CLASSIFICATION OF GREEN TECHNOLOGY PATENTS IN TELECOMMUNICATION INDUSTRY

Lappeenranta–Lahti University of Technology LUT

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ABSTRACT

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Classification of green technology patents in telecommunication industry

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This thesis explores the classification and impact of green patents in the telecommunication sector, focusing on identifying these patents using patent classification codes. The research is driven by the increasing importance of sustainability in the telecommunication industry, prompted by regulatory pressures and stakeholder demands for environmentally responsible business practices. The study aims to provide a systematic approach to categorizing green patents and to analyse their role in promoting environmental sustainability and enhancing corporate strategies.

The methodology includes a literature review, patent data analysis using Espacenet hosted by the European Patent Office (EPO), and expert interviews with senior patent counsels and patent research engineer. The research identifies key green patent classification codes relevant to the telecommunication sector, including the IPC Green Inventory code G01R and the EPO Y02D code. The study also examines the strategic benefits of green patents, such as accelerated examination processes and the use of green patent data as a metric for corporate sustainability reporting.

Key findings indicate that green patents significantly contribute to reducing the environmental impact of telecommunication networks by fostering innovations that improve energy efficiency and reduce carbon emissions. The research highlights the role of stakeholders in driving sustainability efforts and the economic incentives provided by patents to encourage continuous investment in green technologies. The study also identifies the limitations of the current broad definition of green patents and suggests the need for more stricter criteria to ensure the recognition of genuinely impactful technologies.

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Tämä tutkielma tutkii vihreiden patenttien luokittelua ja vaikutuksia tietoliikennesektorilla keskittyen näiden patenttien tunnistamiseen patenttiluokittelukoodeilla. Tutkimusta ohjaa kestävyyden kasvava merkitys tietoliikenneteollisuudessa, joka johtuu sääntelystä sekä muiden sidosryhmien vaatimuksista harjoittaa vastuullisista liiketoimintakäytäntöä. Tutkimuksen tavoitteena on tarjota systemaattinen lähestymistapa vihreiden patenttien luokitteluun tietoliikenneyrityksissä sekä analysoida niiden roolia ympäristön kestävyyden edistämisessä ja yritysstrategioiden parantamisessa.

Menetelmään sisältyy kirjallisuuskatsaus, patenttitietojen analysointi Euroopan patenttiviraston (EPO) ylläpitämän Espacenetin avulla sekä asiantuntijahaastattelut vanhempien patenttiasiamiehien sekä patentti tutkijainsinöörin kanssa. Tutkimuksessa tunnistetaan tietoliikennesektorille keskeiset vihreiden patenttien luokittelukoodit, mukaan lukien IPC Green Inventory -koodi G01R ja EPOn Y02D-koodi. Tutkimus tarkastelee myös vihreiden patenttien strategisia hyötyjä, kuten nopeutettuja tutkimusprosesseja ja vihreiden patenttitietojen käyttöä yritysten kestävän kehityksen raportoinnin mittarina.

Keskeiset havainnot osoittavat, että vihreät patentit voivat edistävät merkittävästi tietoliikenneyritysten ympäristövaikutusten vähentämistä edistämällä innovaatioita, jotka parantavat energiatehokkuutta ja vähentävät hiilidioksidipäästöjä. Tutkimus korostaa sidosryhmien roolia kestävyyspyrkimysten ajureina ja patenttien tarjoamia taloudellisia kannustimia, jotka rohkaisevat jatkuviin investointeihin vihreisiin teknologioihin. Tutkimus tunnistaa myös nykyisen laajan vihreän patentin määritelmän rajoitukset ja ehdottaa tarvetta tiukemmille kriteereille, jotta vaikuttavien teknologioiden tunnistaminen voitaisiin varmistaa.

ABBREVIATIONS

CCMT	Climate Change Mitigation Technologies
CPC	Cooperative Patent Classification
CSDD	Corporate Sustainability Due Diligence
CSRD	Corporate Sustainability Reporting Directive
EPO	European Patent Office
EU	European Union
ICT	Information and Communication Technology
IPC	International Patent Classification
IPCC	Intergovernmental Panel on Climate Change
ITU	International Telecommunication Union
KPI	Key Performance Indicator
NFRD	Non-Financial Reporting Directive
OECD	Organisation for Economic Co-operation and Development
R&D	Research and Development
SDG	Sustainable Development Goal
UNFCCC	United Nations Framework Convention on Climate Change
WIPO	World Intellectual Property Organization

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1 Introduction

This thesis explores the classification and impact of green patents within the telecommunication sector, focusing on developing a methodology to identify these patents using patent classification codes and examining their practical applications and benefits. As climate change becomes an increasingly urgent global issue, the telecommunication industry faces significant pressure to adopt sustainable practices (UN 2020; Ayers et al. 2024). This topic is crucial right now due to the mounting regulatory demands for sustainability and the growing stakeholder expectations for companies to demonstrate environmental responsibility (European Commission 2024a; European Comission 2024c). In general, understanding how green patents can drive innovation and sustainability in telecommunications is can help with advancing environmental goals and fostering a sustainable, low-carbon economy. United Nations sustainable development goal (SDG) 13, emphasizes the importance of controlling emissions as part of a larger effort to combat climate change and its impacts (United Nations 2024).

Previous studies have highlighted the role of patents in promoting innovation and economic growth. For example, the work of Ferreira et al. (2019) demonstrated that environmental patents significantly contribute to sustainable economic development. Other research, such as that by Hascic & Migotto (2015), emphasized the importance of patent data as a reliable metric for assessing technological advancements and sustainability efforts. The European Patent Office (EPO 2023) has also noted the pivotal role of intellectual property rights in driving innovation and supporting business growth, as evidenced by the commercialization of inventions developed by SMEs.

However, previous research has not thoroughly examined the specific classification and analysis of green patents within the telecommunication sector. While there is a general understanding of the importance of green patents, there is a lack of detailed methodologies for identifying and categorizing these patents within various industries. This study aims to fill this gap by developing a methodology for identifying green telecommunication patents using IPC Green Inventory and Y02/Y04S EPO tagging scheme. Additionally, it discusses the impact of these patents on environmental sustainability and industry practices, providing insights into how green innovations can reduce the environmental footprint and transform industry operations.

1.1 Background

In the evolving landscape of corporate responsibility and environmental transparency, the transition from voluntary to mandatory sustainability reporting (European Comission 2024a) marks a significant shift in how companies communicate their environmental impact. This change is driven by a growing concern regarding climate change the demand for authenticity in corporate environmental claims and the need to prevent greenwashing—where companies misleadingly overstate their environmental efforts (European Commission 2024b).

Consumers today face a multitude of environmental labels on products and services, which frequently leads to confusion and scepticism about their accuracy. The reliability of these environmental claims has come under scrutiny, with evidence suggesting that consumer trust in these claims is alarmingly low. This lack of trust stems from instances where companies have misrepresented their environmental impact, leading to a misleading perception of their products' sustainability. This practice, known as greenwashing, not only misleads consumers, but also undermines the efforts of sustainable businesses and harms the environment by concealing the true impact of products. (European Commission 2024b)

There are already examples of companies being sued for misleading consumers with green claims. A notable case involves the lawsuit brought by New York's Attorney General, Letitia James, against JBS, the world's largest meat company. The lawsuit accuses JBS of deceiving consumers about its climate commitments, alleging that the company falsely claimed to be on a path to “Net Zero by 2040” without taking concrete steps towards achieving these goals. The case highlights a broader trend of increasing legal actions against companies that make unsubstantiated environmental claims. This growing scrutiny and the legal consequences exemplify the significant risks businesses face when they fail to support their sustainability assertions with factual evidence. (Bauck 2024)

Recognizing the critical need for accurate and reliable information, the European Union has taken steps to enhance the credibility of environmental claims through new legislation aimed at combatting greenwashing. A proposed law (European Commission 2024b) on green claims is set to enforce stricter regulations to ensure that environmental labels and claims made by companies are verifiable and based on standardized methodologies. This initiative reflects a broader movement within the EU to protect consumers and the environment, while also supporting the market competitiveness of companies that genuinely invest in sustainable development. Although this legislation primarily targets business-to-consumer products, business-to-business entities should not overlook its implications. Consumers form part of the value chain, and business customers often require compliance with these environmental standards as well.

The shift towards mandatory sustainability reporting is encapsulated in several key legislative developments. The EU Taxonomy Regulation (European Commission 2024c), which came into force in July 2020, establishes a framework to facilitate sustainable investment, helping to standardize what constitutes an environmentally sustainable economic activity. Alongside this, drafts of the Corporate Sustainability Reporting Directive (CSRD) and the Directive on Corporate Sustainability Due Diligence (CSDD) are underway, focusing on increasing the scope and detail of reporting required from companies. These legislative measures are part of an effort to ensure that corporate sustainability claims are not only transparent but also backed by concrete evidence reflecting their true environmental impact. (PWC 2024; European commission 2024a)

The transition from voluntary to mandatory reporting mandates that companies must substantiate their claims with factual evidence. This means that for example, claims about the percentage of research and development dedicated to sustainable practices must be supported by tangible data and adhere to strict reporting standards. This not only ensures transparency but also holds companies accountable for their environmental footprint, paving the way for more informed consumer decisions and fostering a market where sustainable practices are a metric of business excellence.

Although traditional metrics like R&D expenditure and scientific personnel counts are frequently used to assess innovation, patent data can be more effective in capturing the detailed aspects of environmental innovation (Hascic & Migotto 2015; Nagaoka et al. 2010). The value of using patents as a measurement tool stems from their easy accessibility, their quantitative nature which allows for straightforward comparison, their focus on the outputs of innovation, and the detailed information they provide. This level of detail is especially useful when delving into the complexities of environmental technologies, allowing for a more accurate and comprehensive analysis of advancements in this critical field. (Hascic & Migotto 2015, 8-14)

1.2 Research objectives, questions and scope

This thesis explores how to classify patents that promote sustainability in the telecommunication industry and more precisely in the telecommunication network. The study aims to develop a comprehensive method for identifying green patents by reviewing and adapting existing patent classification systems to better capture sustainable innovations in telecommunication network. The thesis also identifies which companies are at the forefront of patenting green technologies in telecommunication industry, examining the and understanding the trends in green patenting over recent years. By evaluating the broader implications of green patents, the study explores how they contribute to sustainability goals such as reducing carbon footprints, enhancing energy efficiency, and promoting the use of renewable resources. The research questions and objectives are illustrated in Table 1.

Table 1. Research questions and objectives.

Research question	Objective
Main research question: *How to identify green telecommunication patents by using patent classification codes and how can green patents be utilized?*	Develop a methodology for identifying green telecommunication patents using patent classification codes and to explore the practical applications and benefits of these green patents in enhancing environmental sustainability and industry practices.
Sub 1: *What are the patent classes that define green technology in telecommunication sector?*	Identify the specific patent classes that define green technologies within the telecommunication sector, providing a methodology for classifying and analysing green patents in this field.
Sub 2: *What impact does the adoption of green telecommunication patents have on environmental sustainability and industry practices?*	Assess the impact of adopting green telecommunication patents on environmental sustainability and industry practices, evaluating how these innovations can contribute to reducing environmental footprints and transforming industry operations.

This thesis concentrates on the direct innovations in telecommunications, rather than how these technologies are used in other industries to support their sustainability efforts. For example, the study does not cover how telecommunications assist in greener traffic control systems or commerce. The goal is to clearly identify and assess the unique contributions to green technology made directly by the telecommunications industry itself, providing a focused look at its efforts toward sustainable advancements.

The geographical scope of this study is confined to Europe, taking into account the European Union's legislation and patent systems which significantly influence the framework and outcomes of green innovations. Some examples from the utilization of green patents have been taken from other regions as well. Additionally, in patent search only applicants from European Union member countries were taken under consideration. The thesis aims to dissect the complex landscape of green patents, examining how they are defined, classified, and utilized to drive ecological benefits in line with European regulatory standards.

1.3 Methodology

This thesis employs a combination of research methodologies to address the research questions. The primary methods utilized include a literature review, patent data analysis, and expert interview. These approaches are designed to provide both qualitative and quantitative insights into the topic of green patents in the telecommunications sector.

The literature review serves as the foundation for answering the sub-questions and partially addresses the main research question. The literature review, which examines existing research, industry reports, and relevant theoretical frameworks, aids in identifying and defining the patent classes that constitute green technology in the telecommunications sector, as well as assessing the impact of green technology patents on sustainable development and industry practices.

Patent data analysis is employed to determine effective strategy for identifying green patents in the telecommunications sector. This method involves using patent classification codes to collect and analyse patent data related to green technologies in telecommunications. Patent data analysis offers quantitative insights that complement the qualitative findings from the literature review, resulting in a more complete understanding of the research topic.

Patents are legal documents granted by a government authority that give inventors exclusive rights to their inventions for a limited period, up to 20 years from the filing date. To qualify for a patent, an invention must meet specific criteria: it must be novel, non-obvious, and industrially applicable. Patents provide detailed descriptions of the invention, including technical specifications, which are publicly accessible. This transparency fosters further innovation by allowing others to build on existing knowledge. Patent systems aim to create incentives for innovation activity and incentives to invest in research and development (R&D). (EPO 2024c)

Patents are increasingly used as an innovation indicator. They provide extensive information on new technology that is systematically screened and evaluated by patent offices. They serve as tangible outputs of R&D activities, reflecting the innovative capabilities of individuals, companies, and countries. (Nagaoka et al. 2010) However, not every innovation is patentable, and not all patentable inventions are patented. Despite these limitations, patent data remains an important source of information for studying technological progress and innovation patterns (Hascic & Migotto 2015).

To gain deeper insights into the patenting process and the classification of green patents, expert interviews are conducted. These interviews involve consulting with a Senior Research Engineer from the Finnish Patent Office (PRH) to understand the classification process of patent applications and engaging with patenting experts from telecommunication company to ensure the selection of appropriate patent classes.

1.4 Structure of the thesis

This thesis is structured into eight chapters (Figure 1). The introduction chapter lays the foundation for the thesis by providing background information, stating the research objectives, formulating research questions, defining the scope, and explaining the methodology and overall structure of the thesis. The next chapter “Ecological innovation in telecommunication sector” delves into the telecommunication sector, discussing the technological background and presenting examples of green technologies within the industry. The third chapter of this thesis “Classification of green patents” comprises of a literature review focusing on patenting, patent classification, green patents, and specific green patent classes. Additionally, it reviews the effects of patenting on sustainability.

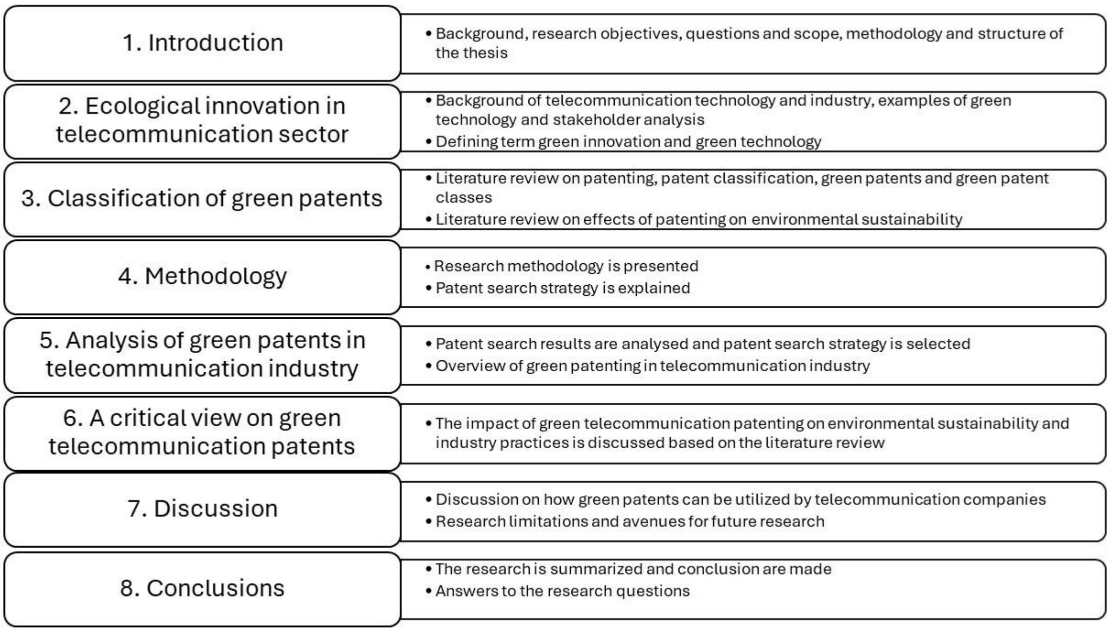

Figure 1. Thesis structure.

The fourth chapter "Methodology" provides an outline of the approaches and techniques used to gather and analyse data. In the fifth chapter "Analysis of green patents in telecommunication industry" the results of the patent search are analysed, and the selected patent search strategy is explained. Sixth chapter "A critical view on green telecommunications patents" discusses the impact of green patenting on environmental sustainability and industry practices, drawing on findings from the literature review and patent search.

