

Mistra REES Annual Report 2016

# Heading for the Future!

Advancing the Swedish manufacturing industry  
through solution-oriented science

Linköping University, Lund University, Chalmers University of Technology  
Attends Healthcare, Din fabrik, Ericsson, Godsinlösen, HTC Sweden, Inrego,  
Lund municipality, Malmö municipality, Off2Off, Polyplank, Qlean Scandinavia,  
Ståthöga MA teknik, Stena Recycling, Stpln, Volvo Car Group, & Volvo Group



**Mistra**  
Resource-Efficient  
and Effective Solutions  
based on circular economy thinking

## A PROGRAMME WITH POTENTIAL TO MAKE A DIFFERENCE

Industrialized society has long been dominated for the most part by a linear way of production and consumption in which raw materials are used to manufacture materials and goods that are sold, then used and finally discarded as waste. However, most of the resources required for making a product exist on a limited scale. There is thus an urgent need for substantial improvement in resource utilization and performance, to seek better ways of using and reusing products and their components, and to restore more of the material, energy and labour inputs. This means that major demands are increasingly imposed on industry to design products that are as energy saving and resource efficient as possible, not only during their production phase but throughout their whole life cycle.

A circular economy is the logical solution for a resource-constrained world. It's a place where almost nothing is wasted, where the re-use and remanufacturing of products has become standard practice, and where sustainability is built into the fabric of society. While the concept of a circular economy has been discussed since the mid-1970s, the urgency of changing direction from a linear model to a circular model is now finally very much in focus. For example, the European Commission's 2015 Circular Economy Action Plan put the circular economy at the core of EU sustainable development policy.

The main objective of the Action Plan is to change the different stages of the life cycle of products and services, namely 1) design, 2) production, 3) consumption, 4) waste management and 5) secondary materials treatment. This ambition is set to be achieved by amending relevant legislation and introducing new legislative initiatives. The transition toward a circular economy will also be a main EU measure to achieve European commitments under UN Sustainable Development Goals (SDGs). In November, 2016, the European Commission set out its strategic approach for achieving sustainable development in Europe and around the world; this will entail, for example, mainstreaming the SDGs in the European Policy Framework.

From the manufacturing industry's perspective, the right business and design model would enable products to stay in the economy many times longer than today, and utilization rates of everything from cars to consumer goods could increase up to ten times using innovative sharing models. To achieve this, products and services need to be designed for resource efficiency building on a life cycle perspective. New methods to reuse, repair, remanufacture and recycle products and their components need to be found in order to re-enter their next use phase.

While there are many actors in Sweden that are active in the broad field of resource efficiency, both in the business and academic sectors, there are very few coherent programs that look upon the issue from a broad perspective using a multidisciplinary approach involving several disciplines and stakeholders. The Mistra REES programme takes this approach, and it is my belief that the programme has great potential for producing results that will make an enormous difference in both the academic and business communities, as well as help politicians to amend current relevant legislation and introduce new smart legislative initiatives.

**Jan-Eric Sundgren**  
Chair of the board, Mistra REES



# Turning resource challenges into opportunities

■ It has been an intriguing and intensive year for Mistra REES (Resource Efficient and Effective Solutions), a cross-disciplinary research program with a unique bottom-up system perspective on the Swedish Manufacturing industry. Today, there are significant gaps in knowledge and practice with regard to developing resource-efficient, effective and circular solutions. Our program meets these challenges by gathering leading academic milieus, industrial companies and societal actors to co-create knowledge about more resource-efficient and effective solutions based on Circular Economy (CE) thinking. Our vision is to advance the Swedish manufacturing industry's transition towards a circular and sustainable economy, and to enhance its capability to develop world-leading, resource-efficient and effective solutions based on CE thinking through close collaboration, knowledge coproduction and mutual learning between industry and academia.

■ The CE and the issues covered by Mistra REES are on the agenda as never before. Over and over again, it is confirmed that what we do matters, and becomes more and more important to Sweden and its manufacturing industry. The European Commission's 2015 CE Action Plan, and not least the UN Sustainable Development Goals, are just examples of drivers, but also the manufacturing industries' own internal drive for these issues is increasing rapidly. More and more, Swedish manufacturing industries have started to see the business opportunities, e.g. due to cost savings by focusing on more resource-efficient and effective solutions.

