GSMA

Strategy Paper for Circular Economy:

Network equipment

Acknowledgments

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AT&T, América Móvil, Bell, BT, Elisa, KPN, MTN, MTS, Orange, Proximus, Rogers, stc, Tele2, Telefónica, Telenor Group, Telia Company, Telstra, TIM, T-Mobile, Verizon, Vodafone

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Contents

Endorsements from the industry

Gabrielle Ginér
Head of Environmental Sustainability, BT

At BT, we are working towards our products, networks and operations becoming circular by 2030. We support the approach in this paper and recognise the need to collaborate across the ICT industry to address the rising e-waste challenge. We can achieve this by working together to create products, networks and operations based on the circular economy model including the redesign, re-use and recycling of devices, hardware and their packaging.

Katie Schindall
Head of Circular Economy, Cisco Systems

Advancing a circular economy is critical both to preserving limited natural resources and to meeting our goal to achieve net-zero carbon emissions by 2040. We must eliminate the concept of waste and drive business models powered by digital technology — transforming our own business and more importantly also supporting others who are looking to achieve their own circular economy and sustainability commitments. We are working to integrate circular principles at every stage of the product lifecycle: from how we design our products through to how we facilitate their return and reuse.

Melanie Kubin-Hardewig
Vice President Group Sustainability Management, Deutsche Telekom AG

The circular economy and circular business models play a major role in DT´s drive to becoming fully climate neutral (incl. Scope 3 emissions) by 2040 and to support our zero-e-waste strategy. Leasing, refurbishing, and reusing existing equipment and devices not only makes sense from a purely economic point of view but also substantially reduce the environmental impact in terms of manufacturing, use of raw materials and waste disposal. As roughly 50% of our Scope 3 emissions are supply chain related we have amended our procurement policy to better assess, rate, and decide on circular aspects when making purchasing and design decisions and continue working with manufacturers and OEMs towards more circular products, packaging and offerings.

Pia Tanskanen
Head of Environment, Nokia

Collaboration is essential if we are to reach the world's sustainability goals. Working across the value chain is key to moving the needle quickly on circular practices and climate change. Nokia has more than 25 years of implementing well-established circular practices to reduce waste, increase reuse and recycling and refurbishing for new use. Nokia continues to contribute to telecommunication-specific circular economy standards in the ITU-T (International Telecommunication Union Telecommunication standardization sector) and ETSI (European Telecommunications Standards Institute).

Ramon Fernandez

Executive Director Finance, Performance and Development, Orange

An exemplary social and environmental track record is an essential factor in supporting sustainable value creation. As part of Orange's commitment to achieving carbon neutrality by 2040, we are striving to transition our infrastructure procurement policy towards a circular economy model. Reusing or reconditioning equipment enables Orange to combine economic performance and sustainable development by reducing CO_2 emissions related to the manufacturing of new equipment and by contributing to improved operational efficiency for the benefit of our customers worldwide.

Maha Alnuhait

Sustainability GM, stc

Telecom operators and the ICT sector at large play a key role in the move towards digital technology and low-carbon economies. As part of stc's commitment towards carbon neutrality by 2050, circularity should become the backbone of asset management, as one of the key principles of the basic circular economy is to keep assets in use longer, therefore reducing the extraction of new raw materials needed and minimise e-waste potential and the associated of CO_2 emissions.

Enrique Blanco

Chief Technology & Information Officer (CTIO), Telefónica S.A

Circular economy enables our networks to operate in a more efficient way. From design to recovery and reuse of equipment, it provides both economic and environmental benefits. It allows CAPEX avoidance through reuse, savings from the purchase of used equipment and additional revenues from sales, all improving the profitability of our networks. Furthermore, circular economy leads to several environmental benefits, including CO_2 emissions savings, which helps us towards our goal of net-zero emissions by 2040, including our entire value chain.

Sara Nordbrand

Head of Group Sustainability, Telia Company

When looking at the industry that Telia Company belongs to through a circular economy lens, it is clear we are both part of the problem and the solution. The connectivity and digital solutions we provide are already enabling societies to tackle many of today's environmental challenges and digitalisation can speed up the transformation from a linear to a circular economy. Simultaneously, we need to forcefully address our own negative environmental impact. Global e-waste flows and greenhouse gas emissions are the most important environmental aspects for our industry to address the coming years.

Executive Summary

The benefits of circular economy and its necessity are undeniable. More than ever, the planet and its people need to reduce resource use and move to more sustainable business models. This also applies to the telecommunications industry and its network equipment. With rapid technological changes and accompanying customer behaviours, lifecycles are shortened, resulting in greater production and increasing waste.

While the industry is already practising circular economy with mostly separate initiatives, this strategy paper outlines opportunities to create a global and unified vision for the whole ecosystem. This will encompass operators, suppliers, policymakers and civil society organisations.

Four challenges have been identified to achieve greater circularity and realise Triple Bottom Line benefits to people, planet and prosperity.

1 **Reducing waste products, components and critical raw materials:** Greater recycling of components and raw materials into remanufacturing processes is essential. Eco design principles as well as proper documentation and regulation to increase reliability are good first steps to lower impact.

2 **Optimising the sourcing, reusing and repurposing of existing network equipment:** current market fragmentation has to be reduced to create a global second-hand market on a larger scale. Many barriers still exist, one of them being a lack of cooperation mode for value and revenue for all.

3 **Harmonising the methods of evaluation to generate a common understanding:** an integrated approach must be agreed upon with unified environmental metrics and recognised benchmark method for universal comparison.

4 **Redesigning the supply chain around the circular principles:** to ensure full support and implementation, a new circular business model with a stronger business case needs to emerge. Contractual, regulatory and design barriers could be re-engineered to become incentives.

This strategy paper is intended to be the start of a discussion about these recommendations across the industry. The next steps will be to agree a way forward and a timeline, and identifying how we can progress towards greater circularity.

Despite the many challenges, progress can be made with these nine key recommendations:

1. Keep current equipment in active use longer
2. Share network infrastructure
3. Develop awareness on circular economy across the industry
4. Give refurbished the same consideration as new in business proposals
5. Create common KPI metrics and guidelines
6. Rethink the business relationship to support reuse
7. Improve the regulatory ecosystem in favour of circular operations
8. Create and interconnect marketplaces
9. Ensure energy efficiency is a priority in network equipment

Purpose of the document

This strategy paper analyses how the network equipment used within the telecommunications ecosystem can evolve towards a circular business model. This will involve co-operation with stakeholders along the whole of the value chain, beginning with changing perceptions of what is considered waste.

The shift towards greater circularity aims to reduce environmental impacts, while realising social and economic benefits at the same time.

The following chapters will explore impacts and opportunities, showcase examples of successfully implemented projects that could be scaled up, and provide recommendations on how to move forward through engagement with mobile network operators, network equipment suppliers, industry organisations, policymakers, civil society organisations and other relevant stakeholders.

Introduction

To reduce our impact on the environment, humanity must move towards a sustainable way of living where we live within the constraints of planet Earth.

Currently, humanity is using the equivalent of 1.75 Earths to provide the resources we use and to absorb our waste[1]. This means it takes the Earth one year and eight months to regenerate what we use in a year. At this rate, we will deplete the Earth's natural resources, resulting in massive biodiversity loss globally and future generations experiencing a lower quality of life.

The shift towards sustainability requires all sectors of the economy to examine how they are using resources. This is particularly important for sectors that are growing, such as the ICT sector. As part of the ICT sector, telecommunications play a vital role in our increasingly connected world. Technologies connect people around the planet and the internet of things continues to grow, offering significant benefits as we better measure, monitor and manage our economy.

1.75 **Earths needed to provide the resources we use and to absorb our waste**

Research published by the GSMA for COP26 in Glasgow, based on Carbon Trust modelling, showed that mobile connectivity can enable up to 40% of the required carbon reductions needed by 2030 in four key sectors: buildings, energy, transport and manufacturing. Telecommunications can therefore play a vital role in helping limit global heating to 1.5°C. But our sector also has an impact on the environment, and there is a risk this will grow significantly with more connected services being used.

40%

carbon reduction that connectivity can enable by 2030 in key sectors

1.5°C

the maximum temperature increase to limit catastrophic climate change

1 www.footprintnetwork.org/our-work/ecological-footprint

Photo sharing, video calling, online gaming and live streaming are just a few of the connected behaviours that have become ubiquitous over the last decade. Behind such actions, there is a hidden matrix of billions of pieces of equipment: servers, cables, antennas, boxes, data centres, smartphones, personal computers, captors, sensors and cameras. This is becoming the largest infrastructure ever built by humanity, with the associated environmental impacts.

The mobile industry made a significant first step in addressing these environmental impacts in 2019 when the Board of the GSMA, representing the largest mobile companies globally, agreed on an ambition to move the mobile industry to net-zero carbon emissions by 2050 at the latest. Since then, the majority of the industry by revenue has committed to carbon reduction targets in line with this commitment.

2050 **the target for zero carbon emissions**

As most emissions of the mobile industry lie upstream in its supply chain, it is important to address the issue of resource re-use with suppliers of network equipment. The majority of emissions throughout the whole mobile sector value chain are from energy use and associated carbon emissions. Mobile network operators and suppliers are making significant investments in renewable electricity to reduce these impacts, but carbon emissions are not the only important metric and, as an industry, we must consider raw material extraction and other environmental pollutants that are generated.

estimated kilotonnes of network equipment are sold each year

There are clear benefits to bringing more people online and there are active efforts in almost every country to close the 'digital divide'. Connectivity improves the livelihoods of billions of people, but it will also require more resources to be used for the infrastructure to enable this. It is estimated that at least 800 kilotonnes of network equipment are sold each year[2] including mobile base stations, fixed access equipment and IP data transmission and core network equipment.