The last two chapters are "Discussion" and "Conclusion". The discussion chapter explores how telecommunication companies can utilize green patents. It also addresses the research limitations and suggests avenues for future research. The final chapter summarizes the research, draws conclusions, and answers the research questions formulated at the beginning of the thesis.

2 Ecological innovation in telecommunication sector

Information and communication technology (ICT) sector is facing significant sustainability challenges, primarily due to its substantial energy consumption and the resulting carbon dioxide (CO2) emissions. The environmental impact of ICTs has become a pivotal area of study, with varying views on their role in environmental sustainability (Alatas 2021). While ICTs are praised for their potential to reduce environmental problems, their widespread use contributes significantly to global CO2 emissions. According to joint report of the World Bank and International Telecommunication Union (ITU) (Ayers et al. 2024, 1) the ICT sector generates at least 1.7% of global greenhouse gas emissions every year. The estimate varies across literature from 1.5 to 4% (Ayers et al. 2024, 1). The United Nations' 2030 Agenda for Sustainable Development, specifically SDG 13, highlights the urgency of addressing emissions as part of a broader goal to combat climate change and its impacts (United Nations 2024). (Alatas 2021)

The dual nature of ICT's environmental impact calls for a nuanced understanding to balance technological advancements and sustainability goals (Alatas 2021). According to the European Commission report (Baldini et al. 2024, 20), the emissions from telecommunication sector are quite low compared to ICT sector overall (as indicated in Figure 2). However, this situation may evolve due to the significant growth in data traffic and the corresponding expansion of infrastructure.

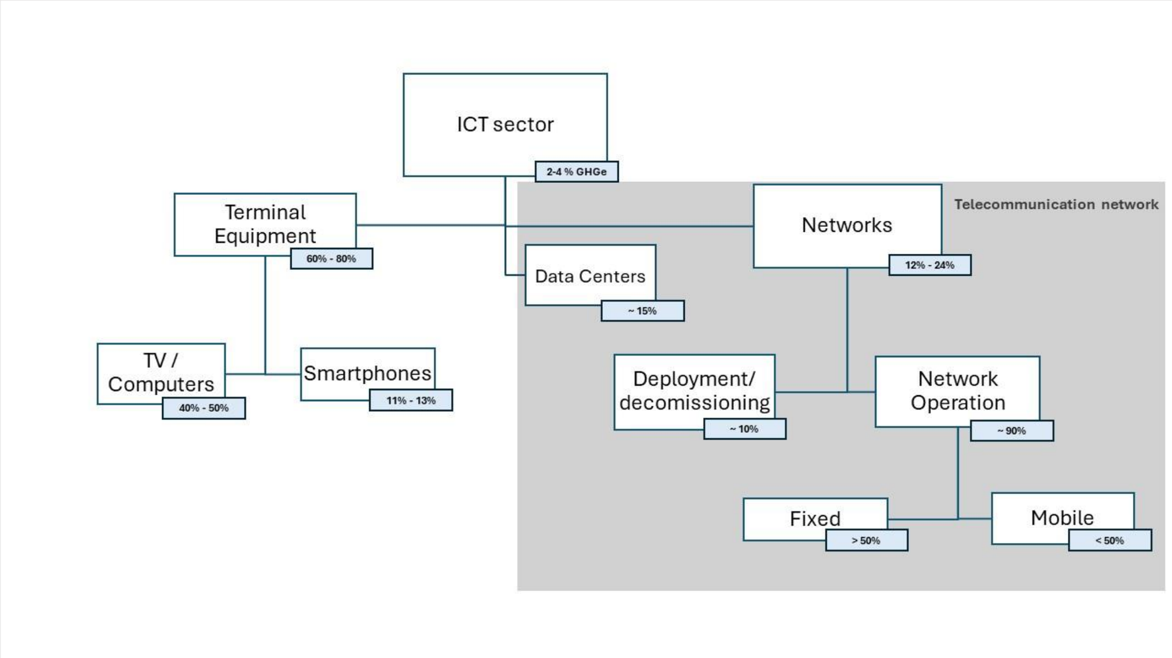

Figure 2. High-level breakdown of ICT sector and their contributions to GHG emissions (Baldini et al. 2024, 20)

While telecommunication networks are a core aspect of the ICT ecosystem, it is important to differentiate their specific environmental impacts from those of broader ICT components. For instance, user-end devices such as smartphones and computers, though crucial to the overall ICT infrastructure, are considered separately from the telecommunication networks. The distinction is crucial for focusing on the specific sustainability challenges and strategies pertinent to the telecommunication sector alone. This thesis focuses on the green innovations in telecommunication networks.

Telecommunication network is a system designed to connect computers and related devices both to each other and to the internet (ITU 2020, 7). Telecommunication network includes both stationary (fixed) and mobile components, forming a structure that handles data traffic. At the core of the network, there are high-capacity cables and equipment that ensure data moves quickly and efficiently. This core part is crucial for maintaining fast and reliable internet service. From there, the network branches out into smaller sections that collect and distribute data to and from local areas. At the edges of this network, there are parts that connect directly to homes, offices, or mobile phones. These edge parts ensure that the final part of the data's journey is smooth, delivering internet services right to the door or directly to a mobile phone. (Baldini et al. 2024, 17-18)

Telecommunication companies and their customers use energy for operating their networks and data centres, contributing to greenhouse gas (GHG) emissions and thus impacting climate change. As a result, environmental sustainability is an essential consideration for the telecommunication industry. Companies in this sector can support sustainability by investing in renewable energy, minimizing energy consumption, and implementing sustainable waste management practices. Moreover, they can advocate for remote working, which helps to reduce emissions related to daily commuting. (Fellenbaum & Taylor 2023, 6)

As the telecommunication industry progresses towards a more sustainable future, the emphasis on accounting for scope 3 emissions becomes increasingly relevant. Scope 3 emissions include upstream emissions associated with the procurement and utilization of goods, services, energy, and capital during production processes (Figure 3). Downstream emissions mostly arise from transportation, processing, usage, and disposal of the company's sold products. Scope 3 also covers emissions related to services such as leased assets, franchises, and investments. (Ayers et al. 2024, 8)

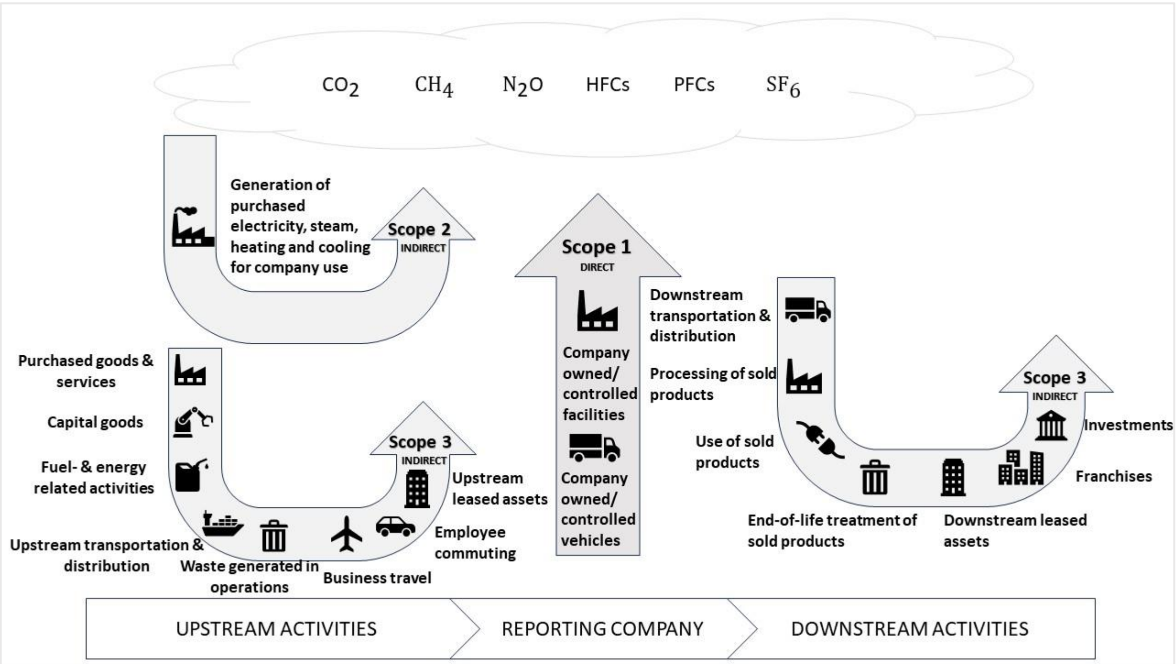

Figure 3. Scope 1, 2 & 3 emissions (Ayers et al. 2024, 8).

According to ITU report (2020, 6). Scope 3 emissions, which encompass the indirect emissions associated with the lifecycle of products, from their production through to their end use by consumers, represent a significant portion of the total emissions footprint for ICT companies.

2.1 Green technology and innovation

In order to examine green patents in the telecommunication sector, it is necessary to define what constitutes as green innovation and green technology. Innovation is the implementation of new ideas, products, or methods in new contexts (OECD 2018). It includes introducing new or significantly improved products (goods or services) to the market, or new processes within an enterprise. Innovations are driven by new technologies, combinations of existing technologies, or other acquired knowledge and must be new to the implementing enterprise. Purely aesthetic changes or reselling external innovations do not count. Innovation covers both product and process improvements and includes active, ongoing, or abandoned innovation activities. Green innovation also known as eco-innovation involves developing and applying new technologies to reduce waste, combat global warming, lower water and air pollution, decrease the use of coal, oil, and electricity, and promote energy conservation (Favot et al. 2023). (Eurostat 2023)

In 2007, Kemp and Pearson offered a widely accepted definition of eco-innovation as "the production, assimilation or exploitation of a product, production process, service or management or business method that is novel to the organisation (developing or adopting it) and which results, throughout its life cycle, in a reduction of environmental risk, pollution and other negative impacts of resources use (including energy use) compared to relevant alternatives." Various other authors and international organizations have also defined eco-innovation, emphasizing the dual goals of reducing negative environmental impacts and improving resource efficiency. Despite differences in definitions, these core effects are universally acknowledged. (Favot et al. 2023)

Green innovation is often used synonymously together with other terms: ecological innovation (or eco-innovation), environmental innovation and sustainable innovation. Even though the definitions have minor differences they can be used largely interchangeably (Table 2). The primary distinction of the terms is that sustainable innovation incorporates social dimensions alongside economic and ecological ones, representing the broadest approach to sustainability. Ecological, environmental, and green innovations, on the other hand, are more focused on ecological impacts, with green innovation taking a pragmatic approach to achieving environmental benefits, regardless of the initial intent. (Schiederig et al. 2012)

Table 2. Term definition (Schiederig et al. 2012)

Aspect	Sustainable Innovation	Ecological Innovation	Environmental Innovation	Green Innovation
Definition focus	Addresses economic, ecological, and social aspects to meet current needs without compromising future generations' ability to meet theirs.	Focuses on new products and processes that significantly decrease environmental impacts, providing customer and business value.	Refers to innovations benefiting the environment and contributing to environmental sustainability.	Innovations related to green products or processes, including energy-saving, pollution-prevention, waste recycling, green product designs, or corporate environmental management.
Environmental aspect	Emphasizes reduced negative environmental impacts, ideally achieving zero impact. Requires comparison to existing alternatives.	Reduced negative environmental impacts.	Reduced negative environmental impacts.	Significant environmental benefits, even if not initially developed with that goal.
Life Cycle analysis	Implied by the need for sustainability over generations.	Explicitly calls for a full life cycle analysis in some definitions.	May not be explicitly mentioned in all definitions.	May not explicitly require full life cycle analysis.
Social dimension	Includes social aspects alongside ecological and economic ones.	Mainly ecological focus, social dimensions are not explicitly covered.	Mainly ecological focus, social dimensions are not explicitly covered.	Mainly ecological focus, social dimensions are not explicitly covered.
Unique attributes	The integration of social dimensions with economic and ecological concerns.	The emphasis on customer and business value alongside environmental impact reduction.	The broad focus on innovations that benefit the environment and contribute to sustainability.	The pragmatic definition that encompasses innovations yielding significant environmental benefits, regardless of the initial intent.

According to the OECD report (OECD 2013, 150), The term "environmental technology" or “green technology” refers to public consensus on specific technical approaches' ability to reduce environmental impacts when compared to available alternatives. Green technologies are defined as technologies that contribute to the restoration or maintenance of the environment by preventing, reducing, or repairing damage caused by pollution, develop renewable or more efficient energy resources or reduce and/or mitigate greenhouse gas emissions and/or climate change impacts. (UNFCCC 2021)

This thesis will examine the concepts of ecological, environmental, and green innovation and technology within the telecommunication industry, with a specific emphasis on technologies that reduce environmental impact. Social and economic factors will not be the primary focus within the scope of the thesis. While these elements are undeniably interconnected with environmental sustainability, the analysis aims to delve specifically into the technological aspects and their direct environmental implications. By doing so, the thesis seeks to provide a clear and concentrated view on how green technologies are being patented within the industry.

The decision to focus the examination on ecological, environmental, and green innovation is motivated by their direct relevance to reducing environmental impacts. These innovations represent an essential solution for the telecommunications industry to address environmental concerns, such as energy efficiency, pollution reduction, and resource conservation.

2.2 Examples of green innovation in the telecommunication sector

Innovations in the telecommunication sector focus on enhancing energy efficiency and reducing emissions. These include advancements in network technology that lower the energy consumption per data unit transmitted. Such green innovations are crucial for reducing the overall carbon footprint of the sector, which is critical given the global climate targets – halving the ICT emissions by 2030. (Ayers et al. 2024, 1-14)

To analyse green innovation in the telecommunications industry, sustainability reports from telecommunications companies can provide guidance on where innovation activities are being directed. Leading telecommunications companies such as Ericsson, and Nokia are actively pursuing green technology to lower their environmental footprint. These inventions are largely concerned with increasing energy efficiency and lowering greenhouse gas (GHG) emissions throughout their operations and product lifecycles.

Ericsson has set targets to improve the energy performance of its product portfolio, aiming to reduce energy consumption of new radio base station sites substantially. Through innovative solutions like AI-based predictive energy management systems, Ericsson has been able to cut energy usage effectively, thereby aiding in the reduction of environmental impact while ensuring network performance. Ericsson also emphasizes the "enabling effect" of ICT solutions on other industries' decarbonization efforts, highlighting the potential of connectivity and network infrastructure in facilitating more sustainable operations across various sectors. (Ericcson 2023)

Nokia has concentrated on embedding energy efficiency into their product development process, notably in their AirScale radio and baseband solutions. These solutions are designed to minimize energy consumption significantly. Additionally, Nokia's AI-powered AVA Energy Efficiency service optimizes energy use across radio networks, reducing carbon emissions and enhancing network energy efficiency. (Nokia 2023)

Moreover, Nokia's focus on circularity is highlighted by its Circular Products and Services portfolio, which promotes the refurbishment, reuse, and recycling of telecom equipment. This initiative not only contributes to environmental sustainability but also supports the transition of the telecommunications industry towards a more circular economy. (Nokia 2023)

When analysing the sustainability reports of two major players in Europe in the telecommunication industry: Ericsson and Nokia, it becomes clear that most of the green innovations created in the examined companies relate to energy efficiency or energy saving in their products and whole value chain. Energy efficiency means technology uses less energy per data bit transfer and energy saving involves technology that enables overall energy use reduction in the network (EIA 2024). Energy efficiency and saving in telecommunication can account to major reduction of energy consumption overall by consumers and with that significantly reduce greenhouse gas emissions.

