Look forward

REES

MISTRA
Resource-Efficient and
Effective Solutions

A Mistra funded programme about Resource Efficient and Effective Solutions (REES)

Contents

Mistra REES

The Mistra REES research program is a collaboration between leading academic environments, industrial companies and societal actors with the aim of creating knowledge about more resource-efficient and effective solutions (REES) based on a circular economy. The research has been ongoing since 2015, and behind the initiative is a consortium of three universities – Linköping University, Lund University and Chalmers – as well as a number of small and large companies. Since December 2019, the research program's focus has been expanded to also include financial analysis and business economics aspects of the circular shift.

Mistra REES financing, 4 years (201912–202312)

	Budget (201912–202311)	Outcome (201912–202112)
Mistra	47.0 MSEK	20.49 MSEK
Academic partners	8.56 MSEK	4.24 MSEK
Non-academic partners	21.0 MSEK	25.23 MSEK
Total	76.56 MSEK	49,96 MSEK

Comment: During 2021, our partners' activities related to our program have more or less exploded when it comes to their work and contribution, and we have done much more with them than originally planned. In a good way, this shows how relevant this program is and right in time for them and other manufacturers out there.

No time to settle down!

Just when we finally thought we saw the end of the covid pandemic "tunnel" that we have experienced during the last two years, a sad, new dark tunnel appeared, the terrible invasion of Ukraine. We all hope that the war will be over soon, that peace can be established, and that freedom and democracy expand in Europe.

However, even though this urgent crisis requires great focus and strong solidarity, we don't have time to forget about the big tunnel we still face. This one is much longer than the pandemic tunnel we are still in and one very scary for society. It is a tunnel that we still see no end to and which we have been in for decades – the resource and climate crisis tunnel.

We have no time to settle down; on the contrary, we need to urgently start to deal with this challenge – and utilize all positive learnings from the covid pandemic tunnel.

It is time to acknowledge how things in society are connected – to see and understand the cause and the consequences – and to stop focusing on symptoms instead of the root of the problem.

It is time to open our eyes and face the fact that our use of resources in society is the cause of climate change and the resource challenges we realize. The wider effects of the war in Ukraine have clearly shown the vulnerability of our society when it comes to resources and the risk of not being able to access them – and that we need a more resilient use of resources in our society.

It is obvious that we cannot continue with current models of how we produce and consume resources in society. To tackle the climate and resource challenges, we need to use our resources in smarter ways and treat them with a long-term perspective – not use them and then waste them, but instead, see them as investments for the future.

We need to become a society based on an economic system focused on maintaining a circular flow of resources by regenerating, retaining, or adding to their value while contributing to sustainable development. It is rewarding to see that an increasing number of actors now have realized this and keep this as a high-priority topic on their agendas.

Mistra REES contributes to this by providing research and results that present opportunities and practical solutions for ways out of the current unwanted situation and towards an exciting and more sustainable future. This year, Mistra REES will intensify its dissemination activities to reach companies and policy makers at all levels, both nationally and internationally.

To conclude, we have no time to settle down in our endeavor towards a more sustainable world – let us collaborate and get out of this resource and climate crisis tunnel as soon as possible!

Ola Alterå,
Chairman of the Board

There is no time left to wait!

We live in a turbulent and uncertain time, to say the least, given the ongoing devastating war in Ukraine. At the same time, we have significant environmental and climate challenges that continue to escalate. Regarding those challenges, the question is not whether we need to make significant changes in our lives and societies but whether we will be able to make them in time.

Last year came the dystopian film "Don't Look Up", about two astronomers who desperately try to warn humanity of an approaching comet that will destroy human civilization. In the film, the comet functions as an allegory for the great life-changing environmental and climate challenges that we face. The film is clearly satirical and illustrates how short-sighted and naive our society is, not least how naive and narrow-minded its decision-makers and media, in general, have handled these challenges.

However, we are not living in a movie; we exist in the real world, and we want it to survive. Unlike the world of computer games, there is no extra life, no extra chance. Humankind cannot afford to continue to be naive and short-sighted in its thinking. There is no time left to wait!

The covid pandemic that has ravaged our society over the past two years has shown that we can, if we want to, come to grips with and make things happen. We can change our behaviors and bring about resources for change. As I wrote in last year's column: if we can change our society because of Covid-19, what can we then not do to meet the even greater threats caused by climate change, resource challenges, and the need for a more sustainable development? It is important that we now emerge from the pandemic, taking with us the lessons learned from this.

Today, on a general level, we have enough knowledge about what we need to do – we cannot continue on the current path – but the problem is that we must start doing things too. No time left to wait! Discussing whether warming due to climate change will be 1.5 or 3 degrees is unimportant if we do not take action to push back the change. Referring to the movie above, it is more or less pointless to argue if the comet will hit us on Monday or Tuesday next week or whether it will destroy all life at once or after some hours.

According to Peter Drucker, "The relevant question is not simply what shall we do tomorrow, but rather what shall we do today in order to get ready for tomorrow." To do so, we must also ask ourselves why we have our major environmental and climate challenges – and what is the cause for these.

Put simply, the cause is our short-term way of managing resources, products, and services, and until now, we have used and wasted natural resources rather unreflectively. Our climate problems are largely a result of the combustion of natural resources needed to produce and meet our constant consumption of resources, products, and services. At the same time, our depletion of the earth's resource reserves has resulted in more and more resources becoming increasingly rare and difficult to access, which requires even more resources and energy – and thus implies an increasing contribution to our climate problems.

To find the solutions to be ready for the future, the focus must be shifted from the climate to the problem of resource consumption. There is no time left to wait!

In Mistra REES, we are doing this now – we are not waiting. Instead, today, together with our partners, we are evolving and contributing to this needed change in society! The number of companies, customers, and others who want to move towards more effective, resource-efficient, circular, and sustainable solutions continues to increase. We help them to start and boost their endeavor to turn environmental challenges into business opportunities. The focus is to "do the right things", and then to do these effectively.

Have you started your endeavor towards a more sustainable future?! If not, there is no time left to wait! Let us support you!

Mattias Lindahl,
Mistra REES Programme Director

A strong research team

Project 1
Design Support










Project 3
Environment




Financial




Project 2
Policy


Project 4–5
Management


Linköping University

Chalmers

Lund University

Highlights from 2021

DISSERTATIONS

Two more PhD theses have been published and defended, mainly based on the work in Phase 1 (see more info under Project 1):

■ **Simulation Modelling of a Shift to Service-Based Offerings: Resource efficiency and operational implications in the context of the circular economy** – On the 15th of January, *Raphael Wasserbaur* defended his thesis (Link to thesis). A shift to a circular economy (CE) needs to happen on many levels of society, and this thesis presents simulation models that can support corporate and political decision makers in the shift to a CE. It shows that to understand the CE, the analysis has to be, on the one hand, able to simulate system dynamics, and on the other hand, connect the multiple levels of society (individual designers, institutions, policy makers and end users); it argues that aspects like governmental policies and business models need to be considered design parameters.

■ **Marianna Lena Kambanou** – On Friday the 11th of June, Marianna became the latest Mistra REES PhD after defending her thesis with the title Life Cycle Costing – Supporting companies towards a circular economy (Link to thesis).

The aim of her research was to explore how life cycle costing (LCC) can be used to support established companies in selecting and implementing circular measures for their offerings. The research was conducted through case studies involving four companies, and data was collected through literature reviews, document and cost data sets analysis, interviews and focus groups. The findings are based on six publications. Her research demonstrates that LCC can have more uses than at first apparent. Maybe this can inspire researchers to re-examine methods and tools and, in the spirit of a circular economy, try "to do more with less".

ACTIVITIES WITH PARTNERS

■ **Activities with our Mistra REES partners** – In parallel with further work with, for example, *Husqvarna AB, Alimak Group Management AB*, and *ABB*, we also had start-up meetings with Epiroc and Volvo. Due to the limited space, we cannot mention all ongoing activities; therefore, only one example is highlighted in this report. Together with Epiroc, we focus on their *"Battery as a Service"*. In this very interesting case, we trace and document their journey and talk with all key persons that have been involved from the start. This documentation will cover all the aspects of issues investigated within Mistra REES and will be something unique. We have also carried out outreach activities. See more about what we have accomplished later in this annual report.

