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breaking-the-energy-curve

Breaking the energy curve

An innovative approach to reducing mobile network energy use

Foreword

Is it possible to quadruple data traffic without increasing energy consumption?

The answer is yes. It is possible to break the energy curve, i.e. lowering total mobile network energy consumption from today's level and meeting the massive traffic growth challenge.

It is not just a possibility. In fact, we believe it is our responsibility, together with all other ICT industry players.

We estimate the current yearly global energy cost of running mobile networks to be USD 25 billion. From both cost and carbon footprint perspectives, energy consumption is one of our industry's biggest challenges.

Through our extensive sustainability research stretching back more than 20 years, we have demonstrated that mobile broadband is an enabler of sustainable development, economic growth and reduced carbon emissions. The ICT sector only contributes 1.4% of the global carbon emissions, but it has the potential to enable a 15% reduction in other sectors, such as energy, industry and transport.

From a lifecycle perspective, the main portion of our carbon footprint comes from the energy use of delivered products. Based on this, we have set reduction targets for our own emissions and product energy performance, which were recognized by the Science Based Targets initiative, in line with a 1.5C trajectory.

Energy consumption is set to increase dramatically if 5G is deployed in the same way as 3G and 4G were. This is an important issue to address. Some communications service providers have even estimated a doubling of their energy consumption to meet increasing traffic demands while improving their network and rolling out 5G. This is not sustainable from a cost or environmental perspective.

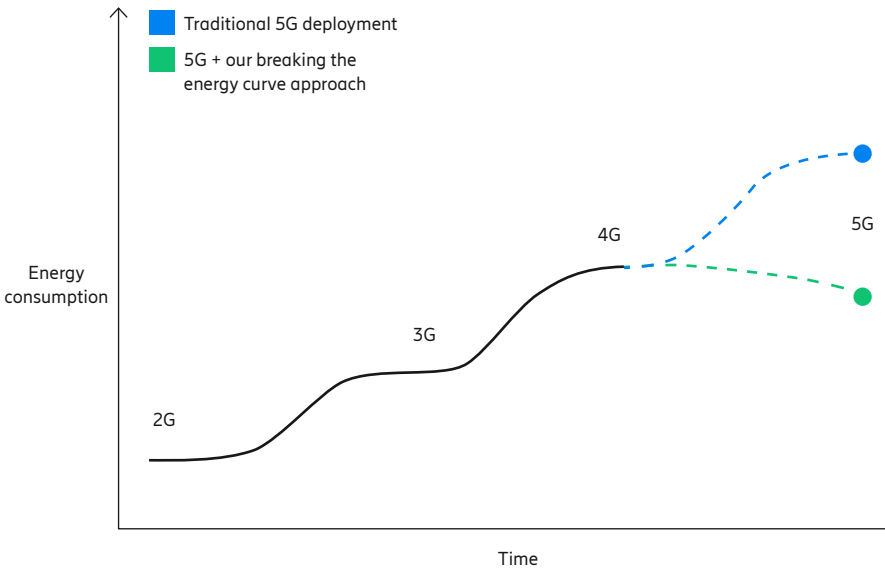
Thanks to the 5G standard and our development efforts, it is possible to significantly reduce energy consumption. 5G, which is the most energy-aware standard, will allow the mobile system to use smart sleep modes more effectively and extend coverage by using lower bands while increasing capacity and speed with carrier aggregation. Fast and effective data transmission enables the system to return to a low-load state faster.

Across Ericsson, we are proud to partner with our customers to evaluate and evolve solutions to address energy challenges. In this report, we present a broad range of solutions from our portfolio – developed for and with our customers. All of these can already be implemented to either prepare for or support 5G deployment.

Start saving now.

Erik Ekudden, Senior VP, CTO and Head of Group Function Technology

Figure 1: Our breaking the energy curve approach



An industry responsibility

To answer the billion-dollar question, we believe that breaking the energy curve is possible. We not only assume our responsibility, but also lead and offer a holistic solution.

Executive summary

Our innovative approach to breaking the energy curve.

To break the increasing energy consumption curve of mobile networks, we have analyzed some of the most ambitious 5G deployments and tested what could happen if our holistic approach is applied. Together with our customers, we have refined different solutions to achieve significant energy savings.

Taking the first step brings immediate savings and provides insights that can be applied later. Where and how to start implementation of our approach depends on each network design and status. Below are the four elements of our approach.

Prepare the network
By modernizing the network with the latest technology and replacing old equipment, it is possible to realize new business opportunities and, at the same time, create significant energy savings. Previous deployments of mobile generations were often managed by adding new equipment while keeping existing network assets. This practice must change. We have seen that modernization in low-traffic areas can yield a payback period of less than three years for energy savings alone.

