
Lyngby-Taarbæk

- Profile of a City of Knowledge

October, 2018

Introduction

The *Lyngby-Taarbæk City of Knowledge Association* (Lyngby-Taarbæk Videnby) was established in January 2012 following an initial process involving a large number of actors in and outside of Lyngby-Taarbæk. The area had an exceptional degree of specialization within knowledge-based sectors and start-ups - in addition to being the home of DTU as one of Europe's leading technical universities, some of Denmark's best primary and secondary schools as well as some of the country's best educated citizens. This leading position was further promoted by the successful and popular retail center and vibrant High Street in central Lyngby.

The purpose of the *City of Knowledge* vision is to develop Lyngby-Taarbæk into one of Europe's leading university towns with the best conditions for research, education, business and entrepreneurship.

Analysis

This analysis has been conducted by IRIS Group with the assistance of Microsoft, DTU Science Park and Lyngby-Taarbæk Municipality.

The purpose of the report and analysis is to present facts on the potential for developing an Innovation District as part of the Lyngby-Taarbæk City of Knowledge. The definition of an innovation district is a geographical area where leading-edge anchor institutions (i.e. universities) and anchor companies (i.e. R&D-intensive, global companies) gather and connect with start-ups, SMEs and public institutions. Innovation districts are based on

explicit research strongholds, a high density of knowledge-intensive industries, a large number of highly educated employees and a strong ecosystem for the development of start-ups and scale-ups. Moreover, innovation districts are physically compact, easily accessible, technically wired -and they offer a diverse set of housing opportunities, offices, and retail.*

The report presents Lyngby-Taarbæk's industrial profile, entrepreneurial specialisation, research strongholds and knowledge-based resources, as well as the level of collaboration between the university, anchor companies and the start-up community. Where appropriate, comparison with other cities in Denmark attempts to provide an indication of the potential for further developing and expanding academic and industrial strongholds in an area of proximity to DTU, other knowledge companies, capital, and labor.

Lyngby-Taarbæk City of Knowledge

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1. Key findings



The Technical University of Denmark (DTU) is one of the leading technical universities in Europe. Benchmarked against other technical universities, it has research strongholds in areas such as energy, life science, materials science, environmental science and sustainability, computer science and construction. These strengths are important assets for DTU, as well as for the Municipality of Lyngby-Taarbæk (The City of Knowledge).



The City of Knowledge has a strong concentration of knowledge-intensive clusters such as consulting engineers and architects and advanced chemistry and life science as the primary, as well as leading companies within ICT, finance and insurance.

Moreover, the City of Knowledge is – compared to the rest of Denmark – strongly specialised within education (supply of jobs within primary schools, colleges, business academies and universities)

The industrial specialisation in the City of Knowledge differs significantly from the specialisation to be found in other university cities in Denmark.



Many large, knowledge-intensive companies, or “anchor companies”, have chosen to locate in the City of Knowledge and neighbouring municipalities. Thus, the area is home to many research and innovation leaders.



Proportionally, the City of Knowledge has a larger share of knowledge-intensive companies than any other Danish university city.



Almost half of the companies within the leading industries in the City of Knowledge are collaborating with DTU in formal research and innovation projects. The anchor companies collaborate typically with several DTU-departments, while a little less than half of the start-ups collaborate with DTU. Almost all DTU-departments collaborate with local businesses on research and innovation projects.

The number of Triple Helix projects – including both the Municipality of Lyngby-Taarbæk, DTU and private companies – is however modest.



Start-up rates for knowledge-intensive industries are higher than in other Danish university city. They are especially high in the industries mentioned above. A huge number of start-ups are located in the city, including a high concentration of deep-tech start-ups located at the DTU campus.

DTU is an entrepreneurial university. Researchers, students and new DTU graduates start about 200 new companies per year. The high level of start-ups is underscored by a strong start-up ecosystem, in which a large supply of facilities and services are provided – including courses in entrepreneurship, events and matchmaking, advisory services, incubation facilities, co-working spaces and access to risk capital.



The number of high growth companies is modest, and while DTU-based start-ups are performing better than other start-ups (in terms of employment and turnover), the total turnover of all DTU-based start-ups established since 1999 is still only DKK 5 billion (or less than one so-called “unicorn”).



The City of Knowledge has a high concentration of highly educated citizens, staff and students.



2. Industrial profile



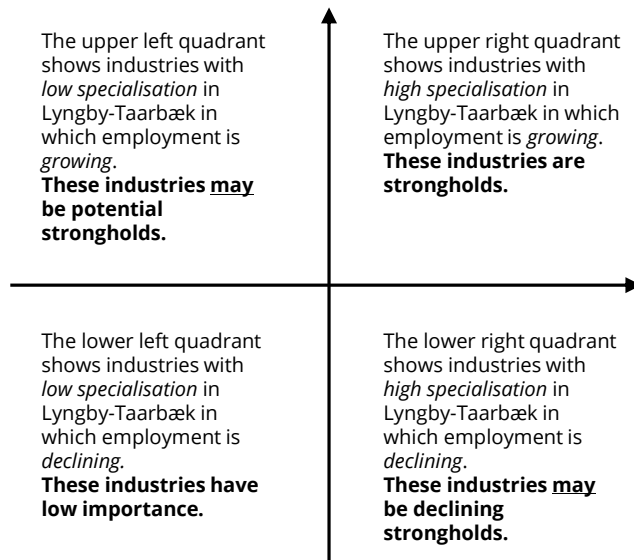
2.1. Industrial specialisation

The slide on the next page presents our analysis of industrial specialisation of Lyngby-Taarbæk (a reading guide to the figure is presented to the right).

As the plot shows, the City of Knowledge specialises strongly in engineering consultancy and architecture. This industrial sector's share of all FTEs is 6.5 times higher than the share in the rest of Denmark. Since 2009 the sector has, however, witnessed a small decline in the number of FTEs. Finance and insurance, education, real estate and IT are areas of high specialisation as well.

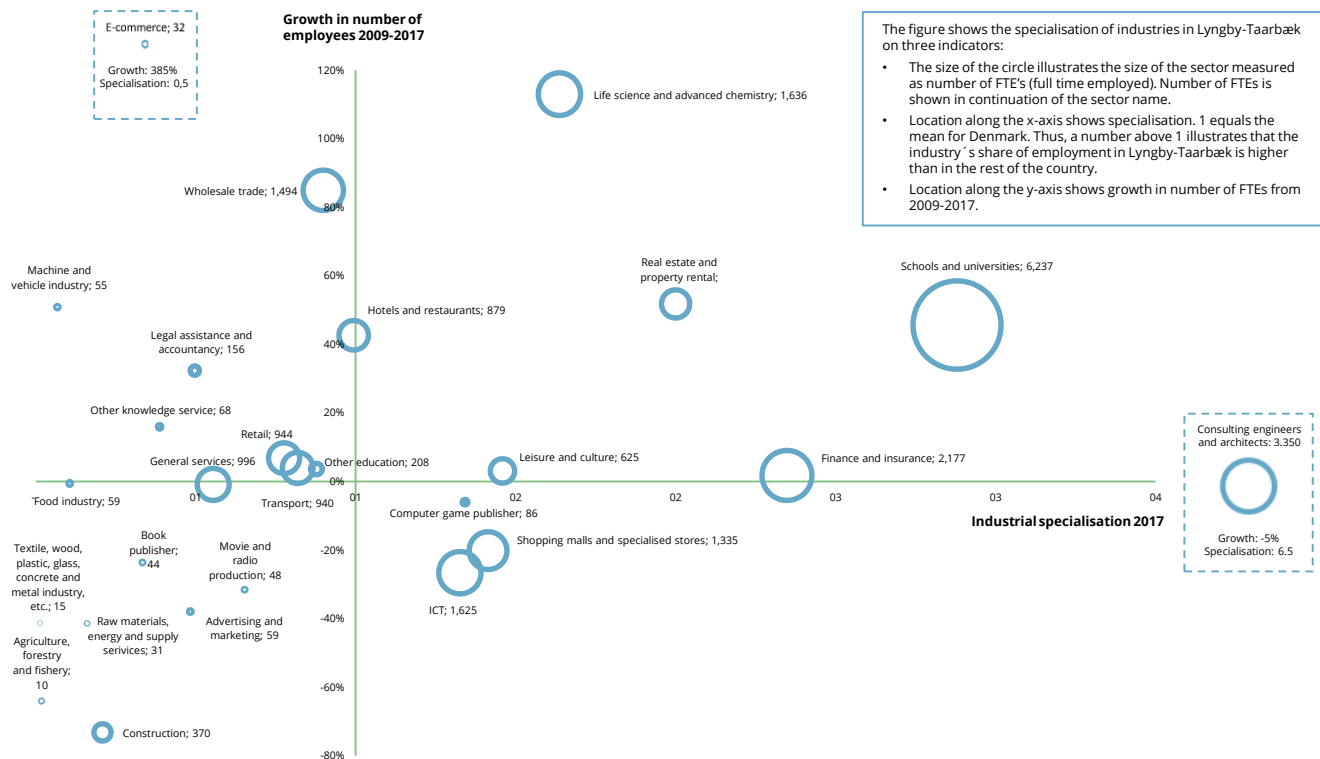
Education, real estate and the wholesale sectors have experienced the highest growth in employment since 2009.

Novozymes belongs to the industry "life science and advanced chemicals". For this particular industry, we have shown the expected specialisation and growth after the relocation of Novozymes activities to Lyngby-Taarbæk (expected to take place by the end of 2018). Thus, for this industry the figure do not reflect the actual specialisation, but the specialisation if Novozymes had moved their activities to the City of Knowledge one year before their actual plans.



Note: Industries in the blue boxes are those with numbers that are higher than the numbers included on the scale.

