Mapping of the Green Tech Sector in the STRING region

Report

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STRING

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Prepared by:
Danish Technological Institute
Policy and Business Development
Gregersensvej 1
DK-2630 Taastrup

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Contact:
Senior Consultant Morten Svendsen
msve@teknologisk.dk

Senior Consultant Stig Yding Sørensen
stys@teknologisk.dk

CVR 5697 6116

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Executive summary for policymakers

The mapping of the green tech sector in the STRING region aims to provide a conceptual understanding of the STRING region's ambition to become a megaregion fostered by green tech solutions. The analysis is primarily based on a data-driven mapping and provides an overview and detailed insights into the current and future development of the green tech sector in the STRING region with a focus on strengths, potentials, and barriers to maintain and further develop this sector.

The definition of the green tech sector is used as an overall framework for this analysis. The definition encompasses *"Any business or organisation that develops and sells technological solutions that improve the relationship between human activity and the natural environment towards sustainability, i.e., through an efficient use of resources, and reducing pollution or waste from human activity".*

The key findings of the mapping are summarised below:

- Green tech companies are spread all over the STRING region, with a higher concentration of jobs in green tech companies around the major cities. Furthermore, the mapping showed several strengths in terms of research and innovation activities in the region. Research and innovation activities are primarily located around metropolitan areas, especially in the Capital Region of Denmark, Hamburg and Gothenburg. Consequently, very few activities are located away from the metropolitan areas.

- STRING has a relatively strong position in the publication of scientific literature in Europe. This position can attract networking, cooperation, funding, and knowledge to STRING. It is also a potential for innovation.

- Companies and organisations in the green tech sector in STRING receive investments, primarily, from outside the region. The investments are mainly from Central Europe, the San Francisco Bay Area and BosWash - some of the world's strongest tech centres. It is an indication of considerable strength in green tech in STRING.

- The existing base of green technologies is a distinct strength for STRING. STRING is innovative in green tech. The number of patented green tech inventions have tripled over 20 years. When studying a world map of the most influential technology centres since 2015, the STRING region stands out, not as the number-one hotspot in the world, but enough to be part of the global top 20. Despite its leading position, it is also clear that innovation in STRING is losing comparative momentum and is at risk of losing the relative strength to the fast-upcoming China and top-regions in the USA, Japan and Korea.

- The common market, free flow of goods, money, and people are strong asserts in the region, but national borders, national networks, and probably personal networks, language, as well as different administrative systems, taxations, and regulations, can be barriers to a more concerted innovation strategy.

Based on the main findings, future progress can be achieved by following these recommendations:

- The existing technology base in STRING provides a strong platform, a potential for further growth - especially if STRING is successful in creating and strengthening the existing innovative cross-border networks that can draw on knowledge throughout STRING and exploit the innovation infrastructure, knowledge, and investor interest that already exists.

- Patent data and publication data cannot be directly compared, but it seems that the scientific publications activity is more intense in Europe and in STRING than patent activity, when compared to competitors. Patent activity seems to be higher in the US and in Asia. This indicates that countries outside the EU are more successful in transforming university research into commercial products, i.e., innovation. The conversion of research knowledge into innovation in companies would be a relevant action area for STRING to stimulate its relative strong position in green tech within science.

- The potential to strengthen its green position in STRING can be improved by increasing focus on cross-border collaboration, especially in private/public projects, among other things. The public sector (procurements) is an important player in the green transition and a major driving force for the innovation and development of green technologies in STRING. Cooperation with the public sector is, for instance, crucial in the energy sector since energy suppliers depend on public priorities. Across the STRING region, potential in sharing knowledge – on, for example, how to embed sustainable standards in public procurements – can be improved.

- Beyond the potential in extended private/public collaborations, actors outside the political-administrative sphere should be included in the green transition. The green impact on project partnerships will probably increase by including many different actors: companies, financing, NGOs, and citizens. Therefore, it is vital that the EU and the public sectors utilise the potential in co-financing green projects in STRING.

- Within STRING, public spending can help create or support an attractive and sustainable market for green tech, which in turn will attract investors. In the toolbox are green purchasing policies, introducing green criteria in public works (energy efficiency, renewable materials, upgradeability, etc.), and applying smart technologies in public services. Also, tools for citizens such as setting standards or developing environmental labelling can help create a market. All of these create incentives for innovation of solutions and attract investors. STRING, as a platform, may have a role in inspiring, coordination, knowledge sharing or common development of tools among the STRING members.

1. Introduction

This report aims to define, map, and describe the green tech sector, its strengths and development in the STRING region stretching from Hamburg to Oslo in order to assess the regional strengths in the field. The analysis is primarily based on data-driven mapping and provides an overview and detailed insights into the current and future development of the green tech sector in the STRING region with a focus on strengths, potentials, and barriers to maintain and further develop this sector.

The mapping of stakeholders who are the key drivers of green growth, such as industries, green tech companies, investors, clusters as well as relevant research and innovation infrastructure[1], will provide an overview of positions of strength, which unify the STRING region as a green hub. It includes similarities, differences, and complementarities in the development of green solutions, which all contribute to strengthening the green focus in the STRING region. In addition to the mapping of the green tech sector, the report includes an analysis of the sector's strengths and potential by comparing the region with the San Francisco Bay Area and the Benelux countries, which are competing regions within the field of green tech. Thus, the current and future strengths, potential and challenges in the STRING region will be outlined.

The report will address answers and data on the following:

- A conceptual understanding of the STRING region's ambition to become a megaregion fostered by green tech solutions, including a description into the current political landscape to encourage this ambition.
- A data-driven mapping of the green tech sector in the STRING region covering four perspectives of the sector; companies, research and innovation activities, types of technologies being developed and characteristics of green investments in the region.
- A comparative analysis with the aim of being able to compare STRING on a global scale and with relevant competing regions.
- An identification of key opportunities and challenges based on the findings of the mapping as well as the comparative analysis, including how to address the challenges to foster continuous green growth and how to meet the potential of joining forces in the region.

Scope of the study

The green tech sector is a term, which in general covers many parameters, and clarification is certainly needed to reach an adjusted definition of the green tech sector in the STRING region. The definition should incorporate the ambition of the STRING region to become a globally acknowledged Green Hub and a leading implementer of sustainable infrastructure to combat climate change while improving the lives of its citizens.[2]

On this basis, the definition of the green tech sector is used as an overall framework for this analysis. The definition encompasses *"Any business or organisation that develops and sell technological solutions that improve the relationship between human activity and the natural environment towards sustainability, i.e., through an efficient use of resources, and reducing pollution or waste from human activity".*

[1] Research and innovation infrastructure refer to the test centers, research institutions, networks, universities etc that a company can reach to get support for its R&D work.
[2] https://STRINGnetwork.org/

The definition includes, for instance, circular economy, alternative energy sources, the substitution of hazardous chemicals, sustainable transport infrastructure, and waste treatment. It can also include technologies that protect nature and wildlife or technologies that protect humans from the weather, such as dikes or water management. The definition clearly integrates a dimension of research, innovation and technology.

2. Background: Green growth in the STRING region at a glance

The regions and cities in the STRING geography are increasingly joining forces in a new, larger scale of economic geography. When connected to each other and to their surrounding territories through the STRING region, they can reach a critical mass of around 14 million people, which harbours an unprecedented potential to bolster the development of a strong, global megaregion through working as one unit. To reap this potential, the members forming STRING have joined forces to be acknowledged as a Green Hub in Northern Europe. Or in other words, the member regions and cities are working together to position themselves as one global market and location for green and circular tech solutions and investments. The cooperation on STRING builds on and is harmonised with existing cooperation networks and initiatives in the region, such as the Northern Connection.

The STRING 2030 strategy sets the scene for this mapping by pointing out climate considerations and green growth as key parts of the approach to all aspects of STRING's activities from implementing sustainable infrastructure to fostering a world-leading region for job creation and investment. In order to provide an understanding of the STRING region's ambition to become a green hub, it is important to know the overall characteristics of the political landscape regarding sustainable development and green tech in the region. The following sections will briefly introduce the overall political visions and strategies of the STRING region, including some of the key framework conditions available for meeting the vision of becoming a green hub. The overall characteristic also includes a description of the region's performance on the UN Sustainable Development Goals (SDGs).

Green political visions and strategies in the STRING region

The STRING partners want the region to be acknowledged as a green hub in Northern Europe, implement sustainable transport infrastructure, and foster a clean, green economy (STRING, 2019). The STRING region already has several strengths when it comes to selling and exporting solutions for green technologies, and the STRING region's vision is reflected in a lot of the visions and strategies in the individual regions and cities. There is a general vision of becoming the centre for green transition and sustainable development. Some elements like sustainable transportation, environmental initiatives and transition to robust energy systems are consistent through the megaregion while others are specific to some regions or cities as described in the next section. Sustainable transportation seems to be an important issue across the STRING region – both in the general STRING strategy and for each individual region and city. Another consistent theme seems to be environmental initiatives. This an important issue, especially around the metropolitan areas. The cities in the STRING region are all invested in the idea of a clean urban environment regarding many different elements related to urban development. Phasing out fossil fuels, lowering emissions and a transition to a more robust energy system based on renewable energy are also themes of importance throughout the region.

The vision for sustainable development is echoed within the different regions and cities in the STRING megaregion. Sustainable development, green visions, and environmental efforts are all part of the cities and regions strategies and visions in the STRING region. They all have green ambitions to some extent and their development strategies all have several green aspects included. In that way, they complement the 2030 strategy of STRING. It is evident that the region wants to be leading and globally acknowledged for its progress towards sustainable development. Even though visions for sustainable development is present across the STRING region, there are differences to be found. When taking a closer look at the individual strategies and visions some elements are specific to a certain region or city. The next section will provide an overview of the strategies and visions of each region, and similarities and differences will be pointed out.

Green political visions and strategies of specific regions and cities in the STRING area
One of the priorities in the Hamburg area is the port and their large maritime industry. OECD has identified this as one of the main strengths in Hamburg (OECD, 2019). The port in Hamburg is the largest in Germany, thus creating an attractive environment, not only for strong clusters related to maritime, logistics, and port-related industries but also for aviation, climate research, renewable energy, and life sciences. Another strength pointed out by OECD is the region's potential to become a global leader in renewable energy with their coastal location, strong capacity to generate wind power, and the presence of competitive firms. One of the recommendations from OECD is for the Hamburg region to strengthen collaboration, particularly with Scandinavia. Besides the strengths pointed out by OECD, the Hamburg region has the vision of becoming the innovation capital of Europe especially regarding technological innovation (The City of Hamburg, 2014). Furthermore, the city of Hamburg has visions for a green and sustainable city (The City of Hamburg, 2020). The city's strategy involves initiatives to preserve, develop, and make nature- and climate protection sustainable while ecological goals are balanced with social and economic responsibilities. Schleswig-Holstein is also committed to the development of sustainable solutions especially in the fields of maritime science and renewable energy (Schleswig-Holstein Government, 2020). The main technologies in maritime science are related to a sustainable use of the sea, energy production, and more efficient use of maritime resources (Schleswig-Holstein - Ministry of Economic Affairs, Transport, Employment, Technology and Tourism, 2014). One stronghold in the renewable energy industry is wind energy, especially offshore wind energy (ibid.).

The region of Southern Denmark has visions for a green transition as well (Region Syddanmark, 2020). The Sustainable Development Goals frame the development strategy, i.e., the main focus is sustainable development. The initiatives revolve around environmental goals such as clean water and soil, climate protection, circular economy, and climate-neutral transportation.

The Öresund region consists of Eastern Denmark and Southern Sweden. The regions and cities are connected through the organisation, Greater Copenhagen. The organisation focuses amongst other things on green transition and sustainable infrastructure in the region (Greater Copenhagen, 2020). Sustainable infrastructure is also an important issue for the regions and cities within the Öresund region. Region Zealand wants a transition to green public transport (Region Sjælland, 2020), the Capital Region of Denmark (incl. Copenhagen) wants effective and sustainable mobility (Region Hovedstaden, 2020), and Region Skåne and the City of Malmö also have sustainable mobility and transition in transport and travel as a focal point (Malmö Stad, 2016). All public transport in Skåne is since 2018 operated by renewable fuels, and there is a consensus in the region to reduce emissions with 80% by 2030 (compared to 1990) (Länsstyrelsen Skåne, 2018).OECD points out that Region Skåne needs to invest further in infrastructure as it will reinforce its role as Sweden's physical gateway to Europe (OECD, 2018). Other visions for the Öresund region include initiatives for clean air, water, and soil, phasing out of the use of fossil fuels and ensuring less CO_2 emission, sustainable use of natural resources, and transition to renewable energy and creating smart sustainable cities through increased innovation.

Western Sweden consists of Region Halland, Region Västra Götaland and the City of Gothenburg. Their development strategies include many of the same elements as previously mentioned, e.g., sustainable transportation, renewable energy, circular economy, and a cleaner environment (Göteborgs Stad, 2020; Västra Götalandsregionen, 2019). The transportsystem in Gothenburg is to be electrified and totally emission free in 2030.Besides the goals mentioned above, this region has a clear vision of becoming a central hub for innovation, entrepreneurship, and start-up companies. OECD acknowledges this vision and describes how the region already has achieved a successful transition to knowledge-based activities with a focus on professional and scientific services in areas such as ICT, packaging, and clean technologies (OECD, 2018). They recommend that the region builds on that momentum by supporting business environments and strengthening regional attractiveness.

One main priority in the Oslo area is the city environment. A lot of the city's visions and strategies revolve around a cleaner and more liveable city (Oslo Kommune, 2020). Elements like the reduction of noise levels, reduction of air pollution and emissions, climate adaption, and green recreation areas all contribute to the overall goal of sustainable urban development. Another important vision in the Oslo region is the transition towards renewable energy systems where fossil fuels and greenhouse gas emissions will be phased out in order to secure a more robust and secure energy system (Oslo Kommune, 2016). Sustainable and eco-efficient transportation is also a clear priority in the Oslo region like in the other regions of STRING (City of Oslo, 2011). In Viken the newly elected county government has presented a regional planning strategy with a specific focus on sustainability. The Sustainable Development Goals (SDGs) works as a holistic framework for implementing the strategy (OECD, 2020), for example by prioritizing actions that creates a sustainable and equitable economic system where products and services places less strain on climate and the environment[3].

Western Sweden and the Hamburg regions have a specific focus on innovation, entrepreneurship, and start-up companies. This is a central part of their development strategy for sustainable development. In that way, they stand out against the other regions as they prioritise attracting knowledge and innovation as a way to secure sustainable development in their regions.

Sustainable Development Goals in the STRING region

Another way to consider the STRING region's sustainable development progress is by analysing the region's performance on the UN Sustainable Development Goals (SDGs)[4]. When considering the SDGs, it becomes clear that the STRING region, in general, is a frontrunner in the world when it comes to sustainable development. OECD has analysed how different regions score on each goal by comparing their progress on each goal with an expected end value in 2030 (OECD, 2020). Not all goals are relevant to green technology and will thus not be further covered, but some are particularly relevant to green technology. One relevant goal is the SGD 6 for "Clean water" and in the STRING region, only the City of Oslo has almost met the criteria for reaching this goal (measured in the change of water bodies). Another relevant goal is number 7 for "Clean energy" which is measured by the percentage of electricity production that comes from renewable energy and the percentage of electricity production that comes from fossil fuels. Both the City of Oslo and County have already achieved the 2030 goal while Region Skåne is almost there. The cities in the STRING region, are doing particularly well on the SDG 11 for "Sustainable

[3] Regional Planstrategi 2020-2024, Viken Fylkeskommune: https://viken.no/tjenester/planlegging/samfunnsplanlegging/regional-planstrategi/veien-til-et-barekraftig-viken/?print=1&securelevel=token#chapter-12892
[4] See Appendix D

cities" which is measured by the environmental quality and sustainable urbanisation. Hamburg, Copenhagen, Malmö, Gothenburg, and Oslo have either reached or have almost reached the goal for 2030, while the regions in Sweden and Viken County also have reached the goal. Looking at the SDG 12 for "Responsible consumption" which is measured by waste rates, the two Swedish cities in the STRING region are doing particularly well. Both Malmö and Gothenburg have already reached the 2030 goal. The last relevant SDG related to green tech is the SDG 13 for "Climate action". This goal is measured by CO2 emissions per electricity production and change in cooling days in the last 30 years (energy consumption). In the STRING region, Norway and Sweden are doing well on those indicators. The regions in Sweden, Viken County, and the city of Oslo have all almost reached the 2030 goal.

To sum up, the STRING region is, in general, performing well on the SDG indicators. The megaregion is especially well on the SDG 11 for "Sustainable cities" where the metropolitan areas are frontrunners. Furthermore, the regions in Norway are leading regions in terms of clean energy and climate action. Finally, the Swedish cities of Gothenburg and Malmö are frontrunners on responsible consumption.

3. Mapping green tech in the STRING region

In this section, the findings from the mapping of the green tech in the STRING region will be presented. The mapping is conducted in four parts - driving actors, collaboration partners, existing technologies and investments – which compose a comprehensive and diversified mapping of the green tech sector in STRING. These four perspectives will structure the following section. We will start by presenting the findings on identification, characterisation, and development of green tech companies in the STRING region. Then, the findings related to the location and classification of research and innovation activities will be presented, followed by a section covering the different types of technologies being developed in the STRING region. Lastly, the characteristics of green investments in the region will be presented.

There is no single source of data that has all information of companies, technologies, research, and investments. The data for the different data sources is collected with different methods from surveys, to databases over manual registering to web-crawling. And none of the data sources have a definition of "green tech" that exactly matches the one presented in the introduction, but all shed light on a part of green tech. Also, none of the databases are complete, since the definition of "green tech" is often in a grey zone, such as how dominant should green tech be in a company to include the company in the count.

As there is no unified database of companies in the STRING region, we have pieced information together from different sources or perspectives. Each data-source offers a perspective on green tech and seeing the perspectives at a whole means, that we stitched together a picture of the green tech sector in STRING, that provides solid insight into strengths and challenges in the STRING area as a green tech region even if the individual sources are not 1:1 comparable. The data sources are presented and accounted for in the analysis and in the appendix.[5]

3.1. Green tech companies

This section presents a mapping of green tech companies in the STRING region. The mapping is initiated by a presentation of the methods and data behind the findings. The following four sections present results of the mapped Green tech companies followed by a presentation of the companies which have taken out green patents which indicate development within green innovation. The following section is a mapping of members companies in clusters and organisations which are related to the green tech sector in STRING. This final section differs from the remaining company mapping since the definition of green tech companies across the involved clusters and organisations is neither identical to each other nor to the other company mapping sections. The different way of mapping Green tech companies in STRING will provide

[5] A short remark on maps. In the presentation the reader will see several maps. Most of the maps are google based and can be found online via the link provided with the map. The maps are interactive and in a browser the map can be zoomed out for the big picture or down to the individual company or research institutions. Right click on the map to switch from a heat map to markers for each data point. Maximize your browser window to get a good overview. The geographical data and the companies in the map are listed at the bottom of the map.

a diversified picture of the company landscape in the region. The final section presents the main findings from the mapping of green tech companies in the STRING region.

3.1.1. Method and data

The definition of the green tech sector presented in Section 2[6] is the underlying basis of this company mapping. According to this definition the definition of green tech companies is companies which develop and/or sell green technologies. The identified companies in the mapping are weighted equal since the definition does not take their extent of environmental impact into account. Hence, the definition of green tech companies is binary thus, the degree of environmental impact on the green technologies is not considered in the analysis.

Time series data on green tech companies on a regional level is limited and poses a challenge for conducting a statistical analysis of the number of green tech companies as well as the development in green employment within in the STRING region. We have investigated different data options in order to overcome these limitations. Several data sources from Eurostat have been considered, including their Structural Business Statistics data, Regional Environmental and Energy Statistics, EGGS accounts (environmental goods and services sector). However, no data source includes regional data for green tech companies which allows us to divide data by specific green industries (NACE-codes). We have also searched for data on the region's national statistics sites (Statistics Denmark, Statistics Sweden etc.), however, in so far as these sites have data on Green tech companies, it is not on the required regional level.[7]

Thus, the mapping includes company data from global databases with company data. The databases are CrunchBase, Kompass and PatSnap.

presents an overview of the data sources used and Appendix B.1 presents a deeper description of the databases and the used company searches.

[6] The definition encompasses "Any business or organisation that develops and sell technological solutions that improve the relationship between human activity and the natural environment towards sustainability, i.e., through an efficient use of resources, and reducing pollution or waste from human activity".
[7] See Appendix B.1.1 for an overview of data sources investigated

Figure 3-1: Overview of used data sources

	Primary data sources			Secondary data source
Method	Green industry codes	Green industry codes and green company description	Assignees of green patents	Membership in organisations, associations and clusters
Advantages	• Regional level data • Comparable data across regions • Robust and detailed delimitation of green companies	• Regional level data • Comparable data across regions	• Regional level data • Comparable data across regions • Measurement of innovation within the green tech sector	• Numerous companies identified across the member organisations, associations and clusters • Validation of the company searches in the primary data sources by checking for matching companies
Limitations	• No industry codes includes all green companies according to the report definition of the green tech sector • No complete identification of all green companies	• Industries code are very broad • The database do not include all registered companies • Using key words is an unsteady method of identifying companies	• Across technologies and cultures different patent strategies exist • Insecurities connected to patent searches since no definitive patent search exist	• Some member lists are on national level • No clear definition of green companies across member organisations • Biased in relation to mapping all regions in STRING
Data source	Kompass	Crunchbase	PatSnap	Member list of selected green organisations, associations and clusters

In the mapping of companies, we have used the company database, Kompass.[8] This is a business-to-business portal with more than 32 million verified companies. The data sources in the database are primary CVR – The Central business Register in Denmark[9], Brønnøysund register in Norway[10], Bolagsverket (Swedish Companies Registration Office) in Sweden[11], and the Common register portal of the German federal states in Germany[12]. The collected companies from national databases are processed by Kompass and assigned with more information about, for instance, date of establishment and number of employees. In addition to Kompass, another company database, Crunchbase, is used.

CrunchBase is a platform with company information collected through its network of investors and companies. In CrunchBase, companies have been identified via the identification of green industries and keywords that were related to the green tech sector. In addition to CrunchBase, the mapping includes patent data from PatSnap.[13] In this section, the patent data is used in mapping the companies who have taken out green patents. Besides using business statistics and patent data, the mapping is supplemented with company data collected via relevant member organisations such as clusters and industry associations. The mapping based on members from green organisations contribute with green companies in another approach than identifying companies based on the above-mentioned company databases. This mapping of members in green organisation is one way to identified green companies in the STRING region, but the limitation is the methodical approach is that the definition of green companies across the organisations is not the same which challenge the transparency in out mapping of green companies. Therefore, the mapping of green companies with membership in green organisation is presented with cautions and are not sufficient in covering all green companies in the STRING region. This mapping of

[8] https://dk.kompass.com/en
[9] https://datacvr.virk.dk/data/index.php?q=forside&language=en-gb
[10] https://www.brreg.no/heim/
[11] https://bolagsverket.se/en
[12] https://www.handelsregister.de/rp_web/welcome.do
[13] See Section 5.3 and Appendix B.2 for a deeper description of the used patent data

green members is a contribution to the quantitative mapping and should be analysed in connection with the mapping based on company databases.

Across the used data sources (primary and secondary data sources in Figure 3-1), no option for delimitation of the search on only green technology companies exist. Therefore, different methods for identifying green tech companies have been used. Hence, the different company mappings add different value to the entire landscape of green tech companies in the STRING region.

The different data sources have inevitable advantages and limitations. It cannot be guaranteed that all relevant green tech companies are identified, but the different searching methods across the data sources enhance the likelihood of identifying the majority of the green tech companies. Our search methods depend on the options in the specific databases, it includes, for instance, using keywords, industries, or technology codes. The advantage in the databases, Crunchbase, Kompass and PatSnap, is that the search is transnational and on a regional level which makes the results comparable. The transversally challenge with three databases is that there is uncertainty about the identification of all green tech companies. It is not possible to do a complete search since no transnational database at a regional level has a precise delimitation of the green tech sector. The delimitation of the green sector varies depending on the allowed options in the specific databases. Therefore, it is an advantage that different data sources are used with different search options to include as many green tech companies as possible.

The following mapping presents, first, the findings from Crunchbase and Kompass and later, the findings from PatSnap. That section is followed by a mapping based on data from member organisations. Thus, the different findings will contribute to the final picture of the green company landscape in STRING.

3.1.2. Location of the green tech companies

The company mapping resulted in 2,366 companies within the green tech sector in STRING, see Table 3-1.[14] The grouping of companies across the regions within STRING is illustrated in the table below. On a general level, the companies are spread widely across the geographical area in STRING. The Swedish regions, as well as the Capital Region of Denmark, Schleswig-Holstein, and Viken County, especially, have a high concentration of green tech companies. In the maps below, Figure 3-2, the location of the green tech companies is mapped in the left picture and the right picture the companies are weighted by numbers of employees.

Table 3-1: Green tech companies in STRING

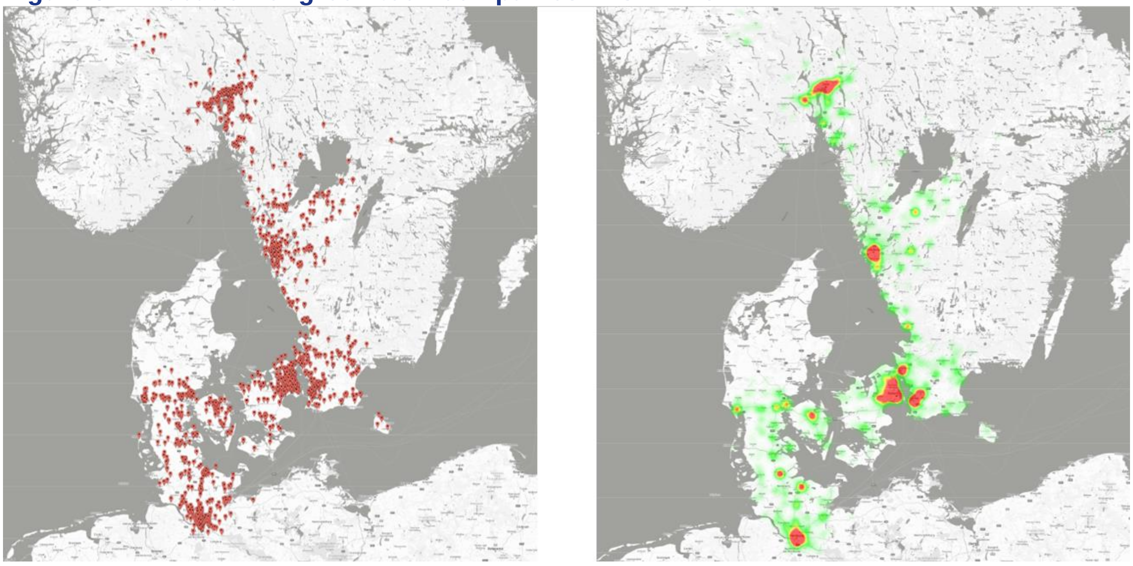
Location	Green tech companies
Västra Götalandsregionen (incl. Goteborg)	369
The Capital Region of Denmark (incl. Copenhagen)	355
Region Skåne (incl. Malmö)	345
Schleswig-Holstein	261
Viken County	232
Region Southern Denmark	220
Hamburg	203
Oslo	194
Region Zealand	107

[14] The definition of the green tech companies is presented in Appendix B.1.2 and B.1.3.

Region Halland	80
Total	**2366**

Data sources: Crunchbase; 604 companies and Kompass; 1842 companies. 81 companies identified in both company databases which resulted in 2366 companies in total.

Figure 3-2: Location of green tech companies in STRING



Data source: Crunchbase and Kompass.
Map online: https://batchgeo.com/map/af5578990f3b28d9d03543e5a8469262
N: 2366 companies in total. 2337 companies identified in the map.
Note: The left picture shows a heating map weighted by numbers of employees. The used databases have registered the number of employees in intervals and the data behind the maps round off to the highest number in the interval. For instance, the interval 0-9 = 9.

The weighted maps present a picture of the job concentration in the green tech sector in STRING. The overall picture indicates that the green focus in the green tech companies in STRING is scattered. The highest concentration of workplaces across the STRING region is in Region Skåne, the districts around Copenhagen, Hamburg, Oslo, and Gothenburg. Beyond these large cities in STRING, smaller cities also draw attention to the green agenda. Especially Schleswig, Kiel, Esbjerg, Fredericia, Odense, and Drammen have a significant number of jobs in the green tech sector.

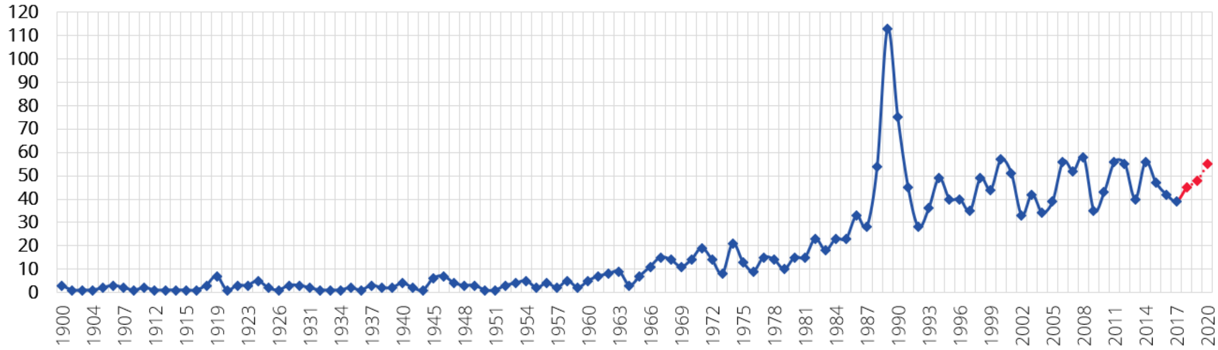
3.1.3. Date of establishment

The number of companies has been steadily increasing since the 1960s, and have been fluctuating until the 2010s, as illustrated in Figure 3-3. Around 1990, there is a significant jump in the number of established green tech companies compared to the other years and no direct explanations exist for the sudden jump.[15] Since the start 1990s and about 25 years since, approximately 50 new Green tech companies have been established per year. According to the graph, there have been no remarkable fluctuations or explosive growth in new Green tech companies. However, the graph does not consider the size of the companies, only the number of companies. In the graph, the years from 2018-2020 are marked with a

[15] Increased attention to sustainability may be a part of the explanation, since awareness of the concept of sustainability was spreading in the wake of the Brundtland Report. The mission of the Brundtland Commission officially dissolved in December 1987 after releasing Our Common Future, also known as the Brundtland Report, in October 1987. The Brundtland Commission draws upon several notions in its definition of sustainable development, which is the most frequently cited definition of the concept to date.

red tendency line since not all companies are registered in these years. Therefore, the results for the past years do not show a complete accurate picture of the region but is an estimate.

Figure 3-3: Date of establishment of the Green tech companies since 1900



Data source: Crunchbase and Kompass.
N: 2043 companies. 323 missing values (13.6%) across the total number of Green tech companies, 2366.
Note: The red dotted line is an estimate based on the previous years.

3.1.4. Size of green tech companies

The mapping of the number of employees in the green tech companies indicates the volume of the companies and thus, how strongly the green area is represented in STRING. The results in Table 3-2 are analysed cautiously as 15 pct. of the mapped companies do not indicate the size of company. Presumably, large companies have registered the number of employees and smaller start-ups are probably more unreliable in their uploads to databases. The list of the companies is showed in the link in the note of Figure 3-2.

Across the STRING region, 37 pct. of the companies have up to and including 10 employees and 31 pct. have between 11-50 employees. This means that about two-thirds of the green tech companies in STRING have less than 51 employees. This distribution is also almost the same across the ten regions in STRING. There is also equal distribution of medium-sized companies across the regions in STRING. Hamburg stands out in their share of companies with over 500 employees; 9 pct. of the green tech companies in Hamburg have more than 500 employees. In addition, the Region of Southern Denmark ranks second highest with 6 pct. Across the STRING region, the average number of companies with more than 500 employees is 3 pct. Big companies are particularly crucial for the green sector, as they typically have more resources and opportunities to work innovative within the green transition.

