

ESS & MAX IV BENCHMARK AND SITUATION ANALYSIS REPORT

COPENHAGEN CAPACITY & INVEST IN SKÅNE



This report is part of the sub-project 'International Attractiveness' in the Öresund-Kattegat-Skagerrak Interreg Project: MAX IV ESS Cross Border Science & Society.

The project partners in the subproject 'International Attractiveness' are



Table of contents

1	<i>Preface</i>	4
2	<i>Benchmark Analysis - Summary</i>	4
3	<i>ESS and MAX IV compared to other research facilities</i>	5
4	<i>Regional comparison – our position compared to other regions</i>	7
4.1	The overall fDi model	7
4.1.1	Quality model structure	7
4.1.2	Cost model structure	8
4.1.3	ESS/MAX IV custom sector profile	8
4.1.4	Locations.....	8
4.2	The defined regions of interest	9
4.2.1	Rhône Alpes (France)	9
4.2.2	Thames Valley (United Kingdom)	9
4.2.3	Aargau (Switzerland and Germany)	9
4.2.4	Overall results	10
4.3	Quality model	10
4.3.1	General Business Environment	11
4.3.2	Industry Cluster.....	12
4.3.3	Infrastructure and Accessibility.....	13
4.3.4	Labour Availability and Quality	14
4.3.5	Living Environment	15
4.4	Cost model	16
4.4.1	Labour costs.....	16
4.4.2	Property costs.....	17
5	<i>Key strongholds in the region of Greater Copenhagen</i>	17
5.1	Life Science	18
5.1.1	The Swedish side of Greater Copenhagen and Southern Sweden region	19
5.1.2	The Danish side of Greater Copenhagen and Southern Sweden region	20
5.1.3	Life Science R&D in the Region	21
5.1.4	Four Areas of Excellence in Life Sciences	23
5.2	ICT Sector	26
5.2.1	The Swedish side of the Greater Copenhagen and Southern Sweden region	26
5.2.2	The Danish side of Greater Copenhagen and Southern Sweden region	27
5.3	Food and Packaging	30
5.3.1	The Swedish side of Greater Copenhagen and Southern Sweden region	30
5.3.2	The Danish side of Greater Copenhagen and Southern Sweden region	32
5.4	Cleantech	32
5.4.1	The Swedish side of Greater Copenhagen and Southern Sweden region	33
5.4.2	The Danish side of Greater Copenhagen and Southern Sweden region	35
6	<i>Conclusion</i>	38
6.1	Appendix: Full weighting model	40

1 Preface

The region of Greater Copenhagen will be home to two world leading research facilities – the European Spallation Source ERIC (ESS) and the MAX IV Laboratory (MAX IV). The ESS is currently under construction, and is expected to deliver its first neutrons in 2019. MAX IV has opened on June 2016, replacing the now decommissioned MAX I, II, and III. These two facilities will have a significant impact on the region and its position as a leading region within life- and material sciences.

Our region is competing with other strong European regions, as well as globally, for attracting the right talent, the right companies, and the right investments. For us to stay competitive, we have laid the framework by analyzing how we compare to regions such as Grenoble in France, the Thames Valley in the UK and Aargau in Switzerland, all regions with similar research facilities, infrastructure and ecosystems. This report gives us a first insight into our competitive position, as well as establishing what our primary areas of strength are. Based on this, we will then formulate the unique selling points (value propositions) and developing a focused marketing and communications strategy to achieve our goal to market the region as a hot spot for materials and life sciences.

This report is a key deliverable for the work-package ‘International Attractiveness’ with the ESS & MAX IV Science and Society Interreg project.



The Region of Greater Copenhagen and Southern Sweden shown together (in a European context)

2 Benchmark Analysis - Summary

The ESS/MAX IV fDi Benchmark analysis focuses on framework conditions for potential foreign direct investment in relation to research and development. Additional focus has been put on companies that operate within material sciences and see an opportunity for further research and development using the ESS and MAX IV research facilities.

Three competing regions with similar facilities have been defined to assess the competitiveness of the Greater Copenhagen and Southern Sweden’s external environment. The analysis has investigated quality and cost separately using weighted averages of relevant data points.

The overall result shows that the **Aargau** region has a significant lead in quality, largely due to Switzerland's rich tradition of research and development and its predominant position in chemical, pharmaceutical and biotech industries. However, this matches an equally high operating cost that exceeds the average by 50 per cent.

Thames Valley benefits from a strong international position as an entry point for overseas companies seeking access to European markets. It has a strong prevalence of foreign ownership, high rate of tertiary education and extensive access to major overseas markets through London.

The industry cluster in the **Greater Copenhagen and Southern Sweden region** suffers from a low number of companies, however it has the largest research and development activity as a percentage of GDP. Although the Greater Copenhagen profiles cover the same geographical area, they differ in some framework conditions. Denmark comes out on top due to a low tax rate of 24.5 per cent and a more flexible labor market.

Rhone Alpes ranks in the lower half in most quality data points. It has advantages in its low cost and large size. The region has the largest population, which also benefits it in numbers of companies in research and development, clinical trials and GDP.

The fDi Benchmark tool has clear strengths in its wide reach of data points and customizability. There are few topics that are not touched upon directly or indirectly. However, this also makes it complex and difficult to make an overall conclusion. It is important to remember that preferences vary depending on the specific firm, and that any conclusions taken from this report should be supported by the data presented.

3 ESS and MAX IV compared to other research facilities

While ESS and MAX IV will be unique in one sense – unparalleled brilliance – it serves well to compare the two facilities, in the framework of their eco-system, to existing neutron and synchrotron X-ray sources. To this end we have chosen to focus on three operating research centres in the respective regions, Aargau, Thames Valley and Rhone-Alpes, where neutron and synchrotron X-ray sources exist side by side. Here, we give a brief introduction into the characteristics and strengths of the various sources and how they compare.

Three of the listed synchrotron facilities have in common that the ring energy is ca 3 GeV, with the exception of the ESRF having 6 GeV. This gives the ESRF a clear advantage in the very high energies >40keV which is useful for many material science and engineering applications. The specific magnet design of MAX IV gives it a particularly small emittance, which in turn makes it the most brilliant and coherent source ever. However, with its compact design, the number of beamlines under construction (15) and planned (up to 25) is small by comparison to other, established facilities, which typically boast 30 to 40+ beam lines. Beam lines in this sense are instruments at the facilities dedicated for a particular type of study. MAX IV has the smallest number of beam lines for the time being, and the energy range accessible at MAX IV makes it less useful for bulk studies. It is therefore used to concentrate on *surface studies*. Diamond and the Swiss Light Source are relatively similar in terms of age, energy, scientific scope and capabilities etc.

Some basic facts about the facilities and the surrounding infrastructures.

	ESS / MAX IV	SINQ/ SLS	ISIS / Diamond	ESRF / ILL
Region	Öresund	Aargau	Thames Valley	Rhone-Alpes
In Service since	2024/ 2016	1997/2001	1977/2007	1992/1972
No. Beamlines	16/15	20/30+	30+ / 30+	40+/40+
International or National Lab (IL/NL)	IL/NL	NL/NL	NL/NL	IL/IL

Campus	Science Village Scandinavia	PSI	Harwell	GIANT/EPN
Employees (approx.)	1000+	2000	5000	11000+
Local university	Lund, Copenhagen, DTU	ETH Zurich, EPFL Lausanne	Oxford University	Grenoble Joseph Fourier, INP

The spectrum of science undertaken at synchrotron and neutrons sources is relatively broad and typically covers all aspects of natural sciences, from chemistry, physics, biology and medicine to materials engineering. While most research is of ‘fundamental’ nature, there is no limit to studying materials and substances for varying technology-readiness levels. Indeed, there is a growing trend to investigate materials in-operando, e.g. battery materials during charge-discharge cycles.

For the neutron facilities, the difference in neutron techniques is rather different. ILL and ISIS have for many decades dominated the field of neutron studies and have been by far the most productive facilities scientific and in terms of publications, supported by the large number of beam lines. While the underlying neutron production methods are different (short pulse spallation at ISIS, highly-enriched uranium fission at the ILL, and continuous spallation at SINQ), the scientific application and methods are very similar. The ESS will have a novel type of spallation pulse structure (long-pulse) but is in principle similar to the SINQ and ISIS spallation sources in the underlying neutron production, and consequently layout of the facility (accelerator based). The trend in neutron science has been towards using spallation as the preferred method of neutron production due to the safety (no criticality or fission) and due to energy considerations. Indeed, part of the motivation towards a new neutron source in Europe has been the phasing-out of reactor-based sources now and in the forthcoming years.

While peak brilliance (neutron per unit time) in the long pulse at ESS will be very high, the time averaged flux of neutrons at the ESS will be on a par with that of the continuous reactor source ILL. So, any instrument that does not require pulsed mode (time-of-flight) but relies on the total number of neutrons delivered to the beam lines will be having an equal performance measure. While others that rely on the pulsed nature of spallation neutrons (TOF method), will see gains of potentially several orders of magnitude.

The organisational structure of all these facilities also differs, ranging from non-profit companies to national laboratories to parts of a local university. But in addition to the way that scientist access these facilities, they share the fact that they are embedded in regional science & innovation eco-systems, where a considerable number of scientists work in the immediate vicinity of the facility. Like the Lund location, the SINQ/SLS installations in the Aargau region lies close to a national border and many employees chose to commute between two countries in order to go to work, which serves as an interesting comparisons to the Öresund region. Likewise, all locations have very strong links to nearby universities, with scientific staff being increasingly often affiliation with one or other university. Together with the local supervision of students, this ensure that staff receive recognition for their work, as well as being embedded in a vibrant academic system.

It is worth mentioning here that all the facilities have the same type of operations model, based on peer-review bi-annual proposal systems, which gives free access to the facility based on the scientific excellence of the proposal and the condition that the results be made publicly available. Commercial access is typically also provided for competitive research, within a similar access framework, but the cost of accessing beam time differs significantly between neutron and synchrotron X-ray facilities, as well as within each class of facilities. The synchrotrons X-ray facilities discussed here all have industrial liaison offices which provide access services to industrial clients. For all synchrotrons, the pharmaceutical industries have a significant portion of commercial access, but several other techniques are emerging as industrially relevant, from tomographic imaging, to chemical analysis of reactions (using absorption spectroscopy) and nano-structural characterisation. Access mechanisms vary slightly between techniques employed and range from mail-in remote sample characterisation to complex experiments planned and executed over a period of months.

The commercial use for neutrons is relatively small by comparison and differs significantly between neutron facilities of the neutron facilities, ISIS is the notable exception for steady, and sometimes pioneering commercial use, partly supported through pragmatic policies of national institutions such as the department of trade and

industry. The SINQ neutron source has been notable in the growth of its commercial neutron imaging facilities. But no facility can and will be self-sustaining in terms of revenue generated, and commercial beam time is essentially subsidised and priced to a market.

For academic access, *national* facilities typically do not reimburse users from outside the home country, but several EU-funded projects exist which reimburse scientists from within the EU for their cost of accessing the facilities. And in some cases, such as MAX IV, not even researchers from the home country are reimbursed. While international facilities typically reimburse all scientific (academic) users from member countries. The same will most likely be the case for the ESS, but its operational modes are not yet defined.

In terms of scientific excellence, and volume of published research, the ESRF/ILL in Grenoble probably have the highest scientific impact, but it is very difficult to assess the scientific productivity quantitatively due to the inability to normalise the output versus e.g. number of beam lines, impact, etc.

4 Regional comparison – our position compared to other regions

To assist corporate analyses of potential fDi locations, the Financial Times has created a tool to benchmark countries or cities against each other. It allows companies, consultancies and investment promotion agencies to create an overview of relevant data on the quality and cost of locations. A subscription to the fDi Benchmark tool grants access to up to 1112 data points from a range of reliable sources.

To use the fDi Benchmark tool, it is required to define two overall variables: Locations and sector profile. Locations are either at country level or city/regional level, however not mixed in the same study. For example, a comparison of Copenhagen and Sweden is not possible. Instead, it is possible to compare either Denmark and Sweden, or Copenhagen and Stockholm. Some data is similar for all regions and cities within a country, such as tax rates or global innovation index, either because it does not differ between cities/regions or because it is not available on a sub-country level. Sector profiles are defined by two overall variables: 1) a quality model that takes into account all data points that are not direct costs of the foreign direct investments, and 2) a cost model that approximates direct costs based on head counts, utility usage, property and their respective unit costs. fDi Benchmark has a premade list of sector profiles to use in different industries. The ESS & MAX IV custom sector profile is made with inspiration from these. Our custom profile therefore has the same framework as the standard fDi Benchmark lists, however we have added and removed variables to customize it for companies in material sciences, who can benefit from the use of the ESS or MAX IV.

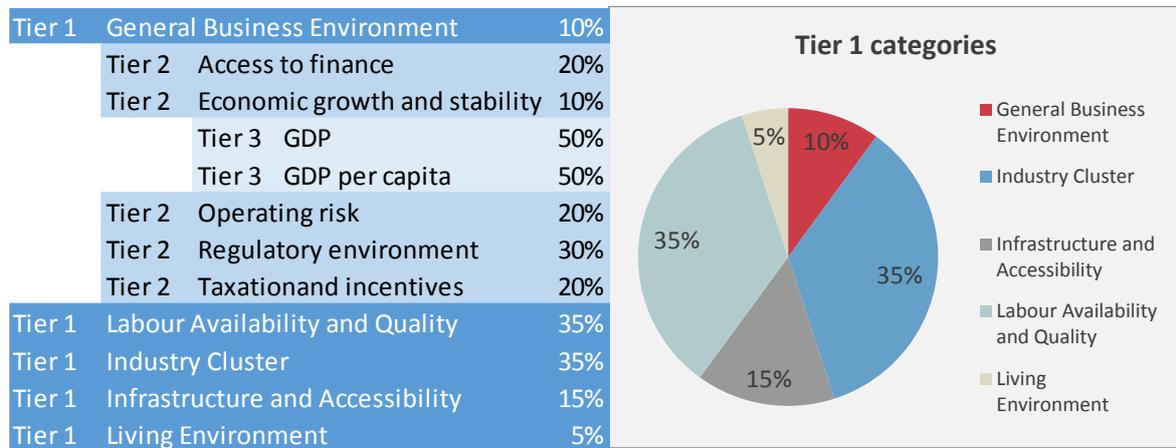
4.1 The overall fDi model

4.1.1 Quality model structure

The overall structure of all quality models is divided into three tiers of categorization, where only Tier 3 contains absolute data. For example, table 1 shows that the ESS & MAX IV custom sector profile has *GDP* (Tier 3) under *Economic growth and stability* (Tier 2), which is under *General Business Environment* (Tier 1).

Due to the large amount of data points, each data point has a small overall weight. For example, GDP has an overall weight of $(0.1 * 0.05 * 0.5 =) 0.25$ per cent. The 10 heaviest tier 3 weights are displayed in table 2. The model takes into account the differences in units and inverse relationships by converting each data point into a standardized score-system. For example, GDP score is estimated based on the minimum and maximum of the five locations, where the higher the GDP, the higher the score. Conversely, a data point like tax rate has an inverse relationship, where a lower tax rate equals a higher score. The consequence of such a system is that comparisons are only viable within the model. Once a new location enters the model, all scores recalibrate to new data points.

Table 1: Example illustration of GDP data point location in the quality model



4.1.2 Cost model structure

The available constituents of the cost model are labour, property and utilities. Labour costs are determined by the local salary levels, social benefit contributions and the head counts of different employees. Property is determined by the rental costs per square meter of office space in the local prime location (including service charges). This is multiplied by total number of m2. Given the labour intensity of the industry, we consider the cost of utilities to be too low to include in the model. It is also important to note that while the quality data points are given a relative score each, the cost index is based on absolute costs in US dollars.

