NTT DATA

Rethinking connectivity: A whitepaper on sustainable telecom and green infrastucture

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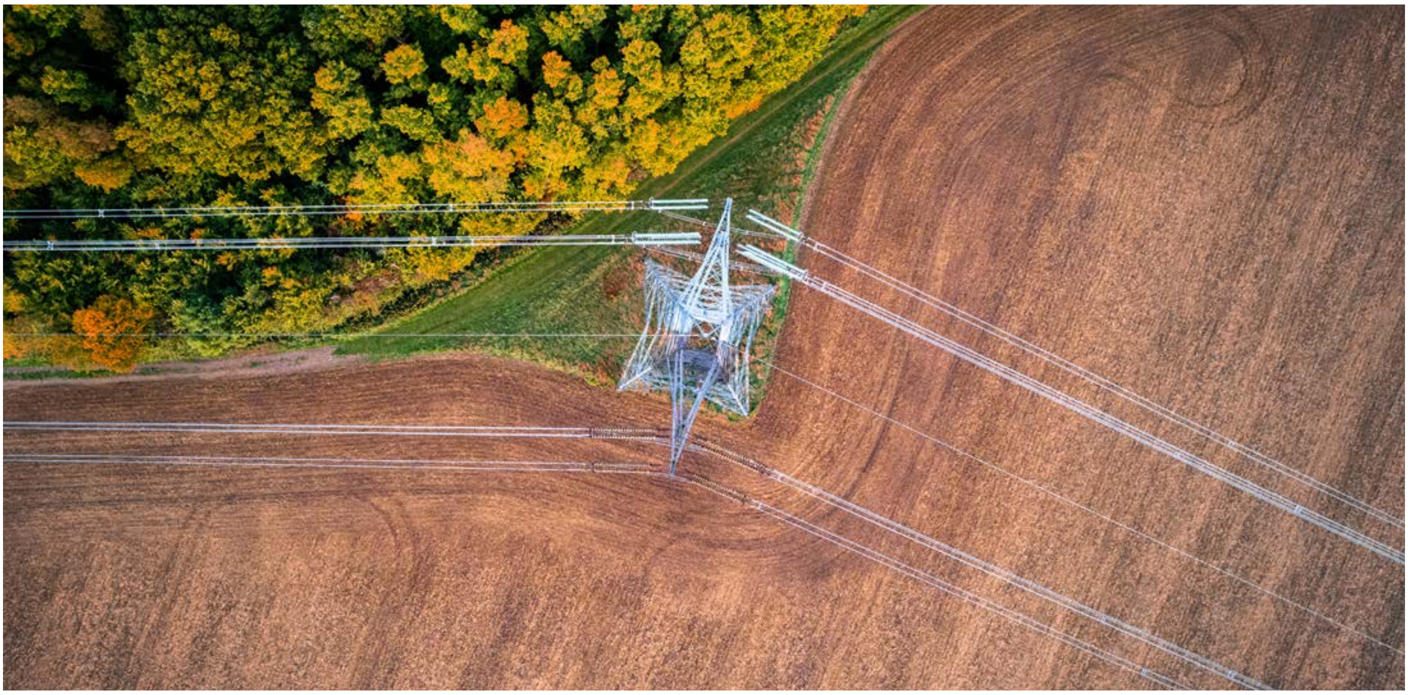


Abstract

Telecoms operators worldwide could be encouraged by the collective resilience they've shown amid the recent geopolitical and economic turbulence. In the past two years, a combination of price increases, Merger & Acquisitions (M&A) deals and Government intervention has helped Communication Service Providers (CSPs) across the globe to broadly recover from the lows they touched during the pandemic — although the rebound remains gradual and uneven. In addition, the deepening integration of telecommunication technology into other industries is giving birth to a new, connected and interdependent ecosystem, supporting a variety of new applications, such as Smart Cities, autonomous vehicles, telemedicine, and intelligent manufacturing.

Whether the telecommunication service is traditional or novel, users are demanding personalized and multidimensional requirements for performance, which can lead to a conflict between the need to deliver customized services and the challenges faced by telecom operators in meeting every requirement. Telco operators, however, are refreshing their strategies to navigate a volatile operating environment. They're expanding the scope and ambition of their digital transformation initiatives. And they're refocusing on **sustainability**, including seeking to improve performance across all dimensions: People, Process, Technology and Infrastructure. Yet the quality of telcos' climate change disclosures has worsened year-over-year, while reporting of Environmental, Social and Governance (ESG) metrics such as renewable **energy consumption** and **e-waste management** is often lacking.

- **39% of telcos** don't disclose a specific net-zero strategy, transition plan or decarbonization pathway.
- Customer needs are also evolving rapidly: **47% of large businesses** do not think that vendor 5G and Internet of Things (IoT) use cases adequately address their sustainability needs.

Telco operators must raise their game and adopt a more sustainable approach if they are to adapt to a changing landscape of **stakeholder expectations, increased OPEX, customer cost of living pressure, evolving security challenges** and a **changing workforce culture**, as these factors have a direct influence on sustainability and continous innovation. But are telcos sufficiently attuned to the current and emerging risks confronting them to achieve these goals?

To address these challenges, in this paper, we have carried out systematic research into collaboration and adaptation between business-model and technological innovation to enable sustainable transformation in the core areas of telco investment.

In the area of business model innovation, this paper proposes a conceptual model named **RITAM (Re-Imagine Technology Acceptance Model)**. From the view of technological innovation, it will design a continous improvement model, and verify its impact on overall sustainability and the regulation of the telecom industry capacity and its significance to Telco business value through a simulation experiment. Our sustainability management implementation framework is a structured approach that organizations can use to embed sustainability into their operations, strategy, and culture. The framework consists of five key steps, which are:

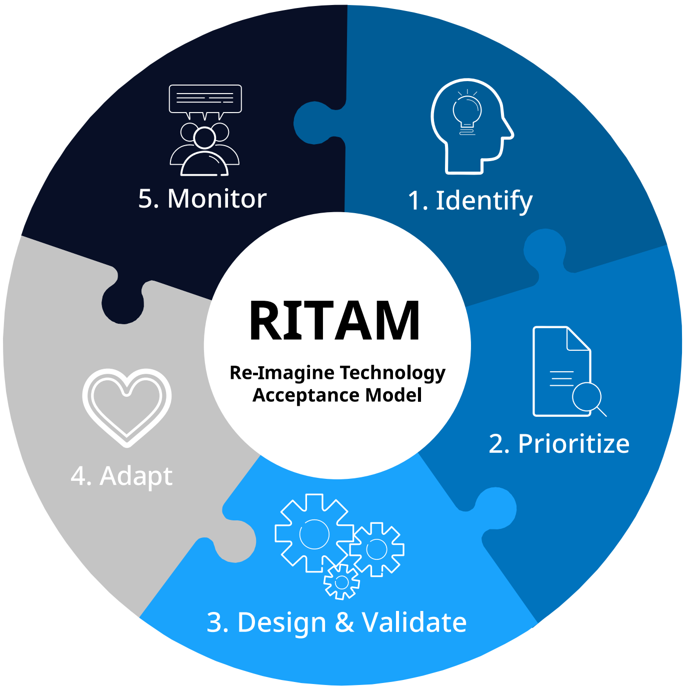


Figure 1. The key areas of activity covered by the framework.

1. **Identify:** Identify the sustainability issues that are relevant to the organization by conducting a sustainability assessment or audit to detect the organization's strengths, weaknesses, opportunities, and threats.
2. **Prioritize:** Prioritization based on significance and relevance to the organization by assessing the risks and opportunities associated with each issue, as well as the potential impact on the organization's reputation, operations, and financial performance.
3. **Design & Validate:** Design and validate sustainability strategies and initiatives that address the prioritized issues. This involves developing specific goals, targets, and action plans for each issue, as well as identifying the resources, capabilities, and stakeholders required to implement the initiatives.
4. **Adapt:** Adapt the sustainability strategies and initiatives as needed to reflect changes in the organization's context, stakeholder expectations, and sustainability trends.
5. **Monitor:** Monitor and report on the organization's sustainability performance, establishing metrics and targets to track progress towards the sustainability goals, collecting and analyzing data on sustainability performance, and communicating the results to stakeholders.

Changing economic landscape

The opportunities of digitization

Digital solutions, accessed via telecommunication technology, are transforming the way we live and work, all around the world. Online learning, remote and hybrid working, eHealth, smart cities and agriculture: these and other solutions have the power to bring new levels of prosperity and an improved way of life, **if used effectively**. It is now clear that access to IT and high-quality telecommunication services can be transformational.

The rise in digital solutions is driving an astonishing growth in telecommunication traffic, with users and usage moving up at high speed. The widespread deployment and use of **Smart Devices** is the key to this growth. These devices include smartphones, Internet of Things devices (from video enabled doorbells to industrial sensors on production assets), Smart City technologies and smart manufacturing applications, together with the mass of sensors and other data-gathering equipment that now form part of our everyday lives. In the end, these services, solutions, and increasingly necessary applications are largely built on wireless cellular networks. Traffic is growing exponentially on these networks, and operators are working tirelessly to increase capacity, satisfy demand and do this while keeping costs under control.

This has major implications for sustainability performance. According to a recent GSMA survey[6], around 50% of an operator's total operational expenditure is taken up with base station energy consumption. This is because to ensure seamless signal coverage over national areas, which can have different morphologies (rural, urban or suburban), operators must deploy large numbers of base station sites.

The energy challenges

The average yearly consumption of a single base station is estimated at 25 MWh, and there are currently estimated to be 3 million of these sites worldwide. As mobile telecom growth is happening at high speed in countries with limited power grid coverage, between 20 and 30% of these are not connected to the electricity grid and use local, standalone power generation that, for the most part, depends on diesel generators.

