ROADMAP FOR
FOSSIL-FREE COMPETITIVENESS

Construction and Civil Engineering Sector

FOSSIL FREE SWEDEN

A carbon-neutral value chain in the construction and civil engineering sector 2045

A roadmap for fossil-free competitiveness

Foreword

As the climate changes, it makes our society vulnerable. It is natural for us, as societal players, to stand behind and live up to the ambitions of the Paris agreement. During 2017, the Swedish Parliament voted that Sweden should have no net greenhouse gas emissions by 2045, and a Climate Act came into force in 2018. As Sweden now acts on its carbon emissions, we in the construction and civil engineering sector need to be a part of this journey, take responsibility and come up with climate solutions. Therefore, within the framework of the government initiative Fossil Free Sweden, the construction and civil engineering sector has agreed on a roadmap under Skanska´s leadership. Together with other industry roadmaps, a unique and powerful force for change in Sweden has been created.

While working with this roadmap for a carbon-neutral and competitive construction and civil engineering sector, we have gathered many key players throughout the value chain. One realisation we have had is that the need for managing carbon emissions is a new pre-condition for managing a business. We need to be more resource-efficient, create new business models and above all cooperate throughout the entire value chain.

With this roadmap, we have taken the first step toward competitive urban carbon-neutral development. We agree that the construction phase and the operational phase in our sector need to be carbon-neutral by 2045. We are now going to move from words into action to decline carbon emissions. With the roadmap as our common guideline, together with the recommendations of action we raise to politicians and players in the sector, we will create conditions for a market that values climate-smart solutions and innovations. We see a need to follow up on the implementation of the roadmap and that a review is made every five years. We also see that those who stand behind the roadmap may need to progress from simply signing it to actually committing to delivering it. This could mean openly reporting the goals and results of their climate work. We need to continue to work together on a strategic level within the sector on the roadmap's implementation.

The work with the roadmap has strived for an inclusive process with broad cooperation throughout the value chain. We have tried to be principled and objective in describing the sector´s intentions. Roadmaps for other sectors go deeper in several areas that are relevant to our sector. Many thanks to all who participated in the process.

It is gratifying that so many stand behind the roadmap and we urge more to join us. We take our responsibility and strengthen our competitiveness through low-carbon transition that is necessary to ensure a better world for future generations.

March 28, 2018

The organisations in the Roadmap steering committee

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The English translation is produced on behalf of Skanska. The original Swedish version kan be find on www.fossilfritt.se.

Contents

Summary

As part of the development of a common roadmap, many key players have united on the vision that the value chain in the construction and civil engineering sector will be carbon-neutral and competitive by 2045, in line with Sweden´s climate goals, as well as societal and global needs.

The goals for reaching a carbon-neutral value chain in the construction and civil engineering sector are:

- 2045: Net-zero greenhouse gas emissions
- 2040: 75 per cent reduction in greenhouse gas emissions (cf. 2015).
- 2030: 50 per cent reduction in greenhouse gas emissions (cf. 2015)
- 2025: Greenhouse gas emissions clearly demonstrate a declining trend.
- 2020-2022: Key players within the construction and civil engineering sector have mapped their emissions and established carbon goals.

In order to manage carbon emissions we have agreed on 26 recommendation of action for politicians, authorities and stakeholders in the value chain. See the section 'Recommendation of action for politicians and players in the construction and civil engineering sector'.

The roadmap´s description of the current situation and trends can be summarised as follows:

- All stakeholders in the construction and civil engineering sector need to work together to achieve carbon-neutrality.
- The greenhouse gas emissions from the construction and civil engineering sector has the potential to be halved by 2030 with current technology, but to reach net-zero or below, a technological shift and commercialisation of innovations are required. In order to achieve this, new incentives and laws, new ways of managing and cooperating throughout the entire value chain are required.
- Greenhouse gas emissions from the construction phase is primarily due to the manufacture of construction materials such as cement and steel.
- Emissions of greenhouse gases from domestic electricity and heat production are approaching zero, while all building types are becoming increasingly energy efficient.
- The construction and civil engineering sector has the potential to minimise waste and move towards circular flows through more efficient resource use, increased reuse and material recycling.
- Digitalisation involves a major change in society, which provides opportunities for new ways of working, services and markets, as well as for more efficient and sustainable construction.

»91 per cent believe that climate issues will have a major impact or are crucial for their business or organisation in the next five years.«

Responses from more than 100 participants of the Roadmap launch Seminar on March 6, 2018.

- A combination of customer requirements, market initiatives, and clear climate goals and long-term instruments contribute to the restructuring of the construction and civil engineering sector.
- The availability of financial capital is of great importance in promoting investments in new technologies and companies that focus on sustainable solutions.

- New technology, market preferences and profitability can change rapidly. A common objective can drive innovations for the carbon transition.

The roadmap´s description of opportunities and challenges is summarised as a barrier analysis. Sustainable development in the construction and civil engineering sector has made significant progress, but there are many challenges that still need to be addressed. The climate situation means that all players in the value chain need to take responsibility, act and collaborate. Procurement is a powerful tool and it needs to be developed along with new business models. Further changes to regulations and laws, as well as the conditions for innovations such as Carbon Capture and Storage are required. Adapting internal processes and knowledge building around new materials and working methods, as well as increasing skills at all levels and clear leadership are crucial. In order to manage carbon emissions, while maintain or strengthen competitiveness, it must be profitable for market players to reduce their carbon emissions. The outcome of the barrier analysis is a set of requests aimed at accelerating the discussion.

»100 per cent consider it crucial or important that the construction and civil engineering sector cooperate to manage climate change.«

Responses from more than 100 participants to the Roadmap Launch Seminar on March 6, 2018.

In order to concrete our position on climate change, we have given examples of action areas from 2018 to 2045 (see the illustration in Chapter 6).

With the roadmap as a starting point, the actual work now begins. With these intentions, in combination with the right prerequisites on the market, based on the recommendations for political decisions and actor actions, we can together ach sustainable development.

Roadmap launch seminar on March 6, 2018.

Recommendation of actions for politicians and players in the construction and civil engineering sector

The goals for reaching a carbon-neutral value chain in the construction and civil engineering sector are:

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- 2040: 75 per cent reduction in greenhouse gas emissions (cf. 2015).
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- 2025: Greenhouse gas emissions clearly demonstrate a declining trend.
- 2020-2022: Key players within the construction and civil engineering sector have mapped their emissions and established carbon goals.

In order to achieve the roadmap´s goals, a life cycle perspective is required in terms of the planning, design, construction and utilisation of the built environment. Success will require clear leadership, innovation and responsiveness from all value chain players in the construction and civil engineering sector. We need to question today´s rules, planning, design and material choices, and work together to find new solutions, methods, materials and business models.

We see five key factors for achieving a carbon-neutral value chain in the construction sector by 2045:

- Collaboration, leadership and knowledge.
- Long-term rules that allow investment and the transition to carbon-neutral materials and processes.
- Progression from linear to circular processes.
- Availability and efficient utilisation of bio-based raw materials.
- Public sector procurement as an engine for carbon transition.

RECOMMENDATION OF ACTIONS TO THE PARLIAMENT AND THE GOVERNMENT

1. Introduce ambitious, long-term and predictable legal requirements for the construction and civil engineering sector based on Sweden's goals to be carbon-neutral to enable necessary investments for transition that maintain or strengthen competitiveness.
2. Create conditions for transformation of the base industry to ensure carbon-neutral cement and steel through financing, risk-sharing, support for innovation and control instruments.
3. Develop a strategy and action plan in consultation with market players for access to and distribution of sustainable, fossil-free fuels for the construction and civil engineering sector.
4. Introduce requirements for carbon impact declarations from a life cycle perspective for buildings, infrastructure and construction products available on the market.
5. Utilise public procurement as an engine for carbon transition. Strengthen knowledge of the Swedish Public Procurement Act for those active in public

procurement and ensure that follow-up is as strict as procurement requirements.

6. Change regulations for the classification of waste to remove obstacles to – and instead drive – circular business models and increased re-use and recycling of excavation materials and building and demolition materials.
7. Work for the possibility of lower capital adequacy requirements and other incentives for green financing solutions aimed at stimulating investments with lower carbon emissions.
8. Introduce incentives that promote efficient use of energy and resources in the refurbishment of existing property holdings, requiring a life cycle perspective and carbon-reducing motivation for renovation and investment decisions.
9. Appropriate organisation to provide and manage an open database of generic carbon data that is life cycle-based, quality-assured and representative of the construction and civil engineering sector in Sweden.
10. Appropriate organisation to investigate a method for visualisation of carbon emissions in value chain transactions, from suppliers of raw materials to consumers.
11. Appropriate organisation to develop procurement criteria and definitions of carbon-neutral and carbon-positive buildings and infrastructure through dialogue with the market.

RECOMMENDATION OF ACTIONS THE CONSTRUCTION AND CIVIL ENGINEERING SECTOR

All players

(Clients, architects, consultants, construction contractors, subcontractors, material suppliers, property owners/managers, authorities, municipalities and county councils)

12. Establish its own climate goals and implement them throughout the organisation.
13. Enhance knowledge about responsibilities and potential for reducing carbon emissions throughout the design and construction process.
14. Use procurement and/or strategic partnerships that promote increased cooperation and dialogue between stakeholders in the value chain.
15. Provide carbon emissions information during tender even when not asked for by the customer in order to drive sustainable development in the market.
16. Use sustainability reporting to account for and set goals regarding organisation's carbon emissions.
17. Digitise the entire planning and construction process to support the minimisation of waste and efficient resource use, production and transportation.

Customers

18. Consider carbon emissions in the early stages of the design and construction process.
19. Set function-based procurement requirements where innovative solutions with low life cycle emissions are promoted. Demand and provide incentives for lower carbon emissions in tenders.
20. Follow up on climate requirements systematically, making it cost effective to make mistakes and profitable to do the right thing.
21. Set requirements for the reuse of materials if/when it is beneficial from a life cycle perspective, for example on renovation projects and when dealing with excavation materials.
22. Implement a prequalification requirement that companies should have a climate policy or actions to submit tenders, particularly on larger projects that are conducted through public procurement.

Consultants, architects

23. Early in the process, propose and/or provide resource-efficient solutions with low life cycle

carbon emissions. Create efficient, flexible floor layouts and structures that can be disassembled to reduce the need for new materials for future renovations or maintenance.

24. Create conditions in the design phase for buildings and projects to be carbon-neutral in the operational phase.

Contractors

25. Develop scalable production methods that enable the use of materials with low or net-zero carbon emissions, increased reuse and closed material flows during new production, renovation and demolition.

26. Set climate requirements in the design phase for suppliers, architects, consultants and subcontractors. Follow up on the climate requirements systematically, make it cost-effective to make mistakes and profitable to do the right thing.