4.1.3 ESS/MAX IV custom sector profile

Using the fDi Benchmark, we have constructed a weighting model that takes into account relevant factors for potential FDI in relation to ESS and MAX IV research facilities. Data points are both related to the general framework conditions and specific industries. To account for national differences within Greater Copenhagen, the region has been divided into two Greater Copenhagen profiles labeled (DK) and (SE). The weighting model is applied to the Greater Copenhagen region for both Denmark and Sweden as well as three competing regions with similar research facilities. Each location is given a quality score and a cost index. We've defined the weight such that both quality and cost weigh 50 per cent in the final ranking, but weights can be redefined to fit prioritizations.

4.1.4 Locations

The three competing regions are Rhône Alpes (France), Thames Valley (UK) and Aargau (Switzerland). These are considered main competitors due to their dual facilities similar to ESS and MAX IV. The regions are additionally defined with population size and geographical size in mind to increase comparability to Greater Copenhagen and Southern Sweden region. Industry clusters connected to the respective facilities are often found in neighboring regions or countries, which occasionally has led to the inclusion of geographically distant, but always connected, regions. The custom regions have been ordered from the Financial Times and are therefore tailored to this project. This has provided us with a more precise picture of the region and continuous support when customizing the locations and sector profile. The picture painted by the analysis is therefore considered accurate, however keep in mind that locations can have inherent advantages in their size. For

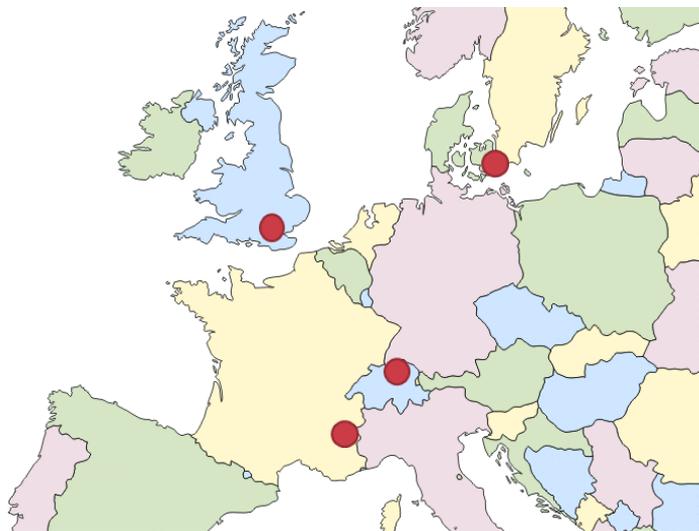
Location	Population
Greater Copenhagen	3,877,887
Rhône Alpes	6,510,561
Thames Valley	2,361,105
Aargau	4,089,991

example, Rhone Alpes has an advantage in labour force due to the encompassing region.

4.2 The defined regions of interest

4.2.1 Rhône Alpes (France)

The Institut Laue-Langevin (ILL) is situated in Grenoble within the department of Isère. The respective competing region is defined as Rhone Alpes with NUTS¹ code FR71. This includes eight departments with a combined population of 6.51 million. According to the Rhone-Alpes Chamber of Commerce and Industry (CCI), Rhone Alpes' strengths are found in high tech industries. The region is the only French member among the 19 member regions in the European Chemical Regions Network. Chemical products make up 17.3 per cent of total exports in the region, placing it second in percentage of total exports behind mechanical, electrical, electronic and computer equipment at 34.6 per cent². A Smart specialization strategy (RIS-3) developed in 2013 by Rhone Alpes Region and the European Commission set down three objectives for further specialization in chosen industries. Two of the objectives are dedicated to innovation, mainly focusing on sustainability and high-tech solutions³.



4.2.2 Thames Valley (United Kingdom)

The ISIS research facility is situated in Harwell, Oxfordshire. Due to the remoteness of the facility and the small size of Oxfordshire, the competing region has been defined as a group of counties within the region of South East England. This includes Oxfordshire, Berkshire and Buckinghamshire (including Milton Keynes), which roughly equals the unofficial region of Thames Valley, a region known for its intense business activity from top global brands and European HQs, and its easy access to London⁴. Compared to other competing regions, Thames Valley has a wider reach in industries. It is nicknamed the 'Silicon Valley of Europe' due to its large activity in technology and science, but it also spans Biopharma, Healthcare and Advanced engineering³.

4.2.3 Aargau (Switzerland and Germany)

The Paul Scherrer Institut (PSI) is located in the Aargau canton of Switzerland, however relevant industry activity exists in many neighboring regions. Thus, we have named the competing region as Aargau, but it includes four Swiss regions as well as parts of the German region of Freiburg equaling 4.1 million in total population. This is half the Swiss population, which makes industry characteristics similar to Switzerland as a whole. The country has been praised as the leader in innovation among European countries due to its strong business-university link⁵, and the Aargau canton has twice the number of people working in R&D as the Swiss average⁶. Both Zurich and Basel contain a large concentration of biotech and pharmaceutical companies. The biotech sector accounted for 45 per cent of all venture capital between 1999 and 2009, and the pharmaceutical industry accounted for 5.7 per cent of gross added value in Switzerland in 2011⁷.

¹ Nomenclature of Territorial Units for Statistics (NUTS) is a standardized system of regions and sub-regions made by Eurostat for statistical purposes.

² CCI Rhone Alpes (2014-2015), *Key figures for Rhône-Alpes Region*

³ European Commission (2013), *Rhône-Alpes Smart specialisation strategy - RIS-3* <https://ec.europa.eu/growth/tools-databases/regional-innovation-monitor/policy-document/rh%C3%B4ne-alpes-smart-specialisation-strategy-ris-3>

⁴ Thames Valley Chamber of Commerce, <http://www.thamesvalley.co.uk/global-brands/>

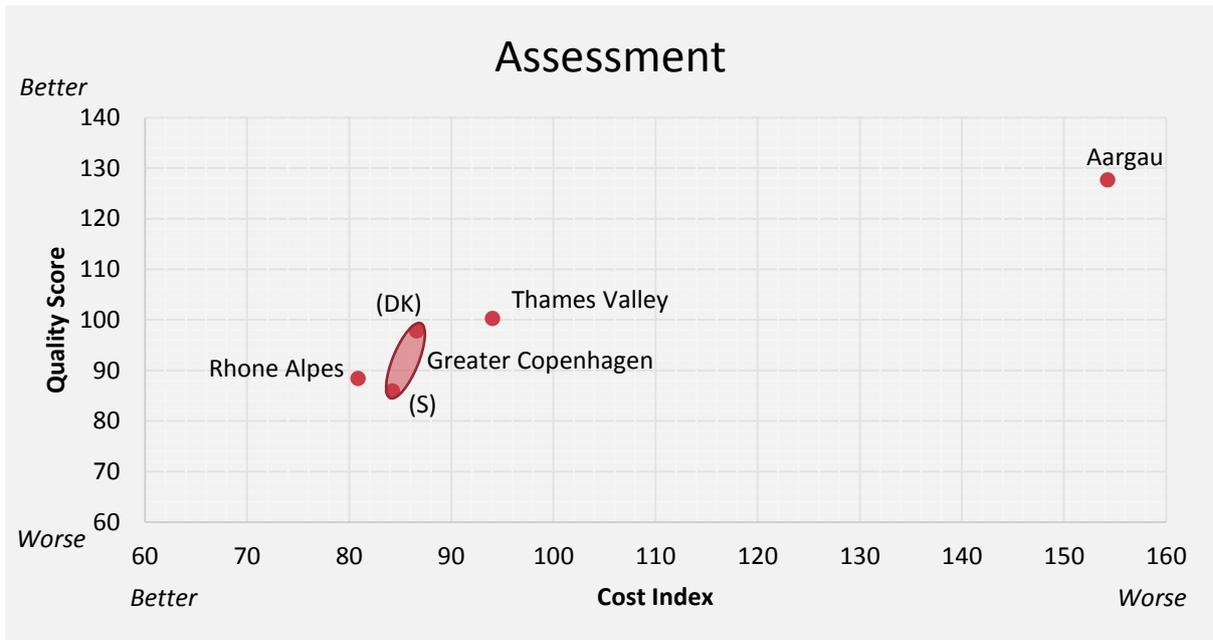
⁵ World Bank (2012), *Golden Growth: Restoring the lustre of the European economic model*

⁶ The European Business Review (2015), Aargau, Switzerland - The Centre for High-Tech Industries

⁷ Interpharma (2011), *The Importance of the Pharmaceutical Industry for Switzerland*

4.2.4 Overall results

The overall result of the sector profile shows Aargau as an outlier in both quality and cost. Although Aargau’s quality score is 28 per cent above average, its cost index is 54 per cent above average. At a fifty-fifty weight between quality and cost, rank 1 is Greater Copenhagen (DK) by a small margin. Rhone Alpes and Thames Valley are both closely following with overall scores of 99.17 and 97.00 respectively. Excluding Aargau, overall deviation is very small between the locations, and we therefore encourage the assessment of individual data points and categories before making conclusions. Differences between the two Greater Copenhagen locations are due to legal framework variations or national level data.



Location	Overall		Quality		Cost		
	Rank	Rating (0-100)	Rank	Score	Rank	Index	TotalCost (USD)
Greater Copenhagen (DK)	1	100.00	3	96.41	3	86.80	1,779,277
Thames Valley	2	99.59	2	103.48	4	93.61	1,918,886
Rhone Alpes	3	99.47	4	87.65	1	81.07	1,661,950
Greater Copenhagen (SE)	4	96.55	5	85.08	2	83.54	1,712,458
Aargau	5	91.80	1	127.43	5	154.98	3,176,917

4.3 Quality model

The quality model is broken down into five Tier 1 categories: 1) General Business Environment, 2) Industry Cluster, 3) Infrastructure and Accessibility, 4) Labour Availability and Quality, and 5) Living Environment. Each Tier 1 category has two additional tiers of subdivisions. The full weighting model can be seen in the appendix. The ten heaviest weights are displayed below.

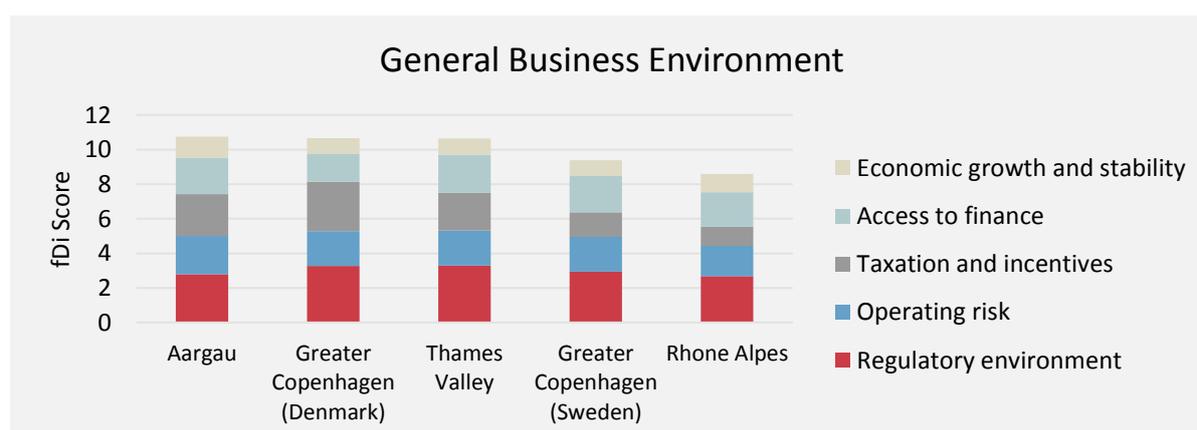
Table 2: Ten heaviest weights in the model

Data point (Tier 3)	Overall weight
1. Companies in research and development	7.0%

2. Specialisation in research and development	7.0%
3. Number of international destinations served from airports	6.3%
4. Proportion of employment in Research and Development	6.1%
5. Research and Development intensity	5.6%
6. Tertiary education	5.6%
7. Rigidity of Employment Index	4.9%
8. Hiring and firing practices	3.7%
9. Research and development (inward FDI)	3.5%
10. Researchers in research and development	3.1%

4.3.1 General Business Environment

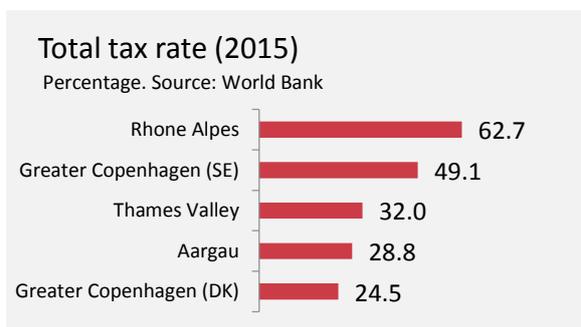
The general business environment describes the external framework for companies settled in the specific location. This includes data on risk, regulation and opportunities within the regional environment. The overall weight of the category is 10 per cent, making it the second smallest category. The result of the general business environment ranks Thames Valley, Greater Copenhagen (DK) and Aargau closely together in the top three⁸.



Total tax rate

Total tax rate takes up two per cent overall. It also makes up the largest discrepancy between locations within the General Business Environment. Total tax rates vary from 24.5 per cent (DK) to 62.7 per cent (FR) and with Denmark having the lowest rate, it claims a noticeably higher fDi score than other locations.

It should be mentioned that corporate tax rates are not transparent in all cases. The tax rate illustrated here is based on a World Bank report that takes into account several types of taxes including corporate taxes on profits, property taxes, turnover taxes etc. However, Deloitte⁹ and PwC¹⁰ are both quoting lower Swiss tax rates in the 11 to 25 per cent range, while the World Bank is citing 28.8 per cent. It largely depends on location and since



⁸ All units are given a standardized fDi score for comparability purposes.

⁹ Deloitte Corporate Tax Rates (2015)

¹⁰ PwC Tax Summaries (2015)

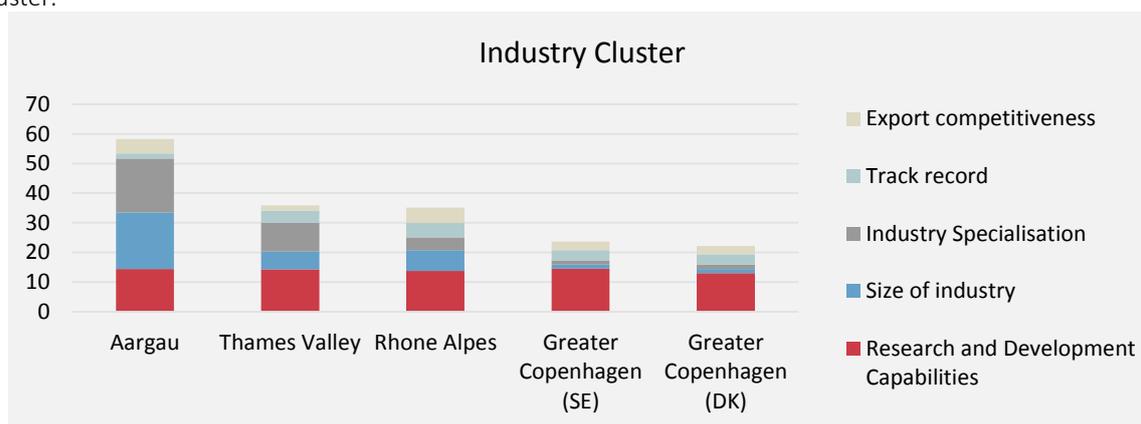
our broad definition of Aargau includes several cantons and parts of Germany, it is hard to pinpoint an exact tax rate.