Energy costs for an “off grid” base station can be anything up to 10 times higher than for a station connected to the grid. We should also note that one diesel generator may emit around 33.3 tons of CO2 in an average year. In recent years, the industry has started to develop ways to use off grid power generation derived from renewable sources, such as wind, solar or other emerging options, using fossil fuel (or even micro-hydro) generators only as back-up.

We believe the yearly number of “green” base station deployments has risen from 13,000 worldwide in 2012 to more than 67,800 (1.3 % of 5.21 million towers)[18] now- with future growth predicted. To help drive clean growth through the world economy, continued growth in wireless connectivity is essential. Yet we must find a way to enable this growth without a huge rise in carbon emissions or overhead costs to operators. **This is the win-win objective we must set for ourselves.**

Studies on the rise of renewables

Sustainability for CSPs is a well-researched area, and we will cite a number of publications that analyze issues related to long-term sustainability in this field. The most salient facts perhaps are these: the industry is growing by 10% a year and all telecom operators, taken together, achieved total annual revenues of €717 billion. They reported emissions of 128 million metric tons of carbon dioxide equivalent (CO_2e)[17].

Growth in use of renewable power sources is significant and positive. The mobile trade organization, GSMA, estimates that there may be around 400,000 base stations powered by renewable energy sources across South Asia, Africa, Latin America, the Caribbean, and the Pacific. Yet this trend, positive though it is, masks some practical difficulties.

A study carried out by Paudel et al[9] noted the need to conduct rigorous feasibility studies when designing renewable energy systems. Renewable systems are frequently over-sized, which imposes high capital and running costs on telecom operators. Yet the same study also states that 99.99% reliability can be achieved if solar and wind are deployed concurrently as a power supply solution, and that the calculated, levelized cost of electricity supplied over the lifetime of the system for an optimum design could be just under $0.90 per kWh.

Other studies (see Yang et al)[10] investigate how to design and optimize renewable energy sources, while Nicola et al[11] proposes a model for energy sharing among cellular base stations (BSs) to minimize the total energy consumption. A study by Faheem et al[12] even investigates how to use the celebrated **Nash Equilibrium**, the Nobel prize winning Game Theory equation, to manage renewable energy and power from a utility provider to base stations.

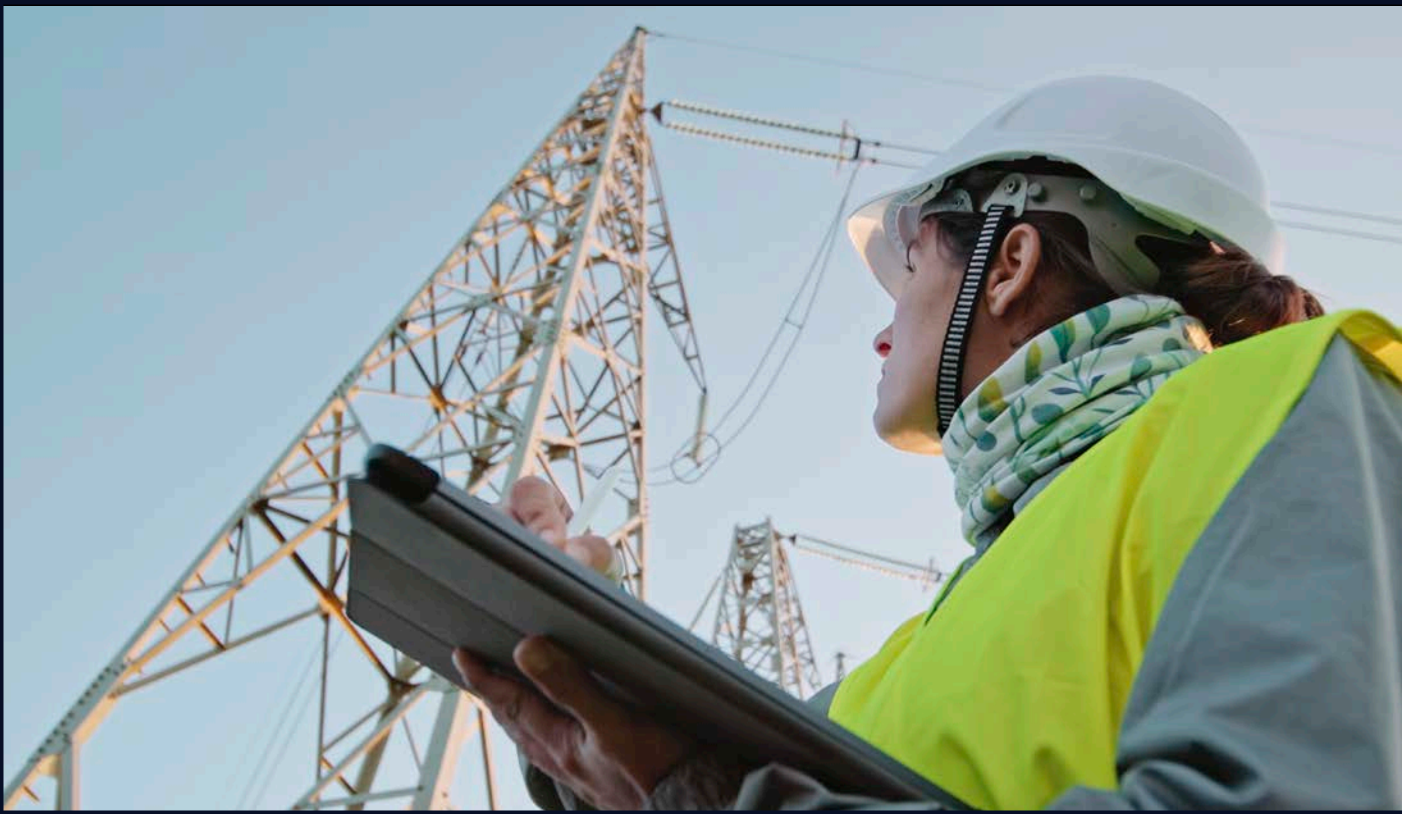
Other studies (Faheem et al) investigate different power supply solutions for off grid base stations; L.D Xu et al sets out plans for integration architecture to support renewables-based power options; while Faheem once more specifically reviews solar and biomass options for power supplies and proposes an energy-aware management system for future wireless access network[14].

Sustainability issues

The telecom sector makes a very significant contribution to the global economy, and we need to understand both that sustainability issues in telecom are different for individual countries and can be highly specific to different geographies. We can reliably conclude that creative use of Information and Communication Technology (ICT), and especially communication technology, can make a vital contribution to overall sustainability performance. In developing countries, the presence of communication infrastructure remains low, and this impacts on the potential for positive change in these areas. Communication technology is a basic enabling technology for growth and development. This explains why network expansion is such a constant theme of economic activity today.

Our concern is to ensure that infrastructure growth happens in step with sustainability improvements. Technology advances should enable us to ensure this happens. **For example, 5G networks can be up to 90% more energy-efficient than 4G networks, depending on the deployment scenario and the type of traffic being carried**[19]. The rise of IoT can also be disruptive and yet also deliver significant benefits. This growing infrastructure of sensor arrays both accounts for a certain amount of energy consumption itself, yet also enables businesses to optimize their performance across the board to reduce their overall energy use.

This provides a good illustration of the sustainability paradox faced by the telecom and wider connectivity industries. They are responsible for significant energy use as they grow and evolve, yet they also have the capacity to help other businesses reduce their own consumption, thereby delivering net sustainability improvements. Our Task is to make sure that telecom connectivity powered by digitization, cloud technologies, 5G, neutral networks and other concepts can reduce emissions and unlock sustainable opportunities to make a zero-emissions economy. We believe that the telco sector can be a gamechanger for sustainability, shrinking its own, and other industries' carbon footprints.



Towards a more sustainable industry

Sustainability is a term used to help us balance the three key dimensions of Environment, Economy and Society, creating an equilibrium that enables the three to coexist for the long term. By striking a delicate balance between *taking what it needs* and *giving back to the planet*, a sustainable organization can pave the way for a bright and prosperous future that benefits everyone.

It is worth noting here that the so-called "Earth Overshoot Day", the day each year when we collectively use a full 12 months' resources, happens earlier every year. In 2022 this came on July 28th. To improve sustainability performance across every organization we need to foster innovation both in technology and business models, which are, of course, closely related. Business model innovation provides direction and value creation for technology innovation, while technology innovation provides a foundation and sense of direction for business model innovation. Telecom operators need to structure their innovation programs with sustainability in mind.

Main types of carbon emissions by telco

The United Nations sustainable development goals place new responsibilities on all commercial organizations. We are now moving from:

- Scope 1: **Direct emissions from an operator**, such as from running its fleet for network maintenance and using diesel to operate base stations in hard-to-reach areas. **This accounts for around 2% of the total.**
- Scope 2: **Indirect emissions**, such as the electricity use or energy bought for heating and cooling buildings, produced on its behalf. **Accounts for an estimated 26%.**
- Scope 3: **Emissions that are not associated with the operator itself** but which the organization is indirectly responsible for, up and down its value chain. For example, emissions related to the buying of network equipment and those produced by its suppliers, as well as emissions from operator services when subscribers and enterprises make use of them. Scope 3 is often the largest in terms of emissions and the hardest to measure accurately. **This is the largest contributor to the total at 72%.**

The diagram below shows how leading CSPs are managing their costs and how they are attributed to specific actions and causes.

