WIK-Consult and Ramboll • Final Study Report

Study for BEREC

Environmental impact of electronic communications

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0 Executive summary

0.1 Background

In 2019, the European Commission (EC) adopted a Communication on the European Green Deal,[1] which sets out a target for the European Union (EU) to achieve climate neutrality by 2050. In a September 2020 Communication,[2] the EC proposed an interim target to reduce greenhouse gas (GHG) emissions by at least 55% by 2030 from 1990 levels. In June 2021, the Council and Parliament adopted legislation that enshrines these objectives into Europe's first Climate Law.[3]

In the 2019 European Green Deal, the EC cites the Information and communication technologies (ICT) sector as an enabler for attaining the sustainability goals in many different sectors. However, the EC also emphasizes that the digital sector itself should be sustainable at its heart,[4] and provides an objective that digital infrastructures should achieve climate neutrality.[5]

This study aims to provide an overview of the scale and trends in the GHG emissions stemming from electronic communications, the sources of these emissions and possible measurement methodologies. The main focus is on GHG emissions as this is the field where the most data and knowledge is available, but impacts on natural resources are also discussed. We also discuss initiatives that have been taken by electronic communication operators (ECN operators) and National Regulatory Authorities (NRAs) to measure and/or limit emissions and other environmental impacts linked to electronic communications. We conclude with an analysis of the potential role that NRAs could play in supporting sustainability goals, along with the limitations that NRAs may face in this context and trade-offs which may arise when sustainability goals are juxtaposed with other objectives and commitments which NRAs must meet in the context of EU and national legislation applying to electronic communications.

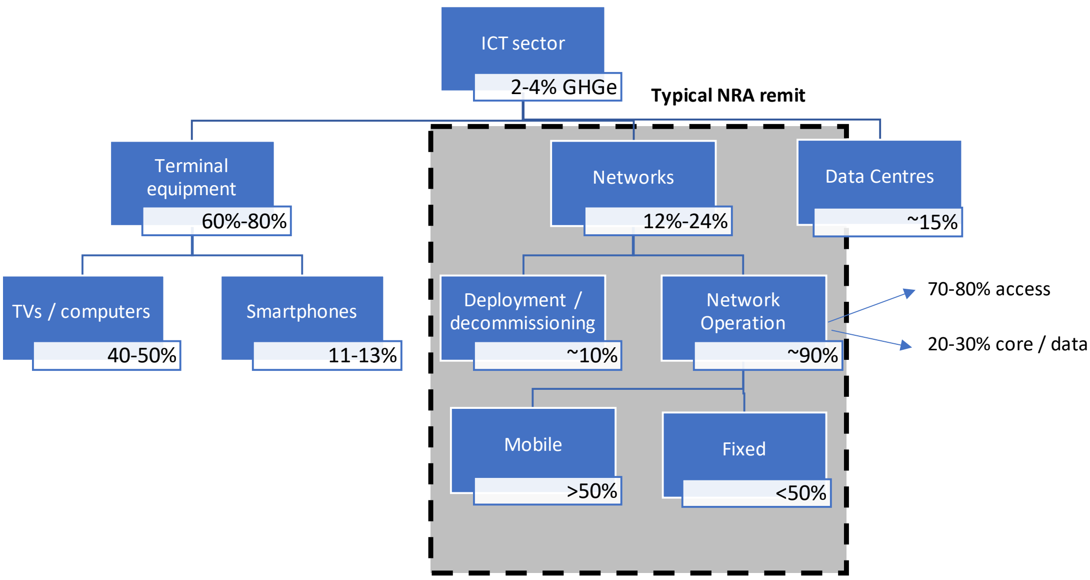
The analysis is based on a comprehensive literature review as well as structured interviews with 10 electronic communications operators and equipment manufacturers. We also received feedback from 22 NRAs via a mix of survey and interviews during the course of Q2 2021.

1 EC (2019) – The European Green Deal, COM(2019) 640 final.
2 COM(2020) 562 final Stepping up Europe's 2030 climate ambition https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52020DC0562
3 https://data.consilium.europa.eu/doc/document/PE-27-2021-INIT/en/pdf
4 2019 European Green Deal
5 EC digital strategy „Shaping Europe's Digital Future" also provides the objective of climate neutrality for digital infrastructures. s.16 Data centres and telecommunications will need to become more energy efficient, reuse waste energy, and use more renewable energy sources. They can and should become climate neutral by 20 https://ec.europa.eu/info/sites/default/files/communication-shaping-europes-digital-future-feb2020_en_4.pdf

0.2 The environmental challenge for electronic communications

The ICT sector accounts for between 2-4% of global GHG emissions across its lifecycle[6]. According to most academic literature,[7] electronic communications networks account for between 12-24% of these emissions (i.e. between 0.25-1% of total global GHG emissions). Emissions associated with the production and use of terminal equipment account for the majority of the rest of emissions stemming from ICT (between 60-80%) with high impacts from large screens (TVs and computers) in particular. Data centres are estimated to account for around 15% of the GHG emissions linked to the ICT sector. The figures from different sources are not directly comparable, due to differences in the scope of the emissions captured and different interpretations of the boundaries between the different segments constituting the ICT sector.[8]

Figure 0-1: Breakdown of contributions to GHG emissions within the ICT sector



Source: WIK-consult based on literature

Projections about future emissions stemming directly from the ICT sector vary with some studies suggesting that emissions from the ICT sector will remain largely stable while

6 Sources underlying this estimation are provided in Table 2-1: Global footprint of ICT. Estimations mostly date from before the COVID pandemic, and thus the implications of the pandemic on the weighting of different sectors on GHG emissions are not reflected in these figures
Table 3-1: Objectives and targets set by operators

7 See section 2.1

8 A further discussion of the environmental impacts of the ICT sector is provided in a study by the European Parliamentary group of the Greens / EFA https://extranet.greens-efa.eu/public/media/file/1/7388?utm_source=POLITICO.EU&utm_campaign=9f38af9d6c-EMAIL_CAMPAIGN_2021_12_07_05_59&utm_medium=email&utm_term=0_10959edeb5-9f38af9d6c-189780953

others suggest that ICT could account for 14-24% global emissions by 2030/40.[9] A key factor underlying the different conclusions are expectations about how far bandwidth demand will increase, and the degree to which emissions stemming from higher data consumption and the proliferation of devices will be counteracted by improved energy efficiency and recycling within the sector. Similarly, while some studies suggest that the energy efficiency that will be achieved through digitisation of other sectors will outweigh impacts from the ICT sector itself,[10] others present the growing contribution of ICTs' footprint as a potential obstacle to achieving Europe's climate neutrality and environmental targets.[11]

Literature suggests that the most significant environmental impact associated with deployment is linked to cable laying in asphalt.[12] These impacts could be mitigated through increased re-use of physical infrastructure such as duct sharing (or if that is not possible) through microtrenching techniques.[13] Mast sharing could limit the environmental footprint associated with the deployment of mobile networks.[14]

The largest environmental impacts associated with ECN operation are linked to electricity use, and could be limited by deploying more energy efficient technologies such as Fibre-to-the-Home (FTTH)[15] and according to some projections, 5G[16] alongside switch-off of legacy technologies.[17] Temporary shut-downs, the use of low power or sleep functions[18]

9 Several studies show stable CO2e footprints despite increased bandwidth consumption e.g. Malmodin and Lunden (2018), Ministry of Transport and Communications, Finland (2020) - The ICT sector, climate and the environment. However, future projections vary with some having a more pessimistic outlook about the future contributions of ICT to global GHG emissions e.g. The Shift Project (2019) – Lean ICT – Towards Digital Sobriety, Andrea and Edler (2015), Belkhir and Elmeligi (2017)

10 GeSi (2015) - GeSI Mobile Carbon Impact, IEA (2017) - Digitalization and Energy. Ericsson (https://www.ericsson.com/4ab228/assets/local/about-ericsson/sustainability-and-corporate-responsibility/environment/accelerate-5g-report-27102021.pdf.) claims that connectivity is needed for climate solutions corresponding to approximately 550MtCO2e (equivalent to 15 percent of the EU's total emissions in 2017). Ericsson claims that by 2030, a further 55–170MtCO2e of emissions savings per annum could be enabled by selected 5G specific use cases applied as an illustration of its potential.

11 The Shift Project, Lean ICT: achieving digital sobriety (2019) https://theshiftproject.org/wp-content/uploads/2019/03/Lean-ICT-Report_The-Shift-Project_2019.pdf

12 Solivan (2015) - Life Cycle Assessment on fiber cable construction methods

13 See for example Carbon Smart (2017) - Our digital infrastructure needn't cost the earth

14 Kouloumpis et al. (Performance and life cycle assessment of a small scale vertical axis wind turbine, 2020) and Stavridou (A comparative life-cycle analysis of tall onshore steel wind-turbine towers, 2020) both find that foundations are a key source of environmental impacts for wind turbines

15 Studies by Obermann (2020), as well as Aleksic and Lovric (2014) find that fibre-based networks (GPON and point to point) are more energy efficient than FTTC (VDSL2 vectoring, super vectoring) and cable

16 Mobile technologies are found to be in general less energy efficient per Gigabit transmitted than fixed. Some studies suggest that 5G is significantly more efficient than earlier generations of mobile technology. For example, Köhn, Gröger and Stobbe (2020) find that 5G networks consume around 5 grams, with 13 grams for 4G and 90 grams CO2e for 3G network per hour of video streaming. However, the overall energy and emissions impacts of 5G, are still uncertain, as studies carried out in Switzerland (https://www.ifi.uzh.ch/en/isr/news/news/5G-study-published.html) and France (https://www.hautconseilclimat.fr/wp-content/uploads/2020/12/rapport-5g_haut-conseil-pour-le-climat.pdf) indicate. While a 5G antenna currently consumes around three times more electricity than a 4G antenna, power-saving features such as sleep mode could narrow the gap to 25% by 2022 https://www.iea.org/reports/data-centres-and-data-transmission-networks

17 Godlovitch et al. (2020) Neutral fibre and the European Green Deal, 2020

18 Mukherjee, A. (2018): Energy Efficiency and Delay in 5G Ultra-Reliable Low-Latency Communications System Architectures, IEEE Network, March/April 2018 and network sharing[19] could all support reductions in energy consumption and associated GHG emissions. Studies suggest[20] that video streaming is associated with greater energy use than broadcast transmission (when transmitting to multiple users), and that large screens are associated with higher data consumption and energy use.

Although the relative effects on emissions of different content distribution methods, technologies and network deployment methods are reasonably clear from the literature, it is not possible to quantify these effects precisely due to the range of different metrics and methodologies that have been used to estimate environmental impacts. The Study Group on the Circular Economy of the European Commission[21] has highlighted the need for standardised methodologies and metrics to be used horizontally as well as for digital technologies in particular. There is limited literature concerning other environmental impacts from ECN besides GHG emissions. However, there may be impacts on material consumption linked to manufacture of cables, the construction of antennas, masts, chambers, and switches, and the upgrade of the network equipment. The use of rare earth elements in devices and water cooling in data centres can also give rise to environmental impacts.

0.3 Actions by electronic communication network and service providers

Most operators interviewed in the process of this study have committed to reducing their greenhouse gas (GHG) emissions and have set relatively ambitious and quantified targets to reach those objectives. These include targets to achieve net zero emissions throughout the value chain, but according to different timescales e.g. by 2030 for Telia, 2040 for Vodafone, Telefonica, and Deutsche Telekom, and 2050 for Iliad.

Specific operational targets that have been set by ECN operators include use of renewable energy (several operators have achieved 100% for their own operations), as well as reductions in energy use for the operation of the network. Direct comparisons for these specific targets are not possible due to the lack of common methodology. Differences include the base year and starting point, as well as the methodology used for carbon emissions measurement and which scopes are covered.[22]Some operators have also set targets regarding the waste generated by their operations. Objectives include

19 Energy Efficient Infrastructure Sharing in Multi-Operator mobile networks https://www.researchgate.net/publication/272089056_Energy_Efficient_Infrastructure_Sharing_in_Multi-Operator_Mobile_Networks

20 Schien et al. (2020), See IEA Commentary (11.12.2020) by Kamiya, G., https://www.iea.org/commentaries/the-carbon-footprint-of-streaming-video-fact-checking-the-headlines, and the Shift Project (2020), https://theshiftproject.org/wp-content/uploads/2020/06/2020-06_Did-TSP-overestimate-the-carbon-footprint-of-online-video_EN.pdf.

21 https://ec.europa.eu/docsroom/documents/44089

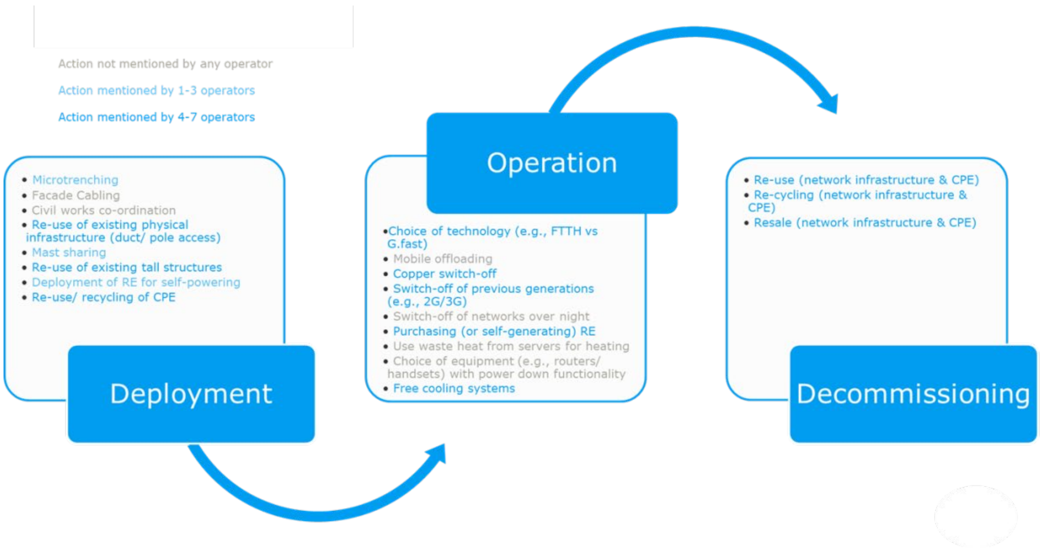
22 In the context of GHG emissions, Scope 1 refers to the emissions related to the organisation's owned or controlled resources (direct emissions); scope 2 to the indirect emissions from the energy purchased by the organisation, and scope 3 to all other indirect emissions along the value chain (upstream and downstream) Scope 3 emissions typically account for the biggest GHG emissions for most organisations .

zero waste from own operations (including networks) by 2030 (Telia) and 100% of network waste recycled/reused/refurbished by 2025 (Vodafone).

The Greenhouse Gas Protocol is the most common methodology used, but Scope 3 measurements within this protocol still vary. ISO 14001 environmental management standards are also commonly applied. Although they are the most ICT-specific of the available standards, there was limited reference to ITU standards by the companies interviewed for the study.

Actions taken by companies to limit GHG emissions and other environmental impacts include the re-use of excavated masses, eco-conception of modems or mobile phone equipment, re-using refurbishing and recycling equipment, alternative cooling techniques, and the switch-off of frequencies during the night or idle periods. Some stakeholders are seeking to influence emissions associated with equipment by setting environmental targets for suppliers and communicating to consumers about the environmental impact of devices. Stakeholders also point to the positive environmental impacts of migrating to more energy efficient FTTH and 5G networks as well as potential positive effects from infrastructure and network sharing. It is possible that mobile antenna technologies such as beamforming antenna could reduce environmental impacts. However, these technologies were not mentioned by operators during the interviews. An overview of the different activities reported by stakeholders is shown in the following figure.

Figure 0-2: Sustainable initiatives mentioned by operators interviewed for the study[23]



Source: Ramboll

23 CPE refers to “customer premise equipment”

0.4 Relevant legislation

There is no overarching objective[24] within the key regulatory instruments applying to the electronic communications sector (EU Electronic Communications Code (EECC)[25] and Broadband Cost Reduction Directive (BCRD)[26]) to promote environmental sustainability. However, measures in the BCRD concerning the re-use of physical infrastructure (including duct access) and civil works co-ordination can contribute to environmental goals, and Article 44 EECC provides scope for competent authorities to impose co-location and sharing of network elements in order to protect the environment in the context of Rights of Way. In addition, the award of State Aid and/or frequencies could in theory take into account environmental concerns.

EU sustainability measures which apply to ICT include the Ecodesign Directive[27] (covering energy consumption and labelling requirements for certain electronic goods), and Waste of Electrical and Electronic Equipment Directive,[28] which seeks to increase recycling of electronic equipment. In addition, the EC has supported the development of voluntary Codes of conduct covering broadband equipment and data centres.[29] In 2021, the EC launched the European Green Digital Coalition,[30] which requires signatories from the industry to sign up to a number of commitments including net zero targets by 2040. The EU Taxonomy[31] will establish criteria under which companies can claim that their activities are “sustainable”. An overview of the environmental measures impacting the ICT sector is shown in the following figure.

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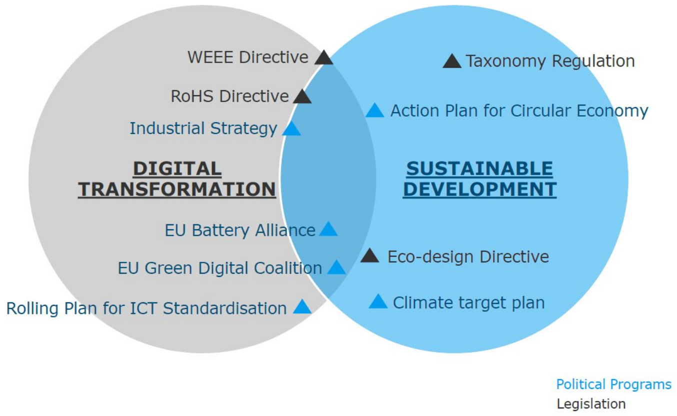
24 For example, competent authorities are given a general objective under article 3 EECC to promote connectivity to VHCN, competition, the internal market, and the interests of citizens
25 https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32018L1972
26 https://eur-lex.europa.eu/legal-content/en/ALL/?uri=CELEX%3A32014L0061
27 https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=celex%3A32009L0125
28 https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:02012L0019-20180704
29 EC ICT Code of Conduct https://e3p.jrc.ec.europa.eu/communities/ict-code-conduct
30 https://digital-strategy.ec.europa.eu/en/policies/european-green-digital-coalition
31 https://ec.europa.eu/info/business-economy-euro/banking-and-finance/sustainable-finance/eu-taxonomy-sustainable-activities_en

Figure 0-3: Existing political frameworks and initiatives influencing the green digital transition



Source: Ramboll

0.5 Initiatives by National Regulatory Authorities

[32] only the French NRA ARCEP has an overarching objective to address environmental concerns in the context of its regulatory activities linked to electronic communications. However, the Norwegian NRA reports that the draft Electronic Communications Act in Norway includes a statutory objective that includes environmental protection, the Polish NRA must take into account environmental objectives in its decision-making, and (since 2021) the Irish NRA must perform its functions in a manner consistent with the Government's climate policies.[33]

32 WIK-Consult conducted interviews with NRAs in Germany, France, Finland, Hungary, Ireland and the UK. A further 16 NRAs provided information in writing in response to a survey distributed via BEREC (Austria, Belgium, Croatia, Cyprus, Czechia, Greece, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain and Sweden)

33 Climate Action and Low Carbon Development (Amendment) Act 2021

Consistent with its wide remit in this area, ARCEP has engaged in a number of initiatives in the environmental field. ARCEP's activities have included data gathering on emissions and energy consumption, workshops and research on impacts associated with customer equipment as well as electronic communications networks. ARCEP is also considering how sustainability should be taken into account in the context of spectrum auctions..

As regards regulatory initiatives falling within the scope of NRA's remit under the EECC and BCRD, passive and active infrastructure sharing and co-ordination of civil works were named by many as important measures to influence environmental outcomes. These measures have been introduced either as a by-product of measures aimed at achieving other (economic) objectives (Austria, Cyprus, Germany, Romania) or specifically targeted to reduce environmental impacts (Croatia, Portugal, Slovenia). Copper switch-off has also been cited as an important policy to facilitate environmental goals.

0.6 Policy options and trade-offs

While some measures (such as re-use of physical infrastructure) are positive for the environment as well as supporting investment and competition in Very High Capacity Networks (VHCN), pursuing other measures might run counter to existing rules applying to the electronic communication sector or require trade-offs to be made against socio-economic objectives. For example

- FTTH is widely considered more energy efficient (per Gbit) than technologies which incorporate legacy copper and cable wiring, but NRAs are required in the context of the EECC to promote "VHCN" (which includes cable, G.fast) and to respect the principle of technological neutrality.
- While encouraging or requiring active network sharing could limit energy use, it could create trade-offs with the objective to promote "infrastructure competition" where efficient and might impact incentives for alternative fixed and mobile operators to invest in their own infrastructure to achieve higher coverage and/or quality than alternative networks and undermine the ability of operators to innovate.
- Strategies to reduce energy consumption might create trade-offs with network coverage and quality, or quality of visual experience (e.g. if there are restrictions on video resolution to limit bandwidth use).
- There may be trade-offs between environmental objectives and cost, for example if the installation of self-generated power is more costly than the alternatives (at least in the initial phase) or if environmental considerations drive deployment of more costly technologies such as FTTH, when alternatives such as FTTC or G.fast might meet the shorter term needs of consumers.

These considerations mean that, if required to take into account environmental impacts, NRAs may need to conduct cost benefit analyses and to identify potential compromises. In this context, it is interesting to note that in draft Guidelines published in Jan 2021[34] concerning sustainability agreements and the implications for competition. Dutch competition authority and NRA ACM advocated that businesses should have more opportunities to co-operate to achieve climate objectives if the benefits for society offset the drawbacks of possible restrictions on competition.

0.7 What role for policy-makers?

Key concerns of the industry are to achieve better alignment of environmental regulations and mitigation measures at EU level as well as nationally and locally. Stakeholders also call for industry standards on methodologies to be used in the sector for environmental impact assessment and communications about sustainability. As regards measures to incentivise sustainable practices, stakeholders call for easier access to renewable energy sources, as well as possible tax incentives and / or reward mechanisms for companies pursuing best practice sustainability measures. Less intensive digging techniques and network sharing and/or collaboration were also cited as solutions that would have beneficial effects.

NRAs have differing views on who should be responsible for tackling environmental challenges in the electronic communications industry with some favouring a horizontal approach primarily pursued by the Environmental Agency, while others favour a sector-specific approach with a more equal split of responsibilities between the NRA and Environmental Agency. All agree however that collaboration is vital.

As regards the scope of any interventions several NRAs stress the importance of taking into account other aspects of the value chain and lifecycle besides operation of telecom networks, to include consideration of end-user devices which are responsible for a significant proportion of emissions. The potential “outsourcing” of GHG emissions when goods are produced or data processed outside the EU also highlights the need for global collaboration and solutions.

Many NRAs highlight the importance of engaging in the development of common methodologies for the measurement of environmental impacts of ECNs and potentially in data gathering. Some NRAs also express interest in promoting best practice by the industry and information campaigns targeted at consumers.

More generally NRAs note that the BCRD and EECC as well as the Connectivity Toolbox[35] provide scope to support environmentally sustainable practices.

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34 https://www.acm.nl/en/publications/guidelines-sustainability-agreements-are-ready-further-european-coordination

35 https://digital-strategy.ec.europa.eu/en/policies/connectivity-toolbox

However, an important limitation is that for the most part, NRAs are not explicitly tasked with promoting sustainability in the context of their regulatory duties. This also means that there is no explicit remit to gather data for environmental purposes under existing EU legislation. It is not excluded that NRAs could engage in these activities, but some NRAs might face challenges in doing so, if their activities are expressly limited under national legislation or if environmental initiatives would create trade-offs with their overarching objectives.

0.8 Conclusions and areas for further research

NRAs can already play a role today in supporting sustainable network deployment and operation by enforcing elements of the EECC and BCRD which have positive effects on the environment,[36] even though environmental goals may not be at the heart of these measures. Depending on the remit of NRAs under these Directives, these could include:

- Promoting the deployment of more energy efficient new technologies such as FTTH[37] and potentially[38] 5G, alongside the switch-off of legacy technologies;[39]
- Promoting the re-use of existing physical infrastructure (PIA), and co-ordination of civil works in accordance with the BCRD as well as co-location or sharing of network elements and facilities in the context of Rights of Way as established in Article 44 of the EECC;
- Permitting or encouraging network sharing where appropriate including in the context of Article 61(4) EECC.

It should however be noted that NRAs will not be able to take such actions to promote environmental goals if in doing so, their actions would undermine the central objectives of the legislation to foster deployment of VHCN, promote competition and efficient

36 In this context, it should be noted that in 2021 BEREC provided an Opinion on the Revision of the BCRD including its potential to support sustainability https://berec.europa.eu/eng/document_register/subject_matter/berec/download/0/9887-berec-opinion-on-the-revision-of-the-bro_0.pdf

37 Although the EECC requires NRAs to respect the principle of technological neutrality, certain measures tend to have the effect of facilitating FTTH deployment including promoting entry by alternative investors and incentivising FTTH deployment by the incumbent as well as alternative investors in the context of access regulation and the associated wholesale pricing regime

38 Although 5G is widely considered to be more energy efficient than previous generations of mobile technology, Deeoa, Beena and Girinath (2018), notes that the energy efficiency of 5G can be reduced for use cases which require ultra-low latency

39 NRAs can influence the pace of migration by limiting regulatory barriers to the extent permitted in accordance with Article 81 EECC as well as by encouraging long term contracts / co-investment which have the effect of achieving “buy-in” to the new technology from multiple service providers including the incumbent in areas where alternative investors have deployed FTTH. Further analysis of policies to foster switch-off is included in the WIK (2020) study https://www.wik.org/fileadmin/Studien/2020/Copper_switch-off_whitepaper.pdf

investment and protect consumer welfare (or to reduce the cost of deployment, in the case of the BCRD).

There could also be a role for NRAs and BEREC to support sustainability programmes more widely if they are given the relevant remit and budget to do so in the context of national legislation or if they are given a mandate to support environmental programmes such as the UN Sustainable Development Goals.

When engaging in environmental programmes, there is consensus that collaboration between NRAs and authorities responsible for environmental protection is important. The balance between the responsibilities of NRAs and environmental agencies in promoting sustainability in ECN is likely to vary in different countries and will also depend on the degree to which emissions from ECN are controlled through horizontal or sector-specific measures. However, NRAs could be involved in:

- Contributing to the development of a consistent and harmonised methodology for the gathering of data on the environmental impacts linked to electronic communications at EU level;
- Supporting in the gathering of data from stakeholders to understand the emissions (including scope 3 emissions) associated with the provision of electronic communications networks and services, and to measure the effects of possible policy measures.

NRAs with a broader remit in the environmental sphere could also consider (depending on their remit and interest) engaging in activities at EU and national level to:

- Build awareness amongst consumers and ECN operators concerning the environmental footprint of devices and network technologies, potentially with the support of information campaigns and potential labelling schemes;
- Engage in the development of Codes of Conduct to encourage stakeholders to engage in sustainable practices;
- Support the sustainable design of digital / ICT products, energy efficiency, and recycling programmes ;
- Support in research on or funding of sustainable solutions;
- Incentivise sustainable solutions (such as the use of self-generated green energy, energy-efficient technologies, re-use of infrastructure) e.g. through voluntary initiatives / Codes of Conduct or in the context of award criteria or conditions attached to spectrum awards, Rights of Way and State Aid;
- Support the introduction of fiscal incentives (such as tax-breaks) to foster sustainable deployments.

Further research could be useful to understand:

- Different reporting methods for environmental impacts within the electronic communications sector with a view to making recommendations on a common indicator framework; and
- The potential for labelling schemes to support consumers in making informed choices concerning environmental sustainability; and
- The potential impact of mid-band and millimetre wave 5G on the environment, as well as the impact of future technologies linked to network operation, and an analysis of how environmental impacts are reflected in R&D relating to future technologies, including 6G.

1 Background

1.1 EU environmental targets

In 2019, the European Commission adopted a Communication on the European Green Deal,[40] which sets out a target for the EU to achieve climate neutrality by 2050. In a September 2020 Communication,[41] the Commission proposed an interim target to reduce greenhouse gas emissions by at least 55% by 2030 from 1990 levels. In June 2021, the Council and Parliament adopted legislation that enshrines these objectives into Europe's first Climate Law.[42]

In the 2019 European Green Deal, the EC cites the ICT sector as an enabler for attaining the sustainability goals in many different sectors. Specifically, the EC notes[43] that it "will explore measures to ensure that digital technologies such as artificial intelligence, 5G, cloud and edge computing and the Internet of things can accelerate and maximise the impact of policies to deal with climate change and protect the environment." The EC also considers that digitalisation presents new opportunities for distance monitoring of air and water pollution, and to monitor and optimise how energy and natural resources are used.

However, the EC also emphasizes in the 2019 European Green Deal that the digital sector itself should be sustainable at its heart. Thus, the EC "will also consider measures to improve the energy efficiency and circular economy performance of the sector itself, from broadband networks to data centres and ICT devices. The Commission will assess the need for more transparency on the environmental impact of electronic communication services, more stringent measures when deploying new networks and the benefits of supporting 'take-back' schemes to incentivise people to return their unwanted devices such as mobile phones, tablets and chargers." In "Shaping Europe's Digital Future", the EC also provides an objective that digital infrastructures should achieve climate neutrality.[44]

1.2 Study objectives and methodology

This study aims to provide an overview of the scale and trends in the GHG emissions stemming from electronic communications, the sources of these emissions and possible measurement methodologies. We also discuss initiatives that have been taken by

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40 EC (2019) – The European Green Deal, COM(2019) 640 final.
41 COM(2020) 562 final Stepping up Europe's 2030 climate ambition https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52020DC0562
42 https://data.consilium.europa.eu/doc/document/PE-27-2021-INIT/en/pdf
43 Chapter 2.1.3 European Green Deal
44 s.16 Data centres and telecommunications will need to become more energy efficient, reuse waste energy, and use more renewable energy sources. They can and should become climate neutral by 20 https://ec.europa.eu/info/sites/default/files/communication-shaping-europes-digital-future-feb2020_en_4.pdf

electronic communication operators (ECN operators) and National Regulatory Authorities (NRAs) to measure and/or limit emissions and other environmental impacts linked to electronic communications. We conclude with an analysis of the potential role that NRAs could play in supporting sustainability goals, along with the limitations that NRAs may face in this context and trade-offs which may arise when sustainability goals are juxtaposed with other objectives and commitments which NRAs must meet in the context of EU legislation applying to electronic communications.

The analysis is based on the following sources:

- A comprehensive literature review conducted in Q1 2021. This was based on a longlist of 155 research papers and in-depth review of 52 reports.[45]
- Written submissions and structured interviews conducted in Q2 2021 with 10 electronic communication operators (Telia, Iliad, Liberty Global, Fastweb, Open Fiber, Vodafone, Telefonica, Deutsche Telekom, Telecoop, CETIN) and the equipment manufacturer Cisco.[46]
- Interviews with 6 NRAs (Germany, France, Finland, Hungary, Ireland and the UK) conducted in Q2 2021 and associated desk research alongside written submissions submitted by a further 16 NRAs[47] in response to a questionnaire circulated by BEREC in May 2021.

Preliminary findings were discussed and feedback received from the BEREC Sustainability Working Group in March and September 2021.

1.3 Structure of the report

The report is structured as follows.

- Chapter 2 describes the scale of the environmental challenge for electronic communications and identifies the main source of environmental impacts;
- Chapter 3 outlines the actions that have been taken by ECN operators to measure and/or limit environmental impacts and discusses the effects of these actions;
- Chapter 4 outlines the legal instruments applying to ECN and the environment, and highlights initiatives taken by NRAs in the field of sustainability;
- Chapter 5 discusses the impact of possible policy measures designed to limit emissions alongside potential unintended consequences or trade-offs;

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45 The methodology for the literature review is contained in Annex 1

46 These stakeholders were selected following consultation with BEREC as providing a representative sample of experiences from different types of operators with operations across the EU.

47 Austria, Belgium, Croatia, Cyprus, Czechia, Greece, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain and Sweden

- Chapter 6 discusses the potential role that could be played by NRAs in addressing sustainability, drawing on interviews and findings from previous chapters;
- Chapter 7 provides conclusions and identifies potential areas for future research.

