Mistra REES
– Solution Oriented Science for a Circular World

REES

MISTRA
Resource-Efficient and
Effective Solutions

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

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Circularity – for a climate neutral economy

The EU's aim to become a climate-neutral economy by 2050 has only just begun, and it is an immense challenge. The European Commission recently stated that there are already theoretical possibilities to make fossil and carbon dioxide-demanding industrial processes climate neutral. The only problem is that these theoretical possibilities are still far from being implemented in practice.

While great progress is being made in the energy and transport sector, climate-neutral initiatives for the industrial sector have thus far been slow. The key challenge is to create a change of mindset in the industry. Today, one can say that everyone agrees there is a need to invest more in this transition, but until today, not enough has been done to achieve it. This is where the Mistra-funded programme for Resource-Efficient and Effective Solutions (hereinafter, Mistra REES) plays a key role.

There is a transition underway to a greener, low-carbon economy. Businesses that successfully decarbonize their operations in line with global climate commitments are more likely to be able to protect their investments, be more competitive, attract new competence and avoid increased costs from carbon pricing.

2018 was the year when everything happened. The world finally opened its eyes to the climate issue. The EU adopted several legislations promoting the circular economy. Increasing focus was placed on reducing emissions already in the construction and production phases. This is also where the big challenge lies. The climate effect will not disappear even if we cease to emit greenhouse gas emissions tomorrow. It's not about emissions; it's about our mindset.

Knowledge and expertise are crucial for making the right decisions. In this area, the gap between theory and practice is obvious. An innovation must be as good and resource efficient as possible, but as long as it remains in a test environment, it cannot lead us to the important changes that we need. It is only when applied in practice that we can see the real change and benefits of smart innovations.

For too long, policy makers and practitioners have operated in separate silos. To stay separated will do no good, but united, one can do wonders. As a consortium for researchers and practitioners, Mistra REES builds a bridge between theory and practice. We are a sounding board, an inspirer, an interlocutor and a blowtorch. Every year we shift the positions forward, and every day we illustrate what benefit our research provides.

In this year's annual report, we have included several examples showing how Mistra REES is the bridge that is needed between business and academia in order to achieve the EU's goal of a carbon-neutral economy by 2050.

The future is circular.

Jan-Eric Sundgren,
Chair of Mistra REES board

Join us on the journey to a resource-effective economy

Rome was not built in a day – even though we really wish that this could be true – considering all the urgent environmental challenges we are facing that need to be solved. The positive thing is that more and more people are starting to understand this and to take action. Sadly, there are still several industry actors operating in denial, not yet convinced that the world society is changing. They desperately try to hang on to old business models, noticeable not the least in the industry lobby, which tries to force the EU to abandon plans for longer-lasting products.

History teaches us that this is a foolish approach; instead, we should focus on turning environmental challenges into business opportunities. To do so, we need to approach this in the right order, as envisaged in the research results from Mistra REES. Industry's starting point often focuses on improving existing solutions or systems, i.e., making them more efficient. Our findings show that the starting point should be to identify what is effective – that is, what are "the right things to do" – followed by spending resources on doing these effectively, or rather, "do things right".

One among many positive examples of initiatives taken during 2018 is that the ISO voted for creating a new technical committee looking at the circular economy. Standardization is key for supporting society to transform into more sustainable solutions, not least since solutions will require increased interaction between various actors during the life cycles of solutions. Another example is that an increasing number of companies have started to take individual actions and are officially making commitments towards how they will contribute to more circular economic solutions.

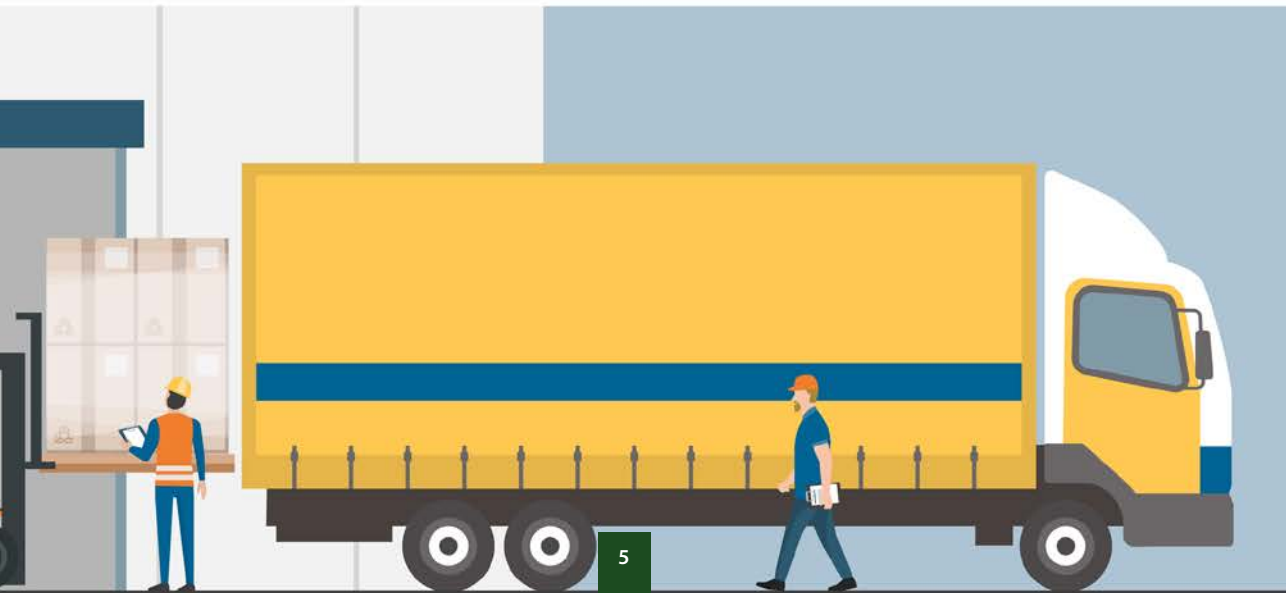
Policymakers have also started to develop policies to advance resource efficiency. They include regulations such as rules on eco-design, as well as market-based approaches like tax deductions for repair activities and the use of public procurement to support remanufacturing and resource efficiency. Adopting an appropriate policy mix is a complicated task – it involves not just the adoption of new policies but also modifications of existing ones, such as waste rules. Further, promoting circular business models may require different policy approaches depending on the sector. While public procurement has a large potential to support such business models, it is not easy to adjust existing practices. In the last three years, we have increased our understanding of the policy-related challenges, but much remains to be done.