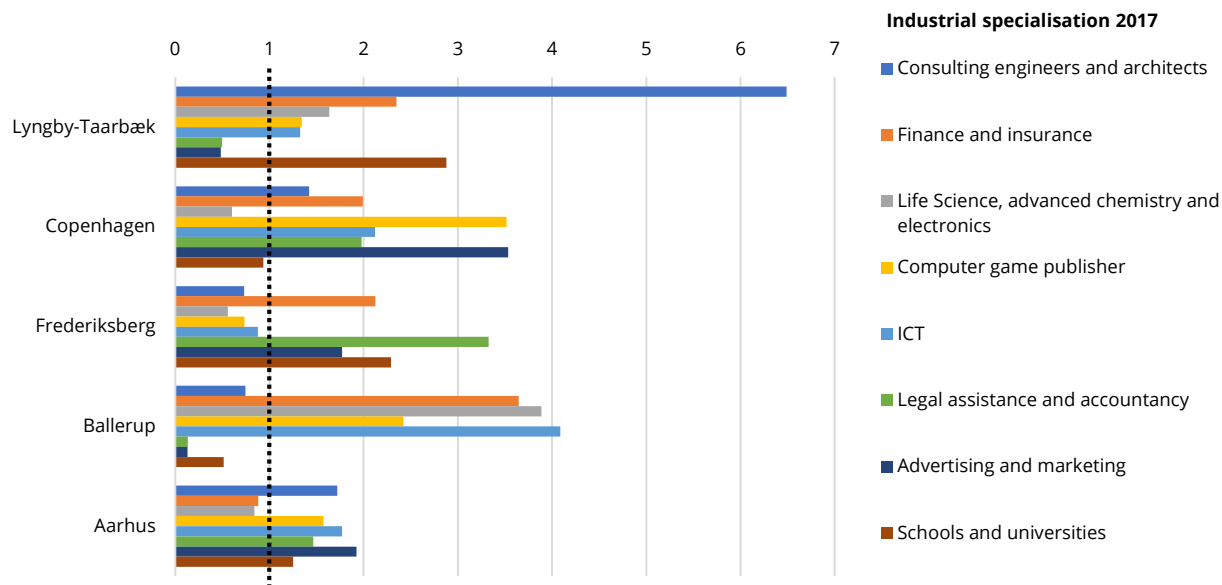
Plot of industrial specialisation in the City of Knowledge



Benchmarking industrial specialisation - Lyngby-Taarbæk and other "knowledge cities"

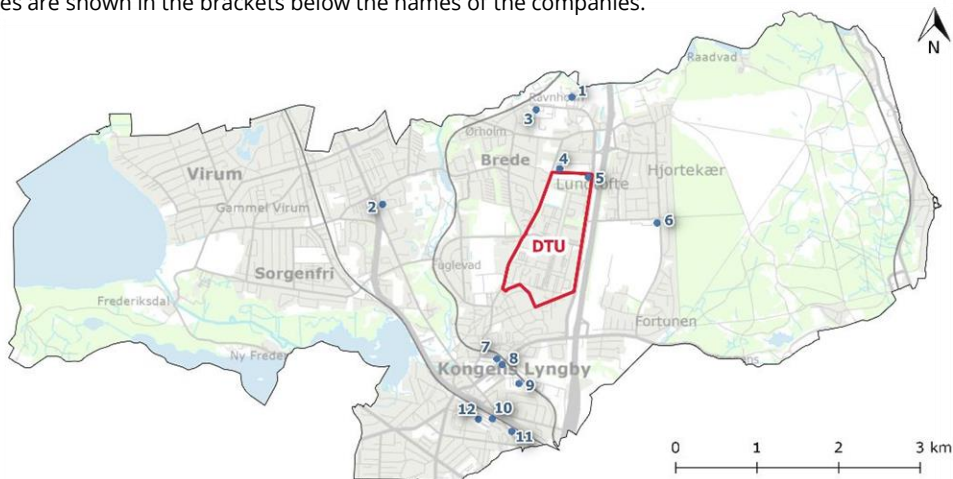


The figure compares the specialisation of industries in Lyngby-Taarbæk with four other Danish university cities. 1 equals the mean for Denmark. Thus, a number above 1 illustrates that the industry's share of employment in the municipality is higher than in the rest of the country.



2.2. Anchor companies

This section provides information on "anchor companies" in terms of leading, knowledge-intensive companies in the City of Knowledge and the surrounding municipalities. The map below provides an overview of the biggest knowledge-intensive companies in Lyngby-Taarbæk – more details are provided at the next page. The number of employees are shown in the brackets below the names of the companies.



- | | |
|---|---|
| 1. Haldor Topsøe A/S (1130) | 7. Microsoft Denmark ApS and Microsoft Development Center (825) |
| 2. NNE A/S (800) | 8. Jyske Bank (incl. BRFKredit A/S) (1146) |
| 3. Geo (185) | 9. Visma Consulting A/S (130) |
| 4. Cobham SATCOM (former Thrane & Thrane A/S) (470) | 10. COWI A/S (incl. KX A/S) (1615) |
| 5. Hempel A/S (325) | 11. Mærsk Drilling, Rederiet A P Møller A/S (500) |
| 6. Force Technology (120) | 12. Danske Bank A/S (incl. Danica Pension) (846) |

Anchor companies in the City of Knowledge – facts

Name	Parent company	Sector	Turnover 2016 (mill. DKK)	Growth in turnover 2012- 2016	No. of employed (LTK)
COWI A/S (incl. KX A/S)	Yes	Consulting engineers and architects	2,918	12%	1,615
Danske Bank A/S (incl. Danica Pension)	No	Finance and insurance	-	-	1,146
Haldor Topsøe A/S	Yes	Consulting engineers and architects	5,824	11%	1,130
Microsoft Denmark ApS and Microsoft Development Center	Yes	ICT	1,552	6% (2013-2016)	825
NNE A/S	Yes	Consulting engineers and architects	1,362	48%	800
Jyske Bank (incl. BRF Kredit)	No	Finance and insurance	-	-	650
Mærsk Drilling, Rederiet A P Møller A/S	No	Transportation	2,439	46% (2013-2016)	500
Cobham Satcom (former Thrane & Thrane A/S)	Yes	Life science, advanced chemistry and electronics	1,343	99%	470
Hempel A/S	Yes	Wholesale trade	818	33%	325
Geo	Yes	Consulting engineers and architects	204	-20%	185
Visma Consulting A/S	Yes	ICT	208	35%	130
Force Technology	No	Consulting engineers and architects	-	-	120
Total	-	-	16,668	-	7,896

Source: Data on turnover and employees are based on company income statements, short interviews and information collected from NN-Markedtsdata.

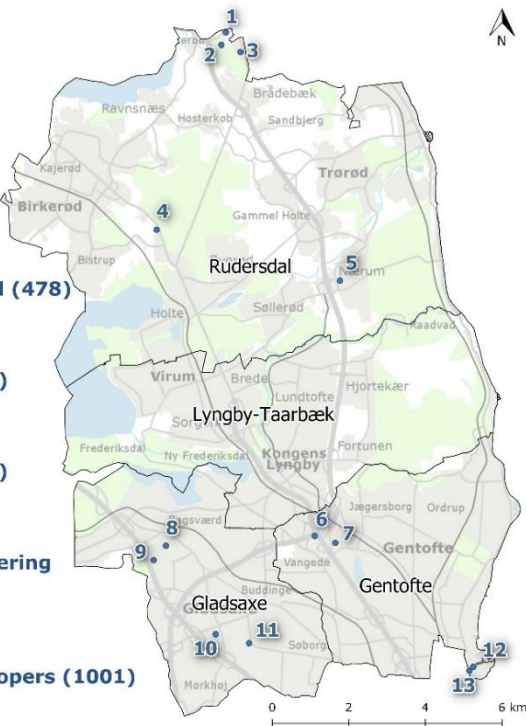
Note: Cells are empty for companies with headquarter in a different municipality than Lyngby-Taarbæk. Information about turnover is not available in NN-Markedtsdata prior to 2012.

Major knowledge-intensive companies in neighbouring municipalities



This map provides an overview of the biggest knowledge-intensive companies in the neighbour municipalities.

1. **Alk-Albello (700)**
2. **Chr. Hansen (750)**
3. **DHI Institut for Vand og Miljø (350)**
4. **IBM Danmark (350)**
5. **Brüel og Kjær Sound (478)**
6. **Ørsted (1001)**
7. **Novo Nordisk (1200)**
8. **Novozymes (1001)**
9. **Novo Nordisk (6451)**
10. **NNIT (1001)**
11. **GEA Process Engineering (750)**
12. **Saxo Bank (647)**
13. **PriceWaterHouseCoopers (1001)**



2.3. Facts on knowledge-intensive companies in Lyngby-Taarbæk and other "knowledge cities"



The table compares knowledge-intensive companies in Lyngby-Taarbæk to other university towns and to all of Denmark. Knowledge-intensive companies are defined as companies belonging to knowledge-intensive sectors (see appendix).

The drop in employment from 2009-2016 can be explained by the fact that three large companies moved out of the municipality between 2010-14 (Rambøll A/S, IBM Denmark A/S and NNIT A/S).

	Lyngby-Taarbæk	Copenhagen	Frederiksberg	Ballerup	Aarhus	Denmark
No. of knowledge-intensive companies (2016)	1,414	13,478	2,095	645	5,708	78,272
Share of all private companies (2016)	51%	42%	42%	33%	40%	29%
Share of private employment (2016)	42%	36%	27%	55%	27%	19%
Growth in employment 2009-2016 in knowledge-intensive companies	-10%	12%	22%	1%	14%	4%
Growth in employment 2012-2016 in knowledge-intensive companies	3%	10%	3%	-3%	10%	6%



3. Entrepreneurship



3.1. Start-ups

An important objective of the City of Knowledge is to develop one of the strongest tech start-up environments in Northern Europe.