The focus of this strategy paper is on this network equipment that is specific to telecommunications and forms the infrastructure that creates connectivity. For details of the equipment, please see the 'Scope' section. More sustainable network equipment will mean moving towards a more circular economy business model, which is defined in the next section.

This is not to suggest that network equipment is the only resource use by the industry. Our industry uses many different materials and products, the most visible and common of which are mobile devices. Improving the circularity of mobile devices will be considered as part of a separate strategy paper to be published later.

A new path to better serve customers, generate profit and provide long-term sustainability with low impacts on the planet must be defined: this strategy paper proposes using circular economy principles as the framework.

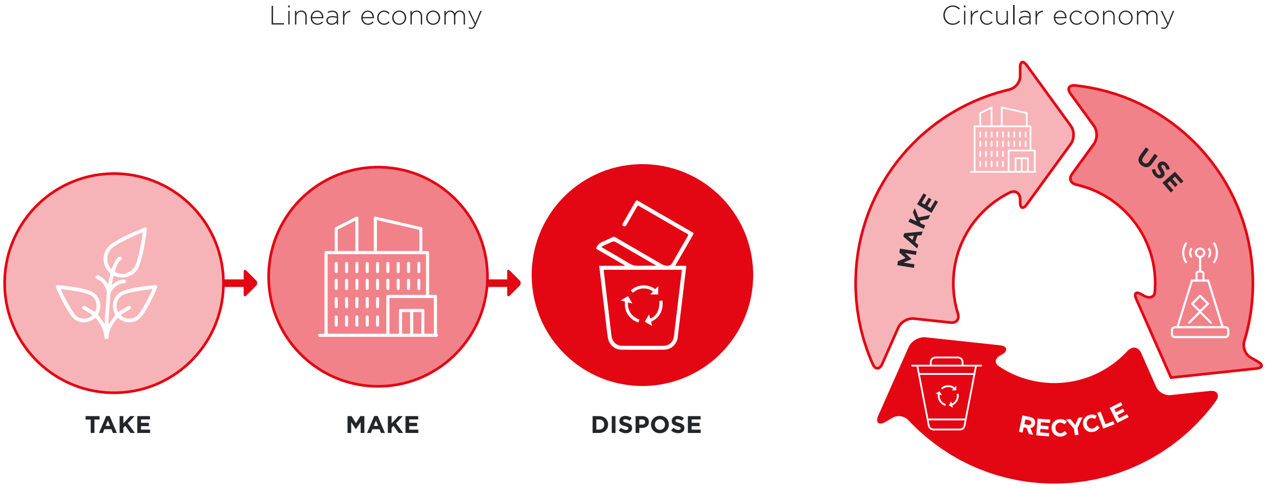
2 https://easychair.org/publications/paper/XvgV

What is a circular economy?

Currently, the global economy, including the ICT sector, is only 8.6% circular[3] – this means less than 10% of the material used in a year is recycled or reused in some way. In contrast, 91.4% of economic activity follows a linear approach to products: raw materials are extracted, products manufactured, customers use the products and then they are discarded with limited reuse and recycling. As discussed in the introduction, this is creating a significant strain on the planet as humanity's demand for goods increases and the planet's ability to provide us with raw materials decreases.

In response to this existential threat, the concept of a circular economy is a transformative model to reutilise products, parts, components and materials in successive production cycles to reduce waste and pollution. It seeks to change the way humanity looks at the goods we use so that nothing becomes waste; everything is seen to retain some value. The inspiration for the concept of the circular economy is from the natural world where living things are created, grow, decline and die, and then their remains are used as food for other organisms.

Figure 1 **Linear and circular economies**



3 www.circularity-gap.world/updates-collection/circle-economy-launches-cgr2020-in-davos

The benefits of this can be huge. Using recycled aluminium saves 90% of energy compared to using virgin aluminium and 54% of the cast aluminium parts used in Nokia products in 2020 have recycled content in them. But currently, telecom network equipment, in general, follows the linear economy. This means there is value that is being unnecessarily destroyed with current business models. By making product, material and energy use become more circular, there is significant potential to both retain this value, as well as enhance it through Triple Bottom Line thinking:

PEOPLE

The positive and negative impact an organisation has on its most important stakeholders. These include employees, families, customers, suppliers, communities and any other person influencing or being affected by the organisation.

PLANET

The positive and negative impact an organisation has on its natural environment. This includes reducing its carbon footprint, usage of natural resources, toxic materials and so on, but also the active removal of waste, reforestation and restoration of natural harm done.

PROSPERITY

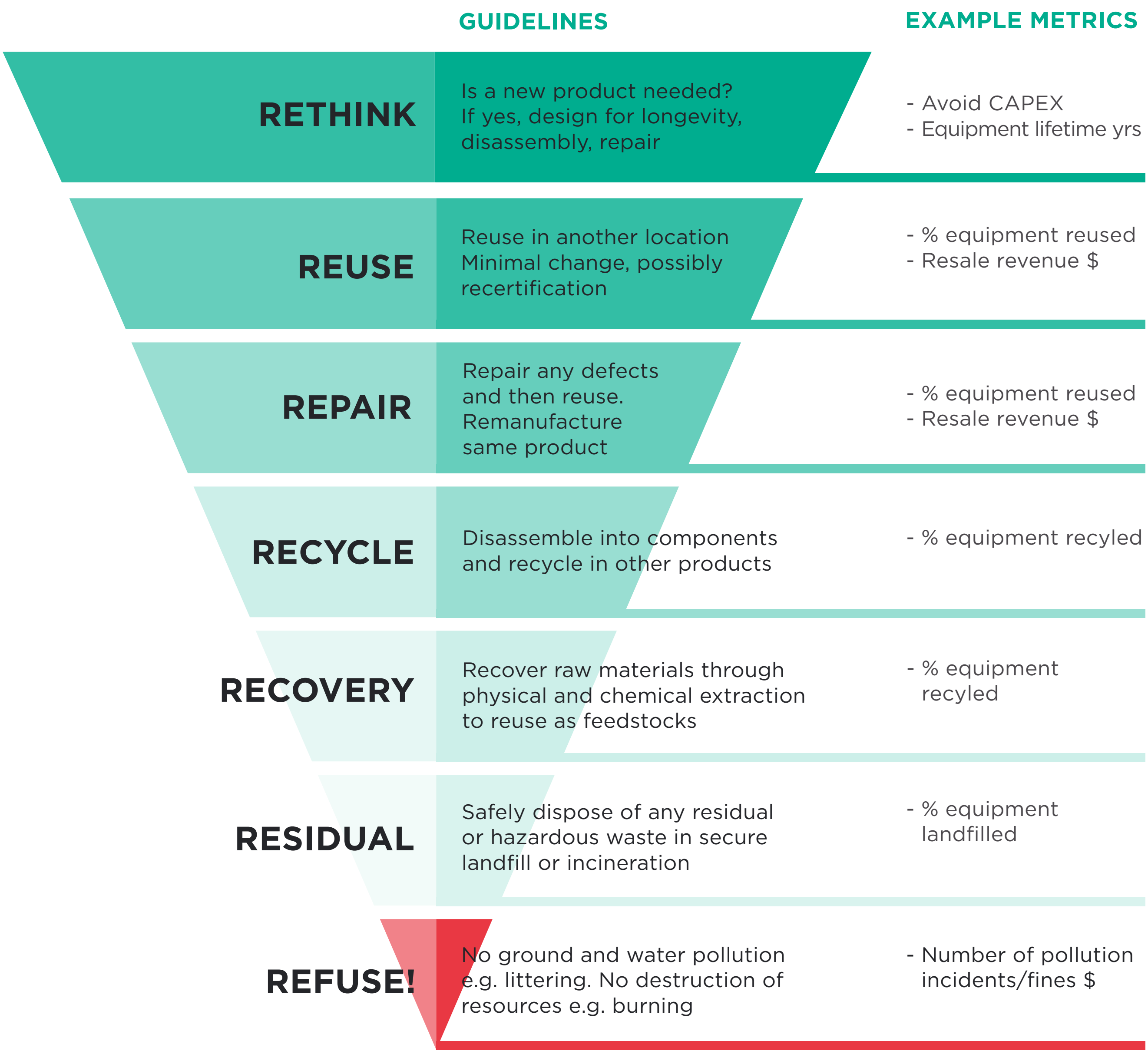
The positive and negative impact an organisation has on the local, national and international economy. This includes creating employment, generating innovation, paying taxes, wealth creation and any other economic impact an organisation has.[4]

4 www.forbes.com/sites/jeroenkraaijenbrink/2019/12/10/what-the-3ps-of-the-triple-bottom-line-really-mean/

The illustration below, created through consultation with GSMA members, shows a framework for how circular economy principles can be applied when considering the expansion or replacement of network equipment. This is based on a hierarchy of actions that can be taken for goods, with the best action at the top and the worst at the bottom. Actions towards the top have the lowest level of environmental impact by avoiding the creation of new goods and repurposing existing goods and components so they can have new uses.

Actions towards the bottom have higher environmental impacts. They will require more energy and resource use, and so should be used only as a last resort when options higher up have been explored. The final category at the bottom is to be avoided completely.

Figure 2 Resource hiearchy



Rethink – Is a new product needed due to improved functionality or energy efficiency? Or can it be avoided? Can a product be designed for longevity, easy disassembly and repair?

Reuse – Can an existing product be reused in another location or by another party without any alteration or with recertification?

Repair – Does a product have defects or shortcomings that can be repaired or upgraded?

Recycling – Can the product be disassembled into components that can be reused in other products or settings?

