5G and Energy Efficiency

Sophia-Antipolis, 23 November 2017

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HORIZON 2020

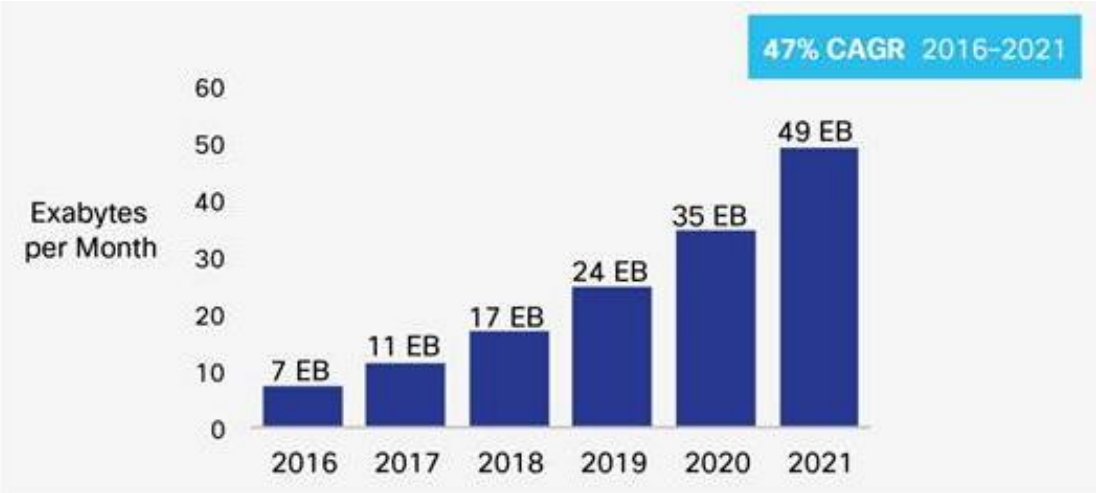
EU actions for Energy Efficiency

- **20-20-20 targets for 2020**
  - **'Climate and energy package' in 2008**
  - **20% EE improvement (vs. projected level in 2020)**
  - **Energy Efficiency Directive 2012/27/EU**
- **2016: EC proposal for "Clean Energy for All Europeans"**
  - **'Energy efficiency first' - Revised EE Directive proposal**
  - **A new binding 30% EE target for 2030 (vs. 2007 level)**
  - **Driving digitalisation forward (5G and verticals!)**
- **Circular Economy**
  - **Action Plan in 2015 – resource efficiency is key!**
  - **Directive on waste electrical & electronic equipment (WEEE)**

Importance of EE

- **Energy is expensive** for operators and users and its production has **environmental effects**;
- **Battery capacity** is increasing only 1.5x/decade (or 4 %/year);
- **Mobile traffic** is increasing exponentially (see below) and power consumption should be adapted to the traffic load;
- **Moore's law** (energy efficiency 100x/decade) is slowing down and will have thermal noise death in about 2020-2022?
- **Cooling efficiency** will not improve significantly, and active cooling is using energy…

A global mobile data traffic forecast (*):

