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CLEANTECH CLUSTER

GREEN AND SMART BUILDINGS IN DENMARK

Asset mapping of the Danish sector
for sustainable construction

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Foreword

The construction industry plays a central role in the transition towards a greener future. Parallel to this, there is a huge economic potential in delivering the solutions in practice. However, in order to realise the enormous potential for resource savings and growth that the sector represents, stakeholders from the private and public sectors as well as the knowledge institutions must come together to create the synergies needed.

The main aim of this report, which is published by Copenhagen Cleantech Cluster, is to support this development. In order to do this, the report provides a broad overview of the Danish competencies within the green and smart building industry. This could be used by a) Danish stakeholders in the sustainable building sector wishing to create new partnerships or show the extent of the Danish competencies within the field of sustainable building, and b) foreign stakeholders wishing to enter the Danish market for sustainable building or create new partnerships with Danish companies.

“It is crucial to adopt a holistic approach to sustainable building, which includes environmental, as well as social and economic concerns.”

Susanne Kuehn, Rockwool

The findings presented in the report are, among other things, based on a survey answered by 219 companies working within the Danish sustainable building sector. The companies were selected by going through the membership databases of relevant interest organisations, including InnoByg, Green Building Council Denmark, The Danish Association of Architectural Firms, SmartCityDK, Danish Ventilation, ICIEE, The Danish Lighting Center, GroentHus.dk, and Building Culture Denmark (Bygningskultur Danmark).

To supplement the quantitative data collected from the survey, a number of interviews have been conducted with representatives from different parts of the sustainable building value chain, and experts within the field of sustainable building. These include Network Manager at InnoByg, Charlotte Darre, Senior Advisor at Rockwool A/S, Susanne Kuehn, Sales and Marketing Director at Marius Pedersen A/S, Jeanett Vikkelse, Head of Energy & Environmental Solutions at Siemens A/S, Lars Nielsen, and Professor at the Department of Civil Engineering at the Danish Technical University, Svend Svendsen. We would like to express our sincere gratitude to the people who have helped us in the making of this report and all the companies participating in the survey.

Finally, it should be noted that this report adopts a holistic definition of sustainable buildings, which includes the social, economic as well as the environmental aspects of the building project. In this regard, sustainable buildings ideally are not just sustainable because they incorporate green technologies such as solar panels and heat pumps. Instead, the ‘greenness’ and ‘smartness’ of a building has to be tried within the broader context of sustainability, where social, environmental, as well as economic factors are taken into account. Therefore, when this report makes use of the word ‘sustainable’ it should serve to indicate that it takes more than just green and smart technologies to design and construct the buildings needed for the future; social and economic aspects have to be an integral part of the planning as well.

Please note that the editing team is solely responsible for the content of the report.

Introduction

The global building industry is developing fast as millions of people worldwide are moving into the cities demanding accommodation. The number of so-called megacities worldwide with more than 10 million inhabitants is set to almost double by 2025, while the number of inhabitants living in urban areas is expected to increase by more than two-and-a-half billion by 2050.

Not only does this global trend of increasing urbanisation¹ call for innovative solutions to the design and construction of new sustainable buildings; there is also a great need to retrofit existing buildings so that they become more energy efficient and pleasant to live and work in. Within the European Union, for instance, the building stock takes up 40% of the total energy consumption, making the building sector the single biggest consumer of energy².

The enormous potential for energy and resource savings has led the sustainable construction sector to become one of the main pillars of the global green growth agenda. This means that the global market for sustainable building projects is growing rapidly. The Global Cleantech report 2012 published by Copenhagen Cleantech Cluster and Complex Cleantech Solutions, pointed to green buildings as one of the fastest-growing platforms in the coming years. In more concrete terms, this means that the market for building efficiency materials will grow 28% towards 2015. The report projects Europe to be the biggest global market for green buildings by 2015 worth around €440 billion³.

Denmark seems to have an edge in many areas related to this. The Danish sustainable construction industry is expected to be a growing source of both increased growth and resource efficiency. In Denmark the focus on energy efficient buildings is great, and the building industry is set to play an important role in the ambition of becoming completely fossil-free by 2050. Low-energy building solutions have been a focus area in Denmark since the oil crisis of the 1970s, which has helped the country develop unique expertise within the sustainable construction sector. With this report supporting many efforts in the sustainable construction industry we hope to contribute to both the attraction of foreign companies to Denmark as well as a further internationalisation of the Danish companies. Before we go into detail with this, however, it is necessary to elaborate on the concept of "sustainable building", which can be both illusive and vague.

1 United Nations, World Urbanization Prospects: The 2011 Revision

2 DTU Risø Energy Report 10. Energy for Smart Cities in an Urbanized World. p. 23

3 Copenhagen Cleantech Cluster, The Global Cleantech Report 2012. P. 4 and 22

The sustainable building

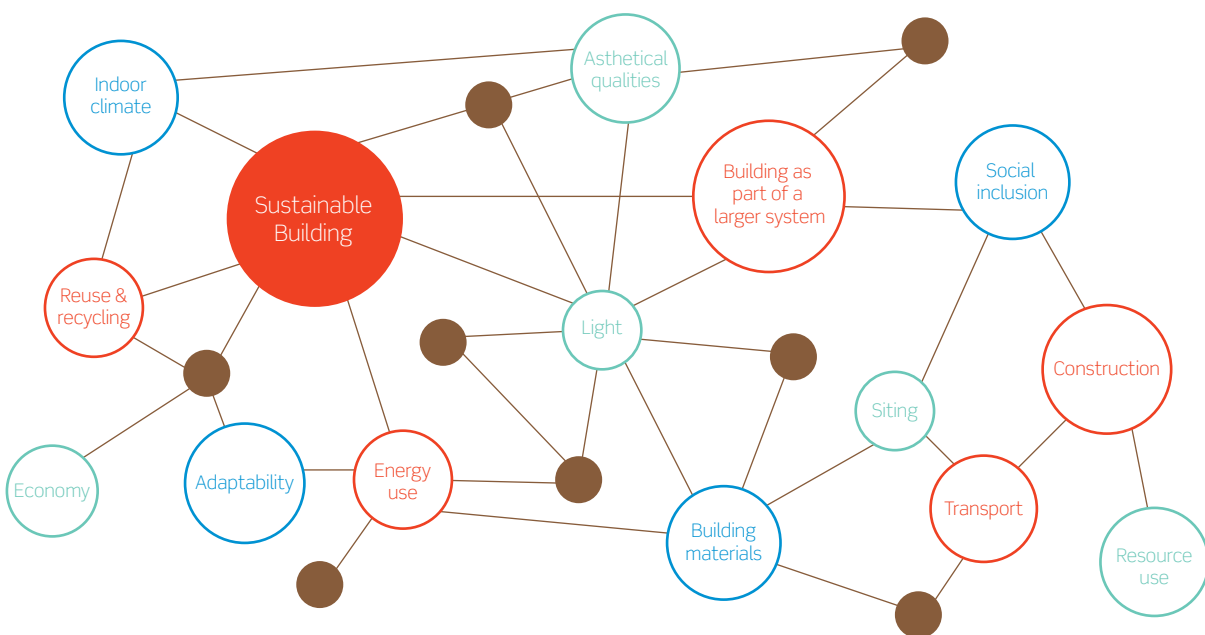
Active houses, zero-energy buildings, smart houses, cradle-to-cradle buildings, green and sustainable buildings; there are many inventive approaches to creating the buildings which meet the requirements of the future. And there are just as many opinions as answers to the question of what it means to build sustainably.

From a general point of view, however, building sustainably means using the best available technology and methods to reduce contamination and resource use throughout the entire lifecycle of a building, while at the same time promoting good health and a sound environment for the people who will use it. Planning for the entire lifecycle of a building means taking a number of considerations into account, which span across the design and construction phase, over building operation and maintenance to considerations regarding how to demolish the building and reuse its materials once the building has served its purpose. Figure 1 gives an idea of some of the

many considerations which have to be taken in order to create a sustainable building. From this perspective, the most sustainable building project will be the one incorporating as many of the considerations as possible.

The complexity of the system surrounding sustainable construction affects the role of the companies operating within it. It is seldom enough to have a good product; companies have to be able to provide integrated and system-oriented solutions. This means that new products have to be designed in a way that enables them to function as part of a larger complex system of products – a task which calls for a more open innovation process as well as an alternative marketing strategy.

Figure 1. Some of the many considerations for sustainable building
Source: Copenhagen Cleantech Cluster



BACKGROUND

The zero-energy building

A zero-energy building is a building with very limited use of energy, which produces an amount of energy at least similar to the amount it uses. This means that there is no excess of demand over supply in terms of energy in such a building. The zero-energy building achieves this by renewable energy technologies implemented in the building fabric. Furthermore, it has to be connected to a smart electricity or district heating grid with which it can exchange energy and/or heat¹.

Many companies are working to develop zero-energy buildings, and many claim that they already have. However, the definitions as to what 'zero-energy' means vary². Furthermore, it should be noted that even zero-energy buildings can be unsustainable. If they, for instance, do not provide a healthy and inspiring indoor climate for their users, they might contribute to a bad working environment ultimately leading to increased levels of stress. Nevertheless, even though the truly sustainable zero-energy building may not have been completed yet, the efforts made by many companies to design and construct buildings which produce more energy than they consume represents an ambition to create a more sustainable future.

1 For more on the Danish Smart Grid sector, please see 'Denmark: A European Smart Grid Hub', Copenhagen Cleantech Cluster 2011

2 DTU Risø Energy Report 10. Energy for Smart Cities in an Urbanized World. p. 23

CASE STUDY

Project Zero - Denmark's first ZERO+ house

In 2009 Sønderborg saw the construction of Denmark's first ZERO+ house completed. The house is named SIB ZERO+ and is capable of producing more energy than a typical family consumes in their everyday life. The house operates with an annual positive energy cost, and the house owners are able to sell the excess power to the national grid at the current market price, similar to the same price the consumers paid originally. This was tested and validated during its first year of operation, the house simply produced more energy than the family consumed, and will continue to do so.