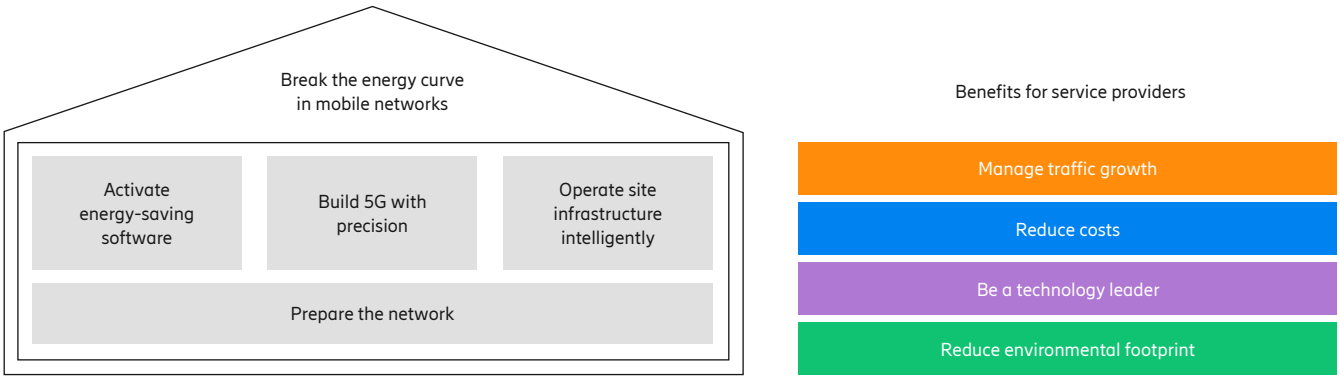
Activate energy-saving software
Energy-saving features are already available in Ericsson Radio Access Network (RAN) and can be activated immediately. Adding machine learning will bring further savings. Features such as Micro Sleep Tx (MSTx) and the Low Energy Scheduler Solution (LESS) can reduce radio equipment energy consumption by up to 15% while maintaining the same user experience.

Our 5G software has energy-saving in its DNA. Its advanced features will continue to evolve and network efficiency will increase over time.

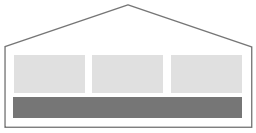
Build 5G with precision
It is important to have the right equipment in the right place. Build 5G with precision is about optimizing network performance on the new 5G frequencies while keeping capex and opex within certain limits. When complemented with unique solutions, such as Ericsson dual-mode 5G Core (5GC), Ericsson Radio System (ERS) and Ericsson Spectrum Sharing (ESS), a swift 5G rollout is enabled without adding any further energy-consuming hardware. This means service providers can limit energy consumption growth when introducing 5G.

Operate site infrastructure intelligently
By using AI, service providers can operate site infrastructure more proactively. Our portfolio offers tools to control passive equipment, and enable predictive maintenance and no-touch problem-solving to reduce costs, site energy usage and site visits. Customer cases show that service providers have reduced site energy consumption by up to 15% through intelligent site control solutions.

Figure 2: The elements and benefits of breaking the energy curve



Prepare the network



Modernize with future-proof hardware for superior performance.

Preparing for and introducing 5G creates an opportunity to modernize and improve existing networks. Considering the limited capacity of current networks, growing traffic demand creates performance challenges. There are large energy and physical footprint savings to be realized in network modernization. This can significantly reduce total mobile network energy consumption and make room for a 5G rollout within the same energy budget.

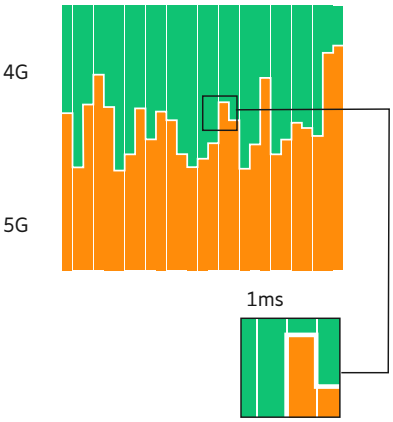
Service providers have different starting points and deployment priorities for their network evolution. We recommend that network modernization encompasses all aspects of site equipment as well as the core, transport and radio access equipment. For example, upgrading from air-conditioned shelter sites to modern site cabinets and convection-cooled, multi-standard remote radio units in the radio tower will substantially reduce energy consumption.

Capable hardware is essential

New multi-standard hardware platforms offer a reduced physical footprint and the latest energy-reducing technologies that contribute to more energy-efficient networks. Updating with the latest Ericsson Radio System (ERS) solutions and dual-mode 5G Core (5GC) provides immediate energy and cost savings, as well as facilitating a swift move to 5G in the future with a software installation.

ERS is a complete platform to build the highest-performing Radio Access Network (RAN) and offers optimal modularity to ensure the lowest total cost of ownership (TCO). All ERS equipment shipped since 2015 is 5G-ready. Having equipment on the ERS platform ensures that the network can migrate to the most efficient technology as soon as devices and services are available.

Figure 3: Ericsson Spectrum Sharing's unique 1ms solution



Only one millisecond to switch between 4G and 5G

With Ericsson Spectrum Sharing (ESS), service providers can run 4G and 5G simultaneously on the same frequencies, without adding new energy-consuming hardware. ESS gives both technologies instant access to the same spectrum and assigns resources at a millisecond level to the devices that need them (Figure 3). The solution is available through a remote software installation on ERS base station hardware.