Start-ups are important job creators. They are often the primary vehicle for translating research into new products and services. Start-ups are fundamental for developing high growth companies stimulating welfare and growth in the society as a whole.

This chapter provides a profile of the start-ups in the City of Knowledge, their locations, and their economic impact. Moreover, it shows examples of some of the most promising start-ups (it should be noted that only a few examples of successful scale-ups exist). The section also compares start-up performance in Lyngby-Taarbæk to other knowledge cities.

Moreover, the section also provides information of the development in DTU-based start-ups and their economic impact.

Finally, the chapter presents the start-up ecosystem at DTU campus (more than 100 start-ups are located at DTU campus – see examples (logos) to the right).

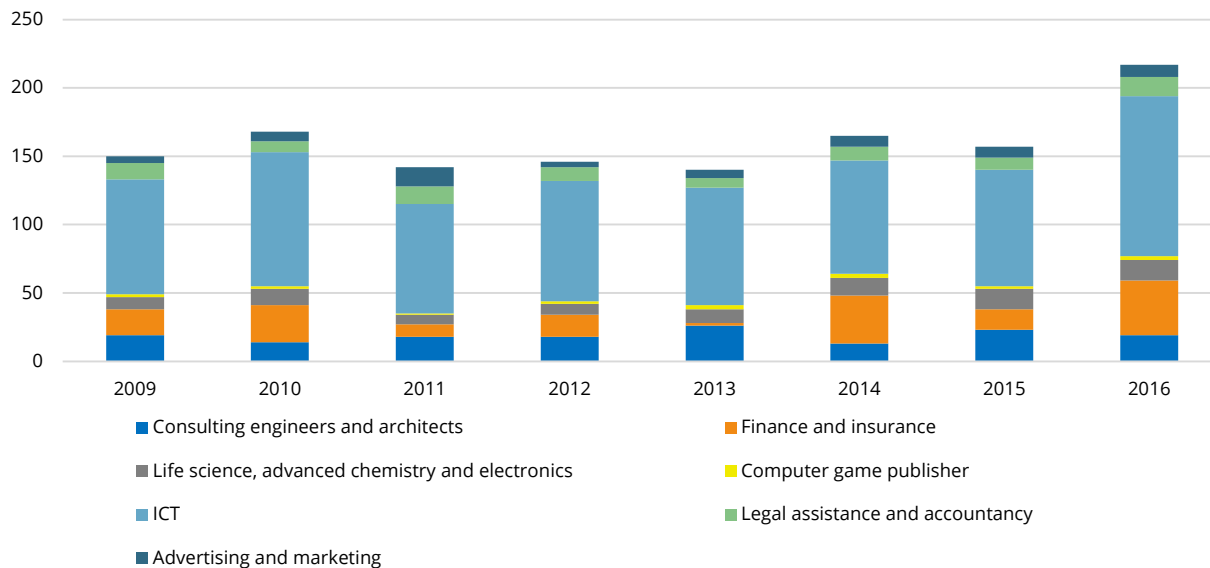


Start-ups in knowledge-intensive industries



The figure shows the number of start-ups in Lyngby-Taarbæk in knowledge-intensive industries and their sectoral distribution, 2009-2016.

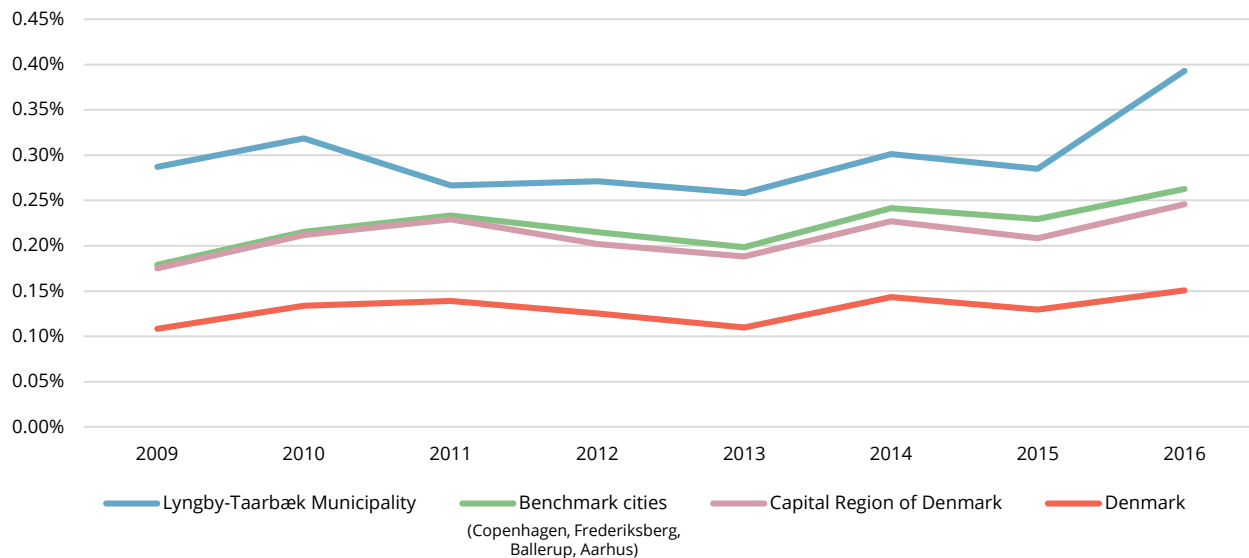
Number of new companies



Benchmarking start-up rates 2009-2016



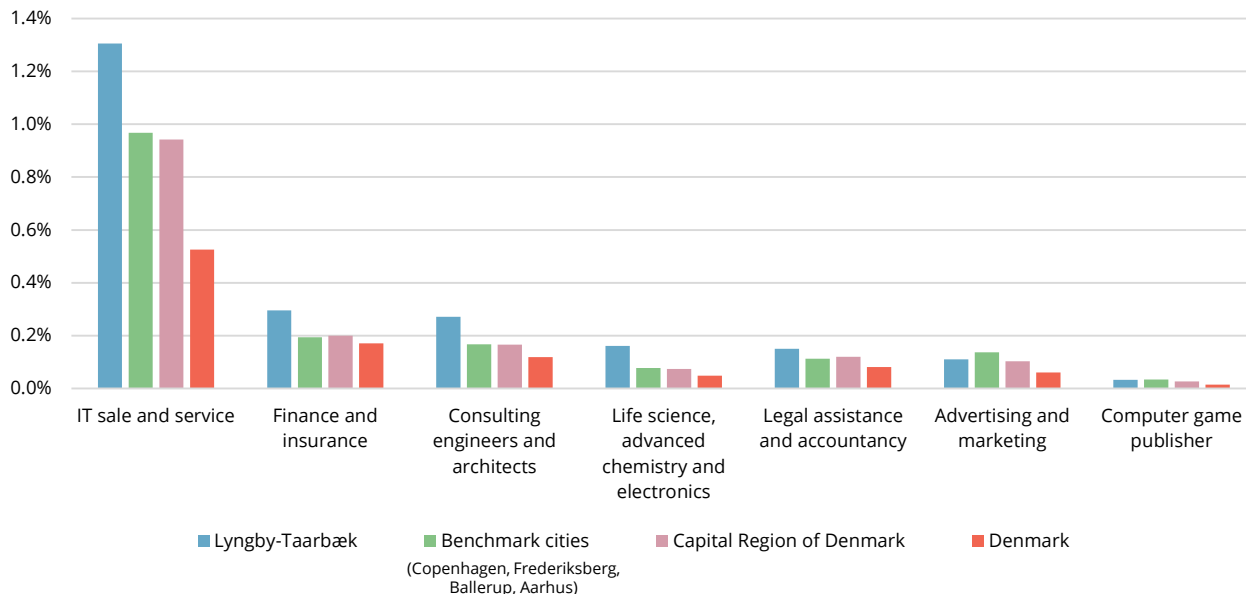
The figure shows start-up rates for knowledge-intensive industries from 2009-2016. The start-up rate is calculated as the number of new companies in knowledge-intensive industries divided by the number of citizens for each year. The City of Knowledge is compared to a group of other university cities (Copenhagen, Frederiksberg, Ballerup, Aarhus), the Capital Region and Denmark as a whole.



Start-up rate in knowledge-intensive industries (2009-2016)



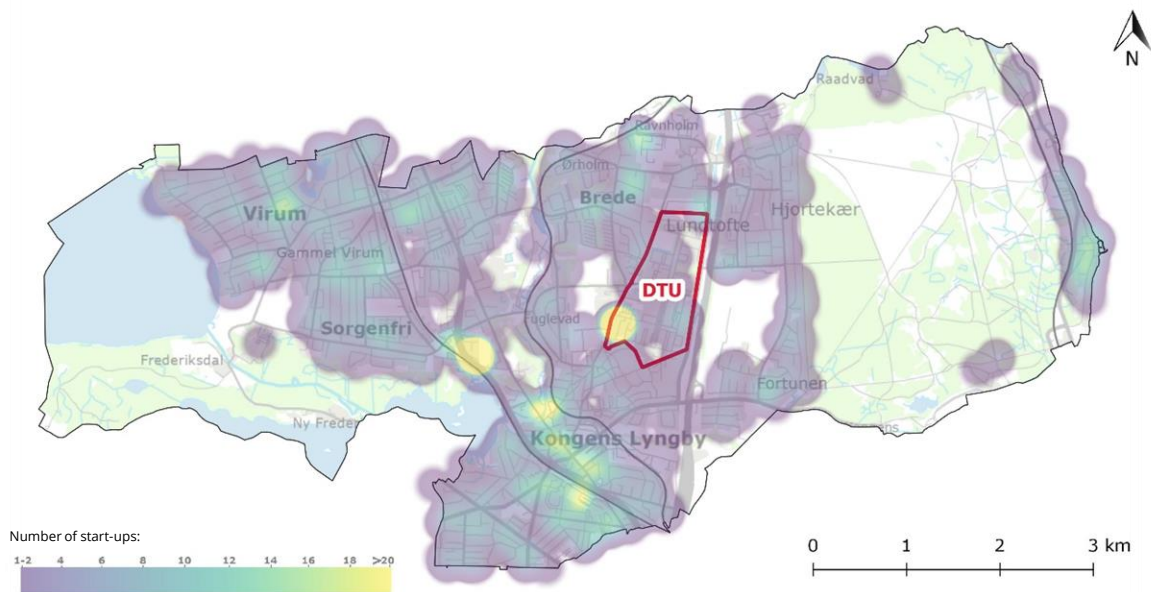
The figure shows start-up rates for knowledge-intensive industries from 2009-2016. The start-up rate is calculated as the number of new companies in knowledge-intensive industries divided by the number of citizens in the period. Lyngby-Taarbæk is compared to a group “knowledge cities” (Copenhagen, Frederiksberg, Ballerup, Aarhus), the Capital Region and all of Denmark. Lyngby-Taarbæk has high start-up rates in the industries where Lyngby-Taarbæk has high specialisation (see slide 7).



