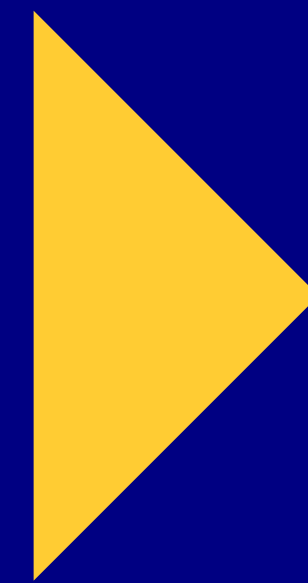




# Ericsson Technology Review



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Breaking the energy curve  
in radio access networks:  
four strategic imperatives

Charting the future of innovation

# Breaking the energy curve in radio access networks: four strategic imperatives

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Energy efficiency is becoming a defining constraint on mobile network evolution toward 2030 and beyond. As traffic demand accelerates, operators must rethink how capacity is delivered without proportionally increasing energy use. Four strategic imperatives provide a practical path to break the energy curve, combining hardware modernization, system evolution and intelligent network management.



Mobile networks are entering a new phase in which traffic demand is expected to grow by around 3.5 times toward 2030. Without targeted intervention, this increase could drive a substantial rise in network energy consumption – with a plausible outcome approaching a 70 percent increase compared to today’s levels – putting both operational expenditure and sustainability targets under increasing pressure. At the same time, energy already represents a significant share of network operating costs, making energy efficiency a core dimension of network performance. In this context, energy efficiency becomes not just an optimization objective, but a hard limit on how future mobile networks scale.

The energy challenge is particularly acute in the radio access network (RAN), which accounts for the majority of mobile network energy use, with radios accounting for the dominant share of consumption. According to GSMA Intelligence [1], roughly 80 percent of the energy used by mobile networks is consumed in the RAN, with the remainder associated with the core network, support systems and cloud infrastructure. A large portion of this energy is fixed, required to keep equipment continuously operational regardless of traffic load, limiting the effectiveness of traditional traffic-dependent, energy-saving approaches. As networks scale to meet rising demand, simply adding capacity without addressing this structural energy profile is no longer sustainable.

A holistic, system-level approach that combines real-world network data with forward-looking simulation of traffic growth, deployment evolution and energy-saving features will be essential to break the energy curve and enable sustainable radio network evolution toward 2030 and beyond [2].

## Four strategic imperatives to break the energy curve

Recent Ericsson research [3] has identified four strategic imperatives to fundamentally alter the trajectory of network energy consumption. Together, they provide a practical and scalable approach to improving network-wide energy efficiency while maintaining coverage, capacity and quality of service (QoS), even in a 3.5 times traffic growth scenario.

### Imperative #1 – Accelerate FDD radio modernization

Many existing frequency division duplex (FDD) deployments rely on multiple single-band radios per site, increasing fixed power consumption, site complexity and physical constraints on further expansion. Addressing this requires reducing the number of active radio units without compromising capacity. Consolidating multiple single-band radios into fewer multi-band radios lowers energy consumption while enabling additional spectrum layers without site reinforcement.

## Terms and abbreviations

**5G SA** – 5G Standalone | **AI** – Artificial Intelligence | **CPE** – Customer Premises Equipment | **CSP** – Communication Service Provider | **DL** – Downlink | **FDD** – Frequency Division Duplex | **FWA** – Fixed Wireless Access | **LTE** – Long Term Evolution | **MBB** – Mobile Broadband | **MIMO** – Multiple-Input, Multiple-Output | **MU-MIMO** – Multi-User MIMO | **NR** – New Radio | **QoS** – Quality of Service | **RAN** – Radio Access Network | **TDD** – Time Division Duplex | **UL** – Uplink



**Imperative #2 – Accelerate the migration of legacy LTE bands to NR**

Legacy long-term evolution (LTE) bands contribute to higher system-level energy consumption due to less efficient signaling, limited support for advanced sleep modes and the need for parallel operation with newer technologies. Improving efficiency requires accelerating the migration of these bands to New Radio (NR) within a 5G Standalone (SA) architecture. This enables a leaner system design with lower signaling overhead and more advanced energy-saving features, while aligning with long-term network evolution.

