TABLE OF CONTENTS

[CHAPTER 1 INTRODUCTION 1](#_Toc183599287)

[**Research problem** 2](#_Toc183599288)

[**Research questions** 9](#_Toc183599289)

[**Dissertation Rationale and Contribution** 10](#_Toc183599290)

[**Dissertation Outline** 15](#_Toc183599291)

[CHAPTER 2 SUSTAINABLE MEDIA AND ICTs 17](#_Toc183599292)

[**Setting the terms: Why “ICTs”? Why “sustainability”?** 17](#_Toc183599293)

[**The rise of sustainable media** 23](#_Toc183599294)

[**Sustainable media in Internet governance scholarship** 27](#_Toc183599295)

[CHAPTER 3 SOCIOTECHNICAL IMAGINARIES AROUND SUSTAINABLE ICT STANDARDS 34](#_Toc183599296)

[**Standardization and politics** 34](#_Toc183599297)

[**Sociotechnical imaginaries in ICT standards** 39](#_Toc183599298)

[**Bridging environmental concerns and ICT standards** 42](#_Toc183599299)

[CHAPTER 4 METHODOLOGY 46](#_Toc183599300)

[**Why the ITU and the IETF?** 49](#_Toc183599301)

[**Ethical considerations** 50](#_Toc183599302)

[CHAPTER 5 CASE STUDIES: THE ITU-T AND THE IETF 52](#_Toc183599303)

[**The International Telecommunication Union (ITU)** 52](#_Toc183599304)

[An organization of parallel sectors 54](#_Toc183599305)

[The International *Telecommunication* Union as part of *Internet* governance? 58](#_Toc183599306)

[Who gets to participate in the ITU, and why it matters? 60](#_Toc183599307)

[Human rights in the ITU: then and now 64](#_Toc183599308)

[Zooming in on the environment: ITU 66](#_Toc183599309)

[**The Internet Engineering Task Force (IETF)** 70](#_Toc183599310)

[Democratic standard-making? Human rights concerns and the IETF’s culture 75](#_Toc183599311)

[Zooming in on the environment: IETF 77](#_Toc183599312)

[**Two among several: situating the ITU and the IETF** 78](#_Toc183599313)

[CHAPTER 6 THE WHAT: ENVIRONMENTAL CONCERNS AMONG ICT STANDARDIZING EFFORTS 80](#_Toc183599314)

[**ITU Telecommunication Standardization Sector** 80](#_Toc183599315)

[Early days of concern: protecting ICTs from the environment 82](#_Toc183599316)

[Current trend of concern: protecting the environment from ICTs 90](#_Toc183599317)

[Acknowledging the problem… But what is the problem? 98](#_Toc183599318)

[A new constraint for ICTs, but a business-as-usual scenario 103](#_Toc183599319)

[The need for measuring 107](#_Toc183599320)

[Conclusion: the limits of ITU-T “ecodesign” 109](#_Toc183599321)

[**Internet Engineering Task Force (IETF)** 110](#_Toc183599322)

[Three moments of concentrated efforts 111](#_Toc183599323)

[Sustainability in the IETF 121](#_Toc183599324)

[Solutions and metrics 129](#_Toc183599325)

CHAPTER 2  
SUSTAINABLE MEDIA AND ICTs

In this chapter, I define what I mean by “ICTs” and “sustainability” to help delineate my object of study: sustainable ICTs standards. I then explain how sustainable media emerged as a field of study that addresses the environmental impact of ICTs. Finally, I demonstrate that sustainable media, more specifically sustainable ICTs, is (and should be) part of Internet governance scholarship and practice concerned with human rights in the digital age.

# Setting the terms: Why “ICTs”? Why “sustainability”?

While writing this dissertation, I have attended several webinars about sustainable ICTs. Once, I participated in an event to discuss how a digital infrastructure company scales “trans-Atlantic submarine cable routes in a sustainable manner.” The webinar description acknowledged that “the submarine network industry is working tirelessly towards sustainably scaling transoceanic capacity to meet the voracious demand for ever-increasing bandwidth” (Carlson, 2024). I was intrigued, so I signed up.

During the webinar, the speakers talked about sustainability indeed. Still, they did not mention the environment-related topics I had thought I might hear about (e.g., energy optimization, energy sources, marine ecology, etc). Instead, the talk concerned the company’s current strategies to increase the resilience and diversity of its undersea cables’ paths to ensure continuous and reliable connection across the network. In this case, a sustainable submarine cable route is one designed to be diverse enough to be always on through efficient and fewer paths. The webinar referred to sustainability as in the dictionary, “the quality of being able to continue over a period of time” (Cambridge, n.d.).

Dictionary-level sustainability is not always helpful to the environment since damaging things can be sustained for a long time. It might be true that some submarine cable route optimization might lead to energy optimization. Still, I was mistaken in assuming the webinar would be about the type of sustainability I am more used to hearing about: sustainability on the terms set by the United Nations, covering issues across the three dimensions of economy, society, and the environment (UN, 2015).

Definitions matter, especially when using terms commonly employed by and in different fields and communities of practice. In this dissertation, I am studying “information and communication technologies” (ICTs) standards, also sometimes referring to digital technologies and the Internet[[1]](#footnote-1). Besides, I am studying the response of ICT standard developing organizations (SDOs) to the need for environmental “sustainability.”

First, information and communication technologies. The term ICTs is employed in various contexts and usually encompasses broad applications, services, industry sectors, and even definitions themselves (Zuppo, 2012). The Organization for Economic Co-operation and Development (OECD) defined the ICT sector in 1998 as both manufacturing and services industries that process, transmit, and display data and information by electronic means (OECD, 2012). It sought to standardize a definition of ICTs to enable proper measuring and comparisons among the OECD nations, in a period of expansion of the commercial Internet.

Such a broad definition allows for several taxonomies dividing ICT industries into different products, patent classes, and underlying technologies (e.g., telecommunications, consumer electronics, digital communication, audio-visual technology, and satellite systems) (Inaba & Squicciarini, 2017; Khan et al., 2020). It also delineates ICT as an economic sector that can convey meanings and applications around socioeconomic development, and educational and business management tools (Zuppo, 2012). The OECD definition is usually employed by SDOs themselves. For instance, some ITU-T standards define the ICT sector as “economic activities including industries of which production of goods, networks and services shall be primarily intended to fulfill or enable the function of information processing and communication by electronic or optical means” (e.g., L1400 (2011) and L1450 (2018)).

In this dissertation, I refer to ICTs as the technical means through which we communicate by creating, storing, transmitting, and processing information through computer networks and components. These means include digital technologies such as the Internet, devices like smartphones and computers, broadcasting technologies, software, and beyond. Instead of framing this dissertation around the “Internet” or “digital technologies” alone, I frame my arguments around ICTs because I am studying standard-developing organizations that cover technologies that may go beyond computer networks and the logic of binary digits (for example, standards for the quantum Internet). Besides, ICT as a term is more capacious than other options such as digital media as it encompasses not only human communication but also other kinds of information flows.

The most recent OECD definition of ICTs is overly optimistic regarding the sector’s role in society, stating that it contributes to technological progress and employment, output, and productivity growth (OECD, n.d.). It supposes that ICTs, directly or indirectly, always lead to development and optimization. Another term that echoes connections to development ideas is sustainability.

Sustainability is an “impossibly ambiguous” and contentious term (Portney, 2015). A commonly used definition comes from the World Commission on Environment and Development (WCED). In 1987, through what became known as the Brundtland Commission, the WCED summarized years of ideas around sustainability and set it as an economic development activity that “meets the needs of the present without compromising the ability of future generations to meet their own needs” (WCED, 1987). The Brundtland Commission also divided sustainability as aspects of three equal parts: environment, economy, and equity (the three e’s). As I will demonstrate in the following chapters, both the ITU and the IETF have referred to the Brundtland definition when delineating what they mean by sustainability.

One year after this definition arose, in 1988, the UN Environmental Program (UNEP) created the Intergovernmental Panel on Climate Change (IPCC). The work of the WCED continued through other UN Conferences and initiatives, now backed by the scientific guidance of the IPCC. For example, the United Nations Conference on Environment and Development 1992 (ECO-92, also known as Earth Summit) created “Agenda 21,” a resolution with guidelines on how to pursue sustainability, and quickly pushed sustainable development as a hegemonic concept in the global arena (Ruggerio, 2021).

Moving forward, in 2015, the UN established a set of 17 sustainable development goals (SDGs) to be achieved by 2030 (the Agenda 2030), building from the previous Agenda 21 three e’s to establish three dimensions of sustainability: environment, economy, and society (UN, 2015). Meanwhile, in the private sector, Environmental, Social, and Governance (ESG), digital transformation, and digital sustainability initiatives fostering corporate social responsibility (CRS) grew parallel to sustainable development discussions at the United Nations, setting a corporate agenda around the need for sustainability (Saetra, 2021; Xavier, 2023; Binder & Wade, 2023).

Sustainable development became mainstream in the international policy discourse and popularized related concepts such as the green economy (Bina, 2013; Wanner, 2015) and the circular economy (Suárez-Eiora et al., 2019). Other concepts, such as eco-development and slow and no-grow economy, did not rise in popularity as sustainable development did. Sustainable development casts a much more neutral or positive role over economic development in solving environmental and social problems (Purvis et. al, 2019). Some accuse it of being an oxymoron (Johnston et al., 2007).

Optimists might believe in decoupling human well-being from consumption of natural resources through technological advances – a world of environmentally sustainable economic growth –, but environmental justice scholars argue that economic growth is invariably connected to negative environmental impacts such as pollution and loss of biodiversity (Keilbach & Pabiś-Orzeszyna, 2021, p. 107). Sustainable development is seen as reductionist for the term became intrinsically connected to economic growth, even if that was not the initial intention of those working on the WCED definition (da Costa Bueno, 2012).

I recognize that sustainability is not consensual, it contrasts with the concept of development and needs to be understood in transdisciplinary contexts (Mikhailova, 2004; Owens, 2007). It is a context-specific and ontologically open concept (Purvis et al., 2017) that is embedded into several contentions’ points rooted in political ideologies and public values. Contention arises from trying to fit sustainability with issues such as individual freedoms, limits to economic growth and consumption, governmental action, and population growth (Portney, 2015). Even among the private sector alone, scholarship has reported on an ESG pushback, with initiatives on GHG emissions, diversity, equity, and inclusion being criticized by those who believe these topics are part of an activist progressive agenda that should not dictate business models and decisions (Saetra, 2021; Masters & Temple-West, 2023).

Still, there are alternative ways to think about sustainability that recognize the disconnect between economic development and the pursuit of sustainability. Concepts of degrowth and buen vivir, for instance, move away from discursive-only definitions of sustainability, and from seeing it as plain preservation of economic, social, and natural capital; they challenge economic growth as a maxim (Mamamni, 2010; Kuhn & Costa, 2017; Ruggerio, 2021; Bonevac, 2010).

In this work, I use the term sustainability while critically distancing it from the dominant connotation of development which is embedded in an exploitative economic paradigm (Santillo, 2007). Despite differences in definitions, I see sustainability as a value such as “social justice” (Veiga, 2010), a particularly important one in light of the need to ensure justice for future generations (Mikhailova, 2004). I also refer to sustainability instead of other terms because it is commonly and widely evoked in the environment-related discussion at the standard-developing organizations I am studying. Sustainability appears in the ICT industry and scholarship connected to other terms such as green ICT and ICT for green, sustainable/green computing, environmental sustainability of ICT and ICT for environmental sustainability. Besides, although the UN definition of sustainability includes three aspects (environment, economy, and society), the environment is the focus of the scholarship and practice currently addressing ICTs and sustainability, especially in terms of the sector’s energy use (Bengtsson, & Ågerfal, 2011). This study focuses on sustainable ICTs standards as those addressing environmental issues, which include diverse topics such as waste, climate change, biodiversity loss, and pollution.

# The rise of sustainable media

In 2021, Microsoft released a joint report with marketing agency Dentsu entitled “The Rise of Sustainable Media.” The report is a “global study into green consumer behaviors and how these redefine business environmental strategy *for corporate growth alongside effective and authentic marketing*” (my emphasis). The giant ICT corporation pushed the narrative that companies could capitalize on current pro-green consumer sentiments by “reducing or removing carbon emissions, while also *reorienting their profit centers*” (my emphasis).

The report included sections entitled “Sustainability: business opportunity or threat?” and “Where green becomes gold.” The sound bites encapsulate Dentsu and Microsoft’s marketing team’s approach to sustainability. Instead of a threat, it is seen as “something which needs to be embedded *for the good of the company* as well as for the planet” (my emphasis). The report explains that large companies such as Microsoft, “regardless of their carbon footprints, have a big brainprint,” the capacity to influence consumers at scale and lead by example (Dentsu International and Microsoft Advertising, 2021).

It is not surprising that companies need to be convinced of the importance of sustainability by evoking environmental concerns as something that leads to capital gains. Media scholars Starosielski and Walker (2016), for example, say that sustainability discourse often serves the interest of the privileged, with companies trying to privatize and capitalize on the environment while hiding their environmental impacts through greenwashing campaigns (p. 6). This is, in fact, a common practice of what conservationist scholars call green neoliberalism: win-win market-based solutions employed to reconcile socio-ecological problems, which give the private sector a growing role in governing global environmental matters (Devine & Baca, 2020).