The SIB ZERO+ project is part of a larger development framework in the city of Sønderborg called Project Zero, which was initiated in 2007. Project Zero aims at driving the city's transformation into a ZERO-carbon community by 2029. Already by 2015, it is expected that the CO₂ emissions in the area of Sønderborg will be reduced by 25% in comparison to their level in 2010. This is to be facilitated through a smarter use of energy in new housing construction, energy retrofits and improved energy efficiency in the production processes of companies. As part of the plan to make private homes in Sønderborg more energy efficient, 1200 house owners will be offered free advice on how to utilise energy better. So far, 600 reviews of houses have already been completed, which has sparked a growing demand for contractors working with implementing energy renovations. The Danish Business Development Fund and Region Southern Denmark have supported ProjectZero with one million euro in order to stimulate increased demand for energy retrofit. It is expected that 500 new green jobs in the construction industry can be created. www.projectzero.dk

Using smart technologies to build intelligently

We live in a time of digital revolution which is not only changing the way we live and communicate; it is also making communication between the thousands of things around us possible in a manner never experienced before¹. New ICT-based technologies, such as smart meters and sensors of all kinds, constantly collect data about their surroundings (e.g. temperature, electricity use, motion). These ICT-based technologies can be used to construct intelligent buildings which constantly adapt to the most appropriate behaviour in terms of energy use. They can even share data with other buildings, connected to the same smart grid, which allows for a much more flexible use of energy.

One example of such an intelligent technology is the Building Management System (BMS),

which allows the building to monitor its own electrical and mechanical equipment. The building's ventilation, lighting, electric power, fire and security systems all provide data for the BMS, which can be used to make more informed decisions regarding for instance energy use.

The potential for energy savings through the deployment of intelligent ICT-based technologies in buildings is enormous. A recent report concludes that ICTs have the capacity to save up to 15% of North America's buildings emissions. Furthermore, the report states that smart buildings technologies could enable emissions savings worth €216 billion². In this regard, intelligent technologies present an enormous potential for the advancement of the sustainable construction sector in general.

1 See The Alexandra Institute 2011: Tegneserien om tingenes internet.

2 The Climate Group et al. 2008: Smart2020. Enabling the low carbon economy in the information age. p. 11.

BACKGROUND

BIM – Building Information Modelling

Building Information Management (BIM) is a new method for building design-, construction- and management modelling. It can be seen as an integrated technique digitalising the building process, creating a joint master model for the whole procedure. It can be thought of as a virtual prototype and is applicable whether you are working with a building, a site, an infrastructure system or a city. The system offers all aspects of a design from idea to demolition to be simulated and assessed before its creation. BIM is mainly related to geometrical 3D models, but additional dimensions are gradually being added. With 4D, the 3D geometric is linked with a time schedule, which makes it possible to visualise the building's progression in a 3D model, and plan the logistics, delivery and assembly process. With 5D, the financial circumstances of the building project are implemented. With price and cost information given, the model becomes an absolute controlling device for the contractor as well as the building owner. The result of this is that the prototype becomes a reference for better construction, as knowledge sharing between stakeholders throughout the lifecycle of the project is facilitated. When information is shared, architects, engineers, owners and operators are able to collaborate, promoting productive and open working relationship, thus increasing the speed of delivery, improving coordination, decreasing costs, etc. The high quality of information in BIM helps the project team involved to understand the implications of their choice, thus allowing faster and more effective building processes in the future¹.

1 www.detdigitalebyggeri.dk/tech-article/bim-%E2%80%93-bygningsinformationsmodeller-og-modellering

More than just a green and smart building

Neither green nor smart technologies alone make a sustainable building. Although these technologies are indeed necessary, sustainable buildings are products of holistic planning and collaboration across the entire value chain from design and construction to demolition and reuse.

One of the main reasons why collaboration and knowledge sharing is pivotal to sustainable building is that there is a need to think of the building not just as an isolated building but as an integral part of a larger system. It is next to impossible to build a sustainable building in an unsustainable system. If the building is not connected to a smart electrical grid, for instance, it is going to be very difficult to have a sustainable energy use in that building. Likewise, if the building is not well integrated into the systems of transportation, energy, water, waste management, etc., in which they are situated, the chances of achieving sustainability are slim. In this way, a sustainable building is more than just a green or smart building.

“Buildings should be seen as part of a larger system of energy. In the future, buildings will be used as storage to balance the energy demand and consumption”

Lars Nielsen, Siemens A/S

BACKGROUND**Sustainable building certifications**

Worldwide, Green Building certifications have long played a role as an important competition parameter for the building industry. This is also the case in Denmark, where efforts have been made since 2010 to create a single, coherent and voluntary certification system for sustainable building which can serve as a driver for green and smart solutions within the Danish building sector. In the spring of 2012 this goal was reached as a Danish version of the German DGNB system was launched. The system is administrated by the Danish Green Building Council, which works as a non-profit organisation with the goal of contributing to a more sustainable Danish building sector.

Besides the DGNB certification system, several international assessment methods and rating systems exist for measuring the degree of sustainability of a building, including the LEED system (US), the BREEAM system (UK), the CASBEE system (Japan), and the HQE system (France)¹. The DGNB system differs from most other certification systems in its holistic focus on sustainable building. In addition to the three traditional pillars of sustainability – environmental, economic, and social – the DGNB certification includes considerations regarding building technology, process and placement. Besides this, the DGNB certification assesses the building’s overall performance rather than the sum of its individual parts. This ensures a greater level of freedom when it comes to choice of building materials and components, which promotes new and innovative building concepts adapted to the building’s surroundings².

However, all the different certification systems spring from a broad definition of the concept of ‘sustainability’, which includes social, economic, as well as environmental concerns. In this regard, the certification systems counteract the tendency to reduce sustainable buildings to matter of energy efficiency as they measure the sustainability of a building in a broader sense. Besides this, it can be economically feasible to certify buildings; surveys have shown that certified buildings have an increased sales and rent value of up to 10%³.

1 DTU Risø Energy Report 10. Energy for Smart Cities in an Urbanized World

2 The Danish Green Building Council - www.dk-gbc.dk

3 BEC 2010. Bæredygtigt byggeri, p 65

The sustainable building industry in Denmark

Just as it is the case in the rest of the EU, the operation of buildings take up around 40% of the total energy consumption in Denmark of which households make up around 25%. This means that there is a huge potential for energy savings. The building industry therefore plays a crucial role in Denmark's quest to become fossil fuel-free by 2050.

An ambitious political climate

The Danish government has long recognised the fact that buildings constitute an energy area which is different from most other areas of energy consumption. Buildings often have a very long life - which means that the consequences of the way that new buildings are constructed and built will have implications for many years to come. In this regard, Denmark

energy renovations of the existing building mass, which holds the greatest potential for energy savings.

It is of crucial importance that long-term decisions are being made both in regards to new construction and already existing buildings. Denmark has a culture of merging different plans and regulations, such as the Building Regulation, the Heat Supply Act, and the Planning Act. This ensures holistic and system-oriented policy-making. Furthermore, the general stability of the Danish political climate helps companies make long-term decisions concerning their areas of business.

The strict political demands for sustainable building function as a lever for Danish companies, forcing them to innovate, develop new business models and find ways of collaborating across the value chain. Sustainable building is no longer just a niche within the Danish building sector, but has become a basic condition for new development. In this regard, sustainability is more and more becoming the foundation which Danish and foreign companies within the building sector must adapt to and compete on. This means that new construction in Denmark in general lives up to a very high environmental standard. Furthermore, it has helped to phase out a number of the environmentally destructive and energy inefficient solutions².

“The strict regulation along with the strong political ambitions to become fossil fuel-free has a positive influence on the building sector in Denmark”

Svend Svendsen, Technical University of Denmark

has one of the strictest green building legislations in the world, which set strict demands for all new building projects¹. Besides this, the new Danish Energy Deal has a great focus on

1 Regeringen 2009, Strategi for reduktion af energiforbruget i bygninger. p. 3

2 Partnerskab for lavere energiforbrug i bygninger 2009 - anbefalinger og egne initiativer, p. 8.

BACKGROUND

New Danish Energy Deal

In 2012, the Danish Government made a new Energy Deal with broad political support. One of the main focus areas of the Energy Deal is on energy renovation of the existing building mass, which will receive €5.4 million in 2012-2015. Furthermore, the Energy Deal supports the transition towards using renewable energy in private homes and business buildings. Among other initiatives, the Government has decided to ban the installation of new oil and gas heaters starting in 2013. Lastly, a holistic strategy for energy renovation of the existing building mass is currently being prepared. The strategy will be done by the end of 2013. The overall goal is to ensure that all buildings are heated without the use of fossil fuels by 2035¹.

1 Energijaftalen 2012

CASE STUDY

Green craftsmanship on the island of Bornholm

The Danish island of Bornholm is committed to becoming a 'Bright Green Island' running on 100% sustainable and renewable energy. One of the cornerstones of this vision is energy efficient and sustainable building, which means that all buildings are to be constructed and renovated with this in mind. Bornholm's sustainable building efforts have created a demand for craftsmen with special skills in energy renovation and sustainable construction. As an answer, the island has started educating 50 craftsmen on Campus Bornholm, on a program recognised as being Denmark's most thorough green craftsman education. The first 32 participants have already acquired the title of "Green Craftsmen". The education, which was started in 2010, gives the student distinctive skills regarding energy savings and sustainable construction, allowing them and their company to effectively consult their future customers. During their education, they will experience working on a test facility in the city of Nexø, where the students are able to combine theory and practice. This house is among several demonstration buildings on the island, presenting new methods, sustainable materials and examples of the energy saving technologies possible today.