Definition of the construction and civil engineering sector value chain

Players in the construction and civil engineering sector value chain are primarily construction contractors, machinery and transport suppliers, material suppliers, service providers, property owners, private and public customers, architects, consultants, industry and non-profit organisations, authorities, municipalities as well as research institutes and colleges that provide skilled labour. The value chain consists of players that interact with each other, and influence and control the development of buildings, projects and infrastructure.

Definition of carbon-neutrality

Net-zero emissions of greenhouse gases into the atmosphere. It involves any emissions that can be absorbed into the ecological cycle or with technical solutions, in order not to contribute to climate change. The strategy is primarily to reduce actual emissions, but carbon offsetting measures can be used to achieve carbon-neutrality.

We stand behind the goals, the recommendations and the roadmap's guideline

AB Familjebostäder
AB Stockholmshem
AFA Fastigheter
Bengt Dahlgren
Bjerking
BoKlok
Bonava i Sverige
Byggherrarna
Byggmaterialindustrierna
Byggmästarń i Skåne AB
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Circle K Sverige AB
Energieffektiviseringsföretagen
E.ON Energilösningar AB
ETTELVA Arkitekter
Fasadglas Bäcklin AB
Fastec
Fastighetsägarna Sverige
Finja Prefab AB
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Lindbäcks
Linköpings universitet
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Saint-Gobain Sweden AB
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Svensk Betong
Sveriges Byggindustrier
Sveriges Kommuner och Landsting
Sveriges Träbyggnadskansli
Swecon Anläggningsmaskiner
Swedbank Robur
Sweden Green Building Council
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WSP Sverige AB
Wästbygg
Återvinningsindustrierna
ÅWL Arkitekter

1 Vision carbon-neutrality 2045

The construction and civil engineering sector value chain is carbon-neutral by 2045, and greenhouse gas emissions have been halved by 2030 compared with 2015, while enhancing competitiveness.

2045

By 2045, the construction sector is carbon-neutral, completely in line with Sweden´s objectives as well as society and the world´s needs. Societal consumption and lifestyles have evolved toward resource efficiency, service-based economy where sharing economy is part of everyday life. Low-carbon solutions are a competitive edge helping to reduce costs and are valued by the market. It pays off to think long-term and to create life cycle value for customers based on societal needs. Through the joint efforts made in the low-carbon transition, more trust and equality was created in Sweden and internationally, although the transition posed many challenges.

The construction and civil engineering sector has shown leadership in the low-carbon transition and today contributes to negative emissions by developing buildings and projects that produce more sustainable energy than they use. Also by contributing to ecological value in buildings that sequester carbon, both above and below ground. Carbon-neutral products dominate the market and climate-positive products are increasingly common. New renewable and efficient materials, production methods, construction, efficient resource use and technology are in place and supported by the financial system. There have been transformative changes in society through technological innovations and new values and lifestyles. Compensatory measures through strengthened ecosystems and new technologies have been necessary to reduce emissions. Several technological shifts have taken place that together gradually have led to system solutions that support a net-zero emissions society.

All materials are recirculated and there is no waste. This ensures better access to materials and reduces cost. New materials are only added if they contribute to functionality in multiple technical life cycles or can be returned to nature without environmental impact. This involves constructing and using buildings and infrastructure in an efficient manner, and that they act as material banks with materials circulating in circular systems. This places demands on materials that we build with, how we manufacture them and what happens when a building or infrastructure is to be decommissioned and recycled.

This all demands a long-term policy with clear goals and requirements that are gradually advanced. Legislation supports and drives the development. This provides security when committing to investments, innovations and system solutions. We have international knowledge exchange, and Sweden is well positioned with several groundbreaking solutions and skills that are being exported. Resource efficiency pays off economically in a society where physical resources are becoming increasingly expensive. Collaboration throughout the value chain, with a business model that successfully quantifies life cycle value creation, is used by the market.

2030

By 2030, we are halfway toward carbon-neutrality. Our lifestyles have begun to change toward resource efficiency and a service-based society, although there are high pressure on resources and on community services particularly in cities. Efforts to create a carbon-neutral future have begun to yield results.

We see that competitiveness has been enhanced and circular economy established in many areas. New businesses and jobs have been created that are filled by workers made redundant in the low-carbon transition. We use several technological solutions that contribute toward resource efficiency. By applying several existing technological solutions in combination with some innovations, the carbon emissions of the construction sector has been halved between 2015 and 2030. Transformation of manufacturing processes and of society's structure is beginning to yield results, although several challenges to achieve carbon-neutrality remain. Products that are carbon-neutral from a life cycle perspective are available on the market.

Clear leadership in business and politics has created a long-term approach and optimism. We have developed procurement requirements to promote carbon-neutral innovations as well as strengthened cooperation between all players in the value chain. New business models that manage distribution of cost and revenue throughout the value chain are increasingly common. Life cycle perspective is beginning to be established from the design to use phase. Legislation is reorganised so that circular flows are facilitated, and higher climate requirements are introduced gradually with clear long-term goals. Resource efficiency and low-carbon solutions have proven to be economically profitable, primarily because many low-hanging fruits have been picked. Digitalisation has created information flows throughout the entire value chain and ensuring good decision-making. Increased collaboration disseminates knowledge and experience in the value chain, which in turn facilitates technological shifts and innovations for the low-carbon transition.

The low-carbon transition in Sweden is an international model, and exchanges with other countries take place to bring about research efforts while we are also able to export more climate solutions. Enhanced expertise in the value of biodiversity and ecosystems services means that our cities develop more sustainably with the ability to manage low-carbon transition.

1.1 GOALS

- 2045: Net-zero greenhouse gas emissions
- 2040: 75 per cent reduction in greenhouse gas emissions (cf. 2015).
- 2030: 50 per cent reduction in greenhouse gas emissions (cf. 2015)
- 2025: Greenhouse gas emissions clearly demonstrate a declining trend.
- 2020-2022: Key players within the construction and civil engineering sector have mapped their emissions and established carbon goals.

The goals are based on 2015 emission levels and are in absolute terms of carbon dioxide equivalents. The goals relate to greenhouse gas emissions throughout the entire value chain from the construction and use phases to recycling, regardless of the country in which emissions arise. Carbon offsetting can be necessary to reach carbon-neutrality, but the main strategy is to reduce emissions. As the sector has limited influence over the use phase, such as emissions from traffic and household energy use, the use phase is not included in the goals. If all players in the value chain reduce their direct emissions, the value chain as a whole will cover all emissions. In order to avoid sub-optimisation and relocation of emissions to other players or life cycle stages, cooperation and an overarching perspective of the value chain is needed. The goals are extremely challenging, but deemed necessary. They may even need to be stepped up in order to achieve Sweden´s climate goals.

Sweden´s climate goals currently refer to the national emissions arising from production within the country´s borders. For a carbon-neutral and competitive construction sector, emissions need to be taken into account regardless of the country in which they arise and at what phase of the life cycle. Otherwise, the competitiveness of Swedish companies is at risk. For example, if a construction project´s carbon emissions in Sweden are reduced by importing materials that have higher emissions, we have only moved the emissions abroad and reduced Swedish business competitiveness. Therefore, a consumer perspective can favour Swedish business, as a complement to climate goals from national production. Exports from Swedish companies that have low-carbon solutions for the production stages or consumption stages would then benefit. Climate goals for the construction and civil engineering sector have a consumption perspective.

1.2 A POTENTIAL OUTLOOK 2045

Flexibility, self-determination, coherence and security are important for many people. Jobs in 2045 are largely independent of geographic location. Many tasks have been replaced by automation and artificial intelligence. Digital communication tools are integrated in both our private and work life, but do not replace physical meetings. We meet, socialise and work at focal points that exist in many places around the country. Many companies and organisations share spaces, which makes it easier to network, collaborate and create value across organisational boundaries. Premises can be rented temporarily or for longer periods through digital platforms, and can be adapted for meetings, showrooms, cafes, restaurants, classrooms or accommodation.

A more decentralised labour market with local hubs brings new opportunities to live where it suits an individual's lifestyle, family or other personal wants. The need to feel at home and to have a local connection is important to many people. The possibility of being able to control their life situation strengthens both individuals and local communities. At the same time, there are many who prefer a more mobile and dynamic existence. In order to respond to this need, there are other ways of living. Homes can be adapted and booked as needed, for shorter or longer periods in the same way as office premises.

This all imposes other infrastructure requirements. IT infrastructure has been developed to cope with decentralised and mobile workplaces. Transport infrastructure is adapted to deal with the changing housing situation and for commuting time to be used productively. Urban accessibility is more adapted to walking, cycle and various types of public transport, and freight transport is coordinated in a more efficient manner. Transport capacity is expanded in some locations and reduced in others. Freed up spaces also provide opportunities to develop new uses, such as parks and allotments or other areas that meet the needs of the society.

Battery and hydrogen-driven vehicles are largely recharged by buildings or infrastructure that are net producers of renewable and sustainable energy. Energy storage for these vehicles also serves to balance the power network – electricity over shorter periods and hydrogen over longer. Urbanisation continues, but technology enables jobs and community services in rural areas while providing cities with ecosystem services and industrial production.

Ecosystem services are necessary for the functioning of cities and are highly valued. Enhanced knowledge and understanding of biodiversity, ecosystems and microbiology enables us to construct in a more integrated manner with nature. This provides us with locally produced food, better air quality, water purification and lower energy consumption.

The existing stock of residential and commercial premises is utilised considerably more efficiently, with several flexible solutions, where the stock is changed and refined through circular business models and refurbishment.

Population increase is managed through refurbishments in addition to the production of new buildings and infrastructure. The role of the construction sector has a greater focus on refurbishment, services related to premises and other community-friendly functions, for example ecosystem services. Value is created in the value chain together with several players in networks. Services and products are widely distributed through common platforms. Platforms can be linked to other important features such as passenger transport, product deliveries and various kinds of services. Companies that create their value through platforms have a lot to gain. It does not necessarily have to be by owning the platform, but by being a part of the system that constitutes the new economy.

Inspiration:
Harvard Business Review[96]
McKinsey & Company[48]
Forbes[97 98]
Accenture[99]
Professor Kevin Anderson[100]

The above scenario describes some of the possible paths now discussed by leading players, paths that supports a zero-emission construction sector – or net positive, to be more accurate. In such a scenario, business models have shifted their focus from volume to function-based value creation. The scenario includes sudden shifts where new opportunities are created for farsighted players.