The Annex contains details about the methodology that was used for the literature review, the results from the Impact Assessment, and a summary of the information received concerning NRAs' remit and activities in the sustainability field.

2 The environmental challenge for electronic communications

This chapter identifies the scale of GHG emissions associated with ECN, and highlights the main drivers of these emissions and other environmental impacts across the ECN lifecycle.

Key findings

- The ICT sector accounts for between 2-4% of global GHG emissions. ECN accounts for between 14-24% of these emissions. Emissions associated with the production and use of terminal equipment account for the majority of the rest (60%-80%), with high impacts from large screens (TVs and computers) in particular.
- Projections about future emissions from the sector depend on which of two effects will dominate: increasing emissions resulting from increased data consumption and the proliferation of devices, or energy efficiency and increased reliance on renewable energy. Somel studies suggest that the energy efficiency that will be achieved through digitisation of other sectors will outweigh impacts from the ICT sector itself, while others consider that emissions from the ICT sector could multiply and undermine achievement of environmental targets.
- Literature suggests that the most significant environmental impact associated with deployment is linked to cable laying in asphalt. These impacts could be mitigated through increased re-use of physical infrastructure (or if that is not possible) through microtrenching techniques. Mast sharing could limit the environmental footprint associated with the deployment of mobile networks.
- The largest environmental impacts associated with ECN operation are linked to electricity use, and could be limited by deploying more energy efficient technologies such as FTTH (and potentially 5G) alongside switch-off of legacy technologies. Temporary shut-downs, the use of sleep functions and network sharing could all support reductions in energy consumption and associated GHG emissions.
- Studies show that video streaming is associated with greater energy use than broadcast transmission (when transmitting to multiple users), and that large screens are associated with higher data consumption and energy use.
- Although the relative effects on emissions of different content distribution methods, technologies and network deployment methods are reasonably clear from the literature, it is not possible to quantify these effects precisely due to the range of different metrics and methodologies that have been used to estimate environmental impacts. The Study Group on the Circular Economy has highlighted the need for standardised methodologies and metrics to be used horizontally as well as for digital technologies specifically.

2.1 Emissions from electronic communications networks

As shown in the following table, various studies put the range of GHG emissions stemming from ICT as a proportion of global GHG emissions at between 2-4%,[48] with higher estimates of up to 5% from Andrae (2020)[49] and a lower figure of around 1.5% from Malmodin and Lunden (2018).[50] The different estimates may result from differences in the scope of the activities captured and the types and proportions of terminals considered as well as in methodological differences, as outlined in the table below.[51]

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48 Belkhir, L. and Elmeligi, A. (2018). Assessing ICT global emissions footprint: Trends to 2040 & recommendations. Journal of Cleaner Production, 177, pp. 448-463. https://doi.org/10.1016/j.jclepro.2017.12.239, GeSI (2012): SMARTer 2020 - The Role of ICT in Driving a Sustainable Future. Online available at https://www.telenor.com/wp-content/uploads/2014/04/SMARTer-2020-The-Role-of-ICT-in-Driving-a-Sustainable-Future-December-2012._2.pdf. IEA (2017). Digitalization and Energy. Online available at https://iea.blob.core.windows.net/assets/b1e6600c-4e40-4d9c-809d-1d1724c763d5/DigitalizationandEnergy3.pdf.

49 Andrae, A. S. G. (2020). Hypotheses for Primary Energy Use, Electricity Use and CO2 Emissions of Global Computing and Its Shares of the Total between 2020 and 2030. WSEAS Transactions on Power Systems, Volume 15, pp. 50-59. https://doi.org/10.37394/232016.2020.15.6.

50 Malmodin, J. and Lundén, D. (2018). The Energy and Carbon Footprint of the Global ICT and E&M Sectors 2010–2015. Sustainability, 10, 3027. https://doi.org/10.3390/su10093027.

51 See Andrea (2020) and Malmodin & Lundén (2018), alongside the discussion in section 2.3.6

Table 2-1: Global footprint of ICT

Study	ICT Footprint	Scope of the study	Relative contribution on ICT CF of ICT networks:
Benqassem et al. (2021).	CF for EU-28 (2019): 185 Mt (4.2%)	including manufacturing, distribution, use and end-of life phase	Energy Footprint for EU-28 (2019): 15,6 % primary energy consumption and 17,9% final energy consumption (use)
Andrae (2020)	CF (2020) 1.76 Gt **(4.7%)** CF (2030, forecast) **(4-5%)**	data centres use, mobile network use, optical network use, device use, manufacturing processes	CF (2020): 7,8% (excl. manufacturing processes)
Belkhir and Elmeligi (2018)	CF (2017): 0.9 – 1.1 Gt **(2.5-3%)** CF (2020, forecast): 1.1-1.3 Gt **(3.1-3.6%)**	including both the production and the operational energy of ICT devices, as well as the operational energy for the supporting ICT infrastructure	CF (2020): 24%
GeSI (2012)	CF (2020, forecast): 1.27 Gt **(2.3%)** CF (2030, forecast): 1.25 Gt **(1.97%)**	data centres, telecommunication networks, end-user devices (All three Scopes of the Greenhouse Gas Protocol)	CF (2020): 23,6%
IEA (2017)	Energy footprint (2015) (excl. devices): 379 TWh (2%)	energy consumption (operational) of data centres and data networks (fixed and mobile),	
Malmodin and Lunden (2018)	CF (2015): 730 Mt **(1.4%)** Energy footprint (2015): 805 TWh **(3.6%)**	primary and secondary data for operational (use stage) energy consumption and life cycle greenhouse gas emissions; user devices, ICT networks, data centres and enterprise networks	CF (2015): 24.6% Energy footprint (2015): 27,3%

Note: CF: Carbon Footprint, Gt: gigatons, Mt: megatons, TWh: terrawatt hours

Source: WIK-Consult based on literature review

Several estimates put the contribution of ECN to GHG emissions at around 24%,[52] **including emissions associated with the manufacturing process,**[53] although some studies also suggest a lower contribution.[54]

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52 Malmodin and Lunden (2018), GeSI (2012), Belkhir and Elmeligi (2018)
53 Andrae (2020) concludes that ECN constitutes around 8% of GHGe excluding manufacturing processes
54 For example Benqassem et al. (2021) suggests a figure of around 16% for the EU28

As regards the contribution to GHG emissions from other parts of the digital value chain, the Shift Project,[55] a think-tank estimated that as of 2017 *production* of devices represented 45% of the global energy consumption associated with ICT, with a greater contribution from the production of larger devices such as TVs and computers (28%) than from smartphones (11%).[56] The remaining 55% of energy consumption was associated with the *operation* of networks (16%), data centres (19%) and end-user devices (20%). When production and use are taken together, this would imply that **terminals are responsible for around 60% of overall energy consumption**, while the remaining consumption is linked to data centres and network operation. These proportions are consistent with research from Ericsson[57] which suggests that the contribution of fixed and mobile network operations and data centres to GHG emissions each lie around 20% with 60% of the emissions stemming from user devices. The GHG emissions associated with production in comparison with operation and the respective contributions of networks compared with end-user devices may vary by country for example as a function of the use of sustainable energy sources by ECN operators. For example, in France the contribution of terminals to GHG emissions is estimated at around 81%.[58]

Looking within the contribution to GHG emissions from ECN, estimates from equipment manufacturers suggest that around 10% of the GHG emissions are associated with deployment and decommissioning of the network, while network operation accounts for around 90% emissions,[59] although estimates of these proportions may differ.[60] Meanwhile, a study by France Stratégie suggests that the operation of the access network accounts for between 70-80% of the emissions linked to ECN.[61] There is also evidence to suggest that mobile networks account for a higher proportion of GHG emissions than fixed networks.[62]

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55 The Shift Project, Lean ICT: achieving digital sobriety (2019) https://theshiftproject.org/wp-content/uploads/2019/03/Lean-ICT-Report_The-Shift-Project_2019.pdf

56 Similarly according to itizing, Digital technology's carbon footprint in France: are public policies enough to handle the rise in usage?, June 2020 televisions alone represent close to a quarter of the total emissions linked to devices, compared to 13% for smartphones. The remainder of the emissions generated by devices is shared between laptop computers (14%), desktop computers (10%), internet routers and set-top boxes (12%).

57 Ericsson (2018) Exponential data growth – constant ICT footprints https://www.ericsson.com/en/reports-and-papers/research-papers/the-future-carbon-footprint-of-the-ict-and-em-sectors

58 See Page 13 ARCEP (2020) Achieving Digital Sustainability.

59 See Nokia (2020) – People & Planet Report 2019

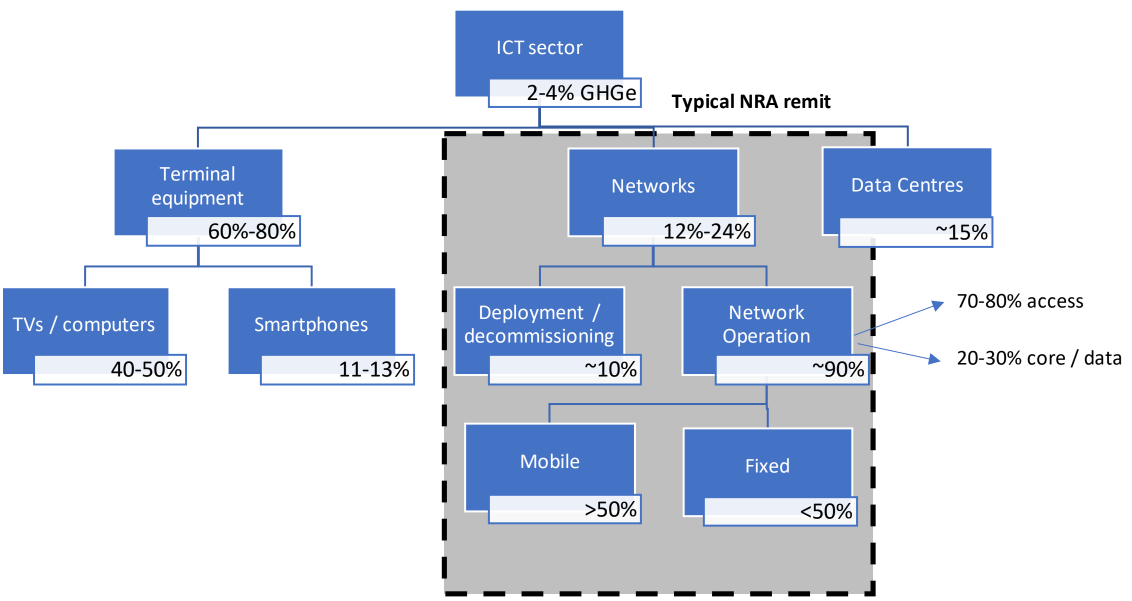
60 Certain other literature implies a greater environmental impact from the manufacturing process. For example, Andrae (2020) concludes that ECN constitutes around 8% of GHGe excluding manufacturing processes. When taken together with other literature that suggests that ECN constitutes around 24% GHGe including manufacturing processes, the implication may be that manufacturing processes play a more significant role in emissions at global level than may be suggested in the Nokia analysis. The differing assessments may be influenced by the scope of the data gathered and assumptions made.

61 47 and 48. France Stratégie, Controlling digital technology's consumption: technological progress will not suffice, October 2020.

62 According to France Stratégie, Controlling digital technology's consumption: technological progress will not suffice, October 2020 mobile networks account for 70% of an access network's power consumption, making them electronic communications networks' greatest source of energy use. A 2017 IEA report, also estimate that data networks consumed 185 TWh globally in 2015, of which mobile networks accounted for around two-thirds.

An overview of the relative contributions of the different elements of the ICT sector to GHG emissions is shown in Figure 2-1. The typical remit of NRAs within Europe tends to be limited to the operation of electronic communications networks and services, which represents less than one quarter of the overall emissions from ICT (corresponding to between 0.25-1% of total global GHG emissions). However, it should be noted that there is a linkage between electronic communications networks and emissions in other parts of the ICT value chain. For example, the popularity of devices or provision of online services on larger devices can drive increased demand for bandwidth, affecting GHGe generated by ECN. On the other hand, increased network capacity, which could result from network upgrades could also give rise to new use cases and stimulate uptake of devices and the usage of remote data storage facilities, increasing the energy demands linked to data centres.

Figure 2-1: Breakdown of contributions to GHG emissions within the ICT sector



Source: WIK-consult based on literature

2.2 Projections around emissions

2.2.1 Emissions projections in the electronic communications sector

Although one would expect that increasing bandwidth demands would lead to higher total energy consumption over time, some studies have found that energy consumption from electronic communications has not increased in absolute terms, as modern technologies compensate with more energy efficient solutions, and as lower energy consumption in end-user devices counteracts higher energy consumption arising from network operation.

For example, based on an analysis for the years between 2010 and 2015 and a 2020 forecast,[63] Malmodin and Lunden (2018) find that while the ICT and Entertainment and Media sectors were previously associated with expanding CO2e footprints, these footprints have been shrinking despite a continuous increase in subscriptions and data traffic. Specifically, Malmodin, Bergmark and Lunden (2018) show that the energy and carbon footprint in the ICT sector in 2015 was similar to that of 2010 (with a possible peak in 2012/2013). The reason may be that, while network energy consumption continues to grow slowly, user device footprints are now decreasing. The authors highlight that the lack of increases in energy consumption is significant given the fact that during the period of 2010 to 2015, ICT subscriptions have grown from 6.7 billion to 9 billion, TV subscriptions have grown by 8% to nearly 1.6 billion, and data traffic in the world's networks have increased by a factor of 4.

These findings are echoed in a 2020 report by the Finnish Ministry of Transport and Communications[64] which concludes that improvements in energy efficiency have helped to keep the growth in the sector's electrical energy consumption at a manageable level despite the expansion of the volume of data transmitted, processed and stored. The study authors suggest that the ICT sector accounts for around 1.5–5% of global GHG emissions, and note that greenhouse gas emissions from electricity consumption depend on the source of electricity production.

However, there is some uncertainty over whether the energy efficiency effect of newer network technologies and devices will continue to outweigh the effects of increasing bandwidth consumption that may be associated with improved and higher resolution services and the roll-out of high capacity FTTH and 5G networks (referred to as the "rebound effect").

For example, a 2017 IEA report,[65] suggested that due to efficiency gains, energy consumption from data centres would only increase by 3 % by 2020,[66] despite workloads tripling in this period. However, the authors conclude that it is challenging to make accurate predictions concerning future energy consumption from networks because of uncertainty about data demand growth and efficiency improvements. For 2021 the

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63 The study is based on an extensive dataset which combines primary and secondary data for operational (use stage) energy consumption and life cycle greenhouse gas emissions (CO2e) for a number of sub-sectors, including energy and carbon footprint data from around 100 of the major global manufacturers, operators, and ICT and E&M service providers. The data set also includes sales statistics and forecasts for equipment to estimate product volumes in addition to published LCA studies and primary manufacturing data to estimate the carbon footprint associated with different products.

64 Ministry of Transport and Communications, Finland (2020) - The ICT sector, climate and the environment.

65 IEA (2017) - Digitalization and Energy.

66 The authors estimate that data centres worldwide consumed around 194 TWh (1 % of total energy demand) authors give a range of 15 % decrease to 70 % increase for energy consumption from data networks.

Moreover, other studies paint a more pessimistic view concerning the evolution of GHG emissions from the ICT sector.

The Shift Project warns in a 2019[67] report about the high uncertainty of the current digital transition on worldwide systemic effects. Although the authors consider that, with appropriate regulation, digital transition can help to reduce energy and raw material consumption in certain sectors, they raise concerns that when all sectors are considered together, the explosion of digital technologies may have damaging environmental impacts. The authors note that the digital industry's energy intensity in increasing globally and observe that digital “overconsumption” is not sustainable in relation to its requirements on energy and raw materials. In their report, they recommend "digital sobriety", with a change in production and consumption behaviours to combat increasing global GHG emissions.

The risk of expanding emissions from the digital sector is also reflected in a study by Andrea and Edler (2015), which presents an estimation of global electricity usage associated with ICT between 2010 and 2030, excluding any enabling effects of ICT. Three different scenarios, best, expected, and worst, are described, based on annual numbers of sold devices, data traffic and electricity intensities/efficiencies, including data centres. The analysis shows that for the worst-case scenario, ICT could use as much as 51% of global electricity in 2030, while the best case scenario predicts usage could amount to 8% of global electricity. Notwithstanding efforts to increase renewable energy generation, the authors suggest that 23% of globally released GHG emissions may still be due to ICT in 2030, in the worst case scenario.

Belkhir and Elmeligi (2017) produce projections for 2040. Their assessment covers a similar scope to that of Andrea and Edler, but they pursue different assumptions regarding efficiency improvements and the overall level of global CO2e emissions. They find that, if left unchecked, the relative contribution of ICT to GHG Emissions could increase from roughly 1-1.6% in 2007 to exceed 14% of the 2016-level worldwide GHGe by 2040. This would be equivalent to more than half of the current relative contribution of the whole transportation sector towards GHGe. Furthermore, they suggest that by 2020, the footprint of smartphones could exceed the contribution to GHGes made by desktops, laptops or displays. **The different conclusions about the impact of ICT (and electronic communications networks) on GHG emissions, may stem in part due to different underlying assumptions, scopes and methodologies, but may also result**

67 The Shift Project (2019) – Lean ICT – Towards Digital Sobriety.

from difficulties in capturing actual GHG emissions and predicting future efficiency improvements[68] and consumer behaviour.

2.2.2 Ecomms as an enabler of energy efficiency in other sectors

On the other hand, some studies predict significant positive spill-over effects when digitisation is used to improve energy efficiency in other highly polluting sectors such as buildings and transport, independent from the ICT sector's own environmental footprint.

For example, a 2015 GeSi report on the CO2e impact of mobile communications[69] argues that applications based on mobile communications can support a reduction in emissions which is approximately five times greater than the carbon emissions from mobile networks themselves. Specifically, the authors claim that mobile communications has enabled a reduction of 180 million tonnes of CO2e a year across the USA and Europe. They claim that 70% of these reductions have been driven by the use of machine-to-machine technologies in buildings, transport and the energy sector, where devices are able to communicate automatically with each other without requiring human intervention. In addition, the authors note that the use of smartphones has enabled behavioural changes in lifestyle and working, which contribute towards a further 20% decrease in emissions.

A similar finding is reported in a 2017 report by the IEA,[70] which examines the impact of digitalization on energy demand in transport, buildings and industry. The report also illustrates how digitalization has increased productivity in oil, gas, coal, and power supply.

2.3 Drivers of environmental impacts and mitigating factors

2.3.1 A range of impacts

As shown in the following diagram, digital infrastructures are associated with a variety of different environmental impacts. These include the use of raw materials and discharge in addition to the use of energy in the production and operation phase, which contribute to GHG emissions and other pollutants. Construction of network elements can also have impacts on biodiversity and create disturbance and noise pollution[71].

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68 Noting for example that forecasts extending beyond 2030 might also be impacted by future technological developments such as 6G, which could be associated with further energy efficiency gains, but may also be linked to increased network densification and an increase in the number of connected devices

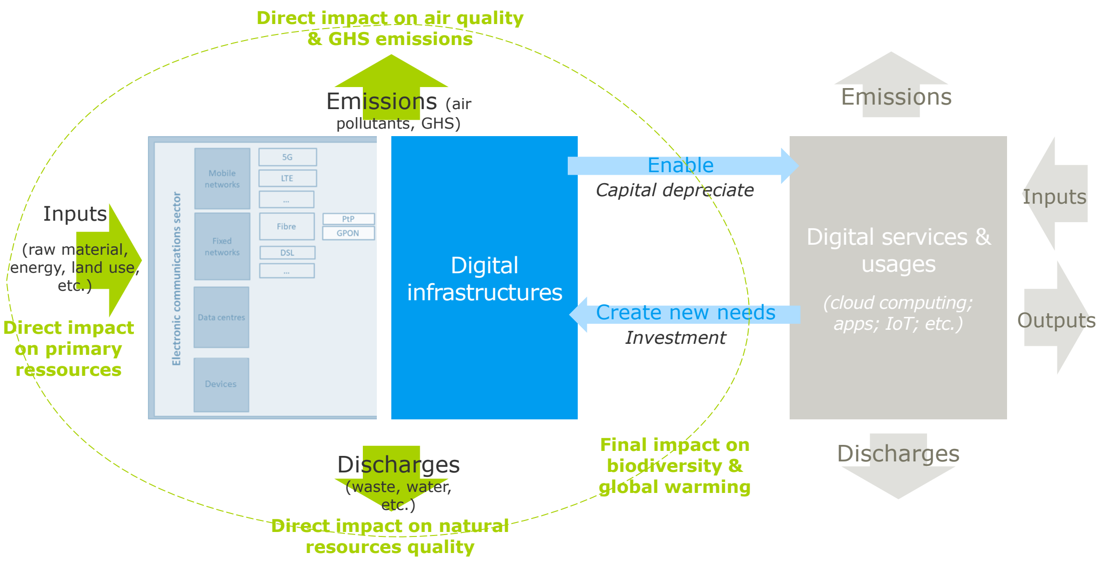
69 GeSi (2015) - GeSI Mobile Carbon Impact.

70 IEA (2017) - Digitalization and Energy.

71 Liu et al. (2019) - Impacts of the digital transformation on the environment and sustainability

It should be noted however that most of the available literature relates to the impact of ECN on energy consumption and GHG emissions, as this is assumed to be the most significant of the environmental impacts associated with ECN.

Figure 2-2: Overview of environmental impacts linked to ECN



Source: Ramboll

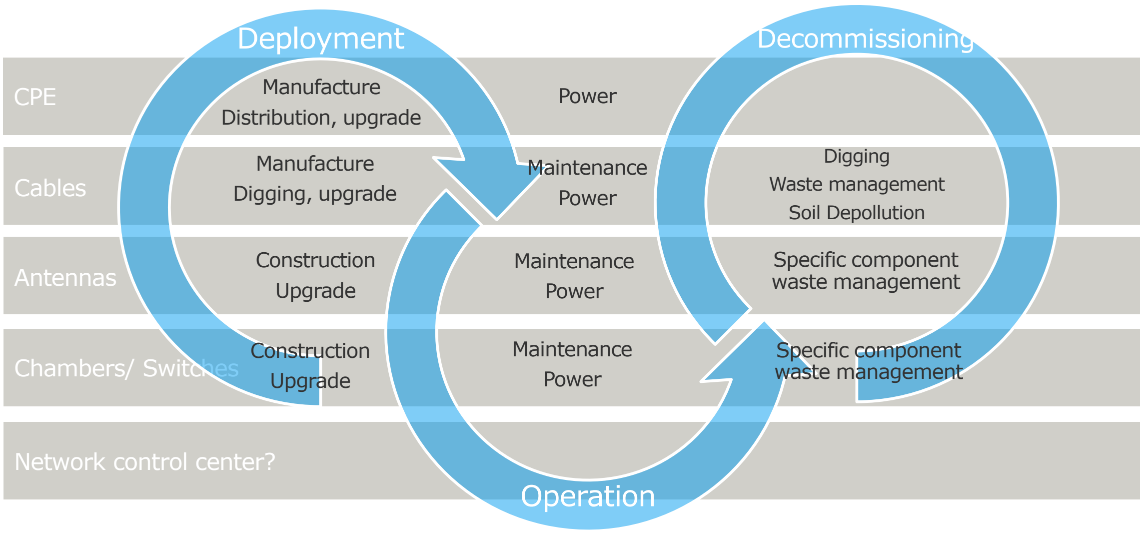
2.3.2 A lifecycle overview of Electronic Communications Networks

The environmental impacts stemming from electronic communications networks can be separated into three distinct phases, as follows:

1. **The "deployment" phase,** which involves the manufacturing of equipment ducts and cables, as well as digging and construction to lay the cables and install the equipment
2. **The "operation" phase,** which involves the ongoing operation of the network including the use of electrical power and activities associated with network maintenance; and
3. **The "decommissioning" phase,** which involves the extraction of the network elements and equipment, and the management of associated waste

These phases, alongside their relationship to the different network components are shown in Figure 2-3.

Figure 2-3: A lifecycle overview of the environmental impacts for electronic communications networks

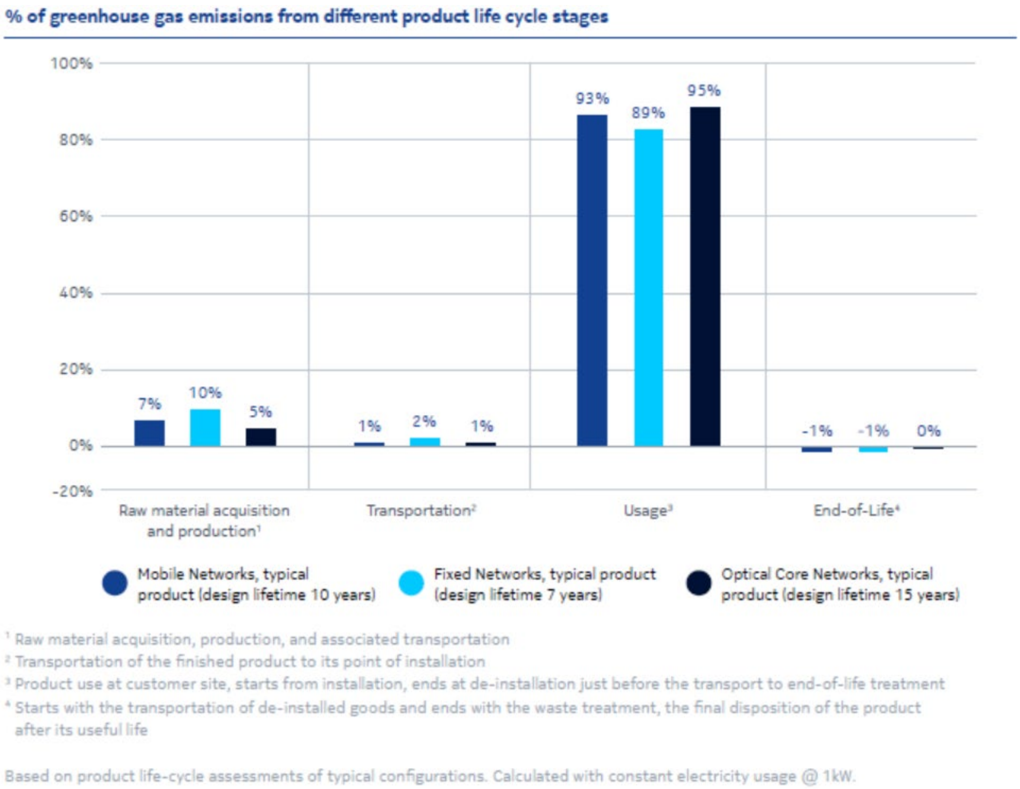


Source: Ramboll and WIK-Consult

As noted above, estimates from equipment manufacturers such as Nokia (2020) shown in Figure 2-4, suggest that the operation phase is responsible for about 90% of the emissions associated with electronic communications networks, with raw materials and transportation associated with the deployment phase accounting for the remainder. The authors indicate that some (but very minor) savings are currently made in the "end-of-life" decommissioning phase as elements are re-used. However, certain other literature implies greater impacts from the production phase.[72]

72 Andrae (2020) concludes that ECN constitutes around 8% of GHGe excluding manufacturing processes. When taken together with other literature that suggests that ECN constitutes around 24% GHGe including manufacturing processes, the implication may be that manufacturing processes play a more significant role in emissions at global level than may be suggested in the Nokia analysis. The differing assessments may be influenced by the scope of the data gathered and assumptions made.

Figure 2-4: % of greenhouse gas emissions at different product lifecycle stages



Source: Nokia (2020).[73]

Further insights from literature on the main drivers of emissions at each stage of the lifecycle as well as potential mitigating factors are provided in the following sections.

2.3.3 Environmental impacts of network deployment

Research concerning the effects of network deployment on the environment include analyses of different construction methods for laying cables and the impact of limiting greenfield construction by re-using existing infrastructure or co-ordinating civil works between different network operators.

Solivan (2015)[74] investigates the construction of fibre cable networks using a Life Cycle Assessment (LCA)[75] approach. The focus is specifically on the methods of micro and

73 Nokia (2020) - People & Planet Report 2019
74 Solivan (2015) - Life Cycle Assessment on fiber cable construction methods
75 Life Cycle Assessment (LCA), also known as life-cycle analysis), is a standardised methodology for assessing environmental impacts associated with all the stages of the life-cycle of a product, process, or service.

narrow trenching. He includes the three main phases of the construction process (excavation, laying, recovery) within the assessment. Additionally, the different methods were studied by distinguishing between asphalt and green space surfaces as well as with or without reusing the excavated masses. The results show that the smaller the excavated masses the better for the environment, as large excavation impacts natural land transformation and requires more fuel for operating machines. Furthermore, ploughing seems to have the least environmental impact of all assessed methods. When cables need to be laid under asphalt, micro-trenching should be the preferred method. Processes involved in asphalt production, fuel consumption for transportation of materials and operating machines and equipment used in fibre construction were identified to be responsible for major impacts.

Carbon Smart (2017)[76] confirms this finding by stating that the micro-trenching process is far less environmentally disruptive than traditional deployment.

Even greater savings can be achieved if existing infrastructure is reused. This is noted for example by Ecobilan (2008),[77] which notes that blowing fibre between existing manholes has significantly lower impact compared to alternative deployments such as traditional civil works. Stockman and Zhao (2014)[78] observe that this can be achieved in a number of ways including:

- Duct Sharing
- Sewer pipes
- Drinking water pipes
- Residential gas pipes
- Cable de-coring

As foundations have been found to be the main source of environmental impacts for the deployment of masts,[79] it seems likely that re-use of existing infrastructure would also help to avoid environmental impacts associated with the deployment of wireless networks.

The visual impact of aerial cabling compared with underground trenching is noted in one study. In a report for the Ministry of Business, Innovation and Employment of New Zealand Ellis (2014)[80] points out that underground cables predominantly impact the environment during the installation process whereas overhead wires have a more permanent visual effect. In addition, some environments are more sensitive regarding

76 Carbon Smart (2017) - Our digital infrastructure needn’t cost the earth
77 Ecobilan (2008) Developing a generic approach for FTTH solutions using LCA methodology
78 Stockman and Zhao (2014) White Paper: Innovative FTTH Deployment Technologies
79 Kouloumpis et al. (Performance and life cycle assessment of a small scale vertical axis wind turbine, 2020) and Stavridou (A comparative life-cycle analysis of tall onshore steel wind-turbine towers, 2020) both find that foundations are a key source of environmental impacts for wind turbines
80 Ellis (2014) - Environmental Effects of Implementing Ultra-Fast Broadband and Mobile Infrastructure

environmental impacts and visual distraction, for example sites of cultural significance, hilltops and ridgelines.

2.3.4 Environmental impacts of network operation

There is a variety of literature which confirms that the energy consumption of more modern generations of fixed and mobile technologies is lower than that which applies for previous generations for given levels of bandwidth consumption (with fixed technologies generally being more energy efficient than wireless). In addition, literature emphasises the importance of switching off legacy technologies in achieving energy efficiency. Fixed and mobile network sharing can also reduce energy consumption for a given level of bandwidth.

There is also a range of literature, which examines the impact that devices and services may have on bandwidth demand and the associated implications for energy consumption.

The findings are summarised below.

FTTH networks are more energy efficient than legacy fixed networks

As regards fixed line technologies, studies by Obermann (2020), as well as Aleksic and Lovric (2014) find that fibre-based networks (GPON and point to point) are more energy efficient than FTTC (VDSL2 vectoring, super vectoring) and cable. Obermann considers various scenarios for country-wide supply in Germany, drawing on real data from existing telecommunications networks in different areas with different population densities. The analysis shows that FTTH technologies considered are more energy efficient than FTTC networks in every scenario and for almost every degree of utilization. Aleksic and Lovric confirm that copper-based access technologies generally have lower energy efficiency than fibre based solutions, and this is true especially for large amounts of data and when network equipment is switched off during times of reduced activity. The authors conclude that for higher levels of bandwidth consumption “high-speed optical access technologies (point to point) providing up to 10 Gbit/s per user may achieve the highest energy efficiency. However, for lower access data rates, 1G-PONs are the most energy efficient access options.”

A study by Aslan et al. (2017) suggests that the electricity intensity of data transmission (core and fixed-line access networks) for Internet transmission has decreased by half approximately every 2 years since 2000 (for developed countries). The study estimates electricity consumption of 0.06 kWh/GB for 2015, and suggests that variations in the estimates tend not to be based on methodology, but rather on the systems included and reference year.