Mistra REES has now been running for three years, and we have not yet had the time to develop all the knowledge and support that we are capable of. Therefore, one month ago we submitted an application for continuing Mistra REES for another four years. Supporting our partners in the manufacturing industry, we aim to advance the transition towards a circular and sustainable economy. Providing scientific evidence, we hope to enhance the manufacturing industry's capability to develop world-leading, resource-efficient and effective solutions based on the circular economy. Within Mistra REES we enable close collaboration, knowledge co-production and mutual learning between industry and academia.

While REES Phase 1 set the scene by exploring business models, product strategies and policies for REES, Mistra REES Phase 2 focuses on closing the "idea-implementation gap". Our consortium will serve as a platform to co-create knowledge on the design of products/services and business models as well as policy measures for resource-efficient and effective solutions and implementing and testing these in practice.

We hope you will join us in this endeavor!

Mattias Lindahl, Mistra REES Programme Director and *Carl Dalhammar*, Project Manager project 4



2018 in brief

It has been a successful year for Mistra REES, in terms of scientific results and enhanced cooperation within the programme as well as with our partners and other external parties.

The 10th CIRP IPS² Conference 2018

In May, Mistra REES welcomed one hundred academics and practitioners to the 10th CIRP IPS², arranged in Linköping. We received a great deal of positive feedback from our participants, who came from all over the world. They enjoyed the opportunity to listen to the latest from the forefront of the REES research field. In addition to fact-finding lectures and panel debates, the conference offered unique opportunities for networking, discussions and meetings between academia and industry. We have been asked to, and are now supporting, 2019's Chinese organizers to carry out their conference.

Mistra in Almedalen 2018

In the beginning of July, we were part of organising a very successful Mistra event in Almedalen. Under the title *Plast, thailandsresor och vår långsiktiga överlevnad*, eight different Mistra programmes arranged an afternoon where research questions, approaches and persons from the programmes laid the foundation for discussions and problematisation of the issues that are being researched in our programmes. The event was popular and attracted an engaged audience throughout the afternoon. This event also provided a good setting for different researchers in the programmes to get to know each other, leading to further integration across the research field covered by Mistra's programmes.

Planned obsolescence mention led to media attention

In January, a statement from the Mistra REES programme director spread throughout the media about companies planning for your technical gadgets not to function for as long as they could. It all started with a comment that Mattias Lindahl gave on the topic to a journalist from Swedish TT and resulted in 16 citations in Swedish media, 16 references in printed media, 1 mention on television and 47 citations in online news. That is what we would like to call a successful dissemination of research results.

Impact and visibility

During 2018, results and quotes from Mistra REES have been visible in several reports and books at the EU and national level. Our researcher Carl Dalhammar was co-editor of the first comprehensive textbook on European environmental product law, *Preventing Environmental Damage from Products – An Analysis of the Policy and Regulatory Framework in Europe (Cambridge University Press)*. The European Parliament's Research Service did an assessment report of the Ecodesign Directive, which has several references to Mistra REES journal articles. Brussels-based think tank CEPS cited several findings from Mistra REES in their publication *The Role of Business in the Circular economy – Markets, Processes and Enabling Policies*. Together with Mistra REES partner Inrego, Mistra REES had an article published in Svenska Dagbladet (SvD) *New tax rules – a blow to the re-utilization and re-manufacturing*

of IT-equipment, highlighting the problems related to the new taxation law for chemical products, in particular for the remanufacturing sector.

Mistra REES now a part of the Supervisory Council for the Swedish Procurement Authority

Research points out that if used in a smart way, public procurement has the potential to add significant impact and help in promoting more sustainable solutions. Mistra REES is therefore very happy that programme director Mattias Lindahl has been appointed a member of the Supervisory Council for the Swedish Procurement Authority. The Supervisory Council shall exercise public transparency in the activities and give advice to the Director General. The Director General is the Chairman of the Supervisory Council and shall keep the Council informed of the activities. This will be a significant way for Mistra REES to make a real impact.

Prominent researchers joined Mistra REES

We are very proud to announce that our Mistra fellow researcher application has been accepted. During the autumn of 2018 Ken Webster, former head of innovation at the Ellen MacArthur Foundation, started a visiting Mistra fellow in the Mistra REES programme. Mattias Lindahl, professor and program director for Mistra REES, is both proud of and satisfied with the recruitment. Ken Webster has unique experiences and insights about how the world can be changed in a more circular direction. Not the least, Ken has played a key role in the world-leading think tank the Ellen McArthur foundation, which since its founding in 2010 has been a global driving force focusing on issues related to the circular economy and resource efficiency. The new collaboration is a clear sign of Mistra REES' international impact. The recruitment of Ken Webster will further strengthen the role of Mistra REES as a research and knowledge hub, both in Sweden and internationally, Lindahl concludes. Another prominent researcher joining REES for a period of time is *Professor Donald Huisingh* from the University of Tennessee, a world-leading researcher and also the founder and now the Editor-in-Chief, Emeritus of the Journal of Cleaner Production. Both Webster and Huisingh will produce scientific and popular science together with the program's researchers and assist in the supervision of Ph.D. students, as well as participate in seminars and workshops.

Mistra REES Ph.D. student course

The Ph.D. course, *REES – A transdisciplinary approach*, was a success! It was established with the aim to promote research integration and develop a common base of reference for the Ph.D. students in the Mistra REES programme, and to support them to develop advanced knowledge and understanding of systems approaches in studies of product and service design, business models, and policies.