According to Boston Consulting Group (2021), improving the energy efficiency of telecommunication networks can significantly reduce telecom operators' energy usage and emissions. For example, upgrading to 5G technology is predicted to cut mobile networks' energy consumption by up to 70% every gigabyte of data transmitted. Furthermore, ITU (2022) states that implementing green network techniques, such as employing renewable energy sources and increasing network efficiency, can result in significant energy and cost savings. For example, Orange, which is French telecommunications company, saved almost

170 million EUR in 2020 by installing green features in their networks, proving the financial and environmental benefits of such measures (ITU 2022; Orange 2024)

2.3 Stakeholder interest in sustainability

Sustainability is becoming increasingly important for telecommunication businesses because of its impact on operational efficiency, risk mitigation, corporate reputation, and driving innovation (Fellenbaum & Taylor 2023, 4). Stakeholders play a crucial role in demanding sustainability efforts from companies. As climate change becomes a prominent concern, consumers, activists, employees, and other stakeholders are increasingly pressuring businesses to adopt sustainable practices. Deloitte Global's 2021 Climate Check (Deloitte 2020) report highlights that shareholder demands and societal and employee activism are primary drivers of sustainability actions. Investors are at the forefront, with their demands significantly motivating companies to prioritize environmental sustainability. This pressure from investors influences corporate strategies and financial decisions. Additionally, activism and consistent media coverage keep climate issues at the forefront, compelling businesses to act. (Forbes 2021)

The key stakeholders in telecommunication companies according to Nokia’s and Ericsson’s sustainability reports are customers, employees, investors, suppliers and partners, industries, academia, civil society and NGOs, governments and regulators, and international institutions. Many of these stakeholders are unified by the demand for responsible business operation from companies (Table 3). Sustainable business operation includes for instance, taking into consideration inclusion, diversity and human rights, climate targets and actions, and responsible sourcing. (Nokia 2024; Ericsson 2024)

Table 3. Stakeholders in telecommunication industry. (Nokia 2024; Ericsson 2024)

Stakeholder group	**Key sustainability demands and collaboration efforts**
Customers	• Energy-efficient and environmentally friendly products • Responsible business operation
Employees	• Well-being, health and safety • Ethical business practices • Flexible work and possibility for development
Investors	• Responsible business operation (Inc. supply chain) • Corporate governance • ESG reporting
Suppliers and Partners	• Responsible sourcing • Good working conditions • Sustainable materials (circularity)
Industries	• Standardization for circularity, responsible use of AI, and energy-saving features
Academia	• Research and development of new technology – climate change mitigation
Civil society, NGOs and other	• Education and digital inclusion
Governments and regulators	• Regulation of new technology • Regulation for sustainability

Also new regulation pressures companies to operate more responsibly. The EU Taxonomy establishes a classification system for environmentally sustainable economic activities, influencing investment decisions and guiding companies towards sustainability (European Comission 2024c). Although telecom networks are not explicitly covered, related activities such as data processing and hosting are included, encouraging telecom companies to align their operations with these standards. Other regulation affecting telecommunication companies are directives such as the Non-Financial Reporting Directive (NFRD) and CSRD that mandate large companies to disclose sustainability-related information. These directives aim to improve transparency and drive investments towards sustainable activities. (Baldini et al. 2024, 21-25)

In conclusion, the telecommunication industry is under significant regulatory and stakeholder pressure to enhance its sustainability practices. Meeting these demands involves not only adhering to regulations but also proactively engaging with various stakeholders to promote sustainable development. Telecommunication companies that effectively navigate these pressures can improve their operational efficiency, mitigate risks, enhance their corporate reputation, and drive innovation, ultimately contributing to a more sustainable future.

3 Classification of green patents

Green patents are becoming increasingly important in the field of technological innovation since they serve as a valuable indicator for environmental innovation (Hascic & Migotto 2015). These patents cover inventions that have an environmental advantage, whether directly or indirectly. This wide definition comprises a variety of technologies designed to reduce negative environmental impacts and improve resource efficiency. (Favot et al. 2023)

Addressing climate change and other environmental challenges will necessitate significant innovation, potentially leading to new business opportunities and markets. While there are several metrics for quantifying innovation, such as R&D expenditure and scientific personnel counts, patent data is more effective at addressing the nuances of environmental innovation (Hascic & Migotto 2015, 12-14). Their usefulness as a tool for measuring environmental innovation stems from their accessibility, quantitative nature, comparability, output orientation, and ability to disaggregate details. This granularity is especially useful when investigating the complexities of environmental technologies. (Hascic & Migotto 2015, 8)

Patent data is a valuable metric for assessing sustainable innovations for various reasons. It is grounded in objective standards, recognizing inventions that are novel, non-obvious, and suitable for industrial application. Unlike R&D data, which solely tracks financial investments, or trade data, which may not accurately reflect innovation levels, patent records capture the outcomes of the creative process. Furthermore, patent databases are publicly available and can be used for quantitative analysis. The data can be broken down by specific technological fields, allowing for a detailed study of environmental innovations. (Hascic & Migotto 2015, 16)

Patents demonstrate the disclosure of the technology they protect, frequently years before the related commercial products become available, offering a unique glimpse into the research and development efforts and future offerings of companies. This makes patent-based metrics both objective and predictive, offering critical insights into global innovation trends and how companies invest in inventions related to the Sustainable Development Goals (SDGs). However, patents are not an all-encompassing solution for measuring innovation comprehensively. Limitations arise from the fact that not all innovations are patentable, not all patentable inventions are patented, and the quality and commercial viability of patented inventions vary. (Hascic & Migotto 2015, 16; WIPO 2024b, 9)

The "publication lag" inherent in patent applications, typically disclosed 18 months after filing, introduces another layer of complexity to the production of patent-based indicators. Despite these challenges, the technological nature of patent classification systems, such as the International Patent Classification System (IPC) and Cooperative Patent Classification (CPC), allows for a detailed characterization of inventions, offering over 300 000 technological classes combined (EPO 2024a; Espacenet 2024b). This richness in detail surpasses the capabilities of commodity and industry classifications, providing a robust framework for analyzing environmental technologies. (Hascic & Migotto 2015, 16)

Identifying relevant patents can be approached through classifications, keyword searches in titles or abstracts, or manual selection, or the combination of the methods. Each method bearing its own set of advantages and limitations. Classification-based searches are most common, leveraging the expertise of patent examiners. In contrast, keyword searches face challenges related to language sensitivity and the complexity of designing multilingual search strategies, potentially introducing biases. Manual selection, while precise, is impractical for large-scale analyses due to its time-consuming and expertise-intensive nature. (Hascic & Migotto 2015, 18)

Keywords are often the starting point for many searches. They involve using descriptive words or phrases that relate to the invention's function, structure, or name. The primary drawback of keyword searches is their imprecision. Keywords can have multiple meanings depending on the context, leading to irrelevant results. For example, the term "bridge" can refer to a structure, a musical term, a dental device, or a component in an electrical circuit. Additionally, differences in terminology across regions or industries can complicate keyword searches, as can spelling variations and typographical errors. (Clarke 2018)

Another method involves the use of patent classifications. These classifications, such as the IPC and CPC, organize patents into hierarchical categories based on their technical content. This method leverages the intellectual effort of patent examiners who have already classified the documents, making it a fast track to finding relevant patents. By using classification terms, researchers can quickly narrow down the vast number of patents to those that are most relevant. However, this method requires a good understanding of the technical field and the specific terms used within these systems. (Clarke 2018)

Combining keyword and classification searches can enhance the search process. Keywords can help identify relevant classifications, which can then be used to refine the search. This combination can reduce the number of irrelevant results and increase the likelihood of finding pertinent patents. Nevertheless, even this combined approach has its challenges. The specialized and sometimes deliberately obscure terminology used in patents can make it difficult to craft effective search terms. Patent writers often use unique phrases or complex language to describe inventions, which can obscure straightforward keyword searches. (Clarke 2018)

Patent databases often allow for Boolean algebra searches, using operators like AND, OR, and NOT to combine or exclude terms. Boolean searches offer a powerful way to refine search results, allowing for more precise queries. For instance, using AND between two keywords will return patents containing both terms, while OR will return patents containing either term. NOT can be used to exclude certain terms from the search results. While Boolean searches add a layer of sophistication to the search process, they require a clear understanding of the relationships between search terms and how to construct queries effectively. (Clarke 2018)

This study employs classification searches to identify green telecommunication patents. By using established classification systems IPC and CPC, it’s possible to systematically and efficiently narrow down the vast number of patents to those that are most relevant to green technologies in the telecommunication sector. This approach leverages the effort of patent examiners and patent offices, ensuring a high degree of accuracy and relevance.

3.1 Patent eligibility

For an invention to be eligible for patent protection, it must exhibit novelty, involve an inventive step, and be industrially applicable. Novelty means that the invention is new and hasn’t been disclosed before in patents, literature or any other public document. Patent is distinguished by an inventive step if it’s not obvious to a person skilled in the art. Lastly patent is capable of industrial application if it’s physically possible to make the invention and it can be used in any kind of industry. (EPO 2024c)

According to Article 52 of European Patent Convention not all creations and ideas are eligible for protection under the patent framework. Specifically, inventions that fall into categories such as discoveries, scientific theories, and mathematical methods are not considered patentable because they are seen as foundational knowledge rather than applied technological innovations. Similarly, aesthetic creations do not qualify for patenting. Additionally, schemes, rules, and methods designed for mental activities, game playing, business operations, and computer programs are excluded from patentability, as they do not constitute inventions in a traditional sense. Presentations of information, regardless of their novelty, are also not deemed as inventions suitable for patent protection. (EPO 2020)

Holding a patent grants the owner exclusive rights to decide the use of their invention and protect it against commercial exploitation by third parties for a limited period, up to 20 years from filing. This exclusivity requires the patent owner to fully disclose the invention upon application, making patent applications and granted patents valuable sources of technical information. (EPO 2024c)

European patent application is published after eighteen months from the date of filing or the earliest priority date. Priority date is the date that an invention's first patent application was filed. However, applicant can request earlier publication (Espacenet 2016b). Upon publication, the application is released with its full description, claims, any accompanying drawings, and the abstract, exactly as submitted. All documents related to European patent applications, including the search reports and patent specifications, are published exclusively in digital format on the European Patent Office's (EPO) publication server. The same eighteen-month period is also used by the patent offices in the United States and China (USPTO 2023; Mueller 2021). (EPO 2024d)

3.2 Patent classification systems

Patent classification is a crucial tool for defining the technical field of an invention and conducting efficient searches in patent databases. The two most widely used patent classification systems are IPC and CPC. The patent classification system facilitates focused searches by allowing users to restrict their queries to specific technical fields, thereby keeping the number of search results manageable. This precision is essential for researchers and inventors who need to navigate vast databases to find relevant patents. (PRH 2021)

The IPC, established in 1971, categorizes patents and utility models with around 70,000 different codes based on their technological domain (EPO 2024b; WIPO 2024c). The IPC patent codes are categorized into 8 sections (Table 4). The framework is used globally across all patent databases. IPC classes are indicated on the front page of each patent document, marked with "Int.Cl." followed by a version number, such as "(2015.01)," which signifies the version of the classification used. The IPC is updated annually, ensuring it remains relevant to current technological advancements. (PRH 2021)

Table 4. IPC sections (WIPO 2024c)

IPC code	**Section**
A	Human necessities
B	Performing operations; Transporting
C	Chemistry; Metallurgy
D	Textiles; Paper
E	Fixed constractions
F	Mechanical engineering; Lighting; Heating; Weapons; Blasting
G	Physics
H	Electricity

The CPC builds on the IPC by adding an extra section, Y, for tagging new technologies and cross-sectional technologies, managed jointly by the European Patent Office (EPO) and the US Patent and Trademark Office. With about 250,000 entries across nine sections, the CPC provides a detailed classification that includes emerging technical fields. Both IPC and CPC are designed to evolve, ensuring they remain relevant by reflecting the latest technological advancements and trends, facilitating efficient patent search and analysis. (EPO 2024a; EPO 2024b)

Countries included in the minimum documentation of the international Patent Cooperation Treaty (PCT), such as Germany, France, the United Kingdom, Switzerland, Russia, Japan, Australia, and Canada, also use the CPC for classifying their patent documents. However, not all patent documents are classified under the CPC, so searches using this system might not yield all relevant information. Unlike the IPC, CPC classification codes are not indicated on patent documents and can only be used in online searches. (PRH 2021)

In patent classification systems IPC and CPC technologies are categorized into classes, subclasses and groups in hierarchical manner as shown in Figure 4 and Figure 5. This hierarchical approach ensures that patent databases are user-friendly and that searches yield relevant and manageable results, aiding researchers, inventors, and industry professionals in finding specific technological information. The first level of the hierarchy contains letters from A to H when examining IPC classification and CPC classification has an extra Y section. This is the broadest category in the IPC and CPC system, representing a major field of technology. For example, "H" stands for "Electricity," encompassing all technologies related to electrical systems and devices.

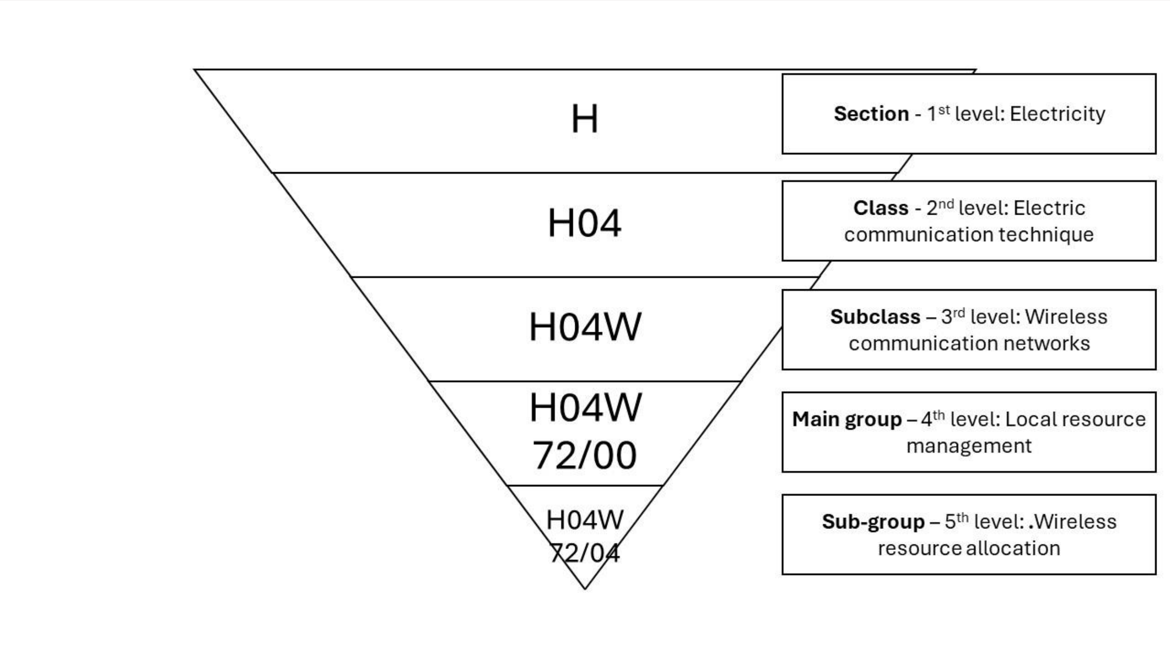

Figure 4. IPC hierarchy (WIPO 2024c)

The class level narrows down the section into more specific areas. For instance, 2nd level class "H04" represents "Electric Communication Technique," which includes technologies related to communication via electrical means. The subclass further refines the class into more detailed technological areas. Third level subclass "H04W" pertains to "Wireless Communication Networks," covering all inventions related to wireless networking technologies. The fourth level, the Main Group, provides more specific categorization within the subclass. "H04W 72/00" pertains to "Local Resource Management," which involves managing resources within wireless communication networks. The fifth level is the Sub-group which goes into more specific technologies that the previous main group. In this example Sub-group "H04W 72/04" focuses on "Wireless Resource Allocation," detailing specific methods and systems for allocating resources within wireless networks. (WIPO 2024c)

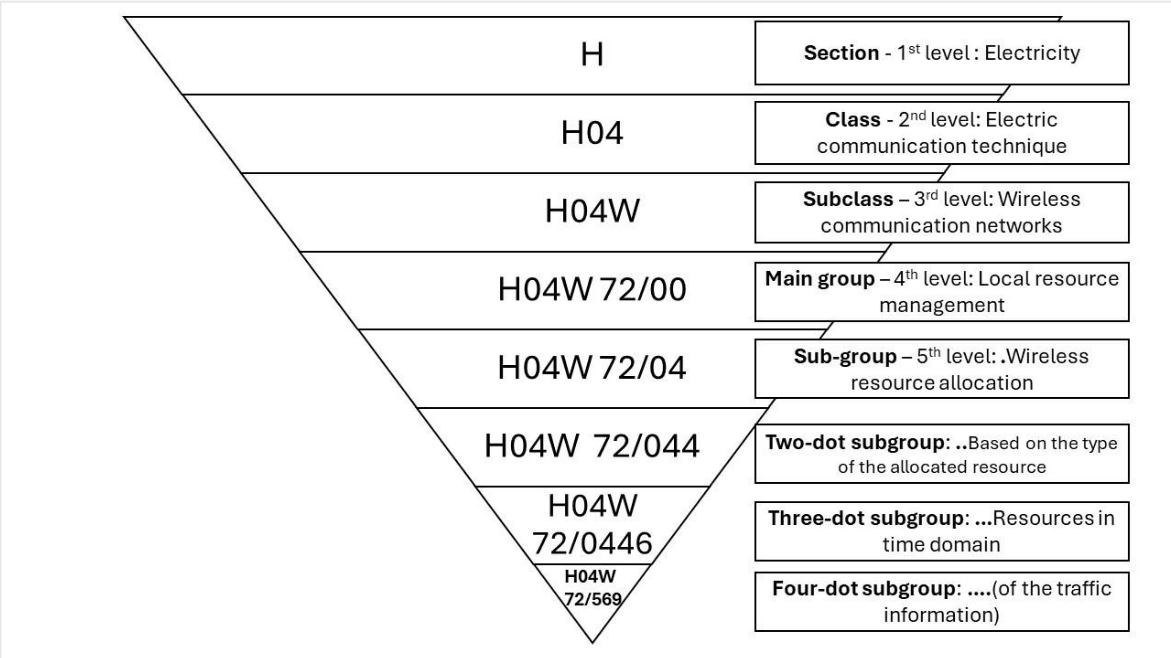

Figure 5. CPC hierarchy (Espacenet 2024a)

The structure of CPC goes more into detail than IPC. It has additional patent classification categories: Two-dot subgroup, Three-dot subgroup and Four-dot subgroup. By narrowing down from broad categories to specific subgroups, patent searches are more precise, ensuring relevant patents are found without sifting through excessive irrelevant data.