Recovery – Can the materials that form the products and its components be extracted so they can be used as feedstocks for new products?

Residuals – Can whatever is residual after the above processes have been completed be safely disposed of secure landfill sites that pose no risk to the surrounding environment? These residuals should always be a small fraction of the product and should decrease over time with a view to being completely eliminated by a future date.

Refuse – Can actions that will lead to environmental pollution be refused? These are actions that obstruct the hierarchy above, destroy resources or are environmentally unacceptable. Examples include landfilling of non-residual waste, littering of products into the environment or combustion of products to generate energy.

By systematically and consciously climbing the resource hierarchy, the industry can offer the following benefits:

PEOPLE

- **Create** new circular economy jobs to support the development of the refurbishment and recertification value chain
- **Develop** a skills training programme for refurbishing high-value products
- **Increase** employee engagement that will help retain and recruit talents as a sector
- **Invest** in re-manufacturing plants
- **Meet** the expectations of society to act as a responsible company

PLANET

- **Reduction** in CO_2 emissions related to the extraction and transformation of raw materials
- **Reduction** of CO_2 emissions related to the manufacturing of equipment
- **Reduced** electronic waste pollution and toxicity
- **Reduction** of raw materials extraction and safeguarding of natural resources

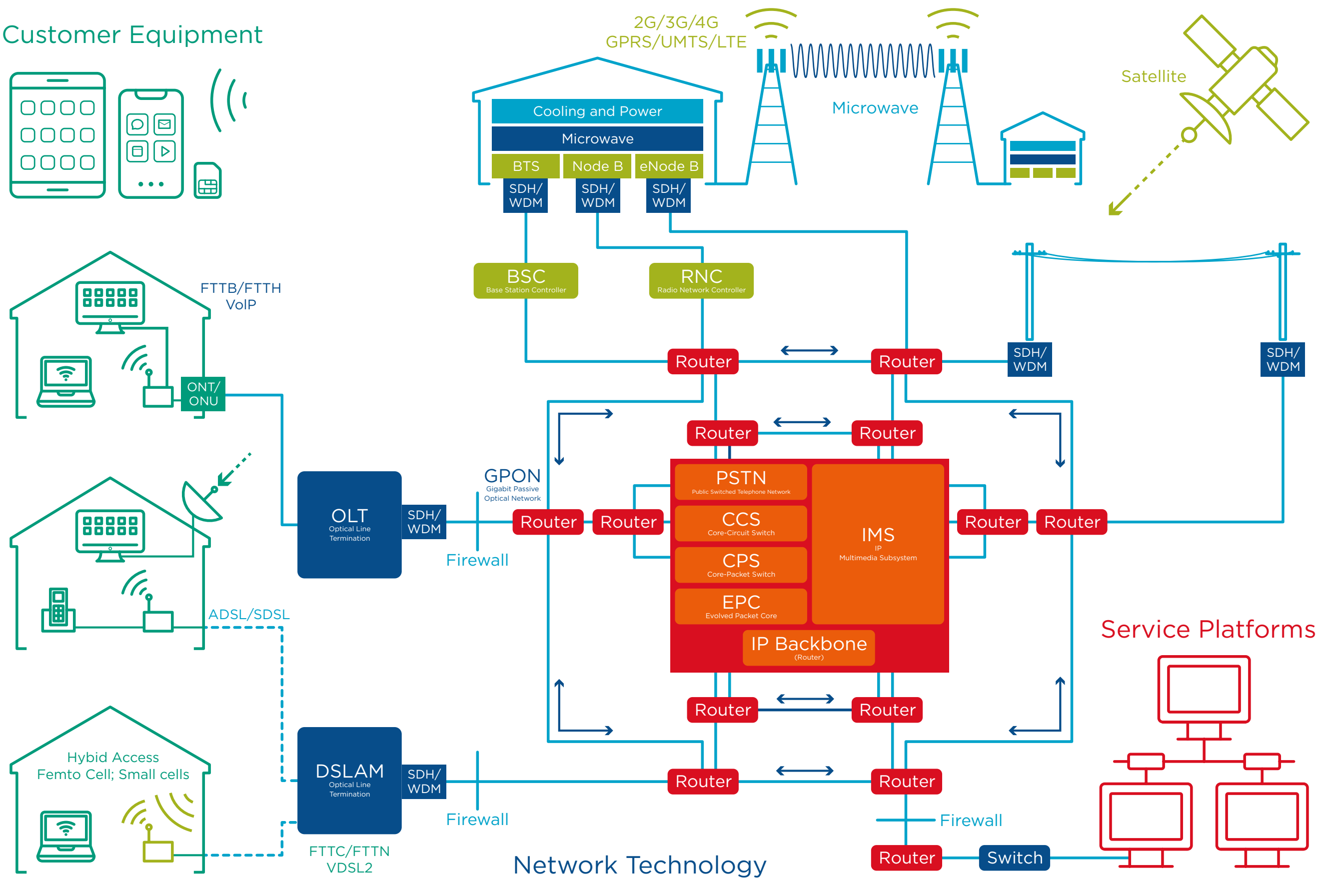
PROSPERITY

- **CAPEX** savings from buying second-hand equipment versus new
- **CAPEX** avoidance related to the re-use of equipment
- **Additional** revenues and new customer acquisitions with coverage/capacity becoming profitable by using used products
- **Additional** revenues from the resale of unused and functional infrastructure
- **Refurbishment** service revenues
- **Creating** alternative sources in case of supply

Scope

The network can be described as channels along which data flows through the telecommunication infrastructure. It is composed of several parts or product categories. The network equipment in scope:

Figure 3 **Network Equipment Overview**



RAN equipment: RRU/BBU; 2G BTS; 3G node B/RNC; 4G eNodeB; 5G antenna; Massive MIMO

FAN equipment: Active equipment (DSLAM, OLT and CTMS), LAN termination (OLT); DSLAM; CTMS

Transmission equipment: PDH/SDH; xWDM; Microwave

IP core network: Switches, routers, firewalls

IT equipment: Data centres (including Edge Computing required for 5G and OTT services) with X86 servers, storage HDD/SSD, value added service platform

Core equipment: MSC; MGW; EPC; IMS; 5G Core e

— **Optics/fibre** --- **Copper**

Please note the following is outside the scope of this strategy paper:

- Equipment on site such as air conditioning, cooling systems, lighting, alarm systems, back-up energy systems are not in scope.
- Common end-user equipment such as mobile phones, home routers, wi-fi devices, TV and IoT devices are not in the scope, but will be considered as part of a separate strategy paper.

5 Please see the appendix on p47

Current challenges to moving towards circularity

1 footnote kalmnklca
2 footnote

This paper will address key challenges faced by the telecom industry where network equipment is concerned, which will help move the industry towards greater circularity:

Challenge 1: To reduce the impacts on the environment from manufacturing products and components and mining raw materials

Challenge 2: To make it easier to source, reuse and repurpose existing network equipment

Challenge 3: To better understand the environmental impacts of network equipment through more comparable methods of evaluation

Challenge 4: To accelerate the shift to more circular principles in the design of the supply chain for network equipment

Challenge 1: To reduce the impacts on the environment from manufacturing products and components and mining raw materials

The culture of ‘new’ in telecom technology

Continuous innovation coupled with strong competition has led to massive investments in new technology and the rapid emergence of new generations of equipment. Constant improvements of energy and spectrum efficiency have positive effects, but inherently also lead to the replacement of equipment and therefore poses a dilemma: what to do with obsolete equipment, components and raw materials?

The rapid pace at which technology advances today, as well as growing customer demand, means that some network products reach the end of their useful lifespan after only a few years of use. Demand for data is increasing, driving new equipment innovations to meet the demand. There is a tendency across the industry is to switch to new technology immediately when a new generation of equipment is available, rather than consider reusing some part of the previous solutions.

This culture of ‘new’ is typical of a linear model - ‘take, make and dispose’ - which leads to the decommissioning of a large amount of equipment which is still functioning with the generation of significant amounts of e-waste. It is estimated that at least 800 kilotonnes of network equipment is sold each year[6] including mobile base stations, fixed access equipment and IP data transmission and core network equipment. There is a lack of data on global levels of reuse and recycling rates, and the material flows of unwanted network equipment.

The ICT supply chain is currently organised and focused to build, ship, and deliver new equipment worldwide. To limit waste, equipment manufacturers have initiated trade-in programmes and brokers are also active in this market, but many products are not reused or recycled. There is a need to innovate and consider alternative business models as other industries currently do, such as the automotive industry..

There is a consensus around reducing climate impacts:

The ambition to limit industry climate impacts is widely shared, and a majority of the industry globally is engaged to reduce its carbon emissions in line with the Paris Agreement. Globally, two-thirds of mobile network operators by revenue have committed to rapidly reducing their carbon emissions over the next decade, including their supply chain emissions. Around one-third have gone even further, committing to reach net-zero for their value chain emissions by 2050 or even before[7].

6 easychair.org/publications/paper/XvgV
7 www.gsma.com/newsroom/press-release/over-a-third-of-mobile-industry-racing-to-net-zero/

Climate targets can help drive greater circularity with its broader benefits

A circular economy brings benefits and short-term results to help reduce supply chain GHG emissions by considering the extension of the life cycle of network equipment.

