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How green intellectual property can help us achieve a more sustainable future

A brief discussion of the development and potential in green IP including case studies with selected organisations:

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P S V

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List of Abbreviations:

CAPEX: Capital expenditures

CCMT: Climate Change Mitigation Technologies

CO2eq: Carbon dioxide equivalent

CPC: Cooperative Patent Classification scheme

DKPTO: Danish Patent and Trademark Office

ENV-TECH: Environment-related technologies

EPO: European Patent Office

EST: Environmentally Sound Technologies

EUIPO: European Union Intellectual Property Office

EU: European Union

GXTI: Green Transformation Technologies Inventory

ICT: Information and Communication Technology

IP: Intellectual Property

IPC: International Patent Classification

IPCC: Intergovernmental Panel on Climate Change

IPR: Intellectual Property Rights

JPO: Japan Patent Office

MIT: Massachusetts Institute of Technology

MZCS: Maersk Zero Carbon Shipping

NACE: National Association of Colleges and Employers

NNF: Novo Nordisk Foundation

OECD DAC: Organisation for Economic Co-operation and Development's Development Assistance Committee

OECD: Organisation for Economic Co-operation and Development

PATSTAT: Patent Statistical Database

PSV: PreSeed Ventures

SDG: Sustainable Development Goals

SME: Small- and Medium-sized Enterprises

UK IPO: United Kingdom Intellectual Property Office

UNEP: United Nations Environment Program

UNFCCC: United Nations Framework Convention on Climate Change

USPTO: United States Patent and Trademark Office

WIPO: The World Intellectual Property Organization

1. Setting the scene

This report sets out to describe the importance of intellectual property (IP) in providing a legal framework that encourages timely development and commercialization of innovative technologies needed to support a green transition. Among other things, we outline important IP mechanisms, discuss the opportunities and challenges inherent in the current IP system, and address a range of international policies aimed at fast-tracking the green transition. Lastly, we evaluate how the system has been leveraged internationally to promote sustainable innovation and reflect on the most viable future direction. The report will also shed light on the possibilities inherent in the international IP system while continuously reflecting on Denmark's positioning and role in supporting it.

In order to set the scene, this section introduces the climate crisis and notions of green IP. Furthermore, it provides a baseline understanding of how IP can support a transition to a greener economy.

1.1. The climate crisis and the role of innovation in solving it

In a recently released report by the Intergovernmental Panel on Climate Change (IPCC)[1], scientists provide new estimates of the risks of crossing the global warming level of 1.5°C in the next decades as set out in the Paris Agreement of 2015. According to the report, achieving the goal of limiting global warming to approximately 1.5°C or even 2°C will be unattainable unless urgent, substantial and widespread reductions in greenhouse gas emissions are achieved.

Accordingly, significant and persistent decreases in carbon dioxide (CO_2) and other greenhouse gas emissions still have the potential to curb the progression of climate change. As stated in the latest report from the IPCC[2], achieving such emission reductions would yield significant improvements to air quality and help stabilize global temperatures. This hinges upon swift and decisive action to mitigate the detrimental effects of climate change and forge a path towards a safer and more sustainable planet.

A transition towards a greener future necessitates global efforts to adopt cleaner technologies, promote renewable energy sources, implement sustainable practices across various industries, and embrace a circular economy that minimizes waste and maximizes resource utilization. Alongside reducing the harm, we are causing, it is evident that we need new and far-reaching green inventions that can help curb emissions while sustaining economic progress[3].

In that regard, the IPCC suggests that innovation must continue within sectors where the cost of green alternatives is currently lower than the broader market (e.g., in wind and solar energy). The IPCC also emphasizes the importance of progress in green sectors that are currently uncompetitive (i.e., sectors where the cost of green alternatives is higher than industry peers) but hold great potential in mitigating emissions towards 2030. Sectors asserted to hold the highest potential based on the IPCC's analysis include carbon sequestration in agriculture, conversion of forests and other ecosystems, and high-energy performing buildings.

In light of these findings, it is evident that the international community must also turn its attention to solutions that address the global biodiversity crisis. As shown, this is not only important to reduce the size of the sixth wave of mass extinction of animal species, but also

[1] IPCC: AR6 Synthesis Report: Climate Change (2023)
[2] IPCC: AR6 Synthesis Report: Climate Change (2023)
[3] EU Intellectual Property Office: IP-intensive industries and economic performance in the European Union (2022)

a critical mitigation option to curb the progression of climate change. Most widely acknowledged is the need for innovative solutions to transform how we currently do agriculture.

Recognizing the magnitude and complexity of climate change, the European Union (EU) and its Member States have, in recent years, made it a top priority in their policies. In 2021, the European Commission introduced the legally binding Green Deal (incl. the Sustainable Europe Investment Plan) aiming to attract a minimum of €1 trillion in public and private investments over the next decade to drive the green transition. The Green Deal provides a clear roadmap for achieving a climate-neutral Europe and sets ambitious targets for the coming years[4]. Lastly, and somewhat linked to emissions reductions, the EU committed to a biodiversity strategy in 2022, that sets out ambitious targets for protecting nature and reversing the degradation of ecosystems towards 2030[5].

In addition, The Green Deal, stresses the importance of global collaboration in integrating environmental sustainability into policy-making and economic activities, while highlighting the need to direct investments toward green innovations and practices[6]. As a key catalyst for achieving this, the EU and the wider international community is advocating greater attention to the legal structures and frameworks that can support mobilization of capital and dissemination of new inventions.

1.2. Definition of green IP

The IP system encompasses various forms of intellectual property, such as trademarks, design rights and patents. The profound influence of IP on a nation's economic growth and social development is widely recognized. However, the potential of the IP system to advance environmental sustainability and incorporate new sustainable practices is still an emerging field.

Environmental sustainability is at the core of the green transition increasingly requiring corporates and investors to develop innovative and creative solutions that protect the environment alongside sustaining their commercial viability. Patents, in particular, are instrumental to the green transition and will be the core focus of this report.

When identifying a potential "green patent" in this report, we rely on the below three internationally recognized organisations that have been active since 2010 in developing common frameworks to facilitate patent search:

WIPO, UNFCCC, and IPCC: In collaboration with United Nations Framework Convention on Climate Change (UNFCCC) and the Intergovernmental Panel on Climate Change (IPCC), The World Intellectual Property Organization (WIPO) has constructed the broadly recognized "IPC Green Inventory" list, which collects IPC codes related to Environmentally Sound Technologies (ESTs). This patent scheme is underpinned by WIPO Green, a marketplace for sustainable technology enabling technology exchange and global collaboration efforts that address climate change.

EPO: The European Patent Office (EPO) has developed the "Y02/Y04S" tagging scheme encompassing all sustainable innovations classified as Climate Change Mitigation Technologies (CCMT) within the cooperative patent classification scheme (CPC). The tagging scheme and accompanied database provides access to over three million patent

[4] EU Commission: The European Green Deal (2020)
[5] EUROPARC Federation: EU 2030 Biodiversity Strategy (2023)
[6] EU Commission: The European Green Deal (2020)

documents and useful technical information. CCMT categories included in the tagging scheme are described in the table below:

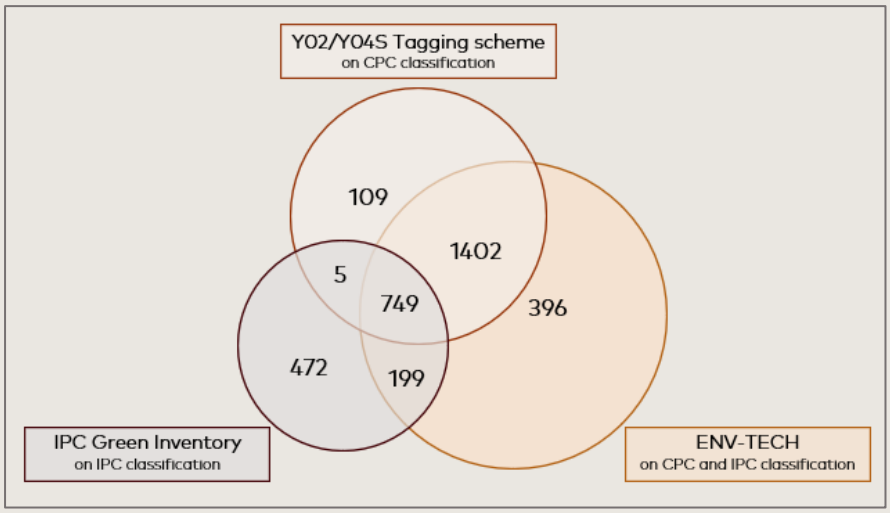
Table 1: Y02/Y04S tagging scheme for CCMTs (within the CPC)

CPC Groups	Description	Label
Y02A	Technoogies for adaptation to climate change	Adaptation
Y02B	CCMTs related to buildings	Buildings
Y02C	Carbon capture storage (CCS), sequestration or disposal of greenhouse gases	CCS
Y02D	CCMTs related to information and communication technology (ICT)	ICT
Y02E	Reduction of greenhouse gases emission, related to energy generation, transmission or distribution	Energy
Y02P	CCMTs in the production or processing of goods	Goods
Y02T	CCMTs related to transportation	Transportation
Y02W	CCMTs related to wastewater treatment or waste management	Waste
Y04S	Systems integrating technologies related to power network operation, communication or information technologies, i.e. smart grids	Smart-Systems

OECD: The OECD has released patent search strategies for the identification of selected environment-related technologies (from now on referred to as 'ENV-TECH') providing a comprehensive methodology for measuring innovation in environmental related technologies.

Overlaps between the three classification codes mentioned above are illustrated below. The figure displays the number of green patents identified by each of the three methodologies, showing intersections between sets that capture patents detected by multiple methodologies.