Location of start-ups in the City of Knowledge (heat map)



The heat map shows the concentration of start-ups in knowledge-intensive sectors in Lyngby-Taarbæk. A start-up is defined as a company established between 2009-2018. Yellow areas indicate a high concentration of start-ups.



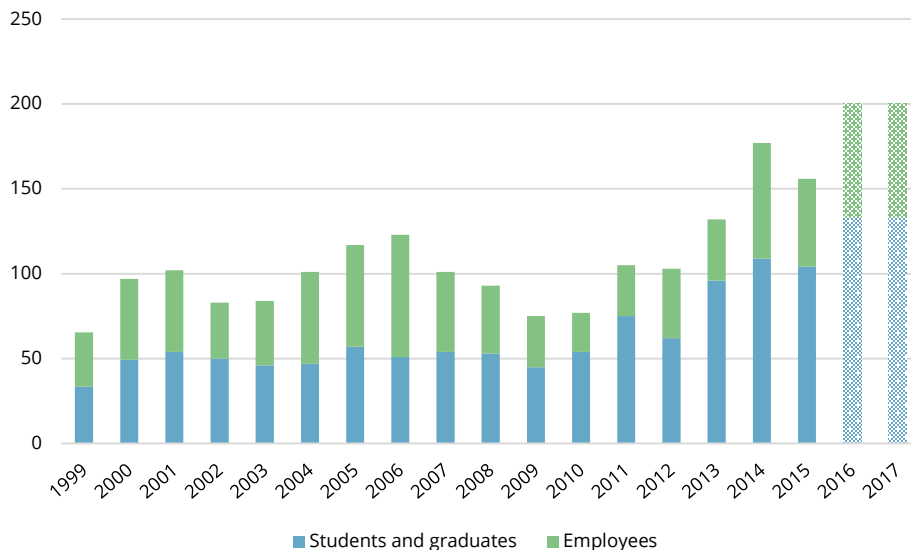
3.2. DTU-based start-ups



The figure below shows the development of DTU-based start-ups from 1999-2017, divided into student and graduate start-ups and start-ups established by DTU-employees (typically researchers). In 2015, 13 percent (or approx. 200 of all surveyed companies established after 1998) of all DTU-based start-ups were located in the City of Knowledge.

Definition:

DTU-based start-ups are defined as IPR-based companies (spin-outs), as well as employees, students and graduates who start a business while affiliated with DTU – or start a business no more than two years after graduation or end of employment at DTU.



Facts on performance of DTU-based start-ups – many start-ups, but only a few scale-ups!



A very high number of new companies have been established by researchers, new graduates and students from DTU. During the period, 1999-2017, DTU affiliates have created approx. 2.200 start-ups.



The annual number of DTU-based start-ups has almost doubled during the last five years. This increase coincides with a number of investments and initiatives that seek to strengthen the start-up ecosystem at DTU (see next section). It includes Skylab, a number of events, training opportunities and more emphasis on developing an entrepreneurship culture at DTU.



The survival rate of DTU-based start-ups is high. Of all companies established between 1999-2015, 74 percent still existed in 2015.



On average the DTU-based start-ups are performing better than other start-ups (in the same industries) in terms of employment, turnover and export (see next slide).

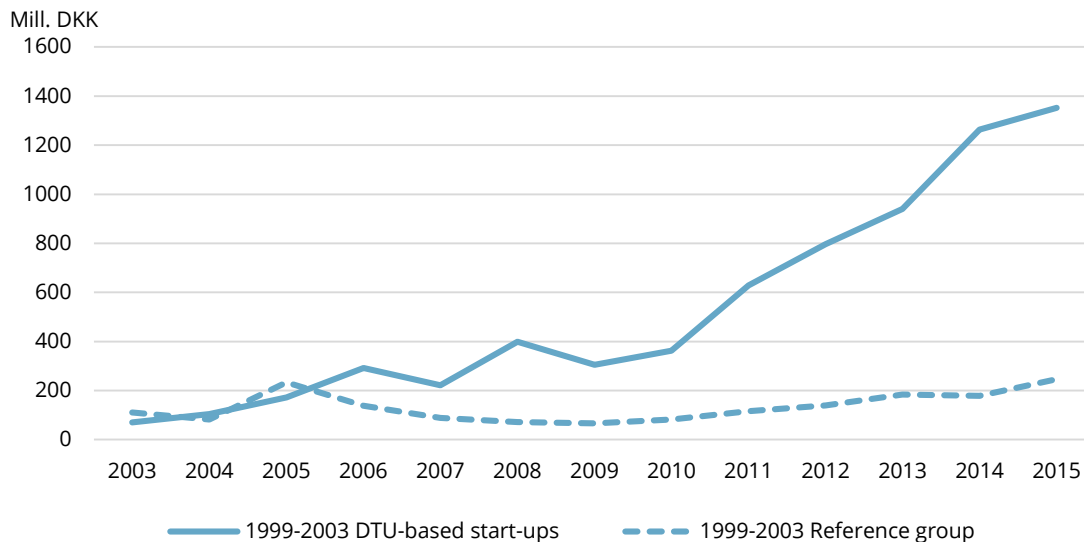


However, the number of “growth companies” (or scale-ups) is still small. In 2015, the total turnover in all DTU-based start-ups (1999-2015) remained as low as 5 bill. DKK. That is less than one so-called “unicorn” company! It is thus important to improve services targeting start-ups with high growth potential.

Development in exports among DTU-based entrepreneurs compared to a reference group



The figure shows the development in exports among DTU-based start-ups (established between 1999-2003) compared to a reference group (of the same size and age) of other start-ups in the same industries.



3.3. The start-up ecosystem at DTU

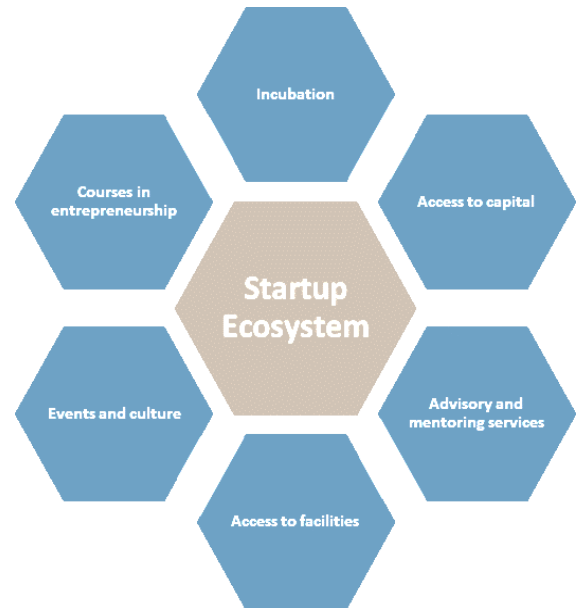
An important precondition for the development (and attraction) of new tech companies is a strong and vibrant ecosystem for start-ups.

A start-up ecosystem is formed by entrepreneurs, investors, counsellors, knowledge institutions, developers, business policy authorities, etc. The best examples of world-class ecosystems are found in Silicon Valley, Boston, Cambridge (UK), Israel and Singapore.

Within the last years, DTU has invested heavily in the development of a start-up ecosystem in cooperation with funds, private sponsors and authorities. Today, the DTU campus contains all the important elements (see next slide) needed for a strong start-up ecosystem. They have directed their efforts on different kind of start-ups (student start-ups, IPR-based start-ups, tech start-ups moving to DTU Science Parks, etc.).

According to a new survey conducted among DTU-based entrepreneurs, almost 80 percent of all start-ups state that the ecosystem played an important role for their birth and development (see slide 28).