■ The result of our program is advanced global sustainability leadership, improved competitiveness and reduced business risks in the Swedish manufacturing industry. It will further the research frontier on a CE by developing principles, methods and guidelines for product and service design, business models, and policy packages. The unique feature of the program is its focus on exploring opportunities for effective interplay between design, business models and policies.

■ To conclude, the recent year has been a very intriguing and intensive one, with an increasing interest in more resource-efficient and effective solutions, and we foresee that 2017 will continue on that path. During 2016 we contributed with several relevant and important findings and our result dissemination will increase, as will our interaction with Swedish manufacturing industries. We will also continue to actively search for relevant receivers, such as CEPS's Task Force: The Role of Business in the Circular Economy. We will also continue to be active in implementing research results in new international standards, e.g. the upcoming IEC/ISO standard about Environmental Conscious Design. We encourage you to follow our progress, and please feel free to contact us via our webpage for more information.

**Mattias Lindahl,**  
Programme Director Mistra REES



Researchers Mattias Lindahl and Christian Kowalkowski at Linköping University

# The Mistra REES programme

■ The programme's overall vision is to advance the Swedish manufacturing industry's transition towards a circular and sustainable economy. The programme brings together competencies from three different research areas, namely product and service design, business models, and policies, with the ambition to understand how these three areas are affected by and interrelated with each other.

■ Mistra REES has a bottom-up and case study-focused approach, looking at specific manufacturing sectors. The main focus is on the automotive, health care, and remanufacturing sectors. With this approach, REES researchers are able to gain a deeper understanding about the practical application and results of resource-efficient and effective business models, as well as related policies and product and service design methods.

■ The strong collaboration between academia and the participating companies fosters an opportunity to co-create, evaluate and implement outcomes from the programme that have clear added value for the participating business partners.

The collaboration will enhance the capability of the manufacturing industry to develop world-leading, resource-efficient and effective solutions based on circular economy thinking.

■ The Mistra REES programme consists of several projects. One provides a knowledge foundation by exploring under what conditions, and for what types of products and sectors, circular solutions are more resource efficient. It furthermore looks at the market and policy drivers and barriers. On this foundation, three projects focus on, respectively, product and service design, business models, and policies for resource-efficient solutions. Finally, a synthesis project investigates the interrelations and explores opportunities for effective interplay between the three projects.

■ Mistra REES is a four-year (2015-2019) research programme funded by Mistra with 42 MSEK. The three participating academic partners contribute with in-kind 9.5 MSEK, and 16 non-academic partners with in-kind 30.5 MSEK and cash 0.9 MSEK.



# Five themes covered in the REES programme

## Characteristics, Conditions, Drivers and Obstacles

aims to 1) investigate which physical means for resource efficiency are effective for which types of products and solutions, and in which respects, and to 2) map the drivers and barriers for their realization.

**Project leader:** Anne-Marie Tillman, Chalmers  
**Involved companies:** Attends healthcare, Din fabrik, Godsintösen, HTC, Inrego, Off2off, Stpln, Volvo Car and Volvo Group.

## Product and Service Design Methods

aims to develop methods for designing not only a product, but also services for REES in its early stages. The methods to be developed in the project will be generic, and thus applicable to a broad range of industrial sectors because of the greater impact on industry.

**Project leader:** Tomohiko Sakao, Linköping University  
**Involved companies:** Attends Healthcare, Ericsson, HTC, Inrego, Polyplank, Qlean, Stena, Ståthöga, Volvo Cars and Volvo Group.

## Business Strategies and Models

aims to improve understanding of the state of the art and advance the academic and practical knowledge on business strategies and business models for REES in Swedish industry.

**Project leader:** Andrius Plepys, Lund University  
**Involved companies:** Attends Healthcare, Ericsson, HTC, Inrego, Off2Off, Polyplank, Qlean, Stena, Ståthöga, Volvo Cars and Volvo Group.

## Policies

aims to provide an overview, analysis and recommendations for policy and policy packages of relevance for REES. It builds on knowledge created as part of the research in Project 1 about policies that enable, facilitate or act as obstacles for resource-efficient and effective business models, products and processes in Sweden, Europe and internationally.

**Project leader:** Carl Dalhammar, Lund University  
**Involved companies:** Din fabrik, Off2Off, Stpin.

## Interrelations

will enable the various elements of REES to be implemented in a more coordinated manner, enabling resource efficiency to be developed in a shorter time. The project will also identify future research questions of relevance, as well as formulate recommendations that facilitate REES in a circular economy.