The ambition is that the new green craftsman education together with the demonstration projects will help to develop new competencies in the construction industry. In this way, Bornholm hopes to become a front runner in the sustainable building industry. Next step of the project will be visiting 12,000 houses, where house owners will be informed about the benefits of choosing energy saving solutions when building or renovating their current housing. The green craftsmanship education is a cooperation between Campus Bornholm and Business Center Bornholm, with financial support from European Social Fund.
www.bornholm.dk/cms/site.aspx?p=29

Turnover and employment numbers

The 219 companies presented in this report have a combined turnover of more than €8.3 billion. Some companies generate their entire turnover from activities directly linked to sustainable building; others only have sustainable building as part of their business portfolio. On average, the companies presented here generate around 40% of their turnover from

activities directly linked to sustainable building. Furthermore, 88% of the companies answer that sustainable building constitutes an important or very important part of their work (see Figure 2).

In terms of employment, the companies participating in the survey provide jobs for more than 52,500 people in Denmark. These numbers indicate the socio-economic importance of the building sector in Denmark, which according to a recent report has an overall employment of 193,000 people (350,000 with service and industry), and a total annual revenue of around €30 billion¹.

“One of the reasons why Danish construction in general is of a very high quality is the fact that it is done by a highly professional and educated workforce”

Charlotte Darre, InnoByg

¹ Iris Group 2009: Innovation af bæredygtige løsninger i byggeriet. P. 7

Positive expectations for the future

Besides testifying to the general socio-economic importance of the building industry in Denmark, the survey shows that the companies operating within the sector in general have very positive expectations towards their future role within the market for sustainable construction. Almost 80% of the companies answer that they expect an increasing turnover within the coming five-year time period 2013-2018. The positive attitude towards the future economic development of the sector is also reflected in the companies' expectations for future employment. More than three thirds

of the companies state that they expect to employ more people within the same period of time in Denmark. In addition, more than 60% of the companies with branches abroad answer that they expect to employ more people there as well see Figure 3. The positive expectations to the future reflect a sector which is developing fast, and which is self-confident about its role in the transition towards a greener future.

Danish competencies across the value chain

In order to get a broad overview of the Danish competencies throughout the entire lifecycle of sustainable building, the survey made for this report has been based on a circular value chain consisting of following three phases: a) building design and construction, including material and component suppliers, b) building operation and maintenance, and c) building demolition and reuse. In addition to this, the consulting companies working across the value chain have been included. Figure 4 on page 12 shows the distribution of the companies participating in the survey throughout the phases of a sustainable construction process.

As can be seen from the figure, the working areas of the companies participating in the survey are distributed across all phases of the value chain. 61% of the companies have competencies within building design and construction, 38% are building material or component suppliers, 43% work within the building operation and maintenance phase, while 14% of the companies from the survey have skills relating to demolition and reuse. Furthermore, the figure indicates that architects and consultancies represent the biggest share of the companies participating in the survey, closely followed by engineers, entrepreneurs, and the different types of material and component suppliers.

Figure 2. How important is sustainable building to the company? (Source: CCC survey, n=214)
Source: Copenhagen Cleantech Cluster

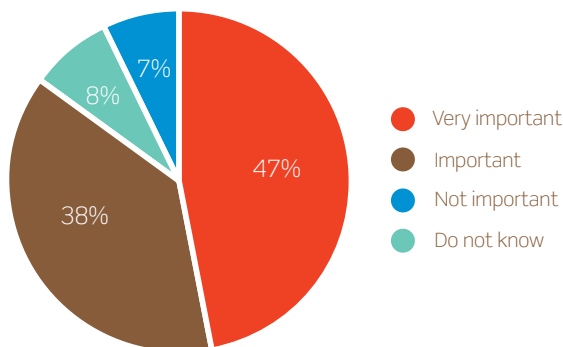


Figure 3. Employment expectations (CCC survey, n = 211)
Source: Copenhagen Cleantech Cluster

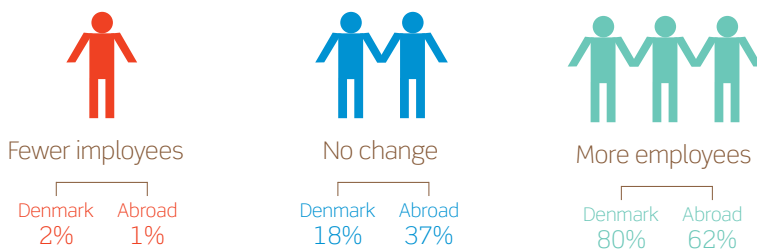
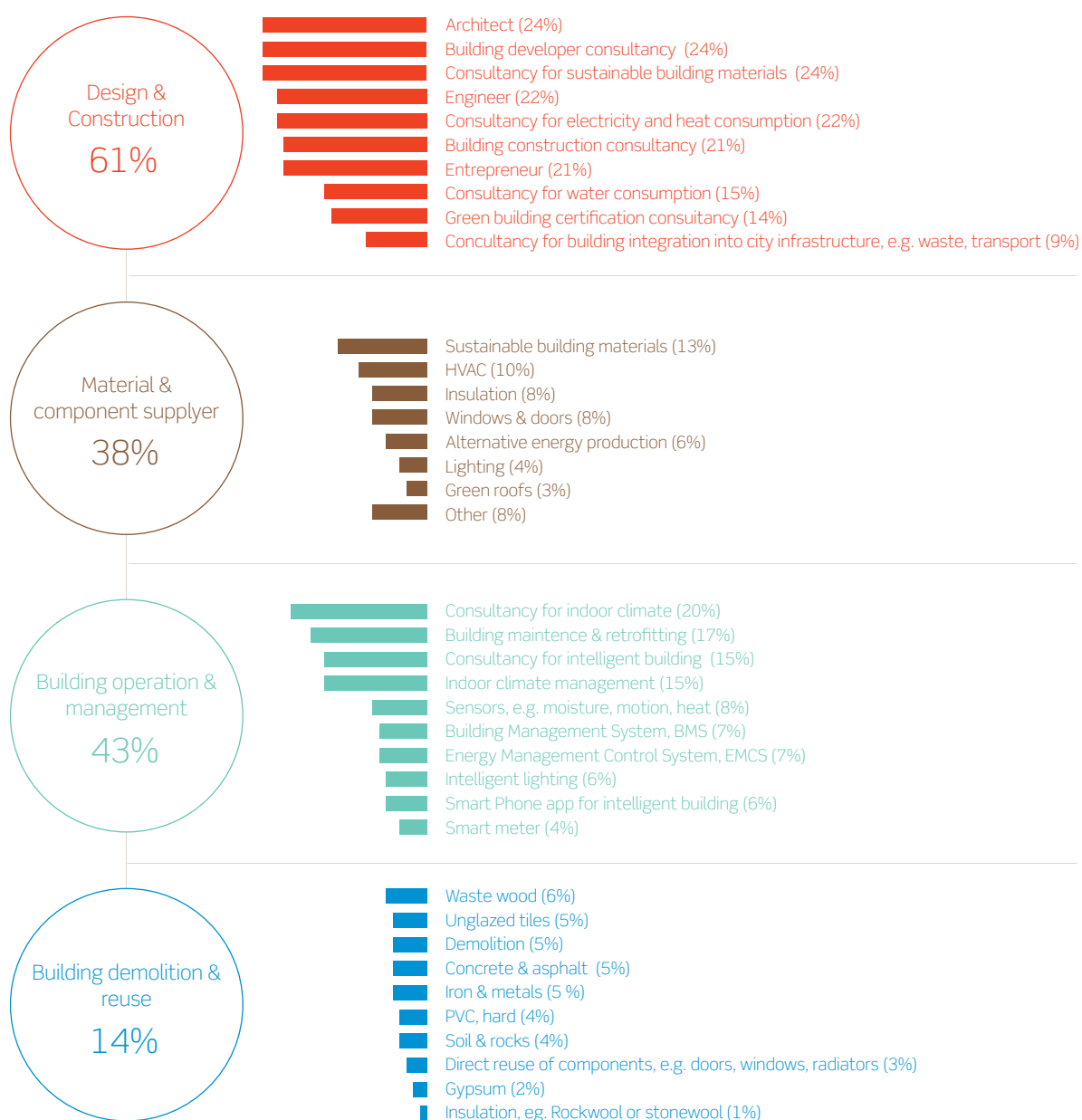


Figure 4. Distribution of the work areas of the companies from the survey across the value chain (CCC figure)*

Source: Copenhagen Cleantech Cluster

Percentages indicate the total percentage of companies from the survey working within the respective categories. They add up to more than 100 because many of the companies have competencies across more than one phase of the value chain and within more than one category in each phase.



Building design and construction

Sustainable buildings are not just energy efficient, green, and smart; they should also contribute to the creation of exiting city spaces and landscapes. Furthermore, they should be integrated into the systems of transportation, energy, water, waste management, people, etc., in which they are situated.

World famous for its architectural and engineering skills, which have laid the foundation for some of the world's largest bridges and many landmark buildings worldwide (e.g. the Sydney Opera House, Paris' La Grande Arche), Denmark has a long architectural and

engineering tradition with a focus on holistic solutions.

Besides this, low-energy building solutions have been a focus area in Denmark since the oil crisis of the 1970s. This has helped a number of Danish companies, such as Velux A/S and Rockwool A/S, develop innovative solutions which reduce the energy loss from commercial and residential buildings. You will find the company matrix for companies working with sustainable building design and construction on page 23.

BACKGROUND

Benchmarking Danish construction

In order to secure transparency and competition based on competencies rather than just the lowest price, Denmark has introduced a benchmarking system for the companies operating within the construction industry. The system, which was developed in 2001 by the non-profit organisation called Benchmark Centre for the Danish Construction Sector (BEC), can be used by the building developers in the bidding process for new building projects.

The system is comprised of a set of key indicators, which are now used to evaluate the construction companies during a bidding process. These indicators include customer satisfaction, defects, compliance with time schedule and budgets, health and safety at the workplace. In 2003, the Danish Government made construction benchmarking compulsory for all construction projects exceeding 5 million DKK. Although the benchmarking system was subject to criticism in the first years after its introduction due to the administrative burdens it caused, it has been overall successful and is now embraced by the industry¹.

