Mobile Networking Perspective

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Scope

Where are we with regards to energy consumption of mobile networks? Energy efficiency wrt. provided value? What components are most power hungry?

Avenues for improvements? Are there relationships between implementations, standards, and fundamentals?

What are some of the useful research directions in this area?
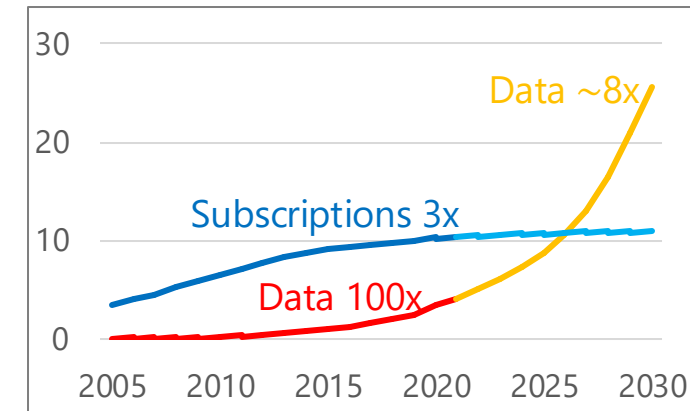
How much energy is consumed?
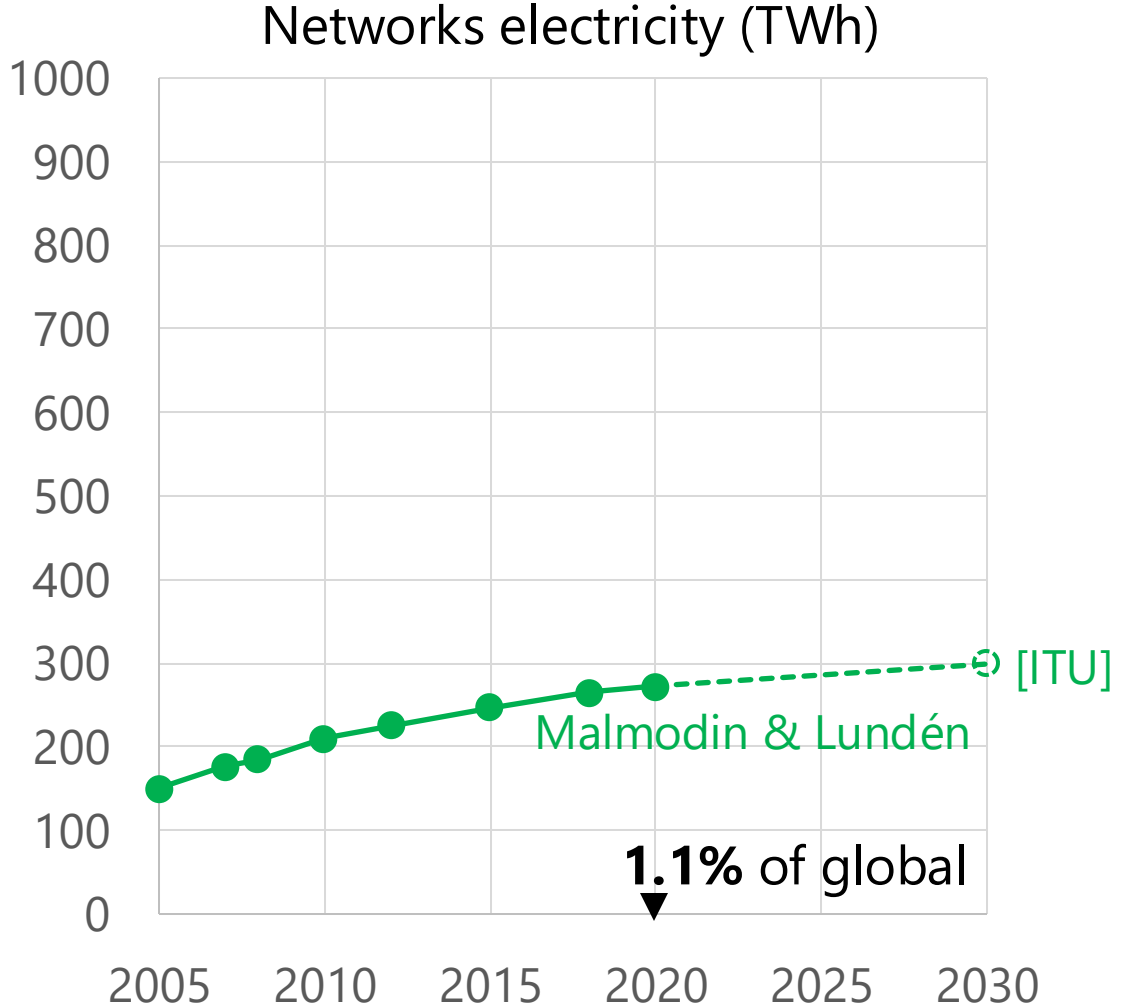
Networks electricity (TWh)