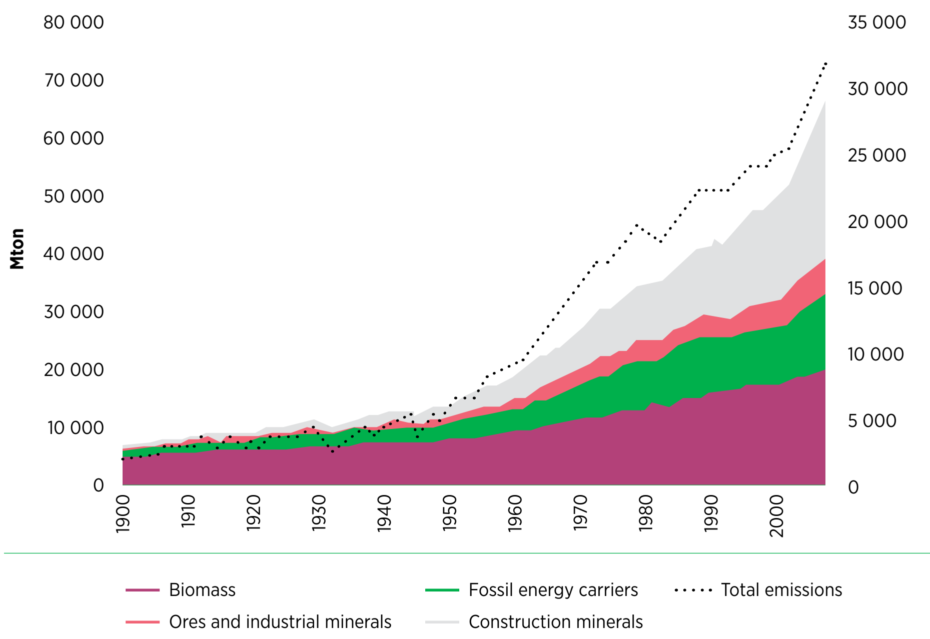
2 Low-carbon transition in the construction and civil engineering sector

All stakeholders in the construction and civil engineering sector have to work together to achieve climate goals.

New technology, improved healthcare and developments in housing and communications have led to the world becoming a better place to live for the majority of the global population over the last century. At the same time, this development has been intimately associated with an increased use of natural resources. The total global consumption today exceeds what is sustainable in the long-term. Estimates show that humanity today consumes its annual budget of renewable resources in just over half a year. If everyone in the world would consume as much as an average Swede, then 4.2 Earth's would be needed[1]. Greenhouse gas emissions have increased at the same rate as the use of natural resources, which has contributed toward climate change (Figure 1). This change is progressing quicker than research previously showed. In parallel, both the global population and the world economy are growing. By the middle of this century, the world´s population is estimated to grow from just over seven billion to almost ten billion people and the global economy by about three times.

In view of the fact that we already currently exceed our planetary limits, a threefold increase in the world economy cannot correspond to a similar increase in resource use and carbon emissions as experienced to date. We are in urgent need of change.[2]

In December 2015, the world´s countries agreed on a



Figur 1: Global withdrawal of material (left axis) and global carbon dioxide emissions (right axis)

new climate agreement in Paris. The Paris agreement came into force in November 2016 and the aim is to keep global warming well below 2 degrees Celsius, with the ambition to limit temperature increase to 1.5 degrees.

Sweden has decided to be a leader in the low-carbon transition and to be a frontrunner in the global work to implement the Paris agreement, which places great demands on our abilities and the need for a clear strategy. This is particularly true for managing societal development in a desirable way.

The construction sector is of major importance to the entire Swedish economy contributing to its growth, development and prosperity. The Swedish construction and civil engineering sector annually accounts for over SEK 1,100 billion and employs around 550,000 persons[5]. No actor alone has the ability or knowledge to lead the transition needed to reduce the sector's greenhouse gas emissions to zero in less than three decades. The low-carbon transition requires a broad consensus and cooperation in the sector, but also political will.

In order to dramatically reduce the carbon emissions from the construction and civil engineering sector while enhancing competitiveness, joint and long-term goals are needed that can be broken down into easily understandable indicators[6]. At the same time, the sector will need to plan for a changed climate, for example by changed building methods related to precipitation, water levels, humidity, heat and cooling.

3 Current situation and trends

3.1 CARBON EMISSIONS FROM THE CONSTRUCTION AND CIVIL ENGINEERING SECTOR

The carbon emissions from the construction and civil engineering sector can be halved by 2030 with existing technology, but to reach zero or below, technological shift and commercialisation of innovations are required.

Carbon emissions from the construction and civil engineering sector has increasingly been in the spotlight in recent years, not least due to the report »Klimatpåverkan från byggprocessen« (»Carbon emissions from the Construction Process«)7 from 2014. The annual emissions from construction and civil engineering sector (excl. heating) are estimated to be about 15 million tons of carbon dioxide equivalent[8], when import and indirect emissions are included. This is almost as much as the total emissions from Sweden´s domestic transport. More than half of emissions derive from imported goods and services. When heating is included, carbon dioxide emissions exceed 22 million tons of carbon dioxide equivalents.

The method for these calculations is based on physical flows over what is consumed in the sector, in combination with life cycle-based environmental data. In the case of object-specific studies, a life cycle analysis (LCA) is usually used to identify the direct and indirect emissions. In the standard LCA method used for construction works[9], life cycle stages are divided into different modules[10 11]. The construction phase encompasses all environmental impacts from raw material extraction or recycling of materials to completed buildings or infrastructure, including all transport between them (Module A1-A5). The use phase includes everything from maintenance and renovation to energy and water use (B1-B7). The final stage includes demolition activities and waste disposal (C1-C4). The analysis of the recovery phase highlights positive or negative impact when materials enter a new life cycle, for example in recycling (module D).

The greatest opportunity to reduce carbon emissions from a building or infrastructure's life cycle is determined in the early planning phases. The planning phases determine whether something should be built and, if so, what function or benefit it will achieve. The further a project progresses, the more parameters are set in stone, which increasingly limits options available. Therefore, the earlier climate issues are considered, the more radical decisions can be made.

3.1.1 CONSTRUCTION PHASE EMISSIONS

Carbon emissions from the construction phase is mainly due to the manufacture of building materials such as steel and cement.

Several studies have made the industry aware that the construction phase – from raw material extraction to completed building – has a significant impact on a building´s overall carbon emissions[12]. However, according to the Swedish National Board of Housing, Building and Planning (Boverket) there are few drivers that promote use of life cycle analyses to reduce emissions[13]. However, for road and rail infrastructure, the Swedish Transport Administration (Trafikverket) sets requirements for climate calculations for all investment projects above SEK 50 million, which the industry welcomed according to investigations done prior to their enforcement[14]. The same investigations show that there is potential for a major reduction of greenhouse gas emissions, both in terms of material use as well as development of material.

In dialogue with industry and academia, a strategic innovation agenda for reducing carbon emissions from the construction phase[6] was launched in 2015. The agenda states that carbon emissions from the construction phase can be halved by 2030 compared with the current situation, providing that there is an industry-wide actor cooperation in a number of areas. Studies conducted by the Swedish Transport Administration show that emissions in the construction phase could be halved with existing technology for high-speed railways[15]. Skanska has analysed what is required to reach a carbon-neutral construction phase, which also indicates that emissions can be reduced by about 40 per cent with existing technology prior to 2030[16]. To achieve further reductions it is required that innovations are made commercially and technically viable, which requires development and a major investment in technological shifts[16]. Introducing new or alternative building materials and construction methods must be done in such a way that it ensures the right quality and functionality over time, taking into account a life cycle approach, including life cycle costs.

Manufacturing of building materials has been found to account for the majority, about 80 per cent, of the construction phase's carbon emissions, while transport to the construction site and the actual construction add around 20 per cent together[12 18]. At the same time, this depends on the project´s prerequisites, as on infrastructure projects, excavation material management and its associated transport constitute a major contribution of the overall emissions of the construction phase[17]. Efficient logistical solutions, electrification and development of sustainable biofuels are therefore important aspects for reducing carbon emissions during construction.

In both construction and civil engineering projects, cement in concrete together with steel contributes to a significant proportion of a project´s emissions. The Swedish Transport Administration (Trafikverket) estimates that about half of the greenhouse gases from the construction of infrastructure, excluding transportation, originate from the manufacture of steel and cement for concrete18; and for building projects, the same material groups can contribute 40-80 per cent of a building´s total emissions[12 22], depending on the type of loadbearing structure.

Research by Chalmers University of Technology shows that the technological shift required to achieve near climate-neutral steel and cement industry would mean investments at a level equivalent to 25-70 per cent in increased production costs[19]. The technological shift includes CCS (Carbon Capture and Storage) technology, where carbon dioxide is separated and stored instead of being released into the atmosphere, as well as technology for replacing coal with hydrogen in steel production. The same study shows that the required investments contribute to a marginal cost increase for completed buildings where steel and cement are used, equivalent to less than 0.5 per cent. Similar analyses have been made for infrastructure projects, which indicate a somewhat higher cost increase, because materials in infrastructure projects generally account for a higher proportion of the total cost compared to building projects. The increase corresponds to less than 2 per cent of the final cost of the infrastructure[20]. However, increased production costs come long before products reach the market and the end customer. A long-term perspective is important to emphasise in order to create conditions for both research and large investment for the implementation of the technological shift.

Housing construction with solid wood loadbearing frames have previously proven to account for almost half the carbon emissions compared with concrete if no active choices are made[21]. However, the emissions from of cement has declined over time[22]. Studies have also shown that there is great potential for reducing the carbon emissions from concrete with existing technology. Between 40 per cent[23] and 70 per cent[24] in reduced emissions from concrete construction have been demonstrated by active choices concerning the concrete mix and design. Similarly, there is potential to reduce the carbon emissions from construction of bridges by almost half with existing technical solutions[26], but also through less traditional designs[27]. The level of emissions on different system choices from a life cycle perspective depends, among other things, on project-specific requirements and production conditions. For example, the study showed that optimised concrete on the Viva residential development project has the potential to have the same carbon emissions as timber construction. However, an important starting point for properly comparing carbon emission from different material choices over the entire life cycle is that alternatives that are compared are based on the same set of functional criteria and governance requirements to ensure that the assumptions are the same. Regardless of the choice, all materials and processes can be optimised in order to reduce emissions.

3.1.2 USE PHASE EMISSIONS

Emissions of greenhouse gases from domestic electricity and heat production are approaching zero, while all building types are becoming increasingly energy-efficient

The housing and service sector accounts for about 40 per cent of Sweden´s total energy use, equivalent to 143 TWh (2015)[28]. The housing and service sector consists of various activities, but only includes building heating, hot water and real estate energy – i.e. not household energy and operational energy, which are equivalent to about 30 per cent of Sweden´s total energy use[8]. Since the 1970s, oil use has gradually been phased out in favour of biofuels, heat pumps, electricity and district heating. This has led to a sharp reduction in carbon emissions from the heating of buildings. Between 1990 and 2015, emissions have fallen by 86 per cent[29]. At the same time, the high energy use in the housing and service sector is a challenge because renewable energy is needed in a society with no use of fossil fuels.

The report to the European Commission of the Swedish climate emissions introduced a reference scenario* for Sweden´s future energy system. It states that domestic electricity origin from renewable sources to a greater extent than today, and nuclear power is phased out[30]. The phase out of nuclear power applies to all the scenarios presented, which also leads to a reduction of total electricity production by 2035. Higher prices on fossil fuel and emission allowances will increase electricity prices, which benefits wind power. Regardless of the electricity price, the future electricity system is predicted to have a greater proportion of variable supply than today. This is a reason to continue to reduce electricity consumption in the use phase and to monitor the carbon emissions of electricity production.