COLLABORATIONS WITH OTHER MISTRA PROGRAMS

■ **Misum** – During the year we have had several meetings with them and have decided that some of us from Project 3, related to financial issues, will continue to have contacts with them and a dialog regarding potential seminars and PhD student courses. We also have a joint project (see more below) and are discussing new collaboration activities.

■ **Mistra Steps** – We have had several activities together with them during the year, for example, teaching activity towards Thailand regarding the circular economy and plastics and a new project, Unity, which you can read more about below.

MISTRA REES-CONNECTED PROJECTS

■ **Public Procurement of Functions** – A Stepping Stone Towards A More Sustainable Future! – This project is funded by the Marianne and Marcus Wallenberg Foundation (see link), and we run it together with the Stockholm School of Economics (Handels). The leader of Misum.

■ **Electrified material handling** – Together with Volvo, we applied and received funding for a project titled *"Electrified material handling"*. *Volvo Construction Equipment AB* is the main partner, and the project is funded by the *Swedish Energy Agency* via its call *"Fossil-free mobile work machines"*. The total budget is 72,7 MSEK, of which 18 MSEK is applied for, and the project involves several of Volvo's customers and is very much in line with what we want to do with Volvo. It will also enable us to do more than initially planned with Volvo AB.

■ **Circular workwear in construction and industry** – In 2015, the textile industry accounted for 1.2 billion tonnes of CO2eq emissions, more than for all international flights and shipping combined. Swedish artisans consume about 3 million work trousers annually. The idea with this project, funded by the Swedish Energy Agency with 1,9 MSEK, is to use modular workwear and a circular value chain to create a circular business model that creates a clear win-win situation between sustainability and the economy for participating actors and society at large. The project will analyze environmental, economic, and legal advantages and disadvantages to better understand the actors' perceived value and conditions and, based on that, develop a circular business model for workwear in construction and industry that is tested and validated. Several Mistra REES researchers participate in this project, and there are several connections between Mistra REES and this project.

■ **The Unity project** – Mistra Step's program director, professor Rajni Hatti-Kaul, and our program director, professor Mattias Lindahl, have started a joint project, *"Unity – A circular plastic handling based on a few thermoplastics with high pre-stand and clear specific properties"*. The purpose is to study whether it is possible to replace today's large number of different thermoplastic variants with a smaller number and which are easier to recycle. This includes examining what requirements for performance and specific properties these thermoplastics should have and what consequences a smaller number would get from an environmental and socio-economic perspective. This project is granted with 0,5 MSEK from Avfall Sverige, 1 MSEK from VINNOVA and 0,8 MSEK from the Swedish EPA.

OUTREACH AND COMMUNICATION ACTIVITIES

■ **TC 323 Circular Economy Standards** – The work has been very intensive during 2021 and will continue to be so during spring 2022. We have had substantial influence in the writing process and have added knowledge from Mistra REES into the work.

■ **Meeting with the Swedish Government Offices (Regeringskansliet)** – As a result of previous meetings with Svenskt näringsliv (the Confederation of Swedish Enterprise), Teknikföretagen (the Association of Swedish Engineering Industries) and two lawyers from the Commercial and Business Law Division at Linköping University, we had a fruitful meeting on the 18th of January with staff from Regering-

skansliet about circular economy and legal aspects. It seems like we pointed out issues that they had not thought of, and they have come back and want some additional information; we are now in the process of preparing that.

■ **Stockholm +50 2022** – On the 22nd of January, some of us were invited to an expert workshop in preparation for Stockholm +50. Stockholm +50 is a high-level meeting that the Swedish government plans to hold in connection with the 50th anniversary of the UN's first environmental conferences, namely the Stockholm Conference in 1972. The result from this meeting is that our program director, professor Mattias Lindahl and Carl Dalhammar from Lund were invited to prepare a background report that will be a part of a report developed by the Stockholm Environment Institute and presented during 2022 as part of the Stockholm +50.

■ **The Circular Economy Outlook Report 2021** – On the 3rd of February, Cradlenet released this report during a seminar. The purpose of the report is to provide a picture of where the circular economy is in Sweden today and what its future looks like. Mistra REES is presented as a research initiative in the area, and several contributors to the report are or have been involved directly and indirectly in Mistra REES (Anders Wijkman, chairman of Climate-KIC and Circular Sweden; Sebastian Holmström, Inrego; Katherine Whalen, former PhD student within Mistra REES and now researcher regarding circular business models at RISE; Matilda Jarbin, operative manager at Godsinlösen). During the seminar, which had more than 300 online viewers, our program director, professor Mattias Lindahl, participated in the panel. Link to the report. Link to the video from the seminar.

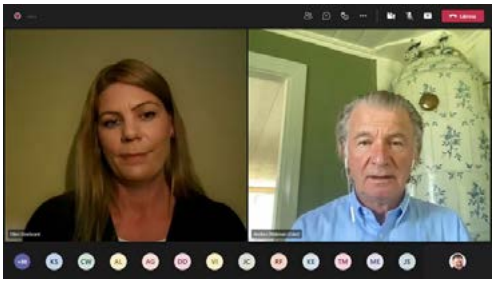
■ **Meeting with the Swedish Environmental Goals Committee** – On the 5th of May, we had a meeting with Miljömålsberedningen (the Swedish Environmental goals committee). They have an ongoing investigation aiming at a proposal on a joint strategy for reducing the consumption-related climate impact. They had been recommended by several actors to listen to us in Mistra REES, and we are thankful for that. In the meeting we disseminated ideas with a focus on how to support a more circular economy. The emphasis was on policies and legal issues that needed to be implemented or improved, for example, related to public procurement and product requirements. It was a great opportunity for us to disseminate knowledge from Mistra REES and our related research activities and projects. We hope to be able to contribute more in the future.

■ **Meetings with political parties, policy makers and companies** – In addition to the above meeting, since my last report, we have had several meetings with different organizations, where they ask us for our opinion, based on our research, of what we think they should think and do, for example, what policies they should put forward. We will continue to do this as much as possible within our time limits.

■ **New course on the circular economy** – The Department of Environmental Technology at LiU has started a new course on the circular economy where knowledge from Mistra REES is disseminated. The course had several guest lecturers from Mistra REES and its partners. There were *281 applicants* for the course that started this autumn, and, in the end, 145 students were admitted. A large number of them had ordinary jobs, and more than 50% finalized the course.

■ **The Swedish Delegation for Circular Economy's latest report** – The delegation has submitted a report to the Minister of Environment and Climate, Per Bolund. As highlighted in previous executive summaries, several of the researchers within Mistra REES have been heavily involved in producing material that has been incorporated into this report. It was, therefore, very delightful that Maria Ljunggren was invited to Swedish Radio's Studio Ett, where she commented on the report's proposals on how to speed up the circular economy. Link to the program.

■ **Circular Sweden's circular report 2021** – On the 18th of June, they presented their annual report (Link to report) in a webinar. A number of their member companies presented their circular goals, ambitions, and activities that they invest in for the transition to a circular economy. Our program director, professor Mattias Lindahl, together with Anders Wijkman, commented on their work. Issues raised included what Swedish companies do to create circular product and material flows, how they will be able to achieve their ambitious goals and how research and policy can help to increase the pace.



■ **Wording a key factor in creating new behaviours and business models** – Waste or resource? Used or vintage? Product or service? Words and definitions express values and influence our thoughts and actions. Mistra held an interview with our program director, professor Mattias Lindahl, published on the 21st of May, regarding this and issues related to the ISO standardisation work that he is involved in. Link to article.

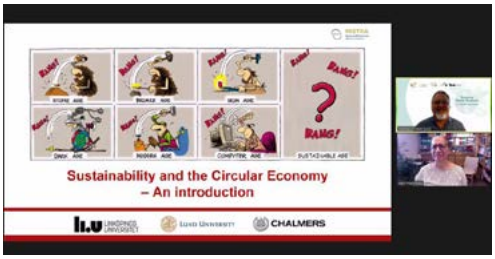
■ **CIRP Annals keynote paper** – Tomohiko Sakao will take a leadership role for the CIRP Annals keynote paper on *"Implementing Circular Economy Activities in Manufacturing for Environmental Sustainability"* (to be published in 2024) for STC A (Life Cycle Engineering and Assembly), and we are very proud of this fact. Publishing a CIRP Annals keynote paper is very exclusive and something that very few get the honour to do. These papers are also generally heavily cited and read.

