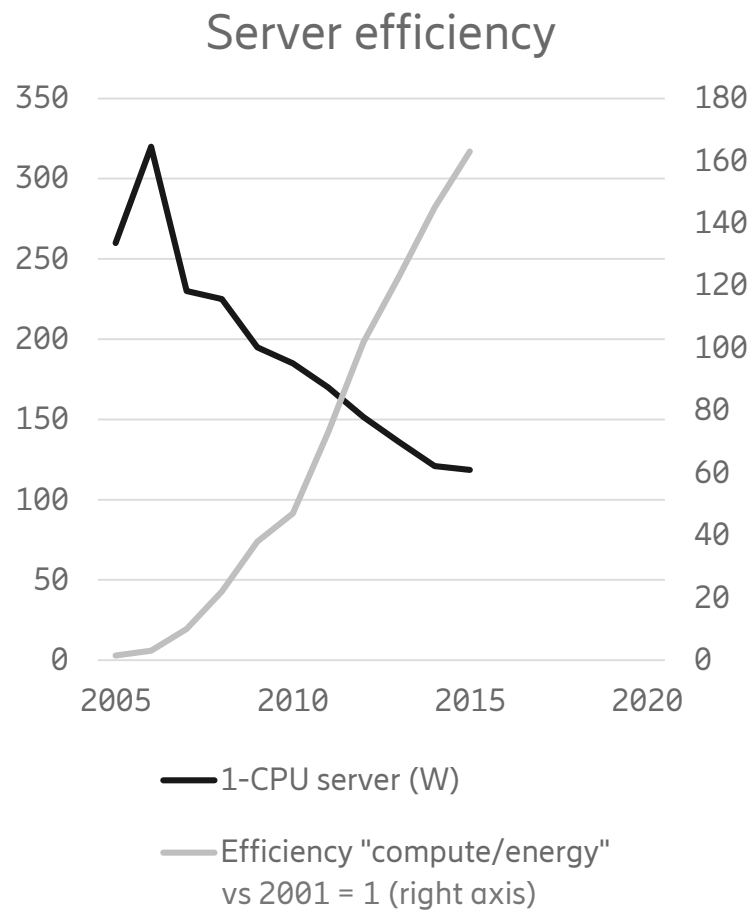
- We built three but have two today: Linköping and Rosersberg
- Consumption was about 100 GWh for both Linköping and Rosersberg in 2018 (similar to one “megablock”, e.g. one of Facebook’s “megablocks” in Luleå)
- Heat exchange to local district heating at the Rosersberg site potential 10 MW / 80 GWh with the potential to reduce CO_2-emissions by about 4 800 ton per year

- Ericsson’s total electricity consumption has been reduced by about 150 GWh in two years, one major reason is the “move” to the new data centers. In addition, the new data centers run on renewables with the possibility to recover the waste heat

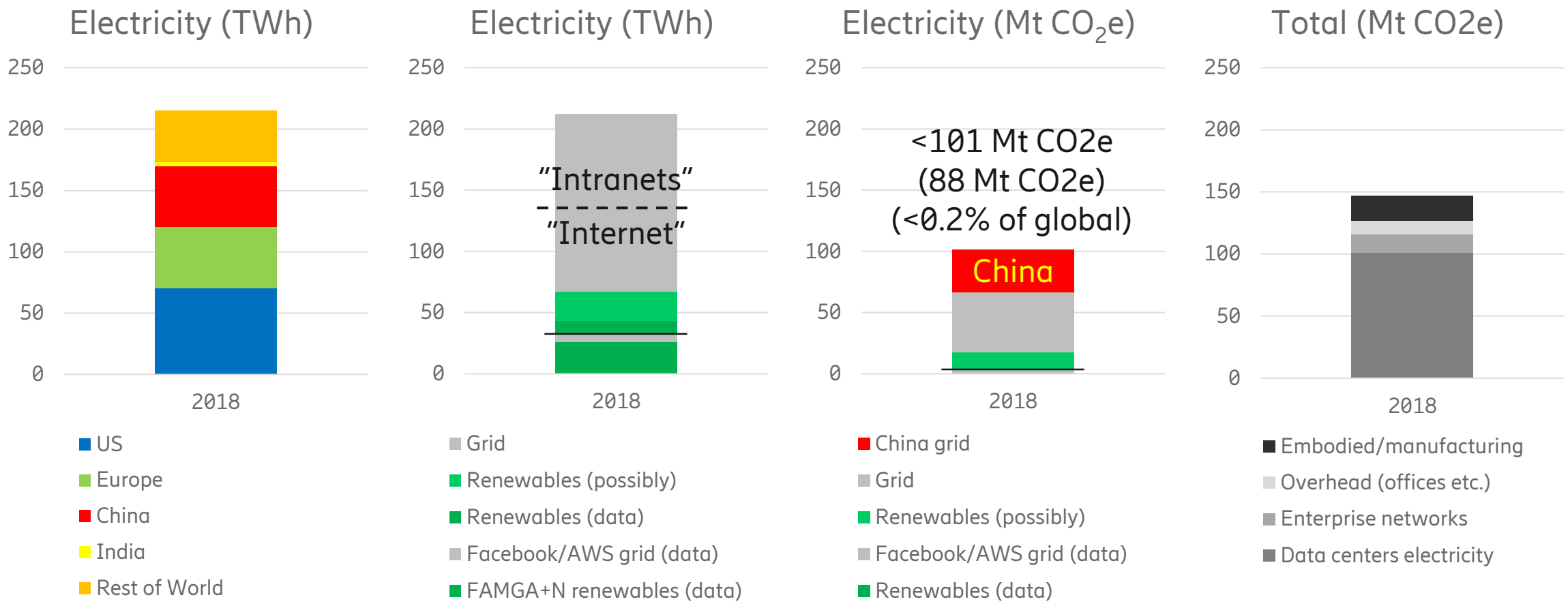
Global data centers (servers)







Global data centers (servers) 2018



215 TWh
(0.9% of global)

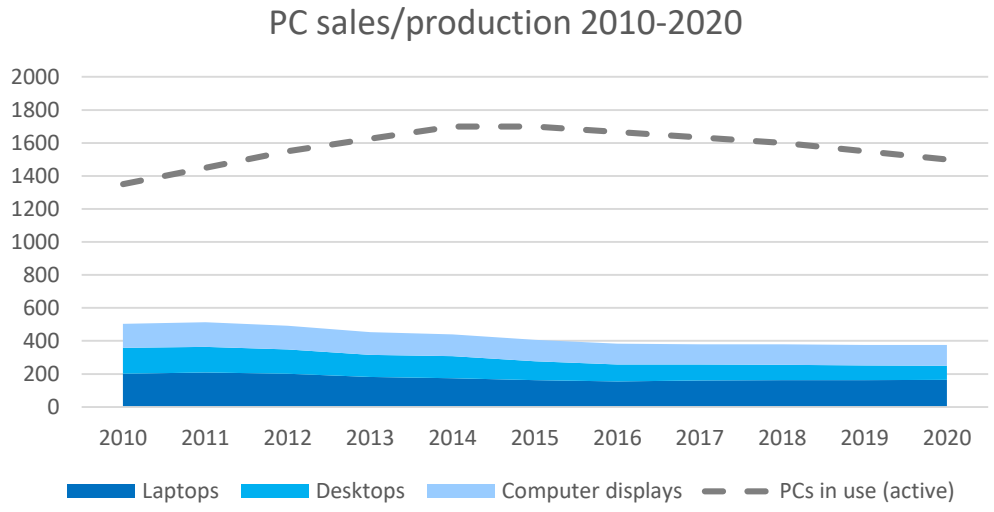
33 TWh (15%)

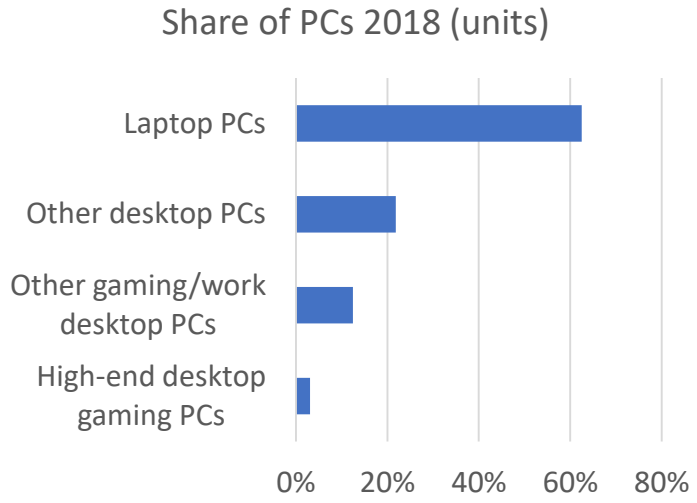
4 Mt CO_2e (4%)