Figure 1[7]: Intersections between OECD, WIPO and EPO patent tagging schemes (number of green patents filed at the EPO identified by each methodology)



The above frameworks are often adopted by national entities and altered to terminologies that can be used for policy making. An example of this is the recently developed Green Transformation Technologies Inventory (GXTI), which has been launched by the Japan

[7] Resources, Conservation & Recycling Advances: Green patents and green codes (2023)

Patent Office (JPO). It is a widely recognized patent technology inventory categorizing Green Transformation (GX) technologies and enabling extensive and consistent patent searches. Building on the International Patent Classification (IPC) scheme, the GXTI supports evidence-based analyses of GX technologies for companies by leveraging patent information.[8]

In several academic discussions, a patent is considered 'green' if the patent includes at least one of the green technology codes[9] listed above. These scholars are, however, aware that a definition based solely on classification codes may sometimes be too simple a representation of what can be considered 'green patents'. Others take a broader approach, stating that a green patent can be defined as "any patent that covers a technology which contributes to the reduction of negative impacts on the environment and/or improves the efficient use of resources".[10] This, on the other hand, poses the risk of categorizing patents as green to inventions that are not truly 'green'.

For the purpose of this report, we use a relatively narrow notion of 'green patent' meaning "a technology which either directly or indirectly contributes to the green transition and the shift towards a more sustainable economy and society". We therefore mainly rely on research related to EPO's patent classification 'Y02/Y04S tagging scheme' (CCMT). Lastly, we describe the notions of green trademarks and design rights, being some of the most common types of IP together with patents.

The EUIPO has refined its definition of a 'green' trademark to better reflect its true relation to environmental protection. While a trademark can still be considered 'green' if it includes at least one green term, the EUIPO now takes into account the overall context and relevance of those terms to determine the extent of its environmental association. This refinement ensures a more accurate assessment of trademarks in relation to their environmental impact.

The concept of 'green design rights' is still not institutionalized as a common practice, however it can be referred to the legal protection and rights surrounding green products and services. The purpose of 'green' design rights is to encourage and incentivize the creation, utilization, and safeguarding of designs that have a positive environmental impact. By providing legal protection, these rights aim to support and promote the adoption of sustainable practices in various industries.

1.3. Outline of IP's relevance for the green transition

The IP system is vital in supporting the green transition and has the potential to provide the necessary legal framework to incentivize the development and commercialization of innovative green technologies. The IP system grants inventors or creators an exclusive right over their invention or creation thereby providing them a possibility to profit from their inventions/creations and allowing them to commercialize their innovations without fear of infringement. An effective IP infrastructure ensures that those who infringe protected rights can be held responsible for their actions. This provides certainty to the rights holder and facilitates the dissemination of green technologies. This, in turn, accelerates the adoption of sustainable practices. To provide a foundational understanding of the potential of IP, we summarize its potential contribution in three categories:

[8] Japan Patent Office, Ministry of Economy, Trade and Industry: The Green Transformation Technologies Inventory (2022)
[9] Resources, Conservation & Recycling Advances: Green patents and green codes (2023)
[10] Resources, Conservation & Recycling Advances: Green patents and green codes (2023)

Incentivise investments:
Sustainable inventions, such as alternative fuels, often require significant initial investments and involve a level of commercial uncertainty. As a worldwide benchmark of innovation, patents provide a rational means for appraising sustainable products and practices in the market. Through exclusive rights and rewards, patents provide the legal certainty and blueprint needed for companies and investors to gain a competitive edge in private markets that can serve as a valuable tool for fundraising[11].

Cultivate dissemination:
In addition, IP plays a crucial role in facilitating the dissemination of sustainable technologies. The legal framework underpinning IP enables technology transfer, licensing agreements, and collaboration among innovators, businesses, and other stakeholders. Such legal frames are also essential to help overcome market failures such as information asymmetry and to encourage private sector involvement in sustainable development. Specifically, we shall later describe notions of patent licensing and pools alongside (semi)open vs. closed patent rights all serving as a testament to the flexibility of the IP system in cultivating dissemination[12].

Promote collaboration:
Another significant benefit of green IP is its ability to promote knowledge sharing and collaboration among researchers, scientists, and inventors. The IP system protects the intellectual property of inventors while facilitating full disclosure of their innovation to the public. As such, the IP system can encourage the exchange of ideas and information, leading to further advancements in existing technologies while fuelling the development of new solutions that address environmental issues.

2. International agreements and frameworks

International agreements and frameworks play a crucial role in addressing the intersection of IP and the environment. Some of the most widespread and broadly recognized agreements include the Sustainable Development Goals (SDG), OECD DAC RIO Markers, and the EU Taxonomy:

Sustainable Development Goals (SDGs)**:** The SDGs, adopted by the United Nations in 2015, provide a comprehensive framework for global development, including environmental sustainability. Several SDGs relate to the green transition, most directly being Goal 9 (Industry, Innovation, and Infrastructure), and indirectly Goal 13 (Climate Action), Goal 16 (Peace, Justice, and Strong Institutions), and Goal 17 (Sustainable Cities and Communities). These goals broadly recognize the importance of innovation, technology transfer, and IP in developing cities and communities that promote sustainable development, which is closely tied to targets for mitigating climate change.

OECD DAC Rio Markers: The Organisation for Economic Co-operation and Development (OECD) Development Assistance Committee (DAC) Rio Markers are used to track the environmental dimensions of development finance. These markers assess the environmental relevance of projects and programs, including those related to renewable energy, climate change mitigation and adaptation, biodiversity, and sustainable agriculture. They help ensure that funding is directed towards environmentally sustainable initiatives and technologies for which patents and associated legal measures is considered crucial.

[11] Dennemeyer: How patents can drive sustainability (2022)
[12] Iamip: The Nexus between Intellectual Property and Sustainability (2023)

EU Taxonomy: The EU Taxonomy is a classification system that aims to establish a common language for sustainable economic activities within the European Union. It sets criteria for identifying environmentally sustainable investments, including those related to climate change mitigation and adaptation, circular economy, and pollution prevention. The taxonomy provides guidance for investors, companies, and policymakers to support the green transition by promoting sustainable investments. The patenting of green technologies is an integral part of assessing alignment to the taxonomy, supporting claims of compliance within the taxonomy's technical screening areas.

3. Development and trends in international IP

Several studies have highlighted that monitoring the development of CCMT patents is instrumental in understanding the status of the green transition[13]. This section examines CCMT patent activity to clarify the relevance and magnitude of "green patents" in supporting the transition to a green economy.

3.1. Outline of CCMTs activity and concentration

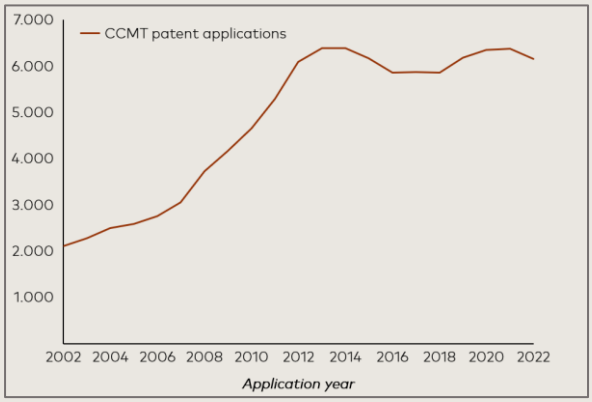
To outline IP's role in promoting and supporting sustainable innovations, we portray the historical development in CCMT patent activity and the concentration of CCMTs across industries. Lastly, we look towards the historical dissemination of CCMT patent families to better understand the development in international collaboration and qualify the link between patent protection and internationalization (i.e., dissemination of technologies).

A notable testament to IP's role in supporting sustainable innovations is found in the recent joint report issued by the European Patent Office (EPO) and the European Union Intellectual Property Office (EUIPO)[14]. The report delves into the relationship between IP-intensive industries and economic performance and outlines specific sectors that drive environmental sustainability within the European Union (EU). In a section dedicated to 'Climate Change Mitigation Technologies' (CCMT), it acknowledges the significance of IP protection in advancing technologies aimed at mitigating climate change.

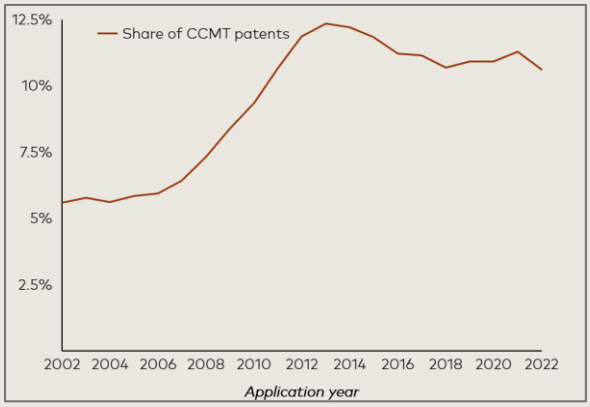
The report reveals that the number of patent applications related to Climate Change Mitigation Technologies (CCMT) filed by EU applicants at the EPO has increased significantly over the last ~20 years. Graph 1 below depicts this development (similar graph to the EUIPO report but updated using PATSTAT data) suggesting an increase of approximately 2,100 applications in 2002 to around ~6,100 applications in 2022[15] despite seeing a recent slowdown in CCMT patent activity (depicted in the graph below). In addition, it is evident from Graph 2 that the share of CCMT patents (to overall patent activity) has almost doubled from ~6% in 2002 to ~11% in 2022.

[13] EU Intellectual Property Office: IP-intensive industries and economic performance in the European Union (2022)
[14] EU Intellectual Property Office: IP-intensive industries and economic performance in the European Union (2022)
[15] EU Intellectual Property Office: IP-intensive industries and economic performance in the European Union (2022) – Using updated PATSTAT data

Graph 1: Number of CCMT patent applications filed by EU countries at the EPO (2002-2022) using latest PATSTAT data



Graph 2: Intensity of CCMT patent applications filed by EU countries at the EPO (2002-2022) using latest PATSTAT data



In addition, the report highlights that green patent- and trademark-intensive industries accounted for 9.3% of the total EU employment from 2017-2019 while contributing to 14% of EU's GDP in the same period[16], signifying the high productivity of such sustainable innovations. Furthermore, the overall contribution of these patent-intensive industries to employment levels and GDP has increased over time (~0.4% and ~0.3% increase respectively comparing the average activity from 2008-2010 and 2017-2019).

CCMT data can further be used to understand the intensity of green patents (labelled CCMT) on an industry-level. The table below depicts the 10 most patent-intensive and trademark-intensive industries across EU NACE-codes where intensity is expressed as the share of green patents to the total number of patents obtained in the industry.