Regulatory environment

Of the nine data points that make up the regulatory environment, intellectual property rights makes up the largest weight at 45 per cent (1.35 per cent overall). However, since these scores are relatively similar, the differences within the tier 2 category are found in the smaller weights. For example, Switzerland’s cost of establishing business is USD \$1,750, which is five times larger than the second most expensive of USD \$345 in France. Similarly, it takes four days to register property in Denmark, while it takes 49 days in France. In the end, the collective differences in the small weights brings Thames Valley and Greater Copenhagen (DK) on top with fDi scores of 3.3, while the rest settle in the range 2.7 to 2.9.

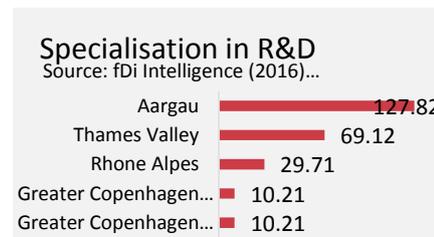
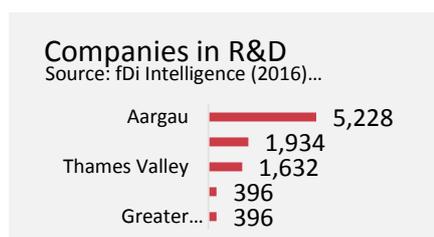
4.3.2 Industry Cluster

Industry cluster covers the existing commercial activity in each location. It contains some of the largest tier 3 weights in the model, most of which focus on current research and development activities. It also includes data on the academic world and the process of university-industry research. As one of the two largest categories in the ESS & MAX IV sector profile, Industry Cluster makes the largest difference in the final score. Aargau comes out strong with a score 145 per cent larger than both Greater Copenhagen locations. Since data is often determined by geographical area, the two Greater Copenhagen profiles are identical in most of the data points under Industry Cluster.



Companies in research and development

Companies in R&D and R&D companies per 100,000 population rank as the heaviest weights in the overall sector profile at 7 per cent each. Not only does Aargau rank first in total number of companies in R&D, it also ranks first when adjusted for population. In 2014, Confederation of Danish Industry ranked Switzerland number one in Innovation and Productivity¹¹, quoting its university-industry research collaboration and high patent activity as key factors for its success. The World Bank adds that Switzerland has a long history of academic activity and high amounts of R&D spending¹².



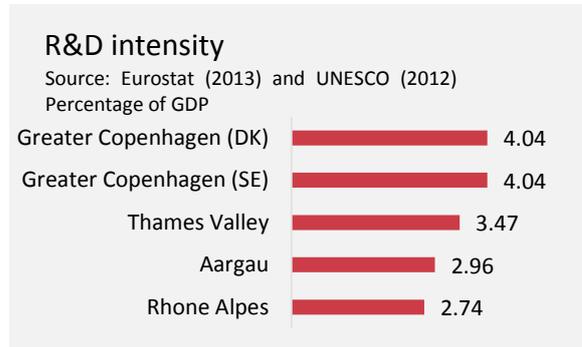
¹¹ Confederation of Danish Industry (2014), *Global Benchmark Report: Ready for globalisation?*

¹² World Bank (2012), *Golden Growth: Restoring the lustre of the European economic model*

Research and development capabilities

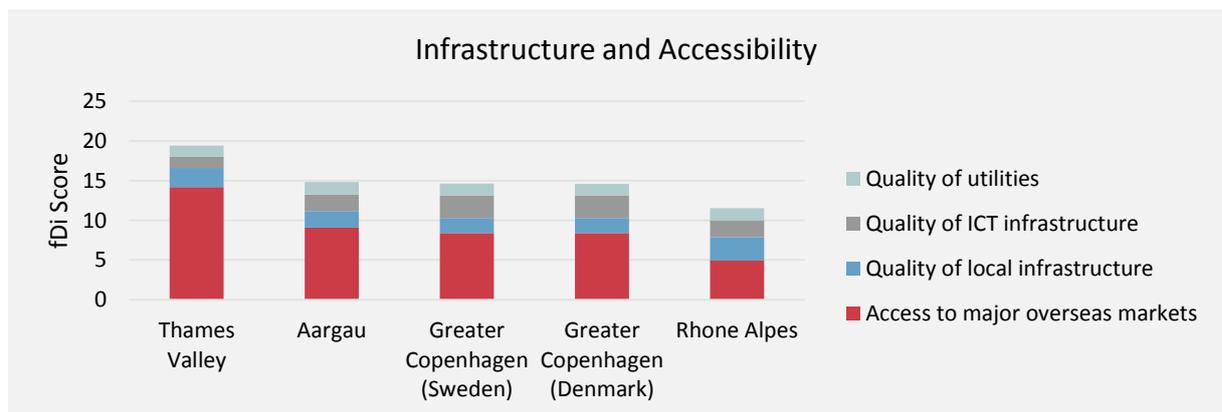
Although Research and development capabilities makes up 40 per cent within Industry Cluster, its impact on the final score is unnoticeable. This is largely due to the mix of seven different data points, in which the locations rank differently and cancel out each other. Looking at specific data points shows noticeable differences in some cases.

As a contrast to its low ranking in the number of companies in R&D, Greater Copenhagen ranks number one in R&D intensity with 4.04 percent of GDP spent on R&D activities. This data point is somewhat misleading since sources vary between location, and in the case of Aargau, it is based on country level data, while other locations have regional data. Nevertheless, it shows that despite a small number of companies in R&D, Greater Copenhagen has a relatively large amount of R&D spending as a percentage of GDP.



4.3.3 Infrastructure and Accessibility

Infrastructure and accessibility covers the smaller aspects of conducting business, such as transport and quality of technology and utilities. Despite its overall weight of 15 per cent, it contains about a third of all data points. The overall result within the category favors Thames Valley, largely due to its international connections, while Greater Copenhagen wins in ICT infrastructure and Rhône Alpes wins in local infrastructure.



Access to overseas markets

Number of international destinations served from airports has an overall weight of 6.3 per cent and therefore makes up 42 per cent of Infrastructure and Accessibility category. Thames Valley has 267 international destinations, which is almost twice that of rank two, Aargau, which has 135. This gives Thames Valley a distinct advantage not only in its tier 2 category, but also overall.

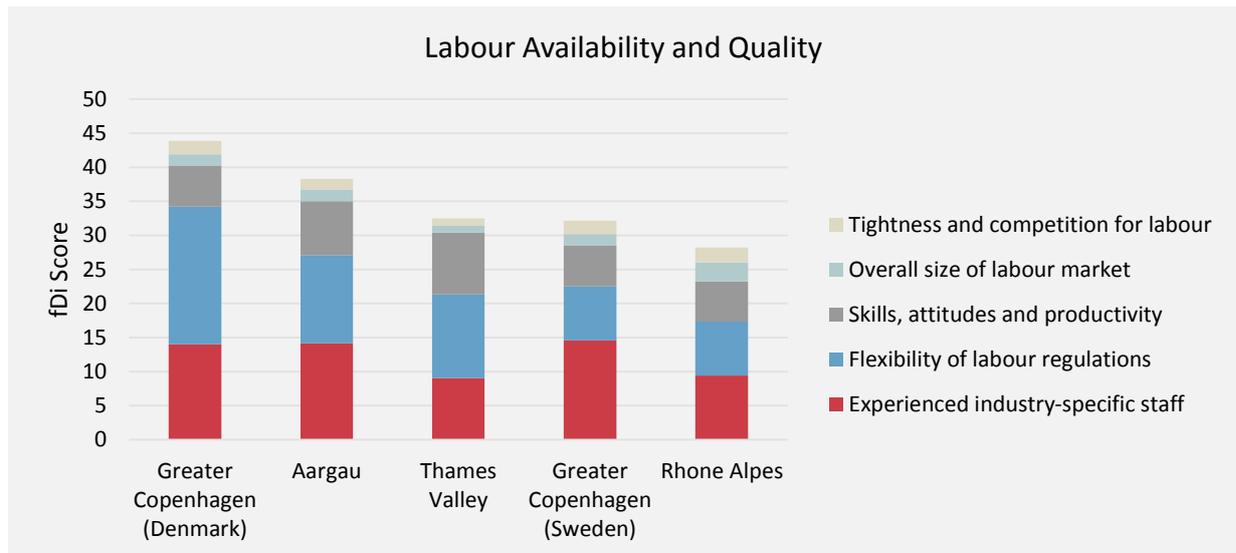


Quality of infrastructure

The scores from quality of local and ICT infrastructure are dispersed among 18 different data points that amount to about 5 per cent overall. Most notably, Internet conditions are more favorable in the two Greater Copenhagen regions with relatively high download and upload speeds, international internet bandwidth, secure internet servers and internet penetration (hosts). In terms of local infrastructure, Rhône Alpes excels in logistics networks and number of passenger-kilometers for railways.

4.3.4 Labour Availability and Quality

Labour availability and quality covers the employment and competencies of the labour market in each location. The fDi Benchmark tool allows for the inclusion of specific industries, for example Employment in Chemicals. However due to the wide application of the ESS & MAX IV facilities, the sector profile can include a long list of industries, which both overcomplicates an already detailed model and distorts the relevance for specific industries. We have chosen to exclude specific industries and use the more general term, research and development, as a proxy instead. Labour Availability and Quality has a 35 per cent weight in the overall model, which makes it the heaviest category along with Industry Cluster. The result shows a lead for Greater Copenhagen due to high labour flexibility and employment in research and development.



Flexibility of labour regulations

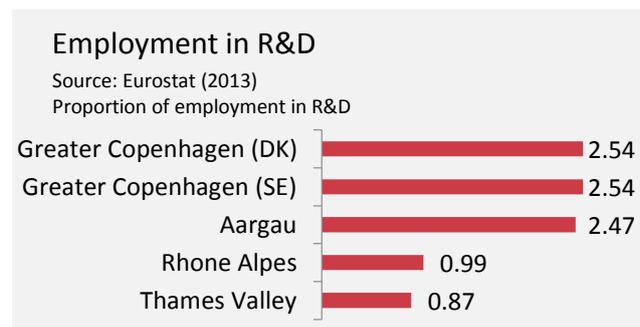
The largest difference within Labour availability and quality is found in flexibility of labour regulation. Here, rigidity of employment has a weight of 40 per cent and an overall weight of 4.9 per cent. At 3.3, Greater Copenhagen (DK) takes a strong lead with the rest settling in the range 10.3 to 24.0 (notice that a lower index equals a higher score). Also highly weighted is hiring and firing practices, where Aargau and Greater Copenhagen (DK) rank highest compared to other locations. Greater Copenhagen (SE) and Rhône Alpes generally suffer from large redundancy costs and an inflexible labour market.



Experienced industry-specific staff

As a complement to number of companies in R&D, we have also included experienced industry-specific staff. Greater Copenhagen and Aargau show high proportions of employment in research and development.

Similar, looking at the specific industries, Aargau and Greater Copenhagen generally have larger proportions in sectors that are considered high technology and R&D heavy, such as manufacturing, life sciences and ICT.

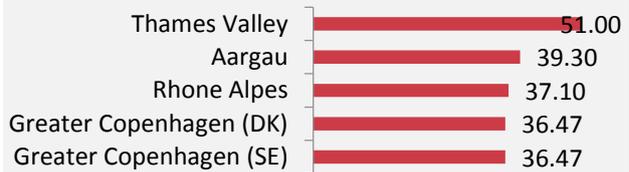


Skills, attitudes and productivity

Aargau and Thames Valley gain a distinct advantage in skills, attitudes and productivity. As a contrast to a low proportion of employment in R&D, tertiary education is 51 per cent in Thames Valley. The remaining locations range from 36.47 per cent for Greater Copenhagen to 39.3 for Aargau. Similarly, the percentages of foreign born population in Aargau and Thames Valley are 21.53 per cent and 18.04 per cent respectively, while Greater Copenhagen and Rhône Alpes have only 8.1 and 6.56 per cent respectively.

Tertiary education

Source: Eurostat (2014) and Orestat (2014)
% of population aged 25-64 with tertiary education

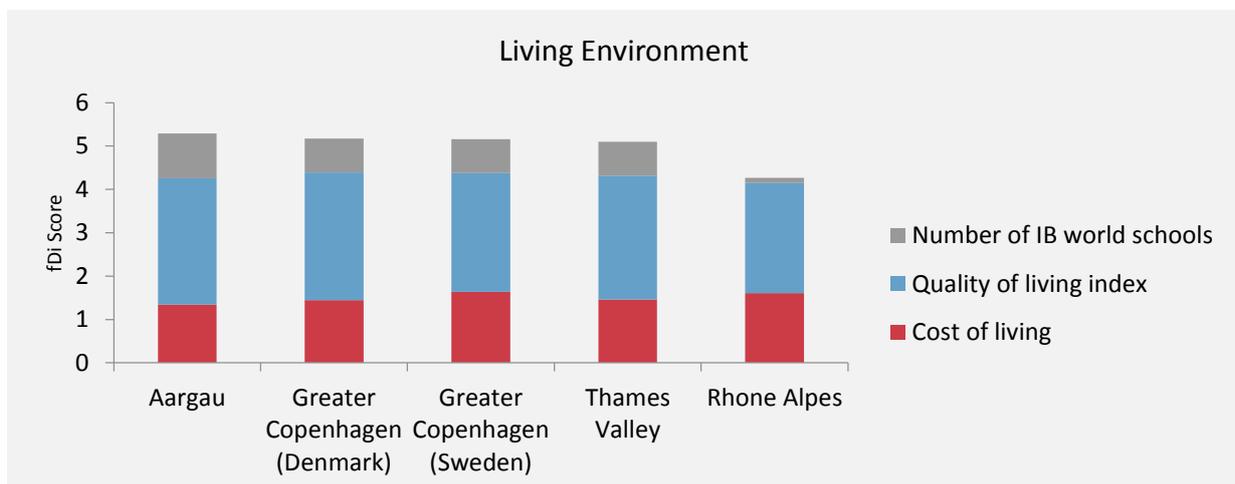


It is difficult to make interim conclusions on R&D activity and potential in the different locations, since they are not consistent across indicators. However, it seems that Aargau and Rhône Alpes consistently appear in the upper and lower ranks respectively in most data points. It should be noted that Rhône Alpes has a relatively large geographical area covering a population 58 per cent larger than the number two in this regard, which might distort the relative numbers due to lack of specificity.

Additionally, there have been obstacles in defining the Aargau location, since it combines many different cantons and parts of Germany. These boundaries include many of the related industry clusters in the area, however fDi Benchmark has not always been able to get data on the exact geographical area. Consequently, there is an inevitable degree of uncertainty in many of the R&D related data points.

4.3.5 Living Environment

As the lightest weighted category in tier 1 at 5 per cent, Living environment contains only three data points: 1) Quality of living index, 2) Number of IB world schools and 3) Cost of living index. The final contributions are similar with the exception of Rhône Alpes. At a tier 1 score of 4.27, it is an outlier from the remaining locations that are all in the 5.09 to 5.33 range. This is largely due to its low number of IB world schools. Quality and cost of living are generally equal across all locations.