In the same scenario, the fuel mix for district heating production in 2045 is expected to include a slightly smaller proportion of fossil fuels, but to be almost similar to today. Total district heating production is expected to increase slightly over time[30]. At the same time, energy use for heating and hot water has decreased for all types of buildings in the past 20 years[31]. Overall, the total temperature-adjusted energy consumption per square meter in homes and premises has decreased by 14 per cent between 1995 and 2015[31]. During the same period, housing construction has increased significantly[32], which has to be taken into account in terms of total energy consumption, as newly constructed buildings are becoming increasingly energy efficient.

The Swedish Energy Agency (Energimyndigheten) has

FINAL ENERGY USE IN THE RESIDENTIAL AND RELATED SERVICES SECTOR. PER ENERGY CARRIER, FROM 1971, TWH

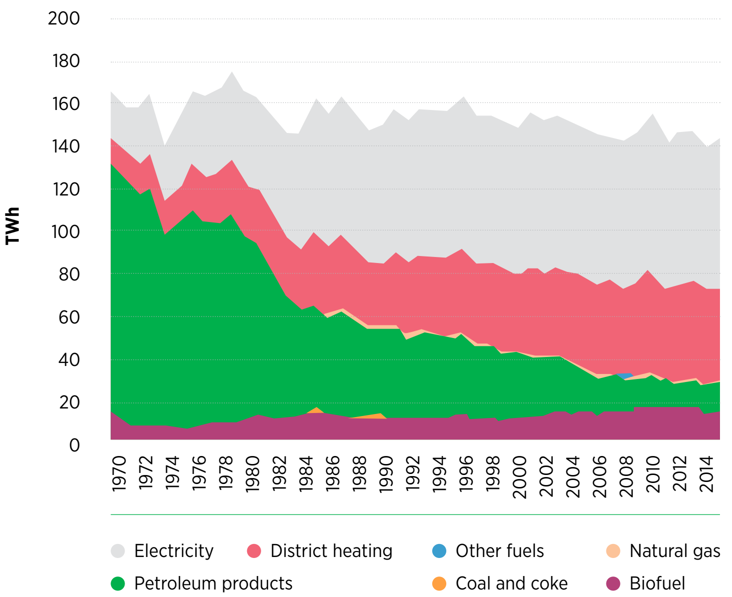


Figure 2: Energy use in the residential and service sector between 1971 and 2015. The sector includes households, public organisations (mainly buildings but also street and road lighting, sewage treatment plants, electricity and waterworks), other service activities, agriculture, forestry, fishing and construction. Households and buildings account for about 90 per cent of the sector´s total energy use.

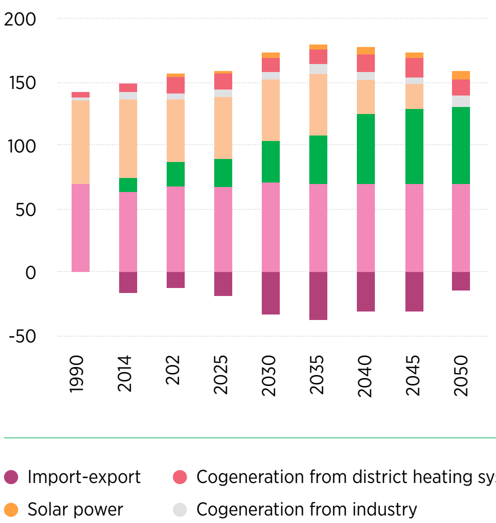
been commissioned to develop sectoral strategies for energy efficiency together with various industries, and in consultation with the relevant authorities. The commission is based on the proposal from a political committee, the Energy Commission, which states that Sweden shall have 50 per cent more efficient energy use in 2030 compared with 2005.

Different sources of energy have different capacities to match supply with demand. Renewable energy is produced when the sun shines and the wind blows, regardless of demand. This problem can be solved through a combination of demand management and energy storage. Demand can be managed through pricing and smart devices, buildings and infrastructure. Storage can take the form of central energy storage or decentralised in rechargeable vehicles and buildings. Buildings and vehicles therefore become an important part of the energy system, which presents an opportunity for business development[34].

In addition to electricity and heat, the use phase includes activities to maintain a building or infrastructure over time, such as renovation, maintenance, building replacement and reinvestment. The life cycle perspective also includes the carbon emissions of future activities, which involves scenario-based assumptions, because more factors than just technical life expectancy determine when something will be demolished, replaced or rebuilt. The emissions of the use phase over time are difficult to estimate, but are important to assess. The National Board of Housing, Building and Planning states that renovations and refurbishments represent more than 25 per cent of the total greenhouse gas emissions from construction and real estate[88]. The Swedish Transport Administration estimates the annual carbon emissions from road maintenance to amount to the same as the investment, if maintenance coatings are included[35]. For buildings, it has proved to be well justified from a climate perspective to build more energy efficiently than the building code. From a life cycle perspective, well-insulated buildings give a relatively small increase in carbon emissions for the increased material use compared with less well-insulated buildings during the use phase[36]. There is consequently great potential from a climate perspective when upgrading the existing housing stock.

In this context, it is important to see the built environment holistically of buildings, civil engineering projects, infrastructure, transport and energy producers. Community planning lays the foundation for how future construction will be, and how design in the planning stage, which contributes to effective construction, mobility and energy systems solutions, is of great importance to avoid sub-optimisations.

ELECTRICITY PRODUCTION (TWH)



Figur 3: Electricity production in TWh for 1990 and 2014 as well as future scenarios based on current measurements and conditions under the requirements for emission reporting to the European Commission.

3.2 RESOURCE USE – FROM VALUE CHAIN TO VALUE CYCLE

The construction and civil engineering sector has the potential to minimise waste and move towards circular flows through a more efficient use of resources, increased reuse and recycling of materials

The construction and civil engineering sector generates about a third of the waste that is produced annually in Sweden (excluding mining waste) and accounts for nearly a quarter of the hazardous waste[37]. Construction and demolition waste consists primarily of excavated materials, followed by mixed construction and demolition waste, dredged material, metal waste and wood waste. Around 9 per cent of the total amount of construction and demolition waste is classified as hazardous waste, mainly including contaminated soils, as well as mineral waste. Besides contaminated soil excavation material, a large proportion of the waste is clean and should be reused or recycled, but nevertheless still goes to landfill.[38]

The construction and civil engineering sector uses and generates large amounts of soil and rock masses. The use of material can usually be optimised on individual projects and partially within individual companies, but in many cases a systematic coordination between neighbouring projects to exchange excavated materials is inadequate. This is inefficient and generates extensive transport as well as and major economic and climate costs. To reduce carbon emissions from mass management as well as other materials and waste, transport should be minimised and fossil-free fuels maximised.[39] In order to enable cooperation and coordination between different players with mass management, local or regional land areas are required, which should be included in regional planning.[40]

Waste to landfill has declined sharply in Sweden over the past 20 years, while the recycling of materials, energy recovery and biological recycling has increased[41]. The development is in line with EU's waste hierarchy, which is enshrined in the Swedish Waste Directive and the Environmental Code. According to the waste hierarchy, waste should be prevented. The following steps in the hierarchy are reuse, recycling, energy recovery and final disposal. Using recycled materials generally reduces carbon emissions compared with using virgin materials. In order to obtain clean waste streams for material recycling and safe quality in the recycled material, it is important to sort the waste near the source. To increase recycling and reduce waste volumes, this should be integrated early on in the planning process.

In an analysis based on the prevailing policies, the National Institute of Economic Research (Konjunkturinstitutet) [42] indicates that a relative decoupling of waste generated and economic growth can be achieved by 2035.

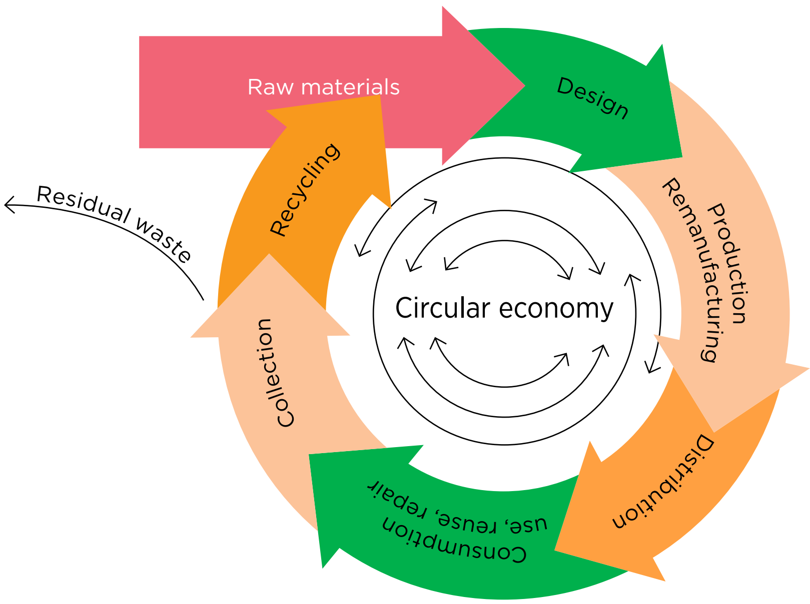


Figure 4: Conceptual diagram of the phases in the circular economy (EU, 2014)

This means that total waste volumes increase at a slower pace than economic growth, primarily because of relative higher growth in the transport and service-based industries than industries that generate large volumes of waste. However, in order to reduce total waste volumes, major changes and powerful instruments are required, such as transition from a linear to circular economy.

A circular economy can be described as »an economy where waste does not, in principle, arise, but resources can be retained in society´s use or sustainably recycled into nature´s own circular systems«[43]. Inspired by nature´s circular systems where no waste arises, circular economy is about transitioning from linear business models – where raw materials are processed, products are consumed and eventually become waste – to economic growth being decoupled from commodity extraction and waste generation through circular business models.

According to an EU report on circular economy from 2014, the concept can be illustrated as a conceptual diagram (figure 4). The main stages of the material flow provide opportunities to reduce costs and the need for natural resources, create growth and jobs, while decreasing the amount of waste and harmful emissions. These phases are interrelated as products and materials can be reused, re-manufactured and recycled. The goal of the circular economy is to minimise the amount of resources that leave the circular system to ensure it works optimally[45].

In a circular economy with circular material flows, there is potential for both cost savings and lower carbon emissions in the building and civil engineering sector[44].

3.3 DIGITALISATION

Digitalisation involves a major change in society that provides opportunities for new processes, services and markets as well as more efficient and sustainable construction.

Society is in the middle of what sometimes is referred to as the Fourth Industrial Revolution[46 47 48]. It already effects how we live, work and socialise and it indicates that the pace of change is rapidly increasing. Two of the main drivers behind the fourth industrial revolution are connectivity and broad-based digitalisation, with others related to automation and advances in biotechnology and materials science. To some extent, it is due to technological breakthroughs in recent years, though much of the technology has been around for a long time. In the past, however, it was too expensive or inaccessible.

