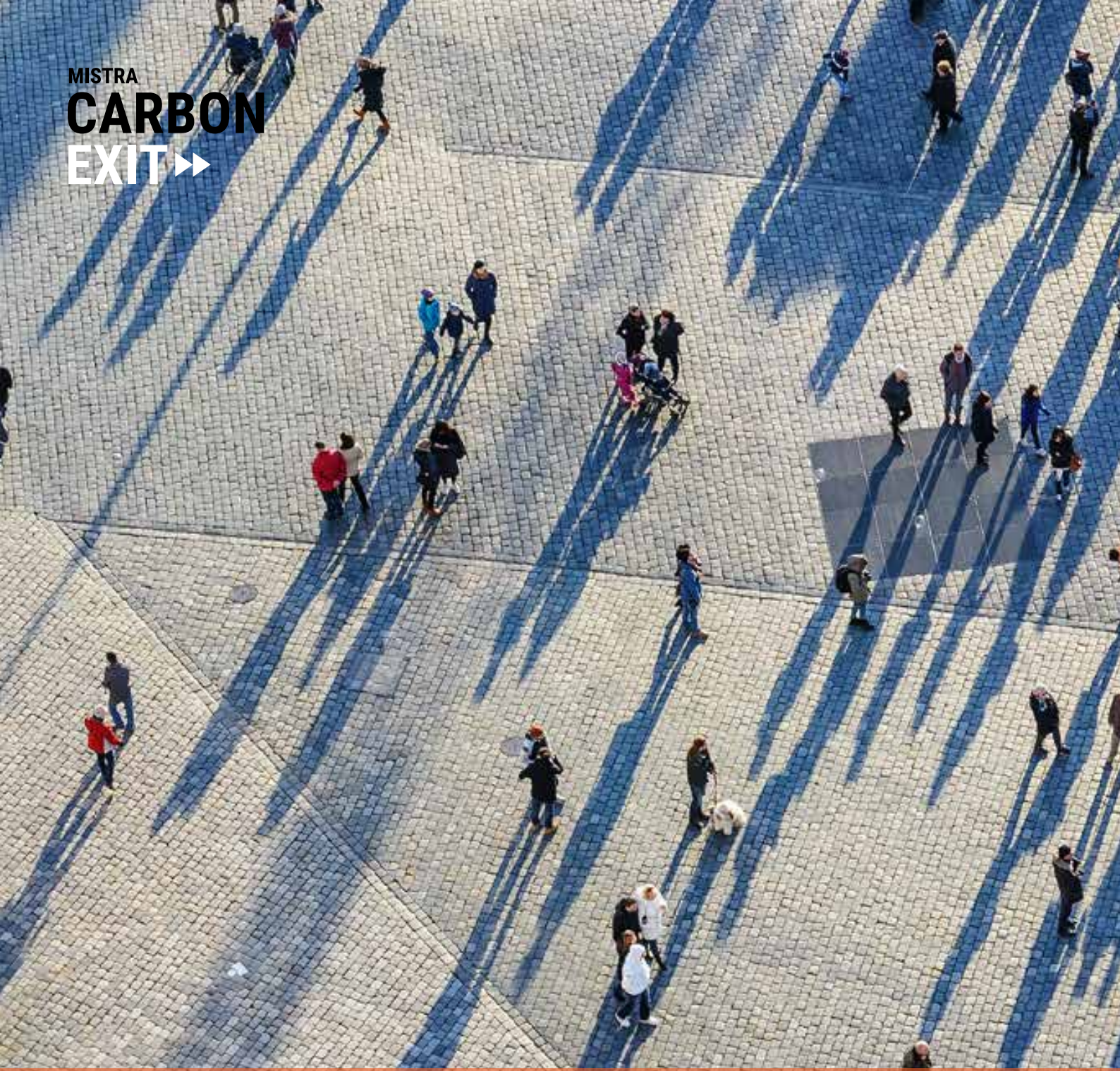
MISTRA
CARBON
EXIT



2017 ANNUAL REPORT
MISTRA CARBON EXIT

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The Swedish Foundation for Strategic Environmental Research

Contents

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Business Strategies for Sustainable Development

PETER NYGÅRDS, CHAIRMAN OF THE BOARD, MISTRA CARBON EXIT

Sweden has set very ambitious, yet necessary, climate targets. By 2045 Sweden's net greenhouse gas emissions should be zero. Mistra Carbon Exit will provide guidance for policy makers how this transformation can be done, including what policies are needed in order to reduce emissions from key actors significantly.

It is a major challenge for the Swedish business and research community to identify strategies that makes it possible to reach this target. It is an equally challenging task for politicians to implement incentives and restrictions and at the same time helps the business community to develop climate friendly products and services that create market opportunities for Swedish industry while serving as a good example for the world community.

How can we help our industry in finding successful business models that allow for profitability and good competitiveness under such ambitious climate objectives? How do we build on the technical know-how we already possess and develop it further?

Mistra Carbon Exit is in an excellent position to provide strategies for this transition, with a unique combination of outstanding research organizations and a large number of successful companies. If we can find the right forms of cooperation between these players Mistra Carbon Exit will generate valuable and much needed results. By focusing on entire supply chains, the project's analyzes will be business-wide, thus providing new aggregated knowledge on how to turn buildings, transport and transport infrastructure carbon neutral.

Peter Nygårds

Introduction

This is the first annual report from Mistra Carbon Exit. The year of 2017 has been a great startup year for the program, setting the framework and establishing our work.

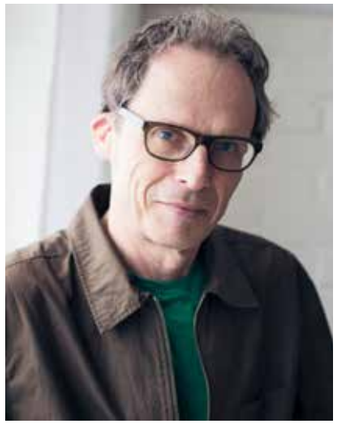
This research programme was formulated in response to Mistras research call "Transformative changes in society to achieve challenging climate goals". The call asked for projects with a focus on the technical and business prospects and potential for Sweden to move closer to zero emissions of greenhouse gases and, second, on how society and its institutions can and should handle the transition. It was further stated that the programme should have a systems perspective and a cross-sectoral approach but, at the same time, explore in depth one or more sectors of society where the challenges are particularly large, such as transport, steel, or building and construction.

