Energy Efficiency

Impacts of BTS radio design and how to manage these?

RF Sampo, 3rd RF Summit Finland

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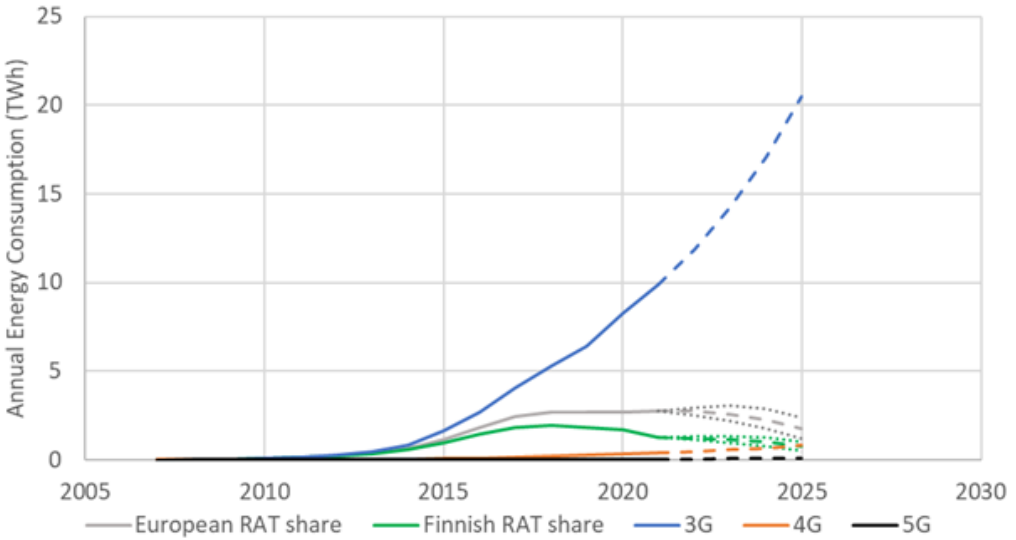
Introduction

- Energy consumption of RAT networks is increasing or staying constant
  - Data usage is increasing year by year
  - Transfer to new Radio Access Technology (RAT) takes time
  - Older technology has worse energy efficiency
- Energy Consumption of the mobile data represented 1.4% of total energy consumption in Finland in 2021
  - Core network is excluded, only Base Transceiver Station (BTS)
  - Power conversion and indoor site cooling can increase energy consumption significantly
  - In countries using the older technology (3G) the share of mobile data is significantly higher

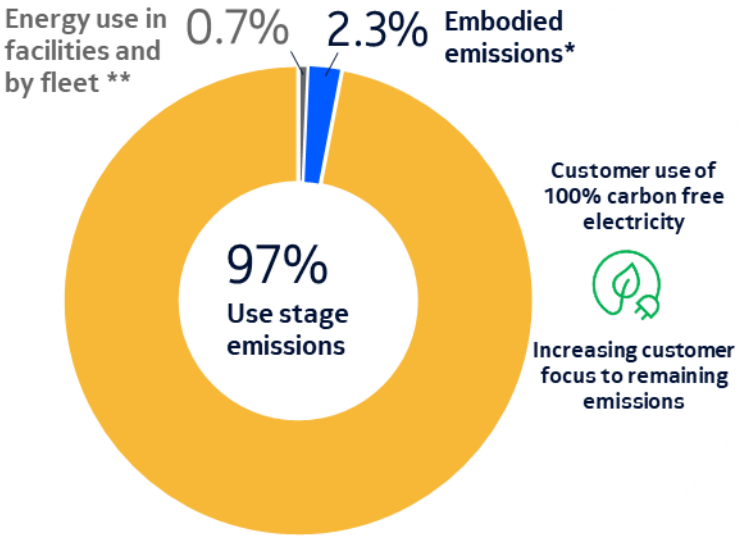


Annual Energy Consumption of the mobile networks in Finland using different RAT assumptions

Reference:
Huttunen et al. BASE STATION ENERGY USE IN DENSE URBAN AND RESIDENTIAL AREAS

Why Energy Efficiency is important?