Sustainable media, however, have been the subject of communication scholarship long before ICT companies such as Microsoft started describing its “rise.” In a book plainly titled Sustainable Media, Walker and Starosielski (2016) situate media and the environment as mutually constitutive and intertwined. They demonstrate that sustainable media not only denotes how media addresses or thematizes environmental matters, but also signals how media infrastructures themselves impact the environment. As the authors put it, their use of the term “sustainable media” aims to evoke “connections that inhere between media *about* the environment and media *in* the environment” (p. 3).

But this conversation even predates evocations to the term “sustainable media”. Media theorists have long been pointing out the materiality of media, of which ICTs are a part of. After all, even in light of the Internet boom, media critic Friedrich Kittler already boldly pointed out that all software is actually bound to hardware (Kittler, 1992). Moreover, in *Greening the Media*, professors of media studies Maxwell and Miller (2012) started a conversation about the environmental consequences of ICTs. The authors mentions that the topic, then and I say even now, is “an unwelcome buzz kill—not a cool way to converse about cool (digital technology) stuff (p.6).” In *Finite Media*, Professor of Screen Studies Sean Cubitt (2016) invites us to reorient our use of media by acknowledging the ecological price of digital technologies.

Other terms referring to media and the environment include ecomedia, which Rust et. al (2015) describe as a field of study that addresses the “ecological meanings encoded in media texts, the environmental impacts of media production, and the relationships between media and cultural perceptions of the environment”. The authors address media as something that is “ecologically entangled” (Rust et al. 2015, p. 3). Similarly, Ivakhiv and López (2023) state that:

Ecomedia reframes media as ecological media; that is, media are a material reality that are in, and a part of, our environment in the broadest sense(s). Media are inseparable from their material conditions and the environment that produced them.

Both ecomedia and environmental media are referred by communication scholarship interested in the entanglements between media and the environment, and media as part of the environment. Some resort to ecomedia to distance themselves from seeing nature as something external to humans. The etymology of the word environment points out to an external surrounding. As Taffel (2023) puts it, the term places nature outside of society, following “a dualistic ontology (...that) separates nonhuman nature from human culture.” Ecology, on the other hand, mixes the Greek term for *household* and the suffix for *the study of*. In contrast to the environment, it more clearly points out the entanglements between humans and non-humans as cohabitants of a single planetary household (Taffel, 2023).

Attending to the materiality of media is a common thread of communication scholarship. To mention some examples, professor of Informatics Jean-François Blanchette (2011), in “A material history of bits,” unravels what is material or physical about computing. STS Professor Fernanda Rosa (2022) coined a research method called “Code ethnography” which highlights the materiality behind the circulation of information online. Besides, a new concept in filmmaking scholarship emerged to account for sustainable mediamaking: green shooting (Lopera-Mármol & Jiménez-Morales, 2021).

Other terms and concepts include geology of media and media archeology (Parikka, 2015), ecological media studies (Carruth, 2016), elemental media (Peters, 2015), digital environmental media studies (Gould, 2016), and electronic environmentalism (Gabrys, 2024), a term that points out that “digital technologies both monitor and exacerbate ecological crises.” In *Slow Media*, media scholar Jennifer Rauch (2018) uses “slow” or “mindful” media as a sustainability goal for the production and consumption of digital media.

Moreover, references to sustainable media go beyond the media studies field as well. For instance, computer ethics scholars Patrignani and Whitehouse (2017) evoke the term “Slow Tech” to advocate for the creation of ICTs that are human-centered, environmentally sustainable, and socially desirable since the design phase. No matter the term, recognizing the entanglements of media and the environment helps to account not only for the sustainable promises of ICTs but also their material relation to and influence over the environment.

Nathan Ensmenger (2018), for example, recounts that the seemingly invisible infrastructure of the Internet follows the contours of geography and human settlement; computing and digital media depend on older infrastructures that are deeply connected to matters of energy, water, and territory. The Professor of Informatics argues that once people understand computing power as “necessarily resource-intensive, pollution-producing, and potentially damaging to the environment”, they can make more informed choices about why, when, and how to employ it (Ensmenger, 2018, p. 27). Adi Kuntsman (2020) also argues in favor of materialist accountability, one in which the usefulness of ICT, specifically concerning its adoption into sustainability projects, is addressed together with the extensive environmental damage brought by digitization itself.

Famous communication theorist Marshall McLuhan and Quentin Fiore (1967), before digital technologies boomed, said that it is not possible to comprehend social and cultural change in the information age if we do not understand how media work as environments (p. 26). Commenting on this assertion, Alisson Carruth (2016) sees an irony. McLuhan and Fiore (1967), as many before and after them, relegated the environment to the rhetorical status of a metaphor for media; on the flipside, sustainable media studies (or ecological media studies, as preferred by the author) takes the metaphor to literal terms, addressing the matter of digital technologies and the ecology of media itself (Carruth, 2016, p. 396).

Throughout this dissertation, I make references to “sustainable ICTs,” recognizing that information and communication technologies are part of the broader umbrella of “sustainable media.” I purposefully use this term in dialogue with media studies scholarship. In doing so, I am not referring to sustainable ICTs as part of the trend of *green-becoming-gold* (Dentsu International and Microsoft Advertising, 2021). I am analyzing the environment-related work of ICT standard-developing organizations considering what López et al. (2023) identify as a political ecology of media: one that “examines the interdependencies between political economy, power, and environments.”

# Sustainable media in Internet governance scholarship

Attending to the entanglements between ICTs and socio-political, economic, and technical issues is at the heart of Internet governance (IG) scholarship. Internet governance refers to the design and management of the technologies that are necessary to maintain the Internet functioning, as well as the policies behind such technologies (DeNardis, 2014, p. 6). It takes shape through a myriad of often discreet and invisible infrastructures, devices, data fluxes, and technical architectures (Epstein, Katzenbach, & Musiani, 2016, p. 6). Moreover, IG covers different tasks and policies promoted by global institutions, national laws and actors, private companies, and intergovernmental agreements.

Internet governance (IG) is one example of the emergence of new transnational regulatory regimes in which the exercise of authority takes place in a diffuse way that is, at times, dissociated from States (Holmes & Anastácio, 2020). Besides, standard-developing organizations are usually cited as one type of institution that commonly engages with IG topics. The two SDOs analyzed in this dissertation are part of the trend of diffuse authority in Internet Governance. While the ITU is an example of an Internet governance institution that works through the cooperation of nation-states and the private sector, the IETF does not share affiliations nor depend on national and/or state-approved entities. Other organizations that exemplify governance models not primarily defined by the leadership of nation-states include the Internet Corporation for Assigned Names and Numbers (ICANN), the organization that oversees the address book for the Internet (the Domain Name System, DNS), and the Internet Governance Forum (IGF), a discursive venue promoted by United Nations but open and dependent on non-state stakeholders.

Internet governance also goes beyond institutions and formal policy instruments. It can take place in decision-making and coordination activities outside the well-defined boundaries of governance institutions - for example, through national regulations alone and/or self-regulation mechanisms by private actors (Musiani, 2015; Hofmann et al., 2017; Epstein, Katzenbach, & Musiani, 2016). Besides, defining the topics and technologies that fall under the IG umbrella reflects particular perspectives and interests (Kurbajila, 2016, p. 19). Defining what counts as IG is political as it determines which stories - and perspectives - about the Internet are perpetuated to the detriment of others (Abbate, 2017 apud Braman, 2020, p. 28).

In the 2000s, an IG-defining moment took place when the United Nations promoted the World Summit on the Information Society (WSIS). The event happened at a moment of international tension over the United States' influence on IG, especially regarding the US-government involvement in institutions administering critical Internet resources such as the Domain Name System (DNS), Internet Protocol (IP) numbers, and the Internet’s root zone (Chenou & Radu, 2014, p. 12).

If in other areas, such as environmental governance and foreign trade, nation-states led governance initiatives that later opened up to other stakeholders, in Internet governance it was the States that became part of governance spaces after many of them had already been up and running. Amid contrasting views about the role of state and non-state actors, a decentralized, private-leaning, and procedural understanding of IG prevailed at WSIS. The UN meeting resulted in a publication that set forth a widely used definition for Internet governance according to which

[Internet governance is] the development and application by Governments, the private sector and civil society, in their respective roles, of shared principles, norms, rules, decision-making procedures, and programs that shape the evolution and use of the Internet.

Such a broad definition leaves the interpretation of what “governance” and “Internet” means open to interpretation. It favors a description of who is involved in IG (Kurbajila, 2016, p. 19), and how such involvement occurs: a multistakeholder to-each-its-own fashion. The definition is also broad in that many national, international, and transnational technologies, institutions, and policies can be seen as part of the evolution and use of the Internet.

DeNardis (2009) demonstrates that some interpretations of Internet governance are narrow in scope, describing Internet governance only as a matter of technical standardization, resource allocation, and dispute resolution around critical Internet resources (e.g., domain names, root servers, exchange points, transmission/networking protocols) (Canabarro, 2014, p. 126; Nanni, 2022). For example, standards for the design of computers would not be seen as an Internet governance issue under a narrow definition of the term, while standards for interconnecting these computers would (DeNardis, 2014, p. 22). In other words, the scope of Internet governance would be bounded by the technologies and protocols deeply associated with the functioning of the Internet itself an no more.

However, I follow a more comprehensive interpretation in which Internet governance is a concept that is loose enough to also encompass issues indirectly related to the Internet critical resources (Canabarro, 2014, p. 134), expanding it to ICTs and including topics such as applications, content, and activities facilitated by the Internet. I also follow a broad approach to what is considered part of the Internet infrastructure, meaning all the underlying requirements for the Internet to function, without limiting it to a specific set of technologies since the Internet itself is constantly evolving (Sandvig, 2013).

Looser approaches are in line with Hofmann’s (2007) definition of Internet governance as a regulative idea in flux and as reflexive coordination (Hofmann, Katzenbach, & Gollatz, 2017). Internet governance occurs through mundane acts of coordination when routine activities become problematic and need to be addressed. Under this understanding, for example, IG is manifested through commercial, policy, and technological innovations driven by Internet companies, the day-to-day regulation of content on Internet media companies, the development and implementation of the Internet infrastructure, as well as agreements, and security measures taken between and by Internet providers, users, and governments (Hofmann, Katzenbach, & Gollatz, 2017, p. 9).

The overarching scope of IG becomes more noticeable since Internet-dependent devices and applications increasingly permeate all aspects of the physical world (DeNardis, 2020). Some call this process digitalization, the entry of ICTs including hardware and software into various areas of life and business (Wäspi, 2022). This process is evident in much of the debate about the environmental impact of digital technologies, in which the implementation of ICTs in distinct economic sectors, or the digitalization of life, is optimistically seen as a step towards sustainability.

From a policymaking perspective, there is more focus on the manifestation of political and societal issues occurring within the content and applications level of the Internet (e.g., social media companies like Facebook). However, control points can occur on and through the underlying infrastructures that keep the Internet running. These infrastructural control points translate into human rights issues (DeNardis & Musiani, 2016).

There is an ever-growing interest in addressing how values and rights can be wired into the Internet infrastructure and ICTs more broadly (Hanseth & Monteiro, 1997; Sinnreich & Trammell, 2011; Massanari, 2017; Jørgensen & Pedersen, 2017; Milan & Ten Oever, 2017; Cath, 2021). However, even when focus shift from content layers towards infrastructural ones, the values and human rights addressed tend to be the ones more clearly and traditionally related to the digital world (e.g., access, data protection, and privacy, freedom of expression and association, security).

The digitalization of life, however, brings forth environmental rights – meaning the right to a healthy environment as recognized by the UNEP – as yet another human rights implication of ICTs that are inscribed in the Internet infrastructure. Just as sustainability, as put forth by the Sustainable Development Goals, integrates social, economic, and environmental pillars, the human rights agenda for Internet Governance should incorporate environmental concerns.

Internet governance practice and scholarships are already increasingly engaging in environmental topics. For example, in 2020, the Internet Governance Forum (IGF) chose “Environment” for the first time as one of the main theme tracks for its annual meeting. The IGF is an UN-sponsored event whose mandate is to be a platform addressing current policy issues about ICTs. Every year, the IGF secretariat and its Multistakeholder Advisory Group (MAG) invite people from all over the world to submit ideas about what they believe are the most important Internet Governance issues for the year. Based on that open consultation, the IGF defines the event’s thematic priorities. Thus, the IGF serves as a thermometer for current IG policy issues. While environment-related discussions have appeared in IGF workshops in the past, the theme gained momentum and was given priority starting in 2020.

The relationship between ICTs and the environment is an emerging issue on IG agendas beyond IGF. On a state level, especially with the growing energy needs of data centers, several countries are starting to tackle the Internet’s environmental harm. ICT standard-developing organizations are also working on issues related to the environment through both the standards they create, and the related policy work they engage in. For example, a joint working group from the International Organization for Standardization and the International Electrotechnical Commission ISO/IEC created the “Green MPEG”, a standard to maintain video quality in the transmission of video data online while optimizing energy consumption in the encoding, decoding, and displaying process. The Institute of Electrical and Electronics Engineers (IEEE) has several committees of ICT professionals working on “green communications and computing” and “environmental engineering” standards.

Internet governance scholarship addresses to the “taken-for-granted, mundane, and often apparently unrelated activities of Internet design, regulation, and use” (Epstein, Katzenbach, & Musiani, 2016, p. 4). Those include the work of ICT standard-developing organizations: not only the technical work that is commonly associated with them but also efforts on environmental action from within them. If SDOs are a space where politics are enacted on and through standards, *environmental* politics are part of the mix.