112 PUBLICATIONS including 5 licentiate theses

42 PEER-REVIEWED JOURNAL PAPERS

27 CONFERENCE PAPERS

24 MASTER'S THESES

Mistra REES financing, 4 years (2015–2019)

	Budget (2015–2019)	Outcome (2015–2018)
Mistra	42.0 MSEK	33.6 MSEK
Academic partners	9.4 MSEK	6 MSEK
Non-academic partners	29.9 MSEK	23.6 MSEK
Total	81.2 MSEK	63.2 MSEK

2018 – a great year for Mistra REES Ph.D. students

In February, Ph.D. student **Sergio Brambila**, Linköping University, defended his licentiate thesis ***Early stages of designing resource-efficient offerings: An initial view of their analysis and evaluation***. The licentiate thesis is about the early stages of designing resource-efficient offerings, underlining the need for academia and industry's interdisciplinary knowledge and common understanding for design.

In December 2017 **Katherine Whalen,** Lund University, presented her research results from the first two years of her involvement in the Mistra REES programme. Whalen's mid-term presentation focused particularly on her work investigating the potential for companies to contribute to product life extension in an economically and environmentally beneficial way. The discussant, externally invited guests, and attending colleagues were positive about her approach to the topic and the expected contribution of her upcoming thesis. In particular, the continued development of a framework she presented which is anticipated to assist companies with innovating resource-efficient, circular business models.

Julia Nussholz, Lund University, presented the work on her Ph.D. thesis ***Business models for circular strategies – Theoretical grounding and industry application*** at a mid-term seminar in April. She has developed a definition that can aid theoretical advancement and effective implementation in practice. The thesis also explores the various elements of business models that help implement circular strategies through empirical research as well as the environmental potential of different strategies for closing material loops. Moreover, this research also contributed to filling the gap in knowledge on design methods for circular business models. It contributed through the development of a visualization tool that offers a standardized representation of the elements and possible cycles of circular business models to prolong the useful life of products and parts and to close material loops. This can reduce complexity and guide practitioners through the interventions for embedding circularity in the business model. Her future research will explore the requirements and characteristics of methods and tools that can be utilized by companies to design business models capable of implementing circular economy practices.

Leonidas Milios had his mid-point Ph.D. seminar in October. The discussant was Dr. Roger Hildingsson, Department of Political Science, Lund University.

Leonidas' research has focused on several issues, including:

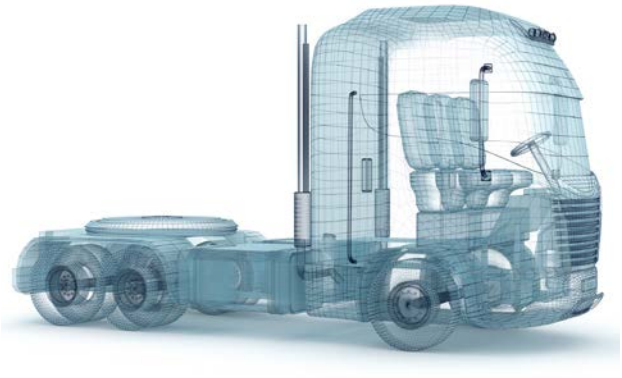
- An overview of different policies related to the circular economy and the manufacturing industry, and identification of areas where there is a strong need for more policy interventions;
- Case studies of new, circular business models, and how policies can support them.

The discussion focused around two of Leonidas' articles and concerned inter alia methodological choices, and to what extent policy evaluation methodology should be complemented with an analysis of the political context: ***Advancing to a circular economy: three essential ingredients for a comprehensive policy mix***

and ***Bridging the gap: Barriers and potential for scaling reuse practices in the Swedish ICT sector***, written together with Katherine Whalen and Julia Nussholz.

Daniel Böckin, Chalmers, presented his licentiate thesis ***Learning from assessments of resource efficiency measures and their impact on resource use and the environment – Based on a case of additive manufacturing and a review of assessment studies*** in September. His research has been carried out in two parts, firstly by synthesising the learnings from a large number of assessment studies. The analysis was built on typologies formulated for mapping resource efficiency measures and product characteristics to the environmental and resource outcomes of the measures in each case. The second part of the research was a life cycle assessment of one such active product, namely 3D-printed truck engines. The aim was to investigate the resource efficiency potential of this emerging technology. Results showed that 3D printing could lead to net improvements in life cycle impacts by allowing redesigns of components for lower weight and thus lower fuel consumption. In conclusion, one can say that useful knowledge on resource efficiency measures was produced both by synthesising many assessment studies and carrying out a single assessment study, especially on the topics of active products and additive manufacturing.

Hampus André, Chalmers, presented his licentiate thesis ***Resource and Environmental Impacts of Resource-Efficiency Measures Applied to Electronic Products*** in September. This thesis builds on three appended papers which are all based on comparative assessments of resource efficiency, studied as resource use and environmental impacts per function delivered, using LCA and material flow analysis. The results indicate that extended use of electronic products through increasing technical lifetimes, reusing and repairing, is generally resource efficient. Exceptions may occur, however, if extended use is insufficient to motivate impacts from producing more durable products or spare parts. Use extension of electronic products leads to resource efficiency in two distinct



ways: through the intended use extension and by increasingly steering material flows into recycling. Further resource efficiency could be realised by combining RE measures over the entire life cycles of products.

At the end of September, **Siri Willskytt**, also from Chalmers, presented her licentiate thesis titled ***How can consumables be made more resource efficient? – Environmental and resource assessment of measures***. She has looked at what measures can be applied to consumables and short-lived products – and whether applying such measures leads to more resource-efficient and environmentally friendly products. Part of the research consists of a case study on incontinence products, where various measures are evaluated through life cycle analyses. Siri has also analysed existing assessment studies in the literature, primarily life cycle analyses, on different products and measures aimed at improving resource use and reducing environmental impact. One important conclusion that Willskytt draws in her licentiate thesis is that it is possible to improve resource use and environmental impacts for consumables and short-lived products with a variety of measures applied at different stages of the life cycle. Another important conclusion is that the context for which a product is used can largely determine if a measure turns out to increase or reduce the life cycle environmental impact.