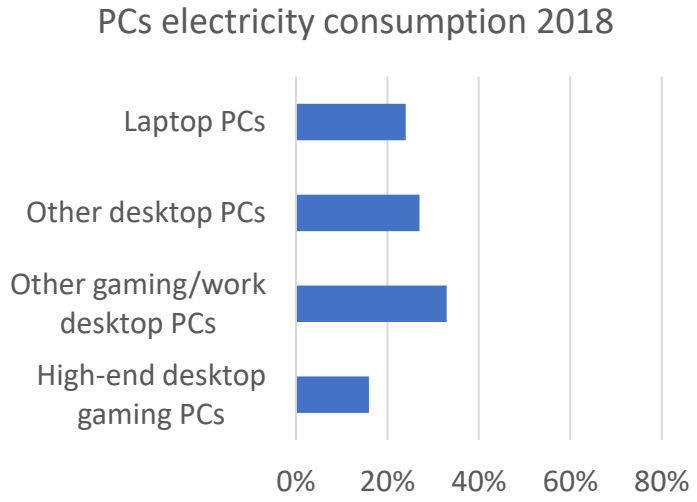
7 Mt CO_2e (5%)

FAMGA+N = Facebook Amazon Microsoft Google Apple + Netflix

Global PC data





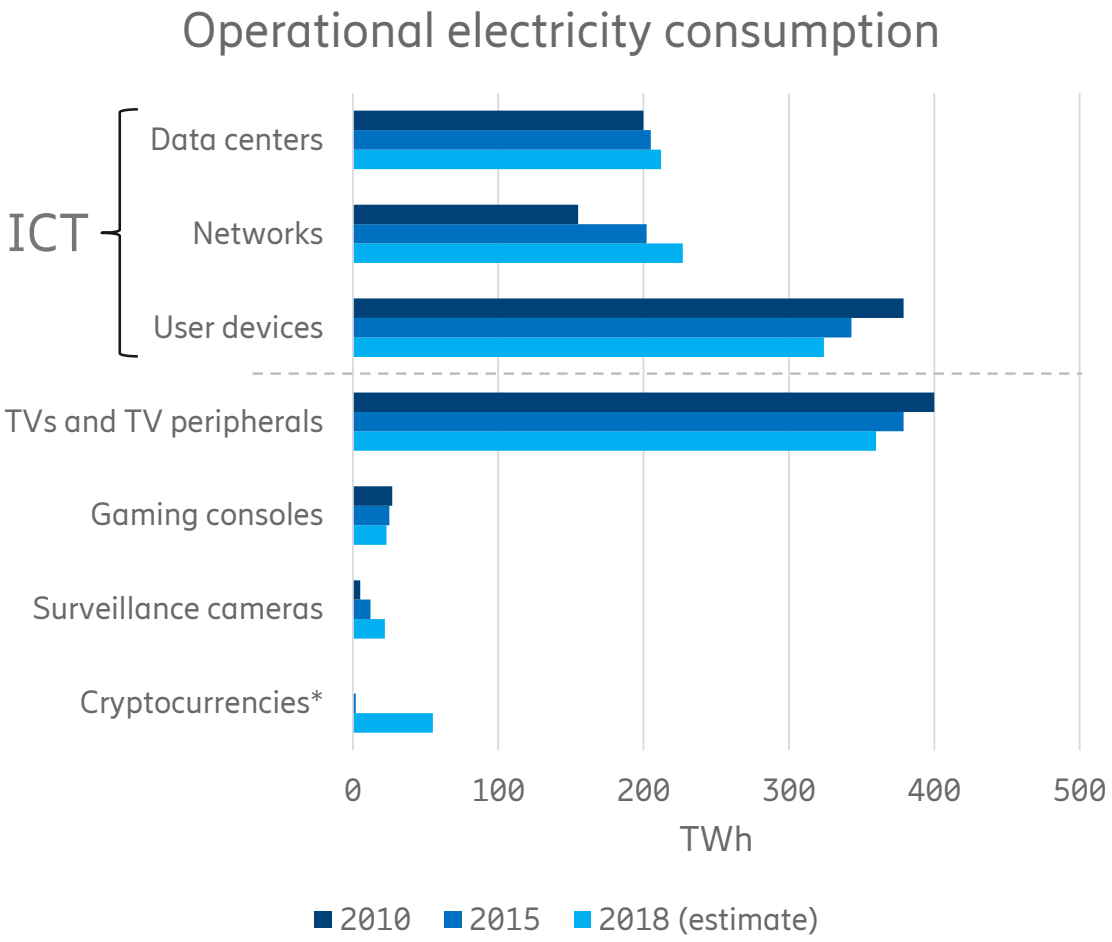


"Peak PC"
2005-2010:
~ 250 TWh

2015:
~ 175 TWh

2018:
~ 160 TWh

Closely related equipment/devices (to ICT)

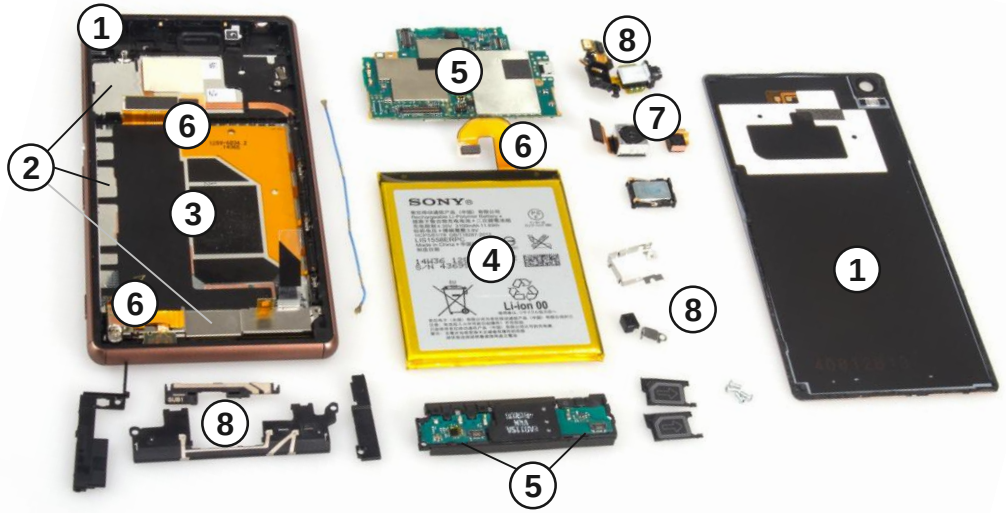


- **TVs, TV peripherals and gaming consoles (E&M):** All TVs, TV peripherals and gaming consoles are allocated to the E&M sector (has always been part of the E&M sector).
- **Surveillance cameras (security sector):** Could possibly be "ICT" due to the high "connected" share and use of media servers. Could also possibly be "E&M" as other "stand-alone" cameras.
- **Cryptocurrencies (financial sector):** The main hardware, the "mining" machines, may be allocated to the financial sector like ATM's and traditional payment media. Could possibly be "media" but payment media has not been a part of the media sector before. Could like surveillance cameras also possibly be "ICT" due to the "networking" nature.

