Breaking Down the Barriers to Sustainability:

Opportunities for Communication Industry to Facilitate Twin Transition

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For Considerations
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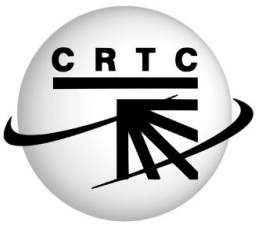
Author: Amjad Iqbal
Network Technology Engineer



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Abstract

Digitalization is revolutionizing every sphere of our daily lives. The use of Internet of Things (IoT), automated processes, smart gadgets, AI, and trends of digital-by-design are improving system efficiency, productivity, and scalability. Along with promising outcomes from the digital revolution, there are several environmental and sustainability-centred challenges in front of us. The risks could bloom if we do not monitor their impacts and ensure that digital transformations are environment-friendly and sustainable for future. The communication industry connecting more than 95% of the world population and close to 15 billion IoTs via wired or wireless networks, can play a pivotal role to ensure digital transformations are sustainable. This article explores the practicality of communication industry backed twin transition (digital and sustainable), appreciates the role of communication industry in achieving environmental, economic, and social sustainability, and highlights the areas of regulatory policies that require attention to supervise emissions, e-waste, and technological growth.

Twin Transition and its Practicality

Twin transition is the combination of sustainable and digital transformations taking place simultaneously. Digital-by-design[1] and sustainable-first[2] are other similar concepts gaining momentum in the industry. These concepts encourage engineers, regulators, and industry stakeholders to accommodate digitalization, scalability, and sustainability at the early stage of the technology development, and to assess the impact of technology on society and the environment. Where industry and regulatory bodies are actively pursuing the goals of sustainability, the communication industry plays a key role in ensuring that twin transition is being materialized by providing sustainable technological solutions.

A number of scholars[3] recognize that digital transformation has a "spillover effect" on industry growth and emission abatement. They recognize this effect in a sequence where communication system and the Internet of Things (IoT) transform the digital structure of big data exchange, cloud computing, and operations of Artificial Intelligence (AI) and they foster machine-to-machine communication. This pattern of machine-to-machine communication and information exchange facilitates business-to-business cooperation. Enhanced co-operation leads to optimal utilization of resources, reduction in energy consumption, and improves system efficiency. Such technological change in one region seeds digital transformation into another region and a spiral of digitalization continues.

Likewise, expedited data exchange process replaces physical mobility with electrical, improves efficiency, and reduces energy needs. As a result, less physical mobility, higher productivity, and less energy consumption abate greenhouse gas emissions. In a spill-over effect, digital transformation keeps expanding its applications through the IoTs which drive digital transformation. The impact of digitalization is seen in all spheres including products, processes, business models, ecosystems, and social life.[4] Likewise, through digital media, information on the

[1] Digital First Thinking for Industrial Companies: An Interview with Youngjin Yoo Youngjin Yoo talks with Jim Euchner about digital value creation for physical products and the Digital First framework. | Request PDF (researchgate.net)
[2] Green Digital Transformation: What Is 'Sustainability-First Design Thinking'? | TechSoup Canada
[3] The impact of digital technology development on carbon emissions: A spatial effect analysis for China - ScienceDirect
[4] UNECE ITS workshop 5 April 2018

importance of environmental protection, the role and responsibilities of every individual, and the consequences of greenhouse gas emissions and environmental pollution encourage the public to adopt environment-friendly activities.

The combination of technology and high-speed communication system has already set the stage for the twin transition with classic examples of remote work culture, e-commerce, online shopping, smart homes, and IoTs. Advanced communication and digital systems are not only providing more efficient alternative solutions, but also more environment-friendly, and user-oriented solutions which are more sustainable. The World Economic Forum (WEF), in its annual report,[5] has also recognized that with the implementation of technology and digital transformation, we can reduce global emissions by more than 20% by 2050, specifically, in the sectors of energy, materials, and mobility.