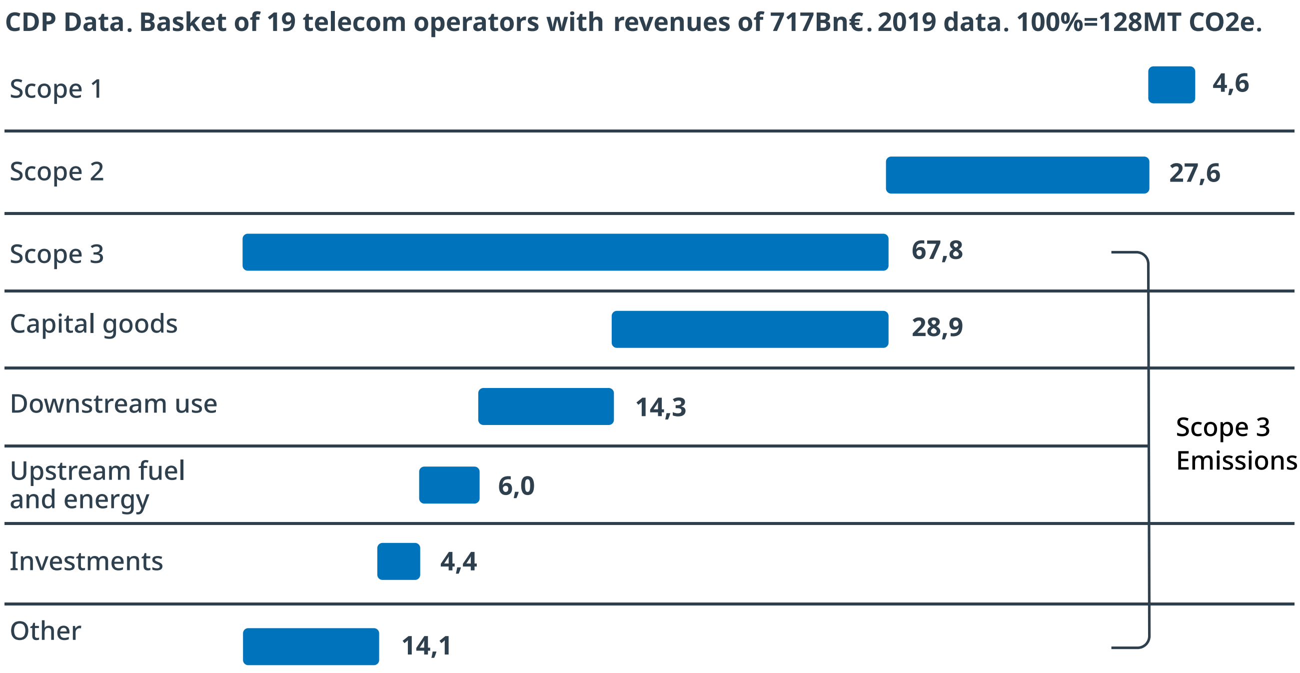


Figure 2. Distribution of carbon emissions across the telecom value chain.

The need to make progress in meeting sustainable development goals encourages telecom operators to optimize operations today and focus on the things they can and should be doing differently in the future. This may involve improving growing power demand through long term investments in sustainable energy and related activities.

Key drivers for sustainability policy

Climate

As climate change leads to rising sea levels and more extreme weather events, so mobile operators' networks are likely to suffer serious damage, and much more frequently. This will lead to service interruptions for customers and greater financial risks for operators. CSPs are already incurring significant losses caused by the need to fix damage resulting from natural disasters, such as flash floods, hurricanes, tornadoes, heat waves and uncontrolled fires.

The diagram below shows the direct correlation between major weather and climate events and numbers of lines and base stations damaged and needing repair in the state of Texas, which provides a useful benchmark for the impact of climate change. Hurricane Katrina, for example, led to a 60% outage across Texas, which was not the epicenter of the event. Other hurricanes and tropical storms, which caused major damage further east (Florida, for example), still led to near 30% outages in Texas. It is assumed that the frequency of such events will increase, and so will the need for greater resilience.

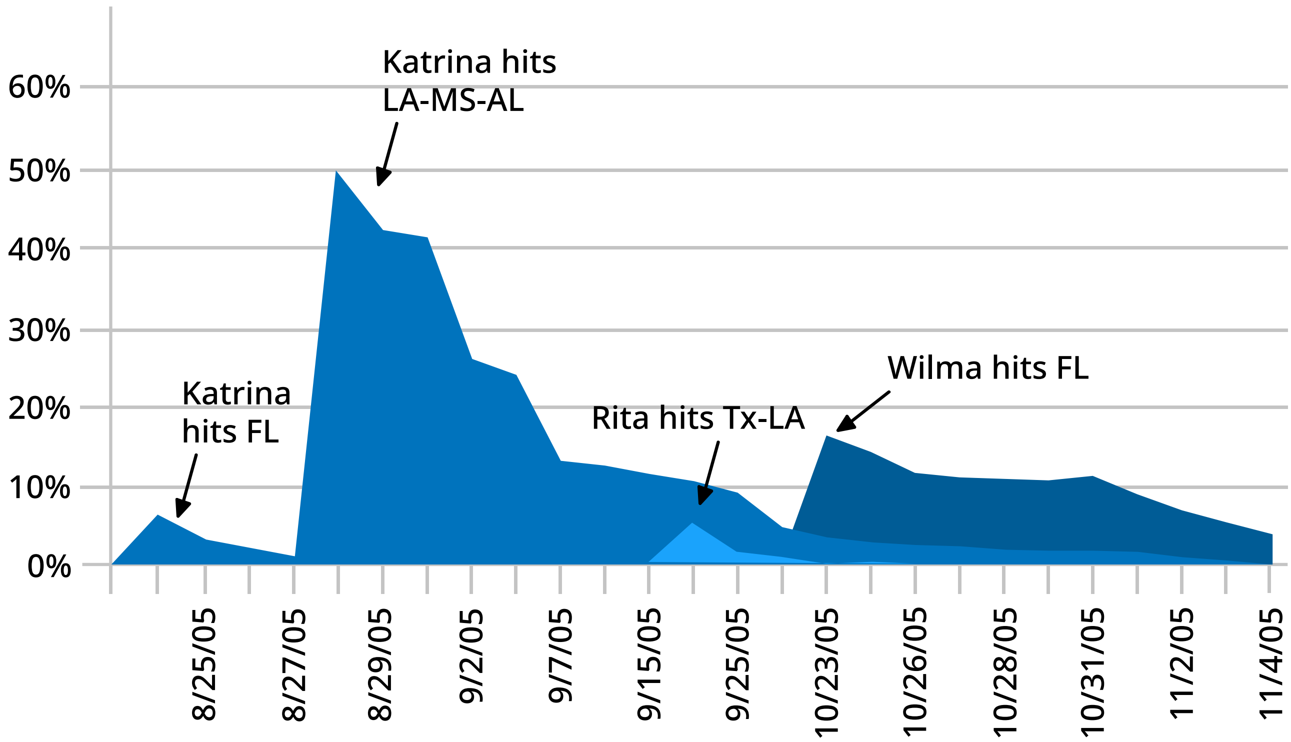


Figure 3. % of wirelines and wireless out of service in Texas (Source: CDP, GSMA Intelligence).

Energy use

The rise of new technologies is fueling apparently insatiable growth in demand for bandwidth and availability. The diagram below shows what exactly this means in terms of energy use.

Energy consumption (%)

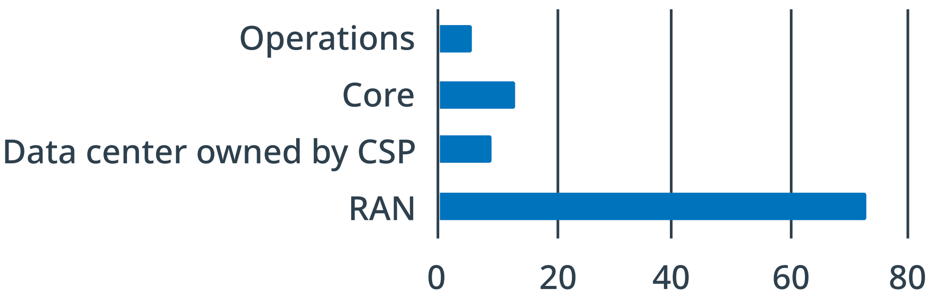


Figure 4. Breakdown of energy by function in a CSP network (Source: CDP, GSMA Intelligence).

Of the energy originally produced in power plants, only 90% "arrives" at the network, so there is already a loss of 10% during energy transmission. Total energy consumption is broken down as follows:

- 73% Radio Access Network (RAN).
- 9% Data centers owned by operators.
- 13% Core.
- 5% Operations.

Of the total amount of energy consumed, 11% is supplied by diesel generators, due to grid electricity being less prevalent in some regions. Even in Europe, however, diesel accounts for 1–6% of consumption and 43% of energy used comes from the grid at the moment.

Electronic waste (e-waste)

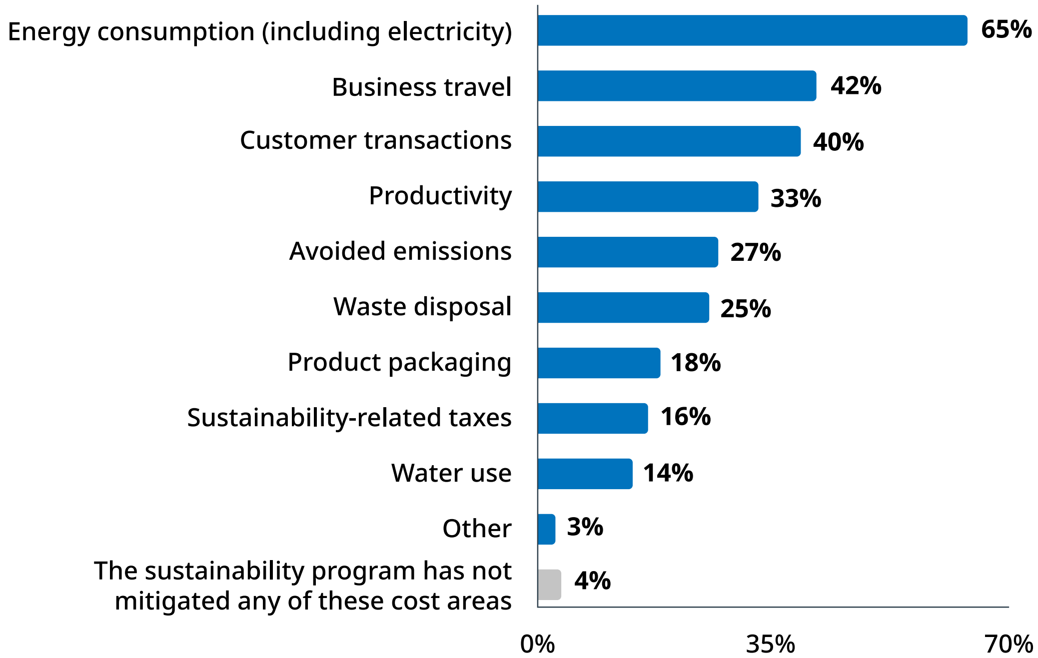
The growth of technology usage, and especially technology that impacts directly on our lives as consumers, leads to a rapid rise in electronic waste. This is becoming extremely damaging to our environment, with 49.8 million metric tons of e-waste collected worldwide as far back as 2018.