The Swedish communal laundry room – a school-book example of REES

Raphael Wasserbaur is a Ph.D. student at Linköping University and participates in Mistra REES. He emphasizes that the Swedish communal laundry room is like a school-book example of how a resource can be used more efficiently by developing alternative models for traditional ownership. We have talked to him about the research he is doing.

Tell us about your research!

Currently, I work with two research projects. One is the EU-funded Circular European Economy Innovative Training Network, which consists of fifteen doctoral students. Within the program, various aspects linked to the circular economy are studied, such as, for example, customer behavior and environmental impact. My second project is part of Mistra REES (resource-efficient and effective solutions), which is a research collaboration between Linköping University, Chalmers and Lund University. My role here is a bit special because I focus on the system perspective to be able to analyze how things can be made more resource efficient. The study on laundry rooms is also my first project within Mistra REES.

What makes laundry rooms so interesting? Is the Swedish communal laundry room really that unique?

The Swedish model with the common laundry room is interesting for several reasons – first and foremost, it is a school-book example of how a resource can be used more efficiently by developing alternative models for traditional ownership. It is also extra interesting because the laundry room has been around for so long and has also been developed in one of the world's richest countries.

To begin with, the common laundry rooms have larger washing machines, which means that larger quantities of clothes can be washed per wash. A common laundry room also means that space in your home that would otherwise have been used for a washing machine can be used for other purposes. The washing machines are not only larger; they are often of higher quality and more modern, which means that they are also more energy efficient. Often, it is also possible to utilize district heating to heat the water – which makes the energy savings even greater, as it is the heating of the water that devours the most energy.

How can your research contribute to a better world?

In our research, we look at how politics, business models and product design can contribute to increased resource efficiency. In this way, we get a bigger and broader perspective. By studying the laundry room, we can get a better understanding of how resources can be used more efficiently and how new business and service models should be designed to function optimally.

What have you come up with? Is there anything that has surprised you in your research?

An interesting observation is that communal laundry rooms in Sweden seem to be increasingly uncommon. It is becoming more and more common for people to buy their own washing machine even though they live in apartment blocks. Some argue that in the future there will only be common laundry rooms in socio-economically weak areas or in buildings with high housing costs.

Everyone agrees that common laundry rooms have great environmental benefits. Despite this, it seems that many households give priority to convenience and buy their own washing machines instead of utilizing the common laundry rooms available.

How can the laundry system inspire and facilitate the transition to a more circular economy?

By analyzing the laundry model from a system perspective, we gain valuable knowledge that can also be applied in other areas. These insights facilitate the work of developing new business models and instruments. Much of what we learn from the communal laundry study can be applied directly to other areas; an example is the systems with car pools that are starting to develop in different parts of the world.

Read more

Wasserbaur, R. Sakao, T. and Lindahl, M. *System analysis including aspects of governmental policies, business models and product/service design*, 11th CIRP Conference on Industrial Product-Service Systems, IPS2 2019, 29-31 May 2019.

Waste from incontinence products – not a drop in the ocean

The discussion about the circular economy focuses a great deal on durable products, which are to be maintained, repaired, reused and shared. However, many of the products we use are consumable, such as food, fuels, cleaning agents, packaging and hygiene products. These products must be made resource efficient as well.

For this reason, the Mistra REES research team at Chalmers and our Mistra REES partners Attends Healthcare undertook a life cycle assessment (LCA) study of a consumable product, incontinence products. They used the life cycle-based typology of measures for resource efficiency developed within the programme to identify what measures could be implemented for incontinence products. The researchers found that many different things can be done to increase resource efficiency for this type of consumable product. For the LCA study, they chose those measures that can be implemented without any further technology development and hence within a short time perspective.

The measures included in the study were:

- Recycling of waste generated in production (compared to incineration).
- Increasing the share of bio-based material in the product by replacing part of the super-absorbing, fossil-based material with wood-based absorption material.
- Shifting to a partly reusable product system. A wholly reusable incontinence product was not considered feasible under current conditions, but a product system with a reusable pant used to hold an absorbing, disposable insert in place already exists on the market. This was compared to a completely disposable product.
- More effective use of products through customization to user's needs. In practice, this means to measure the degree of incontinence and the size of patients and use this together with information on the patients' general health status to generate recommendations for which size and absorption capacity individual patients actually need. Measurements usually result in recommendations for smaller and less-absorbing products.

The LCA study showed that the customization of products to patients' needs led to at least 20% lower environmental impact, with no trade-offs between different types of environmental impact. The partly reusable product system (reusable pant plus disposable insert) decreased climate impact by more than 50% compared to a corresponding disposable product. Washing and drying of the pants did not contribute significantly to environmental impact.

As expected, an increased share of bio-based material in the products led to reduced climate impact, but at the price of increased land use. Recycling of scrap and waste material from production reduced environmental impact by around 5%.

An important observation from the study was that most of the measures can be used in combination. This means that there exists considerable potential to increase the resource efficiency of incontinence products.

Although not shown in the study, the implication is that there are also many ways to make other consumable products more resource efficient.