Digitalisation provides opportunities to provide the right information, in the right place to the right people, which creates enormous opportunities for resource efficiency throughout the value chain. It creates both economic and climate competitive advantages.

Among other things, digitalisation includes the prerequisites for efficient sharing services and opportunities to analyse large amounts of complex information. It also entails new challenges in terms of personal integrity, employment and welfare. Digitalisation requires leadership that manages digitalisation as the major transformational process it entails. There are great challenges in getting individuals and organisations to adopt new ways of working and to feel comfortable with the development.

The construction and civil engineering sector needs knowledge and tools that allow the right construction with the right design, while optimising construction logistics and transport. Effective and appropriate digital information management has great potential to contribute to this. One of the prerequisites for efficiently calculating a construction project's environmental impact is to use existing information from the construction process[49]. Integrating environmental information into existing systems for planning and designing enables environmental-based decision-making support for design and materials selection. In this way, the information already available and used in the construction process can streamline the creation of digital climate calculations. However, quality-assured, representative, open, digital and life cycle environmental data is an important prerequisite for its broad implementation[50].

In order to yield the greatest benefit from the digital information gathered during design and construction, it is very important that this can also be efficiently transferred to the management stage. It is important, for example, that information on what built-in construction materials contain when dismantling or demolishing to facilitate reuse or recycling in the future.

Building Information Modelling (BIM) has been used in the construction sector for a few years and has become increasingly common as a way of working. For example, the Swedish Transport Administration is driving BIM by demanding digital information management[51].

3.4 INSTRUMENTS, CUSTOMER DEMANDS AND MARKET INITIATIVES

A combination of customer demands, market initiatives, and clear climate goals and long-term measures contribute to the construction and civil engineering sector.

A number of existing instruments aim to reduce greenhouse gas emissions. At a Swedish level there is a carbon dioxide tax related to fossil fuels. In Europe there is an emissions trading system that covers certain sectors, including the steel and cement industries. Businesses covered by the common European emission trading system do not need to pay national carbon tax. A report from the National Board of Housing, Building and Planning (Boverket) identifies a number of instruments that directly or indirectly affect climate emissions during a building´s life cycle. Existing measures apply primarily to taxes, but less about building regulation.[107]

3.4.1 CLIMATE ACT

In June 2017, the Swedish parliament passed a national climate policy framework. The framework contains new climate goals, a Climate Act and the establishment of a Climate Policy Council. The Climate Act confirms Sweden´s national climate goal, to have net-zero emissions of greenhouse gases by the year 2045, and subsequently achieving negative emissions. In total, emissions should be at least 85 per cent lower than 1990 levels. The remaining emissions will be compensated by additional measures, such as increased carbon dioxide absorption in forests and land or investments in climate projects in other countries. Sweden has also ruled that emissions of greenhouse gases from domestic transport should decrease by at least 70 per cent by 2030 compared with 2010. Domestic aviation is the exception as it is part of EU Emissions Trading System[52].

According to the Climate Act, the government is to prepare a climate report every four years and draw up an action plan for achieving its specified goals.

Despite the broad support for the Climate Act in Sweden´s parliament, there are clear political differences in how the Climate Act is to be implemented. One conflict concerns whether Sweden can include action in other countries or whether the emission reductions must take place in Sweden to qualify. There are also differences concerning if the climate measures are of the carrot or the stick nature, i.e. whether legislation, high taxation and other economic measures should dominate or whether the focus should be on voluntary stimulus, such

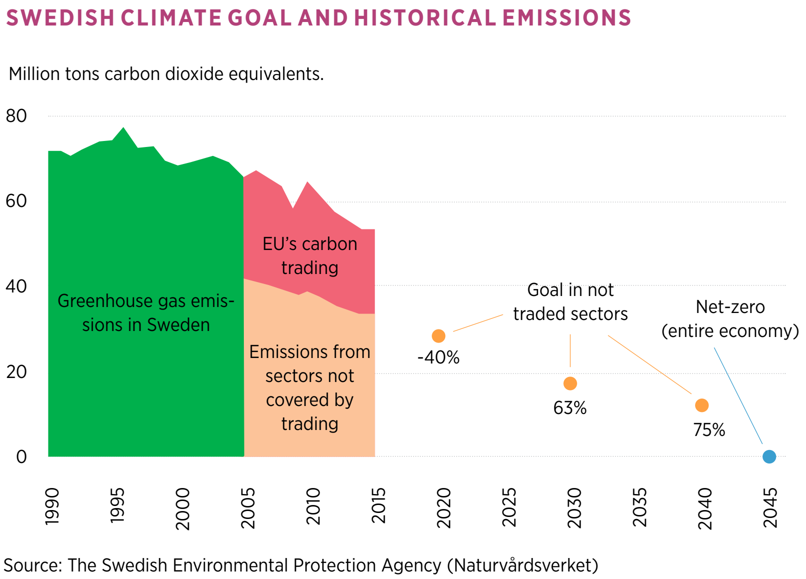


Figure 5: Swedish climate goal and historical emissions

as subsidies. There are also differences between political parties in how much consideration should be given to business objectives and needs.

Sweden is not the first country to introduce climate legislations. The UK´s Climate Change Act was the first in the EU and the world´s first legally binding Climate Act. The UK Climate Change Act means that all players, including the business community, get clarity and a long-term perspective on what it costs to conduct environmentally harmful activities in the future. The majority of the British business community supports the act. If the emissions goals are not met, the government must »compensate« by buying allowances on the international market. Britain has five-year budgets with binding emission levels in its Climate Act. The budget for the UK Climate Act is decided twelve years before the respective period begins to create stability.[53 54]

In UK, emission reductions have been stipulated in a legislative text, which is not the case in Sweden. Therefore, the law in Britain places greater demands on the government[55].

In connection with the introduction of the UK Climate Change Act, HM Treasury, among others presented the report Infrastructure Carbon Review, which had a broad foundation in the construction and civil engineering sector in the UK[105]. As a result of the report, the sector jointly developed a standard for Carbon Management in Infrastructure (PAS2080: 2016)[106]. This has in turn, been the basis for requirements and corporate certifications.

3.4.2 OTHER MEASURES AND ONGOING WORK

The Swedish government has commissioned the Swedish Environmental Protection Agency (Naturvårdsverket) to formulate a proposal for a long-term Swedish climate strategy. The strategy will be based on the climate policy framework established by the government and on the climate control measures that the government has decided or announced. The climate strategy sets the framework for sustainability work and for the overall activity.

In addition to the climate policy framework, the climate policy reforms of the last few years have focused on transport and fuel, and on support programs. In particular, it recognises the introduction of a bonus scheme, which makes it cheaper to buy an environmental-friendly car and more expensive to buy a petrol vehicle, as well as the so called reduction obligation, which forces an inclusion of biofuels into gasoline and diesel.[56]

The climate program Klimatklivet provides state investment support for climate-friendly measures at the local level, and Industriklivet (industry support) aims to support Swedish industry in this low-carbon transition.[57 58] To further drive development, there are a number of government-funded research programs, such as Mistra Carbon Exit. There are also strategic innovation programs[17], including BioInnovation, InfraSweden2030, RE:source, Smart Built Environment and Viable Cities, which in various ways aim to create conditions for collaboration[59]. Within the programs, companies, academia and organisations together develop the sustainable products, services and systems of the future. In the European Commission´s ranking of R&D intensity, the construction sector is only in 14th place, just before the oil and gas sector[60].

Municipalities and county councils may also seek state co-financing for public transport and bicycle infrastructure to promote sustainable urban environments, so-called urban environment agreements[61].

The National Board of Housing, Building and Planning is conducting several government assignments with the purpose of investigating what is needed to reduce the sector's climate impact. In 2018 four proposals have been submitted for new instruments: information on life cycle analyses for buildings, climate declaration for buildings, management of government´s efforts to reduce climate emissions from buildings, and criteria for public procurement[50 107]. The government appointed a new committee Modern Building Code Committee, with the purpose to analyze the need for regulation to reduce carbon emissions of construction sector[62].

As mentioned earlier, the Swedish Energy Agency (Energimyndigheten) has been assigned the task of developing strategies for energy efficiency. In January 2018, the agency made a first sub-report, which proposes that one of five sectoral strategies should have the title Resource Efficient Construction. During 2018, efforts will be made to develop sectoral strategies that will lead to reduced energy use in each sector[33].

There are ideas on how carbon emissions can be priced from a consumer perspective. Such a fee to the consumer would be the same for both domestic and imported goods[63].

3.4.3 PROCUREMENT AND CUSTOMER DEMANDS

As of January 1, 2017, new legislation applies to public procurement in Sweden (Act 2016: 1145). The new procurement act gives public organisations such as authorities, municipalities, county councils and public owned companies more opportunities, and in some cases the obligation, to set environmental procurement demands and requirements from a life cycle perspective[64]. Public procurement in Sweden annually amounts to SEK 642 billion[65] and is therefore a powerful tool for influencing societal development. According to the national procurement strategy, public procurement should be environmentally responsible and promote innovations and alternative solutions[66].

Requirements to reduce the impact of a building´s carbon emissions are being investigated and introduced by an increasing number of players. The Swedish Transport Administration demands carbon emissions are reduced from a life cycle perspective in investment and maintenance projects as well as in the railway project procurement, such as sleepers and rails. The requirements are designed to regulate the reduction of greenhouse gases to be achieved without interfering with how, in order to innovate. Bonuses are used to provide incentives for performance beyond the requirements. The goal is to reduce carbon emissions by 15 per cent by 2020 and 30 percent by 2025 compared with 2015. The vision is a carbon-neutral infrastructure by 2045. An analysis is being carried out to evaluate the requirements and in order to meet the requirements beyond 2030. The Swedish Transport Administration climate assessment[14] is also based on close dialogue with the industry[67]. In 2017, the Swedish Transport Administration, together with the major cities, developed climate requirements on materials with significant carbon emissions, such as cement, concrete and reinforcement steel as well as on fuel. The requirements are adapted for smaller projects that lack climate calculations and have been introduced successively since the beginning of 2018.