Telenor

75% Scope 3 emissions (supply chain) make up 75% of all Telenor's emissions

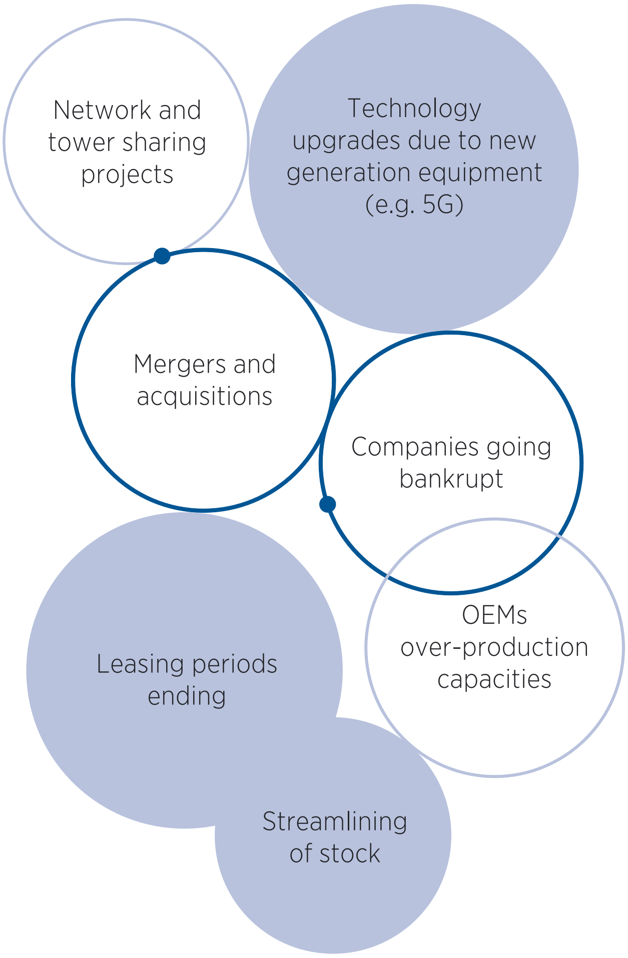
90% of Scope 3 emissions are from purchased goods and services 90%

About a third of this 90% is from the network domain.

- RAN is the dominant sub-category with ~10% of all emissions from purchased goods and services.
- In Europe, devices make up a higher share, while in less developed markets networks make up a much higher share (e.g. >60% in certain markets)

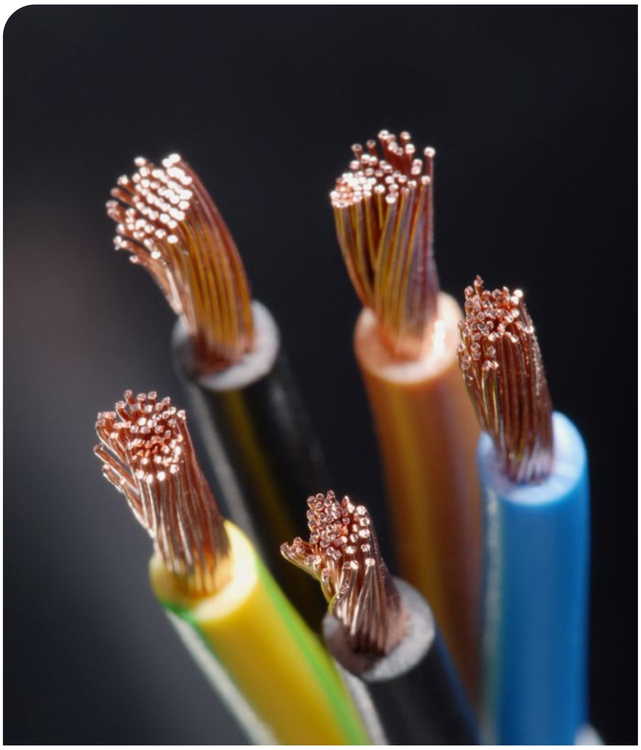
A circular economy is emerging for network equipment

There are trends in the industry toward the consideration and the development of greater circularity; for example, buying and reselling refurbished second-hand equipment (being as reliable as new and warranted), the need to organise a consolidated and regulated second-hand market to ease transactions and give scale to this short-term opportunity. Alongside this, there are a number of factors driving an over-supply of second-hand telecom equipment becoming available worldwide:



This creates an incentive to explore more reuse, remanufacturing, refurbishment and recycling to avoid surplus equipment ending up as wasted products, components and materials.

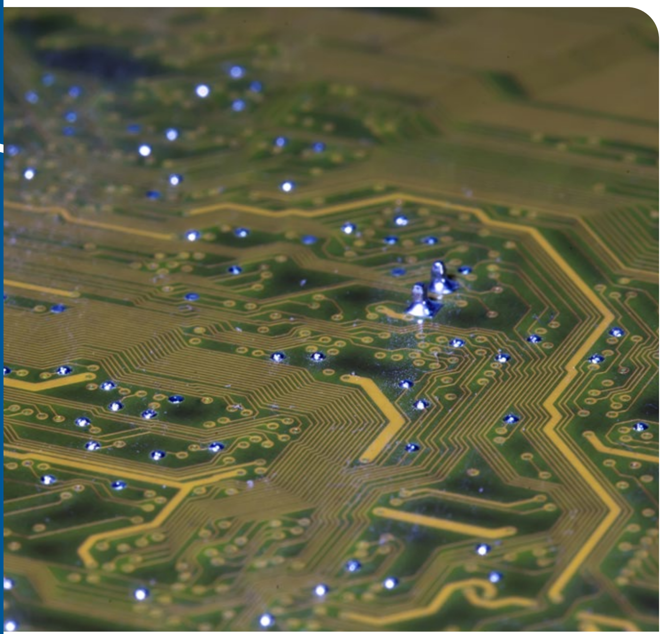
Sourcing scarce and critical materials



Network equipment contains components that are made of scarce/critical materials minerals like gold, cobalt etc. The recovery of those materials in waste and their re-use in production lines helps reduce the need for primary mining with its associated environmental impacts.

However, critical raw materials can be difficult to separate to recycle back into open loop recycling and it is not always economically profitable:

- Products are rarely fully designed or assembled with recycling or eco-design principles having been considered.
- Products are rarely documented with materials inside and recycling capability, although the Global Electronic Council EPEAT label[8] is starting to add network equipment to its list of labelled equipment.
- Material can be widely dispersed in a product, making the cost of recycling higher than the price of extraction and refining raw material



- Recycling of electronics requires large-scale units to be efficient and profitable (current pyrometallurgical processes at smelters are mostly economically viable for precious metals (gold, platinum, silver, palladium etc.) but these are not available in every country).
- Current EU and national waste regulations limit the cross-border transfer of e-waste to avoid dumping, for example, but this also unintentionally limits cross-border recycling options as well as innovation and scaling of circular materials flows.
- Incentives like EU regulation WEEE (waste electrical and electronic equipment) is lacking in other regions.
- The absence of organised flows of documentation along the supply chain makes it difficult for the recycler to know precisely which material can be found in a piece of equipment, in which part/component/sub-assembly they are located and at which concentration.

8 www.epeat.net

The need to reduce and divert ICT waste streams

Very little quantitative data is available regarding the end-of-life treatment of network equipment, but estimations of end-of-life treatment of ICT equipment have been made and these vary hugely by region. Given the significant levels that end up in both informal recycling and landfill, there are clearly opportunities to divert ICT waste streams.

Figure 4 **ICT waste**[9]

Source: Ericsson

REGION	WEIGHT	FORMAL RECYCLING	INFORMAL RECYCLING	LANDFILL
Sub-Saharan Africa	9%	9%	69%	23%
Middle East and North Africa	11%	7%	87%	6%
Europe	13%	63%	8%	29%
Asia Pacific	51%	10%	84%	6%
North America	6%	39%	0%	61%
Latin America	9%	17%	44%	39%
Global	**100%**	**19%**	**64%**	**17%**

Way Forward

Eco-design principles, proper documentation and regulation such as the future European Digital Passport of Products would help to improve the recovery of materials. By improving e-waste collection and recycling practices worldwide, a considerable amount of secondary raw materials (precious, critical and non-critical) could be made readily available to re-enter the manufacturing process while reducing the continuous extraction of new materials. This would reduce manufacturing costs, and also mining water usage and pollution as well as extraction CO_2 emissions.

Circular economy principles and more specifically durability, reparability and recyclability will also help to reuse materials and prevent the need to extract new raw materials.

9 www.ericsson.com/en/reports-and-papers/research-papers/e-waste--major-differences-between-regions

Case Studies

of reducing environmental impacts through circularity

AT&T

The AT&T Global Supply Chain Investment Recovery (IR) group leads the way in establishing our practices for minimising the environmental impact of our internal waste and e-waste. IR works with our contracted R2-certified vendors to recover and recycle network infrastructure assets. Materials are dismantled, sorted and baled by commodity in preparation for sale or recycling. In 2020, IR handled more than 23,863 MT of domestic US operational waste and kept more than 23,298 MT of these materials from landfills, for a diversion rate of 97.63%.

BT

In 2018-19, BT launched an initiative called R3X which stands for Reuse, Recycle and Resale. This is a programme that depowers and recovers redundant assets across its estate in collaboration with BT suppliers. As a result, its exchanges are less cluttered, cleaner and more energy-efficient. And, of course, BT is not wasting resources and supporting the move to a more circular economy. The initiative builds upon BT employees taking ownership of sites and using the vast array of skills to identify and recycle critical spares or generate revenue back into the business by recovering and selling equipment. BT is also recovering and recycling many tonnes of copper cable out of BT exchanges per year, thus preventing extracting copper of out the ground. In addition, BT has a partnership with N2S, a technology lifecycle management company, and together they recovered 257.5 tonnes of legacy equipment and cable from BT's exchanges in 2020/21, avoiding landfill. From this, 257.3 tonnes were recycled and 0.2 tonnes re-used, avoiding an estimated 414 tonnes of CO_2e emissions. BT also used N2S's newly developed refining process which uses bacterial bioleaching technology to recover gold from printed circuit boards.