*) Cryptocurrencies also includes the use of some standard ICT equipment/devices (small double accounting)

LCA of a smartphone

A. The phone itself	152 g (see details to the right)
B. Headset	16 g
C. USB cable	21 g
D. Charger	35 - 50 g (depending on country)
E. Documentation	48 g
X. Delivery packaging	74 g (not included in picture)
Y. Transport packaging	66 g (not included in picture)

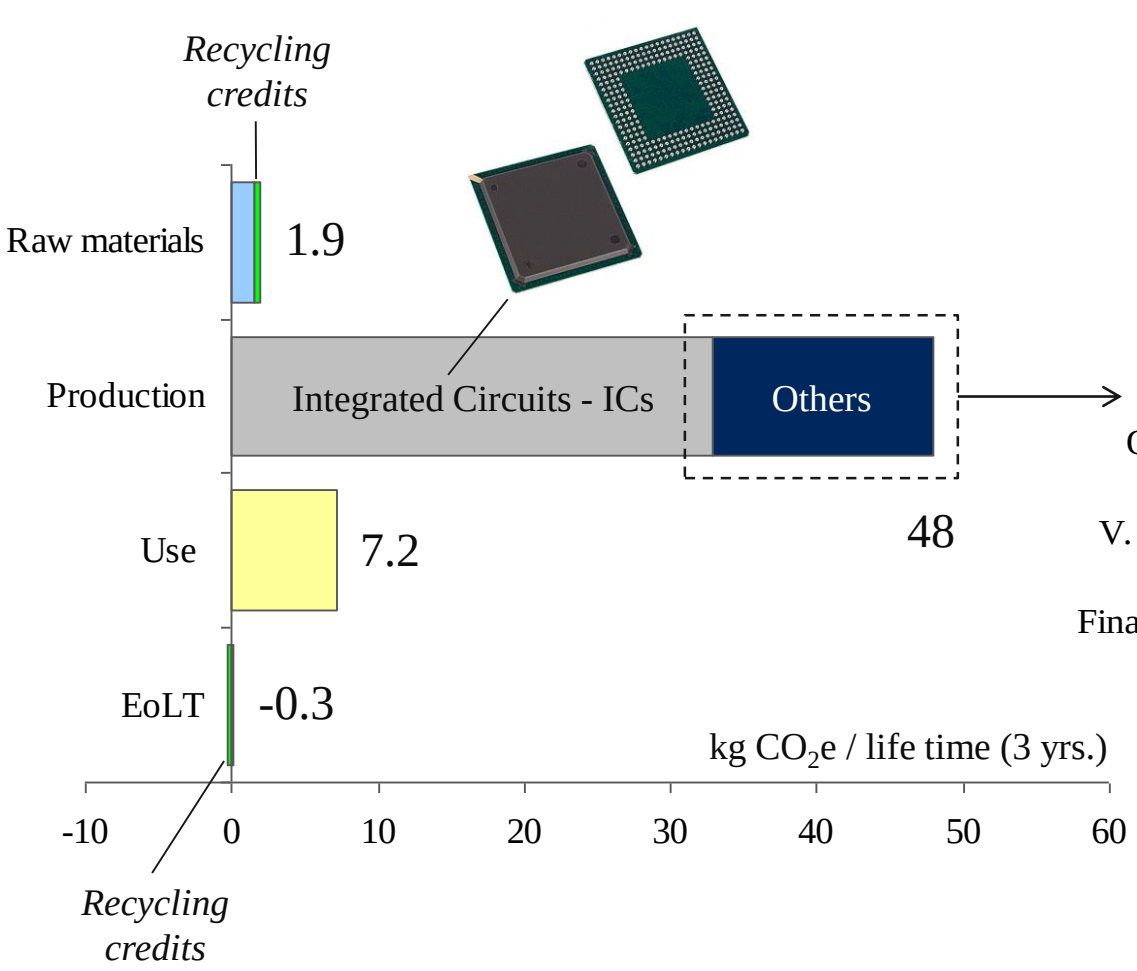


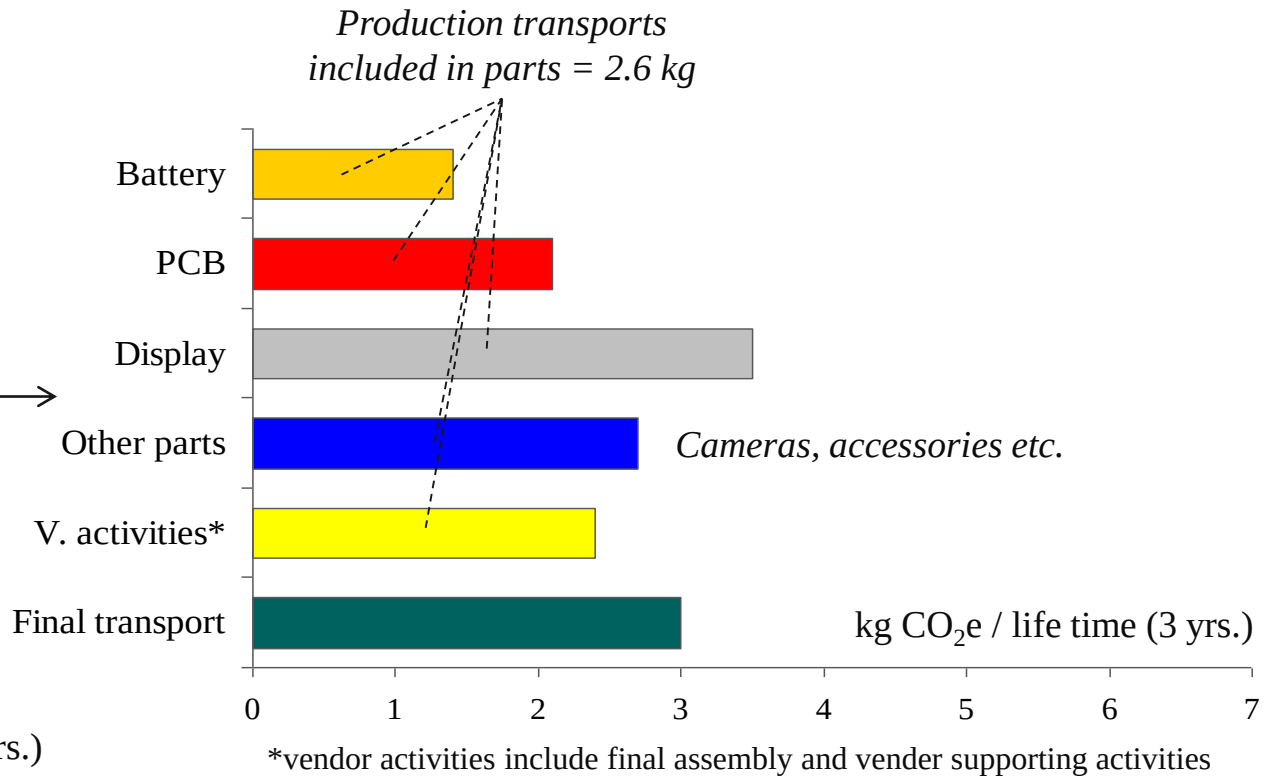
1. Frame/backside	27 g (mainly plastics)
2. Metal sheets	15 g
3. Display	29 g (not visible, facing down)
4. Battery	51 g
5. PBAs / ICs	13 g
6. Flex-films	4.1 g
7. Cameras	1.5 g
8. Other components	12 g

Key LCA parameters:

ICs, total die size	7.5 / 9.5 cm^2
Display size	5” (75 cm^2)
PCB size (main board)	12 layers, 25 cm^2
Gold content	17 mg
Copper content	12 g

LCA of a smartphone





Embodied: ~ 50 kg
Use: ~ 7 kg (3 yrs.)
or ~ 20 kg/year

Smartphone Li-ion battery

- Weight: 51 g
- Capacity: 2 900 mAh (11 Wh)
  Charging 0% battery every day: 4 kWh/year
- "BoM" (Bill of Materials), see right →
- GWP "cradle to gate" excluding raw materials:
  1.4 kg CO_2e per battery
  (28 kg CO_2e / kg battery)
- Electricity consumption, manufacturing:
  1.7 kWh/battery
- Ratio product+waste / product: 1.3

Material name	Abbreviation	Weight [g]
Lithium Cobalt Oxide	LiCoO2	
- Cobalt	Co	8.7
- Other	Li, O	11
Carbon black	C	10
Copper	Cu	7.3
Polycarbonate plastics	PC	4.8
Aluminium	Al	3.2
Other thermoplastics		2.6
Aluminium Oxide	Al2O3	0.77
Lithium hexafluorophosphate	LiPF6	0.73
Silver	Ag	0.02
Other materials		1.2

- Smartphone cobalt use is about 12% of current market (dominated by vehicles already today)
- Smartphone battery (LCO): 10 g vs Medium car battery (LNC): 10 kg (future technology)
- "Superalloys" (SA) use more cobalt than smartphones, main application of SAs is jet turbines

This is a more than 10 year old figure...

Calculator

Media player

Stereos

TV

Radio

GPS

Your mobile device...

Remote controls

Personal post box

Clock

Wallet

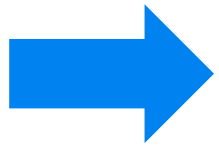
...can dematerialize...