Read more

Willskytt, S. and A.M. Tillman (2019) "Resource efficiency of consumables – Life cycle assessment of incontinence products" Resources, Conservation and Recycling, Volume 144: 13-23

Every year, Europeans generate 25 million tonnes of plastic waste, but less than 30% is collected for recycling. Across the world, plastics make up 85% of beach litter. Because plastic does not decompose quickly, when it becomes waste, it tends to either end up in landfills or wash into the ocean. The World Economic Forum reports that there are 150 million metric tons of plastics in the ocean. And, if we continue this trend, scientists predict there will be more plastic than fish in the ocean by 2050. One of the landmark studies of ocean plastic was published in Science in 2015. The researchers found that we generated 275 million metric tons of plastic waste in one year, of which 4.8 million to 12.7 million metric tons get into the oceans. The EU is now waging war against plastic waste as part of an urgent plan to clean up Europe's act and ensure that every piece of packaging on the continent is reusable or recyclable by 2030. The EU wants 55% of all plastic to be recycled by 2030 and for member states to reduce the use of bags per person from 90 a year to 40 by 2026. Following a Chinese decision to ban imports of foreign recyclable material, the EU Commission recently launched a plastics strategy designed to change minds in Europe, potentially tax damaging behavior, and modernize plastics production and collection by investing €350m in research.

Product-service system designing captured in design science breakthrough

The past century has seen tremendous industrial and technological development which has greatly enhanced human well-being. However, these advancements were also accompanied by several festering environmental challenges faced by societies such as resource depletion, global warming, and climate change.

One of the main drivers of industrial and technological advancements is the activity of designing. Technological innovations are often conceived by a human need and facilitated by the process of designing. This process involves decision-making during the manipulation of the surrounding environment to meet specific human needs by the change agents, i.e., designers. Design researchers have been investigating the activity of designing in an effort to increase its understanding and to develop different methods that support it.

Due to the rising environmental challenges, researchers over the past few decades have attempted to incorporate environmental consciousness into product development in an attempt to reduce its impact. These approaches, however, have proven insufficient in addressing other challenges faced by industries such as market competitiveness, lead time reduction, and so on.

The concept of product-service system (PSS), conceived in the late nineties, is believed by the scientific community to carry significant potential to solve these challenges and thus contribute to REES. Design researchers have developed several methods to support the design of PSS over the past couple of decades. However, there is no research in the state of the art that investigates the activity of PSS designing based on empirical findings from observing designing activities. As of today, the work process of designers is still rather obscure, and with no comprehensive study to draw results from, researchers regard the design process as a grey or black box. As a result, the effectiveness of the existing design methods could be questioned. Further, implementing a design method in a company without understanding designing activities could create problems.

This research aims to shed light on this mysterious activity by investigating what designers focus on during the design process of a resource-efficient PSS, using rigorous and widely accepted scientific methodologies. The preliminary results of the research indicate that the focus seems to be predominantly on the behav-

The PSS is a relatively new concept that is considered to carry great potential to improve the resource efficiency and effectiveness of industrial solutions, which is vital to oversee the transition towards a circular economy. The "activity of designing" is considered to be key to fulfilling that potential, as it determines the characteristics of the PSS solutions being developed by industrial practitioners. Over the past two decades, researchers have developed several design methods to support this activity based on its established "conceptual" understanding. However, the effectiveness of these design methods, and consequently, the support they provide, can be questioned as there is no "empirical evidence" regarding how these solutions are designed in reality. It is important to understand an activity before attempting to enhance or support it. However, there is no established scientific insight into what designers discuss, what issues they focus on, nor what specifically they need support for. For these reasons, the activity of PSS design is considered to be a black box. Many companies have not yet been successful in exploiting the full potential of the circular economy due to their ineffective design – largely due to their poor organizational setup. Mistra REES aims to change this and facilitate the transformation towards increased resource efficiency among businesses and policy makers.

iour of the artefact. Furthermore, PSS design tends to focus on the function or purpose of the artefact being designed, in contrast to product design, which tends to focus mainly on the structure being designed.

It is similar to "Black hole picture captured for first time in space breakthrough" (The Guardian, the 10th of April, 2019): Space scientists researched with the assumption that the black hole exists. Capturing the black hole as an image proved it exists, giving a solid scientific foundation to the research that has been performed about the black hole.

The research conducted in this Mistra REES project will lead to more data from practitioners in order to derive statistically validated insight and thereby make a breakthrough in the science of designing REES.

Read more

Neramballi A., Sakao T., Gero J.S. (2019) What Do Experienced Practitioners Discuss When Designing Product/Service Systems? In: Gero J. (ed) Design Computing and Cognition '18. DCC 2018. Springer, pp. 361-380.

> *"Mistra REES' knowledgeable researchers in the field and companies, in completely different industries but with similar challenges, have been an asset to bolster ideas and get an outsider's view of what we are trying to do.* ***The projects we have participated in have given us insights and future plans for the development of both our offering and the streamlining of our remanufacturing processes.*** *We are now entering a production development phase to equip Inrego for the future. The focus on implementing already developed plans means that Inrego will not participate in Phase 2, but we hope that other companies want to take this opportunity to develop their offers and future plans in our place."*
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> **Erik Pettersson, Sustainability manager, Inrego**

Gap exploiters for re-utilizations

This paper analyses company cases of so-called "gap exploiters", third-party businesses creating value through the re-utilization of existing products. The study focused on business models for extending the lifetime of electronic products and targeting private customers and institutional markets.

Although the gap exploiter model is promising in the transition to a circular economy, several market-related, structural and policy barriers need to be reduced for scaling-up such circular solutions. Issues related to take-back systems, such as the costs of reverse logistics and labour costs, were identified to play a crucial role, especially in countries with high labour taxation. Both business model innovation and policy intervention could address several barriers. When it comes to reusing complex products such as electronics, it is crucial to find ways to reduce the costs of product re-circulation. This implies deciding whether to refurbish or repair and finding an optimal balance between product quality and pricing. Changing fiscal policies on labour taxation and other tax regimes (e.g., value-added, chemical content-related taxes and other) for refurbished products is another domain where opening more business possibilities for circular businesses has great potential. Finally, strong stakeholder collaboration in developing and upscaling circular business models is a key component. This is important for securing sufficient volumes upstream and downstream in the value chain, ensuring product quality, and providing post-sales support and warranty to raise customer's confidence in refurbished products.

Read more

Whalen, K., Nussholz, J., & Milios, L. (2017). Bridging the gap: barriers and potential for scaling repair and reuse practices in the Swedish ICT sector. *Resources, Conservation and Recycling, 135*, 123-131.

