MOBILE TEST SUMMIT 2024

NES IN 3GPP – A TECHNOLOGY OVERVIEW

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Network Energy Saving (NES) in 3GPP – A Technology Overview

Mobile Test Summit 2024 at Rohde & Schwarz
Munich, November 19&20, 2024
Elke Roth-Mandutz, Head of Mobile Communications Group, 3GPP & 5GAA Delegate
Communication Systems Division

Fraunhofer Institut für Integrierte Schaltungen IIS

Standardization, Partnerships and Associations of Fraunhofer Society

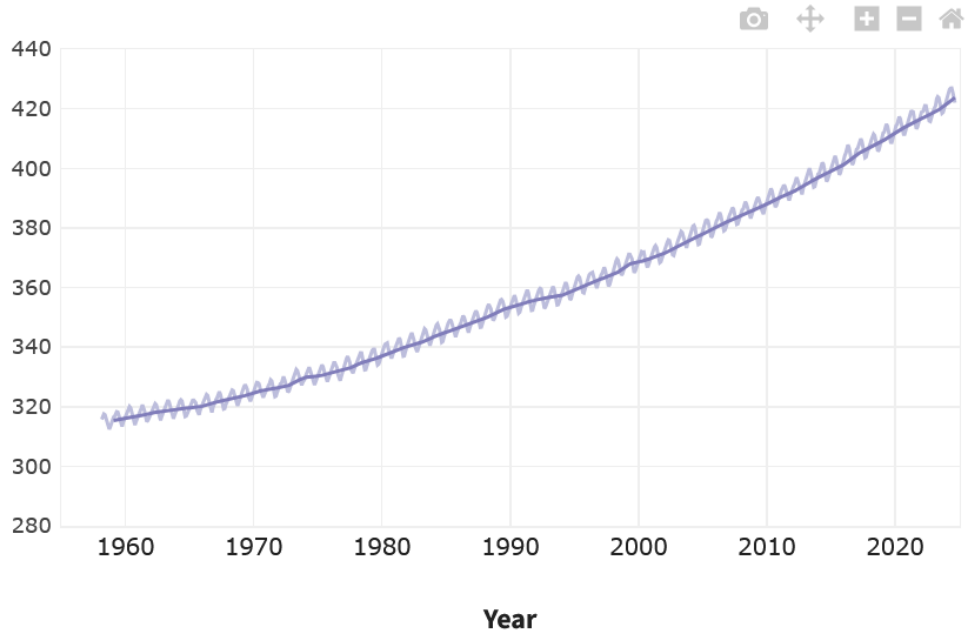
Contributions since 2015:
***Network Energy Saving (NES)**, NTN, V2X,*
MIMO, XR, Positioning, RedCap, AI/ML…

Member since 06/24

Non-profit organization, founded 1985, >1100 employees, annual budget approx. 168 Mio €
16 locations in 12 cities: **Erlangen**, Nuremberg, Fuerth, Ilmenau, Dresden, …