Table 3-2: Size of companies across the green tech companies in STRING

	0-10	11-50	51-100	101-250	251-500	500+	Missing value
Region Halland	35% (28)	25% (20)	5% (4)	5% (4)			30% (24)
Hamburg	24% (48)	44% (90)	4% (9)	7% (15)	1% (3)	**9% (18)**	10% (20)
The Capital Region of Denmark (incl. Copenhagen)	35% (125)	31% (109)	9% (31)	5% (16)	2% (8)	3% (11)	15% (55)
Oslo	47% (91)	30% (58)	8% (15)	7% (13)	3% (5)	3% (6)	3% (6)

Schleswig-Holstein	23% (60)	55% (143)	7% (18)	7% (18)	1% (3)	1% (2)	7% (17)
Region Zealand	38% (41)	27% (29)	8% (9)	4% (4)		1% (1)	21% (23)
Region Skåne (incl. Malmö)	47% (160)	19% (66)	5% (18)	2% (8)	2% (7)	1% (5)	23% (80)
Region Southern Denmark	24% (53)	30% (65)	9% (20)	5% (10)	3% (6)	**6% (13)**	24% (53)
Västra Götalandsregionen (incl. Goteborg)	43% (159)	22% (81)	7% (25)	4% (16)	2% (7)	1% (5)	20% (75)
Viken County	47% (109)	32% (74)	8% (18)	5% (12)	3% (6)	3% (8)	2% (5)
Total	**37% (874)**	**31% (736)**	**7% (167)**	**5% (116)**	**2% (45)**	**3% (69)**	**15%** (358)

Data source: Crunchbase and Kompass
N: 2008 companies. 358 missing values (15.1%) across the total number of green tech companies, 2366.

Figure 3-4 shows five companies within each region, the companies are not listed in any priority order. Regarding the mapping, it is unknown how large the part of green tech is in the company, the focus is on the company as a whole.

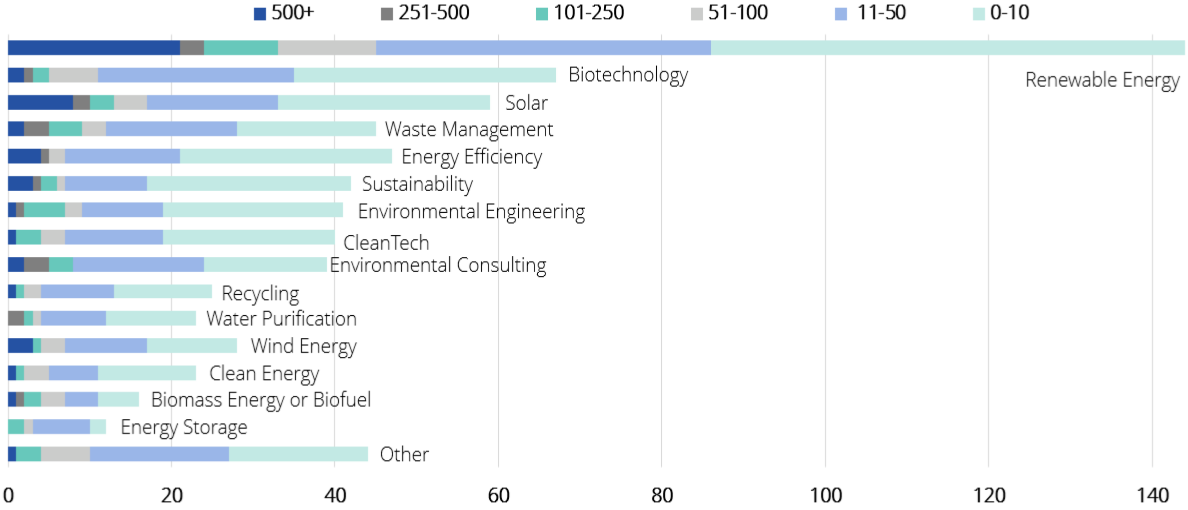
Figure 3-4: Examples on green tech companies across the regions

The Capital Region of Denmark (incl. Copenhagen)	**Västra Götalandsregionen (incl. Goteborg)**
- Haldor Topsøe A/S	- Stena Recycling AB
- Lemvigh-Müller	- Renova AB
- Novozymes Velux A/S	- Borås Energi och Miljö AB
- Ramboll Environ	- CLEANPIPE Sverige AB
- ROCKWOOL Group	- Göteborg Energi
Region Skåne (incl. Malmö)	**Schleswig-Holstein**
- Alfa Laval	- Entsorgungsbetriebe Lübeck
- SWEP International AB	- Emutec
- E.ON Energilösningar Aktiebolag	- Amandus Kahl GmbH & Co. KG
- Metso Sweden AB	- AZV Südholstein
- SUEZ Recycling AB	- Wiedemann GmbH
Viken County	**Region Southern Denmark**
- Borregaard ASA	- Dansk Shell
- Petroliam Nasional Berhad	- Danfoss A/S
- Abb AS	- Ørsted Wind Power A/S
- Norconsult AS	- SE Energi & Klima
- Retura	- Arkil A/S
Hamburg	**Oslo**
- EON Climate & Renewables	- Elkem AS
- Vattenfall Europe New Energy GmbH	- Brødrene Dahl A/S
- Nordex Energy GmbH	- REC Solar Holdings
- Vestas Deutschland GmbH	- Petroleum Geo-Services
- Veolia Umweltservice Nord GmbH	- NorSun
Region Zealand	**Region Halland**
- Dansk Energi Management	- Egain Group
- SEAS-nve	- Halmstads Energi och Miljö AB
- Alfa Laval Nakskov A/S	- Varberg Energi Aktiebolag
- ARGO I/S	- Vatten & Miljö i Väst AB
- BWT Danmark A/S	- Tomal Aktiebolag

3.1.5. Industries within the green sector

In the mapping of the industries behind the green tech companies, it has not been possible to merge the two databases (Crunchbase and Kompass) behind the mapping of green tech companies. Which means that the mapping of industries is split into two.[16] In the first part (based on Crunchbase company data) 605 companies are analysed in Figure 3-5. The companies have typically been registered in more than one industry. As illustrated in the figure, each company in the industries are shown across size of companies. Most companies are in the field of renewable energy; approximately 20 pct. of the companies operate in that industry. The second most frequent industry is biotechnology, which, like renewable energy and several of the others on the list, is a broad category. Therefore, there is, typically, an overlap between the industries. The share of large companies over 251 employees is highest in the renewable energy sector. Compared to the other industries is a high share. Across the remaining industries, most companies have under 51 employees.

Figure 3-5: Numbers of green tech companies across industries and numbers of employees



Data source: Crunchbase.
Note: Other is including following industries: Nuclear, Fuel Cell, Green Consumer Goods, Pollution Control, Organic, Natural Resources, Smart Cities, GreenTech, Smart or Green Building.
N: 695 industries located across 469 companies. 136 companies missing values on numbers of employees or industry.

The second part of the analysis of green industries is based on another company database (Kompass). The industry classification in this database is developed by Kompass and is unique compared to the EU classification of economic activities (NACE codes), the advantage of the classification in Kompass database is that it has a more accurate classification of the green tech sector. 18,754 different industry classifications have been identified across the 1,858 green tech companies. The companies have in average been registered in 43 industries. That resulted in 80,869 industry registrations. Table 3-3 shows the top 20 used industry classifications. Overall, the industries in the table are mostly related to the circular economy.

Table 3-3: Top 20 industry codes across green tech companies in STRING

Industry classification	Numbers of companies within the industry code
Waste collection and recycling services NES	336
Metal waste collection and recycling services	259
Wastewater and water pollution analysis and treatment services	253

[16] Definition of the used green industries is presented in Appendix B.1.2 and B.1.3.

Toxic and chemical waste collection and recycling services	228
Water, sewage and industrial effluent treatment plant and equipment	204
Sewage system maintenance	184
Plastic and rubber waste collection and recycling services	178
Scrap and waste (trade)	177
Electric and electronic waste collection and recycling services	158
Incinerator and landfill waste operators	140
Pumps, by use	136
Pumps NES	125
Domestic and industrial waste collection and recycling equipment (NES)	120
Glass collection and recycling services	119
Domestic and industrial waste management consultants	117
Sewer and drain cleaning contractors	111
Geothermal and aerothermal energy production equipment, parts and accessories	109
Metal ashes and waste	106
Paper and wood waste collection and recycling services	105
Parts and accessories, for ships and boats, NES	104
….	
…. Total 18754 industry codes	
Recycling of tyres and scrap rubber	*79*
Wind energy production equipment parts and accessories	*67*
Nuclear energy research	*61*
Total	**80869**

Data source: Kompass.
N: 80869 industries codes.

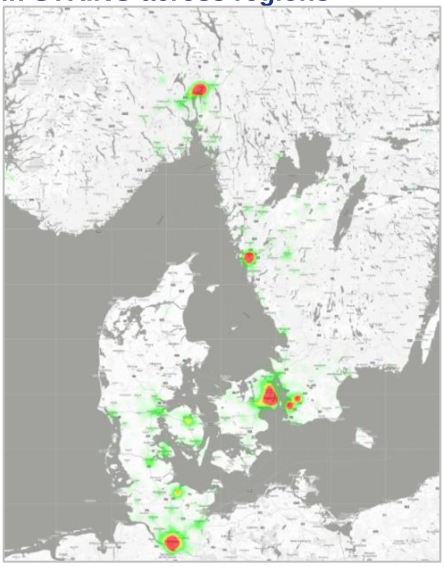
3.1.6. Companies with green patents

This section presents companies in the STRING region that have applied to patent an invention that is categorised as green inventory. In the figure below, the number of companies and patents are calculated at the country level. Across STRING, there are 2,347 companies that have applied for approximately 18,177 green patents.[17] On the map below, the locations of the companies are shown weighted according to the number of patents applied for. The red colour indicates a high concentration of green patents. It turns out, the companies that patent green innovation are largely located in the big cities in STRING. In addition, the smaller cities that also light up the map are Kiel, Flensburg, Lübeck, Odense and in the area around Kolding/Vejle/Fredericia.

[17] The same company may appear with variations of its name on the list; therefore, the number of companies is probably a little less.

Figure 3-6: Location of assignees (companies) of green patents in STRING across regions

Location	Green tech companies*	Numbers of green patents
Hamburg	294	2641
Schleswig-Holstein	308	2716
The Capital Region of Denmark (incl. Co-penhagen)	359	7490
Region Zealand	90	741
Region Southern Denmark	219	1290
Region Skåne (incl. Malmö)	240	547
Region Halland	52	80
Västra Götalandsregionen (incl. Goteborg)	262	937
Oslo	225	712
Viken County	298	1023
Total	**2,347**	**18,177**



Data source: PatSnap. N: 2347 assignees from private companies. 2347 companies geolocated.
Note: The map is weighted by numbers of patents across the position.
Link: https://batchgeo.com/map/bff524df4f7f82d63abe3bb6af2d665a
* The number of assignees have a margin of error; therefore, the numbers are used cautiously and roughly as a strong indication of the number of companies with green patents. Also, both patents and companies may appear in more regions, thus some double counting cannot be avoided, thus the total does not sum up for neither companies nor patents. Note: Only patents from private companies is included in this count.

In the table below, the top 20 patenting companies within green innovation are listed. The list of companies operates in different industries, such as biotechnology, transport industries and wind energy. The strength of using patent data as a supplement to business categories is that it reveals green tech activity in companies where it is otherwise not visible. In the table below Airbus and Volvo turns out to be very active companies with green tech, even if their core business is not green tech.

Table 3-4: Top 20 patent assignees with green technologies

Company	Number of green patents
Novozymes	2718
Haldor Topsoe A/S	1779
Airbus	1267
Rockwool Int	360
LM Wind Power	351
Nordex Energy	315
Aco Severin Ahlmann	305
Novo Nordisk	299
Still	220
Volvo Lastvagnar	204
Gkss Forschungszent Geesthacht	189
Dupont Nutrition Biosci	180
Vkr Hldg	170
Philips Intprop & Standards	162
Skf Ind Trading & Dev Ment Co Bv	148
Caterpillar Motoren	139
Danfoss	130
Topsoe Fuel Cell	120
Jungheinrich	119
Inbicon	104

3.1.7. Companies in green clusters and organisations

In this section, data collected from company members in green clusters and organisations is presented. This mapping differs from the previous sections 3.1.2. to 3.1.6. since the definition of green tech companies in this section (3.1.7) is not consistent with the remaining sections. The different definitions are due to the green clusters and organisations do not have common and transparent categorisation of green tech companies, which limit comparation to the others mapping sections. In addition to the limited comparation there is moreover no guarantee that the included clusters and organisations represented all green tech companies in the STRING region. The included clusters and organisations represent mostly renewable energy, cleantech and environmental technologies. Although the limitation of this mapping of companies in green clusters and organisation it contributes with input to the landscape of green tech companies presented above. The included clusters and organisations are presented in Table 3-1 (the number of companies refers to the ones located in the STRING region).

Table 3-1: Examples of companies in clusters and organisations related to the green tech sector in STRING

Cluster or organisation	Country	No. of members
CLEAN is a cleantech cluster based in Denmark with an international focus. Their mission is to accelerate green and sustainable transition while realising growth for the Danish cleantech sector. CLEAN facilitates cooperation between parties by bringing members closer to markets, customers, and peers.[18]	Denmark	251
Energy Cluster Denmark is Denmark's cluster organisation for the entire energy sector and their focus is to ensure that Danish companies develop new technological energy solutions that the world demands. They help facilitate and raise funds for innovation activities and innovation projects that always involve partnerships between small and medium-sized companies, global market-leading companies and leading research and knowledge institutions.[19]	Denmark	292
The Chambers of Commerce and Industry in Flensburg, Kiel and Lübeck is a modern, customer-oriented institution providing companies and the public with a wide range of products and services. It also carries out mandatory tasks transferred to the chambers by law.[20]	Germany	18: Flensburg 112: Lübeck
UmweltPartnerschaft is an institution for the promotion of voluntary corporate environmental protection in Hamburg.[21]	Germany	1,262
Renewable Energy Hamburg Cluster is a platform for networking and information in its capacity as the central regional industry network. The core elements of cluster activities since 2016 have been in offshore and onshore wind energy, together with heat, sector coupling and storage. One major project in which the Renewable Energy Hamburg Cluster plays a significant role is the project 'Norddeutsche EnergieWende 4.0 (NEW4.0)', which has demonstrated, since 2016, the increasingly important interaction between the energy focal point of Hamburg and the powerful production region of Schleswig-Holstein.[22]	Germany	181
WTSH Business Development and Technology Transfer Corporation of Schleswig-Holstein. WTSH is the main business promotion agency in Schleswig-Holstein. As a one-stop agency, they assist companies as a competent service provider, particularly in supporting their efforts to successfully implement innovations and open up interesting foreign markets.23 WTSH is the responsible body for State coordination of eMobility and Hydrogen Economy in Schleswig Holstein. They are also part of the Cluster Management Renewable Energies Schleswig-Holstein ("EE.SH - Network Agency Renewable Energies Schleswig-Holstein"). WTSH supports funding programmes in the field of energy transition and climate protection such as Energy Transition and Environmental Innovation (EUI), Charging infrastructure for electric vehicles, and Research, Innovation and Technology Transfer (FIT).	Germany	267

[18] https://www.cleancluster.dk/en/about-clean/
[19] https://www.energycluster.dk/en/
[20] https://www.ihk-schleswig-holstein.de/english/service/welcome-1352490
[21] https://www.hamburg.de/die-umweltpartnerschaft-hamburg/
[22] https://www.erneuerbare-energien-hamburg.de/en/about-us/profile.html
[23] Unternehmen - WTSH - Wirtschaftsförderung und Technologietransfer Schleswig-Holstein GmbH

WT.SH have combined a list of Green tech companies based on their knowledge about the region and the companies mapped in CrunchBase, members from Renewable Energy Hamburg Cluster and IHK Schleswig-Holstein.		
Swedish CleanTech contributes to the development, commercialisation, and export of Swedish environmental technology.[24]	Sweden	342
The Norwegian Solar Energy Cluster. A number of the partners in the Solar Energy cluster are among the leading international today, and several have international ambitions. The partners in the Solar Cluster have a vision to make Norway the world's best arena for innovation and testing in solar and energy systems. The partners mission is to provide better solar energy solutions for everyone, through the dissemination of innovative solutions, collaboration through a good national and international ecosystem for innovation and commercialization. The main goal is to develop and create growth by industrialize world-class sustainable solar energy solutions.[25]	Norway	88 (no geograph-ical limitation to the STRING region)
Energy Valley is a technology cluster and Norwegian Centre of Expertise (NCE) in energy tech-nology with a centre of gravity in the greater capital region of Norway. By offering infrastructure for collaboration, knowledge transfer and new insight, we help our members adapt to, benefit from, and contribute to the energy industry in transition.[26]	Norway	200+ (no geograph-ical limitation to the STRING region)

About 3000+ companies are identified in the above table. The organisations have different definitions of green tech companies. The transversal definition used across the organisations is maximalist and inconsistent. Therefore, this result is considered as an additional mapping to the above mapping of green tech companies in STRING. It is used to provide a comprehensive overview of the number of companies, but with uncertainty about all the companies being within the green area.

3.1.8. Main findings in the mapping of green tech companies

The mapping is based on several transnational data sources, therefore, the main findings will be represented in different ways.[27] This includes companies that have been mapped via industry codes, company descriptions, whether they have taken out green patents and membership in clusters and organisations which are related to the green tech sector. In addition to the green members in clusters and organisations[28], there are approximately between 4,000-4,500 green tech companies in STRING. According to the mapping, they are spread all over the region, however, with a higher concentration of jobs in green tech companies around the major cities. It is considered a strength in the STRING region that the green tech companies are represented in the entire region, which enhance possibilities for collaboration and to share experiences on working within the green tech sector. About two-thirds of the companies in the green tech sector have up to 50 employees and about 5 pct. of companies have over 250 employees.[29] Large companies are particularly crucial for the green sector, as they typically have more resources and opportunities to work on innovation within the green transition. The large companies, and the companies in general, typically work with renewable energy, circular economy, and biotechnology. However, the role of SMEs, start-ups and university spin-offs to deliver new and innovative green tech business should not be overlooked.

[24] https://swedishcleantech.com/about-us/
[25] http://solenergiklyngen.no/
[26] https://energyvalley.no/
[27] Different operationalisations of the green tech sector are used across the used databases therefore it has not been possible to merge the companies into one unified dataset.
[28] They not included, as it is not known how the organization has defined its members as being a green company.
[29] Included: Companies identified by industry codes and company description since no data on employee numbers in the companies with the green patents

3.2. Green research and innovation infrastructure

This section provides an overview of the research and innovation infrastructure[30] regarding green technology in the STRING region. The following sections will give different perspectives on the research and innovation infrastructure in the STRING region. The first section will cover the methods and data used. The next section will present an overview of the research and innovation infrastructure and this section will thus provide a general picture of the research and innovation infrastructure in the STRING region, which is followed by a section that presents the innovation potential from research. The following four sections will each provide an overview of the research and innovation infrastructure within each of the four specific industries related to green tech: renewable energy, environmental technologies, transport and logistics, and food and agriculture. The final section presents the main findings from the mapping of green research and innovation infrastructure in the STRING region.

3.2.1. Method and data

The research and innovation structure includes clusters, networks, science parks, incubators, universities, and testbeds. Activities are included in the study if they are related to the development or sale of green technological solutions in some way. The definitions of the activities are listed below. Naturally, some activities cannot be put into just one box, hence grey areas will occur.

- **Clusters and networks**: Gatherings of several different actors like companies, institutions, organisations, government institutions or other actors within a certain industry working with green technology. This also includes public/private partnerships.
- **Science parks and incubators**: Science parks and incubators which fostering green innovation and knowledge.
- **Universities**: Universities which publication activity in the field of green technologies.
- **Testbeds:** Testbed facilities include many disciplines within test, demonstration, and development of green tech solutions, e.g., laboratories, real-world labs and living labs.

This research is based on explorative desk research which clearly showed four dominant industries within the green tech sector in the STRING region: renewable energy, environmental technologies, transport and logistics, and food and agriculture. These industries became the guideline for the identification of the existing research and innovation infrastructure in the STRING region. This will also mean that the mapping will not be complete in terms of all green technology industries but will provide a strong indication of the general picture regarding green technology in the STRING region. The mapping of the infrastructure of the four industries is based on desk research and inputs from stakeholders.

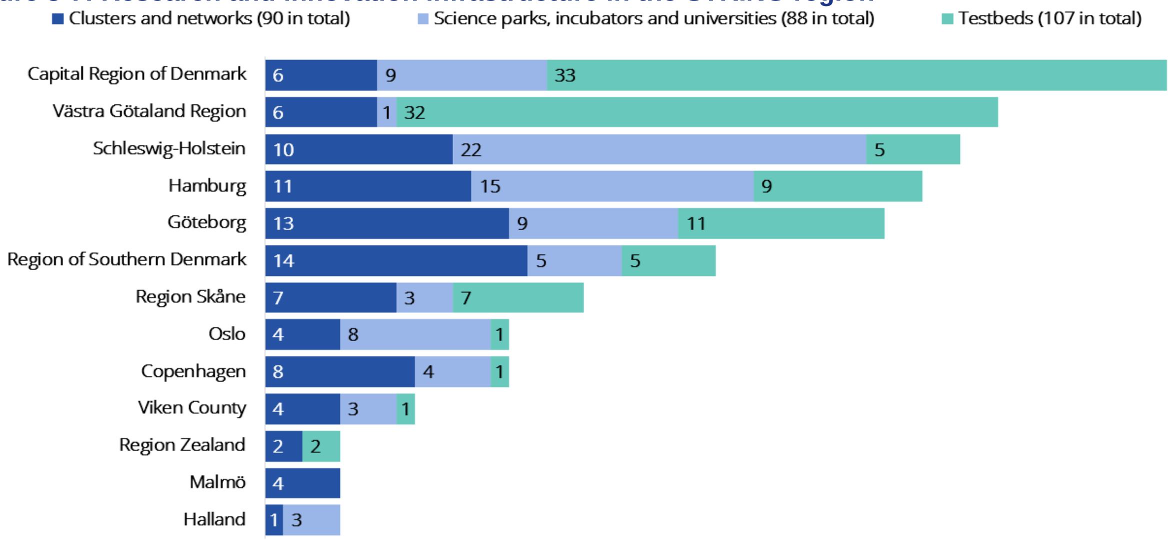
3.2.2. Overview of the green research infrastructure

The distribution of research and innovation activities in the STRING region is presented in Figure 3-7, while the specific locations of these 279 clusters, networks, science parks, incubators, universities, and testbeds can be found in Figure 3-8. The heat map highlights areas of importance regarding research

[30] Research and innovation infrastructure refer to the test centers, networks, universities etc. that a company can reach to get support for its R&D work.

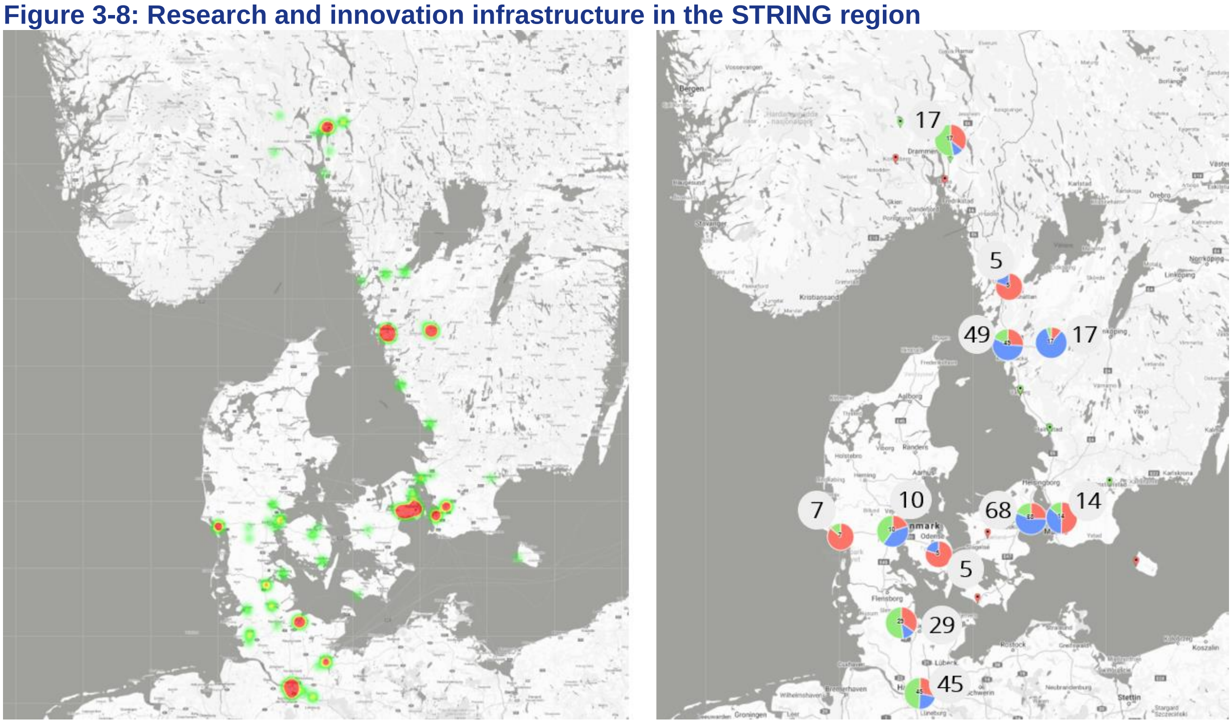
and innovation activities, while the cluster map shows the number of activities. An overview of the activities is presented in Appendix E.

Figure 3-7: Research and innovation infrastructure in the STRING region



Data source: Desk research. Note: The list of these activities is presented in Appendix E.
N: 202 clusters, networks, science parks, incubators, and testbeds

Figure 3-8: Research and innovation infrastructure in the STRING region



Data source: Desk research.
Map online: https://batchgeo.com/map/8dab10c836f5d70f88d7077208dd59cb
N: 279 locations of clusters, networks, science parks, incubators, universities, and testbeds.
Note: Colours in cluster view: Blue = testbeds, red = cluster/network, green = science park/incubator/universities.

It becomes clear in the figure that most of the activities are focused around metropolitan areas and especially around the Capital Region of Denmark, Hamburg, and Gothenburg and in Schleswig-Holstein. Additionally, very few research and innovation activities are located in regions without larger metropolitan areas like Region Zealand and Region Halland. Furthermore, the types of activities are not evenly distributed within the regions according to Figure 3-8. Clusters and networks seem to be dominant in Denmark, especially in the Capital Region of Denmark (incl. Copenhagen) and in the Region of Southern Denmark. Both Hamburg and Gothenburg also have a significant number of clusters and networks. Science parks and incubators mostly appear in Germany, both in Hamburg and in Schleswig-Holstein. Finally, the Capital Region of Denmark contains, by far, the greatest number of testbeds.

Figure 3-8 above shows the specific locations of the research and innovation activities and the maps, therefore, illustrate the distribution of activities that were presented in Figure 3-7 above.

3.2.3. Innovation potential from research

Research in green tech is an important foundation for finding new ways to tackle climate challenges and to accelerate a green transition. The amount of research can be measured by comparing the volume of articles, conference papers and the like related to green tech. In the global database Scopus, we have identified 8,7 million articles[31], conference papers and other scientific publications published since 1990 on green tech. This equals 113,6 green tech publications pr 100.000 inhabitants worldwide. Limiting the search to EU28 the average is 548,1 publications pr. 100.000 inhabitants and that figure almost doubles in the STRING region to 911,4 publications pr. 100.000 inhabitants – all figures measured as the sum of registered publications in the 1990-2021 period. From this perspective science related to green tech is clearly a strength in STRING. It is a strength that can attract both attractive science cooperation and research funding to the region, and a strength than can open doors to cooperation with other leading research centres in the world.

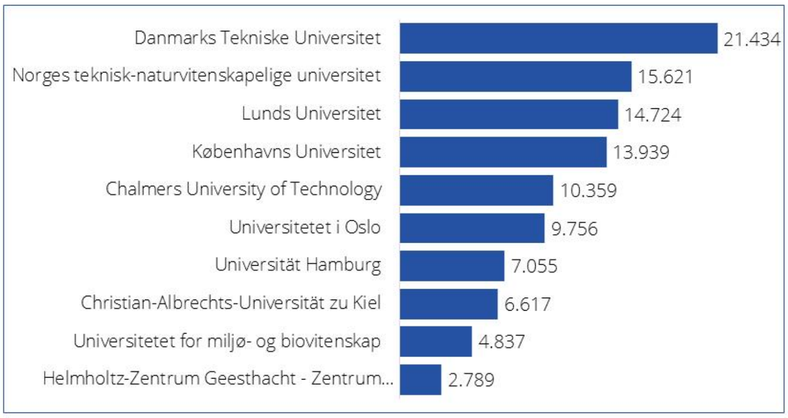
[31] The search included variations of key words for green tech such as: green tech, environmental technology, Sustainability, Renewability, Ecology, Biogas, Life cycle, greenhouse gasses, climate, biofuel, hydro power, solar power, recycling, energy efficiency, wind, water. In addition, SCOPUS have predefined searches for UN SDGs, and we included SDG 6 (water), SDG 7 (Energy), SDG 9 (Industry), SDG 11 (cities) and SDG 12 (consumption) and SDG 13 (climate). The full search string contains 1281 words, before geographical and data limits is added.

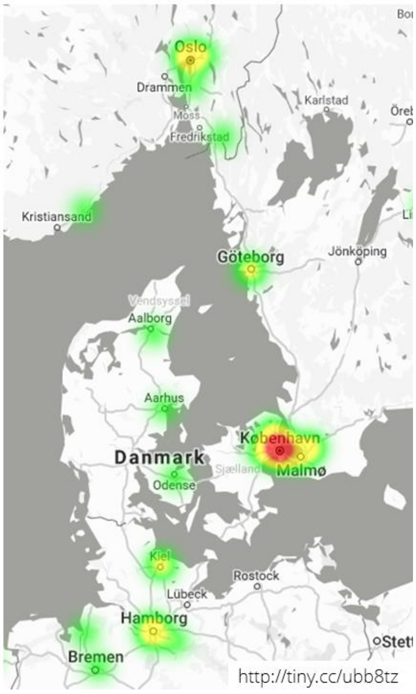
Figure 3-9 Green tech science publications based on SCOPUS

Green tech publications pr capita (100.000)

Geography	Population	Literature No of hits	Pr. capita (100.000)
World	7.673.533.972	8.718.495	113,6
European Union	447.512.041	2.452.670	548,1
STRING	11.977.827	109.165	911,4

Top 10 green tech publishing institutions





Danish Technical University tops the list with 21,434 publications but there is activity throughout the STRING region. The institutions behind publications from the STRING region have been mapped in the figure above. Science publications are very often collaborations between universities and the map shows exclusively data from publications where universities or other research institutions from STRING has been involved.