[ITU]

Malmodin & Lundén

1.1% of global

Source: Malmodin & Lundén (data covers >90% of data traffic
and 80% of subscriptions; includes mobile, fixed & enterprise)

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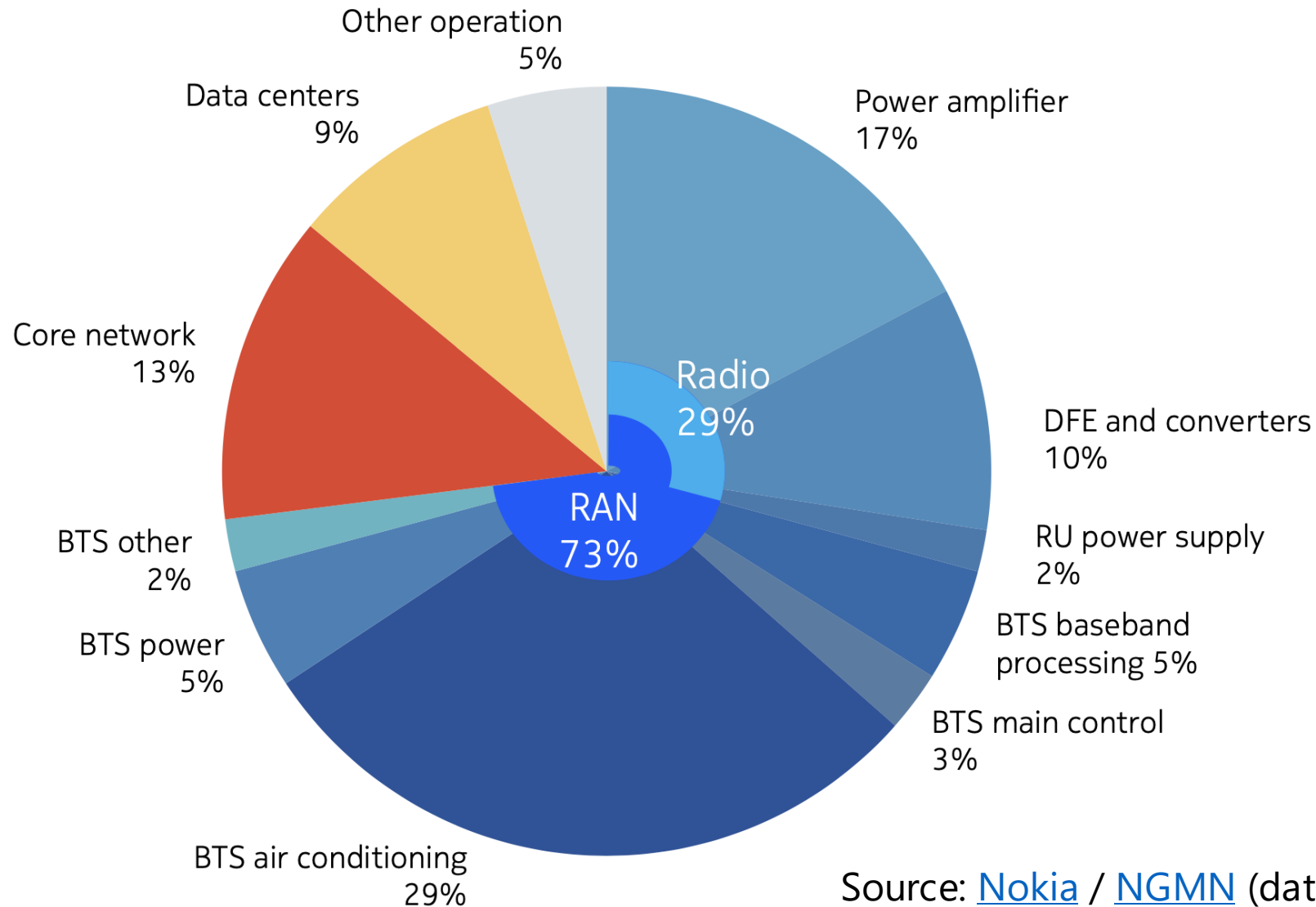
For what? Value?