■ **Mistra REES on LinkedIn** – During the year, we have kept up our visibility on LinkedIn with three posts per week (Monday, Wednesday, and Friday). We hope that you follow us and like us. We now have more than 800 followers, and the number continues to increase.

■ **The Government instructs the Swedish Chamber of Commerce to establish an advisory body to promote innovative and climate-focused standardization and VINNOVA to announce funding that prioritizes areas for standardization linked to business climate change** – (weblink). This is excellent news for Sweden and the rest of the world. Via our participation in the government's collaboration program Business Climate Change and their delegation for the Circular Economy, several of us from Mistra REES have advocated for this. Building knowledge within standards is a powerful way to disseminate and implement knowledge, not only in Sweden but worldwide. If we can help the rest of the world to develop more sustainable and circular solutions, we will win from this. It will support Sweden to further strengthen strategic areas and innovation related to, for example, circular business models and more sustainable, effective and resource-efficient solutions.

■ **Digitalize in Stockholm 2021 – Painting the digital futures – a vision of 2040!** – On the 21st of October, our program director, professor Mattias Lindahl, had the honour to, together with Cathy Yao Chen from ABB Corporate Research, Anna-Giulia Scaglia from Stena Recycling AB, Erik Svedlund from Epiroc and Somayeh Malakuti from ABB Motion, all Mistra REES partners, participate in a panel discussion about *"Digitalization for Sustainability"*. If you want to check out our discussion, click here.

■ **Designing Plastic Products in a Circular Economy** – In June, we organized, in collaboration with the Thailand National Metal and Materials Technology Center (part of the National Science and Technology Development Agency), a practical training course that was six days long, spread out over the month. The goal was to disseminate knowledge from our program to Thai practitioners involved in designing and producing plastic products to those involved in the end-of-life treatment of these in order to help them develop and produce better products, of which many are exported to Sweden. We had a number of guest lectures from, for example, *Mistra Steps*, *Polyplank* and *Volvo Car*. Other involved speakers were, for example, *Åsa Stenmarck, Senior Expert at the Swedish Environmental Protection Agency and National Plastics Coordinator*, and *Mattias Philipsson, CEO of Swedish Plastic Recycling*. The course was a huge success, and over 200 Thai practitioners (more than 40% from senior management and owners) participated – the goal was 50 practitioners – and they were very active.



■ **Mistra REES PhD student seminar** – During the year, we have continued to organize online seminars with and for our PhD Students. Many of us seniors have also joined those seminars. They have been greatly appreciated, and we will continue with them.

■ **Interactive workshop on public procurement of resource-efficient, circular, and sustainable solutions: challenges and findings** – On the 17th of May, we, together with the House of Innovation and *Misum* at the Stockholm School of Economics, the University of Örebro, and the University of Linköping, had this workshop. It is part of our ongoing collaboration between Mistra REES and Misum; see above.

IN MEDIA

■ **Debate article** – On the 29th of January, our debate article "Slöseri med kritiska metaller hotar svensk konkurrenskraft" (Waste of critical metals threatens Swedish competitiveness) was published in NyTeknik (Link to debate article). Involved from Mistra REES were Mattias Lindahl, Carl Dalhammar, Maria Ljunggren, Ola Alterå and Mats Philipsson, but also several partners within Mistra REES (Stena Recycling AB, Hitachi ABB Power Grids i Sverige, and BrightEco AB). We also involved people from Mistra Geopolitics.


NyTeknik

OPINION

"Slöseri med kritiska metaller hotar svensk konkurrenskraft"

2021-01-29 09:22

14 kommentarer

Senaste nytt

- Djupinlärning kan halvera byggnadens energiåtgång
- Lista: 7 värdelösa teknikprylar vi minns
- Hyundais nya robot kan promenera över hinder
- Test: "Stampa på gasen och få en spark i baken"
- Västerås får batterricentrum med Northvolts nya miljoner

Senaste från Ny Teknik Premium

Test: "Stampa på gasen och få en spark i baken"

Här är konfliktfrågorna i kärnavfallsbråket

Northvolt skickar hem halva arbetsstyrkan i Skellefteå

Mer förnybart i England med svenska svänghjul

Stöttas av giganter – nu

■ **Carl Dalhammar** was interviewed by the news agency TT about reduced VAT for the repair sector. Link to article.

■ **Mattias Lindahl** was one of the authors of a debate article in SVD about the chemical tax that strikes against reuse. Link to article. In relation to this, he was interviewed by Mistra about the chemical tax that counteracts the transfer to a circular economy. Link to article.

■ **Mattias Lindahl** was interviewed in an article by the Ministry of Enterprise and Innovation about climate-focused standardization. Link to article. In relation to this, he was also interviewed by Avfall Sverige about standardization as a means to speed up the transition to a circular economy. Link to article.

■ **Durability of dishwashers** – Mattias Lindahl was interviewed for SVT News regarding the durability of products, for example, dishwashers. This was a follow-up by the reporter

on an earlier reportage regarding mobile phones and remanufacturing – one that involved, for example, our former Mistra REES partner Inrego. When she did that reportage, Mattias Lindahl provided her with most of her data and also ideas about whom to interview and contact, for example, Inrego. Link to the program.

■ **At the end of July,** Mistra REES' PhD student Emma Johnson appeared at Rapport, in an SVT news report about renting clothes. She contributed with conclusions from her research on the rental vs. traditional purchasing business models.

■ **Debate article in Aftonbladet the 27th of December 2021** – "Våra prylar måste gå att reparera och återbruka" – This debate article was written by Carl Dalhammar från Mistra REES and Professor Oksana Mont, member of Mistra REES Phase 1. Its focus and message are that our gadgets must be repairable and recyclable. It highlights the fact that many products are wasted every year. They conclude that if we are to change this, consumers need political support:

- we need to see the expansion of producer responsibility as a standard alternative for all goods, not just for individual product categories such as electrical products.
- existing warranties must be extended to stimulate changes in product design
- In order to facilitate repair and remanufacturing as well as information to consumers, each product must have a passport describing what its intended service life is and where it has and should be repaired and upgraded


AFTONBLADET

START SPORT NÖJE PLUS TV TIPSA KULTUR LEDARE

HÅRLIGT HEMMA

Våra prylar måste gå att reparera och återbruka

Konsumtionsforskare: Varje år tillverkar Sverige möbler för 23 miljarder, vilket leder till utsläpp av 150 000 ton koldioxid

Detta är en debattartikel. Det är skribenten som står för åsikterna som förs fram i texten, inte Aftonbladet.

REES Design Supports at a Company Level

This project aims to co-create knowledge with the partner companies so as to improve design supports on products, services and business models. Scientifically validated, and actionable knowledge in these areas that can be used to improve resource efficiency in the circular economy context is still largely absent, yet much needed for the Swedish manufacturing industry. Such knowledge is of paramount importance in today's dynamic business environment, because it will help the companies effectively and efficiently develop their business models, products and services for higher resource-efficiency. In the second year of the Mistra REES research program (2021), the researchers of this project and the partner manufacturers joined forces to deliver results despite a suite of challenges related to the pandemic.

At a practical level, specific achievements are highlighted. First, one partner embarking on new efforts towards carbon neutrality was supported in work to accelerate transformation of their business models as well as design of products and services based on lifecycle assessment (LCA) results. A second manufacturer working towards the launch of a product-as-a-service offering stated "REES helped us to develop a calculation model, much faster and much more realistic than we can do on our own" and "I believe the combination of [the partner's internal initiative] field approach and REES scientific power will help us transform to circular faster than expected".

Shifting focus to scientific knowledge, a PhD thesis was published that addresses circular economy implications for resource efficiency and operations via simulation of a shift to service-based offerings. Five journal papers were published that delivered:

- analysis of emerging circular business models for electric vehicle Lithium-ion batteries in Swedish industry;
- environmental impact scenarios for product-service system models for clothing;
- future insights into how digitalization and big data analytics can facilitate remanufacturing;
- validation of a new way to plan and control remanufacturing processes using loosely coupled systems; and
- a comparison of design support needs between large companies and smaller enterprises as they pursue more effective and resource-efficient offerings.

This project is proud of the achievements thus far based on this transdisciplinary approach and will continue to create actionable knowledge built from scientific research for the Swedish manufacturing industry as a contribution that accelerates transformation to a more sustainable form.