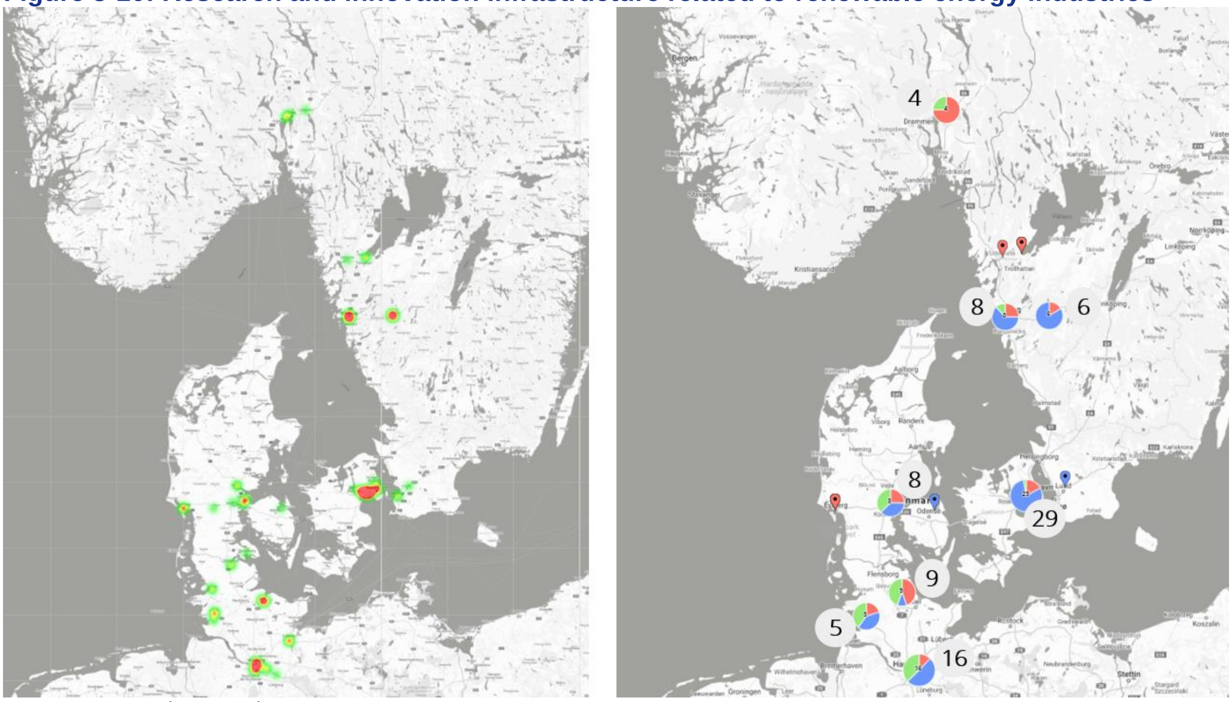
The map can be accessed online by using the link and when zooming out it becomes clear that STRING universities and research institutions are involved in international cooperation with especially other regions within the EU and UK, and outside with institutions in the US. There are co-publications with institutions from China and Japan, but the activity is rather low in comparison. The advantage of cooperation is the possibility to tap into new research and both China and Japan are very active. Measured pr. 100.000 inhabitants, the US produced 500,1 publications, China 94,9 publications and Japan 272 publications pr. 100.000 inhabitants in the period 1990-2020. The growth in the volume is rapidly growing as a reflection of importance and capacity and especially China is changing very fast from 23.000 publications in 1990 to 171.000 publications in 2020. In comparison, STRING publications grew from 5,628 in 1990 to 8,431 in 2021. It is clear, that some of this knowledge will find its way into new technologies and innovative products. But is just as clear, that the strength position today will be challenged by competitors. Research cooperation with other EU institutions should be maintained, the cooperation with the US should be expanded, and cooperation with Asia should be better explored.

In the following sections, the research and innovation infrastructure for each of the four industries (renewable energy, environmental technologies, transport and logistics, and food and agriculture) will be presented.

3.2.4. Renewable energy

Figure 3-10 shows 93 locations of research and innovation activities in the renewable energy industry.[32] This includes green technology activities related to wind power, waterpower, solar energy, energy efficiency, and energy storage, among others. The figure clearly outlines that a lot of the research and innovation activities in the renewable energy industry are focused in the Capital Region of Denmark and Copenhagen, around Hamburg and Gothenburg. Science parks and incubators are concentrated around the Region of Southern Denmark, Schleswig-Holstein, and Hamburg, whereas clusters and networks are spread out across the STRING region.

Figure 3-10: Research and innovation infrastructure related to renewable energy industries



Data source: Desk research.
Map online: https://batchgeo.com/map/fa26a7436fc17ef996c1ca8ededbe3d2
N: 93 locations of clusters, networks, science parks, incubators, and testbeds.
Note: Colours in cluster view: Blue = testbeds, red = cluster/network, green = science park/incubator.

Energy Cluster Denmark is one example of an energy cluster. Energy Cluster Denmark is present in several locations throughout Denmark. The cluster deals with wind, gas, district heating, electricity, and transport and provides support for companies in the energy sector in order for them to develop technological energy solutions (Energy Cluster Denmark, 2020). OffshoreVäst is another example of an energy cluster in the STRING region. OffshoreVäst is located in Borås, Västra Götalandsregionen and they work with blue renewable energy like sea-based energy, offshore wind power and marine bioenergy (OffshoreVäst, 2020). ESS & MAX IV: Cross Border Science and Society is an example of a Danish-Swedish-Norwegian cross border project about synchrotron radiation facilities. The different new techniques developed for MAX IV will for instance reduce energy consumption compared to traditional synchrotron facilities (ESS & MAX IV, 2021). Hanseatic League of Science (HALOS) is a new EU project in

[32] Universities are not included.

the program area Öresund-Kattegatt-Skagerak interreg started in 2019. HALOS will build a unique collaboration between Hamburg and South-West Scandinavia, bringing together the four research facilities MAX IV, ESS, DESY and European XFEL, and create a centre for integrated, world-leading life science innovation and research (HALOS, 2021)

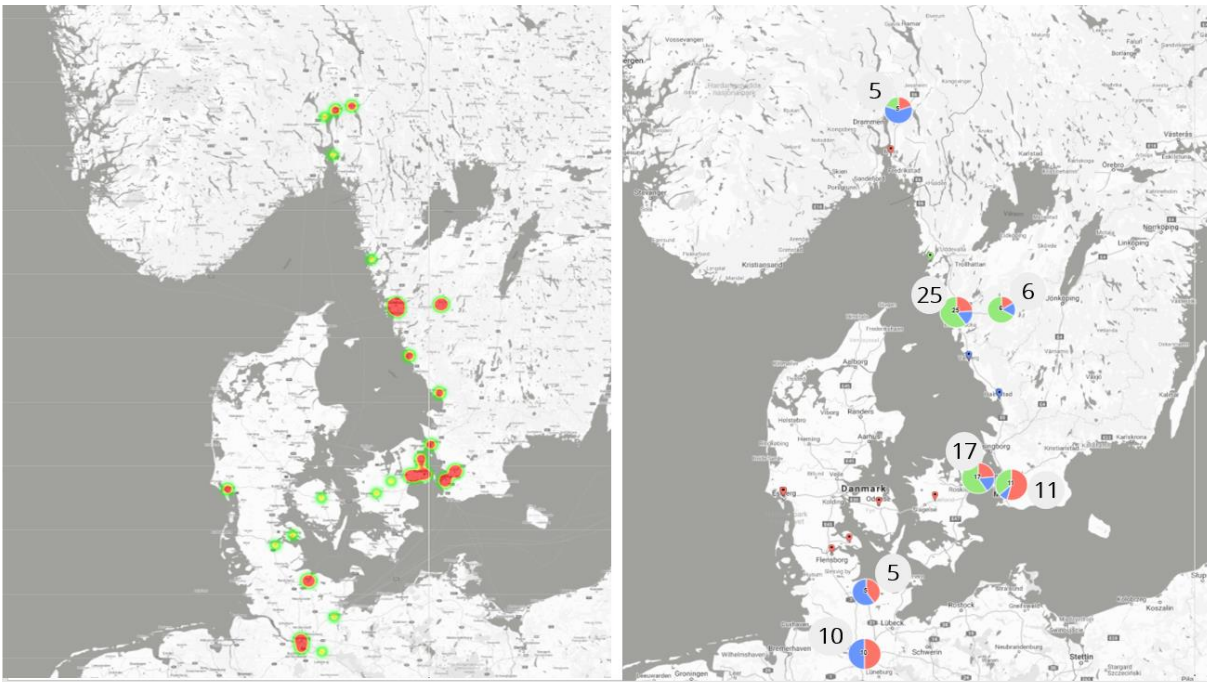
The Center for Sustainable Energy Systems in Schleswig-Holstein can be mentioned as one of the science parks that works with research and development of environment- and climate-compatible energy systems and technologies (Center for Sustainable Energy Systems, 2020). Oslo Tech is another example of a science park that works with innovation and facilitating new businesses (Oslo Science Park, 2020). One of the testbeds is DTU Wind Energy that develops wind energy solutions for both onshore and offshore wind energy (DTU Wind Energy, 2019). Another example is Green Tech Center, located in the Region of Southern Denmark, that provides realistic demonstrations of renewable energy production (Green Tech Center, 2020) and the project NEW 4.0 – Northern German Energy Transition, which is aimed at implementing sustainable energy supply and thus strengthening the sustainability of the region through for example, large-scale practical testing of the system integration of renewable energies (NEW 4.0, 2021).

3.2.5. Environmental technologies

The environmental technology industry includes green technology solutions related to the circular economy, waste management, wastewater management, and soil, water, and air quality among others.[33] These types of technologies are often referred to as cleantech. Thus, the environmental technology industry is a diverse industry. We have located 91 research and innovation activities in the STRING region related to environmental technologies which are reported in Figure 3-11. It is evident that activities related to environmental technologies are primarily located in the Copenhagen/Malmö region, around Gothenburg and Hamburg. The figure on the right shows that clusters, networks, science parks, and incubators are spread out across the STRING region while testbeds are focused around the Copenhagen/Malmö region and around Gothenburg.

[33] Universities are not included.

Figure 3-11: Research and innovation infrastructure for environmental technologies



Source: Desk research.
Map online: https://batchgeo.com/map/7bd9318401295e816c288d8c503d8e79
N: 91 locations of clusters, networks, science parks, incubators, and testbeds.
Colours in cluster view: Red = cluster/network, blue = science park/incubator, green = testbed.

Several clusters and networks are working with environmental technologies. One example is Business Region Göteborg where cleantech is one of the industrial focal points. The cluster provides knowledge and contacts to cleantech companies (Business Region Göteborg, 2020). Another cluster working with environmental technology in the STRING region is CLEAN. The cluster works with cleantech companies and has several locations across Denmark (CLEAN, 2020). Johanneberg Science Park located in Gothenburg focuses on urban development and generates environmental innovations (Johanneberg Science Park, 2020). One example of an environmental technology incubator could be Kjeller Innovasjon Incubator in Viken County that has environmental solutions as one of its focus areas (Kjeller Innovasjon, 2020). Several testbeds are located in the Capital Region of Denmark and around Gothenburg. One example is the Climate Adaptation Lab at the Danish Technological Institute. The lab carries out full-scale product development and tests of climate adaptation solutions and drainage products (Danish Technological Institute, 2020). The Air Testing Laboratory at FORCE Technology is another example of a testbed where tests of air emissions and air quality are performed (FORCE Technology, 2020).

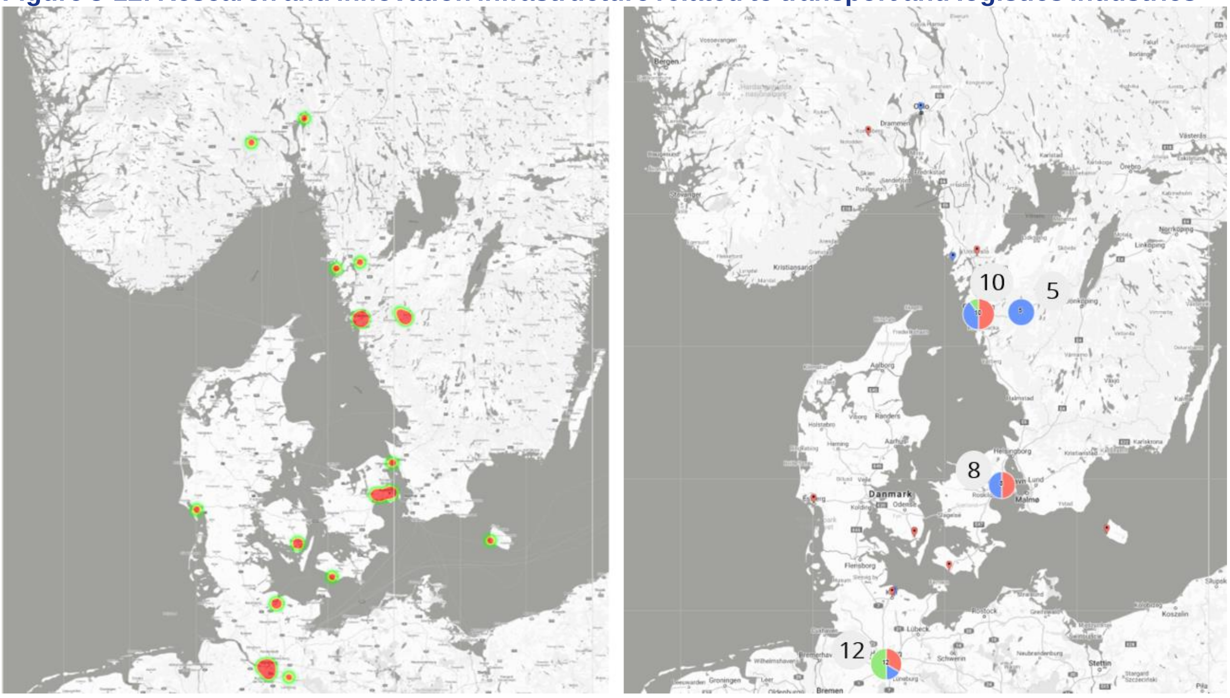
3.2.6. Transport and logistics

When looking at the transport and logistics industry, the research and innovation activities are more evenly situated across the STRING region but there are still some dominating areas.[34] Within this industry, several different subindustries can be identified. This could include but is not limited to, public

[34] Universities are not included.

transport, road transport, air transport, rail transport, waterway transport, and logistics, which also includes city logistics. 46 locations of research and innovation activities are represented in Figure 3-12.

Figure 3-12: Research and innovation infrastructure related to transport and logistics industries



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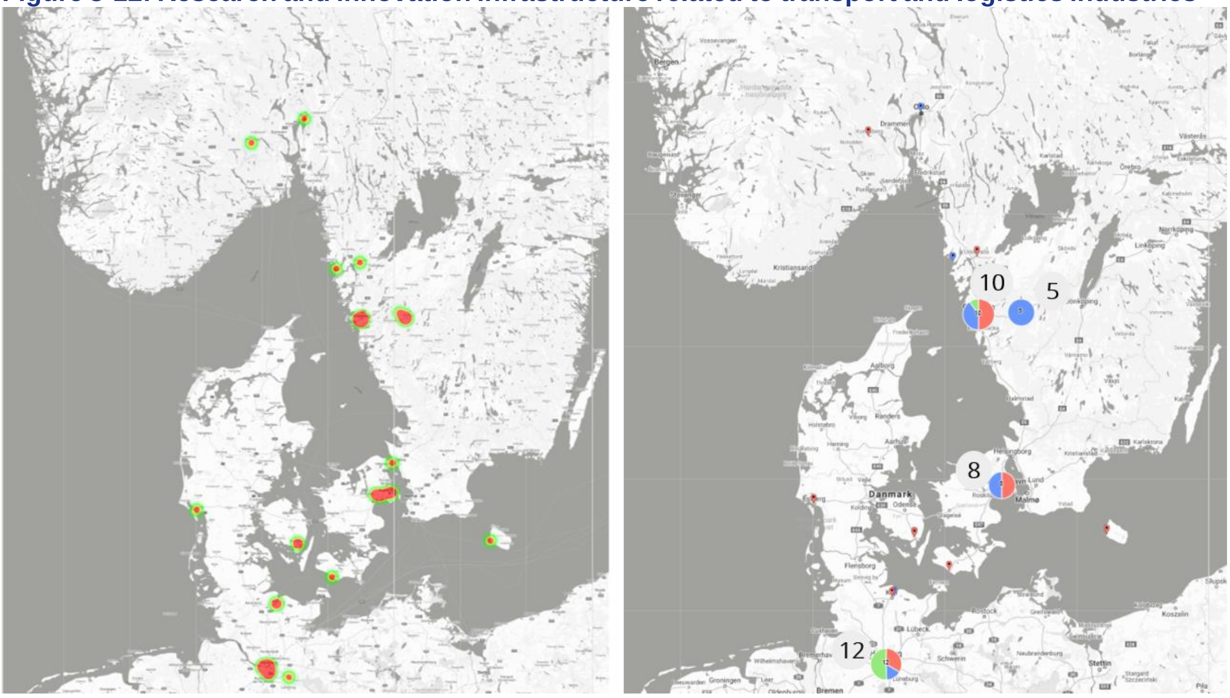
The heat map on the left points out Hamburg and also Copenhagen and Gothenburg as dominating areas. The map on the right shows that most of the research and innovation activities in the transport and logistics industry consist of clusters and networks and a number of testbeds primarily are located around Copenhagen and Gothenburg.

Figure 3-12: Research and innovation infrastructure related to transport and logistics industries



Source: Desk research.
Map online: https://batchgeo.com/map/22ecf8cadd5fb8e8794ce03090957295
N: 46 locations of clusters, networks, science parks, incubators, and testbeds.
Colours in cluster view: Red = cluster/network, green = science park/incubator, blue = testbed.

As mentioned, a lot of research and innovation activities related to transport and logistics are located in Hamburg, Copenhagen, and Gothenburg. One of the clusters located in Northern Germany is the Maritime Cluster Northern Germany located both in Hamburg and Kiel. The cluster promotes and develops cooperation in the maritime industry in Northern Germany (Maritimes Cluster Norddeutschland, 2020). Another example of a cluster in the transport industry is the Transport Innovation Network (TINV) in Copenhagen. The objective for TINV is to create synergy between the transport sector and research- and educational institutions (The Transport Innovation Network, 2020). A few science parks primarily working with transport and logistics are located in the STRING region. One of them is Lindholmen Science Park in Gothenburg whose focus is on mobility for people and goods (Lindholmen Science Park, 2020). In Hamburg, Finkenwerder Innovation Park is another Science Park with a focus on research and development in aviation (HDB, 2020). One example of a test facility in the transport sector is ElectriCity in Gothenburg. This is a project where new solutions in the transport sector are being developed, tested, and demonstrated (ElectriCity, 2020). Another example of a testbed in the transport industry can be found in Hamburg where a test track for automated and connected driving is located (TAVF, 2020).

3.2.7. Food and agriculture

The food and agriculture industry is not as dominating as the other identified industries when it comes to research and innovation activities in the STRING region.[35] We have located 27 research and innovation activities related to the food and agriculture industry. Green technologies in the food and agriculture industry are related to food processing, feed, fishing and aquaculture, greenhouse gas reductions in agriculture, and agricultural machinery and equipment. Copenhagen, Oslo, and Schleswig-Holstein are dominating areas with most activities centred around these areas as shown in the heat map on the left in Figure 3-13. Research and innovation activities in the food and agriculture industry mostly consist of clusters, networks, science parks and incubators. Another example of a test facility and project is EVolution Road in Lund (Region Skåne), where an electric road for charging electric vehicles has been installed (EVolution Road, 2020).

Figure 3-13: Research and innovation infrastructure related to food and agriculture industries

Source: Desk research.
Map online: https://batchgeo.com/map/27e6e2c35254d0855be4a166753fc350
N: 27 locations of clusters, networks, science parks, incubators, and testbeds.
Colours in cluster view: Green = cluster/network, red = science park/incubator/universities, blue = testbed.

[35] Universities are not included.

One of the larger clusters in the food and agriculture industry is the Food and Bio Cluster in Denmark with locations both in Copenhagen and Odense. The cluster helps establish cooperation between companies and knowledge institutions in the food and bio-resource sector (Food and Bio Cluster Denmark, 2020). Another sector network is foodRegio located in Schleswig-Holstein (foodRegio, 2020). The Danish Meat Research Institute (DMRI) is located in the Capital Region of Denmark. This is a research and innovation centre for food of animal origin (Danish Technological Institute, 2020). Foods of Norway located at the Norwegian University of Life Sciences is a Centre for Research-based Innovation (CRI) and contributes to developing sustainable feed ingredients in the agriculture and aquaculture industry (Foods of Norway, 2018). Another incubator in the food and agriculture industry is Krinova in Region Skåne, which offers innovation and development support for companies in the food, environment, and health industry (Krinova, 2020). Only a few testbeds related to food and agriculture are located in the STRING region. The Danish Technological Institute has a couple of testbeds in this industry. One of them is a facility where food and feed among other things can be tested in a pilot production (Danish Technological Institute, 2020). Another testbed is for trials of new plant production methods (Danish Technological Institute, 2020).

3.2.8. Main findings in the mapping of green research and innovation infrastructure

The mapping showed several strengths in terms of research and innovation activities in the STRING region. Out of the four industries mentioned above, the renewable energy industry and environmental technologies industry seem to be dominating in the STRING region. Furthermore, research and innovation activities are primarily located around metropolitan areas and especially in the Capital Region of Denmark, Hamburg and Gothenburg. Consequently, very few activities are located away from the metropolitan areas. This is particularly evident in Region Halland and Region Zealand.

The mapping revealed unexploited potential regarding test facilities. The mapping showed that test facilities are concentrated in the Capital Region of Copenhagen and around Gothenburg. This means that the infrastructure could be improved significantly by distributing green tech test facilities in all industries more evenly across the STRING region. Finally, the mapping revealed great potential for future cooperation across the region. This was evident since the mapping showed, that the individual regions have different strongholds which naturally will create a great potential for cooperation. None of the individual regions are dominating across all types of research and innovation activities, which will encourage the regions to cooperate and thus complement each other. Finally, it is clear that STRING has a relatively strong position in the publication of scientific literature in Europe. This position can attract networking, cooperation, investments, and competencies to STRING. It is also a potential for innovation. The cooperation with the US may be developed more, and the science cooperation with East Asia, China and Japan could be further explored.

3.3. Green technologies

Green tech is about technologies and in this section, we present our results from the mapping of green patents in the STRING region. Identifying patents in global databases within a technology area is called tech mining. The count of patents is an *indicator* of technology development, market interest and technology strength for a region. The patents contain information of patent assignees (owners), inventors, and their addresses as well as dates of publication, abstracts of the patents, and several classification systems for technologies.

The following sections begin with a brief introduction to how green technologies are identified in the global patent databases. A deeper introduction to methodology, limitations and advantages of tech mining is found in appendix b.2. This is followed by a section on development of green tech on a global scale and over time. Finally, there is an analysis of dispersion of green tech innovation in the STRING region and a typology of the of identified green tech in the STRING region. The main findings are then found in the end of this section.

3.3.1. Tech mining for green tech – a brief introduction

Identifying patents in global databases within a technology area is called tech mining. The count of patents is an *indicator* of technology development, market interest and technology strength for a region. The patents contain information of patent assignees (owners), inventors, and their addresses as well as dates of publication, abstracts of the patents, and several classification systems for technologies. Tech mining is a strong tool but patent data has limitations that are important for one to be aware of when reading the analysis. Not all technologies are patented since it may be too costly, some consider the disadvantage of disclosure of information greater than the advantage of the protection of intellectual property, some that the speed of innovation renders patents obsolete too fast, and finally, tradition, regulation or the incentive to take out a patent may vary greatly from technology area to technology area and from country to country. Also, among the limitations is that there is no monetary value connected to patents (so they cannot be ranked according to value), licenses to other companies using the technology are not recorded, and it cannot be directly linked to business information. With these limitations in mind, an analysis of patents can still give an indication of the development of green tech that is far more comprehensive than what any other set of data can provide. See Appendix B.2 for a brief introduction to tech mining.

Though tech mining has its limitations there is no stronger tool or registration of technologies or innovation trends. We have searched for green tech patents among all patents published by national and international patent authorities. All patent applications and published patents are stored by patent authorities in online accessible databases. The searches have been based on technology classifications systems. To identify green tech in the patents, we have combined two international definitions on environmental technologies, one from OECD and one from WIPO. The advantage of combining the two definitions is that they can be regarded as an international standard for searching for environmental technologies in global patent databases.[36]

[36] The more than 800 technology codes mean that the OECD/WIPO combination it is a wide definition that measures both areas where STRING may have a stronghold and since STRING, for size reasons alone, cannot be leading in every aspect and there will be numerous areas where other regions are excelling.

- The first definition is made by **OECD**[37,38] to measure the output of environmental innovation. OECD published a set of green patent indicators in March 2015. The indicators of green technologies have been selected based on whether they are environment-related technologies or not. All patents are categorised according to a patent classification system (CPC codes), where the environmental patents are selected. It is a comprehensive definition and the best place to get a list of categories is in the report from OECD (from page 44) [39]. Worldwide we have identified 3.15 million published patents[40] using the OECD definition of environmental technologies.

- The other definition is from **WIPO** (World Intellectual Property Organisation[41]). The "IPC Green Inventory[42]", developed by the IPC Committee of Experts, to facilitate searches for patent information relating to Environmentally Sound Technologies (ESTs), as listed by the United Nations Framework Convention on Climate Change (UNFCCC). The definition was published on 22 September 2020[43]. This definition uses another widely used classification system for patents, the IPC coding system. Using this definition, we can identify 4.8 million patents globally.

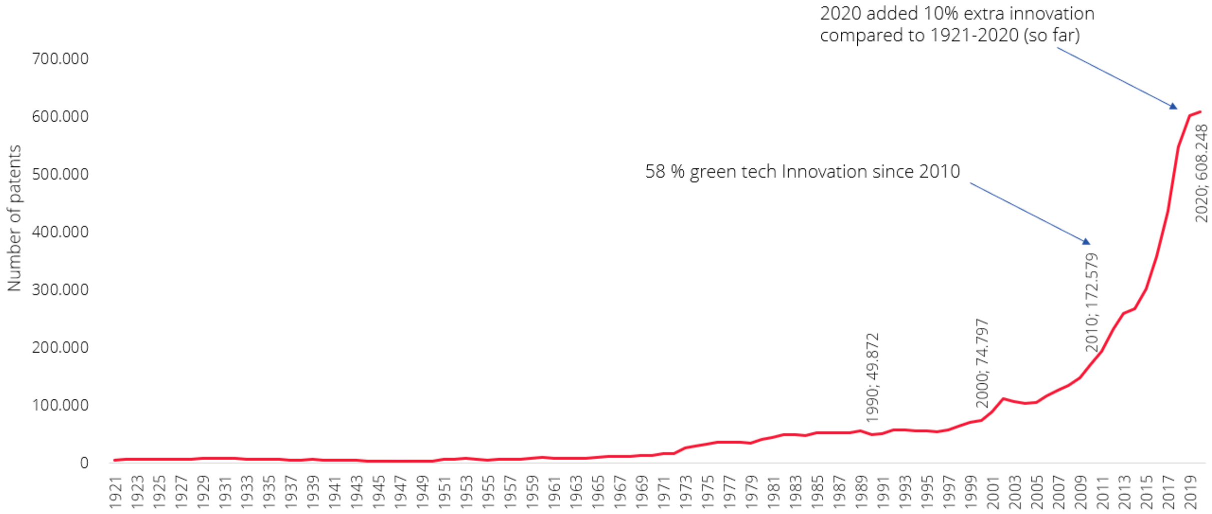
There is some overlap of technologies in the combined search of about 800 technology codes. The total search using a combination of OECD/WIPO identifies 6.9 million[44] patents[45].

Global green tech patents

Figure 3-14 shows the worldwide development of green tech patents over the past 100 years. The overall analysis of the 6.9 million patents reveals a hockey-stick shaped development in R&D and markets with acceleration in innovation over the past 20-30 years. The acceleration is impressive. 2020 alone already added 10 pct. of the total amount of published patents in the past 100 years. The count was made at the beginning of November, so the number of patents – or technology innovation – can be expected to exceed that by perhaps 17 – 20 pct. Out of about 140 million patents, this means that 2.3 pct. of all patents are related to environmental technologies according to the OECD definition.

Figure 3-14: Global green tech patents the last 100 years – the full view

[37] http://www.oecd.org/greengrowth/green-growth-indicators/
[38] Green growth is about fostering economic growth and development while ensuring that natural assets continue to provide the resources and environmental services on which our well-being relies. To do this it must catalyse investment and innovation which will underpin sustained growth and give rise to new economic opportunities. The OECD Green Growth database contains selected indicators for monitoring progress towards green growth to support policymaking and inform the public at large. The indicators contain data on environmental innovation, alongside others on economic opportunities and policy responses. http://www.oecd.org/env/indicators-modelling-outlooks/green-growth-indicators/
[39] https://www.oecd.org/environment/consumption-innovation/ENV-tech%20search%20strategies,%20version%20for%20OECDstat%20(2016).pdf
[40] All figures are for "patent families" since the same technology are often patented in several countries. If it is the same technology the innovation counts as only one technology.
[41] https://www.wipo.int/
[42] https://www.wipo.int/classifications/ipc/en/green_inventory/
[43] https://sciencebusiness.net/news/67797/WIPO-tool-to-make-searching-clean-tech-patents-easier
[44] With the high number of patents with mostly qualitative information, we rely on big data algorithms. For the patent population we identified for STRING, we have made a visual inspection by cross reading company names or patent titles. We found 5-10 assignees who patented roses and clematis and they have been deleted manually from the STRING population of patents.
[45] When counting patents in this study we refer to "patent families". The same technology can be published in several countries, and if it is the same innovation that is patented the are grouped in families. Behind the 6.9 million patent(families) we have identified 14.3 million patents.

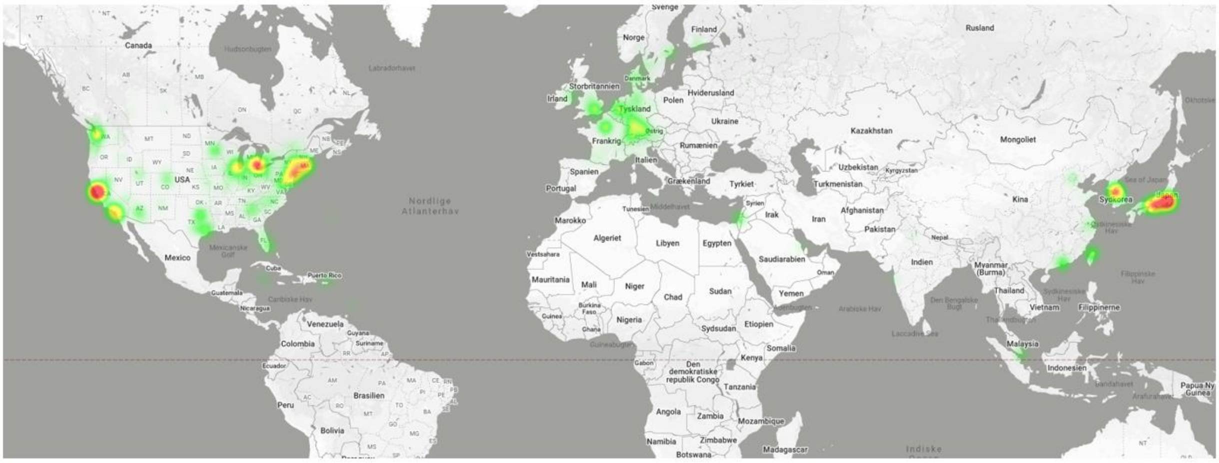


Source: TI Tech-mining – Green tech innovation, extracted 9.11.2020 Combination of OECD definition of WIPO/UN.
Note: The graph is Based on searches in global patent databases using PatSnap with more than 250,000 million innovation and IP datapoints, 140 million patents and 116 patent jurisdictions. Total patent families in the figure: 6.9 million. Administrative procedures and time lag in data-registration means that patent databases are updated daily, and the total number of patent applications or patent grants is not reliable until 2-3 years after registration.

Figure 3-15 is a heat map of the most important green patents granted since 2015. The mapping software can analyse up to 10,000 patents. We have chosen to zoom in on the most innovative and commercially relevant technologies, here defined as patents that have been cited a minimum of 5 times and have been taken out by a minimum of 5 patent authorities. These can be considered current technology leaders within green tech. The red-hot areas are the global hotspots that produce the most patents – meaning that these are areas with the highest turnout of new green tech. The hotspots are weighted by the number of citations for a patent which means that a highly cited patent “glows” even more on the map.

The STRING region is well represented in this comparison when the total number of patents are counted and seen from this perspective, and based on the map below, STRING might rank among top 20 green tech areas worldwide. The most intense areas are the Greater San Francisco Bay Area in the western US, BosWash area in the west and in the Midwest the intense area around the great lakes. Another bright hotspot is found in Japan around Tokyo and Seoul in Korea. Areas on par with STRING region are the greenish areas such as Paris, Texas, and along the “Blue Banana” from London and south along the Rhine River – including the Benelux. Southern Germany is coloured as well.