Spectrum evolution plan – using the most efficient standard

When preparing for future RAN capacity, it is important to look at the current spectrum assets to create a spectrum evolution plan, assessing how spectrum needs will evolve (Figure 4).

Typically, a service provider has several frequency bands for various radio technologies (2G–4G). Over time, new spectrum bands will provide more capacity, but spectrum reallocation is needed to gradually shift traffic towards 4G and 5G.

We are committed to ensuring that the network can migrate to the most efficient technology. This may mean implementing a robust 4G platform to monetize existing use cases and to be the basis of addressing the next wave to 5G. We recommend moving 2G and 3G to a joint lower frequency band, combined in an energy-efficient, mixed-mode configuration and, when possible, switching off one or both technologies.

Replacing 2G/3G with 4G will most likely double capacity for the same spectrum. It also enables the use of more efficient energy-saving functionality, which the 4G standard offers. It is a perfect opportunity to reduce the energy spent on older radio technologies and get ready for implementing future 5G equipment.

Figure 4: An example of a spectrum evolution plan

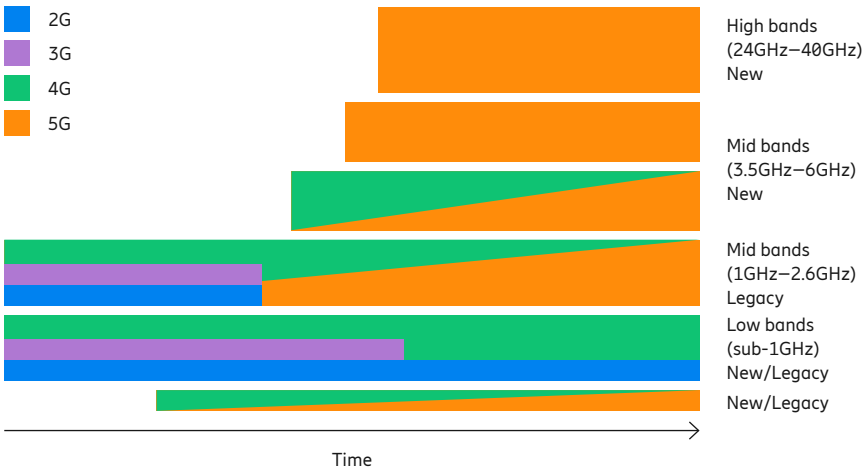
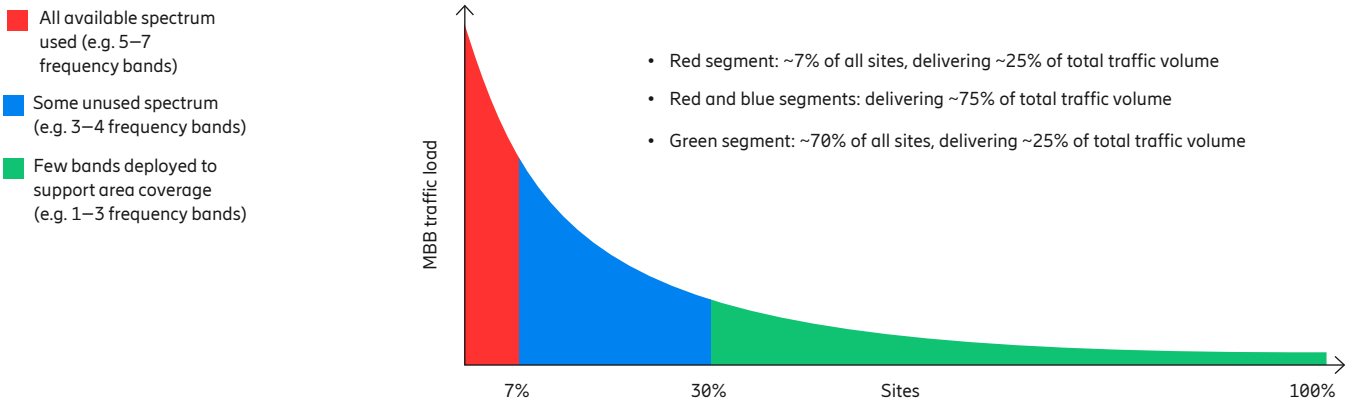


Figure 5: Typical mobile broadband traffic load split into three segments



Network reality

Based on extensive traffic data analysis from networks across the world, we know that 2G, 3G and 4G have an almost identical traffic distribution over the total number of radio sites (Figure 5).

Sites with high traffic load tend to have the largest year-on-year growth, while growth is much lower where traffic volumes are already low.

Our data also shows that low and high loads exist in all environments. Some dense urban sites experience low traffic volumes due to small cell areas, while some rural sites cover large geographical areas and carry comparably high traffic loads.

This understanding enables service providers to model network evolution to meet expected traffic growth while optimizing TCO.