The environmental agenda grows in the IG scholarship and practice as an urgent topic, one with the potential to bring forth different and opposing worldviews. This dissertation stirs the conversation by analyzing two organizations with opposing governance models and contrasting mandates: with more (ITU) and less (IETF) control from nation-states, dealing with broad ICTs (ITU) and networking (IETF) standards. It also adds to the sustainable media debate by focusing on an often overlooked but ever more important piece of the ITC sector: its standards.

CHAPTER 6  
THE WHAT: ENVIRONMENTAL CONCERNS AMONG ICT STANDARDIZING EFFORTS

In this chapter, I begin to unravel how the ITU-T and the IETF engage in environmental matters by focusing on the standards already published by the SDOs or which were or are under discussion. To understand how environmental rights get inscribed in the Internet Infrastructure, I first tend to the question: what environmental themes and concerns are addressed by environment-related ITU-T and IETF standards?

# ITU Telecommunication Standardization Sector

 “ITU is one of the most important stakeholders in terms of climate change” former UN Secretary-General Ban Ki-moon, 2009 ([source](https://firstforum.org/wp-content/uploads/2021/05/Report_00908.pdf))

ITU-T makes information on its published Recommendations publicly available on its website. Contrary to the IETF, draft Recommendations are not open to the general public, but only to ITU-T members (Member States, Sector Members, Associates, Academia, and some personnel of the UN System). To create the dataset for this study, I first searched for standards developed by the ITU-T Study Group (SG) specifically tasked with environment-related topics, SG 5. The ITU-T labels its more than four thousand Recommendations across thematic series identified by alphabetical characters. Currently, Study Group 5, titled “​​​​​​​​​​​​​Environment, climate action, circular economy and electromagnetic fields” is responsible for overseeing two series:

* L-Series: Environment and ICTs, climate change, e-waste, energy efficiency; construction, installation and protection of cables and other elements of outside plant;
* K-Series: Protection against interference.

After gathering K and L-series, I searched for ITU-T environment-related standards beyond SG 5. I looked on the ITU-T website for Recommendations following the query:

“green, sustain, sustainability, sustainable, energy, environmental, carbon, lifecycle, waste, climate, global warming, extractive, mineral, material, pollution, emission, power, biodiversity”

I filtered for responses with some iteration of the query terms in the Recommendations’ title or their short description and did not apply any date filter. The ITU-T online dataset encompasses standards from 1899 to 2024. Moreover, I considered Recommendations both in force and superseded for the search.

Table 2. List of query terms and count of results (ITU-T)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| power | 363 |  | carbon | 13 |
| energy | 138 |  | sustain | 2 |
| environmental | 101 |  | global warming | 2 |
| sustainable | 42 |  | pollution | 1 |
| lifecycle | 29 |  | extractive | 0 |
| green | 26 |  | mineral | 0 |
| emission | 22 |  | biodiversity | 0 |
| waste | 20 |  | ecological | 0 |
| climate | 20 |  | ecology | 0 |
| sustainability | 17 |  |  |  |

The search yielded 796 Recommendations (Table 2), including duplicates since one standard may display more than one term in the query. However, most of the results were outside the scope of this dissertation and, as such, were not considered in the analysis. I disregarded Recommendations already included in my database because they are assigned to SG5 and Recommendations that did not express clear environmental concern. For example, several Bluetooth Low Energy (BLE) and Sustainable Cell Rate (SCR) standards were disregarded, as they refer to technologies that share terms in the query but do not necessarily account for sustainability topics. The same happened with plenty of Recommendations that used terms such as “environmental conditions” or “environmental characteristics” referring to the environment as a synonym for surroundings, ambient, or scenario.

Other excluded standards included terms such as “carbon microphones”, “market power,” and “lifecycle” when the refers to information or application management alone (e.g., data acquisition, processing, storage, deletion). Not surprisingly for ICTs, “energy” and “power” were the two terms that most appeared in the search. However, only a few Recommendations that clearly pointed to a concern for the environment were included in the database, such as those that mentioned energy saving or efficiency in their short summaries.

In addition, regarding sustainability, I disregarded Recommendations that referred to “sustainable” as a synonym for viable or enduring, such as those citing sustainable business models (e.g., ITU-T D.262 (05/2019)). Also, as I will explain further, the ITU-T is very active in creating standards for what it calls smart sustainable cities (SSC). I only considered SSC standards when sustainability was evoked regarding its environmental facet.

Ultimately, the complete dataset of environment-related ITU-T Recommendations comprises of two parts. First, there are 231 recommendations part of the K and L-series that are dedicated to the installation of ICTs in different physical environments, the protection of services from environmental interferences, and studies on the electromagnetic field. Second, there are 171 Recommendations that directly address some environmental topic: 118 standards from the L-series standards and 53 standards from other series.

## Early days of concern: protecting ICTs from the environment

The first 231 Recommendations do not directly engage with sustainability topics but point out a discourse shift within the ITU-T that demonstrates how the SDO approached the environment over time. These standards deal with protecting ICTs from the environment, ensuring ICTs proper work given the conditions of their surroundings, and safety requirements for ICT installations.

In Chapter 5, I explained the “organizational overhaul” that led the ITU to divide its activities into three parallel sectors, formalizing the creation of the Telecommunication Standardization Sector, ITU-T (Irion, 2012). Before ITU-T, ITU international telephone and telegraph standards were mostly developed under the *Comité Consultatif International Téléphonique* (CCIF) and the *Comité Consultatif International des Communications Téléphoniques* (CCIT). These committees merged in 1956 as the International Telegraph and Telephone Consultative Committee (CCITT). Throughout the existence of these three committees, technical specifications were already being created to guide the installation of ICT infrastructures in the natural environment.

For instance, in 1926, CCIF had a study group working on standards about the “Protection of telephone lines against the disturbing influence of power installations,” and another on the “Protection of telephone cables against corrosion due to electrolysis or to chemical action.” In 1929, CCIT had a study group on the “Protection of telegraph lines against strong currents.” The study group names underwent slight changes over time, but their core mandates remained similar. Besides, once CCITT was created, other SGs appeared, such as Study Group 6 on the “Protection and specifications of cable sheaths and poles​” (1957) and Study Group 5, which would later become the specialized SG for all environmental matters within the ITU-T ([quote](https://search.itu.int/history/Pages/StudyGroupsITU-T.aspx#k=Study%20Group%20V)).

A diagram of a diagram

Description automatically generated with medium confidence

Study Group 5, therefore, comes after a history of standards that addressed the perks of building ICT infrastructures in the physical world. Before the formalization of ITU-T, the SG focused mainly on electromagnetic disturbances. It was first titled “Protection against dangers and disturbances of electromagnetic origin​” (1964-1988). Then, it became “Protection against electromagnetic effects​” (1989-1992). With the formal establishment of ITU-T in 1992, the term “environment” became part of the SG 5 title for the first time. From 1993 to 2008, the SG was called “Protection against electromagnetic *environment* effects” (my emphasis). The group was tasked with creating standards to protect telecommunication networks and equipment from interference and lightning and promote studies and guidance on electromagnetic compatibility (EMC) and safety or adverse health effects of electromagnetic fields on humans.

In the previous Chapter, I explained that the ITU increased its verbal commitment to environmental issues at the 2010 Plenipotentiary Conference (PP). The organization mentioned the term “climate change” for the first time in its Final Acts ([Resolution 1](https://www.itu.int/en/ITU-D/Regional-Presence/Europe/Documents/Resolution%20126%20(Rev.%20Guadalajara,%202010).pdf)82) at PP-10, further embracing the role of ICTs in fostering sustainable development as per United Nations goals. The Strategic Plan for 2012-2015 included goals to grow ITU’s involvement with all three sustainability facets (social, economic, environmental). Therefore, it is not surprising that ITU-T relabeled SG 5 as “Environment and climate change” in 2009 and added to its mandate that the group is “responsible for studies on methodologies for evaluating the ICT effects on climate change, publishing guidelines for using ICTs in an Eco-Friendly Way, and energy efficiency of the power feeding system.” In 2017, SG 5 changed its name to “Environment, climate change and circular economy.”

Still, despite the name changes and expanded focus on environmental sustainability, SG 5 never fully stopped working on protecting ICTs from environmental interference or following its mandate to address the electromagnetic compatibility of telecommunication systems and potential hazards to human beings. Most Recommendations from SG 5, or under its responsibility, still deal with the practical technicalities of having ICTs built in and around natural environments. In fact, the last iteration of the SG’s name resumes its initial focus: “Electromagnetic fields (EMF), environment, climate action, sustainable digitalization, and circular economy​” (2022-2028).

Out of the 231 Recommendations on the protection of ICTs from the environment, 68% (158) are maintained by SG 5. The group is responsible for maintaining all 137 Recommendations under the “K series: Protection against interference”, which guide the proper functioning of telecommunication infrastructures and ICT devices in the face of environmental tampering (e.g., lightning, animal interference with cables) or natural effects from electromagnetic fields, as well as guarantee human safety against the exposure to electromagnetic waves and fields. SG 5 is also responsible for the L series, which contains 21 Recommendations on its section on “Construction, installation and protection of cables and other elements of outside plant.” Outside plant elements refer to the physical infrastructure required for the telecommunications networks.

There are several L series recommendations under the responsibility of SG5, but they have to do with the groups more recent focus on sustainability and thus are outside the scope of this section. Still, the image above demonstrates ITU-T's continuous work on standards that address the interaction of ICTs with the environment, albeit from a perspective of ensuring the smooth operation and safety of telecommunication services against interference or hazards.

Table 3 exemplifies what standards are included in the K and L series. I summarized the content of each Recommendation to demonstrate their overarching core concern: not sustainable ICTs or ICTs for sustainability, but the practical consequences of having ICTs built in the physical environment, or based on a natural resource, the electromagnetic field.

Table 3. Examples from the K and L Series (SG 5)

|  |  |  |
| --- | --- | --- |
| Recommendation Title | Series | Summary |
|  |  |  |
| [K.101](https://www.itu.int/ITU-T/recommendations/rec.aspx?rec=12291) (2014)  Shielding factors for lightning protection | K: Protection against interference | It offers guidance on how to protect telecommunication equipment and cable plants from external sources of interference, e.g., overvoltages and overcurrents due to lightning. |
| [K.70](https://www.itu.int/ITU-T/recommendations/rec.aspx?rec=14568) (2020)  Mitigation techniques to limit human exposure to EMFs in the vicinity of radiocommunication stations | K: Protection against interference | It guides telecommunication operators to evaluate the cumulative exposure ratio around transmitting antennas and shows how to mitigate radiation levels to comply with healthy exposure limits. |
| [L.8](https://www.itu.int/ITU-T/recommendations/rec.aspx?rec=1428) (1976, updated in 1988)  Corrosion caused by alternating current | L Series: Construction, installation and protection of cables and other elements of outside plant | It establishes that, in installing telecommunication networks, it should be noted that alternating currents at low voltage are usually unharmful to steel or lead but may corrode aluminum. |
| [L.33](https://www.itu.int/ITU-T/recommendations/rec.aspx?rec=4505) (1998)  Periodic control of fire extinction devices in telecommunication buildings | L Series: Construction, installation and protection of cables and other elements of outside plant | It guides the maintenance and control of fixed and portable fire extinction installations inside telecommunication buildings. |

Other ITU-T groups also work on similar topics. As previously mentioned, since the days of CCITT, ITU had Study Group 6 working on the “Protection and specifications of cable sheaths and poles​” (1957-1984). The group changed its name to “Outside plant” (1985-2004), and then again to “Outside Plant and related indoor installations” (1997-2008). Among other things, SG 6 maintained Recommendations on the resilience of ICT infrastructures against environmental meddling. In 2009, ITU-T terminated the study group and redistributed its Recommendations to two others, SG 5 and SG 15, currently called “Networks, technologies and infrastructures for transport, access and home​.” As seen in the picture below, if 68% of the data set is under SG 5, the other 32% is under SG 15.

SG 15 maintains ITU-T Recommendations across several different series, including subseries dealing with the intersection of ICTs and the surrounding environment. The image below details how the 73 SG 15 Recommendations are divided into different thematic subseries. These subseries reflect SG 15’s current mandate to develop standards for the optical transport network, access/home networks, and power utility network infrastructures (e.g., optical fibers and cables).

As exemplified in the table below, L Series Recommendations under SG 15 attend to the challenges of inserting ICTs infrastructures in nature (or even human-made environments), such as the challenge of maintaining infrastructures buried underground or underwater.

Table 4. Examples from the L Series (SG 15)

|  |  |  |
| --- | --- | --- |
| Recommendation Title | Series | Summary |
|  |  |  |
| [L.259](https://www.itu.int/itu-t/recommendations/rec.aspx?rec=9330) (2008)  Methods for inspecting and repairing underground plastic ducts | L.200-L.299: Optical infrastructures | It guides the repair of underground plastic ducts since plastic conduits conduits can become oval-shaped, pierced or broken. |
| [L.257](https://www.itu.int/itu-t/recommendations/rec.aspx?rec=5063) (2000)  Investigation of the soil before using trenchless techniques | L.200-L.299: Optical infrastructures | It provides techniques to get information about the position of buried infrastructural objects on the ground. |
| [L.315](https://www.itu.int/itu-t/recommendations/rec.aspx?rec=13568) (2018)  Water detection in underground closures for the maintenance of optical fiber cable networks with optical monitoring system | L.300-L.399: Maintenance and operation | It proposes a methodology to detect water penetration in cabinets or closures, which could degrade optical fiber. |
| [L.430](https://www.itu.int/ITU-T/recommendations/rec.aspx?rec=6137) (2002)  External additional protection for marinized terrestrial cables | L.430-L.449: Marinized terrestrial cable | It describes external protection devices to be used when laying or repairing underwater cables. |

Considering both SG 5 and SG 15, only 7% (17) of the 231 Recommendations in this section were published in the last 5 years. However, if we consider not only Recommendations published since 2020 but also older standards updated in the same period, the percentage goes up to 26% (61 Recommendations).