Keys

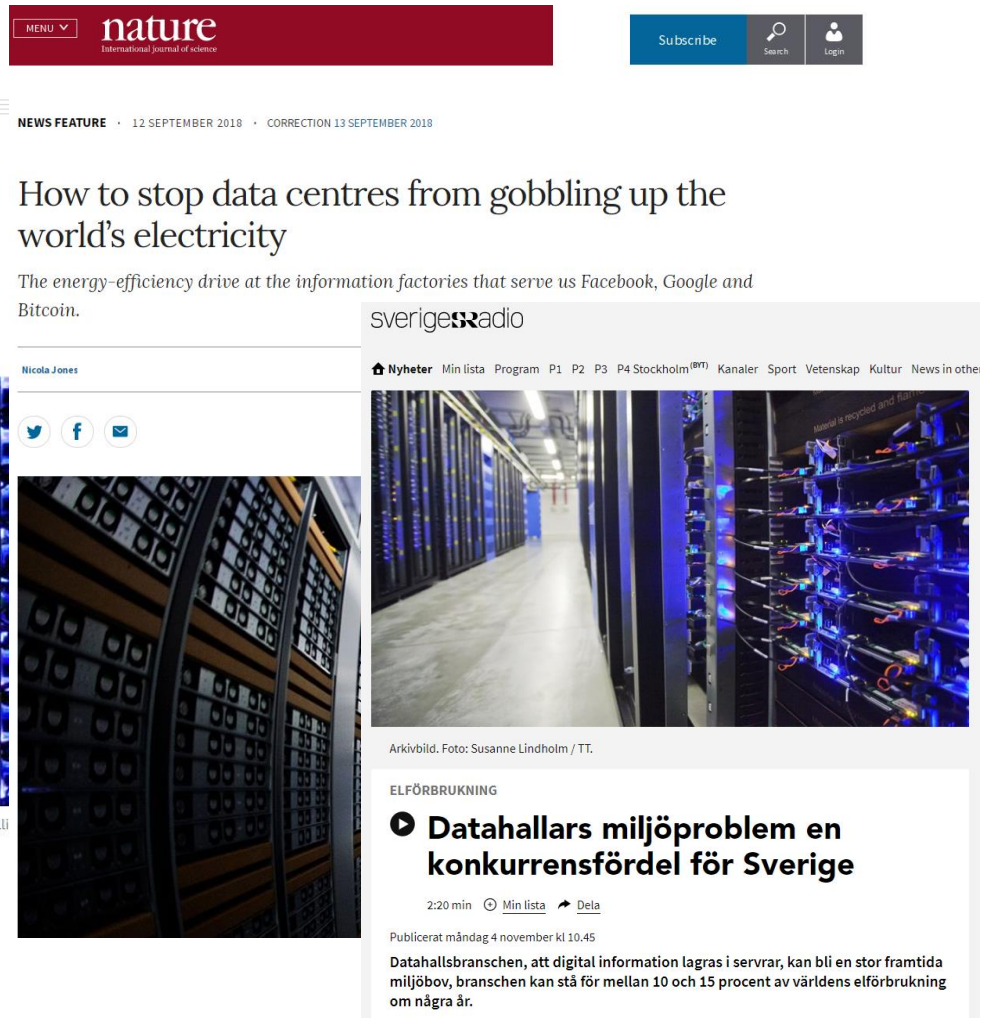
Camera(s)

Games!

...even PCs



Not correct news...



Datacenters electricity use, 10-20%? 50?- It's <1% and decreasing

”Så påverkar ditt strömmande klimatet” (DN 2019-01-30)

- IT-sektorn står för 10% av jordens energiförbrukning
- IT sektorn = Flygindustrin (CO2)
- Låten ”Despacito” har förbrukat 1 TWh när den laddats ner 5 miljarder gånger
- 1 h strömmad video i veckan = 2 kylskåp

- ”...ett värsta tänkbara scenario där kommunikationsteknologin förbrukar mer än hälften av all elektricitet i världen och står för en fjärdedel av utsläppet av växthusgaser vid 2030.”

”Så påverkar ditt strömmande klimatet” (DN 2019-01-30)

- IT-sektorn står för 10% av jordens energiförbrukning
  - **IKT står för ca 2%**
- IT sektorn = Flygindustrin (CO2)
  - **Flygindustrin >2 ggr IKT (CO2e)**
- Låten ”Despacito” har förbrukat ~1 TWh när den laddats ner 5 miljarder gånger
  - **Påståendet är >>100 ggr fel! (2.5-5 kW)**
- 1 h strömmad video i veckan = 2 kylskåp
  - **Påståendet är >>100 ggr fel! (4 kW)**
- ”...ett värsta tänkbara scenario där kommunikationsteknologin förbrukar mer än hälften av all elektricitet i världen och står för en fjärdedel av utsläppet av växthusgaser vid 2030.”
  - **Helt otänkbart! Hur i..?**

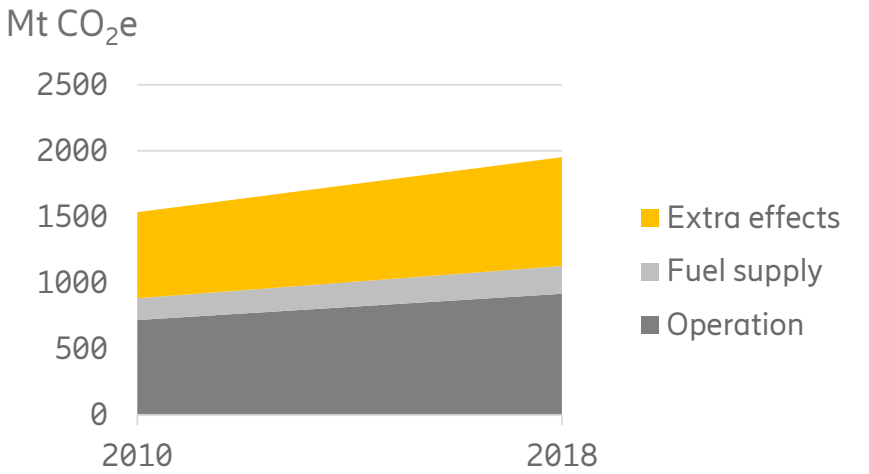
Fair comparison of ICT to aviation

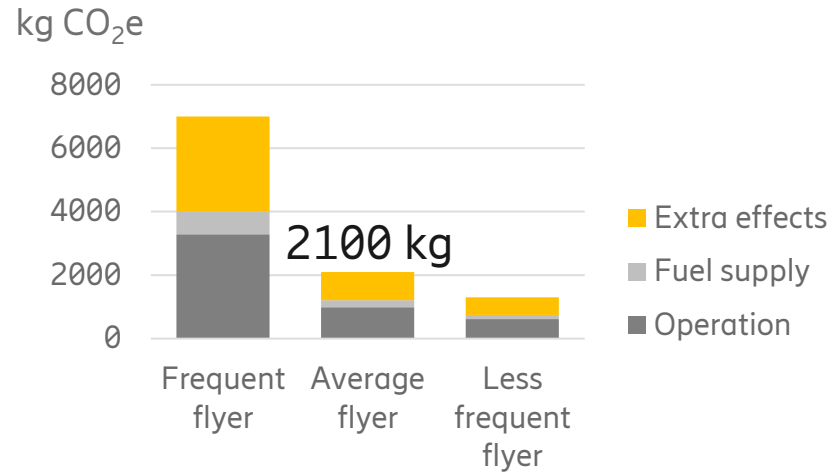
Aviation:

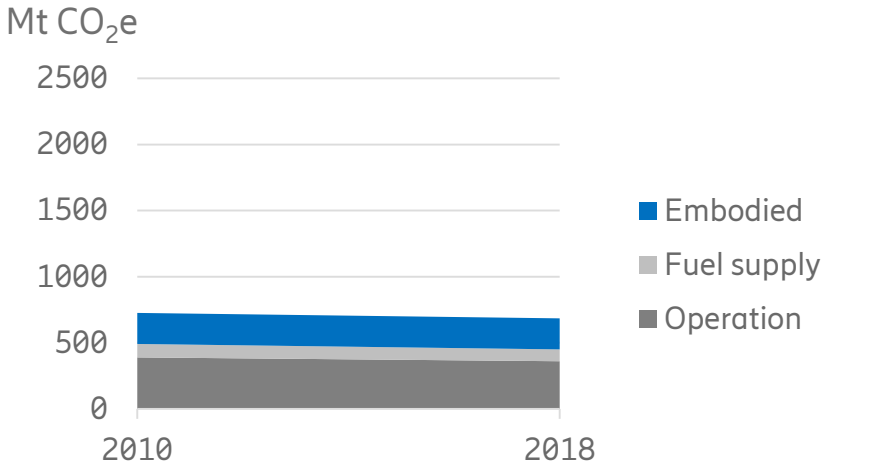
— 1 950 Mt CO_2e
— +27% since 2010
— Air freight 19% of CO_2e
— 750 millon annual users
— 4300 million passengers
— 80% has never flown