MTN

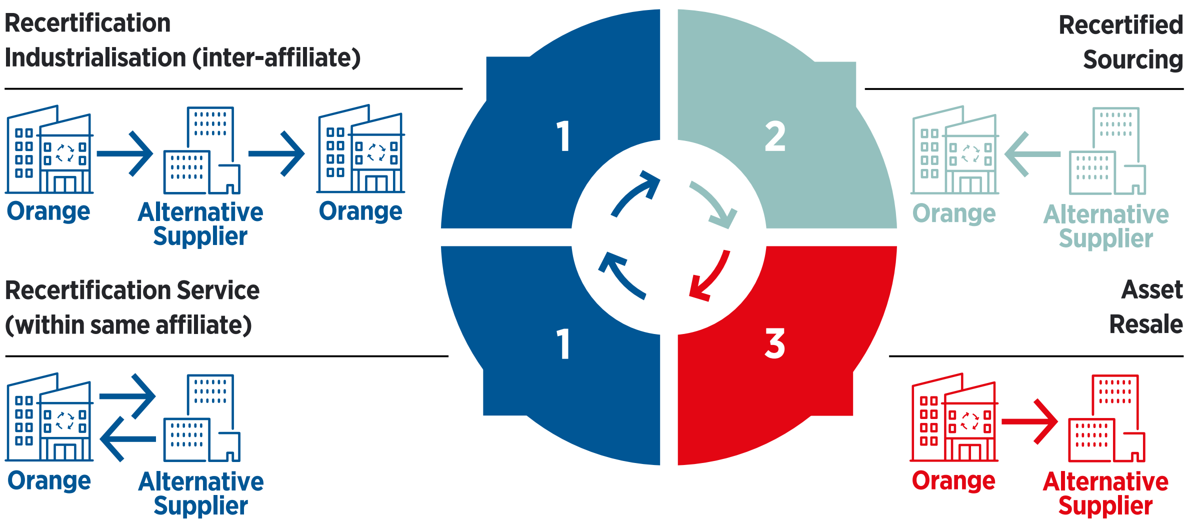
MTN's Circular Economy programme, named "Project Infinity", is one of the key drivers of our Ambition 2025 strategy and for achieving our net-zero by 2040 target. MTN has, since 2018, run a proof of concept and is currently operationalising the programme. It aims to move away from the traditional linear economy model of take-make-use-waste and allows us, together with our partners, to close the loop, extend the lifecycle and maximise the use of our network equipment through responsible production, consumption and disposal and thus saving valuable and precious resources. The programme consists of a digital platform to provide the necessary visibility and intelligence to match supply and demand, and a service partner to facilitate responsible reuse, recycling and movement of equipment across borders. Through cooperation with the relevant industry organisations, our key suppliers and partner operators, we are advocating for broader support and inclusion of circularity within our industry.

Orange

OSCAR (Orange Sustainable and Circular Ambition for Recertification) is Orange's circular economy programme, with the ultimate environmental aim to help reach net-zero carbon goals in 2040. By 2025, Orange targets that the majority of IT infrastructure, networks and data centres will operate with refurbished equipment at a large scale. The programme contributes to Orange's target of €1bn in net cost savings by 2023. The environmental benefits of this business model have been demonstrated in a publication from Orange[10] and in the ITU-T recommendation L.1024.

Figure 5 **Orange operational flow of reuse equipment**

Source: Orange



10 Multiple facets of circular economy applied to telecommunications operator's activities, Mikko Samuli Vaija & Eric Philipot, Care Innovation, 2018, Vienna

Telefonica

During the process of network transformation from copper to optic fibre, a lot of equipment is being reused as spare parts for Telefónica's fixed network. In addition, Telefónica in Mexico is gradually dismantling an important part of their mobile network using a circular perspective view. Decommissioned network equipment is reused internally within their own operations inside Mexico or across Telefónica operations in other countries. Thanks to this initiative and approach, Telefónica has successfully reused more than 30% of the equipment dismantled (it includes all the equipment that has been reused for local needs, between countries, and sold to third parties). To support this process, and as a global initiative, Telefonica launched a programme called MAIA at the end of 2020 which allows to incentive the Reuse, Resell and Recycle of network equipment. MAIA is supported on a digital platform that provides visibility of demand and supply of network equipment across countries and connects them with multiple external partners in order to incentivise the resale when required, always after internal re-allocations within Telefonica have been discarded.

Telia Company

All networks decommissioned by Telia are either reused internally or resold for reuse or recycling externally. Telia's network equipment re-use/resell programme helps reduce both waste and costs and also generates revenue. Used network equipment is primarily re-allocated within Telia or secondly sold to other companies with the ambition to increase the share of reuse over time. In total, around 120 tonnes of equipment were resold for reuse in 2020. These efforts are part of Telia's ambition to achieve zero waste within its own and network operations by 2030 by applying the principles of the waste hierarchy.

Vodafone

To support Vodafone's goal to reuse, resell or recycle 100% of their network waste, Vodafone Group launched Asset Marketplace, a business-to-business solution within Vodafone that allows the business to re-sell and repurpose large decommissioned electrical items like masts and antennae, helping to reduce carbon emissions and resource use by not needing to purchase new items. Since launching at the start of 2020, Vodafone estimates that this has allowed for financial savings of more than €10 million and enabled the avoidance of 1,250 tonnes of CO_2e. Vodafone is currently assessing the possibility of expanding the solution to partner markets and other operators.

Challenge 2: To make it easier to source, reuse and repurpose existing network equipment

The second-hand market is currently very fragmented.

Today, some decentralised and small second-hand markets do exist among different stakeholders: telecom operators, refurbishers and brokers. However, the ecosystem is fragmented and small in scope. Some operators with multiple affiliates are starting internal second-hand markets within their own group, but global second-hand markets are not yet available on a large scale.

The stocks of used equipment collected by third parties largely exceeds the demand from operators. It is estimated that 80% of collected products are dismantled and recycled because of low demand for second-hand use.

Additionally, 2G/3G network sunsets and the decommissioning of certain RAN equipment due to local regulation directives will bring a higher volume of still-functional equipment for potential second use or extended lifespan. A similar effect will be caused by the need to provide networks that can combine 4G and 5G.

Some refurbishing companies such as Collins, GSM Systems, Shield, CTDI, TXO, Deltacom, ITrenew, Evernex, 3Step IT, etc., whose role is to provide asset management services to operators, could be recognised more by equipment manufacturers as value-added partners to re-certify refurbished products and/or to repair and maintain. Also, many brokers are proposing services to buy/resell second-hand network equipment, but most of them are traders with no operational capacity to test/repair/refurbish.

There is a strong potential to improve the demand for used equipment to get a more balanced, active and industrialised second-hand market worldwide.

80% **of collected products are dismantled and recycled** *because of low demand for second-hand use*

At this early stage, the development of re-use practices faces some basic challenges such as:

No motivating mindset

There is a strong need to create trust and bring motivation across the supply chain for sales forces, buyers, specifiers, engineers, skill centres, maintenance, logistics and warehouses. The act of sourcing refurbished equipment is a disruptive practice, exposing practitioners outside their comfort zone in respect of the consolidated long-term established processes.

Financial rules have to be considered

There are no common rules to depreciate the value of the used network equipment as it exists for other markets (for example, for second-hand cars, the value is determined based on age, mileage, street price etc). One option could be to develop TCO (Total Cost of Ownership) models based on equipment specifications and energy cost forecasts to compare the two options.

No common database and shared reference number for products

Product numbers for a specific product of a specific band (such as Part Number) are not always consistent within suppliers. This brings complexity and risks when it comes to creating a second-hand market.

Manufacturers are focusing more on circularity, but barriers still exist:

Several manufacturers are developing and enhancing their circular economy and environmental strategies, but there are currently many barriers slowing or preventing the industry from moving towards full circularity.

A business model that promotes new technologies

Technical design of hardware and software by manufacturers has been made in a way that limits the lifespan of equipment. As a consequence, there is no incentive to manufacture hardware that will cover a longer life span than the expected technological evolution. Priority is placed on better energy consumption of new technology above other environmental impacts. System level optimisation of all environmental impacts is important.

An operational model based on sales of new equipment

The current linear operational model of manufacturers is directed towards the delivery of new and innovative technology to meet the operator's business requirements. Currently, production lines and the process are not developed to enable the repair and refurbishing of second-hand equipment. In general, there are not high-volume reverse logistic operations and new products do not use a majority of recycled materials or components.

Barriers to circular operations by operators and others

The traditional business model means operators and brokers face barriers to reselling and reusing equipment such as non-transferable licences, IPR rules, lack of warranties, maintenance and technical support when ownership of equipment changes. In addition, the use of eco-design principles is not well implemented so repair or remanufacturing cost-effectively is not possible today by third parties.

The Way Forward

Innovation, cooperation and cultural change are at the core of the transformation. To resolve the difficulties mentioned above, the telecom industry needs to come together to create pragmatic co-operation on these issues. This will bring benefits for all stakeholders to create a practical and economical viable second-hand market that brings ESG and financial value for all stakeholders.