**Imperative #3 – Enhance mid-band TDD Massive MIMO energy efficiency**

Scaling traffic and services such as fixed wireless access (FWA) is driving significant increases in absolute energy consumption in mid-band time division duplex (TDD) deployments, where Massive MIMO can account for a large share of site-level energy use. Improvement depends on reducing fixed power consumption while sustaining high-capacity performance. Consolidating multiple Massive MIMO units within a sector into a single wideband unit is one effective way to maintain capacity as demand continues to grow.

**Imperative #4 – Implement service-aware and intent-driven network management**

Static network operation and limited alignment between

resource allocation and real-time demand can result in inefficient use of capacity and unnecessary energy consumption. Greater efficiency comes from more dynamic and adaptive network management. Service-aware and intent-driven capabilities align resource use with demand, complementing hardware-based improvements and providing an additional lever to reduce overall energy consumption.

**Data-driven analysis based on live networks**

To effectively improve the energy efficiency of mobile networks, it is first necessary to establish a clear, fact-based understanding of where energy is consumed in real-world deployments. A data driven analysis based on live networks therefore provides a critical foundation for identifying the most effective opportunities to reduce energy consumption.

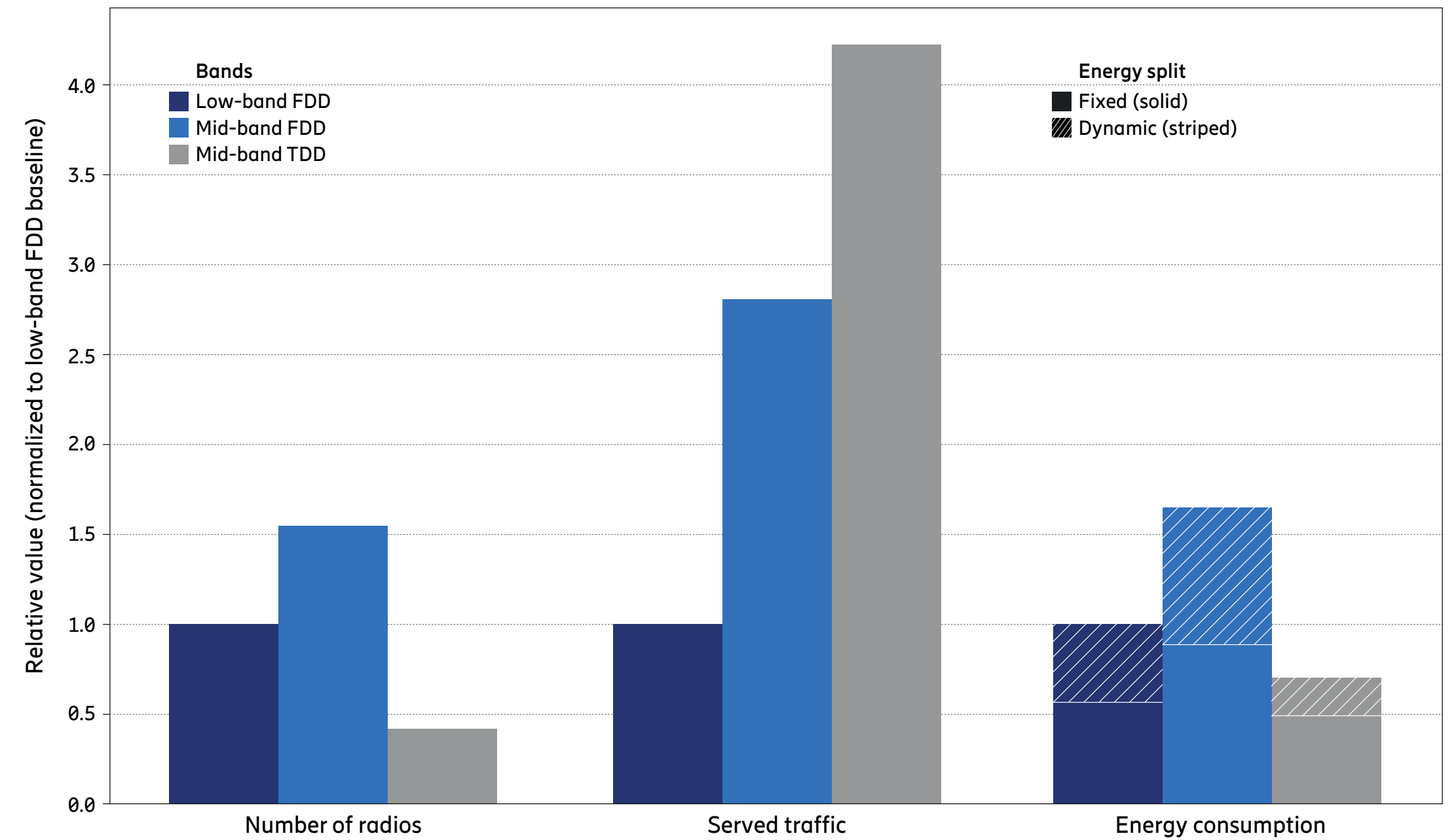
Our analysis is based on Q4 2024 field data from two major North American communication service providers (CSPs) within their Ericsson deployed networks. The dataset includes network configurations, traffic patterns and energy consumption across radios as well as baseband processing to provide a system-level view of RAN energy use, covering both LTE and NR technologies.