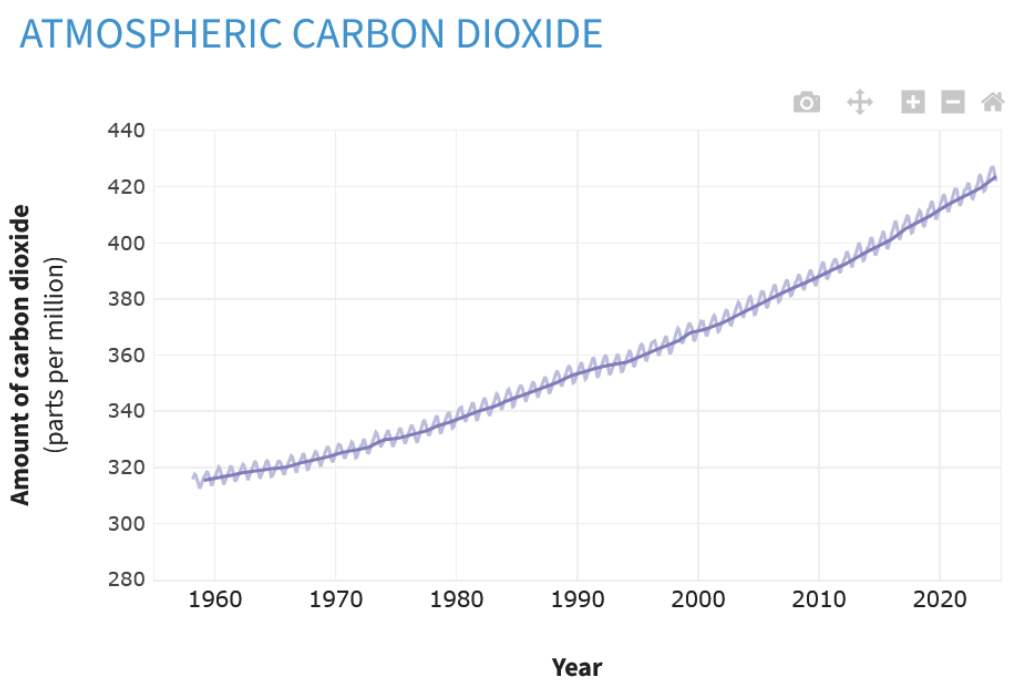
Motivation

Energy Saving



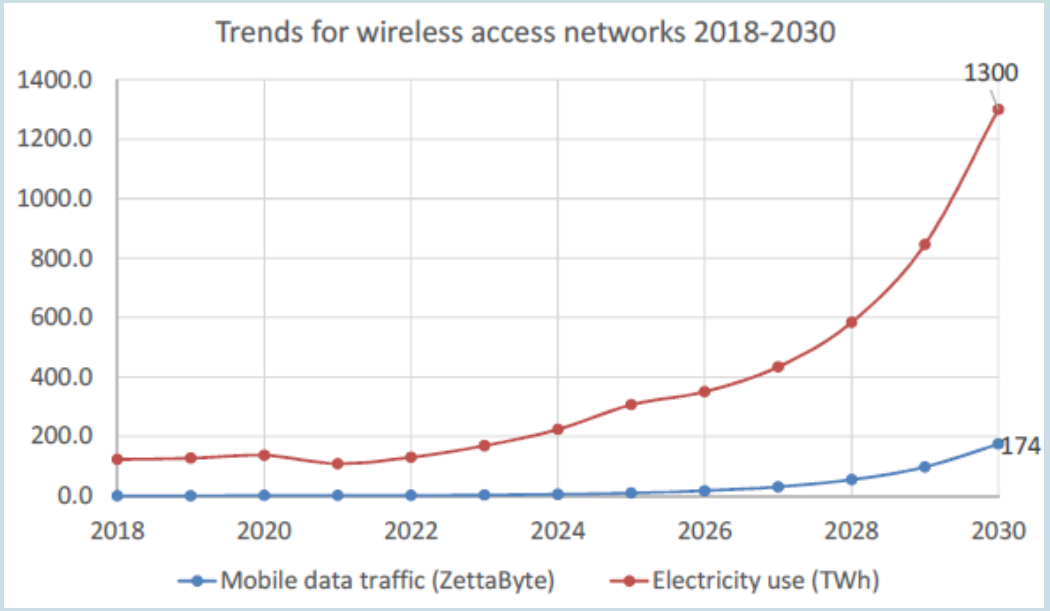
Motivation

Mobile Networks - Energy Saving



Source:
https://www.climate.gov/news-features/understanding-climate/climate-change-atmospheric-carbon-dioxide

RADIO ACCESS NETWORKS: INCREASE IN ENERGIE CONSUMPTION

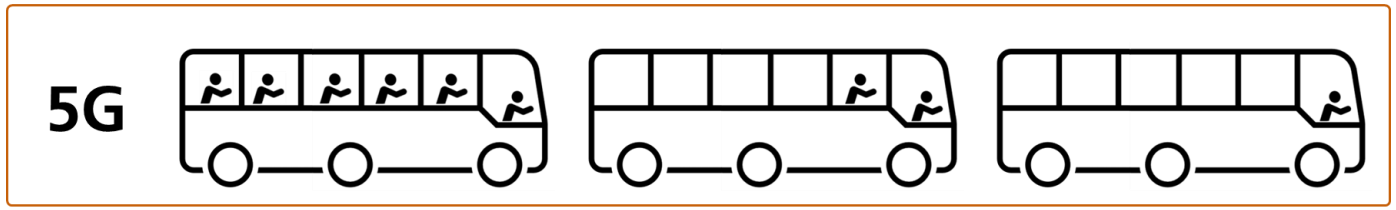


Source: Anders S.G. Andrae: „Projecting the chiaroscuro of the electricity use of communication and computing from 2018 to 2030", **2019**

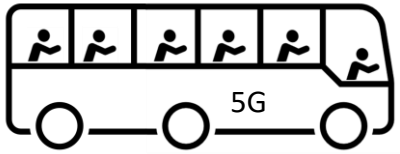
5G vs 4G Network Design

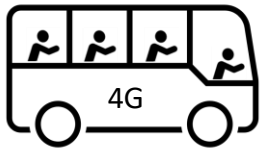
Load - Power

5G: “We designed a “bus”! Very efficient! But what if there is only one passenger?” Cicek Cavdar, KTH



5G can carry much more data than 4G



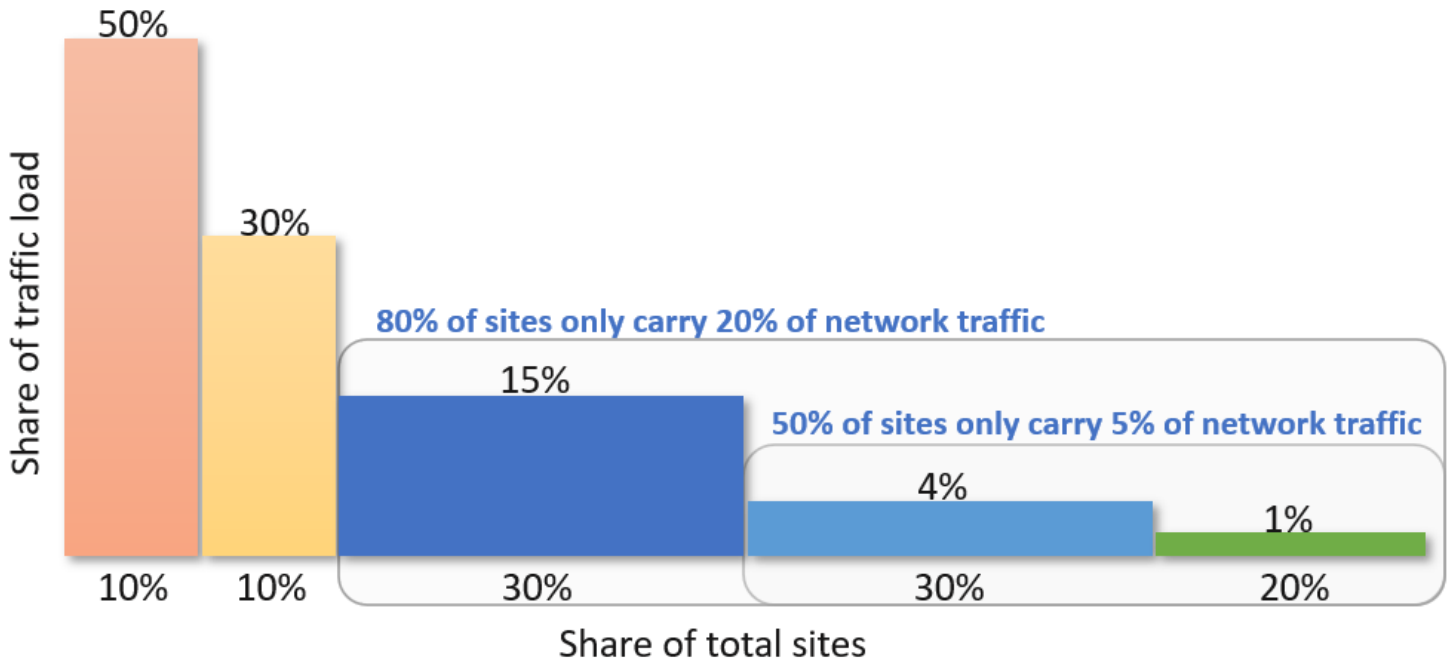


5G is **more energy efficient** than **4G** but **consumes more energy**

→ **Energy savings needed to meet sustainability goals and reduce operational expenditures**