The section also presents a couple of examples of the elements in the ecosystem



Elements in the start-up ecosystem at DTU campus

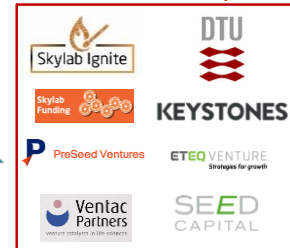
Courses



Advisory services and acceleration programs



Investors and capital



Events and matchmaking



Facilities and co-working spaces



Incubation and "in residence"



Supporting organisations



DTU
framework

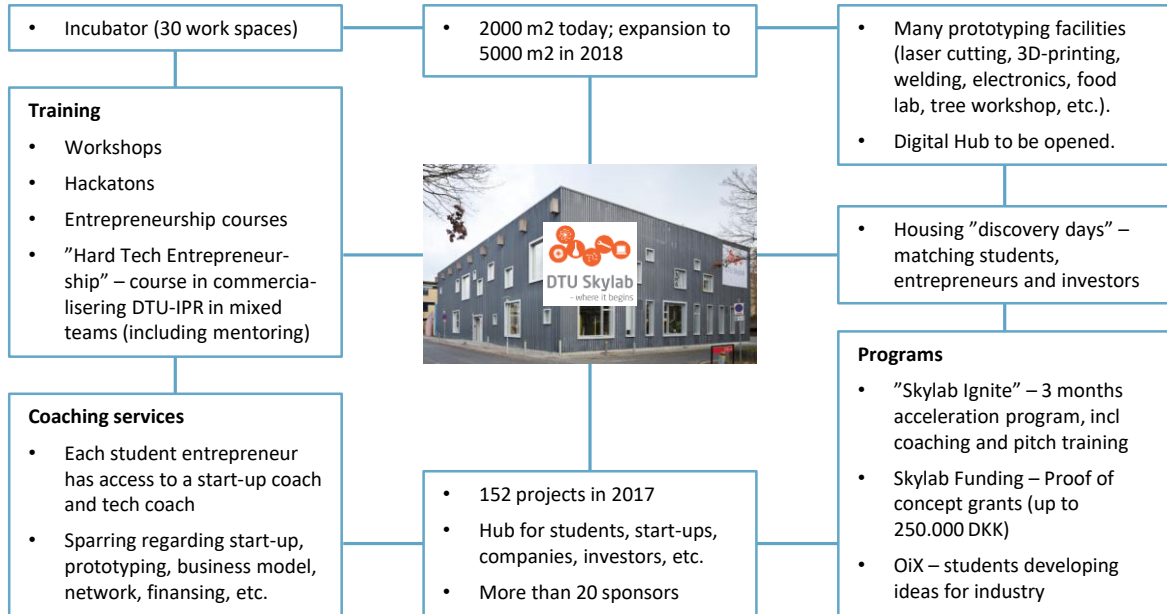
Goals for start-ups at
each DTU-department

Business developers at
each DTU-department


Leave policy
stimulating spin-outs

Commercialisation and
entrepreneurship

Case: DTU Skylab – a melting pot for student entrepreneurship



Case: Open Entrepreneurship – a new approach for turning research into business and spin-outs

 Open Entrepreneurship is a DTU-lead, Danish initiative aiming to turn world-class research into world-class spin-outs. The approach is to match research teams (working with promising research projects and ideas in the early phase) with experienced and external entrepreneurs through six means (see below). Four universities participate in the program, which is financed by The Danish Industry Foundation.

1. Entrepreneurs-in-residence

Experienced entrepreneurs or investors can get a desk at the local Open Entrepreneurship business unit at each university.

2. Intrapreneurs-in-residence

Business developers or intrapreneurs from external companies or organizations can be placed in prosperous research environments.

3. Researchers-in-residence

Researchers can be placed in companies or organizations to build lasting relations and collaborations on research and development.

- Separate business units (at DTU Fotonics, DTU Space and DTU Compute)
- Network of open entrepreneurs linked to the project



OPEN
ENTREPRENEURSHIP

4. Accelerator

During a 3-6 month period, researchers with an idea with commercial potential will get matched with entrepreneurs and will be accelerated to become sustainable, technology based start-ups.

5. Industry collider

This is the opportunity for companies to set a case or a problem, and challenge researchers or students to come up with an innovative solution together.

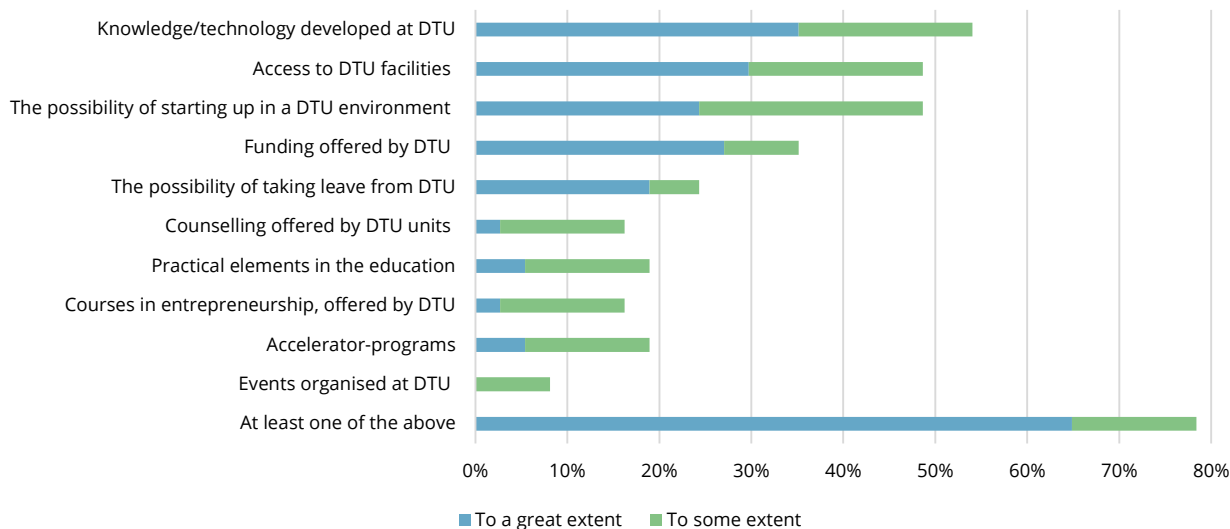
6. Boot camps

One week boot camp where researchers and entrepreneurs collaborate and develop ideas that can grow to spin-outs or start-ups.

The importance of the ecosystem



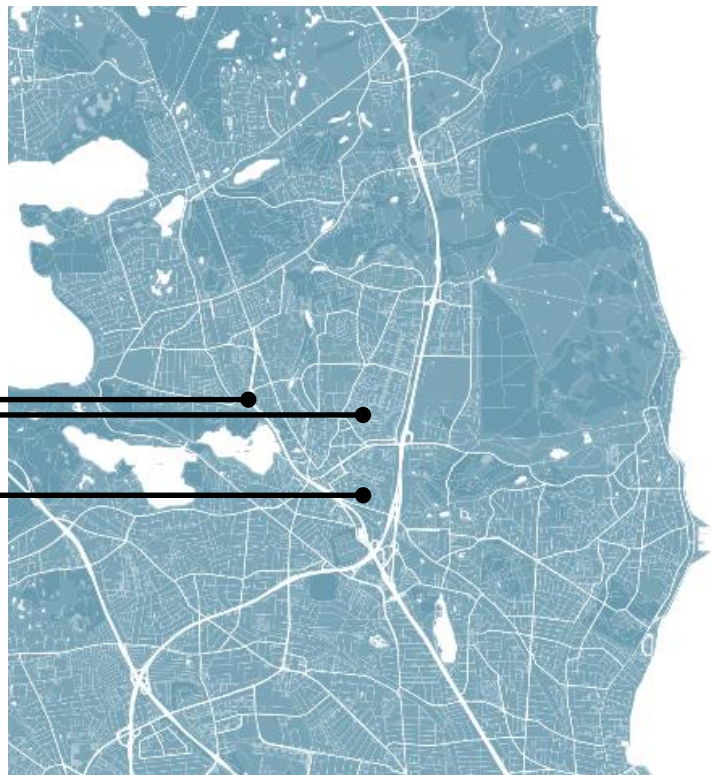
The figure below shows which elements in the ecosystem that have been important for the start-up of companies founded by DTU-based entrepreneurs. Access to investors at DTU campus was not a part of the questionnaire.



Promising start-ups – 3 cases



intomics



Case 1: Aquaporin

Ground-breaking water purification technology

Aquaporin develops and produces highly efficient water purification modules that can be integrated in any type of water supply system. The technology is based on the same protein-based, water treatment method that are found in biological cells.

Aquaporin's technology carries a high potential for solving global water challenges: at maximum capacity, one gram of aquaporins can clean 700 litres of water per second!

Aquaporin was established in 2006 and is a spin-out from DTU. The company is located in Lyngby, north of DTU's campus. The technology has been developed in a close cooperation with four DTU-institutes (DTU Chemistry, DTU Physics, DTU Nanotech and DTU Environment).

Since the company's inception, Aquaporin has raised approximately EUR 40m from investors and EUR 20m from innovation programs.

The company is the highest valued DTU spin-out with an estimated market value between DKK 1-2bn. The company employs 110 people in total, including 65 in Denmark.

Aquaporin's management, R&D, sales and production is located in Lyngby, with R&D activities in Singapore and a joint venture with the large Chinese company Congreen Ecological Acgricatural Co, which is specialised in environmental technology.



Case 2: Intomics

Crunching biological data for drug discovery

Intomics is specialised in analysing large sets of biological data (e.g. from human genome, patient journals, proteins, etc.).

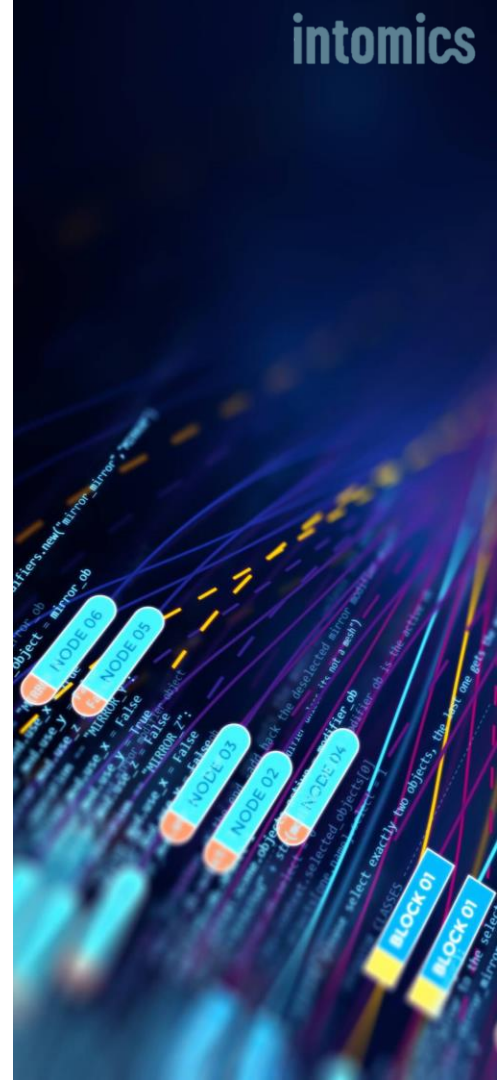
The company's methods are crucial for developing new drugs within personalised medicine, i.e. the ability to target drugs, according to the individual's specific biological properties (phenotype). The company was spun out from DTU in 2008.