Our analysis shows that radios dominate total energy consumption in the RAN when compared with baseband processing. Radios account for about 92 percent of the combined energy consumption of radio units and basebands, while baseband processing contributes only about 8 percent. Given this pronounced imbalance, we have chosen to focus on energy consumption associated with radios.

**Energy distribution over different frequency bands**

CSPs typically deploy a combination of low band FDD (<1GHz), mid band FDD (1-3GHz) and mid band TDD

Our analysis shows that radios dominate energy consumption in the RAN.



**Figure 1:** Relative distribution of number of radios, traffic and energy consumption over frequency bands, normalized to low-band FDD numbers

(2.3-5GHz) carriers within the same sector to meet both coverage and capacity requirements. FDD spectrum provides wide area coverage in challenging environments such as indoor and rural areas, while TDD spectrum delivers higher capacity and throughput in dense traffic scenarios. Together, this combination supports a balance between cost and user experience across diverse geographies.

The deployment density of low-band FDD, mid-band FDD and mid-band TDD varies depending on traffic demand and

CSPs’ spectrum holdings. These differences influence radio configurations, determining whether single-band, dual-band, multi-band or multi-sector radios provide the most energy- and cost-efficient deployment.

**Figure 1** presents an analysis of energy consumption across three radio unit groups – low band FDD, mid band FDD and mid band TDD – showing the distribution of radios, carried traffic and energy consumption. Three key insights emerge:



1. Mid band FDD radios dominate overall radio energy consumption.
2. Mid band TDD delivers the lowest energy consumption per bit in today's mobile networks.
3. Fixed energy cost represents a significant share of total radio unit energy consumption.

The first insight is critical because it highlights one of the most effective opportunities to reduce overall network energy consumption. The extensive deployment of mid-band FDD radios is the main reason why they consume approximately 1.6 times more energy than low band FDD radios and up to 2.4 times more than mid band TDD radios, according to the third set of bars in Figure 1. This insight indicates that modernizing mid band FDD radios will have a major impact on energy use.

The second insight is based on the fact that mid-band TDD carries 4.2 times the traffic of low band FDD while consuming only around 70 percent of the energy, making it the most energy efficient spectrum layer despite its smaller coverage footprint. With rising traffic demand, additional mid band TDD spectrum is expected to be introduced to support high traffic volumes utilizing its superior spectral efficiency and traffic-handling capacity [4]. This underscores the

In dense urban areas, sites often operate under sustained high load during busy hours.

importance of continued investment in energy efficient TDD Massive MIMO solutions and scalable hardware platforms.