We are very pleased with 2017, the first year of the programme and particularly impressed with the great engagement that our researchers, industrial representatives and other partners have shown, and for sharing their extensive experiences. The case studies on buildings, transport infrastructure and transports have had their first workshops and attracted large audiences from both companies and academic centers. We also have a new publication out – "Nine messages from Mistra Carbon Exit" that presents a selection of messages to our stakeholders. We are also proud to highlight the recruitment of five new PhD students.

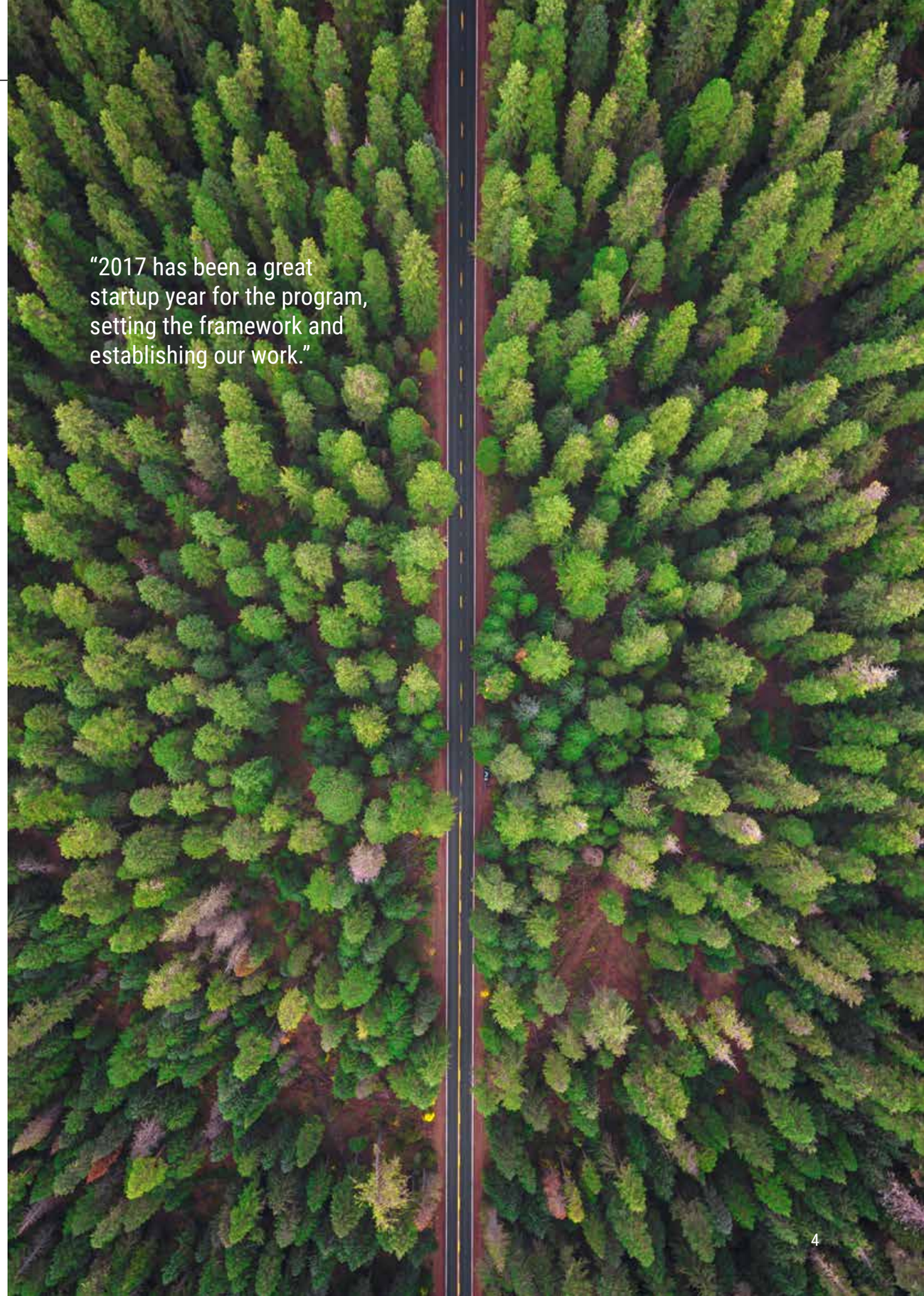
With this report we hope to give you an insight in the program through the eyes of some of the participants.

Lars Zetterberg and Filip Johnsson,
Program Director and Vice Program Director,
Mistra Carbon Exit

Lars Zetterberg



Filip Johnsson



About Mistra Carbon Exit

Mistra Carbon Exit addresses the technical, economic, policy- and market related opportunities for different scenarios and assumptions which meet emission reduction targets up to the year 2045, with focus on three supply chains: buildings, transportation infrastructure and transportation. The programme will analyze and identify pathways and policies for how Sweden and Swedish companies can become frontrunners in transforming society and industries, providing low carbon products and services while at the same time addressing market risks.

The work is divided into four case studies (energy carriers, buildings and transportation infrastructure, transportation and local arenas), five academic work packages and a communication package. The academic work packages investigate and define transformative pathways, technology assessments along supply chains, changing market institutions and behaviours towards Swedish leadership, policies and governance, and integration and sustainability implications.

By focusing on supply chains, rather than on individual economic sectors, we seek to identify key challenges and mitigation opportunities from primary production of materials to final end-uses. A strong involvement from a wide range of actors will make it possible to identify and address the many perspectives on how to improve overall performance, while reducing climate impact associated with the respective supply chains in an effective way.

The Mistra Carbon Exit consortium includes a broad representation of researchers and actors: four universities: Chalmers, University of Gothenburg, Linköping University and the Royal Institute of Technology (KTH), three research institutes: IVL Swedish Environmental Research Institute, Resources for the Future (RFF) and The German Institute for Economic Research (DIW), The Centre for European Policy Studies (CEPS) and some 20 non-academic centres.

“By focusing on supply chains, rather than on individual economic sectors, we seek to identify key challenges and mitigation opportunities from primary production of materials to final end-uses.”