Various studies note that a key reason behind the increased energy efficiency of fibre networks is the reduced role played by active equipment compared with legacy technologies for which active equipment is extensively used to increase network performance. In a study by Baliga et al (2011), based on 2010 energy consumption and drawing on published specifications of representative commercial equipment, the authors conclude that at high data rates PON and point to point optical networks are considerably more energy efficient than the other solutions examined including DSL, HFC, UMTS and WiMAX. They observe that this is because the majority of power consumption for HFC and UMTS comes from power amplifiers, for which there was limited scope for improvements in energy efficiency. Similarly Breide and Hellberg (2017) note that the upgrade of copper and cable technologies has been associated with a significant expansion in active equipment. They observe that this increase will only end when each customer is directly connected via fibre (FTTH/B), because fibre is designed for high-frequency signal transmission and has no significant length restrictions in the access network. The authors conclude that, unlike other technologies, FTTH will not require adaptations in network structure in the medium to long term in order to be able to keep pace with future data demands.

Fixed networks are more efficient than wireless technologies, but 5G is potentially more efficient than previous generations of mobile technologies

As regards the impact of fixed vs wireless technologies, available literature suggests that fixed networks are generally more energy efficient than wireless networks in the transmission of a given volume of data**.** For example, in a study comparing cost, energy consumption and performance of fibre vs 5G fixed wireless access (FWA) based on 3 scenarios (existing commercial macro cells, newly installed mmWave small cells, and hybrid macro and small cells), Forzati (2019) finds that solutions using macro cells have significantly higher levels of energy consumption (in term of the total consumed electricity over 10 years) than the pure fibre-based solution. In particular, for the FWA hybrid solution, the total energy consumption is expected to be nearly 5 times and over 3 times higher than the pure fibre-based solution in urban and rural areas in Sweden, respectively.

Köhn, Gröger and Stobbe (2020) compare the emissions associated with streaming a video for one hour over different technologies,[81] and conclude that fibre technologies offer the most climate-friendly solution. Specifically, they find that FTTH emits 2 grams of GHG, whereas wired broad connection (VDSL) require around 4 grams of CO2e, i.e. double. The authors find that transmission on mobile access networks involves an even higher carbon footprint. Modern 5G networks consume around 5 grams, whereas the currently widespread 4G mobile network (LTE) consumes around 13 grams and the older 3G network (UMTS) is the least efficient of the considered networks with 90 grams CO2e per hour of video streaming.

81 The analysis in this case focuses on the usage phase

Bieser and Hilty (2018)[82] reach the same conclusion, and note that they expect around 4.5 g CO2e/GB for 5G networks in 2030, 85% less than today's mobile networks.

Although 5G is widely considered to be more energy efficient than previous generations of mobile technology, another study, by Deeoa, Beena and Girinath (2018), notes that the energy efficiency of 5G can be reduced for use cases which require ultra-low latency, and thus the practical effect may vary for different applications.

A number of studies also consider the environmental impacts of WiFi for general use as well as IoT applications. It should be noted that Wi-Fi networks are becoming increasingly widespread and represent a substantial source of energy consumption especially in relation to Access Points (APs). Silva, Almeida and Campos (2019) examine the power consumption of different configuration options available in enterprise Wi-Fi Aps, and confirm that the “race to idle” strategy is efficient for all configurations tested, as APs use the least amount of power when in idle mode. The authors also conclude that higher Modulation and Coding Schemes (MCSs) do not result in higher power consumption in the APs. Rather, in both TX (transmitting) and RX (receiving) modes, for the same frequency band, the number of spatial streams and the channel bandwidth have the most impact on power consumption.

As regards network technologies supporting IoT Gray et al. (2015) consider how the power usage for IoT varies depending on different data access rates (of between 1 kb/s and 1 Mb/s at the IoT gateway), and examine which would be the most energy efficient technological solutions. They find that the power usage of the fixed access network technology is largely driven by energy consumption by the CEP modems. They find that shared corporate Wi-Fi networks with PON backhaul are the most energy efficient option if the Wi-Fi background traffic level is modest. Otherwise, 4G Wireless (LTE) access can be more efficient if the site IoT traffic level is low – up to around 100 kb/s. At higher rates, GPON access provides the most energy efficient solution.

Switching off legacy technologies is important in achieving energy efficiency gains

Studies on energy efficiency are often based on theoretical models, but Krug, Shackleton and Saffre (2014) note that energy consumption may be higher than projected in theoretical models when network utilisation is sub-optimal. The study authors note that low utilization may be driven by the need for redundancy, to ensure quality-of-service or the need to provide for peak traffic load. The authors observe that the impact of low utilization could be addressed if equipment could adapt its energy consumption to the current traffic level. Although not a focus of the study, it should also be noted that “below optimal” network utilisation could also result from the operation of parallel networks e.g.

82 Bieser, Jan & Hilty, Lorenz. (2018). An Approach to Assess Indirect Environmental Effects of Digitalization Based on a Time-Use Perspective. 10.1007/978-3-319-99654-7_5.

in the context of infrastructure competition or the maintenance of legacy technologies alongside more modern networks.

In this context, a number of studies aim to assess the implications for energy consumption of switching off legacy fixed or mobile networks and migrating customers to FTTH or 5G.

In a study by WIK-Consult, Godlovitch et al. (Neutral fibre and the European Green Deal, 2020) found that “if there was a complete migration from the current technology mix in the EU to all fibre … the power consumption would be reduced from 52,608 GWh to 10,857 GWh. Moreover, if there is complete switch to PtP connections the power consumption would decrease further to 3,376 GWh.” They find that this would reduce CO2 emissions by more than 90% if all households switched to PtP FTTH connections.

Turning to mobile networks, in a study by (Lee, Pinner, Somers, & Tunuguntla, 2020), McKinsey suggests that the shutdown of legacy systems (2G) could lead to energy savings of 3%.

Rapone et al. (Energy efficiency solutions for the mobile network evolution towards 5G: an operator perspective, 2015) similarly finds that in a scenario involving the introduction of 5G and phasing out 3G energy saving of 50% could be achieved by 2024 compared to 2014.

It is important to note however that assessments of the impact of switching off legacy technologies are highly dependent on associated assumptions about bandwidth consumption on the new networks that will replace the legacy systems for all customers. (SQW, 2013) notes that the switch to fibre may in itself drive demand for data and this would offset some of the savings obtained by the high efficiency (the so-called “rebound effect”). Thus the significant energy savings projected from full copper switch-off to FTTH e.g. in the 2020 WIK-Consult study would likely be considerably more limited if bandwidth increases were taken into account. In addition, the switch-off of legacy networks has an impact on devices that rely on legacy networks and the replacement of this equipment and associated energy consumption of the new equipment should be weighed against positive impacts stemming from the increased energy efficiency of the new network.[83]

Taking a practical example, Verizon reported in 2015 that it had achieved energy savings of around 60% when switching from copper to fibre.[84]

Temporary shut-downs can save on energy

Alongside the full switch-off of legacy infrastructure, temporary shutdowns of certain equipment or low power modes can also contribute to energy savings. This is one of the core principles behind the energy savings possible in 5G networks. For example,

83 Arcep (2020). Achieving Sustainability, Report, P. 95.
84 https://www.lightreading.com/ethernet-ip/new-ip/verizon-saves-60--swapping-copper-for-fiber/d/d-id/715826

Mukherjee (2018) identifies different areas for energy efficiency in 5G networks,[85] which includes on-/off switching of gNBs. When there is a set of adjacent gNBs, they can coordinate and save energy without jeopardizing the URLLC character of 5G.[86]

Ericsson further notes that[87] activating energy-saving software will bring savings by, e.g. machine learning. “Features such as Micro Sleep Tx (MSTx) and the Low Energy Scheduler Solution (LESS), which it claims can reduce radio equipment energy consumption by up to 15% while maintaining the same user experience.”[88]

Certain operators in France such as Free mobile have also chosen to switch off certain 4G frequencies during the night to reduce energy consumption.[89]

Network sharing can limit energy consumption

Network sharing could also in principle limit energy consumption compared with the parallel operation of different networks. This is the subject of a 2015 study by Antonopolous et al,[90] which looks at the potential efficiencies that could be gained from intra-cell roaming-based infrastructure sharing, where the MNOs may switch off their base stations and roam their traffic to active base stations operated by other MNOs in the same cell.

In a 2013 conference paper,[91] Marsan et al, use simple analytical models to show that in most European countries the amount of energy necessary to run mobile networks can be reduced by 35 to 60% with respect to the case in which each operator manages a separate network infrastructure.

Although less attention has been given in the research literature to the effects on energy efficiency of fixed “co-investment” or access-based competition, it seems likely that this would also give rise to lower energy consumption than the operation of parallel networks because it could limit the suboptimal utilisation of the network.

Applications and devices can impact energy use

It is important to note that energy consumption is not only influenced by the efficiency of network operation for the delivery of a given datastream (the supply-side) but also by

85 Mukherjee, A. (2018): Energy Efficiency and Delay in 5G Ultra-Reliable Low-Latency Communications System Architectures, IEEE Network, March/April 2018, p.55-61.
86 Mukherjee, A. (2018): Energy Efficiency and Delay in 5G Ultra-Reliable Low-Latency Communications System Architectures, IEEE Network, March/April 2018, p.57 ff.
87 Ericsson (2020): Breaking the energy curve, An innovative approach to reducing mobile network energy use.
88 Ericsson (2020): Breaking the energy curve, An innovative approach to reducing mobile network energy use.
89 https://twitter.com/free/status/1445057755379798017
90 Energy Efficient Infrastructure Sharing in Multi-Operator mobile networks https://www.researchgate.net/publication/272089056_Energy_Efficient_Infrastructure_Sharing_in_Multi-Operator_Mobile_Networks
91 Marsan et al (2013) Network sharing and its energy benefits: A study of European mobile network operators https://ieeexplore.ieee.org/document/6831460

factors which influence bandwidth demand and energy consumption by the end-user, which is influenced by the type of device, as well as the nature and delivery method of content.

Schien et al. (2013) analyses the energy footprint of content downloaded from a major online newspaper by means of various combinations of user devices and access networks. In their study, the authors simulate different use cases, 10 minutes of reading or streaming a video on different end-user devices ranging from smartphones to desktop PC, and on different networks, differentiating between Internet network, shared access network and customer premise access network. In the reading scenario, the least amount of energy is consumed on a smartphone via 3G for ten minutes, while a desktop PC using Wi-Fi consumes the most. In that case, the user device itself has the largest impact on energy consumption. In the video streaming scenario, however, the smartphone on 3G consumes more than the desktop on Wi-Fi despite the enormous amount of energy the PC itself consumes, compared to the smartphone. The authors conclude that, although energy consumption by data centres deserves attention, for the individual users of the online newspaper they studied, energy use by user devices and 3G mobile network are usually more significant contributors to the energy footprint of the service provided than the data centres. In short, data transfer of video content involves significant energy use on the 3G mobile network, but less so in other settings.

These findings are confirmed in a later study by Yan et al. (2019) which concludes that the main energy consumption for web browsing and instant messaging applications is the smartphone itself, whereas for heavy data applications such as video viewing, video chat and virtual reality applications, the LTE wireless network is the main source of energy consumption.

At least one study considers the energy consumption involved in watching video and considers how this compares between the different technological solutions i.e. terrestrial or satellite broadcasting, cable or streaming. A key finding is that terrestrial broadcasting is the most energy efficient solution, and that streaming is the least energy efficient transmission mechanism for transmitting video to large screens.

The study by Schien et al. (2020) uses a novel methodology[92] to compare electricity consumption for the distribution and viewing of television via terrestrial, satellite and cable broadcasting as well as streaming. Using data derived from the UK BBC, they show that the electricity consumption associated with distribution and viewing of BBC content was 2,171 GWh in 2016, corresponding to 0.6 % of the overall energy consumption in the UK. The authors also show that viewing over streaming, cable and satellite platforms uses a mean of 0.17- 0.18 kWh per device-hour (88-93 gCO2e) while terrestrial broadcasting uses a mean of 0.07 kWh (36 gCO2e). They identify home networking equipment and set-top boxes as key drivers of electricity consumption. They also show that although

92 The analysis combines life cycle assessment techniques with models of the diversity of actual user behaviour, derived from detailed audience monitoring and online behaviour analytics data

streaming has a similar impact in terms of electricity consumption to cable and satellite, this is due to the use of smaller viewing devices (e.g. smartphones, tablets and laptops versus large TV screens) which results in the networking equipment accounting for a greater share of consumption in the case of streaming than the end user device. Higher electricity consumption could however be expected when streaming is carried out at high resolutions to larger devices such as TV screens.

In this context, it should be noted the Shift Project (2020) estimates that online streaming generates 0.4kg CO2e per hour. This sparked a discussion in the scientific community and emphasises how different underlying assumptions produce a wide range of estimates.[93]

2.3.5 Environmental impacts of decommissioning

As shown in Figure 2-4, the decommissioning/ end of life stage of the lifecycle for electronic communications networks represents a very small part of the environmental impact in telecommunications, amounting to less than 1% for mobile networks, fixed networks and optical core networks. Therefore, very little literature and information is available on the topic.

During the interviews, operators highlighted that the impacts at the decommissioning stage mostly consist of waste and its disposal. Waste at this lifecycle stage concerns all elements of the equipment, including cables, poles, and CPE. According the operator Telia, the ongoing decommissioning of the copper network has required considerable efforts, producing waste which was complicated to manage, including chemically treated poles. Such waste requires a special treatment and cannot be recycled. Indeed, the operator explained that the decommissioned poles are processed at a specialised facility in Sweden that incinerates them, and recycles the incineration energy.

The mitigation actions highlighted throughout the study by the operators involve the re-use, re-cycling and re-sale of both the network infrastructure and CPE. These three actions reduce the amount of waste that requires disposal and enable reductions in the raw material extracted to produce new equipment.

93 See IEA Commentary (11.12.2020) by Kamiya, G., https://www.iea.org/commentaries/the-carbon-footprint-of-streaming-video-fact-checking-the-headlines, and the Shift Project (2020), https://theshiftproject.org/wp-content/uploads/2020/06/2020-06_Did-TSP-overestimate-the-carbon-footprint-of-online-video_EN.pdf.

2.3.6 Methodological challenges in measuring the environmental impacts of electronic communication networks

Variations in the literature about the environmental impacts of ECN are due in part to the use of different methodologies. The Report of the Study Group on Circular Economy[94] confirms that a key challenge is the lack of standardised methods and metrics to assess the environmental impact of digital technologies and describes the great diversity of metrics, methodologies and standards that currently exist or that are under development. For example the report notes that:

- There are at least 9 different organisations and initiatives that have developed methodologies to quantify the environmental impacts of ICT. They include methodologies on consumer electronics, servers, data centres, telecommunications, managed service providers, data-related projects including smart cities, software and hardware. Moreover, the ETSI ES 203 199 and the ICT sector guidance are other methodologies to quantify these impacts, although they specifically provide guidelines to compare traditional services with digital services.

- There is a need to properly address some basic aspects of digitalisation at a foundational or horizontal level from a standardisation point of view, such as Connectivity, Cloud and edge computing, Big data / public data / public sector information, Internet of Things, Cybersecurity, Blockchain and other new technologies. So in parallel with the methodologies for quantifying the environmental impacts of ICT, there should be horizontal standards that specify how concepts and actions should be implemented to achieve the circular economy, when done through digitalisation. These standards have direct influence on how the net effect of digital solutions is quantified as they harmonise terms, metrics and activities. Some examples are the CEN / CENELEC standards in support of various Ecodesign and Ecolabelling product regulations on material efficiency (EN 4555X) and of batteries and plastics , the ETSI EN 305 174-8 on Management of end of life of ICT equipment , the ETSI TR 103 476 on Circular Economy (CE) approaches, concepts and metrics in ICT, the ISO/TC 323 on Circular Economy to develop frameworks, guidance, supporting tools including sectoral applications, the German DIN SPEC 91406 and the DIN VDE V 0170-100 describing an approach to assign a unique URL in a concisely recognizable QR code as part of the German Roadmap Industrie 4.0.

There are some industry initiatives, which have focused on developing and/or harmonising standards e.g. for product passport (EN IEC 62890 , DIN 77005-1 and the concept of Digital Twin), the UNECE's work on Enhancing Traceability and Transparency of Sustainable Value Chains in the Garment and Footwear Sector with support from the European Commission and the International Trade Centre, and the registration of stances of concern to the European Chemical Agency by the chemical industry in the SCIP database. The EU Taxonomy also provides a framework on metrics and objectives for

94 https://ec.europa.eu/docsroom/documents/44089

when specific industry sectors should claim to significantly contribute to climate change, circular economy, etc. It classifies the economic activities using NACE codes, and specifies the metrics to be used to measure this contribution for each industry sector. In some cases, the metrics refer only to compliance with minimum requirements (e.g. data centres), but specific target metrics are expected to be developed to replace the compliance metrics.

The development of these metrics and methodologies has significantly ramped up in the recent years. Such an abundance provides a good starting point to develop harmonised metrics and methodologies. However, in some cases the same metric or concept has been handled through separate standards, and horizontal standards focusing on facilitating circular economy define metrics and activities that in some cases complement or cut across the ICT standards. There is thus an important need to harmonise the methodologies and metrics in order to be able to quantify the environmental impact of ECN in a manner that allows for comparisons to be made between operators and countries and to track progress over time.

3 Actions by electronic communications network and service providers

Electronic communication networks and service providers' awareness of the environmental impact of their activities has increased considerably in recent years. In this chapter, we elaborate on the objectives and targets that have been set by electronic communication operators, as well the measurement methodologies that have been deployed and actions that have been undertaken by these actors.

Key findings

- Most operators interviewed in the process of this study have committed to reducing their GHG emissions and have set relatively ambitious and quantified targets to reach those objectives. These include targets to achieve net zero emissions throughout the value chain, but according to different timescales e.g. by 2030 for Telia, 2040 for Vodafone, Telefonica, and Deutsche Telekom, and 2050 for Iliad.
- Specific operational targets that have been set by ECN operators include use of renewable energy (several operators reporting achieving 100% for their own operations), as well as reductions in energy use for the operation of the network. Direct comparisons for these specific targets are not possible due to the lack of common methodology. Differences include the base year and starting point, as well as the methodology used for carbon emissions measurement and which scopes are covered.
- Some operators have also set targets regarding the waste generated by their operations. Objectives include zero waste from own operations (including networks) by 2030 (Telia) and 100% of network waste recycled/reused/refurbished by 2025 (Vodafone).
- The Greenhouse Gas Protocol is the most common methodology used, but Scope 3 measurements within this protocol still vary. ISO 14001 environmental management standards are also commonly applied. There was limited reference to ITU standards by the companies interviewed for the study.
- Actions taken by companies to limit GHG emissions and other environmental impacts include the re-use of excavated masses, eco-conception of modems or mobile phone equipment, re-using refurbishing and recycling equipment, alternative cooling techniques, and the switch-off of frequencies during the night. Some stakeholders are seeking to influence emissions associated with equipment by setting environmental targets for suppliers and communicating to consumers about the environmental impact of devices. Stakeholders also point to the positive environmental impacts of migrating to more energy efficient FTTH and 5G networks and network sharing.

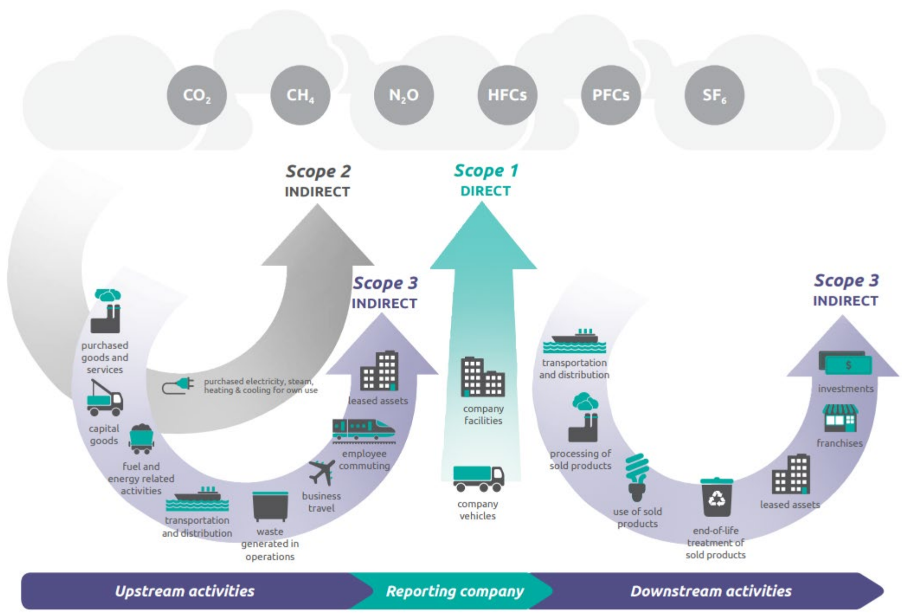
3.1 Objectives and targets

Interviews alongside a review of the sustainability reports of telecommunication operators, reveals that many amongst them have established objectives and targets concerning their environmental footprint as follows.

- GHG emissions objectives

The GHG Protocol defines three categories of those emissions, called “scopes”, depending on the influence the company has on these emissions.

Figure 3-1: Overview of GHG Protocol scopes and emissions across the value chain



Source: Corporate-Value-Chain-Accounting-Reporing-Standard_041613_2.pdf (ghgprotocol.org)

Scope 1 refers to the emissions related to the organisation’s owned or controlled resources (direct emissions); scope 2 to the indirect emissions from the energy purchased by the organisation, and scope 3 to all other indirect emissions along the value chain (upstream and downstream) Scope 3 emissions typically account for the biggest GHG emissions for most organisations[95].

Most operators interviewed in the process of this study have committed to reducing their GHG emissions and have set relatively ambitious and quantified targets to reach those objectives. Among the targets set, we found different reduction objectives such as a reduction of 30,500 tons CO2 equivalent by 2030 for Fastweb or a reduction of Scope 1

95 FAQ.pdf (ghgprotocol.org)

and 2 emissions by 2050 and of 50% of scope 3 emissions by 2030 for Liberty Global. In addition, multiple operators have set an ambitious target of Net Zero throughout the value chain with different timelines, e.g. by 2030 for Telia, 2040 for Vodafone, Telefonica, and Deutsche Telekom, and 2050 for Iliad. In addition, the NRA in Poland highlighted that Orange Polska has set the objective of a reduction by 65% of CO2 emissions compared with the 2015 baseline and achieve climate neutrality by 2040. Similarly, according to ComReg, a number of operators in Ireland have signed up to the Business in the Community's Low Carbon Pledge, committing to reducing their carbon intensity by50% by 2030.

It is important to note that the ambition implied by the different objectives depends on the base year and starting point, as well as the methodology used for carbon emissions measurement and which scopes are covered. ARCEP has highlighted that for scope 1 and 2 there are comparable methodologies for the French operators, but that scope 3 is difficult to compare between operators as there is no common methodology.

- Use of renewable energy

The use of energy is closely related to environmental impacts such as air pollution, climate change, water pollution, thermal pollution, and solid waste disposal[96].The type and magnitude of the environmental impact is directly linked to the source of energy. For example, fossil fuel combustion is one of the main contributors to greenhouse gases emissions, extraction of oil comes with the risk of spills either on the earth or in water leads to pollution, and solid waste is a by-product of some energy sources [97]. In Europe, the most common sources of energy are petroleum products (36%), natural gas (22%), renewable energy (15%), nuclear energy (13%), and solid fossil fuels (13%)[98].

The switch to renewable energy has been found to provide multiple environmental benefits. Indeed, it has been associated in the European Union with a reduction of greenhouse gases emissions, air and water pollution (particulate matter formation, eutrophication, and acidification)[99].

For the majority of the operators consulted in the present study, energy consumption represents the main source of impact linked to their operations. Thus, considerable focus has been placed on running their activities with renewable energy. Several have already reached 100% renewable energy for their own operations (e.g.Telia, Iliad, Fastweb, Deutsche Telekom), while the others are actively working on achieving this goal and have set a 100% renewable energy as a target for their company. Renewable energy is typically partly self-provided and partly based on procurement of energy with Guarantee of Origin certificates. A few operators have quantified the impact of the switch to

96 environmental impact of energy — European Environment Agency (europa.eu)
97 environmental impact of energy — European Environment Agency (europa.eu)
98 In 2018 - Where does our energy come from? (europa.eu)
99 Latest EEA study finds multiple benefits of switch to renewable electricity — European Environment Agency (europa.eu)

renewable energy. Fastweb for example, notes that the purchase of renewable energy has enabled it to avoid the emission of more than 60,000 tons of CO2eq each year. In addition, the Polish NRA has highlighted the commitment of Orange Polska to shift to renewable energy (and reach 60% by 2025) inter alia through a plan to obtain 50 Gwh per year from two wind farms and the commitment through long term power purchase agreement with renewable energy providers[100]. Similarly, NOS Communicações (Portugal) has reached an agreement with a power supply company including a commitment to supply at least 40% of renewable energy by 2030.

However, ARCEP highlights that operators need to be able to have reliable energy sources in case of crisis, and that renewable energy may not always provide this degree of reliability. A solution put forward to mitigate the risk could be to combine energy sources.

- Energy Efficiency

As explained in the renewable energy section above, energy use has considerable impacts on the environment. Energy efficiency refers to the use of less energy to perform the same task and thus eliminate energy waste[101]. Similarly to the shift to renewable energy, enhanced energy efficiency can be directly linked to the reduction of energy consumption, and thus results in lower greenhouse gases emissions and more generally reduced environmental impacts related to energy consumption.[102]

Among the telecommunication operators interviewed, the majority aim to improve the energy efficiency of their networks to reduce their energy consumption, for both environmental and economic reasons. However, although most state that they have an objective to improve their energy efficiency, not all have defined quantified objectives (e.g. Fastweb, Open Fiber). Those which have quantified their objectives have differing KPIs and scopes as follows:

- A reduction of energy consumption per subscription of 5% by 2022 (baseline 2018) for Telia
- A reduction of 15% of energy consumption in the operations by 2025 (baseline 2019) for Iliad
- An energy efficiency multiplied by 10 (baseline 2012) for Liberty Global
- A reduction of energy consumption per traffic unit of 85% by 2025 (baseline 2015) for Telefonica

100 CSR Społeczna Odpowiedzialność Biznesu | Orange Polska; Razem dla Planety | Orange Polska
101 Energy Efficiency | EESI
102 Energy Efficiency | EESI

- An increase of the energy efficiency indicator by 60% for the fixed network and by 80% for the mobile network; maintain the PUE for the data centres (baseline 2016) for Cetin

- Waste

Waste contributes significantly to climate change and air pollution, and might directly impact ecosystems and species. Depending on the method of waste management, impacts can vary: release of methane (greenhouse gas), contamination of soil and water when in landfills; transport and treatment result in co2 emissions and other air pollutants[103]. For an organisation, reducing waste thus means diminishing its environmental impacts linked to waste management.

In the telecommunication sector more precisely, waste includes electronic waste (modems, terminals, network equipment), as well as antennas and infrastructure material (when dismantled) and excavated masses when digging for network deployment. In relation to electronic waste, the environmental concerns are mostly linked to the harmful substances that could be released and pollute the environment, and/or harm the people involved in the recycling process[104].

Acknowledging this concern, some operators have set targets regarding the waste generated by their operations. Objectives include zero waste from own operations (including networks) by 2030 (Telia) and 100% of network waste recycled/reused/refurbished by 2025 (Vodafone).

- Water

All interviewees agree that the telecommunication sector is not water intensive. It should cooling data centres can involve significant water consumption. However, some interviewees also highlighted their business might have a positive impact on water as a resource, through smart metering and better measurement and management methods (Telefonica).

- Toxic substances

Very few operators mentioned targets to reduce their impact on the environment as regards toxic substances. Telia has set a target for zero toxicity through the value chain, and Deutsche Telekom mentioned their monitoring of toxic substances and their aim to prohibit the use of certain substances throughout their value chain.

103 Waste: a problem or a resource? — European Environment Agency (europa.eu)
104 E-waste in the EU: facts and figures (infographic) | News | European Parliament (europa.eu)

Table 3-1: Objectives and targets set by operators

	Telia	Iliad	Liberty Global	Fastweb	Open Fiber	Vodafone	Telefonica	Deutsche Telekom	Telecoop	Cetin
GHG Objectives	Zero CO2eq throughout the value chain	Neutral by 2035 for scope 1&2 Neutral throughout the value chain by 2050 (scope 3)	Reduce scope 1&2 emissions of 80% by 2050 Reduce scope 3 emissions of 50% by 2030	Reduce of 62% scope 1 emissions by 2030 Reduce of 15% scope 3 emissions by 2030	Not stated	Zero CO2 throughout the value chain by 2040 (scopes 1,2&3)	Zero CO2 on main markets by 2025 Zero CO2 throughout the value chain by 2040	Net zero by 2025 for direct and indirect emissions, Zero CO2 emissions through the value chain by 2040	Not stated	Not stated
Renewable energy share	100% in own operations	100% in own operations	83% for the group's own operations	100% in own operations	40% (target: 100%) in own operations	40% (100% by 2025) 100% in Europe by 2021	100% on main markets since 2019 100% by 2030 on all markets	100% in own operations	Not stated	Not stated
Energy efficiency	Reduce consumption per subscription eq. of 5% by 2022 (2018 baseline)	15% lower energy consumption on their operations by 2025 (2019 baseline)	10x more energy efficient (baseline 2012)	Actions to improve but no quantitative goal	Actions to improve but no quantitative goal	Actions to improve but no quantitative goal	Reduce consumption per traffic unit of 85% by 2025 (baseline 2015)	Improve EE (measure of KPIs) – no precise target stated	Not stated	Increase the EE indicator by 60% for fixed net. & 80% for mobile net., keep PUE for data centres (2016 baseline)

	Telia	Iliad	Liberty Global	Fastweb	Open Fiber	Vodafone	Telefonica	Deutsche Telekom	Telecoop	Cetin
Waste	Zero waste in own operations incl. networks by 2030	Reducing waste through reusing, recycl., refurb. + eco-conception of own equipment	Reducing waste through recycl., reusing, refurb. equipment + sell components on the open market	Not stated	Not stated	Reuse, recycle or resell 100% of network waste by 2025	Zero Waste to landfill (no deadline to reach that target)	Reducing waste through reusing, recycling and refurbishing	Promote eco-conception and partner with responsible brands for their offering	Not stated
Water	Not stated	Efficient use of water in their operations, no quantitative target	Not stated	Not stated	Not stated	Not stated	Reduction through Eco Smart services offering /No quantitative target set	Not stated	Not stated	Not stated
Toxic substances	Zero toxicity throughout the value chain	Not stated	Not stated	Not stated	Not stated	Not stated	Not stated	Ban of certain problematic substances through the supply chain	Not stated	Not stated

3.2 Measurement methodologies

When assessing the environmental impacts of an organisation's activities, a framework for the measurement and analysis of said impacts is necessary in order to obtain solid data on which to base the target setting and action plan. In this section we describe the main impact measurement and target setting methodologies encountered in the telecommunication industry, and then discuss the application of these methodologies by the actors interviewed for this study.

- Greenhouse gases emissions measurement methodologies

Among the methodologies to measure the greenhouse gas emissions of an organisation, the Greenhouse Gas Protocol is the most commonly used. The GHG Protocol provides global standardized frameworks to assess and manage the greenhouse gas emissions of a company, organisation, city or country. Typically, these standards address the accounting and reporting of seven gases covered by the Kyoto Protocol[105]. As briefly explained above in 3.1, the GHG Protocol initiative classifies the GHG emissions of an organisation according to the 3 scopes: scope 1, that covers direct emissions arising from the organisation's owned resources; scope 2, that includes the indirect emissions related to the energy purchased by the organisation, and scope 3, that gathers all the remaining indirect emissions along the value chain [106].

Another common methodology, the Bilan Carbone®, is sometimes used by companies as an alternative to the GHG Protocol. The principles of the Bilan Carbone® methodology are very similar to those of the GHG Protocol[107], and this GHG emissions assessment framework is compliant with the GHG Protocol.[108]

Regarding the telecommunication industry and more specifically the operators involved in the present study, the majority are actively using the GHG Protocol to monitor their carbon footprint (e.g., Telia, Liberty Global, Fastweb, Telefonica, Deutsche Telekom), except for Iliad, that uses the Bilan Carbone methodology.