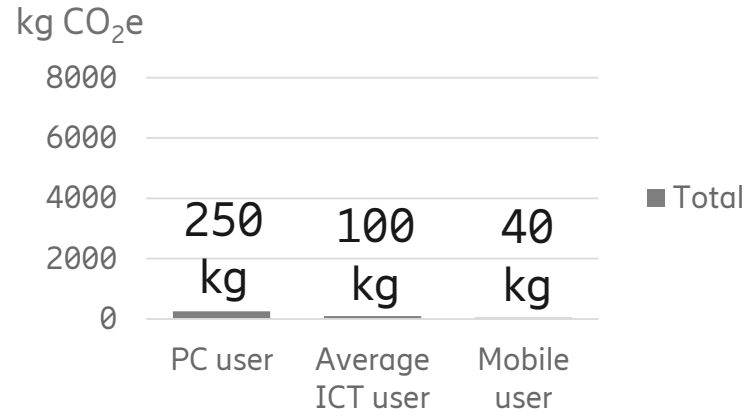
ICT:

— 700 Mt CO_2e
— -3% since 2010
— 5100+ millon daily users
— >90% has probably used ICT









Power consumption = energy consumption

1 W * 8766 h = 8.766 kWh ~ 9 kWh

TV
50-200 W
(<1 W)

STB
2-10 W

Media converter
2-5 W

Fixed access network
1-5 W

PSTN
3-10 W

Enterprise networks
1-5 W

PC
70-400 W
(<1 W)

Home router
7-15 W

Networks: "Always on"

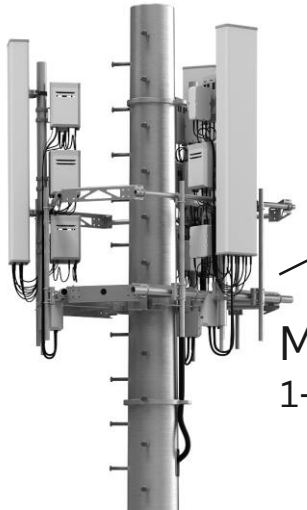
Laptop
15-50 W
(<1 W)

FWA router
5-10 W

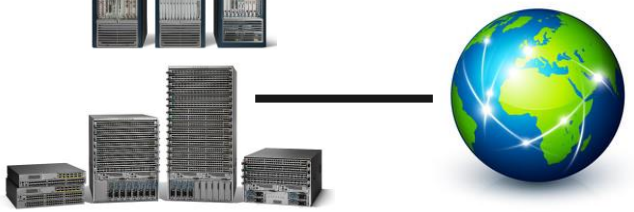
Tablet
5-25 W
(<0.1 W)

Smartphone
1-3 W (<0.1 W)

CPE: "Always on"

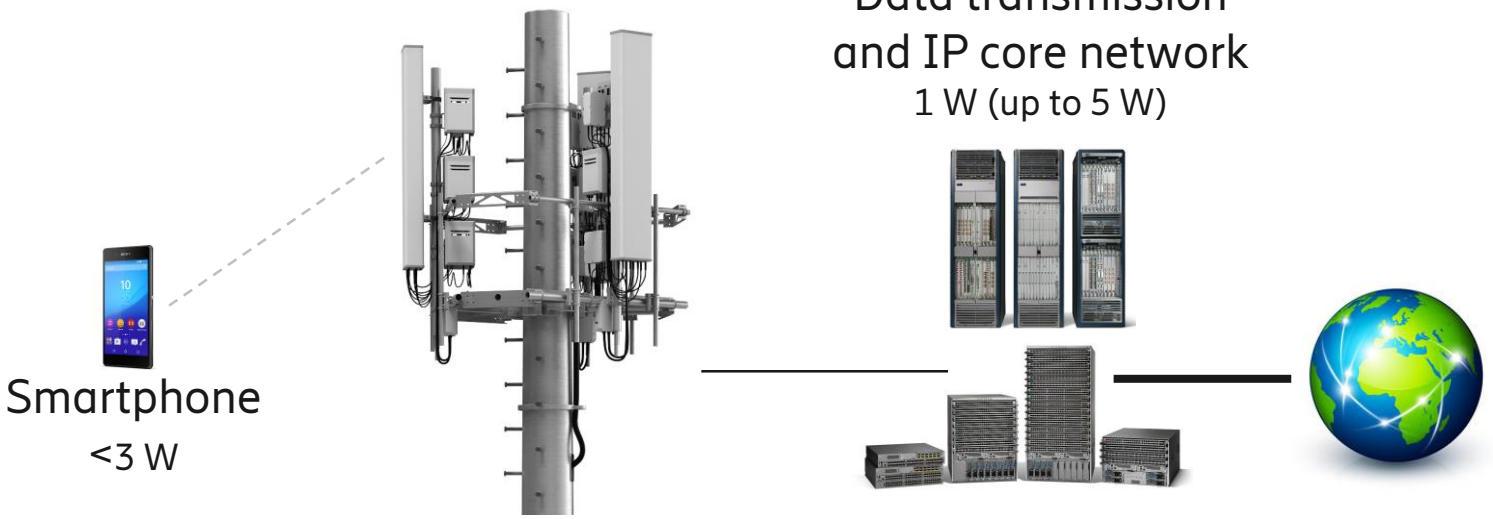


Mobile (radio) access network
1-5 W (6 W for 4G HD video)



Data transmission and IP core network
0.5-3 W

Streaming HD video (mobile)