Constituting almost ~85% of the total patents obtained in the industry, *Manufacture of batteries and accumulators* appear as the NACE code with the highest share of green patents followed by *Mining of other non-ferrous metal ores.* Notably, these industries, along with the other top 10 industries, are also intense users of green trademarks (as depicted in the rightmost column of the table).

Most interestingly, it appears that industries with a high intensity of green patents are also among the industries that causes the most severe harm to the environment (i.e., the most intense emitters of CO_2 and other greenhouse gases). On one hand, a high intensity of CCMTs is considered a key indicator of an industry-wide transition to greener practices and

[16] EU Intellectual Property Office: IP-intensive industries and economic performance in the European Union (2022)

products. As such, CCMTs may hold great potential in mitigating climate change within the most polluting industries[17].

On the other hand, a study conducted by IFI CLAIMS Patent Service, a digital science company dedicated to providing trusted patent data for research, has found that energy companies continue to invest in R&D focused on extracting fuel from the earth alongside obtaining these green patents. Examining the trends in classification E21B (earth drilling for e.g. gas) and Y02E (reduction of greenhouse gas emissions), they found that the lion's share of 'green' patents that these companies obtain are focused on merely modifying the negative effects of conventional drilling activities[18].

Table 2: Top 10 CCMT patent-intensive industries in the EU (ranked by patent intensity, i.e., the share of CCMT patents to total number of patents filed)

NACE code	NACE description	CCMT patent share	Patent-intensity ranking	Green TM-intensive
27.20	Manufacture of batteries and accumulators	84.7%	79	Y
07.29	Mining of other non-ferrous metal ores	78.5%	146	N
35.11	Production of electricity	63.7%	120	Y
35.12	Transmission of electricity	58.9%	148	Y
33.16	Repair and maintenance of aircraft and spacecraft	52.7%	123	N
35.21	Manufacture of gas	49.8%	84	Y
45.19	Sale of other motor vehicles	36.3%	65	N
25.21	Manufacture of central heating radiators and boilers	30.4%	139	Y
28.11	Manufacture of engines and turbines, except aircraft, vehicle and cycle engines	29.4%	6	Y
20.11	Manufacture of industrial gas	27.9%	10	Y

Lastly, we include a study conducted in 2021 by Pasimini et al.[19] to understand the link between patenting activity and sustainable innovation. The authors examine the development in CCMT productivity on a global scale between 2000 and 2014, working from the previous conclusion that patent protection does not necessarily imply technology production and diffusion. As such, they suggest that the link between protected CCMT patents and greenhouse gas reductions can sometimes be blurred.

From this view, the authors map the activity in foreign and domestic patents across the four largest CCMT patent economies (China, US, Japan, and Europe) to quantify internationalization of CCMTs over time as a proxy for technological productivity and dissemination. Firstly, they find that these major economies have become increasingly productive in CCMT-related technologies. In particular, China's development has opened international market opportunities and introduced competition.

Secondly, they find that cross-country cooperation has increased over time across these economies alongside increasing patent protection (compared to previous years of study). This signifies that patent protection and cross-border dissemination of technologies has been complementary.

[17] EU Intellectual Property Office: IP-intensive industries and economic performance in the European Union (2022)
[18] Digital Science: 'Green' energy patents more focused on 'clean' conventional energy instead of renewables (2023)
[19] Energy strategy review: International landscape of the inventive activity on climate change mitigation technologies (2021)

3.2. Outline of trends in CCMTs across geographies and areas of technology

In this section, we highlight international trends in patenting activity. Once again, we rely on scholars using EPO's CCMT patenting data to understand the activity and intensity of green patents across geographies and areas of technology.

Pasimini et al. (2021) found that around 75% of global inventions related to CCMTs between 2000 and 2014 were developed by US, Europe, Japan, and China[20]. While Europe, Japan and the USA have a higher level of globalized inventive activity (i.e., more international inventions are patented in these respective economies), it is evident that Chinese CCMT inventions are more domestically protected.

On a general note, the authors conclude that the inventive performance of these four economies vary substantially, and that the level of specialization depends largely on the technology analyzed. For instance, Europe is a clear leader in innovations related to wind technology, while Japan leads in solar PV.

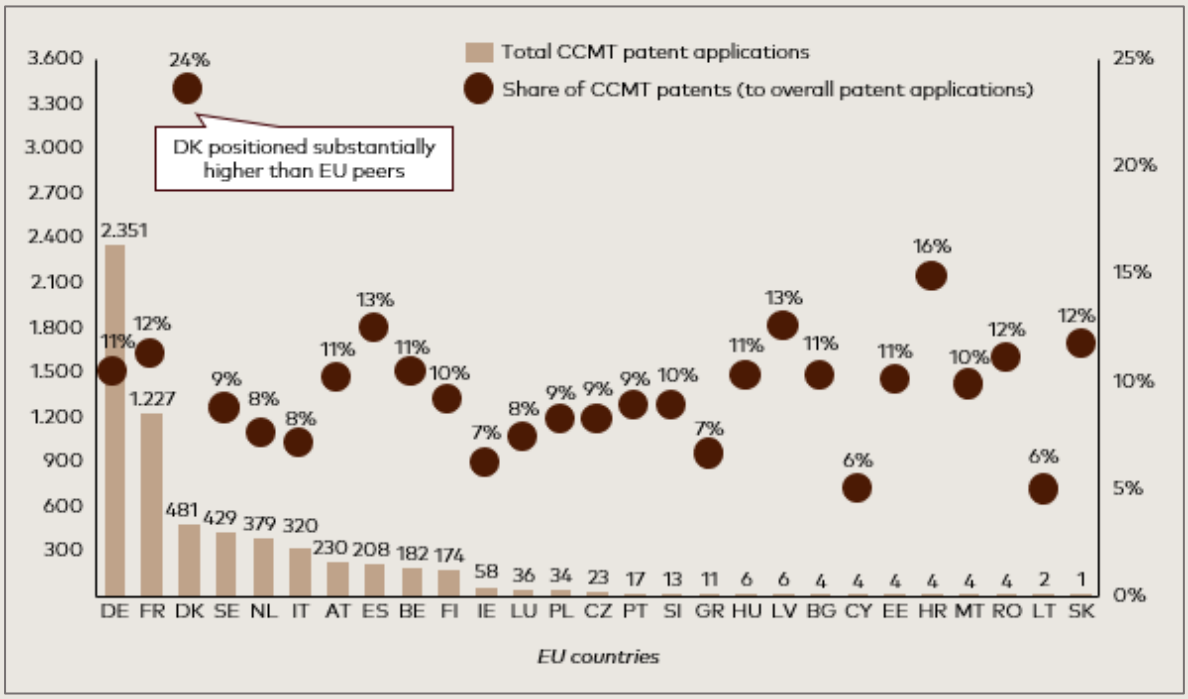
Examining more recent EPO data on CCMT applications in 2022 across EU members states, it is evident that there is a skew towards the larger EU economies (see Graph 3 below). Germany emerges as the dominant country accounting for ~38% of all CCMT patent applications among EU Member States. France follows with 20%, while Denmark, Sweden, and the Netherlands hold 8%, 7%, and 6% respectively[21].

If we instead look at the intensity of green patents (i.e., the share of CCMT patents to overall patents) within each country, we are able to digest the magnitude of these nations' sustainable invention activity. While total patenting activity is measured solely for 2022, patent intensity is calculated as an average of the five years between 2017-2022.

As depicted in Graph 3 below, Denmark stands out as the frontrunner with CCMT patents representing 24% of total patents filed by Danish companies. As such, Denmark surpasses other larger patenting countries where the share is closer to 10%.

[20] Energy strategy review: International landscape of the inventive activity on climate change mitigation technologies (2021)
[21] EU Intellectual Property Office: IP-intensive industries and economic performance in the European Union (2022) – Using updated PATSTAT data

Graph 3: Total CCMT patent application and intensity of CCMTs (to overall patent activity) across EU member states (recorded in EPO's PATSTAT database



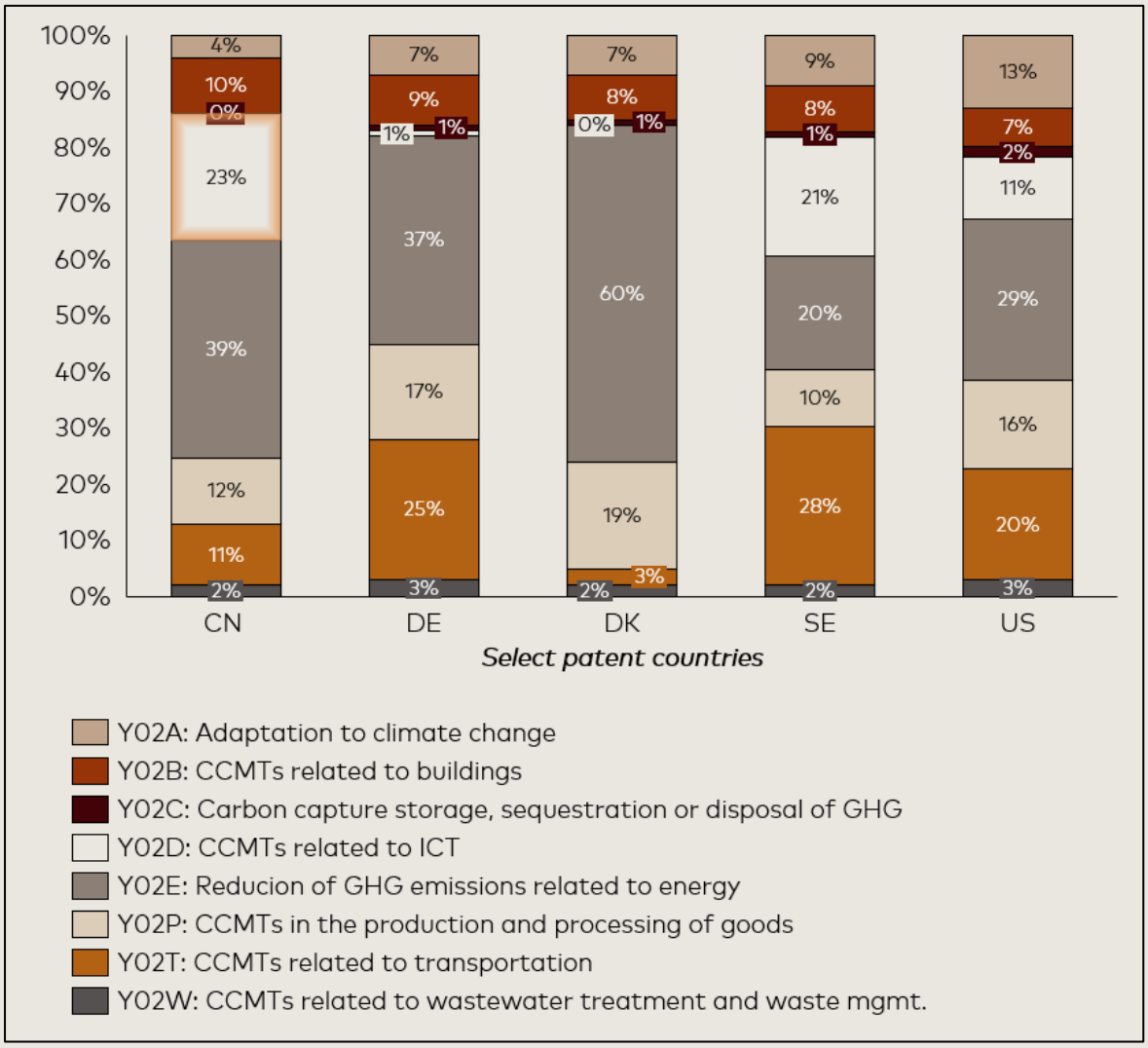
In addition, we draw on statistics published by the DKPTO (citing EPO PATSTAT data from 2020) examining the number of patent applications by country within specific areas of green technologies linked to the CCMT tagging scheme[22]. Accordingly, Graph 4 below depicts the share of CCMT patent application within these technical classes focusing on selected countries to better understand Denmark's relative specialization.