The third insight emerges from the division of RAN energy use into fixed energy cost that is essential to keep equipment continuously operational and dynamic energy cost that scales with traffic. Field data shows that fixed energy cost accounts for more than half of total radio unit energy consumption, ranging from 50 to 70 percent depending on the frequency band and deployment area. This makes the reduction of fixed power consumption a key priority when evaluating energy mitigation measures. It also underscores the importance of scalable radio hardware with power consumption that efficiently adapts to traffic load. The requirement is particularly important for TDD Massive MIMO units, which tend to exhibit a relatively high share of fixed energy consumption.

**Energy distribution over different geographical areas**

Mobile networks must continuously balance two fundamental objectives across diverse geographical areas: providing wide area coverage for dispersed populations while delivering high capacity in locations with dense populations and heavy traffic demand. Population density, traffic demand, regulatory obligations and geography shape network deployment choices. This results in distinct energy efficiency characteristics across dense urban, urban, suburban, rural and deep rural environments.

In dense urban areas, traffic demand is very high and concentrated within a limited area. To meet peak capacity requirements, CSPs deploy a high density of sites, multiple sectors and carriers and substantial spectrum bandwidth including FDD and TDD frequencies. As a result, sites often operate under sustained high load during busy hours. Urban and suburban areas experience moderate to high traffic