Defining quality

Service providers' perceived delivered quality is defined by how well they dimensioned the most valuable sites in the red and blue segments above. Traditionally, the main focus has been on managing capacity expansion and spectrum efficiency on these sites to protect and handle the increasing mobile broadband traffic.

Defining network energy use

To break the energy curve of total mobile network energy consumption, the green segment above must be addressed. It could be perceived that keeping older equipment on these sites can handle the increased traffic demand. However, introducing the latest ERS equipment will immediately lower energy consumption by about 30% in like-for-like modernization. In some cases, it even pays for the upgrade within three years. The business strategy for this 70% of sites should also consider that modernizing means future 5G use cases can deploy nationally with just an Ericsson Spectrum Sharing remote software installation.

Enhanced operational efficiency with dual-mode 5G Core (5GC)

To efficiently prepare the move to 5G, the core network is rapidly transforming to cloud-native implementations.

Our dual-mode 5GC combines network functions from 5G Evolved Packet Core and 5GC architecture into a common cloud-native software platform. This supports standalone and non-standalone 5G, 4G, 3G and 2G access technologies. It delivers high levels of orchestration and automation for operational efficiency, and provides up to 20% savings in infrastructure with cloud-native operations.

30%

Ericsson Radio System will immediately lower energy consumption by about 30% in like-for-like modernization.

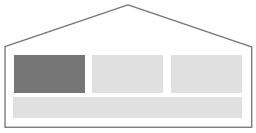
Customer case: Network modernization
Vodafone, London, UK

Challenge
- Modernize the 4G network in London to be 5G- and IoT-ready while retaining a top position for performance benchmarking

Solution
- Modernize ~4,000 sites with Ericsson Radio System carry-to-site equipment

Impact
- Vodafone retained its top performance position
- Increased traffic capacity, better throughput and, on average, 20–30% lower energy consumption
- Removed need for cranes, enabling faster deployment and capex reduction

Activate energy-saving software



Turn on software features without compromising user experience.

We offer energy-saving software functionality that automatically switches equipment on and off to follow traffic demand as it varies over time.

Experience from networks across the world shows that these functions could significantly reduce energy costs without any need for additional hardware investments.

Our suite of solutions enables the optimization of energy-saving functionality across service providers' networks. It provides a helicopter view of energy use, assessment of possible energy savings and myriad Radio Access Network (RAN) energy-saving functionality for all mobile generations.

Energy data access and analysis
Measuring energy consumption and relating it to other aspects of network performance is crucial for proactive decision-making.

Ericsson Network Manager (ENM), Ericsson Network IQ Statistics (ENIQ Statistics) and Ericsson Energy Report provide important insights for service providers to understand, diagnose and identify opportunities to improve network energy performance.

ENM enables access to all energy and network performance data from the network nodes, Ericsson Site Controller and onsite cabinets. ENIQ Statistics helps to collect and store performance management data.

Based on this data, Ericsson Energy Report provides actionable insights by:

- verifying network energy consumption
- analyzing network energy efficiency
- providing status data for energy-saving features and network performance.

RAN energy assessment and optimization using energy-saving software
We can assess and advise on achievable network-wide energy savings, alongside opex reduction potential, when applying energy-saving features to all radio technologies (2G–5G).

We can also support service providers in introducing energy efficiency as a new dimension in the RAN performance assessment, to achieve an expert balance between energy savings and network performance.

RAN sleep modes will reduce energy consumption at minimal effort
Most energy is consumed in the RAN. We can help service providers to automatically make use of low-traffic periods and deactivate capacity when it is not required.

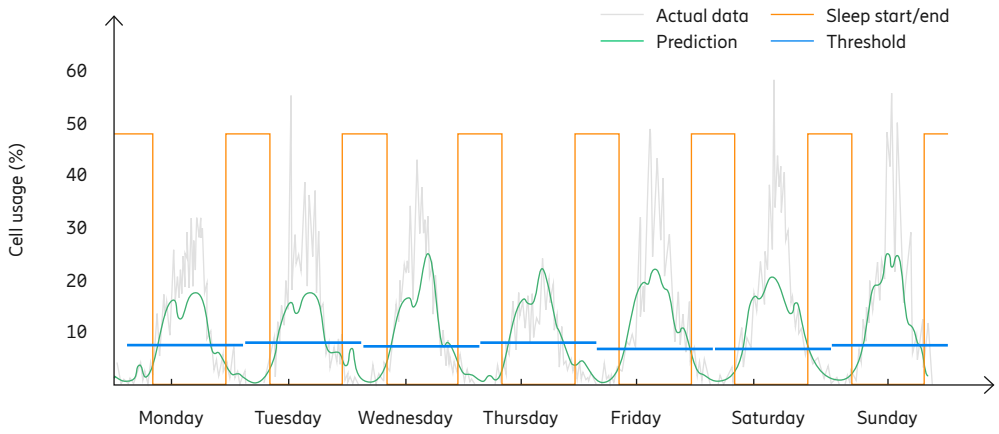
Through advanced measurements that predict traffic patterns and load, and end-user needs, from cell to subframe levels, we can dynamically activate