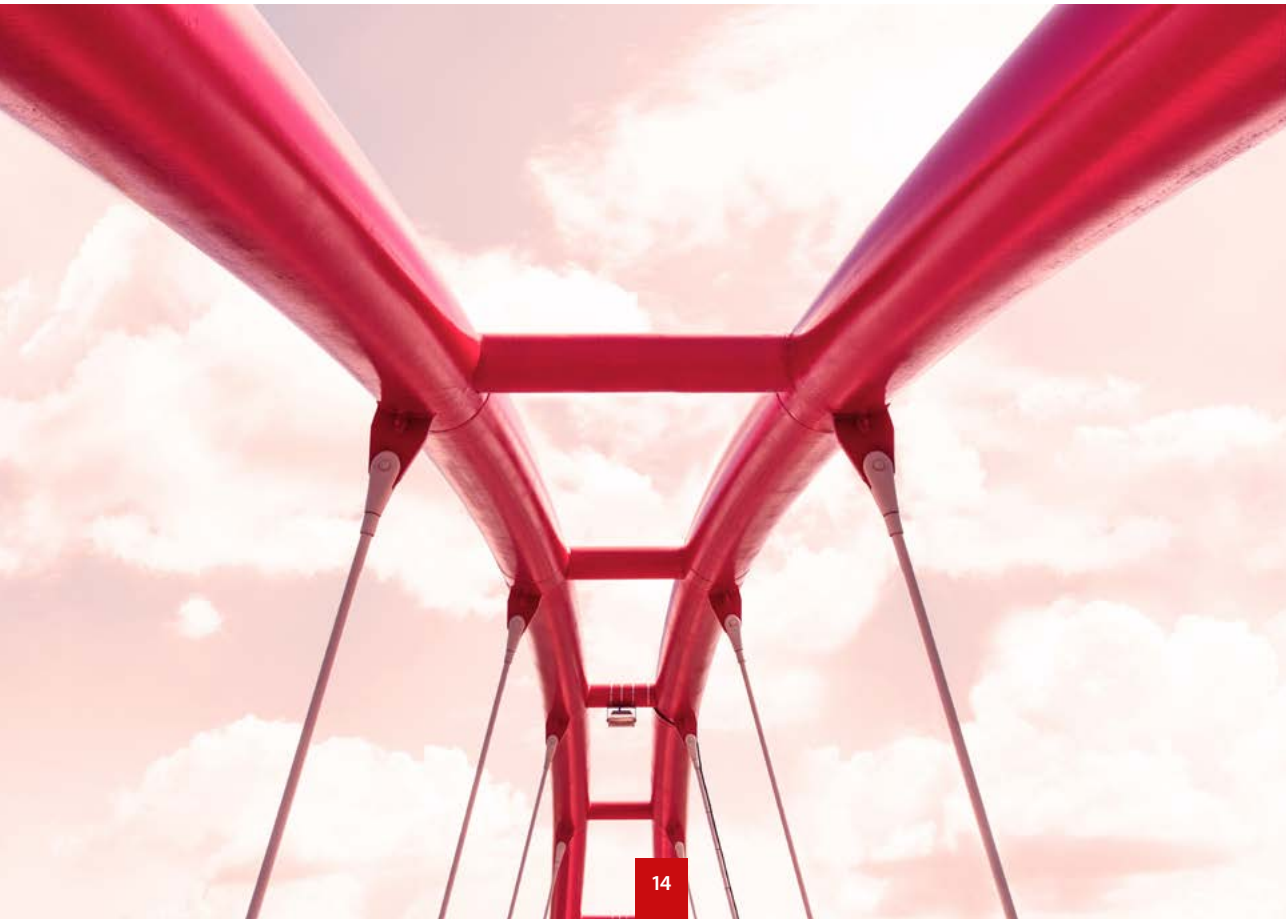
Policy and Laws Affecting REES in Companies

Project 2 deals with public policies, such as laws and taxes, and their role in supporting the societal transition to a circular economy. The research has evaluated various public policy interventions, their expected effects, and analyzed what kind of policy interventions could support circular business models.

In 2021, we published several papers related to the general framework conditions for adopting and upscaling circular business models. For instance, the paper "*Overarching policy framework for product life extension in a circular economy – A bottom-up business perspective*", gathered evidence from several companies in different industry sectors to analyze how public policies could support circular business.

Regarding economic framework conditions, the paper "*Towards a Circular Economy Taxation Framework: Expectations and Challenges of Implementation*" looked at various options to make the taxation framework more "circular" and how taxes can be implemented to have a complimentary effect.

One paper dealt with how re-use of white goods can be supported if re-users take products from waste streams and recondition them. The paper also analyzed legal issues that are important for brand owners. For instance, if a re-user reconditions a product and sells it on the market, the brand owner requires the re-user to take over legal liabilities for the product.



The papers in the project also dealt with other important circular economy topics, such as policies to promote consumer repairs of broken products, the barriers for consumer repairs, and the emergence of markets for spare parts. There was also cooperation with Project 1 on an article about circular business models for electric vehicle lithium-ion batteries.

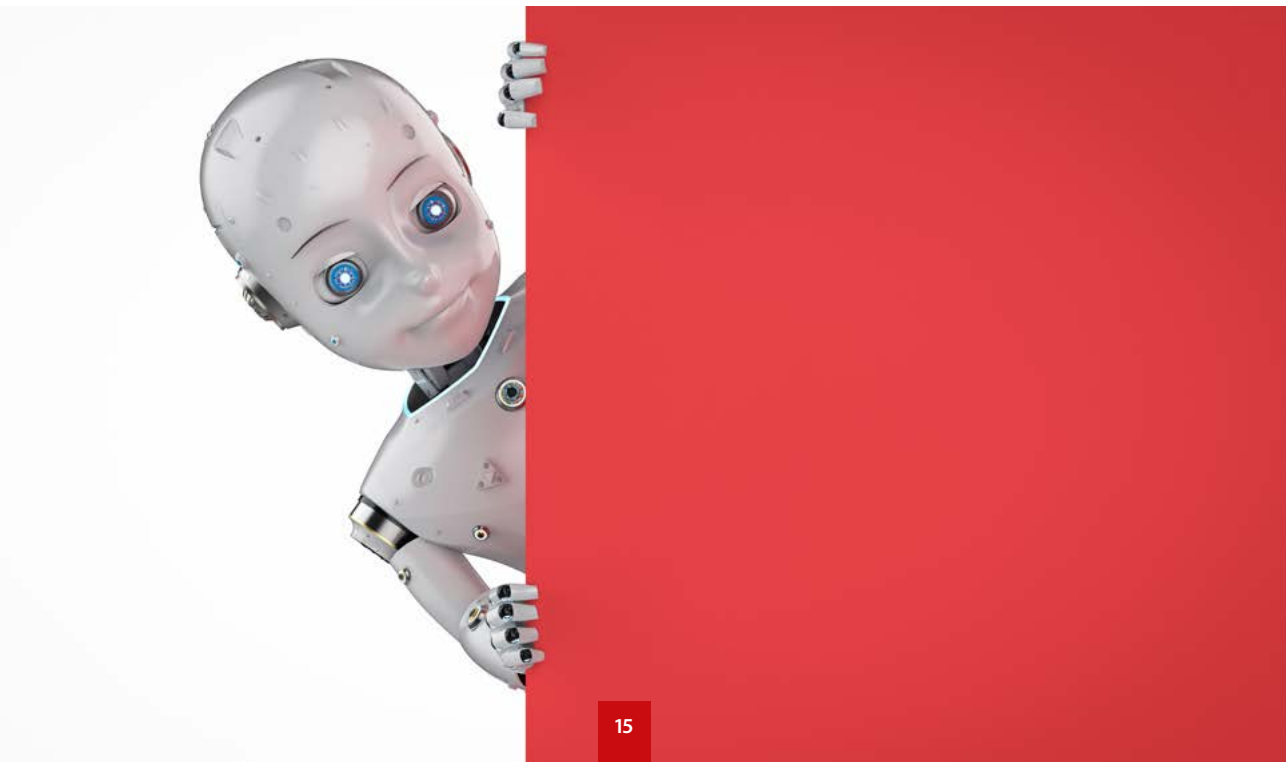
REES researchers Leonidas Milios and Carl Dalhammar have also been involved in publications for policymakers. This includes one report on policies for longer product lifetimes, published by the Swedish Energy Agency, and a report on challenges when using recycled plastics in electronics (with focus on toxic substances), published by the Nordic Council of Ministers.