Data ~8x

Subscriptions 3x

Data 100x
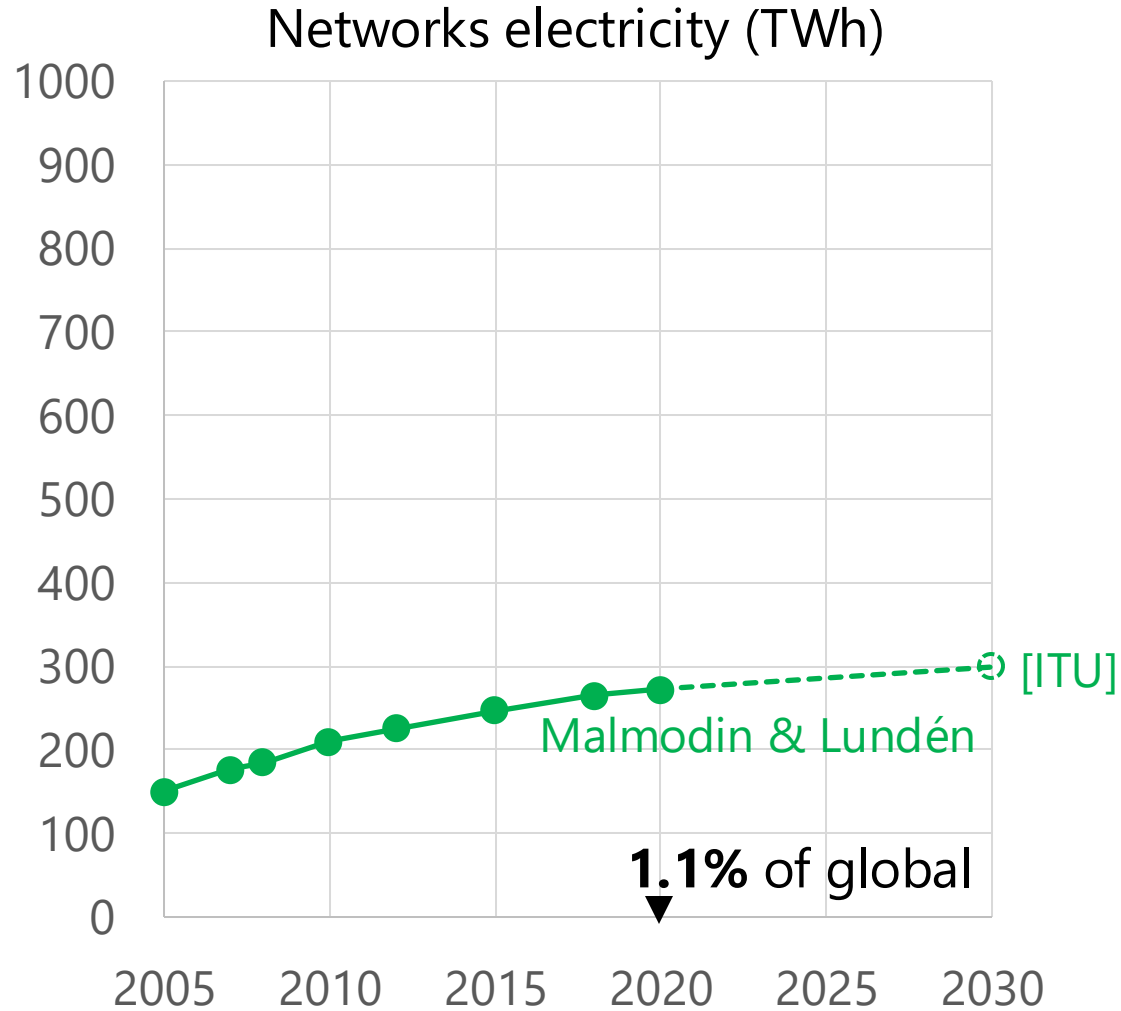
Observations:
- Energy growth != data growth
- Other factors: high base energy consumption, technology advances, # of subscribers, environmental factors, etc.

Where is the energy consumed?

Other operation
5%

Data centers
9%

Core network
13%

BTS other
2%

BTS power
5%

BTS air conditioning
29%

Power amplifier
17%

DFE and converters
10%

RU power supply
2%

BTS baseband
processing 5%

BTS main control
3%

Radio
29%

RAN
73%

Source: Nokia / NGMN (data covers mobile only)

Some Mobile Network Characteristics

Dominant component that uses much of the power => focus

User and usage pattern migrations (daily, weekly)