4.4 Cost model

The cost model has a simpler setup than the quality model due to a much smaller number of data points. It is divided into property costs, containing only the cost of office space in the prime location of respective regions, and labour costs, containing the salary levels of seven different job functions. The cost model allows for customization in head counts, office space and salary range (lower, average or upper). However, the model assumes constant returns to scale, and the largest sensitivity is found in the mix of job functions. The assumed staff combination in an R&D center of 20 employees is listed below. As opposed to the quality model, the cost model uses the same unit, US dollar, and all data points are therefore not standardized measures, but absolute costs.

The overall result shows that Rhone Alpes, Greater Copenhagen (Sweden) and Greater Copenhagen (Denmark) all lie within a \$130,000 range of each other. Thames Valley is slightly more expensive due to significantly higher property costs, while Aargau is 50 per cent more expensive. On average, labour costs make up 87 per cent of total costs, while property costs make up 13 per cent.

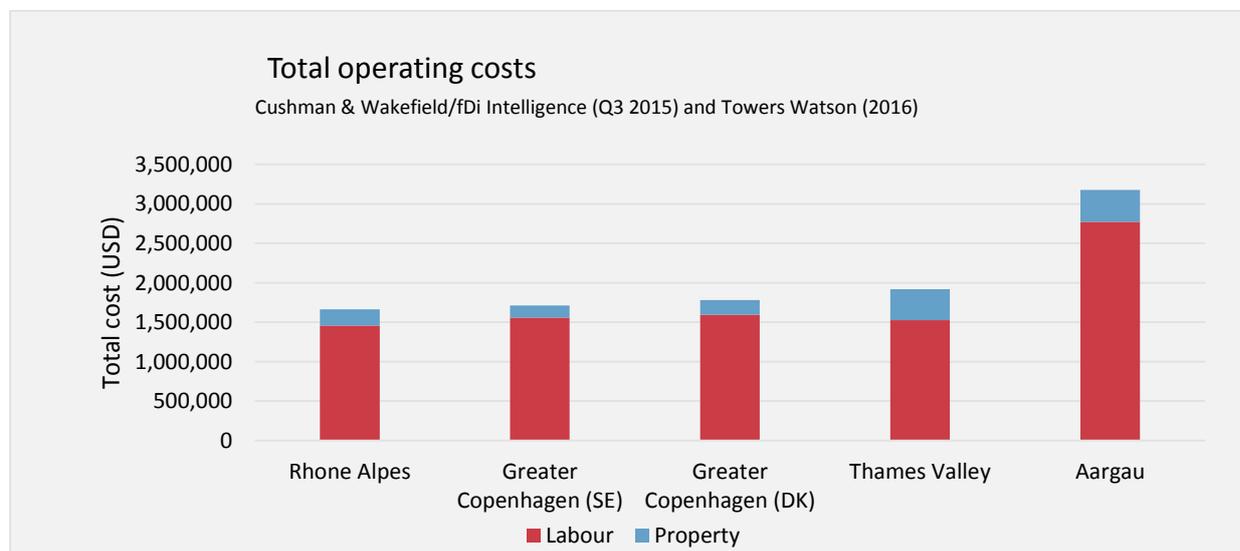


Table 3: Staff structure

Job title	Head count	Average salary (USD)
Head of Research and Development	1	195.354
R&D Team Leader	2	108.094
Software Development Engineer	1	89.549
Technology Engineering Specialist	1	89.549
Senior Engineer	4	83.809
Engineer	10	78.412
Engineering Technician	1	71.684

4.4.1 Labour costs

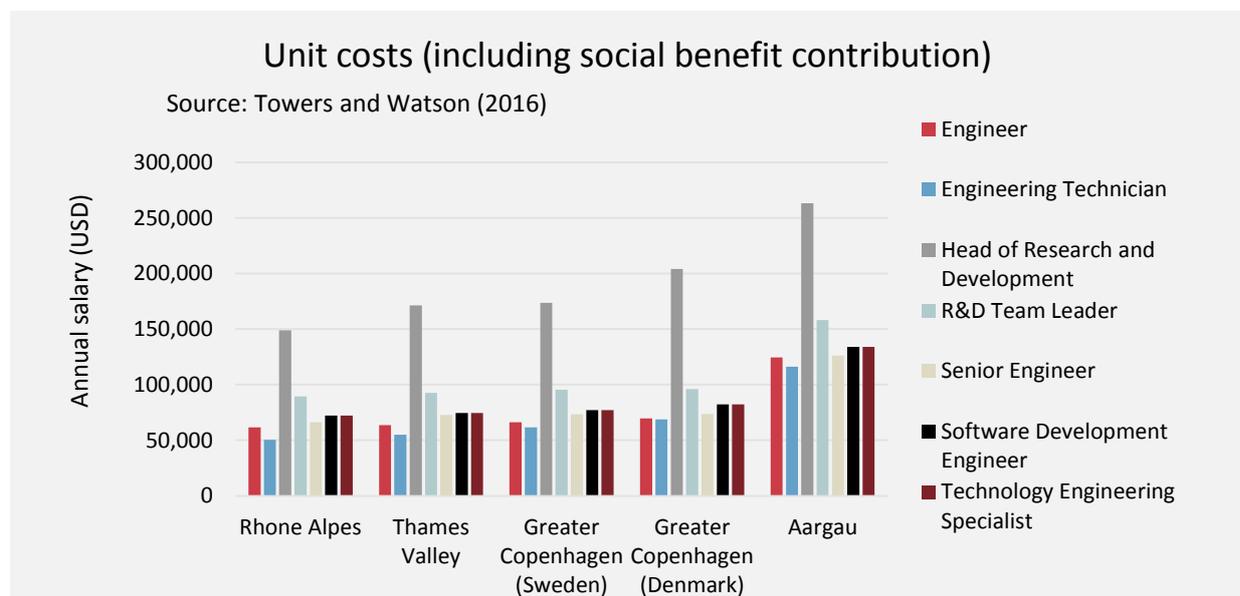
The labour costs are calculated based on salary levels and head counts. This means that although an engineer earns relatively lower than most other job functions in this model, it ends up becoming the largest contribution to the overall cost since its head count constitutes 50 per cent. The differences in unit costs between job functions is fairly consistent across locations. Head of Research and Development has the highest salary in all locations while Engineering Technician has the lowest. The total labour cost is lowest in Rhone Alpes at \$1,428,881, closely

followed by both Greater Copenhagen locations and Thames Valley in the range \$1,528,161 to \$1,562,263. Labour costs in Aargau are on average 30 per cent higher resulting in \$2,713,431 in average annual labour costs.

All labour costs include social benefit contributions. This is a mandatory addition to monthly salary that are implicit in the labour costs illustrated here. Similar to the discussion on total corporate tax rate, social benefit contributions are difficult to determine as a constant rate. Although the official social benefit contribution rate is zero per cent in Denmark, there is a contribution of approximately 10,000 DKK annually per employee depending on pensions and labour market funds¹³. This is not included in the model. All social benefit contributions vary in terms of deductibles, tax brackets and absolute or relative costs. However, the fDi Benchmark data provided by Towers Watson and Deloitte seems to paint a reliable rough picture of social benefit contributions for all locations.

4.4.2 Property costs

Property costs make up 13 per cent of total operating costs on average. The cost of office space generally settle into two price ranges. For Rhone Alpes and the two Greater Copenhagen locations, the cost for 500 m2 is \$150,000 to \$200,000 a year, while Thames Valley and Aargau are closing in on \$400,000. In the final model, this means that Thames Valley becomes slightly more expensive than Rhone Alpes and both Greater Copenhagen locations, despite having similar labour costs.



5 Key strongholds in the region of Greater Copenhagen and Southern Sweden

This chapter looks at the common strongholds on the Swedish and Danish side to complement the fDi benchmarking tool to give a comprehensive overview of region's strengths and focus areas. The strongholds have been selected based on the experience of the two investment promotion agencies on each side of the region – Copenhagen Capacity and Invest in Skåne. The strongholds are the areas that can benefit from the opening of European Spallation Source and upgrading of MAX IV. Historically the chosen strongholds have been exposed to great political attention and this has led to their development into areas with strong pioneer companies as well as great research competencies.

¹³ PwC (2014), *Social security systems around the globe*

The strongholds are described in an overall level looking at key figures, but also what is needed in the future to keep it as a stronghold – thus showing the window of opportunity for foreign investments. Naturally some areas which are considered strongholds in other respects, e.g. science or even industry are left out. The focus of attention have been Life Science, ICT, Food and Packaging and Cleantech industries as well as their sub-areas. These sectors have been selected by the investment promotion agencies as strongholds in the region jointly. Niche areas are covered in the following chapter.

5.1 Life Science

The life science sector in the Greater Copenhagen and Southern Sweden region has a cluster organization named Medicon Valley Alliance. Medicon Valley is a geographical area covering the island of Zealand in eastern Denmark and Skåne in the southern part of Sweden. Medicon Valley is home to 12 universities, 5 of which supply life science related educations, which have a total of 50,000 students enrolled in life science courses and produce around 2,000 PhD's every year¹⁴.

Medicon Valley Alliance was founded in 1997 and has been a frontrunner in establishing this cross border region through close collaboration between public and private entities on both sides of Øresund. Today, the pharmaceutical companies Novo Nordisk A/S, A and H. Lundbeck A/S, for instance, are among the key drivers in the industry along with a significant number of successful smaller innovative biotechnology and medical technology companies. Companies and organizations of the regional life science cluster employ approx. 140.000 people¹⁵ and contribute significantly to making the cluster one of the strongest in its field. The Medicon Valley Alliance members also play a significant role in the national economies. Pharmaceuticals and medical equipment for example, accounted for 11.4 %¹⁶ of all Danish exports in 2013 and 8.1 %¹⁷ of all Swedish exports in 2015. The life science cluster members represent the region's triple helix and include universities, hospitals, human life science businesses, regional governments and service providers. The core industries of this cluster consist of pharmaceutical base products, pharmaceutical preparations, medical equipment and instruments, manufacture of dentures, medical and pharmaceutical R&D.



Photo source: Medicon Valley Alliance website.

¹⁴ Medicon Valley Alliance website: www.mva.org

¹⁵ Medicon Valley Beacons (2014), *Access Medicon Valley*

¹⁶ Access Medicon Valley: Medicon Valley Beacons (page 7)

¹⁷ Swedish Industry Export Data 2015

5.1.1 The Swedish side of Greater Copenhagen and Southern Sweden region

Sweden is considered to be one of the world's most prominent research nations. The government is investing significant resources in research and development as this is considered to be a prerequisite to Sweden being a leading life science nation and reaping the benefits of contemporary globalization.

A distinctive feature of the life science sector in Skåne is that it is heterogeneous in terms of the size and areas of activity of the companies involved. Historically, the pharmaceuticals industry in the region has been dominated by large companies such as Astra and Pharmacia. These companies are now part of multinational pharmaceutical corporations, partly as a result of the massive wave of restructuring that took place in the 1990s. In addition, a number of small research-oriented biotechnology companies focusing on new pharmaceuticals emerged around the University of Lund, the university hospitals and the support structure that has been built up in connection with Ideon Science Park. Today there are around 100 such companies in the region as a whole¹⁸. Several of the companies were founded by scientists at the region's universities, while others are spin offs of the major pharmaceutical companies.

Virtually all biotechnology companies were established after 1995. The sector includes around 6500-7000 active individuals in Skåne which is 16 % of the overall Swedish national employment (data from 2014 –Vinnova).

It is worth mentioning that the international success of Skåne's medical technology companies can be attributed to product development in close collaboration with the region's medical facilities and universities. If we take the region as a whole, medical technology is usually described as the Swedish side's most prominent strength, while the profile of the Danish side leans more towards pharmaceuticals involving less direct interaction with the region's hospitals.

The major research centres include the Biomedical Centre at Lund University, which employs nearly 800 people (researchers, graduate students and technical/administrative staff), and the Clinical Research Centre in Malmö which employs around 420 people, most of whom specialize in the field of diabetes research. Besides diabetes, cancer research, neuroscience and inflammatory diseases are also regarded as fields of excellence¹⁹ in Skåne. Recent years have also seen major growth in stem cells research, blood coagulation and nanotechnology. The University of Lund is a key actor and probably the single most important factor behind the position on this side of the region, even if much of the research is also conducted within companies. As with most other life science clusters in the world, the proximity of academia and industry is highlighted as a recipe for success.

16% of Swedish life science employees are based in Skåne and in a national context, Skåne is usually ranked as third largest in life science, after the Stockholm region (including Uppsala) and Västra Götaland (Gothenburg in particular).

In particular, the Skåne's life science research strengths can be summarized as below²⁰:

- Biobanks for new tests – an obvious link to ESS and MAX IV
- Biomarkers – strong competency in research
- Thorax and neurology – strong technical and clinical trials and research
- Diabetes (solid research and knowledge but not commercially strong yet)
- E-Health
- Oncology (strong research, with significant therapeutic compounds in the pipeline)
- Odontology
- Formulation knowledge
- The peptide chemistry
- Functional food – linked to preventive care

¹⁸ Innovation and regional transformation (Henning, Moodysson and Nilsson)

¹⁹ Innovation and regional transformation, page 139 (Henning, Moodysson and Nilsson)

²⁰ Region Skåne, Life Science Strategy 2014

- Medical and surgical cardiovascular activity. There are links to the industry with pumps and transplantation liquids.
- Medical Nanotechnology/Drug delivery and electro therapy

In addition to the customary fields of strength, Life Science in Skåne is also quite rapidly progressing towards key enabling technologies within materials science and future trend setting by the industry. These include among others regenerative, precision medicine, diabetes, cancer and reproduction medicine. Within reproduction medicine for instance, it is worth mentioning the ReproUnion project that is a cross border collaboration between Sweden and Denmark in the Öresund Region, funded by EU Interreg V. The region emerges as world leading in overcoming infertility and in meeting future demands of managing and preventing infertility problems.

There are 268 companies on the Swedish side of the region²¹ who are conducting state-of-the-art and leading research and product development in biotechnology, pharma as well as medical technology with primary therapeutical areas ranging from neoplasms, cancer and oncology through to infectious and parasitic diseases as well as immune disorders. Some of the prominent regional companies include AnaMar, Active BioTech, BioInvent, Hansa Medical, NeuroVive Pharmaceuticals, Red Glead Discovery, Spago Imaging, Immunovia, Genovis, Idogen Respiratorius, Magle Life Science, Rechon, Galenica, Polypeptides, Glycorex, Probi, Camurus. For a complete list of Skåne life science companies, main business sectors and their therapeutical areas please see the link:

<http://www.mediconvalley.com/industry/database>

5.1.2 The Danish side of Greater Copenhagen and Southern Sweden region

Large companies as Novo Nordisk, Lundbeck and Leo Pharma have dominated the development of the life science sector on the Danish side of Greater Copenhagen. Currently, Denmark has the largest commercial drug development pipeline in Europe measured per capita¹⁶. The long-standing tradition and solid foundation for pharmaceutical research in Denmark has facilitated the establishment of a number of biotech companies.

Key benefits in Medicon Valley on the Danish side are:

- Electronic health data, such as personal registries (CPR), available from several decades past, allowing researchers to follow the course of disease.
- Accurate and comprehensive medical databases of clinical trials provide researchers with a rich source of medical and genetic information.
- The Danish Cancer Registry dating back to 1942 is among the world's best cancer registries.
- Therapeutic strongholds include cancer, metabolic diseases, inflammation and neurology research.
- Medicon Valley ranks no. 1 in Europe for drug pipeline, clinical trials and investment in R&D per capita in biotech and pharma.
- 13% of the Danish population has contributed to a clinical trial or medical research, which is more than 100,000 persons annually.
- Denmark is investing more than 5.6 billion Euro in new hospitals over the next years²².