- Energy cost of telecom operators is a major part of their OPEX
  - 97% of BTS equipment's CO_2 emissions are from the operation phase
- Power capacity on the telecom sites is limited
  - Typical telecom sites are not designed for high power (attic, elevator rooms, basements etc)
  - Battery backup capacity
  - Upgrades are costly and impact on the rent
- Green and environmental reputation
  - Marketing
  - Legislation and tax benefits

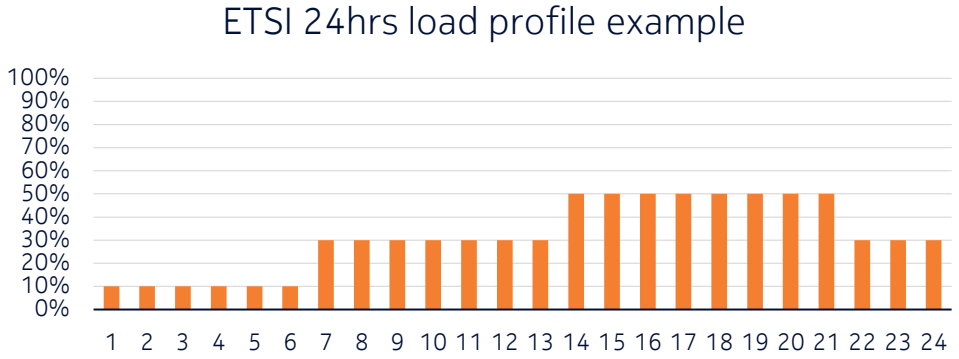


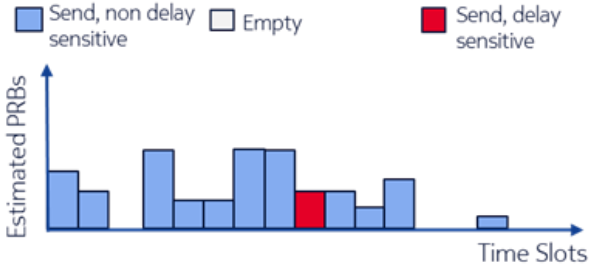
Impacts to HW design

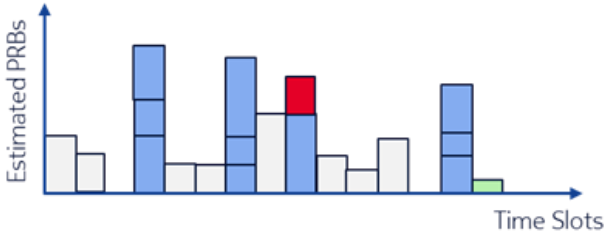
- Power consumption drives the size and cost of the equipment
  - Cooling fin volume
  - 2-phase passive cooling solutions
  - Power feeding and component ratings
- Introducing new RF technology
  - Not enough to reduce peak power but need to support also energy efficiency features
  - Technology starts to be mature and improvement steps are low(ish)
  - However, incremental improvements sum up to high cumulative savings

Reducing the Energy Consumption, SW

- Energy Consumption of the mobile network is load-dependent
  - Load varies based on the time of the day
  - Different areas have different profiles: dense urban vs rural
- SW features are used to optimize the capacity and energy consumption
  - Packing the traffic by the scheduler
  - Load allocation within cells
  - Switching off unnecessary layers
  - Using sleep modes
- 6G will bring substantial savings for low traffic periods compared to 4G/5G