3.3 Green patents and accelerated examination programs

Green patents refer to patents that are associated with environmentally sustainable technologies as section 2.1. describes. These technologies aim to provide significant environmental benefits, such as reducing greenhouse gas emissions, improving energy efficiency, conserving natural resources, and mitigating pollution. According to United Nations framework Convention on Climate change (UNFCCC), green patents play a critical role in addressing climate change by fostering innovation in technologies that contribute to environmental sustainability. Green patents cover a broad range of technologies, including renewable energy sources, energy storage systems, pollution control mechanisms, and sustainable agricultural practices. By promoting the development of these technologies, green patents help transition to a more sustainable and low-carbon economy. (UNFCCC 2021)

When classifying a patent as "green," the common practice is to consider a patent protecting a "green" technology if it includes at least one green technology code. This simplified approach is essential in categorizing patents in large datasets, such as the EPO's database which contains over 120 million documents, including over 3 million related to these technologies. (Favot et al. 2023)

Recognizing the importance of addressing environmental issues, many patent offices around the world have implemented Accelerated Examination Programs (AEPs) designed specifically for green technology patent applications. These programs seek to speed up the processing of green patents, encourage innovation, and facilitate the rapid deployment of environmentally friendly technologies. AEPs significantly reduce the time required to examine and grant patents for green technologies. This acceleration is crucial for bringing environmentally beneficial innovations to market more quickly, allowing them to contribute to sustainability goals sooner. (UNFCCC 2021)

By providing faster patent approvals, AEPs create a more attractive environment for investors. Patents often play a vital role in securing funding for technological development. The certainty of a quicker patent process can enhance investor confidence and attract more capital to green technology ventures. Various countries, including Australia, Brazil, Canada, China, India, Israel, Japan, Korea, Taiwan, the United Kingdom, and the United States, have adopted AEPs for green patents. These programs typically cover a wide range of green technologies, from renewable energy systems to pollution control technologies. (UNFCCC 2021)

While the specific criteria for green patents may vary by jurisdiction, they generally include technologies that contribute to environmental sustainability. Many AEPs explicitly prioritize patents that aim to reduce greenhouse gas emissions or provide alternative, less harmful environmental solutions. AEPs often work alongside other policy instruments, such as R&D tax incentives, grants, and subsidies, to promote green innovation. This multi-faceted approach increases the effectiveness of each policy tool, creating a supportive ecosystem for green technology development.

In the United Kingdom, the Intellectual Property Office (IPO) offers the Green Channel for patent applications, introduced on May 12, 2009. This service allows applicants to request accelerated processing of their patent application if the invention has an environmental benefit. To utilize this service, applicants must make a written request indicating how their application is environmentally friendly and specify which actions they wish to accelerate—such as search, examination, combined search and examination, and/or publication. The service is available to patent applicants who make a reasonable assertion that the invention has some environmental benefit. Simple statements suffice for clear cases like solar panels or wind turbines, whereas more detailed explanations are required for less obvious technologies. The IPO does not conduct detailed investigations into these assertions but will refuse requests that are clearly unfounded. This service can be requested for applications filed both before and after the introduction date and can be submitted electronically or by post with no additional fee (GOV UK 2014).

3.4 Green patent classification

In December 2015, government leaders from 195 countries gathered in Paris for the 21st Conference of the Parties (COP21) of the UNFCCC. The summit marked a pivotal moment in global climate action, culminating in the adoption of the first-ever universal, legally binding climate agreement. This landmark accord sets forth international action plan aimed at curbing the rise in global temperatures, striving to keep the increase well below 2°C above pre-industrial levels. The agreement underscores the critical role of "the best available science" in driving swift reductions in global greenhouse gas (GHG) emissions. (Angelucci et al. 2018; UNFCCC 2024a)

In this context, the patent information system emerges as an essential component of climate strategy, serving a dual purpose. First, it acts as an avenue for providing technical knowledge about climate technologies. Second, it serves as an effective tool for measuring innovation by revealing trends in technology development and ownership patterns. This, in turn, allows for more informed climate policy decisions. (Angelucci et al. 2018)

To measure, categorize and identify green patents, various classification frameworks have been developed. In the scope of Europe classification frameworks like ENV-TECH, IPC Green Inventory, and Y02/Y04S Tagging Scheme are crucial in the identification and categorization of green patents. These systems not only provide a structured methodology for recognizing patents driving eco-innovation but also reflect the evolving landscape of green technology. (Favot et al. 2023).

The ENV-TECH framework did not contain relevant patent classification codes for telecommunication network technology. From the Y02/Y04S tagging scheme, the relevant classification code identified is Y02D, which focuses on "ICT technologies aiming at their own energy reduction." This subclass encompasses various lower class codes, all of which were deemed relevant by the senior patent counsel of a telecommunication company that was interviewed for this thesis. However, to achieve more reliable result with non-relevant patent filings filtered out, class Y02D will be combined with IPC telecommunication technology codes (Table 10). The classification code Y02D covers a range of ICT technologies specifically designed to minimize energy consumption, thereby contributing to environmental sustainability within the telecommunication sector.

From the IPC Green Inventory, the classification code G01R, which pertains to "MEASURING ELECTRIC VARIABLES," was identified as relevant for telecommunication network technology by the senior patent counsel that was interviewed for this thesis. However, it is important to note that this subgroup is broad and includes patents beyond just telecommunication networks. To accurately filter relevant patents, it is necessary to use a combination of G01R with other specific telecommunication patent classification codes. This approach ensures that only the patents pertinent to telecommunication networks are identified, providing a more targeted and efficient patent search strategy.

3.4.1 ENV-TECH

ENV-TECH system, introduced by the Organisation for Economic Co-operation and Development (OECD) in 2015, offers a methodology for measuring innovation in environmental-related technologies (Favot et al. 2023). This system uses both the International Patent Classification (IPC) and the Cooperative Patent Classification (CPC) codes to organize technologies across four distinct areas (Table 5). (Hascic & Migotto 2015, 46-58).

Table 5. ENV-TECH categories (Hascic & Migotto 2015, 20)

Technological field	**Patent search strategy**
Environmental health (human health impacts)	1. Environmental management technologies (air pollution abatement, water pollution abatement, waste management, soil remediation, environmental monitoring)
Water scarcity	2. Water-related adaptation technologies
Ecosystem health and biodiversity	3. Biodiversity protection technologies
Climate Change Mitigation Technologies (CCMT)	4. Climate change mitigation – Energy (generation, transmission or distribution) 5. Climate change mitigation – Greenhouse gases (capture, storage, sequestration or disposal of greenhouse gases) 6. Climate change mitigation – Transport **7.** Climate change mitigation – Buildings

ENV-TECH covers approximately 80 different technological fields, indicating a small but significant portion of all patent activity. This comprehensive classification is critical for identifying patents within specific technological realms and provides a foundational layer for the analysis of trends and patterns in environmental innovation (Hascic & Migotto 2015, 19-20).

In ENV-TECH system relevant technology category for telecommunication network inventions is Climate Change Mitigation Technologies (CCMT). CCMT includes technologies that directly or indirectly reduce emission of greenhouse gases or actively promote the sinks of such gases (Angelucci et al. 2018.). This category is covered more throughly in Y02/Y04s EPO Tagging Scheme. In ENV-TECH system telecommunication invention were categorized under "**7.** Climate change mitigation – Buildings" (Table 2), but as the classification frameworks have evolved, telecommunication inventions have their own category under Y02/Y04s Tagging Scheme: "Y02D - telecommunication technologies aiming at their own energy reduction" (Table 6).

3.4.2 EPO Y02/Y04S Tagging Scheme

The European Patent Office (EPO) established Y02/Y04S Tagging Scheme, launched in 2012 to specifically target Climate Change Mitigation Technologies (CCMTs) (Angelucci et al. 2018). This tagging scheme is intricately integrated within the EPO's CPC system, ensuring seamless compatibility with both the CPC and the IPC systems. The Y02/Y04S tagging scheme is applicable only to patents with CPC codes. (Favot et al. 2023)

The Y02/Y04S scheme is focused on applications and technologies that, in the widest sense, may be thought of as mitigating the consequences of climate change. These include applications and technologies that can reduce emissions of greenhouse gases (GHG) or remove (and store) GHG from the atmosphere. This means that any technology that employs renewable energy or improve resource or power efficiency would either directly or indirectly lower the current usage of fossil fuels and the resulting greenhouse gas emissions. Thus, the effects of climate change will be lessened. (Angelucci et al. 2018).

This scheme is not merely a technical tool within the patent system; it garners significant inputs from external stakeholders including researchers, industry experts, UNFCCC negotiators, non-governmental organizations, and others, enhancing its relevance and applicability across different professional spectrums. The collaborative development process of the Y02/Y04s scheme ensures that it captures a wide array of CCMT-related fields (Table 6), thereby supporting industry professionals to identify market competitors, recognize technical trends, and monitor competitive activities effectively. Consequently, patent information gathered via the Y02/Y04s tagging scheme offers valuable insights into the green economy markets, aiding strategic decision-making. For policymakers, the Y02/Y04S results are instrumental in evaluating the gap between the potential and actual implementation of CCMTs. (European Patent Academy 2024)

Table 6. Y02/Y04s Tagging Scheme technology areas (European Patent Academy 2024)

Classification symbol	**Description**
Y02A	Technologies for adaptation to climate change
Y02B	Climate change mitigation technologies related to buildings
Y02C	Greenhouse gases – capture or storage/sequestration or disposal
Y02D	ICT technologies aiming at their own energy reduction
Y02E	Greenhouse gases – emission-reduction technologies related to energy generation, transmission or distribution
Y02P	CCMTs in the production or processing of goods
Y02T	Climate change mitigation technologies related to transportation
Y02W	Climate change mitigation technologies related to waste
Y04S	Smart grids-related technologies

In developing the Y02/Y04s tagging scheme, EPO examiners adopted a pragmatic approach by initially pinpointing relevant classification entries, such as those for CO2 capture technologies. They refined this process by integrating suitable classification entries and search strategies to effectively locate pertinent documents. This methodology has been encapsulated into search algorithms that were utilized by the EPO to tag documents containing CCMTs with Y02/Y04s, thereby allowing comprehensive searches across different categories without disrupting the existing classification framework. (European Patent Academy 2024)

A quality policy was implemented by verifying the results of the algorithms written for each Y-classification code and changing the search statements to decrease the number of improperly obtained documents to a predetermined threshold. The algorithm developers aimed to achieve an error rate of less than 7% for a random sample of 150 documents using the statistical quality control method. (Angelucci et al. 2018)

According to the interview with senior research engineer from Finnish patent and registration office (PRH 2024), since 2022, the Y-classification—which includes Y02 and

Y04S tags—has been automatically assigned to patent documents by artificial intelligence (AI) systems managed by the EPO. The AI-driven classification process involves the use of keywords to identify relevant patents, with the AI reviewing publications twice a week. Since the Y02/Y04s launched in 2012 older patent applications and patents are also re-classified using the scheme (WIPO 2023). According to the senior patent research engineer the primarily role of tagging documents as CCMT is for statistical purposes, allowing large organizations to monitor the progress of green technology trends effectively.

While the classification is not specifically checked by human examiners, the EPO considers this approach reliable enough for its intended use. The AI-based system ensures consistent and efficient classification, which is crucial given the high volume of patent documents. The PRH, for example, uses the Y-classification to monitor green technology in their domestic database, where the classification is assigned by examiners for internal use. (PRH 2024)

The statement of EPO using AI to classify CCMT-related patens is also confirmed by EPO website forum. In this forum the Innovation networks team from EPO replies to a message asking how the allocation of patents is done to Y02 class. In this reply they state: “Since August this year, Y02 groups are being populated thanks to an artificial intelligence model developed at the EPO. This model uses natural language processing to predict the Y02 allocations. Data is updated twice a week. We are currently checking the quality of the CPC allocations and will feed input back into the model to improve it further over time.” (EPO 2022) The information how the AI selects relevant patents is not specified.

Classes Y02 and Y04 are used exclusively for tagging documents that have already been classified or indexed elsewhere but are relevant to specific major technical fields. These fields are defined by notes following the title of the subclasses within these sections. The primary focus of these classes is on technologies that control, reduce, or prevent anthropogenic emissions of greenhouse gases (GHG), as per the frameworks of the Kyoto Protocol and the Paris Agreement. Additionally, they cover technologies that help adapt to the adverse effects of climate change. (USPTO 2024)

The Y02D subclass (Table 7) is dedicated to ICT specifically designed to minimize energy consumption during their operation. This classification focuses solely on technologies within ICT that aim to reduce energy use, not extending to ICT technologies that support the energy-efficient operation of other equipment or the reuse and recycling of ICT devices. The goal of Y02D is to identify and categorize innovations that directly contribute to lowering the energy footprint of ICT equipment, thereby enhancing overall energy efficiency within the sector. (USPTO 2024)

Table 7. Y02D ICT technology (Espacenet 2024a)

Classification symbol	Title and Description
Y02D	Climate Change Mitigation Technologies in information and communication technologies aiming at the reduction of their own energy use
Y02D 10/00	Energy efficient computing, e.g. low power processors, power management or thermal management
Y02D 30/00	Reducing energy consumption in communication networks
Y02D 30/50	• In wire-line communication networks, e.g. low power modes or reduced link rate
Y02D 30/70	• In wireless communication networks

3.4.3 IPC Green Inventory

Another prominent classification is the IPC Green Inventory, developed through the collaboration of the World Intellectual Property Organization (WIPO) with the UNFCCC and the IPCC. First released in 2010, this inventory focuses on Environmental Sound Technologies, which are characterized by their potential for significantly improved environmental performance relative to other technologies. These technologies are less polluting, use resources sustainably, recycle more of their wastes and products, and handle residual wastes in a more environmentally acceptable way than the technologies they replace. (Favot et al. 2023) IPC green inventory leverages IPC classification to retrieve patent information on green technologies. It contains technologies from 7 different areas (WIPO 2024a):

1. Alternative Energy Production
2. Transportation
3. Energy Conservation

4. Waste Management
5. Agriculture / Forestry
6. Administrative, Regulatory, or Design Aspects
7. Nuclear Power Generation

In IPC Green Inventory two categories out of the seven are relevant to telecommunication sector: “Administrative, Regulatory, or Design Aspects” and “Energy Conservation”. The “Administrative, Regulatory, or Design Aspects” category contains a sub-category “Commuting, E.G., HOV, Teleworking, etc.”, which includes an IPC code G06Q and G08G (Table 8). The classification code G08G encompasses a wide range of traffic control systems, extending its scope beyond mere road traffic management to include maritime, aircraft, and other forms of transportation systems. Specifically, this classification covers technologies and systems designed to manage the flow of traffic and enhance safety through various means such as controlling traffic signals, identifying traffic offenders, and managing parking spaces. It includes sophisticated systems that utilize data processing and communication technologies to guide vehicles, manage vehicle speeds, and ensure efficient navigation and positioning for traffic control purposes. (WIPO 2024a)

Table 8. Green inventory category “Commuting, eg., HOV, Teleworking, etc.” classes (WIPO 2024a)

Title and description	**IPC code**
INFORMATION AND COMMUNICATION TECHNOLOGY [ICT] SPECIALLY ADAPTED FOR ADMINISTRATIVE, COMMERCIAL, FINANCIAL, MANAGERIAL OR SUPERVISORY PURPOSES; SYSTEMS OR METHODS SPECIALLY ADAPTED FOR ADMINISTRATIVE, COMMERCIAL, FINANCIAL, MANAGERIAL OR SUPERVISORY PURPOSES, NOT OTHERWISE PROVIDED FOR	G06Q
TRAFFIC CONTROL SYSTEMS (guiding railway traffic, ensuring the safety of railway traffic B61L; radar or analogous systems, sonar systems or lidar systems specially adapted for traffic control G01S 13/91, G01S 15/88, G01S 17/88; radar or analogous systems, sonar systems or lidar systems specially adapted for anti-collision purposes G01S 13/93, G01S 15/93, G01S 17/93; control of position, course, altitude or attitude of land, water, air or space vehicles, not being specific to a traffic environment G05D 1/00)	G08G

The classification code G06Q encompasses ICT systems and methods specially adapted for administrative, commercial, financial, managerial, or supervisory purposes. This broad category addresses the utilization of significant data processing operations required to manage and optimize various business processes across diverse sectors. These systems are vital in performing complex tasks that involve substantial computational power and data handling, which are essential for the efficient operation of businesses in today's digital age. Within G06Q, the range spans from general administrative and management applications (G06Q 10/00) to specific financial services including payment architectures and protocols (G06Q 20/00). Each subgroup within G06Q caters to particular aspects of business operations, such as logistics, office automation, marketing, or even specialized sectors like agriculture or tourism. (WIPO 2024a)

Because the scope of this thesis is the direct outputs of innovation within telecommunication sector these classifications are not relevant. Both classes G06Q and G08G contain use cases of telecommunication technologies in other industries. Class G06Q includes applications in administration, payment architectures, commerce, finance, and tourism sectors, while class G08G is dedicated to traffic control systems. (WIPO 2024a). Although these classifications highlight significant applications of telecommunication technology, they do not directly pertain to the sector's innovations and are therefore not examined in this thesis.