 Besides, 45% (103) of the Recommendations were published after 2009, when SG 5 received its mandate to address climate change for the first time. This means that, even though ITU-T has increasingly paid attention to the environmental impact of ICTs themselves, its work in protecting ICTs *from* the environment has not disappeared. In the following section, I explore ITU-T’s history of proposing Recommendations that deal directly with the environmental impact of ICTs, or how to leverage ICTs to help the environment.

## Current trend of concern: protecting the environment from ICTs

The previous section had more to do with the ITU-T concern about securing ICT infrastructures from the environment. This section details 171 ITU-T Recommendations that attend more clearly to environmental sustainability. These standards touch upon the environmental impact of ICTs themselves and how ICTs may serve sustainability efforts.

The image below demonstrates the steady publication of sustainability-related ITU-T standards in the past two decades. A standard takes time to be developed and approved, and standardization efforts that start now will probably take a reasonable time to be concluded. 2012 is the first peak in the number of published standards. However, environmental awareness work within the ITU-T had to start years before the approval and publication of these standards.

After PP-10, which set the Strategic Plan for after 2012, the ITU intensified its effort on the UN’s sustainable development agenda.

SG5 received the mandate to work on climate change starting in 2009.

In Chapter 5, I explained that the ITU-T modified the scope of SG 5 in 2009 to include its current mandate to deal with climate change. This change came after a process of raising awareness about global warming in the ITU. In 2008, ITU-T launched a series of symposia on “ICT and Climate Change.” The same year, the World Telecommunication Standardization Assembly (WTSA) published Resolution 73 establishing climate change as a high priority for the ITU as part of the organization’s contribution to UN sustainable development processes. After the symposia, ITU-T created a Focus Group on ICTs and Climate Change (FG ICT&CC). The goal was to develop a methodology for evaluating and quantifying GHG emissions for the ICT sector. The ITU-T Director wrote the following in a report summarizing the group’s conclusions:

“The idea for the Focus Group on ICTs and Climate Change originated during the cherry blossom season in Kyoto 2008. In just one year, the group concluded its work this time during the cherry blossom season in Hiroshima in April 2009. What better symbol of the fragile beauty of Mother Nature than the delicate cherry blossom? Hiroshima is also testament to the destructive power of mankind, but it is now a recognized center for promoting world peace and addressing social and public policy issues. It was therefore an appropriate venue to discuss the issue of climate change, recognized by the UN Secretary-General as the moral issue of our time” (my emphasis). [source](https://www.uncclearn.org/wp-content/uploads/library/itu706.pdf)

FG ICT&CC proposed the first ITU-T standardized methodology for calculating the carbon footprint of the ICT sector and its potential to reduce emissions in other industries. ITU leadership then agreed to transfer the standards first elaborated within the Focus Group to SG 5, changing the SG’s scope to encompass climate change.

Unsurprisingly, the surge of environmental standards started after the formal establishment of SG 5’s new environment-related mandate and increased more significantly after 2012. That is the year that the 2012-2015 Strategic Plan was enacted. To recap, this plan operationalized the commitments made in PP-10, when the term “climate change” appeared for the first time in an ITU Final Acts document. In turn, this document reflected the commitment first set by the WTSA in 2008 to bring the climate change agenda to the SDO.

Also as expected, the first 3 Recommendations in the dataset (2000-2009) are not under SG 5, but SG 15, whose scope concerns optical transport networks and access network infrastructures. The earliest example of a published ITU-T sustainability-related standard addresses the need for life cycle assessment (LCA) of telecommunications equipment and gives one example of an LCA analysis of optical cables in Stockholm and California (L256/45, 2000).

Table 5. First sustainability-related ITU-T standards (SG 15)

|  |  |  |
| --- | --- | --- |
| Recommendation Title | Series | Summary |
|  |  |  |
| [L.256/L.45](https://www.itu.int/itu-t/recommendations/rec.aspx?rec=5158) (2000)  Minimizing the effect on the environment from the outside plant in telecommunication networks | L.200-L.299: Optical infrastructures  L.250-L.299: General aspects and network design | It follows the format of an UN resolution instead of having the usual sections of an ITU-T standard. It proposes guidelines for what it calls a “cradle to the grave” life cycle analysis of telecom cables and equipment. |
| [L.434/L.55](https://www.itu.int/ITU-T/recommendations/rec.aspx?rec=6974) (2003)  Digital database for marine cables and pipelines | L.430-L.449: Marinized terrestrial cables | It sets the types of information that national or regional agencies responsible for marine shorelines should keep. The standard mentions that data on marine cable and pipelines affects the cost and environmental impact of future installations and maintenance. |
| [L.391/81](https://www.itu.int/itu-t/recommendations/rec.aspx?rec=10435) (2009)  Monitoring systems for outside plant facilities | L.300-L.399: Maintenance and operation L.380-L.399: Disaster management | It proposes a mitigation system for telecommunication buildings exposed to natural and human-made disasters, such as strong winds, earthquakes, fires. |

The two other early standards are also under the responsibility of SG 15 and reflect the work of the ITU before it officially established climate change as a priority for the SDO. L434 briefly mentions the environmental impact of marine cables, while L391 is part of the ITU agenda for disaster communications, focusing on ensuring the protection of telecom infrastructures from natural catastrophes. Over time, other SGs started publishing environmental standards, especially SG 5, responsible for 68% of the dataset (117 out of 171).

The second study group with the greatest number of published standards is SG 20 (12%, 33 Recommendations). The history of SG 20 starts with the Focus Group on Smart Sustainable Cities (FG SSC). In 2013, SG 5 established a focus group to address frameworks needed for cities to integrate ICTs into their infrastructures. As a Focus Group, the structure of FG SSC was looser than an SG, as participation in an FG is open to anyone interested, not only ITU members. The FG, thus, invited municipalities, research institutes, NGOs, and industry representatives.

From its inception, one of the FG’s goals was to identify smart-city standardization projects to be undertaken by its parent SG, Study Group 5 ([source](https://unctad.org/system/files/non-official-document/CSTD_2013_ITU_Smart_Cities_ToR.pdf)). However, after three years of operation, TSAG decided to turn the groups’ activities into a newly created ITU-T Study Group, SG 20. From 2013-2016, the SG was called “IoT and its applications including smart cities and communities (SC&C)”. The group changed its name to “Internet of things (IoT) and smart cities and communities (SC&C)” from 2017-2024, finally becoming “Internet of Things, digital twins and smart sustainable cities and communities” (2025-2028). Just as not all recommendations under SG 5 clearly display some environmental sustainability concern (e.g., the L Series standards from the previous section), the same happens with SG 20 standards. The group also proposes IoT specifications that are not connected to the environmental agenda.

Table 6. List of study groups responsible for ITU-T environmental sustainability standards

|  |  |  |  |
| --- | --- | --- | --- |
| SG | Duration | nº of recs | SG Title |
|  |  |  |  |
| SG 5 | 1997- | 117 | Environment, EMF, climate action & circular economy |
| SG 20 | 2013- | 33 | Internet of Things, digital twins and smart sustainable cities and communities |
| SG 13 | 1997- | 10 | Future networks and emerging network technologies |
| SG 15 | 1997- | 6 | Networks, technologies and infrastructures for transport, access and home |
| SG 21 | 2025- | 2 | Technologies for multimedia, content delivery and cable television. A new SG responsible for standards that were maintained by the terminated SG 9 (Broadband cable and TV), SG 16 (Multimedia and related digital technologies​), and SG 8 (Facsimile Terminals and Services) |
| SG 11 | 1997- | 1 | Signaling requirements, protocols, test specifications and combating counterfeit telecommunication/ICT devices |
| SG 2 | 1997- | 1 | Operational aspects of telecommunications and ICTs |

The bulk (88%) of the 171 standards is either part of SG 5 or SG 20. Of the rest, SG 13 on “Future networks and emerging network technologies” represents 6% of the entire dataset. As a development from its first mandate in 1997 to work on future telecommunications architectures, the SG is currently tasked with developing standards for emerging networking technologies, including matters on quantum computing and artificial intelligence. Notably, it is also responsible for enhancing existing ITU-T Recommendations on mobile communications to include energy-saving aspects ([source](https://www.itu.int/en/ITU-T/studygroups/2025-2028/13/Pages/mandate.aspx)).

As seen in the image below, the prominence of SG 5 flourishes in 2012 and is sustained across time. Additionally, although SG 20 (on IoT, digital twins, and SSCC) only began to work officially in 2013, it inherited standards published a year before by other SGs that fit better under the scope of the newly formed group.

As is common for all ITU-T Recommendations, the 171 standards are part of 6 different standardization series identifiable by alphabetical letters. Usually, one SG is responsible for the Recommendations under an entire series, or the different thematic subseries that compose it.

Every Recommendation Series is divided into thematic subseries. For example, the standards under the “L series: Environment and ICTs, climate change, e-waste, energy efficiency; construction, installation and protection of cables and other elements of outside plant,” are separated into numerical subseries such as “L.100-L.199: Optical fiber cables” and “L.1500-L.1599: Adaptation to climate change.”

In total, the 171 Recommendations were distributed across 35 unique ITU-T subseries. Because a standard may be allocated to more than one subseries, there were a total of 225 mentions of different subseries. 41% of these mentions were concentrated under only three subseries (Energy efficiency, E-waste and circular economy, Internet of things and smart cities and communities). Conversely, 17 subseries (almost half of the total 35) were mentioned only one time. The graph below displays the subseries that received at least 5 mentions.

The standards subseries alone points out the main thematic focus of ITU-T sustainability Recommendations: energy efficiency, smart sustainable cities, and e-waste and the circular economy. More than half of the total 225 mentions of subseries is about these topics. 25% come from SG 5, concerning “Power Feeding and Energy Storage” and “Energy Efficiency.” 19% are from the SG 20 subseries on “IoT and SC&C” and “Circular and sustainable cities and communities.” Another 14% are from SG 5 on “E-waste and the circular economy.”

The prominence of these topics is also evident in the standards’ keywords. Most ITU-T Recommendations have keywords assigned to them just as academic papers also do. The 171 Recommendations shared 420 unique keywords. The graph below displays keywords that appeared in at least 5 standards.

Once again, the focus on energy efficiency and the smart city agenda is visible, as well as an emphasis on assessment and quantification methodologies, which are at the core of the entire subseries “L.1400-L.1499: Assessment methodologies of ICTs and CO2 trajectories” (13 Recommendations), although also present in other standards as well.

## Acknowledging the problem… But what is the problem?

Among the171 ITU-T sustainability-related standards, especially some earlier ones do not acknowledge the environmental crisis as a motivation for their proposed solutions. For instance, the standards in the table below deal with adaptation to natural disasters but do not clearly nominate what is behind the increase of floods and strong winds.

Table 7. Examples that do not directly address the environmental crisis (my emphasis)

|  |  |
| --- | --- |
| Recommendation Title | Excerpt |
|  |  |
| [L.391/81](https://www.itu.int/ITU-T/recommendations/rec.aspx?rec=12207) (2009)  Monitoring systems for outside plant facilities | “Natural disasters such as those caused by strong wind, flood, landslide, and earthquake happen more frequently than ever and their damage is increasing. Human-caused disasters such as those caused by fire, explosion, and collapse also happen on a large scale. Outside plant facilities including telecommunication buildings are exposed to these disasters and may be affected adversely, which implies that preventive measures are needed.” |
| [L.390/92](https://www.itu.int/itu-t/recommendations/rec.aspx?rec=11819) (2012)  Disaster management for outside plant facilities | “Recently, natural disasters such as earthquakes and floods have occurred more frequently. Outside plant facilities such as manholes and poles are occasionally damaged by these disasters, and as a result, telecommunication services stop. In order to minimize the damage and/or to safely protect outside plant facilities, appropriate disaster management is needed.” |

This pattern will change over time. L1500 (2014), for example, recognizes that “the adverse effects of climate change pose a threat to the development and sustainability of the ICT sector” itself. In addition, L1502 (2015) establishes guidelines to adapt ICT infrastructures to climate change. Animals such as birds, insects, squirrels, and fungus are known to damage telecommunication infrastructures. Among other things, the Recommendation recognizes that climate change has been causing the migration of species that tamper with ICT equipment, which can then become active in areas where they were not previously present.

We know the evolution of SG 5 and other SGs over time reflects the way ITU-T standards work in conjunction with UN sustainable development agenda. But what does that mean in terms of the environmental topics being addressed by the SDO, and how the SDO frames the problems it tries to tackle?

The first mention to the sustainability agenda among the 171 ITU-T Recommendations is seen in L256/45 (2000), which says: “the use of IT technology can be a possible way towards a more sustainable society with efficient use of energy and with a substantial reduction in the emission of greenhouse gasses”. The standard proposes a life cycle assessment for telecommunication equipment. It was published in the same year that world nations ratified the United Nations Millennium Declaration, which established 8 Millennium Development Goals (MDGs) to be achieved by 2015, including Goal 7 “to ensure environmental sustainability”.