Figure 3-15: Most important green patents since 2015



Note: Based on patent databases with more than 250.000 million innovation and IP datapoints. Total patent families in the figure: up to 10.000, which is the limit of the mapping software. Patent criteria: The patents included are granted after 2015, cited by min. 5 other patents and extracted by min. 5 patent authorities. Extracted 9 November 2020. The maps online can be accessed and browsed for more information: https://batchgeo.com/map/0364b8838fe3c5e9b7432a807500e36f

The map is just one perspective on the publication of green tech patents, and it does take some time for patents to acquire enough citations or to be published in several countries. An analysis that includes all patents reveals a challenging scenario with China a fast-paced, emerging potential superpower within Green tech. The analysis is found and discussed further in appendix C.

What is further clear from the analysis in appendix C is that EU, including STRING, seems to be inventing green tech at a lower rate. In years ahead that might be a threat to both market power of EU and to hopes for creating green jobs in the field of green tech. That is highlighting the need for concerted initiatives in EU like STRING where cross-border strengths can be coordinated to full fill market potentials and the hopes for green jobs and a green transition.

3.3.2. Green tech in STRING

By default, in tech mining software, the number of patents cannot be counted by sub-regions but counting the number of patents per country of the assignees is possible. In the further analysis, we have extracted patents from Denmark, Norway, Sweden, and Germany, and with the help of further algorithms developed at DTI that analyse address information, we have isolated the patents from the STRING region.

The following analysis of green tech patents in STRING[46] is concentrated on patents published after the year 2000 since most patents expire after 20 years. Since the year 2000, 5 million green tech patents were published worldwide. Assignees can be companies, universities, government institutions, NGOs, private institutes, and individuals. In some instances, an agent (Patent Verwertungsagentur) is handling the patent[47]. Assignees have address information and based on the address information (primarily postal codes and city names) from the assignees, we can extract patents from assignees in the STRING region.

[46] We consider "green tech" to be synonymous with the combination of the OECD/WIPO definition of Environmental Technology
[47] That is the case for universities in Hamburg and Schleswig-Holstein. If the agent has provided their address in either Hamburg or Schleswig-Holstein the technology is included but cannot be attributed to the universities. We have not come across agencies with huge patent-portfolios, so that is probably not often the case. If the agency has provided an address in the patent outside of STRING region, then it is not counted at all.

We only have address information from the current assignees, so original assignees that have sold their patents (not to be confused with licences) might not be identified this way[48]. Also, some address information is very sparse such as in Denmark – with no street, postal code, or city information is available. Some of these have been identified based on the assignee's name. The number of patents is too big for a manual inspection, i.e., to identify patents from Hamburg or Schleswig-Holstein 325,000 German patents were classified before the extraction.

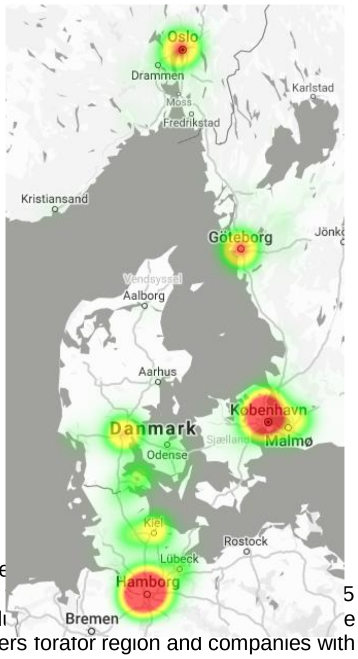
Based on address information we can narrow the search to just the STRING region with a precision of 1-5 pct. error margin[49]. Narrowing the selected green tech patents down to the STRING region, we have found 14,212 green tech patents published since 2000 which equals 0.28 pct. of the green tech patents in the world since the year 2000.

The next figure is a "zoom in" on the STRING region. The hotspots illustrate the concentration of patents in an area where red is a very high concentration and white is a very low concentration. Only patents with at least one citation have been mapped. The hotspots are weighted by the number of citations for a patent which means that a highly cited patent "glows" even more on the map. The interpretation is that important patents, key technologies, or breakthrough technologies get more citations than less important patents or very new patents.

Thus, the map is an interpretation of the green tech centres of gravity in the STING region. As the map shows, innovation activity is in the major cities of the STRING region, especially in Hamburg, the Oresund area, Oslo and Goteborg. The map can be viewed online, and the presentation switched to study individual patents.

Table 3-5 Geographical distribution of patents in STRING

Location	Numbers of green patents (registered since 2000)
Hamburg	3758
Schleswig-Holstein	2102
The Capital Region of Denmark (incl. Copenhagen)	3195
Region Zealand	292
Region Southern Denmark	1230
Region Skåne (incl. Malmö)	693
Region Halland	134
Västra Götalandsregionen (incl. Goteborg)	1126



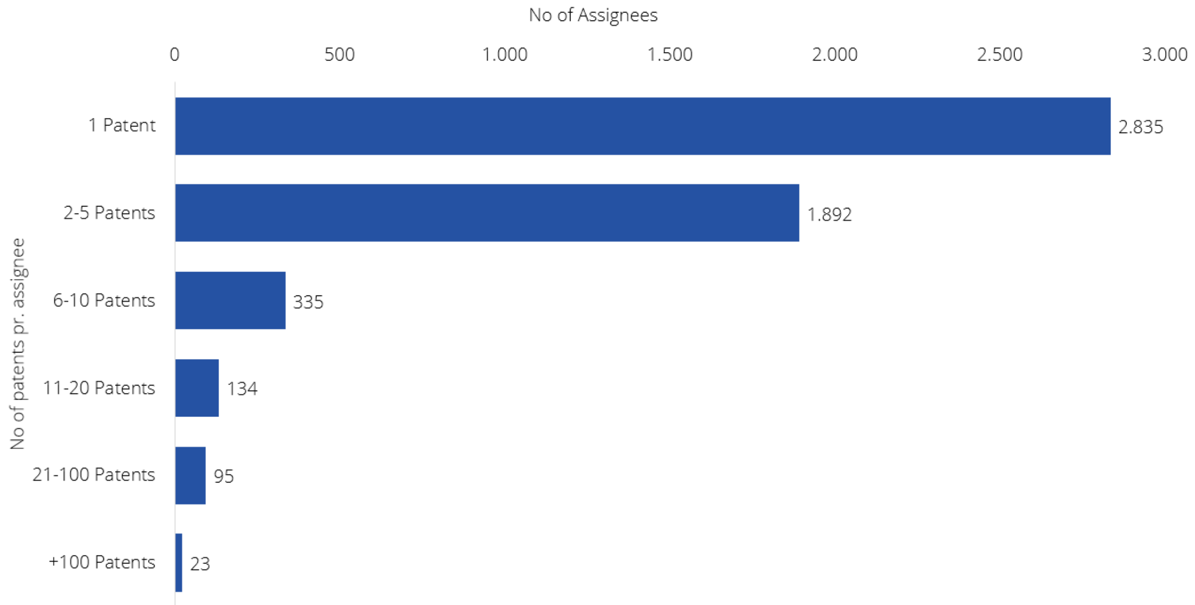
[48] According to interviewees, universities in Hamburg often sells patents and may be under-re
[49] Most address information in a patent registration is mildly or seriously flawed, but cleaning 5 pct. firmly within a postal code and the remaining 1-5 pct. is either not included or wrongly incl e algorithm has several reasons i.e. postal codes do not necessarily follow administrative borders forator region and companies with a postal code belonging to two regions will be included even if the company is located in a non-STRING region. Locating companies based on city names may also produce errors if the name of the city is included in the address information, i.e., as part of the street name or city name.

Oslo	807
Viken County	875
Total	**14,212**

Note: Patents are only counted once, and they are located after the first assignee mentioned. Of the 14.212 patents listed, 5.228 have more than one assignee. The map on the right represents the 9.717 patents published since 2010.
Link: https://batchgeo.com/map/f4bd0b31ec2831cbc035056ed95a7596 NOTE: This table includes all patents, and not just patents from private companies.

The 14 thousand green tech patents in the STRING region have been published by 5,219 Assignees[50], divided between companies (2,347), universities and research institutions (81) and 2,816 individual inventors. Many have published patents in cooperation with other assignees.

Figure 3-16: Number of patents per assignee in STRING



Note: The figure is showing the number of green tech patents per assignees in STRING published since 2000
Source: Analysis of green tech patents by Danish Technological Institute, 2020. Source: TI Tech-mining – Green tech innovation, extracted 9.11.2020. 5314 Assignees with Green Tech Patents in STRING. Combination of OECD definition and WIPO/UN 6,9 million patent families – regardless of legal state

Most assignees have just published one patent within green tech since the year 2000. In the STRING region, 2,835 assignees have published one patent. This equals 20 pct. of the total green tech patents in the STRING region. Many (60 pct.) of the assignees with just only one patent are individuals. Individuals may be company owners, employees at companies, research or government institutions, spawned companies, individual experts from research labs, private inventors, entrepreneurial spawning, individual entrepreneurs, and start-ups.

Research and development works are behind the innovation and technology that is presented in the patents and thus have the potential to create workplaces, companies, and income in the STRING region.

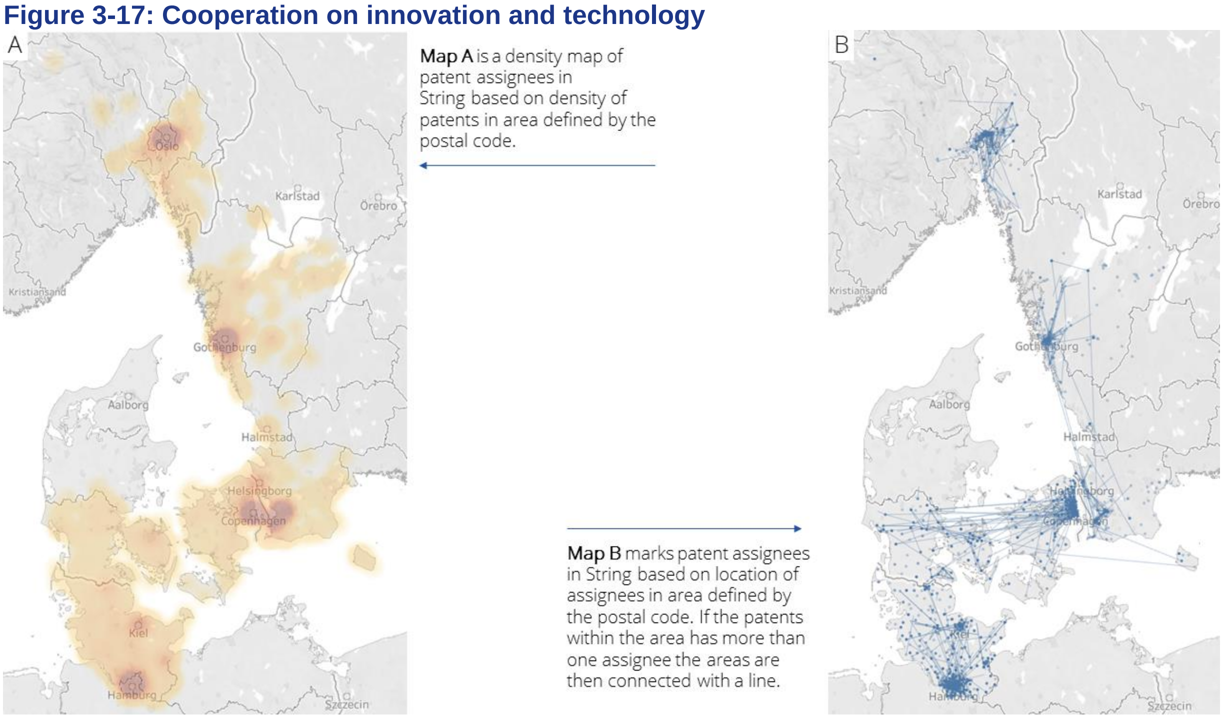
[50] A precise figure is impossible since we group by assignee name and differences in spelling – which is not uncommon – which will inflate the number of assignees i.e.,. DTU, Danish Tech University, Danish Technological University, Danmarks Tekniske Universitet and so on is the same assignee. Also, some individual names represent private companies or universities.

We cannot attach a monetary value to a patent or measure the effect in the number of workplaces, however, the technology behind one patent may be so unique and attractive that it can be the business foundation of an entire company. Other patents are valuable to those that agree on a license to use the technology, and other patents again are published with the expectation that it is an innovative technology but might fail to find its market.

1,892 assignees have published 2-5 patents (36 pct. of assignees), and this *may* indicate a higher professionality or business foundation than those assignees with just 1 published patent. Assignees publishing more than 6 patents within green tech are mostly companies (70 pct.) or company owners.

Research and development can be in cooperation with other actors. 900 of the 14,212 patents have more than one assignee. In the table below, the connections between actors are shown by aggregating patents by postal codes and then connecting postal codes with a line if they have a patent in common. On the map, most cooperation takes places within the region and some across regions. Cross-border relations have not been analysed[51].

Figure 3-17: Cooperation on innovation and technology



Data source: Analysis of green tech patents by Danish Technological Institute, 2020

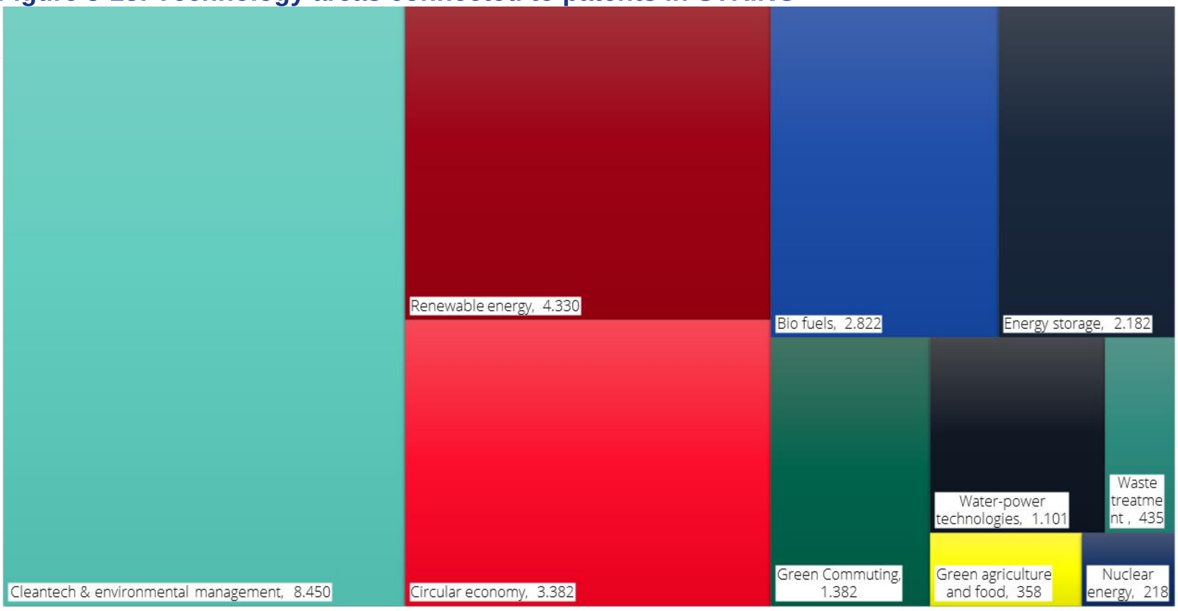
3.3.3. Green tech profile for STRING

The patents can be identified with technology codes and we have grouped the technology codes identified by OECD and WIPO/UN into the main categories to produce a green tech profile of the STRING region.

[51] Due to limitations in data analysis capacity, it has not been possible to include cross-border partners or partners outside the STRING region in this analysis. There will be cross-border linkages within STRING and out of the STRING region to neighbouring regions and countries all over the world. Analysisanalysis will require algorithms to compare all assignees with a global database of cities and postal codes. Thus, the analysis of address information has been limited to national codes.

The green tech profile is shown in the coloured table below. Please note, that some patents have several codes, and most have both IPC and CPC codes. However, if the code for “renewable energy” is found both using IPC and CPC codes it is counted as only one in the same category. The table answers the question “With what frequency do we find each of the tech codes in the patents in the STRING region”. All together 800 technology codes are used to define green tech, and DTI has grouped the technologies into 10 categories to get an overview of the distribution of technologies.

Figure 3-18: Technology areas connected to patents in STRING



Note: Analysis of frequency of technology codes (CPC and IPC) in patents from STRING. Groupings of technologies is made by Danish Technological Institute. A patent may be mentioned in several groups.
Source: Analysis of green tech patents by Danish Technological Institute, 2020

It is not possible to review all technologies in depth, but in appendix C there is a brief presentation of the technology areas with examples from STRING from patented technologies since 2000. The abstracts are directly from the patents and for each example there is a link to the company behind.

3.3.4. Main findings in the mapping of green technologies

The main findings are that the existing base of green tech is a distinct strength for STRING. STRING is innovative in green tech. The number of patented green tech inventions have tripled over 20 years from 3.8 patents pr. 100,000 inhabitants to 11.8 patents pr. 100,000 inhabitants. When studying a world map of the most influential technologies since 2015, the STRING region stands out, not as the number-one hotspot in the world, but enough to be part of the global top 20. Energy-related technologies are, especially, part of various forms of renewable energy, including biofuels. Patent data and publication data cannot be directly compared, but it seems that the scientific publications activity is more intense in Europe and in STRING than patent activity, when compared to the competitors. Patent activity seems to be higher in the US and in Asia. This was also shown to be the case in a recent study on technology strengths (Teknologisk Institut, 2019). This indicates that countries outside the EU are more successful in transforming university research into commercial products, i.e., innovation. The conversion of research knowledge into innovation in companies would be a relevant action area for STRING to stimulate its relative strong position in green tech within science.

There are also numerous technologies in relation to the circular economy, with a focus on sorting, upgrading, and reusing waste materials in new products. And finally, clean tech, in general, with cleaner combustion and purification of exhaust is technology that can be applied widely. The relation to biotech industries is strong and so is the relation to water management technologies.

3.4. Green technology investments

The section presents an overview of green technology investment in the STRING region. The first section will cover the method and used data in identified investors in the green tech sector in STRING. The next section presents the findings from the investment mapping and the final section addresses the overall main findings.

3.4.1. Method and data

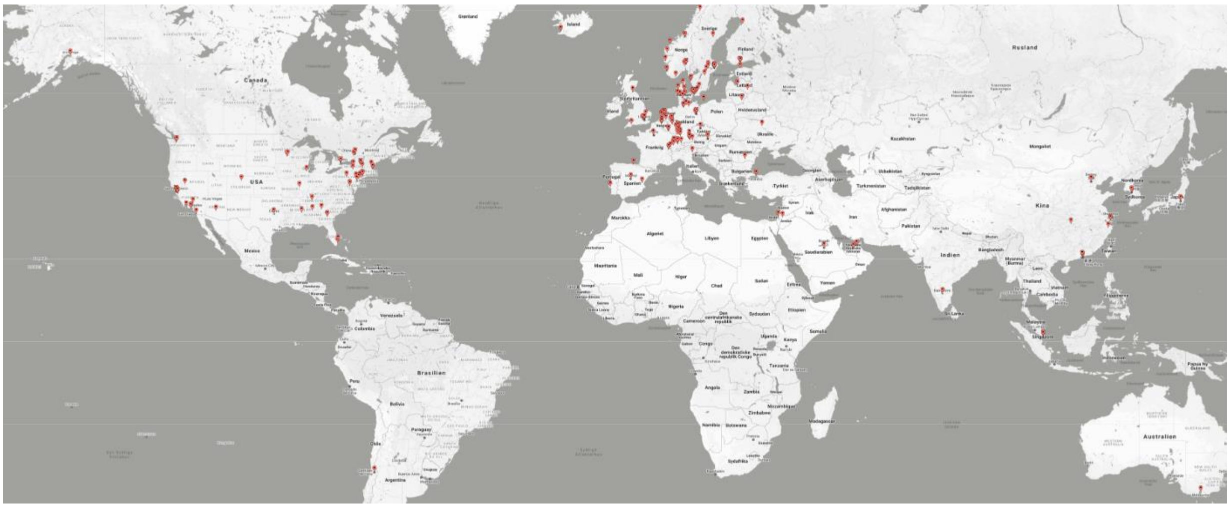
The availability of transnational investment data at regional level is very limited within green technologies. The aim of this mapping was to map the volume of investment, which industry in the green tech sector receives investment and the location of investors. The available investment data that meet parts of these criteria is the database, Crunchbase.[52] The information about technology investments in Crunchbase is after all limited but is the most useable investment data at regional level. The data includes information about location of the investor but does not provide information about the amount invested and which companies they have invested in. Therefore, the only available information within green investment includes the location of the investors who have invested in green technologies in STRING.

3.4.2. Investors in the green tech sector in STRING

In this section, the investors in green technologies are mapped. Since 2010, 713 investors have invested in green technologies in STRING, the investors are illustrated in Figure 3-19. The investors are mainly located in Central Europe, San Francisco Bay Area and in BosWash.

Figure 3-19: Investors in green tech in STRING since 2010

[52] See Appendix B.1.2 for a deeper description of the delimitation of the green tech sector in Crunchbase.



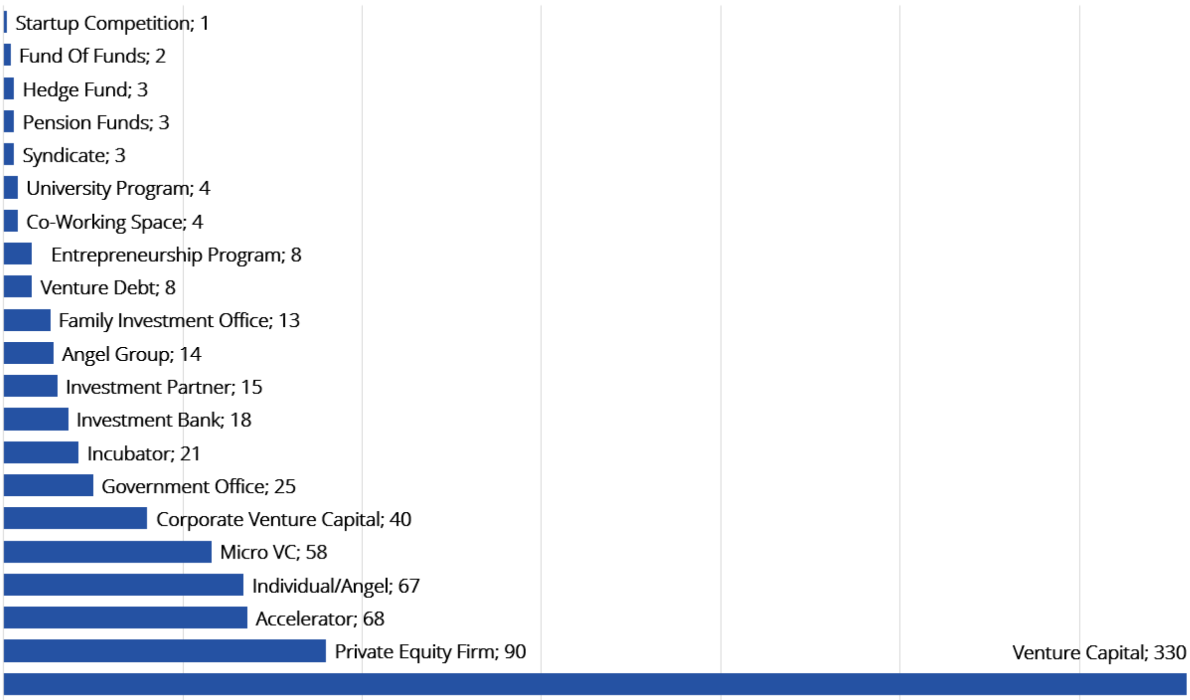
Source: Crunchbase. Note: Map available online: https://batchgeo.com/map/ca6791bdd3e122b5fee4fcb0d48a72ae
N: 646 investors (67 investors with no information about location).

According to the above map the investors are mainly located in Central Europe, San Francisco Bay Area and in BosWash. Out of the 713 investors in green technologies in STRING about 16 pct. (115 investors) are location in the STRING region. These investors are mainly located in the area around Copenhagen, Malmö, and Oslo. It indicates that the majority of the investment in green technologies in STRING (measures by numbers of investments) comes from investors located outside the STRING region.

In the STRING region the numbers of investors in green technologies is actually higher than 115. The mapping of green investors in STRING showed that there have been 162 green investors in STRING since 2010 but only 115 have placed their investments in companies located in the STRING region. It means, that around 30 pct. of the green investments from investors located in STRING is placed in companies outside the STRING region.

Across the investors in green technologies in STRING the most common investor type is venture capital. App. 40 pct. of the investors are categorised as venture capitals. The second ranked investor type is private equity firms and third is accelerators.

Figure 3-20: Investors types in STRING's green tech sector



Source: Crunchbase.
N: 795 investor types across 625 investors (88 investors with no information about investor type).

3.4.3. Main findings in the mapping of green investment

Based on limited available investment data, the most important results are that companies and organisations in the green tech sector in STRING receive investments, primarily, from outside the region. The investments are mainly from Central Europe, the San Francisco Bay Area and BosWash. Inspiring that some of the world's strongest tech centres see the profitability of investing in STRING. It is an indication of considerable strength in green tech in STRING. The mapping shows that only 16 pct. of the investors in green technologies are in STRING. This means that the companies and organisations in STRING manage to attract investment from outside the region. However, it also turns out that 30 pct. of the investors in green technologies located in STRING have placed their investment outside the region. This could indicate that the green tech sector in STRING is not able to attract all the investment in the region since part of it is located elsewhere.

Within STRING, public spending can help create or support an attractive and sustainable market for green tech, which in turn will attract investors. In the toolbox are green purchasing policies, introducing green criteria in public works (energy efficiency, renewable materials, upgradeability, etc.) and applying smart technologies in public services. Also, tools for citizens such as setting standards or developing environmental labelling can help create a market. All of these create incentives for innovation of solutions and attract investors. STRING, as a platform, may have a role in inspiring, coordination, knowledge sharing or common development of tools among the STRING members.

3.5. Conclusion on the main findings of the mapping

The mapping is data-driven and conducted by using a combination of different data sources supplemented with desk research. When mapping such a complex sector like the green tech sector in a region, that has never been defined before, there will naturally be barriers to overcome. By using and combining different types of data, the chance of capturing all relevant data will be enhanced, contrary to using only one data source. Thus, the method of combining data sources is preferable in this case.[53] The main findings from the mapping will be represented in different ways.

The overall finding in the mapping of **green tech companies** is that approximately between 4,000-4,500 Green tech companies in STRING have been identified. It includes companies that have been mapped via industry codes, company descriptions and whether they have taken out green patents. According to the mapping, they are spread all over the region, however, with a higher concentration of jobs in Green tech companies around the major cities. About two-thirds of the companies have up to 50 employees and about 5 pct. of companies have over 250 employees. Large companies are particularly crucial for the green sector, as they typically have more resources and opportunities to work innovative within the green transition. The large companies, and the companies in general, typically work with renewable energy, circular economy, and biotechnology.

The mapping also showed several strengths in terms of **research and innovation activities** in the STRING region, the renewable energy industry and environmental technologies industry seem to be dominating in the STRING region. Furthermore, research and innovation activities are primarily located around metropolitan areas and especially in the Capital Region of Denmark, Hamburg, and Gothenburg. Consequently, very few activities are located away from the metropolitan areas. This is particularly evident in Region Halland and Region Zealand. The mapping revealed unexploited potential regarding test facilities. The mapping showed that test facilities are concentrated in the Capital Region of Copenhagen and around Gothenburg. This means that the infrastructure could be improved significantly by distributing green tech test facilities in all industries more evenly across the STRING region. Finally, the mapping revealed great potential for future cooperation across the region. This was evident since the mapping showed, that the individual regions have different strongholds which naturally will create a great potential for cooperation. None of the individual regions are dominating across all types of research and innovation activities, which will encourage the regions to cooperate and thus complement each other.

In continuation of the strength related to the research and innovation activities in the STRING region the existing base of **green technologies** is a distinct strength for STRING. STRING is innovative in green tech. The innovation dispersion throughout the region reflects that the underlying population and technology innovation in green tech is concentrated around Hamburg, Oresund, and, to a lesser degree, Goteborg, and Oslo. The number of patented green tech inventions have tripled over 20 years. When studying a world map of the most influential technologies since 2015, the STRING region stands out, not as the number-one hotspot in the world, but enough to be part of the global top 20. Energy-related technologies are, especially, part of various forms of renewable energy, including biofuels. There are also numerous technologies in relation to the circular economy, with a focus on sorting, upgrading and reusing waste materials in new products. And finally, clean tech, in general, with cleaner combustion and purification of

[53] For more details on the data sources and methods used, please see Appendix B.

exhaust is technology that can be applied widely. The relation to biotech industries is strong and so is the relation to water management technologies. The existing technology base provides a strong platform, a potential for further growth, especially if STRING is successful in creating innovative cross-border networks that can draw on knowledge throughout STRING and exploit the innovation infrastructure, knowledge and investor interest that already exists. As an example, crucial knowledge sharing area for cross-border networks could be to address the process from science to innovation by creating new knowledge or share information of tools to bridge the gap. More patents cannot be a goal in itself, but patents are to a high degree an indication of technological innovation and commercial value creation.

In addition to the identification of green technologies and how STRING is positioned to become a Green Hub the mapping showed that that companies and organisations in the green tech sector in STRING receive **investments**, primarily, from outside the region. The investments are mainly from Central Europe, the San Francisco Bay Area and BosWash, which is indicative of considerable strengths in Green Tech in STRING. The mapping shows that only 16 pct. of the investors in green technologies are in STRING. This means that the companies and organisations in STRING manage to attract investment from outside the region. However, 30 pct. of the investors in green technologies located in STRING have placed their investment outside the region. STRING will have a role in promoting public initiatives that can create an attractive market for investments among its members.

4. Comparative green regions

In this section, a comparative analysis is performed with the aim of being able to compare the STRING region with relevant competing regions. First, an overall analysis of the development in the number of green tech patents for the most important players in green tech is presented which contributing to the understanding of the relative position of STRING and how it has evolved over time. Patents is a useful indicator for green innovation since it is an objective measure that is comparable across countries. However, it is stressed that using patents is among others one indicator of success in green growth.[54]

Second, we present an in-depth analysis of the two regions that have been selected for a comparative analysis; the San Francisco Bay Area and the Benelux Union, respectively. The San Francisco Bay area has been chosen due to its success in (green) innovation and the Benelux Union due to its cross-border nature and its geographical proximity to the STRING region. The final section is a comparative analysis of what strengths and potentials STRING has in becoming a future Green Hub based on the findings in the comparative case studies.

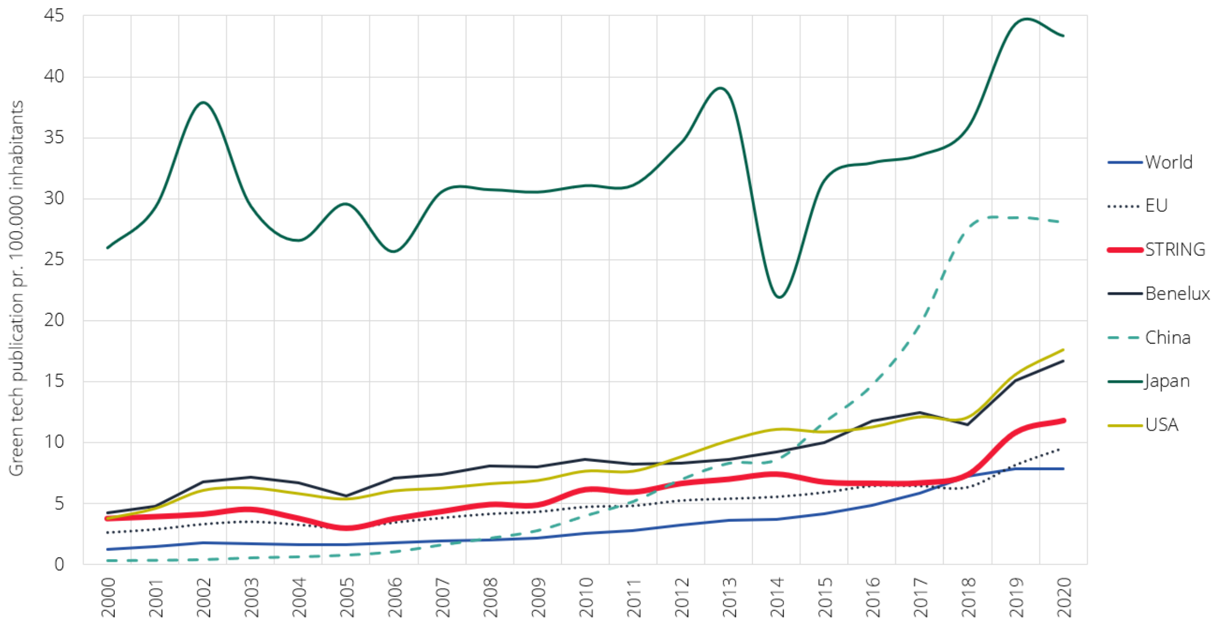
4.1. Comparative patent analysis

The developments in green innovation over time are estimated with a patent search, contributing to a broader perspective on the state of innovation in each area. The search not only compares the areas to one another but, furthermore, allows us to compare patent trends with other important players like the EU, China, Japan and even with the development in the world. It should be mentioned that this analysis looks at the evolution in patents in the US, rather than the San Francisco Bay Area specifically, as the area cannot be isolated for analysis with current analytical techniques. Therefore, the numbers presented here are not directly comparable with those in section 4.2.1.