It appears that *CCMTs relating to transportation (Y02T)* play a significant role in Sweden, Germany, and the United States. This seems to be a natural consequence of the increasing political pressure and demand for sustainable transport, influencing car manufacturers to develop more environmentally friendly vehicles and engines. In addition, Sweden, along with China, is more advanced in *Energy use reduction in information and communication technology* (Y02D). While Sweden is the most advanced in Europe, China is particularly advanced in areas such as artificial intelligence and 5G networks.

Furthermore, the graph clearly shows that Denmark is at the forefront when it comes to "*Energy generation, storage and distribution (Y02E)*", and hence a major contributor to Europe's overall stronghold in green energy. However, these innovations seem to reside within relatively few industries compared to Sweden, Germany and USA, which all appear to be more diversified across green technologies. Taking this view, there is a risk that innovation becomes exclusive to the energy sector, and hence, that a broader transition to a more sustainable economy will be slower[23].

[22] The Danish Patent and Trademark Office: Patents in the green transition (2022)
[23] The Danish Patent and Trademark Office: Patents in the green transition (2022)

Graph 4: Distribution of CCMT patent filings in selected countries (2020)



3.3. Concluding remarks

The increasing adoption of CCMT patents to protect and promote sustainable practices and products is a testament to the importance of patents in driving sustainable innovation. In support of this, the growth in CCMT patent applications (i.e., green patents) has been superior to the growth in total patent applications.

In addition, it is evident that CCMT-intensive industries continue to further contribute to the overall economy (measured as the contribution to GDP) over time, and that CCMT patents are especially adopted by industries that cause the greatest harm to the environment. While the latter demonstrate CCMTs being used at the core of where greenhouse gas emissions are incurred, studies in energy technology confirms that CCMTs can be used to merely modify conventional activities, as opposed to supporting a transition to renewable energy sources.

Around 75% of the historical activity in CCMT patent families has been related to four major patent economies; US, Europe, Japan, and China. Cooperation between these economies has increased historically alongside increasing patent protection, signifying that patent protection is instrumental for internationalization (i.e., dissemination) of green technologies.

While Europe, Japan and the USA have a higher level of globalized inventive activity, China's CCMT inventions have a high degree of domestic protection (i.e., appear less internationalized). Furthermore, these four economies differ substantially in their specialization. As an example, Europe stands out as the clear frontrunner in wind technology, while Japan leads in PV.

Examining patent filings across EU member states specifically, data indicates that CCMTs are largely concentrated within the larger economies of Germany, France, and the Netherlands. More interestingly, examining patent intensity in these countries (i.e., the share of CCMT patents to overall patent filings), Denmark is a clear leader with CCMT patents representing ~24% of the total patents filed by Danish companies.

Finally, within Europe, countries vary significantly in their specialization. For instance, Sweden, Germany, and the USA are well exposed to *Sustainable transportation patents*, while China demonstrates expertise in *Information and Communication Technology (ICT)*.

Denmark has its stronghold primarily in *Energy generation, storage, and distribution* patents. Notably, most of the examined countries exhibit a relatively diversified green patenting activity. As highlighted by DKPTO, Denmark appears almost exclusively focused on the energy sector, indicating an untapped potential for the broader transition to a sustainable economy to be expanded to other sectors and a more diverse composition of companies.

4. IP mechanisms and models

The purpose of this section is to outline relevant IP mechanisms and their use-case in the context of a green transition. It involves broader notions of closed, semi-open, and open IP models and a discussion of how these models can be deployed as stand-alone or in combination.

4.1. Outline of different IP mechanisms

There exist several IP models to support green innovation, each serving different purposes. Below, we outline archetypes of IP models distinguished by the degree of openness in the ownership, access, and commercial usage of the IP[24]:

Closed IP model: In this model, innovators obtain IP, such as patents, trademarks, copyrights, and design rights, to protect their inventions. Patents incentivize inventors by providing temporary exclusivity and requiring public disclosure of the invention. In the most extreme closed IP scenario, inventors keep their invention as a trade secret without patent protection.

Semi-open IP model: This model involves selectively sharing IP with strategic partners through mechanisms such as exclusive or non-exclusive licensing, cross-licensing, or closed patent pools. Patent licensing refers to patentholders granting patent buyers access to a specific patent at a cost, while patent pools involve multiple patent holders collectively licensing their patents to interested parties.

The role of licensing and patent pools in green innovation is heavily debated as it poses a risk of follower firms imitating the invention, thereby reducing innovators competitive advantage. Still, ventures can benefit from adopting semi-open models when lacking complementary assets for technological development and commercialization (i.e,. benefiting from co-developing green technologies). Furthermore, in the context of a green transition, semi-open IP models can be instrumental in facilitating collaboration across value chains to find new business opportunities and create far-reaching impact. As we shall see in later case examples, companies are able to share their IP in project-like constellations without disclosing their core "background IP" (i.e., business secrets).

Open IP model: This model involves openly sharing IP with others free of cost and without imposing commercial restrictions. Examples include royalty-free licensing, patent pledges, and defensive publishing. The open-source software movement is an example of this model, which promotes large inventor networks, cost reduction, and accelerated innovation. Implementing fully open models for green innovations have shown varying results. For example, the Eco-Patent Commons initiative did not facilitate significant diffusion, yet successful initiatives of e.g., open-source hardware do exist.

4.2. Discussion of the use-case of various IP mechanisms to support sustainable innovation

In this section, we discuss how these IP models can be used to support sustainable innovation[25].

The use-cases of these IP models vary considerably and may be used in combination to provide the best legal framework. In literature and research, there seems to be no clear answer as to what model or approach is best suited to steer the green transition. Still, case-

[24] Journal of Cleaner Production: IP strategies for green innovation (2022)
[25] Journal of Cleaner Production: IP strategies for green innovation (2022)

studies signify likely benefits of adopting these IP models contingent on organizational characteristics and the maturity of the innovation process.

From this view, we include a study based on 57 green innovations recognized by the EPO for their "contribution towards technical progress, social and sustainable development and economic prosperity". The authors suggest that the degree of openness in IP sharing is generally increasing as innovations progress and become more established (i.e., move from research stages to development / commercialization, and lastly, diffusion of the technology)[26].

According to the study, closed IP models are generally deployed in research phases while diffusion phases tend to involve notions of semi-open IP models where the venture or organization starts sharing IP with other parties. The study further provides evidence that organizations adopt different IP models and change their IP regime over time as they progress on their innovation. First, these ventures seek to bring their innovations to the market leveraging a closed IP regime. Subsequently, to widen and diffuse the sustainability impact of their invention while maintaining a competitive advantage.

From this perspective, the authors outline the use-cases of IP on green innovations within three types of organizations: 1) new ventures, which mainly use patents for attracting investments, 2) universities, which mainly use patents for attracting industry partners, and 3) established firms, which according to the study mainly use patents to gain a competitive advantage in the market.

The authors conclude that both timing and the extent to which organizations share their IP vary considerably. New ventures and universities tend to adopt closed IP models in research and development phases to protect inventions and later share the IP with others to accelerate commercialization and diffusion. This stands in contrast to established firms which predominantly keep their IP closed in both research and development phases, but tend to engage in collaborations or non-exclusive licensing during diffusion phases[27].

Broadly speaking, all three categories of organizations tend to keep their IP closed during the initial research phase which gives time and opportunity to clearly define their background IP (IP owned by the organization before entering into the open innovation collaboration). This, in turn, enables collaborative efforts in later stages of development (particularly the diffusion phase).

When companies choose IP models with a fairly high degree of openness, they do this mainly for three reasons: 1) to enter new markets (including their first), 2) to accelerate diffusion of green innovations, or 3) to generate revenues by adopting a licensing-based business model. IP models with a fairly low degree of openness (also in diffusion stages) are, on the other hand, predominantly seen among universities and research institutions which lack the expertise to commercialize and disseminate their invention.

When it comes to fully open IP models, the authors are fairly skeptical of the ability to create substantial impact. To that end, the study concludes that successful green innovators seem to adopt and combine different IP models in different phases of the innovation process. These findings underline the flexibility of the IP system while signifying the importance of integrating IP in the corporate strategy of small ventures and large corporates to incentivize sustainable innovation.

[26] Journal of Cleaner Production: IP strategies for green innovation (2022)
[27] Journal of Cleaner Production: IP strategies for green innovation (2022)

5. The potential of IP in supporting the green transition

The purpose of this section is to discuss the role of IP in supporting a green transition. We seek to highlight the opportunities inherent in the IP system drawing on interviews conducted with a large research organization, pre-seed investors, and a start-up (case studies in the sections below).