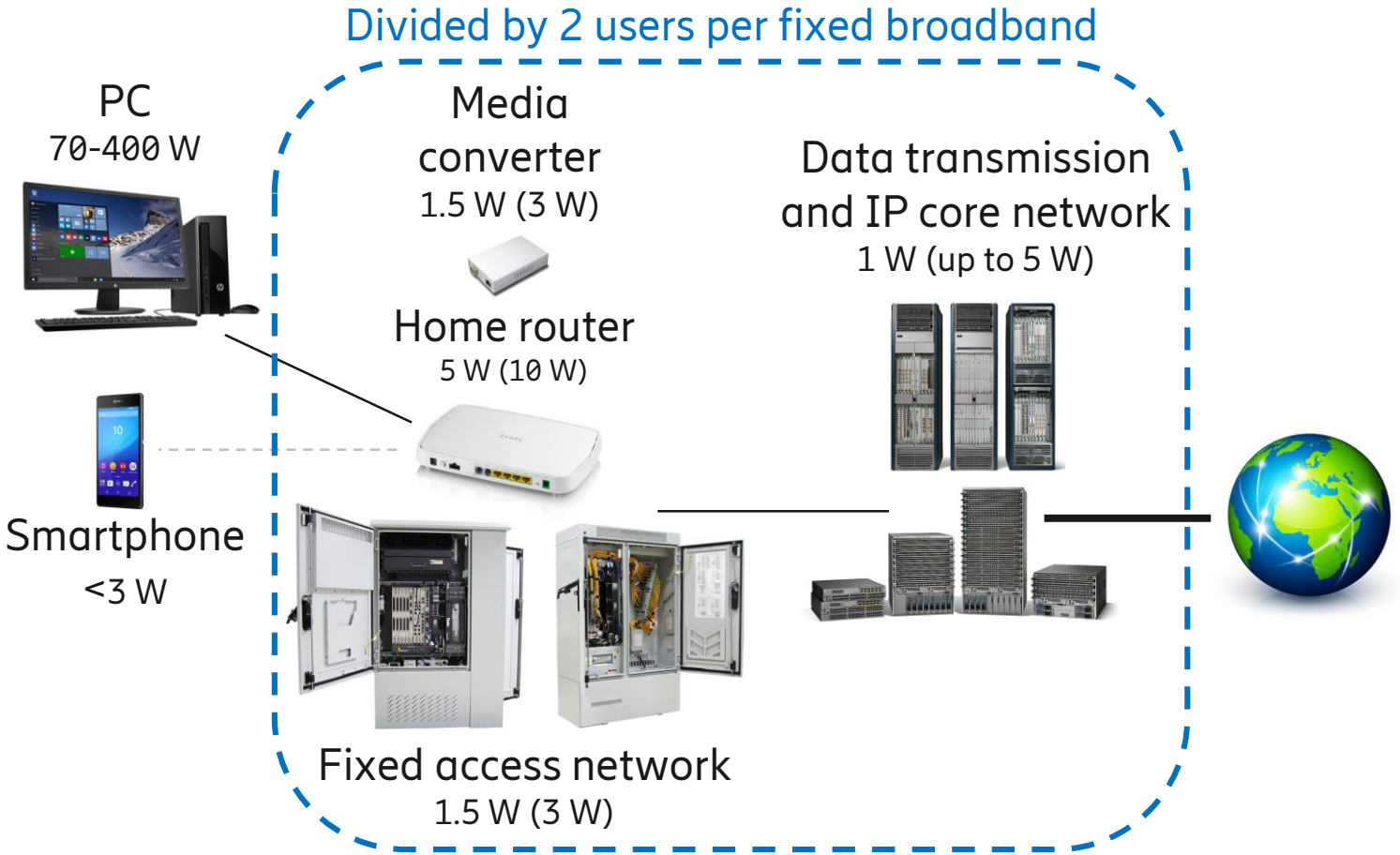


<3 + 6 + 1 + 5 = **15 W** or **6.4 kWh** (427 h)

Netflix (HD video streaming):

- 0.3 TWh (100% green)
- 140 million users
- 2.1 kWh (0.24 W) per user
- 1 h 10 min per day
- 4.9 W/user (when active)
  (<1 W "in theory")
- 15% of global Internet data

Streaming HD video (fixed)

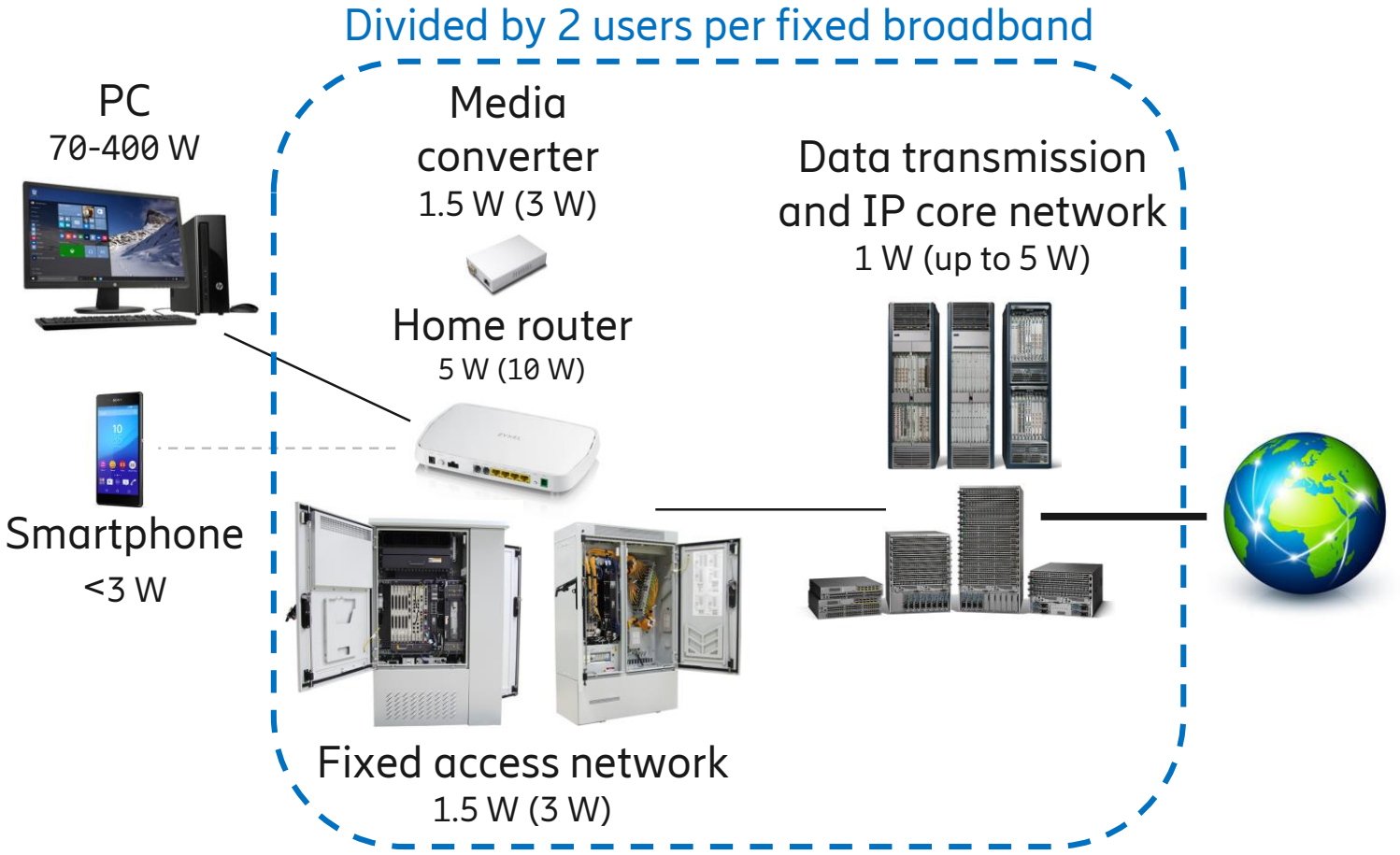


<3 + 8 + 1 + 5 = **17 W** or **7.3 kWh** (427 h)
(PC +150 W)

Netflix (HD video streaming):

- 0.3 TWh (100% green)
- 140 million users
- 2.1 kWh (0.24 W) per user
- 1 h 10 min per day
- 4.9 W/user (when active)
  (<1 W "in theory")
- 15% of global Internet data