Regarding the methodology and their application by organisations, is important to highlight that measurement of scope 3 impacts via such measurement methods varies from one company to another, and thus there is limited comparability.

105 Corporate Standard | Greenhouse Gas Protocol (ghgprotocol.org)
106 FAQ.pdf (ghgprotocol.org)
107 ADEME - Bilans GES Site
108 Bilan Carbone | Greenhouse Gas Protocol (ghgprotocol.org)

- ISO 14001

ISO Standards are international standards defined by experts, that include quality management standards, environmental standards, health and safety standards, energy management standards, food safety standards, and IT security standards.[109]

The ISO 14001 standard is part of the ISO 14000 group that gathers the environmental management standards. It defines the guidelines for an environmental management system and can lead to a certification for the company[110]. The aim of this standard is to promote a more efficient use of resources and a reduction of waste, thus improving the environmental performance of the organisation. The ISO 14001 certification also allows a company to gain a competitive advantage and the trust of stakeholders.[111]

Within the frame of the present study, most companies interviewed have an environmental management system that complies with ISO 14001 environmental management standards, for the whole company (e.g., Fastweb, Open Fiber, Telefonica, Deutsche Telekom, Cetin) or for some of their markets (Vodafone, Telia).

- Lifecycle Analysis

The lifecycle analysis approach provides a comprehensive view of the impact of a product/service from its conception to its disposal. Some operators interviewed for the present study (e.g. Telia and Liberty Global) are using the LCA approach to assess the different options when it comes to network development/dismantlement. Others (e.g. Telia, Vodafone) use the LCA approach to measure impacts in relation to equipment (e.g. modem, phone) lifecycle to measure impacts.

- Science Based Targets initiative (SBTi)

Science-based targets defines a pathway for companies to reduce greenhouse gas emissions, and qualifies the targets of companies as science-based *"if they are in line with what the latest climate science deems necessary to meet the goals of the Paris agreement"*[112].

Most respondents to the present study (including Telia, Liberty Global, Fastweb, Vodafone, Telefonica, Deutsche Telekom) have their environmental targets approved by the Science Based Target initiative.

- ITU Standards

Regarding ITU (International Telecommunication Union) Standards, five of the operators interviewed (Telia, Fastweb, Vodafone, Telefonica, and Deutsche Telekom) are listed as

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109 ISO - Standards
110 ISO - ISO 14000 family — Environmental management
111 ISO 14001 - Introduction to ISO 14001:2015
112 How it works - Science Based Targets

ITU-T sector members[113]. As for the use of the ITU Standards when measuring the environmental impact of their activities, Telefonica and Liberty Global prefer to use more general standards (such as the GRI reporting framework, ISO Standards, or the GHG Protocol). Telefonica explained that the ITU Standards tend to be very aligned with such standards, citing the example of the Recommendation ITU-T L.1470 “GHG emissions trajectories for the ICT sector compatible with UNFCCC Paris Agreement”.

In addition, Fastweb stated that they do not use ITU standards when measuring environmental impact.

As for the other operators, no answer was given regarding that topic.

113 List of ITU-T Sector Members

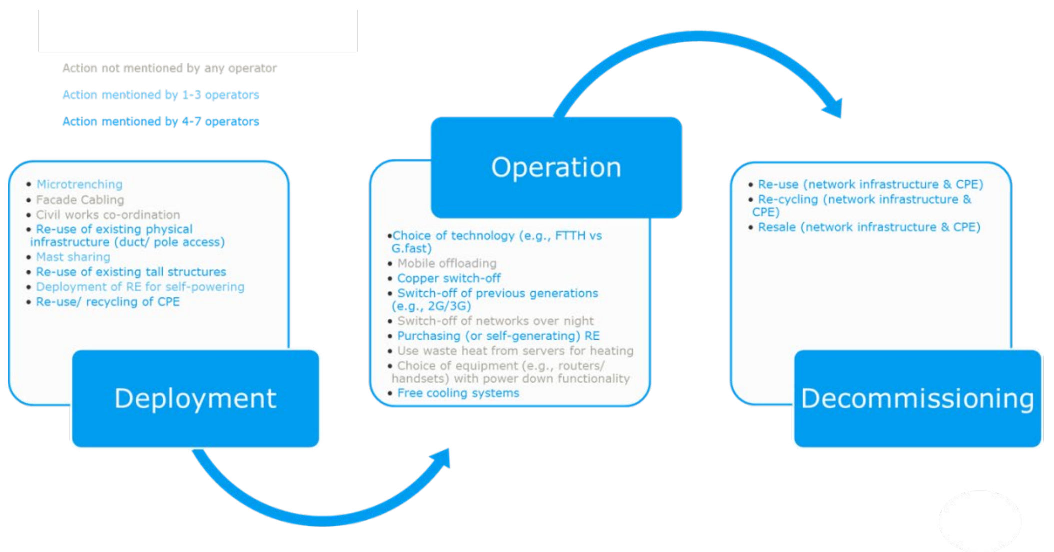
Table 3-2: Measurement and target setting methodologies

	Telia	Iliad	Liberty Global	Fastweb	Open Fiber	Vodafone	Telefonica	Deutsche Telekom	Telecoop	Cetin
GHG Protocol/ Bilan Carbone	Yes, GHG Protocol	Yes, Bilan Carbone	Yes, GHG Protocol	Yes, GHG Protocol	Not stated	Zero CO2 throughout the value chain by 2040 (scopes 1,2&3)	Yes, GHG Protocol	Yes, GHG Protocol	Not stated	Not stated
ISO 14001	Yes (4/6 markets)	Not stated	Not stated	Yes	Yes	Yes (on several market)	Yes	Yes	Not stated	Yes
Lifecycle analysis	Yes (of network infrastructure to prioritize dismantlement/ improvement)	Yes (for conception of equipment such as boxes, modems ; ongoing work on networks in the frame of the French Circular Economy law)	Yes (when assessing projects e.g. improve current network or develop new technologies)	Not stated	Not stated	Yes (for the products, currently at data collecting stage)	Not stated	Not stated	Not stated	Not stated
SBTi targets	Yes	Not stated	Yes	Yes	Not stated	Yes	Yes	Yes	Not stated	Not stated
Listed as ITU-T Sector Members	Yes	Not stated	Not stated	Not stated	Not stated	Yes	Yes	Yes	Not stated	Not stated
Use of ITU standards when measuring the environmental impact	Not stated	Not stated	No (prefer GRI reporting framework and GHG Protocol)	No	Not stated	Not stated	No (prefer more general standards such as ISO Standards and the GHG protocol)	(No clear answer)	Not stated	Not stated

3.3 Best practices and impacts

3.3.1 Best practice actions from the industry

Figure 3-2: Sustainable initiatives mentioned by operators interviewed for the study



Source: Ramboll

Across the industry, various actions to reduce or eliminate the environmental impacts have been or are being undertaken by the actors. Such actions can take place at each stage of the lifecycle: during the deployment, the operation or the commissioning stage.

Actions taken during the deployment phase include the following:

- Microtrenching

During the deployment phase of networks, digging has various impacts on the environment, including waste from excavated masses, energy consumption, and biodiversity disturbance. To tackle this issue, multiple operators have mentioned that they have a preference for micro-trenching. However, the use of such building techniques is subject to approach from local authorities. Fastweb has estimated that the carbon impact of microtrenches is 20x lower than standard trenches (200kg of CO2eq/km vs 10kg of CO2eq/km).

- Reuse excavated masses

When digging for network deployment, operators often find that they are left with excavated masses that end up as waste. Telia is aiming at reusing these masses on site, through local partnerships, if allowed by local authorities and if the masses are not contaminated.

- Mutualisation of network between operators

As mentioned in previous sections, network deployment is associated with certain impacts on the environment. This is why network sharing has been put forward as good practice by several operators. This is the case of Telecoop, which exclusively uses Orange's network to provide its services. Another example is Iliad which partially uses another operator's infrastructure. Iliad also notes that it sought to build a partnership for a common 5G deployment in France, but this attempt was not successful. Finally, we can also cite CETIN that highlights that its network is open to all operators (not only O2).

- Eco conception of the modem/ mobile phone equipment

The impact of an object/device comes partially from the way it is conceived: obsolescence, no-reparability and choice of materials and sourcing. To reduce the impact of their equipment, some operators are using the concept of eco-conception when designing their products. This term means that environmental considerations are taken into account as early as the design phase. This is the case of Iliad, that designed their modem with a eco conception approach. Their new model is conceived to last at least 10 years, is partly made of recycled materials and its energy efficiency has been improved (it consumes 40% less energy than the previous modem). Another example is that of Timer (Finland) which develops cases for mobile phones made of cellulose. Finally, Proximus can also be cited for the development of a circularly designed modem.[114]

During the operation phase, the following initiatives can be highlighted:

- Decommissioning older technologies and optimizing the energy efficiency of their networks

Most network owners are upgrading to more modern technologies such as FTTH and 5G. There are a variety of reasons for these upgrades, including performance, but network operators such as Telia and Vodafone also note that modern networks are more energy efficient. Telefonica estimated that its commitment to transform the network from copper to fibre could lead to an energy efficiency gain of more than 85%.

- Alternative cooling techniques

As traditional cooling techniques like AC are highly energy-consuming, most operators use free air-cooling systems as a more sustainable alternative when allowed by outdoor

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114 Integrated Annual Report Annual Report 2020 | Proximus Group temperatures (e.g. Telia, Liberty Global, Fastweb, Vodafone, Open Fiber, Polkomtel). In addition, Liberty Global reports the use of on-site solar-based material (thermal battery) to supply cooling machines when needed. Fastweb reported that the use of innovative cooling systems enables them to save 3,000 tons of CO2eq, for the Data Centre of Milan alone.

- Switch off during the night

Orange highlighted their practice to switch off 4G during the night in France in order to reduce the consumption of the network.

At the decommissioning stage, the following best practice can be highlighted:

- Reusing, refurbishing and recycling equipment

As mentioned above, waste is a considerable problem in the telecommunication industry, especially when it comes to equipment and terminals. Multiple actions have been taken to address that issue:

- Offering incentives to customers to bring back old devices in order to optimize their end of life (e.g. Vodafone)
- Reusing and refurbishing equipment (e.g. Iliad, Telia and Liberty Global, O2, Proximus, Orange). For example, Liberty Global refurbished 2,116,398 units avoiding approximately 3,459 metric tons of waste in 2020.
- Partnerships with 3rd parties for recycling of network equipment (e.g. Telia)

Traficom highlighted the work of the company Swappies, that has specialised in fixing smartphones and computers, allowing consumers to extend the use of the devices.

Finally, operators mentioned initiatives not directly undertaken within the scope of the three stages, including the following:

- Increase customer awareness of their impact

Telecommunication operators cannot directly influence energy consumption and terminal management on the customer side. However, some of them have taken action to increase customer awareness regarding those impacts. For example, Telia and Vodafone communicate on the device's environmental impact through the eco-rating initiative. Another interesting approach comes from Telecoop: their commercial offering is linked to the actual data consumption, which allows the customer to be aware of its use, and this has proven to lead to decreased data consumption. Orange Polska and Polkomtel also aim to increase customer awareness by sharing good practices such as deleting unnecessary emails, using e-invoicing and the ability to sign online. ARCEP also highlighted that customers are increasingly aware of the environmental challenges and if it is easy and doesn't affect the cost or the quality of service, they would be more willing to choose an environmentally positive option. Finally, Magyar Telekom in Hungary provides a green mobile data package to its customers that includes financing the development of solar energy.

- Setting environmental targets for suppliers

The lifecycle of the network and products often involves 3rd parties. To have an impact throughout their entire value chain, Telia and Eir has defined a set of minimum environmental criteria which must be met by their suppliers, in order to reduce the environmental impact throughout the whole lifecycle of their products. Another example is Vodafone's supply chain team in Luxembourg that set up a 20% scoring weight for sustainability and social demographics to suppliers.

3.3.2 Impact assessment and reporting methods

- Greenhouse gases emissions measurement methodologies

Among the methodologies to measure the greenhouse gas emissions of an organisation, the Greenhouse Gas Protocol is the most commonly used. The GHG Protocol provides global standardized frameworks to assess and manage the greenhouse gas emissions of a company, organisation, city or country. Typically, these standards address the accounting and reporting of seven gases covered by the Kyoto Protocol[115]. As briefly explained above in 3.1, the GHG Protocol initiative classifies the GHG emissions of an organisation according to the 3 scopes: scope 1, that covers direct emissions arising from the organisation's owned resources; scope 2, that includes the indirect emissions related to the energy purchased by the organisation, and scope 3, that gathers all the remaining indirect emissions along the value chain [116].

Another common methodology, the Bilan Carbone®, is sometimes used by companies as an alternative to the GHG Protocol. The principles of the Bilan Carbone® methodology are very similar to those of the GHG Protocol,[117] and this GHG emissions assessment framework is compliant with the GHG Protocol.[118] The main differences are that the Bilan Carbone accounts for a larger group of GHG gases than the GHG Protocol, its reporting does not cover the same categories and the approach of the Bilan Carbone places greater focus on activity streams than sources of emissions. In addition, the data used with Bilan Carbone comes from the French database BASE IMPACT (managed by ADEME). However, the GHG Protocol is better recognised by multinational companies.

Finally, the ISO 14064-2 can be cited as another standard for assessing GHG emissions for organizations.

115 Corporate Standard | Greenhouse Gas Protocol (ghgprotocol.org)
116 FAQ.pdf (ghgprotocol.org)
117 ADEME - Bilans GES Site
118 Bilan Carbone | Greenhouse Gas Protocol (ghgprotocol.org)

Regarding the telecommunication industry and more specifically the operators involved in the present study, the majority are actively using the GHG Protocol to monitor their carbon footprint (e.g., Telia, Liberty Global, Fastweb, Telefonica, Deutsche Telekom), except for Iliad, that uses the Bilan Carbone methodology.

Regarding the methodology and their application by organisations, is important to highlight that measurement of scope 3 impacts via such measurement methods varies from one company to another, and thus there is limited comparability.

- ISO 14001

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The ISO 14001 standard is part of the ISO 14000 group that gathers the environmental management standards. It defines the guidelines for an environmental management system and can lead to a certification for the company[120]. The aim of this standard is to promote a more efficient use of resources and a reduction of waste, thus improving the environmental performance of the organisation. The ISO 14001 certification also allows a company to gain a competitive advantage and the trust of stakeholders.[121]

Within the frame of the present study, most companies interviewed have an environmental management system that complies with ISO 14001 environmental management standards, for the whole company (e.g., Fastweb, Open Fiber, Telefonica, Deutsche Telekom, Cetin) or for some of their markets (Vodafone, Telia).

- ITU Standards

Regarding ITU (International Telecommunication Union) Standards, five of the operators interviewed (Telia, Fastweb, Vodafone, Telefonica, and Deutsche Telekom) are listed as ITU-T sector members[122]. As for the use of the ITU Standards when measuring the environmental impact of their activities, Telefonica and Liberty Global prefer to use more general standards (such as the GRI reporting framework, ISO Standards, or the GHG Protocol). Telefonica explained that the ITU Standards tend to be very aligned with such standards, citing the example of the Recommendation ITU-T L.1470 “GHG emissions trajectories for the ICT sector compatible with UNFCCC Paris Agreement”.

In addition, Fastweb stated that they do not use ITU standards when measuring environmental impact.

119 ISO - Standards
120 ISO - ISO 14000 family — Environmental management
121 ISO 14001 - Introduction to ISO 14001:2015
122 List of ITU-T Sector Members

As for the other operators, no answer was given regarding that topic.

3.3.3 Trajectory methodologies

- Lifecycle Analysis

The lifecycle analysis approach provides a comprehensive view of the impact of a product/service from its conception to its disposal. Some operators interviewed for the present study (e.g. Telia and Liberty Global) are using the LCA approach to assess the different options when it comes to network development/dismantlement. Others (e.g. Telia, Vodafone) use the LCA approach to measure impacts in relation to equipment (e.g. modem, phone) lifecycle to measure impacts.

- Science Based Targets initiative (SBTi)

Science-based targets defines a pathway for companies to reduce greenhouse gas emissions, and qualifies the targets of companies as science-based *"if they are in line with what the latest climate science deems necessary to meet the goals of the Paris agreement"*[123]. Most respondents to the present study (including Telia, Liberty Global, Fastweb, Vodafone, Telefonica, Deutsche Telekom) have their environmental targets approved by the Science Based Target initiative.

123 How it works - Science Based Targets

4 Initiatives by public authorities

In this chapter we describe the EU legislative and policy framework applying to electronic communications and environmental protection, and summarise the initiatives that have been taken by NRAs to support sustainability.

Key findings

There is no overarching objective within the key regulatory instruments applying to the electronic communications sector (EECC and BCRD) to promote environmental sustainability. However, the measures in the BCRD concerning re-use of physical infrastructure (including duct access) and civil works co-ordination can contribute to environmental goals, and Article 44 EECC provides scope for competent authorities to impose co-location and sharing of network elements in order to protect the environment in the context of Rights of Way. In addition, the award of State Aid and/or frequencies could in theory take into account environmental concerns.

EU sustainability measures which apply to ICT include the Ecodesign Directive (covering energy consumption and labelling requirements for certain electronic goods), and Waste of Electrical and Electronic Equipment Directive, which seeks to increase recycling of electronic equipment. In addition the European Comission has supported the development of voluntary Codes of conduct covering broadband equipment and data centres. In 2021, the Commission launched the European Green Digital Coalition, which requires signatories from the industry to sign up to a number of commitments including net zero targets by 2040. The EU Taxonomy will establish criteria under which companies can claim that their activities are „sustainable“.

From 22 NRAs which provided information, only the French NRA ARCEP has an overarching objective to address environmental concerns in the context of its regulatory activities linked to electronic communications. However, the Polish and (since 2021) Irish NRAs are required to perform their regulatory functions in a manner consistent with the Irish government’s climate action and environmental policies. Certain other NRAs, including those in Portugal, Finland and Sweden have been given a mandate to support wider national or international sustainability initiatives. Some NRAs have included sustainability within their annual programmes and/or have undertaken exploratory exercises to understand the scope of the environmental impacts related to electronic communications and assess whether they could potentially play a wider role in supporting their mitigation (Hungary, Ireland, Malta, Norway, Spain, Sweden, UK). However, a number of NRAs stated that they have no legal mandate to establish environmental action plans or take environmental impacts into consideration (Austria, Belgium, Germany, Romania, Slovak Republic).

Key findings (continued)

Consistent with its wide remit in this area, ARCEP has taken a number of initiatives in the environmental field. ARCEP's activities have included data gathering on emissions, workshops and research on impacts associated with customer equipment as well as electronic communications networks. ARCEP is also considering how sustainability should be taken into account in the context of spectrum auctions.

As regards regulatory initiatives falling within the scope of NRA's remit under the EECC and BCRD, passive and active infrastructure sharing and co-ordination of civil works were named by many as important measures to influence environmental outcomes. These measures have been introduced either as a by-product of measures aimed at achieving other (economic) objectives (Austria, Cyprus, Germany, Romania) or specifically targeted to reduce environmental impacts (Croatia, Portugal, Slovenia).

4.1 EU legislative and policy Framework

4.1.1 Measures applying to electronic communication operators

The powers vested in NRAs to gather data, and apply obligations on electronic communications stem primarily from the **2018 EU Electronic Communications Code** (EECC).[124] In addition, most NRAs have been designated as dispute resolution bodies in the context of the **2014 Broadband Cost Reduction Directive**.[125]

Both instruments were adopted prior to the publication of the European Green Deal, and neither include an objective for NRAs to collect data on emissions or to take into account environmental impacts when imposing obligations.[126] However, Article 44 of the EECC provides that "competent authorities" may impose obligations concerning co-location and sharing of network elements "in order to protect the environment" in cases where an operator has exercised the right under national law to install facilities on public or private property.[127] Recital 105 of the EECC further elaborates that "It is necessary to strengthen the powers of the Member States as regards holders of rights of way to ensure the entry or roll-out of a new network in a fair, efficient and environmentally responsible way and independently of any obligation on an undertaking designated as having significant

124 https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32018L1972
125 https://eur-lex.europa.eu/legal-content/en/TXT/?uri=celex%3A32014L0061
126 The objectives in Article 3 EECC rather relate to the promotion of VHCN, competition, consumer welfare and the internal market
127 The full text of Article 44 (1) reads as follows: Where an operator has exercised the right under national law to install facilities on, over or under public or private property, or has taken advantage of a procedure for the expropriation or use of property, competent authorities may impose co-location and sharing of the network elements and associated facilities installed on that basis, in order to protect the environment, public health, public security or to meet town- and country-planning objectives.

market power to grant access to its electronic communications network. Improving facility sharing can lower the environmental cost of deploying electronic communications infrastructure and serve public health, public security and meet town and country planning objectives."

Other provisions of the EECC including provisions on copper switch-off / migration and obligations concerning network sharing and access (whether imposed in the context of symmetric obligations, asymmetric "SMP" obligations or as a conditions for the assignment of frequencies) could also have the effect of limiting energy consumption, even though this is not given as an objective in the Directive. Indeed, it is noted in Recital 22 that "the tasks assigned to competent authorities by this Directive contribute to the fulfilment of broader policies in the areas of culture, employment, the environment, social cohesion and town and country planning." Likewise, provisions in the BCRD which encourage the re-use of existing ducts, poles and other network infrastructure and the co-ordination of civil works should serve to limit emissions associated with network deployment as well as incentivising the deployment of more energy-efficient FTTH networks, even though there is no reference in the text to promoting sustainability. Consideration is being given to whether sustainability goals should be reflected in the context of the ongoing Review of the BCRD, which is expected to lead to a proposal for a revised instrument in Q2 2022.[128]

Member States could also in principle introduce measures which serve to limit emissions (such as taking into account the energy efficiency of technologies in the award process, and promoting the re-use of infrastructure) in the context of granting broadband State Aid. Indeed, the EC's proposal for the revision of the Broadband State Aid Guidelines includes a number of measures on sustainability.[129] In 2021, the RSPG also issued a draft Opinion on the role that could be played by radio spectrum policy in helping to combat climate change.[130]

4.1.2 EU Legislative and policy framework relating to the environment

At the EU level, a number of horizontal measures have been adopted which seek to reduce environmental impacts in particular in relation to electronic goods. These are summarised in the following figure.

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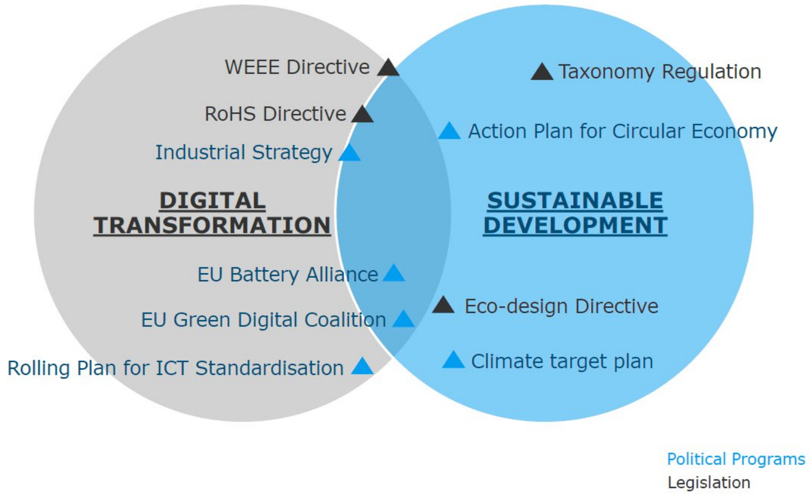
128 https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/12463-High-speed-broadband-in-the-EU-review-of-rules_en. BEREC issued an Opinion on the Review of the BCRD in 2021 which includes BEREC's views on questions around sustainability BoR (21) 30 https://berec.europa.eu/eng/document_register/subject_matter/berec/opinions/9887-berec-opinion-on-the-revision-of-the-broadband-cost-reduction-directive

129 See paragraphs 8: 44; 124 and 127 https://ec.europa.eu/commission/presscorner/detail/en/ip_21_6049

130 RSPG draft Opinion on the role of radio spectrum policy to help combat climate change https://rspg-spectrum.eu/wp-content/uploads/2021/06/RSPG21-027final-Draft_RSPG_Opinion_on_Climate_Change.pdf

Figure 4-1: Existing political frameworks and initiatives influencing the green digital transition



Source: Ramboll

A key legislative measures is the **Ecodesign Directive,** which establishes a framework under which manufacturers of energy-using products are obliged to reduce the energy consumption and other negative environmental impacts occurring throughout the product life cycle. It sets a framework for performance criteria which manufacturers must meet in order to legally bring their product to the market. The performance criteria are set in product-specific regulations, and one of them is the product group of servers and data storage products. The Ecodesign Regulation for servers and data storage products limits the environmental impacts of these products with a set of rules on energy efficiency and support the circular economy.[131]

Meanwhile, the **Waste of Electrical and Electronic Equipment (WEEE) Directive** enables collection schemes where consumers return their WEEE free of charge and aims to increase the recycling and reuse of this waste stream.

In addition, the EC has established a range of voluntary initiatives and Codes of Conduct, which aim to encourage manufacturers and data centre operators as well as electronic communication network operators to commit to meeting certain targets or abiding by certain standards.

131 such as minimum efficiency of the power supply units and minimum server efficiency in active state, maximum consumption in idle state, information on the product operating temperature, extraction of key-components and of critical raw materials, availability of a functionality for secure data deletion and provision of the latest available version of firmware

The 2000 **EU Code of Conduct for ICT**[132] was initially targeted at external Power Supplies, and Digital TV Services. However subsequently, additional Codes of Conduct were introduced for Uninterrupted Power Supplies (UPS), Broadband Equipment, and Data Centres. Participation in these Codes is voluntary, but once a company participates, they bind themselves to meeting the proposed performance levels and report the energy consumption of their products annually. 17 telecommunication operators and manufacturing companies are participating in the Broadband Communication Equipment Code of Conduct. [133]

The **Data Centres Code of Conduct**[134], with 138 participants and 258 endorsers[135] commits participants to a best practice list which provides a common terminology and frame of reference for describing an energy efficient practice. Furthermore, the EC has set concrete sustainability targets for data centres in the 2020 Communication Shaping Europe's digital future[136]. Data centres and telecommunications will need to become more energy efficient, reuse waste energy, and use more renewable energy sources. The aim is for these services to become climate neutral by 2030. The EC notes that how ICT equipment is designed, bought, consumed and recycled also matters. Beyond the energy efficiency requirements of Ecodesign, ICT equipment must become fully circular - designed to last longer, to be properly maintained, to contain recycled material and to be easily dismantled and recycled.

In 2021, following a request from the Council,[137] the EC launched the **European Green Digital Coalition (EGDC)** with the signature of a declaration[138] by 26 CEOs from ICT companies reflecting the different elements of the value chain from telecoms and infrastructure (e.g. Deutsche Telekom, Vodafone, Orange etc) through to equipment manufacturers (e.g. Nokia, Ericsson, Siemens), software and solutions (e.g. SAP, Accenture) and content and application providers (e.g. Bolt – later joined by Google and Uber). The EGDC has also been supported by trade associations representing ICT players such as DigitalEurope (equipment manufacturers), ETNO, GSMA (fixed and mobile electronic communications network operators) and the Digital SME Alliance.

132 EC ICT Code of Conduct https://e3p.jrc.ec.europa.eu/communities/ict-code-conduct

133 List of participants as of February 2021: Nokia, Proximus, Cisco Systems Inc., Deutsche Telekom AG, France Telecom Group, Telefonaktiebolaget LM Ericsson, HUAWEI Technologies CO., LTD, KPN, OTE S.A., Portugal Telecom, SA, Telecom Italia, Telia Company, TDC Services, Technicolor, Telefónica SA, ZTE corporation and TELENOR Group. See https://e3p.jrc.ec.europa.eu/communities/ict-code-conduct-energy-consumption-broadband-communication-equipment.

134 EC (2021) - 2021 Best Practice Guidelines for the EU Code of Conduct on Data Centre Energy Efficiency, JRC Technical Report.

135 As of February 2021, see https://e3p.jrc.ec.europa.eu/node/575 for a list of participating and https://e3p.jrc.ec.europa.eu/node/570 for endorsing companies.

136 EC (2020) – Shaping Europe's digital future, COM(2020) 67 final.

137 See December 2020 Council conclusions https://data.consilium.europa.eu/doc/document/ST-13957-2020-INIT/en/pdf

138 https://digital-strategy.ec.europa.eu/en/news/companies-take-action-support-green-and-digital-transformation-eu

The main aim of the EGDC is to maximise the sustainability benefits of digitisation e.g. by reducing and avoiding more emissions than the footprint of the ICT sector itself.

Members of the EGDC must sign a commitment that:

- They have or will shortly submit a sustainability pledge that is monitored by an independent organisation and is publicly reported;
- The sustainability pledge contains targets for reductions of GHG emissions, such as the SBTi guidance for ICT sector companies to set targets aligned with the objective of limiting global warming to 1.5 degrees C;
- The company commits to become climate neutral or net zero by 2040 at the latest.

In turn, member companies commit to take action to:

- Invest in the development and deployment of green digital solutions which achieve a net positive impact in a wide range of sectors;
- Develop methods and tools to measure the net impact of green digital technologies on the environment and climate; and
- Co-creating, with representatives from other sectors – recommendations and guidelines for green digital transformation of those sectors.

In order to ensure consistent reporting of "sustainability" measures by companies, the EU has introduced a **Taxonomy** which classifies environmentally sustainable economic activities[139]. It defines six environmental objectives: climate change mitigation, climate change adaptation, the sustainable use and protection of water and marine resources, the transition to circular economy, pollution prevention and control, and the protection and restoration of biodiversity and ecosystems.

The EU Taxonomy creates obligations for certain categories of companies to report activities that qualify as sustainable under its technical criteria. The first reporting obligation arises in 2022, and the obligation to report under the EU Taxonomy framework is expected to expand in the coming years. It also provides an EU-wide common definition of which activities can be defined as environmentally sustainable, ensuring harmonization and preventing companies from engaging in greenwashing[140].

Regarding the ICT sector in particular, data processing, hosting and related activities have been defined as eligible for the climate change mitigation and adaptation objectives, and the data-driven solutions for GHG emissions reductions activities are eligible for the climate adaptation objective.

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139 EU taxonomy for sustainable activities | European Commission (europa.eu)
140 EU taxonomy for sustainable activities | European Commission (europa.eu)

Technical screening criteria for the 4 other objectives (sustainable use and protection of water and marine resources, the transition to a circular economy, pollution prevention and control, and the protection and restoration of biodiversity and ecosystems) have not yet been defined, but could also be relevant for the ICT sector.

The EU has also contributed funding to **research**[141] which seeks to boost innovation, including energy efficient inter alia through the Horizon 2020 programme and Digital Europe.

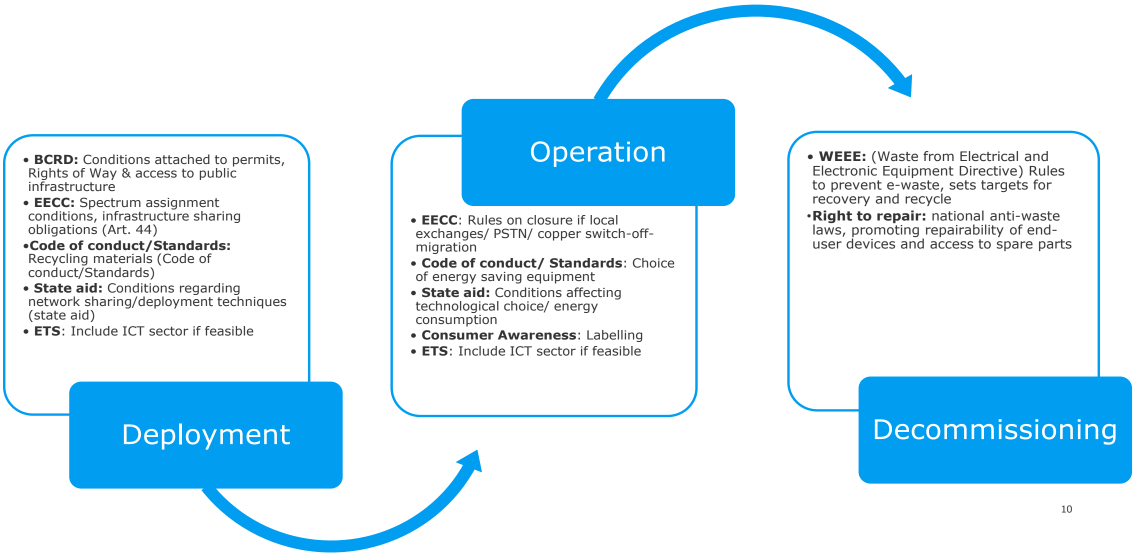
The EU **Emissions Trading Scheme**[142] is a well-known cross-cutting measure which aims to limit GHG emissions by establishing a cap on emissions and creating a market on which emissions can be traded. However, it does not apply to the electronic communications sector.