A function that is fundamentally tied to a location

Relatively low average load rates => power proportionality is mission #1

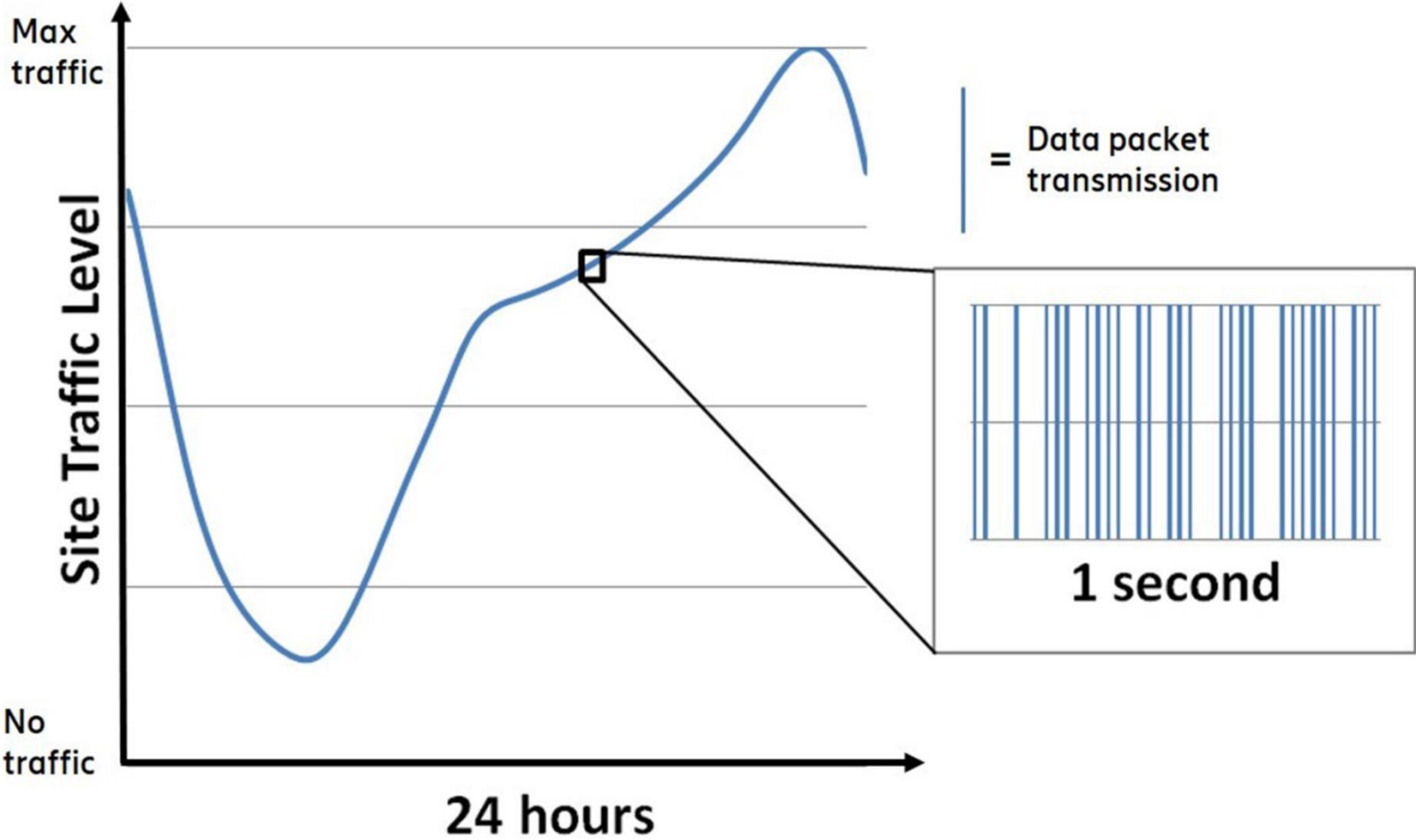Coverage vs. capacity roles => choose the right cells to be on

Serving multiple user segments (smartphones, FWA, IOT, emergency communications, etc.) with different usage patterns

Technology evolution generations, high level of standardization, business landscape with many actors (no dominant global one)