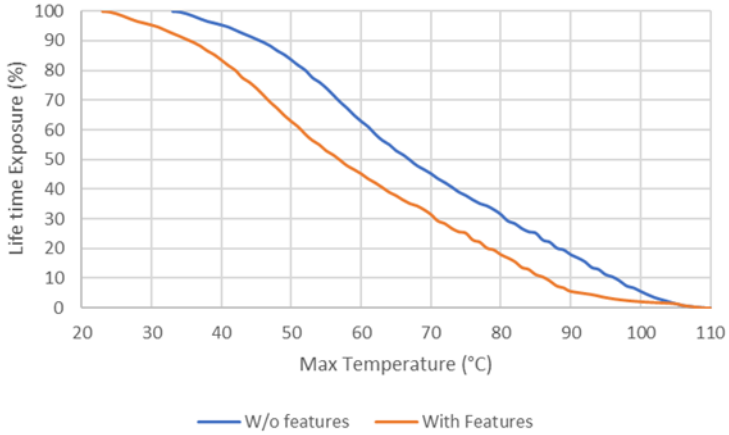




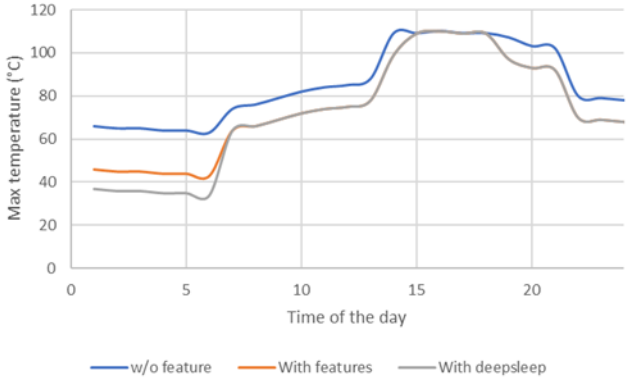


Thermal impact

- Natural convection is an industry trend in radios
  - Wide operating range from -40 to +55°C
  - High power consumption and heat density due to integration
- Both peak and average power consumption are impacting the design
  - Peak is defining the size so that temperature limits are not exceeded
  - Average is defining the reliability due to cumulative temperature sum
- SW features are helping the cooling
  - Power or traffic limitation if temperatures start reaching their limits
  - Minimizing the power consumption on average
  - But are increasing the daily difference



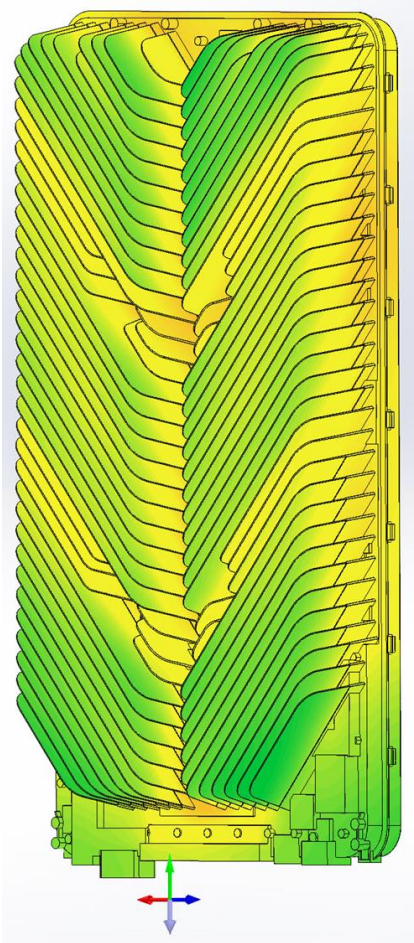
Mission profile example of the radio cumulative temperatures



Diurnal profile example of the radio with features

Managing the design

- Simulations are used heavily and their importance is growing
  - Thermal, reliability, antenna, filter,… simulations
  - Multi physics is needed
  - AI is coming to simulation tools
- Nowadays ML and AI are helping to analyze data
- In the future, AI can be used to control energy efficiency features
  - Proactive instead of reactive
  - More optimized use of features with more parameters
- Testing is still needed
  - Testing with actual traffic and SW
  - Aging and other variables that cannot be simulated
  - Looping the test data to simulation and controls



Conclusions

Energy efficiency is not a separate topic, but a system