The other relevant category for telecommunication sector is “Energy Conservation” with a subcategory “Measurement of electricity consumption”. The IPC code for the category is G01R: “MEASURING ELECTRIC VARIABLES; MEASURING MAGNETIC VARIABLES (indicating correct tuning of resonant circuits H03J 3/12)” (Table 9). The IPC class G01R encompasses the measurement of electrical consumption, a critical function for managing power usage within devices. Power supply circuits are crucial components in telecommunication and computer products. In the IPC class G01R, several codes are relevant to telecommunication technology. These codes focus on measuring, testing, and monitoring electrical properties and faults that are vital for the operation and maintenance of telecommunication equipment. (WIPO 2024a)

Table 9. Examples of telecommunication related G01R subclasses (WIPO 2024a)

Title and description	**IPC code**
Locating faults in cables, transmission lines, or networks	G01R 31/08
Using pulse-reflection methods	G01R 31/11
Testing of electronic circuits, e.g. by signal tracer (testing computers during standby operation or idle time	G01R 31/28
Testing of digital circuits	G01R 31/317
Arrangements for testing, measuring or monitoring the electrical condition of accumulators or electric batteries, e.g. capacity or state of charge [SoC]	G01R 31/36
Testing power supplies (testing photovoltaic devices H02S 50/10)	G01R 31/40

In conclusion, for this thesis that investigates green patents in telecommunication networks, only IPC code G01R from Green Inventory is relevant due to its direct application in energy conservation and power management within telecommunication networks. The other categories, although important for broader environmental technologies, do not have direct implications on telecommunication innovations and are thus outside the scope of this analysis.

3.5 Effect of patenting on sustainability

There is a growing international interest in patents that focus on climate change mitigation and adaptation. According to Probst et al. (2021) to achieve net-zero emissions, it is important to accelerate the global development and spread of climate change mitigation technology. This chapter explores how environmental patents contribute to sustainability. Environmental patents are a key indicator of innovation in technologies aimed at reducing environmental impacts. These patents represent advancements in processes, products, and systems designed to mitigate ecological harm and promote sustainable resource use.

Green patents also stimulate the creation and development of technologies capable of reducing and/or controlling environmental impacts by utilizing patent acceleration programs. Green patent acceleration programs that were also discussed in chapter 3.3, accelerate the examination of patent applications related to environmental technologies. They have been effective in significantly reducing the time required to obtain patents, promoting quicker dissemination and adoption of green technologies. The programs favour socioeconomic growth and sustainable development, benefiting both current society and future generations. It also enhances legal certainty for inventors and encourages more intensive R&D investments in sustainable technologies. (Gomes et al. 2023; UNFCCC 2021)

According to an EPO report “Patents paving the way for more sustainable future” (2023) Intellectual property (IP) rights play a pivotal role in driving innovation, creating employment opportunities, and supporting business growth. They provide inventors and companies with the necessary protection and incentive to develop new products and technologies. This protection encourages further investment in research and development, leading to a continuous cycle of innovation. Around two-thirds of inventions developed by SMEs are actively commercialized after filing a patent application with the European Patent Office. This commercialization is critical because it not only brings new and improved products to market, but also generates revenue that can be reinvested in future innovation. Furthermore, the process of bringing these inventions to market generates numerous job opportunities in a variety of industries, including research and development, manufacturing, and sales. (EPO 2023)

The findings of Ferreira et al. (2019) further elaborate on the positive influence of environmental patents on economic growth. The text highlights that environmental patents significantly contribute to GDP growth in European countries. Additionally, while environmental management patents show no significant association with GDP growth, water-related adaptation technology patents positively influence economic growth across all regions studied, with particularly strong effects in Europe overall.

Furthermore, climate change mitigation patents have a significant positive impact on GDP growth in Europe. This reinforces the idea that sustainable technology transfer and climate change mitigation technologies can drive economic growth while addressing environmental concerns. The research underscores that regional contexts within Europe influence the effectiveness of environmental patents, suggesting that coordinated efforts in innovation and technology transfer are crucial for achieving economic growth alongside environmental sustainability. Technology transfer encompasses more than just the selling or licensing of intellectual property. It also refers to the act of allowing residents from one country or region to use technology developed in another (Ferreira et al. 2019)

Also, regions outside EU show positive results on green patents promoting sustainability. According to a study researching relationship between green patents, R&D expenditure, energy use, and carbon dioxide emissions in 118 Chinese cities under the China Pilot Low Carbon City Program (Abbas et al 2024) the impact of green patenting on environmental sustainability is multifaceted and significant. The study found that green patents promote environmental sustainability by facilitating the development and implementation of technologies designed to reduce carbon emissions and improve energy efficiency.

The research reveals that allocating resources towards R&D and green technological innovation can substantially increase environmental sustainability. Green patents were shown to effectively mitigate emissions, supporting the Environmental Kuznets Curve (EKC) theory, which posits that environmental degradation initially increases with economic growth but decreases after reaching a certain level of economic maturity. The study's findings indicate that, as cities grow economically and invest in green technologies, there is a shift towards lower carbon emissions, thereby validating the EKC hypothesis. (Abbas et al. 2024)

Additionally, a systematic review of the literature by Sadegh Abedi and Mehrnaz Moeenian (2021) underscores the importance of environmental patents in fostering sustainable development. Their research in the Middle East shows that environmental patents and climate change mitigation technologies have a significant positive impact on sustainable economic growth. The results highlight that the environmental patents and environment management and technologies related to climate change mitigation contribute significantly to sustainable economic development and growth rate in the studied countries (Abedi & Moeenian 2021).

Abedi and Moeenian (2021) emphasize the pivotal role of technology transfer in the economic development of the Middle East. The study highlights how the adoption of green technologies developed in other countries can spur local innovation and economic growth. By integrating advanced environmental technologies into their economies, Middle Eastern countries can mitigate environmental degradation while achieving economic advancement. The authors argue that sustainable economic growth is feasible without compromising environmental integrity, provided that innovation and knowledge transfer are strategically managed. This approach not only helps in reducing carbon emissions but also enhances the overall technological capability of the region, fostering a more resilient and sustainable economic structure (Abedi & Moeenian 2021).

In conclusion, environmental patents play a meaningful role in driving technological advancements that support ecological sustainability. By providing economic incentives, patents encourage the development and adoption of green technologies, thereby promoting sustainable growth and mitigating environmental impacts. Despite the broad and inclusive definition of green patents, strategic focus on R&D and effective patent classification systems are essential to ensure that genuinely impactful innovations are recognized and promoted. The positive impact of green patenting on sustainable development emphasizes the need for continued support and refinement of IP systems to address global environmental challenges.

4 Methodology

This chapter outlines the methodology employed in this research to explore the classification and impact of green patents in the telecommunication industry. The study adopts an exploratory research approach, combining qualitative and quantitative methods to seek new insights, and assess phenomena of green telecommunication patenting. The primary aim of this research is to gain new insights into the classification of green patents and their impact telecommunications sector. Exploratory research is particularly useful for clarifying understanding of issues, problems, or phenomena. This approach is flexible and adaptable to change, which is crucial for a study that seeks to explore relatively uncharted territory.

This study adopts a mixed-methods approach, incorporating both qualitative and quantitative research methods to answer the research questions. Chapter two and three covers literature review. This review involves examination of existing literature to establish a foundation for the research questions. It encompasses prior research findings and industry reports. Additionally, interviews are conducted with two patenting experts in telecommunication technology and official from patent registration office. These interviews provide insights into the telecommunication patents and classification processes, offering qualitative data that gives a foundation for the quantitative analysis.

Patent data analysis is used as a quantitative research method in this thesis. The focus is on developing an effective patent search strategy to identify green telecommunication patents and evaluating a telecommunications company's performance in patenting green technology compared to other industry players. This involves utilizing Espacenet, hosted by the European Patent Office (EPO), to obtain relevant data.

4.1 Expert interviews

Interviews were conducted with two senior patent counsels from a telecommunication company and a senior research engineer from the Finnish Patent Office (PRH) to gather detailed insights into the classification and tagging of patents.

Two senior patent counsels from a telecommunication company were interviewed to identify relevant patent classes for telecommunication patents. They assisted in selecting the most pertinent patent classes related to telecommunication network technology. These interviews were free-form, allowing for an in-depth discussion. The results of preliminary research were presented to the counsels, and together, we reviewed which patent classes were relevant for telecommunication network technology.

A senior research engineer from the Finnish Patent Office (PRH) was interviewed about the Y02/Y04S EPO tagging scheme. The objective was to understand the patent classification process, with a particular focus on the Y02/Y04S classifications. Prior to the interview, a list of questions was prepared and refined through brief email exchanges. During the interview, questions were further refined as new information emerged. The translated version of the interview is provided in Appendix 1.

4.2 Data collection and analysis

The primary source of data for this study is Espacenet, an extensive patent search database hosted by the EPO. Espacenet provides access to millions of patent documents from around the world, making it an invaluable tool for conducting comprehensive patent searches. The focus of this study is to identify and analyse green patents within the telecommunication sector with applicants in EU member countries, using the IPC Green Inventory G01R and the Y02 classification codes. The search covers patents with a priority date between January 1, 2003, to December 31, 2022. The data was collected June 12, 2024.

The patent search results will provide filings on a patent family level and by priority date. A patent family is a collection of patent applications or publications that are related to a single invention and are identified by common priority numbers and priority dates. These family members are filed with various national or regional patent offices, as well as the World Intellectual Property Organization (WIPO), and they all claim the same priority or priorities. This means they are linked by one or more priority applications, providing a unified view of the patent's international status. Patent families are critical for understanding an invention's global scope and protection. (Espacenet 2016a; Espacenet 2022)

The objective of this analysis is to demonstrate a practical use case of how green patents can be utilized. By examining green technology patenting in the telecommunications sector, the study aims to illustrate how these patents can help analyse the green technology initiatives of corporations. This analysis can provide insights into how companies are innovating in the field of sustainable technology and highlight their contributions to environmental sustainability.

To obtain the data, the study employs a Boolean search algorithm. Boolean search techniques use specific operators to combine or exclude keywords in a search, enhancing the accuracy and relevance of search results. The primary operators used in Boolean searches are "AND," "OR," and "NOT". (Clarke 2018)

AND operator is used to ensure that all the terms it connects are present in the search results. For example, a search query "G06F AND G06J AND H04B" will return only those patents that include all three of these IPC codes. OR operator is used to include any of the terms it connects. For example, "G06F OR G06J OR H04B" will return patents that include any one of these IPC codes. NOT operator excludes specific terms from the search results. For example, "G06F NOT H04B" will return patents that include the G06F code but exclude those that also include the H04B code.

For this study, the search term used is:

(G06F OR G06J OR H04B OR H04H OR H04J OR H04K OR H04L OR H04M OR H04N OR H04Q OR H04T OR H04W) AND (G01R OR Y02D)

Once the data is collected, the next step involves analysing the dataset to identify trends, patterns, and insights related to green patenting in the telecommunication sector. The analysis focuses on two key aspects: trend analysis and company activity analysis. By plotting the data over time, graphs can be generated to illustrate the recent evolution of green technologies in the telecommunication sector. This helps in identifying growth trends, emerging technologies, and shifts in patenting activities over the selected period. The dataset is also used to determine the most active companies in filing green patents. This involves analysing the number of patents filed by different companies and identifying leaders in green innovation within the telecommunication sector.

5 Analysis of green patents in telecommunication

In the literature review, three green patent classification methods were identified: the ENV-TECH framework, the Y02/Y04S Tagging Scheme, and the IPC Green Inventory. Among these, the Y02/Y04S Tagging Scheme class Y02D was identified as relevant for telecommunication network technology, while the IPC Green Inventory highlighted the patent classification code G01R.

This chapter outlines the patent search strategy employed to identify telecommunication network patents and examines the industry leaders in green technology patenting over a 20-year span from January 1, 2003, to December 31, 2022. The 20-year period was chosen because it represents the maximum age of a patent, ensuring a comprehensive view of the industry's patenting activity. By examining this extended period, we can observe how patenting activity has shifted over time, providing insights into long-term trends and changes in focus within the industry. Due to the typical 18-month publication delay for patents, the analysis includes patents filed up until the end of 2022 to ensure complete data.

It is crucial to consider that not all patent documents and families displayed by Espacenet are active. Furthermore, companies often file patents through subsidiary entities, which can obscure the true patenting activity of the parent company. Despite these limitations, the search results offer an indicative picture of the state of green patenting in the telecommunication sector.

By combining the identified classification methods and employing a patent search strategy, this chapter provides a detailed analysis of green patenting within the telecommunications industry. This analysis helps to illustrate the trends in sustainable innovation among industry leaders, offering insights into both historical and recent advancements in green technology patenting. This comprehensive approach allows us to understand the evolution of green patenting activities and identify key players driving sustainable innovation in telecommunications.

5.1 Patent search strategy

The chosen patent codes G01R and Y02D may contain technologies that are not relevant for telecommunication technology. To effectively filter green telecommunication patents from the patent classes, a combination of IPC codes H04 and G06 will be employed. These classes are crucial for maintaining a focus on telecommunication technology inventions, and their selection is further refined with the expertise of a Senior Patent Counsel from a telecommunication company. Within the IPC class G06 “Computing; Calculating or counting”, the relevant subclasses for telecommunication network patents are F and J. Similarly, within the class H04 “Electric communication technigue”, the relevant subclasses include B, H, J, K, L, M, N, Q, T, and W (Table 10). These specific subclasses are utilized to filter the search results because they are frequently associated with telecommunication network patents, covering the majority of relevant inventions in this field. (Espacenet 2024a)

Table 10. Codes for telecommunication network technology (Espacenet 2024a)

Title	IPC code
Electric digital data processing	G06F
Hybrid computing arrangements	G06J
Transmission	H04B
Broadcast communication	H04H
Multiplex communication	H04J
Secret communication; Jamming of communication	H04K
Transmission of digital information, e.g. telegraphic communication	H04L
Telephonic communication	H04M
Pictoral communication	H04N
Selecting	H04Q
Indexing scheme relationg to standards for electric communication tehcnique	H04T
Wireless communication networks	H04W

By employing these specific IPC subclasses, the search strategy ensures a high level of precision in identifying patents that are genuinely related to telecommunication network technologies. This targeted approach minimizes the inclusion of irrelevant patents, thereby enhancing the accuracy and relevance of the search results. With these classifications selected the search term is:

(G06F OR G06J OR H04B OR H04H OR H04J OR H04K OR H04L OR H04M OR H04N OR H04Q OR H04T OR H04W) AND (G01R OR Y02D)

Its important to note that IPC classes identified above also contain CPC classes, for example three-dot subclass. For this reason classes identified are searched with the term IPC or CPC. To simplify the illustration of the search process, the first part of the search term can be represented as X. Thus, the search term becomes:

X AND (G01R OR Y02D

The area marked with grey in figure 6 represents the patent search scope. This figure does not accurately represent the actual ratio of overlap between the technologies classified under G01R, Y02D, and X. Instead, it serves as a conceptual illustration to define the scope of the search.