A few classic examples of communication and digital transformation leading to sustainability are smart grids, smart manufacturing, and e-agriculture (see Figure 1). With distributed renewable energy sources (such as wind farms, solar energy, and battery energy storage systems), an electrical grid becomes highly unstable because of the unpredictability of load and energy generation. The communication system and the IoT devices tie all unstable entities (such as energy generation sources, load, and storage systems) into a ring with a centralized control system. This central controller, with access to the entire ring of entities, buffers the instability of the electrical grid and enables the harnessing of sustainable and green energy.[6] Likewise, communication systems with higher bandwidth (i.e. 4G) and IoTs have dramatically improved manufacturing process by reducing waste, accelerating production, and improving yield and quality of goods.[7] The manufacturing sector alone has more than 14 billion IoT devices and is transitioning into 4th industrial revolution (Smart Manufacturing).[8] With the advent of integrated digital solutions, data insights, fast communication, and IoT, the agriculture sector has also evolved by leveraging technologies for smart irrigation, fertilization, harvesting, water management, and soil salinity detection.[9] As described in the examples above, we can see the influence of green and sustainable digital transformation on every sphere of life, and this is primarily due to the integration of modern communication systems, IoTs, and data processing. Therefore, it is reasonable to conclude that not only digital and sustainable transitions can co-exist, but they can also reinforce each other for a greener, sustainable, and digital future.

[5] Digital technologies can cut global emissions by 20%. Here's how | World Economic Forum (weforum.org)
[6] Revolutionizing the Electrical Field-Smart Grid and Internet of Things (IoT) Integration (linkedin.com)
[7] Smart manufacturing and the IoT (thalesgroup.com)
[8] IoT in Manufacturing Industry: Transforming the Way We Make Things » A-Team Global
[9] IoT Applications in Agriculture (iotforall.com).