Distribution of Network Data Traffic Load

High Proportion of Lightly Loaded Cells

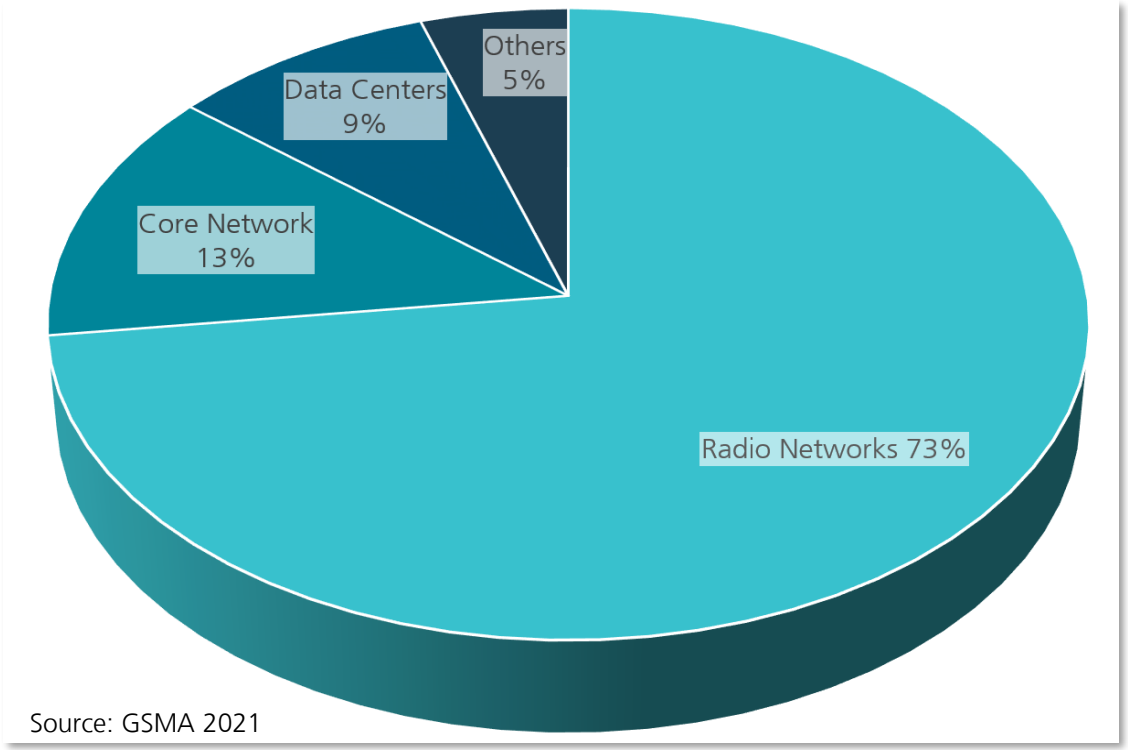


Source: Mavenir Intel Whitepaper, "A Holistic Study of Power Consumption and Energy Savings Strategies for Open vRAN Systems", Feb 2023

- Always-ON common signals are transmitted from all sites irrespective of traffic load
  - gNB sites consume significant energy even with no traffic load

Network Energy Consumption Breakdown

Need for Energy Savings in RAN



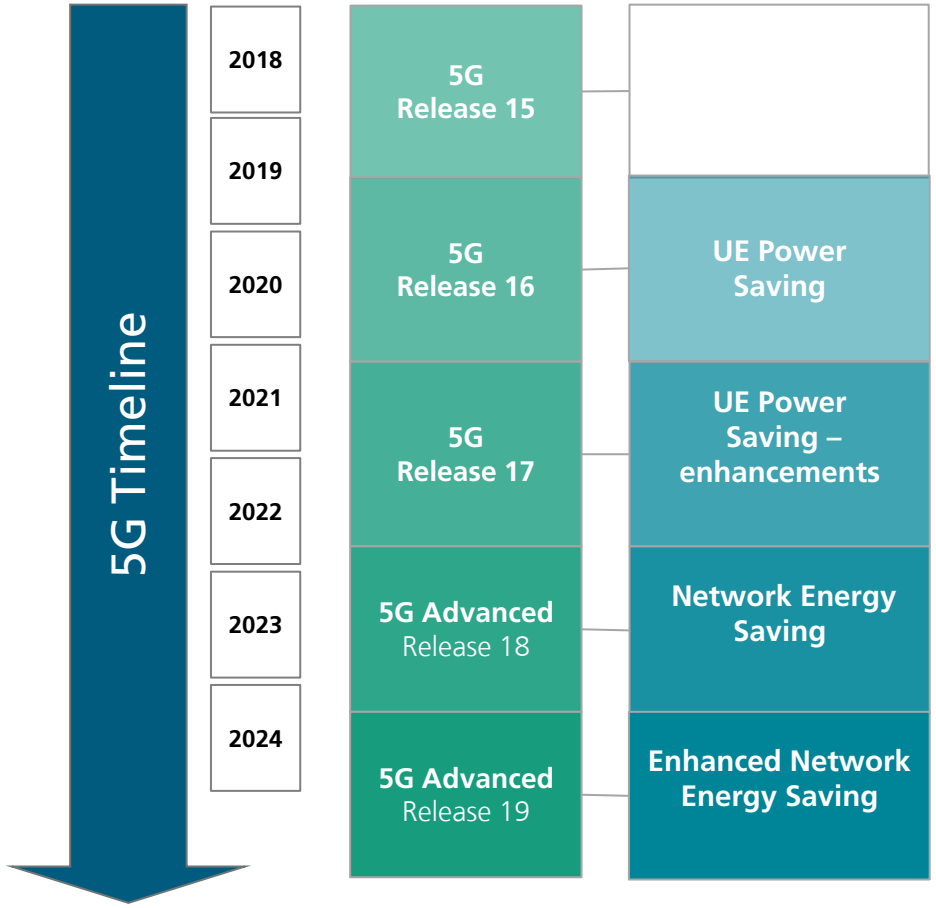
Source: GSMA 2021

Energy Savings in 3GPP 5G NR / 5G NR Advanced

3GPP Timeline

Network Energy Savings (NES) in RAN

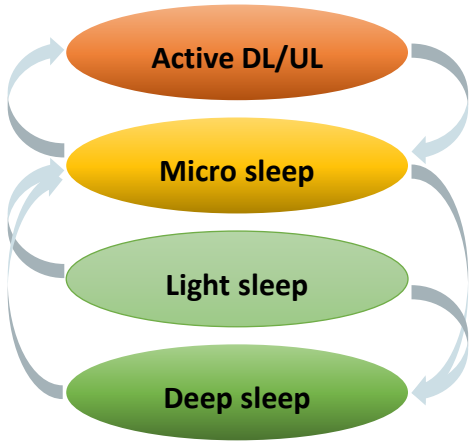
- **Release 18**
  - Study Item on NES (finalized by Q4 2022)
  - Work Item on NES (Q1 to Q4 2023)
- **Release 19**
  - Work Item - further enhancements on NES
  - Q1 2024 – Q2 2025