Figure 6: Examples of our 4G and 5G energy-saving features*

Energy-saving feature	Capabilities – energy-saving mechanism	Benefits
Micro Sleep Tx (MSTx)	Automatically switches off the radio power amplifiers on a symbol-time basis, when no signaling or user data needs to be transmitted on downlink.	MSTx enables discontinuous transmission on downlink to save energy during low traffic.
Low Energy Scheduler Solution (LESS)	Reschedules downlink transmissions for non-critical data. Time-sensitive transfers, such as voice, are excluded, making sure the quality of service is never compromised.	Improves MSTx efficiency as even more timeslots are emptied and can trigger micro sleep.
MIMO Sleep Mode (MSM)	Deactivates power for a subset of the antenna branches. The feature automatically reconfigures from MIMO to SIMO mode and back, based on traffic load.	Automatically reduces power consumption in the radio during low-traffic hours.
Cell Sleep Mode (CSM)	Turns off the power amplifier for a capacity cell when the total traffic is below a set threshold.	Automatically reduces power consumption in the radio during low-traffic hours.
Massive MIMO Sleep Mode	Deactivates one or several M-MIMO antenna elements, depending on traffic needs.	Improves an advanced antenna system site's energy efficiency.

*Availability according to the road map

Figure 7: Traffic prediction using machine learning for augmented MIMO Sleep Mode



RAN Compute and radio equipment. This will achieve the lowest possible energy consumption with maintained network performance.

By activating energy-saving features, such as Micro Sleep Tx (MSTx) and the Low Energy Scheduler Solution (LESS), service providers can achieve immediate savings (Figure 6). In 4G, MSTx and LESS can reduce the energy consumption for radio equipment with up to 15% while maintaining user experience. From 5G, MSTx will always be activated.

Augmented MIMO and Cell Sleep Mode enhance traffic-aware power savings

Machine learning (ML) will be applied to energy-saving functionality to enhance efficiency and make the features more autonomous. MIMO Sleep Mode (MSM) and Cell Sleep Mode (CSM) are among the first energy-saving features where ML will be used.

Data traffic patterns can change due to environmental variations, such as new buildings and roads. ML utilizes real-time traffic predictions to augment existing functionalities (Figure 7). For augmented MSM in a cell with 4x4 MIMO, the ML algorithms analyze traffic continuously. It will then predict when to use all four radio antenna branches or just one branch to transmit, and when to change back to make sure the features never compromise user experience and associated key performance indicators (KPIs). In a trial cluster, field data showed an average of 14% savings in energy consumption per site while KPIs were maintained.

The savings will increase as this functionality is deployed in 5G networks. The 5G radio interface enables longer sleep periods for the radio power amplifiers due to more generous discontinuous reception cycles in the downlink.

In dense networks, overlaid cells are deployed. With CSM, overlaid capacity cells can detect low-traffic conditions and turn themselves off to save energy, with confirmed support from coverage cells. The coverage cell monitors traffic conditions to turn on the sleeping cells. This is a self-organizing network (SON) capability that adapts to network traffic conditions. When an overlaid capacity cell is turned off, the traffic load existing in the cell is offloaded to the coverage cells.

ML can predict and increase the time when one or more cells should be in MSM or CSM. Our real-time trials show higher accuracy predictions are achievable over time.

Customer case: 4G advanced energy savings trial
Indosat Ooredoo, Indonesia

Challenge
- Reduce power consumption without penalty to KPIs in a highly loaded 4G residential cluster (68 macro sites)

Solution
Activate 4G energy-saving features:
- Micro Sleep Tx
- Low Energy Scheduler Solution
- MIMO Sleep Mode

Impact
- Achieved 20–25% 4G power savings with KPIs maintained
- The best-performing site provides >50% 4G power savings
- Successful trial resulted in network-wide rollout of 4G energy-saving features (>3,000 sites) with estimated savings of USD 2–3 million

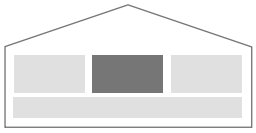
Customer case: Automating MIMO energy management with machine learning
Vodafone, Portugal

Challenge
- Reduce energy consumption through increased use of MIMO Sleep Mode while meeting performance requirements
- Automate parameter settings, when to activate and deactivate transmitter branches

Solution
- Apply machine learning to MIMO Sleep Mode for optimization of energy allocation
- Train machine learning algorithms on four weeks of traffic data, identifying traffic patterns and predicting when to activate or deactivate each location's transmitter branches

Impact
- Automated MIMO Sleep Mode management outperformed manual management by delivering 14% energy savings on average at each site
- Tailored energy efficiency of each site
- Maintained user experience KPIs

Build 5G with precision



Our best practice for network expansion.

The precise radio solution for every site type
Building with precision creates a network with the optimal radio solution for every site type. It is about optimizing network performance to avoid over-dimensioning hardware which results in unnecessarily increased capex and opex.

When introducing 5G, it is crucial to decide what, where and when to deploy new equipment on 5G frequency bands.

The total 5G energy cost addition will be impacted by service provider deployment strategies and equipment choice.