The gap exploiter model: new products are made from the leftover value of other products

"Extending product value" is concerned with exploiting the residual value of products. An example of a business model is the case where the remanufacturing operation would simply recover products which have ceased to function, with no new net consumption of materials, other than those consumed during transport and processing.

In 1993, Daniel and Markus Freitag, two young Swiss men barely 20 years old and respectively studying design and art at the University of Zurich, had their books frequently drenched by the rain as they moved around the campus. One afternoon, from their balcony, they noticed the highway with all the tarp-covered trucks speeding along. Eureka! At a time when few people cared about recycling, they came up with the idea of making a bag from old tarpaulin, bike wheel inner tubes and used seat belts whose robustness and practicality are equaled only by their waterproofing. The now-famous "messenger bag" was born. Today, the Freitag range has 70 products, from smartphone covers to backpacks and luxury leather goods. The company recycles almost 400 tonnes of tarp (the equivalent of 110 km of trucks lined up in a row) every year, producing 400,000 items.

“For us - as a small NGO with circular thinking as one of its pillars - it is interesting to learn about the experiences of large, industrial companies. Working on a small scale with prototypes, experiments and testing at a local level, participating in Mistra REES gives us a greater understanding of the complexity of large-scale implementation. But it also shows us how much of what we do in the small scale that could be scaled up and used in the industry with a completely different potential. Not the least, it has been very rewarding to sit down with the young students and researchers in different contexts and exchange experiences on formal education versus non-formal and informal learning.”

Bertil Björk, Head of Activity – STPLN

Regulating planned obsolescence

While policymakers and industries have traditionally argued that market demand can drive the design and marketing of new and more environment-friendly products, this view is increasingly questioned. One way to save resources is by designing more durable products that last longer and are easy to repair. But many manufacturers currently have a business model where it makes more sense to produce short-lived products with "reasonable" quality, and constantly issue and market new models.

Thus, we now see emerging policies that aim to incentivize design for durability more directly. In the EU, all regulation related to product design must be regulated at the EU level and be the same in all EU member states, in order to ensure a free flow of goods in the market. So far, the European Union has set durability requirements for two product groups under the Eco-design Directive: vacuum cleaners and lighting products. In the case of lighting products, durability relates to several product characteristics apart from pure product breakdown, including number of switching cycles (turning the light on/off), and lumen depreciation over

Planned obsolescence, or built-in obsolescence, in industrial design and economics is a policy of planning or designing a product with an artificially limited useful life so that it will become obsolete (that is, unfashionable or no longer functional) after a certain period of time. The rationale behind the strategy is to generate long-term sales volume by reducing the time between repeat purchases (referred to as "shortening the replacement cycle"). Producers that pursue this strategy believe that the additional sales revenue it creates more than offsets the additional costs of research and development, and offsets the opportunity costs of repurposing an existing product line. In a competitive industry, this is a risky policy, because customers may decide to buy from competitors instead if they notice the strategy.

"The opportunity to get a broad connection to academia and Swedish research has been incredibly valuable to us at PolyPlank AB. We are a small company that does not have the opportunity to conduct high-level research on its own. The connection to other companies and the exchange of experience has also been valuable. We find that projects have been a catalyst and coordinator in the journey towards a Swedish sustainable manufacturing industry where the circular economy is a prerequisite."

Annika Fernlund, Chairwoman of the Board, Polyplank

time (the lighting product may provide light, but if it has lost more than 30 % of the lighting output – the luminous flux – it is not functioning properly). Therefore, minimum requirements for these issues are set in the regulation. In the case of vacuum cleaners, the two parts that tend to break down are the motor and the hose. Therefore, specified requirements – proven by lab tests – are set for motors and hoses. It is likely that more durability requirements for additional product groups will be adopted in the future. Further, there is currently a lot of discussion on adopting a labeling scheme to communicate product lifetime at the EU level. This can be done through a new scheme, or through inclusion of such information in the energy labeling scheme.

Read more

Maitre-Ekern, E. and C. Dalhammar (2016). "Regulating Planned Obsolescence: A Review of Legal Approaches to Increase Product Durability and Reparability in Europe." Review of European, Comparative & International Environmental Law 25(3): 378-394.

Bridging the gap between disciplines

Research problems tend to be addressed through siloed disciplines, through a specific lens. While this approach has brought great progress in different disciplines, e.g., mathematics, chemistry, biology and physics, some caveats remain. Addressing problems with one single discipline could represent a certain fixation to solve them.

For instance, an unknown disease could be overlooked if a cardiologist or a neurologist look at a patient separately instead of collaborating. If knowledge remains insufficient, then further research can contribute to gathering information, analyzing, creating, proving and disproving new theories. A remedy or a solution for a new disease could fall into an interdisciplinary field of knowledge where two or more disciplines hold different parts of the puzzle.

Even more, if a similar problem presents itself on several occasions, then a new discipline can be formed holding the necessary knowledge for specific problems until new problems appear and further research is again carried out. An example can be seen in what we know as mechatronics, which emerged from mechanics and electronics, or in biochemistry, the merging of biology and chemistry.

The literature has shown that PSS providers have struggled to fully capture the benefits of PSS offerings. One reason could be that PSS providers are failing to capture the value from various customers' perspectives, which is a central issue in marketing. The PSS is a multidimensional activity that requires interaction between the designer, social actors (including those involved in marketing) and technological artifacts. Such necessary interactions in PSS design are, however, insufficiently achieved in industrial practice. A discipline is an area of knowledge with its own traditions regarding research training, definitions, content areas and methods. When a research project involves two or more disciplines for comparison it is then classified as multidisciplinary. If instead, the effort is integration between disciplines to solve a problem, it's interdisciplinary. An attempt to create a standing collaboration between disciplines, hence creating new, mutual traditions, is transdisciplinary. There are some common problems that occur in transdisciplinary research. Lack of motivation and effort among the different actors is one, and lack of coherency regarding problem framing, integration of methods and designing the research process is another. A common understanding is crucial when solving problems, since it is difficult to compare and evaluate results without it. In environmental sustainability research, this type of approach could help in creating a common goal across disciplines.