NES in 3GPP: Release 18 Study Item

gNB Power Consumption Modeling [TR 38.864]: **Sleep States**

- Active DL/UL: power consumption scaled with antenna/frequency/TX-power resources
- Different sleep states: relative power levels and transition times



← Active transmission/reception (Max value: $P_4 = 280, 32$)

← No TX/RX with some RF components turned off ($P_3 = 55, 5.5$)

← Many RF and baseband components are turned off ($P_2 = 25, 2.5$)

← Most of the RF and baseband components are turned off ($P_1 = 1$)

(examples of relative power levels are noted)

Total transition time

Power State	BS Category 1	BS Category 2
Deep Sleep	50 ms	10 s
Light Sleep	6 ms	640 ms

NES in 3GPP: Release 18 Study Item

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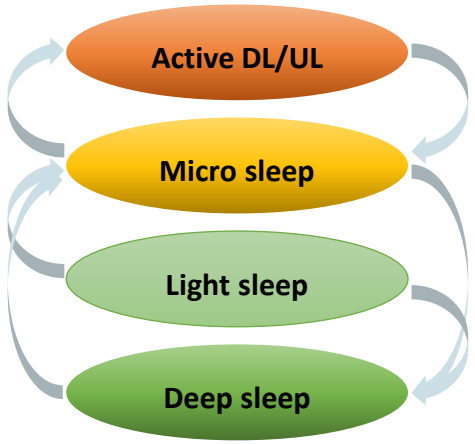
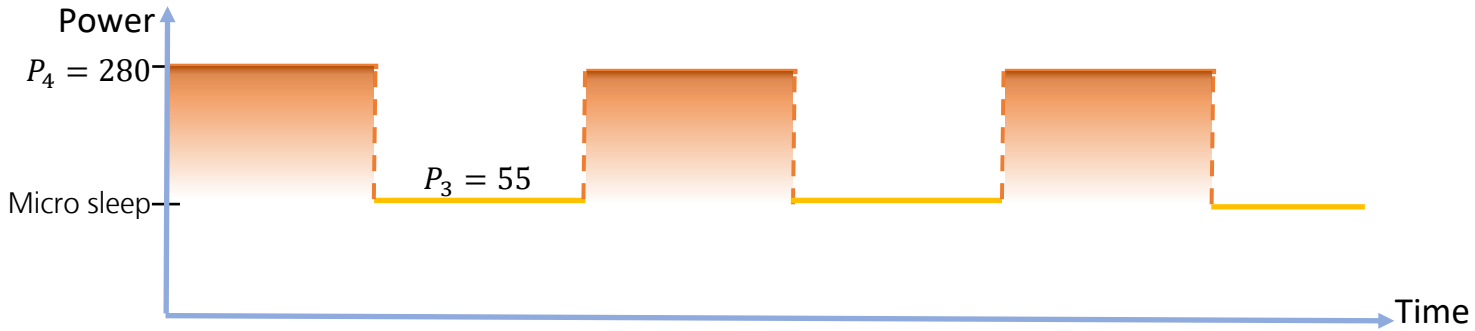


DL power consumption:

- Simply **micro-sleeping 50%** of the time gives **40% NES**
  - ➢ Time domain techniques to enter sleep states are very beneficial for NES
- **Disabling 50% antennas** gives **40% NES**
  - ➢ Adaptation of spatial elements can provide significant NES gains
- **Scaling bandwidth** or **TX-power down by 50%** gives **24% NES**
  - ➢ TX-power adaptation has less performance impact



NES in 3GPP: Release 18 Study Item

Categorization of NES Techniques

Time domain: increase inactive periods to enter sleep modes

Frequency/Time domain: increase inactive periods in a subset of carriers in carrier aggregated systems

Spatial domain: use only a subset of antenna elements and/or TRPs (TX/RX points) in multi-TRP operation

Power domain: TX power adaptation, energy efficient TX

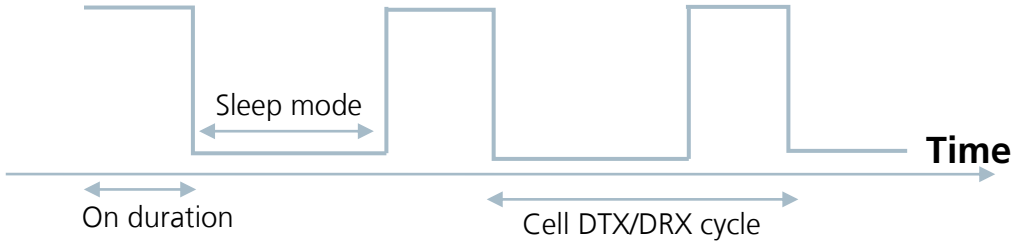
Along with NES benefits, impact on performance (coverage, throughput, delay, UE power consumption, UE complexity etc.) and **specification effort** play key roles in reaching standardization agreements!

➢ In Rel-18 work item the NES techniques were focused on keeping the common signals unchanged