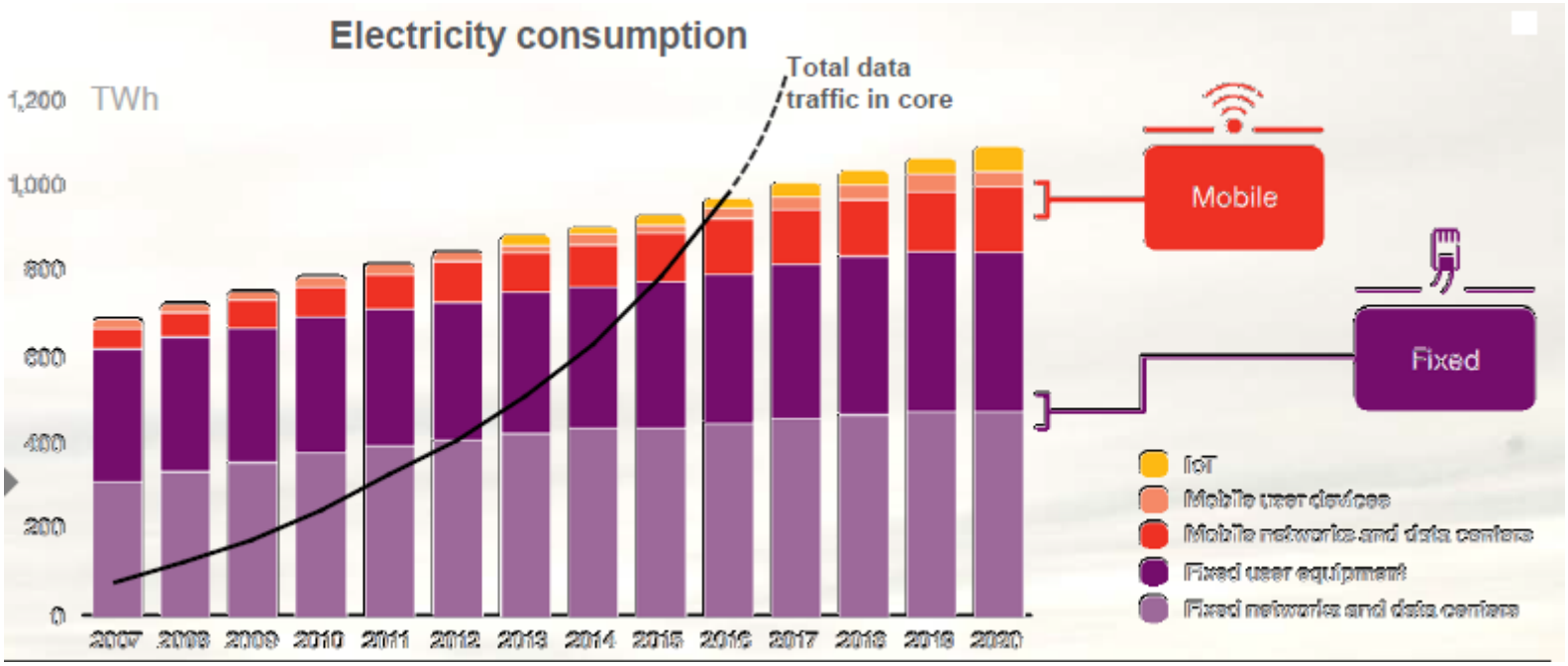


(*) Source: Cisco VNI Mobile, 2017

Connectivity footprint

European Commission

- **Global consumption of network infra & user equipment (*)**



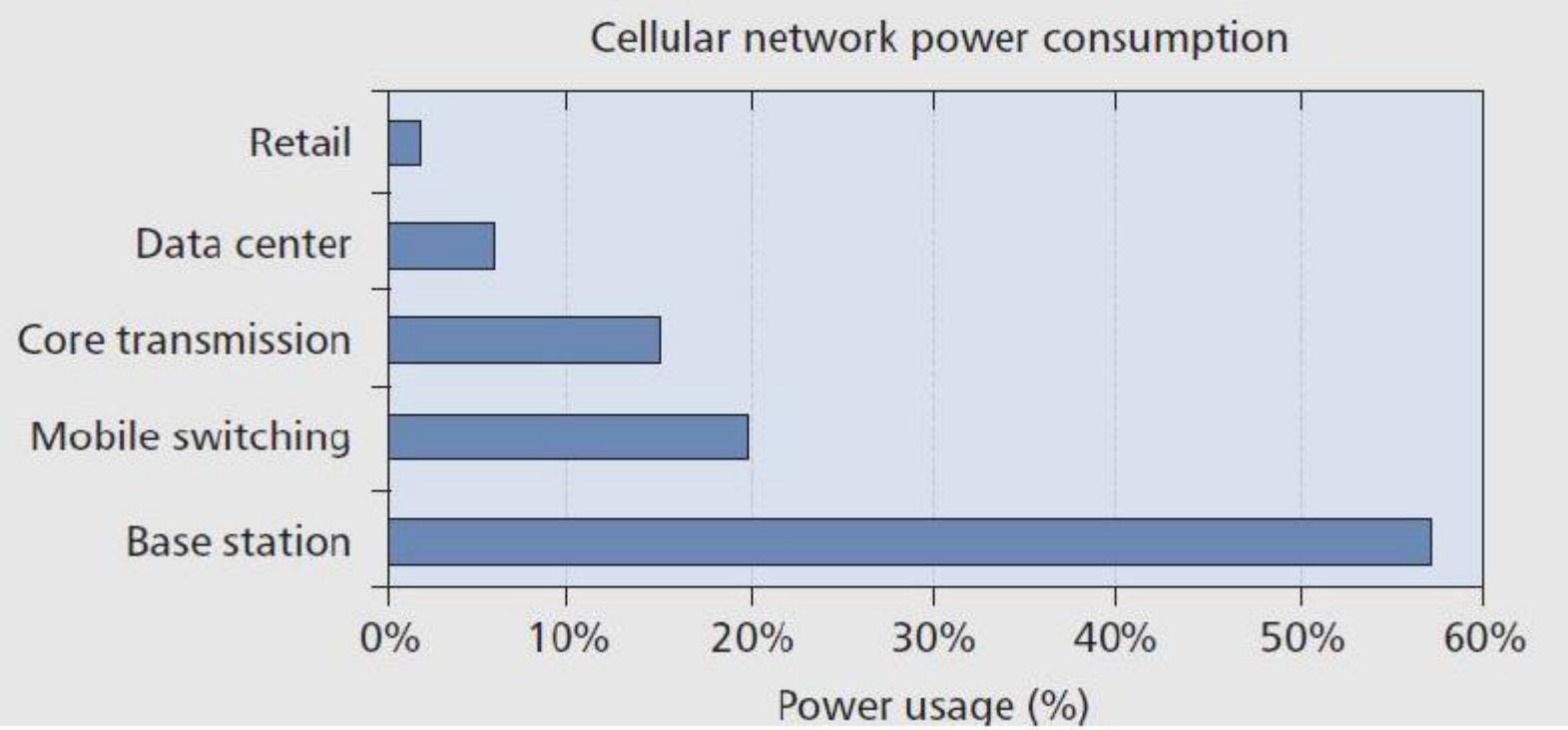
Of global CO_2 : 1.3% 1.6% 1.9% …. ~2% (in 2030)