To achieve the wanted energy savings, insights from the spectrum evolution plan and network reality assessment will be key to evaluating the best radio solutions. We can help service providers to evaluate and select preferred radio solutions, supporting the expected traffic growth for the planned time horizon. Building 5G with precision enables network-wide power savings and reduces the total cost of ownership (TCO).

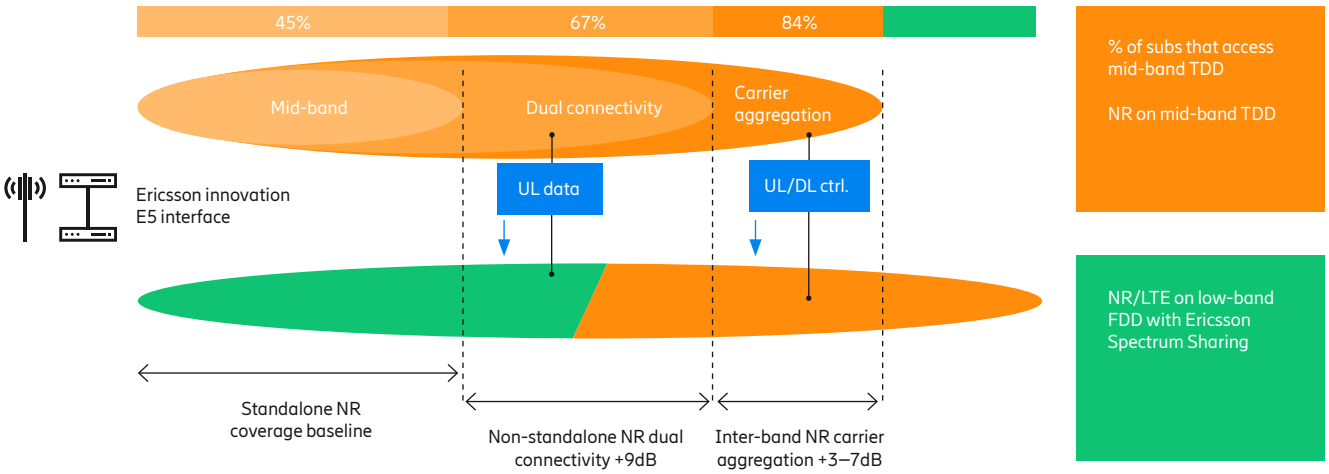
Rolling out nationwide 5G
The radio network build-out on 5G mid- and high-band cells is complemented by unique capabilities in our portfolio that enable a sustainable 5G rollout. All Ericsson Radio System (ERS) equipment shipped since 2015 is 5G-ready. Ericsson Spectrum Sharing (ESS) enables operators to quickly introduce 5G in current 2G, 3G or 4G bands for nationwide 5G coverage, without adding new energy-consuming hardware. ESS, in combination with 5G dual-connectivity and carrier aggregation, also increases the coverage area of 5G mid- and high-band cells (Figure 8).

When deploying a standalone 5G network, a 5G Core (5GC) network is the only option. With our dual-mode 5GC, service providers can migrate from today's Evolved Packet Core networks to a fully enabled 5G core network efficiently. This enables service providers to launch 5G services over a wide area and to expand their coverage in a tailored way, through existing network infrastructure from 2G to 4G. It also takes advantage of previous spectrum investments. Service providers can, therefore, provide 5G commercial services and move toward standalone 5G without a costly TCO.

Zero-touch to optimize the network
Our Self-Organizing Network (SON) Optimization Manager solution maintains end-user experience with minimal efforts from service providers while optimizing energy performance. It does so by providing granular network performance information paired with machine learning to predict coverage and capacity. The SON Optimization Manager suggests options to improve the network while considering energy performance. Such data and insights help service providers to make informed decisions as to where additions to the network will be needed. This means more balanced use of resources and ensures that the network can be dimensioned towards average network loads rather than peak loads.

Our SON can provide almost 20% better distribution of traffic load in a network. This, in turn, will lead to significant energy savings.

Figure 8: Combining 5G mid-band with low-band Ericsson Spectrum Sharing



Introducing flexibility

Our highly diverse Radio Access Network (RAN) portfolio provides the flexibility to choose radio models that consume less energy, yet match each site's traffic and coverage needs.