**Project leader:** Tomohiko Sakao, Linköping University  
**Involved companies:** all that are involved in Mistra REES.

# Mistra REES financing (4 years, 2015-2019)

	Budget (2015-2019)	Outcome (2015-2016)
Mistra	42.0 MSEK	10.5 MSEK
Academic partners	9.4 MSEK	2.0 MSEK
Non-academic partners	29.8 MSEK	10.2 MSEK
Total	81.2 MSEK	22.7 MSEK

# One circular solution does not fit all

■ A measure that increases resource efficiency for one type of product can have exactly the opposite effect on another. The framework that researchers from Chalmers University of Technology have constructed is one step along the way to determining which methods for resource efficiency are best suited for which products.

Volvo Construction Equipment can achieve large savings in its use of resources with the new design of a fuel filter for its wheel loaders that can be cleaned and reused, instead of the current solution that uses disposable filters. In this way, a single filter could replace the 40 or so that are currently consumed during the lifetime of the vehicle.

For electronic equipment, reuse has the greatest impact on resource efficiency, particularly when considering the contents of scarce metals. Few scarce metals can be recycled with currently available methods.

■ In the case of disposable items such as incontinence protection, other solutions must be sought to reduce resource consumption, such as reducing the amounts of materials and energy wasted during manufacture. There may, however, be other solutions; a study is in its initial phase.

“There’s a big difference between incontinence products and wheel loaders. We want to be able to evaluate and specify which types of circular solutions are suitable for which types of products. We also want to identify the product characteristics that determine the measures to increase resource

efficiency that give the best results,” says Anne-Marie Tillman, professor at Chalmers University of Technology and leader of one of the seven projects in Mistra REES.

■ The group has drawn up a framework in which a number of measures to increase efficiency have been listed. The list includes, for example, sharing, which can increase the use of products that are seldom used, the marketing of services rather than products, remanufacturing, reuse within the same or a completely new area, the reduction of waste during production, and changes in the design of a product, such as using different raw materials. These measures are subsequently considered against the background of the characteristics of the product, such as its function, the sector to which it belongs, its degree of complexity, whether it consumes energy or other intermediate goods when in use, and whether it contains scarce or toxic materials.

■ Doctoral students Siri Willskytt and Daniel Böckin have subsequently carried out a pilot study, together with senior researchers Anne-Marie Tillman and Maria Ljunggren Söderman, in which they have used the framework to review studies of 17 products, some of them from companies participating in Mistra REES. The products and processes studied ranged from plastic wall plugs and drills to lawn mowers, lithium batteries, façade cleaning agents, and the production of milk.

Wheel loader from Volvo





- The research group has been able to draw the following preliminary conclusions from the pilot study:
  - Easy disassembly promotes remanufacturing.
  - Upgrading is sometimes important for remanufacturing.
  - Products with a long lifetime or low frequency of use are suitable for sharing.
  - Efforts to make consumable products resource-efficient need to focus on production efficiency and/or recycling.
  - Repurposing is a good option in some cases.

“In contrast with other research in this field, we are carrying out a bottom-up investigation and are trying to draw conclusions from as many case studies as possible in which the resource efficiencies of various solutions have been examined. Many other projects take a top-down approach and investigate global flows of material, or the flows within certain countries or sectors”, says Anne-Marie Tillman.

- “We don’t yet know what it is that determines which circular solution is to be used for which product, but we hope to be able to produce basic recommendations when we continue our analysis of the hundred or so studies that we have collected from published studies, from companies participating in REES, and from our own investigations.

“In contrast with other research in this field, we are carrying out a bottom-up investigation and are trying to draw conclusions from as many case studies as possible”

- The doctoral students will be carrying out further case studies during the spring of 2017.

Siri Willskytt will investigate Attends’ incontinence products, and specifically how to make them more resource efficient. Daniel Böckin will examine whether efficiency can be improved by using 3D printing as a production method for parts in diesel engines at Volvo Group. Hampus André has just started to look into the reuse of laptops together with the companies Inrego and Godsinslösen, among others.

“They will then use the autumn for analysis and writing up their licentiate theses. The work is on schedule: the doctoral students work well together and with the companies, and I’m completely satisfied with the progress of the work,” says Anne-Marie Tillman.