(*) Source: Digitaleurope / Ericsson Mobility Report Nov 2015

- **In the EU, broadband equipment accounts for ~15% of the ICT sector's overall energy consumption; at least 50 TWh in 2015!**
  (NB: this equals roughly to an annual power output of 2 nuclear power reactors)

Cellular networks

- **Power consumption is driven by radio access network (*):**



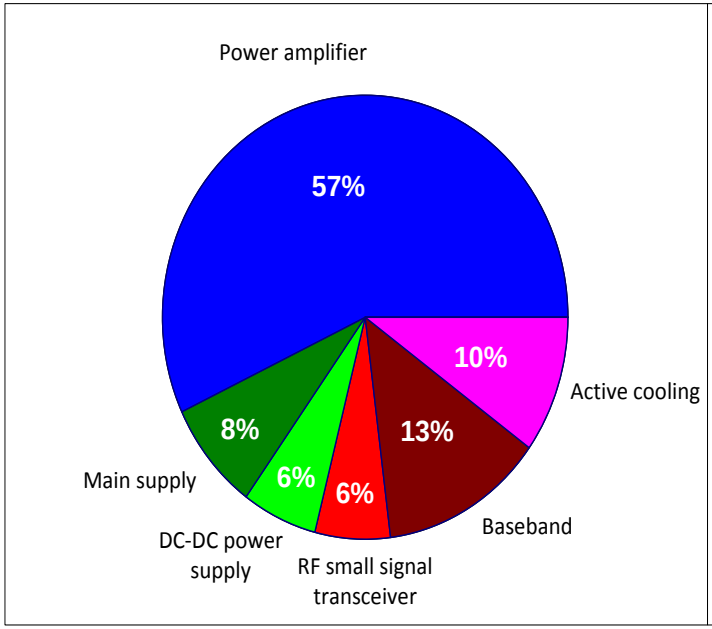
(*) Source: Han C. et al., "Green Radio: Radio Techniques to Enable Energy-efficient Wireless Networks," IEEE Wireless Communications Magazine. vol. 49, no. 6, June 2011, pp. 46–54

- **Also applicable to LTE, where the power consumption targets (EC Code of Conduct 2017) aim at 30-40% savings 2011…18**

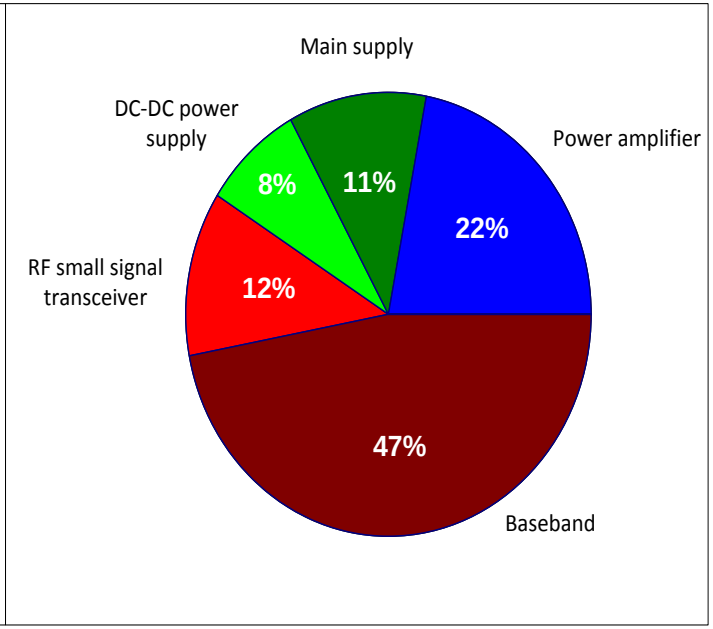
LTE base stations

Power consumption of various LTE BS types (%)