Increasing use of COTS and cloud systems
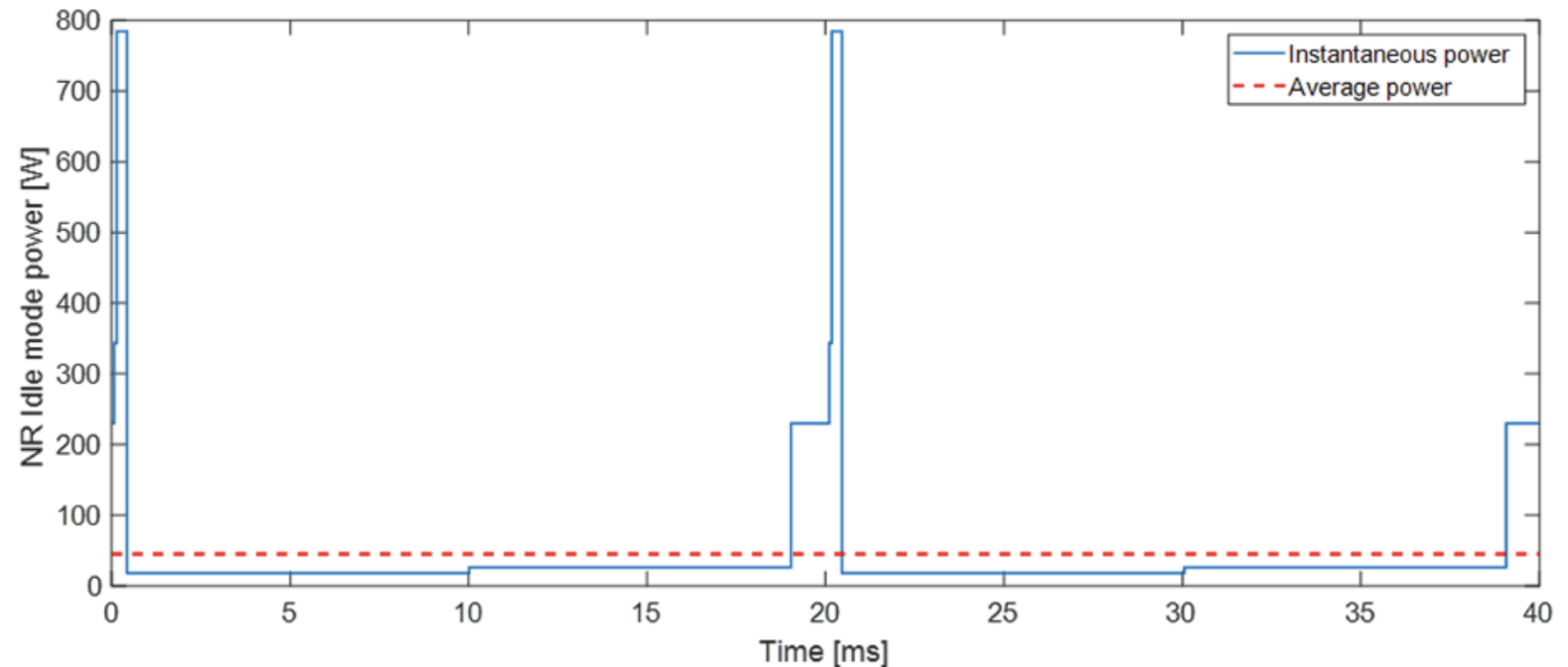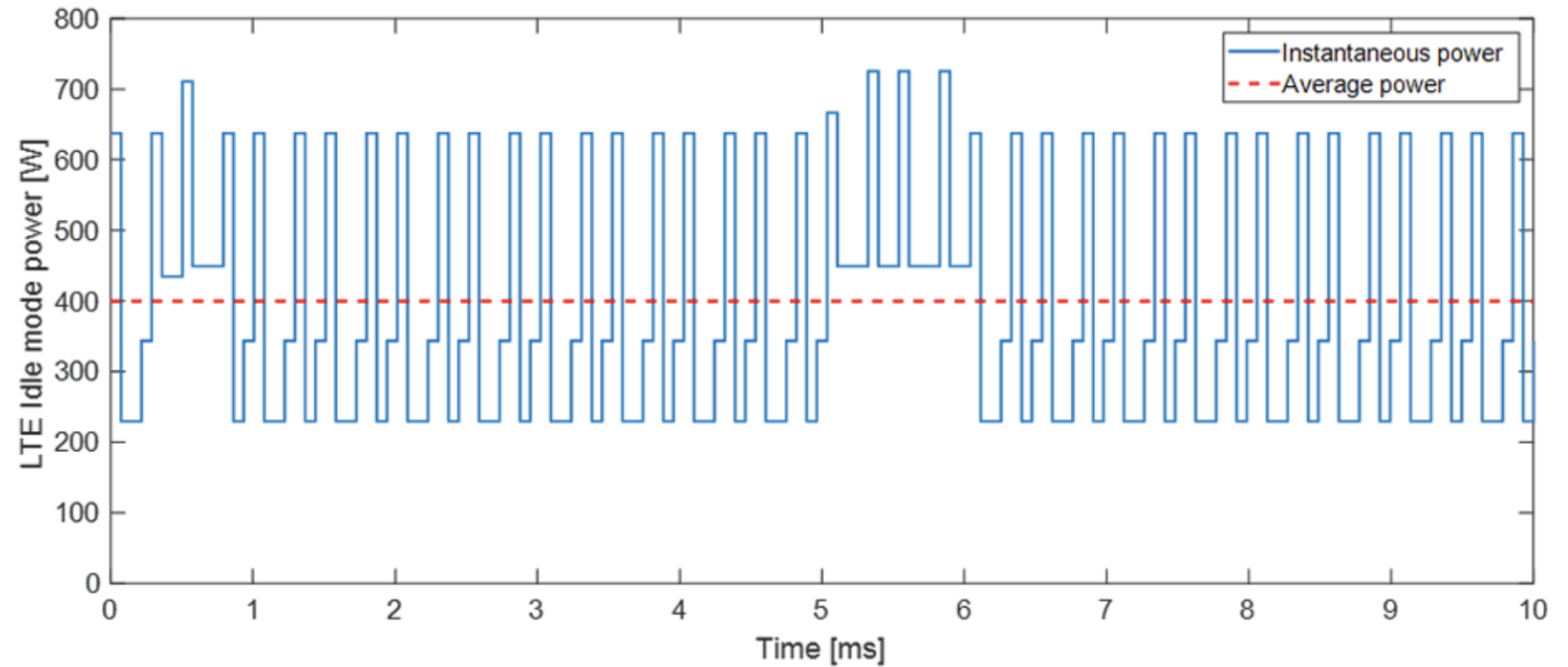
Looking at Traffic