Regarding outreach, REES researchers have been invited speakers at several events. This has included speeches at the NOVA consumer conference. Two papers were presented at ERSCP conference in Graz. REES researcher Carl Dalhammar was elected board member of Re:Source, one of the national Swedish strategic innovation programs, which funds many circular economy projects. He was also appointed as a member of two new working groups under the Swedish Delegation for Circular Economy. Carl has also been interviewed in Swedish media about a proposed Swedish VAT reduction for the repair sector.

Environmental and Financial Assessment of REES

Environmental impacts

The circular economy, CE, can involve, for instance, recycling, reuse, increasing efficiency in production, or extending product lifetimes, and is expected to increase resource availability and reduce environmental impacts such as climate change. A crucial task for our research is to provide support to companies and public policy makers so that they can develop circular strategies with high potential and implement them in ways that realize these potentials. Through syntheses of research findings on circular strategies combined with case studies using indicators, dynamic material flow analysis, criticality assessment and life cycle assessment (LCA), such support is developed. A selection of research results and outreach during 2021 follows.



One of the main contributions of the doctoral thesis "Towards empirically grounded guidance for resource efficiency" was a novel adaptation of LCA, namely the business model LCA in which the business model itself is made the unit of analysis. This allows companies to assess the environmental impacts of business models. The key innovation on LCA methodology is the development of a functional unit that captures the economic performance of a business and links it to a product system. Companies can directly see the impact of business decisions on their environmental performance and plan their activities accordingly. When applied in a case study, results indicate that the company can achieve more decoupling of environmental impacts from economic profit by renting jackets instead of selling them.

When developing circular products and services, it is appealing to use indicators since they are usually not too time consuming to compute and simple to communicate. But the broadness of the CE concept means there are many ways to measure progress, which has subsequently led to the development of a multitude of different indicators. For instance, more than 30 indicators have been suggested for assessing the resource-related effects of implementing the CE at the product level. A review of indicators for CE, Mapping and testing circular economy product-level indicators: A critical review, clarifies how existing product-level indicators differ. Indicators can show conflicting outcomes when assessing the same product, and that they do not necessarily align with the results of environmental assessments such as LCA. A visual tool, based on a flowchart model, is provided to easily understand which flows and processes involved in a product system are captured or left out by an indicator. The visual tool facilitates the selection of indicators is presented in the study, which also provides general recommendations for both the selection and further development of CE indicators.

During the year, two extensive case studies were initiated – one on comparing the envi-

ronmental impacts of two large industrial electric motors, one on assessing the potential for reuse and recycling in a battery as a service system. Both are performed in close collaboration with Swedish manufacturing companies operating globally, ABB and Epiroc, respectively. Such case studies enable mutual learning between researchers and company partners. This was also the case for the two Master thesis projects in which environmental impacts of a mine hosting system and an automated testing offered by ABB.

Partly building on research on criticality performed in Mistra REES, an international team held three online courses on criticality assessments in 2021, funded by EIT Raw materials. The three courses were directed to Master students, professionals and PhD students, respectively and attracted close to 100 participants from Europe, Asia and South America.

Financial impacts

The financial performance perspective of circular business models, such as resource-efficient and effective solutions, is an emerging research area (new to Mistra REES Phase 2), where financial performance and method development will continue to be important tasks for facilitating the transition to circular and resource-efficient and effective solutions.

Two PhD students have been hired to WP3 – Financial Implications. In Mistra REES Phase 2, the PhDs are planned to write and defend two Licentiate theses. The PhDs have almost completed their coursework during 2021. The PhDs licentiate theses will be based on empirical cases with Mistra REES partners.

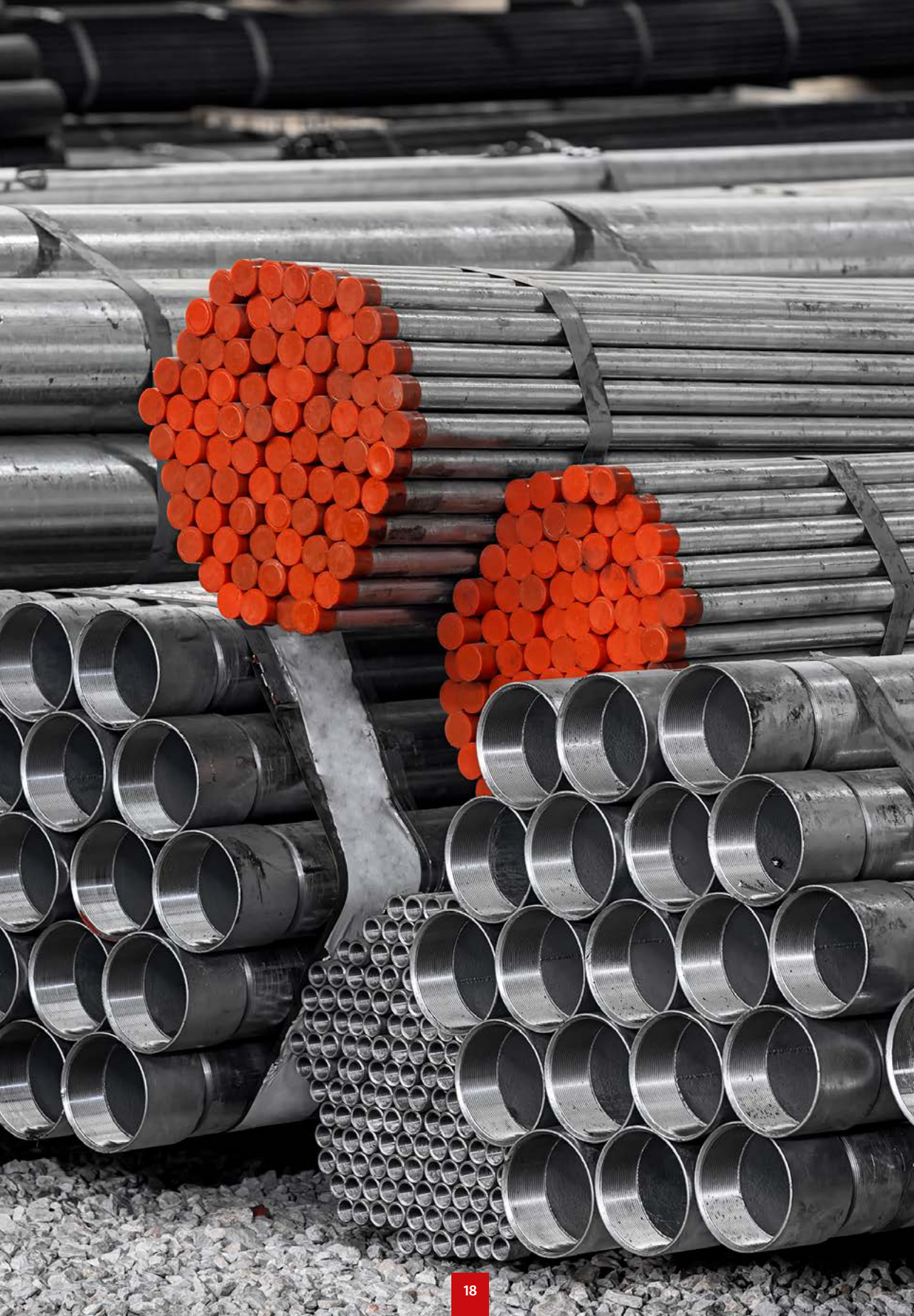
One PhD has been working with two in-depth case studies cases with ABB and selected customers. One case (VMH) is centred on a novel circular business model for sharing standardized low-voltage motors and financial performance. The other case (HEM) is focusing on circular offerings and financial performance of more customized high-efficiency, high-voltage motors. Later, the results of the two cases will be the foundation for a licentiate thesis.

The other PhD student is also working with two in-depth case studies. One case at Volvo Construction Equipment. The case is about financial performance/LCC of CBM in an Electrical Material Handling context (EMH). Several customers are also included in the project, e.g., Stena Recycling and Cementa/HC Miljö. The other case is at Epiroc/Rocvolt and is focusing on the financial performance of an emerging business model "battery as a service" and the electrification of mining equipment. Later, the results from the two electrification cases will be the foundation for a licentiate thesis.