Award criteria based on a life cycle perspective have been tested by Stockholm municipality in the land competition for the Brofästet project in Northern Djurgården. Carbon emissions are evaluated along with other aspects such as energy and architectural value[68]. LCA-based requirements for low-carbon emissions of buildings have been introduced in various ways in Ger-

NUMBER OF CERTIFIED GREEN PROJECTS AND BUILDINGS IN SWEDEN (REGISTERED / IMPLEMENTED)

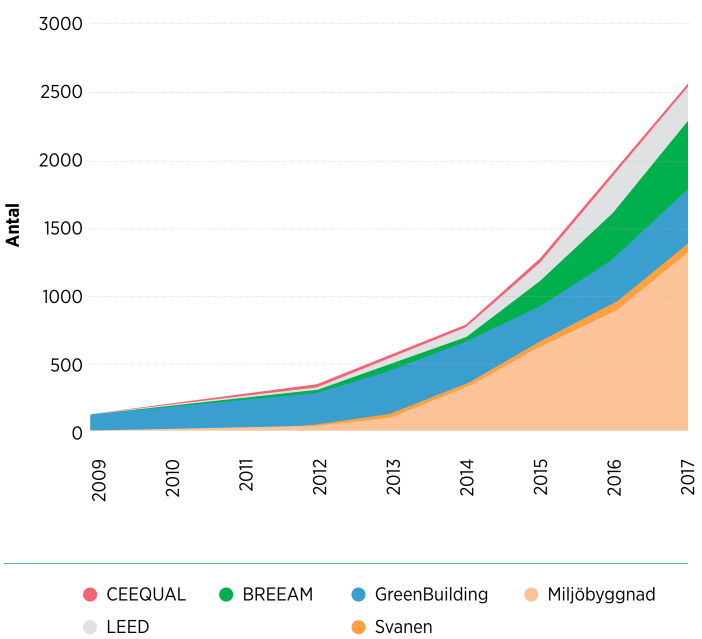


Figure 6: Number of registered or completed certifications of the green building certification systems CEEQUAL, LEED, BREEAM, Green Building, Svanen and Miljöbyggnad. BREEAM indicates the number of certifications, not the number of buildings. The number of buildings is lower. Svanen certification comprises of completed projects in Sweden (multi-family houses, single-family and pre-schools). Source: SGBC and the Svanen.

many, Norway, the Netherlands and several countries investigating the possibility of imposing requirements on building rules, such as the UK, Denmark and Austria[69]. The Riksbyggen company has used LCA, with the results providing the basis for active selection and requirements. Requirements were made for the procurement of prefabricated contractors and cast concrete in order to reduce carbon emissions. The requirements were directed to promote measures that the LCA showed to provide good greenhouse gas reductions, which involved regulating the proportion of clinker in cement, the proportion of cement in concrete and the choice of steel reinforcement with a high recovery rate[70 71].

Municipalities such as Östersund and Växjö have promoted builders who propose sustainable solutions through lower land prices. Municipalities such as Växjö and Skellefteå have adopted wood construction strategies to promote the local industry and increase the market for wood as a building material and reduce climate impact[72 73]. Regulations have been modified to allow high-rise wooden buildings, and wooden construction increased by 44 per cent in 2015. That corresponds to approximately 10 per cent of the market new apartments[74]. At the same time, statistics show that the total volume of concrete produced increased by 7 per cent in 2017 compared with 2016. The change shows increases in both categories of houses and infrastructure[75].

3.4.4 MARKET INITIATIVES

Some companies use internal carbon pricing, for various reasons: take into account the risk of stranded assets in investment decisions, reduce emissions in operations or compensate for emissions. Design and scope vary greatly between companies.

Green building certification systems are other market driven initiatives. Almost half of the country´s builders have a pronounced strategy to increase their sustainable and eco-labelled construction[76] and the number of certified buildings and infrastructure projects is growing rapidly (Figure 6). There are several different energy and green building certification systems (such as BREEAM LEED, CEEQUAL, Miljöbyggnad and Svanen) aiming to systematise the work of increasing, assessing and informing about a building or infrastructure´s energy or environmental performance. Climate and LCA-based requirements provide points in several of them. There are also initiatives for national certification systems for zero-emission buildings[77].

In order to support the market-driven development of low-carbon products and solutions, there are many joint development projects being conducted. Market players co-finance Smart Built Environment, which has the objective to reduce the climate impact from construction projects by 40 per cent by 2030[78]. Many players in the construction sector have also set their own climate goals as part of the organisation´s business strategy[79].

Players in the sector have also made recommendations for driving environmental improvement from a life cycle perspective in the procurement of construction works[80]. Recommendations give the opportunity for a comprehensive approach on how life cycle analysis (LCA) can be applied in a neutral and robust manner in procurement. That contributes to fair competition between all players in the construction and civil engineering sector.

3.5 SUSTAINABLE INVESTMENTS

Access to financial capital is of great importance in promoting investment in new technologies and companies that focus on sustainable solutions.

The National Board of Housing, Building and Planning estimates that 600,000 new homes are needed 2017-2025[81]. There is also a major renovation and maintenance requirement of both housing (approximately 800,000) and infrastructure. Renovations mean great opportunities to reduce energy needs and carbon emissions. New housing will involve developing accessibility in the transport system for both personal and goods travel. How energy and transport needs can be optimised must be part of the planning of new homes and workplaces[82]. For example, the building of housing, schools and infrastructure will require major investments – both public and private.

Access to financial capital is of great importance for promoting investments that involve low-carbon solutions. Sustainable investments means that investors analyse and take into account the three different dimensions of sustainability (economic, social and environmental sustainability) in portfolio selection and management [83]. A global trend shows a steep rise in sustainable investments. Between 2012 and 2014, durable assets expanded from USD 13.3 billion to USD 21.4 billion and 2014-2016 to USD 22.9 billion globally[83].

The European Fund for Strategic Investments (EFSI) has already resulted in investments of more than EUR 250 billion. By 2017, one third of the funding went to energy, environment, resource efficiency and social infrastructure. The EFSI is now being extended until 2020 and the investment objective is raised to EUR 500 billion, of which at least 40 per cent will go to investments that contribute to Paris agreement climate goals[84].

In the 2010s, climate change has been generally a driving force, together with regulation, to influence the investment market. During the One Planet conference in Paris, nine industrial players who issued green bonds worth USD 26 billion announced that they would double their green funding[85]. The number of green bonds is increasing, but today they account for less than one per cent of the global bond market[84]. In addition to political activity, that globally influences investment markets, private players and institutions influence the investment market locally through various movements. One example is investors divesting their shares in fossil-dependent companies, such as companies that profit from coal and oil. Through the Fossil Free movement, approximately 58,000 individuals and around 830 institutions announced their divestiture worth USD 6 billion in 2017. Among those institutions were the Church of Sweden, Chalmers University of Technology Foundation and the Norwegian Sovereign Wealth Fund[86].

In 2018, the EU recommendations for the regulation of sustainable investments from the High-Level Expert Group on Sustainable Finance [84], as well as the EU´s Action Plan on Financing Sustainable Growth were published[108]. The reports state that the EU needs to increase its investment by around EUR 180 billion a year, primarily in renovation projects and energy efficient buildings, renewable energy and transmission, and in low-carbon transport operations, to achieve the 2030 climate goals. Recommendations for frameworks are also available from, for example, TCFD (The Task Force on Climate-related Financial Disclosures), which began work after COP2185.

Within the Swedish Ministry of Finance, an investigation is being carried out into the opportunities to promote green bonds recently submitted to the government. The purpose of the investigation has been to promote the development of a sustainable financial market[87].

Good examples can be found in the construction and civil engineering sector. For example, the Vasakronan company issued the world´s first green corporate bond[88] and Skanska was the first construction company in the world to issue a green bond in collaboration with a green creditor[89]. Another example is Gothenburg municipality, which works with green bonds, or investment money earmarked for green projects, in Gothenburg[90].

3.6 DEMAND-DRIVEN INNOVATION

New technology, market preferences and business profitability can change rapidly. A common goal can drive innovation for the low-carbon transition.

Existing analytical tools tend to be based on historical developments. When it comes to system-level changes, these tools are often inadequate. Forecasts are based on knowledge of the present, and innovations can initially be perceived as inferior to proven technology. Innovations only reach their full potential when a certain technological maturity is reached by a solution, which becomes available to the masses and the market adapts to the new conditions. We do not know which innovations will change market conditions. What is important to remember is that the future is not predetermined. The outcome is influenced by the choices we make, so it is important to have a vision of what is desirable. This method of planning is called backcasting and is proactive as opposed to forecasting (forecasts) that is reactive.

Technological development is often portrayed as a solution to our global challenges[91]. At the same time, some are sceptical that technology and consumer behaviour will solve all challenges[92 93]. Technology has a huge potential to improve our living standards while providing positive environmental and climate benefits. However, the innovation cannot be ‘blind’; there must be a goal and direction[94].

No matter how beneficial or disadvantageous a technological revolution is from an environmental perspective, it influences market conditions. There are several modern-day examples of radically changed market conditions. In just a few years, the music industry has replaced its products with digital services. A similar development has taken place in the film industry, where video rental companies have lost almost their entire market due to digital services. Now analysts at Morgan Stanley believe that AirBnB´s threats to the hotel industry are becoming increasingly real[95]. AirBnB has expanded its business to offer experiences through its platform, which may alter the market for travel agencies and planners.

Companies may need to have a more transformational focus – markets can change quickly. However, there are no guarantees that they change for the better from an environmental perspective. Therefore, it is important that value-based companies take the lead role in a changing world. Consensus is necessary for new technology, innovation and system changes to contribute to the efforts to combat climate change.

4 Opportunities and challenges – a barrier analysis

There are many initiatives supporting sustainable development in the construction and civil engineering sector, but there are also many challenges that need to be addressed.

Working actively with sustainability issues today is often a prerequisite for recruiting young competent employees. Many players in the construction sector have climate goals as part of the company or organisation´s strategy, and some clients have begun to integrate climate prerequisites into procurement. Many goals are comprehensive and take into account the entire value chain. This is positive and suggests an insight into the extent of the climate issue, while the question of accountability among players can be unclear. Everyone has a responsibility but no one alone is responsible for everything, which places demands on finding new ways of working in the sector.

4.1 EVERYONE AND NO ONE

Politicians and authorities would like to see market players themselves take responsibility for climate actions. Market players want clear and long-term incentives to drive the low-carbon transition. Entrepreneurs and consultants want clients to demand construction with low carbon emissions. Customers want contractors and consultants to present solutions with low carbon emissions. Customers and contractors want suppliers to develop materials with low carbon emissions. Suppliers want buyers and contractors to demand low-carbon materials before investing in product development. This situation of going around in circles risks contributing to the status quo inhibiting the construction sector´s shift toward carbon-neutrality.

To overcome this issue, the construction and civil engineering sector needs a common goal going forward which must also be clearly linked to business. The climate policy framework provides the long-term goal. It can also contribute to the predictability required for long-term investments that companies need in order to transition their processes to reduce. In addition, players in the construction and civil engineering sector need to create goals that can become measures and set a division of responsibility for reduced greenhouse gas emissions. Analyses have shown that existing technological solutions can halve the carbon emissions from the construction industry compared to today. These technological solutions should be considered as low-hanging fruits, yet their application is limited.

Reducing greenhouse gas emissions cannot be treated as a special interest or as a partial solution that is dealt with by a few people in the organisation. There must be a holistic perspective. That means plans and actions are integrated and permeated both in individual contracts and in entire organisations, both by the private and public sectors. The courage and foresight of players and politicians who are prepared to lead the way is essential, but in order to speed up the carbon transition, a clear link to business is needed to bring about the incentive for change.