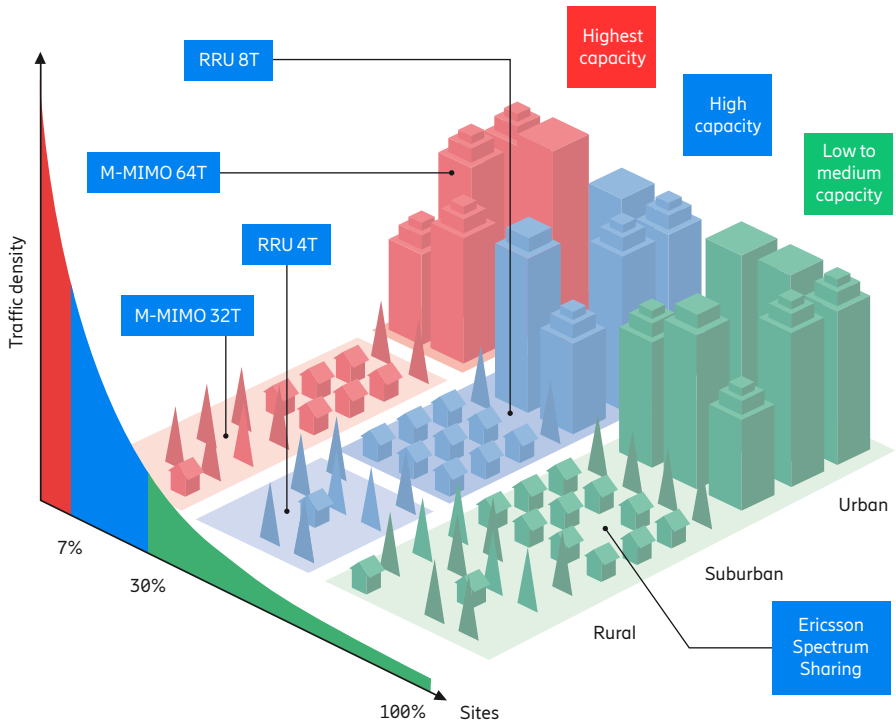
Our tools show how mobile broadband capacity can grow alongside the expected traffic growth, where different traffic characteristics for urban, suburban and rural can be assessed (Figure 9). Service providers need to match a site's demand growth curve with a solution's technical capacity.

For a massive MIMO radio, power consumption increases proportionately with the number of radios and transmitters incorporated within an antenna-integrated radio design. Therefore, deploying the right 5G radio base station site configuration is key to meeting performance demands with lower TCO and to save energy. For example, a 64T64R massive MIMO consumes 20–100% more energy than a 32T32R version of the same antenna-integrated radio, depending on the traffic load.

Furthermore, in areas with lower capacity demands, 5G remote radio units (RRU) with two to eight antenna branches would be a good fit while providing the same end-user peak rate with even lower energy use.

This understanding helps service providers to make a better decision in deploying 5G flexibly.

Figure 9: Build 5G with precision for optimized TCO



Customer case: 5G network built with precision
SK Telecom, South Korea

Challenge
- Deploy 5G efficiently and economically while meeting customer data speed and coverage expectations

Solution
- Our build 5G with precision approach
- Three different 3.5GHz radio configurations, deployed to match each network radio site's capacity and coverage requirements:
  - 64T64R massive MIMO radio
  - 32T32R massive MIMO radio
  - 4T4R radio unit

Impact
- 5G speeds achieved
- Reduced capex and opex while meeting service requirements
- Energy consumption savings compared to deploying 64T64R:
  - 32T32R radios – 45% energy saved
  - 4T4R radios – 60% energy saved

Operate site infrastructure intelligently

Traffic growth demands more on-site equipment and complexity.

Site traffic capacity growth will demand more equipment to be hosted and integrated. Available site power budget and space are often limited and, therefore, require solutions to be compact and energy-efficient. On top of this, sites incorporate efficient, environmentally friendly technology.

With increasing onsite demand and complexity, service providers face substantial challenges. Among them, decreasing operational efficiencies, fragmented data from "passive" site systems and lack of a holistic view of all sites are a high priority.

Using automation and AI technologies, we enable smart site energy management through accessibility from either the Network Operations Center (NOC) or on a tablet, smartphone or laptop in the field. Using 24/7 data points, service providers can benefit from predictive maintenance, as well as lower operations and maintenance (O&M) costs, carbon emissions and site power consumption

Digitally integrate site elements with smart connected sites

Ericsson Smart Connected Site with smart enclosures (Figure 10) is an intelligent and unified way to digitalize the site, enabling remote control and monitoring of all site equipment. The visualization can be at network, site and cabinet levels, and accessible from the NOC or field devices.