L256/45 (2000) predates much of the environment-related work taken up by the ITU, which intensified years later, following the Sustainable Development Goals (SDGs) that replaced the MDGs in 2015. Still, the standard already shows a trend. When we look at the published ITU-T Recommendations, we notice two common narratives around the intersection of ICTs and the environment. First, ITU-T standards tend to advance an optimistic understanding of the ICTs potential to make different industry sectors sustainable. Second, the call to care for the environment within the standards is usually framed as a call towards efficiency. Framing sustainability as efficiency may allow a business-as-usual scenario for the ICT sector that does not necessarily challenge extractive or harmful practices.

The term “sustainability” appears in almost a third of the 171ITU-T Recommendations (33%, 56). For reference, the term “global warming” appears in only 15% (25 out of 171). Whenever a standard employs the term and defines it, it usually restores to the traditional UN definition: a “development that meets the needs of the present without compromising the ability of future generations to meet their needs,” as seen in L1033 (2021) and L1070 (2023).

As table 8 demonstrates, it is common for standards to advance the idea of ICTs as a tool in the fight for sustainability. That is not to say that the standards dismiss any negative environmental impact of ICTs. While not all Recommendations clearly explain the motivations behind their standardizing intentions, some of them mimic much of the literature on the environmental impact of ICTs, presenting a dichotomy between the environmental impact of ICTs themselves and the enabling effects of ICTs over other sectors.

Table 8. Excerpts demonstrating an environmentally optimistic view of ICTs (my emphasis)

|  |  |
| --- | --- |
| Recommendation Title | Excerpt |
|  |  |
| [L.1410](https://www.itu.int/ITU-T/recommendations/rec.aspx?rec=12207) (2012)  Methodology for environmental life cycle assessments of information and communication technology goods, networks and services | “***Needless to say, ICTs have brought huge positive impacts on economic activities***. Use of ICTs in manufacturing have improved efficiency in production activities and required labor and time in production have been reduced. ICTs create a lot of new jobs for people and make human life more convenient. ICT can contribute to both economic growth and environmental load reduction. Therefore, it is desirable to assess the positive economic impacts of using ICT, as well as the environmental impacts.” |
| [L.1410](https://www.itu.int/ITU-T/recommendations/rec.aspx?rec=12207) (2012)  Methodology for environmental life cycle assessments of information and communication technology goods, networks and services | “Unlike many products and services sold in the world today, ICT distinguishes itself by its double-edged nature. On the one hand, ICTs have an environmental impact at each stage of its life cycle, e.g., from energy and natural resource consumption to e-waste. On the other hand, ***ICTs can enable vast efficiencies in lifestyle and in all sectors of the economy*** through the provision of digital solutions that can improve energy efficiency, inventory management, and business efficiency” |
| [L.1400](https://www.itu.int/ITU-T/recommendations/rec.aspx?rec=15182) (2011)  Overview and general principles of methodologies for assessing the environmental impact of information and communication technologies | “When using ICT, it becomes increasingly important to consider and evaluate not only environmental impacts of the ICT sector itself, but also ***the environmental reduction benefits (enabling effect) that the usage of ICT and ICT services can have in many other sectors***.” |
| [L.1501](https://www.itu.int/ITU-T/recommendations/rec.aspx?rec=12206) (2014)  Best practices on how countries can utilize ICTs to adapt to the effects of climate change | “ICT permeates every aspect of human endeavor and climate change adaptation is no exception. ***Leveraging and harnessing the immense potential of ICT will act as a force multiplier in increasing the impact of efforts to tackle climate change***. In this context” |
| [L.1020](https://www.itu.int/ITU-T/recommendations/rec.aspx?rec=13457) (2018)  Circular economy: Guide for operators and suppliers on approaches to migrate towards circular ICT goods and networks | “***ICT services will be key to enable energy reduction and dematerialization in society***, for instance by reducing fuel consumption due to reduced travelling, and by decreasing the use of materials through cloud services” |

Some standards mention examples of how ICTs may both increase and leverage the environmental crisis. L1390 (2022), for instance, states: “While it is an important enabler for the digitalization of other industries and thereby contributes to significant energy savings and emission reductions, it is also important to consider the energy consumption of the 5G network infrastructure itself.” Moreover, L1382 (2020) says: “"Digitalization drives ICT infrastructure to become wider, faster and smarter. (...) However, the running of the ICT infrastructure and its connected terminals also consumes huge amounts of energy and resources.”

ITU-T Recommendations, therefore, both acknowledge and work on ICTs for sustainability and the sustainability of ICTs themselves. Nevertheless, when we consider the overall narrative among the standards, the dichotomy of positive and negative environmental impacts of ICTs implies a balance that reinforces the dematerialization of ICTs. It cements the idea that the potential positive role ICTs play in the sustainable development agenda outweighs or may outweigh negative effects.

This narrative is visible in yet another concept commonly present in the ITU-T standards: the circular economy. As seen in image X, 18% of the mentions to ITU-T subseries come from ones nominally mentioning circularity: “L.1000-L.1199: E-waste and circular economy” and “L.1600-L.1699: Circular and sustainable cities and communities.”

The first standard to mention sustainability in the ITU is also the first one to propose a “cradle to the grave” perspective for telecom equipment (L256/45 (2000)). But what does the circular economy mean for the ITU-T? L1020 (2018) is a guide for operators and suppliers to migrate towards circular ICT goods and networks. It uses a definition of circular economy that is adapted from an Ellen McArthur publication, and echoed in other Recommendations such as L2021 (2018), L1030 (2018), L1031 (2020):

“A circular economy is restorative and regenerative by design, and aims to keep products, components, and materials at their highest utility and value at all times while reducing waste streams. (...) The circular economy is a continuous, positive development cycle.” (my emphasis)

ITU standards working on the concept of circularity do so under the assumption of constant development or, in other words, sustainable growth. Such a growth is enabled by efficiency gains in the manufacturing and usage of ICTs themselves, and in employing ICTs in all sectors of society. It is a bet and a hope on efficiency as the ultimate goal. For example, L1023 (2020) and L1604 (2022) define a circular economy as one “closing the loop between different life cycles through design and corporate actions/practices that enable recycling and reuse in order to use raw materials, goods and waste *in a more efficient way*” (my emphasis).

Faith in efficiency is also seen in ITU-T standards on smart cities and communities, which state that:

“A smart sustainable city is an innovative city that uses information and communication technologies (ICTs) and other means to improve quality of life, the efficiency of urban operation and services, and competitiveness, while ensuring that it meets the needs of the present and future generations with respect to economic, social, environmental as well as cultural aspects.” (Y4900 (2016), Y4260 (2022), Y4903 (2022)).

## A new constraint for ICTs, but a business-as-usual scenario

ITU-T works as a public-private partnership. It is not surprising to see some standards acknowledging that the need to address the environmental impact of ICTs comes also from a market demand for sustainability. The Recommendations in Table X exemplify this stance, as they acknowledge that addressing (or appearing to address) the environmental impact of ICTs makes sense from a business perspective.

Table 9. Examples of market-led environmental concerns (my emphasis)

|  |  |
| --- | --- |
| Recommendation Title | Excerpt |
|  |  |
| [L.1460](https://www.itu.int/ITU-T/recommendations/rec.aspx?rec=13582) (2018)  Connect 2020 greenhouse gases emissions - Guidelines | “***Private investors are more and more demanding about the GHG strategy of companies*** and the environmental impact of their activity. So, more and more companies are taking commitments to reduce their GHG emissions” |
| [L.1317](https://www.itu.int/ITU-T/recommendations/rec.aspx?rec=14718) (2021)  Guidelines on energy efficient blockchain systems | “It is important to understand how to reduce the environmental impact of these technologies because ***it will contribute to the well-being of the market economy*** as well as to the quality of life of citizens and the users of these technologies.” |
| [Y.3021](https://www.itu.int/ITU-T/recommendations/rec.aspx?rec=11446) (2012)  Framework of energy saving for future networks | “Historically, energy saving has been studied for increasing benefits to the user or company, such as reduced energy costs and temperature management for stable machine operation. The importance of these issues is increasing due to the more widespread implementation of network equipment and the greater energy consumption that this requires. ***It is also becoming increasingly important from a social aspect to support the reduction of greenhouse gas (GHG) emissions***." |
| [Y.3001](https://www.itu.int/ITU-T/recommendations/rec.aspx?rec=11083&lang=en) (2011)  Future networks: Objectives and design goals | “(future networks, FNs) are recommended to consider social and economic issues to reduce barriers to entry of the various actors involved in the network ecosystem. FNs are recommended to also consider the need to reduce their lifecycle costs in order for them to be deployable and sustainable. These factors will help to universalize the services, and ***allow appropriate competition and an appropriate return for all actors***.” |
| [L.1035](https://www.itu.int/ITU-T/recommendations/rec.aspx?rec=14848) (2022)  Sustainable management of batteries | “***E-waste could represent an opportunity worth over USD 62.5 billion per year*** if treated through appropriate recycling channels and methods, with the potential of creating millions of ‘clean and green’ jobs worldwide.” |
| [L.1390](https://www.itu.int/ITU-T/recommendations/rec.aspx?rec=15029) (2022)  Energy saving technologies and best practices for 5G radio access network (RAN) equipment | “Energy saving and emission reduction is not only the social responsibility of telecommunications operators but ***also inherent development needs of operators to continuously reduce electricity costs and improve market competitiveness***.” |
| [L.1333](https://www.itu.int/ITU-T/recommendations/rec.aspx?rec=15028) (2022)  Carbon data intensity for network energy performance monitoring | “In recent years***, a significant interest in GHG emission level from industry has been taken.*** The need to respect the Paris Agreement and carry out the activities linked to the United Nations Sustainable Development Goals are important aims and the possibility of setting of targets for countries and industries to reduce the amount of CO2 that they emit also exists. As a consequence, it is clear and accepted that telecom operators, like other industries, need to set targets for emission reductions in line with the trajectories put forward in [b-ITU-T L.1470] to arrive at a net zero state” |
| [L.1332](https://www.itu.int/ITU-T/recommendations/rec.aspx?rec=13963) (2019)  Guidelines and certification schemes for e-waste recyclers | “***From an economic perspective, WEEE (Waste from Electrical and Electronic Equipment) includes non-renewable precious components, such as gold, silver and copper in a much higher grade than that present in mineral ores***. The extraction of these materials from WEEE, if conducted properly, provides jobs and economic opportunities, reduces greenhouse gas (GHG) emissions and fosters a circular economy.” |

Engaging in environmental sustainability standards makes sense because companies operate in countries that are already committed to targets such as the Paris Agreement, or they have net carbon goals of their own (e.g., L 1333 (2022)). It makes sense because environmental awareness is becoming more and more a market demand from consumers and/or investors (e.g., L1460 (2018)). And it also makes sense from a purely technical standard-point: ICTs run on electricity and energy efficiency have long been a concern for the industry; if not for the smooth operation of ICTs alone, for reduced energy costs.

For example, Recommendation L1390 (2022) covers best practices for 5G equipment, and it states that “energy saving and emission reduction is not only the social responsibility of telecommunications operators but also *inherent development needs of operators to continuously reduce electricity costs and improve market competitiveness*.” As the ICT sector grows, so do demand for energy. Considering this situation, L1360 (2016) states:

“Energy efficiency has become one of the most important aspects for both current and future telecommunications infrastructures. Taking energy into account induces a new constraint when managing a network. This constraint is added to the three already existing constraints, namely quality of service (QoS), resilience and security”

The scenario proposed seems to be one where the ICT sector expands its reach to encompass more and more economic sectors, but now dealing with a new constraint, that of energy. In doing so, the sector sustains its never-ending path of growth, albeit in an energy-efficient way. For example, L1033 (2021) guides higher-learning institutions in addressing their own e-waste and strengthening their curriculum on ICT life-cycle perspectives. It exemplifies what it means by circularity by citing the well-known “doughnut economics” figure proposed by the economist Kate Raworth (2012). In doing so, it states that “there is a feasibility region within the planetary and social boundaries that is also seen as economically viable.”

Moreover, the figures below belong to ITU-T standards on smart sustainable cities and agriculture, and illustrate what a “sustainable” development and growth scenario could look like:

A diagram of smart home

Description automatically generatedA collage of cows in a pen

Description automatically generated

Extracted from Y2064 (2014) on “Energy saving using smart objects in home networks” (left)

and Y2248 (2023) on “Service model for entry-level smart farms” (right)

The goal is a world filled with ICTs that will be designed efficiently to demand less and less of the environment, but that will still grow. ICTs will assist in turning all things “smart” and “sustainable” (e.g., above). For instance, not only ICTs will improve the efficiency of smart farms (Y2248, 2023), they will also help sustain the agricultural sector through disasters triggered by climate change (L1504, 2016). For example, L1503 (2016) explains that “climate change adaptation strategies could receive a fundamental boost if national, regional and local governments choose to harness and utilize the transformational potential of ICTs.” And L1022 (2019) adds: “Artificial intelligence (AI) can play an important role in the shift from a linear to a circular economy because AI allows us to deal effectively with complexity and make sense of abundant data.”

## The need for measuring

The ICT-enabled sustainable world requires measurements. The terms “metrics” and “Key Performance Indicators” (KPIs) ranked among the most used keywords in the ITU-T standards (image X). In total, 43% of the 171 standards address assessment or measurement needs. Some standards directly propose methodologies for assessing the environmental impact of ICTs, engaging with the literature on life cycle assessments (LCAs). As a result, the fifth most mentioned subseries in the data set (Graph X) is “L.1400-L.1499: Assessment methodologies of ICTs and CO2 trajectories.” To give one example from this subseries, L1471(2021) is a guide “clarifying the meaning of Net Zero in the context of the ICT sector and setting Net Zero targets and strategies.”