# Opportunities in the design phase

■ The very first design phase offers the greatest opportunities to influence the impact that a product will have on the environment during its lifetime. The objective of Project 2 is to develop design methods, in close collaboration with the participating companies, that can provide the support that designers and construction engineers need.

“The number of factors that construction engineers and designers must take into consideration is increasing, and this is where we can make a difference,” says Tomohiko Sakao, researcher at Linköping University, and leader of one of the seven Mistra REES projects.

“Our objective is to provide flexible, easy support suitable for companies of different sizes. We also want to bridge the divide between the design of products and the design of services.”

■ Researchers in the project have thus far carried out a literature review, drawn up an inventory, documented the methods that are used in the industry, and interviewed the companies that are participating in Mistra REES. In association with the interviews, they have requested requirements specifications – i.e., how the support should be provided in order to gain true benefit.

“We have identified methods and requirements, but now we need our partners to confirm that we are on the right track, before we continue to the next phase,” says Tomohiko Sakao.

■ He continues: “It must be remembered that our results so far are preliminary, but we can already see that there are large differences between small and large companies. A large company with many people and levels involved in the design process can gain a great deal by increasing efficiency by, say, 5%. In a small company, in contrast, there may be only one or two people working with design and effectiveness (e.g. not forgetting to consider a specific aspect at a specific time) seems more interesting rather than efficiency. Effectiveness and efficiency are both interesting to a company of any size, but there seems differences in the support needed by large and small companies.”

■ A further clear trend he can see is that management interest for environmental and resource-management issues has increased greatly in the companies during the past year. This means that engagement in the design departments has also increased.

“This is something that will be significant for us in the next stage.”

“We have identified methods and requirements, but now we need our partners to confirm that we are on the right track.”



Doctoral student Sara Nilsson at work at Linköping University

# Business models for a circular economy

■ Most current business models are tailored for a linear economy. The transition to a circular economy with increased competitiveness for companies will require new, innovative business models. At the same time, such a transition will encounter both obstacles and driving forces.

The driving forces are related to improved control of material flows, ensuring access to critical components, the opportunity to create a niche market and increased profitability. Other aspects are public procurement processes currently in progress that give priority to circular products, and greater access for companies to a profitable post-sales market. Strategic partnerships will also become more important.

■ The obstacles are related to low prices for virgin raw materials, the high cost of labour, lock-in effects and – not least – the need for companies to invest not only in infrastructure, but also in management systems and expertise. Some of these factors result in companies perceiving high commercial risks when making the transition to a circular economy.

■ “Business models are often complex, and in-depth studies close enough to companies to make the results useful require considerable time. And businesses are reluctant to talk openly about their business models, since they are often confidential,” says Andrius Plepys, researcher at the International Institute for Industrial Environmental Economics in Lund and leader of the work on business models for a circular economy.

“We encouraged the companies participating in REES to describe their research needs with respect to business models, and they made many interesting suggestions. We have now formulated several of these in a manner that makes them suitable for master’s degree projects,” says Andrius Plepys.

■ The research group has subsequently taken on several master’s students to help with collecting material and examining case studies. Five master’s theses have been produced in collaboration with Volvo Group, investigating several aspects of functional sales. Master’s projects on functional sales have also been carried out together with companies outside of the REES sphere, such as IKEA.

Focusing on the IT industry, the doctoral students have mainly concentrated on business models for remanufacturing, working close with Inrego and Godsintösen.

■ The group has also build up a large database of companies that provides offerings based on circular economy thinking.

“We are now identifying the structure and designs of the business models that these companies use, to determine which are the most common and which appear to be the most successful for particular products.”

No less than seven master’s degree projects are currently in progress, looking in depth at the second-hand market in Lund. These are led by Carl Dalhammar, IIIIEE.

“Businesses are reluctant to talk openly about their business models since they are often confidential.”



# There is no optimal policy

“There are many EU directives, and many different regulations and agreements that sometimes work together and sometimes contradict each other.”

■ A number of elements are required in a circular economy: knowledge about materials and design that takes the effective use of resources into account, new business models that do not reward a throw-away mentality, the reuse of resources also at the global level, and – not least – legislation, regulations and directives that support a circular economy.

“We do not believe that there is a single optimal policy for a circular economy. There are many

EU directives, and many different regulations and agreements that sometimes work together and sometimes contradict each other,” says Carl Dalhammar, researcher at the International Institute for Industrial Environmental Economics (IIIEE), and head of the project within Mistra REES looking at policy.