Mistra Carbon Exit on one page

PATHWAYS TO NET ZERO GREENHOUSE GAS EMISSIONS IN SUPPLY CHAINS

The Mistra Carbon Exit research programme is identifying and analyzing the technical, economic and political opportunities and challenges for Sweden to reach the target of net zero greenhouse gas emissions by 2045. The programme is designed to generate new knowledge and develop strategies that will enable Swedish society and Swedish companies to become front runners in offering low- or zero-carbon products and services.

FACTS

Programme period: 2017-2021

Budget: SEK 81.9 million SEK

Funding: Mistra is investing SEK 56 million of the total programme funding, with the remainder coming from partner organisations.

Main contractor: IVL Swedish Environmental Research Institute

Programme director: Lars Zetterberg, IVL

Chairman of the Programme board: Peter Nygårds

Website: www.mistracarbonexit.com

CASE STUDIES AND WORK PACKAGES

The programme consists of four case studies, focusing on buildings, transport, transport infrastructure, energy carriers and local arenas. In addition, there are five academic work packages that will analyse issues relevant to the case studies. These work packages adress transformative pathways, technology assessment along supply chains, business models and consumption patterns, policies and governance, and integration and sustainability.

PARTICIPANTS

Academic Partners
IVL Swedish Environmental Research Institute
Chalmers University of Technology
University of Gothenburg
Linköping University
KTH Royal Institute of Technology
Resources for the Future (RFF)
The German Institute for Economic Research (DIW Berlin)
Centre for European Policy Studies (CEPS)

Non-academic Partners
Volvo Cars
Volvo CE
JM
NCC
Skanska
Cementa
Peab
Voestalpine
Outokumpu
Stena Metall
Fortum
Göteborg Energi
Energiforsk
Danske bank
Trafikverket
Naturvårdsverket
A-betong
Thomas Betong
Västra Götalandsregionen
Uppsala klimatprotokoll
Hagainitiativet
FORES
Sacramento Metropoletan Air Quality Management

Organization of the programme

MANAGEMENT GROUP

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Mathias Gutsavsson, IVL Swedish Environmental Research Institute

Magnus Hennlock, IVL Swedish Environmental Research Institute

Anders Ahlbäck, University of Gothenburg

Björn-Ola Linnér, University of Linköping

PROGRAMME BOARD

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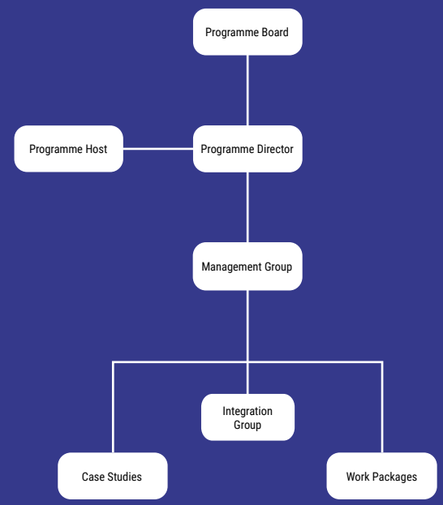


Case studies is a valuable platform for exchanging experiences

JOHAN ROOTZÉN, LEADER FOR CASE STUDY BUILDINGS AND TRANSPORTATION INFRASTRUCTURE

Initial work in our case study has created a common understanding of the current status and best practices within the supply chains of buildings and transportation infrastructure. We have also begun to identify key challenges and knowledge gaps that need to be overcome to meet the goal of net zero greenhouse gas emissions by the year 2045.

Our first phase has included a workshop and several video conferences involving some 30 stakeholders along the supply chain; material suppliers, contractors, consultants, architects, clients, governmental agencies, municipalities, research institutes and universities.

Theses gatherings have confirmed a consensus around the fact that no single actor alone has the means and tools required to achieve the goal of net-zero emission from Swedish construction and civil engineering projects. Thus, the case study provides a valuable platform for exchanging information and experiences, to learn from each other and co-produce new knowledge.

One important outcome of these initial talks has been the formulation of two overarching questions guiding the case study work, namely: How to realise the potential of the emission reduction measures that have been shown to exist already today. And: How to, as soon as possible, create the economic and organisational conditions that will lay the foundations for reaching zero or near-zero emissions of the entire supply chain - from raw materials to completed buildings and infrastructure. Although related, the two questions tend to be associated with two quite different sets of opportunities and challenges.

Failure to realise the potential for existing emission reduction measures tends to be explained by factors such as implicit or explicit constraints within organisations of individual companies, inadequate communication between actors in the supply chain, overly conservative regulations and norms or lack of information.

With respect to the second question the task is to, already today, lay the foundation for a number of key technologies that is likely to be rquired to achieve deep decarbonisation within a couple of decades, for example through electric construction machines, carbon capture and storage and hydrogen-reduced iron and steel production. These technologies involve above all adaptation of legislation and innovative schemes to share risks and costs associated with developing and implementing new technology.

The next step in our case study is to begin probing into the construction projects that has been singled out as suitable for exploring how challenges and opportunities related to the decarbonisation of the supply chains for buildings and transport infrastructure are manifested under real market conditions. We have also identified a number of cross-cutting focus areas that will be investigated throughout the project period. First up is a study of the potential for scaling up the use of alternative binders in concrete production.

Johan Rootzén

Environmental economist Åsa Löfgren, member of the Swedish climate policy council

ÅSA LÖFGREN, LEADER FOR WORK PACKAGE 4 POLICIES AND GOVERNANCE

As of 1st of January 2018 the Swedish government initiated a climate policy council with the task to evaluate how the government policy is consistent with the national climate targets. Mistra Carbon Exit researcher Åsa Löfgren is one of the eight council members.

– The members of the council all have different areas of expertise and my role as an economist will be to look at if current and suggested climate policy supports individuals, companies and agencies to efficiently respond to incentives and market signals, Åsa Löfgren says.

Åsa Löfgren is Associate Professor at the Department of Economics, University of Gothenburg. She is an international expert in the area of climate economics; in particular she has focused on climate change and behavioral economics.

Åsa Löfgren

The Swedish parliament has set a very ambitious climate target for Sweden to reach zero net emissions of greenhouse gases in 2045 and the target will require major changes in society over the next 25 years.

On a yearly basis the council presents an assessment to the government on how the national climate policy is progressing and if and how we are reducing emissions.

What is the general message in the assessment report?

– The council was established very recently and in the first report we focus on presenting the council and its mission as part of the Swedish Climate Policy framework. In addition, the report provides an overview of the national and international context in which the council will act.