4.1.3 Overview of available tools

Figure 4-2 provides an overview of different legislative and other measures which could in theory help to reduce environmental impacts at each stage of the electronic communication network lifecycle. It should be noted however that the measures that lie within NRAs remit (EECC and BCRD) do not explicitly refer to environmental objectives, while measures which do focus on sustainability goals, such as WEEE and Right to Repair generally fall outside NRAs' remit.

141 See missions for EU research and innovation https://ec.europa.eu/info/sites/default/files/mazzucato_report_2018.pdf
142 https://ec.europa.eu/clima/eu-action/eu-emissions-trading-system-eu-ets_en

Figure 4-2: Potential policy and legislative levers to achieve sustainability goals



Source: WIK-Consult

4.2 Initiatives by NRAs

In order to gather data on sustainability initiatives pursued by NRAs, the study team conducted interviews with 6 NRAs as well as circulating a questionnaire to NRAs via BEREC during the course of Q2 2021.

An overview of their responses is provided below, with further detail in Annex 2.

4.2.1 Mandates for sustainability

From the 22 NRAs[143] which provided information, only the French NRA has an overarching objective[144] to address environmental concerns in the context of its regulatory activities linked to electronic communications.

However, the Norwegian NRA reports that the draft Electronic Communications Act in Norway includes a statutory objective that includes environmental protection, the Polish NRA must take into account environmental objectives in its decision-making, and (since

143 WIK-Consult conducted interviews with NRAs in Germany, France, Finland, Hungary, Ireland and the UK. A further 16 NRAs provided information in writing in response to a survey distributed via BEREC (Austria, Belgium, Croatia, Cyprus, Czechia, Greece, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain and Sweden)

144 Some NRAs such as ANACOM have a remit to take into account environmental considerations in relation to specific provisions such as network sharing. Other NRAs will have such a remit in the context of the transposition of Article 44 of the EECC into national law

2021) the Irish NRA must perform its functions in a manner consistent with the Government's climate policies.[145]

Certain other NRAs have been given a mandate to support national or international initiatives on sustainability as follows:

- The Portuguese NRA ANACOM has been mandated by the Ministry to pursue the national strategy for adaption to climate change in relation to Electronic Communications;[146]
- The Finnish NRA Traficom is working alongside the Ministry in connection with its Environmental Strategy for the ICT sector.[147]
- In 2021, the Swedish NRA PTS was commissioned to work with Agenda 2030 (UN Sustainable Development Goals). PTS has also received a new assignment from the Government to explain in the context of its reporting how PTS considers its work contributes to the achievement of the Sustainable Development Goals.

A number of NRAs stated that they have no legal mandate to establish environmental action plans or take environmental impacts into consideration (Austria, Belgium, Germany, Romania, Slovak Republic). However, as described in the following section, even amongst countries without a specific environmental agenda, many NRAs have taken regulatory decisions which should have positive effects on the environment, even though the environment may not have been the key driver for these initiatives.

4.2.2 Actions taken

Consistent with its formal remit in this area, ARCEP has engaged in a number of initiatives in the field of sustainability. ARCEP's activities have included **data gathering on emissions**, **workshops and research on impacts associated with customer equipment** as well as electronic communications networks. ARCEP is also considering how sustainability should be taken into account in the context of **spectrum auctions** (section 4.2.3 provides more details about ARCEP's activities).

Some NRAs have also included sustainability within their annual programmes and/or have undertaken exploratory exercises to understand the scope of the environmental impacts related to electronic communications and assess whether they could potentially

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145 Climate Action and Low Carbon Development (Amendment) Act 2021

146 Resolução do Conselho de Ministros n.º 56/2015 https://dre.pt/pesquisa/-/search/69905665/details/maximized Despacho n.º 2262/2021 https://dre.pt/home/-/dre/158480003/details/maximized

147 Ministry of Transport and Communications (2021). Climate and Environmental Strategy for the ICT Sector. Available at: https://julkaisut.valtioneuvosto.fi/bitstream/handle/10024/162912/LVM_2021_06.pdf?sequence=1&isAllowed=y (Accessed: 13.07.2021).

play a wider role in supporting their mitigation (Hungary, Ireland, Malta, Norway, Spain, Sweden, UK). In this context:

- The Irish NRA ComReg launched a **call for inputs** in December 2019 to better understand the electronic communications sector's relationship with climate change and has received responses from stakeholders and the environment authority;
- The Spanish NRA CNMC has included **sustainability objectives in its Strategic Plan** (2021-2026) and Action Plan (2021-2022);[148]
- The Hungarian NRA NMHH is planning to include **environmental questions in its 2021 annual online consumer survey** and is considering a workshop and consultation with stakeholders;
- The Maltese authority MCA has consulted a number of stakeholders and in this context **discussed with the Maltese Environmental Authority (ERA) the possibility of future collaboration**, once there is a more developed holistic strategic direction on environmental matters.

As regards regulatory initiatives falling within the scope of NRA's remit under the EECC and BCRD, **passive and active infrastructure sharing and co-ordination of civil works** were named by many as important measures to influence environmental outcomes. These measures have been introduced either as a by-product of measures aimed at achieving other (economic) objectives (Austria, Cyprus, Germany, Romania) or specifically targeted to reduce environmental impacts (Croatia, Portugal,[149] Slovenia). Some NRAs also note that they have encouraged **mobile network sharing** in part with a view to meeting environmental objectives (e.g. Greece[150], Portugal[151]).

148 The integration of sustainable development goals is contemplated as a Strategic Action (6) in the Action Plan. Associated actions include the promotion of ultra-fast networks through ex ante regulation and supervision of markets (broadband markets), the imposition of obligations, contributing to the achievement of goals 8 and 9 of the Paris Agreement (industry, innovation and infrastructure) or detecting any restrictive practices, in particular bid rigging or manipulation of public tenders, which could limit the responsible consumption and production or the objective of promoting the sustainable industrialization and foster innovation CNMC (2021). Strategic Plan (2021-2026). Available at: https://www.cnmc.es/novedades/2021-05-18-plan-estrategico-2021-2026-y-plan-de-actuaciones-2021-2022-de-la-cnmc-388434 (Accessed: 13.07.2021).

149 In one of the first ANACOM decisions related to the access to ducts of the incumbent operator (decision of 17th July 2004 which implemented the minimum elements of the RDAO) it was mentioned that: "Investment in ducts should be compatible with economic efficiency criteria, avoiding any inefficient duplication in infrastructures or inconveniences for citizens and economic activities due to the frequent and extensive realization of soil and subsoil works, with consequent disturbances at traffic and territory planning level, apart from the repercussions of environmental order arising out from it".

150 In the context of the recently awarded 5G spectrum bands, ECN operators have the right to enter into commercial infrastructure sharing agreements with a simple notification to EETT. Moreover, legislation in force prior to the EECC (Par 7 of article 29 of Law 4070) required operators to collocate antennae on request on reasonable terms, for environmental reasons and to provide collocation where technically feasible. In this context, EETT has published a Regulation concerning collocation

151 Auction rules (from spectrum allocations in 2020 and 2011) include provisions to facilitate passive and also active sharing, including roaming.

As collaboration including measures such as network sharing can in some cases be viewed as having an anti-competitive effect, the Dutch NRA and competition authority ACM published draft Guidelines in Jan 2021[152] concerning **sustainability agreements and the implications for competition**. ACM advocated that businesses should have more opportunities to co-operate to achieve climate objectives if the benefits for society offset the drawbacks of possible restrictions on competition.

In Romania, within the implementation framework of the *National Plan for Next Generation Network (NGN) infrastructure development (2015)*[153] a project was elaborated, aiming at identifying the infrastructure requirements and network performance for energy efficient NGN, including the examination of regulatory provisions linked to the energy consumption and GHG emissions of communications technologies, such as, among others, **eco-design and eco-labelling**.

Meanwhile, the CNMC notes that it is planning to take into account environmental aspects as one of the factors supporting the need to **accelerate copper switch-off.** This issue will be addressed in the upcoming analysis of the Wholesale Local Access market.

The environmental initiatives pursued by NRAs in France, Finland and Ireland are described in the following sections. Information about the remit and role played by other NRAs in supporting sustainability is provided in the Annex.

4.2.3 France

Government initiatives and legislation

Of all countries considered in this report, the French NRA ARCEP is the only national authority that has an overarching responsibility to promote environmental preservation. This responsibility was included in legislation in 2010 in Article L32-1 of the Code for Post and Electronic Communications as follows.

> *"II.-Within the framework of their respective attributions, the Minister in charge of electronic communications and the Regulatory Authority for Electronic and Postal Communications, under objective and transparent conditions, reasonable measures proportionate to the objectives pursued and ensure: (...) 12. addendum*

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152 https://www.acm.nl/en/publications/guidelines-sustainability-agreements-are-ready-further-european-coordination

153 The project to promote "Energy efficient technologies and architectures for NGN" (available at> https://www.academia.edu/37135503/TEHNOLOGII_%C8%98I_ARHITECTURI_EFICIENTE_ENERGETIC_PENTRU_RE%C8%9AELE_DE_COMUNICA%C8%9AII_NGN_AII_IP) falls within the implementation framework of the National Plan for Next Generation Network (NGN) infrastructure development (2015) See, European Commission - Shaping Europe's digital future: Country information - Romania (2021). Available at: https://ec.europa.eu/digital-single-market/en/country-information-romania (Accessed: 13.07.2021).

- A high level of protection of the environment and the health of the population, jointly with the ministers responsible for health and the environment;".[154]

In recent years, the Government and administrative bodies in France have pursued a number of specific initiatives to foster sustainability in ICT.

In 2020, the French Digital Council (Conseil national du numérique) together with the French High Council on Climate (Haut conseil pour le climat) and with various contributors, including ARCEP, published the **Roadmap on the Environment and Digital Technology**. The roadmap consists of 50 proposed measures aimed at supporting ecological and digital transitions that will help to meet the 17 sustainable development goals (SDGs) of the United Nations (UN). The roadmap is based on three pillars:

- reduce the environmental footprint of digital technologies;
- harness the potential of digital technology to serve the ecological and inclusive transition and
- accompany society as a whole towards responsible use of digital technologies.[155]

In view of the growing importance of sustainability in ICT for public authorities as well as initiatives led by civil society and digital stakeholders, in February 2021 the French Government published a roadmap called "**Numérique et environnement**"[156] addressing the specific role of ICT in the ecological transition, which assigned a number of actions to ARCEP in the environmental sphere. These are described in the following section.

The French Senate has also put forward a proposal for a law supported by a preliminary report in June 2020[157], to reduce the environmental footprint of digital technology in France. This law was adopted on 15th November 2021 and includes provisions for:

- An observatory of the environmental impact of digital technology, under the joint responsibility of the Environmental Agency (namely ADEME) and ARCEP
- A requirement for producers of electrical and electronic equipment to conduct annual collection procedures and offer a return bonus for phones, tablets and laptops, when necessary to achieve recycling objectives
- ARCEP and the audiovisual media regulator (CSA) together with the environmental agency to define a general ecoconception toolkit to be operational from 1st January 2024

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154 Article L32-1 du code des postes et des communications électroniques Modifié par LOI n° 2010-788 du 12 juillet 2010 - art. 183 (V). Available at: https://www.arcep.fr/fileadmin/reprise/textes/lois/article-L32-1-cpce-loi-2010-788.pdf (Accessed: 13.07.2021).

155 Conseil national du numérique (2020). Roadmap on the environment and digital technology. Available at: https://cnnumerique.fr/files/uploads/2020/CNNum%20-%20Press%20kit%20environment%20%26%20digital.pdf (Accessed: 13.07.2021).

156 https://www.economie.gouv.fr/files/files/PDF/2021/Feuille_de_route_Numerique_Environnement_vremerciement1802.pdf

157 www.senat.fr/rap/r19-555/r19-5551.pdf

- The audiovisual media regulator, alongside ARCEP and the environmental agency to publish a recommendation on consumer information concerning energy consumption and GHG emissions associated with data consumption linked to television services, on-demand media and video-sharing platform services.The integration of the environmental objective in the conditions of frequencies allocation from 1st January 2023.

The law also envisages that the Government should submit a report to Parliament on the development of crypto-currencies and the associated environmental impacts. The environmental footprint of ICT was also one of the topics discussed in the course of the recent adoption of the 'Climate and Resilience' bill in July 2021.[158] ARCEP and the audiovisual media regulator (CSA) are also obliged to publish a report every two years on the environmental footprint of audiovisual media services.

Another French Senate proposal for a law adopted on 13 December 2021 includes provision for ARCEP to be given powers to collect data from telecom operators, data centre operators, terminal equipment manufacturers, network equipment manufacturers and operating system providers concerning the environmental footprint of the electronic communications sector and closely related sectors.[159]

Another existing legislative measure, the 2020 French anti-waste law for a circular economy also includes a number of provisions to manage the environmental footprint of ICT. The law aims to promote climate-friendly practices, for example through provisions that require manufacturers to provide consumers with more information on the environmental impacts, lifecycle and repairability of products. Regarding networks, article 13 of this law provides that electronic communication providers must inform consumers about the carbon footprint associated with their consumption of data[160]. The report on the environmental footprint of ICT conducted by ADEME and ARCEP will provide a first step enabling ISP's to comply with this obligation, and facilitate refinements to the methodology for data to be collected during 2022.

158 https://www.legifrance.gouv.fr/dossierlegislatif/JORFDOLE000043113774/
159 Through amendment to Article L. 32-4 of the French Post and Electronic Communications Code
160 French Ministry of Ecological Transition (2020. The anti-waste law in the daily lives of the French people, what does that mean in practice? Available at: https://circulareconomy.europa.eu/platform/sites/default/files/anti-waste_law_in_the_daily_lives_of_french_people.pdf (Accessed: 13.07.2021).

Initiatives by the NRA

To gain a deeper understanding of the sector's environmental footprint as well as to be able to inform public policymakers and consumers about the sector's impact, **ARCEP has incorporated environmental indicators into its regular data gathering exercises**.[161] The data requested from major telecom operators includes information about GHG emissions from network operation as well as energy consumption associated with customer premise equipment (CPE) supplied by telecom operators - specifically:

- Overall GHG emissions as well as their breakdown by scope (1-3) as defined in ISO 14064-1
- Average power consumption of all boxes and decoders in service for the operator in active and standby mode
- Average power consumption of networks
- Number of cellphones sold (distinguishing new and refurbished) and the number of cellphones collected for recycling or refurbishment

ARCEP is planning to report on this data by the end of the first quarter of 2022, and further indicators have been requested in the data request submitted in 2021. ARCEP plans to use this information to create an environmental index for participants in the digital sector, the so-called "Environmental Barometer". With the Environmental Barometer, and additional measurement and comparison tools, consumers will be enabled to reduce their environmental footprint by making informed choices.[162]

Furthermore, in June 2020 ARCEP launched a platform named "Achieving digital sustainability" and held a series of nine workshops and discussions with external stakeholders (particularly associations, institutions, electronic communications operators, tech companies, civil society stakeholders, government agencies and experts) in order to facilitate an exchange on best practices, methodologies for measuring the environmental footprint of ICT and levers of action to reconcile the ecological and digital transitions.[163]

At the end of 2020, ARCEP published a report, which presented the conclusions from this collaboration platform and the associated events, as well as feedback from 42 written contributions. At the end of this report, the French authority formulated 11 proposals

161 Decision n°2020-0305 of the Autorité de régulation des communications électroniques, des postes et de la distribution of the press. Available at: https://www.arcep.fr/uploads/tx_gsavis/20-0305.pdf (Accessed: 13.07.2021).

162 ARCEP (2020). Press release 11th June 2020: Networks and the Environment - "Achieving digital sustainability". Available at: https://en.arcep.fr/fileadmin/cru-1624346775/user_upload/25-20-english-version.pdf (Accessed: 13.07.2021).

163 ARCEP (2020). Workshop - "Achieving digital sustainability". Available at: https://en.arcep.fr/news/calendar-events/view/n/default-50121921ad.html (Accessed: 13.07.2021).

aimed at increasing use of digital technologies while mitigating its environmental footprint.[164] The proposals included, amongst others:

- Grant data gathering powers, create common methodology for measurement (with environmental agency)
- Publish an "Environmental Barometer" to highlight best practices from across digital ecosystem / inform consumers (data-driven regulation)
- Facilitate copper to fibre transition and encourage sharing of civil infrastructure; promote automatic sleep
- Analyse effects of 2G/3G switch-off – lift barriers; reflect environment issues in network performance indicators; work with stakeholders to optimise mobile networks' impact especially through sharing and frequency use; analyse mobile distribution and renewal
- Develop Codes of Conduct with a view to legally binding commitments covering content and application providers, operators and data centres.

A significant number of these proposals were incorporated in the Government's roadmap "Numérique et Environnement" described above, particularly regarding the measures involving ARCEP. The French authority is currently implementing four workstreams foreseen by this road map:

- ARCEP is co-leading with ADEME (French agency for the environmental transition) a study to develop a **methodology to quantify the environmental impact of digital technologies in France**. The two authorities delivered the first two chapters of the report proving a methodological analysis and a multi-component, multi-criteria and lifecycle analysis of the environmental footprint of the ICT sector in France.[165] A third and final deliverable will be published later on projections regarding the evolution of this environmental footprint until 2030 and 2050.ARCEP is mandated to build "an Environmental **Barometer**", an environmental index for participants in the digital sector, and plans to use for this purpose the environmental information gathered through its data collection inquiries. Through the Environmental Barometer, and additional measurement and comparison tools, consumers will be enabled to reduce their environmental footprint by making informed choices. This "data-driven approach" is intended to provide public authorities with more information to understand the degree to which ICT is sustainable[166].

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164 ARCEP (2020). Achieving Digital Sustainability. Report 15.12.2020. Available at: https://en.arcep.fr/uploads/tx_gspublication/achieving-digital-sustainability-report-dec2020.pdf (Accessed: 13.07.2021).

165 ARCEP-ADEME « Study on the environmental footprint of the ICT sector and prospective analysis", 2022. First deliverable : https://www.arcep.fr/uploads/tx_gspublication/etude-numerique-environnement-ademe-arcep-volet01_janv2022.pdf
Second deliverable : https://www.arcep.fr/uploads/tx_gspublication/etude-numerique-environnement-ademe-arcep-volet02_janv2022.pdf

166 ARCEP (2020). Press release 11th June 2020: Networks and the Environment - "Achieving digital sustainability". Available at: https://en.arcep.fr/fileadmin/cru-1624346775/user_upload/25-20-english-version.pdf (Accessed: 13.07.2021).

- ARCEP has also been tasked by the Government to investigate how to **incorporate environmental issues in the next spectrum awards (notably in the context of the assignment of 26 GHz)**.
- ARCEP was also mandated to study **mobile device replacement** and the impact of distribution practices. The French authority published a report on this subject on 12 July 2021. The French Authority concluded that bundled or "subsidized" offers including the provision of a terminal with a subscription did not necessarily have a significant influence on the renewal frequency of smartphones. However, ARCEP also addressed other issues relating to the environmental footprint of mobile phones in its report, noting that levers such as reparability, fighting programmed obsolescence, developing second-hand acquisition models or and improving waste collection and recycling could help to address the issue.[167]
- ARCEP also recently published a technical note comparing 4G and 5G scenarios for network deployment regarding energy consumption.[168] One of the main findings was that the energy gains from the 4G+5G scenario compared to the 4G-only scenario would be greater for deployments in urban areas, but weaker or zero for deployments in rural areas.
- Since 2020, ARCEP and Ademe have been co-managing a technical expert Committee on measuring the environmental impact of ICT. By leveraging the technical expertise of its members, the Committee aims to bridge the technical gap and foster mutual understanding between ICT/industrial players and ICT-focused environmental players

Targets, impacts and costs

No targets to reduce emissions in the ICT sector have been defined at this stage. ARCEP notes that the GHG emissions emitted by different types of participants in the digital sector are not clear, and thus it would not be clear what the effects of specific targets would be. It is thought however that the largest share of the environmental footprint in France – around 80 % – is linked to consumer devices such as TVs, computers and smartphones.

A specific aspect of the French market is that because a high proportion of energy is generated from nuclear power (around 72%), consumption of electricity through the operation of telecom networks and equipment in France may have less of an impact than in countries which have a more carbon-intensive energy mix. However, ARCEP notes that electronic communication network operators have started to provide information about how much of the network is supported by sustainable and carbon neutral energy sources. Different deployment techniques are also being evaluated, as well as the switch-off of equipment while it is not used and the sharing of equipment.

167 https://www.arcep.fr/uploads/tx_gspublication/rapport-renouvellement-terminaux-mobiles-pratiques-commerciales-distribution-juillet2021.pdf

168 https://www.arcep.fr/fileadmin/cru-1638195168/user_upload/grands_dossiers/environnement/etude-environnement-4Gvs5G-executive-summary-comite-expert-mobile_janv2022.pdf

In order to support its extensive environmental programme, ARCEP has engaged 2 FTEs to focus on activities concerning environmental sustainability. ARCEP noted that 2 or 3 additional FTEs might be required within ARCEP if its remit is expanded, as proposed in the draft law. In addition, operators must also make available resources on their side.

4.2.4 Ireland

Government initiatives

The Irish Government published its "Climate Action Plan 2019" ('Climate Action Plan') which charts a course towards ambitious decarbonisation targets. The Climate Action Plan recognises that Ireland must step up its commitments to tackle climate disruption and highlights the importance of Government and public bodies taking action to reach Ireland's decarbonisation goals. This plan also calls for greater action from all public bodies in the response to climate change. Not only should public bodies work towards reducing their own emissions, but the Climate Action Plan calls for public bodies to stimulate action across Irish society.

In its Climate Action Plan, the Government noted that a rising proportion of Irish electricity demand is powering data centres and that action is required. The Climate Action Plan aims to establish networks in key sectors (such as data centres) to promote industry-led sectoral plans for decarbonisation.[169] An updated version of the Climate Action Plan was published in November 2021.[170]

Another priority is to reduce emissions from transport. The Climate Action Plan estimates that for each new remote worker, an estimated average net saving of up to 10 kWh per day will be achieved, reducing commuter transport energy use and carbon emissions. Similarly, availability of better online conferencing and collaboration tools will reduce the need for business travel and the associated carbon emissions.[171] Given that transport contributes around 20% of Irish CO2 emissions in Ireland,[172] growth in the use of teleworking and videoconferencing could be a way to significantly reduce GHG emissions.

In 2021, the Government passed into law the Climate Action and Low Carbon Development (Amendment) Act.[173] This requires relevant authorities in Ireland, including

169 DCCAE (2019). "Climate Action Plan 2019" https://www.dccae.gov.ie/en-ie/climate-action/publications/Pages/Climate-Action-Plan.aspx
170 https://www.gov.ie/en/publication/6223e-climate-action-plan-2021/
171 DCCAE, (2019). "Climate Action Plan 2019" https://www.dccae.gov.ie/en-ie/climate-action/publications/Documents/16/Climate_Action_Plan_2019.pdf
172 EPA (2019). "Provisional Greenhouse Gas Emissions 1990-2018" http://www.epa.ie/pubs/reports/air/airemissions/ghgprovemissions2018/Report_GHG%201990-2018%20Provisional%20Inventory%20October%202019.pdf
173 https://www.irishstatutebook.ie/eli/2021/act/32/enacted/en/print

ComReg, in so far as practicable, perform its functions in a manner consistent with and to act in a manner consistent with the government's climate policies, including:

- the most recent approved climate action plan,
- the most recent approved national long term climate action strategy,
- the most recent approved national adaptation framework and approved sectoral adaptation plans,
- the furtherance of the national climate objective, and
- the objective of mitigating greenhouse gas emissions and adapting to the effects of climate change in the State.

NRA initiatives

While other Irish agencies have a direct remit in this area (notably the Environmental Protection Agency (EPA))[174], ComReg is interested in understanding if more can be done to minimise the carbon footprint of the electronic communications sector. Another focus for ComReg is to support the enabling effect of electronic communications.

In December 2019, ComReg launched a **call for inputs** to better understand the electronic communications sector's relationship with climate change, including how the sector can assist in facilitating decarbonisation across the economy, how the sector can reduce its own carbon footprint and how it can adapt to a changing environment.[175] There were nine submissions. Five companies including telecom operators, network and energy providers as well as an agriculture and food research organisation and the EPA participated. The four use cases identified in the CFI were: transport (e.g. traffic optimisation), agriculture (e.g. precision farming), electricity (e.g. smart grids) and industry (e.g. Machine to machine - M2M, and Internet of Things - IoT).

The intention is to use this call for inputs to initiate a discussion with a range of interested stakeholders, including operators and other Irish agencies. This call for inputs has helped inform ComReg's contribution to the national strategy regarding climate change and the role of the electronic communications sector.

In its submission, the EPA recommends that ComReg should explore opportunities across all sectors of the economy where abatement of GHG emissions can be facilitated by electronic communications networks and services, including also for example, the residential, commercial and public services sectors, besides electricity, transport,

174 https://www.epa.ie/who-we-are/roles--responsibilities/

175 ComReg (2019). Submissions to Call for Inputs - Connectivity and Decarbonisation, Reference Number: 19/126. Available at: https://www.comreg.ie/publication/call-for-inputs-connectivity-and-decarbonisation (Accessed: 13.07.2021).

agriculture and industry underlining again the enabling factor of ICT instead of emphasising on the direct impact of the ICT sector itself.

ComReg has made efforts to ensure that it facilitates decarbonisation. Smart Grids are efficient utility network systems that typically use digital automation technology for monitoring, control, and analysis within the supply chain. In acknowledging the key role of Smart Grid as an enabler in the reduction of Greenhouse Gas ('GHG') emissions, ComReg recently assigned radio spectrum rights of use specifically for the provision of Smart Grid in a 400 MHz Award process. [176]

ComReg was one of the sponsors for an ongoing CERRE project researching the role of data centres (an industry adjacent to the telecommunications sector) for the overall 'greening' of ICT.[177]

Targets, impacts and costs

Currently, ComReg is not aware of estimates specifically regarding the GHG emissions of the electronic communications sector in Ireland, but considers that gathering information about the sources of GHG emissions in the sector may be useful to identify potential solutions to reduce GHG emissions.

In its submission to ComReg's call for inputs, the EPA notes that its latest greenhouse gas Inventory and Projections show that Ireland is falling short in terms of lowering emissions, being climate neutral by mid-century and playing part in holding the increase in the global temperature to well below 2 °C above pre-industrial levels. A strong focus on policy implementation of the measures set out in the 2019 Climate Action Plan will be needed if Ireland is to achieve the 2030 EU Climate and renewable energy targets and national climate commitments for 2050, EPA states. The EPA Inventory data shows that four sectors make up 82% of Ireland's emission: agriculture (34%), transport (20.2%), energy industries (17 %) and residential (10.2%).[178]

4.2.5 Finland

Government initiatives

The Finnish Ministry of Transport and Communication (LVM) published a Climate and Environmental Strategy for the ICT sector in 2021,[179] which was the first strategy on ICT

176 https://www.comreg.ie/comreg-completes-the-400-mhz-spectrum-award/
177 https://cerre.eu/publications/data-centres-and-the-energy-grid/
178 ComReg (2019). Submissions to Call for Inputs - Connectivity and Decarbonisation, Reference Number: 19/126. Available at: https://www.comreg.ie/publication/call-for-inputs-connectivity-and-decarbonisation (Accessed: 13.07.2021).
179 Ministry of Transport and Communications (2021). Climate and Environmental Strategy for the ICT Sector. Available at: https://julkaisut.valtioneuvosto.fi/bitstream/handle/10024/162912/LVM_2021_06.pdf?sequence=1&isAllowed=y (Accessed: 13.07.2021).

of this kind in Finland.[180] The working group preparing the strategy was appointed in 2019 and included representatives from government (including Traficom, the national regulatory authority for the ICT sector), CSOs, higher education institutions and businesses. The final report of the working group was made available for public consultation and the current strategy was finalised by the LVM on the basis of the final report of the working group and the consultation round.[181]

The published strategy states that the objective of the Finnish Government is a carbon-neutral Finland by 2035. This will require emissions to be reduced in all sectors. It recognises that while ICT sector will deliver solutions that promote emission reductions, attention must also be paid to the sector's own carbon footprint and its other impacts on the environment, including biodiversity impacts.

The Climate and Environmental Strategy for the ICT Sector is based on voluntary action by operators, equipment manufacturers, research institutes and policy makers. The strategy covers the following objectives:[182]

- the ICT infrastructure
- the data economy
- sustainable material flows and the circular economy
- knowledge base expansion and development of measuring
- increasing consumer awareness and competence
- utilising emerging technologies and responding to challenges

For each of the objectives, the strategy recommends a number of measures that should be taken by the main actors. Identifying the objectives and measures in collaboration with the stakeholders was not difficult, according to the LVM, as the stakeholders were aware of the importance of the issue.

Besides the Strategy, the Finnish Government is preparing a tax benefit scheme which would reward the application of best practice in data centres. The planned law will give tax relief for data centres that apply heat recovery by reducing the electricity tax of heat pumps and data centres to a lower tax class.[183] According to Traficom, many data centre

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180 For example, in Finland, there have been numerous strategies concerning the environmental impact of transportation or the energy sector.

181 The working group's interim report "The ICT sector, climate and the environment" was published on 15 June 2020 (Available at: https://julkaisut.valtioneuvosto.fi/handle/10024/162473, Accessed 13.07.2021) and their final report "Ecologically sustainable digitalisation contributes to climate targets" on 30 November 2020 (in Finnish, Available at: https://julkaisut.valtioneuvosto.fi/handle/10024/162562, Accessed 13.07.2021.)

182 Ministry of Transport and Communications (2021). Climate and Environmental Strategy for the ICT Sector. Available at: https://julkaisut.valtioneuvosto.fi/bitstream/handle/10024/162912/LVM_2021_06.pdf?sequence=1&isAllowed=y (Accessed: 13.07.2021).

183 See, for example, Telia Company (2021). Carbon-neutral district heat from the waste heat of data centres: homes in Helsinki to be heated by Telia's data centre. Available at: https://www.teliacompany.com/en/news/news-articles/2021/carbon-neutral-district-heat-from-the-companies already recover waste heat on a voluntary bases. However, a tax relief might further increase the use of these measures.

Furthermore although it is not specific to the ICT sector, an environmental permit is needed to build a large data centre. The permit does not make any legal stipulations on energy consumption or GHG emissions but includes requirements regarding air and noise pollution and the use of the best available technology.[184]

Targets, impacts and costs

No targets have been set for the ICT sector, but the general target carbon neutrality in 2035 will require a wide suite of measures and the ICT sector may be specifically targeted in the future. As the Finnish energy mix is already low in GHG emissions, high electricity demand from the ICT sector does not pose a significant problem.

However, the material consumption of ICT devices is a growing concern, according to the interview partners, and future targets might be formulated to address this. A study on material use in ICT is currently conducted by Sitra, a think tank in Finland.[185]

During the process of formulating the Climate and Environmental Strategy for the ICT Sector, the interview partners noted that stakeholders had shown willingness to take responsibility in helping to reduce emissions. In this respect, stakeholders involved in passive infrastructure sharing have been briefed on the environmental benefits and were prepared to take this into account.

waste-heat-of-data-centres-homes-in-helsinki-to-be-heated-by-telias-data-centre/ (Accessed: 13.07.2021).

184 Environmental Protection Act 527/2014 (English translation). Chapter 4 Section 27 and Section 28. Available at: https://www.finlex.fi/en/laki/kaannokset/2014/en20140527_20190049.pdf (Accessed: 13.07.2021).

185 https://www.sitra.fi/en/. For another study on the material side conducted by a Geological Survey of Finland, see GTK Digitalisation and natural resources. Available at: https://www.gtk.fi/en/research-project/digitalisation-and-natural-resources/ (Accessed: 13.07.2021).