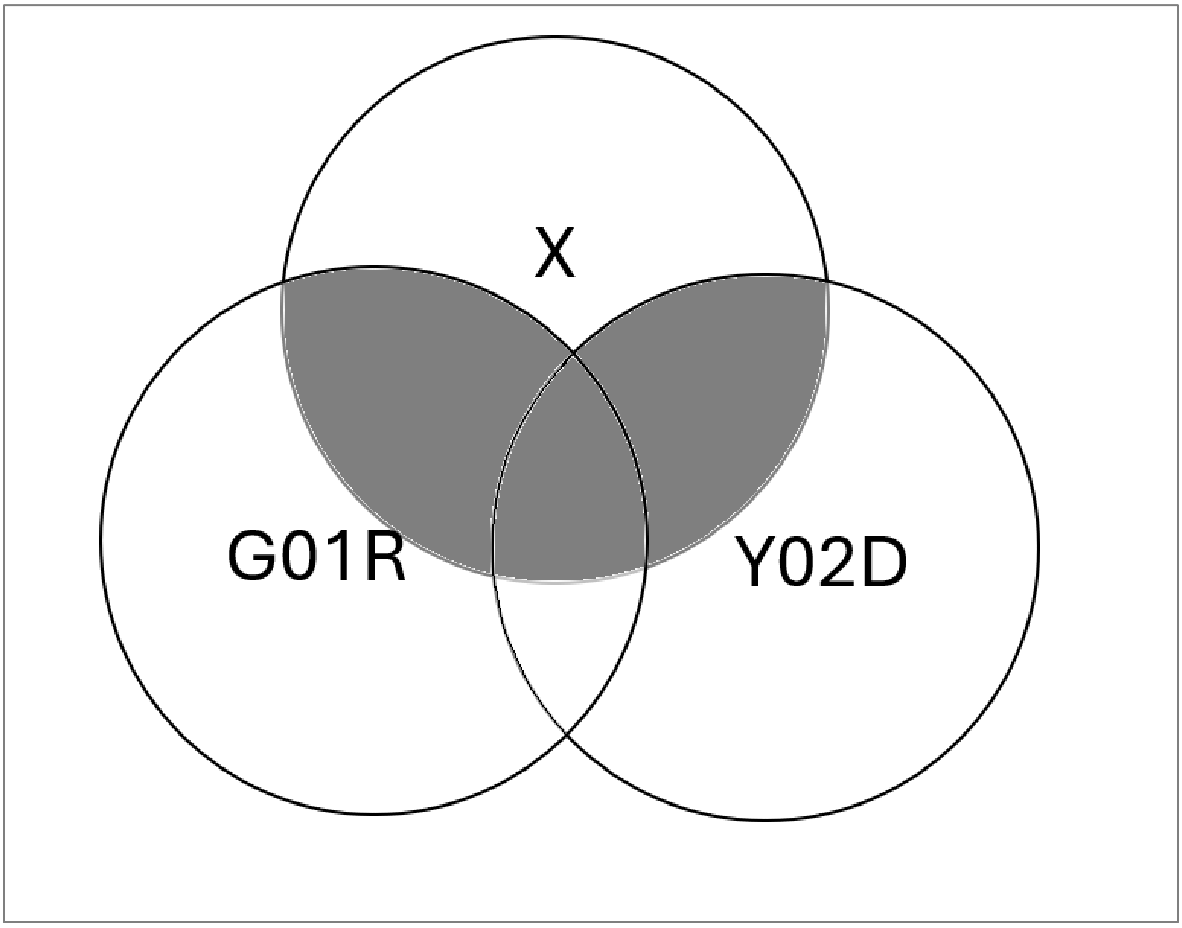

Figure 6. Illustration of green telecommunication network patent search results

An alternative approach for conducting a green patent search in the telecommunication sector involves combining all green patent codes from the IPC Green Inventory, the EPO Y02/Y04S tagging scheme, and the ENV-TECH framework. By utilizing the AND function in a Boolean search method, these green patent codes can be cross-referenced with the frequently used telecommunication network technology codes mentioned earlier: G06 and H04. This comprehensive search strategy would help identify patents that might be classified in less obvious categories, ensuring a broader capture of relevant green technologies.

This method is particularly beneficial when examining the green patents of a specific company, as it provides a holistic view of the company's green patenting activities. By encompassing a wider range of green patent codes, this approach can reveal the full extent of a company's innovation efforts in environmental sustainability.

However, to maintain the focus and scope of this research, the study is confined to the most relevant green patent classes for telecommunication network technology: Y02D and G01R. By concentrating on these specific classifications, the research remains contained and manageable, while still providing a thorough analysis of green patenting in the telecommunication sector.

5.2 Industry overview

This section examines the trends of green patents within the telecommunication sector, focusing on major industry players and their contributions to environmental sustainability through innovation. The analysis utilizes two critical classification codes identified in the previous chapters G01R and Y02D.

The search will cover a span of 20 years (1.1.2003 – 31.12.2022), corresponding to the maximum lifespan of a patent, providing a comprehensive view of long-term trends and patterns in green patenting within the industry. To ensure the most accurate representation of when innovations were initially developed and introduced, the search will utilize the priority date of patents. This approach not only highlights when the inventive activities actually took place but also avoids the variations introduced by publication delays, thus giving a more precise timeline for the development of green technologies in the telecommunication sector. Since the geographical scope of this thesis is European union, non-EU companies are filtered from this search:

Applicants - country: DE OR SE OR FR OR FI OR NL OR IT OR IE OR AT OR ES OR BE OR DK OR LU OR PL OR HU OR CZ OR GR OR RO OR PT OR EE OR BG OR CY OR SI OR HR OR SK OR LT OR MT OR LV

When examining green telecommunication patents in EU region during 20-year period 11,836 search results are identified. Search result provides the number of patent families filed and not individual patent applications. When examining the patents filed under the main company names alone, Ericsson Telefon AB L M holds 1,664 filings, and Nokia Corporation has 542 filings (Figure 7). However, this initial count does not account for the patents filed by their respective subsidiary companies, which substantially increase their total patent portfolios.

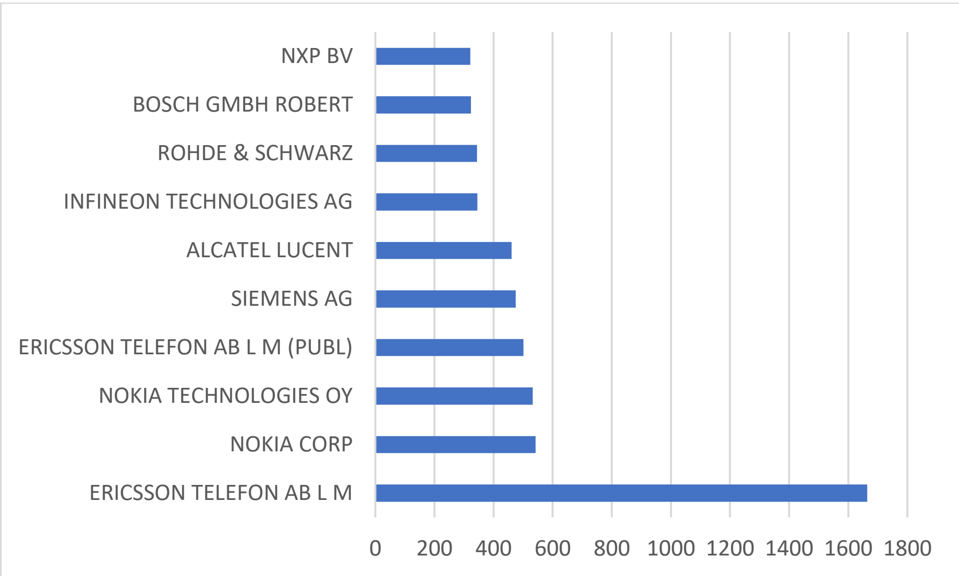

Figure 7. Top 10 EU companies in filing green telecommunication network patents during 20-year period (Espacenet 2024a)

When considering the patents filed by all identified Ericsson subsidiaries, the total number of patent filings for Ericsson rises to 2 373 families. This figure includes the patents held by Ericsson Telefon AB L M (Publ) with 501 patent families. In the same twenty-year period Ericsson and its subsidiaries has filed overall 34,998 patents on a family level. Which means that 6.78% of all the patents filed during this period are green patents families. (Espacenet 2024a)

Similarly, when combining the patents filed by all identified subsidiaries of Nokia, total rises to 2,297 patent filings. This combined total includes 533 patent families held by Nokia Technologies OY and 461 patent families from Alcatel Lucent. In the same period of time Nokia has filed for 41,052 patents on a patent family level. Which means that 5,6% of all patent families filed during this period are considered as green. (Espacenet 2024a)

This data highlights Ericsson's stronger emphasis on green technology, with a higher percentage of its patents classified as green compared to Nokia. While Nokia has a larger total number of patent filings, a smaller portion of its innovations focus on green technologies, reflecting potentially different strategic R&D priorities between the two companies.

Other notable European companies in the green telecommunication patent landscape include Siemens AG, which holds 475 patents, Infineon Technologies AG, with 345 patents, and Rohde & Schwarz, with 344 patents, also make significant contributions.

Bosch GmbH Robert, holding 322 patents, and NXP BV, with 320 patents, are key players in the automotive and semiconductor industries. Their involvement in telecommunication network technology patents illustrates the cross-industry importance of green innovations and the integration of sustainable practices across different technological domains. (Bosch 2024; NXP 2024)

The analysis of European companies' patent data reveals that Ericsson and Nokia are the primary drivers of green innovation in the telecommunication sector. Their substantial patent portfolios, when considering all subsidiaries, highlight their significant contributions. Additionally, companies like Siemens, Infineon Technologies and Rohde & Schwarz, are also pivotal in advancing green technologies within the industry. These companies' efforts are crucial in shaping the future of sustainable telecommunications, emphasizing the critical role of innovation in achieving environmental sustainability goals.

To understand the trends in green patenting in the telecommunication sector, the frequency of patents filed from January 1, 2003, to December 31, 2022, was analysed. The data shows a dynamic landscape, reflecting various economic, regulatory, and technological influences over the two decades (Figure 8).

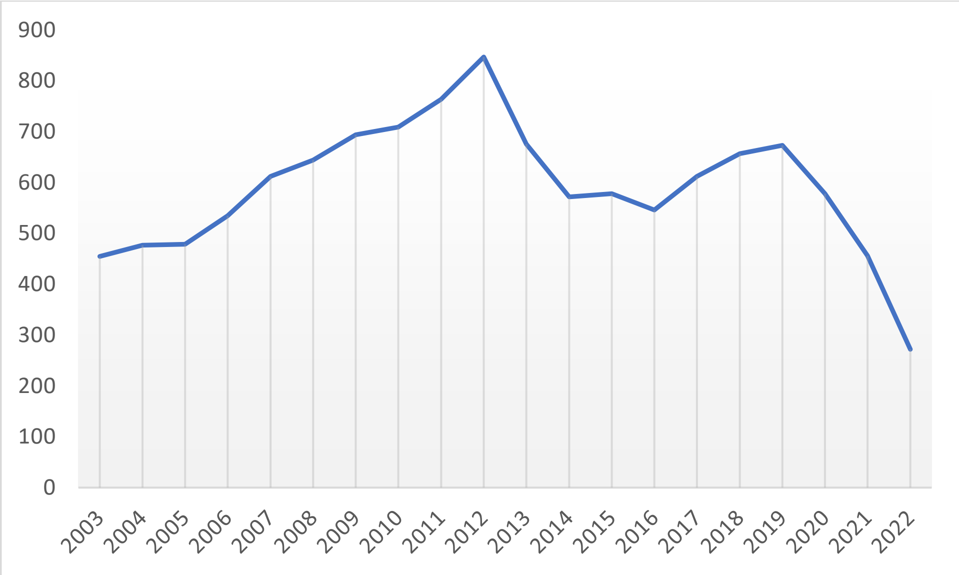

Figure 8. Patenting frequency of green telecommunication network patents by EU applicants during 20-year period (Espacenet 2024a)

When examining all telecommunication patent filings in EU during the same period of time, the graph reflects similar trends in patenting than in green telecommunication patent filings but with relatively more moderate fluctuations (Figure 9).

Search term: G06F OR G06J OR H04B OR H04H OR H04J OR H04K OR H04L OR H04M OR H04N OR H04Q OR H04T OR H04W

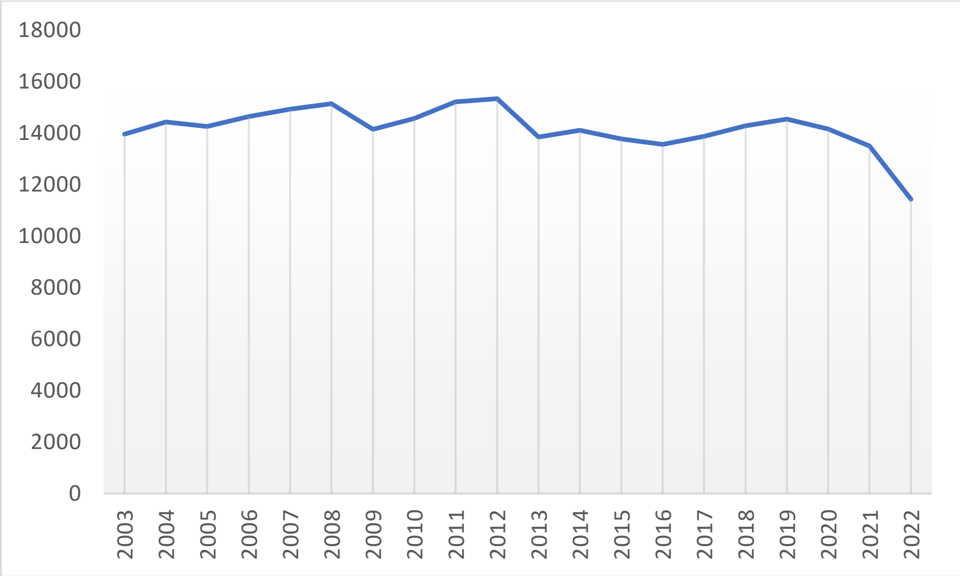

Figure 9. Patenting frequency of telecommunication network patents by EU applicants during 20-year period (Espacenet 2024a)

Both data sets show an overall increasing trend from 2003 to 2012, with green telecommunication patent filings starting at 455 in 2003 and peaking at 847 in 2012, while all telecommunication patent filings start at 13,961 in 2003 and peak at 15,333 in 2012. This simultaneous peak in 2012 indicates a period of heightened innovation and patent activity within the telecommunications sector, likely driven by similar underlying factors such as advancements in technology, increased market demand, and supportive regulatory environments. Green telecommunication patent filing spike can also be attributed to heightened regulatory pressures and global commitments to address climate change, such as the Kyoto Protocol and the Copenhagen Accord that entered into force 2005, which emphasized the need for sustainable development and green technology innovation (UNFCCC 2024b; UNFCCC 2009).

Following the peak year of 2012, both green and general telecommunication patent filings exhibit a decline, though not uniformly steady. Green patent filings drop to 676 in 2013, stabilize around the mid-500s to 600s range from 2014 to 2016, and then show a rebound in 2017 with 612 filings. However, the numbers decline again, reaching a low of 272 in 2022. Similarly, all telecommunication patent filings decrease to 13,849 in 2013 and continue to fluctuate, generally maintaining numbers between 13,000 and 14,000 until a further decline to 11,428 in 2022.

The parallel trends suggest that broader industry dynamics, such as economic conditions, shifts in regulatory policies, and changes in investment strategies, impacted both green and general telecommunication innovations similarly. The noticeable decline after 2012 might reflect market saturation, a strategic shift towards more focused research and development efforts, or evolving priorities within the sector, including the impact of global economic disruptions like the COVID-19 pandemic in 2020.

The global trend in green telecommunication patent filings reveals a different pattern compared to the European Union (Figure 10). While the EU experienced a peak in 2012 followed by fluctuations and a decline in recent years, the worldwide data shows a consistent and substantial increase, particularly from 2016 onwards. The number of green patent filings rises significantly, with a notable surge starting in 2017 and continuing to skyrocket through 2021. This global surge contrasts with the EU's more varied trend, suggesting that other regions might be investing more heavily or experiencing fewer disruptions in green telecommunication innovations. The sharp rise in global patent filings, peaking at over 30,000 in 2021, underscores a robust and expanding commitment to green technology on a global scale, driven by international policies, increased environmental awareness, and possibly more aggressive R&D investment strategies outside the EU.