Overall, among the ITU-T standards, there is an agreement on the need for more data on both the way ICTs negatively and positively affect the environment. For example, L1451 (2019) states that “without a standard methodology evaluating the positive impacts of ICT, the role of ICTs in the fight against global warming will be only partially perceived.” Standard L1015 (2019) establishes criteria for the evaluation of the environmental impact of mobile phones. It summarizes the problem of many environmental assessments:

“Manufacturers and network operators have been reporting for several years the sustainability credentials of mobile phones based on consumer needs, corporate sustainability initiatives or environmental footprint assessments, amongst others. However, inconsistencies among approaches cause confusion and make comparisons difficult, wasting time and resources for both operators and manufacturers when collecting and providing similar data.”

Back when the ITU changed the mandate of SG 5 to encompass environmental sustainability, it did so precisely in order to first establish assessment methodologies. This work started in 2009 at the the Focus Group on ICTs and Climate Change, which laid the ground of what would become one of the first and most famous ICT life cycle assessments methodologies (L1410, 2012). Over time, generating data in regard to the intersection of ICTs and the environment is still one of ITU-T’s main focuses.

For example, L1102 (2016) proposes label printing methods for rare metals, standardizing a way of obtaining information on rare metals in ICT goods. More recently, ITU-T published L1070 (2023) together with the European Telecommunications Standards Institute (ETSI). It establishes guidelines for the Digital Product Passport (DPP) and responds to the European Union Circular Economy Action Plan. The stated goal is to increase transparency and visibility of information about all the value chain of ICT goods in the continent.

If most standards aim to measure or establish requirements regarding the environmental impact of ICTs, some focus on the other way around: how the environment impacts ICTs. L1506 (2018), for example, proposes a framework for assessing climate change risk to telecommunication and electrical facilities.

## Conclusion: the limits of ITU-T “ecodesign”

ITU-T standards respond to a UN call to address the Sustainable Development Agenda. For example, standards L1451 (2019) and L1460 (2018) propose assessment methodologies to support SDG Goal 13 (Address climate change and its impacts) and the objectives of the Paris Agreement. The current SDO focus relies on an optimist understanding of the role of ICTs in sustainability, and on faith in efficiency. These two assumptions are encapsulated in what some ITU-T Recommendations call “ecodesign” (e.g., L1010, 2014).

For instance, L1000 (2010) is one of the most famous ITU-T environmental sustainability recommendations. It establishes a universal power adapter and charger solution for mobile devices. The standard mentions that electronics should follow “ecodesign” criteria, which would “cover the key areas of more environmentally sound materials, provisions for reuse and ease of recycling.” Moreover, L1031 proposes an e-waste management system and states:

“One of the best practices to prevent the generation of e-waste is the development of sustainable products to incorporate an environmentally conscious design scheme throughout the life cycle of a product, from development and manufacture, through to end-of-life treatment.”

There seems to be an understanding that sustainable ICTs require new design paradigms, and even business models. For example, L1022 (2019) discusses the material efficiency of ICTs and states that “new forms of business models drive the success of the (circular economy),” suggesting a change from a product sales model to an as-a-service model. Besides, Q4069 (2022) sets requirements for IoT-based “green data centers,” challenging future installations to be designed “for maximum energy efficiency and minimum environmental impact.”

Ecodesign and constant development, however, are not aligned. SG 5 current name summarizes the overall ITU-T approach to the environment: “Electromagnetic fields (EMF), environment, climate action, sustainable digitalization, and circular economy​.” It points out to ITU-T’s concern about the environment, but within the limits of economic growth and upon the expansion of ICTs towards all aspects of life.

# Internet Engineering Task Force (IETF)

 “IETF technologies and especially the Internet are the most important enabler of the digital economy, and the energy consumption it produces.” Eckert et al., 2023 ([source](https://ftp.fi.muni.cz/pub/internet-drafts/draft-eckert-ietf-and-energy-overview-05.html#section-3-2))

The IETF makes information about its standards, mailing lists, minutes, and other related content available to anyone interested through a website application called Datatracker. I searched for IETF standards, called Request for Comments (RFCs), following the same query I used for the ITU-T:

“green, sustain, sustainability, sustainable, energy, environmental, carbon, lifecycle, waste, climate, global warming, extractive, mineral, material, pollution, emission, power, biodiversity”

I filtered responses that included published RFCs, but also active, expired, or withdrawn Internet-Drafts (I-Ds), which are IETF proposed RFCs that have not been published yet. The search returned documents that had the words on the query within the name of the document or in the title of the proposed standards (e.g., the Internet-Draft titled “Energy Metrics For Data Networks” has the document name of “draft-bogdanovic-green-energy-metrics-00”).

 Table 10. List of query terms and count of results (IETF)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| power | 407 |  | waste | 0 |
| energy | 70 |  | climate | 0 |
| green | 50 |  | global warming | 0 |
| lifecycle | 13 |  | pollution | 0 |
| sustain | 10 |  | extractive | 0 |
| environmental | 7 |  | mineral | 0 |
| sustainability | 6 |  | biodiversity | 0 |
| carbon | 4 |  | ecological | 0 |
| emission | 3 |  | ecology | 0 |
| sustainable | 1 |  |  |  |

The search yielded 571 results (Table 10), including duplicates because one standard can share more than one term in the query. However, most of the results were outside the scope of the dissertation. For example, IETF publishes several standards on Low-Power Wide Area Network (LPWAN), a type of wireless telecommunication network mostly used by IoT devices, and Low-Power and Lossy Networks (LLN), a routing protocol for wireless networks constrained by processing/energy power. Only LPWAN and LNN RFCs and Internet-Drafts that mentioned some environmental concern (e.g., energy-saving methods) were included in the dataset. I also removed documents that appeared repeatedly in the search because they were superseded. Finally, I gave preference to analyzing only the last version of a document, as it is common for a single I-D to go through various iterations. Ultimately, the complete data set consists of 107 Internet-drafts (I-Ds) and 9 RFCs, totaling 116 documents.

## Three moments of concentrated efforts

The IETF mandate is considerably narrower than the ITU, as the SDO focuses mostly on standards under the Internet protocol suite (TCP/IP). For the IETF, most of the dataset (65%, 75) comprises expired Internet-drafts that were never published as RFCs. An Internet-draft is valid for a maximum of six months if left without updates (e.g., an upload of a new version of the document, updates on the status of the discussion on a document, its publication as an RFC). And for a draft to become an RFC, there must be community consensus on the solution proposed, and industry support and momentum for the need for it.

Besides, the IETF differentiates between the different purposes of its I-Ds. RFC 2026 establishes that Requests for Comments may be:

* Internet Standard (standard-track), if it is an interoperable and widely deployed solution;
* Informational, if it is published for the general information of the community, not necessarily representing wide community consensus or ready-to-deploy solutions;
* Experimental, if it is part of a research or development endeavor serving as an archival record of the work;
* Historic, if it was superseded or considered obsolete for any reason;
* Best Current Practice (BCP), if it documents IETF processes or offers common policies and operations for the Internet community that are not closely concerned with technical specifications for interconnected networks.

As the image below shows, half of the documents in the dataset are informational in nature (50%, 58). This means that the IETF environmental standards tend to address general information and not propose deployable technologies. Moreover, more than half of the data set (55%, 64) was not assigned to a specific working group or is under the responsibility of a working group with three or fewer documents. The I-Ds and RFCs are spread across 36 different working groups, with only 5 working groups having more than 5 documents assigned to them.

The graph below exemplifies the evolution of the RFCs and I-Ds over time. It also points out three different moments of concentrated effort on environmental sustainability matters within the IETF. To plot the graph, I considered the first date a document was submitted to the IETF, and not the date of its last update[[2]](#footnote-2).

IAB workshop,

e-impact, GREEN WG

PANET

I-Ds

EMAN

WG

Most of the environment-related work in the IETF can be traced to three moments in time: in 2010-2011 at the EMAN working group, 2012-2014 with initiatives about “Power-Aware Networks (PANET), and 2022-2024 at the GREEN working group. Still, some I-Ds predate these concentrated efforts.

For instance, the first document in the dataset was proposed years before these key moments took place. In 2001, an Internet-draft introduced a power-aware routing optimization solution for wireless networks (Gomez et al., 2001). The motivation for proposing a power-efficient routing protocol came from a technical necessity. As explained in the I-D,

“For small computing/communication devices with built-in/attached radios (e.g., cellular phones, PDAs, etc.) reducing transmission power may extend the operational lifetime of a device significantly, thus, enhancing the overall user experience” (Gomez et al., 2001).

In other words, some wireless devices in mobile networks have a critical need to preserve battery power, especially as they rely on batteries with finite amounts of power, and thus a power-aware routing protocol could help implement power-saving techniques. The pattern of proposing energy-efficiency solutions for solely logistical necessity continued over time. The following I-D, published in 2003, proposed an energy-aware dynamic source routing (DRS) protocol which would primarily consider energy efficiency metrics when choosing routes. Besides, there were scattered I-Ds on energy consumption and controlling power states of managed devices and networks over time, which culminated in the creation of a working group precisely to address energy management among Internet protocols.

The Energy Management (EMAN) working group started in 2010. Its task was to discuss requirements for communication networks to operate with a minimal amount of energy while maintaining sufficient performance. In its charter, the WG explained that energy management:

“is becoming an additional requirement for network management systems due to several factors including the rising and fluctuating energy costs, the increased awareness of the ecological impact of operating networks and devices, and the regulation of governments on energy consumption and production.” (my emphasis)

Thus, the EMAN working group mentioned in its foundational document some awareness about the environmental impact of ICTs and the growing governmental pressure around energy consumption. Until then, few IETF documents reported on or addressed energy monitoring. Quittek et al. (2010) wrote an I-D showing that until then “existing IETF standards are not sufficient for energy management and that energy management requires architectural considerations that are different from common other management functions.” One of the WG’s main objectives, thus, was to reduce energy consumption. EMAN concluded its activities in 2015. It published a total of 7 RFCs (Table 11), totaling 64% of all the published RFCs in the dataset.

Table 11. RFCs elaborated at the EMAN working group

|  |  |
| --- | --- |
| Recommendation Title | Summary |
|  |  |
| [RFC 7326](https://datatracker.ietf.org/doc/rfc7326/) (2010, published in 2014)  Energy Management Framework | It defines an energy management framework for devices and components in communication networks. |
| [RFC 6988](https://datatracker.ietf.org/doc/rfc6988/) (2010, published in 2013)  Requirements for Energy Management | It defines requirements for energy management standards specifications. |
| [RFC 6933](https://datatracker.ietf.org/doc/rfc6933/) (2012, published in 2013)  Entity MIB (version 4) | A management information base (MIB) is a database that stores relevant information for managing communication networks. The standard specifies a MIB module for managing logical and physical entities by a single Simple Network Management Protocol (SNMP) agent. |
| [RFC 7603](https://datatracker.ietf.org/doc/rfc7603/) (2011, published in 2015)  Energy Management (EMAN) Applicability Statement | It provides an energy management framework for networked devices, describing their applicability in different cases and scenarios. |
| [RFC 7577](https://datatracker.ietf.org/doc/rfc7577/) (2011, published in 2015)  Definition of Managed Objects for Battery Monitoring | It defines a way for network management systems to monitor the battery status of devices such as computers and smartphones. |
| [RFC 7460](https://datatracker.ietf.org/doc/rfc7460/) (2010, published in 2015)  Monitoring and Control MIB for Power and Energy | The standard details what information on power and energy monitoring of devices shall be stored. |
| [RFC 7461](https://datatracker.ietf.org/doc/rfc7461/) (2010, published in 2015)  Energy Object Context MIB | It defines MIB modules on Energy Object identification, Energy Object context, and Energy Object relationships. |

During the existence of the EMAN WG, unspecified proposals on the intersection of the IETF protocols and energy also existed. For example, in 2012, a group of researchers proposed an informational I-D called “Towards an Energy-Efficient Internet.” The draft stated that climate change and cost are industry and society drivers towards more energy-efficient technologies, and summarized obstacles and options for the IETF work on energy-efficient technologies. They recognized that “Energy-efficiency certainly is important” but asked, “Is the Internet infrastructure a good place to look at, and what is already out there that addresses energy-efficient communication?” Despite recognizing the scope limitations, the document concluded that there were realistic action items that could be taken up by the IETF.

While the I-Ds and RFCs within the EMAN working group did address solutions for energy-aware devices, much of its activities and documents were framed on logistical aspects of energy optimization and not around environmental concerns. For example, much of the IETF discussions among its members occur through mailing lists. The archives of all mailing list communications are available on the IETF website. A quick search in the EMAN mailing list archive for the terms “sustainability,” “climate,” and “global warming” yielded no results.

Moving forward, between 2012 and 2014, some IETF members pushed for initiatives about what they called “Power-Aware Networks” (PANET). First, a group of researchers from the Indian Institute of Technology Madras (IIT Madras) published 17 I-Ds on power-aware networks in a short time span. They labeled some of the I-Ds as if they were part of a self-titled “PANET Working Group” (see image X). However, the IETF never created a dedicated WG to address the topic, and thus the PANET WG did not exist. Of the 17 I-Ds from this group, some were proposed as if they were part of the non-existent PANET working group, and some with almost the exact same content were proposed as if they were part of the Routing Area Working Group (RTGWG).