To understand the innovative strength in green technologies in STRING, the number of patents per capita is calculated below for the most important players in green tech, see Figure 4-1. Overall, STRING has experienced a positive trend in the number of green tech patents in the period 2000-2020. In 2000, STRING had 3.76 patents pr. 100,000 inhabitant and in 2020 this number had risen to 11.83. This is an increase of 8.07 patents per capita or roughly 214 pct. In comparison, the US moved from a similar level in 2000 to 17.56 patents per 100,000 inhabitants in 2020. For the US, it should be noted that the innovation is primarily located at the coasts[55] and lakes, which means that the trend in the San Francisco Bay Area most probably would be steeper. The patent trend in the Benelux Union is very similar to that of the US. Also noteworthy is the enormous rise in Chinese patents during this period. The Chinese shift from 0.3 patents per 100,000 inhabitants to 28 patents is almost 100 times as high in just over 20 years.

[54] See Section 3.3 for a more detailed discussion of the methodological considerations in using patents as an indicator of innovation within green technologies.
[55] Clearly, the strength in per capita is even stronger for the San Francisco Bay Area. However, the San Francisco Bay Area cannot be isolated for analysis with the current analytical techniques.

Figure 4-1 Number of green tech patents pr. capita 2000-2020



Data source: TI Tech-mining – Green tech innovation. Extracted 9.11.2020. Green tech patent publications per year pr. 100.000 inhabitants. Combination of OECD definition and WIPO. 6.9 million patent families – regardless of legal state

The relative strength of regions can be measured by setting the innovative strength in the world as the benchmark (Appendix A1). In 2000, Japan produced 21 times as many patents per capita as the world in total. Citizens in the EU were twice as innovative in green tech as the average world citizen. In the area now defined by STRING, innovation was three times as high and in the Benelux, almost four times as high. In 2020, the EU, the Benelux Union and the STRING regions are relatively less innovative compared to China, who is fast on the move to take the pole position.

4.2. Comparative case study

With the above comparative patent findings in mind, we now move on to present a more in-depth portrait of the two chosen comparative regions to pinpoint areas from which STRING might take inspiration. Both areas are known as green technology hotspots and could be clearly identified in the patent search. The San Francisco Bay Area differs from the STRING region in both organisation and geographical location; whereas the Benelux Union and STRING share a lot of similarities – both are cross-national "entities" and both share the European market and are under EU-regulation. Thus, we get two different comparative cases. An in-depth analysis of the regions can be found in Appendix A1 and A2. Information on education and research environment, technology strongholds, the size of Green tech companies, green patent trends, as well as the political environment is provided. Data consistency is prioritized to the widest possible degree; however, data limitations obviously exist when working with very different geographical areas on the regional level. Therefore, the information provided is not suited for strict comparison. It should rather be used as rough indicators of the status on green growth in the regions. These indicators are the basis of the comparative analysis in section 4.3.

4.2.1. San Francisco Bay Area

The San Francisco Bay Area is located in Northern California and consists of nine counties and three major cities: San Francisco, Oakland and San Jose and covers 18,040 km2 (Bay Area Census, 2020). The prominent technology stronghold, Silicon Valley, is located within the northern section of the county of Santa Clara. A total of 7,150,739 people lived in the area by the latest census in 2010 (Ibid.) The area has access to an extraordinarily rich education and research infrastructure with 46 pct. of the adult population (25+) holding a bachelor's degree (Ibid.) The universities of Stanford and Berkeley, particularly, have several clean tech related education centres (Cleantech hubs - Innovations by Sweden, 2020) and the area spans over a diverse set of research institutions with a cleantech focus (Ibid.).

The Bay Area including the Silicon Valley is a significant hub for several green industries, especially Smart Grid/Energy Efficiency, Transportation, Energy Storage and Clean Energy Production (Ibid.). Nearly 60,000 people were employed in the green energy sector in 2014 (Next10, 2014) and the most important green tech companies (based on revenue) are in the solar energy sector (Crunchbase, 2020). Solar City, as the nation's leading provider of solar energy systems, has an estimated revenue between $1B and $10B and 10,000+ employees (Ibid.).

The San Francisco Bay Area is indeed an innovation hub. It is possible to identify a total of 24,911 green tech patents in the area from the year 2000 with the majority located in Silicon Valley (Appendix A1; PatSnap). This finding is based on a narrow search that is not directly comparable with the searches of the other regions, but nevertheless gives a conservative estimate of the innovation capacity of the area.[56]The patent application trend in the San Francisco Bay Area has generally been positive until 2011 with a mean annual growth of 10.74 pct. In the period 2011-2017 however, the application trend has experienced a mean annual negative growth of -3.92 pct. The Regents of The University of California is on top of the list of assignees with 1,066 patents since 2000, followed by SunPower Corp and Eaton Intelligent Power LTD (Appendix A1).

The Bay Area is a strong venture capital base with venture capital investment in clean technologies of 5.8 billion in total in the US in 2018 (Next 10). This remains true despite the fact that the cleantech sector has seen a decrease in interest from the venture capital community with investments declining by nearly 30 pct. from 2011-2016 (Cleantech hubs - Innovations by Sweden, 2020).

The San Francisco Bay Area has a favourable political climate towards the green energy transition. An example is the SF Clean Technology Payroll Tax Exclusion: a payroll tax exclusion for up to 10 years to clean technology companies located in the city that employs between 10 and 99 employees (Port of San Francisco, 2020). Also, commercial solar systems can qualify for federal and state depreciation (Cobalt, 2020). However, under the Trump Presidential Administration, the cleantech sector has been losing federal funding and initiative. For example, President Trump has stated a wish to withdraw the Obama Clean Power Plan aiming to reduce CO2 emissions from electrical power generation by 32 pct. within 25 years (relative to 2005) (Cleantech hubs - Innovations by Sweden, 2020). Even though a new Presidential Administration has now been elected, one might expect that it will take some time before the trust in the political system's will to invest in green growth has recovered.

[56] The patent analysis for the SF Bay Area is based on the OECD definition only, as it was not possible to limit our search to the geographical area. Based on the patent search for the STRING and Benelux region in which both the OECD definition and the WIPO definition was employed, it can be roughly estimated that an alternative search would result in a number of patents in the SF-region twice as large as the one reported here.

4.2.2. The Benelux Union

The Benelux Union is a political-economic union between three neighbouring nations: Belgium, Netherlands, and Luxemburg, located in Western Europe. The Benelux Union is highly institutionalised with a General Secretariat located in Brussels, a Committee of Ministers, a Council, and their own Court of Justice.

The Benelux Union has a population of over 28 million people and a GDP per capita of nearly twice the European average, making the area one of the wealthiest in Europe (Benelux Connect). Also, all three Benelux countries are ranked in the top 10 of the 2019 European Innovation Scoreboard, based on the country's research and innovation performance (I AM EXPAT, 2019).

The Union has a rich education and research infrastructure with all three countries having universities ranked within the world's top 100 as well as offering a wide range of education possibilities within the green tech area (Appendix A2). Also, there are lots of green tech research and knowledge facilities, mostly nationally located (Appendix A2). For example, Wageningen University in the Netherlands is one of the leading research facilities looking to revolutionise food production. It ranks as the top agricultural institute of higher education in the world according to the National Taiwan Ranking.

Despite this positive background, there remains unresolved potential in the area. The Benelux Union underperforms on its transition towards renewable energy sources, with all three countries' renewable energy shares staying below the EU mean of 18 pct. in the year 2018 (Eurostat, 2020). Also, Belgium scores lower than average on the eco-innovation index measuring the comparative strengths and weaknesses of green innovation in the EU countries, landing the country in the "average performer category" together with the Netherlands. Luxembourg, however, takes the position as the most innovation-friendly country within the green sector in 2019 (European Commission, 2019).

The Benelux Union has a strong position within recycling of waste, offshore wind energy, solar energy, and sustainable agriculture (Appendix A2). To illustrate this further, Belgium is the European champion in recycling of waste and the Netherlands has the fourth greatest installed wind power capacity in the world (Ibid).

Examples of the most important companies[57] committed to green technology in the area count EVBox in the Netherlands (a leading global manufacturer of electric vehicle charging stations and charging management software), Essents in Belgium (a supplier of sustainable electricity and gas) and lastly UFODRIVE in Luxembourg (a car-rental service based on electric vehicles). Combined, these three companies alone have an estimated annual revenue on more than $1.5B and an estimated 1000 employees (Crunchbase, 2020).

There were roughly 200,000 green jobs in the Benelux Union in 2017 (Eurostat, 2020), and there has been a green job growth of 11.3 pct. in the period 2014-2017. The number of green jobs in the area has grown in all three Benelux countries in the period 2014-2017, with Luxembourg experiencing the biggest growth in green employment (+29.9 pct.) (Eurostat, 2020).

[57] Based on the size of revenue.

A total of 23,000 clean tech-specific patents can be identified in the Benelux Union since the year 2000[58], which is an indication of a busy cleantech innovation culture (PatSnap 2020). A prominent hotspot is located in the region of Eindhoven, primarily caused by the residence of Philips. In addition, Amsterdam, Haag, Brussels and Luxembourg can clearly be identified on the map. The most important assignee is Philips with 3,167 patents in the period (Appendix B).

The Benelux as an organisation does not have a stated comprehensive policy towards green growth or low-carbon economy policies. The three member countries, Belgium, the Netherlands and Luxembourg, are developing their own pathways, strategies, and policies independent of each other (OECD, 2013). A table with examples of sustainability incentives (tax credits, subsidies, and other incentives) on the national level is shown below (CMS Law, 2020).

Taxes	Subsidies
Tax on waste products for companies with a waste incineration plant, Netherlands (CMS Law, 2020) Coaltax levied on companies that import, transport or consume coal, Netherlands (CMS Law, 2020) CO2 tax in the beginning of 2021, Netherlands (CMS Law, 2020) Company vehicle tax based on CO2 emission, Belgium (CMS Law, 2020)	Renewable energy grants for smart technologies that combine production and storage or contribute to smart grids, Netherlands (Government of the Netherlands) Energy Investment Tax Credits, Netherlands (Government of the Netherlands) Green power certificate: subsidy for green energy produced, Belgium (CMS Law, 2020) Subsidies for innovative enterprises who invest in ecological or energy saving technology, Belgium (CMS Law, 2020) Subsidies for sewerage companies to reduce spillage, Belgium (CMS Law, 2020) There are no policies in Luxembourg especially devoted specifically to the promotion of research and development in the field of renewable energies. However, the Law of 5 June 2009 provides for a general support scheme for companies willing to undertake research and development activities. (RES LEGAL, 2019)

4.3. Comparative analysis – Main findings

Based on the comparative patent analysis and portraits of the two competing regions we are able to pinpoint areas from which the STRING regions could take inspiration. The findings in this comparative analysis will contribute to the overall analysis of STRINGs strengths, potentials, and barriers in becoming a future Green Hub in section 5.

We find an extremely good **education and research environment** in the San Francisco Bay Area that is hard to compete with – both in terms of their access to qualified workers in the area and also their ability to attract highly qualified workers from other countries. STRING does have a strong education and research environment as well (strong research institutions and cross-border corporations like Max Iv), but it is worth being inspired by the San Francisco Bay Area.

Attraction of green tech companies. The San Francisco Bay Area has very strong companies within the green tech sector with its biggest company having an estimated revenue of nearly 10 billion dollars.

[58] Patents with at least two citations. Search based on both OECD definition and WIPO definition of green technology.

Even though both the Benelux region and the STRING region have strong green tech companies, they could look to the San Francisco Bay Area to find better ways to attract and keep green tech companies and workers. Some of the tools available outside of EU for supporting industries might not be available inside the common market, but access to test facilities, experts and qualified labour is important, as well as a dual focus in strategies that promote innovation. New technologies are not innovative unless they create monetary value, so green research is need to invent new technologies and creating attractive business environments that attract growth is equally important.

It is an advantage for the San Francisco Bay Area that it is **geographically** delimited, as it increases possibilities of collaboration across workers/companies/universities/organisations and secures a high level of mobility. In comparison, STRING extends over several regions in four countries, meaning that the cohesion is naturally not as high as in San Francisco Bay Area. The geographical location of STRING cannot be changed, but the region may secure mobility through persistent investments critical infrastructure binding the region together. As an example, STRING should see the Femern Belt connection as a window of opportunity to attracting qualified workers in and outside STRING. Also, STRING could be further connected by high-speed trains between the large cities in the region. Such infrastructure initiatives demand comprehensive planning and financing which is a challenge for STRING because of their cross-border delimitation compared to San Francisco Bay Area. In addition to meeting the geographical challenges in STRING by improving the connecting infrastructure, a potential strength in STRING could be to focus on making the infrastructure as green as possible. It will be aligned with STRING's ambition to create a green megaregion and become a leading implementer of sustainable infrastructure.

It seems that STRING has **green tech strongholds** that are differentiated from those of the two other regions, giving the area a comparative advantage – especially within the circular economy, biotechnology, and renewable energy. In the area of waste management, the Benelux area is also strong though. Here STRING can take inspiration. The San Francisco Bay Area is extremely strong in areas like energy storage, smart grid, and solar energy. These strengths in the energy sector can potentially play well together with the strength of renewable energy in STRING, where, among other things, wind energy, solar energy and energy efficiency rank high. This overlap of industry focus increases the potential for collaboration between the regions in STRING to develop green energy solutions as well as solutions within the circular economy. Additionally, the wind energy sector in STRING is considered strong compared to the competing regions which possible pave the way for a position of strength in STRING.

Based on the patent searches, we see that the STRING region is falling behind in the area of green tech innovation compared to both Benelux and the San Francisco Bay Area. The number of patents per capita was 11.83 in STRING in 2020, 16.66 in Benelux and 17.56 in the US – and very possibly double in the San Francisco Bay Area specifically. It is important to emphasise that the STRING region is formed later than the two competing regions and therefore, is not as well-established as the competing regions thus direct comparison is considered as inappropriately. The STRING region can be regarded as an emerging region and thus as a Green Hub and in that perspective the number of green patents per capita compared to the two competing regions provides indication of that the STRING region is a serious player within the green technologies. This comparison suggests as well that STRING has the potential to improve its innovation capacity in order to realise the ambition of becoming a future green megaregion. Also, it should not be overlooked that STRING is bordering other regions that also have a strong position in green tech and the exchange of knowledge and division of labour among the regions plays an important part and is to everyone's advantage.

When comparing the **policy climate** fostering green growth, it can be said that all comparative regions have formulated policies aiming to foster green growth – but to different degrees. The San Francisco Bay Area offers some very attractive tax deductions for green businesses such as the payroll tax exclusion for up to 10 years to clean technology companies located in the city. Similar far-reaching policies do not exist in neither the Benelux Union nor the STRING region, even though the regions do readily employ subsidies and provide incentives through taxes on fossil fuels on the national level. An aggressive tax deduction on the regional level in STRING might be unrealistic, but a comprehensive policy for the STRING area within the green tech area has a big potential and could give the region a comparative advantage. The political climate fostering green technology has been deteriorating in the San Francisco Bay Area since the establishment of the Trump Administration, resulting in the fact that the clean tech sector has been losing federal funding and initiative. The Benelux, as an organisation, does not have a stated comprehensive policy towards green growth or low-carbon economy policies but does comply with EU-policy regulations on a national basis. Our interviews show that both STRING and its regions show big political interest and engagement towards the green transition, laying out a favourable foundation. We do not have strong figures on investment for comparison of investments, and STRING do not possess the order of magnitude in the attractiveness of the San Francisco Bay area. However, according to World Economic Forum reports the regions are all part of countries that rank among the most competitive in the world, and hence attractive for investments. This position should be supported in every way possible.

5. STRING as a Green Hub: Strengths, potential, and barriers

This section presents the STRING region's strengths, potential, and barriers in becoming a future green investment hub including how to address the challenges to foster continuous green growth and how to meet the potential of joining forces in the region. The analysis is based on the above mapping, the comparative analysis as well as supplementary interviews with relevant organisations and clusters. Eight interviews are included to contribute to an interpretive perspective on the mapping findings.

The first section presents an overview of strengths, potential, and barriers in the green tech sector in STRING in bullet point form. Subsequently, the strengths are presented more detailed, afterwards the potentials and finally the barriers.

5.1. Overview of strengths, potentials, and barriers

The highlighted strengths, potential and barriers are presented in the below table and are afterwards described more detailed.

Table 5-1: Overview of strengths, potential, and barriers in the green tech sector in STRING

Strengths

- Green tech is a strength for STRING. The region is not a leading region in terms of number of patents but is clearly visible on the map of the most influential green tech technologies since 2015.
- Broad and historical focus on green technologies across STRING
- Position within renewable energy, a significant share of large companies compared to other green industries. This is also seen in the mapping of green tech. There is also a significant relationship with biotech and water management. Finally, clean tech in relation to e.g., cleaner combustion and so forth are also visible
- High concentration of green jobs in the area around large cities but also smaller city draw attention to green focus
- The STRING region has been able to attract investments from investors located outside STRING
- Research and innovation activities related to energy and environmental technologies
- High concentration of research and innovation activities in Copenhagen, Hamburg, and Gothenburg
- Northern Connections partnership facilitate cooperation and STRING can further build on such programmes as well as existing networks/projects e.g., Hanseatic League of Science (HALOS)
- Education and research infrastructure able to compete with the nearest competitor (Benelux)
- Differentiated green technology strongholds from other comparative regions

Potentials

- Growth in green tech companies in the regions without the top 5 large cities in STRING
- Increasing focus on green transition (UN Sustainable Goals) - positive for existing and future green tech companies
- Increased cross-border public/private innovation by having standardised conditions
- Sharing experiences regarding research and innovation
- Include Northern Germany as a natural partner when collaborating in the Nordics
- Distribution of test facilities across STRING
- STRING has a competent workforce, established networks in relation to green tech, at least nationally, and if combined across borders, it may stand even stronger. It is worth drawing inspiration from e.g., the San Francisco Bay Area.
- Even if Green Tech innovation is increasing in STRING, and has tripled over the past two years, the acceleration is even stronger in other parts of the world. The current base of technology, knowledge, industrial power may be the foundation for accelerated innovation in STRING if improved ways of cross-border cooperation can be found. Digital communication and applications may be part of the solution for breaching the considerable distances from north to south
- Accelerated innovation may lead to more workplaces, and awareness of competitive high-tech regions with excellent, but a low-cost workforce is paramount, as are active countermeasures
- The San Francisco Bay Area uses serious tax deductions to attract and *keep* bigger green tech companies and offer depreciations aiming at the solar energy sector specifically. The STRING region could investigate how tax deductions could be used in a similar way.

- A comprehensive policy on green transition for STRING would give the region a comparative advantage, primarily over Benelux, but it would also narrow the gap towards the San Francisco Bay, which has experienced decreasing public funding and interest in the green transition under the Trump Administration.

Barriers

- STRING is a very extensive region with almost 1,000 kilometres from Hamburg to Oslo and four nations and even though connected by road[59] there are three national borders to cross from north to south, four languages, as well as different administrative systems, taxations, and regulations. The power to improve conditions lie mainly with national governments and the EU. The chances to make change happen is improved with a concerted effort from STRING instead of promoting the interests of just one region.
- In comparison with the San Francisco Bay Area, STRING has to overcome the challenge of distance, language, different administrative traditions, different legislations, and taxation systems
- Be able to attract investments from green investors in STRING to a greater extent
- It is unclear for companies exactly what you can test and how to get started

5.2. Strengths in becoming a green megaregion

In the mapping of companies that develop or sell green technologies, solutions, or services, it is evident that those companies are widely represented in the regions of STRING. Not surprisingly, the largest concentration of green jobs is located around large cities, but a strength of STRING is that the green tech sector extends outside the large cities and smaller cities have activities within the green sector as well. That is in fact one of the main strengths of the STRING region with its structure as a megaregion, that expands further than the large cities including the hinterlands thus creating an extensive geographically region.

Another strength in the STRING region is the shared history and culture in the area which forms the basis of a shared understanding and potentially can strengthen the collaboration in the region. In addition to the geographically broad representation of Green tech companies, STRING also shows a historical strength in the green area. Since the 1960s, Green tech companies have increasingly been established in STRING, which indicates a solid and established strength in the green tech sector. The mapping brought another strength to light. Green tech companies and organisations are able to attract green investment from outside STRING. The investments are mainly raised in the US, Central Europe and in the STRING region.

In particular, green tech companies are represented in renewable energy and within the circular economy. In the field of renewable energy, STRING has a special advantage within large companies with more than 500 employees compared to the other green industries represented in STRING. The mapping also revealed that out of the industries inspected in the mapping of research and innovation infrastructure - renewable energy, environmental technologies, transport and logistics, and food and agriculture - the renewable energy industry and industries related to environmental technologies stand out by being particularly dominating when it comes to research and innovation activities. The activities include test facilities, clusters, networks, science parks and incubators related to green technology in the inspected industries, although all aspects of the industries were not necessarily mapped.

The mapping also showed a concentration of activities in the area around the Capital Region of Denmark, Hamburg, and Gothenburg, thus making these areas particularly strong in the STRING region. Furthermore, the individual regions complement each other well by having different types of activities spread out across the STRING region, i.e. clusters and networks seem to be dominant in Denmark, science parks and incubators mostly appear in Germany while testbeds seem to be concentrated in the Capital Region of Denmark. This distribution of activities will ultimately make collaboration more convenient. Another

[59] By road, only the north south route via Great Belt and Öresund is 1,255 kilometres from Hamburg to Hemsedal in the North of Viken Region.

strength regarding research and innovation infrastructure is the cooperation within the Interreg Programme, Northern Connections. This programme was pointed out by several interviewees because of the programme's ability to facilitate cooperation in the STRING region.

STRING seems to be able to compete with its nearest competitor (the Benelux region) in education and research, which is crucial since the regions share the same markets. Furthermore, it is positive that STRING has green tech strongholds that are differentiated from that of the two other regions – especially within the circular economy, biotechnology, and renewable energy. This means that the regions can work together and complement each other in many areas.

5.3. Unexploited potential in the green tech sector in STRING

The general attention to green transition has expanded during recent years. When a potential for collaboration opportunities and synergy appears, it will attract more and bigger companies. The mapping has shown that the green tech companies in STRING have a long history and experience with green innovation that goes far back indicating that the potential to improve the competitive advantage in the green area is promising. However, based on the patent searches, we see that the STRING region is falling behind in the area of green tech innovation compared to both Benelux and the San Francisco Bay Area. It is mainly a function of accelerated innovation in China and it is a challenge not for STRING alone but all the EU area – including Norway. And regional initiatives like STRING might very well be part of the solution to meet the challenge from China. The number of patents per capita was 11.83 in STRING in 2020, 16.66 in Benelux and 17.56 in the US – and very possibly the double in the San Francisco Bay Area specifically. As mentioned previously, a larger number of patents does not necessarily have to mean that the region is a frontrunner within a certain industry (please see appendix B.2), but it can highlight certain trends. This comparison suggests that STRING has a solid platform to accelerate innovation to realise the ambition of becoming a green megaregion.

According to the conducted interviews, the potential to strengthen its green position in STRING can be improved by increasing focus on cross-border collaboration, especially in private/public projects, among other things. The public sector (procurements) is an important player in the green transition and a major driving force for the innovation and development of green technologies in STRING. Cooperation with the public sector is, for instance, crucial in the energy sector since energy suppliers depend on public priorities. Across the STRING region, potential in sharing knowledge – on, for instance, how to embed sustainable standards in public procurements – can be improved. Beyond the potential in extended private/public collaborations, actors outside the political-administrative sphere should be included in the green transition. The green impact on project partnerships will probably increase by including many different actors: companies, financing, NGOs, and citizens. Therefore, it is vital that the EU and the public sectors utilise the potential in co-financing green projects in STRING.

Because of the already strong research and innovation infrastructure, the STRING region could potentially produce even more patents if more funding were provided and more collaboration could be established. The STRING region also has the potential to improve the research and innovation infrastructure within green technology in general even more by changing some specific characteristics. The STRING region could strengthen the research and innovation infrastructure significantly if the test facilities were distributed more evenly across the region as the activities are now concentrated around Gothenburg and Copenhagen. The interviewees also pointed out potential based on the mapping.

One thing that potentially could improve the research and innovation infrastructure in the STRING region is to strengthen cross-border public/private innovation. It could also be an improvement for the individual regions and cities within the STRING region to share experiences on research and innovation, e.g., experiences with smart-city development through living labs. One important aspect in improving the research and innovation infrastructure would be to include Northern Germany even more in the collaboration on test facilities. The Scandinavian countries already have a strong collaboration on test facilities, but if Northern Germany to a greater extent was a natural part of that collaboration it would improve the research and innovation infrastructure in general and establish a more coherent region.

Another potential for a comparative advantage is forming a comprehensive policy on the green transition for the STRING region. The political climate for green innovation in the San Francisco Bay has been worsened under the Trump administration and the Benelux does not yet have a comprehensive policy. Besides that, the actual geography of the STRING region makes a great potential for establishing a green megaregion with five large cities. Furthermore, the San Francisco Bay Area uses serious tax deductions to attract and keep bigger green tech companies and offers depreciations aiming at the solar energy sector specifically. The STRING region could investigate how tax deductions could be used in a similar way.

5.4. Barriers to become a green megaregion

STRING is a very extensive region with almost 1,000 kilometres from Hamburg to Oslo, four countries connected by road and rail, three national borders to cross from north to south, four languages as well as different administrative systems, taxations, and regulations. In comparison with the San Francisco Bay Area, STRING has to overcome the challenges of distance, language, different administrative traditions, different legislation (even though the countries do share a lot of similar EU legislation), and taxation systems. The geographical location of STRING cannot be changed, but the region should continuously focus on implementing critical infrastructure and binding the region together.

For the current and future companies in the green tech sector in the STRING region, it is crucial to position themselves in the green area by attracting green investments. According to the mapping of green investments – however limited by the fact that there is no information about the amount invested - is it a challenge that green investors place their capital outside STRING. This could indicate that companies in STRING ineffectually demand, attract, or pay attention to green inventors. There are some barriers and/or challenges since green tech companies do not absorb all green investment in the STRING region. One of the barriers could be the competitiveness within the STRING region, where the individual regions compete for the same investments which ultimately will cause a decrease in investments. In the interviews, it was mentioned that investors are looking for industries within the future green technologies. That statement and the findings in the mapping could indicate that the green tech sector in STRING region is not sufficiently mature to attract all available green investments. A second challenge mentioned in the interviews was that it can be a challenge for investors to find relevant green projects to invest in. The market for green projects and growing ideas is difficult to command as there is no unified unit with an overview of green innovation. In addition, it is stated in the interviews that there is a lack of investments in the phase between innovation/start-up and production/operation. This means that it is difficult to raise investments in the development phase when green technologies begin to create social and economic value. That barrier is crucial to overcome in order to become a future megaregion within green technologies.

The research and innovation infrastructure in the STRING region has some barriers that one needs to be aware of. The mapping revealed that research and innovation activities are primarily located in metropolitan areas. When looking beyond these areas the activities are located further apart with very few activities located in Region Zealand and none in Region Halland. Based on the mapping, the interviewees also pointed out some barriers related to the research and innovation infrastructure. One barrier is the lack of geographical proximity in the STRING region. The STRING region covers a relatively large geographical area with a significant distance from Oslo to Hamburg, which makes it more difficult for the individual regions to collaborate on test facilities. Furthermore, it is not clear to the regions and cities within the STRING region exactly what can be tested and how to get started.

6. Conclusion

The key findings of the mapping of the green tech sector in the STRING region indicate that STRING's ambition to become a megaregion fostered by green tech solutions is a realistic vision. The mapping has shown that the green tech companies in STRING have a long history and experience with creating green innovation. This indicates that the potential in STRING to improve the competitive advantage in the green area is promising. Also, the existing base of green technologies is a distinct strength for STRING. STRING is innovative in green tech. The existing technology base in STRING provides a strong platform, a potential, for further growth - especially if STRING is successful in creating and strengthening the existing innovative cross-border networks that can draw on knowledge throughout STRING and exploit the innovation infrastructure, knowledge and investor interest that already exists.

The number of patented green tech inventions have tripled over 20 years in the STRING region. When studying a world map of the most influential technologies since 2015, the STRING region stands out, not as the number-one hotspot in the world, but enough to be part of the global top 20. Despite its leading position, it is also clear that innovation in STRING, as well as Benelux and the EU as a whole, is at risk of losing comparative momentum and are at risk of losing the relative strength to the fast-upcoming China and top-regions in the US at the coast and lakes, Japan, and Korea. It is a challenge not for STRING alone but for the entire EU area – including Norway. And regional initiatives like STRING might very well be part of the solution to meet the competition from China.

A barrier might be, paradoxically, the too-narrow focus of stakeholders, investors, and funders on developing innovative technologies rather than innovative ways of producing, selling, and marketing existing green technologies. The conversion of research knowledge into innovation in companies would be a relevant action area for STRING that could activate the relative strong position in green tech within science.

While the national borders as well as different administrative systems, taxations, and regulations can be barriers to be a more concerted innovation hub in STRING the potential to strengthen its green position of the area can be improved by increasing focus on cross-border collaboration, especially in private/public projects, among other things. The public sector (procurement) is an important actor in the green transition and a major driving force for the innovation and development of green technologies in STRING. Cooperation with the public sector is, for instance, crucial in the energy sector since energy suppliers depend on public priorities. Across the STRING region, potential in sharing knowledge – on, for example, how to embed sustainable standards in public procurements – can be improved.

Within STRING, public spending can help create or support an attractive and sustainable market for green tech, which in turn will attract investors. In the toolbox are green purchasing policies, introducing green criteria in public works (energy efficiency, renewable materials, upgradeability, etc.), and applying smart technologies in public services. Also, tools for citizens such as setting standards or developing environmental labelling can help create a market. All of these create incentives for innovation of solutions and attract investors. STRING, as a platform, may have role in inspiring, coordination, knowledge sharing or common development of tools among the STRING members.

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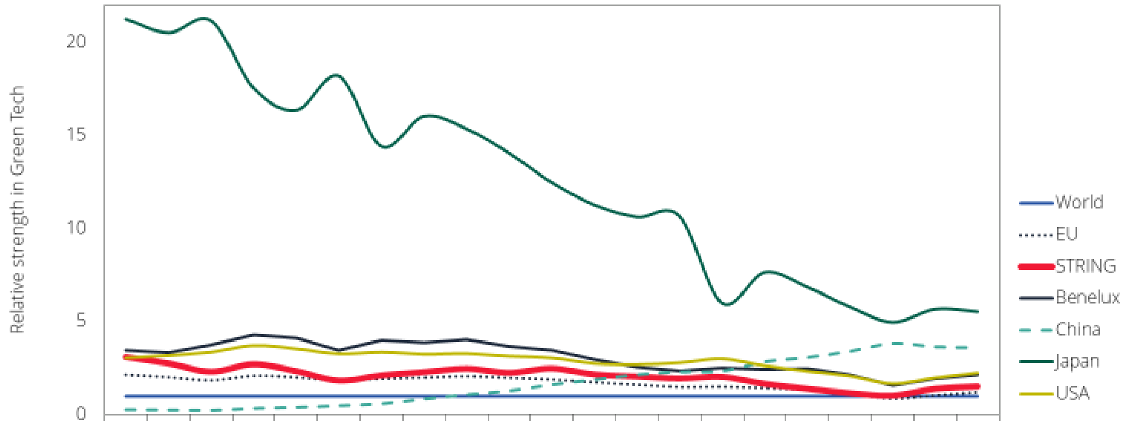
Appendix A: Comparative regions

A.1: Comparative patent analysis

The graph below illustrates how green tech measured as number of green tech patents pr. Capita develops over time from 2000-2020 in STRING and in other areas of the world. Numbers are calculated against the world average. Thus 1,00 means a development equal to world average. A figure of 0,5 means half the development and a figure of 2 twice the development.