A GSMA study shows that 800 kilotons of network equipment are sold each year. That's the equivalent to the weight of around 5,000 Eiffel Towers of electronic equipment discarded in one single year. The trend is relentlessly up and there is no doubt that more recent figures will show further growth.

Action is being taken in many areas to mitigate all these issues, although lack of specific domain expertise and knowledge is causing some difficulties here. The diagram below illustrates these issues. The first shows carbon emissions as a result of daily operational activities. This shows that as data traffic increased by 31% in 2021, electricity costs rose by 5% and carbon emissions by 2%.

At the same time, action is being taken fairly systematically across most large enterprises to apply mitigation. In such cases, the goal is to reduce costs and environmental negative effects by reducing waste, energy use and consequent carbon emissions. These offsetting activities cover most corporate activities, as the table below illustrates:

Top operations-related costs being mitigated through sustainability programs (source: Gartner).



n = 220, All leaders director level and above, excluding "don't know".

Figure 5. Mitigation activities by percentage and function in the telecom sector.

Our vision

Opportunities in sustainability

As the topic of sustainability in the telecommunication industry continues to gain traction, many of our clients and other tech savvy Communication Service Providers (CSPs) and Communication Technology Providers (CTPs) are innovating rapidly. We are now working with many of them to build a roadmap to Net Zero and help them become truly sustainable businesses. We take a three-stage approach in line with the key challenges identified:

1. Reduce carbon emissions.
2. Avoid carbon emissions.
3. Remove pollution and waste.

We do this by enabling **process re-engineering, resource readiness** and implementing **digital technologies** that not only deliver on performance and optimize operational efficiencies, but also reduce overall energy consumption and carbon emissions at the same time. Based on our extensive telecom and IT operations experience, our vision for sustainability covers all aspects of infrastructure operations, including energy management, smart operations, e-waste management and the neutral network model.

Moving the whole mobile industry to net zero emissions by 2050 will require concerted effort and action by all key industry stakeholders.

Vision	Objectives
2022-2025	The short-term analysis period is from 2021 to 2025, which covers the immediate impacts already being experienced and the expected impacts over the next five years. This is also well aligned with the Telco 2025 mission and strategy.
2025-2030	The medium-term analysis period is between 2025 and 2030, which covers the medium-term impacts expected to occur in the future. Medium-term risks are dependent on the scenario chosen and how early action is taken, with significant differences between three temperature increase scenarios on both risks and opportunities.
2030 -	The long-term risk and opportunity analysis period is from 2030 onwards, which covers the longer-term impacts expected under various climate scenarios, with a range of temperature increases from <1.5°C to >3°C under different scenarios. Each scenario has different risks and opportunities over both physical and transitional areas across this time range.

Table 1.

Energy management

The first issue to address here is **direct power consumption**, which can be a serious problem for more remote and rural areas, where delivering power to Base Transceiver Stations (BTS) can be a difficult issue. A BTS is a set of wireless and wired telecommunications equipment that facilitates communication between a mobile user and a public network: they are the most important components of GSM mobile networks.

The antennae installed on these towers are connected to the network via microwave radio, which makes it possible to cover a city-like area with an efficient mobile network. Service quality therefore depends directly on a non-stop power supply. In remote areas, supplying uninterrupted power for a BTS network is not an easy task, largely because they tend to be away from the reach of the power distribution grid. Finding a reliable and economical solution to supply the BTS power installed in rural areas and away from the grid has become a challenge for mobile operators.

Mobile operators often use diesel generators for their power supply, but not only is this very far from a green option, generators have a high start-up failure rate (up to 15%).

New options are urgently needed to connect the equipment and operation support systems via a centralized control center by adapting innovative technologies (Smart Analytics, AI etc.) to manage and control network load, CPU load, heat source and power effectively by taking inputs from both equipment's and Operation Support systems.

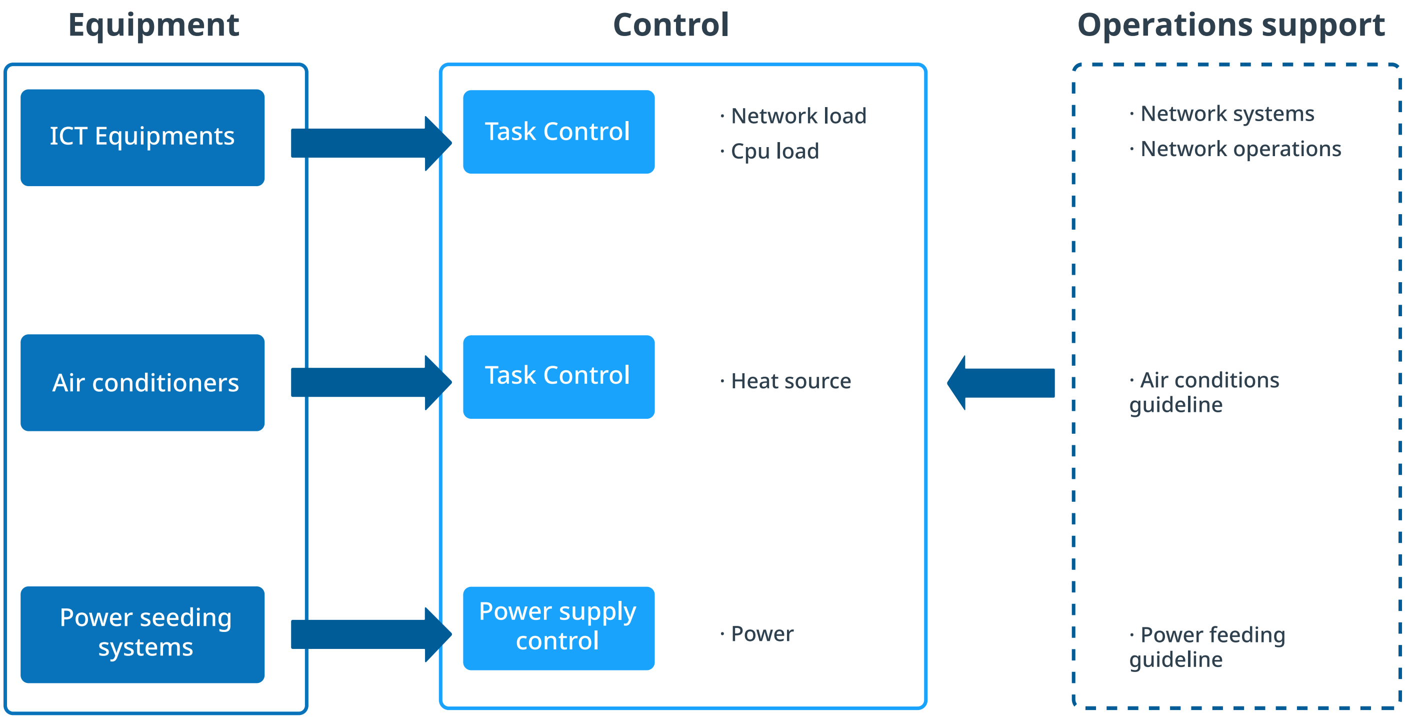


Figure 6. NTT DATA vision towards power management using technology.

We are now working with CSPs of every size to optimize their network design model by implementing lithium-ion batteries, remote intelligent controllers, and green power generation, all monitored in real-time with cloud-based software. This will help them increase renewable energy consumption from self-generation or purchased electricity.

Smart operations

Simply measuring how mobile networks are operating will become an increasing challenge as operators embrace fixed-mobile convergence. Operators are currently in a transition phase, with distinctions between fixed and mobile networks becoming less important as services use a combination of fixed broadband and local access wireless technologies.

Through 5G standards and specification, new innovations are being deployed not only to continue supporting growing data demands, but to help drive down energy consumption. The Radio Access Network (RAN) is a key focus area, as it accounts for most of the total energy consumption in mobile networks.

When examining typical network traffic patterns, several short gaps in data transmissions can be observed, even during highly loaded times. During these gaps, power consumption is reduced by quickly putting components into sleep mode, and only activating them again before the next transmission. Longer gaps mean more components can be put to sleep, further reducing energy consumption.

To help our partners make their operations more sustainable, we propose a three-stage approach:

1. **Gather data insights & generate intelligence**. Collect data from Operation Support System (OSS) network elements to analyze and understand the patterns of availability and capacity of each component, building an accurate picture of future needs.
2. **Transform operations**. Ensure we can:
   - Optimize network performance with no disruption as we deploy 5G.
   - Dynamically shift workloads across multiple clouds and on-premises deployments, with a well-orchestrated ecosystem of Open RAN including technical governance.
   - Use smart network design support to fit in more locations, with ultra-lightweight design, such as Massive Multiple-Input Multiple-Output (MIMO) radios, to make them smaller and more energy efficient.
3. **Maintain and run efficient operations.** We do this by:
   - Generating a more holistic approach to monitor and resolve issues or incidents, implementing energy-saving software to ensure efficient site operations.
   - Use AR and VR-enabled training to resolve maintenance issues from remote locations wherever possible.
   - Provide real-time support for partner onboarding and activation for private network operations.