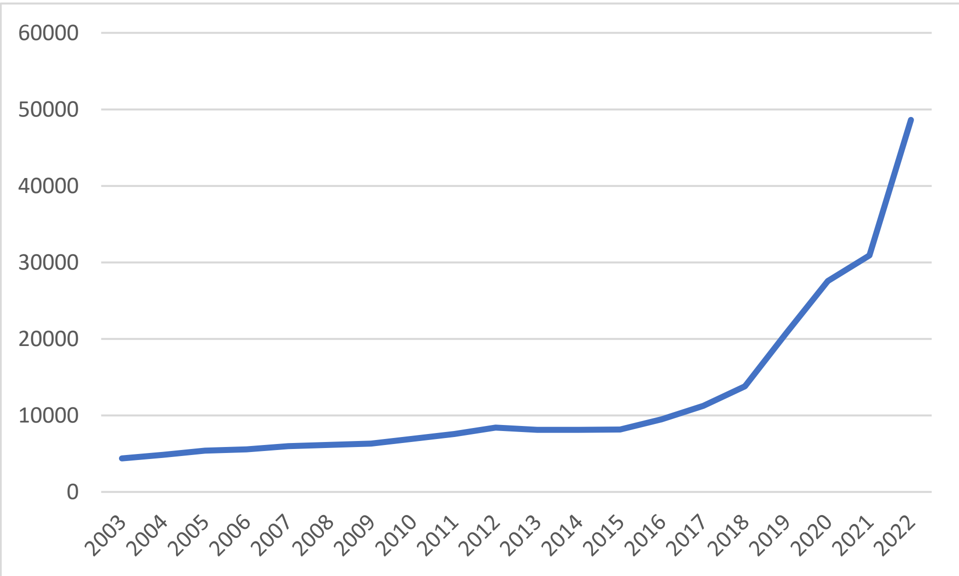

Figure 10. Patenting frequency of green telecommunication network patents by global applicants during 20-year period (Espacenet 2024a)

The global landscape of green telecommunication patents is significantly influenced by three leading companies: Samsung Electronics Co. Ltd., Huawei Technologies Co. Ltd., and

Qualcomm Inc. Samsung, with 4879 patents, leads in innovations focused on energy-efficient telecom infrastructure and sustainable materials (Samsung 2024). Huawei, closely following with 4,582 patents, excels in developing energy-efficient base stations and smart grid technologies, underscoring its strategic emphasis on reducing the environmental impact of its extensive telecom networks (Huawei 2022). Qualcomm, with 3,743 patents, pioneers in energy-efficient communication protocols and chipsets, crucial for minimizing power consumption in mobile devices and networks (Qualcomm 2024). Collectively, these companies drive significant advancements in green telecommunications, playing a pivotal role in the industry's efforts to meet global sustainability goals. (Espacenet 2024a)

Overall, the analysis of patenting frequency over the past 20 years provides valuable insights into the evolution of green innovation in the telecommunications industry. It highlights the interplay between regulatory environments, economic conditions, and technological advancements in shaping the trajectory of green patenting activities.

6 A critical view on green telecommunication patents

This chapter discusses the effect of green patenting on environmental sustainability and business operation of telecommunication companies. taking into account the demands of stakeholders, financial incentives, and the strategic distribution of resources for R&D.

Telecommunications stakeholders, including customers, employees, investors, suppliers, and regulators, increasingly demand sustainability from companies. These stakeholders exert significant pressure on businesses to adopt sustainable practices, driven by growing concerns about climate change. Deloitte Global's 2021 Climate Check report highlights that shareholder demands and societal and employee activism are primary drivers of sustainability actions. Investors, in particular, play a crucial role in motivating companies to prioritize environmental sustainability, influencing corporate strategies and financial decisions.

Patenting incentivizes environmentally sustainable innovation. By providing legal protection and economic incentives, patents encourage companies to invest in the development of new technologies that address environmental challenges. The protection offered by intellectual property rights is essential for fostering innovation, as it provides inventors and companies with the assurance that their investments in R&D will be safeguarded. This protection encourages further investment in green technologies, leading to a continuous cycle of innovation and commercialization. This commercialization process also creates numerous job opportunities across various industries, including research, development, manufacturing, and sales.

The loose definition of "green patent" in patenting raises significant concerns about the integrity and effectiveness of environmental sustainability efforts. Under the current framework, a patent is considered "green" if it includes even a single green technology code, which can be granted if the technology in any way mitigates climate change. This broad definition allows nearly any new technology to be classified as green in telecommunication industry, primarily because new advancements in telecommunications often result in improved energy efficiency.

This overly inclusive definition dilutes the meaning and impact of green patents. By labelling almost all new technologies as green, it becomes challenging to differentiate between genuinely transformative innovations and incremental improvements. The distinction between technologies that are fundamentally designed to address environmental issues and those that merely offer marginal energy savings is blurred. This can lead to a scenario where the term "green patent" loses its value, undermining efforts to highlight and incentivize truly groundbreaking green technologies.

Moreover, the telecommunications industry, known for its rapid technological advancements, could see an increase of green patents that do little to advance substantial environmental goals. This can result in a misallocation of resources and attention, diverting support from technologies with the potential for significant environmental impact to those with minor efficiency gains. Such a situation not only misguides policymakers and investors but also hampers the industry's overall progress toward meaningful sustainability.

In addition, this broad definition may encourage companies to prioritize patenting any marginally efficient technology as green, rather than investing in more substantial and challenging, innovations that could offer greater environmental benefits. The focus can shift from quality to quantity, with the sheer number of green patents overshadowing their actual environmental value.

Despite the broad and inclusive definition of green patents, which allows a wide range of technologies to be classified as green if they contribute to climate change mitigation in any capacity, it is noteworthy that only 5-7% of the patents filed by the top two EU telecommunication companies—Ericsson and Nokia—are categorized as green. This percentage may rise if all green codes would be taken into account when analysing the selected companies.

One explanation to the low green patent filings might be related to the AI used in the Y02/Y02s classification system, which identifies relevant patent applications by keywords. If the language used in the patent applications does not align well with the keywords or phrases that the AI is programmed to recognize, relevant green patents may not be accurately classified. This misalignment can result in underreporting of green patents, even when the inventions themselves are environmentally beneficial.

Another reason could be the strategic focus of the companies' R&D efforts. If the research and development strategy of these telecommunication companies does not prioritize environmental sustainability, the proportion of green patents in their portfolios will naturally be lower. Companies like Ericsson and Nokia might be directing their R&D resources towards advancements in network infrastructure, data transmission, and mobile technology—areas that are crucial for maintaining competitive advantage and meeting market demands but do not always directly address environmental sustainability.

6.1 Strategic positioning and competitive advantage through green patents

Green patents can play a pivotal role in the strategic positioning and competitive advantage of companies within the telecommunications sector. By leveraging green patents, companies can enhance their market standing, demonstrate corporate responsibility, and gain several strategic benefits.

One of the primary advantages of green patents is the possibility of accelerated patent examination. Many countries have implemented Accelerated Examination Programs specifically designed for green technologies. These programs significantly reduce the time required to process and grant patents for environmentally friendly innovations. Faster patent approvals not only bring products to market more quickly but also enhance a company's ability to capitalize on first-mover advantages and secure market leadership in green technology segments. This swift process is crucial for companies aiming to stay ahead in the competitive telecommunications industry, where technological advancements are rapid and continuous.

Green patents can also serve as a tool to signal corporate responsibility. Patent data is a valuable metric for assessing sustainable innovations because it is grounded in objective standards. Patents are awarded based on novelty, non-obviousness, and industrial applicability, providing a rigorous benchmark that financial investment or trade data alone cannot offer. In this approach only granted patents should be considered and not all patent filings. Unlike R&D data, which only tracks financial investments, patent records capture the tangible outcomes of the creative process. Moreover, patent databases are publicly accessible and can be used for quantitative analysis, allowing detailed studies of environmental innovations across various technological fields. This transparency enables stakeholders to evaluate a company's commitment to sustainability based on concrete evidence of their innovative activities.

Furthermore, patents necessitate the disclosure of the technology they protect, often years before the related commercial products are available. This early disclosure provides a unique glimpse into the research and development efforts and future offerings of companies, making patent-based metrics both objective and predictive. Such metrics offer critical insights into global innovation trends and how companies invest in inventions related to the SDGs. By analysing patent data, companies can position themselves as leaders in sustainable innovation, attracting environmentally conscious consumers, investors, and partners.

However, it is important to recognize that patents are not a comprehensive measure of innovation. Not all innovations are patentable, and not all patentable inventions are patented. The quality and commercial viability of patented inventions can also vary significantly. Additionally, because of the limited requirements for a patent to be qualified as a “green” patent it raises a concern if they can be used as sustainability indicator for a company. Despite these limitations, green patents remain a good indicator of a company’s innovation capacity and strategic focus.

In conclusion, green patents offer strategic benefits, including accelerated examination, enhanced corporate responsibility communication, and insights into future technological trends. By utilizing green patents, companies in the telecommunications sector can achieve a competitive advantage, aligning their innovation efforts with sustainability goals and securing their position as leaders in the industry.

7 Discussion

This thesis presents a general methodology for classifying green patents in the telecommunication sector, offering a method that can be extended to other industries to examine green patenting activities. The approach involves using patent classifications to identify green patents, a method that would benefit from further refinement and detailed analysis down to the four-dot subgroup level. Such detailed classification can enhance the precision of the analysis, ensuring a more accurate representation of green technological advancements.

One of the primary motivations for this research is the growing regulatory pressure on sustainability reporting and the need to combat greenwashing. Patents, as concrete outputs of R&D investments, provide a tangible measure of a company's commitment to green innovation. Incorporating patent data as a key performance indicator (KPI) in annual sustainability reports could offer a more transparent and verifiable metric for assessing a company's green initiatives. For instance, setting a target where 15% of all patents filed by 2030 would be green could drive companies to align their R&D efforts with sustainability goals. However, this approach is complicated by the loose definition of what constitutes a green patent.

To address these issues, it is essential to refine the criteria for green patents. A more strict and specific definition would help ensure that only technologies with a clear, significant impact on mitigating climate change receive the green label. This would enhance the credibility of green patents and better align the telecommunications industry's innovation efforts with global sustainability goals. By raising the bar for what constitutes a green telecommunication patent, we can better support and promote technologies that truly contribute to a sustainable future.

Additionally, the Y02/Y04s tagging scheme poses challenges. Patent filings within these classifications are identified through the use of AI-driven keyword searches. While this method allows for the efficient processing of large volumes of data, it is not without its flaws. Keyword-based searches can be imprecise, capturing patents that are not relevant to green technologies while potentially missing those that are. This can lead to the inclusion of irrelevant patents and the exclusion of pertinent ones, thus compromising the accuracy of the classification.

The inclusion of environmental patents in sustainability reporting can be a strategic move that can influence investor confidence and consumer trust. Investors are increasingly factoring environmental, social, and governance (ESG) criteria into their decision-making processes. Transparent reporting on green patents can provide a clear indication of a company's commitment to sustainable innovation, thereby enhancing its attractiveness to ESG-focused investors. Furthermore, consumers are becoming more environmentally conscious and are likely to support companies that demonstrate genuine efforts in sustainability.

8 Conclusions

This thesis set out to explore the classification and impact of green patents within the telecommunication sector, aiming to develop a methodology for identifying green telecommunication patents using patent classification codes and examining their practical applications and benefits. The research addressed the main question: "How to identify green telecommunication patents by using patent classification codes and how can green patents be utilized?" as well as two sub-questions regarding the specific patent classes defining green technology in telecommunications and the impact of these patents on environmental sustainability and industry practices.

The research developed a methodology for identifying green telecommunication patents by leveraging patent classification codes from the IPC Green Inventory and the Y02/Y04S EPO tagging scheme. Specifically, the study identified relevant classifications such as Y02D for telecommunication technologies aiming at their own energy reduction and G01R for measuring electric variables. Through the analysis of patent data from Espacenet, the study revealed significant trends and insights. It highlighted that companies like Ericsson and Nokia are leading in green telecommunication network patents within the EU, with notable contributions from their subsidiary companies. Patent analysis also highlighted how patent data can be used to investigate the R&D outputs of companies.

The findings suggest that green patents can play a meaningful role in driving sustainable innovation in the telecommunication sector. The adoption of green patents aligns with increasing stakeholder demands for sustainability, regulatory pressures, and the need for companies to demonstrate corporate responsibility. Green patents serve as a valuable metric for assessing sustainable innovations, grounded in objective standards and offering insights into the future directions of technological advancements. However, it’s important to take into account that not all inventions are patentable or patented.

Theoretically, this thesis contributes to the existing body of knowledge by providing a methodology for identifying and classifying green patents in the telecommunication sector. It bridges the gap in understanding how patent classification systems can be utilized to categorize and analyse green technologies. Practically, the research offers insights for telecommunication companies, policymakers, and investors. It provides a framework for companies to benchmark their green patent portfolios, align their innovation strategies with sustainability goals, and enhance their competitive advantage. Policymakers can leverage the findings to support the development of regulations and incentives that promote green technological innovation. Investors can use patent data as a key performance indicator for assessing the sustainability efforts of companies.

Despite the comprehensive approach, the study faced limitations. The broad definition of green patents, which includes any technology with a single green technology code, may dilute the specific focus on transformative environmental innovations. Furthermore, it's possible that not all relevant patents—especially those that aren't categorized under the chosen codes—will be included in the Espacenet patent data. Furthermore, there's a chance that irrelevant patents will be chosen. Additionally, Espacenet lacks a filter for examining only active patents. This feature might exist in other patent search databases, though.

Future research should focus on refining the criteria for green patents to ensure a more precise identification of genuinely impactful technologies. Further studies could also explore the longitudinal impact of green patents on corporate sustainability performance and extend the analysis to other sectors beyond telecommunications.

References

Abbas, S. Saqib, N. Mohammed, K. Sahore, N. Shahzad, U. 2024. ‘Pathways towards carbon neutrality in low carbon cities: The role of green patents, R&D and energy use for carbon emissions’, Technological Forecasting and Social Change, Volume 200, [Electronic journal]. [Cited 31.5.2024]. Available: https://www.sciencedirect.com/science/article/pii/S0040162523007941

Abedi, S. & Moeenian, M. (2021). "Investigating the effects of environmental patents and climate change mitigation technologies on sustainable economic growth in the Middle East." *International Journal of Low-Carbon Technologies*, Volume 16, [Electronic journal]. [Cited 13.6.2024]. Available: https://doi.org/10.1093/ijlct/ctab007

Alatas, S. 2021. ‘The role of information and communication technologies for environmental sustainability: Evidence from a large panel data analysis’, *Journal of Environmental Management*, Volume 293, [Electronic journal]. [Cited 4.4.2024]. Available: https://www.sciencedirect.com/science/article/pii/S0301479721009518

Angelucci, S. Hurtado-Albir, F. Volpe, A. 2018. ‘Supporting global initiatives on climate change: The EPO's “Y02-Y04S” tagging scheme’, *World Patent Information*, Volume 54, [Electronic journal]. [Cited 2.6.2024]. Available: https://www.sciencedirect.com/science/article/pii/S0172219016300618

Ayers, S. Ballan, S. Gray, V. McDonald, R 2024, Measuring the Emissions and Energy Footprint of the ICT Sector: Implications for Climate Action, The World Bank, [Report]. [Cited 21.4.2024] Available: https://documents.worldbank.org/en/publication/documents-reports/documentdetail/099121223165540890/p17859702a98880540a4b70d57876048abb

Bauck. W 2024, ‘New York is suing the world’s biggest meat company. It might be a tipping point for greenwashing’, The Guardian, 5.4.2024, [Online] [Cited 21.4.2024], Available: https://www.theguardian.com/environment/2024/apr/05/letitia-james-jbs-meat-lawsuit-greenwashing .

Baldini, G. Cerutti, I. Chountala, C. 2024, Identifying common indicators for measuring the environmental footprint of electronic communications networks (ECNs) for the provision of electronic communications services (ECSs), [Report]. [Cited 22.4.24]. Available: https://publications.jrc.ec.europa.eu/repository/handle/JRC136475

Bosch 2024, What we do, [Online]. [Cited 13.6.2024]. Available: https://www.bosch.com/company/#what-we-do

Boston Consulting Group 2021, Putting Sustainability at the Top of the Telco Agenda, [Online]. [Cited 10.6.2024]. Available: https://www.bcg.com/publications/2021/building-sustainable-telecommunications-companies

Clarke, N. 2018, 'The basics of patent searching', *World Patent Information*, Volume 54, [Electronic journal]. [Cited 2.6.2024]. Available: https://www.sciencedirect.com/science/article/pii/S017221901630103X

Deloitte 2020, 2021 Climate Check: Business' views on environmental sustainability, [Website], [Cited 16.5.2024]. Available: https://www.deloitte.com/global/en.html

EIA 2024, Use of energy explained, [Website]. [Cited 20.5,2024]. Available: https://www.eia.gov/energyexplained/use-of-energy/efficiency-and-conservation.php

EPO 2020, European Patent Convention, [Website], [Cited 4.3.2024]. Available: https://www.epo.org/en/legal/epc

EPO 2022, Y02 Allocation, [Website], [Cited 2.6.2024]. Available: https://forums.epo.org/y02-allocation-12598

EPO 2023, Patents paving the way to a more sustainable future, [Online]. [Cited 1.6.2024]. Available https://link.epo.org/web/en-patents-paving-the-way

EPO 2024a, Cooperative Patent Classification (CPC), [Website]. [Cited 5.3.2024]. Available: https://www.epo.org/en/searching-for-patents/helpful-resources/first-time-here/classification/cpc

EPO 2024b, Patent classification, [Website]. [Cited 5.3.2024]. Available: https://www.epo.org/en/searching-for-patents/helpful-resources/first-time-here/classification

EPO 2024c, The patenting process, [Website]. [Cited 4.3.2024]. Available: https://www.epo.org/en/learning/learning-resources-profile/business-and-ip-managers/inventors-handbook/protecting-your-idea/patenting-process

EPO 2024d, Publication of the European patent application, [Website]. [Cited 7.5.2024]. Available: https://www.epo.org/en/legal/guide-epc/2022/ga_c5_3.html

Ericsson 2023, Sustainability & CR report 2023, [Report]. [Cited 20.3.2024] Available: https://www.ericsson.com/en/about-us/sustainability-and-corporate-responsibility/sustainability-report