1 Benchmarking Danish Construction. BEC 2010:6-7

CASE STUDY

The Mountain – a residential apartment building and big city oasis

One of the most iconic architectural projects in Denmark in recent years has been a unique combination of a state of the art residential apartment building and a car park. "The Mountain", as the building is called, comprises 80 residential apartments which are built on top of each other in steps so as to form the shape of a big mountain. All the apartments have green rooftop decks which serve as individual green oases for the residents, making the Mountain seem like a classical suburban villa district flowing down a ten storey apartment building. The interior of The Mountain is a car park with space for 650 cars which not only serve the residents, but connect the building to the surrounding cityscape. In this way, The Mountain combines the social intensity of the dense city centre of modern Copenhagen with the traditional relaxing atmosphere of the suburban gardens.

The Mountain serves as a wonderful example of the resourceful and creative solutions which have made the Danish architectural firm behind the project - Bjarke Ingels Group (BIG) - world famous. Since its completion in 2008, The Mountain has won several prizes, including the Best Housing Project at the MIPIM International Property Conference in Cannes, the Forum AID Award in Stockholm, and the ArchDaily Building of the Year Award. Furthermore, it was part of the reason why Bjarke Ingels Group was announced as the winner of the Housing category at the annual World Architecture Festival (WAF) in 2008.

www.big.dk

Building operation and management

It is estimated that ongoing operating costs represent between 50% and 80% of a building's total lifecycle costs over a 40-year period¹. This means that there is huge potential for energy saving in the building management and operation phase. This is certainly true in Denmark where 75% of the total Danish residential building stock was constructed before 1979, when the first significant Danish regulation for energy performance in buildings was launched². The market potential for energy savings in Danish residential buildings is therefore promising - especially regarding space heating, which accounts for around 85% of the energy used in private households in Denmark³.

Just as it is the case in many other countries, intelligent house control, building manage-

ment systems, smart meters, etc., constitute a fast growing market in Denmark. This is also reflected in the survey, where 74 of the 219 participating companies indicate that they have activities relating to intelligent building operation and management. In general, the Danish market for intelligent building technologies is ripe. This is partly due to the political willingness to invest in this area, partly due to the well-developed digital infrastructure in Denmark, which is one of the world's leading countries both when it comes to smart grid and broadband penetration. In this regard, Denmark serves as a unique location for test and demonstration of smart technologies, for instance hosting 22% of all European R&D projects concerning intelligent energy grids⁴. You will find the company matrix for companies working with sustainable building operation and management on page on page 38.

1 Bright Green Buildings. Convergence of Green and Intelligent Buildings. Frost & Sullivan 2008, p. 9

2 Energy savings in Danish residential building stock. Tommerup & Svendsen 2006, p. 1

3 DTU Risø Energy Report 10. Energy for Smart Cities in an Urbanized World. p. 23

4 EU Commission. www.ses.jrc.ec.europa.eu/sites/ses/files/documents/smart_grid_projects_in_europe_lessons_learned_and_current_developments.pdf

CASE STUDY

Rockwool – Energy efficient and sustainable insulation

Rockwool is a world leading Danish company within the field of building insulation. The foundation of the company's success is its sustainable products, which incorporate environmental, social, as well as economic concerns. From an environmental point of view, Rockwool insulation ensures a low energy use. The social aspects of Rockwool products include fire safety and sound reduction. Besides this, Rockwool is an economically cheap solution which has a long lifespan.

Rockwool differs from many other companies due to its efforts to reach out to customers within the building sector and collaborate with them. One example of this is the Rockwool calculation program, which enables architects, engineers, etc., to measure the impact of the different Rockwool products on the overall performance of the building as early as in the design phase of new buildings. Another example is the technical service that Rockwool provides for its customers. Every month, the company receives around one thousand contacts from entrepreneurs, engineers, etc., wanting to know more about the technicalities of the Rockwool products.

Lastly, Rockwool is constantly optimising the environmental performance of its products. This not only means that all products from Rockwool have been evaluated on the basis of a lifecycle analysis; it has also led Rockwool to launch a take-back system for used rock wool. The system, which was launched in August 2012, ensures that waste Rockwool products are turned into recyclates which are used directly in the production of new Rockwool products. This minimises the amount of waste and closes the loop for Rockwool products.
www.rockwool.dk

Consultancy

Another stronghold of the Danish sector for sustainable building is consultancy. Eighty of the 219 companies from the survey have answered that they provide some form of consultancy for sustainable building processes. The most prolific type of consultancy provided by the companies in the survey is building developer consultancy, closely followed by consultancy concerning sustainable building materials, and heat and electricity consumption.

Denmark is a stronghold when it comes to lifecycle-oriented and holistic building consultancy. The country has unique experience regarding integration of buildings into larger systems of waste, transportation, energy, etc. One example is the Danish district heating system, which spans for more than 30,000 kilometres and delivers heating for around 1.6 million households¹, equivalent to around 62% of all Danish households².

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- 1 The Danish Statistics Database, BOL102
 - 2 www.fjernvarme.info

Another example is the Danish smart grid efforts, which constantly increase the country's capacity to integrate decentralised energy supplies like wind power, heat pumps, solar power into the national energy grid. Denmark is regarded to be one of the world's leading countries when it comes to smart grid development³.

Danish consultancies are frontrunners when it comes to providing consultancy regarding these big and integrated solutions, and companies like Rambøll, COWI, and Force Technology are all leading global players within this field. You will find the company matrix for consultancy companies providing consultancy for the sustainable building process on page 47.

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- 3 www.energinet.dk, For more on the Danish Smart Grid sector, please see 'Denmark: A European Smart Grid Hub', Copenhagen Cleantech Cluster 2011.

CASE STUDY

EnergyFlexHouse – a living lab for energy efficiency in buildings

The newly created EnergyFlexHouse is a framework set up by the Danish Technological Institute for the Danish building industry. The EnergyFlexHouse offers tests and documentations, and presents a unique opportunity for products to be prepared for entering commercial markets. EnergyFlexHouse is a part of the Danish "Green Lab for Energy Efficient Buildings" and collaborates with the other laboratories of the Danish technological institute, and with a large spectrum of entrepreneurs, producers, consultants and national as well as international knowledge centres. EnergyFlexHouse consists of two similar buildings. One is the EnergyFlexHouse lab which is designed as a test building. In EnergyFlexHouse Lab, technologies are developed and documented by system thinking, where individual components and systems are tested for their ability to live up to market demands for energy efficiency. The building offers a measurement instrument evaluating more than 700 variables and makes it possible not only to monitor, but to make precise analyses of the energy consumption.

The second building is EnergyFlexHouse Family, which is a one-family house where a test family currently lives. The EnergyFlexHouse Family building is a living lab focusing on testing the interaction between the users and the various energy elements implemented in the building.

Together, the two buildings set up a practical framework for the innovation process from idea and development of prototypes, to test and documentation in a living lab. This process allows products to mature and get ready for the market¹. www.teknologisk.dk/projekter/energyflexhouse

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- 1 www.teknologisk.dk/projekter/EnergyFlexHouse; www.activehouse.info/cases/EnergyFlexHouse

Reuse of construction waste

Denmark is one of the leading countries in the world when it comes to reusing building materials with a reuse and recycling rate of more than 90%¹. The success is based on the country's many years of experience with waste handling, and the unique interplay between public and private actors which characterise the Danish waste treatment system. In Denmark, the municipalities have historically been responsible for the treatment of all waste.

1 The Danish Environmental Protection Agency 2010, Affaldsstatistik 2007 og 2008, p. 9

This has led to a system in which the quantities and qualities of all the different waste streams have been thoroughly registered. The actual end-treatment of the waste is often done by a public-private or purely private company on behalf of the municipality. This has provided the groundwork for a number of Danish companies specialising in reusing and recycling specific waste streams, such as tarpaper, gypsum, tiles, waste glass, and stone wool. You will find the company matrix for companies working with building demolition and reuse of construction waste on page 45.

BACKGROUND

New Danish Resource Plan

The Danish Government is drafting a new Resource Plan, which will be set in motion sometime during the spring of 2013. The Plan contains four areas of waste resource management, which will be further prioritised in Denmark in the years to come. These include household waste with a special focus on bio-waste, plastic waste, electronic waste, and metals. The new Resource Plan is part of a larger development framework in Denmark towards a more circular economy, which supports the elimination of waste for the benefit of resource-based lifecycle thinking. The same thinking is taking hold in the construction sector where cradle-to-cradle concepts receive more and more attention.

CASE STUDY

The first cradle-to-cradle building in Denmark

In February 2013, the first cradle-to-cradle building in Denmark is expected to be completed. The result will be a state of the art 150 m² conference pavilion, built by materials 100% degradable or 100% recyclable. Solar cells on the roof are angled, to make sure they are used most effectively. Furthermore, a heating pump installed produces three times the heating energy consumed in electric energy, thus securing a surplus of energy. Green walls are able to clean and cool the air, while at the same time improving the acoustics and thereby the whole experience and comfort within the building.

The building is mobile and is meant to spread knowledge about the cradle-to-cradle experiences nationally. Furthermore, the mobility of the building enables it to be continuously developed and updated every time it is moved and reconstructed in new locations. The aim of the project is to present the newest solutions within sustainable building technology, energy control, indoor climate and water. An illustration of this standard will help Danish companies' inspire green growth by developing the building industry further, thus securing growth in international as well as domestic markets.

The project is an example of an innovative project from the building industry of Denmark supported by the Business Innovation Fund, Realdania, and the COWI Foundation. The project is facilitated by COWI, who together with an interdisciplinary team of researchers, architects, material specialist and engineers, is responsible for its realisation. The team consists of 3XN Architects, Vugge til vugge Danmark (cradle-to-cradle Denmark), the Danish Technological Institute, Risø DTU and Nordea Realstate, and is working with a budget of €1.2 million¹.
www.cowi.dk

1 www.dac.dk/da/service-sider/nyheder/2011/november/danmarks-foerste-cradle-to-cradle-byggeri; www.3xn.dk/da/GXN/rd_projects//rd_cradle-2-cradle-pavilion

“The distance between knowledge institutions and companies in Denmark is very short. This provides a good basis for collaboration”

Alfred Heller, Technological University of Denmark, DTU

Collaboration across the value chain

It is next to impossible for one company alone to possess all the complex knowledge needed to create truly sustainable buildings. Therefore, collaboration across the value chain is necessary, in order to ensure that the building becomes sustainable throughout its entire lifetime.