By supplementing these methods with AI and ML-led solutions, we will help to ensure that operations are more energy efficient, reducing both network energy consumption and carbon emissions.

E-waste management

We increasingly depend on advanced technologies in homes, places of work, on the move-everywhere. The rate of technology advance means that turnover and replacement of our devices is accelerating all the time. This is leading to a rapid and alarming growth in the amount of e-waste, especially in Telecom, and this is becoming a serious liability for CSPs.

By 2030 the amount of global e-waste is projected to hit 74.7 million tons[16].

> "Very little quantitative data is available regarding end-of-life treatment of network. equipment, but estimations for ICT equipment end of life have been made by Ericsson based on their study and these vary hugely by region demonstrated below.
>
> Source: Ericsson

The environmental benefits of keeping these materials flowing inside the economy instead of going to landfill are therefore clear. A study conducted by Shield's, a UK based telco solutions provider with an established focus on sustainability policy, found there is a **lower carbon impact of up to 89%[16]** for reused equipment compared with purchasing new hardware. We need to treat this issue as a priority by:

1. **Creating a circular economy model:** Based on the current state of CSPs' supply chains, Partner Management and Operation support process, we can design a customized model for the Circular economy to suit CSP needs and enable e-waste liability to become a source of additional revenue, as well as reducing OPEX.
2. **Systematic refurbishment:**
   - Creating a recycling mindset, encouraging customers to hand in their old devices.
   - Proactively monitoring devices as they come to the end of their life or simply end of contract.
   - Incentivizing the sale and reuse of refurbished devices.
   - Use refurbished materials in technical support, wherever possible.
   - Closely monitor the practices of vendor partners.
3. **Green disposal:** We recognize that items will need to be disposed of at some point so building a partner ecosystem that includes onboarding, execution, revenue sharing, monitoring and certification, will become essential. These will all be targeted at responsible and non-polluting disposal by segregating as many visible contaminants as possible, such as treated wood, plastic bags and other non-biodegradable materials. This should ensure that waste is treated appropriately for their chemical composition before being re-introduced to the ecosystem.

Our vision is to create a sustainable model to empower the circular economy with optimum utilization of resources, based on their End-of-Life support.

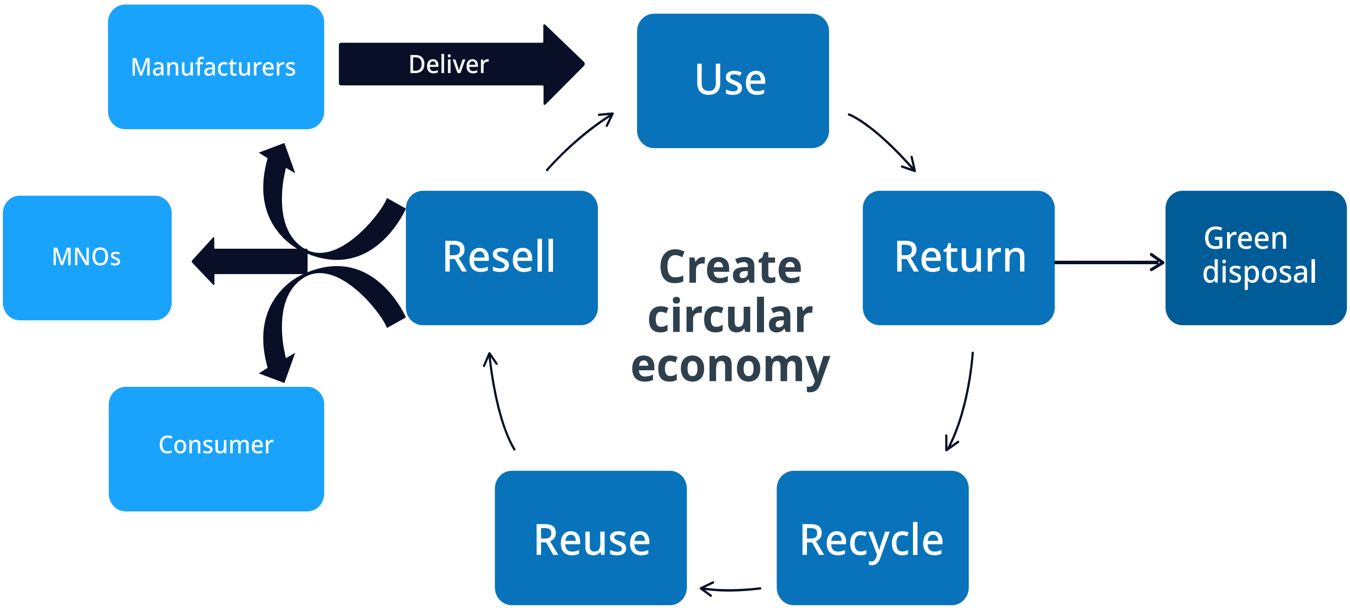


Figure 7. E-waste and circular economy: high-level process depiction.

Neutral network model

Perhaps the most important contribution we can make to achieving rapid decarbonization is by developing and fostering uptake of shared resource usage, through the Neutral Network approach. The first stage is to develop a shared infrastructure, which has been an operator-led initiative in most markets, although regulators are also very much involved now in encouraging uptake of this approach.

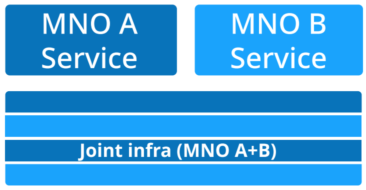
Tower sharing makes it unnecessary to build multiple towers on the same cell sites, reducing the environmental and visual impact of operator networks, especially in urban and ecologically sensitive areas. **Tower sharing also helps in driving competition because it reduces the entry level costs for new operators.**

More importantly, from a regulatory perspective the pooling of tower infrastructure helps operators expand into rural markets to increase coverage, while ensuring that operators do not incur significant CapEx. Tower sharing is a win-win for operators, regulators and society as a whole. It reduces cost duplication, cuts energy use and carbon emissions, while improving and extending network coverage, especially into areas that have previously been hard to reach.

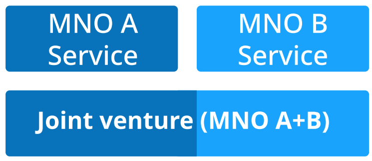
Shared infrastructure is not just about towers. To provide effective indoor coverage for subscribers, every room or unit of space in a building will need to have a deployed and wired cell in place. Wiring for multiple operators adds to complexity for the building owners and also increases costs for mobile operators. A shared approach to building and campus networks will enable faster network roll-out while providing a more cost efficient, sustainable solution.

The options for Neutral Network building can be summarized in the following models:

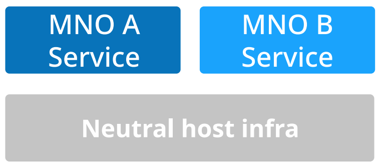
1. **Selective tower sharing.** The first type of infrastructure sharing agreement is unilateral service provisioning, where ownership of infrastructure remains separate (each company owns its own network) and only one of the participating companies provides its infrastructure to be shared.



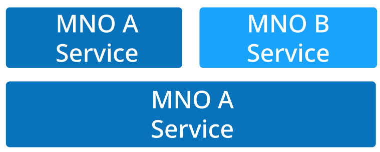
2. **Sharing separate tower assets:** Mutual service provisioning is like unilateral service provisioning except that two or more of the participating companies provide their infrastructure to be shared.



3. **Full sharing of resources:** A joint venture is where companies in the agreement form a joint venture to own and operate the networks, which means that the shared infrastructure is consolidated, owned, and operated by the joint venture (but the companies do not directly own the infrastructure).



4. **Neutral host:** 3rd party service provider is where a company, not necessarily affiliated with a mobile operator, leases infrastructure to mobile operators for use.



5. **Centralized QoS management:** Joint KPIs and SLAs, with proactive contract management and renewals.
6. **Centralized regulatory and compliance management:**
   - Collaborative policy creation & mapping.
   - Real-time notifications and survey reports for advance intelligence.
   - Effective change monitoring & triage.
   - Centralized advice request and publishing.
7. **Shared services:** This can potentially bring service agility and cloud–scale economics, enabling smaller vendors and operators to introduce their own services or customize the network to suit their own unique needs. We do this by enabling a competitive and vibrant supplier ecosystem with open interfaces, open-source software with standardized southbound interfaces, and AI-optimized closed-loop automation.

Partner shared services are multi-dimensional and may cover:

- Collaboration with Telecom Infra Project (TIP) and O-RAN alliances.
- Design and develop interfaces for Interoperability between different RAN hardware and software.
- Focus on new open transport network based on shared architecture.
- Implement centralized Service Management and Orchastration (SMO) for onboarding and activations.
- Set up shared monitoring & operation centers.

This approach reduces operator costs, improves sustainability performance, enables subscribers to receive better and faster service, improves network coverage and helps regulators to carry our more robust and controlled audits and security management.

Suggested use cases across Telecom value chain

Sustainability-related use cases are growing all the time, and below we briefly describe just a few of these. We believe the telecom sector has a special part to play in enhanced sustainability performance for enterprises and society at large. Digitization and connectivity are key instruments for dealing with the environmental challenges affecting society at large: climate change, water shortages, circular economy, pollution and loss of biodiversity.

NTT DATA is committed to reducing its own carbon footprint, but we also offer solutions to reduce our customers' emissions across the value chain.

Use case 1: AI-powered energy management for networks

Our estimates indicate the cost of the energy required to power networks represents between 10-30% of the network operating expenses of a communication service provider (CSP), depending on the specifics of its local energy market. In total, this expenditure adds up to approximately 25 billion USD per year[1].

Our research indicates that additional energy efficiency gains can be achieved by using ML techniques that enable higher levels of automation.