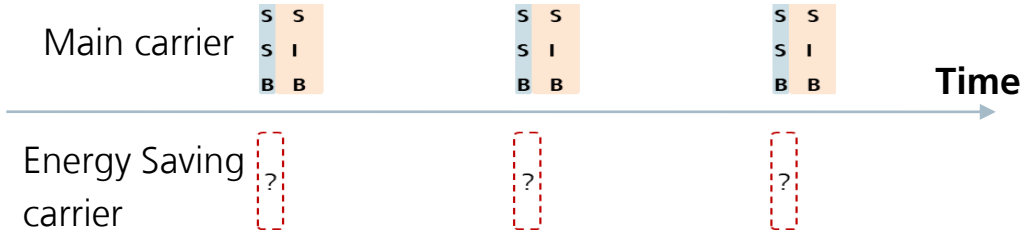
NES in 3GPP: Release 18 Work Item

Techniques Standardized in Release 18 Specifications

Time domain: Cell DTX/DRX (discontinuous transmission/reception) mechanism

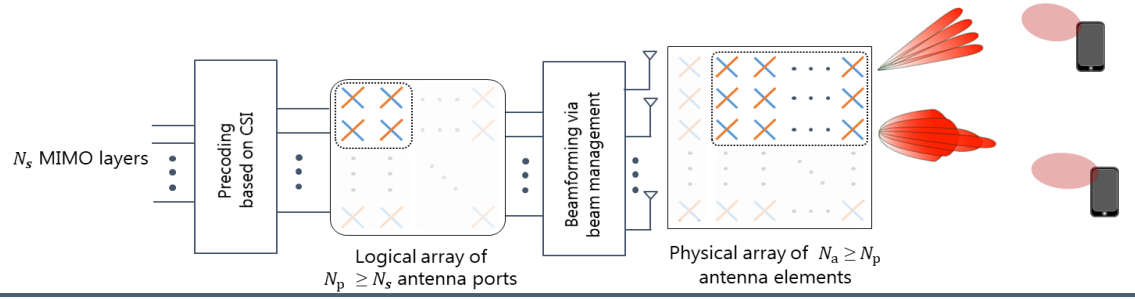


Frequency domain: In carrier aggregated systems, secondary carriers to transmit without synchronization signals (SSB)



Spatial domain: Dynamic adaptation of spatial (antenna) elements, necessary enhancements to CSI (channel state information)

Power domain: Dynamic adaptation of DL data transmission power, necessary enhancements to CSI)



NES in 3GPP: Rel-19 & Rel-20

Ongoing & Future

Release 19

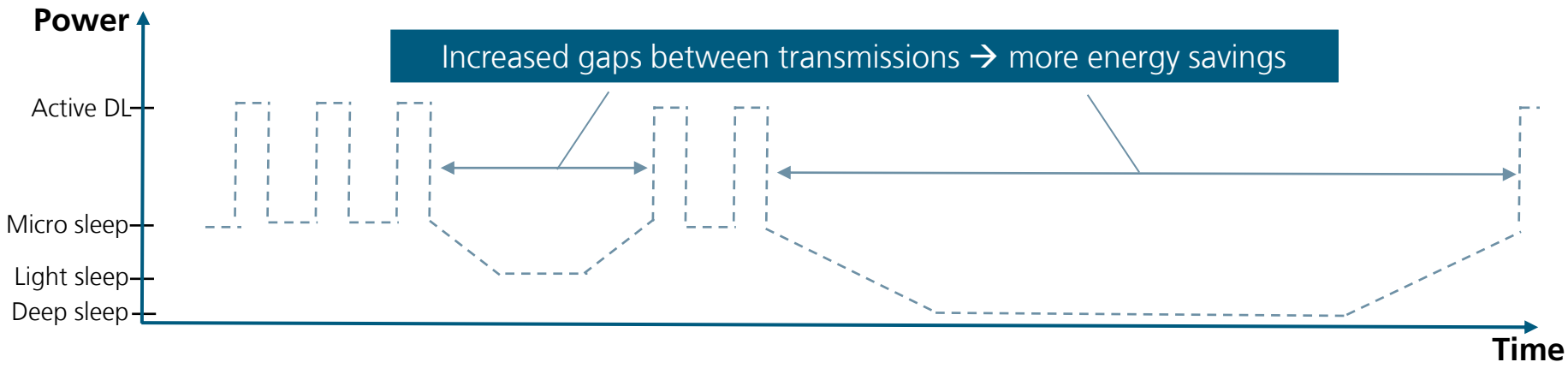
- **RAN Plenary, December 2023**
  - NES content & effort / time units heavily discussed
  - Only 3 out of 6 proposed NES methods discussed
- **Timeline Rel-19:** Q1 2024 – Q2 2025

Release 20 – SPLIT

1. December 2024 RAN Plenary → **5G Advanced**
2. March 2025 RAN Plenary → **6G Study Items**

NES in 3GPP: Release 19 Motivation

Common Signal Optimization

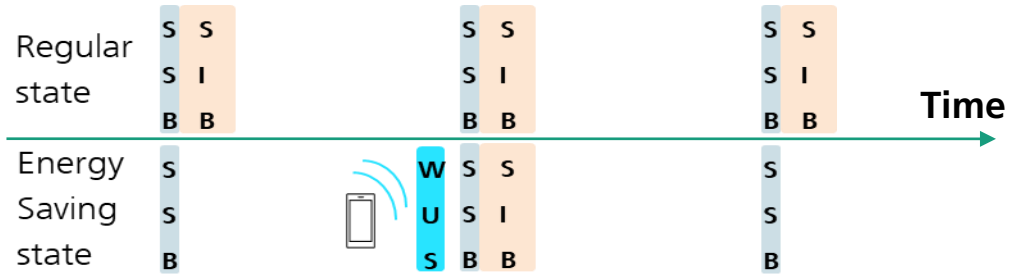


- Periodic common signals transmission limits NES
- Rel-19: Different to Rel-18: Adaptation of common signals
  → SSB, SIB1, PRACH, PACH

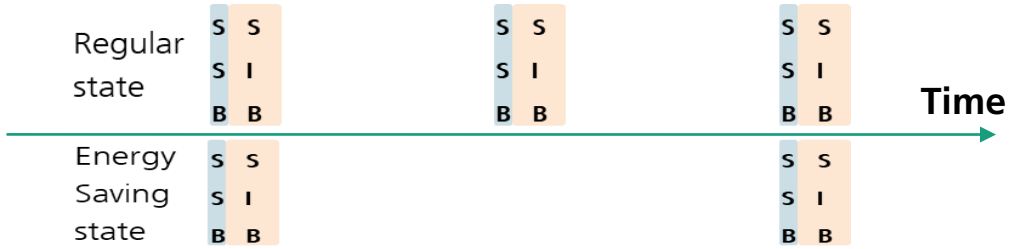
NES in 3GPP: Release 19 Work Item

Techniques in Release 19 – Ongoing

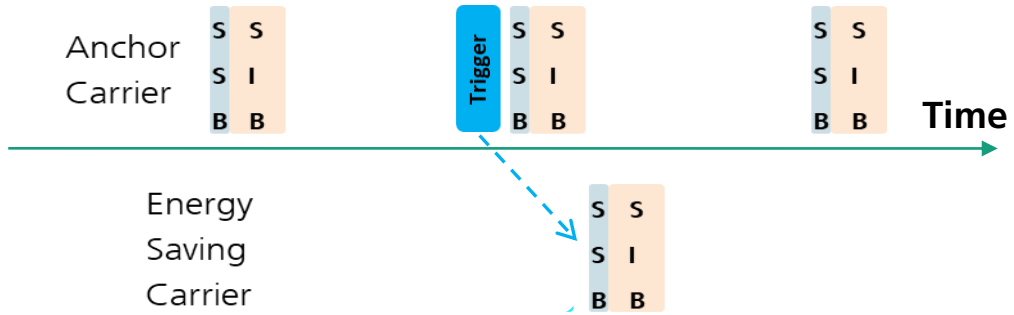
Time domain: On-demand transmission of system information block (SIB1) signals