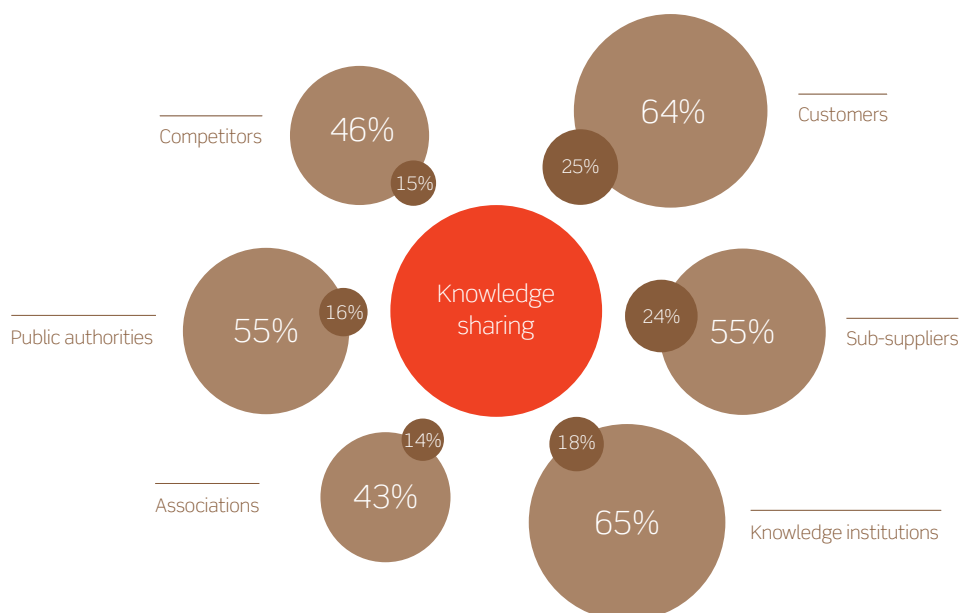
In this regard, the companies participating in the survey were asked which forms of collaboration they currently engage in. More than 60% of the companies answer that they engage in some form of knowledge sharing

with knowledge institutions and customers. Besides this, more than half of the companies indicate that they share knowledge with sub-suppliers and public authorities, while more than 40% state that they engage in knowledge sharing with competitors and associations (see Figure 6).

Especially knowledge institutions play an active role in generating and disseminating knowledge of sustainable construction practices and technologies. Universities like the Technological University of Denmark (DTU), Aarhus University, Aalborg University, and Roskilde University (RUC) all engage actively in triple helix partnerships with public authorities and private companies. Moreover, a number of non-profit institutes and knowledge centres support collaboration and knowledge sharing across the value chain and take active part in developing new technologies.

Figure 5. Knowledge sharing (source: CCC survey, n=164)
Source: Copenhagen Cleantech Cluster

Percentage of companies engaging in knowledge sharing with Danish stakeholders (outer circles) and foreign stakeholders (inner circles)



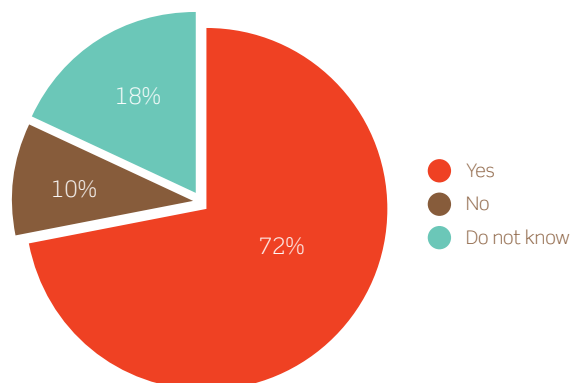
Amongst others, the self-governing non-profit Danish Technological Institute works to promote research and technology based knowledge in Danish and international business sectors. The Danish Technological Institute is involved in several development projects in sustainable building and construction, including the EnergyFlexHouse (page 15). In general, the distance between knowledge institutions and companies in Denmark is very short. As a result the basis for collaboration is excellent. Please see page 53 for a list of

Danish knowledge institutions and triple helix projects in sustainable construction.

As the survey indicates, collaboration is already taking place across the value chain of the Danish sector for sustainable building. However, according to a recent report published by the IRIS Group, the Danish building industry is still characterised by a number of professional gaps which need to be closed in order to create the synergies needed for the development of the integrated solutions which are in demand. In order to bridge the professional gaps and create synergies across the value chain, existing knowledge silos need to be brought down and new business models developed, which support cooperation across the value chain¹.

Figure 6. Distribution of companies' interests in creating partnerships with foreign stakeholders (source: CCC survey, n=190)

Source: Copenhagen Cleantech Cluster



Foreign companies play a crucial role in these efforts to create partnerships with the sufficient know-how and expertise to deliver the system-oriented and integrated solutions, which are in demand. And the survey suggests that the Danish companies within the sustainable building sector are open for new partnerships. When asked if the company is interested in engaging in partnerships with foreign stakeholders, 72% of the companies participating in the survey provide a positive answer. Only 10% of the companies indicate that they are not ready to engage in international partnerships, while the last 18% do not know (see Figure 6). These numbers draw a picture of a sector which is very internationally oriented in terms of engaging in new partnerships with foreign companies.

“I think there is an increasing need for collaboration because of the demands of holistic and system-oriented thinking that sustainable building set forth”

Susanne Kuehn, Rockwool

¹ IRIS Group 2009: Innovation af bæredygtige løsninger i byggeriet. Hvordan forbedrer vi rammerne? P. 21

However, looking at the industry today the situation is quite diverse and even polarised when it comes to international activities. Like the wider construction industry it is characterised by a lot of small to medium sized companies – many of them oriented towards serving a local market. The construction industry in general is faced by a variety of barriers in relation to internationalisation. The barriers range from formal regulation to de facto market standards making it difficult to operate in different countries. Consequently, parts of the industry are very international, including professional construction services, some architects and some component suppli-

ers. But many of the suppliers and implementing companies are very national or even local in their mode of operation. On the positive side, there is potential for actors to be able to overcome the barriers for internationalisation – and it seems that the Danish construction industry is very keen to do so.

CASE STUDY**Marius Pedersen A/S – a frontrunner in reuse and recycling**

Marius Pedersen A/S is a frontrunner company in Denmark when it comes to reuse and recycling of waste resources, including resources from building and construction residues. According to Sales and Marketing Director from Marius Pedersen A/S, Jeanett Vikkelse, the company's work is inspired by a circular economy or cradle-to-cradle thinking in which all resources are reused as components or raw materials in the production of new products. Examples of such closed loop recycling made possible by Marius Pedersen A/S include used gypsum plates, which are reprocessed into gypsum powder. The gypsum powder can be used in cement production or in the production of new gypsum plates. Other examples include waste wood, which is reprocessed for the chip plate industry so that it can be used to create new chip plates used for construction and waste glass, which is cleansed and reprocessed so it can be sold to window manufacturers. Furthermore, Marius Pedersen A/S is collaborating with relevant Danish stakeholders on a project, which should allow them to reuse rock and stone wool sometime in the near future as well as recycle tar paper.

The cradle-to-cradle thinking also requires dialogue across the value chain as new products have to be designed and manufactured with their end-of-life treatment in mind. In this regard, Jeanett Vikkelse calls for a bigger degree of collaboration across the value chain. "We would like to engage in further dialogue with, for instance, architects and engineers regarding the recyclability of the materials used". Although this dialogue currently only takes place to a very limited degree, Jeanett Vikkelse thinks that it will be strengthened in the future.

www.mariuspedersen.dk

Conclusion

The sustainable building industry is situated right at the heart of the global green growth agenda, which is affecting business worldwide. One of the reasons for this is the enormous potential for energy saving that can be found in the building sector.

A sustainable building, however, is not only energy efficient, but provides a healthy and inspiring environment for its users at a reasonable economic cost. Furthermore, it is well-integrated into the larger system of transport, energy, etc., in which it takes part, it contributes positively to the surrounding city space and landscape, and its building components can be reused or recycled once the building is demolished. All these factors have to be incorporated, which makes sustainable construction a highly complex and knowledge intensive process which calls for a high degree of collaboration across all phases of the value chain.

The Danish sustainable building industry is very well suited to meet the challenge of creating sustainable buildings. For many years, the ambitious political climate in Denmark has served as a lever for the sustainable building industry, which has helped the country develop unique expertise within all the differ-

ent phases of a sustainable building process. In the design and construction phase, Danish architecture and entrepreneurship is famous worldwide for its high quality and innovation, and the Danish workforce is highly educated and resourceful. Furthermore, component suppliers like Rockwool, Velux, Danfoss, and Grundfos have all become global players within their field contributing to sustainable construction worldwide. Regarding the building operation and maintenance phase, the Danish market holds a big potential for those companies working with energy saving because of the country's relatively old residential building stock. This is especially true regarding space heating. Besides this, the well-developed digital infrastructure and smart grid in Denmark makes the market for intelligent building management ripe, and the country serves as an ideal test site for new intelligent technologies. Lastly, Denmark has a long tradition for waste management, which has ensured a reuse and recycling rate of more than 90% when it comes to building materials.

Denmark's skills and expertise in sustainable building are reflected in the survey for this report, which draws a picture of a self-confident Danish sustainable building industry with high expectations for the future both in terms of turnover and employment. The challenge for the future consists of promoting collaboration and knowledge sharing across the value chain and across borders. Foreign companies wishing to take part of this development will find an interesting and knowledge-laden market in Denmark.

“The Danish framework legislation ensures a great level of flexibility, which gives room for a more holistic design”

Charlotte Darre, InnoByg

**72 % OF THE
COMPANIES
PRESENTED IN
THIS REPORT
ARE OPEN FOR
INTERNATIONAL
PARTNERSHIPS**

Mapping of the Danish sector for sustainable building

To provide a general overview of the Danish companies working within the sustainable building sector, we have listed them in four different matrixes containing information on their size and areas of expertise.