All the data used in our work on the energy recommendation engine was collected from a live network. We primarily used Performance Management (PM) and Configuration Management (CM) data as measured in the base station, where energy measurements are already part of the collected dataset within the PM. As a result, there is no need to deploy new hardware to get the data. The radio network performance counter data sets contain observations on cell performance such as the activity count in Downlink (DL) and Uplink (UL) directions, and the utilization in the cell and units. Key KPIs considered are:

- Number of connection attempts to a cell.
- Average number of users in a cell.
- Throughput.
- Latency.
- Interference.

The CM data set that we used consists of hundreds of configuration attributes of the sector, including the settings of each radio cell (such as frequency in DL and UL directions) and installed hardware types. We used this information to be able to recommend multiple configuration changes at once, rather than focusing on one at a time.

The output of the energy recommendation engine consists of a set of configuration attribute changes for a corresponding node. The output captures the interplay between different nodes and configurations rather than focusing on isolated fine tuning on a per-node level, which may have an effect on other nodes.

Our approach delivers:

1. Process re-engineering

- Identify process bottlenecks, generate process maps through process intelligence.
- Map all field service productivity & resolution rates to process & volume drivers, along with impact & KPIs.

2. AI/ML Predictive validation

- Process standardization by AI.
- Analyze and anticipate changing traffic volumes in the sites and cells of a RAN — to determine when radio resources can be powered down to reduce energy consumption.
- Coordinate across multiple neighbouring cells to achieve the best overall power savings within a coverage area.

Example: In cases of cross coverage, one cell could be turned off completely at times of low traffic as long as the area is sufficiently served by adjacent cells.

Proposed benefits:

- No impact on network performance while dynamically shutting down network resources.
- Minimizes all kinds of energy waste across active radio and auxiliary equipment.
- Reduces cost of operations by 15%.
- Up to 30% energy savings and less CO_2 emission for telco radio networks.

To increase the efficacy of our energy recommendation engine explained above, we enhanced its ability to improve energy efficiency by applying recommendations in radio signal interference detection and power supply unit load utilization:

- **Radio signal interference detection:** Current radio equipment is designed to handle interference in a way that avoids unwanted emissions, while variable techniques are used to limit the interference in the network. Yet despite this strong focus, radio signal interference has proven to be a formidable challenge to overcome completely.
  - Detect energy efficient nodes.
  - Non energy efficient nodes.
    - With high interference.
    - With low interference.
  - Other nodes.

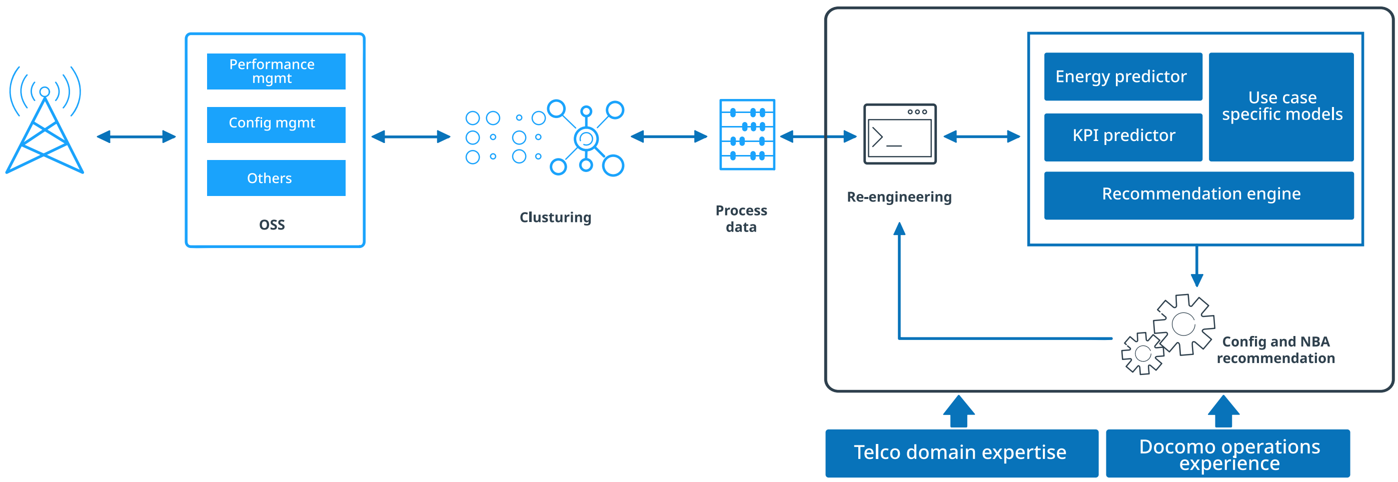


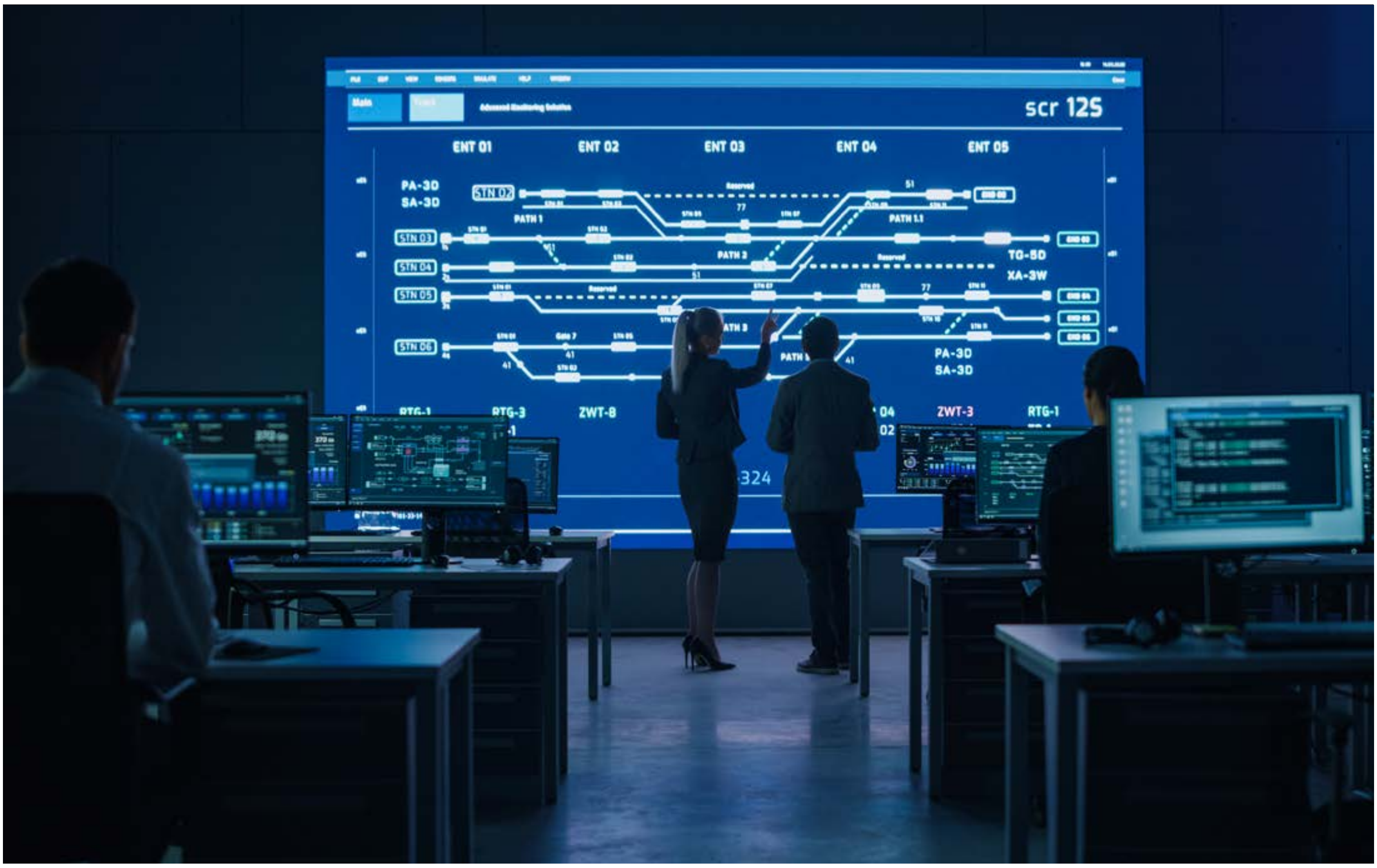
Figure 8. Solution architecture: Top level view.

By modeling the network traffic load, consumed energy and interference-related KPIs, we can save energy by recommending action on the interference cells (such as locking them) to avoid the high energy consumption state. The cell interference parameters are therefore unique and connected to the network activity and consumed energy.

- **Power Supply Unit (PSU) load utilization:** A radio base station consists of several PSUs supplying power to the radio units. Active but underutilized PSUs may not be working efficiently within the operational range of the unit and may consume more power than necessary due to power dissipation. It should be noted that PSU efficiency depends on the load. To identify nodes for PSU load utilization improvement, we clustered them according to:
  - The PSU load.
  - The number of PSUs.
  - Relation to the radio network activity (such as the relative radio resource usage).
  - The number of active users.
  - PRB utilization and the number of connected users.

We focused on PSUs with less than 50% utilization. Our research shows it is possible to propose dynamic power supply control, such as putting underutilized PSUs in sleep mode or turning them off.

PSU efficiency is highly dependent on the load that is applied on the PSU output. Setting one of several PSUs in a system to sleep mode enables savings of 1%. At the same time, the improved utilization and operational efficiency of the PSUs that remain active can provide an additional 1% in savings.



Use case 2: Intelligent Multidimensional Service Provisioning

At present, Telecom enterprises are far from being able to provide the kind of highly customized services increasingly demanded by users, which is an obstacle to sustainable growth.

In response to this problem, we propose a new form of Intelligent Multidimensional Service Provision to meet users' customization requirements, named Multidimensional Customization of Telecom Services for Each User. Under this model, each user can customize the service in multiple performance dimensions according to their specific requirements, and the telecom enterprises will provide services according to each user's customized details.