Mistra REES researchers Sakao and Brambila-Macias hope that clearing up the definition of transdisciplinary will result in a "how to" approach, which in turn will lead to better communication across disciplines.

In the paper "Do we share an understanding of transdisciplinary in environmental sustainability research?" REES researchers Sakao and Brambila-Macias argue that the field of product/service systems (PSSs) could benefit from more collaboration between engineering design and marketing, as both disciplines contribute to the field but in most cases do so separately. PSSs are integrated offerings that comprise products, services and systems which can contribute to more effective and resource-efficient offerings. This is a crucial research field of the 4-year Mistra REES. In the paper "Bridging the gap between engineering design and marketing: insights for research and practice in product/service system design." Sakao, Brambila-Macias and Kowalkowski argue that real-world problems need collaboration among academics and industrial partners, what is described as Transdisciplinary Research Type 2. In those cases where knowledge seems insufficient, a new discipline could be formed, described as Transdisciplinary Research Type 1. The great challenges of climate change, loss of biodiversity and pollution in our air, water and soil call for more cross-collaboration among different disciplines. This could hold the key for a clean atmosphere, oceans and earth for us and future generations.

Read more

Sakao, T. and S. A. Brambila-Macias "Do we share an understanding of transdisciplinarity in environmental sustainability research?" Journal of Cleaner Production Volume 170, 1 January 2018, Pages 1399-1403.

Brambila-Macias, S. A., T. Sakao and C. Kowalkowski (2018). "Bridging the gap between engineering design and marketing: insights for research and practice in product/service system design." Design Science 4: e7.

Science and industry – a sustainable affair

There is a multi-trillion-dollar gap between where we are now and where we need to be for a low-carbon and more resilient world. According to a recent study by Circle Economy, the global economy is only 9% circular – just 9% of the 92.8 billion tonnes of minerals, fossil fuels, metals and biomass that enter the economy are re-used and recycled annually.

A major barrier towards a circular economy is the sheer difficulty of breaking ingrained habits. Many aspects of the current system reflect decisions made long ago. Misaligned incentives dot the industrial landscape, making it hard to create, capture, and redistribute value in a circular manner. Customers, for instance, are used to evaluating the expense of products only at the point of sale, even if costlier but longer-lasting products would be more economical in the long term. REES models are still unheard of in several industries, although they could benefit both customers and companies.

The circular economy is about much more than increasing the efficiency of products and materials use. It is about rethinking how to design differently, sell differently, use differently, value differently, treat risks differently and finance differently. Companies that make an effort to apply circular economy principles to their business models have an immense opportunity to go beyond simply fending off disruption and positioning themselves for future success. They have the opportunity to create new markets, redefine the customer relationship and lead entire industries.

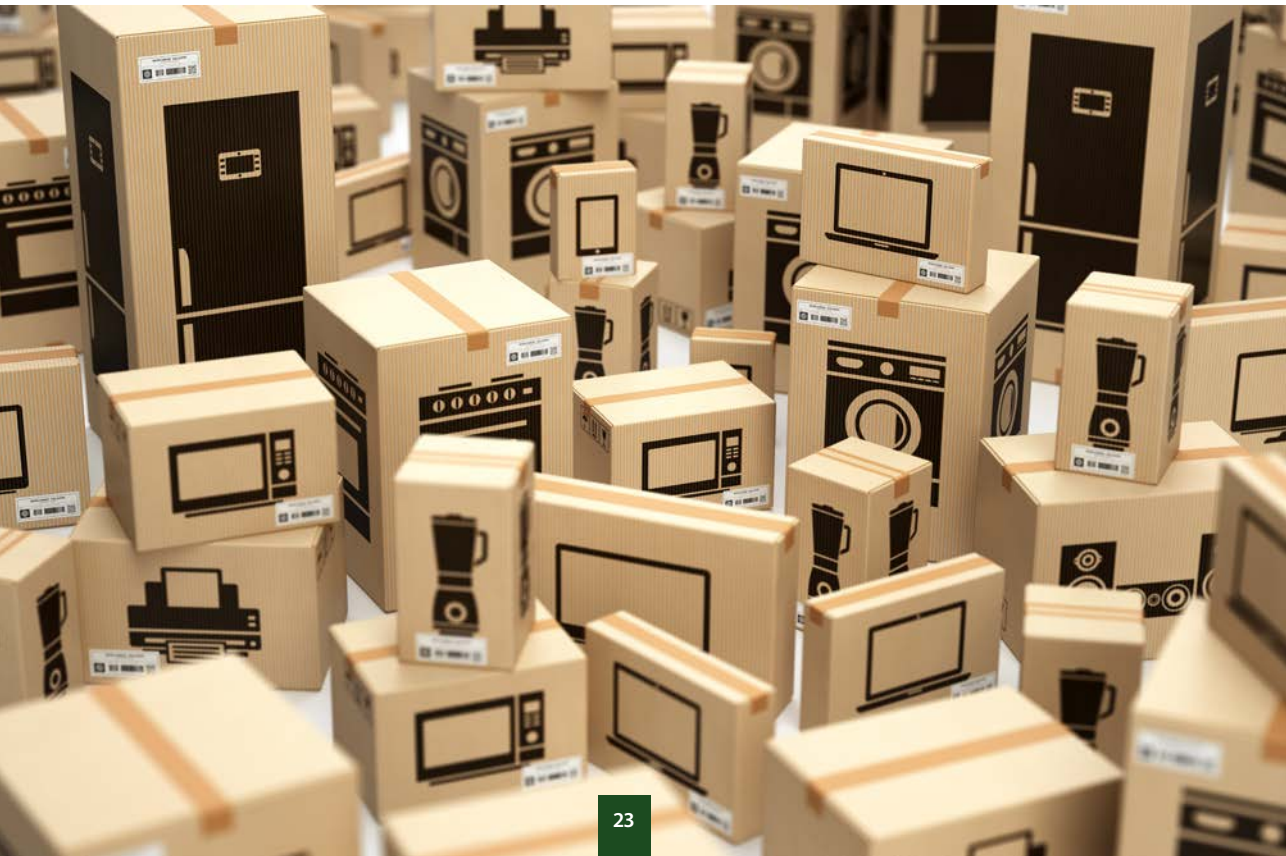
Cooperation, knowledge transfer and innovation are all crucial building blocks in the journey towards a circular, resource-efficient economy. This is where Mistra REES comes in.