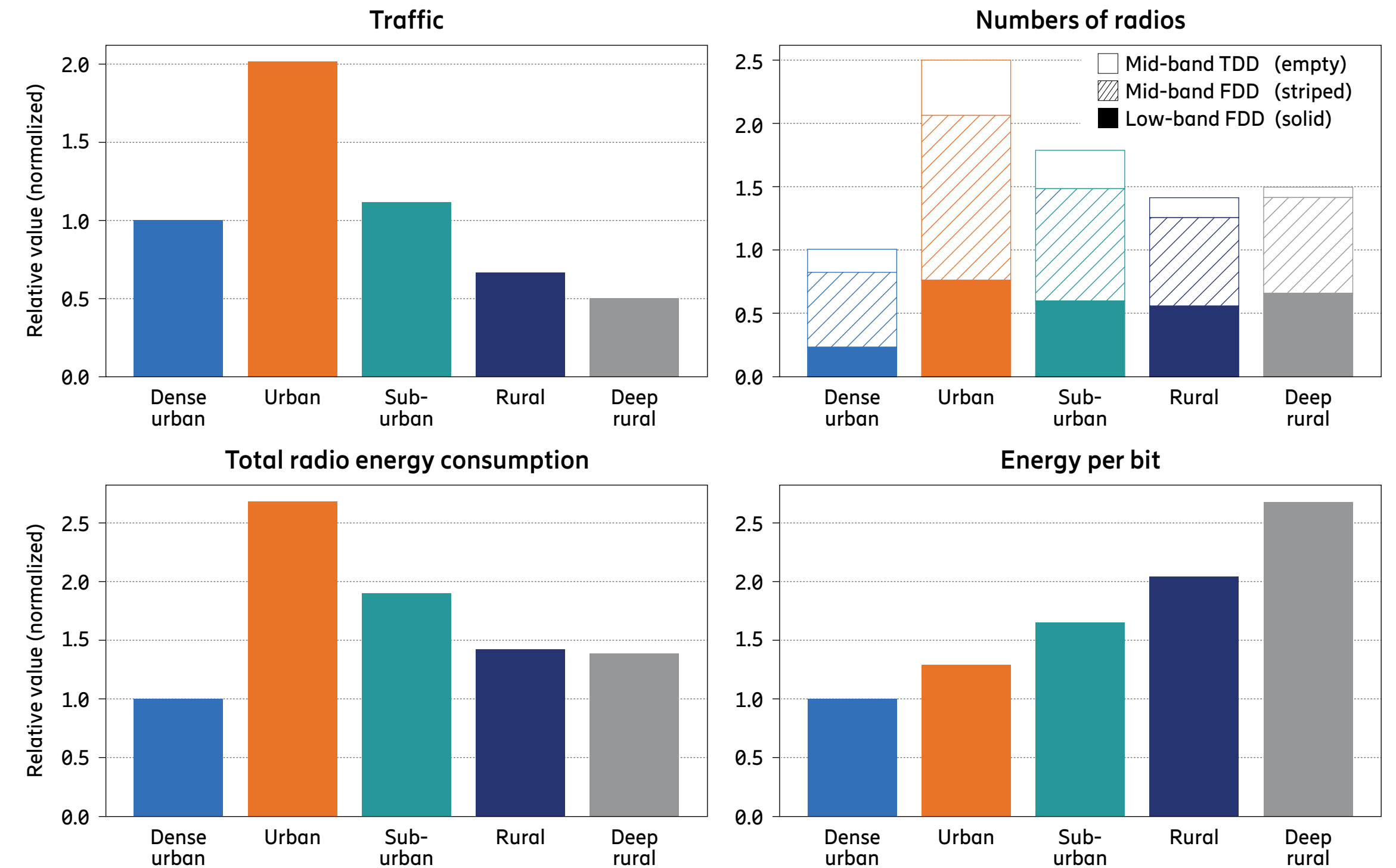


Figure 2: Distribution of number of radios, traffic and energy consumption over geographical areas

spread over larger areas, relying on a mix of FDD and TDD spectrum to balance coverage and capacity. Increasing adoption of FWA in these areas can further raise sustained traffic levels per site [5].

Rural areas cover large geographical areas with lower average traffic per site, where FDD spectrum dominates due

to its superior coverage characteristics, although selective TDD deployment may still be required to support growing demand for FWA due to limited spectrum bandwidth on FDD bands. In deep rural areas, extremely low population density and traffic demand mean that coverage considerations dominate network design, often requiring higher transmission power to serve widely dispersed users.



Figure 2 shows the distribution of radios, carried traffic and energy consumption across these area types, normalized to dense urban conditions. Three key observations can be drawn from this data:

1. Traffic is unevenly distributed across areas: urban environments carry the highest relative traffic.
2. The number of deployed radios broadly follows traffic demand, with urban and suburban areas accounting for the largest share of radios due to their higher sustained traffic levels.
3. Energy per bit – expressed as energy consumption per delivered bit – increases with declining population density, because there is less traffic sharing the fixed energy cost of operating the radios.

These three observations underline the need for geographically-tailored modernization strategies. Dense urban, urban and suburban areas benefit most from capacity oriented solutions and scalable mid band TDD deployments to efficiently handle high and sustained traffic demand. At the same time, modernization of FDD radios remains essential across all area types, as their large installed base makes them the dominant contributor to overall radio-unit energy consumption.

Our research considers a traffic growth scenario of 3.5 times toward the 2030 time frame.

### The coming challenge: traffic growth versus energy use

Mobile data demand is expected to increase significantly over the coming years, driven by high demand services such as high resolution video and cloud gaming, the emergence of new services including generative artificial intelligence (AI) and extended reality, and continued growth in both mobile broadband (MBB) and FWA. While the precise magnitude of future traffic growth remains uncertain, scenario-based analysis provides a structured way to explore potential outcomes. Our research considers a traffic growth scenario of 3.5 times toward the 2030 time frame, assuming moderate to high FWA expansion across urban, suburban and rural areas [6], together with an average annual growth rate of 15 percent for MBB traffic [7].

Traffic growth, however, does not translate linearly into energy consumption. Under the 3.5× traffic scenario and in the absence of targeted energy reduction actions, Change to modeled radio and baseband energy consumption increases substantially, with a plausible outcome approaching a 70 percent rise relative to today's network baseline. This increase is driven by several reinforcing mechanisms. Higher traffic volumes lead to increased dynamic power consumption, as radios operate at a higher load for longer periods, particularly in urban, suburban and rural areas with expanding FWA usage.

In parallel, meeting future capacity requirements typically requires additional spectrum and capacity layers, including the expansion of mid band TDD footprint across a substantial share of sites, ranging from 60 to 90 percent depending on area type. This expansion increases fixed energy cost as well as baseband energy consumption and associated cooling demand. Furthermore, as sites become

busier, opportunities to exploit low power and sleep modes are reduced, diminishing the effectiveness of idle mode, energy saving features.

As network energy use rises alongside continued expansion of capacity and coverage, it becomes increasingly important to minimize energy consumption while continuing to meet strict service and performance requirements. Achieving this balance requires a holistic approach, in which CSPs and vendors work together to combine hardware modernization, technology evolution and intelligent network management to drive long term energy efficiency across mobile networks.