From LTE to 5G

Dealing with, for instance, the synchronization, reference, and system information signals – "always on"

Standards change: relaxed requirements on how often these are sent, flexibility in achieving the needed functions
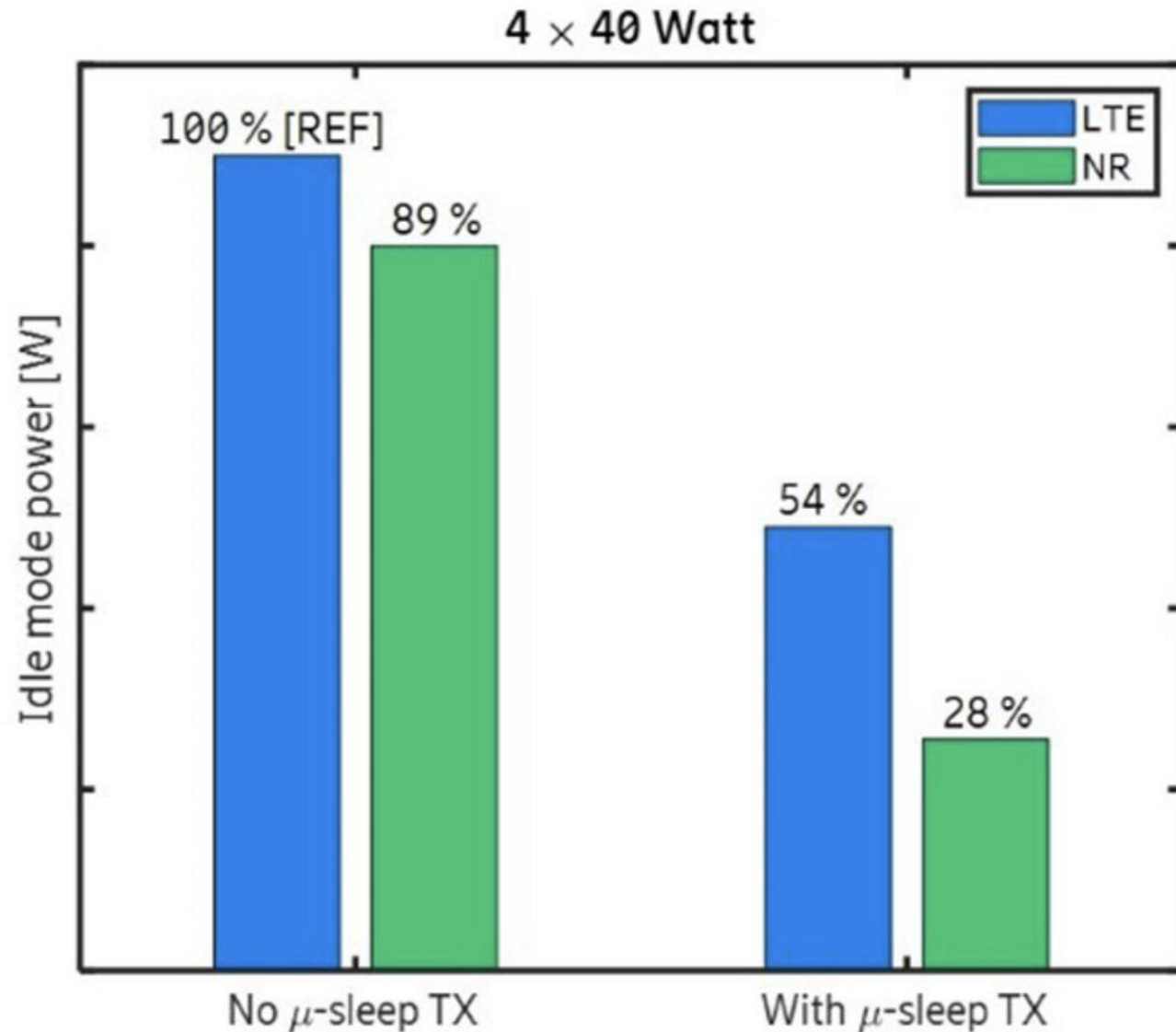
Implementation change: μ-sleep tx