The MedTech industry in Denmark is well-reputed abroad for a number of leading global companies in consumables, hearing aids, diabetes devices and diagnostic devices. These companies are prominent in Danish business and industry, and they spearhead a strong position in the Danish MedTech industry, which is one of the largest in the world measured in exports per capita²³. The medical devices industry is sustained by innovation and product R&D, and Danish enterprises benefit from an array of well-established innovation centers distributed throughout Denmark.

²¹ Medicon Valley Alliance Database

²² Copenhagen Capacity (2016), www.copenhagencapacity.com

²³ Invest in Denmark (2014), *Peak Conditions for MedTech Companies*

The Danish side of the Medicon Valley is home to more than 200 + medico companies of which 200 conduct R&D and/or production. Strongholds include:

- **Disposables.** Syringes, needles, wound-care products, single-use devices and other disposables account for 40% of the Danish medtech industry.
- **Diagnostics.** Around 20 companies are engaged in R&D developing various diagnostics kits, blood analysis equipment, ultrasound scanners and bioinformatics diagnostics.
- **Hearing devices.** Denmark has captured 40% of the global hearing aid market, owing to strong R&D competences.
- **Assistive technology.** Design, functionality, quality and user-friendliness characterises Danish assistive technology products, giving Denmark a leading position.²⁴

5.1.3 Life Science R&D in the Region

The Greater Copenhagen and Southern Sweden region is home to pioneering research that is breaking new ground in cancer treatment, diabetes, inflammation and neurological disorders. World-class research is matched by world-class facilities with knowledge sharing networks, advanced medical record databases, comprehensive health registers, and support organizations. The University of Copenhagen and the University of Lund are the two largest in terms of number of students and researchers – they account for more than 90% of the life science related students in Scandinavia²⁵. Copenhagen Bio Science Park is a newly built 12,000 m² science park, which is located closely to Copenhagen University Hospital, Faculty of Health Sciences and the Faculty of Pharmaceutical Sciences from Copenhagen University.

Diabetes

Medicon Valley has more than 10 companies dedicated solely to diabetes research, making this area a world leader in diabetes care. There are currently over 40 compounds in the pipeline for diabetes and metabolic disease, with a large portion of the cluster's R&D expenditure focused on this field.

LUDC (Lund University Diabetes Centre) and AFC (the Anti-diabetic Food Centre) at Lund University and Center for Diabetes Research at Gentofte Hospital and the Novo Nordisk Foundation Center for Basic Metabolic Research in Denmark make Medicon Valley the home of one of the largest and most respected diabetes research centers in the world.

Neuroscience

Applied Neuroscience is another area in which Medicon Valley excels, and is considered to be a world leader. Although the volume of organisations in the region is small, there are over 60 compounds in development.

The multidisciplinary research at the Wallenberg Research Centre focuses on understanding neurodegenerative diseases. The centre studies cell and animal models of Huntington and Parkinson diseases to develop therapies that benefit both patients and their caregivers.

Additionally an Epilepsy Center was recently established in Lund as part of a large European project. Advancements are being achieved through the strong cooperation with other universities and industry leaders within Medicon Valley.

Research at The Brain Research and Integrative Neuroscience Laboratory (BRAINlab) at Copenhagen University is aimed at understanding normal, pathological and adaptive brain functioning, both at the molecular and systems level, thereby using a wide variety of techniques and approaches.

²⁴ Copenhagen Capacity (2016), www.copenhagencapacity.com

²⁵ Medicon Valley (2007), *A Danish-Swedish Life Science Cluster*

The Center for Neuropsychiatric Schizophrenia Research (CNSR) conducts multidisciplinary neuropsychiatric research. CNSR hosts a Lundbeck Foundation Center of Excellence for Clinical Intervention and Neuropsychiatric Schizophrenia Research (CINS).

Cancer

Cancer research is Europe's fastest and largest growing field, with 23 % of first round venture investments being commanded by companies focused on this area. Medicon Valley is home to more than 25 organisations focusing on cancer research, which collectively have over 75 therapeutic compounds in the pipeline.

Rigshospitalet in Copenhagen has a new unit dedicated to Phase I and II cancer research trials, which recruits patients from across Medicon Valley. At the Sino Danish Breast Cancer Research Center Danish researchers collaborate with leading Chinese geneticists from Beijing Genomics Institute.

Another successful initiative is CREATE Health, which is a strategic center for clinical cancer research. The center brings together researchers from diverse fields, such as nanotechnology, proteomics, cancer genetics and tumor cell biology to develop novel cancer treatments and diagnostics.

The MAD for Cancer program is a unique concept in that it brings together several different facets of cancer biology into a multifocal approach. Areas including early diagnosis, patient stratification, targeted therapies attacking every tumour cell type and resilience are studied. The hallmark of this battle is the creative force generated by national and international collaborators from different scientific disciplines.

Inflammation and autoimmune diseases

There are over 20 pioneering companies in Medicon Valley working in the field of arthritis. There are also many world-class research groups exploring arthritis from basic immunology to applied inflammation research. The organisations involved in this research have over 45 compounds in the pipeline.

The university city of Lund has had a lot of commercial success in this area, from developed treatments for allergic asthma to infection control. Here, industry works with academia to create a synergy resulting in one of the most respected centres for inflammation study, prevention, and treatment in the world.

In Denmark there are several research groups conducting research within this area; the Institute for Inflammation Research (University Hospital of Copenhagen), the Centre for Inflammation and Metabolism (CIM) and the Department of Drug Design and Pharmacology (University of Copenhagen).

Stem Cell Research

With the focus on stem cell and developmental biology, the research covers developing stem cells, cell replacement, and gene therapy. Stem cell research has become an integral and important part of the research carried out at Lund Stem Cell Centre at Lund University. This is both as stand-alone research, and as an essential part of other research areas and projects. The aim is to pioneer advancements in new cell therapies, particularly those treating diseases that currently have no treatment options.

The Danish Center for Stem Cell Research (DanStem) at the University of Copenhagen comprises two sections; the Novo Nordisk Foundation Section for Basic Stem Cell Biology and the Section for Strategic Translational Stem Cell Research and Therapy.

At University of Copenhagen, healthcare research is undertaken across the biomedical, natural and social sciences. Human and veterinary health and disease are addressed as one, from a 'singlehealth' perspective. Key areas include metabolic, neurological and mental health, healthy ageing, lifestyle diseases, cancer and communicable diseases including zoonoses.

For Medicon Valley to be a serious contender in the highly competitive global life science race, the cluster as a whole needs to strengthen its ability to attract a constant stream of talent and capital. The objective is to develop, expand and brand selected research environments that build on Swedish-Danish synergies between existing

strongholds – in both the private and public sector – and which span the entire life science value chain from early research all the way to commercialization, in order to drive economic growth and job creation in the region.

5.1.4 Four Areas of Excellence in Life Sciences

In addition to the pioneering and ground-breaking research, the region of Greater Copenhagen and Southern Sweden has four key common strongholds within life sciences. To address future challenges, the region's cluster organization initiated the "Beacon Initiative" in 2014. The aim of this initiative was to identify 3-5 areas (so-called "beacons") in which Medicon Valley could become world leading. By doing so, it was not only the intention to strengthen the selected research areas, but also to stimulate innovation, business development, and economic growth in the entire region. Following an extensive evaluation of existing life science strongholds in the region based on analysis and input from regional stakeholders four Beacons had been selected– systems biology, structural biology, immune regulation and drug delivery. Four beacons, which potentially have specific relevance to use of ESS and MAX IV are focused on in this analysis.

Systems biology

Systems biology is the study of how different components, such as molecules, genes or cells, in a biological system interact and how their interaction shapes the function and behavior of the system.

Using computational models, systems biologists analyze the impact of different variables on biological systems. Variables could be genetic variations or the vast amounts of phenotypic data found in e.g. patient records and biobanks. By running correlations of such data, it becomes possible to reveal undiscovered disease trajectories. Systems biology essentially applies the principles of Big Data to life science. Just like retailers use data from a range of sources to predict which additional goods an individual is likely to purchase, systems biologists use data to forecast the likelihood of an individual developing a certain disease and to assess whether a drug is likely to have the desired effect on a patient²⁶.

Systems biology has the potential to revolutionize the treatment of complex diseases like cancer as it allows doctors to design highly personalized patient treatments. Cancer research is one of the research strongholds of University of Copenhagen and the University of Lund, making this area specifically interesting since it will provide an ecosystem for companies within e.g. cancer. By providing a highly accurate means of predicting and measuring the efficacy of drugs on different patient groups, systems biology also plays an important role in determining the commercial viability of a new drug. Moreover, it opens up the possibility for offering preventative treatments to certain patient groups and for gaining a better understanding of how environmental factors affect health.

Denmark and Sweden have a long history of collecting longitudinal health data sets through the social security number systems. Structuring this data and creating models and platforms to analyze it would provide a strong foundation for researchers to describe the effects of genotype on phenotype including the non-uniform response to interventions for diseases. This beacon is mostly relevant for companies working in the very early stages of product development making the two research facilities in Lund an interesting proposition for them to use in their drug development.

The region of Greater Copenhagen have a many strong research centers related directed to systems biology:

- DTU Systems Biology, Technical University of Denmark
- Create Health – A Strategic Center for Translational Cancer Research, Lund University
- The Novo Nordisk Center for Protein Research, University of Copenhagen
- Computational Biology & Biological Physics, Lund University
- The Bioinformatics Center, University of Copenhagen

²⁶ Medicon Valley Beacons, *Structural biology - Accelerating drug discovery*

- Lund University Diabetes Centre, Lund University
- Department of Biomedical Sciences, University of Copenhagen
- The Division of Applied Microbiology, Lund University

Structural Biology

Structural biology is the field of science seeking to visualize the structure of biological molecules, such as proteins, in order to understand their functions and properties. There is a strong emphasis on proteins in structural biology as they carry out many of the key functions in living organisms.

By using various techniques such as x-rays or neutron scattering, structural biologists can obtain a three-dimensional picture of a protein involved in a disease i.e. a target protein. Knowing the structure of the target protein helps predict which drugs will either inhibit or stimulate it. This greatly optimizes the drug discovery process – without information about the target molecule, drug discovery is a bit like trying to find a needle in a haystack.

All companies involved in drug discovery today have a high interest in structural biology. Knowing the structure of both the target related to a disease and the structure of the possible new compound to treat it is essential in drug discovery. Missing either could have tremendous economic consequences.

The structure of some proteins currently remains unknown despite an almost exponential growth in discovered protein structures over the past twenty years. Membrane proteins, for instance, are key to understanding cell physiology, but it is notoriously difficult to obtain their structural information. Macromolecular complexes, such as protein-protein interactions, present another big challenge. Once the structure of such molecules is known, there is huge potential for developing new ways to treat several diseases such as diabetes, obesity and cancer.

The MAX IV facility and the ESS will be game-changers in this respect, as they will make it possible to visualize the structures of these molecules.

Medicon Valley is home to several excellent research centers and facilities directly related to structural biology such as the Novo Nordisk Foundation Center for Protein Research at the University of Copenhagen, the Department of Systems Biology at the Technical University of Denmark and the Department of Biochemistry & Structural Biology at Lund University. Once the state-of-the-art technologies in the MAX IV facility and the ESS are up and running, Medicon Valley will be in a unique position to push the scientific boundaries within structural biology, especially by fostering greater collaboration between academia and industry.

Immune regulation

The immune system protects the body by responding to foreign organisms and substances (known as antigens), which invade the body and cause disease or infection. When the immune system fails to function properly, it can lead to a range of disorders such as allergies, cancer, autoimmune and immunodeficiency diseases. Autoimmune diseases include disabling inflammatory chronic diseases such as diabetes and arthritis, several skin diseases including psoriasis and dermatitis, and chronic neurological diseases including multiple sclerosis and Alzheimer's disease. AIDS is an example of an immunodeficiency disease.

Immune regulation enables the treatment of these disorders by blocking or controlling immune responses. It also plays a vital role during organ transplants and in the development of new vaccines.

Millions of people around the world suffer from chronic diseases caused by immune system disorders, creating a huge demand for effective and safe treatments. Increasing our understanding of immune regulation opens the door for manipulating and regulating the immune system in a therapeutically desirable manner. Within oncology there are, for instance, several promising signs that immunotherapies can be used to treat or slow down the

progression of cancer by manipulating the patient's immune system to specifically target cancerous cells. Moreover, there is a big need for increasing the success rates of organ transplants given the considerable gap between the number of those in need of new organs and the number of organ donors. Developing effective immune suppressive agents is fundamental to this.

Finally, immune regulation also holds the key to producing new and better vaccines.

Medicon Valley has a strong tradition within both basic and clinical immunological research to build on. Several researchers are internationally recognized and cutting-edge research is taking place at the regional universities. Numerous pharmaceutical and biotechnological companies in the region are also engaged in developing ways to treat immunological diseases while several diagnostic companies in the region have products and R&D projects related to immunology. As such, there is considerable potential in Medicon Valley for pushing the boundaries within immune regulation by encouraging all these players to collaborate more closely. There are significant regional companies involved with research and development in immune regulation such as Lundbeck, Novo Nordisk, Leo Pharma, Novozymes, ALK Bello, Active Biotech and Genzyme among others.

Drug delivery – optimizing drug transport and targeting

Drug delivery is the process by which drugs are administered to patients to optimize the localization or the duration of the treatment. For drugs to be effective, they need to arrive where they are required in the body in the right concentration. Ensuring that drugs mainly target a diseased area is also highly desirable as it reduces the side effects, which may occur when drugs influence other parts of the body. Drug delivery R&D focuses on developing new ways of getting drugs absorbed into the body, new ways of ensuring targeted delivery (i.e. that the drug is mainly active in the target area of the body), and new ways of ensuring sustained release (i.e. that the drug is released over a period of time in a controlled manner).

Optimizing drug delivery plays a central role in drug development. Many promising drug candidates are discarded, because there is no known method of directing them to the diseased area of the body. The blood-brain barrier is, for instance, notoriously difficult to penetrate, making it difficult to treat brain tumours or diseases such as epilepsy and Alzheimer's. The shift towards treating patients with macromolecular biopharmaceuticals, such as protein-based and nucleic-acid-based drugs, is also intensifying the race to develop new innovative drug delivery systems – not least because biopharmaceuticals are key to personalizing medicine.

Biopharmaceuticals are difficult to deliver orally because they are vulnerable to enzymatic degradation in the gastrointestinal tract and their large molecular size makes them difficult to absorb. The success of bringing new biopharmaceuticals to the market and tailoring treatment to the individual patient is therefore closely linked to the development of drug delivery systems.

Medicon Valley is home to several academic research groups developing new approaches for better drug delivery. Examples include the Section of Pharmaceutical Design and Drug Delivery at the University of Copenhagen, the Center for Nanomedicine and Theranostics at the Technical University of Denmark, the Drug Delivery Development Group at Lund University and the Biofilms Research Center for Biointerfaces at Malmö University.

Furthermore, the MAX IV facility and the ESS have the potential to accelerate innovation within drug delivery systems as detailed nano-scale structural information about potential drugs are a valuable asset to researchers designing new drug delivery systems. Finally, developing drug delivery systems requires a great deal of collaboration between the different academic life science disciplines, biotech, medtech and pharmaceutical companies as well as hospitals. Medicon Valley, with its strong culture of collaboration, is therefore well equipped to foster innovation in this field – especially given the local industry's strong track record in pioneering drug delivery systems.

Regional companies leading the way and actively engaged in drug delivery and optimizing drug transport and targeting are NovoNordisk and Camurus.