5.1. Discussion of the possibilities of strong IP protection to incentivize development and attract funding

As reflected in our interviews and related case studies, the practical contributions of IP with respect to development and funding options can be summarized into three categories:

IP protection is vital to build reputation and secure funding in green start-ups:

From the interviews conducted with the early-stage investor PreSeed Ventures (PSV) and start-up Agrain, it is evident that strong IP protection is critical for attracting capital in the start-up environment. Early-stage investors seek assurance that their investment will be safeguarded to generate commercial returns, to which IP protection is a key lever. Marianne Hyltoft, DeepTech Impact Fund Director at PSV, says: "The IP of a start-up in our Greentech vertical is one of the first things we are looking at when looking into investing".

New, green technologies often involve a high degree of radical innovation while there are significant costs associated with developing and commercializing such inventions. This, in turn, increases the importance of IP protection. Marianne highlights that while investments in early-stage technology companies always require close attention to IP, particularly 'DeepTech' inventions (incl. GreenTech) are often less proven and, hence, more reliant on being able to showcase a strong IP proposition. Even in cases where "... the start-up has not been through the IP process on a product level...", she mentions that "...we still look into IP on processes and the overall potential to secure these IP positions".

In support of this, our interview confirms that investors are attracted to companies with a strong portfolio of green IP, as it signifies a commitment to innovation and the potential for future profitability. Robust green IP protection demonstrates that a company is serious about protecting and commercializing its sustainable technologies, which hold strong signaling value in the market and prove important in funding rounds[28]. This is largely evidenced in a study conducted by the European Commission concluding that green innovators are more likely to receive VC funding than firms without green patents[29].

This is largely echoed by Karin, Co-Founder of Agrain and PhD scholar in IP, arguing that: "...patents are crucial to build reputation in the market. This is important for us to attract larger companies that want to work with us, and hence also critical for securing funding".

IP models can support collaboration to advance sustainable impact in large corporates:

From the perspective of research and development in mature organizations, efforts to advance on sustainability may increasingly entail collaboration across the value chain. While isolated sustainable innovations can be achieved within companies, far-reaching effects are most often seen when actors in the value chain come together to improve the structure and circularity of the underlying system. Indeed, companies in energy-intensive industries are increasingly incentivized to collaborate to ensure future viability of the value chain they

[28] Journal of Cleaner Production: IP strategies for green innovation (2022)
[29] European Commission: Venture Capital Financing and Green Patenting (2021)

engage in. Such collaboration requires legal structures that enable businesses to engage in open development while able to protect their business secrets.

As evidenced in the Maersk Zero Carbon Shipping (MZCS) case below, the IP system holds the flexibility needed to facilitate impactful and commercially attractive cooperation. In this model, collaboration partners are able to safeguard their own inventions (i.e. protecting their background IP) while simultaneously engaging in open IP development in a project-like constellation. Having adopted this approach, close competitors are co-developing new solutions likely to help decarbonize the shipping sector.

IP models can support collaborative efforts to advance sustainable SMEs:

In this regard, Marianne, from PSV, highlights that the IP regime of the start-ups will most often be closed in early stages where products and practices are still being developed, yet preferably open up over time to achieve greater impact. She emphasizes that PSV seeks to find investments where the core IP is deep and protected but also well positioned to overlap with other actors in the value chain. In later stages of development, such touchpoints can be a key driver to gain access to resources and engage in co-development with other ventures.

In addition to this, Karin from Agrain – a green start-up - confirms that they seek to obtain very specific patents in innovation stages but see a vast potential for more open IP engagement over time. Specifically, in order to address larger climate challenges, she stresses that IP can be used as an 'anchor' (i.e., holding patents that overlap other industries' IP regime) to work with other parties in the value chain. This in turn can cultivate large CAPEX investments that will be key in allowing Agrain to scale their production and achieve greater impact.

This is largely in line with aforementioned research, suggesting that early-stage development tends to happen in closed IP environments, and that these firms may benefit from opening up as they progress on their innovation.

Maersk Mc-Kinney Møller Center for Zero Carbon Shipping:
Independent R&D center dedicated to decarbonize the shipping industry

5.1.1. Case 1: Maersk Mc-Kinney Møller Center for Zero Carbon Shipping (MZCS)

MZCS is a research and development center dedicated to decarbonizing the shipping industry. It focuses on developing and implementing innovative technologies and solutions to eliminate greenhouse gas emissions from maritime transportation. The institute operates through a collaborative model bringing together leading maritime corporates, researchers, and policymakers. Across the value chain, the MZCS counts 24 strategic partners, all contributing with resources and knowledge that go into publicly available research projects.

Tanja Dalgaard, Chief Strategist & Operations Officer in MZCS, highlights the importance of the IP strategy in achieving the institute's overall mission to decarbonize the shipping sector. According to her, the IP regime is instrumental to "...incentivize the broadest possible sharing of knowledge while creating viable commercial opportunities for the partners involved"[30].

In order to facilitate this, MZCS has constructed an IP regime that is "...flexible and agile enough to cover different models of IP ownership, usage rights, license setups, spin-offs etc." (Tanja Dalgaard, MZCS).

Accordingly, MZCS works with the notions of *Background IP,* involving ownership of the IP that collaboration partners bring to specific projects, and *Foreground IP*, constituting the different contractual paths with respect to e.g. ownership and license grants that are installed in project-like constellations. Tanja argues that the clauses and protection inherent in the background IP enable foreground collaboration between competing companies:

"It is important that all our strategic institute partners (i.e., companies in the shipping value chain) have similar legal boundaries and strong protection of their background IP, so that no one is prohibited in talking about the right things on our projects..." (Tanja Dalgaard, MZCS)

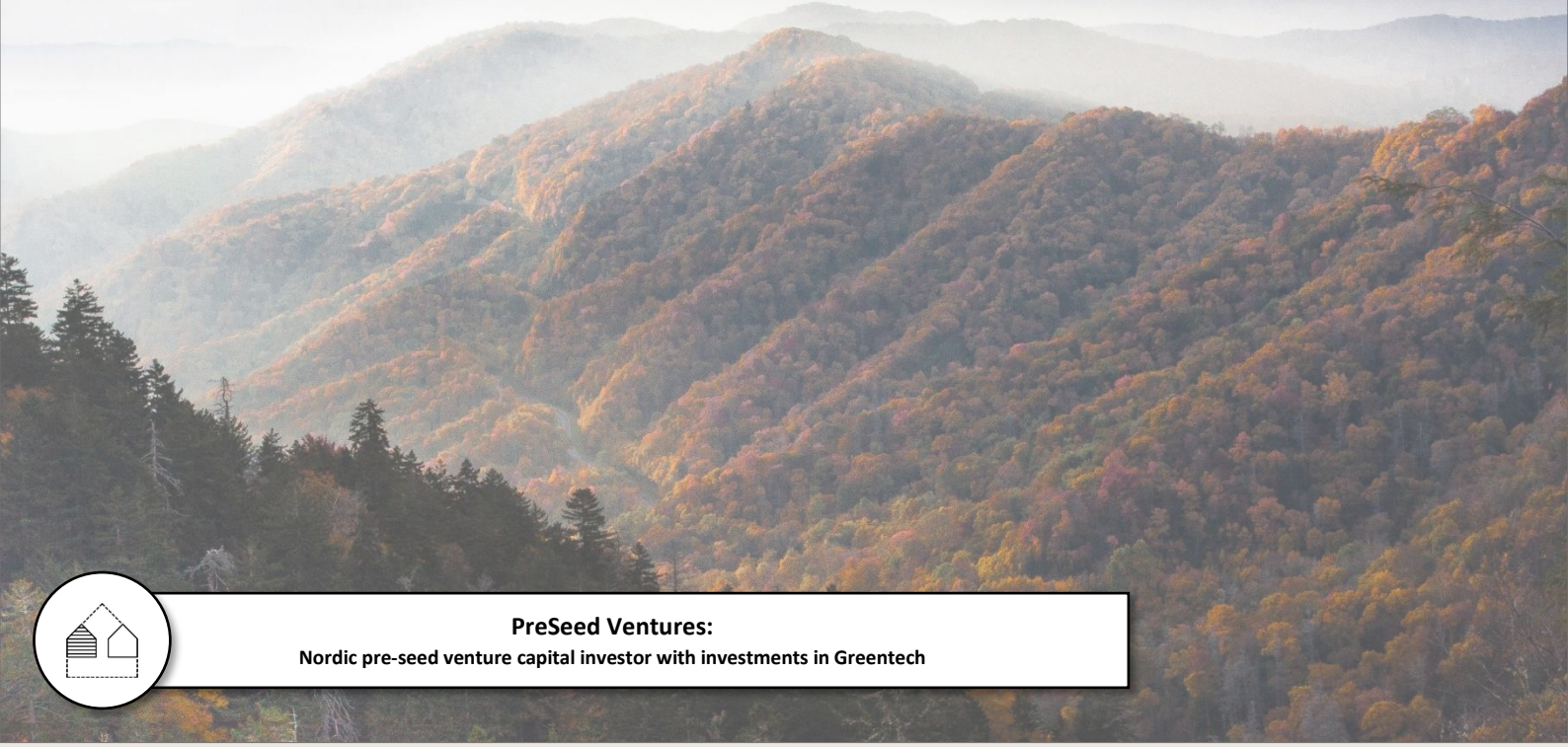
On the other hand, it is the semi-open nature of MZCS's IP regime that promotes collaboration and innovation across the value chain. Partners to the institute contribute to projects with resources and knowledge, while the foreground IP (e.g. ownership rights) is typically fully or jointly owned by the research institute. MZCS can subsequently license out the foreground IP to partners associated with the institute while making the research available to the public. As such, these projects may help partners discover new business

[30] MZCS Case material (2023)

opportunities while continuously advancing inventions that are needed for shipping to reach net zero:

"All our partners are motivated to make the value chain more responsible, but also interested in the business development opportunities that the collaboration efforts can bring... It is the open nature of our IP strategy that makes collaboration possible... and also what helps us secure funding as an independent research organization." (Tanja Dalgaard, MZCS).