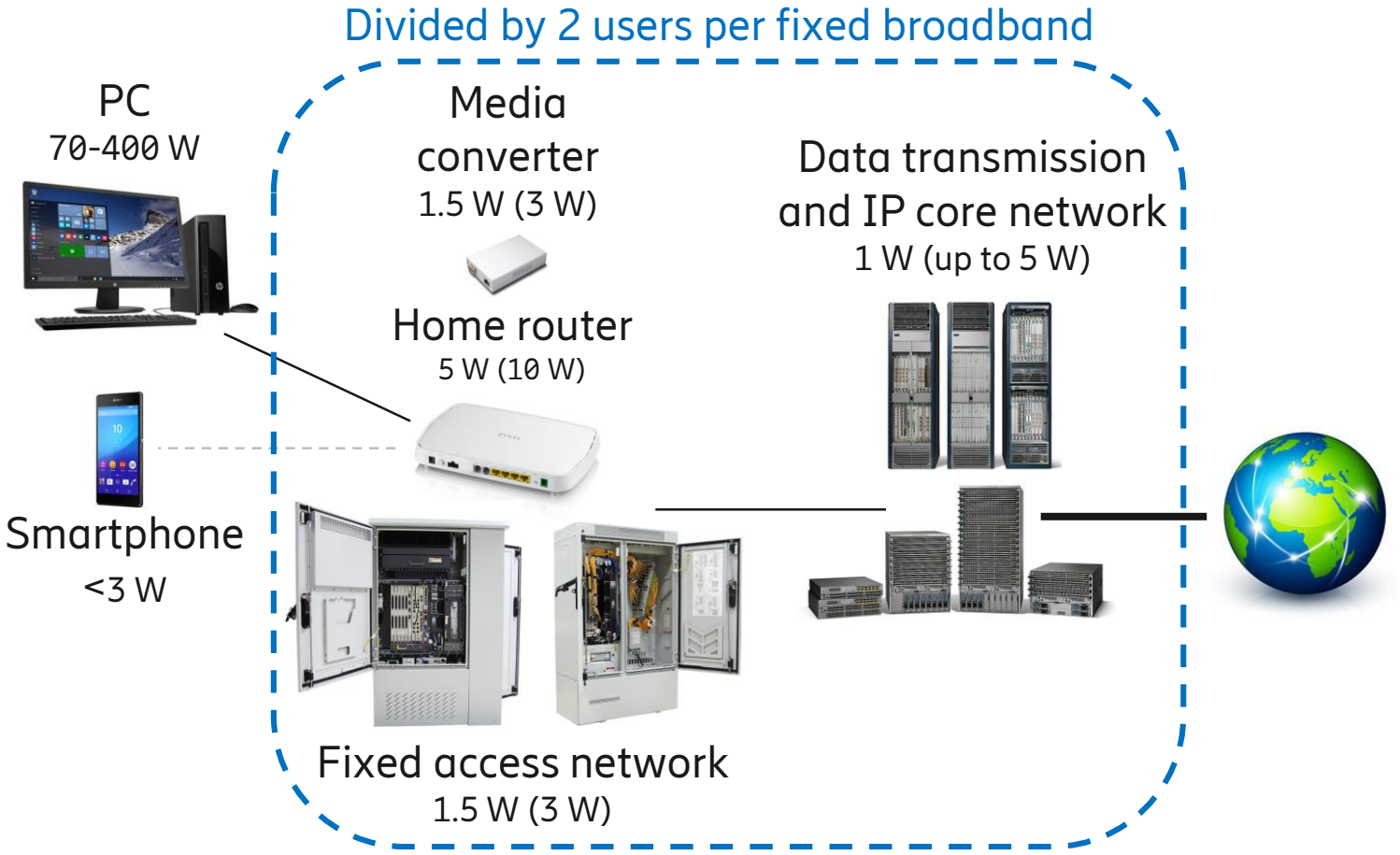
Other Internet use



Google ("everything"):
- 10.1 TWh (100% green)
- 3.8 billion / 3.5 billion
- 2.7 kWh/useryear
- 0.31 W/user
- 1-1.5 h per day
- 5-7.4 W/user (when active)

Facebook (social media):
- 3.4 TWh (75% green)
- 2.4 billion users
- 1.4 kWh/useryear
- 0.16 W/user
- 35 min per day
- 6.6 W/user (when active)

Other Internet use



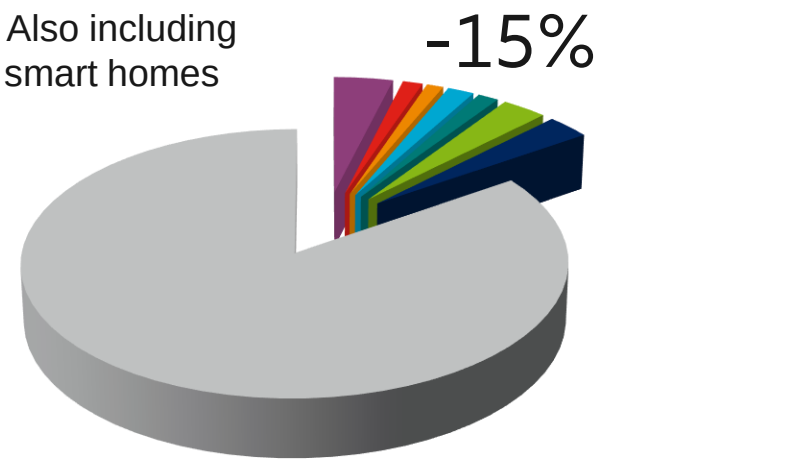
"Internet":

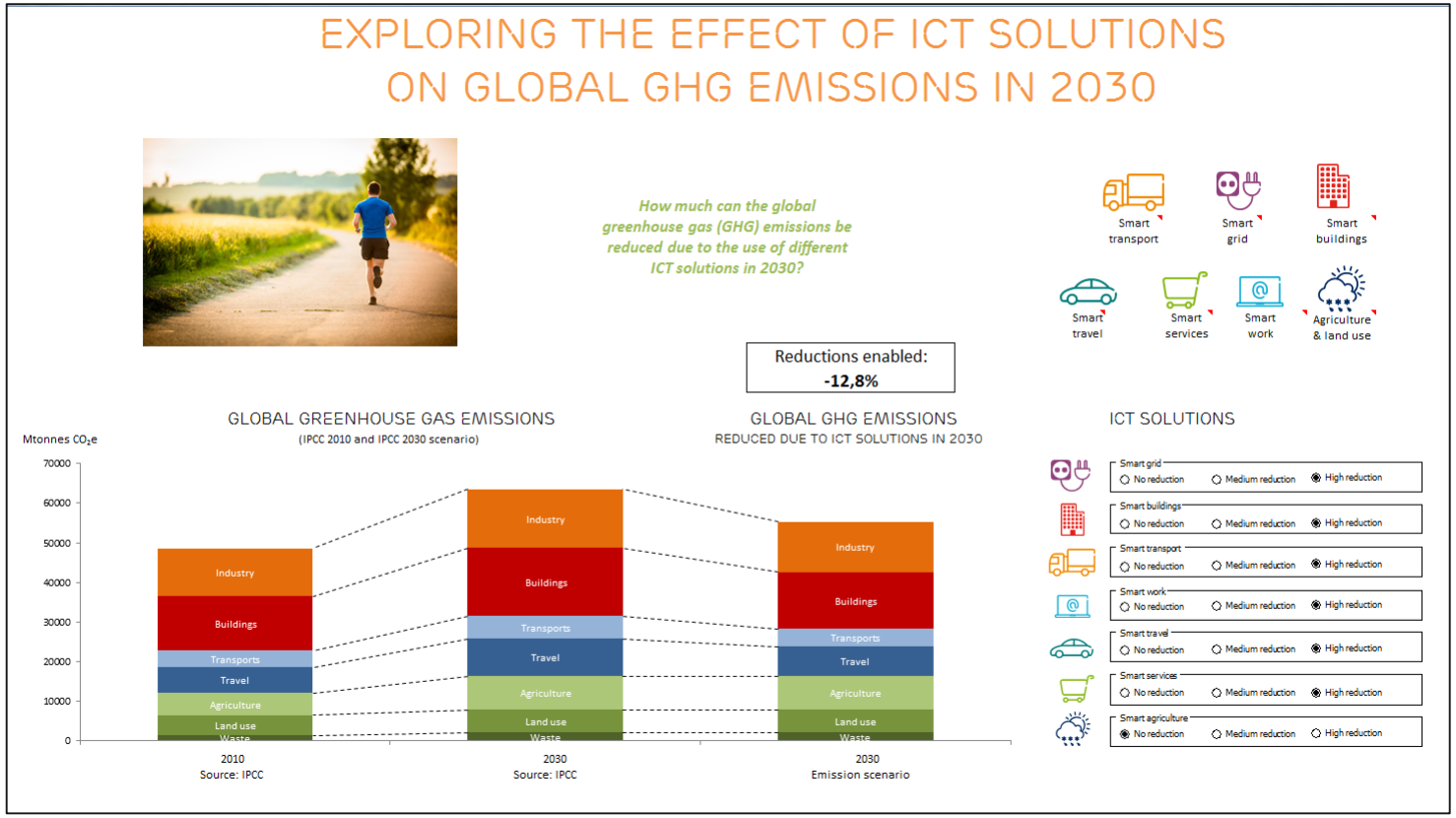
- 135 TWh (hard to measure)
- 3.8 billion users
- 36 kWh/useryear
- 4.1 W/user
- 4-6 h per day
- 16-25 W/user (when active)

How can ICT help society reduce CO2e?