The matrixes contain information about companies working within 1) building design and construction, 2) building operation and maintenance, 3) building demolition and reuse of building materials, and 4) sustainable building consultancy. There are a total of 219 companies listed in the four matrixes. Some of them are listed in more than one matrix according to their business areas.

The company matrixes are limited to companies based in Denmark working within the Danish sustainable building sector. However, many of the companies presented have international activities as well. The matrix does not contain all companies working within the sustainable construction sector in Denmark, but is limited to the companies, which have participated in the survey for this report. The information presented in the matrixes was provided by the companies through the survey on which this report is based.

The symbols for number of employees in the matrixes are as follows:

- 1-10
- 11-25
- 26-50
- 51-100
- 101-500
- >500

Company name	Contribution to sustainable building	Architect	Engineer	Entrepreneur	Insulation	Green roof	Ventilation & Air condition	Building materials	Renewable energy production	Windows & Doors	Lighting	Other
ClimateConsult ○○	We deliver HVAC system solutions which are designed on the basis of obtaining the lowest possible use of electricity throughout the entire lifecycle of the building.		●				●					
Coromatic ○○	We design and build data centres, server rooms and emergency generators.		●		●	●	●	●	●	●	●	
COWI ○○○○○○	We provide consultancy within all aspects of sustainable building, including climate adaption.		●									
CRH Concrete A/S ○○○○○○	We are suppliers of buildings and constructions, which are the foundation of the green buildings of the future.							●				
Danfoss ○○○○○○	We produce heat pumps, ventilation, and heating control, which all reduce energy use.						●					
Danish Management A/S ○○○○○○	We provide consultancy for ESCO projects, energy administration of buildings, code of conduct campaigns regarding energy use, and energy efficient engineering regarding new building and building renovation.		●									
Danish Wood Technology ○	We introduce a new technology for wood impregnation against rotteness, sponges, insect attacks, and fire protection. This will help ensure a longer life time for the products.							●		●		
Dansk Miljøentreprise ApS ○	We have developed a climate screen consisting of Fibre Concrete with moulded-in Pex tubes and polystyrene insulation. Our technology ensures a better indoor climate and reduced energy consumption.				●		●	●				
Dantherm ○○○○○○	We develop and produce indoor climate solutions in the form of ventilation solutions, which minimise the buildings' use of energy and increase the comfort for people and machines.						●					
DBS Lys A/S ○○○	We provide consultancy regarding energy optimisation, energy renovation, and dissemination of the State's energy subsidies for completed energy renovations.										●	
DC-System Insulation A/S* ○○	DC-System develops and produces insulation panels in sandwich construction, which are used for industrial construction and housing.		●	●								
Dem Fra Nordlunde ApS ○○	We recycle as much as possible, and sell as much as possible within the green building sector.			●	●			●		●		●
Dines Jørgensen & Co. A/S* ○○○○	Dines Jørgensen & Co. A/S consulting engineers provide building developer consultancy, and all kinds of technical consultancy regarding building facilities, geotechnical issues and more.		●									
DONG Energy ○○○○○○	We provide consultancy regarding energy savings in order to save energy and support the use of renewable energy. We deliver reused mineral products for building materials, which can substitute the use of virgin raw materials.							●				

Company name	Contribution to sustainable building	Architect	Engineer	Entrepreneur	Insulation	Green roof	Ventilation & Air condition	Building materials	Renewable energy production	Windows & Doors	Lighting	Other
ERCO Light Scout ○	We produce and deliver effective lighting, which contributes to creating a healthy work environment and reducing buildings' energy needs. Most of our products can be reused.										●	
ErikJuul Architects ○	We develop architectural textiles, which contribute to the optimisation of buildings' energy use.	●										
Euro Therm A/S ○○	We supply heat and electricity based on biomass.		●	●					●			
Exhausto A/S ○○○○○	We develop, produce, and deliver ventilation installations with heat recovery, in order to reduce buildings' energy consumption, while at the same time ensuring a good indoor climate.						●					
Factotech A/S ○	We develop software which calculates and optimises the energy use and overall sustainability.	●	●									●
FORCE Technology ○○○○○	We provide consultancy for 'green' building products and conduct LCA-based environmental declarations for building products.		●									
Franck Geoteknik A/S ○○○	We provide consultancy and engineering experience regarding rainwater infiltration, sewerage, and environmental impact assessment.		●									
Golder Associates A/S ○○	We ensure that building and construction waste is sorted out so that as much as possible can be prepared for reuse.		●									
GPP Arkitekter ○○○	We certify buildings according to the DGNB system, and we always conduct a screening in regards to the built environment and energy in our buildings.	●										
Green Machine ○	We develop sensors which measure use and dissipation of heat, and motion sensors which control light, office machines and window positions. We help customers develop products which can later be reused.		●									
Grontmij ○○○○○	We provide consultancy for property owners, energy companies, decision makers, and local authorities regarding holistic solutions for the sustainable building sector.		●									
Grundfos A/S ○○○○○	We develop, produce, and deliver pumps for heating/cooling installations, water supply and drainage waste water, with the highest efficiency and great energy saving potentials in buildings.						●					●
Gyproc ○○○○○	We produce building products, which are based on sustainable production and materials. Our products are used in all types of construction, including sustainable buildings.							●				
H+H Danmark A/S ○○	We provide consultancy regarding product use and properties, and products which minimise the working time and optimise the workflow.							●				

Company name	Contribution to sustainable building	Architect	Engineer	Entrepreneur	Insulation	Green roof	Ventilation & Air condition	Building materials	Renewable energy production	Windows & Doors	Lighting	Other
Aak Bygninger ○○	SmartCity is a trader Fund, which support green and sustainable activities in the building sector, primarily in Northern Jutland.	●	●									
Aalborg CSP A/S* ○○○	Aalborg CSP A/S is a world leader in steam generators for large scale concentrated solar power (CSP) plants.		●						●			
Aalborg Portland A/S ○○○○○	We produce and deliver cement, which among other things is produced using alternative fuels. Furthermore, the company delivers surplus heat to the municipality of Aalborg.							●				
Aarhus Architects ○○○○	We plan all of our projects, including housing, healthand industrial buildings, according to the principle of sustainability where more buildings are certified.	●										
AART A/S ○○○○	For more than ten years AART architects have worked purposefully to promote sustainable building. Among other things, Aart Architects helped to develop the 'Housing for Life' project in Lystrup, designed as the world's first Active House. In addition, AART Architects have established the research department AART, where a research team works in the cross field between research and development in order to pave the way for future sustainable building.	●										

* Information in the 'Contribution to sustainable building' column provided by CCC

**THE 219
COMPANIES PRE-
SENTED IN THIS
REPORT HAVE A
COMBINED
TURNOVER OF
MORE THAN
€8.3 BILLION**

Company name	Contribution to sustainable building	Indoor climate management	Building maintenance & retrofitting	Building Management System	Energy Management Control System	Intelligent Lighting	Smart Meters	Energy modelling software	Sensors (e.g. moisture, heat, motion)	Apps for intelligent buildings	Other
ThermoLogica ○	Thermologica builds on a new construction principle, which uses steel plates for the outer walls. This has several advantages, including decreased heat loss through the outer walls, full control over the indoor climate, and no condensation and thermal bridges.	●									
Thorkild Jørgensen Rådgivende Ingeniører ApS ○	Our mission is to optimise and design the next generation of eco-friendly green buildings which are socially, environmentally and financially responsible and resource-efficient throughout their lifecycle.	●									
Thorn Lighting A/S ○○	We produce and deliver energy efficient lighting solutions, which save energy and create wellbeing and comfort.		●								
Uridan A/S ○	Uridan A/S is a producer of water and odour free urinals. The newest generation of water traps ensures that only between 60-90 cubic meters of water is used for every 15,000-20,000 uses.		●								
Vandteknik ApS* ○	Vandteknik ApS is a waterworks service company to private and municipal water supplies.						●		●	●	
Vikingegaarden ○	We produce intelligent on-street charging stations for electrical vehicles, which automatically charge the electric vehicles with the cheapest and most environmentally friendly energy.										●
Woodmade ○	We develop, produce, and deliver environmentally sound solutions, which contain carbon dioxide binding materials.	●						●			
Zensehome A/S ○○	We develop and produce electrical systems with built in intelligent energy meters, which automatically reduce buildings' use of energy and increase the comfort.			●	●	●	●		●	●	
Aalborg Portland A/S ○○○○○	We produce and deliver cement, which among other things is produced using alternative fuels. Furthermore, the company delivers surplus heat to the municipality of Aalborg.		●								

* Information in the 'Contribution to sustainable building' column provided by Copenhagen Cleantech Cluster