Time domain: Adaptation of common signals and channels, such as synchronization signal blocks (SSB)

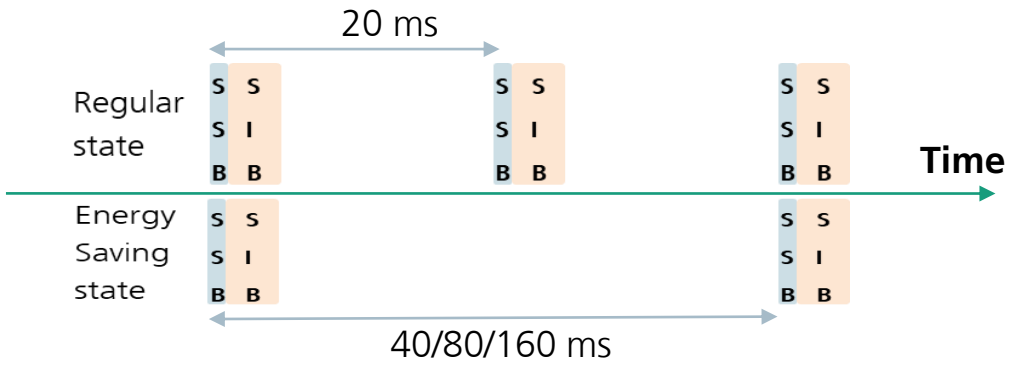


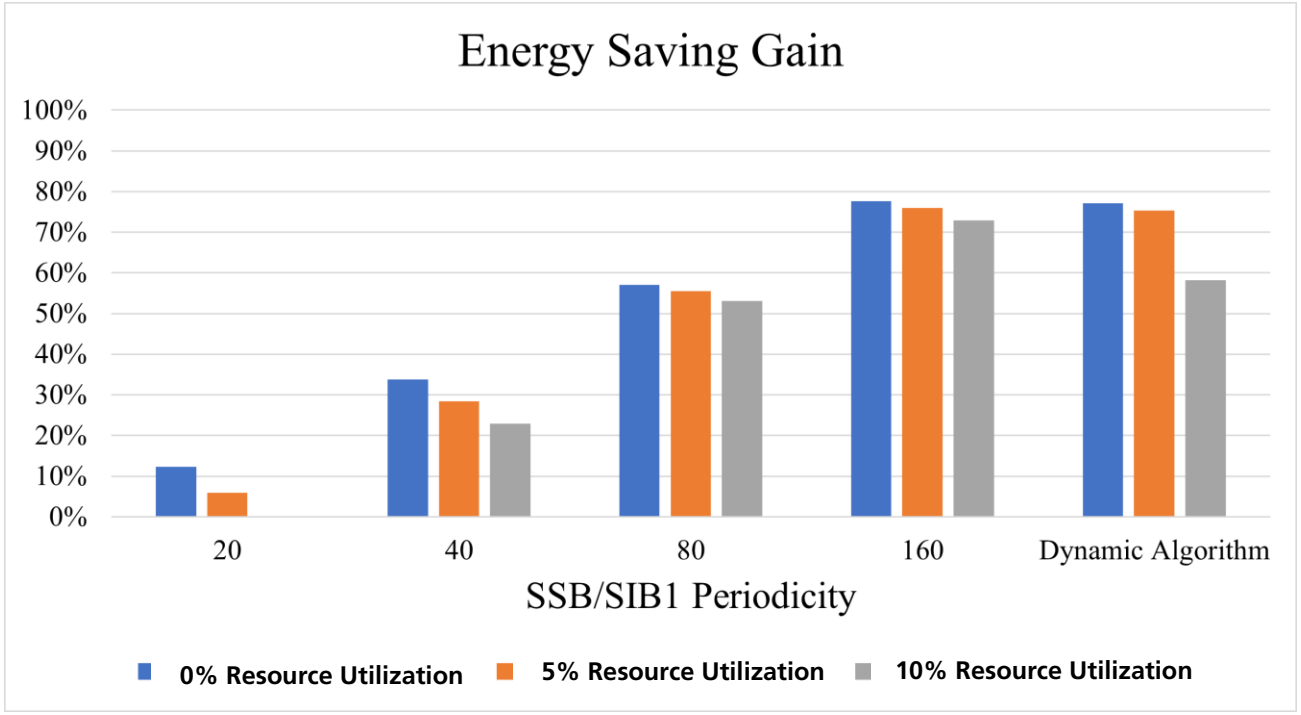
Frequency/Time domain: On-demand transmission of synchronization (SSB) signals on secondary carriers in carrier aggregated systems



NES in 3GPP: Release 19 Work Item

Adaptation of Common Signals and Channels





Source: N. Vatanian, G. Costa, E. Roth-Mandutz, G. George and N. Franchi, "Energy Savings in 5G-Advanced Radio Access Networks: Downlink Signaling Adaptation", IEEE VTC fall, 2024.

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Outlook

6G Vision for Enhanced Network Energy Savings

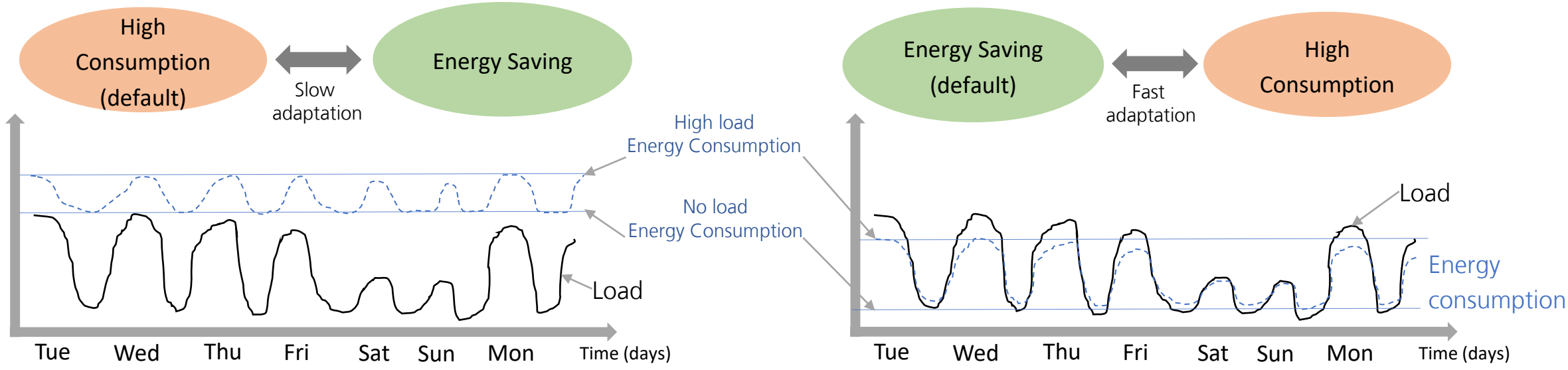
Focus of Network Design: Low Energy Consumption