Intomics works with major pharma and biotech companies, e.g. AstraZeneca, Leo Pharma and Lundbeck. Intomics' approach is highly partnership-oriented, by working together with their customers from an early stage in the development process and all the way to the market. Furthermore, Intomics is also helping big pharma companies to carry out biological, big data analysis.

Intomics was a Gazelle-company in 2016 and 2017, and they have experienced an annual doubling of their turnover, as well as the number of employees, during these two years. Today, the company has 25 employees.

Intomics is currently active in 10-12 countries, and approximately 35% of the major European pharmaceutical companies have worked together with Intomics.

Intomics headquarter is located in Sorgenfri. The company is planning opening up a branch in the US.



Case 3: MASH Biotech

Turning waste into value and creating self-reliance

MASH Biotech is specialised in turning waste into utility through flash pyrolysis. Feedstocks such as sludge, used car tyres, wooden biomass and waste water can be transformed into fertilizer, bunker oil and coke.

The bunker oil can make an entire ship's use of oil CO₂-neutral by adding as little as 11% to the normal fossil based oil supply.

MASH's technology is primarily aimed at developing countries. The technology is low-cost and can be transported all around the world in containers, e.g. for waste treatment facilities or farms.

The company's solutions furthermore carries a social dimension by providing new jobs in refugee camps and making local communities self-reliant.

The company is located at DTU Science Park and was started by DTU students and a professor in 2015. The company currently employs seven people in a management team.

During its first years, the turnover has been DKK 1.3m per year. However, the company is expecting a turnover of DKK 20m in 2018, due to an expansive sales process.

The company has attracted approximately DKK 2.9m in soft funding.





4. Knowledge assets



4.1. Research strongholds

DTU - The Technical University of Denmark is one of the leading technical universities in Europe.

Benchmarked against other European technical universities, DTU is performing excellent within a number of research areas. The most dominant strongholds at DTU are energy, life science, materials science, environment and sustainability, computer science and construction.* Within these areas, research groups at DTU are among the best groups in Europe in terms of publications, citations and ability to publish in the most prestigious journals. Moreover, DTU has a widespread cooperation with businesses in these fields.

The six areas also contain a critical mass of research, talents and research infrastructure, and they represent a high potential for further external partnerships and commercialisation of research.

DTU-specialisation within each stronghold is briefly elaborated on the next slide.



**DTU also has a stronghold within veterinary science. But most of the research within this area will be moved to University of Copenhagen in 2020. Space research is also a stronghold, but this area is small with a relative low interaction with businesses.*

Six important DTU-strongholds

Energy



The largest research field at DTU is energy science. DTU carries out research in many areas of this field, and they are particularly strong within the area of renewable energy (including wind, solar and bio based energy), fuel cells, energy conversion, energy storage and catalysis.

Moreover, DTU is among the top performing universities within integrated energy systems, smart grids, plasma physics and fusion energy.

Life science



14 DTU-departments carry out research within life science*. DTU research strongholds encompass basic research within micro biology, synthetic biology, protein chemistry, enzymes, biomedicine and bioinformatics.

Moreover, DTU performs excellent within a number of research areas connected to health technology (drug delivery, ultra sound, audiology and magnetic resonance/scanning technologies).

Finally, DTU is leading within certain areas of food research (toxicology, epidemiology, nutrition and fermentation).

* Life science is a branch of research that studies living organisms and life processes. Within life science, researchers also develop technologies and production processes based on knowledge of living organisms (cells, bacteria, animals, humans, etc.).

Materials science



DTU is strong within a number of materials sciences. Their strengths include surface technologies (including nanotechnology), polymers, topology photonics (science of light) and imaging. Many of these fields are relevant for a large number of industries.

Environment and sustainability



The DTU Environment Department is leading within a large number of research topics, including water technologies, life cycle analyses, sustainability, waste management, risk assessments and environmental regulations.

Computer science



Computer Science is primarily a research topic at DTU Compute and DTU Physics. Strengths include mathematical modelling, algorithms, cognitive systems, and certain areas of artificial intelligence.

Construction



DTU is performing excellent within the field of indoor climate. This field includes sustainable heating, cooling of buildings, ventilation, air quality in buildings and vehicles as well as maritime construction techniques.

4.2. Knowledge resources in the City of Knowledge

A City of Knowledge is characterised by a high concentration of researchers, students and highly educated people. Access to highly skilled people is fundamental for innovation and for attracting and developing a high number of knowledge-intensive companies.

Lyngby-Taarbæk is no. 1-2 in Denmark measured in terms of the concentration of researchers, students and knowledge workers (see next slide).

Moreover, the city has a broad supply of educational institutions and educations covering 1) technical educations (from EUD to MA in engineering), 2) mercantile educations, 3) educations in innovation and entrepreneurship (i.e. BA in innovation and entrepreneurship) and 4) all types of secondary education (STX, HHX, HTX).

Facts on knowledge resources



1.723 university researchers work in the city (from post-docs to professors).



1.454 PhD-students are enrolled at DTU.

11.895 students are enrolled at institutions of higher education and DTU.



Lyngby-Taarbæk has 16.663 inhabitants with a higher education.



23 per cent of the university researchers, 52 per cent of the PhD-students, and 10 per cent of the students enrolled at higher educations are international.



A university, a university college, a school of marine engineering, a business academy, a vocational school, and three high schools are located in Lyngby-Taarbæk

The City of Knowledge has a very high concentration of knowledge workers and students



The table below shows the concentration of young researchers, students and highly educated inhabitants in the City of Knowledge, four other university cities and Denmark as a whole. Researchers and students are measured in terms of no. working/studying in the city, while highly educated people are measured in terms of inhabitants with a bachelor, master or Ph.D. degree.

	Lyngby-Taarbæk	Copenhagen	Frederiksberg	Ballerup	Aarhus	Denmark
Ph.D.-students enrolled at universities as a share of workforce	4.2%	0.8%	0.5%	0.0%	0.8%	0.3%
Students enrolled at higher educations as a share of workforce	36%	21%	32%	4%	5%	11%
Citizens with a bachelor degree or more as a share of work force	49%	42%	52%	26%	37%	28%
Citizens with a master degree or Ph.D. as a share of workforce	27%	21%	28%	10%	15%	10%



5. Collaborative research and innovation



5.1. Introduction

This final chapter provides a picture of the extent and content of formal collaboration between DTU and companies belonging to the leading industries/clusters in the City of Knowledge. Moreover, it gives examples of broader, collaborative innovation projects involving knowledge institutions, companies and the municipality (Triple Helix projects).

In section 5.2, we have mapped to what degree companies belonging to the leading industries collaborate with DTU, and which DTU-institutes that are involved in collaboration companies from with these industries. The industries are divided into three groups:

- Life science and advanced chemistry (including pharma, medico, enzymes, proteins, catalysts, coatings)
- ICT and finance (including ICT-hardware, software and IoT-companies).
- Engineering (including consulting engineers, instruments, cleantech/energy, off shore industry).

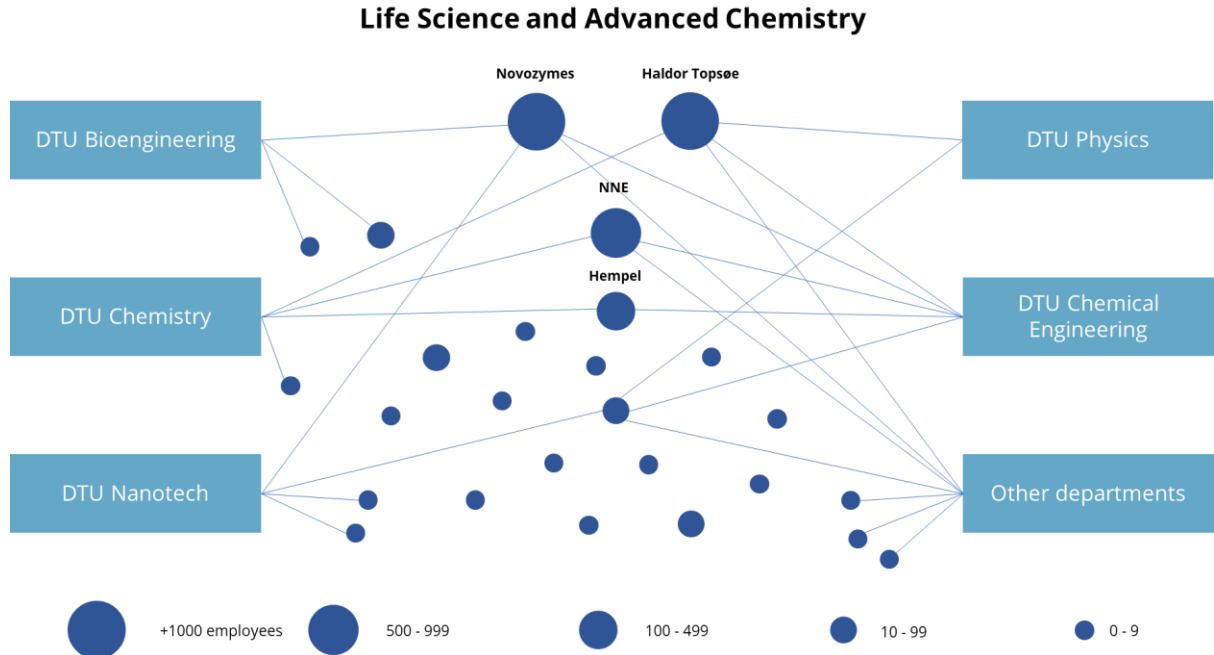
The analysis is based on interviews (carried out by DTU Science Park and IRIS Group) with a majority of the companies in these industries. The smaller companies (less than 100 employees) in the figures are all located in DTU Science Park.