4.2 BUSINESS MODELS AND PROCUREMENT

Business models are unique for a product or service and influences business between supplier and customer. The market price is based on what the customer thinks the product or service is worth, while providing cost coverage for the supplier. Greenhouse gas emissions and the societal costs resulting from the greenhouse effect and a changing climate have traditionally not been evaluated by the market. Still, it costs to develop and manufacture methods and products with low-carbon emissions. The result is that new low-carbon products are difficult to be profitable. Market prices have not been able to fully reflect the societal cost of production and consumption, which has caused a market failure

One possible way to evaluate reduced climate impact is to quantify emissions and to price them. In procurement situations, clients can then show how much they value low-carbon solutions. The Swedish Transport Administration (Trafikverket) has introduced a model, which involves providing a requirement for a percentage reduction of carbon emissions in the project, with an economic incentive in the form of bonuses if the decrease exceeds the requirements. It creates conditions for integrating and highlighting low-carbon solutions with other governing project parameters.

However, in procurement situations, the lowest price is often decisive. It risks not capitalising on the value that the construction sector has potential to contribute with in addition to cost-effectiveness. Unless otherwise required, a high level of competence is required from the customer to capture values such as low greenhouse gas emissions in specification requirements. Generally, there is a knowledge gap, which prevents demand for reduced greenhouse gas emissions. Demands made on products and construction projects today are often too cautious. Even though they often do not lead to reduced climate impact, they enable some knowledge building about the source and amount of emissions, which in itself is also important. However, to achieve noticeable emission reductions, life cycle-based functional requirements for reduced greenhouse gas emissions need to be incorporated into procurement and taken into account throughout the planning process, including thorough environmental impact assessments. It is also of great importance that the outcome of the requirements at one stage is carried forward to the next - from planning, design and construction and then onto the use of the built environment. The National Agency for Public Procurement has an important role to play in supporting and pursuing the development of criteria and skills for life cycle-based requirements that reduce greenhouse gas emissions.

Due to its large volume, public procurement has great potential to contribute to the low-carbon transition in the construction and civil engineering sector, as well as sustainability requirements from municipalities in land allocation. Criteria that prioritise low climate impact in land allocation, for example through lower land prices, can be a way for municipalities to push for the development of carbon-neutral buildings and infrastructure. Politicians govern public procurement. This is why politicians must provide clear instructions to public organisations and public-owned companies to reduce greenhouse gas emissions. In addition to the competence development of the procuring organisation, awareness raising is needed both politically and in management so that they can capitalise on the opportunities in the Swedish Public Procurement Act

At the same time, a follow-up of compliance with relevant requirements must be carried out, potentially together with an incentive model for future procurement to benefit those who comply with the requirements. Furthermore, procurement tends to focus on individual projects meaning that contracted players have high ambitions and perform well on specific projects, but in the long-term, they return to a lower level of ambition on subsequent projects. In order for companies to develop successfully and provide sustainable impact, procurement opportunities should be developed together with platforms for easy sharing of good examples among players in the sector.

For small and medium-sized enterprises, low-carbon transition is both a challenge and an opportunity. A number of small companies will quickly be able to adapt and will consequently benefit. For many other companies it is important that sustainable solutions are standardised as quickly as possible. They often cannot afford to use new and untested technology. It may take longer for these companies to compete on projects that impose high sustainability requirements that are not clearly specified.

The construction sector is characterised by different types of contract that provide completely different conditions for the various players to influence. From idea to design, execution and management, the process can vary significantly between different construction projects. The client (developer, project developer, property owner) has overall responsibility. A construction company hired as a general contractor is able to influence throughout the construction phase, and together with the customer, should ensure that all sustainability requirements can be met within the budget.

Subcontractors and material suppliers can only influence certain stages of a project. Increased cooperation between different players in the value chain is desirable because many business relations are considered short-term. Collaborative procurement and partnering contracts can lead to more sustainable solutions, as other players can work together to pursue common emission reduction goals while at the same time can exploit the skills of different players. Enhanced knowledge exchange with players in other countries can contribute to good examples and solutions that can accelerate the carbon transition in the Swedish construction and civil engineering sector.

4.3 INNOVATIONS, PROCESSES AND NEW MATERIALS

The construction sector is characterised by fragmentation, with many different players in long and complex value chains. It makes it difficult for an individual player to have a comprehensive research and development strategy (R&D). Implementing results and knowledge from different investments can often be a challenge. This may be why the construction and civil engineering sector has relatively low level of R&D investment. Another reason may be the extensive regulation in the construction and civil engineering sector. Regulation is important from a quality perspective, and the introduction of new solutions must not be at the expense of functional criteria, such as indoor climate in buildings. The risk of departing from conventional and well-proven solutions can lead to a conservation of current solutions and production methods while minimising innovation.

In order to manage the required low-carbon transition, the sector and individual players need to review their processes and ways of driving and implementing necessary changes. The sector is characterised by a project structure, which complicates the exchange of experiences and long-term perspectives[107]. This means that pilot projects can do good progress, but they can take time to scale up and share generated knowledge. It takes time for low-carbon solutions and ways of working to become established in both organisational cultures and structures.

There is a lack of knowledge and experience for optimising both existing and new materials in combination with new production techniques. The use of new materials needs to be tested together with new production methods, such as in non-critical construction works or in extended and scaled laboratory tests. The schedule is often critical for profitability and when introducing new materials or combinations of materials, predictability is necessary for possible effects on production. The testing and development of new materials or combinations of materials must therefore take place in conjunction with the development of production technology as well as external circumstances such as weather conditions. Furthermore, there is a need to pioneer circular material flows with net-zero waste production as well as standardised and modular construction that enables more functions over time. This requires design for reuse so that the materials can contribute to functionality in several technical life cycles before returning to natural systems without environmental impact. Examples are bio-based and non-virgin materials and hybrid solutions, or products from a transformed base industry.

Risks in the construction sector are often handled cautiously and excessive risk calculating is a common phenomenon. Increased cooperation should also involve a holistic approach on product development, with risk sharing in the application of less proven technology. The opportunity to share these risks needs to be reviewed with various possibilities for financing potential risk projects, as well as finding ways that the risk assessment does not exclude new players and innovations. A significant gap has been identified between what the estimated technological potential for energy efficiency is and what is actually realised. One explanation to the gap is that the effort to acquire a new product or material, or the potential early adaption risk is not considered.[101 102]

To achieve near carbon-neutrality from the steel and cement industries, technological shifts, such as CCS (Carbon Capture and Storage), technology where carbon dioxide is separated and stored instead of being released into the atmosphere, as well as technology for replacing coal with hydrogen in steel production. Long-term funding and risk sharing needs to be developed to implement such technological shifts. One such solution in the area of research is a 'transformation fund[103], for interdisciplinary cooperation and as a concrete tool for bringing about transition in industry.

There are several ways to support innovations, but it is significantly more difficult to obtain support with transforming pilot projects into commercially viable solutions. Innovations and pilot projects have been carried out for a long time, but few of the pilot projects have been implemented on a larger scale, despite good results. There must be long-term development, both environmentally, economically and legally.

4.4 FRAMEWORK AND LEGISLATION

Today there is no legal requirement to declare and regulate the life cycle carbon emissions of buildings and infrastructure. The market incentives for limiting greenhouse gas emissions from a life cycle perspective have so far been limited, for example, to the Swedish Transport Agency's reduction requirements in procurement as well as scoring criteria in green building certification systems, which are often voluntary. In order to raise awareness about how different players in the building and construction industry´s value chain can reduce greenhouse gas emissions, as well as lay the foundation for market-driven emission reduction initiatives, there is a need to introduce legislation on the climate impact of buildings and infrastructure. For example, legal requirements for material and climate declarations in the planning and construction process can be formulated, and if necessary, requirements for emission limits from a life cycle perspective may be gradually tightened.

Waste legislation prevents the development of circular models and limits recycling in the construction and civil engineering sector. Today, for example, large amounts of soil and excavation materials are sent to landfill, instead of being recycled locally. This results in potentially increased emissions of greenhouse gases from transport and increased handling costs. In order to minimise the transportation of soil and excavation material to landfill, as well as reduce the extraction and use of virgin material, a review of waste legislation and its application is needed. When allowing recycling, the environmental impact from the final use of the excavation materials, for instance road transport, should also be considered. Further guidance and cooperation between authorities and players may be needed to increase the recycling of excavation materials at a regional level. Procurement requirements also need to be harmonised with standards and the requirements for sorting, as well as the maximum proportion of waste to landfill, must be stricter. For example, the Swedish Transport Administration has removed previous restrictions on the permissible amount of waste in asphalt production, as well as requirements for specific types of adhesives in concrete plants, and replaced these with functional requirements.

Today, economic models and legislation allowing energy sharing between users and properties are lacking. Property owners are to a limited extent energy producers. In the future, most property owners will also be energy producers, and even construction sites will be used to a greater degree for energy production. This means that new economic models and ownership agreements need to be developed. One challenge is to handle the EU´s free trade agreement, which entails that the customer has the right to change energy supplier. There is also a need for incentives for the construction of flexible spaces and co-usage. It includes the introduction of flexible parking spaces and parking on public spaces not to prevent certain types of sharing services. Similarly, transport planning needs to be developed so that infrastructure measures that are planned and implemented suit a future in which climate goals will be achieved.

Financial sector investments are often influenced by traditional investment calculations and a short-term focus. In order to address the climate issue, legislation can clarify that the financial management sector should report how sustainability issues are taken into account in the investment process based on the customer's interests. Well-accepted and established classification systems and standards would promote the investor´s ability to compare investment options, follow up, report, identify and allocate capital to green assets on a large scale and at lower transaction costs. Requirements for forward-looking accounting to assess sustainability risks and financial consequences because of climate scenarios are also recommended. Investments deemed to be at lower risk may have lower capital adequacy requirements. Such incentives for sustainable/green bonds and other financing solutions can stimulate investments that contribute to innovation and decreased carbon emissions. Good economic return combined with incentives for climate change is the objective.

4.5 COMPETENCE AND LEADERSHIP

The construction and civil engineering sector players need to enhance their basic knowledge of what can be done and at what stage to reduce life cycle carbon emissions. Contracting entities must raise awareness of how buildings and infrastructure with low carbon emissions can be achieved. Planners and contractors need to increase their knowledge about how carbon emissions in construction or civil engineering projects can be mapped to propose measures with lower carbon emissions. Similarly, tools and working methods need to be developed and provided.

However, it is not enough just to strengthen skills in some positions and instances. Brave leaders and clear leadership are required to succeed in the climate transformation. The Swedish government has the ambition for Sweden to be a pioneer for reducing climate emissions. Through the initiative Fossil Free Sweden, we want to highlight players that help solve the climate issue, both in Sweden and internationally, and with roadmaps developed by several industries to demonstrate business leadership.