This new mode will bring better service experience and satisfaction to users, while it will also help the telecom industry extend its value chain through growing integration with other industries.

Due to the diversified requirements of different fields, a refined and on-demand customization mode is of great significance for expanding the types and quantity of telecom services and bringing better development opportunities.

The diagram below shows how on demand customization works:

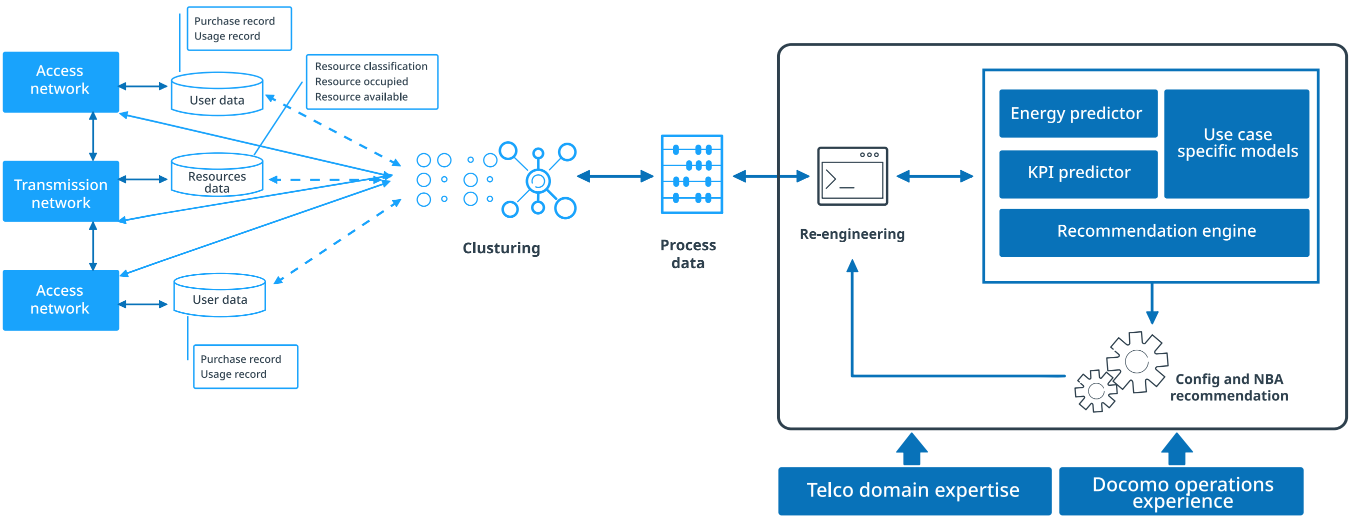


Figure 9. Intelligent Multidimensional Service Provisioning: On-demand solution model.

The key functions of the core modules are:

- The intelligent control module ensures automatic processing of service customization;
- The access network module has strong capability for integrated service access, for either wireline services or wireless services;
- The user data repository module collects all the historical and real-time data of users as well as network resources to provide data for intelligent service processing;
- The transmission network module carries service connections and transfers user data.

The following example describes a typical service customization process supposing a telecom user A wants to customize a VR game service:

1. User A sends the service customization request to the intelligent control platform through the access network;
2. Referring to user data and network resource data, the intelligent control platform interacts with user A to confirm the details and price of the customization until an agreement is reached;
3. After the agreement, user A pays for the service, and the platform generates strategies of service connection according to the user's customized content;
4. Under the control of the intelligent control platform, with the participation of network slicing technology, the system allocates network resources and sets up traffic connections;
5. User A starts to use the VR game service customized under the intelligent process.

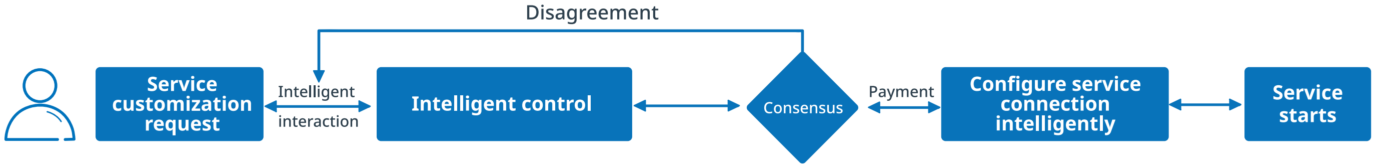
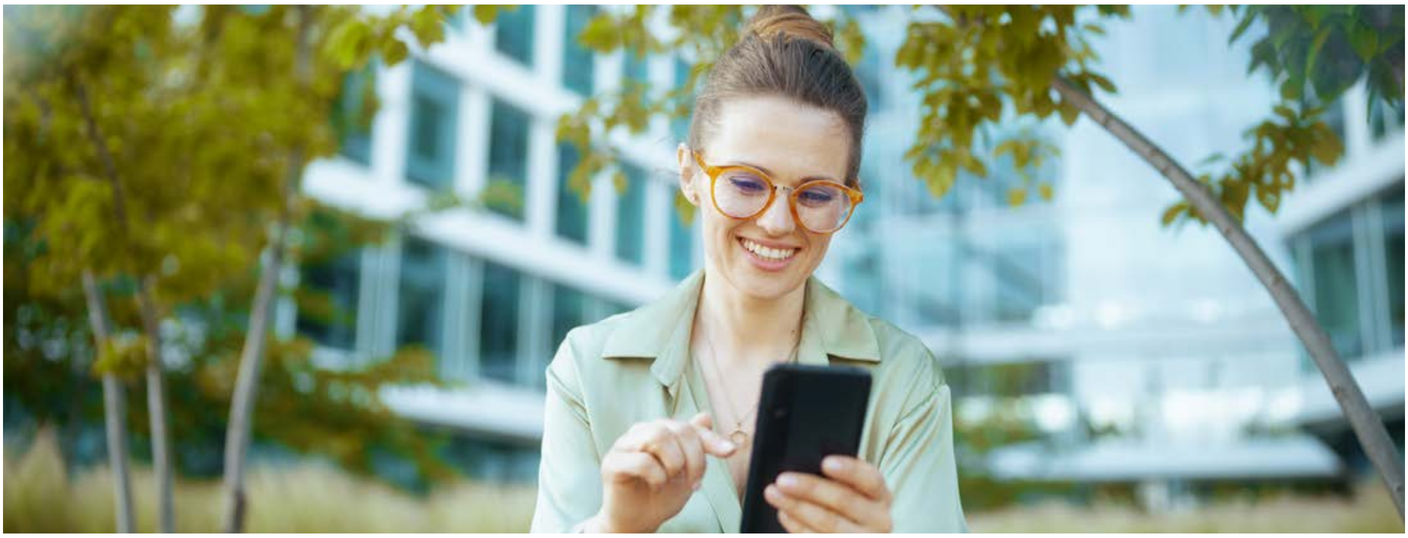


Figure 10. Flow diagram for on-demand service.

The more customization dimensions there are, the lower the blocking rate, meaning greater the utilization of network resources and users held in the same network. With our proposed solution the utilization of network resources can be improved to a greater extent and more users can be offered customization. This intelligent service provision mode is strongly beneficial to sustainable development of the telecom industry, from both a user and provider viewpoint.

Compared with the traditional service provision mode, the intelligent service mode proposed in this paper will only increase the data flow of service customization and service control in the network and the energy consumption of the related equipment. Moreover, with the help of intelligent service processes, related activities in the telecom service customization process will be greatly reduced. Overall, if this new model can be implemented on a large scale, it will be beneficial for reducing carbon emissions and will have a positive impact on environmental sustainability.



Use case 3: Circular economy (e-waste management)

There is a strong business case for telcos adopting circularity strategies within their daily operations. Recent research estimates the value of recycled hardware to the telco industry will lie between $45-$80bn annually by 2030[16], and that $20-$30bn can be generated through resale of infrastructure and waste mitigation in infrastructure installation, while $15 to $20bn could be earned by selling devices as a service and refurbished.

With this analysis in mind we propose a CSP Circular Economy approach for e-waste generated from infrastructure, devices, and other equipment.

1. **Internal asset marketplace:** The creation will enable CSPs to repurpose the stocks of decomissioned hardware (antennae), other retired equipment and re-usable refurbished items.
2. **Systemic refurbishment:**
   - Use refurbished materials in technical support and repair scenarios.
   - Incentivizing the sale and reuse of refurbished devices.
   - Closely monitor and manage the practices of vendor partners.
3. **Seamless supply chain management:**
   - Model to design the stock in, stock out and transfer inventory solution for:
     - Re-used stocks.
     - Re-cycled stocks.
     - Waste stocks.
   - Auto reconciliation for inventory stocks.
   - Create an incentive model for vendors to generate more reusable and recyclable materials.
   - Co-relation model for repair (fixed and repeated) issues using analytics.
4. **Re-imagine partnership:** Model to create or renegotiate commercial relationships commercial relationships for reselling recyclable items to manufacturers and partners.
5. **Smart analytics:** Define use case models for hardware durability validation and proactive rating of devices based on such factors as reusable materials, recyclable materials, life cycle support, points of failure and other related matters.