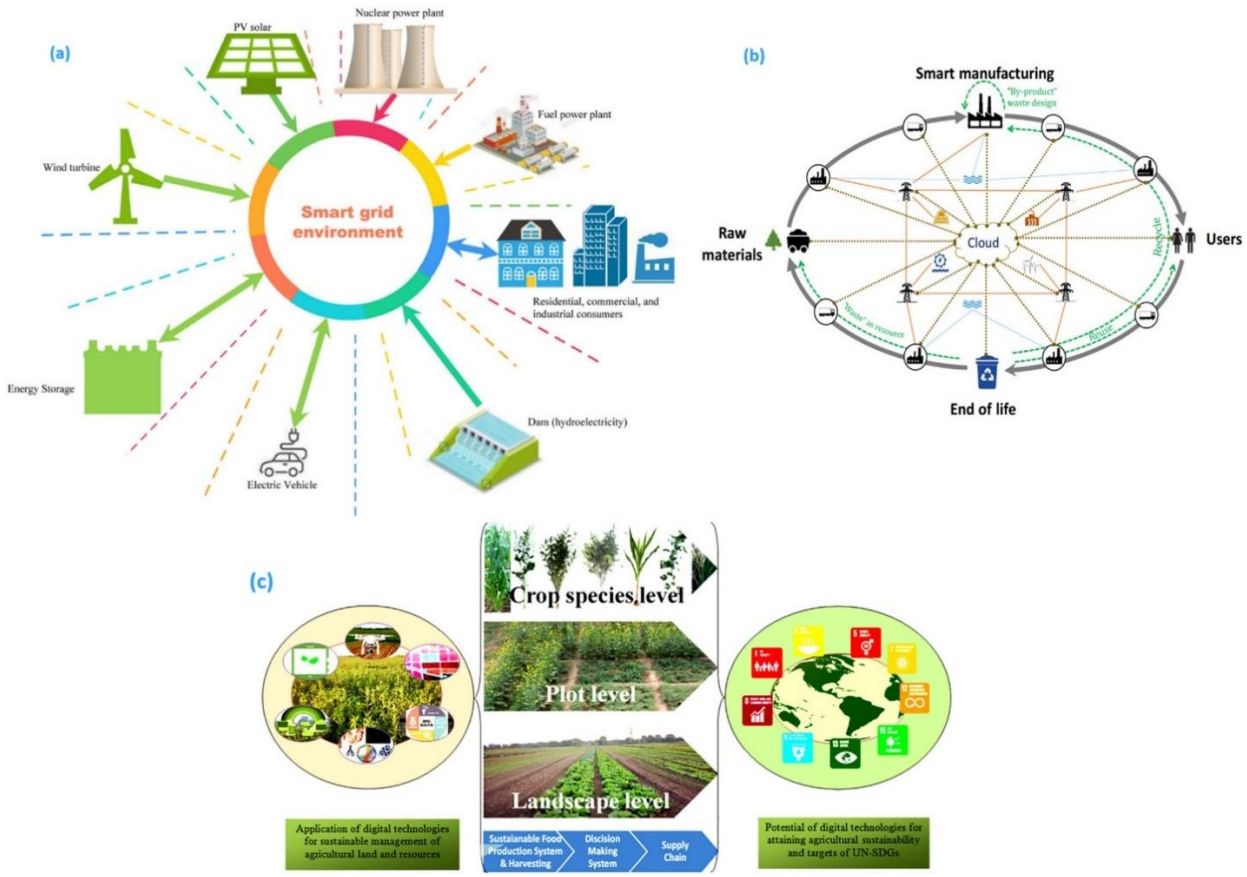

Figure 1 Overview of the applications of information communication and technology to materialize twin transition[10]

Opportunities in the Communication Industry to Facilitate Sustainability

The communication industry is at the backbone of digitalization which is connecting all sectors into a giant ecosystem.[11] It connects more than 95% of the global population and close to 15 billion machines (via IoT) over wired or wireless networks. As such, it can play an integral role in strengthening all three pillars of sustainability. These pillars, shown in Figure 2, were first introduced in 1987, in the annual report of World Commission on Environment and Development[12] and in this essay these pillars have been reviewed through the lens of communication industry.

[10] Digitalization to achieve sustainable development goals: Steps towards a Smart Green Planet - ScienceDirect

[11] UNECE ITS workshop 5 April 2018

[12] Our Common Future: Report of the World Commission on Environment and Development (un.org)

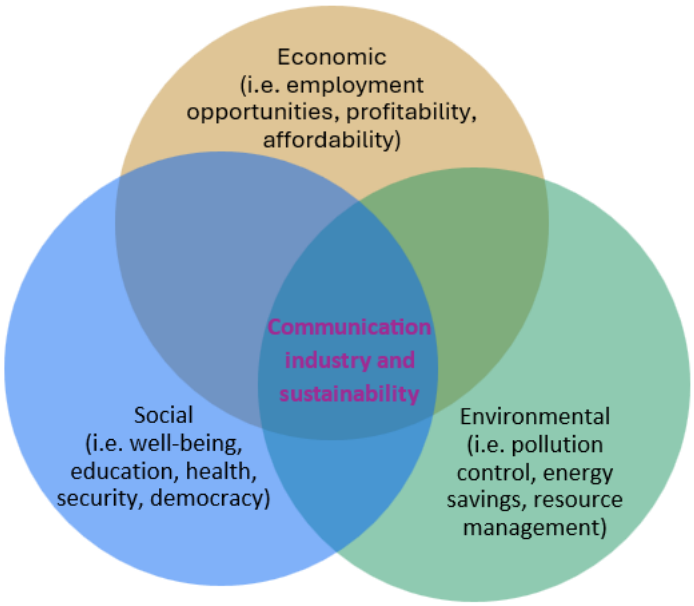

Figure 2 Three pillars of sustainability through the lens of communication industry and sustainability[13,14]

Environmental Sustainability (reduction in CO2 emission, energy savings, resource management, and pollution control)[15,16]

Reducing carbon footprint: Currently, the communication industry is responsible for 1.8% to 2.4% of global Green House Gas (GHG) emissions. In 2023 alone, its emissions were estimated to range from 650Mt to 900Mt.[17] On the other hand, in 2015, GHG emissions from the communication industry were in the range of 580-610Mt.[18] This shows that, although its existing green energy initiatives are keeping pace with growing energy demand in this industry, its net emissions are still continuously growing. According to the Paris Agreement, in order to achieve net-zero emissions by 2050, the global communication industry should reduce its GHG emissions by 2.5% on a yearly basis and developed countries should target for 4.2% annual linear reduction.[19] It is safe to conclude that, communication industry does have room to reduce its carbon footprint to achieve this emission target and achieve environmental sustainability.