5 Policy options, impacts and trade-offs

In this chapter we consider, with the aid of literature (see section 2.3) and practical examples in the field the relative impact of different policy measures on GHG emissions at different points in the electronic communications network lifecycle. These estimates are given to provide an indication of what effects may be associated with pursuing given strategies, and what legal basis there may be, if any for NRAs or other authorities to pursue them. In section 5.4, we consider overarching questions around the trade-offs that may be associated with pursuing some of these measures with reference to the objectives established for the regulation of electronic communications in the EECC.

Key findings

- While some measures (such as re-use of physical infrastructure) are positive for the environment as well as supporting investment and competition in VHCN, pursuing other measures might run counter to existing rules applying to the electronic communication sector or require trade-offs to be made against socio-economic objectives. For example
  - FTTH is widely considered more energy efficient (per Gbit) than technologies which incorporate legacy copper and cable wiring, but NRAs are required in the context of the EECC to promote „VHCN“ (which includes cable, G.fast) **and to respect the principle of technological neutrality.**
  - While encouraging or **requiring active network sharing** could limit energy use, it **could create trade-offs with the objective to promote "infrastructure competition",** where efficient and might impact incentives for alternative fixed and mobile operators to invest in their own infrastructure to achieve higher coverage and/or quality than alternative networks and undermine the ability of operators to innovate.
  - Strategies to reduce energy consumption might create **trade-offs with network coverage and quality**, or quality of visual experience (e.g. if there are restrictions on video resolution to limit bandwidth use)
  - There may be trade-offs between **environmental objectives and cost**, for example if the installation of self-generated power is more costly than the alternatives (at least in the initial phase) or if environmental considerations drive deployment of more costly technologies such as FTTH, when alternatives such as FTTC or G.fast might meet the shorter term needs of consumers.
- These considerations mean that, if required to take into account environmental impacts, NRAs may need to conduct cost benefit analyses and to identify potential compromises.

5.1 Measures to limit environmental impacts in the deployment phase

As noted in section 2.1, the deployment phase accounts for only around 10% of the footprint of GHG emissions from electronic communications networks. However, reductions in emissions can nonetheless be achieved in this area, in particular by facilitating the re-use of existing ducts, poles and other physical infrastructure (physical infrastructure access (PIA)).

NRAs have powers to mandate sharing of telecommunication ducts, poles and other physical infrastructure in the context of regulation applied to operators with Significant Market Power (SMP) under the EECC.[186] When acting as Dispute Settlement Bodies (DSBs) in the context of the BCRD, NRAs may also resolve disputes concerning access to the physical infrastructure of network operators including transport, energy and sewerage companies, as well as electronic communication network operators.[187]

PIA is well-understood and is implemented in many countries across the EU. In some countries including France, Spain and Portugal, SMP PIA is the main mechanism used, while there is significant reliance on utility ducts and poles through BCRD PIA in countries such as Italy, Germany, Poland, Lithuania and Hungary as well as rural areas of Portugal and France. BCRD PIA is also used as the basis of regulation for the ducts of electronic communication providers in Romania, Bulgaria and Sweden. In Italy and Malta, spare ducts are deployed in the context of roadworks in order to facilitate duct re-use, while the municipality of Stockholm in Sweden requires all network operators to deploy spare ducts as a condition of the permit granting process.

Studies[188] suggest that the active involvement of the NRA in establishing the price and conditions for PIA is an important factor in rendering this measure effective. In addition to reducing the environmental impact associated with network construction, PIA is also associated with significant cost reductions[189] and can also therefore serve to boost VHCN deployment. It is especially useful in areas where there could be infrastructure-based competition or competition for the deployment of VHCN e.g. in areas including State Aid zones where there is not yet a VHCN deployed and only one VHCN may be viable. However, it may create concerns around potential cherry-picking undermining

186 See Article 72 EECC

187 Article 3 BCRD. Obligations are not limited to SMP, but when applied to operators deploying VHCN, pricing should take into account the impact on the business case of the operators concerned

188 See in particular WIK-Consult (2017) Best practice for passive infrastructure access, as well as studies conducted by WIK-Consult for the EC in support of the review of the Electronic Communications Framework

189 Estimates from the study conducted in support of the Impact Assessment associated with the BCRD Regulation alongside previous research by WIK-Consult (Jay, S.; Neumann, K-H.; Plückebaum, T.; Comparing FTTH access networks based on P2P and PMP fibre topologies, Conference on Telecommunications, Media and Internet Tecno-Economics (CTTE) 2011, Berlin, 16. - 18. May 2011) suggest that it could account for up to 80% of the total costs incurred

investment in areas where a VHCN is present or planned and there is limited potential for infrastructure competition.[190]

Although literature suggests that it is less environmentally efficient that PIA, civil works co-ordination (which is used extensively in Belgium, as well as Slovenia and Finland)[191] or the use of microtrenching techniques,[192] can also reduce the GHG emissions associated with network deployment compared with a greenfield scenario involving deployment in regular trenches. Joint planning of 5G and FTTH deployments could also in principle reduce the environmental impact of network construction.

Figure 5-1 illustrates potential emissions savings from deployment in a hypothetical case where PIA, civil works co-ordinations and microtrenching can be applied to 10% or 30% (optimistic) of trenches needed for VHCN deployment in Germany. This analysis, presented in a June 2021 workshop in the context of the study by WIK-Consult, ICF and EcoAct[193] in support of the Impact Assessment associated with the Review of the Broadband Cost Reduction Directive uses the results of Ecobilan (2008)[194] and Solivan (2015)[195] to provide an estimate for potential emissions reductions.

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190 The impact of overbuild on the business case for deployment in rural areas has been investigated inter alia in the context of modelling by WIK-Consult conducted in the course of the preparation of the 2020 study “The role of State Aid for the rapid deployment of broadband networks in the EU https://op.europa.eu/en/publication-detail/-/publication/d6b8368d-f3dd-11ea-991b-01aa75ed71a1/language-en

191 According to responses given by DSBs in the context of a study by WIK-Consult on the Review of the Broadband Cost Reduction Directive

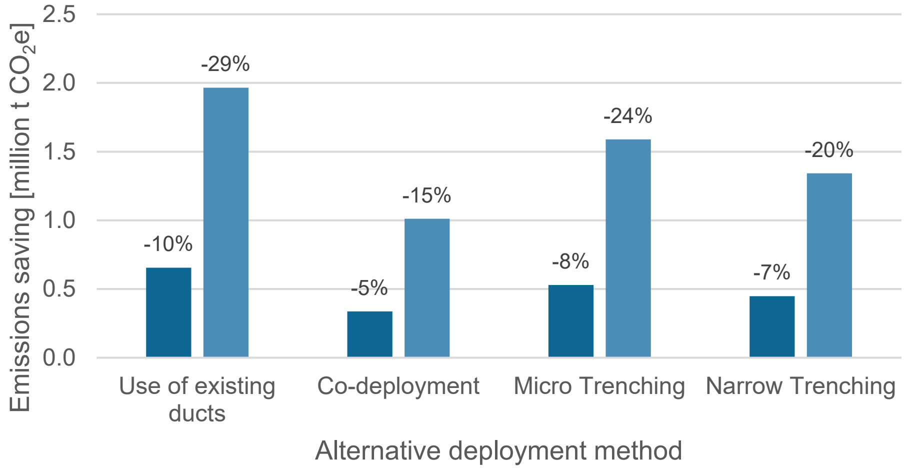
192 Microtrenching is supported by legislation in Italy, but frequently opposed by local authorities due to perceived challenges in avoiding cables during subsequent work to roads or pavements

193 These preliminary findings were reported in the context of a June 2021 workshop conducted on the BCRD Review https://www.wik.org/veranstaltungen/review-of-the-bcrd

194 Ecobilan (2008) Developing a generic approach for FTTH solutions using LCA methodology,

195 Solivan (2015) Life Cycle Assessment on fiber cable construction methods

Figure 5-1: Potential emissions savings from alternative deployment



Source: EcoAct on the basis of evidence from literature, presented at the June 2021 WIK-Consult workshop on the review of the BCRD. Orange represents pessimistic and yellow, optimistic scenarios concerning the % network that could be deployed using these techniques

Mast sharing, which is use in many European countries and is subject to legislation in Denmark,[196] can also reduce GHG emissions associated with mobile network deployment, because it avoids the duplication of foundations which are a key source of environmental impact in construction (see discussion in section 2.3.3). Mast sharing can also contribute to significant cost reductions, thereby facilitating coverage of mobile technologies in economically challenging areas. This may become increasingly important as the bandwidth and quality demands of 5G require network densification.[197] However, if ownership of masts becomes highly concentrated due to extensive mast sharing or the consolidation of assets within a limited number of infrastructure companies, this can lead to concerns that it may limit competition in wholesale pricing[198] and/or network quality, especially if sharing takes place in areas which could support duplication in physical infrastructure.[199]

196 The Mast Act aims to enable the use of existing masts and tall structures for the deployment of antennas. This is achieved via a set of rules obliging owners of masts and certain tall structures (rooftops, chimneys, facades etc.) to give others access to setting up antennae on their mast/structure. Municipalities can also require owners of masts/tall structures to give such access in the context of permit granting procedures. Source: Toolbox answer Denmark.

197 The pressure for increased facility and network sharing in the context of 5G is discussed inter alia in the WIK (2019) study: Competition and investment in the Danish mobile market https://ens.dk/sites/ens.dk/files/Tele/final_mobile_report_denmark_clean_non-confidential.pdf

198 If MNOs rely on tower companies to access this infrastructure

199 Competition concerns were for example raised by the UK competition authority CMA in the context of Cellnex' proposed purchase of Hutchison UK's passive infrastructure assets https://www.gov.uk/government/news/cellnex-and-ck-hutchison-deal-raises-competition-concerns

The sharing of network elements downstream from the underlying physical infrastructure, e.g. through unbundling, VULA or bitstream (in the case of fixed broadband) or RAN sharing in the case of mobile networks, also reduces GHG emissions associated with deployment compared with infrastructure-based competition, by avoiding emissions that would otherwise be associated with deployment of a parallel network. However, competition based on network sharing or wholesale access may reduce the scope for innovation by service providers[200] and some literature suggests that focusing on service competition at the expense of infrastructure competition may limit incentives for investment in the underlying network.[201]

The following table provides an overview of the relative impact of these different measures on GHG emissions as well as the impact on VHCN deployment, degree of administrative costs for authorities seeking to implement them and possible unintended consequences.

200 The potential for limitations on innovation and pricing even in the context of VULA products are highlighted in a study by WIK-Consult for DG Competition concerning VULA products offered in the context of State Aid https://www.wik.org/veroeffentlichungen/studien/weitere-seiten/2018-vula

201 For example, while supporting the need for and value of service-based competition, various studies by WIK-Consult including studies for Ofcom (2015) on Competition and Investment in NGA, and for the EC on Regulatory, in particular access regimes for network investment in Europe, have found that upgrades to FTTH have primarily been stimulated by policies designed to promote infrastructure-based competition

Table 5-1: Policies related to deployment

		Benefits		Costs			EU added value	
Policy / regulatory initiative	Target behavioural effect	Impact of action on GHG emissions	Effects on VCHN deployment	Effects on deployment cost	Administrative cost / ease of implementation for authorities	Unintended consequences	Current prevalence across EU	Relevance / significance at EU level
Mandate / operationalise PIA (SMP or BCRD)	Increased duct, pole and mast sharing, reduced excavation	+	++	++	- (-- for BCRD PIA)	Potential investment impacts for challengers (rural areas)	Strong take-up in some MS	High
Promote civil works co-ordination including potential joint planning of fibre / 5G deployments	Increased joint deployment, reduced excavation	(+)	+	+	--	Delays, possible inv. impacts for (rural areas)	Limited	Medium
Permit microtrenching	Reduced excavation	(+)	+	+	+	Impede pavement repair	Variable	Medium
Mandate / encourage mast sharing	Reduced duplication of masts	((+))	+	+	+	Reduced coverage competition	Strong in some MS	High
Require / promote fixed network sharing / access	Reduced duplication of cables	+	+/-	++	-	Reduced investment incentives	High	High

Source: WIK-Consult

5.2 Measures to limit impact in the operation phase

As noted in section 2.1, the operational phase is associated with around 90% of the GHG emissions linked to electronic communications networks. There are broadly four types of initiatives that could be taken or supported by policy-makers to reduce GHG emissions in the operation phase:

1. Promoting the deployment of more energy efficient networks and the switch-off of less energy-efficient legacy networks
2. Encouraging or permitting active network sharing (as opposed to infrastructure competition)
3. Introducing measures such as voluntary Codes of Conduct to limit energy consumption of network and terminal equipment; and
4. Informing consumers regarding the energy consumption of devices and / or the broadband services e.g. through labelling schemes

Promoting more energy efficient networks

Although the electronic communications framework is in principle "technologically neutral", the approach taken to SMP regulation under the EECC could influence the relative incentives for SMP operators to deploy FTTH vs intermediate technologies such as FTTC as well as influencing the ability and incentive of alternative investors to deploy FTTH. NRAs have taken action which serves to promote FTTH deployment inter alia by fostering infrastructure competition through mandating physical infrastructure access (PIA), or through measures which seek to incentive SMP operators to upgrade their networks to FTTH (e.g. by applying temporary or more lasting forbearance on regulation of higher speeds or FTTH as in Spain and Portugal), or by differentiated wholesale pricing of FTTH compared with FTTC e.g. in Ireland, Sweden.[202] FTTH has also been favoured directly or indirectly (e.g. in the context of bandwidth or quality standards) in the context of State Aid awards inter alia in Italy, Spain, Portugal, as well as in more recent schemes in Austria and Germany.[203]

As regards copper switch-off, the EU electronic communications Code (EECC) includes provisions on „migration from legacy infrastructure“ (Art 81), and new guidance on these provisions is being developed in the context of the ongoing review of the EC Access

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202 An overview of the different types of pricing strategy aimed at stimulating investment in VHCN is provided in the 2016 study by WIK-Consult, IDATE and Deloitte on "Regulatory, in particular access regimes, for network investment in Europe" as well as in a 2016 study for Ofcom on "Risky bottleneck assets" https://www.ofcom.org.uk/__data/assets/pdf_file/0027/82728/wik_regulatory_approaches_to_risky_bottleneck_assets.pdf

203 Further details about the criteria used for State Aid awards and the resulting technologies used are provided in the 2020 study by WIK et al The role of State Aid for the Rapid Deployment of Broadband Networks in the EU https://op.europa.eu/en/publication-detail/-/publication/d6b8368d-f3dd-11ea-991b-01aa75ed71a1/language-en

Recommendations, which is due to conclude in 2022. Some Member States such as Estonia have also taken a light touch regulatory approach which has facilitated the switch-off of copper networks,[204] while the rules applying to copper switch-off are set to be reviewed in others such as Spain in the context of the WLA market review.[205] One estimate suggests that 90% reductions in GHG emissions could be achieved with copper switch-off to all-FTTH networks.[206] However, experience suggests that migration to all-FTTH is unlikely and that some wireless infrastructure is likely to persist at least in rural areas due to the high costs of fibre in areas with low population density.[207] Moreover, the 90% estimated reductions in GHG emissions assume that the transition to fibre would not affect bandwidth consumption, while in practice consumers using FTTH may consume several times more bandwidth than those making use of lower speed technologies.[208] As the carbon footprint of copper is high and parallel networks might be associated with underutilisation, switching off copper and migrating to more energy efficient technologies should have a positive impact on the environment, but the scale of the energy savings depends on the replacement technology or technologies and the "rebound" effect. In any event, even if there is some rebound from FTTH resulting in no net energy savings following copper switch-off, increased data consumption may be associated with economically or socially productive activities, resulting in net benefits to the economy and society.

Activities aimed at accelerating the deployment of 5G, which are already advocated at EU level,[209] could also have a positive impact on energy use. However, it should be noted that the rebound effect of higher usage may be even greater for mobile than for fixed, due in part to the lower bandwidths currently available on mobile technologies, and the new IoT applications that have been promised, in particular for the deployment of mid-band 5G.[210] It should be noted in this context that there are some questions concerning the efficiency gains that can be achieved with low latency 5G technologies, that would be

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204 For details, see WIK-Consult (2020) Copper switch-off: European experience and practical considerations https://www.wik.org/fileadmin/Studien/2020/Copper_switch-off_whitepaper.pdf

205 Interview conducted Q2 2021

206 See estimated made in the WIK (2020) study Neutral Fibre and the European Green Deal https://www.wik.org/en/veroeffentlichungen/studien/weitere-seiten/neutral-fibre as well as other literature references therein

207 As noted in WIK-Consult (2020) Copper switch-off, copper is being replaced by wireless or mobile solutions in rural areas in Sweden and Estonia. Cost estimates conducted by WIK-Consult in the context of the 2020 study Supporting the Implementation of CEF2 Digital https://op.europa.eu/en/publication-detail/-/publication/8947e9db-4eda-11ea-aece-01aa75ed71a1/language-en also show that using 5G FWA in rural areas could be a cost effective solution to achieve universal coverage.

208 Precise figures on consumption by technology are not readily available but According to a report from Ofcom, (https://www.ofcom.org.uk/__data/assets/pdf_file/0024/209373/connected-nations-2020.pdf) consumers in the UK consumed 429 GB per connection per connection in 2020. This implies a significantly higher consumption rate from higher speed cable offers than from FTTC, noting that Openreach, which has a nearly ubiquitous FTTC network, reported that at around the same time, they experienced average usage of around 250GB per month.

209 For example in the context of the 5G Action plan (https://digital-strategy.ec.europa.eu/en/policies/5g-action-plan) and the Connectivity toolbox https://digital-strategy.ec.europa.eu/en/policies/connectivity-toolbox

210 See for example the description of use cases for mid-band 5G in the conference paper by Schwechel et al of Ericsson (https://www.nctatechnicalpapers.com/Paper/2019/2019-mid-band-spectrum-opportunities-and-challenges) provided via mid-band frequencies.[211] However, as discussed in section 2.2.2, some literature suggests that new 5G applications could facilitate energy savings in other sectors such as transport, as well as generating wider economic benefits.

Authorities with responsibility for spectrum awards and associated conditions can influence the timing of deployment of more efficient new generation technologies such as 5G and may be able to facilitate the switch-off of previous generations of mobile technology, or assign spectrum for use cases which may have environmental benefits in other sectors such as Industry 4.0 (Germany), smart grids (Ireland).

Permitting or encouraging active network sharing

The use of active network sharing (RAN sharing) in the context of mobile or bitstream access in the context of fixed networks could also in principle achieve energy savings compared with the operation of parallel networks. There is relatively limited literature available on this subject but one estimate suggests RAN sharing could save 43% energy compared with operating independent RANs.[212] In addition, by increasing the penetration / market share of the network at the wholesale level, network sharing can reduce unit costs and facilitate VHCN deployment.

There are a range of provisions that could be used by NRAs or other authorities to mandate active network sharing. EECC Article 61(4) provides that competent authorities should be able to impose localised roaming access agreements and/or sharing of active infrastructure under certain circumstances and if this is foreseen in the relevant licences – thereby limiting inefficient operation of networks. Meanwhile, SMP regulation (and in limited circumstances symmetric regulation) can be used to require SMP operators to provide access, including active forms of access with shared backhaul, which may be more energy efficient. However, these provisions are aimed at facilitating competition in circumstances where there would otherwise be barriers to competition, and the EECC does not provide a remit for NRAs to mandate these forms of access for environmental purposes. Moreover, active network sharing is generally considered to provide less flexibility for innovation by the operators relying on it than sharing only passive network elements, and active sharing has therefore been subject to objections by competition authorities in some cases, although there are also examples where RAN sharing has been approved e.g. in Sweden and Denmark, with few noticeable effects on retail outcomes.[213]

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211 https://www.iea.org/reports/data-centres-and-data-transmission-networks
212 https://www.linkedin.com/pulse/reducing-operator-carbon-footprint-ran-sharing-case-jerker-berglund/
213 A description of the types of network sharing and analysis provided by various regulatory and competition authorities is included in the WIK-Consult (2019) study Competition and investment in the Danish mobile market https://ens.dk/sites/ens.dk/files/Tele/final_mobile_report_denmark_clean_non-confidential.pdf

Codes of Conduct to limit energy consumption from equipment

As noted in section 2.1, energy consumption associated with terminal and networking equipment constitutes a high proportion of the overall energy footprint of the sector. Reducing energy consumption in this area should deliver both environmental benefits and cost reductions (from lower energy consumption) with few or no adverse effects, if the impact on service quality can be maintained.

Energy efficiency savings in this area have been achieved through a combination of legislation which imposes “Ecodesign” requirements, on devices such as set-top boxes, computers, servers and games consoles (see section 4.1.2), and voluntary Codes of Conduct. There is a Code of Conduct currently in place at EU level for broadband equipment which sets a target that 90% of new models should meet energy efficiency goals. Available evidence suggests that this approach is relatively effective, with reductions in power consumption reported in all categories year on year[214]. The European Commission is targeting a 50% reduction in electricity consumption from broadband equipment from 2015 levels through this tool.[215]

Similarly, the Commission reports[216] that Codes of Conduct on energy efficiency in data centres have led to increased Power Usage Effectiveness (PUE) year on year, although energy consumption by data centres in the EU is still expected to increase overall due to usage patterns.[217]

There may be scope to build further on these kinds of initiatives to reduce the CO2e footprint of devices. Such intervention may be most effective at EU level, given the Europe-wide footprint of most manufacturers. A positive aspect of initiatives of this kind is that they do not require legislation and their effectiveness may be boosted by the direct involvement and buy-in from stakeholders. On the other hand, the voluntary nature of these initiatives means that certain actors could seek to gain cost and competitive advantages by opting out. Thus, Codes of Conduct could be coupled with other tools of moral suasion such as labelling or economic incentives such as requirements in the context of public procurement.

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214 https://www.itu.int/en/ITU-T/climatechange/Documents/AI%20and%20environmental%20efficiency_9%20December/2.2_Paolo%20Bertholdi_Tiago%20Serrenho.pdf?csf=1&e=mgtyX6

215 https://www.itu.int/dms_pub/itu-t/oth/09/05/T09050000010004PDFE.pdf

216 https://www.itu.int/en/ITU-T/climatechange/Documents/AI%20and%20environmental%20efficiency_9%20December/2.2_Paolo%20Bertholdi_Tiago%20Serrenho.pdf?csf=1&e=mgtyX6

217 Energy consumption of data centres in the EU is expected to increase from 76.8 TWh in 2018 to 98.52 TWh by 2030: https://digital-strategy.ec.europa.eu/en/library/energy-efficient-cloud-computing-technologies-and-policies-eco-friendly-cloud-market

Consumer awareness and labelling

Labelling has been used to indicate the energy efficiency of large electrical appliances in Europe for some time.[218] In the electronic sphere, mandatory labelling applies to TV, but not to other items covered by the ecodesign requirements such as computers, set-top boxes and games consoles. There is evidence that labelling may provide useful signals to influence consumer purchasing decisions. For example, surveys suggest that 85% of Europeans use the energy label when making a purchase.[219] However, the effectiveness of labelling schemes requires targets associated with the coloured labels to be regularly updated.[220] Consideration could be given to whether mandatory energy efficiency labels should be extended to other electronic consumer goods besides TVs.

Labelling has also been used in certain countries – specifically in Italy – to inform consumers about the quality of broadband services, based on the underlying technology used.[221] It is possible that labels could also be used to indicate or to integrate (amongst other features) the average energy consumption associated with operating broadband networks of a given technology. A 2021 study by WIK based on a representative survey and conjoint analysis of consumers in the UK found that a traffic light label to indicate broadband performance, when coupled with an information campaign could increase take-up of FTTH by 40%.[222] Although it was not tested in this exercise, it is possible that consumers might also find information about environmental impact relevant to their purchasing decision. However, it should be noted that, unlike consumer equipment, the cost of increased energy consumption in the provision of broadband services, does not fall on the consumer, but rather on the service provider, which might limit its impact in purchasing decisions.

A summary of the impacts of different measures affecting network operation on the environment as well as on VHCN deployment is shown in the following table, alongside the associated costs and possible unintended consequences.

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218 A description of these measures is provided at https://ec.europa.eu/info/energy-climate-change-environment/standards-tools-and-labels/products-labelling-rules-and-requirements/energy-label-and-ecodesign/about_en#:~:text=for%20European%20companies.-,Energy%20labels,which%20are%20more%20energy%20efficient.

219 https://ec.europa.eu/info/sites/default/files/impact_of_energy_labels_on_consumer_behaviour_en.pdf

220 https://www.eca.europa.eu/Lists/ECADocuments/SR20_01/SR_Ecodesign_and_energy_labels_EN.pdf

221 Further detail is provided in the WIK-Consult 2020 study Identifying European Best Practice in Fibre Advertising https://www.wik.org/fileadmin/Studien/2020/Study_-_Identifying_European_Best_Practice_in_Fibre_Advertising_-_FTTH_Conference.pdf

222 WIK-Consult (2021) Impact of labelling on full fibre adoption https://www.cityfibre.com/wp-content/uploads/2021/03/WIK-Consult-study-impact-of-labelling-on-full-fibre-adoption-March-2021.pdf

Table 5-2: Policies related to network operation

		Benefits		Costs			EU added value	
Policy / regulatory initiative	Target behavioural effect	Impact of action on GHG emissions	Effects on VCHN deployment	Effects on deployment / operational cost	Administrative cost / ease of implementation for authorities	Unintended consequences	Current prevalence across EU	Relevance / significance at EU level
Promotion of energy efficient technologies (e.g. FTTH, 5G), copper switch-off	Accelerate deployment of FTTH, 5G	+ to +++	+	Higher capex lower opex	-	Rebound effects, Reduced coverage vs tech mix	Widespread, but with variations	Very high
Permit active mobile network sharing	Increased RAN sharing	+++	++ (5G)	++	+ / -	May impact comp / investment incentives	Limited (e.g. SE, DK)	Medium / high
CoC re network & terminal equipment	Reduced energy consumption from equipment	++++	0	+ (reduced energy cost)		Limited negative effects	EU-wide CoC, but national initiatives limited	Very high
Consumer awareness / labelling	Increase take-up of FTTH	++ (per Gigabit)	+	+ (improves FTTH business case)	-	Limited negative effects	Limited e.g. IT	Medium

Source: WIK-Consult

5.3 Measures to limit impacts in the decommissioning phase

Environmental impacts associated with the decommissioning phase include GHG emissions associated with the removal and dismantling or destruction of legacy equipment along with possible benefits associated with the re-use or recycling of equipment or materials. Given that the production phase can be associated with significant impacts associated with the extraction of materials and manufacturing, recycling and re-use could potentially bring significant benefits, not only for the environment, but also in terms of reduced costs.

National authorities can contribute by facilitating the decommissioning of legacy infrastructure, if this is coupled by responsible actions by stakeholders to recover and recycle the material.

Measures providing a “right to repair” and encouraging recycling by broadband service providers and network operators could also support sustainability in this phase.

Table 5-3: Policies related to decommissioning

		Benefits		Costs			EU added value	
Policy / regulatory initiative	Target behavioural effect	Impact of action on GHG emissions	Effects on VCHN deployment	Effects on deployment cost	Administrative cost / ease of implementation	Unintended consequences	Current prevalence across EU	Relevance / significance at EU level
Facilitate copper switch-off	Enable removal of copper wires and associated infrastructure	+++ (per Gigabit) with FTTH	++	+	+	Potential impact on service comp.	Limited (e.g. EE, SE)	Very high
Promote 2G/3G switch-off	Enable decommissioning of legacy equipment	++	+++			additional material costs		
Anti-waste / right to repair laws	Reduction and e-waste and prolonging of service life	+	±	Low costs	Low to medium costs ?			

Source: WIK-Consult

5.4 Trade-offs

The analysis of the impact of different policy measures highlights that while some measures (such as re-use of physical infrastructure) are positive for the environment as well as supporting investment and competition in VHCN, pursuing other measures might run counter to existing rules applying to the electronic communication sector or require trade-offs to be made against socio-economic objectives.

For example, FTTH is widely considered more energy efficient (per Gbit) than technologies which incorporate legacy copper and cable wiring, but NRAs are required in the context of the EECC to promote „VHCN“ (which includes cable, G.fast) **and to respect the principle of technological neutrality.**[223]

Moreover, while encouraging or **requiring active network sharing** could limit energy use, it **could create trade-offs with the objective to promote "infrastructure competition"** where efficient and might impact incentives for alternative fixed and mobile operators to invest in their own infrastructure to achieve higher coverage and/or quality than alternative networks and undermine the ability of operators to innovate.

Strategies to reduce energy consumption might also create **trade-offs with coverage and quality** in some circumstances, for example if full geographic coverage would entail disproportionate construction and energy consumption.

There may also be trade-offs between **environmental objectives and cost**, for example if the installation of self-generated power is more costly than the alternatives (at least in the initial phase) or if environmental considerations drive deployment of more costly technologies such as FTTH, when alternatives such as FTTC or G.fast might meet the shorter term needs of consumers. In this context, NRAs interviewed for the study observe that **consumers** may be willing to make environmentally positive choices, but not if they are associated with additional cost.

These considerations mean that, if required to take into account environmental impacts, NRAs may need to conduct cost benefit analyses and to identify potential compromises. Regulatory authorities which have an environmental objective might also need to identify whether there might be a given type or degree of network sharing which achieves energy efficiency without compromising independence.

Given that energy consumption is strongly linked to bandwidth consumption in the operation of networks, another question is whether it may be justified to limit the quality of certain services such as **restricting the resolution of video in the interests of environmental protection**, extending the example of the video resolution limitations that were voluntarily applied to reduce the burden on network operators at the beginning of

223 Article 3 EECC

the COVID pandemic,[224] or to provide more favourable conditions for broadcasting to limit the trend towards less energy efficient video streaming. Taking this line of reasoning to its limit, there might even be questions about whether it could be justified on environmental grounds to restrict access to certain bandwidth-intensive services that might be considered to offer limited socio-economic benefit (such as behavioural advertising, or cryptocurrencies).

Many of these questions are theoretical for the moment, but might arise if environmental concerns are given equal weight to other objectives such as the promotion of competition and economic growth.

224 https://www.weforum.org/agenda/2020/03/netflix-is-reducing-the-quality-of-its-streams-in-europe-to-avoid-straining-the-internet-during-the-coronavirus-outbreak/

6 What role for policy-makers?

In this chapter, we discuss possible priority areas for action in the field of sustainability and explore possible options for the involvement of NRAs and BEREC, alongside potential barriers to their involvement.

Perspective of NRAs

- NRAs have differing views on who should be responsible for tackling environmental challenges with some favouring a horizontal approach primarily pursued by the Environmental Agency, while others favour a sector-specific approach with a more equal split of responsibilities between the NRA and Environmental Agency. All agree however that collaboration is vital.
- As regards the scope of any interventions several NRAs stress the importance of taking into account other aspects of the value chain and lifecycle besides operation of telecom networks, to include consideration of end-user devices which are responsible for a significant proportion of emissions. The potential „outsourcing“ of GHG emissions when goods are produced or data processed outside the EU also highlights the need for global collaboration and solutions.
- Many NRAs highlight the importance of engaging in the development of common methodologies for the measurement of environmental impacts of ECNs and potentially in data gathering. Some NRAs also express interest in:
    - Promoting best practice and encouraging network operators to engage in more energy efficient practices
    - Publishing information about emissions by operator and publicly recognising operators with positive sustainability efforts
    - Information campaigns for consumers about the energy consumption of different technological solutions and devices, repairability and recycling, and actions to limit data storage

  More generally NRAs note that the BCRD and EECC as well as the Toolbox provide scope to support environmentally sustainable practices such as the deployment of energy-efficient networks, promotion of migration, sharing of physical infrastructure and networks. The incentivisation of sustainable practices in spectrum awards could also be examined. However, an important limitation is that NRAs have no remit to gather data for environmental purposes under existing EU legislation, and NRAs could not take action to support sustainability if it undermines existing objectives.

Perspective of industry

- Key concerns of the industry are to achieve better alignment of environmental regulations and mitigation measures at EU level as well as nationally and locally. Stakeholders also call for industry standards on methodologies to be used in the sector for environmental impact assessment and communications about sustainability. As regards measures to incentivise sustainable practices, stakeholders call for easier access to renewable energy sources, as well as possible tax incentives and / or reward mechanisms for companies pursuing best practice sustainability measures. Less intensive digging techniques and network sharing and/or collaboration were also cited as solutions that would have beneficial effects.