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
World	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00
EU	2,16	2,03	1,86	2,10	2,02	1,84	1,95	2,01	2,08	1,99	1,90	1,75	1,62	1,49	1,51	1,44	1,34	1,11	0,88	1,04	1,22
STRING	3,07	2,74	2,30	2,69	2,32	1,82	2,10	2,28	2,45	2,24	2,46	2,15	2,04	1,93	2,01	1,64	1,39	1,15	1,02	1,39	1,51
Benelux	3,45	3,33	3,75	4,28	4,12	3,45	3,97	3,88	4,02	3,66	3,44	2,98	2,54	2,36	2,51	2,43	2,45	2,14	1,58	1,92	2,12
China	0,25	0,23	0,22	0,32	0,38	0,46	0,58	0,84	1,07	1,27	1,60	1,86	2,13	2,29	2,33	2,82	3,05	3,38	3,81	3,63	3,57
Japan	21,23	20,51	21,14	17,53	16,35	18,18	14,40	16,02	15,34	14,04	12,47	11,26	10,61	10,65	5,98	7,65	6,85	5,78	4,96	5,66	5,53
USA	3,05	3,18	3,36	3,72	3,55	3,27	3,36	3,25	3,28	3,14	3,05	2,75	2,70	2,79	3,00	2,63	2,33	2,08	1,66	1,98	2,24

Source: TI Tech-mining – Green tech innovation, extracted 9.11.2020. Relative strength. Strength 1 = Publication pr capitat equals world pr capita publication
Combination af OECD defintion and WIPO/UN 6,9 million patentfamilies – regardless of legal state

A.2 San Francisco Bay Area - Silicon Valley

Education and research infrastructure

The San Francisco Bay Area is highly educated with 46% of its grown population (25+) holding a bachelor's degree (Bay Area Council Economic Institute, 2018). This is well above the national average of 32.6 pct. pct. (U.S. Census Bureau, 2020).

The area is home to over 50 universities of which Stanford and Berkeley is the most prominent. Since 2005, Bay Area University R&D research spending has increased by 12%, equaling 2.9 BUSD (Cleantech hubs - Innovations by Sweden, 2020).

Both Stanford and Berkeley are mentioned on numerous lists on the best Universities for a career in cleantech (BusinessBecause) (NewEngineer).

Stanford University (located in Palo Alto, CA) ranks number 4 on the World University Ranking (The World University Rankings, 2020)**.** It has a number of world class environmental and cleantech-related centers for education: Precourt Institute for Energy, TomKat Center for Sustainable Energy, Center for Sustainable Development and Global Competitiveness, Woods Institute for the Environment (Cleantech hubs - Innovations by Sweden, 2020).

Berkeley University (located at Berkeley, CA) ranks number 13 on the World University Rankings (The World University Rankings, 2020)**.** Berkeley also has reputable centers for education in the realm of cleantech, including the Energy Institute at Haas and the Berkeley Energy Resources Collaborative – although fewer than the university of Stanford.

The area is also home to a diverse set of research institutions with a cleantech focus, offering yet another resource for green tech companies (Cleantech hubs - Innovations by Sweden, 2020).

- Electric Power Research Institute (Palo Alto, CA)
- Lawrence Berkeley National Laboratory (Berkeley, CA)
- Lawrence Livermore National Laboratory (Livermore, CA)
- Joint Bioenergy Institute (Berkeley CA)
- Silicon Valley Toxics Coalition (San Jose, CA)
- Pacific Research Institute (San Francisco, CA)
- SRI International (Menlo Park, CA)
- USDA Western Regional Research Center (Albany CA)

These institutions maintain a culture of innovation and talent development in the area to the benefit of the nearby corporations. However, over 57% of the STEM workers[60] within the area come from another country and approximately 50% of all founders of start-ups are foreign born (Cleantech hubs - Innovations by Sweden, 2020).

Green technologies in the area

Based on the number of California-headquartered companies represented in Cleantech Group's 2017 Global Cleantech 100 list, the Bay Area and Silicon Valley is a significant hub for the following green industries: Smart Grid/Energy Efficiency, Transportation, Energy Storage and Clean Energy Production (Cleantech hubs - Innovations by Sweden, 2020).

Transportation: The region is a global leader in developing and implementing advanced transportation technologies, which include electric vehicles (EVs) as well as technology that increases transportation infrastructure efficiency and car connectivity (Next10, 2014)

Energy storage: The region is a global center of innovation in energy storage, with one of the largest concentrations of energy storage companies in the world. Recently, San Jose State University developed the first master's degree program in the country focused exclusively on battery science to prepare Bay Area students for careers in the industry (Next10, 2014)

Important green tech companies

Top cleantech companies in San Francisco (Crunchbase 2020).

Company	Description	Revenue & Employees
SolarCity SolarCity	SolarCity is the nation's 1 leading provider of solar energy systems that deliver reliable clean energy to homes and businesses.	- Estimated revenue: **$1B to $10B** - Number of employees**:** **10,000+**

[60] STEM workers = students of science, technology, engineering, and mathematics

SunPower	SunPower Corporation delivers high-performance solar electric systems worldwide for residential, commercial, and utility-scale customers.	○ Estimated revenue: **$100M to $500M** ○ Number of employees: **5000 to 10,000**
Sunrun	Provides solar electricity and energy services for homeowners across the U.S.	○ Estimated revenue: **$100M to $500M** ○ Number of employees: **4,400**
Bloom Energy	Bloom Energy offers on-site power generation systems that can use a wide variety of inputs to generate electricity.	○ Estimated revenue: **$100M to $500M** ○ Est. number of employees: **500 to 1000**
Proterra	Proterra makes zero-emission, battery-electric buses that help eliminate fossil fuel dependency and reduce costs.	○ Estimated revenue: **$100M - $500M** ○ Number of employees: **500 to 1000**
d.light desig	d.light is an international social enterprise that serves people without access to reliable electricity.	○ Estimated revenue: **$100M - $500M** ○ Number of employees: **500 to 1000**

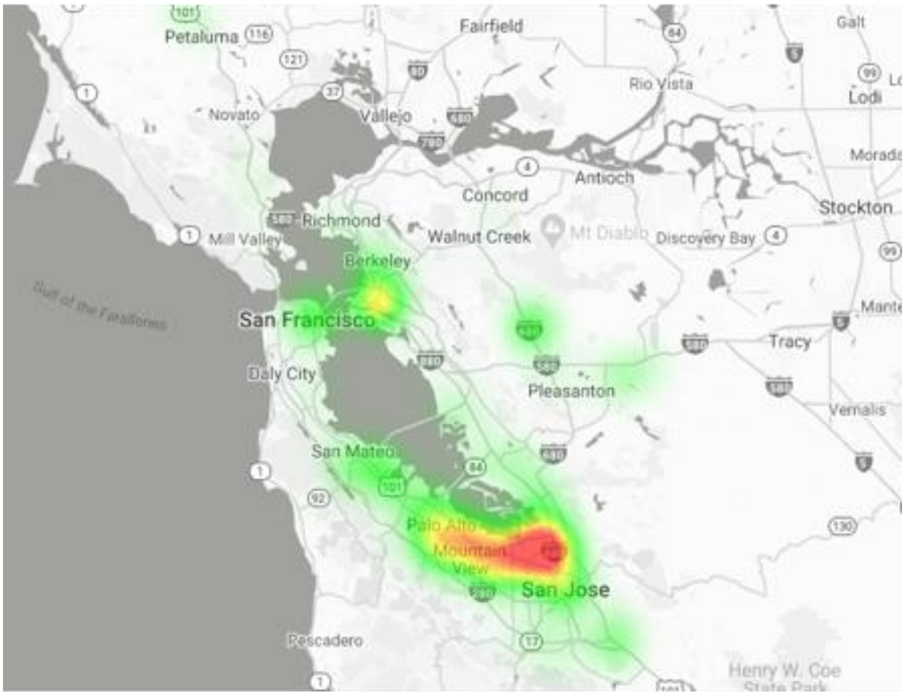
Enphase Energy	Enphase Energy offers a micro-inverter system that delivers solar energy to homes and businesses.	○ Estimated revenue: **$100M - $500M** ○ Number of employees: **250 to 500**

Green jobs: Industry breakdown

In 2014 there was nearly 60,000 Total Clean Economy Jobs in the Bay Area. The sector with the biggest number of employees is Energy Generation (more than 16,000), followed by Air & Environment (roughly 9000) and Energy Infrastructure (roughly 9000) (Next10, 2014).

Patents

A total of 24,911 green tech patents can be identified in the San Francisco Bay Area since the year 2000 (PatSnap 2020) using the OECD green tech definition. As can be seen on the heatmap below, the majority of the patents are located in the area of Silicon Valley.



http://bit.ly/GreenTechSFBayArea

The patent application trend in the Bay Area has generally been positive until 2011 with a mean annual growth of 10.74%. In the period 2011-2017 however, the application trend has experienced a mean annual negative growth of -3.92%.

Top-ten Assignees

Assignee	Patents
The Regents of The University of California	1,066
Sunpower Corp	503
Eaton Intelligent Power LTD	458
Chevron	439
Google	388
Advanced Micro Devices	311
Cisco Systems	272
Stanford University	267
Lawrence Livermore National Laboratory	264

Investments in green tech

The Bay Area is a strong venure capital base. Venture capital investment in clean technologies totaled 5.8 billion in the U.S. in 2018, of which 58% (3.4 billion) was invested in California (Next 10). The clean-tech sector has seen a decrease interest from the venture capital community, primarily due to lower than expected returns. Between 2011 and 2016, VC cleantech investments declined by nearly 30 pct., from 7.5 billion dollars to 5.24 billion (Cleantech hubs - Innovations by Sweden, 2020)

Politics

SF Clean Technology Payroll Tax Exclusion: a payroll tax exclusion for up to 10 years to clean technology companies located in the City. Any business that employs between 10 and 99 employees is eligible for the payroll tax exclusion. (Port of San Francisco, 2020)

Under the new Presidential Administration, the cleantech sector is losing federal funding and initiative. For example, President Trump has stated a wish to withdraw the Obama Clean Power Plan aiming to reduce CO_2 emissions from electrical power generation by 32 pct. within 25 years (relative to 2005). However, several states such as California have indicated a will to proceed with the plan, in spite of the change in federal policy in the cleantech area (Ibid.).

A.3 The Benelux Area

Education and research infrastructure

The area in general has a rich education and research infrastructure with all three countries having universities ranked within the world top 100 (ARWU, 2019), offering a wide range of education possibilities within green tech area. This gives the area a solid knowledge base for the businesses looking for qualified workers for the green sector.

Belgium	The University of Gent is the highest ranked university in Belgium and has a world rank (WR) of 66. The university is home to the CleanChem research cluster which functions as a gateway for all activities related to sustainable chemical technologies targeting a transition from fossil to renewable resources (Flanders Investment and Trade, 2020) The Katholeke Universiteit Leuven (KU Leuven) has a WR of 85 and is considered the most innovative university in Europe and the 7th most innovative university in the world (Reuters, 2018). The university is home to ELECTA research group, which focuses on the development of the future smart grid (Ibid.).
Netherlands	The Utrecht University has a world rank of 52 and offers several Master's within green tech, such as Sustainable Development as well as Energy Science Wageningen University is one of the leading research facilities looking to revolutionize food production. It ranks as the top agricultural institute of higher education in the world according to the National Taiwan Ranking (InvestinHolland, 2020). The University of Groningen has a world rank of 69 and offers Masters in Sustainable Entrepreneurship, Environmental and Infrastructure Planning as well as Global responsibility & Leadership, Vrije Universiteit Amsterdam (VU Amsterdam) has won the title of the Netherland's most sustainable university and ranked second on the international Times Higher Education Impact Ranking 2020 (VU, 2020).
Luxembourg	The *Environmental Research and Innovation (ERIN)* department of the Luxembourg Institute of Science and Technology (LIST) develops strategies, technologies and tools to better monitor, assess, use and safeguard natural and renewable resources. The *University of Luxembourg* conducts research of interest to the CleanTech sector, in particular in the fields of photovoltaics and energy and environment aspects of engineering.

Research and knowledge centers (regional + country level)

Benelux	*EIT Climate-KIC Benelux* o Accelerates climate innovations in zero carbon economy by offering innovation programs, entrepreneurship programs for start-ups with climate solutions, as well as education programs for students with climate ideas. It is home to some of the leading innovation projects within the green tech area, including Smart Sustainable Districts, CarbonLed, The Building Technology Accelerator and the Climate Smart Agriculture Booster. The leading clean tech start-up accelerator in Europe, the *Accelerator programme*, is also based in the Benelux.
Belgium	Flanders region (Flanders Investment and Trade, 2020):

- *EnergyVille:* Was launched in 2016 and unites the research institutes of Leuven, VITO and imec to investigate sustainable energy and intelligent energy systems.
- *VITO* (Flanders' Institute for Technological Research): Is a leading European research and technology organization active in the areas of cleantech and sustainable development.
- *Imec*: Is Europe's leading research center in micro- and nanoelectronics as well as digital technology – works with solar cell production to maximize solar efficiency using photovoltaic technology.
- *Flanders' Smart Hub*: A knowledge region in the center of Belgium encircling Brussels. Its hallmark technologies focus on health, food, logistics, media, creative industry and cleantech.
- *InnoEnergy*: An investment company in sustainable innovation in energy.
- *CES&T* (Centre Environmental Science & Technology): Is a central research platform with a strong focus on sustainable water technology

Wallonia region

- *GREENWIN:* The cluster brings together more than 200 companies involved in the development of the green economy. The cluster represents more than 20,00 jobs in Wallonia and Brussels as well as 31 certified projects (27 in RD and 4 in training).
- *TWEED:* (Walloon Energy Environment and Sustainable Development Technology) brings together more than 100 companies and is occupied with investment in the production and exploitation of sustainable energy.

Netherlands

New Energy Coalition (Groningen)

- The New Energy Coalition is a wide network and knowledge coalition committed to the transition to the sustainable energy. The network has 5 key themes: North Sea as an Energy Region, Green Hydrogen Economy, Industrial Transformation, Greening of the Gas System and Local Energy Systems. They provide a network for research, having just started a formation of research consortia and provide courses to train professionals required for the energy transition.

TNO (Hague)

- The TNO is an independent research organization with over 3400 professionals working to connect people, businesses, and knowledge towards sustainability in 9 themes, such as circular economy, buildings, and infrastructure. The organization has several testbed facilities.

Clean Tech Delta (Rotterdam)

- Collaborates with other organizations and businesses to close the implementation gap between an idea and a sustainable enterprise. With strong industrial, maritime, water and agrofood clusters in the region, the Clean Tech Delta can play an important role in the development of green solutions.

TKI Wind Op Zee

- Top consortium for knowledge and innovation Offshore Wind

Luxembourg

Luxembourg Clean Tech Cluster

- Aims to enhance the fields of energy, environment and sustainable development in Luxembourg. The Cluster's actions seek to create and develop new and sustainable business opportunities, mainly through collaborative R&D and innovation projects. Its focus is mainly on circular economy and resource management.

Neobuild

- An innovation cluster for sustainable construction and a living lab for innovation in the construction sector.

Other green tech innovation trends:
Another way of investigation the innovation capacity of the countries is by looking to the *Eco-Innovation Index* by the European Commission, which shows how well individual Member States perform in different dimensions of eco-innovation compared to the EU average and presents their strengths and weaknesses. In 2019 Luxembourg topped the list as the most eco-innovation friendly country and the Netherlands as well as Belgium as average performers. Both Luxembourg and the Netherlands has seen great improvement over the last few years, however, the Belgian trend seems more stagnant, staying right below the EU average. In the table below the countries are compared on the basis of the individual components (indicators) of the eco-innovation index.

Indicator	Inputs	Activities	Output
Description	*Financial resources, human resources, technical resources that provide an initiative for eco-innovation activities at companies, research organizations, and other institutions*	*Efforts towards developing new or improved products and services, changing business models, and introducing eco-management in companies or organizations.*	*Immediate results of eco-innovation activities. Indicators in this component are used to monitor the extent to which knowledge outputs generated by businesses and researchers relate to eco-innovation*
Luxembourg	11	8	1
Netherlands	12	23	17
Belgium	5	27	16

Note: Score = position out of 28 countries.

Lastly, it should be noted that the Benelux countries apparently underperform in terms of their share of energy from renewable sources, with all three country shares under the EU mean of 18% energy from renewable sources. The lowest proportion of renewables in 2018 was actually registered in the Netherlands (7.4%), closely followed by Luxembourg (9.1%) and Belgium (9.4%). Furthermore, the Netherlands is the country furthest away from meeting its national 2020 target, which considers the country's starting point as well as potential (eurostat, 2020). This testifies to the fact that the area still has great unresolved potential.

Green technologies in the area

Belgium	Belgium is the European champion in terms of recycling packaging, cartons, cans, glass or plastic (Wallonia). It has the highest recycling rate in Europe with nearly three fourths of residential waste reused, recycled or turned into compost. Belgium has reached an installed capacity of 1,775 MW of *offshore* wind energy, placing it in fourth place in the world (BOP, 2020). If you compare the national installed capacity to the number of inhabitants, Belgium comes third, after Denmark and the UK Belgium is the country with the fourth greatest installed solar photovoltaics capacity per capita in the world, 2019 (416 watts/inhabitant) (Solaredition, 2020) The region of Flanders is particularly evolved in the following cleantech domains (Flanders Investment and Trade, 2020): o wind energy: on- and offshore.

- solar energy: photovoltaics, concentrated photovoltaics, concentrated solar power and solar thermal energy, etc.
- bioenergy: biofuel, biomass, biogas, energy-from-waste, etc.
- other green resources: hydropower, wave and tidal energy, geothermal energy, heat pumps, etc.

Netherlands

The country with the fifth greatest installed solar photovoltaics capacity per capita in the world, 2019 (384 watts/inhabitant) (Solaredition, 2020)

The country ranks 6th in the world in offshore wind energy in 2019 (1,126 MW). A new project by the Dutch power grid and utility company, TeneT, aims to build the world's largest wind farm on an artificial island 14 miles off the coast of the Netherlands

Strong in waste recycling (TheFifthState, 2018).

The Netherlands is a leader in sustainable and efficient agriculture. The Netherlands is the world's second-largest exporter of food as measured by value, second only to the U.S. That is amazing, considering the U.S. has 270 times the landmass of the Netherlands. WUR, located 50 miles southeast of Amsterdam, has helped to key the country's agricultural success (Successful Farming, 2018). The country uses geothermal energy to heat its greenhouses and hydroponic systems to use less water.

Cultured meat: Companies such as Mosa Meat, a Maastricht University spin-off are creating lab-grown meat. The project began in 2013 with the world's most expensive hamburger, costing $330,000 the burger was made using cultured meat. In 2018 the company already backed by the likes of Google's Sergey Brin raised $8.8M to begin commercializing the manufacturing the process

Luxembourg

Luxembourg is home to a significant number of clean tech companies, which mainly work in the fields of renewable energy, waste management, water treatment and eco-construction.

Important green tech companies

Crunchbase October 2020

	Description	**Revenue and Employees**
Royal Dutch Shell	Royal Dutch Shell is a global group of energy and petrochemicals companies. Hague, Netherlands www.shell.com/	Estimated Revenue: $1B+ Number of Employees: 10,000+
EVBox	EVBox is a leading global manufacturer of electric vehicle charging stations and charging management software. Amsterdam, Netherlands www.evbox.com	Estimated Revenue: $100M to $500M Number of Employees: 251-500

NewMotion	Electric Mobility Service Provider. Acquired by Royal Dutch Shell. Amsterdam, Netherlands www.newmotion.com	Estimated Revenue: $50M to $100M Number of Employees: 51-100
Essents Belgium	Essent is a supplier of gas and electricity that is tailored to suit the customer perfectly with sustainable solutions. Antwerpen, Belgium www.essent.be	Estimated Revenue: $500M-$1B Number of Employees: 101-250
LBC Tank Terminals	LBC Tank Terminals is a global provider of responsible logistics solutions. Antwerpen, Belgium www.lbctt.com/	Estimated Revenue: $100M-$500M Number of Employees: 501-1000
Vaillant	Vaillant produces energy-saving heating and ventilation appliances that work on sustainable energy. Vlaams-Brabant, Belgium www.vaillant.be	Estimated Revenue: $100M to $500M Number of Employees: 101-250
Encevo	Encevo Group is a provider of electricity and gas transmission as well as power generation including renewables. Esch-sur-alzette, Luxembourg www.encevo.eu/en/	Estimated Revenue: $50M-$100M Number of Employees: 101-250
UFODRIVE	UFODRIVE develops an app for a fast and easy car rental experience. Capellen, Luxembourg	Estimated Revenue: $100M to $500M Number of Employees: 101-250

Green Jobs

Eurostat: Number of people employed in the green sector

	2014	2015	2016	2017	Change 2014-2018	
Belgium	32,957	33,111	37,364	34,641	+1,684	+5.1%
Luxembourg	10,133	9,671	11,209	13,166	+3,033	+29,9%
Netherlands	135,717	137,593	145,914	151,254	+15,537	+11,4%
Benelux	178,807	180,375	194,487	199,061	+20,254	+11,3%

Note: Employment in the environmental goods and services sector [enc_ac:eggs1] (Eurostat, 2020)

There was nearly 200,000 green jobs in the Benelux area in 2017 (Eurostat, 2020), and there has been a green job growth of 11,3% in the period 2014-2017. The number of green jobs in the area has grown in all three Benelux countries in the period 2014-2017, with Luxembourg experiencing the biggest growth in green employment (+29,9%).

IRENA: Jobs in the renewable energy sector

	Number of employed	Top sectors
Belgium	13,400	Wind energy (7,400)
		Solar Photovoltaic (1,700)
		Solid Biomass (1,500)
Luxembourg	1,300	Hydropower sector (500)
Netherlands	32,400	Solar Photovoltaic (14,300)
		Wind energy (6,800)
		Municipal and Industrial Waste (3,400)

Patents

Belgium, The Netherlands and Luxemburg are all ranked among the top 25 most innovative countries in the world (Global Innovation Index, 2018). We have identified a total of 23,000 clean tech specific patents in the Benelux area since the year 2000 (with at least two citations), which is an indication of a busy cleantech innovation culture (Patsnap, October 2020). 23% of these patents are active, amounting to roughly 4000 patents. As can be seen on the heatmap below there is a lot of hot spots located in the Dutch regions of Eindhoven, Arnhem and Haag. The technology hotspot in Belgium is mainly around Brussels and the Flemish region in general. Lastly, Luxembourg does not present itself as a strong green tech innovation hub on the map, with few patents showing up. We believe that Luxemburg instead functions as a crucial financial center for the region.

http://bit.ly/GreenTechBeNeLux

Top Ten Assignees

Assignee	Patents
Philips	3167
Shell Group	1320
NXP Semiconductors	715
DSM Group	405
ASML Holding	401
HERE Global	304
Sabic Global Tech	252
Solvay	232
TNO[61]	282
Umicore	180

Investments in Green Tech

[61] Netherlands Organisation for Applied Scientific Research

Belgium among the top ten investors in the renewables according to 2017 renewable energy report of the REN21 expert network.

Politics
The Benelux as an organization does not have a stated comprehensive policy towards green growth or low-carbon economy policies. The three member countries, Belgium, the Netherlands and Luxembourg, are developing their own pathways, strategies, and policies independently of each other (OECD, 2013). Also, the countries are all committed to political targets set by the EU.

Belgium

There is now an EU-wide renewable energy target of 32% by 2030. In the current draft of its NECP, Belgium promises a 2030 total renewables target of 18.3%. This stands in contrast to Belgium's 2020 renewable energy target of 13%. At the moment, renewables account for just 9.1% of Belgium's energy demand (windeurope, 2019)

On 19 December 2018, Belgium adopted the first version of the National Energy & Climate Plan, which is a compilation of three individual climate plans from each of Belgium's regions. It contains specific measures aiming to reduce CO2 emissions in Belgium by 35% by 2030 and to increase the share of renewable energy to 18.3% (stibbe, 2019)

(CMS Law, 2020):

- Green power certificate: subsidy for green energy produced.
- Subsidies for innovative enterprises who invest in ecological or energy saving technology.

Subsidies for sewerage companies to reduce spillage

Netherlands

In 2019, the *National Climate Agreement* was concluded, setting The Netherlands on a track for a 95% reduction in greenhouse gas emissions by 2050.

The Dutch *action plan* to support the transition to circular agriculture was presented in 2019. The plan entails a shift towards improving the efficiency of resources used in agriculture and producing food in harmony with nature.

(CMS Law, 2020):

- Tax on waste products for companies with a waste inceneration plant
- Coaltax levied on companies that import, transport or consume coal
- Co2 tax in the beginning of 2021

Renewable energy grants for smart technologies that combine production and storage or contribute to smart grids (Government of the Netherlands)

Energy Investment Tax Credits (Government of the Netherlands)

Recycling tax on electronic and household equipment

Luxembourg

*Luxembourg's draft National Energy and Climate Plan (NECP) defines its 2030 energy sector targets. The government has adopted a 2030 target to reduce non-ETS emissions by **50-55%** versus 2005 levels, which exceeds the 40% reduction required by the EU and is in line with a below 2°/1.5° global temperature target* (iea, 2020)

There are no policies in Luxembourg especially devoted specifically to the promotion of research and development in the field of renewable energies. However, the Law of 5 June 2009 provides for a general support scheme for companies willing to undertake research and development activities. (RES LEGAL, 2019)

Appendix B: Data sources

B.1 Company data

B.1.1 Overview of data sources investigated

Source	Name	Regional data	Green focus	Time	Industries	Business Indicator
EUROSTAT (sbs_r-nuts06_r2)	Structural Business Statistics data by NUTS 2 regions and NACE Rev. 2	Yes	No	Yearly	NACE 2	Number of employees, number of businesses
EUROSTAT	Regional environmental and energy statistics	Yes	Yes	Yearly	Only waste, water, and heating industries	No
EUROSTAT (env_ac_eggs1)	Employment in the environmental goods and services sector	No	Yes	Yearly	Total of all NACE activities in one	Employment
EUROSTAT (TEN00134)	Gross value added in the EU environmental economy by NACE Rev. 2	No	Yes	Yearly	Only the European Union	Gross value added
Statistics Denmark (GRON2)	Environmental goods and services by industry, environmental purpose and unit	No	Yes	Yearly	Certain NACE 2 industries	Number of green employees, green turnover

B.1.2 Crunchbase

The Crunchbase database[62] has been used in the mapping of Green tech companies in STRING. Crunchbase is a database with company information which makes it possible to study investment trends and business ecosystems. The company data is based on four different sources.

1. The largest venture program network. Crunchbase has a large partnership with the venture community with over 4,000+ members part of a Venture Program. These firms submit monthly portfolio updates to Crunchbase in exchange for access to data.
2. An active community of contributors. 600,000+ executives, entrepreneurs, and investors update over 100,000 company, people, and investor profiles per month. Hundreds of thousands of monthly visitors ensure our data is as up to date and accurate as possible.
3. AI and machine learning. Over 400+ algorithms search for and validate data on a daily basis. They follow over 2,000 of the top news publications to ensure we are capturing every notable funding round, acquisition, and exit.
4. The human touch. They have a house team of data experts provides manual verification for daily updates. The team of data analysts provides live data verification 24 hours a day, 365 days a year.

Crunchbase platform make it possible to delimit the company search into national regions. Furthermore, each company in the database is labelled with different categories such as one or more industries as well as a full description of the company. In these company descriptions we searched for keywords that were related the green technologies. We have delimited the search to for instance to include following themes:

- Circular economy
- Renewable energy
- Alternatives to fossil energy
- Cleantech
- Waste treatment
- Biotechnology
- Green buildings

In the mapping of Green tech companies, we have used several different keywords, which describe these themes, to capture as many relevant companies as possible. The keywords must be included in the company name, industry code or description of the company. A methodological challenge in delimiting the company search by keywords is that it presupposes that the Green tech companies mention the words in their company description, which not all Green tech companies do. Therefore, the search is combined with industry codes, which, however, are at an overall level. We have selected the following:

- Renewable energy
- CleanTech
- Energy efficiency
- Sustainability
- Solar

[62] https://about.crunchbase.com/partners/

- Wind energy
- Recycling
- Energy storage
- Biotechnology
- GreenTech
- Clean energy
- Biofuel
- Waste management

These industrial areas capture relevant parts of the green tech sector, which in combination with the keywords form the basis for a mapping of the companies that are employed in the green area. Uncertainties still exist as to whether the search captures all relevant companies. Therefore, the search is combined with company searches from Kompass. Together, the two searches from two different databases will form a more comprehensive picture of the Green tech companies in STRING. Still with some degree of uncertainty as to whether there are relevant companies that are not included for various reasons, such as that they are not registered in the databases or are captured in our keywords and industrial areas.

B.1.3 Kompass

In the mapping of companies, in addition to Crunchbase, we have also a the company database from Kompass.[63] The Kompass business is a business to business portal with more than 32 million verified companies. The data sources in the database is primary CVR – The Central business Register in Denmark[64], Brønnøysund register in Norway[65], Bolagsverket (Swedish Companies Registration Office) in Sweden[66], and the Common register portal of the German federal states in Germany[67]. After collecting the companies from national databases, they are processed by Kompass and assigned more information. Kompass cannot disclose our entire concept - but with over 50 years of experience, a long and good algorithm is formed.

Across the companies following industry codes are selected which all are related to the green tech sector:

07 - Energy, fuel and water
12 - Textiles
14 - Timber, wooden products, machinery and equipment for the woodworking industry
15 - Furniture and linen
18 - Rubber products
20 - Plastic products
21 - Chemical base materials
22 - Chemical products
23 - Health, medical and pharmaceutical
24 - Hygiene and cleaning
25 - Basic metal products
26 - Metal constructions for the building industry
27 - Metal pipework, valves and containers
28 - Hardware, ironmongery, cutlery and tools
29 - Security equipment
31 - Glass, cement and ceramics
32 - Engines and mechanical parts
33 - Heating, ventilation, air conditioning (HVAC) and refrigeration equipment
37 - Machinery and equipment for metalworking
39 - Electrical equipment. Nuclear equipment
40 - Electronic equipment. Telecommunications equipment
42 - Measuring and testing equipment
43 - Optical, photographic and cinematographic equipment
48 - Agricultural and forestry machinery and equipment
49 - Food, drink, tobacco and catering industry machinery and equipment
52 - Chemical industry plant and equipment
53 - Rubber and plastic industry plant and equipment
56 - Printing equipment. Office and shop equipment
57 - Information technology (IT) and Internet
59 - Oil and gas industry plant and equipment
60 - Mining, quarrying and stoneworking plant and equipment
61 - Civil engineering and building machinery and equipment
62 - Handling and storage plant and equipment

[63] https://dk.kompass.com/en
[64] https://datacvr.virk.dk/data/index.php?q=forside&language=en-gb
[65] https://www.brreg.no/heim/
[66] https://bolagsverket.se/en
[67] https://www.handelsregister.de/rp_web/welcome.do

63 - Packaging machinery, equipment and services
65 - Industrial subcontractors
66 - Means of transport
70 - Civil and marine engineering contractors
71 - Building industry
72 - Environmental services, renewable energies
75 - Transportation and logistics services
80 - Services to businesses
81 - General traders, department and retail stores
84 - Technical offices and engineering consultancies, architects
85 - Research and testing

Based on the above industry codes, as with the search in Crunchbase, there is uncertainty about whether all irrelevant companies are excluded, and all relevant companies are included. The advantage of using industry codes is that the search is not dependent on any specific keywords popping up in the business descriptions. But that the search may be more stringent on which industries relate to the green area. The challenge in the selection of the industry codes is also that there are no codes that deal specifically with the green sector, but it is based on a manual selection.