Case Studies

of re-use, remanufacturing and repurposing network

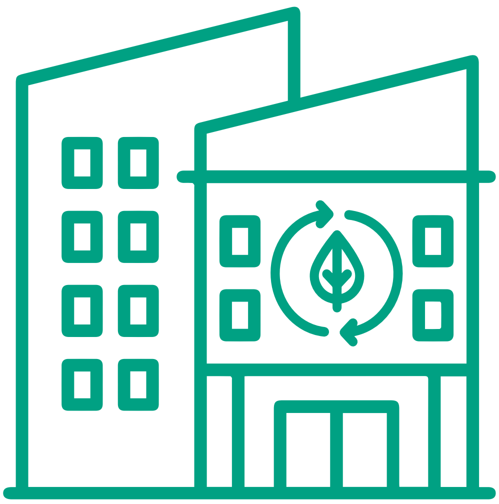
Cisco

Cisco is committed to maintaining assets at their best and highest use for as long as possible. To support this goal, the company has had programmes in place for more than two decades to facilitate product returns for reuse and recycling, to offer comprehensive service and repair and to remanufacture used equipment for sale through Cisco Refresh. In 2018, Cisco signed the Capital Equipment Pledge at the World Economic Forum, committing to 100 percent product return upon request, at no cost to its customers. Cisco continues to simplify the returns process for customers and partners, as well as develop as-a-service and subscription-based models to advance increased reuse and remanufacturing of network equipment. In 2021, 99.9% of product returned to Cisco was recycled or reused.

In 2021 . . .

99.9%

of product returned to Cisco was recycled or reused



Ericsson

For Ericsson, efficient and sustainable use of materials is part of a circular economy approach, including responsible materials selection and product design, effective reuse and efficient recycling. In 2005, they launched a global Product Take-Back Programme which is now offered to customers in 180 countries. Ericsson is also continuously developing new sustainable business models and services. One example is the customer collaboration that has led to development of a Product Reuse segment with offerings such as Refurbished Network Equipment and Refurbished Spare Parts, both being a sustainable complement to traditional new product sales. These circular business offerings have sustainability benefits based on internal LCA calculations and are important for Ericsson to achieve its Circular Economy ambitions and long-term plans.[11]

HPE

HPE Financial Services offer finance solutions and as-a-service finance structures for certified Pre-Owned equipment, accelerated migration services and Asset Upcycling Services, where it aims to repurpose client equipment and keep it in the circular economy. All manufacturers of IT equipment are accepted. Accelerated migration and Asset Upcycling has returned close to $1.6B to customers in the last four years. HPE processed more than 1.4 million network equipment assets (servers, storage, switches) in 2020, with close to 90% being remarketed. Clients using the Asset Upcycling Service receive a Circular Economy report summarising by commodity type the percentage remarketed and the percentage recycled. Additionally, the report will include the amount of CO_2e avoided, the amount of energy saved and the amount of waste diverted from landfill. Measurements are provided that can be used for Scope 3 reporting.

11 www.hpe.com/uk/en/services/asset-lifecycle.html

Huawei

Huawei contributes to the circular economy via more eco-friendly materials, product design for greater longevity, use of more sustainable packaging and waste reduction. In its product manufacturing, Huawei is already using a dozen renewable materials such as recycled aluminium, tin, gold, cobalt and paper. In close collaboration with leading recycling service providers, Huawei classifies its waste and disposes of each category separately. Much of its waste is recycled for raw materials or incinerated and used to produce thermal energy. Huawei and its recycling service providers have also identified materials that may be harmful to the environment and developed targeted disposal plans that minimise environmental impact. In 2020, Huawei disposed of 13,184 tonnes of ICT e-waste, only 0.79% of which was landfilled.

Nokia

For 25 years, Nokia has had circular practices that use the full value of the products. As an original equipment manufacturer, processes are maintained to keep products at their highest value and quality for multiple uses and for the longest time possible through global services. Nokia takes back or acquires excess and obsolete products from customers and markets, and then repairs or refurbishes these units for inclusion in the product supply chain for customer purchase or in own internal use. Products that cannot be reused are sent to recycling and recovery to generate raw material for another application or industry. 99% of the material contained in Nokia products can be used and only 1% needs to be sent to landfill. Nokia is taking steps to increase recycled content; for example, there is currently around 50% recycled content in the cast aluminium parts.

Challenge 3: To better understand the environmental impacts of network equipment through more comparable methods of evaluation

There is not yet a harmonised approach to assess environmental impacts:

The creation of a new model requires metrics to enable equivalent comparison of both e-waste and CO_2 effects to provide evidence of its value to the stakeholders. It is therefore important for the industry to be aligned on a methodology to allow fair benchmarking by leveraging an internationally recognised method. While different methodologies exist, for the purpose of this strategy paper, the following models will be proposed as possible options to be taken into account:

A

Life Cycle Assessment (LCA): This is the main method to enable identifying which are the materials, the manufacturing and logistic process, the usage profiles and end-of-life steps that generate environmental impacts (e.g. kg of CO_2 equivalent or impact on the abiotic resources depletion). LCA analyses are not performed on every product, thus operators must conduct their own studies or rely on data provided by the manufacturers. There is an existing international standard, related to Information and Communication Technologies, developed jointly by the ITU-T and ETSI on 'Methodology for environmental life cycle assessments of information and communication technology goods, networks and services': the Recommendation ITU L.1410[12]. However, the application of the LCA method is subject to different variables (standards[13], database and software) that can lead to varying evaluations of the performance of network equipment in terms of environmental impacts.

Consequently, LCA may lead to significant differences if results provided by company A are compared to the one provided by company B. This has been demonstrated in a publication done within the framework of the ITU-T and ETSI standards on LCA, ITU L.1410[14].

The ITU-T L.1024 recommendation[15] shows examples for which the refurbishment of network equipment allows substantial environmental footprint reduction. However, it has to be noted that the exact figures are subject to variations due to the type of equipment, the expected energy efficiency gain for the next-generation equipment, the location of the refurbishment centre or the percentage of parts/components that have to be replaced during the refurbishment process. The reduction is mainly due to the mitigation of raw material extraction and electronic component manufacturing.

12 www.itu.int/rec/T-REC-L.1410
13 Such as ISO 14040/14044, ITU-T L.1410, JRC : Product Environmental Footprint; ETSI: ES 203-199 ; BSI - PAS 2050
14 doi.org/10.3390/challe5020409
15 www.itu.int/rec/T-REC-L.1024

B

Circularity scores:
To assess a score regarding Circular Economy, items such as reparability, ability to refurbish and durability should be considered. The ITU-T has developed a method (L.1023[16]) to enable such assessment. This method aims to assess the capability of a product to be repaired, recycled and refurbished. L.1023 is currently the best-in-class method to assess the circularity score based on 21 criteria that are commonly used in the RFP process.
A pilot is ongoing with different operators to assess the reliability of the method.
The assessment is made using two metrics:

- Relevance of the Circular Criteria with respect to the type of equipment and business model that applied to the equipment to evaluate. The idea is to evaluate if a given criterion helps to reduce the environmental footprint.

- Margin of improvement to evaluate how the equipment design stands compared to the circularity of the best in class design.

The effectiveness of this method has been demonstrated in several research papers.[17]

Corporate circular metrics have also been developed, and these include metrics related to product returns and look to evaluate company circularity overall:

- The Ellen MacArthur Foundation has developed 'Circulytics' with a free company-level measuring tool that reveals the extent to which a company has achieved circularity across its entire operations.[18]

- WBSCD has developed 'Circular Transition Indicators (CTIs)' – a framework to measure circularity that can be applied to businesses of all industries, sizes, value chain positions and geographies.[19]

16 www.itu.int/rec/T-REC-L.1023
17 Multiple facets of circular economy applied to telecommunications operator's activities, Mikko Samuli Vaija & Eric Philipot, Care Innovation, 2018, Vienna;
- Assessing the Different Aspects of Circular Economy: Pathway to a Method for ICT Equipment, Mikko Samuli Vaija & Marcel Villanueva, Electronics Goes Green, 2020, Berlin
- Life cycle analysis of material efficiency strategies for Network goods, Mikko Samuli Vaija & Anders S.G. Andrae, Going Green Electronics, 2021, Nara
18 ellenmacarthurfoundation.org/resources/circulytics/overview
19 www.wbcsd.org/Programs/Circular-Economy/Metrics-Measurement/Circular-transition-indicators

C

Environmental Social Governance (ESG) metrics

It is expected most ESG frameworks will contain metrics related to the circular economy. An example is SASB, which contains a metric for 'End-of-life' specifically distinguishing between reuse, recycling and landfilling[20]. Operators that have adopted SASB use this metric both for general e-waste that includes network equipment as well as for end-user devices, primarily phones. The idea is to evaluate if a given criterion helps to reduce the environmental footprint.

Figure 6 **SASB product end-of-life metric**

Source: SASB

Topic	Accounting Metric	Category	Unit of Measure	Code
Product End-of-life Management	(1) Materials recovered through take back programs, percentage of recovered materials that were (2) reused, (3) recycled, and (4) land-filled	Quantitative	Metric tonnes (t), percentage (%)	TC-TL-440a. 1

D

Additional technical metrics

In addition to LCA and circular score, energy efficiency is also a key parameter to consider. At infrastructure scale (for example, a data centre), Power Usage Effectiveness (PUE) is the main indicator for measuring energy efficiency. A PUE equal to 1.00 represents the best theoretical achievable value. In 2020, the average PUE value was 1.58 (Uptime Institute Global Data Centre Survey 2019).

E

Innovative financial KPIs

There is no financial model to estimate the financial impacts of an extension of the product life cycle (for instance, from five to 10 years), nor a model where impacts are estimated when the product is used in another geographic area in the case of resale and reuse.