6.1 Expectations from the industry

During the interviews conducted for this study, ECN operators and equipment manufacturers provided the following feedback about initiatives that might support their sustainability efforts. The main themes coming from the operators concern harmonisation and standardisation, incentives and support for specific solutions or business models.

Harmonisation

A frequent request from operators is to **achieve better alignment of regulations as well as of environmental mitigation** requirements for the telecommunication industry not only at EU level, but also in relation to regulations applying at the national, regional and local levels. Interviewees highlight the complexity of complying with different requirements/ regulations across different markets.

Another request is to work towards a **simplification of the administrative processes associated with environmental compliance** as these are perceived to be burdensome and time-consuming.

In addition, interviewees suggested that it would be helpful to **define industry standards regarding the methodologies used in the sector for environmental impact assessment and communications about sustainability**. Several stakeholders expressed concern about the lack of comparability between the reports provided by different actors and the overall lack of transparency.

Similarly, the **definition of standards for equipment** (e.g. definition of a rating system) was suggested to achieve a more homogenous basis for comparison within the industry.

Support for sustainable solutions

Ensuring access to renewable energy across the European Union was highlighted as a key point to improve the environmental performance of the industry. Although some operators are already purchasing/ producing renewable energy for their own consumption, stakeholders noted that the impacts of their services when used by the end-user could be even further reduced if the use of renewable energy was generalised across the EU.

In addition, the introduction of **tax incentives for companies that have a strong sustainability agenda**, was suggested by various operators. According to certain actors, this could motivate change towards more sustainability within the industry.

Following the same reasoning, the development of **reward mechanisms for best practices** or initiatives was mentioned as a potential lever to support increased sustainability.

Turning to specific business practices, one operator proposed incentives **collaborate or mutualise the network between operators**, while another advocated **adapting regulation to promote less intensive digging techniques.**

6.2 The perspective of NRAs

NRAs also provided feedback concerning their role and possible actions to promote sustainability in the course of interviews and the survey conducted for this study.

6.2.1 Who should tackle sustainability issues?

There are differing views amongst NRAs on whether the problem should primarily be tackled through horizontal measures also applying to other sectors, such as an extension of the EU emission trading scheme, or whether it would be more appropriate to set targets and establish "vertical" measures which are specific to the electronic communications sector. While some NRAs declared themselves broadly favourable to a horizontal approach,[225] others such as ARCEP do not exclude a possible sectoral approach, noting that further information is required on the sources and drivers of emissions before targets can be set, and a decision made on how best to tackle emissions.

225 This horizontal approach would be focused on increasing energy efficiency and reducing energy consumption in the commercial interests of all market participants. ComReg notes that horizontal rather than vertical or sectoral regulations would allow for a focus on pricing emissions at the source on a cross-sector basis such as through a carbon tax or emission trading scheme. Ofcom similarly supports a holistic approach rather than sector specific targets, noting that cross-sector regulations will also impact the ICT sector.

In turn, the decision on whether to approach the issues from the perspective of environmental legislation as opposed to sectoral legislation or other measures also affects the division of responsibilities between European and national environmental agencies on the one hand, and BEREC and NRAs on the other. Many of the NRAs interviewed highlighted that collaboration between authorities responsible for the environment and NRAs is important.[226]

However, the differing responses from NRAs generally confirm that different member states may arrive at differing balances in competencies between authorities tasked with regulating electronic communications and those focused on environmental objectives. For example, ComReg observes that the environmental authority has expert knowledge both on what is best for the environment and on what indicators should be considered. ComReg prefers therefore to follow the expertise and guidance of the Environmental Protection Agency (EPA) instead of trying to substitute it, whereas in France, the relationship is relatively equal, and ARCEP and ADEME collaborate on a range of projects, with ARCEP taking project leadership in some areas (including indicators) and ADEME in others (see section 4.2.3). The views of other NRAs tend to fall along a spectrum, with some advocating that they should have an objective to promote environmental goals in same cases going beyond electronic communications networks and services to cover equipment,[227] while others take a more cautious approach.[228]

6.2.2 Where should the focus of any interventions lie?

When it comes to the scope of intervention, a number of NRAs highlighted the need to go beyond consideration of the impact of operating electronic communications networks, and also consider **other aspects of the lifecycle** as well as – importantly – take into account **end-user devices**.

For example, ARCEP noted that in France, 80% of the environmental footprint from ICT is linked to devices. The impact is linked to the size of the devices with the most emissions associated with TV, followed by computers and then smartphones. Moreover, when looking at smartphones, the French environmental agency concluded that 75% of the

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226 NRAs including ARCEP, PTS, ComReg and others highlight the importance, when engaging in environmental policies, of collaborating with other NRAs through BEREC and international organisations, as well as collaborating with the authorities directly tasked with delivering on environmental objectives, such as environment agencies at national and EU level. However some note that close collaboration could be difficult to achieve in practice.

227 For example, PTS favours being given a specific objective to include consideration of environmental aspects in the field of telecom networks and services, while ANCOM suggests that the remit of the NRAs could further be extended to promote sustainable measures (greener technologies, energy efficiency, sustainable design of digital and ICT products) in addition to providing access to existing infrastructure and co-ordination of civil work from an environmental standpoint. CNMC expresses an interest in engaging with challenges associated with e-waste.

228 Many NRAs prefer to gather information and conduct internal reflections before proposing an extension to their remit. In this context, CTU notes that problems identified regarding the energy efficiency of equipment and recycling plans may be addressed by other authorities in the context of the expanding eco-design regulatory framework under the Circular Economy Action Plan.

impact is associated with its production and only 25% on its use. This increases the relative importance of **prolonging the lifespan of devices and ensuring adequate processes for recycling and re-use**.

In similar vein, ComReg noted that the focus for electronics and network equipment has been on running costs and not enough on life cycle costs – which is a global problem. ComReg suggested that the development of international or European standards could help to address some of the environmental challenges associated with the proliferation of ICT-related materials. For example, standards could be used to mandate **one type of charger for all handsets**.

However, the **balance between emissions associated with operation and production may also be influenced by the electricity generation mix of the countries concerned**. For example, higher reliance on fossil fuels for electricity was reported in Hungary, compared with France and Finland, where a higher proportion of electricity is generated from nuclear and renewable energy sources. This may lead to different priorities concerning environmental impacts in different countries.

Another challenge observed by the Finnish authorities is that some of the impacts from data consumption might be under-reported, due to the processing of data abroad, effectively leading to the **"outsourcing" of GHG emissions**. A study is under way to assess this impact. This effect could increase the need for international standards on the reporting of ICT-related emissions and collaboration (or action in the context of trade agreements) concerning associated measures.

6.2.3 What kinds of actions could NRAs take?

A significant number of NRAs which provided feedback considered that NRAs could play a valuable role in **gathering data** in order to be able to track the emissions associated with electronic communications networks and services.

The availability of data on GHG emissions, and potentially other metrics, is an important prerequisite for any actions that are taken to promote sustainability in electronic communications. The need to provide transparency on GHG emissions in the sector were highlighted by multiple NRAs[229] in the course of the interviews and surveys conducted for this study.

The main actions that could be taken include formulating common methodologies for data gathering, which NRAs agree should be conducted at least EU level,[230] to ensure that

229 Including NRAs in France, Ireland, Czechia, Spain, Greece, Portugal, Slovenia, Finland, Belgium and Hungary.

230 ComReg favours international standards results are comparable, and regular data gathering exercises, which could be conducted by NRAs and then compiled at EU level.

NRAs interviewed for the study, noted that that questions that will need to be addressed during the development of data gathering methodologies include the **scope of emissions** to be covered and methods to measure scope 3 emissions,[231] **which aspects of the lifecycle** should be covered,[232] and whether **emissions associated with different services and OTT applications** should also be assessed.[233] ARCEP also highlighted the need to rely on existing international (ITU) standards where possible.[234]

As regards other initiatives that could fall within their remit if they were given more responsibility in the sustainability field, a number of NRAs[235] note that they see a **valuable role for NRAs in raising awareness of environmental impacts amongst consumers and operators**. Examples given in the course of interviews included the following, although NRAs noted that transparency alone was unlikely to have a significant effect on emissions:

- Promoting best practice and encouraging[236] network operators to engage in more energy efficient practices such as shutting down obsolete networks, engaging in temporary switch-off of unnecessary capacity and self-generating energy for base stations.
- Publishing information about emissions by operator and publicly recognizing operators which have a greener focus
- Information campaigns advising consumers about
    - the energy consumption of different technological solutions for broadband as well as routers and end-user devices (potentially accompanied with a labelling scheme)
    - the repairability of products, the potential to extend the lifetime of products and recycling;
    - actions they can take to limit data storage including the deletion of unnecessary files and emails and limitations on spam

More generally, NRAs note that the existing regulatory framework (and specifically the BCRD, Article 44 of the EECC and measures relating to symmetric and SMP access

231 ARCEP noted that, while scope 1 and 2 methodologies are relatively comparable between operators and vendors, there is no common methodology on scope 3 emissions, which have the most significant impact. ARCEP observes that there are issues regarding double counting a complete sector-wide view is difficult to obtain. Changes in methodologies by operators can also lead to problems in assessing trends in emissions.

232 Highlighted inter alia by ComReg

233 CTU highlighted the need to measure emissions associated with different services and OTT applications in order to understand the source of the problem.

234 In this context, the French environmental agency has developed different Product Category Rules for digital services, ISPs and data centres / cloud services

235 Including BIPT, CTU, ANCOM, AKOS, CNMC, ANACOM

236 For example through voluntary measures / Codes of Conduct or, where relevant in the context of award criteria or conditions attached to frequencies, Rights of Way or State Aid regulation) already provides them with scope to support environmentally sustainable practices such as the **deployment of energy-efficient FTTH and 5G networks, copper switch-off, network sharing and sharing of physical infrastructure**. The Connectivity Toolbox provides further good practice examples in this regard.

ANACOM also notes that (where compatible with existing regulatory frameworks) it could be discussed whether **licensing and permit granting procedures** as well as the allocation of **spectrum frequency usage rights and granting of State Aid could evolve to take greater account of the environmental impact of certain technology rollouts**, including their impact on the landscape. In this context, faster and less costly procedures and / or better conditions to access public funding (if applicable) could be envisaged for rollouts which have a reduced impact on the environment. Another measure which could potentially be incentivised in the context of these procedures might be the use of **self-generated renewable energy** to power facilities such as base stations.

ANACOM also notes that, in cases where the NRA has competencies concerning the promotion of **scientific research** in the field of communications or ICT in general, NRAs could support initiatives which incentivize the development of technologies that are more environmentally friendly, such as more efficient data centre cooling methods or perfecting sleep modes for certain 5G NR active equipment.

6.2.4 Limitations on the potential for NRAs to engage in promoting sustainability

An important limitation on NRAs ability to engage in the sustainability agenda is that, with the exception of ARCEP, NRAs are not tasked with promoting environmental sustainability within EU or national legislation relating to electronic communications.[237] Environmental objectives are not covered by the EECC or the BCRD (and associated implementing measures), and thus NRAs (and BCRD DSBs) may face challenges in using their general budget for exploratory work that goes beyond any limited remit they may have (e.g. in relation to Article 44 EECC).

NRAs may also lack the remit to gather data for the purposes of understanding environmental impacts of electronic communications networks and services. Article 20 of the EECC provides only that ECN operators must provide information necessary for NRAs and BEREC to ensure conformity with the provisions of or decisions adopted in accordance with the EECC or BEREC Regulation. [238] Data gathering could thus only be conducted on a voluntary basis today in many countries.

237 The President of the Polish authority UKE is required however to take into account environmental impacts in the context of decision-making

238 https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv%3AOJ.L_.2018.321.01.0001.01.ENG

In view of these limitations, NRAs' involvement in the sustainability agenda is dependent on any additional responsibilities or roles they may be assigned at a national level. As previously noted, there are plans to grant ARCEP data gathering powers and other responsibilities in the context of a planned law to reduce the environmental footprint of digital technology in France.[239] Another option would be for NRAs to become involved in tandem with the relevant ministries in wider environmental programmes such as the Agenda 2030 UN Sustainable Development Goals,[240] or national strategies linked to the implementation of the European Green Deal.

239 https://www.senat.fr/rap/l21-068/l21-068.html
240 https://sdgs.un.org/goals

7 Conclusions and further areas for research

NRAs can already play a role today in supporting sustainable network deployment and operation by enforcing elements of the EECC and BCRD which have positive effects on the environment, even though environmental goals may not be at the heart of these measures. Depending on the remit of NRAs under these Directives, these could include:

- Promoting the deployment of more energy efficient new technologies such as FTTH[241] and 5G[242], alongside the switch-off of legacy technologies;[243]
- Promoting the re-use of existing physical infrastructure (PIA), and co-ordination of civil works in accordance with the BCRD as well as co-location or sharing of network elements and facilities in the context of Rights of Way as established in Article 44 of the EECC;
- Permitting or encouraging network sharing where appropriate including in the context of Article 61(4) EECC.

It should however be noted that NRAs will not be able to take such actions to promote environmental goals if in doing so, their actions would undermine the central objectives of the legislation to foster deployment of VHCN, promote competition and efficient investment and protect consumer welfare (or to reduce the cost of deployment, in the case of the BCRD). Making trade-offs between environmental goals and those relating to competition, investment and consumer welfare can only be made if NRAs are formally required to take into account the environmental impact of their decisions.

There could also be a role for NRAs and BEREC to support sustainability programmes more widely if they are given the relevant remit and budget to do so in the context of national legislation or if they are given a mandate to support environmental programmes such as the UN Sustainable Development Goals or the European Green Deal.

When engaging in environmental programmes, there is consensus that collaboration between NRAs and authorities responsible for environmental protection is important. The balance between the responsibilities of NRAs and environmental agencies in promoting sustainability in ECN is likely to vary in different countries and will also depend on the degree to which emissions from ECN are controlled through horizontal or sector-specific

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241 Although the EECC requires NRAs to respect the principle of technological neutrality, certain measures tend to have the effect of facilitating FTTH deployment including promoting entry by alternative investors and incentivising FTTH deployment by the incumbent as well as alternative investors in the context of access regulation and the associated wholesale pricing regime

242 Taking into account any findings concerning energy efficiency for different use cases

243 NRAs can influence the pace of migration by limiting regulatory barriers to the extent permitted in accordance with Article 81 EECC as well as by encouraging long term contracts / co-investment which have the effect of achieving “buy-in” to the new technology from multiple service providers including the incumbent in areas where alternative investors have deployed FTTH. Further analysis of policies to foster switch-off is included in the WIK (2020) study https://www.wik.org/fileadmin/Studien/2020/Copper_switch-off_whitepaper.pdf measures. However, a minimum degree of involvement for NRA might for example include:

- contributing to the development of a consistent and harmonised methodology for the gathering of data on the environmental impacts linked to electronic communications at EU level;
- Supporting in the gathering of data from stakeholders to understand the emissions (including scope 3 emissions) associated with the provision of electronic communications networks and services, and to measure the effects of possible policy measures.

NRAs with a broader remit in the environmental sphere could also consider (depending on their remit and interest) engaging in activities at EU and national level to:

- Build awareness amongst consumers and ECN operators concerning the environmental footprint of devices and network technologies, potentially with the support of information campaigns and potential labelling schemes;
- Engage in the development of Codes of Conduct to encourage stakeholders to engage in sustainable practices;
- Support the sustainable design of digital / ICT products, energy efficiency, and recycling programmes;
- Support in research on or funding of sustainable solutions;
- Incentivise sustainable solutions (such as the use of self-generated green energy, energy-efficient technologies, re-use of infrastructure) e.g. through voluntary initiatives / Codes of Conduct or in the context of award criteria or conditions attached to spectrum awards, Rights of Way and State Aid;
- Support the introduction of fiscal incentives (such as tax-breaks) to foster sustainable deployments.

Further research could be useful to understand:

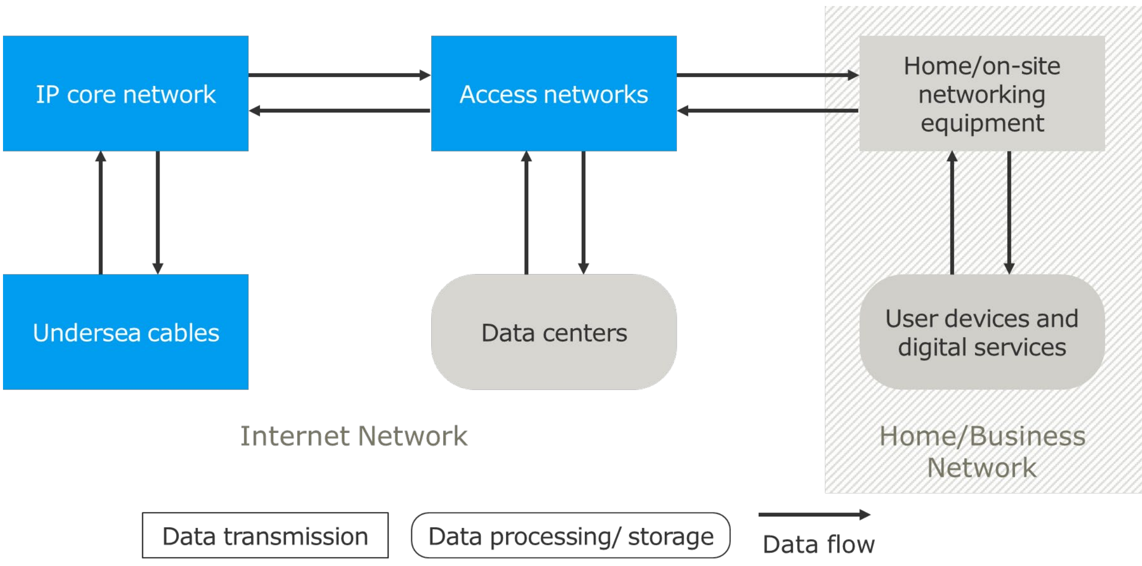
- Different reporting methods for environmental impacts within the electronic communications sector with a view to making recommendations on a common indicator framework;
- The potential for labelling schemes to support consumers in making informed choices concerning environmental sustainability;
- The potential impact of mid-band and millimetre wave 5G on the environment, as well as the impact of future technologies linked to network operation, and an analysis of how environmental impacts are reflected in R&D relating to future technologies including 6G.

Annex 1: Literature review methodology

Scope of the literature review

The project focus is on the environmental impact of the material side of the digital capital: digital infrastructures. Material and associated environmental implications of the digital capital are determined by the various life-cycle stages of respective subsystems of the internet (i.e. raw material extraction, manufacturing, operation, and recycling or disposal of equipment). Figure 0-1 provides a simplified categorisation of these subsystems, while the focus of this literature review is predominantly on indicated data transmission systems (i.e. IP core network, undersea cables, and access networks).

Figure 0-1: Subsystems of the internet (own depiction based on Aslan et al. (2018) and Malmodin et al. (2014))



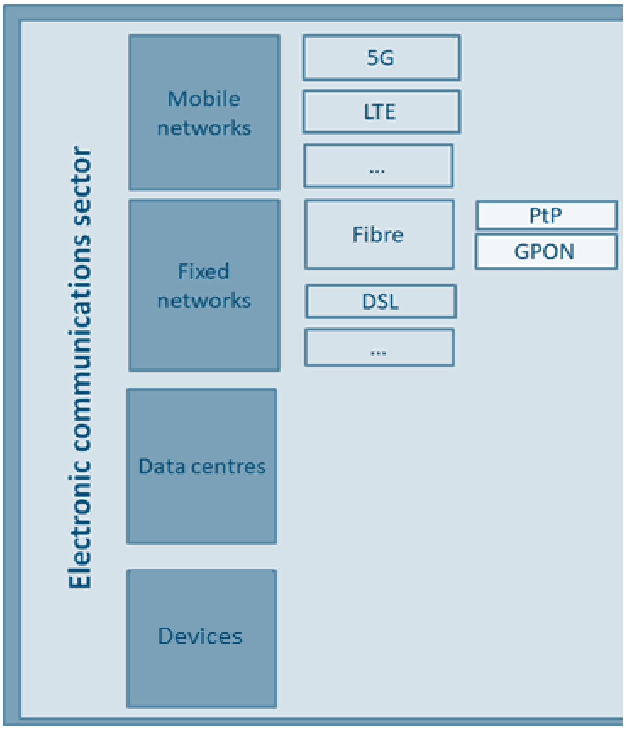
It is understood that electronic communication networks comprise most transmission networks, whether the signals are conveyed by wire, radio, optical or other electromagnetic means. In this respect, the following networks are concerned:

- satellite networks;
- fixed and mobile terrestrial networks;
- electricity cable systems to the extent that they are used for transmitting signals;

- cable television networks, irrespective of the type of information conveyed.

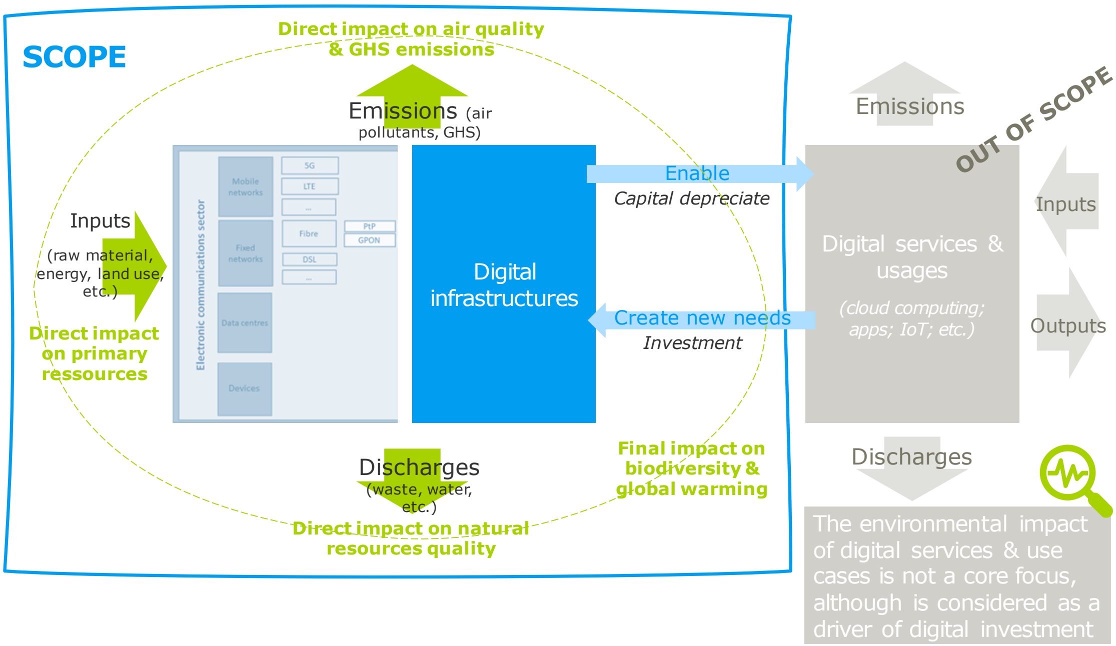
These digital infrastructures comprise the whole range of the electronic communications sector components, as presented in the following figure.

Figure 0-2: Digital infrastructures



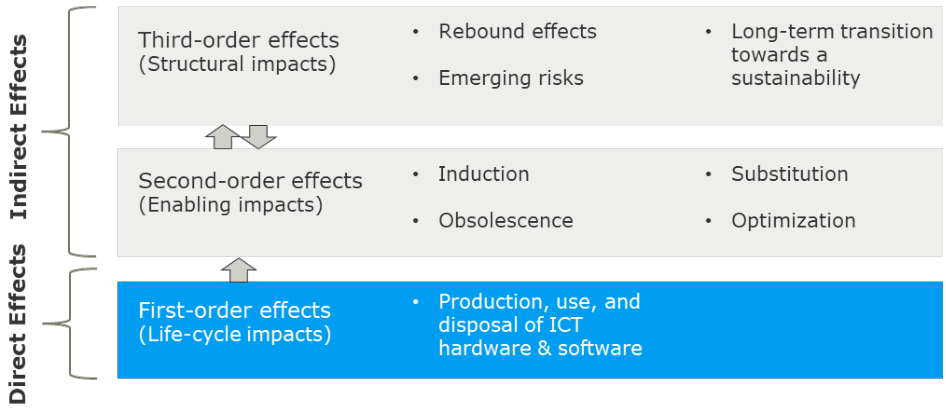
The environmental impacts of digital services and use cases are not considered as such for this literature review. For this project, services and uses are considered as variables that have an effect on digital infrastructure as well as investment drivers. Figure 0-3 provides an illustration of the scope of the study, stressing the interlinks between infrastructures and services.

Figure 0-3: Scope of the literature review



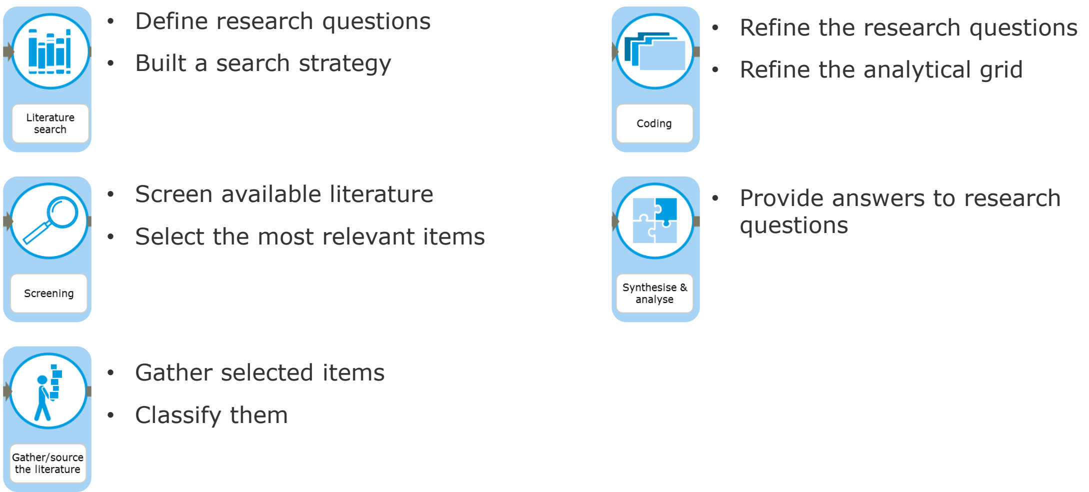
The scope is defined based on a simplified approach of the classification scheme below, developed in academia to facilitate holistic assessments of specific ICT applications. According to this, environmental effects of ICT are commonly classified into first (direct), second (enabling), and third (systemic)-order effects (Hilty and Aebischer, 2015). Following this classification, the literature review mainly addresses first-order (direct) effects (see Figure 0-4).

Figure 0-4: Generic environmental effects of ICT (own depiction based on Hilty and Aebischer (2015)).



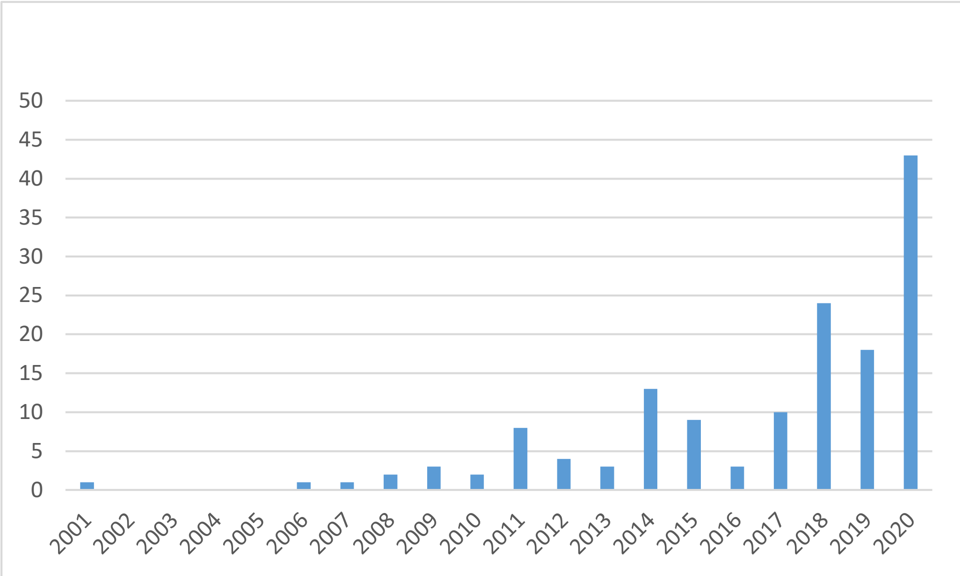
Process

The review started early January 2021 and the report was delivered in March 2021. The literature review has been conducted under a classical approach to this type of exercise:



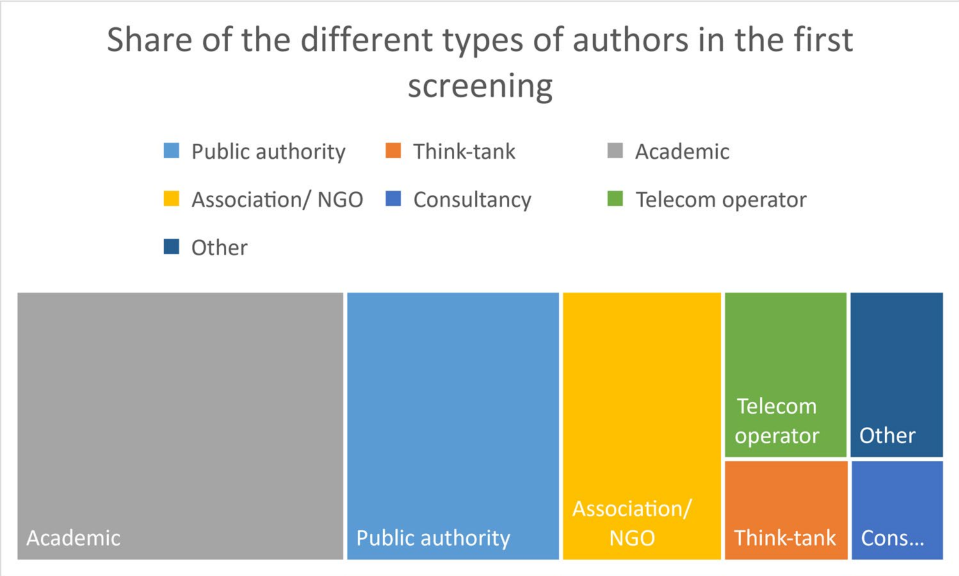
In total, 155 documents were first identified. As shown is the following figure, 142 were published between 2010 and 2020, some older documents have been considered on specific topics such as deep sea and 5G, considering they remain appropriate references to work with. Even if our screening is not scientifically representative of all the literature produced within the scope of the study, we could see most of the documents were produced during the last three years. It reflects the growing concern among society about the environmental impacts of digital technologies and ICT.

Figure 0-5: Share of reports identified per year of publication



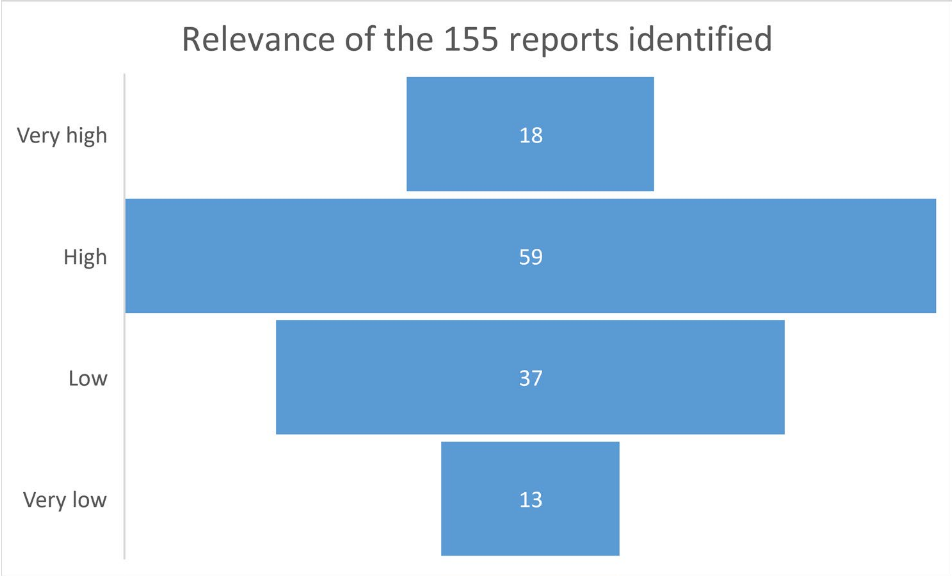
As illustrated in the following figure, most of the documents were produced by academics or public authorities, while associations, NGO's and Think-tanks also showed a growing interest in the topic.