The Climate Policy Council is an independent body consisting of people with vast scientific expertise:

Ingrid Bonde (Chair), Johan Kuylenstierna (vice Chair), Karin Bäckstrand, Katarina Eckerberg, Tomas Kåberger, Åsa Löfgren, Markku Rummukainen and Sverker Sörlin. All members are appointed for three years.

For more information about the Swedish Climate Policy Council: http://www.formas.se/en/About-Sustainability-Formas-Research-Council/Swedish-Climate-Policy-Council/

The first report (Swedish): http://www.formas.se/PageFiles/22123/Klimatramverket%20rapport%2018%20v2.pdf

How to find both plausible and divergent scenarios

SONIA YEH, LEADER FOR WORK PACKAGE DEFINING TRANSFORMATIVE PATHWAYS

Our first task has been to start defining a set of scenarios that covers plausible, yet divergent narratives and assumptions on how the future may evolve. That is, looking at external factors influencing the Swedish energy pathways towards net zero greenhouse gas emissions.

These factors include GDP in other regions, climate ambitions of individual countries, EU climate policies and availability and costs of fossil resources as well as for renewable energy. These external drivers will be critical for the Swedish net zero-emission pathways since they affect the benefits, costs and risks for Sweden to be a front runner in reducing its greenhouse gas emissions towards net zero by 2045.

Instrumental for this work is a new scenario framework called Shared Socioeconomic Pathways, SSP's, established by the climate change research community to facilitate the integrated analysis of future climate impacts. This framework provides well-established, internationally recognized and comparable narratives which will also guide other quantitative scenarios and qualitative narrative studies within Mistra Carbon Exit.

Specially, the SSP's will be used to develop narratives and quantitative assessments that include both the technology development within the supply chain (WP2) as well as the development towards the UN sustainable development goals (WP5).

Though some national level SSP data such as population, GDP and urbanization data is publicly available, most of the more detailed data is not. We thus collaborate with Pacific Northwest National Laboratory at the University of Maryland, US to get the most updated and regionalized data about for example carbon prices, technology development rate, fossil fuel use and constraints and land use regarding biofuel availability.

Our plan is to select two or three SSP scenarios that will aim to cover a best case - as in a sustainable future, a worst case – as in regional rivalry or fossil development and a middle-of-the-road case. We will develop storylines that are consistent with the other work packages and case studies in Mistra Carbon Exit to use consistent storylines.

Sonia Yeh

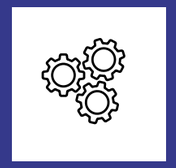
Work Packages & Case Studies

The work is organized in four case studies (CS) and five academic work packages (WP) . The case studies have a high level of involvement from our non-academic partners and address: Energy carriers, Buildings, Transportation infrastructure, Transportation and Local Arenas. The work packages are mainly academic and focus on: Defining Transformative Pathways (WP1), Technology Assessments along supply chains (WP2), Market behaviour and attitudes (WP3), Policies and Governance (WP4) and Integration and sustainability Assessments (WP5).

Under each work package there are a number of tasks. The case studies are supported by results from the academic work packages. The continuous and close dialogue and information exchange is an important part of the cooperation between case studies and the work packages. To support this process we have allocated significant resources to integration and communication activities across the programme.

Work Packages

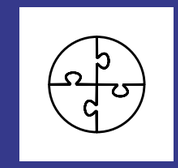
WP1 Defining Transformative Pathways



WP2 Technology Assessment Along Supply Chains

WP3 Changing Market Institutions and Behaviors Towards Swedish Leadership

WP4 Policies and Governance



WP5 Integration and Sustainability Assessment

WP1 DEFINING TRANSFORMATIVE PATHWAYS

The target of net zero greenhouse gas emissions by 2045 will require transformative pathways with respect to virtually all industrial processes and their associated products and services. We divide this work into investigation and definition of external and internal scenarios. The external scenarios define the development of external factors of importance as input to the internal scenarios, which cover how buildings, transports and industry can be decarbonised. The external scenarios are analysed and defined on Global, EU and Swedish level. The internal scenarios cover available strategic decisions regarding how buildings, transports and industry are decarbonized by means of, for instance, electrification, biofuels, carbon capture and sequestration (CCS), modal shifts, planning and changes in behaviour.

WP2 TECHNOLOGY ASSESSMENT ALONG SUPPLY CHAINS

The scientific base of WP2 is technology assessments of technologies along the supply chain from raw material to final product and/or service provision,in order to identify what options are available for mitigating carbon emissions along the supply chains and at what cost the carbon emissions can be reduced. An important aspect is to include the time line. i.e. how the supply chains, including production of energy carriers, especially electricity, will develop over time. As for electricity, this will – as pointed out above - be increasingly provided by variable electricity (wind and solar) which makes it important to investigate links to other sectors.

WP3 TECHNOLOGY ASSESSMENT ALONG SUPPLY CHAINS

The work in WP3 departs from the state of art research in social sciences, including economics, social psychology, management science and political science, which complement each other to provide a comprehensive picture of market behaviour and response to attitudes and climate policies. The behavioural approach used specifically draws on behavioural economics and social psychology which recognise that society can shape individual preferences and beliefs; in particular through institutions and social norms, and socialization processes.

WP4 POLICIES AND GOVERNANCE

The research in WP 4 is firmly grounded in primarily economic theory but goes far beyond the simple textbook models of the "homo economicus." The methods used in WP 4 spans from theoretical approaches using economic modelling, to more empirical work based on econometric methods using register data as well as data from experimental approaches. Some tasks also include collaboration with case studies. Further, in all tasks attention is given to identify potential overlapping- or interaction effects (negative or positive) that might arise from policies that affect activities in multiple sectors.

WP5 INTEGRATION AND SUSTAINABILITY ASSESSMENT

WP5 Integration and sustainability assessment will contribute to the project with work on synthesis of the results from the different activities in the other WPs and case studies. Since the Mistra Carbon Exit project takes on scientific research from a number of disciplines, as well as applying different methods including modelling, experimentations and case studies, the scientific challenge is to close in on synthesizing results and knowledge from various scientific fields.

WP5 also includes tasks relating to sustainable development – here represented by the sustainable development goals (SDG) and the Swedish environmental objectives (SEO). These overarching goals will provide a framework that enables the linking of results from WP1-4 on transformative pathways to a development agenda that includes global and regional development challenges.