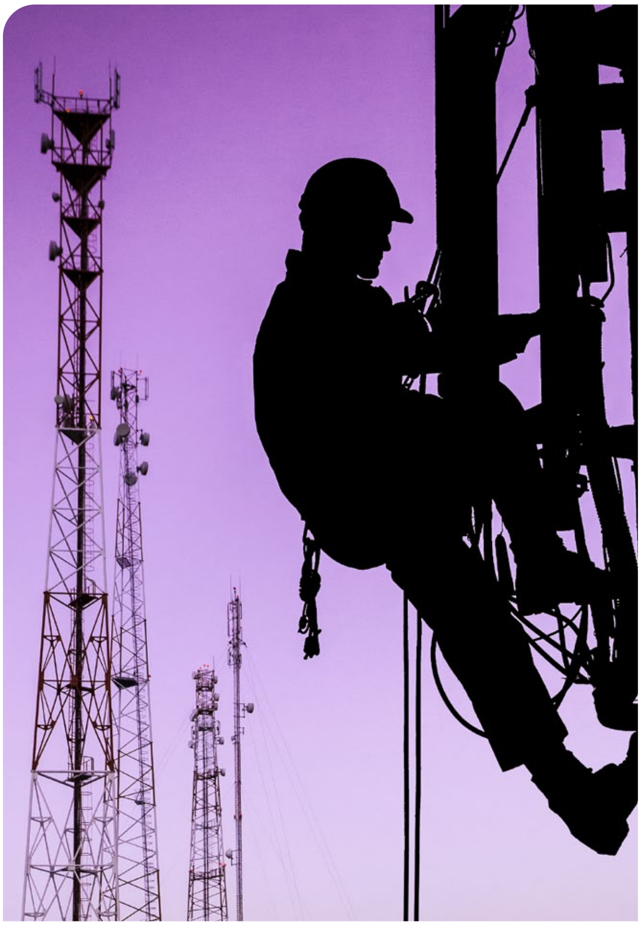
The need for better accounting practices for both buyers and sellers of equipment will also help to provide further guidance for the buyer of used equipment on tackling salient challenges in realising environmentally sustainable systems.

20 www.sasb.org/standards/download/

The challenge to compare the CO_2 impacts of refurbished product versus new

It is commonly stated that new equipment is more energy-efficient than the previous generation. The industry trend is to deliver products with lower weight and improved design than the previous generation. This means less power on average is needed to run the equipment. Globally, the latest generation of a product with similar functionalities will always be more efficient.

However, it is only one of several parameters to be included in the complete assessment. Factors such as the percentage of equipment recovered for the refurbishing/recertification process, the percentage of faulty parts/components, the location of the refurbishing/recertification centre or even how the equipment is shipped to the next customer play a major role. All these data points should be used as inputs for comparative LCAs. The complexity of this calculation has been demonstrated in a publication[21] and in the ITU-T recommendation L.1024.



Conclusion: a methodology to benchmark new and remanufactured is required

To foster the development of the circular economy, it is therefore important that the industry is aligned on a methodology to allow fair benchmarking of a combination of environmental, social and economic KPIs, leveraging with an internationally recognised method. Buyers, decision-makers and all relevant stakeholders need stable indicators to perform the best considerations and decisions. The questions of data quality, secondary data, hypothesis etc. remains open to interpretation. A common guideline, dedicated authorities and validation process, similar to the Science-based Targets approach for carbon emissions, would be beneficial.

21 *Life cycle analysis of material efficiency strategies for network goods*, Mikko Samuli Vaija and Anders S.G. Andrae, Going Green Electronics, 2021, Nara

Case Studies

of industry-led environmental evaluation of equipment

MGMN Network Equipment Eco-design[22]

This white paper by MGMN gives an overview of the existent procedures and visions for eco-design of ICT network equipment. In order to introduce network equipment eco-design principles, the paper investigates the strategy to reduce the environmental footprint and then presents the basis of circularity.

Mobile Device Ecorating[23]

A consortium, led by Deutsche Telekom, Orange, Telefónica (operating under the O2 and Movistar brands), Telia Company and Vodafone, has set up a method (named Eco-rating) to assess the environmental footprint of mobile phones. This evaluation scheme includes several environmental indicators calculated with a life cycle assessment approach (e.g. climate change or abiotic resources depletion) as well as circular economy indicators (e.g. durability or ability to repair). The Eco-rating is based on several international standards (e.g. ITU-T L.1410, L.1015, EN 4555X series on material efficiency, Product Environmental Footprint) and scientific research on eco-labelling systems.[24]

22 www.ngmn.org/wp-content/uploads/210719-NGMN_Green-future-Networks_Eco-design-v1.0.pdf
23 www.ecoratingdevices.com/
24 doi.org/10.3390/challe8020021

Challenge 4: To accelerate the shift to more circular principles in the design of the supply chain for network equipment

Many commercial and non-trade barriers still exist

As a general practice, suppliers contractually limit the possibilities of an operator to purchase equipment from the secondary market, or have alternative repair and recertification companies, for the following reasons:

Cybersecurity impacts

Manufacturers are concerned the destination of used products can be misused and create new cybersecurity risks. Therefore, they could face potential complaints and brand damage in case of infringement of security rules by second-hand users.

IP rules

Manufacturers are concerned that the refurbishing process performed by third parties could lead to potential IPR spoliation, enabling new and unfair competition. This also means that manufacturers shall consider keeping the refurbishing process in-house, which will add costs because of product collection, additional transportation and handling.

Repair & maintenance costs

Products are designed for a certain period of usage (typically five years). There are no or few maintenance or support services if the product is kept in service longer. The location of use is also a problem as services may vary according to markets and local conditions.

Current business model constraints

A new business model and circular supply chain needs to be developed and managed because circular economy models require multiple processes: dismantling, packing, transportation, import/exports costs and administrative tasks, refurbishing with dedicated lines of production in various factories and location, recertification, installation and commissioning.

Lack of upgradability

New technologies such as 5G can only be deployed with new equipment because there is no suitable second-hand or upgradable equipment on the market. From experience, 5G networks are built with numerous IP sub-components such as X86 servers, virtualised routers, switch, firewall etc.) that can be sourced as second-hand.

Contractual terms are sometimes inappropriate for reuse and refurbish

Voiding of warranty on the network:

when introducing technologies not purchased through OEMs

Swap outs or end-of-life commercial terms:

designed so discounts on new equipment are commercially incentivised, limiting the entrance to the market for reuse

Commercial discussions:

often limit the attractiveness of reuse by questioning the quality and technical reliability of refurbished or repaired products

Third-party certification:

Reluctance to consider and leverage the value of third-party certification process

Joint hardware and software purchase clauses:

do not allow the operator to purchase the hardware separately from the software. This leads to higher costs for the operator on purchase of standalone software, making the alternative to new products not attractive enough

Product design is not circular economy compliant

Large disparity of software-hardware combinations . . .

makes it extremely complex to repair and recertify, impacting the development of agile test environments.

Use of non-marked components . . .

or custom components is not yet available in the market, making refurbishing or repairing extremely complex and costly operations.

Gluing of inner boards . . .

makes it difficult or impossible to remove certain components or boards for repair.

Part numbers are often not the same . . .

between countries and products or may vary according to the factory where the product has been manufactured. This situation makes the reuse market very complex and increases potential risk to the customer experience.

Bundled equipment . . .

with all brand-new equipment, while a large share of the bundle may actually be composed of older parts that already exist on the refurbished market.

The recycling ecosystem regulations and design does not support circularity

- Many different legislations across the EU and beyond oblige manufacturers and network operators to become physically and financially responsible for their used equipment and for the reverse channels they are using to collect and to recycle through collective or individual schemes.

- None of these schemes are currently organised in a closed loop supply chain model and there is little incentive to help develop a closed loop structure involving any third-party recycling partner to recover and reinject raw materials into production. The existing ecotaxes or advanced disposal fee solutions are already included in the initial pricing and are paid by the network operators to the manufacturers upfront without any circular economy benefits.

- Today, the waste management collective scheme to which network operators must adhere does not bring any added value nor transparency on the outcome of the recycling process as it lacks the closed loop approach.

- Developing closed loop solutions for dismantling and recycling should enable a true circular economy approach, especially for conflict minerals such as tin, tantalum, tungsten and gold.

- Public authorities could also reduce raw materials depletion during the manufacturing phase by leveraging a specific closed loop (limited to the EU region, for example).

EU WEEE regulation makes the reuse of equipment very complex and costly

The WEEE EU regulation, which is designed to prevent e-waste spread across EU countries, also applies to second-hand equipment when it comes to shipping refurbished product from one country to another. Network operators must comply with complex administrative papers to get customs clearance, facing delays and bureaucracy constraints.

The Way Forward

With a view to overcoming the barriers identified, manufacturers could do more to include circularity into their commercial offer and services. Regulation could also help the ecosystem to arbitrate between the new and the refurbished to promote more sustainable development. There is room for regulators to invent incentives to improve the business case. One approach could be to ease licences and IPR regulations when it comes to the circular economy to engage all economic stakeholders.

Ongoing 2G/3G sunsets, 5G rollouts and the resulting de-commissioning of equipment is a unique opportunity to act now and help emerging countries' markets get better deals for network equipment. In addition, coordinated action will reduce e-waste and improve CAPEX in the value chain. The evolution of carbon markets may hold the keys to making circular economy business models more financially attractive.

Case Studies

of current industry circularity equipment

Orange and Ericsson

Orange has signed a framework agreement with Ericsson to collaborate for circularity. The purpose of the framework is to handle recertification of equipment through a refurbishment process, enabling circularity. During the last year, Orange received their first shipment of refurbished radio equipment from Ericsson. The use of refurbished equipment will reduce CO_2 emissions substantially compared to manufacturing new equipment. The ambition is now to further increase the use of Refurbished Network Equipment in the market to meet both parties' ambitious sustainability goals.