Implementing efficient technologies to reduce energy needs: A comparative study of energy consumption shows that a 5G network is almost 85% more efficient than a 4G, and that a 4G is

[13] Our Common Future: Report of the World Commission on Environment and Development (un.org)
[14] Sustainability | Description, Theories, & Practices | Britannica
[15] The Environmental, Economic, and Social Components of Sustainability - HubPages
[16] Sustainability | Description, Theories, & Practices | Britannica
[17] For year 2023, annual CO2 emission was almost 37.5 billion tons with communication sector contributing from 1.8-2.4% Global CO2 emissions by year 1940-2023 | Statista and Global carbon emissions from fossil fuels reached record high in 2023 | Stanford Doerr School of Sustainability
[18] Annex A Table A.1 page # 34/98 of ITU-T Recommendation database
[19] ITU-T Recommendation database (Sec I.4 page 36/98)

15% more efficient than a 3G network.[20] Likewise, legacy technologies of fixed networks (i.e. PSTN, ISDN, DSL, FTTC, and co-axial cable)[21] use 80% more energy than newer technologies[22] (i.e. fibre). Further, integrating AI to optimize power-saving features, network asset planning, customer mapping, and field operations can make operations more efficient from the standpoint of all three aspects: energy, economics, and emissions. This illustrates that communication industry has room to adopt energy-efficient network technologies to improve its sustainability.

Reducing e-waste: The International Telecommunication Union (ITU), has recognized that for an increasingly digital society, e-waste is an active challenge to sustainability and that the Communication industry can play a vital role in mitigating this challenge. In 2022, according to the annual report from the United Nations Institute for Training and Research for Global E-waste,[23] more than 62 million tons of e-waste were produced. That trend is projected to grow by more than 30% by 2030. This e-waste caused a loss of more than 30 million tons of valuable metals (i.e. copper, gold, and iron). Only 22.3% of this e-waste was properly collected and recycled, and this fractional recycling prevented more than 93 million tons of carbon dioxide emissions.[24,25] Therefore, in the telecommunication industry, limiting e-waste, promoting repairs, recycling, and remanufacturing will not only make resource management sustainable but also seed a circular economy.

Economic Sustainability (employment opportunities, profitability, and affordability) [26,27]

Tapping the potential of the global talent pool: By continuously improving connectivity across the globe, communication industry has bridged the gap between businesses and the pool of global talent.[28] Due to demographic barriers and aging populations, many countries (i.e. US, Canada, UK, France, Germany, and Japan) have begun experiencing a shortage of experts and professionals.[29] Digital nomads and high-speed broadband facilities are significantly mitigating these challenges.[30] Businesses and their virtual staff are leveraging modernized communication system for remote work, have been freed of geographical constraints, and are keeping the wheel of the economy running. At the same time, many experts and companies recognize investment gaps in communication system networks[31] that preclude from fully leveraging the full potential of the global talent pool. Specifically, more investments are needed to reduce latency and to