Case Studies

The aim of the case studies is to provide concrete examples around which the industry and the research can meet and exchange knowledge and experiences. The case studies have been developed and defined in the early phase of the programme. The aim is to develop and analyze transformative pathways using examples for buildings, transportation infrastructure and transportation with an additional case study for energy carriers since energy supply and demand is a key issue shared by all three areas. There is also a case study on regional setting ("Local arenas") with the aim to link and discuss the results in a local setting. Concrete examples covering innovative technologies, business models and support mechanisms is applied within the case studies. The aim is to identify ways which can accelerate the transition towards zero-emission practices in the construction and operation of buildings, transportation infrastructure and transportation. The results from the case studies will be generalized in the research carried out in the WPs.

ENERGY CARRIERS

This case study takes departure in an available modelling package of the European electricity generation system (ELIN and EPOD models) from which different future scenarios of the electricity generation can be assessed, considering different policies on emission reduction, share of renewable electricity and energy efficiency measures. The case study will focus on and assess the use of electricity and biomass derived fuels along the supply chains for buildings, transportation infrastructure and transportation.

The case study will be carried out in dialogue with industrial partners, including Energiforsk and associated networks with the energy industry (especially the network established within the North European Power Perspective project).

BUILDINGS AND TRANSPORTATION INFRASTRUCTURE

This case study take departure in one (or several) ongoing building and infrastructure construction projects which provide a reference for how material, energy and transport and mobility services are used in the construction process including way construction materials are produced and supplied. The mapping and description of the energy, material and value flows involved provides the basis for an investigation of how the supply and value chains can be transformed in future, similar, building projects while maintaining competitiveness on carbon restricted markets. The formulation of the transportation case study will be done in close cooperation with the transportation and energy carrier case studies since these will share scenarios on the future pathways of the transportation and energy system towards zero emissions and increased use of renewable energy supply.

TRANSPORTATION

There are different potential energy supply options to achieve net zero emissions in transportation (primarily biofuels, electricity, hydrogen), where each option corresponds to different challenges and constraints. In addition to the growing interests in various low CO_2 energy propulsion options, the transport sector is also experiencing several trends such as digitalization, servitization, and automation that could radically transform the way we transport people and goods. A key challenge is to drive this development towards high energy efficiency and low supply chain CO_2 emissions. The aim is to assess the impacts from alternative low CO_2 energy propulsion options, autonomous vehicles and increased use of shared transportation including use of intermodal urban transport on the transformation of the transport supply chain towards net zero CO_2 emissions.

The case study will be based on output from WP1 (scenarios), WP2 (low carbon supply chains in transports), WP3 (business models) and WP4 (policies) and will be performed together with industry and agency partners.

LOCAL ARENAS

In Sweden, regions have so far often had more ambitious climate targets than the Swedish national target and are willing to move faster (for instance Uppsala, Västra Götaland, Stockholm, Växjö, Skåneregionen aim at being fossil free by the year 2030). Such tendencies are also seen throughout Europe and in the US, where the state of California has a long record of being a frontrunner in environmental policies.

The aim of the Mistra Carbon Exit local arena case study is to:

- Use the local area to test transformative solutions and identify opportunities and barriers from both a technology and policy perspective.
- Analyse if national technology and policies are compatible with local targets and actions. For instance power availability; national transport solutions and standards that are decisive for local initiatives; climate footprints of steel and cement used in housing. What local policies are within the control of the municipality?
- Investigate the value of being frontrunners in the transformation, with focus on buildings, transportation and transportation infrastructure, including the possibility to boost renewable technologies such as wind power and the use of biomass.
- Explore if and how the dialogue and cooperation between the regional and national level can be improved.
- Provide local stakeholders with science based advice to implement solutions for their prioritised actions areas.

"Through Mistra Carbon Exit we see the opportunity to take part in leading research, future demands and opportunities in areas close to our operation and business."

"We expect to strengthen our own work and the work that has to be implemented in our value chain."

"We hope to receive valuable input on how we, as well as other actors, can stimulate the development towards a climate-neutral infrastructure."

MISTRA CARBON EXIT PARTNER

Volvo Construction and Equipment

Within Volvo CE, we are actively working to reduce our own and our products' climate footprints from a life-cycle perspective. One of our experiences is that many improvements are possible only through joint work over the value chains and that, in some areas, new technologies, methods and behaviors are required to succeed in reaching the 2045 goal. This is in line with the approach in Mistra Carbon Exit and why it feels important for us to participate.

In general, we consider it important to be at the forefront of issues relating to climate and the environment, both from a business perspective and as a responsible player in society. Through Mistra Carbon Exit we see the opportunity to take part in leading research, future demands and opportunities in areas close to our operation and business. We also hope to connect with stakeholders in our value chain to increase the speed and efficiency in reaching the goal of a climate neutral society. Being a global company, Volvo CE can provide knowledge and international experience about our own products and their use in different stages of the value chain.

Niklas Nillroth,
Vice President Environment & Sustainability at Volvo Construction Equipment

MISTRA CARBON EXIT PARTNER

Skanska

Skanska has since 2015 a goal to become carbon neutral in our value chain. The Mistra programme is very well aligned with Skanskas work and ambitions. We are therefore very happy to be part of the programme.

As a partner of the Mistra Carbon Exit programme we expect to strengthen our own work and the work that has to be implemented in our value chain. We also expect to increase the collaboration with partners that share our ambitions as well as increase the competence and knowledge through research and development.

With more than ten years of experience of working with climate issues and carbon calculations we are looking forward to contributing to the programme. In addition to this Skanska also have internal experts and a lot of projects suitable for case studies.

Johan Gerklev
Skanska, Sustainability Manager

MISTRA CARBON EXIT PARTNER

The Swedish Transport Administration

In order to reach the climate targets, major emission reductions are rapidly needed. For the Swedish Transport Administration, we must be able to build and maintain our transport infrastructure while minimizing its climate impact.

In Mistra Carbon Exit we focus on the case study for buildings and transport were we hope to receive valuable input on how we, as well as other actors, can stimulate the development towards a climate-neutral infrastructure. For example, how should procurement requirements and incentives be designed to stimulate the development of new climate-neutral methods and materials? We also participate in the transport case study.