The MZCS case serves as a testament to the flexibility of the IP system and its potential to support the advancements of green innovations. In the case of MZCS, the IP regime has proven instrumental in facilitating collaboration between leading actors in the industry, and hence, instrumental for the shipping industry to move towards net zero emissions. While MZCS can be considered a rather unique constellation, one can expect similar constellations to arise in other energy-intensive industries where there is an urgent need to find innovative solutions across the value chain, that are both sustainable and commercially attractive to the partners involved.



PreSeed Ventures:
Nordic pre-seed venture capital investor with investments in Greentech

5.1.2. Case 2: PreSeed Ventures

PreSeed Ventures is a leading Nordic venture house headquartered in Copenhagen. Through two decades of taking the startup journey with well over 450 founders, PreSeed Ventures have specialized in helping founders get from the pre-seed and early seed stage to series A and beyond. That means they take the bet on founders in the very initial funding rounds, often as the first institutional investor. And then they bring in all the learnings, competencies, and support functions they have developed from taking the journey again and again to help the founders get to the next stages of their journey. This will often be around the completion of proof-of-concept phase, but before entering product/service development and the commercialization phase. In addition to providing financial backing, PSV actively engages with its investments, offering strategic guidance and operational support as required.

Across their house PreSeed Ventures operates a wide spectrum of the technology space. The PSV DeepTech fund, specifically focuses on startups whose business models is rooted in turning deep scientific advances and breakthrough research into breakthrough impact. Among others, they invest in GreenTech start-ups, referring to environment-friendly technologies.

According to Marianne Hyltoft, Director in PSV's DeepTech fund and responsible for the GreenTech vertical, the IP of these ventures is one the first things that PSV assesses in the screening processes. The patent profile of these start-ups is key to understanding the potential of the investment. Even in cases where "…not all [investment targets] have been through the IP process on a product level, [PSV] still look into IP on processes". If the IP proposition cannot be supported, Marianne argues that valuations can rarely be supported.

Particularly within DeepTech (incl. GreenTech), Marianne argues that it is instrumental that the IP regime of the start-ups is "deep", meaning that the underlying technology is unique and protected. In addition, it is preferred that "…the ventures are positioned well within the overarching value chain and hold patents that can overlap product and services of other value chain partners". As such, these start-ups should have their core technology protected while being attractive to work with in later development stages. This is relevant for the venture to engage in co-development across the value chain but can also be leveraged in a licensing model where external parties gain rights to the invention at a cost.

The need for IP protection within technology ventures is high whether it addresses conventional or environmentally focused start-ups. Still, GreenTech start-ups focusing on climate change mitigation or environmental protection tend to address challenges that are relatively "new" in nature and, in some cases, still to be fully understood. As such, one can argue that these may, to a greater extent, rely on IP protection to support the core technology that contributes to valuation profiles and becomes the decisive factor for pre-seed investors.

In summary, the legal certainty inherent in IP is essential for pre-seed investors (e.g. PSV) to assess the commercial potential of an investment. This appears particularly important in Deep- or Greentech start-ups that tend to involve a higher degree of risk.

5.1.3. Case 3: Agrain

Agrain is a Copenhagen based start-up backed by Nordic and Swiss venture capital investors. The company was founded in 2018 dedicated to produce ingredients made from spent grain from the production of beer.

Once breweries have extracted sugars from grains to ferment the beer, producers have no more use of the grain. Agrain connects with organic craft breweries to purchase the grain and process (i.e. upcycle) it into flours. Beer is the 3rd most consumed beverage in the world, which speaks to the potential of both reducing food loss and for producing secondary flour that can substitute production of new flour. Accordingly, the CO2-equivalent emissions incurred from Agrain's flour production (0.59 CO2eq per kg flour) are substantially below global averages for wheat flour.

To sustain a scalable business model, it is vital for Agrain to accommodate various streams of spent grain (i.e. mask). This in turn requires complex processing facilities underpinned with an intelligent use of data. To further advance Agrain's ability to undertake these processes and sustain a viable long-term business model, Agrain has asserted great importance to obtaining the right patents in early stages of production. To better understand the implications of IP, we have interviewed Karin Beukel, co-founder of Agrain, PhD, and author of several books and research papers within IP Management.

With vast experience within IP and from the food sector, Karin highlights that the use of patents in Agrain serves two main purposes: reputation (incl. the ability to attract investments) and empowerment of the business.

First, Karin explains how patents on the processing of spent grain have been essential for Agrain to build a reputation and attract collaboration partners in the food and beverage value chain. Operating between suppliers (e.g. of beers) and offtakers (i.e. demand side) of upcycled flour, patents are key to building reputation and attracting collaboration with large companies:

"Our access to the breweries is strong because we can help them up-cycle the spent grains that they currently discard as feed or biomass. You need to be relevant for large players to want to work with you, and this is where patents can be crucial".

In the market where Agrain operates there are, according to Karin, very few large players: "If we can say to a producer that we can give exclusivity on IPR, it has huge value."

These collaborations ultimately enable Agrain to operate, and hence are crucial to attract funding. According to Karin, patents showcase an external commitment while de-risking investors' committed capital. Without such protection, Agrain would have difficulties in advancing their business and contributing to a greener food and beverage sector.

Secondly, Karin highlights that Agrain has used their patents to provide a firm description of what the company is set out to do, which has become a strong source for internal and external empowerment. Circular business models, she argues, can be difficult for investors and large corporates to digest. Here patents can be used as a credible way to communicate how a company intends to create impact in new ways and address the transition to a more circular (i.e. greener) economy.

Discussing the broader role of patents in the context of green start-ups, Karin shares the view that scaling through relatively open IP models can be beneficial for green start-ups from both a commercial and impact standpoint:

"We do not use these semi-open patents right now as our focus has been on establishing a strong IP position within a very specific part of the value chain, but I can imagine us doing it in later stages... A strong portfolio of patents allows you to be the 'anchor' for larger CAPEX investments (made by collaboration partners) that can drive huge impact"

Similar to Marianne from PSV, it is evident that Agrain focuses on proving their business model through niche IP's while highlighting the importance of patents to engage in collaborative efforts in later stages of development.

5.2. Concluding remarks:

From the interviews conducted with PSV and Agrain, it is evident that IP protection is crucial for green start-ups to build reputation and secure funding. Investors, particularly in the realm of green technologies, tend to prioritize strong IP in screening processes as it ensures that their investment is safeguarded and will generate commercial returns. Having a robust portfolio of IP demonstrates a commitment to innovation.

Secondly, the case of MZCS signified how the IP system can become a key lever in facilitating corporate partnerships that advance sustainable impact. Collaboration across the value chain will be necessary to achieve far-reaching progress on sustainability. As such, legal structures that enable protection of business secrets while unlocking sector-wide collaboration seems vital. In the case of MZCS, the IP regime adopted enabled partners to secure their background IP while contributing to projects owned by the research center. These projects are in turn likely to drive new and impactful inventions that can be commercialized by the partners involved.

Lastly, it is evident that the IP system can support collaboration between SMEs and contribute to the dissemination of green technologies. Aligned with literature, our interviews confirm that start-ups tend to commence securing their unique IP position before gradually adoption more open IP models. From this view, patents can serve as the "anchor" that enables the company to work with – and be relevant to – other companies in the value chain. Leveraging e.g. licensing models, patents is considered a key enabler of scaling sustainable impact.

6. Challenges and opportunities – reflection for future action

The scale of the environmental challenge is such that we need to carefully consider IP system may be calibrated and utilized to best support a green transition. As such, the purpose of this section is to discuss the role of the IP system in the context of the green transition seen from the perspective of governmental entities. This is followed by concrete initiatives for future action.

6.1. Discuss challenges to the IP system in supporting a green transition

Particularly in the context of the green transition, it is evident from the number of e.g. CCMT patents that the patent system is edging it way onto the public and political agenda. Still, public perception of the patent system is often marked by apprehension and unease, and hence, serious efforts are required to ensure awareness, accessibility, and credibility of the system.

According to WIPO, the international IP system faces two main challenges; an internal challenge that concerns the operations of the patent system, and an external challenge concerning the policy role and economic and social impact of the system[31]. In the realm of green patents, we decompose these challenges and categorize them into four groups: 1) the awareness and ease of access to the system, 2) the need for bridging information asymmetries in e.g. licensing market, 3) the cost of obtaining and enforcing patents, and 4) the need for adequate identification and verification of 'green' innovations.

Awareness and ease of access:
As the international community looks towards improving the IP system to better protect and promote green inventions, efforts to create awareness and increase accessibility to the system are of paramount importance.

In terms of general awareness, one notable effort is the World Intellectual Property Organization's (WIPO) Green Initiative. The initiative aims to enhance the understanding of intellectual property and their role in supporting environmentally friendly technologies. Additionally, organizations like the United Nations Environment Program (UNEP) and various national patent offices have been promoting awareness campaigns, providing educational resources, and facilitating discussions to highlight the importance of patents in advancing green innovation and sustainable development.

It is, however, clear that also national initiatives are needed to create awareness of the system. As an example, the DKPTO has committed to provide guidance and support to start-ups working, among others, in green technologies including workshops and specialized training. Furthermore, allocated resources to connect with technology clusters throughout the country to advocate for the possibilities inherent in IP.

Despite these efforts, and in order for SMEs to reap the benefits of the system, awareness of the patent system must increase substantially. Indeed, initiatives that commence from national governing entities but anchored in smaller communities seem to have a positive effect.

More pressing, inventors face challenges when it comes to accessing and searching for relevant patent documents. Indeed, efforts are being made to enhance accessibility, such as EPO's utilization of Y tags in the Cooperative Patent Classification (CPC) system, which facilitates user-friendly searches. Most recently, the Japan Patent Office has launched the GXTI enabling extensive patent search and considered one of the most effective methods to

[31] WIPO: Current and Emerging Issues Relating to Patents (2023 update)

screen for IP trends within specific areas of the green transformation. These initiatives arguably help innovators overcome the daunting and time-consuming task of reviewing prior work.

Still, our interviewees highlight that many SMEs do not have the knowledge or legal capacity to understand how patents can be taken into use. As there are fewer reference cases to be found in the realm of green technologies (given the still immature landscape), such knowledge gaps are sometimes intensified. The realm IP remains extremely complex by nature and often leave SME's without a fair chance to conduct the necessary legal assessment to obtain a patent.