Source: Ericsson

From LTE to 5G

Together these
changes can have
a significant
practical impact

Source: Ericsson (These
results are with specific
equipment; in general
the results vary but
should show similar
patterns)

4 × 40 Watt

Idle mode power [W]

- LTE
- NR

100 % [REF]
89 %
54 %
28 %

No μ-sleep TX   With μ-sleep TX

Research Topics

o More measurements = good

o Understanding linkages between energy/ carbon, implementations & standards

o Understanding tradeoffs

o Other resources beyond energy

o Incentives & mechanisms for cross-domain information sharing and control

o Resources in virtualized environments

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  - E.g., better breakdown of where, when, or why

  - Or more independent measurements

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    - E.g., link technologies vs. implementations

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  - Cross-feature/band/timeslot dependencies

  - In-network use of AI for optimization

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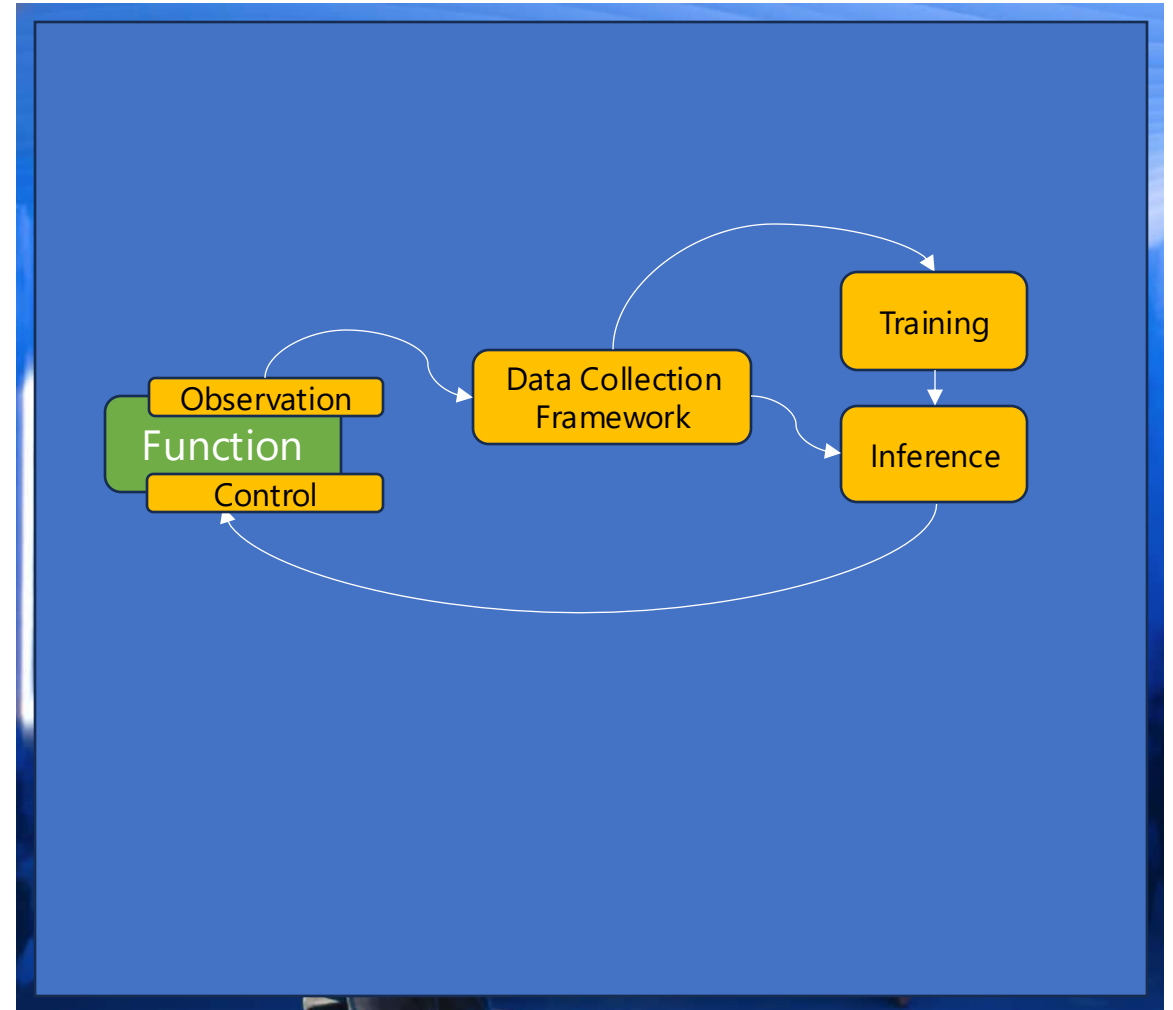
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  - E.g., end-user devices