■ The objective of the project is to draw up proposals for regulations and policy instruments that can facilitate the transition. The researchers have found major challenges within the very core of the circular economy, where also the largest losses in value occur, namely within processes such as reuse, repair and remanufacturing.

“An innovative article that we have written deals with the problem of planned obsolescence, in which a product is designed to become out-of-date or obsolescent within a few years,” says Carl Dalhammar. One of the starting points of the article has been regulations about the ecodesign of vacuum cleaners and lighting, and it discusses the policy instruments that the EU can use to increase product durability.

■ Together with other actors that include companies within Mistra REES, the municipalities of Lund and Malmö, and IKEA and other companies outside of the programme, a number of challenges have been identified. These have given rise to several student projects, such as a study of the attitudes of young consumers toward the concept of circular consumption, carried out in collaboration with IKEA.

One of the projects that has recently started concerns how quality labelling of remanufactured products could be realised – companies want to be able to communicate that the quality is equal to or greater than the quality of a corresponding new product direct from the factory.

Another project deals with the procurement of remanufactured products.

■ “A Swedish inquiry into the circular economy was published in March 2017, and contains a number of policy proposals related to inter alia tax on repairs, waste reduction and consumer guarantees. These policy proposals will of course be studied and taken into account in the future work in the REES program” says Carl Dalhammar.



Carl Dalhammar  
at Lund University

# Drawing the threads together

■ A newly started project is to draw together the results from the first four projects.

This project is to show how the relationships between policies, business models and design methods influence efficiency and economics.

“We need to increase our knowledge about correlations, and the relationships between these three factors have not previously been studied,” says Tomohiko Sakao.

It will build on knowledge gained in the other projects, and all senior researchers within Mistra REES are taking part.

■ Data collection is in progress. System Dynamics, a computer-based method that examines the behaviour of complex systems and how they develop, will subsequently be used to analyse the data. System Dynamics has previously been used in, for example, the Limits to Growth project, with excellent results.

“The earlier studies with System Dynamics have strengthened our conviction that this is a useful and efficient method to reach concrete results,” says Tomohiko Sakao.

## A COMPANY PERSPECTIVE – POLYPLANK

“We’re hoping to gain a great deal from the hours we put into Mistra REES, and it’s looking very promising,” says Annika Fernlund, board member of Polyplank, a company based in the southern Swedish county of Småland.

The company is not only participating in several research projects within Mistra REES; it has also taken on a student from Lund University for a master’s thesis project. Furthermore, three groups of students at Linköping University are working on projects related to Polyplank.

“The students visited our factory on Öland. The time we spent together was stimulating and very productive, and I’ve had positive feedback from both the students and my colleagues,” says Annika Fernlund.

Polyplank develops and markets products – such as environmentally friendly sheds, noise shielding and balcony screens – manufactured from a patented composite material. The material consists of recycled thermoplastic resins mixed with organic fibres.

“We are already working in the circular economy, and our knowledge will benefit the REES programme. But it is difficult for companies of our size to invest major resources in research and development. We aspire to continuous development and the programme will be a great help for us,” says Annika Fernlund.

The master’s thesis project will involve an analysis of potential markets in Africa, and the company hopes that it will lead to a business model suitable for use in developing countries.

“The conclusions will be really interesting,” says Annika Fernlund, who is co-supervisor and following the project work closely.

The student groups at Linköping University are to get to grips with life cycle analysis. One group of students working in industrial design will examine the design development of one of Polyplank’s products, and possibly also some supplementary products. The two other groups will carry out life cycle analyses of a small shed and Polyplank’s highly popular noise shielding screens.

“This is time-consuming work, and we’re happy that the groups are willing to take it on. Their results will be highly valuable for us,” says Annika Fernlund.

She is also hoping for useful results from the actual research projects, and from the interviews, workshops and seminars that the company representatives will participate in.

“The tools and reports produced within the programme will be extremely useful for us. Industry and the academic world are two completely different worlds, but exciting things happen when the two worlds finally meet.”



Researchers discussing one of Polyplank’s solutions

“Our participation in REES gives us the opportunity to look at ways to reconstruct a component in our machines to make them more fit for the circular economy approach, and at the same time reflect upon what businesslike consequences such reconstruction has. This work has strategic importance both technically and in supporting our arguments for moving the business towards a more sustainable development.”

**Peter Eriksson, Volvo Construction Equipment**

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