Orange and Nokia

Orange and Nokia have signed an agreement to increase the use of refurbished equipment in telecoms infrastructure. Refurbished network equipment will be offered by Nokia to all Orange subsidiaries via BuyIn, the procurement alliance of Orange and Deutsche Telekom. This joint commitment will comprise radio-based equipment ('Radio Access Network'), with medium- and long-term plans to also encompass other network equipment. The refurbishment process is expected to generate reductions in carbon emissions as opposed to manufacturing new equipment. Furthermore, with this contract, Orange and Nokia want to offer a competitive and reliable alternative to network operators.[25]

Telia and Telenor

In Denmark, Telia and Telenor are sharing a network through the jointly commonly owned JV TT Netværket to enable wireless technologies ranging from 2G to 5G. Through network sharing, the rollout of mobile networks such as 5G can happen at scale and at lower cost, since efforts do not need to be replicated per operator. As a result, fewer physical sites and network equipment units are needed while ensuring fast deployment of new broadband offers.[26]

25 www.orange.com/en/newsroom/press-releases/2021/orange-and-nokia-develop-use-refurbished-equipment-network
26 www.teliacompany.com/globalassets/telia-company/documents/sustainability/the-shift---the-role-of-telcos-in-the-circular-economy.pdf

Recommendations and next steps

I

Start with the basics: initiate internal quick-win processes with already existing equipment

Keep current equipment in active use longer

Consider the opportunity to run equipment longer than they do today (from five to seven or eight years, for instance). This practice will help to optimise budget constraints while answering the need for equipment renewal.

Optimise the loading rate of existing equipment to increase its usage before considering buying new. Manufacturers could provide common metrics to compare best loading rate advice.

When rolling out new generations (typically starting in cities/urban areas), operators may reuse prior generation equipment to extend coverage or capacity in rural areas or to extend the 'profitable' coverage edge.

Share infrastructure with other operators

Operators should consider the opportunity to mutualise network equipment as a first step to reduce the need for new equipment. Active RAN sharing can be an option.

Manufacturers should consider a modular conception approach to facilitate the reuse of hardware components by operators. Intelligence and software hosted in the cloud now enable greater reuse and refurbishment of basic hardware. A common standard approach will facilitate innovation in the field.

Tower companies and site owners to be engaged by operators to help facilitate infrastructure sharing.

Develop awareness on circular economy

The industry should consider coordinated communication, in a similar way to commitments to carbon emission reduction, to inform and help spread the benefits of the circular economy as a means to reduce the sector's environmental impact.

Recommend the continuation and expansion of the project group created to facilitate this strategy paper to share best practice and take forward next steps.

II

Create the building blocks to scale-up product durability, ability to repair/upgrade equipment and availability of spare parts

Give refurbished the same presence as new in business requests and proposals

- Manufacturers could offer catalogues with both new and refurbished products, and detail the level of reused and recycled components and materials in products sold.
- Operators could welcome business proposals with either new and refurbished products or any combination of both and associated TCO and e-waste calculation models.

Create common metrics and guidelines

- Align on metrics for circularity promoted by common ESG reporting standards like SASB.
- Industry stakeholders could create metrics to enable fair benchmarking on global CO_2 equivalent impacts, level of repairability and e-waste/recycling.
- A first step could be to set up Product Environmental Footprint Category Rules (PEFCRs) between operators and manufacturers.
- Manufactures could provide, at the time of purchase, for network equipment:
  - The reuse share at purchase and the reuse/recycle/buyback provisions during the contract period and at the end-of-life.
  - The CO_2 equivalent emissions during (i) production phase, (ii) transport between manufacturing and installation sites (iii) and any reconditioning phase.
- As a first step, operators could share LCA results and the methodology in a common database to increase awareness.

Shift strategies and operations towards circularity

7

Improve the regulatory ecosystem in favour of circular operations in the telco sector

Adjust regulations around the shipping of refurbished and used equipment across countries and clearance at customs, for instance by facilitating the use of licences across the product life span ownership.

Regulators could promote rules to consider the value of refurbished and used equipment in sales books and financial records. New rules should be developed to take into account the stakes of the Circular Economy, such as the CARE approach currently available in France (Comptabilité Adaptée au Renouvellement de l'Environnement).

Regulators may discuss financial and accounting metrics to measure the carbon equivalent impact (for instance, a carbon debt ratio similar to white good electrical consumption) of any new equipment purchase.

Regulators could promote eco-design, durability and repairability to change the business models and also attract talent in these sectors.

6

Rethink the business relationship

Operators could put a greater weighting on sustainability characteristics of network equipment, such as low-carbon technologies, eco-designed products or recycled content when making purchasing decisions.

This will create rising demand for circular products and encourage manufacturers to innovate more sustainable solutions.

Ensure energy efficiency is a priority in network equipment

- The industry should continue to drive improvements in the energy efficiency of each new generation of equipment.
- Operators and manufacturers could recruit skills to apply these targets through dedicated labs, which should be selected by markets or location.
- Eco-design principles should be applied to system architecture and software development, helping to make solutions and equipment more energy efficient and reach a longer life cycle.
- Artificial intelligence could be applied to better manage network traffic and optimise equipment sleep cycles to reduce energy use.
- Other innovative measures should be explored to limit future growth in energy consumption.

Create and interconnect marketplaces

- Operators could develop, interconnect or promote consolidation of marketplaces to create necessary financial, volume and standardisation scale effects to enable the transformation. To reach scale, marketplaces should be expanded at the regional level or can be dedicated to specific corridors (for example Europe to Africa or Developed to Developing nations).
- When considering the reuse of network equipment in other countries, evaluation should be made of the carbon intensity of electricity used to power the equipment. High carbon electricity can negate the environmental benefits of equipment reuse.

Appendix

Appendix

RAN equipment: RRU/BBU; 2G BTS; 3G node B/RNC; 4G eNodeB; 5G antenna; Massive MIMO

Radio Access Network (RAN) is the part of a telecommunications system that connects individual devices to other parts of a network through radio connections. A RAN resides between user equipment, such as a mobile phone, a computer or any remotely controlled machine, and provides the connection with its core network.

In the 2G GSM network, the RAN is composed of several Base Transceiver Station (BTSs) and one base station controller (BSC). BTS is responsible for managing all the radio communication between a mobile handset and the mobile network.

Remote Radio Unit (RRU) acts as a transceiver to the mobile devices. RRU is basically an antenna array arranged in different directions to cover a large area surrounding the cell tower.

Baseband unit (BBU) is a unit that processes baseband in telecommunications systems. A typical wireless telecom station consists of the baseband processing unit and the RF processing unit (remote radio unit, or RRU). The baseband unit is placed in the equipment room and connected with the RRU via optical fibre.

Node B is the telecommunications node in particular mobile communication networks, namely those that adhere to the UMTS standard. The Node B provides the connection between mobile phones (UEs) and the wider telephone network. UMTS is the dominating 3G standard.

3G, 4G and 5G are the third, four and fifth generations of cellular technology, respectively. The difference between each generation primarily comes down to their capabilities. For example, each generation has made improvements to speed (lower latency) and network volume (higher bandwidth).

Massive MIMO is an emerging technology for new communication systems and the Internet of Things, based on the use of hundreds of interfering antennas. It is one of the candidate techniques for 5G and the successor to 4G LTE and LTE-A.

FAN (Fix Access Network) equipment: active equipment (DSLAM, OLT & CTMS)

Digital-Subscriber-Line-Access-Multiplexer (DSLAM) is a network distribution device that aggregates individual subscriber lines into a high-capacity uplink. DSLAM units are typically located in telephone exchanges or distribution points.

Optical Network Terminals (OLTs) has two primary functions: converting the standard signals use by a FiOS service provider to the frequency and framing used by the PON system; or coordinating the multiplexing between the conversion devices on the OLTs located on the customers' premises.

IP core network: switches, routers, firewalls

IP core network is the central part of a telecommunications network that provides various services to customers connected by the Access Network.

Switches, routers and firewalls are the main elements eligible to Circular Economy.

IT equipment: data centres (including Edge Computing required for 5G and OTT services), with X86 servers, storage HDD/SSD, value added service platform

Information Technology (IT) refers to the use of computers (Edge Computing), storage (X86 server, storage HDD/SSD), networks and devices, infrastructure and processes to create, process, store, secure and exchange all kinds of electronic data.

Transmission equipment: PDH/SDH; xWDM; Microwave

Plesiochronous Digital Hierarchy (PDH) is a technology used in telecommunications networks to transport large quantities of data over digital transport equipment such as fibre optic and microwave radio systems.

Synchronous Digital Hierarchy (SDH) refers to a multiplex technology used in telecommunications. SDH is suitable as a transmission system for broadband ISDN and for transporting ATM cells, PDH signals, Ethernet aggregations, SAN signals and other communication signals.

Core equipment: MSC; MGW; EPC; IMS; 5G Core

Mobile Switching Centre (MSC) is a telephone exchange that makes the connection between mobile users within the network, from mobile users to the public switched telephone network and from mobile users to other mobile networks.

Media gateway (MGW) is a device used in the core network of a telecom network operator to provide transformation and interworking between media streams that use different network standards, communication protocols, codecs and physical connections, so phone calls work properly between networks using different technologies.

Evolved Packet Core (EPC) is a framework for providing converged voice and data on a 4G Long-Term Evolution (LTE) network. This allows operators to deploy and operate one packet network for 2G, 3G, WLAN, WiMax, LTE and fixed access (Ethernet, DSL, cable and fibre).

IP Multimedia Subsystem (IMS) refers to the standard for a telecommunication system which controls multimedia services accessing different networks. The IMS is based on the All-IP network. IMS systems are primarily used in mobile networks, but are also used in fixed-line networks.

5G Core (5GC) is the heart of a 5G mobile network. It establishes reliable, secure connectivity to the network for end users and provides access to its services. In this new architecture, each network function (NF) offers one or more services to other NFs via Application Programming Interfaces (API).

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