**THE REUSE
AND RECY-
CLING RATE
OF BUILDING
MATERIALS IN
DENMARK IS
MORE THAN
90 %**

Building demolition and reuse matrix

Company name	Contribution to sustainable building	PVC (hard)	Gypsum	Unglazed tiles	Concrete or asphalt	Soil & rocks	Iron & metals	Insulation (E.g. Rockwool or stone-wool)	waste wood	Direct reuse of components (e.g. doors, windows, radiators)	Other
Arkitekturministeriet ○	We draw, develop, and produce small scale architecture and design. Our own production in-house consists almost entirely of FSC-labelled sustainable materials.	●							●	●	
Bango A/S ○	We buy and sell reused building materials.								●	●	
Barsmark Composites ○○	Barsmark connects industries with waste overflow problems and customers with specific green materials needs. We connect the dots by engineering recycling processes to reutilise industrial surplus material into high-performing up-cycled materials, e.g. recycling of PUR foam, recycling of epoxy-fibreglass, recycling of mixed glass, etc.							●			●
BHC A/S ○	We receive contaminated soil and demolition waste, which we prepare for reuse. Furthermore, we crush bricks, concrete, and asphalt, which is reused in new construction.			●	●	●					
Dem Fra Nordlunde ApS ○○	We recycle as much as possible, and sell as much as possible within the green building sector.			●	●	●	●		●	●	
Gendan ○	We handle discarded building materials in order to ensure the greatest possible recycling rate.	●					●		●		
Genknus ○	We reuse bricks, concrete, and asphalt for new road construction materials. Furthermore, we clean contaminated soil and recover waste wood through incineration.			●	●	●			●		
Gips Recycling Danmark A/S ○○	We reuse gypsum waste as a clean, new gypsum raw material, which can substitute virgin gypsum in the production of gypsum products.		●								
Golder Associates A/S ○○	We ensure that building and construction waste is sorted out so that as much as possible can be prepared for reuse.			●	●	●	●		●	●	●
Hundsbæk & Henriksen A/S ○○○	Our consultancy is always based on a green thinking perspective which takes sustainability, CO2 emissions, and limited use of resource and energy use into account.										●
Jakobsen Tegl ApS ○	We buy used roofing tiles which we sell for building renovation and extension projects.			●							
Katrinédals Tagstensdepot ApS ○	We deliver everything within the market for used roofing tiles in brick or concrete, with a main emphasis on roofing tiles which are not produced anymore.			●							●
Kingo Karlsen A/S ○○○○	We conduct environmentally friendly and selective building demolition, where all environmentally hazardous substances and materials are removed before demolition of the buildings components suitable for reuse.	●	●	●	●	●	●		●	●	
Lotra A/S ○○○	We sort out waste fractions, which could be incinerated or disposed, and reuse materials from these.	●	●	●	●		●		●		

Company name	Contribution to sustainable building	PVC (hard)	Gypsum	Unglazed tiles	Concrete or asphalt	Soil & rocks	Iron & metals	Insulation (E.g. Rockwool or stone-wool)	waste wood	Direct reuse of components (e.g. doors, windows, radiators)	Other
Marius Pedersen A/S ○○○○○○○	We produce gypsum powder from used gypsum plates for the gypsum plate industry, wood shavings from waste wood for the chip plate industry, insulation material from used newspapers, and stability material from used concrete, bricks, and asphalt.	●	●	●	●	●	●	●	●		
Meldgaard Recycling A/S ○○○○○○○	We sort waste and prepare it for recycling.	●			●	●	●		●		
Pluskontoret A/S, Arkitekter M.A.A ○○	Within our core business areas, we always work with sustainability as a general parameter.				●	●			●	●	
Preben Hockerup A/S ○○○	Preben Hockerup A/S is an ISO 9001 certified company within building demolition, which reuses building materials.			●	●		●				
Reno Djurs I/S ○○○	We receive building waste in different fractions on ten recycling stations and prepare it for recycling in the building sector.	●	●	●	●	●	●		●		
Rubow Arkitekter ○○○	We conduct integrated and optimised design solutions for passive houses, which create surplus value for users and building developers. In addition, we design active houses which create more energy than they use.										●
Stenklint A/S ○○	We insulate and maintain all climate screens, and innovate constantly in regards to new materials and methods.			●	●			●			
Terkelsen A/S ○○	We provide consultancy for - and set up - storage systems for sorting out iron, metals, and other waste fractions.						●				
Terra Cycle ApS* ○	Terra Cycle ApS contributes to scrap the idea of trash by creating functional recovery systems for waste, which today would otherwise be thrown in the dustbin.	●									
ThermoLogica ○	Thermologica builds on a new construction principle, which uses steel plates for the outer walls. This has several advantages, including decreased heat loss through the outer walls, full control over the indoor climate, and no condensation and thermal bridges.						●		●		
Thors-Design ○	We produce furniture of 60 years' recycled wood, which can stand inside or outside the house.								●		

* Information in the 'Contribution to sustainable building' column provided by Copenhagen Cleantech Cluster

Sustainable building consultancy matrix

Company name	Contribution to sustainable building	Electricity & heat consumption	Water consumption	Indoor climate	Sustainable building materials	Building construction	Building developer consultancy	Sustainable building certification	Intelligent buildings	Building integration into infrastructure (e.g. transport, waste)	Other
AB Clausen ApS ○	We produce and deliver building automation, which ensures intelligent control of heat, cooling, and light. In addition to this, we produce and deliver solar inverters, which convert solar energy into electricity.				●	●					
Agner Thulesen ○	We produce mass ovens of stone, which have an optimal use of wood and create a good indoor climate. Low installation price and few operating expenses.										●
Ai-Gruppen ○○○○	We think energy improvements into all projects. We engineer low energy building, passive house building, and energy renovations.	●	●	●	●	●	●	●	●	●	
Ajos A/S ○○○○	We work to ensure that developers, consultancies, and entrepreneurs choose the smartest and most environmentally sound solutions for their construction sites. We try to make them think of the sustainability of the construction site layout and operation.						●				●
Alectia A/S ○○○○○○	Our entire consultancy is based upon sustainable solutions, which benefit society, developers, users, our employees - and ultimately the company.	●	●	●	●	●	●	●	●		
Arkitektfirmaet C.F. Møller A/S Aalborg ○○○○○	C. F. Møller provide consultancy for the building industry, which ensure solutions, which are economically, environmentally, and socially sustainable - in the construction, operation, and phase-out of buildings.	●	●	●	●	●	●	●	●	●	●
Aurora Development ApS ○	We produce and deliver paint, varnish, wood and floor care products, colours, and cleaning products based on natural, ecological, and sustainable raw materials. All of our products live up to the highest demands regarding atoxity, allergy-friendliness etc., and are 100% biodegradable.			●	●		●	●			
Balslev ○○○○○	We create tomorrow's sustainable and intelligent solutions using specialised consultancy to our customers which helps them realise the opportunities of the future.	●	●	●	●	●	●	●	●		
Betech Data A/S ○○	We deliver software for building engineering, which support more environmentally friendly construction using applications such as Autodesk Green Building Studio, Autodesk Vasari, Autodesk 3D Studio Max Design and Autodesk Revit.				●		●				●
Bjerg Arkitektur A/S ○○	We provide consultancy for Danish building developers - big and small - with two core competencies: Consultancy and certification of passive house and DGNB.	●	●	●	●	●	●	●			
BJK Byg A/S ○○	We engineer and build with a view to better indoor climate, lower energy use, reuse of building materials, better derivation of water, renewable and optimised energy supply, and economic sustainability for the project and the local community.	●		●	●	●	●				
Bravida Danmark ○○○○○	Energy optimisation: better use of existing industrial installations.		●						●		

Company name	Contribution to sustainable building	Electricity & heat consumption	Water consumption	Indoor climate	Sustainable building materials	Building construction	Building developer consultancy	Sustainable building certification	Intelligent buildings	Building integration into infrastructure (e.g. transport, waste)	Other
Bureau Veritas A/S ○○○○○	We certify companies according to a range of standards, which strengthen the companies' systematic efforts regarding sustainable building.							●			
Capgemini* ○○○○○	Capgemini is one of the world's leading suppliers of consultancy, technology, and outsourcing services.								●		●
Cebra A/S, Arkitekter MAA ○○	We provide consultancy and draw our projects on the basis of a holistic thinking, which includes environmental, as well as energy-related, social, economic, and cultural concerns, ensuring low energy use, a long life time and a great adaptability for our buildings.				●	●	●				
Christensen & Co. Arkitekter A/S ○○○	We have great experience with low-energy building and aim to have all of our buildings live up to the requirements of the coming 2020 building regulations.	●		●				●			
Coromatic ○○	We design and build data centres, server rooms and emergency generators.	●									
COWI ○○○○○○	We provide consultancy within all aspects of sustainable building, including climate adaption.	●	●	●	●	●	●	●	●	●	
Danish Management A/S ○○○○○	We provide consultancy for ESCO projects, energy administration of buildings, code of conduct campaigns regarding energy use, and energy efficient engineering regarding new building and building renovation.	●	●	●							●
DATEA A/S ○○○○○	We aim at always being able to offer rentals, which as a minimum live up to the expectations set by the market. Therefore, we have tuned into the green and sustainable buildings agenda, which is always profitable in the long run.	●		●	●	●	●		●		
DBS Lys A/S ○○○	We provide consultancy regarding energy optimisation, energy renovation, and dissemination of the State's energy subsidies for completed energy renovations.						●		●		
DONG Energy ○○○○○○	We provide consultancy regarding energy savings in order to save energy and support the use of renewable energy. We deliver reused mineral products for building materials, which can substitute the use of virgin raw materials.	●									
Drees & Sommer Nordic A/S* ○	Drees & Sommer Nordic A/S is one of the leading service and consulting companies in the construction and real estate industry, with expertise in green and sustainable building projects.	●	●	●	●		●	●	●		
E. Pihl & Søn A/S ○○○○○○	We energy optimise our building sites. We make sure to get experience with the different certification systems and energy strategies. We do what we can to find the most sustainable solutions for all phases of the building projects.					●					●
EBM-Papst Denmark ApS ○○	We deliver ventilators which save energy both for retrofitting and new buildings.	●		●			●		●		