### Simulation methodology to estimate coverage, capacity and energy performance

Our simulations include both MBB and FWA traffic across a range of scenarios from urban to deep rural environments. Energy consumption is estimated using a combined view of two modeled North American CSP networks: we simulated each CSP separately and aggregated the results across both. Daily energy consumption (in kWh), including both radio and baseband units, serves as the primary metric.

When measuring network energy consumption, the following requirements must be met:

- User experience for MBB – the ability to deliver 50Mbps in the downlink (DL) and 0.5Mbps in the uplink (UL) for at least 95 percent of all users [8].
- User experience for FWA – the ability to deliver 100Mbps in the DL and 1Mbps in the UL for at least 95 percent of all users [8].
- Capacity – the ability to serve the expected MBB and FWA traffic demand.

Our simulations indicate that FWA service is up to 60% more energy efficient than MBB.

Baseline inputs, including frequency bands deployment, and MBB and FWA traffic loads, are derived from field data and weighted across multiple CSPs. FWA services are considered in urban, suburban and rural areas, with traffic growth varying by area type. To assess the potential impact in line with the Ericsson Mobility Report [6], a moderate FWA expansion scenario is assumed, in which FWA traffic accounts for more than 40 percent of total mobile network traffic. Under this scenario, total mobile data traffic, including both MBB and FWA, is projected to reach 3.5 times today's baseline by 2030.

To meet this future demand, network evolution measures are considered for existing macro sites, including the addition and upgrade of mid-band TDD layers, as well as modernization of radios in existing FDD bands. The extent of mid-band TDD deployment varies by area type and is initially more concentrated in higher-population areas.

### Simulation results

Our simulations indicate that FWA service is up to 60 percent more energy efficient than MBB in terms of watt-hour per delivered bit, due to better customer premises equipment (CPE) antenna [9] and favorable location of installation. FWA also benefits more from multi-user MIMO (MU-MIMO)



## Modernization of FDD radios plays a key role in improving energy efficiency.

than MBB, largely because FWA CPEs remain stationary. This stability enables highly accurate and persistent channel state information, which is essential for efficient MU-MIMO beamforming [10]. Furthermore, the diversity of service requirements and traffic characteristics creates additional opportunities for service-aware management and scalable TDD Massive MIMO configurations, enabling even greater improvements in network-wide energy efficiency.

These characteristics are reflected in **Figure 3**, which presents simulated network energy consumption under traffic growth scenarios combined with different energy reduction measures, relative to today's baseline, with results analyzed across various geographical areas.

The second, third and fourth bars in Figure 3 clearly demonstrate that modernization of FDD radios plays a key role in improving energy efficiency. The analysis focuses on replacing a representative share of legacy mid-band and low-band FDD radios with more energy-efficient generations, reflecting typical upgrade opportunities in existing deployments. This modernization delivers substantial energy savings, primarily by reducing fixed energy consumption, with an estimated 10 percent reduction from mid-band FDD modernization and a further 9 percent reduction from low-band FDD modernization. In addition to lowering energy consumption, FDD

radio modernization is essential for meeting future UL performance requirements [11], reinforcing its importance beyond energy efficiency alone.