RTGWG was created in 2004. Its mandate is to evaluate proposals for emerging work on the routing systems that could lead to the creation of new working groups. RTGWG also works on small topics that do not fit existing working groups and/or lack support and momentum for the creation of a dedicated WG. Whereas the PANET working group was never created, during the IETF 86 meeting in 2013, the RTGWG dedicated a time slot to discuss the potential for future IETF work to engage with PANET ideas. At the time, a group of authors from the University of Arizona, Huawei, and France Telecom presented their ideas to the RTGWG audience (slides available [here](https://www.ietf.org/proceedings/86/slides/slides-86-rtgwg-9.pdf)). That same group of authors had won just two years before, in 2011, the very first IRTF “Applied Networking Research Prize.” The IRTF recognized their research effort in a paper precisely on power-aware traffic engineering ([source](https://www.irtf.org/anrp/)).

However, there was no consensus or wide community interest to engage in the matter, and the PANET-related I-Ds soon expired. None of the proposals materialized as published RFCs or were pushed towards the creation of a dedicated working group. Almost ten years later, the IETF would create the Getting Ready for Energy-Efficient Networking (GREEN) working group. In preparation for the work of this group, an I-D was proposed under the title “An Overview of Energy-related Effort within the IETF” ([Eckert et al.](https://datatracker.ietf.org/doc/draft-eckert-ietf-and-energy-overview/00/), 2023). The document explains some of the shortcomings of PANET endeavors.

According to the I-D, a core market driver for the 17 I-Ds proposed by researchers from IIT Madras was the frequent rolling blackouts in India at that time, which called for energy awareness. However, the document explains that the market significance of the topic for most of the vendors in the IETF “was considered as not to be important enough” at the time. Besides, the I-D implies that some proposals lacked feasibility.

Looking back at the discussions at the RTGWG mailing list during that period, we see criticism of PANET I-Ds for mostly two reasons: technical flaws and a supposed lack of understanding of the IETF working culture. First, some RTGWG members pointed out that some of the drafts read more like research papers, whereas IETF works on solutions that are already cemented by previous research and real-world applications. Second, they pointed out that, in most cases, the IETF community gathers around a topic to first conceive a problem statement, then discuss it in smaller forums, then finally produce solutions or indicate what type of work should be done. PANET I-Ds, therefore, were short-lived and never received the support to formalize any organized work within the IETF.

Meanwhile, the Light-Weight Implementation Guidance (LWIG) working group was also dealing with energy efficiency matters. The working group started in 2011. In its charter, it acknowledges that “communications technology is being embedded into our environment,” and that many different types of devices in buildings, homes, and vehicles increasingly employ the Internet Protocol suite. In light of the IoT boom, the WG was tasked with implementation techniques for reducing the complexity, memory footprint, or power usage of such networked devices. The group published two RFCs on energy efficiency, RFC 8352 on “Energy-Efficient Features of Internet of Things Protocols” ([Gomez et al., 2018](https://datatracker.ietf.org/doc/rfc8352/)) and RFC 9178 on “Building Power-Efficient Constrained Application Protocol (CoAP) Devices for Cellular Networks” ([Arkko et al., 2022](https://datatracker.ietf.org/doc/rfc9178/)). At least three other I-Ds introduced in the WG also dealt with energy optimization. As acknowledged in an LWIG I-D, “a lot of implicit energy efficient design principles have been used in (IETF protocols for constrained networked devices)” ([Cao, et al., 2014](https://datatracker.ietf.org/doc/draft-hex-lwig-energy-efficient/)).  As usual, the proposals were guided by the technical need of controlling power usage, and not necessarily an environmental concern.

More recently, there has been a consistent increase in the number of proposals aiming to address environmental concerns in the IETF. This increase started after the Internet Architecture Board (IAB) held a workshop in 2022 on the “Environmental Impacts of the Internet Applications and Systems”. Summarizing the energy-related IETF until the IAB meeting, Informational I-D “An Overview of Energy-related Effort within the IETF” stated:

“Conventionally, digitization had only "incidental", but not "intentional" relationship to energy consumption: If it saved energy, this was not only not a target benefit, it was not even recognized as one, until probably recently. Instead, the evolution was driven from anything-but-energy benefits, but instead utility benefits such as improved speed, functionality/flexibility, accessibility, usability, scalability, and reduced cost.” ([Eckert](https://datatracker.ietf.org/doc/draft-eckert-ietf-and-energy-overview/00/) et al., 2023)

In sum, energy efficiency in the IETF was more a collateral effect than an effort guided by the principle of sustainability. The same I-D states that “there seems to be no IETF work specifically intending to target sustainability” but that the Internet can “play a key role in building sustainable networked IT infrastructures.” As per usual until this moment, the focus remained on energy-related solutions.

After the IAB workshop, three venues for environmental work within the IETF were opened. First, the organization established the E-Impact Program with a mailing list called “Environmental Impacts of Internet Technology (eimpact).” Per its charter, the program is a venue within both the IETF and the IRTF for discussing the role of Internet architecture on “energy and other environmentally impacting attributes”. It targets “topics not yet progressed into concrete standards or research efforts in the IETF or IRTF while also being a coordination point for work across multiple WGs/RGs, and a venue to highlight ongoing work in the IETF/IRTF as well as external SDOs.” Because it is not a working group, the mailing list works as a space for conversations on any environment-related topic, even if it does not necessarily convert into actionable IETF efforts. Since its creation, E-Impact has held side meetings in IETF 116-118 and 120.

Second, the IETF established the Getting Ready for Energy-Efficient Networking (GREEN) working group in 2024. The group started first as a Birds of Feather (BoF) in May 2024. Usually, BoFs gather the IETF community to discuss the creation of a working group charter. This format ensures that there is enough willingness to work on standards of a certain topic and that they can be eventually adopted by industry. The GREEN BoF had the goal to determine whether there was interest in working on network energy-efficient management to optimize energy use and minimize environmental impact, and, if so, establish the scope and actionable targets of the future working group.

In June 2024, GREEN became an IETF working group. The Energy Management (EMAN) working group, which worked from 2010 to 2015, already dealt with some of the topics covered by GREEN. However, the newly founded WG charter explains that EMAN’s standards did not achieve industry-wide adoption nor solved the lack of standardized interfaces for measuring and reporting on the energy consumption of diverse networks. Besides, EMAN proposed standards based on Management Information Base (MIB) data models (see Table 11). GREEN is developing solutions based on a different data modeling language called Yet Another Next Generation (YANG).

The group states it will liaise with other SDOs that also work on benchmarking methodologies related to energy management, citing ITU-T’s SG5. Currently, there are 13 Internet-drafts under the GREEN working group, considering both proposals that appeared as GREEN-related documents on the IETF website and those whose authors identified as part of GREEN in the drafts themselves. Since its creation, GREEN has held meetings in IETF 120 and 121.

Finally, there is ongoing work for the creation of an IRTF research group to be called “Sustainability and the Internet” (SUSTAIN RG). There was a public side meeting in November 2024 at IETF 121 to advance the development of the group. As of now, it has yet to become an RG, and its charter is still being developed. A draft charter states that SUSTAIN RG’s long-term goal is to “contribute to the advancement of the Internet as a fundamental part of sustainable and resilient societies and planet, through conceptual and evidence-based research collaboration.” It acknowledges the need to support the UN Sustainable Development Goals and states that “recognizing their interconnectedness, (the group) will focus on the Sustainability of the Internet (footprint) while fostering an appreciation of the Internet for Sustainability (handprint)([source](https://github.com/rezaki-ali/IRTF_SUSTAIN_RG/blob/main/IRTF_Proposed_Research_Group_SUSTAIN_RG_Draft_Charter_v1_0.pdf))”. As a research group within the IRTF, the group will not be tasked with creating short-term immediate solutions but focus on longer-term research sustainability issues.

## Sustainability in the IETF

The majority of IETF standards that dealt with environmental topics did so as a collateral effect up until recently. The table below exemplifies the rationale behind such standards, which focus mostly on energy efficiency[[3]](#footnote-3). Two arguments abound to justify working on energy efficiency and management: the energy cost of networking and the need for optimization in constrained technologies (e.g., Low-Power and Lossy Networks).

Table 12. Financial and technical reasons for energy efficiency (my emphasis)

|  |  |
| --- | --- |
| Recommendation Title | Excerpt |
|  |  |
| Requirements for Power Aware Network ([2012](https://datatracker.ietf.org/doc/draft-dong-panet-requirement/)) | “***As energy price continues to rise, the increasing network energy consumption becomes a significant portion of the network operational costs.*** (...) While energy consumption has become an important issue, network operators are very cautious about energy conservation solutions due to the concerns about the potential impacts on the network performance and resiliency. (…) Most of the existing networks are over-provisioned for better service performance and redundancy, which means they are not energy efficient by default. In order to save energy, the entire network should become power aware, then it can make appropriate decisions to save energy when possible.” |
| Energy Aware Control Approach for QoS in heterogeneous packet access networks ([2013](https://datatracker.ietf.org/doc/draft-vonhugo-eacp-hetnet/)) | “***Due to large contribution of expenses for stable provision of mainly electrical power*** to overall network operational costs carrier grade network operators try to reduce energy consumption in the access and transport domain. A major challenge here is to grant customer satisfaction in terms of preventing any perceivable service quality degradation.” |
| An energy optimization routing scheme for LLSs ([2017](https://datatracker.ietf.org/doc/draft-wang-roll-energy-optimization-scheme/)) | “Low-Power and Lossy Networks (LLNs) have recently attracted a lot of interest to the researchers due to its wide range of applications such as military implementations in a battlefield, an environmental monitoring, and multifunction in health sector. However, due to the characteristics of LLNs, it has such limitations as limited battery power, finite computing and memory capability, the large scale of deployment and narrow communication bandwidth. Therefore, ***there is an urgent need for conserving energy in the LLNs so as to ensure long term operation***.” |

That is not to say that there was no environmental awareness before the IAB workshop, and that the I-Ds and RFCs focused on energy efficiency for practical reasons alone. For instance, Table 13 demonstrates some early cases in which cost was cited together with environmental concerns to justify the need for energy-related standards.

Table 13. Reasons linking cost and environmental awareness (my emphasis)

|  |  |
| --- | --- |
| Recommendation Title | Excerpt |
|  |  |
| Definition of Managed Objects for Energy Management ([2010](https://datatracker.ietf.org/doc/draft-quittek-power-mib/)) | “Energy management in communication networks is ***a topic that has been neglected for many years when energy was cheap and global warming not recognized***. This has changed recently. Energy management is becoming a significant component of network planning, operations and management and new energy management strategies are currently being explored.” |
| [RFC 7603](https://datatracker.ietf.org/doc/rfc7603/) (2011, published in 2015) Energy Management (EMAN) Applicability Statement | “There are multiple scenarios where (energy management framework) is desirable, particularly considering ***the increased importance of limiting consumption of finite energy resources and reducing operational expenses***.” |
| [RFC 6988](https://datatracker.ietf.org/doc/rfc6988/) (2010, published in 2013) Requirements for Energy Management | “With ***rising energy costs and an increasing awareness of the ecological impact of running information technology equipment***, Energy Management (EMAN) functions and interfaces are becoming an additional basic requirement for network management systems and devices connected to a network.” |
| Requirements for Power Monitoring ([2009](https://datatracker.ietf.org/doc/draft-quittek-power-monitoring-requirements/)) | “With ***rising energy cost and with an increasing awareness of the ecological impact of running IT*** and networking equipment, energy management is becoming an additional basic requirement for network management frameworks and systems.” |
| Considerations for Power and Energy Management ([2011](https://datatracker.ietf.org/doc/draft-norwin-energy-consider/02/)) | “With ***rising cost and an increasing awareness of the environmental impact of energy consumption, a desirable feature of networked devices is to be able to assess their power state*** and energy consumption at will. With this data available, one can build sophisticated applications such as monitoring applications or even active energy management systems.” |
| RFC 9547 Report from the IAB Workshop on Environmental Impact of Internet ([2024](https://datatracker.ietf.org/doc/rfc9547/)) | “The Internet runs on systems that require energy and raw materials to manufacture and operate. While the environmental benefits of the Internet may certainly outweigh this use of resources in many cases, it is incumbent on the Internet industry to ensure that this use of resources is minimized and optimized. In many cases, ***this is already an economic necessity due to operational costs***. And because many consumers, businesses, and civil societies care deeply about the environmental impact of the services and technologies they use, there is also a ***clear demand for providing Internet services with minimal environmental impact***.” |

Similarly, cost and logistical justifications did not disappear after 2022. For example, Internet-draft “Sustainability Considerations for Networking Protocols and Applications” states that “minimizing energy consumption typically comes also with important economic side benefits associated with reducing operational expenses and making network providers more competitive” (Pignataro et al., 2024). Still, there is a recent disposition shift within the IETF to engage with the environmental agenda, even beyond the energy efficiency paradigm alone.

Internet-drafts increasingly recognize that addressing the environmental impact of ICTs as a topic under the scope of the IETF. The examples in Table 14 point out the challenge of addressing sustainability among the technologies the IETF advances. Contrary to the ITU-T whose mandate is intrinsically connected to that of the United Nations, in the IETF the concept of sustainability and the role the IETF may play on this agenda is much less defined.