Today

- Network designed for high capacity
- Energy consumption: inelastic to load
- Basic NES techniques to opportunistically reduce energy consumption

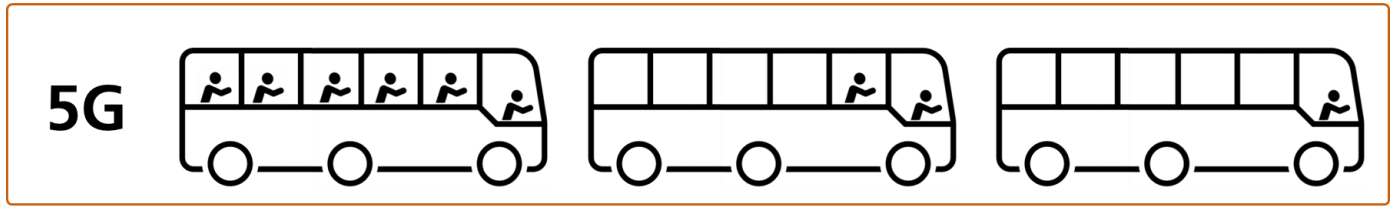
Future

- Adaptive adjustment of energy consumption according to load
- Longer periods in energy saving states



Adaptive 6G Network Design

Power Profile - Load Profile



What should 6G be?

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Contact

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NES in 3GPP: Release 18 Study Item

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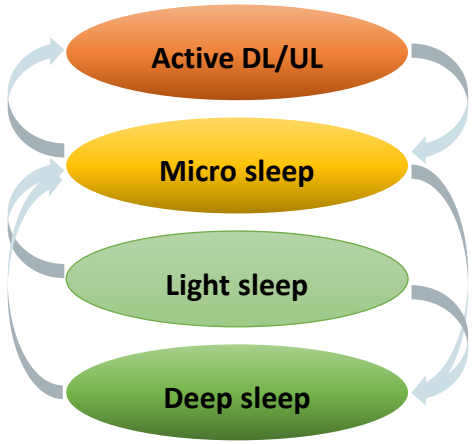
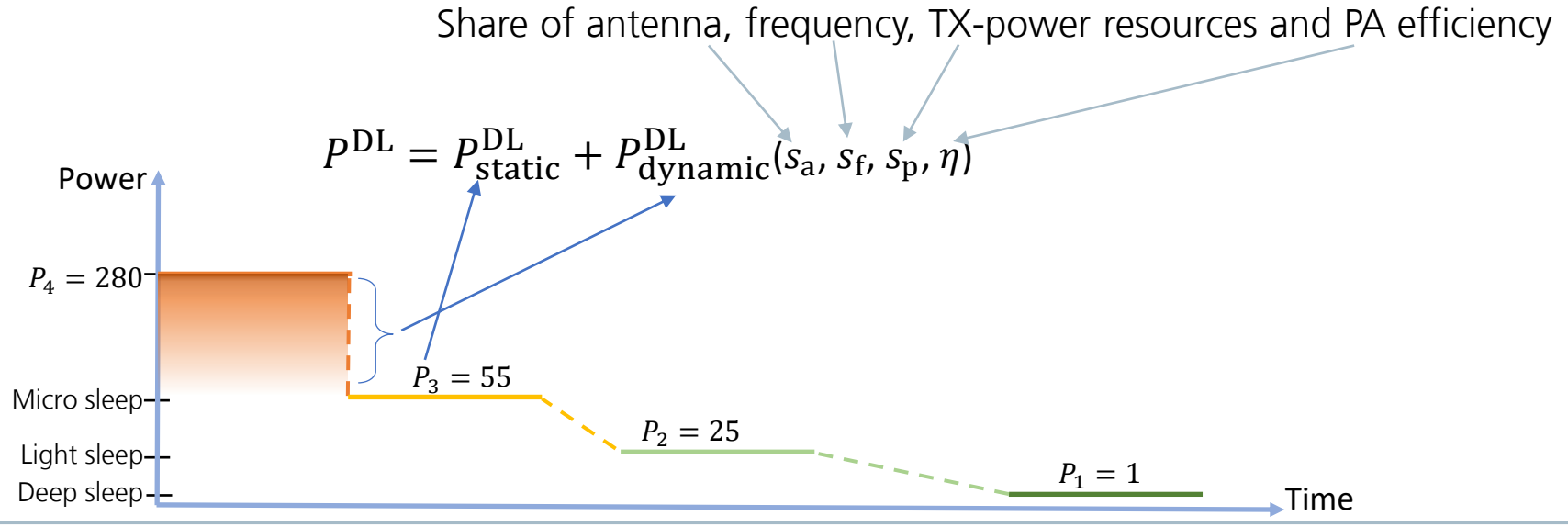


Consider DL power consumption



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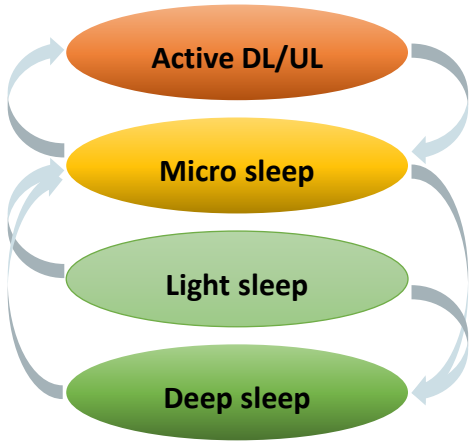