Macrocells > 1 km



Femtocells < 10 m

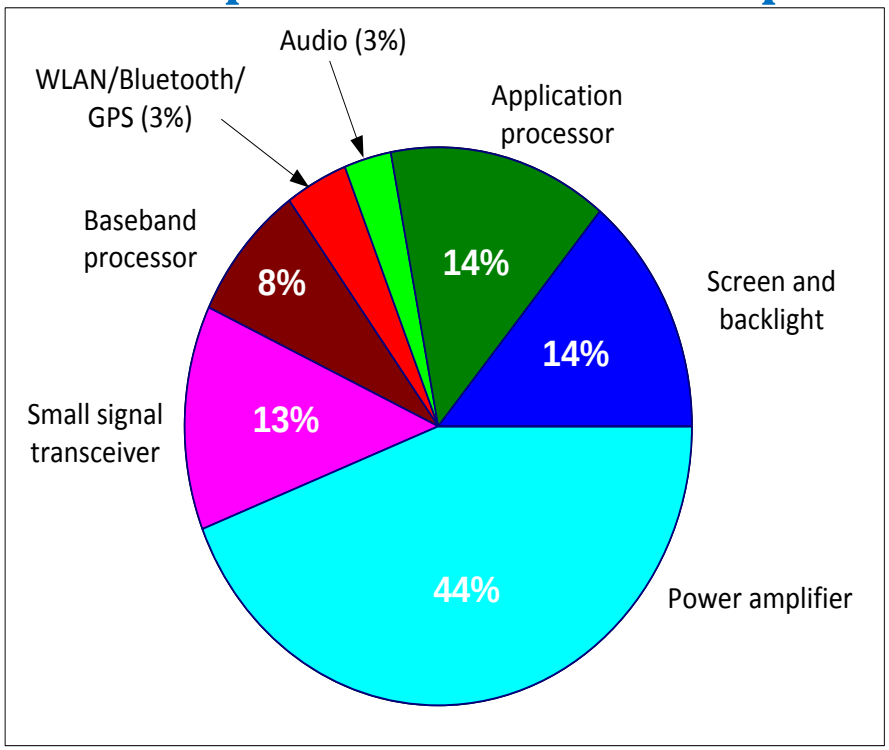


- **Baseband dominates in small cells because of computation-communication trade-off;**
  - **the transmission power is reduced and computation or circuit power starts to dominate**
- **Increasing carrier frequency will increase path loss and transmission power;**
- **Increasing number of antennas will increase antenna gain and decrease transmission power, but it will then increase computation power**

Source: Aarne Mämmelä (VTT) at EuCNC in June 2017

LTE smart phones

Power consumption in an LTE smart phone (%)



Source: Aarne Mämmelä (VTT) at EuCNC in June 2017

- Power amplifier portion is smaller at short links (here max TX power = 200 mW);
- Power control reduces the average power amplifier power

NB: for now, the main energy consumer is radio access network, but when the number of connected devices is 10-fold (and more), their order of magnitude becomes similar…

5G and Energy Efficiency I

- **5G key technical performance requirements**
  - **KPI target: *90% reduction in energy usage*!**
  - ***Network EE* is the capability of RIT/SRIT to minimise the RAN energy consumption in relation to the traffic capacity provided;**
  - ***Device EE* is the capability of RIT/SRIT to minimise the power consumed by the device modem in relation to the traffic characteristics**
- **Energy efficiency improvement is a cross-cutting 'expected impact' in various 5G PPP topics**

5G and Energy Efficiency II

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- **How to improve energy efficiency in 5G networks?**
  - **With efficient data transmission in a loaded case, and with (especially) *low energy consumption when there is no data***

    -> RIT/SRIT need to have the capability to support a high sleep ratio and long sleep duration ('deep sleep' mode)
  - ***Densification* / small(er) cells: computing energy becomes more important, as consumption is moved from the telecom equipment to BB processing**
  - **Keeping information *optical* as long as possible**
    - **Avoiding optical-electronic-optical switches;**
    - **We are considering a theme in FP9 on all-optical networks, with an emphasis on Energy Efficiency!**