The Swedish Transport Administration has set tough targets to reduce emissions and has also adopted a vision for climate neutral infrastructure in 2045. We have transposed the goals in to procurement requirements, which also provide incentives for greater reductions than demanded for. As a purchaser, the requirements do not impliy major additional costs, even though the cement and steel raw materials become significantly more expensive. We therefore believe that a key to the conversion can be procurement requirements of the kind taken by the Swedish Transport Administration.

We have long experience of calculating the climate impact of the infrastructure and this experience can be used in the project. As far as transport is concerned, the Swedish Transport Administration has for a long time developed scenarios for how the transport sector can become fossil free and climate-neutral in the long term - something that can certainly contribute to the program.

Main challenges for Mistra Carbon Exit may, for example, include to analyze which business models and policies that may be suitable in the process of creating a climate neutral infrastructure. Other challenges are the design of procurement requirements, as well as approaches to new trends to ensure that they lead to sustainability.

Håkan Johansson,
Coordinator climate mitigation, The Swedish Transport Administration

Which barriers limits disruptive behavioral changes?

MAGNUS HENNLOCK, LEADER FOR WORK PACKAGE 3 CHANGING MARKET INSTITUTIONS AND BEHAVIORS TOWARDS SWEDISH LEADERSHIP

Our behavioral research has commenced with a number of pre-studies identifying structural and psychological barriers preventing necessary behavioral changes in the buildings and transportation case studies. The results from these pre-studies will inform the work on focus groups and hypotheses formulations in the experimental research phase that will start in the fall of 2018.

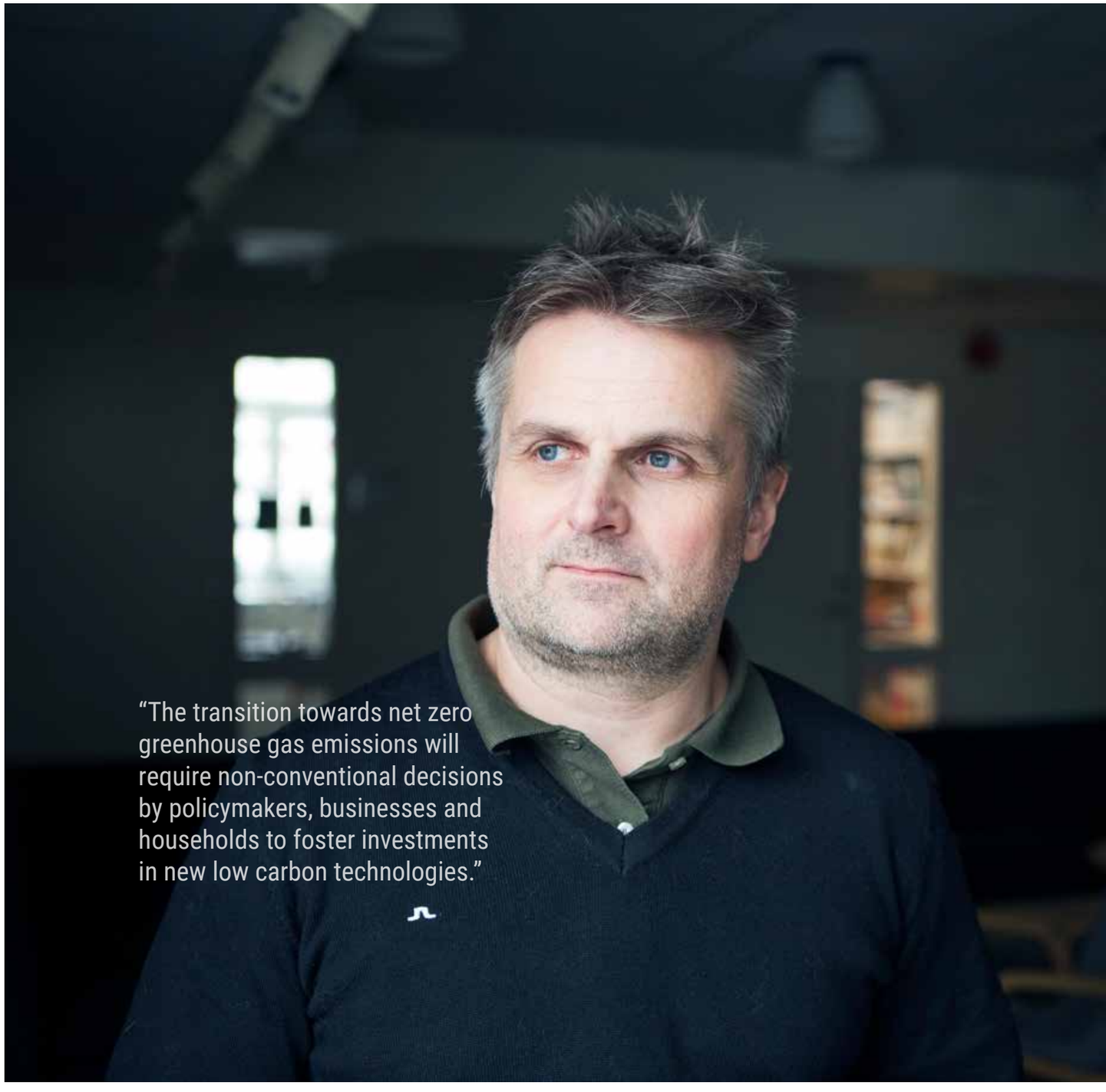
The transition towards net zero greenhouse gas emissions will require non-conventional decisions by policymakers, businesses and households to foster investments in new low carbon technologies. Even when low carbon technologies exist, structural and psychological barriers often stand in the way towards taking these decisions.

Since these decisions often imply disruptive behavioral changes there is still limited empirical evidence of such decisions in today's market behavior. Much of our research in WP3 is therefore undertaken in focus groups and experimental research together with stakeholders in several case studies related to buildings and transportation.

Initially, we study for instance barriers - whether market actors experience uncertainty with new and non-conventional measures, if they are unsure of what measures to take, or experience that the problem is elsewhere in the value chain. Do actors perceive competitive cost disadvantages even when no such disadvantages exist? Is decision-making bounded by limited time and efforts such that decision makers tend to choose conventional solutions? Does decision-making rely on rules of thumb, such as looking at technologies of well-performing rivals on the market, or are they relying on existing methods using data on conventional materials and processes?