Company name	Contribution to sustainable building	Electricity & heat consumption	Water consumption	Indoor climate	Sustainable building materials	Building construction	Building developer consultancy	Sustainable building certification	Intelligent buildings	Building integration into infrastructure (e.g. transport, waste)	Other
EgerByg ApS* ○○	EgerByg ApS is a carpentry company and consultancy with market leading competencies within sustainable building and social responsibility.	●			●	●	●			●	
EKJ Rådgivende Ingeniører A/S ○○○○○	We design and engineer sustainable construction, low-energy buildings, and we energy renovate existing buildings. We conduct energy labelling and certify buildings according to the new certification system DGNB.	●	●	●	●	●	●	●	●	●	
Ekolab ○	We provide consultancy for low-energy building and renewable energy.	●		●				●		●	
Energidata ApS ○○	We provide consultancy and optimise operation, customer's energy use, and technical facilities, which are controlled by an energy registration programme.	●	●								
EnergyRoofs.dk ○○○	Dansk Solenergi produces solar cell modules and integrated building solutions.	●			●	●					
Exergi ○	We use the product IC-Meter.com for measuring and analysing indoor climate. We compare indoor climate measurements with local weather data and energy measurements in order to model the flow of air, moisture and energy in the building.			●				●	●		
FORCE Technology ○○○○○	We provide consultancy for 'green' building products and conduct LCA-based environmental declarations for building products.				●			●			
Franck Geoteknik A/S ○○○	We provide consultancy and engineering experience regarding rainwater infiltration, sewerage, and environmental impact assessment.					●					
Gendan ○	We handle discarded building materials in order to ensure the greatest possible recycling rate.									●	
Golder Associates A/S ○○	We ensure that building and construction waste is sorted out so that as much as possible can be prepared for reuse.			●	●	●	●	●			●
GPP Arkitekter ○○○	We certify buildings according to the DGNB system, and we always conduct a screening in regards to the built environment and energy in our buildings.				●	●	●				
Green Machine ○	We develop sensors which measure use and dissipation of heat, and motion sensors which control light, office machines and window positions. We help customers develop products which can later be reused.				●						●
Grontmij ○○○○○	We provide consultancy for property owners, energy companies, decision makers, and local authorities regarding holistic solutions for the sustainable building sector.	●	●	●	●	●	●	●	●	●	
H+H Danmark A/S ○○	We provide consultancy regarding product use and properties, and products which minimise the working time and optimise the workflow.				●	●					

Knowledge institutions for sustainable building in Denmark

Company name	What do they do?	Website
Activehouse.info	Active House is a vision of buildings that create healthier and more comfortable lives for their occupants without negative impact on the climate - moving us towards a cleaner, healthier and safer world.	www.activehouse.info
bips	BIPS is a membership, non-profit organisation, which develop standards and tools for construction branches. BIPS stands for: Construction, information, technology, productivity and cooperation.	www.bips.dk
BL - Danmarks Almene Boliger	BL is an association with about 650 social housing organisation and more than 560,000 homes. It provides services and advises to housing organisation and educating residents.	www.bl.dk
bo-energi.net	Bo-energi.net has a focus on energy renovation of rental housing, which has carried out many initiatives and pilot projects to improve energy efficiency for rental housing.	www.bo-energi.net
By & Havn	By & Havn I/S (City and Harbour I/S) was founded in 2007, which facilities partnerships to develop and manage Ørestad, Copenhagen Harbour.	www.byoghavn.dk
Byggesocietetet	Byggesocietetet (Association for Building) is a vibrant and influential network. The association speaks for entire building branches and has great impacts on government, parliamentary committees, regions and municipalities' decisions.	www.byggesocietetet.dk
Bygningskultur Danmark	Building culture Denmark is the umbrella organisation for 28 associations, industry groups, foundations and institutions working with the conservation and development of the Danish building culture.	www.bygningskultur.dk
Bæredygtigt Byggeri (blog)	Bæredygtigt Byggeri is an internet blog run by three COWI employees, which spurs debate about the concept of sustainability in buildings.	www.baeredygtigt-byggeri.dk
Climate Change and Innovation in the Building Sector (CIBS)	A research project with the aim of contributing to dialogue, learning and innovation among compagnies, institutions, planners and residents on future demands to the building sector.	www.climatebuildings.dk
Cradle-to-Cradle Danmark	Cradle-to-Cradle Danmark is a Danish consultancy working with the Cradle-to-Cradle concept.	www.vuggetilvugge.dk
CradlePeople	CradlePeople is an organisation for businesses, educational institutions, authorities and sustainability experts promoting the Cradle-to-Cradle concept.	www.cradlepeople.dk
DAC - Danish Architecture Centre	The Danish Architecture Centre is a gathering point for all those stakeholders interested in architecture and sustainable city development.	www.DAC.dk
DAKOFA	Danish Competency Centre for Waste, DAKOFA, is a quota-based member organisation focusing on waste resources.	www.dakofa.dk
Dansk Byøkologi	Dansk Byøkologi is a data base with examples of Danish new buildings and renovations, where building developers and consultants have been working to reduce the environmental impact of the building.	www.danskyokologi.dk
Danish Construction Association	The Danish Construction Association is an employers' organisation for approximately 6.000 companies, comprising about 70.000 workers from contracting and manufacturing companies within the Danish building and construction sector.	www.danskyggeri.dk
Danish Design Centre	DDC is an open platform for knowledge sharing and a productive and innovative collaboration between designers, professionals, researchers and authorities	www.ddc.dk
Danish District Heating Association	Danish district heating is the industry organisation for 405 district heating stations distributed throughout the country.	www.danskfjernvarme.dk
Danish Energy Association	The Danish Energy Association is a commercial and professional organisation for Danish energy companies	www.danskenergi.dk
Danish Lighting Innovation Network	The vision of the Danish Lighting Innovation Network is to promote the Danish lighting industry and to support the industry to be at the forefront when it comes to the global light market.	

Company name	What do they do?	Website
Danish Waste Association	Danish Waste Association is a political interest organisation consisting of municipal waste entities.	www.danskaaffaldsforening.dk
Danske Isoleringsfirmaers Branche forening (DIB)	Danske Isoleringsfirmaers Branche forening (DIB) is the industry association for Danish insulation companies.	www.dibnet.dk
Dansk Ventilation	Danish Ventilation is a trade association with a focus on how to create and maintain a good, healthy, and energy efficient indoor climate.	www.danskventilation.dk
DI Byg	DI Byg is a professional community for producers, suppliers, distributors and contractors in the Danish construction industry.	www.bm.di.dk
DTU byg	DTU Byg is the Department of Civil Engineering at the Danish Technical University.	www.byg.dtu.dk
EnergiSpiren	Energi Spiren provides independent free information and inspiration that can help building owners to adopt energy efficient and sustainable building solutions.	www.energispiren.dk
Gate21	Gate 21 is a partnership between municipalities, private companies and research institutions that are working together for a sustainable society and green business development.	www.gate21.dk
Green Building Council Denmark	Green Building Council Denmark is a not-for-profit organisation working to promote sustainability in the construction industry.	www.dk-gbc.dk
Green Lab for Energy Efficient Buildings (GLEEB)	GLEEB tests and documents technologies and system solutions for climate screens, heating and ventilation systems, solar energy, energy management and monitoring, intelligent buildings and Smart Grids.	www.teknologisk.dk/projekter/gleeb
Grønt HUS	GroentHus.dk is a database where private contractors, architects and construction companies can find the latest knowledge in the field of energy and environmental solutions for the construction industry	www.groenthus.dk
IndustriNetvaerk.dk	IndustriNetvaerk.dk is an open forum for the communication of knowledge on industrialisation and system deliveries.	www.industrinetaerk.dk
InfinIT	Non-finite is a Danish network for innovative utilisation of IT with a goal to convert the infinite possibilities that technology offers into concrete collaborations between research and industry.	www.infinit.dk
InnoByg	The innovation network for energy efficient and sustainable construction - Inno-BYG - is the new innovation network of the construction industry in Denmark.	www.innobyg.dk
KNX National Group Denmark	KNX National Group Denmark is a member organisation with the aim to promote KNX-certified technology products for intelligent buildings.	www.knxdenmark.dk
Nordic Built	Nordic Built is a Nordic initiative to accelerate the development of sustainable building concepts initiated by the Nordic ministers for trade and industry.	www.nordicinnovation.org
Parcelhusejernes Landsforening	Parcelhusejernes Landsforening seeks to protect Danish house owners' interests.	www.parcelhus.dk
Sekretariatet for Energifeffektive Bygninger (SEEB)	SEEB works to improve the quality of energy certifications and inspections of Danish buildings	www.seeb.dk
SmartCityDK	SmartCityDK is a trader Fund focusing on developing a framework for the promotion of intelligent business models, building concepts, and dynamic building materials.	www.SmartCityDK.dk
Technological Institute	The Danish Technological Institute is a self-owned and not-for-profit institution which develops, applies, and disseminates research and technologically-based knowledge for the Danish and International business sectors.	www.dti.dk

Company name	What do they do?	Website
Tekniq	Tekniq is the branch organisation for 2.800 technical installation companies in the Danish electricity and HVAC industry.	www.tekniq.dk
The Benchmark Centre for the Danish Construction Sector	The Benchmark Centre for the Danish Construction Sector works to promote competition on quality in Danish construction through a benchmarking system.	www.byggeevaluering.dk
The Danish Association of Architectural Firms	The Danish Association of Architectural Firms is the Danish association of private firms of consulting architects	www.danskeark.dk
The Danish Association of Building Experts, Managers and Surveyors	The aims and objectives of the Danish Association of Building Experts, Managers and Surveyors are to safeguard the professional interests of members.	www.kf.dk
The Danish Association of Consulting Engineers	The Danish Association of Consulting Engineers is a trade association of Danish consulting firms providing consulting services, planning and project management on a technical-scientific basis.	www.frinet.dk
The Danish Building Information Centre	The Danish Building Information Centre provides the necessary information, services and tools for professionals within the building industry, to obtain the best results within the areas of construction, energy saving products and services.	www.byggecentrum.dk
The Danish Building Research Institute	The Danish Building Research Institute (SBI) is the national Danish building research institute and develops research-based knowledge to improve buildings and the built environment.	www.sbi.dk
The Danish Business Authority	The Danish Business Authority endeavours to create the best conditions for growth in Europe, and to make it easy and attractive to run a business in Denmark.	www.ebst.dk
The Danish Energy Agency	The Agency is responsible for the entire chain of tasks linked to energy production and supply, transportation and consumption, including energy efficiency and savings as well as Danish national CO2 targets and initiatives to limit emissions of greenhouse gasses.	www.ens.dk
The Danish Knowledge Centre for Energy Savings in Buildings	The Danish Knowledge Centre for Energy Savings in Buildings gathers expertise and best practices in the field of energy savings in buildings.	www.byggeriogenergi.dk
The Danish Lighting Center	The object of the Danish Lighting Center is to promote the use of good and appropriate lighting.	www.centerforlys.dk
Veltek	Veltek is a branch organisation for companies working within the Danish HVAC and electro industry.	www.veltek.dk

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