Appendix C: Tech mining in STRING

Tech mining as a tool to find the hot spots of advanced technology

The appendix C first presents methodological advantages and limitations in using patent data for tech mining. The second section of appendix C presents an analysis of developments of green tech in china, and finally there is a typology or profile of the green tech developed in STRING.

Patent information is information about intellectual property rights. With a patent a sovereign state or intergovernmental organisation grants exclusive rights to the owner of an invention in form of a specific solution, product, or process for a limited period. In exchange for the patent, there is a detailed public disclosure of the invention. The following is a brief presentation of the information stored in global patent databases and the advantages and limitations of tech-mining

The information is stored in national and international patent databases. Each national authority stores the information on the invention, the inventors, reference to other patents and technical classifications such as CPC [Cooperative Patent Classification] codes. The technical code systems are very detailed and was developed in a cooperation between the European Patent Office (EPO) and the patent office of the United States (USPTO)[68].

The same patent can be registered with patent authorities in several countries. In 2016, the number of new patent applications registered in a year passed 3 million patents according to WIPO[69]. Almost two out of three patents in 2016 were filed in Asia – in 2006 about half of the patents in the world were filed in Asia. In 2016, almost 21 pct. of the patents were filed in North America and 11 pct. in Europe. In the present study we have identified 3,15 million patents within “Environmental Technology”.
The information is kept in publicly accessible databases and can be used for news searches to make sure that a “new” invention is in fact new.

The attraction of the patent databases from an analytical point of view is that the databases are updated constantly with detailed information of new technologies and their assignees. Using big data techniques the wealth of patent data can be analysed for strategic information on technological development over time and place. This type of analysis is referred to a tech mining. The data source for tech mining can be patent databases or it maybe global publication databases or business-related databases

Tech mining is a relatively new analytical tool that has been developed over the past 10-15 years. Patent information has always been publicly available, but tech mining the big data in the databases is only possible thanks to the internet, powerful computers, and analytical software. The analysis that we do now in matters of seconds where virtually impossible and almost unthinkable a decade ago.

The leader in tech mining is Georgia Tech, USA and over the years, Danish Technological Institute has worked with Georgia Tech and their analytical software package, Vantage Point, and with Thomson Innovation to understand tech mining. The tools have been applied in studies for the Danish government

[68] http://www.cooperativepatentclassification.org/
[69] http://www.wipo.int/edocs/pubdocs/en/wipo_pub_941_2017-chapter2.pdf

and for private companies. Tech mining is a fast-evolving discipline and new tools for tech mining emerges such as PatSnap.

Tech mining provides insights that can be found nowhere else, but tech mining patent data is not an exact methodology. The advantage of tech mining is to identify trends and patterns in the data, but it is not sufficient for a full analysis or a complete understanding of technological developments and markets. The purpose of tech mining is to extract strategic insights on technologies, actors and markets from the data. In this analysis we have used the search results to extract information relating only to the STRING region and to find businesses that works with greener technologies.

Tech mining patent data is useful for gaining insights into trends, insight into how one technology develops and relates to other technologies. Tech mining patent data is useful for identifying technological leaders and knowledge clusters, a growth in the number of patents might indicate a strategic interest or a market interest in a specific technological area. Tech mining also give insights to where the actors (universities, research institutions, companies, inventors) are clustering.

Tech mining in patents do not answer every relevant question. There are several blind spots in tech mining to be aware of:

- **First**, for several reasons not all technologies are patented, for example: Some companies wants secrecy around their innovations, in some areas the technological innovation is moving so fast that technologies are obsolete before the patent process is done or some companies thinks that patenting is to expensive.
- **Secondly**, national authorities and local offices are located all over the world and this lead to inconsistencies in the written information manage the databases, for example: Danish Technological Institute is one of the leading patenting companies in Denmark, but the recorded name of the company may also be “DTI”, “technological institute” and other variations. So poor data consistency means that data may be overlooked and misinterpreted. Smart software helps to alleviate this problem to some degree.
- **Third**, patenting cultures may differ for country to country, for example: Chinese patents may be over-rated since there are personal rewards for taking out patents, and in the US fights over technology rights in the judicial system might also inflate the number of patents as compared with patents taking in Europe.[70,71]
- **Fourth**, there is no market information connected to the patent data, there is no data on licensing, on value of patents and often there is no links to business databases and the data cannot be readily summed into measures or indicators of strength. Tech mining should not stand as the only source for an analysis, but it provides a useful supplement to any technology analysis with data and insights there are impossible to gain through other types of sources.

[70] Chinapower: “Are patents indicative of Chinese innovation?” See https://chinapower.csis.org/patents/ and Markovich, “U.S. Patents and Innovation”, Council on foreign relations, 2012 see https://www.cfr.org/backgrounder/us-patents-and-innovation

[71] Europe has a loser pays cost juridical system, where often in the US it is each party is responsible for paying its own attorney's fees. That has led to some inflation in the patent system in the US, where “patent troll”s are companies with patents attempts to enforce patent rights against accused infringers far beyond the patent's actual value using hardball legal tactics. See Strowel & Utko,”The trends and current practices in the area of patentability of computer implemented inventions within the EU and the U.S.”, EU Commission, 2016. https://ec.europa.eu/digital-single-market/en/news/report-trends-and-current-practices-area-patentability-computer-implemented-inventions-within

An overview of the insights and blind-spots of tech mining discussed above is provided in the table below.

Figure 0-1: Insights and blind-spots in tech mining patents

Insights	Blind-spots
Trend overview Insight into related technologies Identification of leaders Identification of knowledge clusters Insight to new technologies Geographic information Indication of market interest	Not all technologies are patented - To keep innovation secret - Innovation is to fast - Patenting to expensive Poor data stringency / consistency Different patent registrering cultures Data to dream of: - Data on licensing - Value of patents - Links to business databases - Strength point indicators / measures

Source: Danish Technological Institute

In interpreting the results from tech-mining these limitations must stand clear. Tech mining does not provide a complete or a faultless answer. It provides an indication of trends and direction and there is no other data source that provides a more comprehensive picture.

STRING and the green tech challenge from China

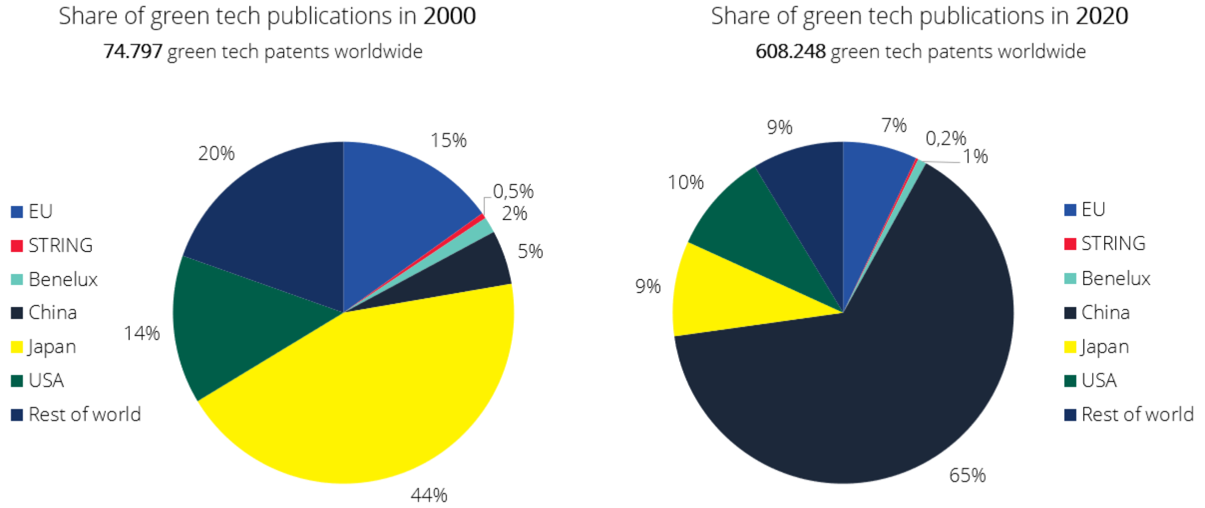
In the figure below we have counted all patents published in the EU[72], STRING[73], Benelux, China, Japan, and the US and compare their share of the total number of patents published in year the 2000 and the year 2020[74]. The total number has increased by a factor 8 from 74,797 patents in 2000 to 608,248 patents in 2020 (and counting).

[72] Note: The search STRINGs that identify the patents cannot exceed 15,000 characters. And in searches including all EU countries the limit is exceeded. We have excluded small countries like the Baltic countries, Cyprus and Bulgaria, Romania, Slovenia from the search in order to not exceed the limit. In this regard, the number of patents in the EU is a little underestimated.

[73] Also, note than in the calculations, STRING population and BENELUX populations are also included in the EU population. Thus, in the graphs illustrating shares, there is a little double calculation and the shares of STRING + Benelux + EU cannot be added.

[74] Note: The figures for 2020 is from 11 November 2020, so the figures may rise by 10-15 pct. in the final count for 2020.

Figure 0-2 Change in green tech strength by patent share 2000 -> 2020



Source: TI Tech-mining – Green tech innovation, extracted 9.11.2020. For EU small economies like Baltic countries, Cyprus as well as Bulgaria, Romania, Slovenia is not included. Combination of OECD definition of WIPO/UN 6,9 million patent families – regardless of legal state. After Assignee countries.

Over the past 20 years, the innovation of green tech expressed as patents has been concentrated in the EU, China, Japan, and the US. In 2000, 15 pct. of green tech innovation took place in the rest of the world. In 2020, that share is reduced to 9 pct. 20 years ago, Japan was dominating green tech innovation with 44 pct. of the green tech patents and today the Japanese share has been reduced to 9 pct. Another important shift is the Chinese activity that over the 20 years has shifted from 5 pct. of published patents to 65 pct. This extreme growth in China has, of course, diminished the share for everybody else.

In STRING the yearly number of patents has more than tripled since 2000 from 402 patents to 1,428 green tech patents. But the growth rate is not enough to maintain the position on a global scale and the share has shrunk from 0.5 pct. of global green tech patents to 0.2 pct. The development is no different from the EU, the Benelux, or the USA.

Patenting intellectual property has a high priority in China. State sponsorship is an important catalyst behind the rapid increase in Chinese patents that is seen in all key technologies. Chinese companies qualifying for government subsidies upon filing a patent application. These subsidies are given regardless of whether the patent is granted, although further subsidies are available for successful applications[75]. The Chinese advance should be worrying since China, in this way, is constructing a wall for intellectual property which solidifies the industrial position of China.

The discussion (ibid) is that the quality or innovative strength of Chinese patents may be lower, which is reflected in the fact that in 2019 China was the leading patenting country in the world, but still only fifth to file patents outside Chinese borders. Only 42,000 Chinese green tech patents have been filed in more 5 countries out of 2.4 million. The US holds 781,000 patents of which 385,000 patents have been filed in more than 5 countries. Thus, indicating – perhaps – a lower innovation value of green tech patents from China and reflected in the map above where Chinese activity is barely visible. Both perspectives are

[75] https://tech.newstatesman.com/guest-opinion/china-patent-rates#:~:text=State%20sponsorship%20is%20undoubt-edly%20a,upon%20filing%20a%20patent%20application.

important to have in mind, and though the position of the EU and STRING is not weak, there is fierce competition in green technology innovation. At the same time, it should be noted that "Chinese firms already have higher R&D expenditures than their EU counterparts and are fast catching up with the US. The output of the R&I system, measured in terms of patents and high impact publications, has grown exponentially" (EU Commission, 2019).

Another important risk, which is not directly reflected by the above analysis, is the risk that investments in STRING and the EU in research and development in green technologies is turned into innovation and workplaces in China, and not where the investment in innovation initially was made[76]. For example, China's share in manufacturing global value chains has risen sharply from 6 to 19 pct. in the past 15 years at the expense of the EU (whose share dropped from 27 to 16 pct.), through competitiveness, gains and demand factors related to the growth of the Chinese market (EU Commission, 2019).

The same report from JRC also concludes that "while the EU currently imposes few limitations on investments by Chinese firms, the reverse is not the case for European firms investing in China. In some sectors, European firms are forced to engage in joint ventures with Chinese firms and transfer technology, including IPR. In others, FDI is blocked completely".

Green Tech typology for STRING with examples

In the overview below we have a short introduction of the main green tech areas that was identified through tech mining. Each of the areas is supplement with a few examples from patents of companies and their inventions. The description of the inventions is from the patents.

Cleantech. 8,450 patents relating to a wide variety of technologies within cleantech and environmental management in relation to combustion. This can be processes, apparatus or devices specially adapted for purification of engine exhaust gases, materials for treating liquid pollutants, e.g., oil, gasoline or fat, methods of operating engines involving adding non-fuel substances including exhaust gas to combustion air, fuel, or fuel-air mixtures of engines, substances including exhaust gas or arrangements of devices for treating smoke or fumes of purifiers, e.g., for removing noxious material. This section is specifically included in the OECD definition. Examples from patent abstracts:

- *ACO-Severin, Schleswig-Holstein*: The invention relates to a fat separator system, in particular to a mobile fat separator system, comprising a fat separator (11) having an inflow (12) for supplying a fluid, an outflow (13) for discharging a fluid and a separation region [2020]. https://www.aco.com/
- *Novozymes, the Capital Region of Denmark*: Methods for cleaning water filtration membranes by treatment with a DNase containing cleaning composition. Optionally the composition also comprises a biocidal and/or other enzymes such as proteases. The DNase may be derived from Aspergillus oryzae or from Bacillus licheniformis [2020]. https://www.novozymes.com/en/news/news-archive/2017/12/grundfos-and-novozymes-kick-off-collaboration-for-clean-water
- *NOV PROCESS & FLOW TECH AS, Oslo:* A hydrocyclone for separating solid particles from a liquid is disclosed. The hydrocyclone includes a ceramic cyclone head, a ceramic cyclone main body, and a metal enclosure. The metal enclosure includes at least an upper metallic enclosure part and a main metallic enclosure part. A lower section of the upper metallic en-

[76] The European Commission has recently issued the report "CHINA - CHALLENGES AND PROSPECTS FROM AN INDUSTRIAL AND INNOVATION POWERHOUSE", 2019 (EU Commission, 2019)

closure part includes mateable circumferential threads and an upper section of the main metallic enclosure part includes mateable circumferential threads. The mateable circumferential threads of the upper metallic enclosure part and the mateable circumferential threads of the main metallic enclosure part are mateable with each other. [2020] https://www.nov.com/about/our-business-units/process-and-flow-technologies

- *BIOFUEL SOLUTION, Region Skåne*: process for converting glycerol to propane in a petroleum refinery. In the process, glycerol is mixed with a petroleum refinery intermediate stream, such as vacuum gas oil and/or light gas oil, to provide a mixed stream comprising glycerol. The mixed stream comprising glycerol is refined by hydrotreatment in a reactor in the petroleum refinery with hydrogen over a porous catalyst, the hydrotreatment reducing glycerol to propane, to provide a refined, mixed stream having an increased relative content of propane. Subsequently, a fraction comprising propane from is separated from the refined, mixed stream. [2020] https://www.biofuel-solution.com/

Renewable energy. 4,330 patents are in relation to renewable energy including wind energy, geothermal energy, hydro energy, marine energy, and a variety of solar energy technologies. It also includes fuel cells. Examples from patent abstracts:

- *SENVION, Hamburg*: Lubricating grease supply device and method for lubricating a bearing of a wind turbine [2020]. https://www.senvion.com/global/en/products-services/wind-turbines/
- *COTES, Region Zealand*: Windturbine dehumidifier system comprising secondary wind power source [2020]. https://www.cotes.com/
- *VOLVO LASTVAGNAR, Västra Götaland***:** Electrically powered commercial vehicle having a battery structure [2020]. https://www.volvotrucks.com/splash.html
- *OCEAN SUN AS, Viken County*: An offshore photovoltaic power plant comprising a pliable mat configured to be arranged on a surface of a body of water, the mat having a plurality of photovoltaic modules fixed thereon. The photovoltaic modules may be marinized and equipped with a buoyant rigid aluminium structure which prevents mechanical damage to the cells. The rigid backside structure may also serve as an efficient heat sink by direct thermal conduction from the solar cells to the pliable mat. There is also provided a fish farm, an offshore power plant, a method of constructing an offshore photovoltaic power plant and a method of installing a floating photovoltaic power plant. [2020]. https://oceansun.no/

Circular economy technologies are related to technologies that increase the recyclability of materials. Most technologies here are in relation to waste treatment technologies from the treatment of municipal or industrial waste, reclamation of contaminated soil, manufacture of articles from scrap or waste metal particles, recovery of plastics or other constituents of waste material containing plastics, stripping waste material from cores or formers, e.g., to permit their re-use, paper-making: fibrous raw materials or their mechanical treatment - using waste paper, Textiles: disintegrating fibre-containing articles to obtain fibres for re-use, reclaiming serviceable parts of waste cells or batteries, working-up raw materials other than ores, e.g. scrap, to produce non-ferrous metals or compounds thereof, footwear made of rubber waste, systematic disassembly of vehicles for recovery of salvageable components, e.g. for recycling. 3,382 patents relate to the circular economy. Examples from patents abstracts:

- *DYNATEC ENGINEERING, Viken County*: Reactor for production of silicon, comprising a reactor volume, distinctive in that the reactor comprises or is operatively arranged to at least one means for setting a silicon-containing reaction gas for chemical vapor deposition (CVD) into rotation inside the reactor volume. Method for production of silicon. [2020] http://www.dynatec.no/
- *C.C.JENSEN, Region Southern Denmark***:** The present invention relates to a system for removing water from oil from an oil supply, where the system comprises a housing comprising an inner opening…The invention further relates to a method of removing water from oil from an oil supply [2020] https://www.cjc.dk/

- *Mats Hedman, Region Halland*: Process and arrangement for reducing carbon dioxide in combustion exhaust gases [2020] https://kkuriren.se/jobbpengar/ny-landvinning-for-innovator-sm5153646.aspx
- *CLEAN ENERGY ONE GMBH, Hamburg*: Wind turbine with CO2 collector, and wind turbine CO2 collector control and/or operating method [2020]. https://www.northdata.com/clean+energy+one+GmbH,+Hamburg/HRB+142063

Biofuels. 2,822 patents relate to biofuels which are technologies in relation to bioethanol, vegetable oils or biomass. Examples from patents abstracts:

- *HAMBURG INNOVATION GMBH, Hamburg*: High-efficiency fuel cell [2020] https://hamburginnovation.de/
- *RENESCI, Region Southern Denmark*: Non-Pressurised Pre-Treatment, Enzymatic Hydrolysis and fermentation of waste fractions [2020] https://orsted.com/en/our-business/bioenergy/renescience
- *RISE Research Institute, Västra Götalandsregion*: Edible organic compounds which can serve as food or feed, or as components of food or feed, are synthesized from oxidized carbon and water, through the input of energy, and using well-known and validated synthesis pathways, leading to free fatty acids and optionally esterified to triglycerides. The source of carbon is preferably C02 from the atmosphere, or more preferably point sources of C02 from industry and/or energy production [2020] https://www.ri.se/en
- *GLOMMEN TECHNOLOGY AS, Viken County*: The invention provides a method for generating a solid wood-based material and a hemicellulose-derived material from a wood raw material. The method includes treating the wood raw material under aqueous conditions at elevated temperature and pressure to generate a hemicellulose-containing fluid component [2020] https://www.innovasjonnorge.no/no/tjenester/kundehistorier/case-2018/glommen-skog-sa/

Green commuting is related to technologies for carbon emission trading, commuting, and teleworking or high-occupancy vehicle (HOV) lanes to encourage carpools, reduce traffic congestion, and improve air quality. Examples from patents abstracts:

- *WYRWOLL, CLAUDIA, Hamburg*: Method and computer product for automatically generating a sorted list from user-generated input and/or metadata derived from social media platforms [2015] https://www.inf.uni-hamburg.de/en/inst/ab/hci/people/wyrwoll.html
- *APACE RESOURCES AS, Oslo*: System for counting passengers [2017] http://www.apace.no/
- *Aporta, The Capital Region of Denmark*: System, passenger train, method and software product for assisting a passenger to locate a seat on a train [2020]
- *ZENUITY AB, Region Halland*: Method and arrangement for validating speed limit information for a road vehicle [2020] https://www.zenuity.com/

Energy storage includes storage of electrical energy, recovering of mechanical energy, thermal insulation. Examples from patents abstracts:

- *ALFA LAVAL, Region Skåne*: A plate heat exchanger and a heat exchanging plate for treating feed such as sea water [2020] https://www.alfalaval.com/
- *DIFFER AS, OSLO*: Solar cooking apparatus with heat storage capacity [2019] https://www.differgroup.com/
- *STILL GMBH, Hamburg*: Electrical energy storage device for vehicles with electric drive [2015] https://www.still.de/
- *INNOCELL A/S, Region of Southern Denmark*: Electrochemical and capacitative energy storage device and method of manufacture [2019] http://innocell.dk/

Water-power technologies include waterpower, propulsion from wave-movement, tidal energy, or ocean thermal energy. Examples from patents abstracts:

- *Jytte Gramkow, Region of Southern Denmark*: System for storage of energy and/or water [2020] https://energiforskning.dk/en/node/9801

- *AZELIO AB, Vestra Götalandsregion***:** Methods of pumping heat transfer fluid in thermal energy storage systems [2019] https://www.azelio.com/
- *Krÿger A/S, The Capital Region of Denmark***:** A method for treatment of waste water in an activated sludge plant [2016] https://www.kruger.dk/
- *ORCAS AS, OSLO***,** Marine vessel for removing debris particles in a water column [2020] http://www.orcas.no/

Green agriculture and food are technologies in relation to animal feeding – stuff from distillers' or brewers' waste; waste products of dairy plants; meat, fish, or bones; from kitchen waste, alternative pesticides, forestry techniques and different forms of soil improvement. Examples from patents abstracts:

- *TECHNISCHE UNIVERSITÄT HAMBURG-HARBURG*: Pre-treating horse manure including urine and litter for subsequent fermentation, comprises bringing horse manure with aqueous medium, and circulating a mixture of horse manure and an aqueous medium for separation of horse manure and litter [2014] https://www.tuhh.de/alt/tuhh/startpage.html
- *Yara International, Oslo*: Methods for removing chloride from fertilizer wastewater [2018] https://www.yara.com/
- *EKOBALANS FENIX AB, Region Skåne*: Method for the production of fertilizer products from residues [2017] https://ekobalans.se/
- *Danmarks Tekniske Universitet, The Capital Region of Denmark*: The invention relates to a method for homo-ethanol production from lactose using a genetically modified lactic acid bacterium of the invention, where the cells are provided with a substrate comprising dairy waste supplemented with an amino nitrogen source (such as acid hydrolysed corn steep liquor). [2019] https://www.dtu.dk/english

Waste treatment is technologies related to waste disposal technologies, presses specially adapted for consolidating scrap metal or for compacting used cars, technologies for compacting glass batches, e.g., pelletizing, cement from oil shales, residues or waste other than slag, technologies for transporting, gathering or removal of domestic or like refuse.

- *FARMATIC BIOTECH ENERGY AG, Schleswig-Holstein:* Disposal of slaughterhouse animal wastes comprises chopping and mixing wastes with organic residues to a defined ratio of dry matter to liquid, useful for energy generation [2002] https://www.expo21xx.com/bioenergy/22309_st3_biogas-plants/default.htm
- *REATECH, Region Zealand*: Method for reducing agglomeration, sintering and deposit formation in gasification and combustion of biomass [2003] http://www.reatech.dk/
- *AGRONOVA AS, Oslo:* Method for manufacture of sanitized organic sludge [2010] https://agronova.no/about-us
- *KEMIMÄKLARNA INT. AB, Region Skåne*: Process for producing a building component or an absorbent product from waste in papermaking [2004] https://www.kemimaklarna.com/

Nuclear energy is fossil-free energy and 218 patents are related to nuclear energy.

- *Copenhagen ATOMICS Aps, The Capital Region of Denmark*: Method for operating a molten salt nuclear reactor: A method for operating a molten salt nuclear reactor having a melt of molten salt. The method comprises: determining the chemical composition of the melt and using the information about the chemical composition of the melt to determine the need for adjusting the composition of the melt in order to operate the reactor efficiently, directing a laser beam on the melt or on a sample of the melt thereby generating plasma, collecting light from the plasma and analyzing the light with a spectrometer to obtain information about the composition of the melt and, using the information about the composition of the melt to optimize the composition of the melt by addition of material to the melt and/or by reprocessing of molten salt from the melt, in order to operate the reactor efficiently and/or safely. https://www.copenhagenatomics.com/

- *Ringhals, Halland*: The present invention relates to a casting device that is suitable for replica casting of surfaces of details that are hard to access. The device comprises positioning means for placing the device in a position for casting, fixation means for keeping the device in place, confinement means for creating a confined area around the detail and a cast compound distributing means for distributing cast compound to the confined area around the detail. https://group.vattenfall.com/se/var-verksamhet/ringhals
- *Thor Energy, Oslo*: The present invention concerns a fuel assembly for a nuclear power boiling water reactor. The fuel assembly comprises fuel rods. At least 95% of the fuel rods comprise nuclear fuel material in the form of U enriched in 235U. At least 20% of the fuel rods belong to a first set of fuel rods. The fuel rods in this first set comprise both U enriched in 235U and Th. The first set comprises a first and a second subset of fuel rods. The ratio, with regard to weight, between Th and U, in each fuel rod of said first subset, is higher than the ratio, with regard to weight, between Th and U, in each fuel rod of said second subset. The invention also concerns a nuclear power boiling water reactor and a manner of operating such a reactor. http://thorenergy.no/
- *Condias, Schleswig-Holstein:* Wastewater e.g. aqueous caustic liquid, treatment method for use in nuclear power station, involves partially separating radio active particles from water by mechanical filters and supplying remaining particles to disposal system. The method involves reducing organic components up to a fractional amount in waste water by electrochemical mineralization. https://www.condias.de/

Appendix D: UN Sustainable Development Goals

Source: https://sdgs.un.org/goals

Appendix E: List of research and innovation infrastructure activities in STRING

Name	Geography	Adress	Type	GreenTech area
Smart Energy Networks	Capital Region of Denmark	Elektrovej 322, 2800 Kongens Lyngby	Cluster/network	Energy
High Pressure High Temperature (HPHT)	Capital Region of Denmark	Park Alle 345, 2605 Brøndby, Denmark	Testbed	Energy
Flow Laboratory	Capital Region of Denmark	Park Alle 345, 2605 Brøndby, Denmark	Testbed	Energy
Corrosion and materials examinations	Capital Region of Denmark	Park Alle 345, 2605 Brøndby, Denmark	Testbed	Energy
Test and analysis of plastics and composites	Capital Region of Denmark	Park Alle 345, 2605 Brøndby, Denmark	Testbed	Energy
Wind tunnels	Capital Region of Denmark	Park Alle 345, 2605 Brøndby, Denmark	Testbed	Energy
Water laboratory for testing and type approval of flow meters	Capital Region of Denmark	Park Alle 345, 2605 Brøndby, Denmark	Testbed	Energy
Air calibration facility - The Bulderbaan	Capital Region of Denmark	Park Alle 345, 2605 Brøndby, Denmark	Testbed	Energy
The Air Testing Laboratory	Capital Region of Denmark	Park Alle 345, 2605 Brøndby, Denmark	Testbed	Energy
Standardised tests and special procedures	Capital Region of Denmark	park Alle 345, 2605 Brøndby, Denmark	Testbed	Energy
Mechanical tests of large structures	Capital Region of Denmark	Park Alle 345, 2605 Brøndby, Denmark	Testbed	Energy
Chemical analysis laboratory	Capital Region of Denmark	Park Alle 345, 2605 Brøndby, Denmark	Testbed	Energy
Towing Tank facilities	Capital Region of Denmark	Park Alle 345, 2605 Brøndby, Denmark	Testbed	Energy
Battery test	Capital Region of Denmark	Gregersensvej 1, 2630 Taastrup, Denmark	Testbed	Energy
Biomass	Capital Region of Denmark	Gregersensvej 1, 2630 Taastrup, Denmark	Testbed	Energy
CO2 and NH3 laboratory	Capital Region of Denmark	Gregersensvej 1, 2630 Taastrup, Denmark	Testbed	Energy
Biomass boilers and wood stoves	Capital Region of Denmark	Gregersensvej 1, 2630 Taastrup, Denmark	Testbed	Energy
EnergyFlexHouse - Technology to the global challenge	Capital Region of Denmark	Gregersensvej 1, 2630 Taastrup, Denmark	Testbed	Energy
EnergyFlexLab	Capital Region of Denmark	Gregersensvej 1, 2630 Taastrup, Denmark	Testbed	Energy
Laboratory for energy efficiency	Capital Region of Denmark	Gregersensvej 1, 2630 Taastrup, Denmark	Testbed	Energy
Solar Energy Laboratory	Capital Region of Denmark	Gregersensvej 1, 2630 Taastrup, Denmark	Testbed	Energy
Heat pump laboratory	Capital Region of Denmark	Gregersensvej 1, 2630 Taastrup, Denmark	Testbed	Energy
Smart City Cluster Denmark	Capital Region of Denmark	Liljens Kvarter 2, 2620 Albertslund, Denmark	Cluster/network	Environmental technologies
Innovation Network for Sustainable Buildings	Capital Region of Denmark	Gregersensvej 1, 2630 Taastrup, Denmark	Cluster/network	Environmental technologies
DTU Science Park	Capital Region of Denmark	Diplomvej 381, 2800 Kongens Lyngby, Denmark	Science park/incubator	Environmental technologies
The Air Testing Laboratory	Capital Region of Denmark	Park Alle 345, 2605 Brøndby, Denmark	Testbed	Environmental technologies
Odour Laboratory	Capital Region of Denmark	Park Alle 345, 2605 Brøndby, Denmark	Testbed	Environmental

				technologies
The Climate Adaptation Lab	Capital Region of Denmark	Gregersensvej 1, 2630 Taastrup, Denmark	Testbed	Environmental technologies
Piping systems and components for tap water, distribution and sewerage - Pipes and components for drinking water	Capital Region of Denmark	Gregersensvej 1, 2630 Taastrup, Denmark	Testbed	Environmental technologies
Measurement of Relative Intensity Noise (RIN)	Capital Region of Denmark	Kogle Allé 5, 2970 Hørsholm, Denmark	Testbed	Environmental technologies
Ballast water management	Capital Region of Denmark	Agern Allé 5, 2970 Hørsholm, Denmark	Testbed	Environmental technologies
Using microorganisms for pollution control in soil and groundwater	Capital Region of Denmark	Gregersensvej 1, 2630 Taastrup, Denmark	Testbed	Environmental technologies
Danish Meat Research Institute (DMRI)	Capital Region of Denmark	Gregersensvej 9, 2630 Taastrup, Denmark	Science park/incubator	Food and agriculture
Innovative Plant Production	Capital Region of Denmark	Gregersensvej 1, 2630 Taastrup, Denmark	Testbed	Food and agriculture
Maritime Cluster Copenhagen North	Capital Region of Denmark	Nordhavnsvej 1c, 3000 Helsingør, Denmark	Cluster/network	Transport
EMC test facilities	Capital Region of Denmark	Park Alle 345, 2605 Brøndby, Denmark	Testbed	Transport
Towing Tank facilities	Capital Region of Denmark	Park Alle 345, 2605 Brøndby, Denmark	Testbed	Transport
Real Driving Emission Measurements (RDE) of Vehicles	Capital Region of Denmark	Gregersensvej 1, 2630 Taastrup, Denmark	Testbed	Transport
E-mobility	Capital Region of Denmark	Gregersensvej 1, 2630 Taastrup, Denmark	Testbed	Transport
Maritime & Logistics Innovation Denmark – MARLOG	Capital Region of Denmark	Rønne, Denmark	Cluster/network	Transport
Energy Innovation Cluster	Capital Region of Denmark	Vodroffsvej 59, 1900 Frederiksberg, Denmark	Cluster/network	Energy
Danmarks Tekniske Universitet	Capital Region of Denmark		University	
Københavns Universitet	Capital Region of Denmark		University	
Geological Survey of Denmark and Greenland	Capital Region of Denmark		University	
University of Copenhagen, Faculty of Life Sciences	Capital Region of Denmark		University	
Niels Bohr Institute	Capital Region of Denmark		University	
Danmarks Meteorologiske Institut	Capital Region of Denmark		University	
Roskilde University	Capital Region of Denmark		University	
Energy Cluster Denmark	Copenhagen	Bryghuspladsen 8, 1550 København V, Denmark	Cluster/network	Energy
Accelerace	Copenhagen	Fruebjergvej 3, 2100 København Ø, Denmark	Science park/incubator	Energy
Energylab Nordhavn	Copenhagen	Sundkaj 125, 2150 Nordhavn, Denmark	Testbed	Energy