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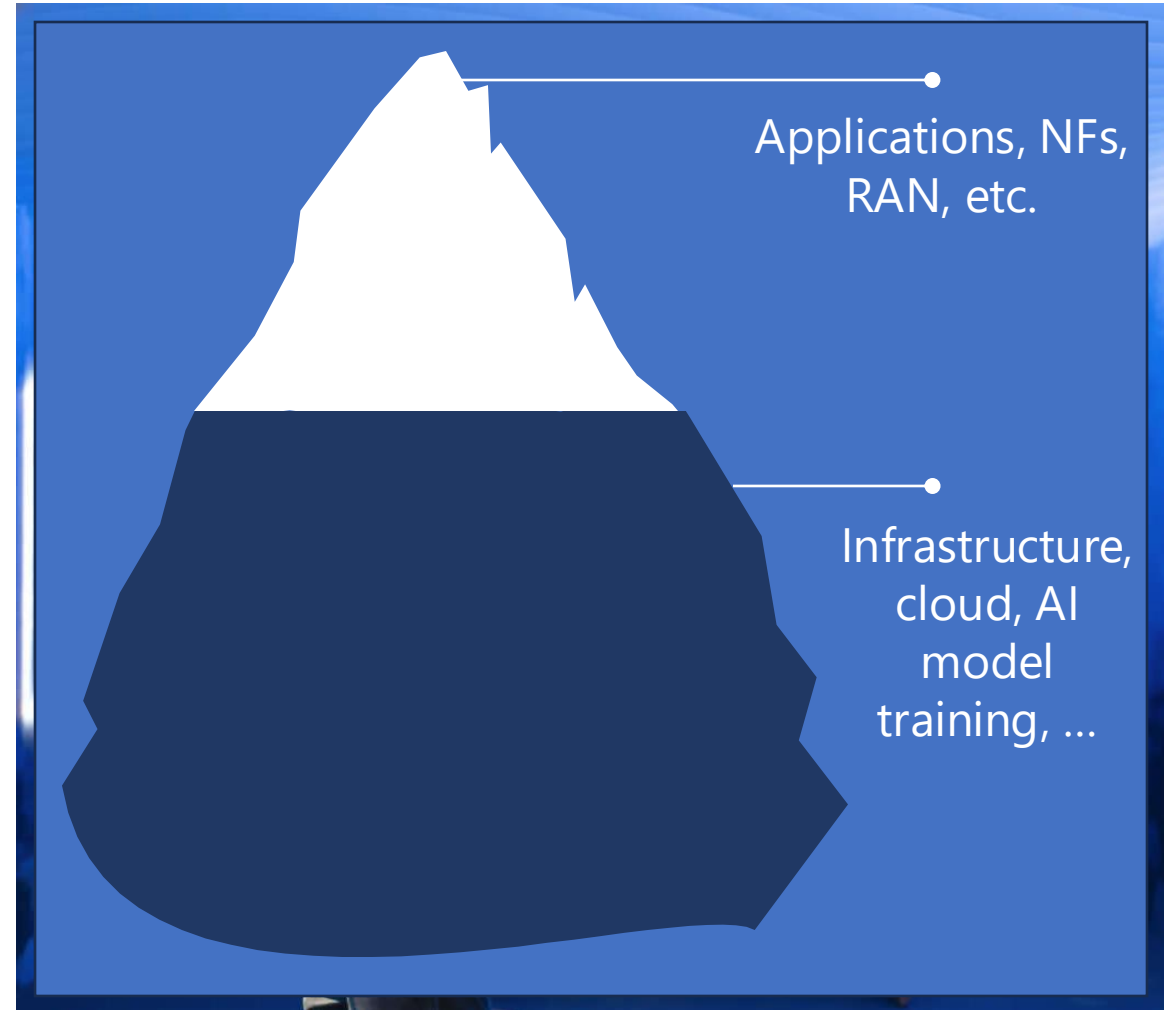o   Resources in virtualized environments

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   - User to provider may be a simple case

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○ Incentives & mechanisms for cross-domain information sharing and control
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○ **Resources in virtualized environments**
  - How to attribute resources across layers?

Applications, NFs, RAN, etc.

Infrastructure, cloud, AI model training, …

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o **More? Discussion?**