5.2 ICT Sector

In both Sweden and Denmark, the ICT sector plays a significant role as a source for economic growth, as a key employer and as a provider for solutions to societal challenges. The Nordic countries have a great legacy both as leading ICT providers and as the world's foremost knowledge economies. For example, the World Economic Forum, which publishes the Networked Readiness Index (NRI) as a part of its annual Global Information Technology Report, placed Sweden 3rd, and Denmark 15th, among the 143 countries ranked in the 2015 edition of NRI. Among the ten sub-indices of NRI, Sweden ranks the highest in "individual usage" and "economic impacts" while Denmark gets its best marks in "individual usage" that measures ICT penetration and diffusion at the individual level. In international comparison, Denmark and Sweden are undeniably among the most intense and advanced ICT-using countries in the world.

5.2.1 The Swedish side of the region

Swedish companies are highly innovative in creating new products and services and are leaders in patenting ICT-related technology. Almost half of the Swedish workforce is employed in knowledge-intensive jobs²⁷.

The ICT sector in Skåne can be best defined by its core activities: manufacture of electronics and ICT equipment, computer consultancy activities and computer services and telecommunications. While in the past the ICT in Skåne was characterized by high knowledge content, extensive research and good growth potential, the lack of relative regional agglomeration and a limited amount of strategic exchanges meant that the sector could not be said to constitute a regional cluster²⁸.

Internationally, Sweden has a strong position within the ICT sector and a major contributing factor is Ericsson's evolution into a multinational telecommunications company. In Skåne, just as in the nation as a whole, Ericsson's development has been of great importance for practically the entire ICT sector. Ericsson, Sony Mobile, AXIS and other ICT players in the region, employ a significant number of highly qualified individuals in the sector – almost 5,000 individuals according to Mobile Heights²⁹. One factor that contributes to explaining why Ericsson and a number of IT companies have been able to grow relatively strong in Lund is the ready availability of labour that has come about as a result of the emergence of the Lund Institute of Technology (LTH). LTH (which is part of LU) was founded in the 1960s and is today a major actor for research and skills provision in ICT in Skåne. The interdependence between LTH (the knowledge infrastructure) and the region's industry (the production structure) is something that is often emphasized by the actors in the industry today. This applies mainly to the development of Ericsson's operations in Lund, which have been dependent on a steady stream of workers who are highly skilled in specific technical fields and the research and development conducted at the university.

The ICT sector in Skåne employs about 17,000 people³⁰. The vast majority of those working in the ICT sector are based in Malmö and Lund. This illustrates the close relationships that exist between the industry and LTH. Several of the most prominent companies in the region (such as Ericsson, Sony Mobile and Axis Communications) are situated within or directly adjacent to Ideon Science Park, just next to LTH in Lund. In addition, there are more than 50 small and medium-sized businesses that are classified as ICT companies in Ideon Science Park³¹. It is worth emphasizing that the Blekinge Institute of Technology³², also helps to maintain a flow of highly skilled workers in the relevant fields.

²⁷ World Economic Forum – Global Information Technology Report 2015.

²⁸ Innovation och regional omvandling – från skånska kluster till nya kombinationer (Henning, Moodysson, Nilsson)

²⁹ Mobile Heights website: <http://mobileheights.org/>

³⁰ Innovation och regional omvandling – från skånska kluster till nya kombinationer (Henning, Moodysson, Nilsson)

³¹ <http://www.ideon.se/en/companies/business-catalogue-all/>

³² <https://www.bth.se/eng/>

The ICT sector in Skåne has gone through a positive evolution in the region, despite there being no general over-specialization. For instance Skåne today is a hub in IoT technologies and has many successful companies active across all the IoT verticals; bringing smart devices to diverse applications ranging from payment systems, utility solutions and surveillance to health monitoring and a mobile workforce. A key player in delivering end-to-end IoT solutions is Sigma Connectivity, based in Lund, which has the technology, experience and people to realize IoT for third parties.

Skåne has significantly advanced research related to the future development of IoT. The cluster organizations Mobile Heights and MAPCI (Mobile And Pervasive Computing Institute) are at the forefront of IoT research and are working towards realizing a smarter world with billions of connected devices. Mobile Heights for instance, is an industry driven triple helix initiative where members like Ericsson, Sony Mobile, Huawei, HTC, Blackberry, TeliaSonera, Lund University and the Regional Council of Skåne cooperate to boost the mobile ecosystem. By investing in research, open innovation and entrepreneurship, the common vision is to maintain and strengthen the region as an international hotspot for mobile communications and its entire value chain.

Three research centers constitute the base for research within Mobile Heights, ensuring access to world class knowledge for all members. Based at Lund University and Malmö University - closely connected to industry - these research centers cover hardware, software as well as services; System Design on Silicon (SoS), Embedded Applications Software Engineering (EASE) and Network for Mobile Services & Applications (NMSA) and the new Mobile and Pervasive Computing Institute at Lund University (MAPCI).

MAPCI is a collaborative research institute between academia, industry and the Skåne region and focuses on research on distributed cloud architecture and also functions as a bridge between the research programs for the three research centers. The institute lays the foundation for a truly connected world through world-class research, disruptive innovation, and industry collaboration. The main focus area of the institute is Mobile Cloud Computing and the mobile ecosystem building on the regional strength in systems design and control, software and hardware design in mobile and wireless systems. The institute is financed by the partners Sony Mobile Communication, Region Skåne, Lund University and Ericsson. The Institute is located in Mobile Heights Center in North-Eastern Lund, in close proximity to Lund Institute of Technology, Sony Mobile Communications and Ericsson. Members of Mobile Heights benefit from the knowledge, as well as the international network of strong research environments like Silicon Valley and Boston, and have the possibility to engage in active research projects.

The Mobile Heights Business Center increases speed to market for innovative, mobile startups. By combining innovation expertise and mobile technology with unexplored patents, market pull and research, this is a community where new companies are founded. Mobile Heights functions as an innovation platform providing cross-sectorial innovation projects addressing global challenges and thus attracting public funding. These multi-disciplinary projects creates possibilities for members to cooperate in creating innovative and competitive solutions to the grand challenges of our future society - solutions leading to international competitiveness in business and research. In these projects, the public sector is often an important customer by demanding solutions to complex societal problems, e.g., Mobile Health and Smart Sustainable Cities.

Companies – members of the Mobile Heights ICT cluster <http://mobileheights.org/>

5.2.2 The Danish side of the region

Denmark is a small, highly integrated, and homogenous society. The consumers often play an active part in developing new technology and are quick at adapting new technologies. Using Greater Copenhagen as a test market gives international corporations the advantage of quickly being able to adjust and improve a product at low costs before releasing it on the world market.

Denmark has one of the most advanced ICT infrastructures in Europe, and the network is fully digitalized. Denmark's penetration of mobile telephone subscriptions is ahead of the average European level. The grand

challenges are centered on – Health and well-being – Secure, clean and efficient energy – Green transport – Safe food and sustainable agriculture – Efficient use of resources – Inclusive and safe societies. ICT development is central for all these challenges and ICT thus is a key technology in pursuing growth through research and innovation.

The research and development effort of the Danish ICT industry is extensive, and in particular the development part is high. The ICT industry is stimulating growth and productivity gains in other industries, and accounts for almost 7 per cent employment in the private sector. The private sector's focus is primarily on development and less on research. Development accounts for approximately 80 per cent of total private expenditure on R&D and it is primarily customer-centric development. The research part accounts for approximately 20 per cent.

Well-known Danish brands such as Bang & Olufsen, Brüel & Kjær, Oticon, Widex and AM3D, among others, are based on worldwide recognized Danish sound technology research. Their products are aimed at improving sound quality, reducing noise and many other aspects of acoustics, making this area within ICT one of the regional strongholds. Together with five other, the six key strongholds on the Danish side of Greater Copenhagen have been listed. Main strongholds in ICT can be categorized within Smart City, Energy Technology, Internet of Everything, Network for technologies and software, Intelligent Lighting and Photonics, Sound and Acoustics.

The ICT area is characterized by many small and medium-sized enterprises. In 2006 SMEs with 50 to 1,000 employees employed 45% of the employees, which accounted for 35% of exports. In comparison, 25% were employed by companies with more than 1000 employees, which also accounted for 14% of exports. The largest share of exports, 52% was therefore attributed to small businesses with less than 50 employees. These companies employed 30% of ICT employees.

Significant companies for the Danish side of Greater Copenhagen are a number of large companies such as GN Store Nord, TDC, CSC, NetsDanmark, KMD, IBM, Microsoft, Logica, Accenture, CapGemini, Tieto, Sony and HP. Many of these are foreign owned and it is estimated that more than half of the employees in the ICT cluster are working for a foreign company (Oxford Research 2012).

Smart City and Big Data

Being a leading Smart City has always been of great priority for City of Copenhagen. Copenhagen, like many other large cities, suffers from massive problems with congestion and flash floods; this has created the need to rethink how the city's solutions are structured in new smart ways, such as the utilization of big data and new technologies. With three key goals the city aims to be a frontrunner;

1. To be carbon neutral by 2025
2. To improve the quality of life in the Copenhagen area
3. To stimulate business activities³³

Copenhagen Solutions Lab is a governing body for all Smart City projects across sector and focuses on triple helix collaborations. In 2014 Copenhagen won the World Smart Cities Award for its Copenhagen Connecting project – e.g. the Copenhagen Solutions Lab. The award was won for the city's collection and use of data, to create a greener city and for its efforts to improve the quality of life and the city's business climate. Greater Copenhagen has become a living test lab for Smart City solutions, owing to easy access to collaboration and partnerships with the public sector, industry and academia.

Greater Copenhagen offers unique access to electronic databases and registries which foreign companies can use freely for research, test and development purposes. Hitachi has opened its first mainland Europe big data research laboratory in Copenhagen and is building the world's first city data exchange in Copenhagen.

³³ Hitachi Consulting, 2016. <http://learn.hitachiconsulting.com/CityDataExchange>

Intelligent lighting

Greater Copenhagen is a world leader in lighting and photonics research, with the Technical University of Denmark repeatedly breaking the world record in data transmission. This is also the only university with an Ms.C in Lighting Design bridging talent and innovation effectively.

Greater Copenhagen's ICT cluster includes the Danish Outdoor Lighting Lab (DOLL), consisting of three laboratories: Quality Lab, Virtual Lab and Living Lab, which includes 9.2 km of road and pathways for testing lighting solutions. DOLL is open for foreign lighting firms to test new solutions.

The Danish Outdoor Living Lab, DOLL, is Europe's largest showroom and test-field for intelligent lighting and smart urban services.

DOLL consists of three laboratories:

- Living Lab offers a 1:1 experience of outdoor lighting products on pathways, streets, passages, parks and squares.
- Quality Lab, located at the Photonics Department of the Technical University of Denmark, offers manufacturers and buyers test and documentation of all aspects of artificial lighting.
- Virtual Lab, located at the Photonics Department of the Technical University of Denmark, offers the technology to recreate spaces in 3D computer models to visualise the effect, distribution, reflection and glare of illuminates and sockets early in the development process.³⁴

With a budget of 7.3 million euros, Lighting Metropolis aims to set new standards for innovation, uniting public and private sector partners, including incubator pods, start-ups and scientists, and making city spaces and buildings available to development, test and demonstration. Lighting Metropolis is a ground-breaking partnership between Danish and Swedish regions, municipalities and universities, inviting international and local companies to create a world leading region for smart urban lighting.

ICT in the finance sector

Copenhagen is a hotspot for developing innovative ICT solutions for the finance sector. Well-operated partnerships between government and private sector companies are the result of a long tradition of developing common infrastructure solutions for the financial sector and have led to Denmark being a global leader in digitising secure processes. A survey done by Oxford Research in 2009 shows this area as a potential stronghold in the region (Oxford Research 2009). The financial and ICT sectors are some of the most growing areas in the region (Ministry of Business and Growth 2013). The readiness of the society for test of technologies combined with the representation of significant companies in this sector creates an environment and ecosystem which supports this area as a stronghold.

The University of Copenhagen, the IT University, Copenhagen Business School and the Technical University of Denmark are strong within this field adding to the requirement of talent in companies.

A number of companies are a part of the fintech ecosystem: Danske Bank, Nykredit, Saxo Bank, Nordea, SimCorp, IBM, Tieto, Nets, CSC and Microsoft Development Center (Copenhagen Capacity, Klynger I Region Hovedstaden). According to Oxford Research this area has great potential of growing significantly in the years ahead making it prone to investments in the future. ESS and MAX IV can be useful in developing new products in the sector analyzing materials used create new components (Oxford Research, 2009).

³⁴ Danish Outdoor Lighting Lab, 2016. <http://www.lightinglab.dk/UK/>

5.3 Food and Packaging

5.3.1 The Swedish side of the region

The food sector has long been strongly associated with Skåne. The sector's historical strength in Skåne is largely due to the natural conditions in the form of good access to fertile agriculture land and a climate that is well suited to cultivation. Skåne enjoys a strong national position in food, in terms of both primary production and food processing. However, over the past 15-20 years, the Skåne food industry has significantly changed as a result of a transition away from traditional bulk production that was initiated in the 90's and is still ongoing today. The Skåne food industry now focuses to a greater degree than previously on more specialized and highly processed products (such as convenience foods, functional foods and health food) (Nilsson et al 2002). The core industries in the Skåne food industry cluster employ about 25,000 people³⁵.

Skåne's core industries today, correspond to categories of primary production (cultivation, animal husbandry, and fishing), the food processing industry and several of directly supporting activities. It is evident a significant over-specialization in Skåne within many fields, from the potato processing industry to manufacturing of food machinery, cultivation of horticultural products and processed meat businesses. The fact that the Skåne food industry cluster contains actors throughout the whole value chain is often highlighted as a regional strength. The food industry in Skåne is geographically diffused across the region, particularly in terms of primary production (agriculture). The majority of the processing is, however, in the western parts of Skåne and around Kristianstad. Research and development takes place primarily in close proximity to the universities in Lund and Malmö.

The packaging industry is especially interesting in Skåne, as it represents a large sector in the region with internationally successful actors such as TetraPak and what used to be Åkerlund & Rausing (ÅR packaging). At the same time, there are also several small, innovative businesses that have developed customized solutions for packaging food, such as EcoLean, which has developed a new packaging for liquid foods.

Sweden has a very well developed forest industry that is mirrored in the fact that the packaging industry is dominated by fibre based packaging solutions. Producers of carton board and converters thereof, represent about two thirds of the industry's revenue. This is twice the size compared to the global fibre share. Innovation and research are of highest interest in packaging industry as the branch is developing in an even more environmentally adapted way. Food safety is one of the priority areas and of very high global interest.

Packaging is often seen as garbage among the consumers and also as waste of resources. At the same time there is a vivid discussion about food waste, and how edible food could be prevented from being thrown away or from being destroyed during storage? There are some estimates that 25 to 30% of all food waste is caused by packaging. Many people are also reacting negatively to the use of preservatives in food, creating demand for smarter and more advanced packages. Today the packaging industry in Skåne is strongly focused on active and intelligent packaging, or advanced packages.

Active packages are defined as solution with nano or plasma technology, sensors, innovative materials, oxygen and gas scavenging, security and anti-counterfeiting. Intelligent packages are solutions with sensors/RFID/NFC, printed electronics, mobile commerce and track, trace and control. New materials, for example bioplastics help to create new advanced solutions and coatings, an area where nano and plasma technology already are playing an important role.