A major part of the work in WP3 aims to improve new business models and design of policy interventions. Key to this work is to improve our understanding of the market behaviors that drive climate change by developing better behavioral packages in economic models based on empirical analysis, providing deeper understanding of current business and household behavior. This is essential for understanding contextual factors in designing effective policy instruments and in understanding when and why businesses and households do or do not respond to economic incentives, information, and new technologies.

Magnus Hennlock



The unavoidable industrial transformation challenge

The value chains that are in focus in the Mistra Carbon Exit case studies all include energy-intensive material producers playing a pivotal role. For buildings and transport infrastructure alike, cement and steel production are essential materials, but also have some of the most energy- and emissions intensive production processes of any sector in the economy.

While material substitution may, more generally, play an important role in transitioning to a carbon neutral economy it is difficult all the same for now, to imagine a world where such materials are not in high demand. As such, the steel and cement sectors require transformational new technologies that will enable them to produce at radically lower levels of emissions: technological improvement that go beyond efficiency improvements.

CCS and (green) hydrogen are likely to play an important role here; even if both technology groups come with enormous production and infrastructure challenges of their own. It will also require a different policy mix. Carbon pricing through the EU ETS has so far been the main climate policy instrument for energy-intensive industry, but a carbon price on its own does not usher transformational new technology and infrastructure into being.

Milan Elkerbout

Nevertheless, creating a market for low/zero carbon materials is an essential step if industry is to invest in, and adopt the requisite future production processes.

Milan Elkerbout, Research Fellow, Centre for European Policy Studies (CEPS)
Brussels

“Development relies on energy”

Alla Toktarova is now starting as a PhD student at the Department of Space, Earth and Environment at Chalmers University of Technology. Her research within Mistra Carbon Exit will assess the future use of energy carriers in industrial processes, with focus on the production and use of materials such as cement and steel in buildings and transport infrastructure.

Growing up in an energy intensive region, I realized that development relies on energy and this motivated me to undertake studies in energy systems at the Moscow Power Engineering Institute in Russia. To deepen my knowledge, I commenced a double degree at Lappeenranta University of Technology (LUT) in Finland, a university with a strong focus on renewable energy systems says Alla.

Alla Toktarova

“A privilege to be part of this research”

Mistra Carbon Exit welcomes Ida Karlsson, our new PhD in Energy Technology. Ida Karlsson joins the Mistra Carbon Exit team at Chalmers University of Technology.

–Being part of and able to contribute to such an important research project as the Mistra Carbon Exit is to me an utter privilege, a privilege which has led me back to academia and to Sweden after a decade in various sustainability roles in industry and international institutions, says Ida Karlsson.

With a Master in Biotechnology and Environmental Management at the core, Ida has explored the sustainability field with experiences ranging from managing projects and building capacity as an environmental management consultant, performing environmental risk assessments for mainstream sustainability integration in the Australian finance sector, to enhancing the sustainability governance and founding a sustainability research portfolio at the Maersk Group. Ida has also done work to incorporate environmental aspects in the global procurement operations of the UN Office for Project Services.

I am a strong supporter of bridging the gap between academia and centers of decision-making, why I appreciate the aim of Mistra Carbon Exit to take an active role in societal debate and contributing to the international climate cooperation says Ida Karlsson.

Ida Karlsson

Scientific deliverables at program level in 2017

Meetings and seminars with stakeholders

Regular and close interaction with industry and authorities is key to the program. These meetings allow us to provide decision support to authorities and industry based on current know-how within the consortium. The meetings also provide a meeting place for our stakeholders to tell us what issues are most important to them and hereby guide us concerning the focus of our research. In 2017 Mistra Carbon Exit has organized the following events including researchers and stakeholders:

- Kick-off meeting in June, where researches and stakeholders met in a number of breakout sessions, and worked jointly to identify and analyze critical issues for deep de-carbonization.
- The first of a series of supply chain workshops was organized on October 24th. We invited clients, consultants, contractors and material suppliers involved in the supply chain of buildings and infrastructure to explore how innovative production practices, material choices, business models and policies can contribute to significantly reduce the climate impact of building construction processes. The workshop was intended to set the case studies focusing on buildings and transportation infrastructure in motion. The findings from this WS guides us in what issues to focus on in the program
- Organized a workshop with the Swedish EPA and researches in Stockholm in September to discuss how Sweden can pursue deep de-carbonization targets while under an EU emissions cap.
- Organized a policy seminar with Dallas Burtraw, a leading carbon markets expert in from Resources for the Future, USA on the topic: "Making emissions trading work - The North American experience".
- Co-hosted the third International Transport Energy Modeling (iTEM3) workshop, in Paris, at the International Transport Forum-OECD. The agenda focused on topics such as New transport models, Beyond 2 degrees and NDCs, Electric vehicles and behavior change and Future declines in diesel markets
- Co-hosted a workshop in Berlin in October: Policies to stimulate climate friendly innovation in the materials sector, where researchers from the program, industry and representatives from the EU Commission met to present and discuss options for incentivizing investments and innovation in climate friendly materials production in the EU.

PhD students

In 2017 5 PhD students have been recruited to participate in the program:

- Vera Zipperer at DIW, PhD expected to be completed in 2018
- Rui Jie Tian at Gothenburg University, PhD expected to be completed in 2021
- Alla Toktarova and Ida Karlsson at Chalmers-ET, PhD expected to be completed in 2022
- Ella Rebalskij at Chalmers FRT, PhD expected to be completed in 2022

International scientific conferences

The program has presented two scientific papers at two international scientific conferences:

- The Case for a Reserve Price in the EU ETS. Presentation given by C Fischer at CESifo conference in Munich Oct 13-14
- Policy sequencing toward decarbonization, J Meckling, T Sterner, G Wagner - Nature Energy, 2017, presented at Berkeley School of Economics October 2.
- Engaging in other programs of relevance. Researches from Mistra Carbon Exit have engaged in other programs of relevance:
- Fossilfritt Sverige. Several meetings with Svante Axelsson and participation at their seminars, for instance at UN:s climate conference COP23 in Bonn.
- Innovation competition"Transformative infrastructure - innovation for zero emissions" a project run by Naturvårdsverket, Energimyndigheten and Formas.
- Participation in a workshop in Berkeley, California, comparing climate and energy policies in California and Germany. The workshop provides an opportunity to integrate Swedish research with an existing California-Germany project.
- On December 1st, programme director Lars Zetterberg gave a key note presentation on the role of the EU ETS for future climate policy at an conference organized by Centre for European Policy Studies (CEPS) and the International Emissions Trading association (IETA).