One of the PhDs presented a systematic literature review paper "*Understanding financial performance facilitate the transition towards Circular Business Models – Insights from a literature review*" two times during the autumn. First at an internal Mistra REES seminar, and thereafter at a PhD Conference 16th of December. The PhD student is finalizing review comments from the conference and will submit the paper in the near future. An extended abstract of the paper has also been submitted to the International Sustainable Development Research Society (ISDRS) Conference, to be held in Stockholm, June 2022.

At the end of 2021 the board of Mistra REES decided to make a further contribution of SEK 500.000 as a strategic activity to do more research on circularity, financing and financial performance in small and medium sized enterprises (SMEs). Initially, we have started up a master thesis in the new SME-project: "*Financial challenges of the circular economy for SMEs*".

Two Mistra REES master's theses, one graded with "passed with distinction", were successfully presented and defended in June: "*How does the cash flow change in the event of a shift to functional sales? – Financial implications due to responsibility for the entire product life cycle*" and "*Access without owning – Incentives and barriers that affect the development and implementation of functional sales in retail industry*".



Six Principles for a Circular Economy

Mistra REES is taking an active role in developing and crafting a new set of ISO standards regarding the circular economy, e.g., its definitions, principles and how to design it. In relation to that work, still in progress, we present six simple principles that can make our economy more circular.

The greatest danger in times of turbulence is not the turbulence itself; rather, it is to act with yesterday's logic. We all should be concerned about this, especially given the current environmental turbulence we are now experiencing. The circular economy is a logic based on, e.g., systems thinking, value creation, and a focus on resources, which has shown an acknowledged potential to contribute to a more effective, resource-efficient, sustainable, and circular society.

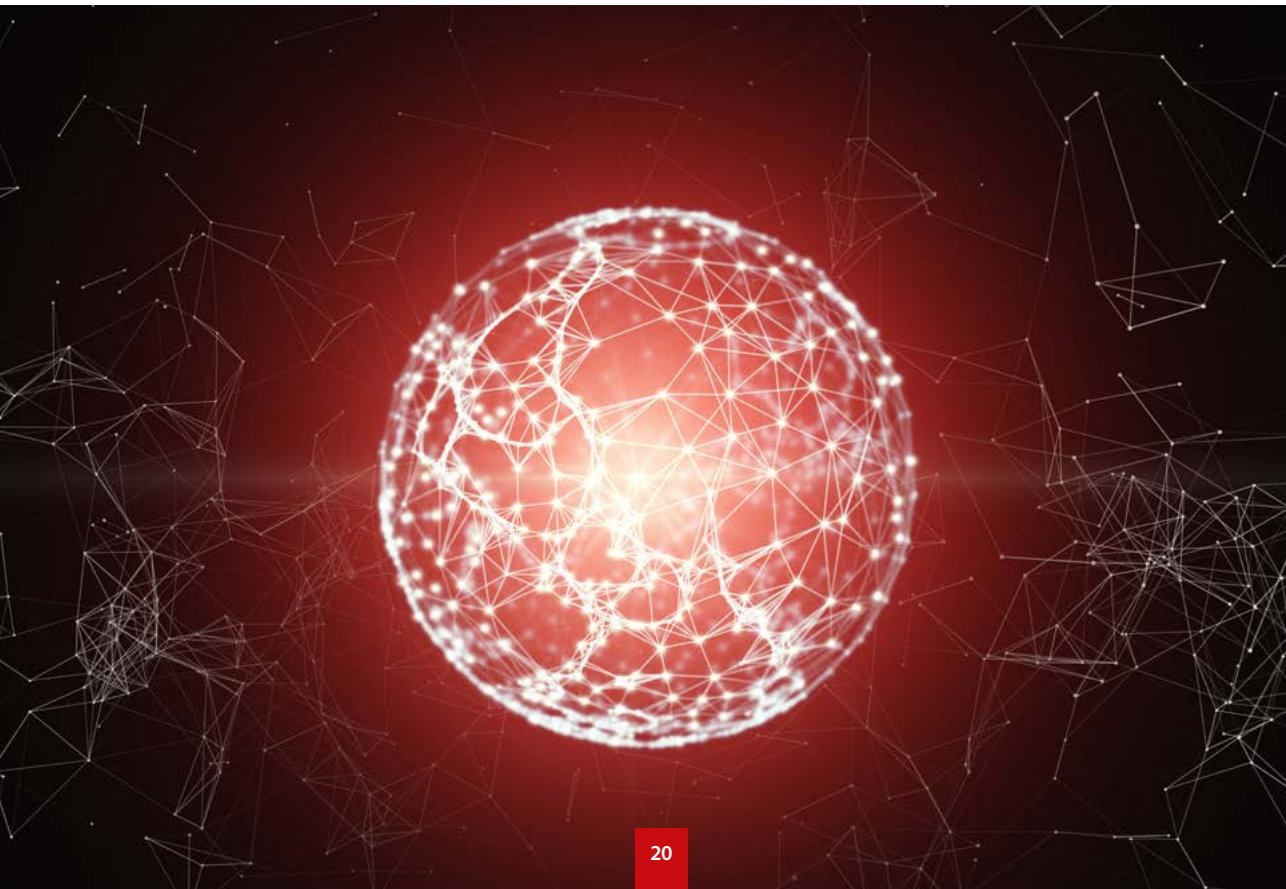
While there is still no well-established definition of the circular economy, the ISO is now developing one and a related set of standards. Based on this work so far, the circular economy can be defined as "an economic system that uses a systemic approach to maintain a circular flow of resources, by regenerating, retaining or adding to their value, while contributing to sustainable development". Value is experienced gain(s) from satisfying needs and expectations in relation to the use of resources.

Today's society is based on linear logic and principles that have neglected the fact that our resources are not unlimited and that our use of resources, especially our way of using them, causes numerous unwanted and negative environmental effects. The logic and principles for the future must be designed to prevent those negative effects. Therefore, in line with the definition of the "circular economy", we ought to design based on a systems thinking approach and the following interlinked set of principles. Each principle focuses on a specific dimension of the system that, in combination, makes a more sustainable economic system.

- **Systems Thinking** – Apply a long-term systems perspective considering the impacts of interactions among environmental, social, and economic systems, considering the life-cycle perspective of solutions.
- **Value Creation** – Regenerate, retain, or add value by providing effective solutions that efficiently use resources and contribute to meeting the needs of society.
- **Value Sharing** – Organizations and stakeholders collaborate along the value chain or value network inclusively and equitably for the benefit and well-being of society by sharing the value created with the provision of a solution.
- **Resource Availability Focus** – Manage and regenerate stocks and flows of resources in a sustainable way to contribute to their availability for present and future generations and continue to regenerate, retain, or add value while securing the quality and resilience of ecosystems.
- **Resource Traceability** – Manage and track stocks and flows of resources in a transparent and accountable way so that they continue to regenerate, retain, or add value while maintaining the circular flow of resources.
- **Ecosystem Resilience** – Develop and implement practices and strategies that protect and contribute to the regeneration of ecosystems and their biodiversity, considering the planetary boundaries.

The principles above are short and clear. Now it is up to us to implement them and break with yesterday's logic. Do you dare not start the journey towards a more effective and resource-efficient, sustainable, and circular society?

Mattias Lindahl, professor and program director Mistra REES



After the dissertation: Max leads Alimak's climate work

On Thursday, Max Bäck presented his degree project – from a hotel room in Croatia as well – and on Monday he started his new, permanent job. Now he is involved in leading the environmental work in a large Swedish engineering company. A good transition from school to professional life, he thinks.

Big differences

In the master's thesis Generating Product-Service Design Improvements from a Climate Impact and Energy Use Perspective Using Life Cycle Assessment – The case of Vertical Access Equipment, Max Bäck and co-author Vishnu Teja Tirumalasetty investigate the climate impact of three different elevators and a so-called BMU (Building Maintenance Unit) from the company Alimak Group.

With life cycle analyzes, Max and Vishnu have partly calculated how large carbon dioxide emissions are wwith current production and service, and partly how various improvement measures could reduce the climate footprint. And there are no small differences – 32 percent less greenhouse gases where the difference is least and 68 percent where it is greatest.