“The journey towards increasing resource efficiency has already started. Increasing raw material cost, or even access to engineering materials, will play an increasingly important role in future business. This is why research and research implementation in industry on circularity topics like reusing, remanufacturing and recycling are so important. Mistra REES has played an important role in Volvo Cars’ strategic ambition to effectively apply resource efficiency in future products.”

Axel Edh, former Environmental strategist, Volvo Cars

“Circular economy thinking is becoming increasingly important, both in its own right and as an important part of decarbonization in line with the IPCC 1.5 degree report. As such, we need a holistic perspective considering technology, policies and business practices, e.g., service models. As for all societal transformations, a solid fact base and deep knowledge are needed to leverage the potential. We, therefore, appreciate being a partner of Mistra REES, which combines learning opportunities and includes the wider societal implications of changed industrial practices.”

Pernilla Bergmark, Ericsson



Mistra REES Partners

The Mistra REES programme brings together leading Swedish universities, large and small companies and societal actors. The strong collaboration between academia and the participating partners fosters an opportunity to co-create, evaluate and implement research results that have proven added value for our external partners.

Go ahead – derange my circles

During 2018 Ken Webster, a long-standing voice in the global debate on circular economics and resource efficiency, joined the Mistra REES programme through a special research collaboration enabled through Mistra. With his base at Linköping University, Ken is spending one year working part-time together with the research groups that form Mistra REES. He is a great resource in contributing to scientific and popular science production together with the program's researchers. He also assists with the supervision of PhD students, and has been co-organizing seminars and workshops. Ken will use the opportunity to gain an increased knowledge of Swedish activities related to the circular economy and Mistra REES.

To learn more about his view on the movement in the circular economy, we interviewed Ken Webster when visiting Sweden in May 2018.

What are the biggest issues in circular thinking right now?

There is a lot going on in the circular economy right now. To fully realize the vision of a circular economy, we must cooperate and test different ideas – in this phase, there is no right or wrong. It is only when you have tested different models and theories in reality that you know what works and what is worth investing in. Occasional setbacks are nothing to be afraid of – on the contrary, they are often necessary to reach breakthroughs and develop new models and approaches.

How can we speed up the transition to a circular economy?

Basically, everything is about innovation – in the broadest sense of the concept, where everything from new technology to digitalization and new business models is included. The world is full of promising examples, and development cooperation is ongoing. Much of what we see today can be refined, developed and improved. To take an example: in China, there are a variety of companies that offer loan bikes. In many cases, they have failed completely – several of the companies that were at the forefront of this offering are bankrupt. The problem was that there were no systematic business models for this offering; by that I mean the approach was to go to scale as fast as possible and squash the competition, while ignoring the effects of dockless bikes littering the streets, or responsibilities to subscribers. There was tremendous potential, but no one knew how to use it. Now, these companies have learned from their previous mistakes, and amazing things are starting to happen.

How can companies and industry prepare for the circular economy of the future?

I always think of what the circular economy's founder, Waler Stahel, used to say: "in business, survival is not mandatory". There is no guarantee the world will be rearranged for your benefit! For individual companies, it is not so much about what you must do – the important thing is what you want to do and in what way you can take advantage of the opportunities brought by the transition. A very important part of the transition to a circular economy is to develop new and innovative business models. New thinking taking advantage of increasing resource efficiency and selling access rather than ownership will have a central role going forward.

How will society change when the economy becomes more circular?

Many old truths will have to be reconsidered as the economy becomes increasingly circular. We must invest more in local and regional production infrastructure. It will also pay to repair and renovate instead of buying new – if tax incentives and regulations are realigned. Digitization will obviously be a very important driving force in the transition. I usually describe the ongoing process of increasing resource efficien-

cy and systemic effectiveness as a cross-fertilization between digitization, design and business models.

In the future, the seller's responsibility for a product will not be over the moment it has been handed over to the customer. On the contrary, the focus will be on the entire life cycle, where service and opportunities for reuse and recycling will be much more important than today. In the future, a deeper co-operation will be required throughout the value chain and a need for a new type of service provider will be created.

What can the world learn from Sweden in terms of circularity?

I believe that Sweden, with its experience, technological skills and expertise, is well placed to become an international model in the work towards a circular economy. There are many interesting examples of how Sweden managed to exploit the opportunities that exist. For example, I was very inspired when I was told about a shopping center in Skåne that only sells recycled and recovered goods and does this with some style and a contemporary feel. I am inspired by companies such as Inrego, the suppliers of next-use computer equipment, and Qlean, and with its revolutionary, no-chemical cleaning technology.

What role will politics play in this transition?

Political governance will, of course, be crucial to speed up the transition work. Not the least, there must be an underlying infrastructure that makes the transition ahead of us possible. For example, there must be marketplaces to facilitate and promote recycling and reuse. Legislation must also be updated to be better adapted to the new economy. It simply must be worthwhile to be resource-smart – like it should cost more to waste resources that could be reused or recycled.

The challenge is to strengthen the circular economy and make use of the opportunities that already exist. In this work, only our own imagination sets boundaries for what we can do.

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MISTRA REES – Resource-Efficient and Effective Solutions based on a circular economy thinking is a 4-year program that started in 2015. It is run by a consortium of leading Swedish universities, large and small companies and community actors.

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

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