5G and Energy Efficiency III

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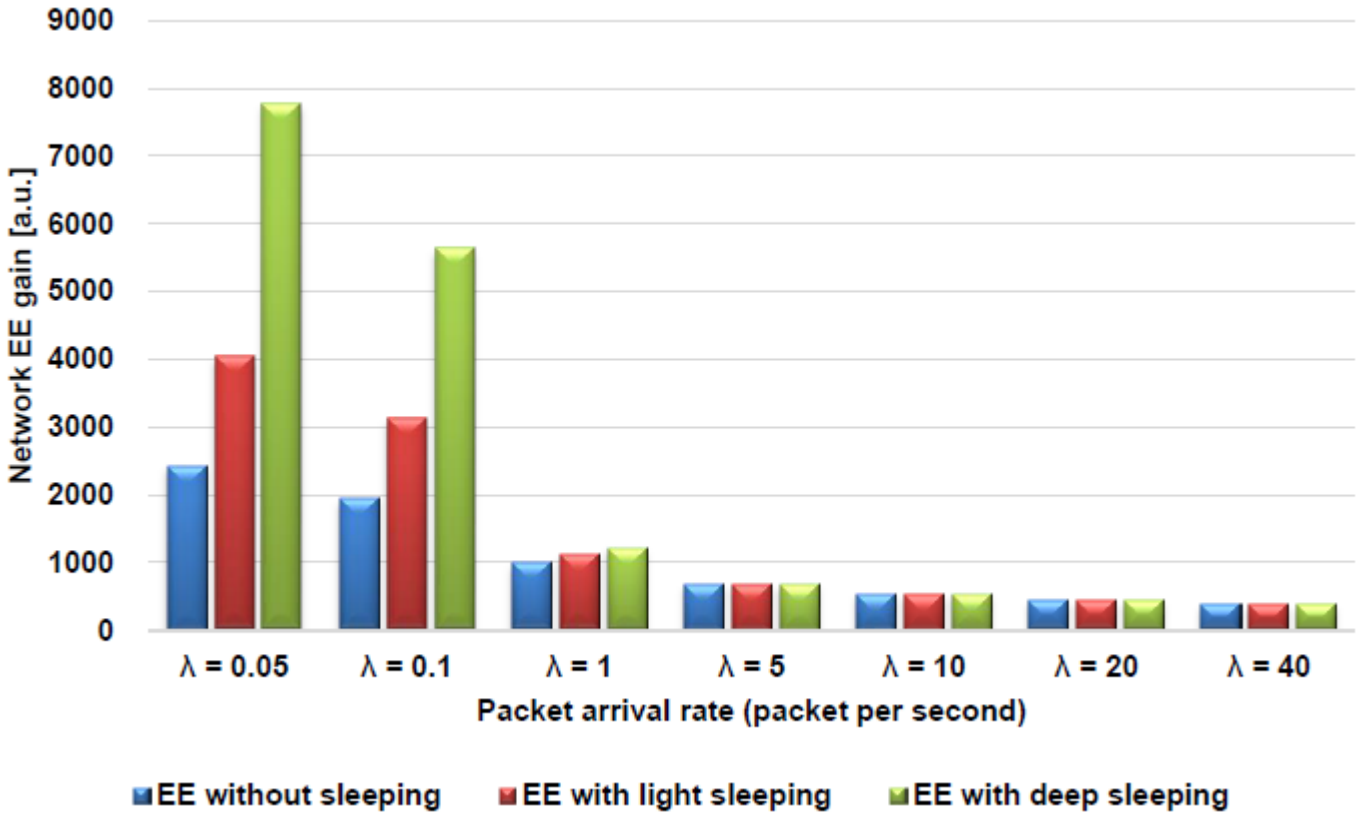
- **METIS-II: RAN energy efficiency performance**



Circular economy and other aspects

- **Circular economy aspects in 5G**
  - **Software-based upgrades -> network elements can usually be reused when new functionalities are added**
  - **Virtualisation of network functions increases the efficiency -> smaller nbr of physical hardware elements needed**
  - **All this leads to a less amount of equipment waste**
- **5G also offers solutions for Societal Challenges**
  - **SC3: Secure, Clean and Efficient Energy**
  - **Usefulness for smart energy grids**
  - **Virtual Reality, enabling telepresence**
- **EMF less critical with small cells & mm-waves?**
  - **But is EMC another critical aspect for 5G deployment…?**

Thank You!