Section 5.3 shows planned, ongoing and completed Triple Helix projects (involving DTU, companies and the Municipality of Lyngby-Taarbæk).

How to read the figures in section 5.2:

- Each dot represents an interviewed company.
- All major companies in each industry (“anchor companies” – see section 2) have been interviewed. Moreover, approximately 80 per cent of all companies located in DTU Science Park Lyngby have been interviewed. Specialised service providers (such as patent companies, suppliers of advisory services, venture capital providers, etc.) are not included in the maps.
- In total, more than 100 companies from the three industries have been interviewed. The biggest industry, in terms of no. of companies, is ICT and finance. 47 companies from this industry are represented in the figure on page 39.
- Each line represents either an ongoing, formal collaboration or – in a few cases – expectations in the interviewed company to engage in formal collaboration with DTU in the near future. By a formal collaboration we mean a collaboration based on a contract. Examples are contract research, Industrial PhD projects, InnoBooster projects, Grand Solution projects, Horizon 2020-projects, etc.
- A dot without any lines represents a company with no formal collaboration with DTU. Many of these companies have informal relations with DTU-Institutes – in terms of ad hoc knowledge sharing. Moreover, they are users of the services provided by DTU Science Park (section 3).

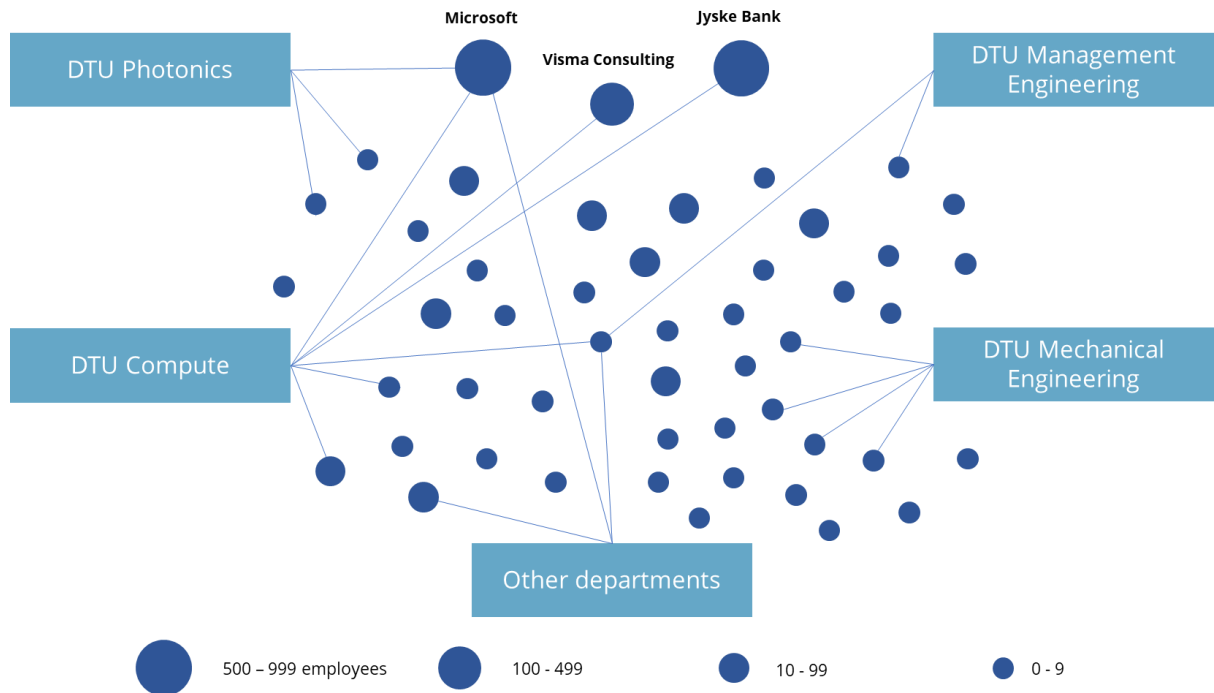
5.2. Collaboration between companies from leading local clusters and DTU



Note: "Other departments" are departments with only one connection to a company. This includes DTU Biosustain, DTU Biotechnology, DTU Food, DTU Compute, DTU Electrical Engineering, DTU Civil Engineering, DTU Bioinformatics, DTU Aqua, DTU Management Engineering and DTU Energy

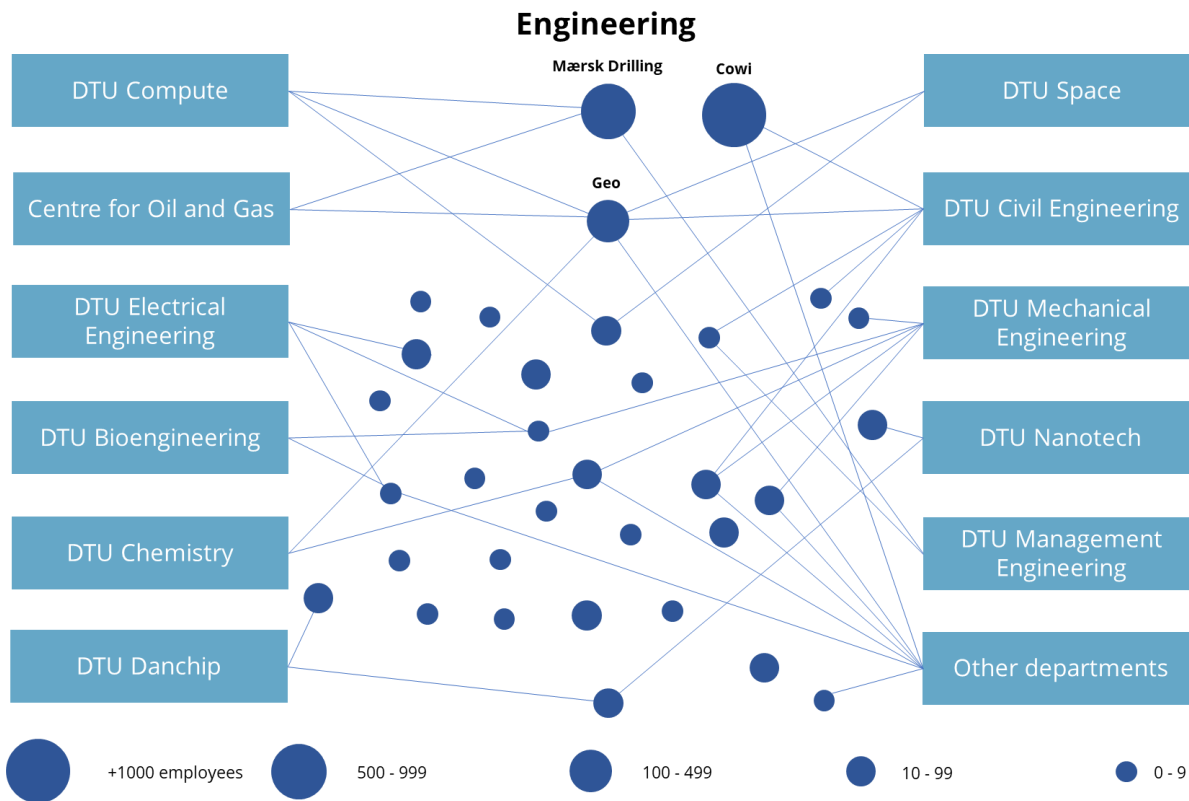
Collaboration between leading local clusters and DTU

ICT and Finance



Note: "Other departments" are departments with only one connection to a company. This includes DTU Physics and DTU Civil Engineering.

Collaboration between leading local clusters and DTU



Note: "Other departments" are departments with only one connection to a company. This includes DTU Energy, DTU Photonics, DTU Physics, DTU Chemistry, DTU Management Engineering, DTU Environment, DTU Civil Engineering, and DTU Wind Energy.

Conclusions

The three figures on page 37-39 indicate that DTU is involved in many collaborative research and innovation projects with companies from the leading industries in the City of Knowledge.

More than 40 companies are currently engaged in collaborative projects with one or more DTU-departments. The share of companies collaborating with DTU is highest within life science and engineering. In these industries about half of the companies state that they collaborate with DTU.

Another interesting result is that each industry is involved in collaboration with many different DTU-departments. Thus, formal collaboration within life science, engineering and ICT is not limited to a few research fields.

Local companies from the engineering industry are collaborating with 16 out of the 23 DTU-departments, and 15 different DTU-departments are collaborating with life science companies located in the City of Knowledge.

This picture partly reflects a high degree of diversity in the specialisation pattern in the local industries. The companies within life science, engineering and ICT do not all belong to the same technology niches or value chains. It is more broadly engineering skills and a "deep-tech" focus that connects the companies.

But the results also reflect the fact that the research at DTU concerns all parts of the industrial value chain – from development of new technologies, to product development, industrial production and quality control.

In many industries, different DTU-departments can assist with research and knowledge in different parts of the value chain. A life science company might collaborate with DTU Bioengineering when developing insight into the characteristics of new molecules and proteins. It may develop new products in collaboration with DTU Chemistry, and it may collaborate with DTU Chemical Engineering in the development of production techniques, etc.