The journey toward carbon-neutrality will require leaders who have the ability to see and act beyond annual financial results and mandate periods. Leaders who can unite contradictory interests and see climate change as part of the economic system. Leadership that can convey hope for a better future, and with courage and stamina, stick to high-level climate goals that do not always mean the greatest short-term profit, but the greatest long-term value. There is a need to create incentives that pay attention to and reward those who contribute to reaching Sweden´s climate goals while strengthening Swedish competitiveness. Clear leadership among decision makers is a key factor, as well as individual leadership that we all need to exercise.

Challenges facing the construction industry are complex. Collaborative forms and partnerships where several players cooperate and develop each other's competences are desirable. Small and medium-sized enterprises often have the challenge of not having designated resources that can take full responsibility for the areas of energy, climate and the environment. In small companies, an employee typically carries responsibilities for several areas. However, when cooperating with third-party specialists, such as consultants, results can often be very successful. It is therefore important for small and medium-sized enterprises to have good cooperation with value chain players. Close dialogue is necessary to obtain information and knowledge of sustainable technology solutions.

Common tools include an open national database with generic climate data that is life cycle-based, quality assured and representative of the construction and civil engineering sector. These will be available to the public and in digital format, and instrumental in raising relevant skills for all stakeholders in the value chain, and will accelerate climate change work. This also applies to digital environmental information systems. Such a database may also provide incentives for suppliers to provide quality-assured environmental product declarations, known as EPDs, to demonstrate that their products have a lower climate impact than the equivalent product category in the environmental database.

It also requires significantly better expertise on how regulation on public procurement and procurement in the supply sectors can be used to drive development. In order to support the market-driven development of low-carbon products and solutions, procurement situations need to benefit those companies that drive this development. For example, by choosing suppliers that can demonstrate having the best climate solution in their product group with the help of environmental product declarations.

Higher education institutions also need to be influenced so that education programs include more practical sustainability cases. This will enable students to engage more with sustainability and deepen its collaboration with other areas of studies. Likewise, end-user/consumer knowledge needs to be increased. For example within housing societies in order to drive and encourage such measures as solar panels, car pools and local storm water management.

5 Competitiveness

Sustainability is widely considered a prerequisite to being competitive in the market today and for a long-term survival. Working with low-carbon transition is proven to give companies a stronger brand, increased customer loyalty and cost savings, as well as improved talent attraction and employees' productivity. Working to prevent climate change also leads to new products and areas of business provides proactive risk management and better financing opportunities. This in turn improves the company's bottom line[104].

There are huge socio-economic gains with sustainable social development when it helps reduce costs and create more value. One challenge is that such value can be difficult to quantify, especially for companies and for a project. An example of this is how EU's emissions trading system has worked and how the price or cost per ton of carbon dioxide is valued in certain markets. Investments and costs in one link of the value chain affect values, costs, sustainability and climate aspects in other links over a long period. Many believe that the low-carbon transition of society will entail both profitable efficiency and costly investments, but that the costs can be economically viable for both companies and society in the long-term.

The low-carbon transition requires a long-term commitment of a variety of players to succeed in a fiercely competitive market. Work on carbon-neutrality will require cooperation, resource efficiency, innovations and new ways of doing business. More and more customers are likely to impose climate requirements on procurement demands in order to live up to climate goals and to reduce costs. Customer requirements bring about change in the entire value chain - from architects and contractors to material suppliers.

For companies to compete in the market it is crucial to keep up with trends and new market conditions, and to ensure that they have the resources and expertise necessary to meet new procurement and project requirements. Changes require a long adaptation time and many resources for transition, although low-carbon solutions can ultimately lead to lower costs through resource efficiency and higher revenues by way of increased value creation and through new markets.

It is essential that all companies have the ability to compete. One or two lost assignments in a short period may pose a bankruptcy or employee redundancy risk. Large companies may be somewhat more resistant to changes in the market. However, for small businesses there is a risk that excessive climate requirements may endanger them in the short-term. Larger companies can be expected to contribute more with new solutions and working methods. At the same time, the need for new climate solutions provides business opportunities for small, innovative fast-paced companies.

A clear long-term view of how market requirements will develop is therefore central to how competitiveness can be developed and secured. It needs to be profitable to offer climate solutions and invest in innovations. However, there is a danger that customers primarily opt for low prices and thus risk ignoring climate impacts. There is also a risk that climate requirements will be implemented but not followed up on, which would detrimental to a healthy competition. In the long-term, new climate-based solutions can not only create jobs but also ensure that we retain existing jobs. Additionally there is potential for increased exports, especially for material suppliers, but also for increased growth of companies in the construction and civil engineering sector value chain.

High construction costs in Sweden have been debated over the years. Working unilaterally to reduce construction costs without taking into account the goals to decline carbon emissions across the entire value chain can lead to a conflict of interest. Climate requirements need to apply regardless of where and when emissions arise in the value chain. If climate requirements are imposed on production in Sweden, without being imposed on imported materials and services, that will hurt Sweden's business competitiveness. The low-carbon transition and changes that will be required to achieve climate goals will also trigger other changes, such as increased efficiency and productivity. The construction and civil engineering sector should therefore use the transition as a motor, even in terms of productivity. Therefore, the entire value chain must be involved in the transition and that set requirements are followed up on. Then we can strengthen the competitiveness of the Swedish business community at the same time as we act as a model in the carbon transition.

In order to cope with the low-carbon transition, it must be profitable for market players to reduce climate emissions. It is highly likely that less dependence on carbon-intensive materials and processes will pay off economically and reduce risks in the long-term. Actions perceived as costly today can prove to be economically profitable in the long-term, such as lower costs through resource efficiency and increased revenue through new markets.

6 The journey to carbon-neutrality 2045

The construction sector value chain must achieve carbon-neutrality while retaining or strengthening competitiveness. The journey involves changes in a number of areas and is likely to affect all players in some way. It is not just about technical solutions and innovations, but equally about collaboration and changing market conditions to pave the way for climate change. The below illustration is a commitment to concretise our common journey to carbon-neutrality from 2018 to 2045. Based on three themes, action areas that are considered important for achieving the climate goals are proposed. All players need to do their analysis and action plan for how they can help achieve carbon-neutrality together.

2018 — 2030 — 2045

MARKET AND BUSINESS

- Low life cycle carbon emissions is required in function-based procurement. Incentives for lower carbon emissions are introduced in procurement. →
- Transition from linear to circular models in the value chain →
- Digital public climate declarations are conducted for all construction products on the market →
- Life cycle carbon emissions is declared for all buildings and infrastructure →
- Buildings and infrastructure projects contribute with added value: ecosystem services, energy and material supply, distribution of goods and services →
- The financial sector integrates climate into investment decisions →
- Carbon emissions are made visible and reflected in transactions in the value chain, from raw materials supplier to consumer →
- All players in the sector have implemented strategies to achieve net-zero carbon emissions →
- All players in the sector have mapped emissions and set climate goals →

CONSTRUCTION PHASE

- Gradually increased addition of cement replacement products in cement, minimised amount of cement in concrete →
- Cement production toward carbon-neutrality/CCS technology →
- Steel production develops toward net-zero carbon emissions →
- Optimised concrete with respect to the amount and type of cement, as well as by replacing cement clinkers with alternative binders →
- Gradually increased proportion of reused, recycled, renewable (e.g. wood-based), resource-efficient materials and materials with net-zero emissions →
- Optimised use of all materials and energy, such as concrete, wood, steel, fuels and energy →
- Gradually reduced transport through logistics management and shared transport solutions →
- Gradually increased proportion of renewable energy in material production facilities → 100 % renewable energy in material production facilities →
- Gradual increase of electric and gas-driven vehicles, and access to fossil-free and sustainable fuels → Net-zero carbon emissions from vehicles and machines →
- Life cycle-based decisions with regard to carbon emissions for the construction phase and use phase →
- Materials are increasingly recycled and reused in circular flows, until waste as a term is no longer used →
- Digital and unbroken information flows for life cycle-based environmental data are implemented →

USE PHASE

- Increased shared transports, i.e. utilisation of self-driving cars and shared services →
- Renovation and refurbishments increase relative to new construction, although new construction continues →
- Near zero emissions from district heating production →
- Efficient utilisation of existing buildings and infrastructure, platform economy and built-in flexibility →
- Infrastructure for the next generation transport fuel →
- 100 % near zero energy new buildings → 100 % energy positive new buildings →
- 100 % renewable electricity →
- Carbon-neutral buildings and infrastructure → Climate-positive buildings and infrastructure →
- Strategic collaboration for smarter construction work (control technology, installations) →

7 Terminology

BASIC INDUSTRY The major industrial sectors that are important for Sweden´s exports and economy – including forestry, mining, chemistry and steel.

BIODIVERSITY The wide variety of species that are important for robust and viable ecosystems. One of the planetary boundaries that is important for our long-term survival.

CIRCULAR BUSINESS MODELS Business models based on the minimal use and waste of materials. Instead, products and materials are reused and recycled.

ECOSYSTEM SERVICES The functions that ecosystems freely provide and are important to people´s survival and wellbeing. For example, natural pollination, air and water purification, material and food supply.

FOSSIL-FREE Free from fossil fuel/raw materials.

FUNCTION-BASED PROCUREMENT REQUIREMENTS (functional requirements) Procurement where the function is specified for a well-defined product or service.

CARBON-NEUTRAL Net-zero emissions of greenhouse gases into the atmosphere. It involves any emissions that can be absorbed into the ecological cycle or with technical solutions, in order not to contribute to climate change. The strategy is primarily to reduce actual emissions, but carbon offsetting measures can be used to achieve carbon-neutrality.

CLIMATE POSITIVE Carbon dioxide uptake and capture exceeds emissions. Same as negative emissions.

CARBON DIOXIDE EQUIVALENTS Unites of measurement of carbon footprint that includes all greenhouse gases.

LIFE CYCLE ANALYSIS A method of calculating environmental impact from raw material extraction to end of product's life.

LIFE CYCLE COSTS Costs for a product or service over its entire life cycle.

NEGATIVE EMISSIONS Carbon dioxide uptake and capture exceeds emissions. Same as climate positive.

NEW/ALTERNATIVE BUILDING MATERIALS/METHODS Building materials and methods that do not yet occur or are not standard practice in the Swedish market.

PREQUALIFICATION REQUIREMENTS Requirements to participate in a procurement, i.e. regarding safety or quality.

PARTNERING CONTRACT Involvement, transparency and cooperation with several parties based on common project objectives.

VALUE CHAIN IN THE CONSTRUCTION AND CIVIL ENGINEERING SECTOR Players in the construction and civil engineering sector value chain are primarily construction contractors, machinery and transport suppliers, material suppliers, service providers, property owners, private and public customers, architects, consultants, industry and non-profit organisations, authorities, municipalities as well as research institutes and colleges that provide skilled labour. The value chain consists of players that interact with each other, and influence and control the development of buildings, projects and infrastructure.

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