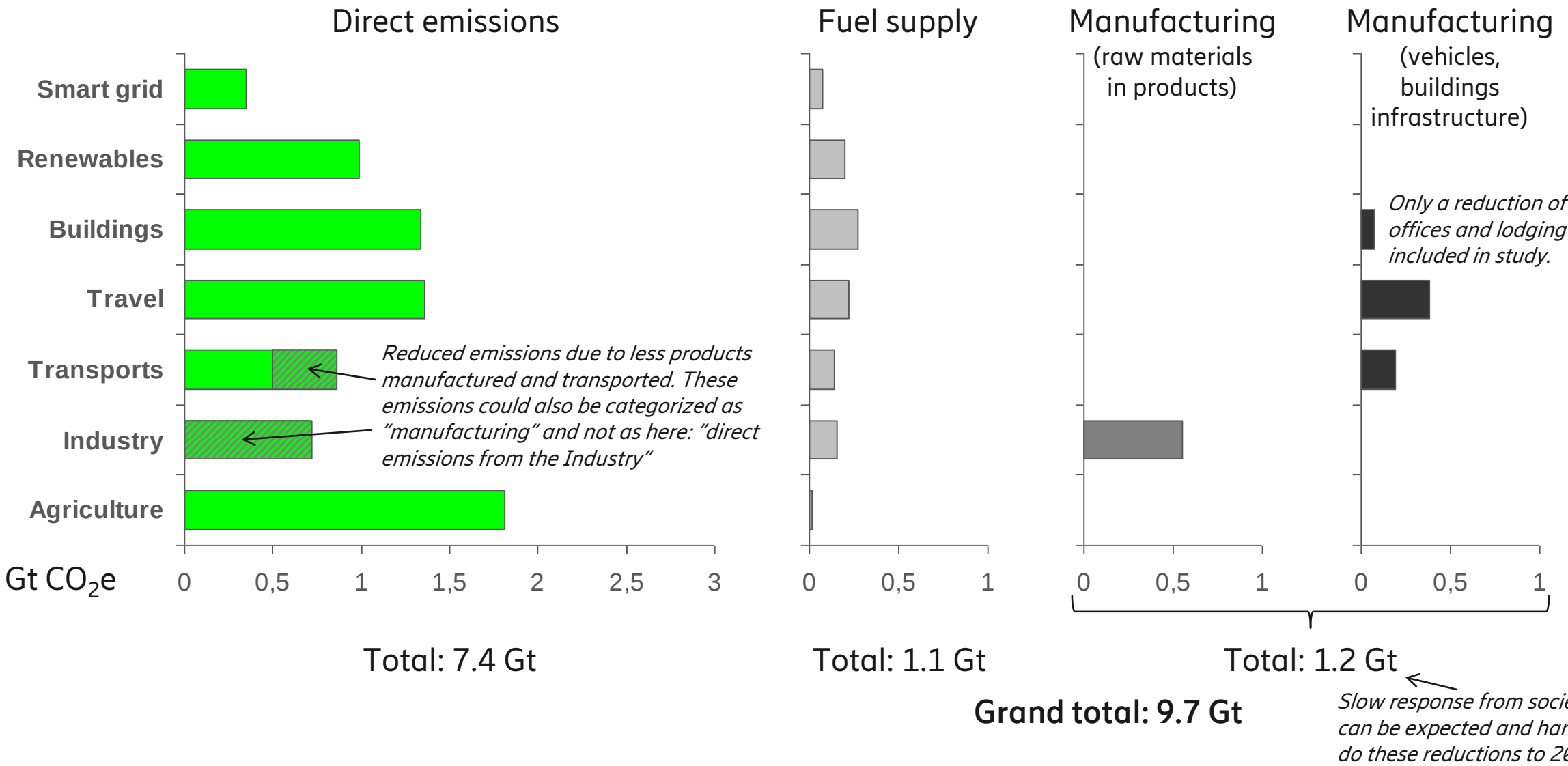
Scale proven emission reductions by ICT solutions to a global level

* Also including smart homes

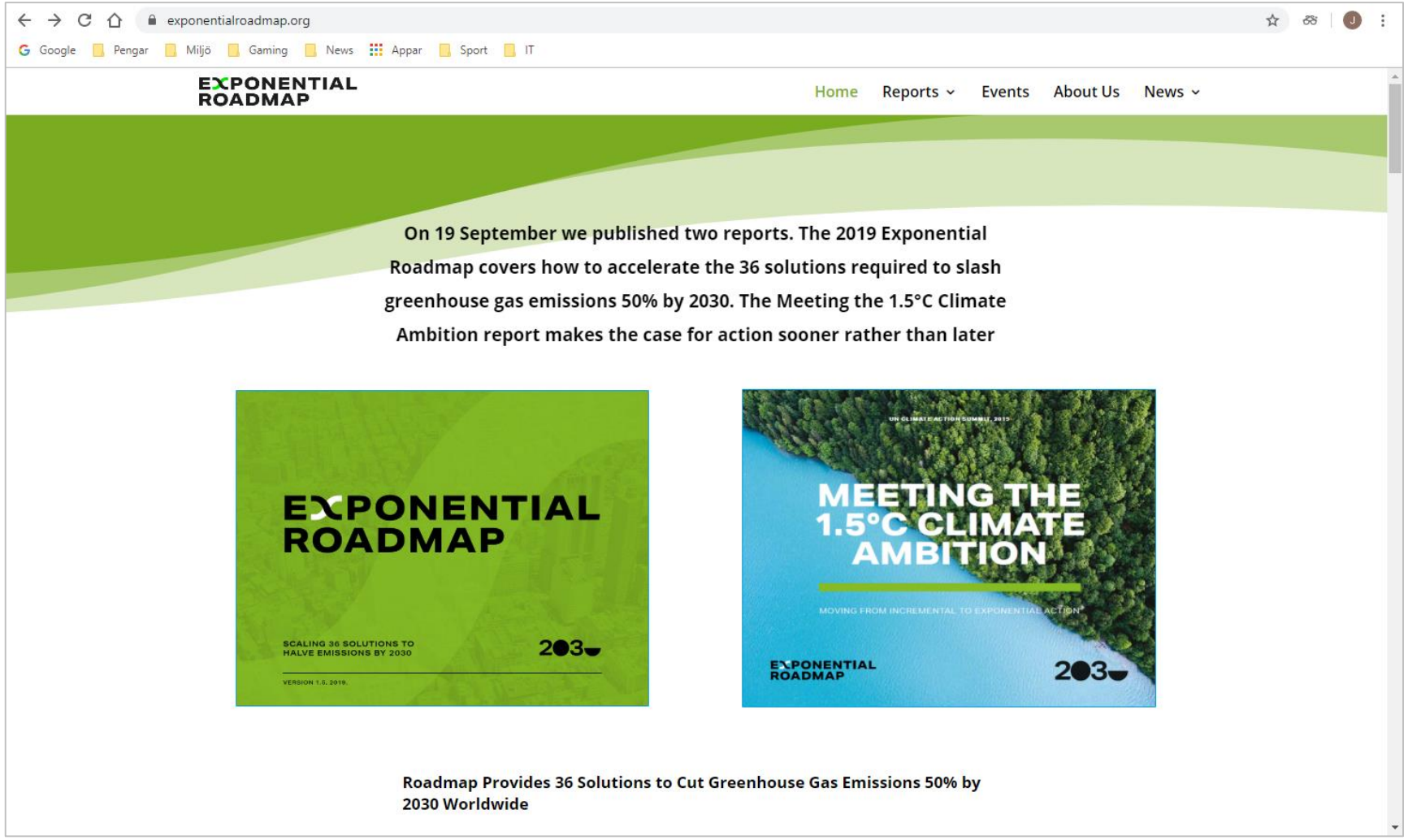




How can ICT help society reduce CO2e?



exponentialroadmap.org



GLOBAL CLIMATE ACTION SUMMIT

EXPONENTIAL CLIMATE ACTION ROADMAP

For more information, see these papers and web sites:

The effects of ICT solutions on GHG emissions in 2030 (2015)
https://www.slideshare.net/Ericsson/conference-paper-exploring-the-effects-of-ict-solutions-on-ghg-emissions-in-2030
(also available through ICT4S proceedings http://ict4s.org/conference-proceedings/)

The electricity consumption and operational carbon emissions of ICT network operators 2010-2015 (2018)
http://kth.diva-portal.org/smash/record.jsf?pid=diva2%3A1177210&dswid=-2471

The energy and carbon footprint of the global ICT and E&M sectors 2010-2015 (2018)
https://easychair.org/publications/download/MRdh
- note that the link ends up in the middle of the document so you ned to scroll for the first page

A high-level estimate of the material footprints of the ICT and the E&M sector (2018)
https://easychair.org/publications/open/XvgV
- note that the link ends up in the middle of the document so you ned to scroll for the first page

Life-cycle assessment of a smartphone (2016)
https://www.atlantis-press.com/proceedings/ict4s-16/25860375

Life Cycle Assessment of ICT (2014)
https://onlinelibrary.wiley.com/doi/full/10.1111/jiec.12145#support-information-section

The future carbon footprint of ICT and E&M sectors (2013)
https://pdfs.semanticscholar.org/2d24/59dbf04c61b5bc1aa296b07419a9d9db00d3.pdf

https://exponentialroadmap.org/