Particularly green start-ups may face difficulties in understanding how their invention fit to classifications of green patents. From the perspective of Agrain, Karin highlights that start-ups focusing on increased circularity in existing value chains, such as the upcycling of food waste, struggle to become eligible for conventional notions of process patents while green patent classifications are too narrowly defined for companies like Agrain to fit in. Securing the right protection in such new – and still evolving – areas is important for gaining access to green capital and only increase the legal capacity needed to protect core IP.

Furthermore, patent offices (both international and national) hold an instrumental role in expediting green applications at pace. Some IP offices have started offering procedural benefits to sustainable technologies with the aim of incentivizing innovation and expediting examination procedures. For example, the UK IPO has established the Green Channel, which expedites the patent application process for inventions that have environmental benefits. Similarly, The USPTO has introduced the Climate Change Mitigation Pilot Program, designed to fast-track the examination of qualifying patent applications.

While efforts have been made to improve accessibility (i.e. ease and speed of access), it is evident that national and international entities should continue to take an informative role and support SMEs in building the legal capacity needed to adequately access the system.

Bridging information asymmetries:
In early stages of innovation (but still after the initial development phase), we have covered how semi-open IP models can be efficient in accelerating the diffusion of new inventions. From this view, licensing of sustainable technologies seems to play a vital role in securing innovation and dissemination across sectors. Several initiatives have been attempted to mitigate information asymmetries and promote these markets such as common databases and platforms alongside harmonized rules for patent sharing.

As an example, WIPO GREEN serves as a platform connecting seekers and providers of environmentally friendly technologies through a database of patents, networking opportunities, and acceleration projects. This platform celebrates success stories, motivates innovators, and facilitates the development of pivotal new technologies. As such, the effective licensing can unlock the potential of patents and expedite the introduction of innovative products.

However, with respect to databases, the European Commission has found that, in practice, patent transactions are rarely carried out in the open marketplace. IP collaboration between e.g., SMEs will often happen in closed innovation clusters and commence from a business perspective (not IP), and thus be highly relational. In addition, it has been voiced by our interviewees that start-ups with a strong IP tend to get acquired by larger businesses not only due to their IP proposition, but because their business as a whole hold a great potential.

Still, national IP offices can take a facilitating role ensuring that e.g., innovation clusters (where patent-related relationships tend to be formed) are well equipped to support SMEs in working together on their IP. Karin from Agrain echoes this by saying that while a direct bridging role is extremely difficult for national authorities to take, these bodies should take an informative role. This could involve information packages that enable companies to better collaborate on IP (e.g., containing industry-specific standard-agreements).

Cost of obtaining and enforcing patents

Another key challenge for innovators to access the IP system is the cost of obtaining and maintaining a patent. Filing fees, attorney fees, and ongoing maintenance fees can be a barrier for especially start-ups. In addition to conventional barriers, green technologies and sustainable innovations tend to be more global in nature. This in turn requires broader patent protection, which includes fillings in multiple jurisdictions and obtaining international patent protection.

Acknowledging the importance of green start-ups in the green transition, and the barrier of costly patent processes, several international initiatives have been launched to reduce the cost of obtaining green patents. As an example, the USPTO offers a reduced fee structure for applicant seeking patents within certain sustainable areas. In addition, several US states support patent pro bono programs where volunteer patent attorneys and agents provide free legal assistance to businesses working on green technologies.

On a national level, it is worth highlighting DKPTO's collaboration with the Novo Nordisk Foundation (NNF), serving as a testament to how public-private partnerships can prove beneficial to the green transition. Accordingly, NNF is co-funding a patent voucher scheme aimed at advancing inventions in small tech companies, the majority of which are operating within life science and green technology. The successful patent voucher scheme was launched by the Danish government in 2021 and supports small- and medium-sized ventures[32].

Acknowledging that patents provide the legal certainty needed to drive innovation in e.g., green technologies, it seems evident that local and international entities must come together to further ease the cost burden of obtaining patents.

Identification and verification of 'green' innovations

The identification of green patents and the broader use of patents to drive sustainable innovation remain central themes in the public debate. While it is evident that the adequate identification and use of patents can be a key lever in supporting a green transition, it also seems clear that the scope of green patents must be continuously scrutinized.

International and national regulatory bodies play a vital role in establishing more holistic criteria for assessing which patents fall into green categories. As seen in the venture capital environmental, green patents may be a key lever for early-stage companies to gain a competitive advantage and attract funding from sustainable investors. Ensuring that these grants are used to advance impactful innovation that contribute to sustainability will be important to the credibility of the green IP system.

To better identify green patent classification and assess the eligibility of new technologies, transparency and disclosure requirements seems instrumental. While such efforts are still to mature in the realm of IP, global organizations like the United Nations provides access to open data platforms, such as the "SDG Indicators Global Database", allowing users to

[32] DKPTO: The Novo Nordisk Foundation donates millions to successful patent support scheme (2022)

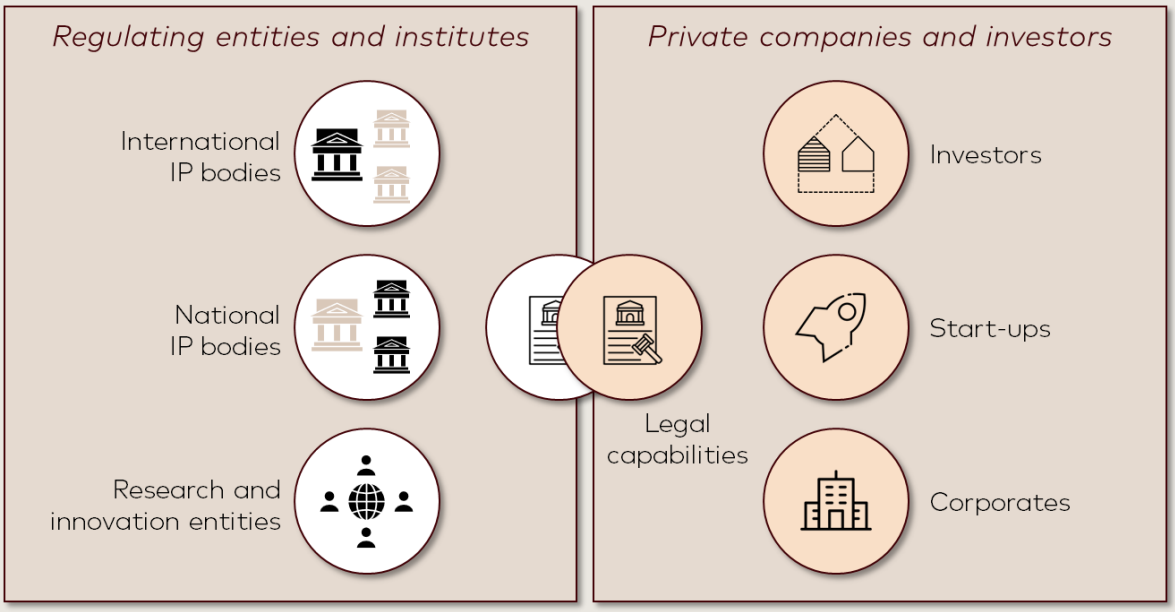
access and analyze data related to Sustainable Development Goals (SDGs). This, in turn, enables researchers and companies to find benchmarks for sustainability and search through lists of recognized green innovations and technology transfers, which provides insights into the potential for obtaining green patents in different regions.

6.2. Outline of specific initiatives that can drive a sustainable future direction

For the IP system to better support a green transition, commitment is needed from public entities in order for private actors to be adequately incentivized. That said, private actors (categorized into investors, start-ups, and corporates) can benefit from being on the forefront of the development in green patenting. Bridging public and private actors, legal capabilities are instrumental for IP to contribute to the advancement and dissemination of sustainable inventions.

As illustrated in the picture below, we address how regulating entities and private actors respectively can improve on – and benefit from – their engagement in green IP. Legal capacities are at the center of the ecosystem and unlikely to drive advancement alone, hence addressed in connection to these actors.

Figure 2: Ecosystem of actors enabling green IP



6.2.1. Regulating entities and non-profits

<u>International IP bodies:</u>
International IP bodies are central to ensure alignment on the classification and verification of green technologies. First, these entities should work to further detail what can be considered 'green'. A key initiative is to ensure that patents granted in the Y02/Y04S tagging scheme are aligned with what can later on be considered "substantial contributions" to the climate and environment in the EU taxonomy.

Secondly, these bodies should make sure that sufficient governance structures are in place to continuously ensure quality and uniformity in patent grants. Indeed, several initiatives have gone into securing quality assurance within Europe, most predominant being the European opposition system allowing companies with competing products to object against granted patents.

Thirdly, international IP bodies should continue their work to further centralize the court system and harmonize patent rules where possible as seen in Europe with the establishment of a Unitary Patent. Particularly in the realm of licensing, legal frameworks remain fragmented. While such licensing contracts are private legal matters, international bodies should continue efforts to spread the use of "standard agreements" likely to reduce complexity in cross-border patent agreements.

Lastly, international IP offices should support national IP offices in providing SMEs with better access to prior art. This could involve increasing the awareness of international patent databases or by providing access to discounted expert resources.

National IP bodies:
National IP offices have an important role to play in supporting investors and companies navigate the IP landscape of green technologies. First, national entities should raise awareness of the possibilities of IP through websites, campaigns, workshops or training programs. This is essential to ensure that companies understand the benefits of securing a strong IP, and vice versa the risks of not being protected.

Secondly, national IP offices can support companies in easing the access to – and the associated cost of using – the IP system. By offering funding opportunities e.g., vouchers or reduced fees for green innovation projects, these companies can bridge funding and resource gaps in vital early stages of development. Another lever is to install fast-track services that allow green innovations to be processed faster than conventional innovations. Recognizing the urgent need for impactful green technologies (and the costs associated with not reacting in time), governments should assert great attention to such mitigating actions.

Thirdly, these bodies are well positioned to facilitate cooperation across the IP ecosystem. Accordingly, national IP offices should focus on establishing work-sharing arrangements and information exchange with counterpart IP offices. Identifying the relative specialization of e.g., countries, such efforts can be targeted to specific areas of green technologies. This can be particularly beneficial in the attempt to improve the objective identification of truly green innovations and ensure that the right verification processes are installed.