Innovation Network for Environmental Technology	Copenhagen	Rådhuspladsen 59, 1550 København V, Denmark	Cluster/network	Environmental technologies
CLEAN	Copenhagen	Rådhuspladsen 59, 1550 København V, Denmark	Cluster/network	Environmental technologies
Danish Institute for Sustainable Innovation and Entrepreneurship (DISIE)	Copenhagen	Enghavevej 80C, 2450 København, Denmark	Science park/incubator	Environmental technologies
BLOXHUB	Copenhagen	Bryghusgade 8, 1473 København K, Denmark	Science park/incubator	Environmental technologies
MADE - Manufacturing Academy of Denmark	Copenhagen	Vesterbrogade 1E, 1620 København V, Denmark	Cluster/network	Food and agriculture
Food & Bio Cluster	Copenhagen	Fruebjergvej 3, 2100 København Ø, Denmark	Cluster/network	Food and agriculture
Copenhagen Agrifood Incubator	Copenhagen	Fruebjergvej 3, 2100 København Ø, Denmark	Science park/incubator	Food and agriculture
The Transport Innovation Network	Copenhagen	Amaliegade 33b, 1256 København K, Denmark	Cluster/network	Transport
Greater Copenhagen	Copenhagen	Nørregade 7b, 1165 København K, Denmark	Cluster/network	Transport
Maritime & Logistics Innovation Denmark – MARLOG	Copenhagen	Copenhagen, Denmark	Cluster/network	Transport
Smart City Sweden West	Göteborg	Norra Hamngatan 14, Göteborg, Sweden	Cluster/network	Energy
Business Region Göteborg	Göteborg	Östra Hamngatan 5, 411 10 Göteborg, Sweden	Cluster/network	Energy
Lindholmen Science Park	Göteborg	Lindholmspiren 5, 402 78 Göteborg, Sweden	Science park/incubator	Transport
HSB Living Lab	Göteborg	Elektrovägen 4, 412 58 Göteborg, Sweden	Testbed	Energy
Stadslandet Göteborg	Göteborg	Folkvisegatan 14, 422 41 Hisings Backa, Sweden	Testbed	Energy
Business Region Göteborg	Göteborg	Östra Hamngatan 5, Göteborg, Sweden	Cluster/network	Environmental technologies
Green Gothenburg	Göteborg	Östra Hamngatan 5, Göteborg, Sweden	Cluster/network	Environmental technologies
CSR Västsverige	Göteborg	Gamlestadsvägen 4, 415 11 Göteborg, Sweden	Cluster/network	Environmental technologies
Greenups	Göteborg	Sven Hultins gata 2, 412 58 Göteborg, Sweden	Cluster/network	Environmental technologies
Celsius City	Göteborg	Sven Hultins gata 2, 412 58 Göteborg, Sweden	Cluster/network	Environmental technologies
GU Ventures	Göteborg	Erik Dahlbergsgatan 11, 411 26 Göteborg, Sweden	Science park/incubator	Environmental technologies
Chalmers Ventures	Göteborg	Vera Sandbergs Allé 8, Göteborg, Sweden	Science park/incubator	Environmental

				technologies
Lindholmen Science Park	Göteborg	Lindholmspiren 5, 402 78 Göteborg, Sweden	Science park/incubator	Environmental technologies
Johanneberg Science Park	Göteborg	Sven Hultins gata 2, 412 58 Göteborg, Sweden	Science park/incubator	Environmental technologies
Testbed for Evaluation of Stormwater Techniques	Göteborg	Chalmersplatsen 4, 412 58 Göteborg, Sweden	Testbed	Environmental technologies
RiverCity	Göteborg	Göteborg, Sweden	Testbed	Environmental technologies
Sharing City Göteborg	Göteborg	Göteborg, Sweden	Testbed	Environmental technologies
Stadslandet Göteborg	Göteborg	Folkvisegatan 14, 422 41 Hisings Backa, Sweden	Testbed	Environmental technologies
HSB Living Lab	Göteborg	Elektrovägen 4, 412 58 Göteborg, Sweden	Testbed	Environmental technologies
Eco-smart and effective cleaning and disinfection	Göteborg	Frans Perssons väg 6, 402 29 Göteborg, Sweden	Testbed	Environmental technologies
Lindholmen Science Park	Göteborg	Lindholmspiren 5, 402 78 Göteborg, Sweden	Science park/incubator	Food and agriculture
Business Region Göteborg	Göteborg	Östra Hamngatan 5, 411 10 Göteborg, Sweden	Cluster/network	Transport
City of Gothenburg's Goods Network	Göteborg	Göteborg, Sweden	Cluster/network	Transport
Region Västra Götalands Freight Transport Group	Göteborg	Göteborg, Sweden	Cluster/network	Transport
The Gothenburg Region's Infrastructure Network	Göteborg	Göteborg, Sweden	Cluster/network	Transport
KNEG - Klimanautrala godstansporter på väg	Göteborg	Chalmersplatsen 4, 412 96 Göteborg, Sweden	Cluster/network	Transport
ElectriCity	Göteborg	Lindholmspiren 3-5, 402 78 Göteborg, Sweden	Testbed	Transport
Living Lab within Electromobility	Göteborg	Lindholmspiren 7a, 402 78 Göteborg, Sweden	Testbed	Transport
Test Site Sweden (TSS)	Göteborg	Lindholmspiren 3-5, 402 78 Göteborg, Sweden	Testbed	Transport
Energikontor Väst (Innovatum)	Göteborg	Arvid Hedvalls backe 6, 411 33 Göteborg	Science park/incubator	Energy
Vinnväxt	Göteborg		Cluster/network	Environmental technologies
Chalmers University of Technology	Göteborg		University	
Göteborgs Universitet	Göteborg		University	
Högskolan i Halmstad	Halland	Kristian IV:s väg 3, 301 18 Halmstad, Sverige	Science park/incubator	Environmental

				technologies
Halmstad Business Incubator (High Five)	Halland	Box 806, SE-301 18 Halmstad	Science park/incubator	Environmental technologies
Potential.VBG	Halland	Birger Svenssons väg 34 A, 432 40 Varberg	Science park/incubator	
EMC	Halland	Impact House Östra Långgatan 47, 432 41 Varberg	Cluster/network	
Hamburg University of Technology, Institute of Energy Systems (M-5)	Hamburg	Denickestraße 15, D-21073 Hamburg, Germany	Testbed	Energy
NEW 4.0 - Northern German Energy Transition	Hamburg	Alexanderstrasse 1, 20099 Hamburg, Germany	Testbed	Energy
Bergedorf Innovation park	Hamburg	Bergedorf, Hamburg, Germany	Science park/incubator	Energy
Bergedorf Innovation park	Hamburg	Bergedorf, Hamburg, Germany	Testbed	Energy
Innovation Park Harburg	Hamburg	Schlachthofstrasse, 21079 Hamburg, Germany	Science park/incubator	Environmental technologies
Innovation Park Harburg	Hamburg	Schlachthofstrasse, 21079 Hamburg, Germany	Science park/incubator	Transport
Test track for automated and connected driving in Hamburg	Hamburg	Platz der Deutschen Einheit, 20457 Hamburg, Tyskland	Testbed	Transport
Süderelbe AG	Hamburg	Veritaskai 4, 21079 Hamburg, Germany	Cluster/network	Transport
Maritime Cluster Northern Germany	Hamburg	Wexstrasse 7, 20355 Hamburg, Germany	Cluster/network	Transport
Logistics Initiative Hamburg	Hamburg	Wexstrasse 7, 20355 Hamburg, Germany	Cluster/network	Transport
Hamburg Aviation	Hamburg	Wexstrasse 7, 20355 Hamburg, Germany	Cluster/network	Transport
Innovation Park Finkenwerder	Hamburg	Hein-Sass-Stieg, 21129 Hamburg, Germany	Science park/incubator	Transport
Renewable Energy Hamburg Cluster	Hamburg	Wexstrasse 7, 20355 Hamburg, Germany	Cluster/network	Energy
hit-Technopark	Hamburg	Tempowerkring 6, 21079 Hamburg, Germany	Science park/incubator	Energy
Hamburg Innovation Port	Hamburg	Blohmstraße 18, 21079 Hamburg, Germany	Science park/incubator	Transport
Integrierte WärmeWende Wilhelmsburg	Hamburg	Wilhelmsburg, Hamburg, Germany	Testbed	Energy
Norddeutsche reallabore	Hamburg	Alexanderstrasse 1, 20099 Hamburg, Germany	Testbed	Energy
TuTech Innovation GmbH	Hamburg	Harburger Schloßstraße 6-12, 21079 Hamburg, Germany	Science park/incubator	Energy
TuTech Innovation GmbH	Hamburg	Harburger Schloßstraße 6-12, 21079 Hamburg, Germany	Science park/incubator	Environmental technologies
TuTech Innovation GmbH	Hamburg	Harburger Schloßstraße 6-12, 21079 Hamburg, Germany	Science park/incubator	Transport

UmweltPartnerschaft Hamburg	Hamburg	Neuenfelder Straße 19, 21109 Hamburg, Germany	Cluster/network	Environmental technologies
foodactive	Hamburg	Veritaskai 4, 21079 Hamburg, Germany	Cluster/network	Food and agriculture
Energieforschungsverbund Hamburg (EFH)	Hamburg	Wexstrasse 7, 20355 Hamburg, Germany	Cluster/network	Energy
Center of Applied Aeronautical Research	Hamburg	Hein-Saß-Weg 22, 21129 Hamburg, Germany	Testbed	Transport
Center of Applied Aeronautical Research	Hamburg	Hein-Saß-Weg 22, 21129 Hamburg, Germany	Science park/incubator	Transport
Cluster of Excellence Climate, Climatic Change and Society	Hamburg	Bundesstraße 53, 20146 Hamburg, Germany	Cluster/network	Environmental technologies
The German Climate Computing Center	Hamburg	Bundesstraße 45a, 20146 Hamburg, Germany	Cluster/network	Environmental technologies
Max Planck Institute for Meteorology	Hamburg	Bundesstraße 53, 20146 Hamburg, Germany	Science park/incubator	Environmental technologies
KlimaCampus Hamburg	Hamburg	Grindelberg 5, 20144 Hamburg, Germany	Cluster/network	Environmental technologies
Climate Service Center Germany	Hamburg	Fischertwiete 1, 20095 Hamburg, Germany	Science park/incubator	Environmental technologies
IW3 (Integrierte WärmeWende Wilhelmsburg)	Hamburg	Ballindamm 1, 20095 Hamburg, Tyskland	Testbed	Energy
Norddeutsches Reallabor	Hamburg	20095 Hamburg, Germany	Testbed	Energy
Universität Hamburg	Hamburg		University	
Max Planck Institute for Meteorology	Hamburg		University	
Hamburg University of Technology	Hamburg		University	
Smart City Sweden South	Malmö	Nordenskiöldsgatan 24, 211 19 Malmö, Sweden	Cluster/network	Energy
Sustainable Business Hub	Malmö	Nordenskiöldsgatan 24, 211 19 Malmö, Sweden	Cluster/network	Energy
Livsmedelsakademin	Malmö	Anckargripsgatan 3, 211 19 Malmö, Sweden	Cluster/network	Food and agriculture
Packbridge	Malmö	Anckargripsgatan 3, 211 19 Malmö, Sweden	Cluster/network	Food and agriculture
Energy Valley	Oslo	Oksenøyveien 10, 1366 Lysaker, Norway	Cluster/network	Energy
The Norwegian Solar Energy Cluster	Oslo	Widerøvien 5, 1360 Fornebur, Norway	Cluster/network	Energy
Oslo Tech	Oslo	Gaustadaleen 21, 0349 Oslo, Norway	Science park/incubator	Energy
Oslo Tech Forskningsparken	Oslo	Gaustadalleen 21, 0349 Oslo, Norway	Science park/incubator	Environmental technologies
Norselab	Oslo	Karenslyst Allé 9a, 0278 Oslo, Norway	Science park/incubator	Environmental

				technologies
Innovasjon Norge	Oslo	Akersgata 13, 0104 Oslo, Norway	Cluster/network	Food and agriculture
The Life Science Cluster	Oslo	Gaustadaleen 21, 0349 Oslo, Norway	Cluster/network	Food and agriculture
Foods of Norway	Oslo	Ullevålsveien 72, 0454 Oslo, Norway	Science park/incubator	Food and agriculture
Project with self-driving buses in Oslo	Oslo	Oslo, Norway	Testbed	Transport
Norges teknisk-naturvitenskapelige universitet	Oslo		University	
Universitetet i Oslo	Oslo		University	
Universitetet for miljø- og biovitenskap	Oslo		University	
Norsk institutt for luftforskning	Oslo		University	
Innovation Network Smart Energy	Region of Southern Denmark	Hindsgavl Allé 2, 5500 Middelfart, Denmark	Cluster/network	Energy
Energy Innovation Cluster	Region of Southern Denmark	Kanalen 1, 6700 Esbjerg, Denmark	Cluster/network	Energy
Energy Cluster Denmark	Region of Southern Denmark	Kanalen 1, 6700 Esbjerg, Denmark	Cluster/network	Energy
Energy Cluster Denmark	Region of Southern Denmark	Vendersgade 74, 7000 Fredericia, Denmark	Cluster/network	Energy
Energy Cluster Denmark	Region of Southern Denmark	Alsion 2, 6400 Sønderborg, Denmark	Cluster/network	Energy
Digital Energy Hub Denmark	Region of Southern Denmark	Kokbjerg 30, 6000 Kolding, Denmark	Science park/incubator	Energy
High-pressure calibration facility - The world's largest closed loop	Region of Southern Denmark	Vejen, Denmark	Testbed	Energy
Green Tech Center	Region of Southern Denmark	Lysholt Allé 6-8, 7100 Vejle, Denmark	Science park/incubator	Energy
Green Tech Center	Region of Southern Denmark	Lysholt Allé 6-8, 7100 Vejle, Denmark	Testbed	Energy
Lindø Offshore Renewables Center	Region of Southern Denmark	Lindø Sydvej 30, 5330 Munkebo, Denmark	Testbed	Energy
Plast Center Danmark	Region of Southern Denmark	Niels Bohrs Vej 6, 6700 Esbjerg, Denmark	Cluster/network	Environmental technologies
CLEAN	Region of Southern Denmark	Munkebjergvænget 1, 5230 Odense M, Denmark	Cluster/network	Environmental technologies
CLEAN	Region of Southern Denmark	Sundsmarkvej 20, 6400 Sønderborg, Denmark	Cluster/network	Environmental technologies
Danish Materials Network	Region of Southern Denmark	Niels Bohrs Vej 6, 6700 Esbjerg, Denmark	Cluster/network	Environmental technologies
Danish Materials Network	Region of Southern Denmark	Niels Bohrs Vej 6, 6700 Esbjerg, Denmark	Cluster/network	Food and agriculture
Food & Bio Cluster	Region of Southern Denmark	Munkebjergvænget 1, 5230 Odense M, Denmark	Cluster/network	Food and agriculture

Pilot production - Feed, Food and Biomass	Region of Southern Denmark	Gammel Ålbovej 1, 6092 Sønder Stenderup, Denmark	Testbed	Food and agriculture
Maritime Cluster Funen	Region of Southern Denmark	Frederiksgade 8, 5700 Svendborg, Denmark	Cluster/network	Transport
Maritime & Logistics Innovation Denmark – MARLOG	Region of Southern Denmark	Esbjerg, Denmark	Cluster/network	Transport
Maritime & Logistics Innovation Denmark – MARLOG	Region of Southern Denmark	Svendborg, Denmark	Cluster/network	Transport
Center Denmark	Region of Southern Denmark	Vendersgade 74, 7000 Fredericia, Denmark	Testbed	Energy
Center Denmark	Region of Southern Denmark	Vendersgade 74, 7000 Fredericia, Denmark	Science park/incubator	Energy
House of Offshore Innovation	Region of Southern Denmark	Kanalen 1, 6700 Esbjerg, Denmark	Science park/incubator	Energy
Syddansk Universitet	Region of Southern Denmark		University	
European Spallation Source (ESS)	Region Skåne	Odarslövsvägen 113, 224 84 Lund, Sweden	Testbed	Energy
Ideon Science Park	Region Skåne	Scheelevägen 15, Lund, Sweden	Science park/incubator	Environmental technologies
Reco Lab	Region Skåne	Rönnowsgatan 12, 252 25 Helsingborg, Sweden	Testbed	Environmental technologies
Krinova Incubator and Science park	Region Skåne	Stridsvagnvägen 14, 291 39 Kristianstad, Sweden	Science park/incubator	Food and agriculture
Sensors and sensor systems	Region Skåne	215 32 Malmö, Sverige	Testbed	Environmental technologies
Sustainable Business Hub Scandinavia AB	Region Skåne	Nordenskiöldsgatan 24, 211 19 Malmö, Sverige	Cluster/network	Environmental technologies
Swedish Maritime Technology Forum	Region Skåne	Scheelevägen 17, 223 63 Lund, Sverige	Cluster/network	Environmental technologies
Cleantech Scandinavia	Region Skåne	ScheelevÃ¤gen 2, 223 63, Lund, Sweden	Cluster/network	Environmental technologies
Klimatsamverkan Skåne	Region Skåne	Gasverksgatan 3a, Armaturen, Lund	Cluster/network	Environmental technologies
EIT Climate-KIC	Region Skåne	Lund, Sverige	Cluster/network	Environmental technologies
Future by Lund	Region Skåne	Scheelevägen 2, 223 63 Lund, Sverige	Cluster/network	Environmental technologies
H22	Region Skåne	Hbg Works, Drottninggatan 14, 252 21 Helsingborg, Sverige	Testbed	Environmental technologies
M21	Region Skåne	211 19 Malmø	Testbed	Environmental technologies

VERA PARK	Region Skåne	Nordenskiöldsgatan 24, 211 19 Malmö	Testbed	Environ-mental technolo-gies
Sege Park	Region Skåne	Malmö stad, 205 80 Malmö	Testbed	Environ-mental technolo-gies
Food Valley of Bjuv	Region Skåne	Food Valley of Bjuv, Mejerigatan 3, Box 501 Bjuv, Sweden	Cluster/net-work	Food and agriculture
Lunds Universitet	Region Skåne		University	
DTU Vindenergi	Region Zealand	Frederiksborgvej 399, 4000 Roskilde, Denmark	Testbed	Energy
Test site 'Stengården' for decontami-nation of soil and water	Region Zealand	Roskildevej 17, 4330 Roskilde, Denmark	Testbed	Environ-mental technolo-gies
Innovation Network Femern Belt	Region Zealand	Vestre Kaj 50C, 4970 Rødby, Denmark	Cluster/net-work	Transport
STRING Network	Region Zealand	Alléen 15, 4180 Sorø, Denmark	Cluster/net-work	Environ-mental technolo-gies
The Schleswig-Holstein Renewable Energy Network Agency	Schleswig-Holstein	Schlossstrasse 7, 25813 Husum, Germany	Cluster/net-work	Energy
foodRegio	Schleswig-Holstein	Falkenstrasse 11, 23564 Lübeck, Germany	Cluster/net-work	Food and agriculture
Maritime Cluster Northern Germany	Schleswig-Holstein	Lorentzendamm 24, 24103 Kiel, Germany	Cluster/net-work	Transport
Field Test eHighway Schleswig-Hol-stein	Schleswig-Holstein	Schwentinestr. 24, 24149 Kiel, Germany	Testbed	Transport
Westküste 100	Schleswig-Holstein	Fritz-Thiedemann-Ring 20, 25746 Heide, Ger-many	Testbed	Energy
Centre for materials and Coastal Re-search	Schleswig-Holstein	Max-Planck-Straße 1, 21502 Geesthacht, Ger-many	Science park/incuba-tor	Environ-mental technolo-gies
NEW 4.0 - Northern German Energy Transition	Schleswig-Holstein	Boschstraße 1, 24118 Kiel, Germany	Testbed	Energy
Competence center for renewable en-ergies and climate protection Schles-wig-Holstein	Schleswig-Holstein	Schwentinestrasse 24, 24149 Kiel, Germany	Science park/incuba-tor	Energy
The geo-energy competence center	Schleswig-Holstein	Ludewig-Meyn-Strasse 10, 24118 Kiel, Germany	Science park/incuba-tor	Energy
Institute for Maritime Energy Systems	Schleswig-Holstein	Max-Planck-Straße 2, 21502 Geesthacht, Ger-many	Science park/incuba-tor	Energy
Institute for the transformation of the energy system (ITE)	Schleswig-Holstein	Carl-Friedrich-Benz-Straße 5, 25770 Hem-mingstedt, Germany	Science park/incuba-tor	Energy
Competence and Science Center for Intelligent Energy Use (WiE)	Schleswig-Holstein	Mönkhofer Weg 239, 23562 Lübeck, Germany	Science park/incuba-tor	Energy
Center for Sustainable Energy Sys-tems	Schleswig-Holstein	Kanzleistraße 91-93, 24943 Flensburg, Tyskland	Science park/incuba-tor	Energy
Wind Energy Technology Institute	Schleswig-Holstein	Kanzleistraße 91-93, 24943 Flensburg, Tyskland	Science park/incuba-tor	Energy
Competence center for renewable en-ergies and climate protection Schles-wig-Holstein	Schleswig-Holstein	Schwentinestrasse 24, 24149 Kiel, Germany	Science park/incuba-tor	Environ-mental technolo-gies

The geo-energy competence center	Schleswig-Holstein	Ludewig-Meyn-Strasse 10, 24118 Kiel, Germany	Science park/incubator	Environmental technologies
Thünen Institute of Organic Farming	Schleswig-Holstein	Trenthorst 32, 23847 Westerau, Germany	Science park/incubator	Food and agriculture
The Faculty of Agricultural and Nutritional Sciences of Kiel University	Schleswig-Holstein	Hermann-Rodewald-Strasse 4, 24118 Kiel, Germany	Science park/incubator	Food and agriculture
Kiel University of Applied Sciences, Department of Agriculture	Schleswig-Holstein	Grüner Kamp 11, 24783 Osterrönfeld, Germany	Science park/incubator	Food and agriculture
Kiel Marine Science - Center for Ocean and Society	Schleswig-Holstein	Ludewig-Meyn-Strasse 10, 24118 Kiel, Germany	Science park/incubator	Environmental technologies
Center for Analysis in Technology Transfer for Biotech and Food Innovations	Schleswig-Holstein	Kanzleistraße 91-93, 24943 Flensburg, Tyskland	Science park/incubator	Food and agriculture
Center for Industrial Biotechnology	Schleswig-Holstein	Stephensonstraße 3, 23562 Lübeck, Germany	Science park/incubator	Food and agriculture
Institute for Maritime Energy Systems	Schleswig-Holstein	Max-Planck-Straße 2, 21502 Geesthacht, Germany	Science park/incubator	Transport
The Schleswig-Holstein Renewable Energy Cluster EE.SH (Netzwerkagentur Erneuerbare Energien Schleswig-Holstein):	Schleswig-Holstein	Schlossstrasse 7, 25813 Husum, Germany	Cluster/network	Energy
Renewable energy – EE.SH	Schleswig-Holstein	Lorentzendamm 24, 24103 Kiel	Cluster/network	Energy
WTSH Wirtschaftsförderung und Technologietransfer Schleswig-Holstein GmbH	Schleswig-Holstein	Lorentzendamm 24, 24103 Kiel	Cluster/network	Environmental technologies
IHK: The Chambers of Commerce and Industry in Flensburg, Kiel and Lübeck	Schleswig-Holstein	Heinrichstr. 28 - 34, 24937 Flensburg, Germany	Cluster/network	Environmental technologies
IHK: The Chambers of Commerce and Industry in Flensburg, Kiel and Lübeck	Schleswig-Holstein	Bergstraße 2, 24103 Kiel, Germany	Cluster/network	Environmental technologies
IHK: The Chambers of Commerce and Industry in Flensburg, Kiel and Lübeck	Schleswig-Holstein	Fackenburger Allee 2, 23554 Lübeck, Germany	Cluster/network	Environmental technologies
Kompetenzzentrum Erneuerbare Energien und Klimaschutz Schleswig-Holstein	Schleswig-Holstein	Fachhochschule Kiel GmbH, Schwentinestr. 24, 24149 Kiel	Cluster/network	Energy
Kompetenz- und Wissenschaftszentrum für intelligente Energienutzung (WiE)	Schleswig-Holstein	Mönkhofer Weg 239, 23562 Lübeck	Science park/incubator	Energy
Norddeutsches Reallabor	Schleswig-Holstein	23562 Lübeck, Germany	Testbed	Energy
ReWest100 – Reallabor Westküste 100	Schleswig-Holstein	25704 Meldorf, Germany	Testbed	Energy
Christian-Albrechts-Universität zu Kiel	Schleswig-Holstein		University	
Helmholtz-Zentrum Geesthacht - Zentrum für Material- und Küstenforschung GmbH	Schleswig-Holstein		University	

GEOMAR - Helmholtz-Zentrum für Ozeanforschung Kiel	Schleswig-Holstein		University	
Norsk Hydrogenforum	Viken County	Gunnar Randers Vei 24, 2007 Kjeller, Norway	Cluster/net-work	Energy
Viken Technology Cluster 4.0	Viken County	Strandgata 10, 1531 Moss, Norway	Cluster/net-work	Environ-mental technolo-gies
Kjeller Innovasjon Incubator	Viken County	Gunnar Randers vei 24, 2007 Kjeller, Norway	Science park/incuba-tor	Environ-mental technolo-gies
Measurement and analysis of odours	Viken County	Nye Vakås vei 32, 1395 Hvalstad, Norway	Testbed	Environ-mental technolo-gies
Foods of Norway	Viken County	Chr. Magnus Falsens vei 1, 1432 Ås, Norway	Science park/incuba-tor	Food and agriculture
The Norwegian Hydrogen Cluster (H2)	Viken County	Gunnar Randers vei 24, 2007 Kjeller, Norway	Cluster/net-work	Environ-mental technolo-gies
SAMS Norway	Viken County	Kirkegaardsv. 45, 3616 Kongsberg, Norway	Cluster/net-work	Transport
Institutt for energiteknikk	Viken County		University	
OffshoreVäst	Västra Götaland Region	Brinellgatan 4, 504 62 Borås, Sweden	Cluster/net-work	Energy
Swedish Maritime Technology Forum	Västra Götaland Region	Agnebergsgatan, 45130 Uddevalla, Sweden	Cluster/net-work	Energy
Production and use of biofuels	Västra Götaland Region	Brinellgatan 4, 504 62 Borås, Sweden	Testbed	Energy
Testbed for District Heating & Cooling	Västra Götaland Region	Brinellgatan 4, 504 62 Borås, Sweden	Testbed	Energy
Testbed for Solar Energy Solutions	Västra Götaland Region	Brinellgatan 4, 504 62 Borås, Sweden	Testbed	Energy
Smart Textiles	Västra Götaland Region	Skaraborgsvägen 3a, 506 30 Borås, Sweden	Cluster/net-work	Environ-mental technolo-gies
Circular Hub (Science Park Borås)	Västra Götaland Region	Skaraborgsvägen 3a, 506 30 Borås, Sweden	Science park/incuba-tor	Environ-mental technolo-gies
Testbed for Textile Recycling	Västra Götaland Region	Argongatan 30, 431 53 Mölndal, Sweden	Testbed	Environ-mental technolo-gies
Testbed for recycling of plastics	Västra Götaland Region	Argongatan 30, 431 53 Mölndal, Sweden	Testbed	Environ-mental technolo-gies
Durability of Materials and Products	Västra Götaland Region	Brinellgatan 4, 50462 Borås, Sweden	Testbed	Environ-mental technolo-gies
Emission 2.0 for a non-toxic environ-ment	Västra Götaland Region	Brinellgatan 4, 50462 Borås, Sweden	Testbed	Environ-mental technolo-gies
Swedish Maritime Technology Forum	Västra Götaland Region	Agnebergsgatan, 451 30 Uddevalla, Sweden	Cluster/net-work	Transport
Battery, hybrid system, fuelcell and hydrogen applications	Västra Götaland Region	Brinellgatan 4, 50462 Borås, Sweden	Testbed	Transport

Automotive Wireless Test and Research Facility	Västra Götaland Region	Brinellgatan 4, 50462 Borås, Sweden	Testbed	Transport
Test site Skagerak	Västra Götaland Region	Lysekil, Sweden	Testbed	Transport
Sensors and sensor systems	Västra Götaland Region	Göteborg, Sweden	Testbed	Environmental technologies
Surface Analysis and Surface Design	Västra Götaland Region	Göteborg, Sweden	Testbed	Environmental technologies
Testbed for magnetic analysis, magnetic characterization and modelling	Västra Götaland Region	Arvid Hedvalls Backe 4, 411 33 Göteborg	Testbed	Environmental technologies
Testbed for Pipes and Pipe Systems	Västra Götaland Region	Gibraltargatan 35, 412 79 Göteborg	Testbed	Energy
Emission 2.0 for a non-toxic environment	Västra Götaland Region	Brinellgatan 4, 504 62 Borås	Testbed	Environmental technologies
Testbed for evaluation of stormwater techniques	Västra Götaland Region	Chalmersplatsen 4, 412 58 Göteborg	Testbed	Environmental technologies
Mechanical reliability and life	Västra Götaland Region	Brinellgatan 4, 504 62 Borås	Testbed	Transport
Testbed for materials in marine environment	Västra Götaland Region	Kristineberg 566, 450 34 Fiskebäckskil	Testbed	Environmental technologies
Corrosion in soil	Västra Götaland Region	Göteborg, Sweden	Testbed	Energy
Hybrid joining testbed	Västra Götaland Region	Göteborg, Sweden	Testbed	Transport
AstaZero	Västra Götaland Region	Göksholmen 1, 504 91 Sandhult	Testbed	Transport
Algae biomass as raw material – from cultivation to material prototype	Västra Götaland Region	Brinellgatan 4, 504 62 Borås	Testbed	Environmental technologies
Heat pumps and cooling technology	Västra Götaland Region	Industrigatan 4, 504 62 Borås	Testbed	Energy
Product tests in extreme climate	Västra Götaland Region	Industrigatan 4, 504 62 Borås	Testbed	Transport
Eco-smart and effective cleaning and disinfection	Västra Götaland Region	Frans Perssons väg 6, 402 29 Göteborg	Testbed	Environmental technologies
Textile fiber development test bed	Västra Götaland Region	Argongatan 30, 431 53 Mölndal	Testbed	Environmental technologies
Testbed within the high voltage area	Västra Götaland Region	Göteborg, Sweden	Testbed	Energy
Virtual testbed for simulation and modeling of material and structres in fire	Västra Götaland Region	Brinellgatan 4, 504 62 Borås	Testbed	Energy
Surface Analysis and Surface Design	Västra Götaland Region	Göteborg, Sweden	Testbed	Environmental technologies
Power Väst	Västra Götaland Region	Regionens hus, SE 462 80 Vänersborg	Cluster/network	Energy
Biogas Väst	Västra Götaland Region	Regionens hus, SE 462 80 Vänersborg	Cluster/network	Energy

Molecular analysis of materials and surfaces with imaging mass spectrometry	Västra Götaland Region	Frans Perssons väg 6, 402 29 Göteborg	Testbed	Food and agriculture
Sensory laboratory including preparation kitchen	Västra Götaland Region	Frans Perssons väg 6, 402 29 Göteborg	Testbed	Food and agriculture
Microwave and Infrared Processing Technology of Foods and Biomaterials	Västra Götaland Region	Frans Perssons väg 6, 402 29 Göteborg	Testbed	Food and agriculture
INSTITUT FÜR DIE TRANSFORMATION DES ENERGIESYSTEMS (ITE)		Markt 18, 25746 Heide	Science park/incubator	Energy
			Cluster/network	Food and agriculture