[20] Purchasing Renewable Energy Removes CO2 Emissions Equal to 20 Million Barrels of Oil a Year for Leading Telco Operators (abiresearch.com)
[21] These are different network technologies and have been named based on infrastructure designs. The abbreviations stand for PSTN: Public Switched Telephone Network, ISDN: Integrated Services Digital Network, DSL: Digital Subscriber Line, and FTTC: Fibre to the Cabinet
[22] Decommissioning networks will reduce operators' energy usage (analysysmason.com)
[23] The Global E-waste Monitor 2024 - E-Waste Monitor (ewastemonitor.info)
[24] The Global E-waste Monitor 2024 - E-Waste Monitor (ewastemonitor.info)
[25] Creating a Circular Economy for Electronic and Electrical Equipment (itu.int)
[26] The Environmental, Economic, and Social Components of Sustainability - HubPages
[27] Sustainability | Description, Theories, & Practices | Britannica
[28] Navigating the Global Talent Pool — The Role of Remote Staffing Services in Talent Acquisition - CForce Global
[29] Remote Trends for 2023 - Future of Work is Remote (jobgether.com)
[30] Beyond Borders: Unlocking Global Talent Through Digital Nomads (forbes.com)
[31] Navigating the Global Talent Pool — The Role of Remote Staffing Services in Talent Acquisition - CForce Global

improve coverage, connectivity, and broadband speed to achieve economic sustainability in rural areas.

Business Profitability with IoT: By leveraging data collected through IoT devices and networking, businesses can optimize their processes, reduce costs, and provide more personalized services.[32] Likewise, IoTs deployment is improving business profitability by reducing downtime, equipment failure, and repair costs by identifying needs-based maintenance opportunities.[33] Where IoT devices are driving digitalization to materialize sustainable benefits for businesses, these devices rely on robust communication systems to transform data into information, intelligence, and to derive smart business decisions. By providing a more reliable and more efficient communication system, communication industry can facilitate a sustainable digital transformation.

Affordability: Multiple studies show that close to 70% of global businesses are either small entrepreneurial start-ups or family businesses.[34] In the face of growing needs for digitalization, these small businesses face limitations in their ability to deploy costly standalone computing and analytical platforms (i.e. Hadoop, Spark, databases, cybersecure servers, and robust computing facilities). Moreover, if small businesses manage to deploy these platforms, they are under-utilized. A robust, reliable communication system can bridge the gaps by connecting these businesses with virtual computing platforms.[35] By providing access to virtual data processing facilities, communication industry can increase business opportunities, raise success rate of startups, ensure sustainable growth of small and family-owned businesses, and improve overall affordability.

Social Sustainability (well-being, education, health, security, and democracy) [36,37]

Well-being, privacy, and cyber security: communication industry can play a significant role in ensuring public well-being and privacy for digital and sustainable societies. A vast majority of growing online frauds, cyber-attacks, incidents of cyber harassment, and privacy breaches take place when malicious actors go undetected in communication networks and hit their targets. With shared responsibility as a primary stakeholder, communication industry with a safer network can enhance users' well-being with stronger trust towards sustainable digital transformation.

IoT devices and security: Though IoT devices are expanding business opportunities at a rapid pace, these devices are also prone to cyber threats as well as network reliability challenges. By improving the reliability of network infrastructure and cybersecurity layers, communication industry can ensure a sustainable growth in the use of IoT devices and can support in building public trust. Further, this industry has the potential to expand digitalization in more sensitive

[32] The ROI of IoT: The 7 benefits it can bring to your business - Worldsensing
[33] The ROI of IoT: The 7 benefits it can bring to your business - Worldsensing
[34] Families Own and Manage Majority of Businesses Worldwide, According to New Family Entrepreneurship Data GEM Global Entrepreneurship Monitor (gemconsortium.org)
[35] 8 ways technology will impact our lives in the future | World Economic Forum (weforum.org)
[36] The Environmental, Economic, and Social Components of Sustainability - HubPages
[37] Sustainability | Description, Theories, & Practices | Britannica

fields of life, including self-driving vehicles, primary and secondary education, e-healthcare system, enhanced cybersecurity, and trusted democratic policies.