Finally, national IP offices should take an active role in forming partnerships with public entities (e.g., research institutions and universities), innovation entities (e.g., research centers and innovations hubs), and the private sector to advance on sustainability. This could involve exchange of legal capacity or public-private partnership on the funding of vouchers (as seen in Denmark).

Research and innovation entities
Universities, research centers and innovation entities (i.e., hubs or clusters) are often the origin of entrepreneurial ideas that eventually become impactful companies. However, the process of testing and demonstrating the effect of new green technologies remains time-consuming due to a lack of legal and commercial expertise. Mitigating this obstacle has become a global priority, which has led to the launch of various initiatives worldwide, some more efficient than others. One prominent example is the Massachusetts Institute of Technology (MIT) pioneering an effective model for technology transfer[33].

[33] MIT Startup Exchange: Creating powerful synergies (2022)

Furthermore, research and innovation entities should continue efforts to equip innovators with the knowledge and skillset needed to safeguard and harness their green innovations through IP. Collaboration with national IP offices may be efficient in providing founders with a general understanding of how IP works, which can be complemented with educational opportunities that provide insights into specific technology areas.

Lastly, research and innovation entities are essential to build expertise and evidence-based recommendations to policymakers. To ensure timely action on climate issues, it is important that these entities continue to engage in policy discussions and shape the public debate by raising awareness of the importance of IP in the context of the green transition.

6.2.2.Private companies and investors

Investors:
During the investment process, investors should pay great attention not only to the IP portfolio of green start-ups but also the potential to secure a strong IP going forward. Start-ups with inadequate legal capacity to secure these positions can benefit from engaging with ambitious investors while investors may benefit commercially from progressing the IP position of the start-up.

Secondly, in management phases (i.e., after having invested), investors can take a crucial role in supporting SMEs (particularly start-ups) in building the legal capacity needed to advance the technology in a safe environment. Leveraging knowledge across the portfolio, investors are well positioned to facilitate knowledge sharing between green start-ups in later stages of development which can prove essential for unlocking commercially attractive IP-sharing.

Start-ups:
It is evident that start-ups should work to secure a comprehensive IP strategy early on, identifying their valuable IP assets and onboarding resources that can support the identification and filling of patents. Legal capabilities are likely to be of paramount importance to these ventures, particularly along development phases. Indeed, start-ups can leverage information packages and legal support offered by international and national IP entities, yet leveraging these resources to build a strong IP will eventually require internal legal capabilities.

As we have seen, securing IP rights is important not only for protection, but also to build reputation in the market. IP can be the 'anchor' that allows ventures to engage in open collaboration with larger companies in the value chain. This is often crucial to scale technologies and secure funding from early-stage investors. As such, deep IP positions can enable open IP co-development in later innovation stages.

Lastly, to ease the continuous management and communication of IP assets, start-ups should assert great attention to document their progress on IP matters to be prepared for legal due diligence in fundraising rounds. Understanding what the company is set out to do from an IP perspective can furthermore prove instrumental for internal empowerment.

Large corporates:
Large corporates should invest in developing a comprehensive IP strategy that aligns with their sustainability goals. This involves future-proofing current products and services by taking a long-term perspective of how these inventions can be made more sustainable.

Identifying and protecting key innovations, trademarks, and trade secrets, corporates will be better positioned to explore opportunities for licensing or collaborations with external

partners. As seen in the shipping sector, collaborative efforts across the value chain are possible, hold great commercial potential, and may be vital to ensure timely action on climate- and environmental issues.

Lastly, corporates should maintain an organized and up-to-date inventory of their IP assets, including patents, trademarks, copyrights, and trade secrets related to sustainable innovation. This documentation ensures that IP assets are effectively managed, protected, and adequately utilized for driving sustainable initiatives. As large corporates face increasing regulation on sustainability topics, transparency and documentation of IP positions is likely to be on the executive agenda.

7. Summary of key findings

A transition to a greener future necessitates global efforts to adopt cleaner technologies, promote renewable energy sources, implement sustainable practices across various industries, and embrace a circular economy that minimizes waste and maximizes resource utilization. Alongside reducing the harm we are causing, it is evident that we also need new and far-reaching green inventions that can help curb emissions while sustaining economic progress. This report has signified the importance and relevant use-cases of IP in facilitating the legal framework needed to develop and commercialize green inventions.

Examining the overall development and international trends in green patenting activity, it is evident that:

- The adoption of CCMTs has been growing rapidly, surpassing the overall increase in patent applications registered by the EPO within the last decade.
- CCMT-intensive industries continue to play an important role in the economy, especially in sectors that have a detrimental impact on the environment. In the energy sector specifically, studies have signified the vast potential of CCMTs to curb emissions.
- The majority of CCMT patent activity is concentrated in US, Europe, Japan, and China, with increasing cooperation between these economies. China's development has opened market opportunities and introduced competition, yet inventions are more domestically protected than seen in other economies.
- Internationalization of green inventions has seen an uptake alongside increasing patent protection, indicating that protection and dissemination of green technologies have been complementary historically.
- Within Europe - Germany, France, and the Netherlands are the primary centers for CCMT patent filings, while Denmark stands out as a clear leader in CCMT patent intensity. Specializations vary considerably among countries, yet most nations showcase some diversification across CCMT categories.
- Denmark, however, appear largely concentrated within renewable energy (wind energy in particular), indicating an untapped potential for the broader transition to a sustainable economy still to be expanded to other sectors and a more diverse composition of companies (e.g. size).
- Discussing the role of IP in incentivizing sustainable development and securing funding to green ventures, we leveraged insights from interview with; 1) a green start-up, 2) a venture capital investor present in the Greentech space, and 3) an independent research institute working to decarbonize the shipping sector. It was found that:
    - The IP system is instrumental in providing the protection needed for green start-ups to build reputation and secure funding. Particularly in the realm of green technologies often addressing complex and still evolving challenges, investors look for strong IP portfolios in screening processes as a key measure for de-risking their capital (i.e., increasing the likelihood that inventions will advance and generate commercial returns).
    - The IP system can play a crucial role in facilitating corporate partnerships that drive sustainable impact at scale. Collaboration across the value chain is essential for widespread sustainability effects, and legal structures (i.e., semi-open IP models) are needed to protect business secrets while enabling sector-wide collaboration. The MZCS example in shipping demonstrates how the IP system can, on one hand, protect 'background IP' of the collaboration

partners while supporting the open IP development needed to reengineer and decarbonize the shipping value chain.
    - The IP system can support collaboration between SMEs in later innovation phases, which can prove vital for scaling impactful green technologies. Green start-ups tend to focus on first securing their unique IP proposition and then gradually exploiting more open IP models (e.g., patent licensing). Furthermore, rethinking conventional value chains may require SMEs to engage with larger corporates for which a strong IP can be an enabler (i.e., anchor point to secure collaborative agreements).

Despite the vast opportunities inherent in the IP system, it is clear that the system still faces challenges to fully support a green transition:

- Awareness and ease of access: While the notion of green patents is coming into the public spotlight, companies and investors are still not fully aware of green patent classifications. Even when informed, SMEs, in particular, struggle to build the legal capacity that allows them to make use of the system. This is especially predominant for green start-ups seeking to obtain patents that deviate from conventional patent types, i.e., patents concerned with reengineering value chains (e.g., Agrain seeking to turn waste residuals into secondary material).
- Bridging information asymmetries: Ensuring that patent holders and seekers (buyers) come together in symmetric markets remains an obstacle in e.g., licensing markets. International and national attempts have been made to e.g., establish databases, yet such patent transactions tend to occur in close communities (i.e., innovation clusters). Still, authorities can play a significant role in connecting with these clusters and communicating the use of IP to facilitate collaborative efforts (transactions).
- Cost of obtaining patents: The cost of obtaining and maintaining patents is considered a barrier for green ventures; green start-ups pursuing multiple fillings and obtaining international protection are particularly exposed. Initiatives to e.g., fund patent vouchers and provide discounted legal assistance are increasingly implemented by the European Commission and the EUIPO as well as across national patent offices, seemingly effective in reducing the burden.
- Identification and verification of 'green' innovation: There is a need for regulatory bodies and national IP offices to establish more holistic criteria for positioning patents within 'green' categories, subsequently to ensure that green patents become 'active' in advancing impactful innovations that contribute to sustainability.

Lastly, we suggest high-level initiatives that can support a sustainable future:

- International IP bodies: Hold a key role in supporting a green transition by establishing clear definitions and frameworks for identifying green technologies. Furthermore, these entities should continue centralizing the court system and harmonizing patent rules to increase the accessibility of the system.
- National IP offices: Can support green innovation by offering their expertise (i.e., to examine patent eligibility) alongside raising awareness of IP benefits within local communities or innovation clusters alongside referring to educational resources. In addition, they can offer funding opportunities, fast-track services, and expert knowledge sessions to green ventures. Lastly, national entities are well positioned to

facilitate cooperation with other IP offices, which may help companies navigate differences in cross-border regulation and build adequate legal capabilities.

- Research and innovation entities: Play a crucial role in fostering innovative new green technologies yet tend to lack the legal and commercial expertise needed to advance and commercialize these inventions. As such, there is an urgent need to establish sustainable models for e.g., technology transfers. Furthermore, these entities should focus on educating SMEs on green IP and actively engage in policy discussions that shape the public opinion on the use of IP to support a green transition.
- Investors: Can benefit from advancing the IP position of green start-ups in the early stages of development. In managing a portfolio of companies, investors are well positioned to facilitate knowledge sharing between start-ups and unlock beneficial partnerships between them in later stages of development.
- Green start-ups: Must assert great attention to develop a comprehensive IP strategy and build an internal legal capacity early on to secure protection of core technologies. A strong IP position is essential to build reputation in the market (relevant to attract both collaboration partners and investors) while helping to efficiently drive internal empowerment.
- Corporates: Should work to deepen their IP strategy on products and services that can contribute to a green transition. As evidenced in the case of shipping, far-reaching efforts are required to make energy-intensive value chains more sustainable. By ensuring a protected and organized inventory of IP assets, corporates will be better positioned – and incentivized – to enter collaborations across the value chain that can prove both impactful and commercially beneficial.

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