The reuse and recycle model are shown in the diagram below:

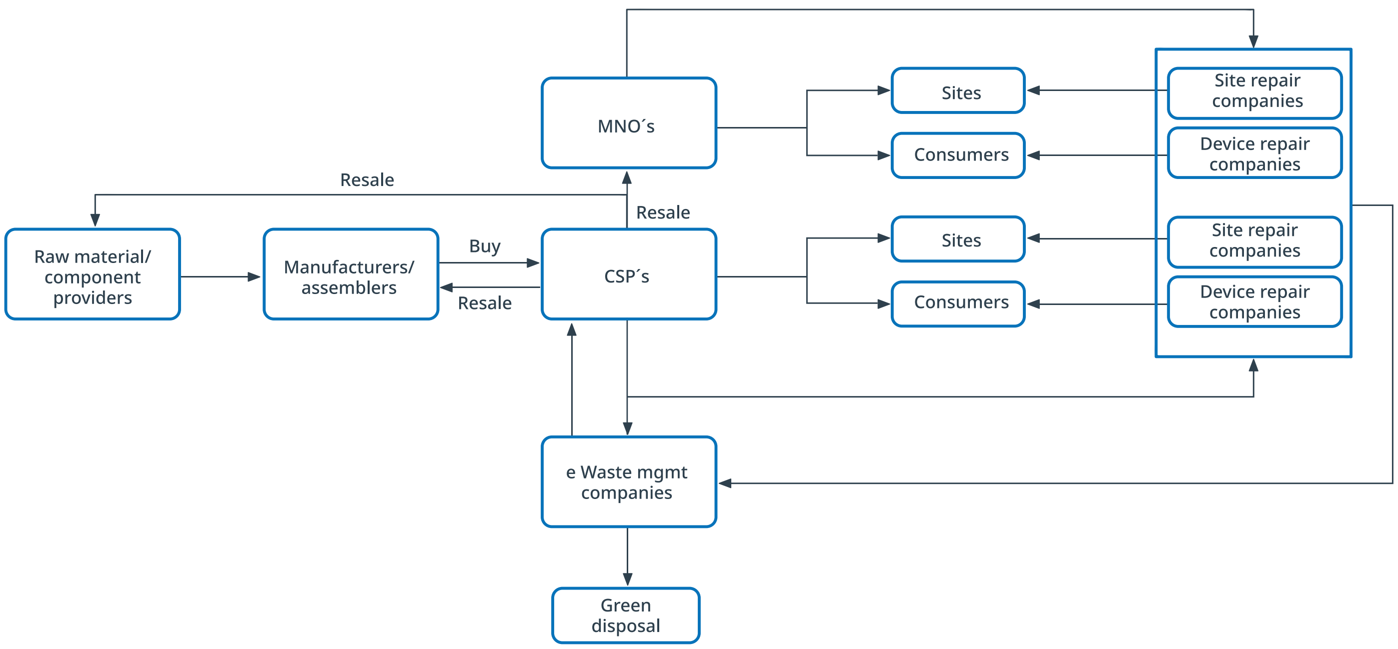


Figure 11. Flow of materials through their lifecycle, from manufacture to use, retirement, reuse and recycle wherever possible.

Our current value proposition in sustainability development

NTT DATA has set up a dedicated cross industry unit as **"Green Services Green Deal & Sustainable Engineering Business Unit"** to maximize company value through provision of end-to-end sustainability services by leveraging our established cross domain digital and partner ecosystems.

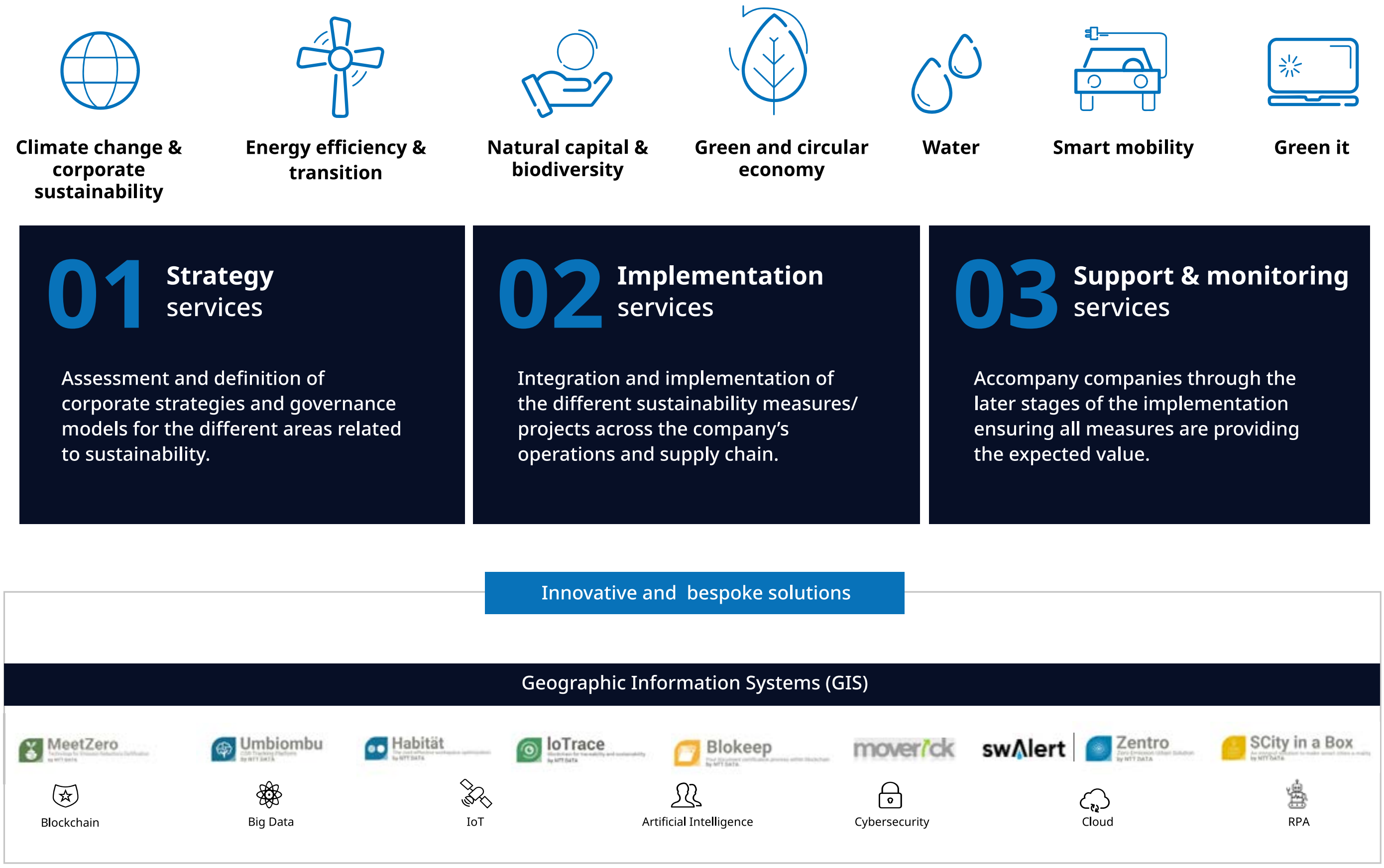


Figure 12. NTT DATA Green Services Green Deal & Sustainable Engineering Business Unit.

We are now driving multiple use cases across climate change & corporate sustainability, energy efficiency & transition, natural capital & biodiversity, green and circular economy, water, smart mobility and green IT.

Below are our few dedicated telecom use cases and the outcomes delivered:

NTT DATA Capability	Features	Outcomes
Advanced monitoring IoT & energy cost savings	• Alarm transmission and current monitoring. • Energy consumption monitoring. • Site temperature monitoring and control. • Equipment temperature control. • Network Infrastructure. • Security and integrity. • Transmission of alarms and information after connectivity problem.	More efficient system that not only generates savings but also the improves cost predictability, which implies a model of sustainable growth with 10-15% cost savings.
Smart operations - Technical assistant	• Network management needs continuous, real-time knowledge of the entire network infrastructure. Operators need to adopt new technologies to optimize O&M activities and reduce maintenance costs. • Smart Operations IoT & XR assets that support an operating model of new generation with the goal of Self-operations.	• Reduce the number of site visits. • More efficient on-site interventions. • Ensure integrity and correct operability. • Complete control and audit of assets. • Optimization of energy consumption times.
Deployment strategy – NETCos	• Reducing number of deployments and operational duplication. • Focusing on improved operational efficiency, enabling MNOs to give more attention to services.	• + 10,000 rural villages with no 4G coverage, while +500 villages had no network coverage at all in France, 2018. • + 200 towers have been built along transportation axes and other network white spots, so supporting MNOs in filling this gap. • Upgrade to 5G coverage in the future is expected at these sites.
Network technology – Open RAN & cloudification	• Flexible and scalable radio access networks. • Expands opportunities for new vendors to enter the base station market, which will revitalize the market. • Allows vendors to focus on their core strengths. • RAN disaggregation enables a more software-centric approach to RAN leveraging. virtualization and cloudification, which brings higher utilization rate as resources are shared between multiple businesses, with higher equipment refreshment frequency.	• Accelerate wide adoption of Open RAN and enable flexible 5G network deployment. • Develop best of breed vRAN products with higher flexibility and scalability to drive Open RAN commercialization.
Deployment & operations strategy - Autonomous network	• Drive revenues from the B2B market by commercializing attractive digital services, leveraging 5G Network Slicing. • Enable optimized Open RAN Network sharing scenario with NaaS operators. • Guarantee QoS level requirement of 5G Network Slices by automation and self-healing. • Expand the FTTH coverage in rural and low-density areas leveraging network sharing with NaaS operators and using open and disaggregated broadband access nodes.	• 5G slicing-a-Service for B2B2X over. • Convergent cloud central offices. • AI automation solution. • Other NW automation cases.

Table 2.

Why choose NTT DATA

NTT DATA combines the capabilities and experience of a global telecommunication and mobile network provider, with an exceptional pedigree as IT service provider, specialist applications developer and industry subject matter expert. We bring together all the skills needed, therefore, to build and evolve the advanced networking solutions that enterprises of every size and in every market require.

We are proven innovators, and the NTT Group has an annual R&D budget of around 3.6 billion USD, while NTT DATA is a leading proponent and support of Open Standards, placing us in a leadership position for concepts built on collaborative working, co-creation and joint innovation. We are developing 5G based solutions to support our own operations as a global enterprise, so even the most advanced concepts we take to market are mature and proven to add value. As a strong commercial player, with decades long commitment to the telephony and mobility markets, we are a natural go to market partner for any telco determined to move up the value chain and become an essential service provider to ambitious enterprises, today and into the future.

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