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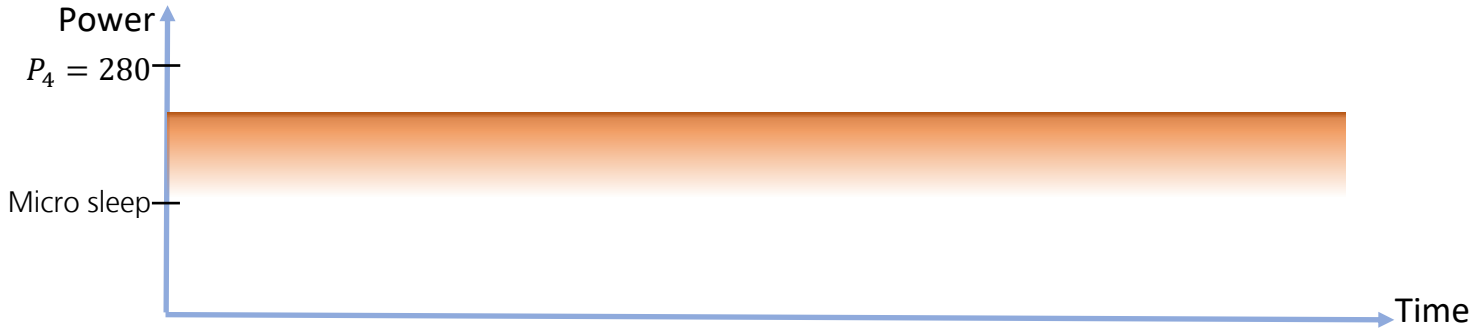
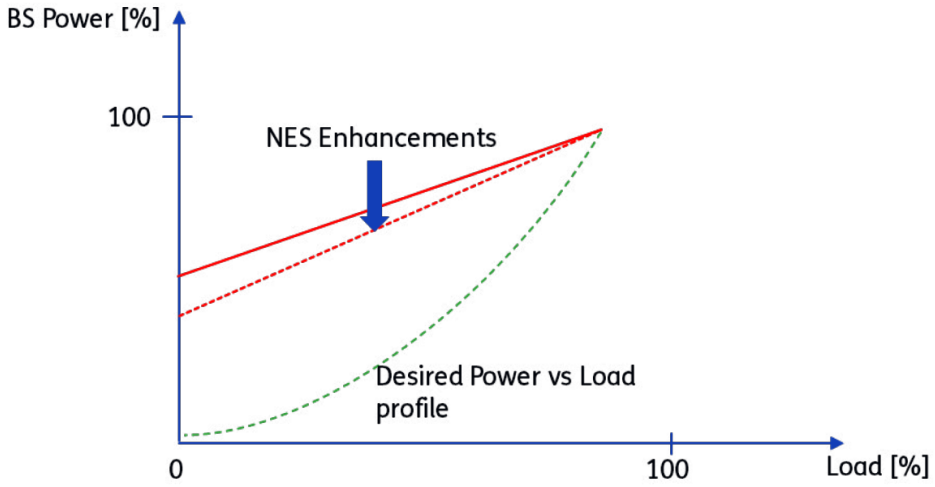


Desired Power vs Load Profile

Network design with focus on low energy consumption



Source: NGMN Alliance, "Green Future Networks: A Roadmap to Energy Efficient Mobile Network", July 2024.

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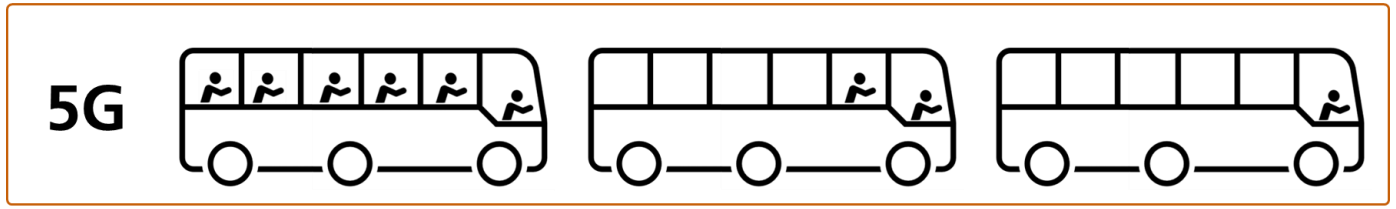

What should 6G be?

- Ideal BS power profile: power consumption close to zero Watt for zero carrier load
  - ➢ Would require hardware optimizations together with NES enhancements in standardization

Our Contributions on NES

- Participation in 3GPP RAN plenary, RAN1 and RAN2 meetings; a few example contributions:
  - R1-2408950, 3GPP TSG RAN WG2 Meeting #127bis, "Adaptation of Common Signals and Channels for NES", Fraunhofer IIS, Fraunhofer HHI, , Hefei, China, Oct 14th – 18th, 2024
  - R2-2409144, 3GPP TSG RAN WG2 Meeting #127bis, "Discussion on On-demand SIB1 for NES", Fraunhofer IIS, Fraunhofer HHI, Hefei, China, Oct 14th – 18th, 2024
  - R1-2407103, "On-demand SIB1 for NES", Fraunhofer IIS, Fraunhofer HHI, Vodafone, Deutsche Telekom, CEWiT, 3GPP TSG RAN WG1 #118, Maastricht, Netherlands, Aug 19th – 23rd, 2024
  - RP-242141, 3GPP TSG-RAN Plenary Meeting #105, "On demand SIB 1 and the need for case 1 for multi-vendor RAN", Vodafone, Deutsche Telekom, Orange, Lenovo, Google, Fraunhofer IIS and Fraunhofer HHI, ETRI, CEWiT, Sep 9th -12th 2024, Melbourne, Australia
- 10+ IPRs relevant to completed/ongoing and future (expected) standardization on NES
- Publications (mainly related to Nazanin's PhD work)
  - N. Vatanian, G. Costa, E. Roth-Mandutz, G. George and N. Franchi, "Energy Savings in 5G-Advanced Radio Access Networks: Downlink Signaling Adaptation", IEEE VTC fall, 2024.
  - NGMN Alliance, "Green Future Networks: A Roadmap To Energy Efficient Mobile Networks", Whitepaper, July 2024
  - Fraunhofer IIS, "6G Energy Efficiency and Sustainability", Whitepaper, January 2023
- System-level simulator development
- Research projects: 5G-ECONET, 6G-Plattform, 6G-RIC and hopefully more to come!

MOBILE TEST SUMMIT 2024

Test. Measure. Innovate

THANK YOU VERY MUCH

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Make ideas real