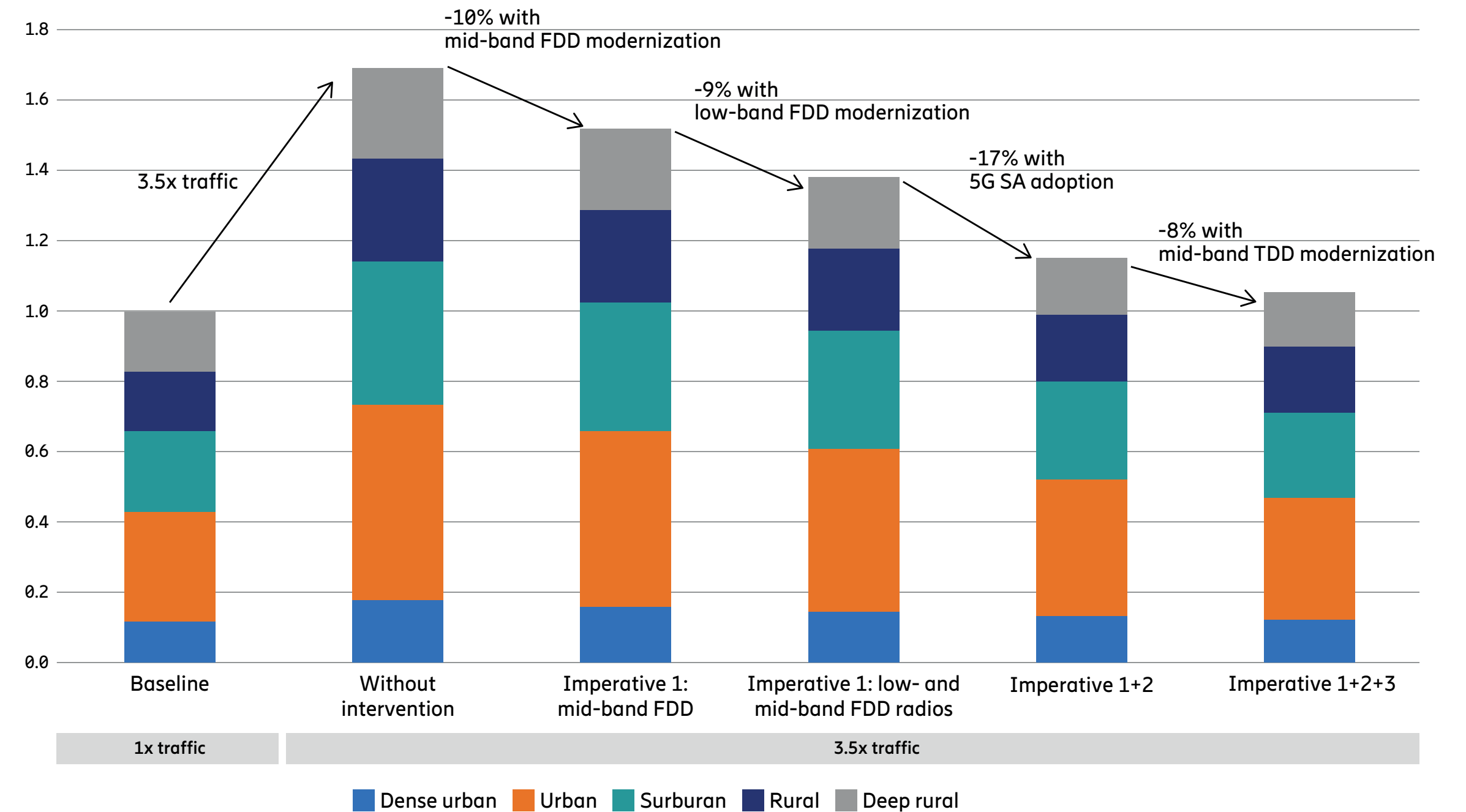
Figure 3 also shows that modernizing mid-band FDD radios offers greater energy-saving potential than upgrading low-band FDD radios, primarily due to the higher prevalence of mid-band deployments and the enhanced efficiency provided by multi-band radio configurations in the studied networks. Notably, the impact of mid-band modernization is comparable to that of low-band modernization while requiring fewer radio-unit replacements. These findings help guide prioritization of radio-unit modernization across different frequency bands.

The fifth bar in Figure 3 shows that accelerating the shift to 5G SA delivers significant additional energy savings. Migrating remaining LTE bands to NR yields an estimated 17 percent reduction in energy consumption, enabled by NR's leaner system design, including lower signaling overhead, reduced interference, longer radio sleep opportunities and more efficient data transmission.

The sixth bar in Figure 3 indicates that enhancing mid-band TDD MIMO energy efficiency contributes to additional reductions in fixed power consumption while sustaining high-capacity performance. This is particularly important in environments with high traffic demand, where TDD layers play a central role in supporting continued growth.

Figure 3 also shows that the energy savings resulting from radio-unit modernization are highest in urban and suburban areas, compared with dense urban and deep rural environments. This is mainly due to the larger share of deployed radios and higher traffic volumes in urban and

### Estimated energy consumption



**Figure 3:** Estimated energy consumption based on simulations

suburban regions. These insights help inform region-specific prioritization of modernization efforts across different geographical areas.