Espacenet 2016a, Patent families. [Online]. [Cited 11.6.2024]. Available: https://fi.espacenet.com/help?locale=fi_FI&method=handleHelpTopic&topic=patentfamily

Espacenet 2016b, Priority date. [Online]. [Cited 11.6.2024].Available: https://is.espacenet.com/help?locale=en_IS&method=handleHelpTopic&topic=prioritydate

Espacenet 2022, Espacenet – pocket guide. [Online]. [Cited 11.6.2024]. Available: https://link.epo.org/web/technical/espacenet/espacenet-pocket-guide-en.pdf

Espacenet 2024a, Classification search [Online database]. [Cited 22.4.2024]. Available: https://worldwide.espacenet.com/patent/cpc-browser

Espacenet 2024b, IPC. [Website]. [Cited 23.5.2024]. Available: https://worldwide.espacenet.com/patent/help/ipc

European Commission 2024a, Corporate sustainability reporting, [Online]. [Cited 05.02.2024]. Available: https://finance.ec.europa.eu/capital-markets-union-and-financial-markets/company-reporting-and-auditing/company-reporting/corporate-sustainability-reporting_en

European Comission 2024b, Green claims, [Online]. [Cited 18.4.24]. Available: https://environment.ec.europa.eu/topics/circular-economy/green-claims_en

European Comission 2024c, EU taxonomy for sustainable activities, [Online]. [Cited 10.6.2024]. Available: https://finance.ec.europa.eu/sustainable-finance/tools-and-standards/eu-taxonomy-sustainable-activities_en

European Patent Academy 2024, Patent Classification, [Website], [Cited 22.4.24]. Available: https://e-courses.epo.org/course/view.php?id=46#section-3

Eurostat 2023, Glossary:Innovation, [Website]. [Cited 16.5.2024]. Available: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Glossary:Innovation

Favot, M. Vesnic, L. Priore, R. Bincoletto, A. Morea. F., 2023. ‘Green patents and green codes: How different methodologies lead to different results.*’ Resources, Conservation & Recycling Advances*, Volume. 18. [Electronic journal], [Cited 29.01.2024]. Available: https://www.sciencedirect.com/science/article/pii/S2667378923000044

Fellenbaum, A. Taylor, H. 2023, Evaluating the telecom industry’s sustainability potential, [Report]. [Cited 15.5.2024]. Available: https://worldbroadbandassociation.com/wp-content/uploads/2023/09/WP-WG3.pdf

Ferreira, J. Fernandes C. Ferreira, F., 2020. ‘Technology transfer, climate change mitigation, and environmental patent impact on sustainability and economic growth: A comparison of European countries’, *Technological Forecasting and Social Change*, Volume 150, [Electronic journal]. [Cited 1.6.2024]. Available: https://www.sciencedirect.com/science/article/pii/S0040162519310662

Forbes 2021, ‘How Stakeholders Can Make Or Break Companies’ Sustainability Efforts’, Forbes, 13.5.2021 [Online], [Cited 16.5.2024]. Available: https://www.forbes.com/sites/deloitte/2021/05/13/how-stakeholders-can-make-or-break-companies-sustainability-efforts/

Salgado, E. Franchi, R. 2023., ‘Green Technologies: The Role of Green Patents for Innovation, Preservation and Sustainable Development.’*RGSA : Revista de Gestão Social e Ambiental*, Volume 17, [Electronic journal]. [Cited 13.6.2024]. Available: https://ezproxy.cc.lut.fi/scholarly-journals/green-technologies-role-patents-innovation/docview/3053576145/se-2?accountid=27292

GOV UK 2014, Patents: accelerated processing. [Online]. [Cited 1.6.2024]. Available: https://www.gov.uk/guidance/patents-accelerated-processing

Hascic, I. Migotto, M. 2015. Measuring environmental innovation using patent data. [Report]. [Cited 6.4.2024]. Available: https://www.oecd-ilibrary.org/environment/measuring-environmental-innovation-using-patent-data_5js009kf48xw-en

Schiederig, T. Tietze, F. Herstatt C.,2012. ‘Green innovation in technology and innovation management – an exploratory literature review’. *R&D Management*, Volume 42, [Electronic journal]. [Cited 28.02.2024]. Available: https://doi-org.ezproxy.cc.lut.fi/10.1111/j.1467-9310.2011.00672.x

Huawei 2022, 2022 Sustainability Report, [Report]. [Cited 20.3.2024] Available: https://www.huawei.com/en/sustainability

ITU 2020, Guidance for ICT companies setting science based targets. [Report]. [Cited 22.3.2024]. Available: https://sciencebasedtargets.org/resources/legacy/2020/04/GSMA_IP_SBT-report_WEB-SINGLE.pdf

ITU 2020, Can telecom networks go green? [Report]. [Cited 10.6.2024]. Available: https://www.itu.int/hub/2022/01/can-telecom-networks-go-green/

Kemp, R. Pearson, P. 2007, Final report MEI project about measuring eco-innovation. [Report]. [Cited 24.5.2024]. Available: https://www.oecd.org/greengrowth/consumption-innovation/43960830.pdf

Mueller 2021, Expediting Patent Publication and Examination in China. [Website]. [Cited 7.5.2024] Available: https://www.lexology.com/library/detail.aspx?g=bd9918da-26f7-4757-b86e-c0e467b0e6d3

Nagaoka, S. Motohashi, K, Goto, A., 2010. 'Chapter 25 - Patent Statistics as an Innovation Indicator', *Handbook of the Economics of Innovation*, Volume 2, [Electronic journal]. [Cited 10.6.2024]. Available: https://doi.org/10.1016/S0169-7218(10)02009-5

Nokia 2023, 2023 People and Planet report, [Report]. [Cited 20.03.2024] Available: https://www.nokia.com/about-us/sustainability/

NXP 2024, We are NXP, [Online]. [Cited 13.6.2024]. Available: www.nxp.com/company/about-nxp/we-are-nxp:WE-ARE-NXP

OECD 2013, OECD Regions at a Glance 2013, [Report]. [Cited 23.5.2024] Available: https://www.oecd-ilibrary.org/urban-rural-and-regional-development/oecd-regions-at-a-glance-2013_reg_glance-2013-en

OECD 2018, Oslo manual 2018, [Report], [Cited 10.6.2024]. Available: https://www.oecd-ilibrary.org/science-and-technology/oecd-patent-statistics-manual_9789264056442-en

Orange 2024, Orange Business: A leading network and digital integrator. [Website]. [Cited 10.6.2024]. Available: https://www.orange-business.com/en/corporate

PRH 2021, Patent classification helps conduct searches. [Online]. [Cited 30.5.2024]. Available: https://www.prh.fi/en/patentit/servicesanddatabases/freedatabases/patentclassification.htm

PRH (2024). Interviewed by Maria Kahila. 6 March, Espoo.

Probst, B. Touboul, S. Glachant, M., 2021. Global trends in the invention and diffusion of climate change mitigation technologies. *Nat Energy*, Volume 6, [Electronic journal]. [Cited 13.6.2024]. Available: https://doi.org/10.1038/s41560-021-00931-5

PWC 2024, ESG reporting and preparation of a Sustainability Report. [Online]. [Cited 18.4.24]. Available: https://www.pwc.com/sk/en/environmental-social-and-corporate-governance-esg/esg-reporting.html

Qualcomm 2024, Corporate Responsibility Report. [Online]. [Cited 12.6.2024]. Available: https://www.qualcomm.com/content/dam/qcomm-martech/dm-assets/documents/2023-qualcomm-corporate-responsibility-report.pdf

Samsung 2024, Samsung Electronics Sustainability Report 2023. [Online]. [Cited 12.6.2024]. Available: https://www.samsung.com/global/sustainability/media/pdf/Samsung_Electronics_Sustainability_Report_2023_ENG.pdf

UN 2020, The Climate Crisis – A Race We Can Win, [Online]. [Cited 10.6.2024]. Available: https://www.un.org/en/un75/climate-crisis-race-we-can-win

UNFCCC 2009, Copenhagen Accord, [Report]. [Cited 1.6.2024]. Available: https://unfccc.int/resource/docs/2009/cop15/eng/l07.pdf

UNFCCC 2021, Response to Katowice Committee of Experts on the Impacts of the Implementation of Response Measures (KCI) Call for Inputs, [Report]. [Cited 31.5.2024]. Available: https://unfccc.int/sites/default/files/resource/Inputs%20from%20AIPPI%20Standing%20Committee%20on%20IP%20and%20Green%20Technologies.pdf

UNFCCC 2024a, The Paris Agreement. [Online]. [Cited 12.6.2024]. Available: https://unfccc.int/process-and-meetings/the-paris-agreement

UNFCCC 2024b, What is the Kyoto Protocol?, [Online]. [Cited 1.6.2024]. Available: https://unfccc.int/kyoto_protocol

United Nations 2024, THE 17 GOALS, [Online]. [Cited 10.6.2024]. Available: https://sdgs.un.org/goals

USPTO 2023, Eighteen-Month Publication of Patent Applications [R-07.2022], [Website]. [Cited 7.5.2024]. Available: https://www.uspto.gov/web/offices/pac/mpep/s1120.html

USPTO 2024, CPC Section Y, [Website]. [Cited 31.5.2024]. Available: https://www.uspto.gov/web/patents/classification/cpc/html/cpc-Y.html

WIPO 2023, AI applied to Classification Use Cases at the European Patent Office. [Online]. [Cited 13.6.2024]. Available: https://www.wipo.int/edocs/mdocs/classifications/en/ipc_ce_54/ipc_ce_54_p4.pdf

WIPO 2024a, IPC Green Inventory. [Online]. [Cited 5.2.24], Available: https://www.wipo.int/classifications/ipc/green-inventory/home

WIPO 2024b, Mapping Innovations Patents and the Sustainable Development Goals. [Online]. [Cited 7.5.2024] Available: https://www.wipo.int/edocs/pubdocs/en/wipo-pub-rn2024-18-en-mapping-innovations.pdf

WIPO 2024c, Patent Classification (IPC). [Online]. [Cited 28.5.2024]. Available: https://www.wipo.int/classifications/ipc/en/

Appendix 1. Interview with the Senior Research Engineer of Finnish patent office (PRH) about the Y02/Y04s classification.

Translated oral interview from Finnish to English. Some answers have been modified and summarized for clarity.

1. What is your job description in the company?

My title is senior research engineer and I work as a patent examiner and I'm a part of classification working group.

2. How are classifications given to patent applications?

Classification is done manually, the patent application is classified when the novelty examination is carried out, i.e. when the first office action is written. It is the duty of every research engineer.

3. When patent is further filed to other patenting offices do they use the classifications given by previous office?

At least EPO reclassifies patents again.

3. How is Y classification assigned to patents?

Y classes are automatically added to the documents by the EPO in databases maintained by the EPO. Since 2022, Y-classification has been done by artificial intelligence, i.e., the EPO has stopped using the algorithm (actually a search preparation done by researchers). The AI reviews publications twice a week, whereas previously this was done maybe a couple of times a year. The AI uses keywords to determine Y-classification. The classification is not specifically checked by humans, but the EPO does not consider this very problematic because Y-classes are mainly intended for statistical use.

On the other hand, for example, we at PRH use the Y-classification to monitor green technology. This means that researchers can give a Y-rating when examining domestic applications. In this case, the information on the Y-class remains in the domestic database (Patent Database). And is therefore a classification given by the examiner.

4. Why is the Y-classification given by AI and not by patent examiners?

Y-Classification should not be given by then national examiners because it's the duty of EPO to give the classification. The Y-Classification may be given by the examiners in national patent offices only for internal data bases – for statistical purposes.

I assume that for EPO, the Y class is not a research class but a way for large organizations to track the progress of green technology. It is not intended to be a very precise class. I would assume that it is only meant to describe trends in green technology, and the Y classification is not used to search for specific publications. However, it can also be used to narrow down search results.

5. How accurate do you think the Y-classification is?

I consider it quite reliable. In wireless technology, simply saving power gives an invention a green label. I believe that the Y class is, on average, a reliable indicator of green technology. However, there may be errors. One could imagine that the algorithm works more reliably and consistently than examiner.

6. Do you believe that green patent codes could be misused, for example, by including green language in the application?

I don't consider it a very big risk. I don't see what benefit there would be. A patent applicant wants to get a patent for a specific invention, and this invention must be truthfully described in the application. Of course, one could include some green terms in the description, but I don't know if the algorithm would then select the patent.

Appendix 2. Top 100 applicant results when searching green telecommunication patents in EU priority date 1.1.2003-31.1.2022. Data collected 12 June 2024.

Applicants	Number of documents
ERICSSON TELEFON AB L M	1664
NOKIA CORP	542
NOKIA TECHNOLOGIES OY	533
ERICSSON TELEFON AB L M (PUBL)	501
SIEMENS AG	475
ALCATEL LUCENT	461
INFINEON TECHNOLOGIES AG	345
ROHDE & SCHWARZ	344
BOSCH GMBH ROBERT	323
NXP BV	321
KONINKL PHILIPS ELECTRONICS NV	303
NOKIA SOLUTIONS & NETWORKS OY	241
NOKIA INC	150
COMMISSARIAT ENERGIE ATOMIQUE	143
INTEL CORP	130
KONINKLIJKE PHILIPS NV	126
SIEMENS HEALTHCARE GMBH	126
ST MICROELECTRONICS SRL	115
KONINKL PHILIPS NV	106
NOKIA SIEMENS NETWORKS OY	105
THOMSON LICENSING	101
FRAUNHOFER GES FORSCHUNG	95
NOKIA SHANGHAI BELL CO LTD	95
ORANGE	88
IBM	87
SONY ERICSSON MOBILE COMM AB	85
CIT ALCATEL	81
HUAWEI TECH CO LTD	79
DEUTSCHE TELEKOM AG	77
ALCATEL LUCENT USA INC	75
ST MICROELECTRONICS SA	69
SONY CORP	67
FRANCE TELECOM	65
TEXAS INSTRUMENTS INC	61
CONTINENTAL AUTOMOTIVE GMBH	59
SONY MOBILE COMM AB	57
ST ERICSSON SA	57
CISCO TECH INC	56
THALES SA	55
ST MICROELECTRONICS ROUSSET	53
FREESCALE SEMICONDUCTOR INC	52
SHANGHAI NOKIA BELL CO LTD	52

PHILIPS LIGHTING HOLDING BV	51
SAGEMCOM ENERGY & TELECOM SAS	49
SIGNIFY HOLDING BV	48
ST MICROELECTRONICS GRENOBLE 2	48
SCHNEIDER ELECTRIC IND SAS	47
BAYERISCHE MOTOREN WERKE AG	46
ST MICROELECTRONICS INT NV	45
SONY MOBILE COMMUNICATIONS INC	44
COMMISSARIAT L ENERGIE ATOMIQUE ET AUX ENERGIES ALTERNATIVES	42
PHILIPS INTELLECTUAL PROPERTY	42
VOLKSWAGEN AG	42
ATMEL CORP	41
AUDI AG	40
LINDOFF BENGT	40
QUALCOMM INC	40
CENTRE NAT RECH SCIENT	39
TEXAS INSTRUMENTS DEUTSCHLAND	39
BROADCOM CORP	38
FUJITSU TECH SOLUTIONS IP GMBH	37
INTEL MOBILE COMM GMBH	37
THOMSON LICENSING SA	36
NEC EUROPE LTD	35
QIMONDA AG	35
ALCATEL LUCENT SHANGHAI BELL	34
PEUGEOT CITROEN AUTOMOBILES SA	34
ADVANTEST CORP	33
ALCATEL LUCENT INC	33
INTEL IP CORP	33
APPLE INC	32
RENESAS MOBILE CORP	32
NOKIA USA INC	31
TELECOM ITALIA SPA	30
LUCENT TECHNOLOGIES INC	28
NEC CORP	28
SAP AG	28
ANALOG DEVICES INTERNATIONAL UNLIMITED CO	27
LANTIQ DEUTSCHLAND GMBH	27
BULL SAS	26
SAMSUNG ELECTRONICS CO LTD	26
SAP SE	26
SONY GROUP CORP	26
HGST NETHERLANDS BV	25
EATON INTELLIGENT POWER LTD	24
GIESECKE DEVRIENT MOBILE SECURITY GMBH	24
INTERDIGITAL CE PATENT HOLDINGS	24
PARKVALL STEFAN	24

VASSEUR JEAN-PHILIPPE	24
COMMISSARIAT A L'ENERGIE ATOMIQUE ET AUX ENERGIES ALTERNATIVES	23
CONTINENTAL AUTOMOTIVE FRANCE	23
SAMSUNG SDI CO LTD	23
DSPACE GMBH	22
INTEL DEUTSCHLAND GMBH	22
NOKIA SIEMENS NETWORKS GMBH	22
SWEDEN ERICSSON CO LTD	22
BLACKBERRY LTD	21
ELECTRICITE DE FRANCE	21
GIESECKE & DEVRIENT GMBH	21
MENTOR GRAPHICS CORP	21