Other key points:

- The anchor companies typically collaborate with 2-3 different DTU-institutes.
- A little less than half of the start-ups and scale-ups in DTU Science Park collaborate with DTU-departments.
- Within life science and advanced chemistry, the most common collaboration partners are DTU Chemistry and DTU Chemical Engineering.
- The most common DTU-partner among companies in the ICT and finance industries is DTU Compute,
- The engineering industry collaborates with many different DTU-departments. But the most widespread partner in this industry is DTU Mechanical Engineering.
- A vast majority of the 23 DTU-institutes are collaborating with local businesses.

Key areas of collaboration

Below we have highlighted some of the most important areas of collaboration highlighted by the companies in the three industries. Most of the areas concerns ongoing cooperation with DTU-institutes, but the list also includes areas where the companies expect to collaborate with DTU in the future.

Life science / advanced chemistry

- Design of production processes in the pharmaceutical industry
- Use of 3D techniques in life science production
- Optimisation of production through the use of big data technologies
- Characterisation of enzymes
- Research in the application of microorganisms
- Fermentation
- Coating (surface technologies)
- Use and test of new chemicals
- Methods for characterisation and production of enzymes and proteins
- Test of new products for water cleaning, chemical production, etc.
- New processes for production of chemicals and catalysts
- Development of new catalysts (e.g. for conversion of biomass)
- Use of ultra sound technologies

ICT and finance

- Development of algorithms (for big data analyses) and machine learning
- Quantum computing
- Virtual reality (to be in production processes and in retail)
- Artificial intelligence
- Use of big data technology for the development of new financial products
- Cybersecurity
- 3D-printing
- Wireless communication

Engineering

- Predictive maintenance
- Intelligent networks and system integration
- Operation of high voltage systems
- High efficiency offshore drilling
- Drone technology (i.e. mapping of landscapes, seabeds, etc.)
- Methods for purification of contaminated areas
- Machine learning
- Digital integration of activities in the different parts of the value chain
- Methods for forecasting in the production of wind energy
- Use of laser technology in new products
- Efficient performance of large infrastructure
- Innovative design of bridges
- Modelling strength and capacity of concrete
- Hydroeconomic models
- Waste to value

5.3. Triple Helix Innovation Projects

One of the visions for "The City of Knowledge" is to develop the city as an European hotspot for developing and testing new technologies in areas of great societal importance.

The combination of world-class research, unique research facilities, advanced data infrastructures, research intensive anchor firms, a vibrant start-up ecosystem and abundant student resources represent top preconditions for the development of such a hotspot.

Moreover, the municipality of Lyngby-Taarbæk, as well as the Loop City network*, is strongly committed to the development of smart city solutions, welfare technologies and technologies for CO2-reductions.

This final section presents current innovation projects and pipeline projects in Lyngby-Taarbæk. The purpose is partly to highlight examples of how the local resources can be utilized, and partly to stimulate a discussion of how to engage the city's key stakeholders in the development of more projects dealing with tech solutions to great societal challenges.

The table on the right shows both pipeline, ongoing and past innovation projects. The three following pages present case descriptions of three of the projects.

Project name	Partners	Status
City level facility management	Universities: DTU Municipalities: Lyngby-Taarbæk, Copenhagen Private companies: Microsoft	Completed
Autonomous busses	Universities: DTU, Roskilde University Municipalities: Albertslund, Gladaxe Private companies: Autonomous Mobility, Nobina Technology, IBM Other: LOOP CITY, Gate 21	Ongoing
Smart City Hub	Universities: DTU Municipalities: Lyngby-Taarbæk Private companies: Niras Other: The City of Knowledge	Ongoing
"Trongårds-projektet"	Universities: DTU Municipalities: Lyngby-Taarbæk Private companies: Elf Development, Novozymes, TEC.	Pipeline
Rain Water Management along "Mølleåen"	Universities: DTU Municipalities: Lyngby-Taarbæk (and probably more) Private companies: Not settled Other: Not settled	Pipeline

*A cooperation between 10 municipalities and Greater Copenhagen

Case 1: Autonomous busses on DTU Lyngby Campus

At DTU Campus Lyngby, two separate innovation projects will test autonomous busses on the streets among cars, cyclists and pedestrians.

An amendment to the Danish Road Traffic Act in July 2017 made it possible to apply for test driving of autonomous vehicles on public roads. Shortly after, the Lyngby based company Autonomous Mobility handed in the first application paving the way for the first innovation project in which Autonomous Mobility tests their first self-driving shuttle busses in collaboration with DTU.

The second innovation project – called LINC - assembles researchers and students from DTU and Roskilde University, regional partner organisations, leading private companies within the autonomous vehicle industry and local authorities (see box to the right). It is vital for all partners that self-driving vehicles on campus are not just a demonstration of technological achievements, but a vibrant living lab that constantly evolves.

At DTU, the ambition is that the autonomous busses will contribute to research-related themes such as bus route optimization, transport on-demand, machine learning, and image recognition technology.

The expectation is that the region and local municipalities will benefit from a fleet of autonomous busses that can commute passengers from the future light rail stations to their final destinations (e.g. a specific department at DTU).

For now, the busses are operating on closed areas while waiting for a permission to test drive on public roads. DTU Lyngby Campus forms a perfect test bed for such an innovation project as researchers from DTU Management Engineering can monitor the demand for transport in real time in order to create dynamic bus routes adapting to the passengers needs. DTU's students and researchers have access to test and study the technologies associated with future dynamic transport systems, the interplay between autonomous systems and their surroundings, and the use of advanced sensor technology.



Duration
2018



Budget
DKK 31.4 m



Project partners

DTU, Roskilde University, LOOP CITY, Gate 21, Nobina Technology, IBM, Albertslund Municipality, Gladsaxe Municipality.

Note: The picture shows Autonomous Mobility's bus "Olli", while the factsheet relates to the innovation project LINC.

Case 2: Rain Water Management along “Mølleåen”

As a pipeline project, Lyngby-Taarbæk and DTU are coining the first ideas of a new vision for “Mølleåen” – a stream that winds through four municipalities and may be a vital part of future adjustments to a changing climate.

The four municipalities with access to “Mølleåen” discharge rain water into the stream, but the total amount of rain water discharged during heavy showers is unknown. Thus, the purpose of the project is to better understand the robustness of the stream in order to manage rain water release.

Today a handful of locks are manually operated along the stream. The signal is a simple phone call to the house nearest the lock. An innovation project will introduce sensors and IoT-technology to real time monitor and automatically adjust locks to optimise the amount of water running through the stream. Furthermore, sensors will provide a valuable data stream for researchers, and it will open up for smarter governance between the local municipalities.

DTU students already use different monitoring stations along “Mølleåen” in their education. A large scale innovation project would boost the possibilities to include “Mølleåen” in more DTU-educations such as computer and sensor technology.

The project is still at a very early stage. All four municipalities need to commit and the project still needs funding in order to be realised. However, the project potentially could bring along several interesting possibilities.



Duration
Pipeline project



Budget
Not determined



Project partners
DTU, Lyngby-Taarbæk Municipality,
and probably more municipalities
and companies.

Case 3: Smart City Hub

A hub for big data and smart city solutions tackles real world challenges faced by private and public stakeholders. The Smart City Hub is a platform and a physical space that allows researchers, students, companies, start-ups, and public authorities to co-create the smart city technologies of tomorrow.

The hub is like an ongoing hackathon, where everyone can “hack in” and contribute - or simply follow discussions on smart city technologies and possibilities. There is no commitment needed – participants share, work and create together.

The hub was initiated by the City of Knowledge, DTU, the engineering consultancy firm NIRAS, and Lyngby-Taarbæk Municipality, and the first event took place in February 2017. A total of eight events were held in 2017 - each with a different case presented and a facilitator to encourage and stimulate the discussion.

The core of the hub is data from Lyngby-Taarbæk Municipality and companies, and the goal is to collaborate on using data in new ways in order to create a smart city with smart buildings, smart roads, smart transport, smart energy and waste disposal solutions, etc.

Among the participants there is a common understanding of the hub as an open space where challenges and ideas are freely debated. Companies like NIRAS, Microsoft and Siemens get the chance to meet researchers, students and experts from the municipality in a different setting, and often take home alternative views on a particular case. Students and researchers build their networks and establish new collaborations. And Lyngby-Taarbæk Municipality develops in smarter ways.

In 2018, the interregional innovation project 'Lighting Metropolis' joined the project, and several other Danish university cities have shown interest in adopting the concept.



Duration
2017-2018



Budget
Approx. DKK 8.000
per event



Project partners
DTU, NIRAS, Lyngby-Taarbæk
Municipality, Lighting Metropolis



6. Appendix



Appendix

The appendix shows NACE codes and descriptions of knowledge intensive industries as defined in this publication.

Life science, advanced chemistry and electronics

- C20 - Manufacture of chemicals and chemical products
- C21 - Manufacture of basic pharmaceutical products and pharmaceutical preparations
- C26 - Manufacture of computer, electronic and optical products
- C27 - Manufacture of electrical equipment
- C32 - Other manufacturing
- M72 - Scientific research and development

Computer game publisher

- J58.2 - Software publishing

ICT

- G46.5 - Wholesale of information and communication equipment
- J61 - Telecommunications
- J62 - Computer programming, consultancy and related activities
- J63 - Information service activities
- M70 - Activities of head offices; management consultancy activities

Finance and insurance

- K64 - Financial service activities, except insurance and pension funding
- K65 - Insurance, reinsurance and pension funding, except compulsory social security
- K66 - Activities auxiliary to financial services and insurance activities

Legal assistance and accountancy

- M69 - Legal and accounting activities

Consulting engineers and architects

- M71 - Architectural and engineering activities; technical testing and analysis

Advertising and marketing

- M73.1 - Advertising

Schools and universities

- P85.1 - Pre-primary education
- P85.2 - Primary education
- P85.3 - Secondary education
- P85.4 - Higher education