The progression from the second to the sixth bar in Figure 3 shows that when measures related to strategic imperatives

1, 2 and 3 are implemented together, overall network energy consumption increases by only around 6 percent, even with 3.5 times traffic growth. Further improvements can be achieved through service-aware energy features and AI- and intent-driven network management.



## Conclusion

Field analysis from two large North American networks confirms that radios – and frequency division duplex (FDD) radios in particular – are the dominant contributors to energy consumption of all radio and baseband units, with fixed energy cost accounting for more than half of total radio energy use. This underscores hardware modernization and efficient spectrum utilization as critical measures for reducing network-level energy consumption toward 6G.

At the same time, continued traffic growth fundamentally changes the challenge. Under a scenario assuming a 3.5 times increase in traffic relative to today, RAN energy consumption could rise significantly in the absence of targeted mitigation measures. The results presented in this article show that this trajectory can be altered. Coordinated modernization – combining FDD radio upgrades, accelerated adoption of 5G Standalone and more efficient mid-band time division duplex MIMO (multiple-input, multiple-output) deployments – can largely offset traffic-driven energy growth while preserving performance and capacity. The results reinforce a clear strategic message: breaking the energy curve requires a coordinated, system-level transformation across hardware, software and network architecture.

Communication service providers that proactively modernize their networks, expand New Radio adoption and introduce more intelligent, service-aware operation will be best positioned to control operational expenditure, meet sustainability commitments and support future services. As networks evolve toward 2030 and 6G, energy efficiency will become a central dimension of network performance – shaping the next generation of scalable, high-performance and sustainable connectivity.

## The authors



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**Fredric Kronestedt** has taken on many roles since he joined Ericsson in 1993 to work on RAN research. At present, he serves as an expert in radio network deployment strategies at Business Area Networks, where he focuses on radio network deployment and evolution aspects for 5G and 6G. Kronestedt holds an M.Sc. in electrical engineering from KTH Royal Institute of Technology in Stockholm, Sweden.



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**Jonas Bengtsson** joined Ericsson in 2002 and has been working to increase the energy efficiency of radio base stations since 2014. He currently serves as the technical lead of a highly skilled energy performance team that has produced multiple innovations in the area including LTE base station interference and power-saving technology. Bengtsson also played a major role in the work that has made Ericsson mobile phone modems the most energy-efficient modems on the market for the past 15 years. He studied computer science at Lund University in Sweden.

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## References

1. GSMA Intelligence, Going green: measuring the energy efficiency of mobile networks (Fourth edition), 2025 ↗
2. Ericsson blog, 6G – Taking radio access technologies to the next level, June 24, 2025, Parkvall, S. ↗
3. Ericsson report, On the road to breaking the energy curve: A key building block for a Net Zero future, 2022 ↗
4. Ericsson report, Elevating the consumer experience at big events with 5G: Exploring the benefits of 5G mid-band TDD, 2024 ↗
5. Ericsson, Fixed Wireless Access Handbook 2026 ↗
6. Ericsson Mobility Report, Fixed Wireless Access outlook, November 2025 ↗
7. Ericsson Mobility Report, Next wave of mobile, November 2025 ↗
8. Ericsson blog, Who cares about peak download speeds in 5G?, January 18, 2022, Ludwig, R. ↗
9. T-Mobile, Radio exposure test report, October 29, 2021 ↗
10. Ericsson, Massive MIMO Handbook 2025 ↗
11. Ericsson Technology Review, Enhancing 5G uplink performance to enable differentiated services, November 12, 2025, Kronestedt, F., Chen, T., Kaur, A., Furuskär, A ↗



## Further reading

- Ericsson, 5G energy efficiency ↗
- Ericsson blog, 5G energy consumption: what's the impact of 5G NR in real networks? ↗
- Ericsson, Empowering sustainability ↗
- Ericsson, 5G Advanced solutions ↗
- Ericsson, SK Telecom and Ericsson honored for 'Lean' and 'Green' solution ↗