Need to Expand Regulatory Framework from Telcos to Tech-cos

With innovative technology in the communication industry (i.e. 5G and 6G), growing users' expectations, and the promising future of digital algorithms (artificial intelligence, big data analytics, and data processing) on the horizon, communication industry is rapidly absorbing the sector of information technology. Its expansion from conventional broadcasting (AM, FM, and TV) to cellular, broadband, IoT, and now its foreseeable projection to the unregulated territories of AI, Big Data management, and ethical data processing provides insights about the industry momentum and future expansion. The digital technology industry (i.e., 5G, 6G, IoT devices, AI, block-chaining, cloud computing, and quantum computing) with limited operational regulations (i.e. for data management, cybersecurity, data quality, AI, and privacy) strongly depends on communication networks. This dependence creates a conducive environment for the expansion of communication industry from telcos to tech-cos and brings its own benefits and challenges. From sustainability perspective, where this expansion adds digital transformation and process efficiency, it increases regulatory responsibility for communication industry to keep the broader industry (telecom network and data centres)[38] sustainable, progressive, and environment-friendly.[39] The new regulations should foster a balanced win-win situation to achieve the objectives of empowering the communication industry, promoting twin transition with perpetual sustainability, and meeting the expectations of end users and other stakeholders. Below are a few primary areas which hold room for more comprehensive regulations.

Net zero emissions across all three scopes: Net carbon footprint of the communication sector is growing with increasing digitalization and growing needs for fast communication systems, data storage, processing and data analysis. To materialize sustainable digital transformation, the communication industry needs to reduce its direct carbon footprint (currently 700-900Mt in 2023) to zero. The communication industry can regulate its players to report their net carbon emissions regularly. Regulatory bodies should take responsibility to give them a roadmap to achieve net-zero emissions including scope-2[40] and scope-3[41] emissions. The major steps for this roadmap may include:

1) Time-bound goal setting for transitioning to clean energy and reducing dependency on conventional energy sources in the communication sector to reduce emissions.
2) Use of superior, smart, and high-capacity core networks to reduce network traffic congestion, energy consumption and to improve network reliability and efficiency.
3) Smart power management systems for infrastructure to reduce energy consumption.

[38] The real climate and transformative impact of ICT: A critique of estimates, trends, and regulations - ScienceDirect
[39] Digital Disruption in Telecommunication: Shifting from Teleco to Tech Co (IEEE Xplor)
[40] Scope-2 accounts indirect emissions, specifically, from consumption of energy (electricity, steam, and other similar sources) generated elsewhere.
[41] Scope-3 emissions account all forms of indirect emissions in the value chain of the communication industry. It includes part of emissions from suppliers (transportation, manufacturing, mining, and resourcing process), during product use time, product end of life emissions (recycling or disposal), and auxiliary emissions i.e., employees' transportation.

4) Mandating regular ESG reporting with emission target details (i.e. decarbonization goals vs achievements for data centres, AI, 5G, IoT, cloud system, fleet, building, energy, material, etc.)

It is worth noting that all businesses do not see compliance requirements as their organizational core values or ethical social responsibilities. A growing number of businesses conduct profit-loss analysis for compliance cost of applicable regulations. If the compliance costs are higher than enforcements or penalties, they create loopholes for regulation evasion. Therefore, this business psychology could be recognized in new regulations.

Further to that, the proportion of emissions and their impact are not equal for all countries. Typically, countries with larger economies (i.e. USA, China, Russia, EU, and India) have significantly high contributions in emissions[42,43] than developing regions (i.e. from Africa and South America). Therefore, the communication sector of larger economies should take more responsibility to reduce their carbon footprint setting up more ambitious targets.

Circular economy design to curb e-waste: According to the sustainability research program[44] of the United Nations, close to 80% of e-waste ends up in landfills with 30 million tons of valuable metals (copper, iron, gold)[45] comprising a high proportion of waste from the communication industry. This growing e-waste is projected to further increase with growing IoT devices if no measures or regulations are put in place. Therefore, regulatory bodies have a responsibility to address this issue by encouraging and strengthening recycling programs, and reducing the e-waste from telcos by:

1) Introducing regulatory accreditation and appreciation programs for telcos that achieve responsible recycling targets and educate end users.
2) Reducing e-waste by promoting telcos and tech-cos to introduce universal electronics compatible with the network of all communication service providers.
3) Encouraging procurements of electronics and infrastructure items made with recyclable materials.