³⁵ Innovation och regional omvandling – från skånska kluster till nya kombinationer (Henning, Moodysson, Nilsson)

New developments in the Region

Skåne is home to several organizations with the aim to strengthen the food industry. The organization with the highest profile is the Skåne Food Innovation Network. Skåne Food Innovation Network is currently running a ten-year development project, *Innovation I Gränsland* (primarily funded by Vinnova, Region Skåne, Lund University and food companies in Skåne). The project involves more than SEK 200 million³⁶ and its overall objectives are to strengthen network links within the industry in Skåne and to stimulate innovation and growth.

Within the food industry in Skåne, there are vertical links running along the various value chains. For example, fishing is linked to fish processing, which in turn is linked to various forms of trade (general food wholesale, commission trade in food, supermarkets and fish shops).

For individuals active in the food sector, Skåne represents an attractive labor market, partly because the region is considered to be an attractive living environment, but also because of the existence of a large number of food companies (i.e. potential employers) within a limited area. Being the leading food & packaging region in Scandinavia means that Skåne has an ultramodern and advanced eco system of support and partnership. This includes Packbridge and Food Innovation Network both of whom nurture networks of innovators, researchers, suppliers and customers. This along with leading universities, such as [Lund University](#) and [Swedish University of Agriculture Sciences](#), provide a dynamic culture of openness and cooperation between research and the food and packaging business.

This cooperation creates a fertile environment for new innovations, such as in functional foods and pro-biotics, where Sweden has a leading global position. It has also led to important food packaging innovations in the consumer market, such as MAP (Modified Atmosphere Packaging), and Tetra Pak aseptic packaging. This critical mass of high-tech companies, research facilities and competence makes Skåne a very attractive region in Europe for investment in food and packaging technology. In Skåne companies can reduce time-to-market by utilising the advanced knowledge, competence and network of the food and packaging technology cluster. And with a mature and sophisticated consumer market companies have a perfect test ground for new ideas and products.

Food and Packaging Industry facts

- Food industry turnover in the Skåne region: 20 Billion Euro³⁷
- Skåne: 50% of Swedish food production
- The majority of R&D for the Swedish food industry is located in Skåne
- Strong, internationally established food companies with world market experience Carlsberg, Arla Foods, Lantmännen, Danish Crown, Findus
- Strong, internationally established ingredients-, process-and packaging companies with world market experience Danisco, Chr. Hansen A/S, TetraPak, AlfaLaval, Foss Electric, REXAM, CP Kelco, Novozymes, APV, ABB, Atlas-Stord, Foss Electric
- Mixture of many innovative companies Probi, Glucanova, Double Good, Skåne Dairy, BioGaia, Oatly, Indevex
- Presence of world leading producers of consumers brands Nestlé, Findus, Unilever, Kraft, Carlsberg, Tulip, Absolut, Campbell, Arla, Orkla, Scan, Dole

³⁶ Innovation och regional omvandling – från skånska kluster till nya kombinationer (Henning, Moodysson, Nilsson)

³⁷ Invest in Skåne - Food & Packaging – a Stronghold in Sweden (Ulf Åberg)

5.3.2 The Danish side of the region

Several of the major Danish companies in the Danish food industry date back to the 19th century. Denmark has a large population of cows and pigs to support meat and dairy industries, and its history of strong innovation and demand for organic products makes it an ideal place for research and development in the food industry. Consequently, many international producers have chosen Denmark as their headquarters³⁸.

The Danish food sector is one of the largest sectors of the Danish economy and is one of the worlds strongest food clusters. Denmark has the highest food production per capita globally, and it produces enough food to feed the Danish population three times³⁹. Europe's third largest food cluster is located in Greater Copenhagen with 20 per cent of total Danish exports and total revenues increasing by 15 per cent between 2009 and 2014⁴⁰.

The Danish food industry enjoys a reputation of high quality, safety and hygienic production. This is due to an industry focus on social responsibility and collaboration with food safety authorities. As a result, 82 per cent of companies in the food sector consider quality as their competitive strategy⁴¹. This is assisted by Danish government and EU regulation that emphasise consumer protection through hygiene, animal welfare and safety standards.

As a result of this quality focus, Danish food industry is on the forefront of international food innovation. With global top performers in many sectors of the food industry, Denmark has been named the most innovative food cluster in the Europe⁴². Although the cluster is widely dispersed across Denmark, Greater Copenhagen employs 140.000 people in food and agriculture. Greater Copenhagen is also home to University of Copenhagen and its dedicated food department as well as company facilities such as Chr Hansens Lab and Carlsberg Lab.

Danes are true pioneers in organic and natural food with the highest per capita consumption of organic food products. This is a result of efforts to establish the world's first government rules for organic production and inspection. About a third of oatmeal and milk products sold and a fourth eggs sold are organic⁴³. Many ingredient suppliers are producing organically making Denmark an ideal location for testing new organic products in an early stage.

Due to close vertical integration, the Danish Food industry represents not only meat and dairy producers, but also supporting industries such as processing equipment and food additives, both with very high degrees of export.

Danish Food Cluster: <http://danishfoodcluster.dk/>

The Danish Food Cluster was founded in 2013 and represents 75 per cent of industry turnover, five universities, GTS institutes and major organizations. As a part of its 2018 strategy, the cluster seeks to strengthen the Danish food sector through branding and visibility.

5.4 Cleantech

Back in the 1970's no one foresaw the climate crisis the world is facing today. Fast population growth, galloping global energy consumption and heavy use of fossil fuels are straining the earth - not to mention the geopolitical instability caused by this increasing demand for energy. Since this oil crisis in the 1970s, Denmark, Sweden and Norway – in the Nordics – have had a strong political focus on transitioning the societies into green fossil-free societies, where energy is generated from natural resources or reused from materials available – e.g. using incinerated waste to create heating.

³⁸ Ministry of Food and Agriculture (2013), *Vækstteam for fødevarer, Anbefalinger*

³⁹ Ministry of Foreign Affairs of Denmark & Invest In Denmark, *The Danish Food Sector*

⁴⁰ Confederation of Danish Industry (2014), *Stigende omsætning i fødevarerindustrien*

⁴¹ Copenhagen Capacity, *Food & additives in Greater Copenhagen*: <http://www.copcap.com/set-up-a-business/key-sectors/food-and-additives>

⁴² Invest In Denmark - *The Danish Food Sector*, supported by 'M. van Galen et al.: *Innovation in the food industry - an international benchmark study* (2013)' and 'A. Renwick et al.: *Innovation in the Irish Agrifood Sector* (2014)'

⁴³ Danish Agriculture & Food Council, *Danish Food and Gastronomy*

This mindset of becoming independent of foreign energy has made the Nordics frontrunners in developing new technologies and solutions to problems which are ever more present today than before. The region of Greater Copenhagen and Southern Sweden which has the Capital of Denmark on the Danish side and a strong production industry on the Swedish side, has made this region a strong test market for new products and technologies creating conditions where a large population is available as well as many large market leading companies. Greater Copenhagen and Southern Sweden is a green region with strongholds within many key sectors all contributing to further greening the region.

5.4.1 The Swedish side of the region

In Skåne, cleantech has emerged as a focal area in a number of established sectors. Several of these belong to what is described as environmental technology, which includes water and wastewater technology, waste technology/recycling, air treatment, water treatment and renewable energy. In addition, there are specific environmental applications and environmental solutions in other sectors, such as the construction sector and sustainable urban development.

The industrial structure in southern Sweden differs from other parts of the country and resembles more of Denmark. There is no mining or steel industry, and relatively weak forestry and the environmental technology industry is largely rooted in technologies related to the food industry. Three generic technologies that grew up around the food were:

- Heat exchange;
- Liquid handling, separation;
- Process automation, control and regulation technology;

These generic technologies spread to the packaging industry, medical technology and environmental technology. Environmental technology industry has its development roots linked to the major infrastructure investments that were made in Sweden, mainly in the decades after World War II. Today, a large part of the Swedish export-oriented sanitary engineering industry is in the south of Sweden, with companies such as: Xylem, Malmberg Water, Läckby Water, Kemira, Feralco, Sulzer (former Cardo), SPIRAC, Veoliabolagen Hydrotech and Anox Kaldnes.

When it comes to heat exchangers, there are about 80 heat exchanger companies in southern Sweden. Large heat exchanger manufacturers in Skåne are Alfa Laval, Swep and Heatex.

The Cleantech sector in Skåne is characterized by strong entrepreneurship, innovation and investment. Business activities and development range from aiming to disrupt the renewable energy market for instance, by introducing an innovative design for wind turbine rotor blades (Winfloor), to a multi-fuel, zero emission burner system for heating systems in Electric and Hybrid vehicles (Zemission). In addition, there are companies like Orbital Systems who have developed a disruptive water recycling technology in the form of the world's most efficient shower unit. Other areas where Skåne cleantech companies are strong include:

- **Advanced Materials** (QuNano, Nexam)
- **Water and Wastewater** (Orbital Systems, Watersprint)
- **Waste and Recycling** (Agrilogik)
- **Energy Efficiency** (Airec, Bioprocess Control, Glo)
- **Transportation and Logistics** (Drivec, Daca Pallet System)
- **Manufacturing and Industrial** (Arc Aroma Pure, Oco Nordic, Pastair)
- **Agriculture** (Björkemmar Construction & Consulting BCC, Ekobalans)
- **Energy Generation** (Energy Opticon, BioMil)
- **Energy Storage** (Blue Fire)
- **Air and Environment** (Clay Technology, Catator)
- **Energy Infrastructure** (Comsys, Dlaboratory).

BioGas

During the 2000s, there were investments in biogas production and upgrading of biogas to natural gas quality speed and today, Skåne produces 25% of the Swedish biogas, with a substrate mainly from sewage sludge and food waste. The Swedish suppliers Malmberg Water and Purac for example, are pioneers in the world of technological solutions in upgrading biogas to vehicle fuel. As a result of continuous investment and innovation, a large part of Skåne's buses run on biogas today. There are also a few formidable examples of start-ups in this field, for example, Bioprocess Control that optimize biogas processes.

Sweden is quite ambitious is setting targets to decrease its carbon footprint and significantly reduce greenhouse gas emissions in the coming years and decades. For instance, the target has been set by the national stakeholders to achieve a fossil fuel free vehicle fleet in 2030. Moreover, Sweden aims to be a climate neutral country by 2045, and have ambitions to reduce the greenhouse gas emissions in the transport sector by 70% in 2030 (compared with figures from 2010).

To prepare the groundwork for these plans, there are several policies underway. In Sweden for instance, the bonus-malus system for light vehicles, quota obligation-system for liquid biofuels, and emission zones for light vehicles will be introduced in the near future. When it comes to Region Skåne specifically, the regional authorities have set a target to achieve a climate neutral and fossil free status by 2030 and biogas is prioritized in contracts for public transportation.

Development initiatives in the region

Sustainable Business Hub (SBH) is a network aimed at helping companies active in the environmental and energy field to strengthen their competitive edge. SBH was initiated as early as 2002, but only in 2007 did the organization get the specific mandate to work on creating business opportunities for Skåne companies in cleantech and to profile and market the region internationally. The members of SBH (some 90 organizations and companies <http://www.sbhub.se/teknikforetag>) fall within the relatively broad ETAP definition of cleantech, i.e. companies working on products and services that involve less environmental impact, for example less energy consumption, than comparable alternatives. Leading cleantech cluster organizations in Skåne:

Sustainable Business Hub <http://www.sbhub.se/>

The mission of the Sustainable Business Hub is to work in various ways to help environmental technology companies in southern Sweden sharpen their competitive edge and develop their businesses in Sweden and abroad. They are a member-owned company, primarily companies in the environmental technology sector, but also include local authorities and academic institutions. Their expansive network includes companies, local authorities, municipally owned companies, academic institutions, supportive organisations and other clusters.

They pursue their activities through a core selection of services, such as arranging seminars in areas of topical interest and offering networking opportunities, as well as participating in or running projects that promote their members' business and other activities in a variety of ways.

Cleantech Scandinavia <http://cleantechscandinavia.com/>

Cleantech Scandinavia runs an internationally established network of investors, industrials and public actors, all with an interest in Nordic Cleantech. During their eight years in business, they have established themselves as a trusted source of cleantech-related investment opportunities, business intelligence, investment statistics and they

are an active provider and promoter of Nordic Cleantech. Today they embrace some 70 members including venture funds, industrial ventures from leading multinational companies and government organisations. Their members come from Scandinavia, Continental Europe, China, North America and other locations. Their core activities include sourcing and evaluation, testing and validation and acceleration⁴⁴.

Malmö Cleantech City - <http://www.malmocleantechcity.se/>

Malmö Cleantech City ensures that environmental engineering prospers in the city of Malmö. Through a unique collaboration between companies, universities and municipalities, we create a green cluster and develop cleantech-companies in the city. In the project, tangible business opportunities are born and prepared for innovative collaboration. At the same time, they aim to strengthen Malmö City's environmental profile and attractiveness for both people and companies.

5.4.2 The Danish side of Greater Copenhagen and Southern Sweden region

Denmark has gone from being 99 % dependent on foreign fossil fuel to being completely energy self-sufficient. Almost forty years of focused energy policy has catapulted Denmark ahead of most other nations in the use of renewable energy technology.

The Danish government has set the goal to be completely independent of fossil fuels by 2050.

The Government also has ambitious short term goals of a 6% reduction in gross energy consumption by 2020 in comparison to 2006. In addition, the dependency on fossil fuels will be decreased by 33 % in comparison to 2009, while sustainable energy dependency will increase to 33 % of the total energy consumption⁴⁵.

The Danish society exemplifies how sustainable development can go hand in hand with increasing consumption and economic growth. Danish energy consumption hit the lowest point in 32 years⁴⁶. Cleantech has been the fastest-growing sector of Danish exports in recent years, and exports are expected to quadruple in the next four to five years (Ministry of Foreign Affairs). Main strongholds within cleantech are waste and recycling, SMART city solutions, Biogas, Energy Efficiency, Wind Power and Energy Storage, and Green Transportation.

In aiming to become the first carbon-neutral capital by 2025, Copenhagen is a frontrunner in green transformation, renewable energy, upcycling and recycling, green mobility and smart city solutions.

Copenhagen's ambitious climate target has sparked a strong commitment to green transportation, water and waste management, sustainable buildings and renewable energy such as wind power, solar energy, green energy plants and biofuels.

Copenhagen's 2025 Climate Plan is part of the city's green growth strategy, which includes inviting leading international innovation projects, researchers and companies to Greater Copenhagen. By 2025, around 27-34 billion euros are expected to be invested in sustainable mobility and energy consumption and production, as well as in the latest smart city, smart grid and intelligent lighting solutions.

This side of the region has leading green test & demo facilities:

- The Resource City, a test center for waste management, upcycling and recycling.
- The Danish Outdoor Lighting Lab (DOLL), a world-leading test city for photonics and intelligent lighting solutions (see ICT, the Danish side of Greater Copenhagen).
- The Kalundborg Industrial Symbiosis, a renowned example of industrial ecology with four industrial facilities collaborating to use each other's by-products and share resources - a power plant, an oil refinery,

⁴⁴ <http://cleantechscandinavia.com>

⁴⁵ Energistyrelsen (2011), *Energistrategi 2050: Fra kul, olie og gas til grøn energi*

⁴⁶ Energistyrelsen (2015), *Laveste energiforbrug i 32 år*: <http://www.ens.dk/info/nyheder/nyhedsarkiv/laveste-energiforbrug-32-aar>

a plasterboard plant and a pharmaceuticals production plant, as well as the Kalundborg Municipality, supplying water, electricity and district heating to its citizens.