– If you make the right changes and find customers who are willing to pay a little extra, you can eventually come down to zero. But it is a huge change and will, in that case, take time, says Max Bäck, who studied in the Industrial Economics program at LiU.

Max Bäck's calculations of carbon dioxide emissions have a dual purpose. It will be a kind of product declaration that is communicated to customers, and it will be a driving force for lower emissions in the future. To the left, one of the construction lifts that Alimak Group manufactures.

First issue

An important conclusion in the thesis is that different measures are differently effective for different products. It is not so simple that materials and transport mean the most in all cases. For any product, higher efficiency in use is recommended in the first place, for another longer service life and for a third remanufacturing and use of recycled materials.

For service lifts for wind turbines, maintenance is the most critical. The shorter and more efficient the service can be made, the less the climate impact will be. Alternatively, the service may be automated or digitized.

– If it is a person who performs the service, the wind turbine must be stopped in the meantime, and then the energy must be produced elsewhere. This was a rather surprising result and something we had not expected from the beginning, says Max Bäck.

The degree project is carried out within the framework of the research program Mistra REES, which is led by LiU and conducts research on the circular economy. After a couple of months, Max received an initial request regarding if he was interested in starting work at Alimak Group after graduation.

Tips for others

Then discussions followed back and forth via email before he finally accepted the offer. Among other things, he wanted to make sure that the company was really serious about its environmental work. When the dissertation was presented digitally, Max Bäck was on holiday, hence the hotel room, and a few days later he started his new job.

– I started working in October. It was a very nice transition from study to work, he states.

Lecture for employees at Alimak.

At Alimak Group, Max has the title "lead engineer sustainability" (roughly "responsible sustainability engineer") and reports directly to the technical manager in the company management. The assignment is, simply put, to continue the work from LiU – in the long run, all Alimaks Group's products will be climate calculated and possible changes assessed.

So far, the work has taken Max to Alimak Group's factories in Germany, Spain and Skellefteå. Exciting, of course.

– Not least Skellefteå is interesting due to the proximity to the large investments in fossil-free steel that are made up there. This means short transports in the future.

You are young and newly graduated and have directly been given a leading role in the environmental work in a large engineering company. How is it working out?

– I have been very well received. The individual factories have worked with this before but not to the same extent. Now the company has brought the work up to a common, central level. The factories are also usually happy when I come and present a clear way to go where I will have a supportive role. I guess people would not have been as positive if they made various demands without having a clear action plan.

Do you have any tips for others who are going to do a dissertation?

– Yes, try to find something that you are really interested in, it is a big job that takes a long time. Then try to find a company with the same focus and needs. And then have close contact with the company, especially in the beginning, so that you know that what you are working on is really what the company needs.

Visiting Alimak Group's Spanish factory.


Elevator for maintenance in wind turbines. Here, the time for maintenance is critical from an environmental point of view.

ABB – collaboration is the key to sustainable success

Long before sustainability was taken seriously by any company with a vision for the future, it was anchored on the agenda at ABB. This global technology company is driving the transformation of industry and society to achieve a resource-efficient and sustainable future.

ABB has been working strategically with goals in sustainability for 30 years. Resource efficiency and circularity are an extremely important part of our sustainability strategy. The goal is for 80 percent of ABB's products, solutions and services to be covered by the framework for circularity by 2030 and the company's progress to be measured with a number of key figures.

Lena Westerholm,
head of sustainability at ABB in Sweden

To help conserve the earth's resources for future generations, ABB is taking a holistic approach to the circular economy. The company is happy to take on the leadership jersey for Swedish industry, but also in the global arena for sustainability. To succeed, collaborations and exchanges of knowledge with both the corporate and research worlds are required.

We have done a lot together with Mistra REES. The rewarding collaboration within the research program teaches us to realize and concretize the ambitions we have when it comes to the circular economy. Mistra REES helps us to realize our sustainability strategy and to build circularity into our customer offering.

Lena Westerholm emphasizes that ABB is happy to share experiences and knowledge in the area of sustainability in order to manage our joint transition to a more sustainable society.

We must work together, be humble and learn from each other. Several companies that are part of Mistra REES are also our customers. Through the natural exchange we have through the research program, we also strengthen our other collaboration with each other. Equally important is that it contributes to consensus within circularity, which facilitates the way forward. It is important that we communicate with a common language. We need to understand our customers in order to be able to offer what they need for a sustainable business.

ABB's technology enables their customers to reduce their emissions and manage their resources better. Lena Westerholm points out that "it is a great challenge we face, and the company must do even more together with customers, suppliers, partners and consumers to succeed."

As a partner in Mistra REES' research program, ABB is involved in several ongoing projects. Peter Isberg, digital leader for ABB Motion, concretizes the collaboration with innovation in, for example, spare parts management.

It is an incredibly complex project where we have worked for a year together with qualified graduates in the research program, and only now are we starting to complete the business model. It is basically a completely new model for spare parts handling from a more sustainable perspective compared to traditional handling. You could say that we are trying to apply a business model for the sharing economy.

Peter Isberg

The process industry needs access to spare parts to ensure availability for production in case something goes wrong. Today, companies lock a lot of capital into spare parts that may never be used. This has both environmental and economic consequences.

We are working to develop a more resource-efficient model. It aims to increase the turnover of spare parts so that they are used within a reasonable time. We have a strong sustainability factor, but it is also an economic issue.

Peter Isberg sees significant benefits in the in-depth collaboration with the research program:

We have great help from Mistra REES in this project. Not least as a sounding board when we get stuck. We brainstorm ideas with each other and are innovative in this thinking. Therefore, it is interesting to include the academic thinking in the process. This business model can also be cloned into a completely different set of products in the rest of the world. We want to contribute with knowledge about the problems. We only see opportunities in terms of resource efficiency and the circular economy. Challenges must be tackled and solved.

Brighteco – for a Bright and sustainable future

Joel Smedberg's company Brighteco is developing a new way of looking at light – selling it as a service. Running the business commercially is a prerequisite for success, but Joel is driven above all by bringing about sustainable change.

Light is just the beginning… There is much more than lighting you can imagine selling as services instead of products to use in real estate. Everything from acoustics to ventilation. You can see Brighteco as a kind of action research company. Through the collaboration with Mistra REES, I can discuss challenges and opportunities with a party that understands where I want to go.

Joel Smedberg,
CEO and founder of Gävle-based Brighteco

Joel Smedberg had a bad conscience and realized one day that he wanted to put an end to the unsustainable "madness" of constantly buying new stuff. Partly for his own part, but also in a larger perspective.

I see it as my duty to do what I can as a counterpoint to the huge waste of resources, to find new ways towards a circular economy. Why, for example, buy new lamps when you can instead lease lighting as a service?

Sustainable solutions for the future require innovations and new ways of thinking. For example, to think of function instead of product. Joel Smedberg enthusiastically talks about his passion for sustainability and recycling, which has been channeled and developed into a company that offers Light as a service. To date, a number of municipalities and real estate companies have signed up for the innovative service.

We want to accelerate the shift to a more sustainable whole. Instead of buying new, the customer subscribes to lighting at a fixed price per month. This means that the lighting can be adapted and replaced in the future, at no extra cost. The customer no longer has to pay for the lamps themselves, but only for the light used. The service includes installation and maintenance of the lighting, and it is gentle on the environment as the lighting is largely made of recycled material.

Joel Smedberg

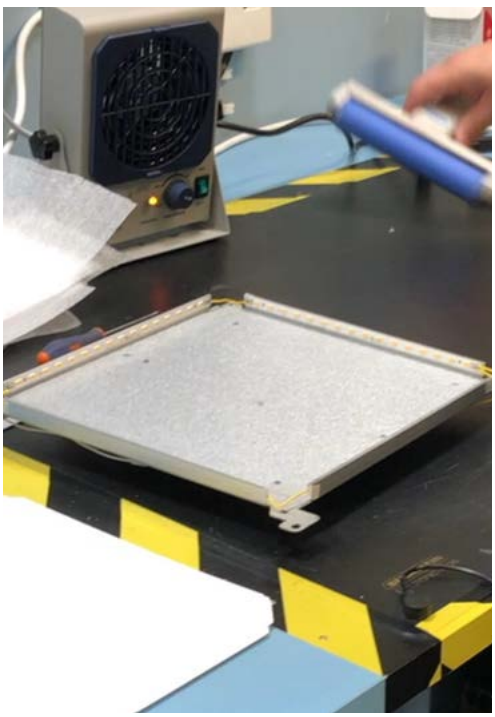
In collaboration with Samhall, Brighteco has a production line where they manufacture the luminaires used in the lighting. They use the optical components from old flat screens, but also parts from their own luminaires that have been taken out of use.