Figure 0-6: Share of reports identified per type of authors



As shown in the following figure, around half of the reports identified were considered as highly or very highly relevant considering the scope of the research. We excluded some relevant reports when another report covered the same scope, to avoid overlaps. For instance, we excluded some position papers, stressing some societal or political concerns, but not adding new information to the research. Some academic papers are also converging to the same conclusions and we selected the more recent ones to go in-depth in.

Figure 0-7: Relevance of the 155 reports identified



52 reports were selected to be analysed in depth. To select the 53 reports that have been analysed in depth, we relied on criteria to prioritise literature:

- Relevance to the research questions;
- Complementarity in the topics covered ;
- Diversity of literature sources.

The sample show the characteristics illustrated in the figures below.

Figure 0-8: Share of reports selected per year of publication

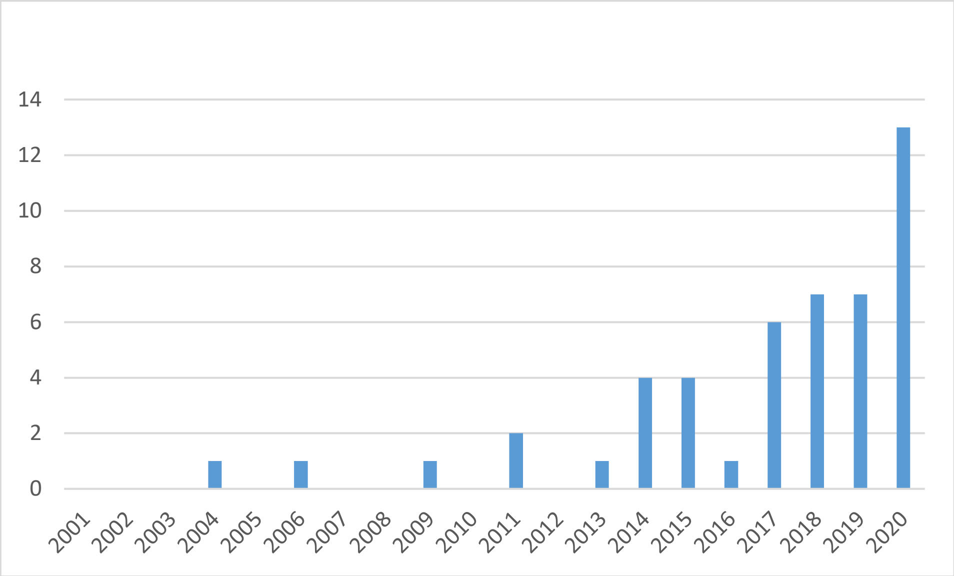
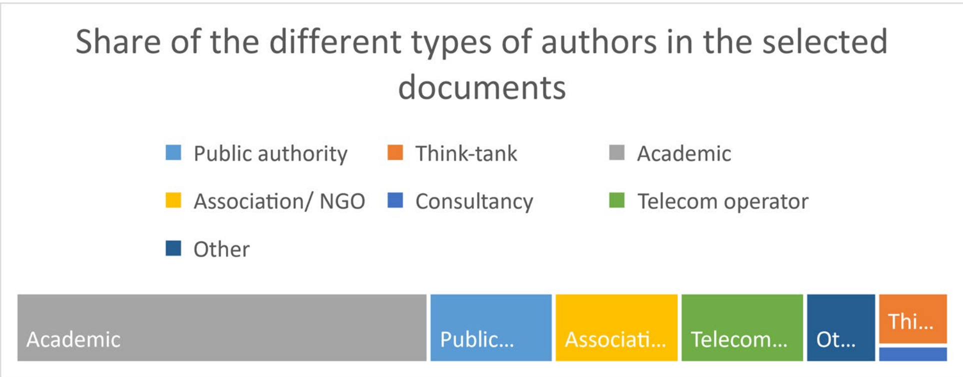
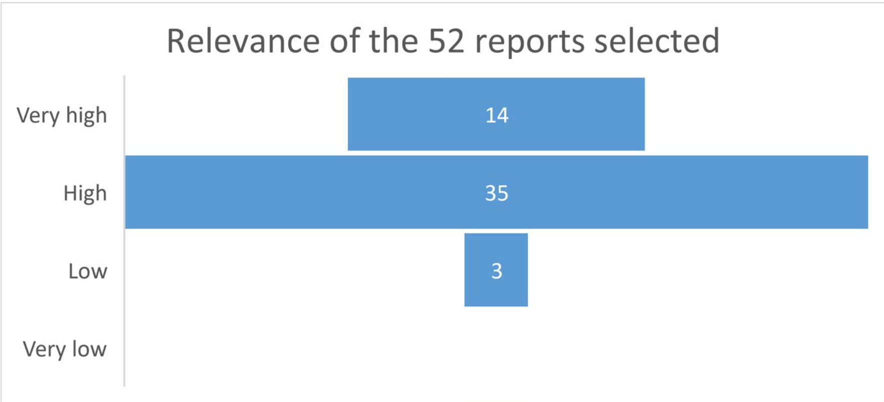


Figure 0-9: Share of reports identified per type of authors



As shown in the following figure, 3 reports considered classified as less relevant during the first screening were included in the sample of documents that were analysed in depth. The reason is the report give limited but complementary inputs for research questions 4 and 6.

Figure 0-10: Relevance of the 52 reports identified



Research questions

The set of research questions agreed on during the official kick-off meeting of the project are listed in the table below.

Theme	Research questions
Context: Telecom usage patterns	• What is the current coverage of different fixed and mobile telecoms technologies across the EU and how is this evolving? • What are the take-up rates of different fixed and mobile technologies and associated average bandwidth consumed in the EU (separately for fixed and mobile)? How is bandwidth consumption evolving? • What kinds of deployment techniques are being used to deploy fixed and wireless networks e.g. use of microtrenching? • What types of networking, end-user and IoT equipment are used for fixed and wireless electronic communication services? What are the volumes of this equipment and how is this evolving? • What are the main types of knock-on effects (on other industries and the public sector) – both positive and negative – of increased digitisation?
What is the (environmental) problem and what are the causes?	• What is the energy consumption footprint of different kinds of fixed and wireless telecom network, end-user and IoT equipment? What are the consequences for CO_2 emissions, assuming current trends in energy generation mix continue? • What are the environmental impacts of different kinds of network deployment techniques (e.g. microtrenching vs standard trench deployment)? Please distinguish impacts associated with materials, water and land. • Are there other problems not listed here ? (please see our understanding of potential problem areas in slides 8, 9 and 10) • What are the environmental impacts of parallel deployment of fixed and wireless technologies (end to end infrastructure competition) as compared with network sharing? Please distinguish impacts associated with materials, water and land. • What are the environmental impacts of maintaining different generations of networks as opposed to switch-off of legacy technologies e.g. maintaining copper and fibre vs copper switch-off, maintaining multiple generations of mobile technologies vs phase-out of older generations? Please distinguish impacts associated with carbon and air emissions as well as identifying impacts associated with materials, water and land. • What are the environmental impacts associated with the production, distribution, decommissioning and disposal of equipment used in networking, as well as terminal equipment and equipment used for IoT? Please distinguish impacts associated with carbon and air emissions as well as identifying impacts associated with materials, water and land.

What should be the objective?	• What are the objectives at EU level concerning limiting the environmental impact of the telecom sector? • What objectives have been set at national level concerning limitations on environmental impact of the telecom sector? • What objectives have telecom operators and equipment manufacturers set concerning limitations on the environmental impact of the telecom sector? • Please distinguish between objectives associated with limiting carbon and air emissions as well as objectives associated with materials, water and land.
What solutions have been deployed?	• What does literature say about the strategies that have been deployed by operators and equipment manufacturers to limit environmental impacts (distinguished between measures aimed at limiting emissions as well as impacts on materials, water and land)? For example, have actions been taken in the following areas with the explicit aim of limiting environmental impacts? ▪ Copper switch-off ▪ Consolidation of mobile technologies – single RAN ▪ Network sharing fixed and wireless ▪ Less intrusive construction methods ▪ Changes to the energy mix ▪ Re-use of energy generated in the context of network operation ▪ Use of more environmentally friendly materials ▪ Recycling ▪ Other • What does literature say about the measures that have been taken by regional, national or multi-national authorities to limit environmental impacts (distinguished between measures aimed at limiting emissions as well as impacts on materials, water and land)? Do any of these measures aim to facilitate or incentivise the types of potential actions described above?
How effective and efficient have the solutions been at limiting environmental damage?	• Per measure taken (please see previous section), what evidence has been provided concerning the effects of the actions on the environment (in terms of limiting emissions and reduced impacts on materials, land and water)? • Per measure taken (please see previous section) what evidence has been provided concerning the costs of pursuing the measures described compared with the status quo, and any unintended costs? Were the measures associated with benefits other than the environmental benefits described above?

Annex 2: Initiatives by NRAs relating to the environment

This Annex provides a summary of the feedback provided by 19 NRAs in the EU/EEA and UK concerning their remit and activities in the field of sustainability. The countries covered are Austria, Belgium, Croatia, Cyprus, Czechia, Germany, Greece, Hungary, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovak Republic, Slovenia, Spain, Sweden and the UK. A detailed description of the activities of NRAs in France (ARCEP), Finland (Traficom) and Ireland (ComReg) is provided in sections 4.2.3 to 4.2.5 of the report.

Austria (RTR)

There are no initiatives regarding sustainability of the ICT sector itself. The Broadband strategy (2030) of 2019 does not focus on sustainability.[244]

With the current framework in Austria, RTR does not see the legal basis for mandatory measures to limit the environmental impact of operators' operations. For the time being, reducing the environmental footprint of networks can constitute a "by-product" of regulatory decisions; for example the coordination of civil works and joint use of existing physical infrastructure might reduce the environmental impact of the deployment of electronic communications networks deployment, the regulator says.

Belgium (BIPT)

BIPT has not taken any steps concerning the promotion of environmental sustainability as they currently have no legal basis to do so.

The Belgium regulator argues that as a first step, NRAs need to have the possibility to inquire the operators about the details of their energy footprint without any restrictions. Without proper access to data, it is difficult to make any decisions.

Croatia (HAKOM)

On the basis of Article 30 Paragraph 1 of the current Croatian Electronic Communications Act,[245] HAKOM encourages the sharing of electronic communications infrastructure and other related equipment for specific purposes such as protection of environment, space protection and reducing excessive construction. HAKOM has also taken some steps to limit environmental impacts through reducing the need for parallel networks on the basis of the ordinance on joint sharing of networks and infrastructures.

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244 See, European Commission - Shaping Europe's digital future: Country information - Austria (2021). Available at: https://ec.europa.eu/digital-single-market/en/country-information-austria (Accessed: 13.07.2021).

245 Ministry of the Sea, Transport and Infrastructure, Electronic Communications Act (Official Gazette 73/08, 90/11, 133/12, 80/13, 71/14, 72/17). Available at: https://mmpi.gov.hr/UserDocsImages/arhiva/ZEK2008-2017-procisceni.pdf (Accessed: 13.07.2021).

Besides regulation concerning passive infrastructure sharing, there have been no other initiatives and HAKOM has no legal basis to mandate measures with the specific aim of limiting the environmental impact of electronic communication networks.

Cyprus (OCECPR)

In Cyprus, infrastructure sharing for fixed and mobile networks is in place. However, this was introduced without a specific focus of reducing the environmental impact, and thus positive effects are a by-product of the measures.[246]

Czechia (CTU)

There are no current initiatives by the CTU concerning ICT and environmental issues.

Some measures have been taken by Czech operators, but these are all voluntary. Any initiatives taken are likely to be driven by the Ministry of Industry and Trade and the Ministry of the Environment.

Germany (BNetzA)

For Germany, sharing of passive infrastructure of public supply networks is primarily focused on leveraging synergies and achieving cost reduction. Environmental protection is not the criterion used to justify intervention but rather constitutes an additional positive side effect.[247] However, going forwards, the transposition of Article 44 of the EECC (Directive 2018/1972/EU) into the new German Telecommunication Act (Article 128(4) and 134(5)), which came into force on 1st December 2021, will enable BNetzA to mandate shared use of property and telecommunication networks in order to protect the environment, amongst other factors.

Greece (EETT)

EETT has not yet engaged in activities such as meetings, workshops or exchange of information, regarding sustainability issues.

As regards its remit to take into account environmental provisions in the context of electronic communications regulation, EETT can impose co-location and sharing of network elements (including masts, towers and similar antenna supporting structures) in order, among other reasons, to protect the environment. The relevant legal basis is article 152 of Law 4727 of 2020 (transposition of article 44 of EU Directive 2018/1972). Legislation in place beforehand[248] also required operators to collocate antennae on

246 Colocation and Sharing of facilities' Decree 247/2013 of OCECPR.
247 Directive 2014/61/EU recital 30.
248 Par 7 of article 29 of Law 4070

request on reasonable terms, for environmental reasons and to provide collocation where technically feasible. EETT has published a Regulation concerning collocation.[249]

Sustainable deployment can also be promoted through passive network sharing. EETT notes that in the context of the recently awarded 5G spectrum bands, ECN operators have the right to enter into commercial infrastructure sharing agreements with a simple notification to EETT.

More generally, Greece is developing criteria and methodologies to assist in monitoring the environmental footprint of the electronic communication sector with a view to enabling the administration to make appropriate provision to ensure the sustainability of electronic communications networks.

Hungary (NMHH)

The Hungarian regulator for telecommunication, National Media and Infocommunications Authority (NMHH), is in the initial phase of work on sustainability. They are active members in the BEREC ad-hoc sustainability working group. They have held a “brainstorming session” and are considering possible actions that could be taken and information that might be gathered. A consultation with stakeholders and a workshop are also possible steps the regulator is considering. NMHH plans to include environmental aspects in its 2021 annual online consumer survey. The aim of the survey is to collect data about consumer habits, devices and trust in digital services and technologies.

According to NMHH, in order to take further action, there is a need first to be able to collect environmental data from market players as well as engaging in closer collaboration with other authorities, especially those which mainly focus on environmental regulation.

Malta (MCA)

In the absence of any current specific legal powers in this area the Malta Communications Authority (MCA) has not yet taken any formal initiatives to try to limit the environmental impact of networks.

The MCA, notes that operators in Malta have started to take steps to mitigate the negative environmental effects of their operations and considers that they are inclined to favour a pro-active and self-regulatory approach. Two of the three operators consulted have carried out comprehensive assessments of their operations’ energy consumption and have stated that they will commit to targets based on the SBTi. The third operator which was interviewed stated that, amongst other measures taken, it has deployed technologies aimed at minimising the electricity consumption of its network.

Netherlands (ACM)

249 (750/5/2015) with a latter modification on 2018 (859/3).

ACM has not taken steps yet to limit the environmental impact of electronic communications networks, and are not aware of any targets that have been set by other public authorities in the Netherlands. ACM notes that the largest operators (KPN, VodafoneZiggo and T-mobile) all show sustainability objectives on their website. ACM has not discussed sustainability initiatives with the network operators, but has not discussed these initiatives with the operators concerned.

In January 2021, ACM published draft guidelines concerning sustainability agreements and the implications for competition.[250] In the draft Guidelines ACM discusses the situations under which competitors should be able to work together in order to help combat the climate crisis, and to realize other sustainability objectives. ACM notes that businesses should have more opportunities to co-operate in order to achieve climate objectives, such as reducing CO2 emissions. According to ACM, this should be allowed if the benefits for society as a whole offset the drawbacks of the possible restriction of competition. However, ACM advocates that the European Commission should ensure that a common approach is taken to this issue.

Norway (Nkom)

At the moment, the National Communications Authority (Nkom) does not have any specific legal basis for regulating environmental aspects related to electronic communications.

However, as of December 2021, the Ministry of Transport and Communications was working on new Electronic Communications Act, and as a part of this proposal, a broader statutory objective, that also includes climate and environmental aspects, was proposed.

Both Ministry and regulator will follow up the sustainability goals and environmental and climate challenges linked to the telecom sector. For instance, Nkom emphasises that it is important to assess how the sector's own climate impact might be reduced, besides only viewing the enabling factors of the ICT sector.

Nkom states that, as a starting point, soft regulation will be preferred, and it is expected that the telecom sector in cooperation with the government will find sufficient solutions to monitor the development and implement measures, if found necessary.

Poland (UKE)

The President of the Polish NRA UKE has a legal obligation to take into account environmental concerns when issuing Decisions. UKE has not yet pursued specific initiatives which aim to limit the environmental impact of electronic communications networks. However, UKE reports that they are aware of a number of measures that have been taken by network operators, including in particular Orange Polska, which has

250 https://www.acm.nl/en/publications/guidelines-sustainability-agreements-are-ready-further-european-coordination committed to sourcing 60% of its energy from renewable sources by 2025 and to achieving net climate neutrality by 2040.[251]

Portugal (ANACOM)

After major wildfires occurred in Portugal in 2017, ANACOM has taken many steps to increase resilience of electronic communication infrastructure. ANACOM considers either passive and active infrastructure sharing plays an important role in limiting the environmental impact of the ICT sector. In one of the first ANACOM decisions related to the access to ducts of the incumbent operator (decision of 17th July 2004 which implemented the minimum elements of the RDAO) it was mentioned that: “Investment in ducts should be compatible with economic efficiency criteria, avoiding any inefficient duplication in infrastructures or inconveniences for citizens and economic activities due to the frequent and extensive realization of soil and subsoil works, with consequent disturbances at traffic and territory planning level, apart from the repercussions of environmental order arising out from it”.

Portuguese legislation, has for some time incentivised passive sharing,[252] subject to competition conditions being met. In the specific case of mobile operations, auction rules (from spectrum allocations in 2020 and 2011) include provisions to facilitate passive and also active sharing, including roaming.

Romania (ANCOM)

Although sustainability measures are not part of ANCOM’s mandate/legal framework, the Romanian authorities have given attention to limiting the negative effects of (deploying) electronic communication network on the environment.

One element has been a project to promote “Energy efficient technologies and architectures for NGN” within the implementation framework of the National Plan for Next Generation Network (NGN) infrastructure development (2015).[253] The scope of the project was to identify the infrastructure requirements and network performance for energy efficient NGN. The regulatory provisions regarding the energy consumption and GHG emissions of communications technologies, the ecological design (eco-design) or the green eco-label were assessed. Moreover, despite not being explicitly mentioned, some measures specified in the National Plan for NGN infrastructure development have positive environmental impacts such as encouraging access to existing passive infrastructure and improving transparency and coordination of civil works.

251 https://www.orange.pl/view/csr#czyste-srodowisko
252 See, Decree-law n.er 123/2009, dated 21st May. Available at: https://www.anacom.pt/render.jsp?contentId=975261 (Accessed: 13.07.2021).
253 See, European Commission - Shaping Europe’s digital future: Country information - Romania (2021). Available at: https://ec.europa.eu/digital-single-market/en/country-information-romania (Accessed: 13.07.2021).

Furthermore, there is a general reference to environmental protection in the Law no. 159/2016 on the regime of electronic communications networks infrastructure and on establishing certain measures for reducing the cost of electronic communications networks roll-out. The provision states that the electronic communication networks provider should respect requirements regarding the protection of environment when executing works as a result of their right of access on, over, in or under to public/private properties, including roadways, bridges, tunnels, technical and public works infrastructure, passways and viaducts, masts, pillars and agriculture lands.

Slovak Republic (RU)

RU has no competence with regard to the environmental impact of networks. The European Green Deal and its objectives fall within the remit of the Ministry of Environment of the Slovak Republic.

Slovenia (AKOS)

AKOS has imposed certain measures which, in addition to protecting competition, have an impact on the sustainability of networks. Such measures include:

- promoting the transition to more energy-efficient networks (e.g. optical fibre network) and
- promoting the sharing of electronic communications infrastructure between operators, co-investments in infrastructure, to reduce unnecessary duplication of electronic communications networks.

The legal basis for these measures is the national legislation (ZEKom in compliance with EECC, BCRD).

Spain (CNMC)

The National Commission of Markets and Competition (CNMC), is currently assessing measures which could be adopted to limit the environmental impact of the activities of operators in regulated sectors.

Recently, the CNMC has published its Strategic Plan (2021-2026) and its **Action Plan (2021-2022) which include objectives related to sustainability**. In particular, in the telecommunications area, the integration of sustainable development goals is contemplated as a Strategic Action (6) in the Action Plan. Associated actions include the promotion of ultra-fast networks through ex ante regulation and supervision of markets (broadband markets), the imposition of obligations, contributing to the achievement of goals 8 and 9 of the Paris Agreement (industry, innovation and infrastructure) or detecting any restrictive practices, in particular bid rigging or manipulation of public tenders, which could limit the responsible consumption and production or the objective of promoting the sustainable industrialization and foster innovation.[254]

Recently, the Spanish Parliament has adopted the **Law 7/2021, 20th May, on Climate Change and Energy Transition**. Article 6 provides that the Government will adopt actions to promote the digitization of the economy that contribute to achieving the decarbonisation objectives, within the framework of the Spanish Digital 2025 Strategy. These actions will, among others, include actions to limit the environmental impact from the ICT sector itself including:

- Inform and disseminate new proposals for reducing greenhouse gas emissions from the digital economy and new business models.
- Employ the potential of new technologies, such as artificial intelligence, to move towards a green economy, including, among other aspects, the design of energy efficient algorithms by design.
- Encourage companies to take into account the impact of their services and their digitization process and adopt a responsible approach to the innovation of existing digital services to achieve sustainable digitization within the scope of the Law.

The CNMC considers that the process of copper switch-off must be encouraged in order to reduce the impact of these networks on environment. This aspect will be taken into account in the following revision of the market in order to try to accelerate the process of **copper switch-off**.

Sweden (PTS)

Although PTS, the Swedish Post and Telecom Authority, is still in a learning phase when it comes to how they can integrate an environmental and sustainability approach in their core mission, several measures have been initiated, both at a national and international level.

PTS participates in international work related to sustainability and climate change including BEREC's ad-hoc Working Group on Sustainability and the RSPG Sub-Group on Climate Change. PTS has prioritized participating in these groups, but have no assignment within the authority to work on limiting the environmental impact of networks specifically.

During 2021, PTS was commissioned to work with Agenda 2030 (UN Sustainable Development Goals), which will be included in its reporting in February 2022. In addition, PTS has recently received a new assignment from the government to explain in the

254 CNMC (2021). Strategic Plan (2021-2026). Available at: https://www.cnmc.es/novedades/2021-05-18-plan-estrategico-2021-2026-y-plan-de-actuaciones-2021-2022-de-la-cnmc-388434 (Accessed: 13.07.2021).

context of their reporting how PTS considers its work contributes to the achievement of the Sustainable Development Goals.

Although it was not classified as work under the label of Agenda 2030 or the SDGs, PTS has gathered some examples of their contribution to environmental goals in an internal workshop in October 2020. This includes activities to promote sustainable cooling and exploring greener fuel alternatives for back-up power.

PTS also subsidises certain investments by operators in the context of building more robust networks and ensuring back-up power. Through these subsidies, PTS encourages and supports more climate neutral initiatives such as:

- The use of synthetic diesel or similar, with a lesser environmental impact and good storage characteristics, compared to regular diesel.
- Evaluations of fuel cells with hydrogen and diesel reformers.
- Facilities with fuel cells powered with hydrogen in a colder climate.
- Research initiatives related to the storage of hydrogen - storage time is vital for endurance at the location (e.g. mobile cell tower).

PTS also notes that they currently have a limited mandate in the EECC, Article 44, to take action to protect the environment.

The UK (Ofcom)

While Ofcom's current statutory functions (objectives, duties and powers) do not cover environmental matters, Ofcom considers that it is vital that communications companies invest to put themselves on a sustainable footing so that their networks and services are fit for the long term. Achieving that outcome requires communications companies to consider their own environmental footprint and how they deliver services and networks in a sustainable matter. Going forwards, Ofcom will continue to engage with regulated firms on these matters.[255]

As part of its work on this, Ofcom has been undertaking research to better understand the CO2 emissions produced in Ofcom's regulated sectors and how regulated firms are working towards a net-zero target. This work has been done through internal and commissioned research together with engagement with communications companies which have voluntarily shared information about their environmental initiatives.[256]

255 https://www.ofcom.org.uk/__data/assets/pdf_file/0023/229640/Consultation-Ofcoms-proposed-plan-of-work-2022-23.pdf

256 https://www.ofcom.org.uk/__data/assets/pdf_file/0035/229688/connected-nations-2021-uk.pdf

Annex 3: Strategic Environmental Assessment methodology and detailed results

Methodology

The strategic environmental assessment that was conducted for this study followed the methodology described below.

1) Scoping

The scoping identified the different components of the value chain to be assessed. Three stages in the lifecycle of the telecommunication have been distinguished: deployment, operation and decommissioning. Each stage is also divided into substages, namely manufacture, digging, construction and upgrade for the deployment stage, maintenance and power for the operation stage, and digging. Waste management and soil depollution for the decommissioning stage.

2) Screening of potential impacts

Following the scoping, potential environmental impacts for each stage have been identified, based on the literature review conducted previously and the interviews conducted with both operators and NRAs. Three broad categories of potential impacts have been defined: GHG emissions, resources, including raw materials, land and water, and biodiversity.

3) Environmental impacts analysis

Finally, based on the literature review and the analysis of the of the sustainability reports of ECN operators, the impacts have been assessed. For each of the network lifecycle stage identified in the scoping phase, and for each type of impact identified in the screening phase, the magnitude of impact, the type and the duration have been assessed. The results of the assessment are presented in cross-tables using different symbols (“++”, “+”, “0”, “-” and “?”,to shows the degree of relevance).

Table 0-1: SEA on GHG emissions (1)

	Equipment category									
Lifecycle stage	Cables	Mast/ Antennas	Chambers/ switches	Lifecycle sub stage	Nature of environmental impact	Type of impact	Severity of the negative impact	Probability of occurrence	Frequency/ duration	Certainty about the severity of the impact
Deployment	x			Manufacture	Negative	Indirect/ Upstream	+++	+++	Occasional/ Short term	+
Deployment	x			Digging	Negative	Direct / Core activities	+	+++	Occasional/ Short term	++
Deployment	x			Upgrade	Negative	Direct / Core activities	+	+++	Occasional/ Short term	+
Deployment		X		Construction	Negative	Indirect/ Upstream	+	+++	Occasional/ Short term	+
Deployment		X		Upgrade	Negative	Indirect/ Upstream	+	+++	Occasional/ Short term	+
Deployment			X	Construction	Negative	Indirect/ Upstream	+	+++	Occasional/ Short term	+
Deployment			X	Upgrade	Negative	Indirect/ Upstream	+	+++	Occasional/ Short term	+

Table 0-2: SEA on GHG emissions (2)

	Equipment category									
Lifecycle stage	Cables	Mast/ Antennas	Chambers/ switches	Lifecycle sub stage	Nature of environmental impact	Type of impact	Severity of the negative impact	Probability of occurrence	Frequency/ duration	Certainty about the severity of the impact
Operation				Power	Negative	Direct / Core activities	+	+++	Permanent / Mid term	+++
Operation	x			Maintenace	Negative	Direct / Core activities	+	+++	Permanent / Mid term	+
Operation	x			Power	Negative	Indirect/ Upstream	++	+++	Permanent / Mid term	+++
Operation		x		Maintenace	Negative	Direct / Core activities	+	+++	Permanent / Mid term	+
Operation		x		Power	Negative	Indirect/ Upstream	+	+++	Permanent / Mid term	+++
Operation			x	Maintenace	Negative	Direct / Core activities	+	+++	Permanent / Mid term	+
Operation			x	Power	Negative	Direct / Core activities	+	+++	Permanent / Mid term	+++
Decommissionning	x			Digging	Negative	Direct / Core activities	+	+++	Occasional/ Short term	+
Decommissionning	x			Waste management	Negative	Indirect / downstream	+++	+++	Irrevocable/ Long term	+
Decommissionning	x			Soil depollution	Negative	Direct / Core activities	+	+++	Irrevocable/ Long term	+
Decommissionning		x		Waste management	Negative	Indirect / downstream	+	+++	Irrevocable/ Long term	+
Decommissionning			x	Waste management	Negative	Indirect / downstream	+	+++	Irrevocable/ Long term	+

Table 0-3: SEA on resources (raw materials, land & water) (1)

	Equipment category									
Lifecycle stage	Cables	Mast/ Antennas	Chambers/ switches	Lifecycle sub stage	Nature of environmental impact	Type of impact	Severity of the negative impact	Probability of occurrence	Frequency/ duration	Certainty about the severity of the impact
Deployment	x			Manufacture	Negative	Indirect/ Upstream	+++	+++	Irrevocable/ Long term	+
Deployment	x			Digging	Neutral					
Deployment	x			Upgrade	Negative	Indirect/ Upstream	++	+++	Irrevocable/ Long term	+
Deployment		X		Construction	Negative	Indirect/ Upstream	++	+++	Irrevocable/ Long term	+
Deployment		X		Upgrade	Negative	Indirect/ Upstream	+	+++	Irrevocable/ Long term	+
Deployment			X	Construction	Negative	Indirect/ Upstream	+++	+++	Irrevocable/ Long term	
Deployment			X	Upgrade	Negative	Indirect/ Upstream	++	+++	Irrevocable/ Long term	

Table 0-4: SEA on resources (raw materials, land & water) (2)

Lifecycle stage	Equipment category: Cables	Mast/ Antennas	Chambers/ switches	Lifecycle sub stage	Nature of environmental impact	Type of impact	Severity of the negative impact	Probability of occurrence	Frequency/ duration	Certainty about the severity of the impact
Operation				Power	Neutral					
Operation	X			Maintenance	Neutral					
Operation	X			Power	Neutral					
Operation		X		Maintenance	Neutral					
Operation		X		Power	Neutral					
Operation			X	Maintenance	Negative	Direct / Core activities	+	+++	Permanent / Mid term	
Operation			X	Power	Negative	Direct / Core activities	+	+++	Permanent / Mid term	
Decommissionning	x			Digging	Neutral					
Decommissionning	x			Waste management	Neutral					
Decommissionning	x			Soil depollution	Positive					
Decommissionning		x		Waste management	Neutral					
Decommissionning			x	Waste management	Neutral					

Table 0-5: SEA on biodiversity (1)

	Equipment category									
Lifecycle stage	Cables	Mast/ Antennas	Chambers/ switches	Lifecycle sub stage	Nature of environmental impact	Type of impact	Severity of the negative impact	Probability of occurrence	Frequency/ duration	Certainty about the severity of the impact
Deployment				Manufacture	Neutral					
Deployment				Digging	Negative	Direct / Core activities	+	+	Occasional/ Short term	+
Deployment				Upgrade	Neutral					
Deployment	x			Manufacture	Neutral					
Deployment	x			Digging	Negative	Direct / Core activities	+	+	Occasional/ Short term	+
Deployment	x			Upgrade	Neutral					
Deployment		X		Construction	Neutral					
Deployment		X		Upgrade	Neutral					
Deployment			X	Construction	Neutral					
Deployment			X	Upgrade	Neutral					

Table 0-6: SEA on biodiversity (2)

	Equipment category										
Lifecycle stage	**Cables**	**Mast/ Antennas**	**Chambers / switches**	**Lifecycle sub stage**	**Nature of environmental impact**	**Type of impact**	**Severity of the negative impact**	**Probability of occurrence**	**Frequency/ duration**	**Certainty about the severity of the impact**
Operation				Power	Neutral					
Operation	X			Maintenace	Neutral					
Operation	X			Power	Neutral					
Operation		X		Maintenace	Neutral					
Operation		X		Power	Neutral					
Operation			X	Maintenace	Neutral					
Operation			X	Power	Neutral					
Decommissionning	x			Digging	Negative	Direct / Core activities	+	+	Occasional/ Short term	+
Decommissionning	x			Waste management	Negative	Indirect / downstream	++	++	Irrevocable/ Long term	+
Decommissionning	x			Soil depollution	Neutral					
Decommissionning		x		Waste management	Neutral	Indirect / downstream	++	++	Irrevocable/ Long term	+
Decommissionning			x	Waste management	Neutral	Indirect / downstream	++	++	Irrevocable/ Long term	+

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