In Copenhagen, companies have access to unique, high-quality data and electronic registries dating back decades. This is turning Greater Copenhagen into a preferred laboratory for smart city technologies to build, monitor and manage the data infrastructure of large cities, able to handle the challenges of climate change and urbanization. Close collaboration between business, academia and the public sector as well as across industry sectors is a strong tradition in Greater Copenhagen, providing a competitive advantage for developing and testing smart city solutions.

More than 250 companies, including Cisco and Hitachi, are involved in smart city activities in Greater Copenhagen, owing to the early-adopter citizens and the high level of digitalization in the public sector.

Cisco has entered into an innovation partnership with Greater Copenhagen to test and develop tomorrow's digital infrastructure, the Internet of Everything. Cisco chose Copenhagen because of its green ambitions and unique test facilities. The partnership agreement includes a number of technological solutions to improve citizen services and to help the city of Copenhagen reach its target of becoming carbon-neutral by 2025. By using Internet of Everything strategies, multiple solutions – existing and radically new ones – will be converged onto one network. Typical solutions addressed by an Internet of Everything Strategy include smart traffic lights, outdoor lighting, sensor-based water defenses, parking, mobility services, and smart energy management.

Biogas and waste

Denmark, a small country of 5.2 million inhabitants and 40.000 km², is probably the country in the world with a highest concentration of bioenergy competences:

- 5 Universities, 10 R&D institutions and more than 300 technology and know-how suppliers
- More than 1,000 industrial-size operating bioenergy plants
- Intensive public funding of R&D and Demonstration projects: more than 400 projects in the bioenergy sector have been funded since 1999.

Recently the University of Copenhagen made a study on how the amount of available biomass could be increased by 10 million tones, and there are several projects aiming to map bioenergy resources at a local and regional level and, more important, which technologies might be the more appropriate to optimize the energy yield⁴⁷.

There are several large and world known Danish players in bioenergy sector, as Novozymes, Haldor Topsøe or DONG, but the major part of the Danish companies in the sector are small and medium sized engineering based companies, which enjoy a leading position in their niche of activity and, despite their size, have many years of experience developing international projects. An increasingly important part of the companies operating in the market is foreign owned, which is an undisputable sign of the relevance of Denmark in the global bioenergy sector, both in terms of relative market size, presence of specific competences and opportunities to engage in partnerships with local players⁴⁸.

In Denmark, the biogas sector was developed during the 80's and 90's as a mean to process in a sustainable way the manure waste from the Danish pig and cattle production.

The Danish side of this region is actively supporting the national goals for 2020:

- Increased use of biomass in large coal energy plants, by changing the Heating Act
- Increased use of biomass in industrial companies, buildings and households
- Rapid phasing out of oil and natural gas boilers in buildings
- Higher feed in tariffs to biogas, and inclusion of new biogas applications in the system
- Increased capex subsidy rate to biogas plants from 20 to 30%
- 10% of biofuels in the transportation sector

⁴⁷ Ministry of Foreign Affairs (2012), *Bioenergy and Waste to Energy in Denmark*

⁴⁸ Ministry of Foreign Affairs (2012), *Bioenergy and Waste to Energy in Denmark*

What does it mean for global players in the bioenergy sector?

- Increased domestic market with a long term, certain and fair retribution
- Denmark will remain leading the technology development of biomass, biogas and biofuel
- Development of new applications for biogas: upgrading to the grid and use in transport
- Possibilities of investment in large scale plants and grants to demonstration plants
- First mover market in the development of bio & waste refinery concept ³²

Just as bioenergy has been a priority for the Danish government the waste sector has also been focus of a new strategy presented in 2015 – *Denmark without waste, recycle more incinerate less*.

The Government has set a goal that in 2022 the country will be recycling 50 % of household waste. This means that we will have to more than double the recycling rate for household waste in Denmark in less than 10 years. This is an ambitious goal, because in future the ambition is not only to be separating the waste, such as paper, cardboard and glass, but also to focus reuse through recycling and upcycling of other household waste, including food waste.

Denmark has come a long way in environmentally responsible waste management and in waste incineration. However, Denmark is also one of the countries in Europe producing the most waste per inhabitant. In 2011 Danish households produced 447 kg of waste per person. This corresponds to every Dane throwing away more than 8 kg of waste every week.

Over the past 20 years, by far the majority of Danish waste has been recycled (figure 3). The recycling rate went up from 55 % in 1994 to 61 % in 2011. The incineration rate went from 21 % in 1994 to 29 % in 2011, whereas the percentage of waste landfilled dropped considerably from 22 % to 6 % during the same period. The low percentage of waste being landfilled is due to a mixture of bans against organic waste in landfills and taxes on landfilling.

The Government's ambition is that over the next 10 years or so we will recycle twice as much household waste, so that one-half of household waste is recycled in 2022. Today we recycle just 22 %. New solutions and technologies within this field will be largely required on the market, making foreign attraction from this area crucial in the years to come. This side of the region has Amager Resource Center (ARC).

ARC manages the waste of larger Copenhagen area. Through incineration the plant sends heat out the many citizens in the city. ARC has always been focused on improve their recycling and reuse of waste. They have decided to draw up a concrete suggestion (rough outline) for a big, automatic sorting plant that is able to manage waste sorted at source.

CLEAN and the GTS Institutes

CLEAN is Denmark's leading green cluster organization with more than 170 members from the entire cleantech sector. They are a politically and technologically neutral platform where domestic and foreign companies, knowledge institutions and public authorities exchange knowledge and enter into new partnerships.

Situated in Greater Copenhagen the cluster organization works closely with the ecosystem here within Smart City, Energy Efficiency, Waste and Internationalization. The members of the cluster organization represent the public, private and research sector. Danish companies have developed efficient methods of combustion, gasification and liquefaction of biomass for biofuels and biogas, and they have pioneered enzyme technologies to maximize the efficiency of biofuels.

Owing to the strong biotech, chemical and agricultural science industries in Greater Copenhagen, companies excel in the latest technologies supporting carbon mitigation.

GTS – Advanced Technology Group is a network consisting of independent Danish research and technology organizations. They are called the GTS institutes and together they make the GTS network.

The GTS institutes offer knowledge, technology and consultancy, co-operation on technological and market-related innovation, testing, optimization, quality assurance, certifications and benchmarking – all of which contribute to enhancing the international competitiveness of the Danish business sector and benefit Danish society in general.

The institutes are: Alexandra Institute, Bioneer, DBI – Danish Institute of Fire and Security Technology, DELTA – Danish Electronics, Light & Acoustics, DFM – Danish Institute of Fundamental Metrology, DHI – Water and Environment, DTI – Danish Technological Institute and FORCE Technology.

The GTS institutes are independent not-for-profit organizations whose purpose is to spread technical know-how, new methods and knowledge to industry and society in order to create and increase development. The GTS institutes are independent from political or economic interests and profit is reinvested in research and development.

All services are marketed on a commercial and competitive basis in Denmark and abroad. The government does not financially support these services. In general the GTS network has two main functions:

- To develop and maintain the basic technological infrastructure in Denmark.
- To create technological innovation and development within Danish industry.

The GTS institutes are involved in research and development projects in cooperation with companies, universities and research institutions in Denmark and abroad. Government-approved institutes have the opportunity to apply for government-financed performance contracts.

The purpose of performance contracts is to develop, transform and communicate new and existing knowledge and technology to companies and institutions. They can also focus on developing new technological infrastructure such as testing facilities and laboratories.

6 Conclusion

The region of Greater Copenhagen and Southern Sweden as a modern, knowledge-based location with excellent national framework conditions for research-based industry, is now equipped with the world-leading synchrotron radiation facility, and in a few years will be further strengthened with the world-leading neutron scattering facility. These two large research infrastructures combined, will have the ability to conduct cutting-edge research in areas ranging from clean energy and the environment, pharmaceuticals and health care, through to nanotechnology, materials engineering and IT and will form one of the foremost materials science research hubs in the world when fully up and running.

It is important to emphasize that the region of Greater Copenhagen and Southern Sweden as a whole, is greater than the sum of its parts. This comprehensive report shows that unlike any other location in Europe, our region is equipped with solid and complex ecosystems, with innovative companies, supporting infrastructure, advanced R&D, leading research facilities, favorable test bed environments and supportive government incentives and policies.

The list of regional strongholds confirms that Greater Copenhagen and Southern Sweden offers Scandinavia's most knowledge-intensive research and business environment. The overall result of the benchmarking analysis however, disclosed that the industry cluster in the Greater Copenhagen and Southern Sweden region suffers from a low number of companies, but it has the largest research and development activity as a percentage of GDP. The report also revealed a more fragile standing in terms of quality, but a distinct competitive position in terms of cost categories compared to other European regions with similar infrastructures and environments analyzed in this report.

Undoubtedly, there is enormous potential in Greater Copenhagen and Southern Sweden. However, all relevant regional stakeholders, have to pull together to create the foundation and preconditions to release that potential.

Currently, MAX IV is the brightest x-ray source in the world, and it is estimated that it will hold that position for about 5 to 6 years ⁴⁹, when other facilities around the world might challenge MAX IV's leading position. This

⁴⁹ Colin Carlyle, Senior Advisor, Science Village Scandinavia

provides a unique opportunity for our region to further develop and enhance the environment around these facilities but also provides a short window to use regional strongholds in a smart way to attract the right companies, capital and talent. MAX IV has a paramount role to play. With an adequate industrial liaison strategy and with systems and resources in place for increased industry usage, MAX IV can serve as a driver for regional growth.

Similarly, the ESS, once operational will be the world's leading facility for research using neutrons. And it is estimated that it will hold this position for about 30 years⁵⁰. However, the challenges the ESS is facing are of different nature. Finding a common vision, adequate funding sources and access paths to industry are issues that relevant stakeholders have to take into consideration before the first user programs are in place in 2023.

It is evident that our region focuses a large part of its resources on promoting university-industry collaboration across and within many technologically complex industries and this is in many ways unique. However, in a world where countries and regions engage in fierce competition to attract investments and talent, by offering advanced research facilities, expertise, industry and support systems, the region of Greater Copenhagen and Southern Sweden needs to stand out. We need to let the world know about our unique ability to collaborate on complex issues because the more known our region and brand is, the easier it will be to attract investments, talent and capital.

This report gives us a first insight into our competitive position, as well as establishing what our primary areas of strength are. This report will be used to formulate the regional unique selling points (value propositions) and develop a focused marketing and communications strategy.

In order to market the region as a hot spot for materials and life sciences, relevant stakeholders need to demonstrate how these two exceptional infrastructures can meet complex business and scientific requirements and provide researchers as well as industry players with key resources and possibilities for their R&D efforts and future business growth.

⁵⁰ Same as above

6.1 Appendix: Full weighting model

Category	Individual weight	Overall weight
Tier 1: General Business Environment:	10%	10%
<i>Tier 2: Access to finance :</i>	20%	2%
> Venture capital availability	70%	1.4%
> Depth of credit information index	15%	0.3%
> Ease of access to loans	15%	0.3%
<i>Tier 2: Economic growth and stability :</i>	10%	1%
> GDP (PPP, estimated)	50%	0.5%
> GDP per capita (PPP, estimated)	50%	0.5%
<i>Tier 2: Operating risk :</i>	20%	2%
> Index of Economic Freedom	80%	1.6%
> Soundness of banks	20%	0.4%
<i>Tier 2: Regulatory environment :</i>	30%	3%
> Intellectual property protection	45%	1.35%
> Efficiency of legal framework	15%	0.45%
> Number of days to enforce a contract	10%	0.3%
> Cost of establishing a business	5%	0.15%
> Number of days required to register a firm	5%	0.15%
> Number of days required to register a property	5%	0.15%
> Number of procedures required to register a firm	5%	0.15%
> Perceived level of public sector corruption	5%	0.15%
> Property rights	5%	0.15%
<i>Tier 2: Taxation and incentives :</i>	20%	2%
> Total tax rate (% profit)	100%	2%
Tier 1: Labour Availability and Quality:	35%	35%
<i>Tier 2: Experienced industry-specific staff :</i>	35%	12.25%
> Availability of scientists and engineers	50%	6.13%
> Proportion of employment in R&D	25%	3.06 %
> Proportion of employment in R&D	25%	3.06%
<i>Tier 2: Flexibility of labour regulations :</i>	35%	12.25%
> Rigidity of Employment Index	40%	4.90%
> Hiring and firing practices	30%	3.68%
> Cooperation in labour-employer relations	10%	1.23%
> Flexibility of wage determination	10%	1.23%
> Redundancy costs	10%	1.23%
<i>Tier 2: Overall size of labour market :</i>	5%	1.75%
> Population	100%	1.75%
<i>Tier 2: Skills, attitudes and productivity :</i>	20%	7%
> Tertiary education	80%	5.6%

> Foreign-born population	20%	1.4%
<i>Tier 2: Tightness and competition for labour</i>	5%	1.75%
> Unemployment rate	100%	1.75%
Tier 1: Industry Cluster:	35%	35%
<i>Tier 2: Export competitiveness :</i>	10%	3.5%
> High-technology exports	80%	2.8%
> Documents to export	20%	0.7%
<i>Tier 2: Industry Specialisation :</i>	20%	7%
> Specialisation in Research and Development	100%	7%
<i>Tier 2: Research and Development Capabilities :</i>	40%	14%
> Research and Development intensity	40%	5.6%
> Global Innovation Index	20%	2.8%
> Charges for the use of intellectual property	20%	2.8%
> Number of clinical trials	20%	2.8%
<i>Tier 2: Size of industry:</i>	20%	7%
> Companies in research and development	100%	7%
<i>Tier 2: Track record:</i>	10%	3.5%
> Research and development (inward FDI)	100%	3.5%
Tier 1: Infrastructure and Accessibility:	15%	15%
<i>Tier 2: Access to major overseas markets :</i>	60%	9%
> Number of international destinations from airports	70%	6.3%
> Distance to nearest international airport	15%	1.35%
> Quality of air transport infrastructure	15%	1.35%
<i>Tier 2: Quality of ICT infrastructure :</i>	15%	2.25%
> Internet download speed (kb/s)	35%	0.79%
> Internet upload speed (kb/s)	30%	0.68%
> ICT expenditure (% GDP)	5%	0.11%
> International internet bandwidth (bits per person)	5%	0.11%
> Internet penetration (hosts)	5%	0.11%
> Internet penetration (users)	5%	0.11%
> Mobile cellular subscriptions (per 100 people)	5%	0.11%
> Personal computer penetration	5%	0.11%
> Secure internet servers (per 1 million people)	5%	0.11%
<i>Tier 2: Quality of local infrastructure :</i>	15%	2.25%
> Average commute time	35%	0.79%
> Logistics Performance Index	10%	0.23%
> Overall infrastructure quality	10%	0.23%
> Quality of roads	10%	0.23%
> Railroad infrastructure development	10%	0.23%
> Railways, passengers carried	10%	0.23%
> Roads, goods transported	5%	0.11%
> Roads, paved (% of total roads)	5%	0.11%

> Roads, total network	5%	0.11%
<i>Tier 2: Quality of utilities :</i>	10%	1.5%
> Electric power transmission and distribution losses	50%	0.75%
> Quality of electricity supply	50%	0.75%
<i>Tier 1: Living Environment:</i>	5%	5%
<i>Tier 2: Attractiveness for international staff :</i>	70%	3.5%
> Quality of living index	80%	2.8%
> Number of IB world schools	20%	0.7%
<i>Tier 2: Cost of living :</i>	30%	1.5%
> Cost of living Index	100%	1.5%

Source: fDi Benchmark from the Financial Times Ltd 2016