Joel Smedberg sees a very great value in having researchers within Mistra REES as a professional sounding board and support, above all to move forward on the legal level.

One of the big challenges for our development opportunities is the legal part. We map the possibilities within the legal framework. What are the conditions for selling functions such as lights, but also other functions instead of products? As I see it, basically everything inside the shell of a house can be offered as a function or service, even air in the form of ventilation systems. But according to the legal provisions in the Land Code, everything that is attached belongs to the property, which poses problems for a leasing-based solution. A fundamental change is needed here. This is what we are discussing together with Mistra REES researchers in law.

Joel Smedberg is considering further paths and discusses the taxation of goods and services. He sees it as unsustainably cheap to buy new things in relation to services.

With a different taxation – instead of high taxation on labor and low on goods – service companies like us would benefit. Today, it's all too easy to just keep buying new things. A circular change is needed for a circular economy.



Husqvarna – testing new model in the circular economy

With the help of a new business model for pricing developed by researchers within Mistra REES, a pilot project is underway at Husqvarna Construction. The goal is to increase reuse and extend the life of used machines.

Some parts of a machine wear out quickly, while some last a long time. It feels wasteful to throw products on metal recycling when they can work with partially new parts for a long time. Given the volumes involved, we see opportunities for a major environmental boost, but also challenges.

Stigbjörn Juhojuntti, project manager with a focus on sustainability issues

The multinational Husqvarna Group, where Husqvarna Construction is one of three divisions, has long been at the forefront of its sustainability focus on the road to a resource-smart economy. The circular economy is a central part of the acclaimed Husqvarna's sustainability strategy.

Stigbjörn Juhojuntti points out that the collaboration with Mistra REES, which began with the start of Phase 2, works very well and also has the potential to be further expanded. As a concrete example, he highlights a global development project that aims to extend the life of handheld machines.

A colleague at Husqvarna Construction is working on a pilot project for cutting machines that cut into concrete and stone. He is also investigating whether the project can be switched up with other machines in the same segment. Say a machine stops working because some parts are worn out. For this reason, the entire machine should not need to be discarded. Instead, parts can be replaced and the machine resold, as used but of course with all safety requirements met.

Stigbjörn Juhojuntti

This is where the collaboration with Mistra REES comes into the picture. Researchers in the program have built up an economic model for pricing both used and new parts, a business model that can be applied to different products. This is to get an accurate price picture of the used product when it goes on the market again.

Our customers are professional users. Contractors are not so dependent on the price, but buy new ones out of old habit and to feel confident that the product works. When it comes to larger and more expensive machines, however, it is accepted to replace parts instead of buying brand new ones. It is important to get that thinking in even when it comes to smaller machines, where the large volumes are available. The challenge is to bring our customers fully with us to bring about a full-scale change.

Stigbjörn Juhojuntti is considering whether legal requirements can speed up the transition to a circular economy. He can imagine that in the future, there will be requirements for products to contain recycled or bio-based material to some extent. Within Husqvarna, a number of projects are underway to investigate whether fossil-extracted plastic can be replaced by biological plastic material.

We have a lot of projects underway in sustainability that will roll out until 2025. Here I see opportunities for further collaborations with Mistra REES. We have ongoing discussions about getting help from researchers within the program to develop a basic thinking in our employees, where they design products with sustainability in focus. It may be too easy to choose the material you are familiar with instead of a renewable but untested material. But then there will be no change.

Project manager Stigbjörn Juhojuntti

Volvo CE values long-term collaborations with academia

Volvo Construction Equipment (Volvo CE) is currently working on defining new ambitions for the circular economy. The collaboration within Mistra REES is part of this, where leading researchers contribute valuable insights and knowledge. In exchange, researchers gain unique insight into the industry's challenges.

Volvo CE strives to create and strengthen long-term collaborations, which clarify both the academic and industrial benefits of the joint research studies. The case studies that Volvo CE has contributed to Mistra REES have been identified thanks to this type of collaboration.

We at Volvo CE want to be active participants in research that affects us and helps us build a better tomorrow. By doing research together with academia, instead of being passive research objects, we get a better exchange and increased learning.

Volvo CE targets zero emissions by 2040

Anna Sannö is coordinating the Mistra REES collaboration at Volvo CE. Her formal title is Research Strategy Manager at Volvo CE Advanced Engineering department. This means managing the research portfolio with external partners, including collaboration with partner universities. Her work is strategically important for Volvo CE, and a key to their ability to achieve the global sustainability goals. Volvo CE is committed to achieve net-zero value chain emissions by 2040, with significant emission reductions as early as 2030. The target of net-zero value chain greenhouse gas emissions by 2040 is a united commitment for Volvo Group across all business areas. Volvo products have an average lifetime of 10 years in the customer use-phase, so for the entire rolling fleet to have net-zero emissions by 2050, it is necessary that all products delivered after 2040 have net-zero emissions..

Within Mistra REES, Volvo CE contributes with several concrete case studies that are used for joint exploration of the circular business models of the future. However, the technical and business details of the case studies are confidential. Instead, Anna highlights other aspects, where the collaboration within Mistra REES has made a big impression.

We are happy to take part in the broad platform that Mistra REES offers. The collaboration with the research groups within Mistra REES has given a lot, and we want to continue to build on this. The value lies in the dialogue that is established between industry and academia.

Valuable input to academic research

An example of the type of collaboration that Volvo CE values is a study done by a doctoral student, Amal Kanzari, and her supervisors Josefin Rasmussen and Henrik Nehler at

Anna Sannö, Research Strategy Manager at Volvo Construction Equipment.

Linköping University. Amal has studied the financial implications of new circular business models based on a concrete case study from Volvo CE and has seen the benefit of including Volvo in the study:

Collaborative research with Volvo CE means a valuable and reliable input from a global pioneer in sustainable innovation. This is crucial for advancing both research and industry.

Her PhD supervisors Josefine Rasmussen and Henrik Nehler, see academic-corporate relationships as a possibility for win-win opportunities. Josefine comments:

As a researcher, you get the possibility to learn directly from the company's experiences. The results from our analysis can then help companies in various ways. In this case, we contribute our knowledge to developing new circular business models. Both academia and companies like Volvo CE have a responsibility for the sustainability transition, and collaborations like the one between Mistra REES and Volvo CE are an important means in that regard. In addition to theoretical advancements, we as researchers should also contribute with constructive knowledge that is useful in practice and can guide action.

Amal Kanzari (front), PhD student and her supervisor Josefine Rasmussen (background), assistant professor at Linköping University.

Commitment to Science-Based Targets initiative

Anna Sannö from Volvo CE also emphasizes the value of the collaboration and underscores the importance it has from a strategic perspective for the company.

We clearly see the importance of building this type of environment, at the right time. The development is very fast now. In order to be transparent with progress and ensure a safe path to the goal, we have, for example, recently committed ourselves to follow the initiative for scientific goals (Science-Based Targets initiative).

Anna emphasizes that it is important for all actors to review their value chains so that the transition to a circular and fossil-free economy can reach full scale. The collaboration with academia within Mistra REES has enabled Volvo CE to identify not only organizational and business changes but also changes that are needed at the societal level. This will soon lead to new initiatives and collaborations.

Links:

Beyond academia: how to select your first scientific role in industry
(Nature careers podcast)
Link to article

Volvo CE Science-Based Targets initiative:
Link to article

Volvo Group commits to Science-Based Targets initiative:
Link to article

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MISTRA REES – Resource-Efficient and Effective Solutions based on a circular economy thinking is a research program run by a consortium of leading Swedish universities, large and small companies etc.

The vision of the program is to accelerate the transformation of the Swedish manufacturing industry towards a circular and sustainable economy.

Mistra REES
Linköping University
581 83 Linköping

www.mistrarees.se

Contact

***Mattias Lindahl*, Programme Director**

mattias.lindahl@liu.se
Tel: 013-28 11 08

***Theresa Apelqvist*, Programme coordinator**

theresa.apelqvist@liu.se
Tel: 013-28 11 78

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