Administrative results in 2017

- A program board has been formed consisting of the following fivemembers: Peter Nygårds (Chair), Birgitta Resvik, Fortum, Erik Eriksson, Energimyndigheten, Stefan Nyström, Naturvårdsverket and Anna Ledin, Göteborgs stad. The board has met twice during the year and has scheduled four meetings in 2018, following an annual cycle.
- A management group has been formed. The management group has met four times.
- The program plan is the main steering document for the programme. The Programme Plan 2017 was developed based on the research proposal that was submitted to Mistra in September 2016 and on the feedback received by Mistra and the Mistra board in December 2016. It was submitted in June and was endorsed by Mistra.
- An agreement between Mistra and IVL, the program host, was signed in April 2017.
- A consortia agreement has been signed by all partners.

Increasing visibility and strengthening the team

Examples of Communication Activities 2017

PUBLICATION: NINE MESSAGES FROM MISTRA CARBON EXIT

The aim of the report has been to formulate and communicate a set of messages to our end-users. Messages that we are aware of, but might perhaps not be well known to our end-users. The report is part of the effort to make the programme known at an early stage. The report also allows us to present what each WP and Case study will do in the coming years.

WORKSHOPS

On October 24th clients, consultants, contractors and material suppliers involved in the supply chain of buildings and infrastructure came together for the first of a series of supply chain workshops. The workshop was intended to set the case studies focusing on buildings and transportation infrastructure in motion.

On October 20th, DIW, supported by Mistra Carbon Exit, organized a workshop in Berlin. The aim of the workshop was to explore what elements need to be put in place at the European and Member State level to allow for large scale emission reductions from material production.

LAUNCHING THE WEBSITE MISTRACARBONEXIT.COM

A website has been developed (www.mistracarbonexit.com). The website serves as a portal for programme output and other communication activities such as news, upcoming events, short films, articles etc.

INTERNATIONAL TRANSPORT ENERGY MODELING (ITEM3)

On October 26-27th Mistra Carbon Exits WP1 ("Defining Transformative Pathways") co-hosted the third International Transport Energy Modeling (iTEM3) workshop. The workshop took place at Organisation for Economic Co-operation and Development (OECD), Paris, France.

Topics discussed during the workshop was for example; New transport models; Beyond 2 degrees and NDCs; Electric vehicles and behaviour change; and Autonomous vehicles and shared mobility.

KICK OFF JUNE 2017

On the 7-8th of June the almost entire Mistra Carbon Exit team – 46 participants from 26 different organisations and four different countries - came together at Hotel 11 in Gothenburg.

While sharing dozens of presentations and workshops from both work packages and case studies Mistra Carbon Exit set the course for the following four, but hopefully eight, years of critical and influential research.

NEWSLETTER

The Mistra Carbon Exit Newsletter will be published four times a year (issue No.2 in May 2018). The newsletter informs our programme partners about current programme updates, upcoming activities as well as giving an administrative summary and status report.

Additional communications activities during the year

Date	Activity	Channel	Responsible	Place	Additional Information
May 19	Policy seminar	Seminar	Dallas Burtaw, Resources for the Future	Göteborg	Theme: "Making emissions trading work – The North American experiences"
May 24	Key Note	Conferences	Filip Johnsson, Lars Zetterberg	Stockholm	Tillståndet i Miljön
May 30	Key Note at Workshop	Semiar	NV	Östersund	Theme: "Transformative Industry – Pioneering innovations for zero emissions"
Jun 7 – 8	Kick off Mistra Carbon Exit	Meeting	MCE	Göteborg	(46 participants from 26 different organisations and four different countries were present)
Jun 25	Launch website	Website			Program website (results, news, contact, etc)
Sep	Meeting Fossilfritt Sverige	Meeting	Lars Zettererg		
Sep 6	Workshop	Meeting	Lars Zetterberg (organised by Tillväxtverket)	Stockholm	Mistra Carbon Exit participates in panel.
Sept 18	Article	MCE website	Helena Larsson/ Dallas Burtraw		Theme: "The EU-ETS has a lot to learn from US carbon trading systems"
Sep 21	Press/Article	Mistra Newsletter	Lars Zetterberg		Theme: "Ingenjören som pusslar samman ett klimtneutralt Sverige"
Sep 22	Scientific article	Publication Nature Energy (2017)	Thomas Sterner (J Meckling, G Wagner)		Theme: "Policy sequencing towards decarbonization"
Sep	Meeting with California Air Resources Board	Meeting	Lars Zetterberg, Dallas Burtraw	California	
Oct	Report	Report	(Draft)		Theme: "The Case for a Reserve Price in the EU ETS"
Oct 10-11	Innovation Seminar		Lars Zetterberg (organized by Naturvårdsverket, Energimyndigheten, Formas.)	Malmö	Innovationstävling "Transformativ infrastruktur – innovation för nollutsläpp"
Oct 20	Policy Workshop	Workshop	DIW supported by Mistra Carbon Exit	Berlin	Theme: "Policies to stimulate climate friendly innovation in the materials sector"
Oct 24	Case Study Meeting: Buildings and Infrastructuree	Meeting	MCE Case Study Buildings and Transportation Infrastructure	Göteborg	Case study start up.
Oct 26-27	International Transport Energy Modeling (iTEM3)	Workshop	iTEM, Co-hosted by Mistra Carbon Exits WP1 ("Defining Transformative Pathways")	Paris	
Oct 29	Workshop Report	MCE Website			Theme: "Supply chain of buildings and infrastructure"
Nov 16	Press/ Comment	Newspaper Aktuell Hållbarhet	Lars Zetterberg		Theme: "Commetn on the EU ETS reform"
Dec 1	Workshop		Jos Delbecke, Zetterberg (Organization by CEPS)	Berlin	Theme: "EU ETS"

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WORK PACKAGE 2: TECHNOLOGY ASSESSMENT ALONG SUPPLY CHAINS
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WORK PACKAGE 3: CHANGING MARKET INSTITUTIONS AND BEHAVIORS TOWARDS SWEDISH LEADERSHIP
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WORK PACKAGE 4: POLICIES AND GOVERNANCE
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WORK PACKAGE 5: INTEGRATION AND SUSTAINABILITY ASSESSMENT
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