A detailed set of regulations and standards is required to establish a strong close loop process for equipment manufacturers, telcos, and end users. In this loop, end users' behaviour, education, awareness, and collaboration play a significant role in achieving e-waste reduction targets.[46] Therefore, regulatory bodies and telcos should share the responsibility in educating end users and fostering a sustainability culture to reduce e-waste.

Network co-construction and infrastructure sharing: Optimal utilization of network infrastructure improves sustainability by reducing material needs for parallel under-utilized networks, energy consumption, and maintenance cost. Network sharing also helps to hedge the cost incurred due to technology obsolescence. A report from McKinsey Consulting Group shows

[42] Countries and Sectors with highest greenhouse gas emissions | World Economic Forum (weforum.org)
[43] Global Greenhouse Gas Overview | US EPA
[44] The Global E-waste Monitor 2024 - E-Waste Monitor (ewastemonitor.info)
[45] Creating a Circular Economy for Electronic and Electrical Equipment (itu.int)
[46] Engaging the End User in Waste from Electrical and Electronic Equipment Management: An Action Research Study | Systemic Practice and Action Research (springer.com)

that the cost of infrastructure (i.e. a cell deployment of 5G network) could be reduced up to 50 percent if any given three players share the same network.[47] Even though the industry also recognizes these benefits, there are some challenges where regulatory bodies can provide detailed guidelines and standards alike to the following:

1) Network policies for streamlined data exchange between shared and private networks, configuration and operations alignment, and bilateral big data support.
2) Supervisory guidelines for configuration changes and consistency of network quality.
3) Consultation with telcos to resolve issues of trust and commercial benefits (i.e. privacy, infrastructure maintenance, and cost-sharing plans).

Mandating the unregulated territory of AI and customers' big data: AI has immense potential to enhance communication system network efficiency, virtualization, and network planning based on multi-dimensional AI-assisted simulations and optimization. AI has also reduced the complexities around network co-sharing strategies, traffic flow optimization, and has enhanced seamless collaboration. However, with its unregulated terrain, AI is a double-edged sword for the communication industry. The communication industry is well-regulated and strives for a sustainable system in the interests of customers, businesses, and societies by respecting general data protection, cybersecurity, and intellectual property regulations. Integration of AI into communication industry poses compliance challenges notably in protecting intellectual property, privacy, and cybersecurity. To minimize such disruptions and to ensure sustainability in all three spheres; environmental, economic, and socio-political, regulators have a responsibility to provide guidelines and standards alike to the following:

1) Classifying the permissible and prohibited use of AI and defining standards to keep its environmental footprint under control.
2) Guidelines and standards for telcos to identify and restrict AI-assisted cyber attacks, deep fakes, and intellectual property breaches.
3) General guidelines and standard operating procedures for AI to ensure its integration is sustainable for society and compliant with existing regulations.

Conclusion

With continuous innovations, digital transformation is evident and by virtue of its design it can reinforce sustainability objectives if adopted prudently. To ensure these transformations are sustainable for environment, economy, and society, communication industry should play a vital role as it provides network and connectivity. Innovations and digital transformation trends empower communication industry to achieve more ambitious sustainability targets. They also uncover room for new regulations in the industry. Consequently, the continuous transformation in technology requires evolving regulatory standards and guidelines tailored with industry trends for maintaining sustainability. Therefore, existing regulatory policies have capacity to optimize previously defined sustainability goals, as well as to introduce new policies, tailored with the expanding communication industry. The regulatory gaps identified in this article and proposed new areas for regulations can help to achieve global sustainability targets. Overall, efforts are

[47] Network sharing and 5G: A turning point for lone riders | McKinsey

required on all levels and from all stakeholders (i.e., regulatory bodies, industry, telcos, and individuals) to make sure digital transition is sustainable for our environment, economy, and society.