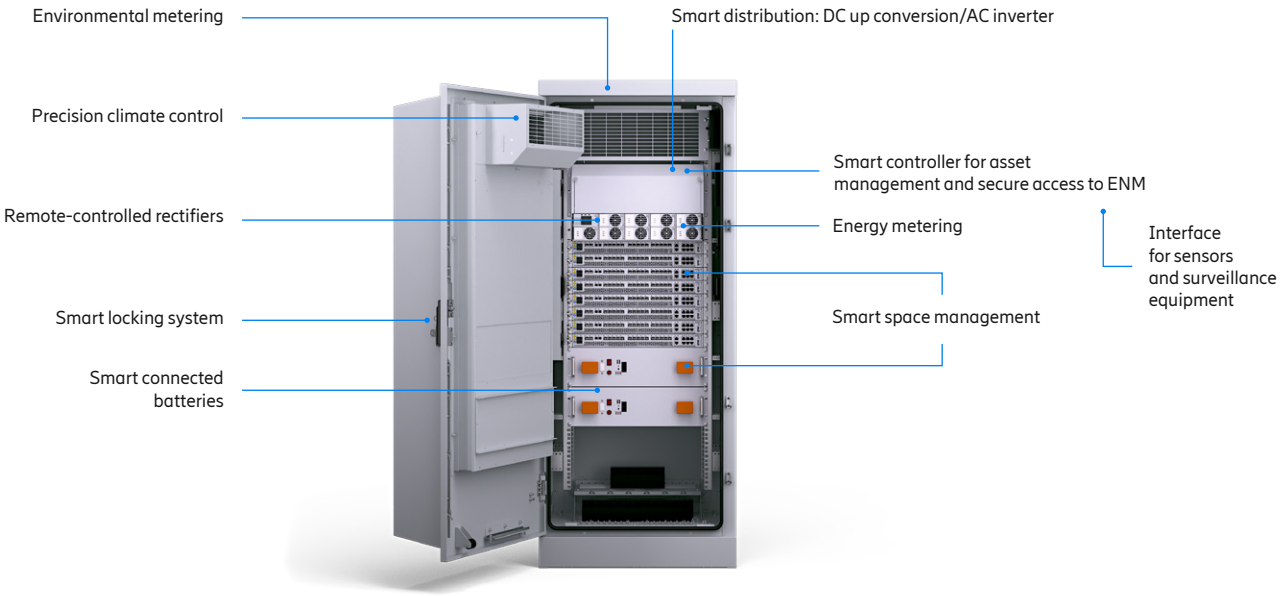
The Smart Connected Site combines various measurements and alarms from passive infrastructure with the active (radio, baseband and transport) data into one O&M tool: our Ericsson Network Manager (ENM) system. This enables automated and AI-driven data collection and site data analysis, so the service provider can manage the network more efficiently through real-time insights and control. Service providers also benefit from more intelligent site management with 24/7 information on availability, capacity, network performance and energy management, along with unprecedented control over network stability. The result is a drastic reduction in lifecycle costs, site visits and energy consumption, alongside improved network quality.

AI-powered infrastructure operations

Our Energy Infrastructure Operations (EIO) is a data-driven service offering that delivers energy-related opex and capex savings, as well as operational efficiencies to substantially reduce carbon emissions.

EIO is multivendor, focusing on gaining energy efficiencies from the passive infrastructure, as well as active radio and transmission equipment on site. While there are many features available for optimizing active site elements (i.e. radio equipment), passive elements supporting the Radio Access Network (RAN) are often overlooked, even though they could represent over 50% of the overall site power consumption.

Figure 10: An overview of Ericsson Smart Connected Site



Viewing the smart site from the NOC.

Hence, we have developed EIO as an end-to-end energy management solution to address and manage all site elements impacting the site energy consumption, utilizing AI and data analytics.

The offering is based on data from Ericsson Smart Connected Site's smart enclosures or separately deployed site controllers, connected to all relevant passive infrastructure (battery, diesel generator, rectifier, HVAC, solar, etc.). This enables all site elements to be visible, measurable and controllable to enable remote and intelligent site management. Powered by AI and supported by over 30 fully automated efficiency cases, EIO:

- collects and measures all relevant passive and active infrastructure data
- analyzes it in real-time and proactively
- automatically initiates trouble tickets and work orders based on enriched alarms and performance measurements

EIO also provides recommendations to improve site energy efficiency, site visit optimization, network performance and, ultimately, to significantly reduce site total cost of ownership. This solution is unique as it comes with an innovative business model, where value delivered through the overall energy savings is offered with an attractive return on investment profile.

Our service offering provides the following indicative benefits:

- ~15% decrease in energy-related opex
- ~15% reduction in passive infrastructure-related site visits
- ~30% decrease in energy-related outages

Our EIO solution is vendor, equipment and technology agnostic, as service providers can utilize its capabilities even if they might not have our equipment in their networks.

EIO trials

The Energy Infrastructure Operations solution has been trialed with customers in Europe, Asia, the Middle East and Latin America and is currently live in Telenor Myanmar's network.

>50%

Passive elements supporting the RAN could represent over 50% of overall site power consumption.

Figure 11: Our Energy Infrastructure Operations at a glance

Deploy and measure	Analyze	Recommend	Implement
We deploy sensors and a site controller to generate, gather and transmit measurements, and alarm data via Energy Management Server or We integrate toward the existing RSM solution.	We compute many analytical scenarios and form insights with the data from the sites.	We provide recommendations to the customer through reports and configurable dashboards. These concern potential site-level adjustments and feasible automations.	We take the required actions, where a number of solutions can be implemented from the NOC, to potentially increase revenue through site availability and reduced energy-related opex and capex.

Ericsson enables communications service providers to capture the full value of connectivity. The company's portfolio spans Networks, Digital Services, Managed Services, and Emerging Business and is designed to help our customers go digital, increase efficiency and find new revenue streams. Ericsson's investments in innovation have delivered the benefits of telephony and mobile broadband to billions of people around the world. The Ericsson stock is listed on Nasdaq Stockholm and on Nasdaq New York.

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Cover photo: a high traffic and well-dimensioned rural site – Australia

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