Table 14. IETF examples that acknowledge the environmental agenda (my emphasis)

|  |  |
| --- | --- |
| Recommendation Title | Excerpt |
|  |  |
| Path Energy Traffic Ratio API (PETRA) ([2023](https://datatracker.ietf.org/doc/draft-petra-path-energy-api/)) | “***Sustainability is becoming one of the major societal goals for the next decade, and networks are one of the major consumers of energy nowadays.*** Sustainability of network services is thus one of the forefronts of innovation and action from network service stakeholders, involving manufacturers, operators and customers. In this line, there is a shared goal of achieving better energy awareness.” |
| Green Challenges in Computing-Aware Traffic Steering (CATS) ([2023](https://datatracker.ietf.org/doc/draft-wang-cats-green-challenges/)) | “Green has become a global topic. ***The United Nations and the vast majority of governments agree that climate change and the need to curb greenhouse gas emissions are the major challenges of our time***. Therefore, improving energy efficiency and reducing electricity consumption are becoming increasingly important for society and many industries. ***The networking industry is no exception”*** |
| Challenges and Opportunities in Management for Green Networking ([2023](https://datatracker.ietf.org/doc/html/draft-irtf-nmrg-green-ps-03)) | “***Reducing humankind's environmental footprint and making technology more environmentally sustainable are among the biggest challenges of our age***. Networks play an important part in this challenge. On one hand, they enable applications that help to reduce this footprint. On the other hand, they contribute to this footprint themselves in no insignificant way. Therefore, methods to make networking technology itself "greener" and to manage and operate networks in ways that reduce their environmental footprint without impacting their utility need to be explored.” |

IETF Internet-drafts usually have a “Definitions and Acronyms” section that is an index of important terms. In this section, on I-D on “green networking” defines “green” simply as “sustainable” without detailing what either of the terms means ([Clemm et al](https://datatracker.ietf.org/doc/html/draft-cx-green-green-metrics-00#name-definitions-and-acronyms)., 2014b). Another I-D on “green networking” states that “energy-efficiency and greenness are aspects that are rarely considered when designing network protocols” and that “this suggests that there may be plenty of untapped potential” to be uncovered in the IETF ([Clemm et al](https://datatracker.ietf.org/doc/html/draft-irtf-nmrg-green-ps-03)., 2024a). According to the I-D, “green” would include technologies that help to lower networking's greenhouse gas emissions, increase efficiency, realize energy savings, and facilitate managing networks toward stronger use of renewables.

In that sense, the authors state that “arguably, networks can already be considered a "green" technology (because they) enable many applications that allow users and whole industries to save energy and become more sustainable in a significant way.” However, since networks themselves consume significant amounts of energy, “the networking industry has an important role to play in meeting sustainability goals not just by enabling others to reduce their reliance on energy, but by also reducing its own” (Clemm et al., 2024).

Such a rationale is present in other I-Ds, too. The most recent Internet-drafts seem to mix optimism concerning the role of technology in sustainability efforts with an acknowledgment that more should be done regarding the sustainability of technologies themselves. For example, one I-D states: “The impact of Internet technologies has been overwhelmingly positive over the past years (e.g., providing alternatives to travel, enabling remote and hybrid work, enabling technology-based endangered species conservation, etc.), and there is still room for improvement” ([Pignataro, et al., 2024](https://www.ietf.org/archive/id/draft-pignataro-green-enviro-sust-terminology-00.txt)). Another one explains that “networks are the main enablers of carbon reductions” (Wang et al., [2023](https://datatracker.ietf.org/doc/draft-wang-cats-green-challenges/04/))). Yet another states:

“The Internet as well as all other IP/MPLS networks are likely the biggest energy saving development of the past few decades if only the energy consumption of equivalent services is compared. On the other hand, they are also the cause for the biggest new type of new energy consumption because of all the new services introduced in the past decades with the Internet and the hyper-scaling that the Internet affords them” ([Eckert](https://datatracker.ietf.org/doc/draft-eckert-ietf-and-energy-overview/00/) et al., 2023).

An informational I-D called “Environmental Sustainability Terminology and Concepts” introduces key definitions to network and protocol designers and implementors.” For sustainability, it turns to the Brundtland Commission’s concept, i.e., meeting “the needs of the present without compromising the ability of future generations to meet their own needs,” and divides sustainability into balancing economic, environmental, and social factors ([Pignataro, et al., 2024](https://www.ietf.org/archive/id/draft-pignataro-green-enviro-sust-terminology-00.txt)). It also introduces terms such as circularity, doughnut economics, and energy equity.

In bringing sustainability and sustainability-related concepts to the IETF, however, much of the work done until now is still bounded by energy topics. These topics are the most visible and imminent environment-related aspects drawing from the SDO’s mandate on the Internet protocol suite. Energy-efficiency seems to become a new principle for networking, one that I-Ds recognize that need to be balanced with other long standing goals such as network resilience and security.

Table 15. Balancing energy efficiency with other principles (my emphasis)

|  |  |
| --- | --- |
| Recommendation Title | Excerpt |
|  |  |
| Power-aware Routing and Traffic Engineering: Requirements, Approaches, and Issues ([2012](https://datatracker.ietf.org/doc/draft-zhang-greennet/)) | “Power-aware routing and traffic engineering is a tradeoff between energy consumption and network resilience. They save power by turning off or slowing down some links, which were previously over-provisioned to obtain better resilience. ***Any power-aware approach will cause loss of network resilience to some extent***.” |
| Challenges and Opportunities in Management for Green Networking ([2022](https://datatracker.ietf.org/doc/draft-irtf-nmrg-green-ps/)) | “Considerable energy savings can potentially be realized by taking resources offline (e.g., putting them into power- saving or hibernation mode) when they are not currently needed under current network demand and load conditions. (…) This contrasts and indeed conflicts with existing schemes that typically aim to create redundancy and load-balance traffic across a network to achieve even resource utilization. This usually occurs for important reasons, such as making networks more resilient, optimizing service levels, and increasing fairness. ***One of the big challenges hence concerns how resource weaning schemes to realize energy savings can be accommodated while preventing the cannibalization of other important goals, counteracting other established mechanisms, and avoiding destabilization of the network.”*** |
| Design Considerations for Low Power Internet Protocols ([2018](https://datatracker.ietf.org/doc/draft-ayers-low-power-interop/)) | “A new generation of low-power devices face a connectivity dilemma: Internet protocols are not designed for energy efficiency, but compression and other energy saving adaptations takes up precious code space. (...) Part of the challenge is that some traditional protocol design principles do not apply well to the low-power setting. We present three design principles for low-power protocols that attempt to remedy this. These principles explicitly acknowledge the ***unique code space/energy tradeoffs of low-power devices***.” |
| A Framework for Energy Aware Control Planes ([2012](https://datatracker.ietf.org/doc/draft-retana-rtgwg-eacp/)) | “As with all network and protocol design, however, reducing energy use represents a tradeoff. In the case of networks, increasing energy efficiency can result in a loss of optimization in network operations in other areas. These kinds of tradeoffs can be described in terms of the state/optimization/surface triad; ***increasing local optimization in one area, energy consumption, can result in global sub-optimization through increased state, more complex interaction surfaces, or even suboptimal global energy usage***.” |
| Architectural Considerations for Environmental Sustainability ([2023](https://datatracker.ietf.org/doc/draft-pignataro-enviro-sustainability-architecture/)) | “Optimizing only network availability (e.g., by having excess capacity and backup paths) or optimizing only performance (e.g., by increasing speeds selecting paths based on delays only) can seemingly be in opposition to optimizing sustainability objectives. For a given application, use-case, or vertical realization of technology, ***a Pareto-efficient choice can potentially improve sustainability without sacrificing availability or performance beyond the application tolerance***. That is, a win-win. Consequently, network architects and designers are presented with a set of new design tradeoffs: a multi-objective optimization that satisfies border requirements and global optima for availability, performance, and sustainability simultaneously.” |
| RFC 6988, Requirements for Energy Management ([2010](https://datatracker.ietf.org/doc/rfc6988/)) | “In many cases, there is no way to reduce power without the consequence of a potential service (performance or capacity) degradation. In this case, ***a trade-off needs to be made between service-level objectives and energy minimization***” |

## Solutions and metrics

The literature recognizes that the bulk of the environmental impact of ICTs resides outside the scope of networking alone, and so do IETF I-Ds. For example, Clemm et al. ([2024](https://datatracker.ietf.org/doc/html/draft-irtf-nmrg-green-ps-03)a) explain that “perhaps the most obvious opportunities to make networking technology more energy efficient exist at the equipment level. After all, networking involves physical equipment to receive and transmit data.” However, equipment specifications are outside the IETF mandate. The SDO, in turn, could play a role in considering the “energy cost of running the network” (Clemm et al., 2024a). The SDO focus on energy efficiency stems from its history in addressing the topic even before the growth of interest on environmental sustainability and its scope within the Internet protocol suite. One I-D explains that “energy efficiency is one of these topics that need to be a design goal or otherwise it will be difficult to retrofit it into a protocol specification” ([Winter](https://datatracker.ietf.org/doc/draft-winter-energy-efficient-internet/) et al., 2012). Because of that, it suggests that the IETF/IRTF could develop a protocol specification against which design patterns could be compared. This process is similar to what happens to security considerations. Every new IETF draft or RFC has a mandatory section detailing any security considerations that might arise from the topic.

Still, IETF should and could acknowledge and work with other layers of the Internet infrastructure. Some Internet-drafts such as Pignataro et al. ([2023](https://datatracker.ietf.org/doc/draft-pignataro-enviro-sustainability-consid/)a; [2023](https://datatracker.ietf.org/doc/draft-almprs-sustainability-insights/)b) and Knodel ([2024](https://datatracker.ietf.org/doc/draft-knodel-beyond-carbon/)) recognize a need for the IETF to move beyond carbon emissions and energy alone, noting the need to address the full spectrum of environmental impacts such as the supply chain of ICTs and its relation to raw materials.

Still, the IETF historically positions itself as responsible only for a particular section of the ICT sector - the Internet protocol suite. As such, the SDO is still navigating what types of topics it wants to and can tackle when it comes to sustainability. For instance, RFC 9547 reports on the results from the IAB workshop and proposes the next steps. It states that “it is useful to find a role and a scope for IETF work in this area. (but) The IETF will not develop alternative energy sources, work on social issues, or have detailed discussions about implementation strategies or electronics design.” Its role resides “in measurement mechanisms, protocol design, and standards” regarding networking technologies ([Arkko](https://datatracker.ietf.org/doc/rfc9547/) et al., 2024).

Clemm et al.’s ([2024](https://datatracker.ietf.org/doc/draft-cx-green-green-metrics/00/)b) informational draft summarizes IETF opportunities “at the level of protocols themselves (e.g., reduction of transmission waste and enabling of rapid control loops), at the level of the overall network (e.g., path optimization under consideration of energy efficiency as a cost factor), and architecture level (e.g., placement of contents and functions).” Other solutions include improving the network utilization of devices that run at low rates (Manral et al., [2013](https://datatracker.ietf.org/doc/html/draft-manral-bmwg-power-usage-04#page-3)) and enhancing management tools to monitor sustainability metrics ([Pignataro, et al](https://datatracker.ietf.org/doc/draft-pignataro-green-enviro-icmp/)., 2024b). Specifically in regard to metrics, one draft calls for industry cooperation on core KPIs, trying to counter greenwashing. It states:

“There is reason to suspect that nebulous definitions combined with the competitive pressure might produce greenwashing. Greenwashing involves making an unsubstantiated claim to deceive consumers into believing that a vendor's product or solution is environmentally friendly or has a greater positive environmental impact than it does.” (Andersson, et al., [2023](https://datatracker.ietf.org/doc/draft-almprs-sustainability-insights/03/)).

The same draft mentions that, aside from the need for consistency in metrics to reduce the environmental impact and increase the benefit of ICTs, it aims to support the European Union’s Digital Product Passport initiative, saying that “there is not much time for businesses to prepare and for IETF work to influence this development” (Andersson, et al., 2023). This is not the only recent draft to refer to EU guidelines. There is a current I-D extending the work started in RFC 6988, on Energy Management, to incorporate the mandate of GREEN WG. It refers to lifecycle management as established in the European Union ecodesign framework (EU 2024/1781), also in connection with the digital passport (Stephan et al., [2024](https://datatracker.ietf.org/doc/draft-stephan-green-ucs-and-reqs/)).

Sustainability-related work within the IETF seems to be gaining momentum just now, after years of minor unsuccessful attempts. In the following chapter, I analyze what types of actors and companies proposed the standards and drafts addressed in this section. I also discuss the motives for their engagement with sustainability topics in the ITU-T and the IETF.

1. In using all of these terms, I follow a pattern that is seen in the standards themselves. For instance, ITU-T standards most of the times use the term ICTs, but also mention digital technologies (L1508/2024). [↑](#footnote-ref-1)
2. For example, RFC 7460 on “Monitoring and Control MIB for Power and Energy” was first introduced in the IETF as an Internet-Draft in 2010. After several updates and debates, it was finally published as an RFC in 2015. In the Graph, it appears under the year 2010. [↑](#footnote-ref-2)
3. While each I-D or RFC may refer to different things when dealing with energy efficiency, one recent draft lay down a definition based off Wikipedia that is in line with past drafts: “Energy Efficiency refers to the ability of an asset to perform its intended functions while minimizing energy consumption. It refers to the ratio between the useful output energy and input energy given by an asset. ([Lindblad](https://www.ietf.org/archive/id/draft-opsawg-poweff-01.txt), et al., 2024). [↑](#footnote-ref-3)