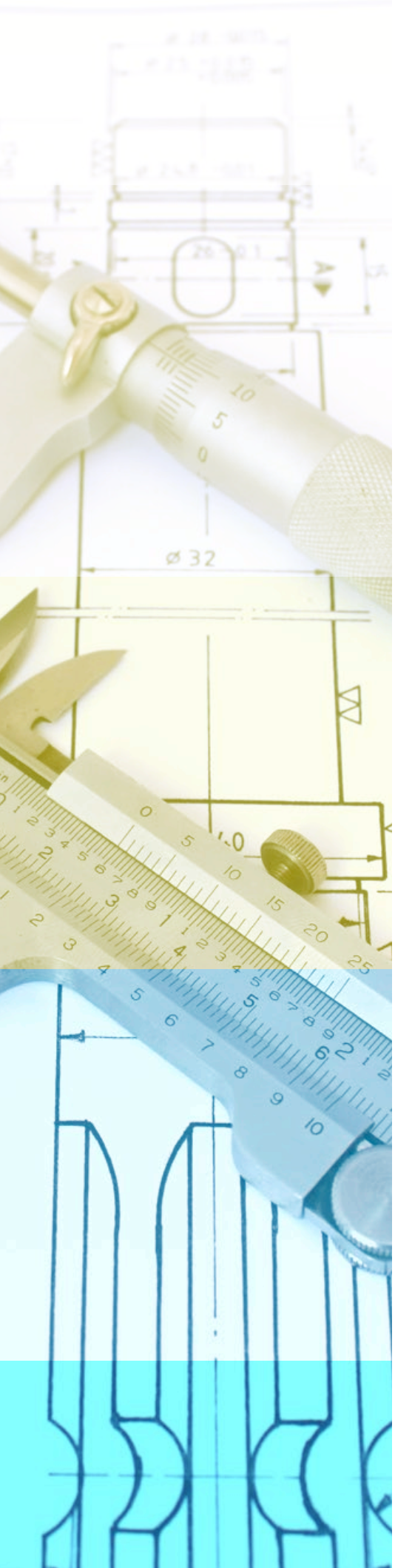
MISTRA
The Swedish Foundation for
Strategic Environmental Research



Background paper

# Product design for resource efficiency

August 1, 2014

**Authors:**
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**Tim C. McAloone**
**Walter R. Stahel**
**Jan-Eric Sundgren** (chairman)
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# Content

# 1 Terms of reference for the working group

## Background

Mistra's Board decided in December 2013 that a proposal for a funding application call in the research area of 'Product design for resource efficiency' should be drawn up. This proposal is to be based on an analysis of the current state of the art of research and of society's knowledge needs.

A preliminary proposal is that the research program should focus on how various types of product should be designed in a life cycle perspective. Not only manufacturing should be resource-efficient; equally important is how the product is used during its active service life and how it can successively be maintained, repaired, renovated and eventually re-manufactured. Since a product as a whole, or in its consistent parts, can be renovated and remade and thereafter be sold or leased again, products can go through several life cycles.

The program should adopt a comprehensive approach to resource-efficient use of energy, materials and raw materials. The starting point should be product development and design, and in addition circular material flows, life cycle assessment and life cycle cost should be included. The program should be interdisciplinary in nature and include not only design and technology but also private individuals' (consumers') and companies' behaviour, business models and the importance of financial incentives and other motivational/regulatory instruments. Collaboration with the business sector is expected, as is co-funding from businesses.

## The assignment

A working group comprising international experts will draw up a background report as documentation for Mistra's Board, ahead of a forthcoming decision on whether to call for applications for research funds in the area described above. Mistra is very pleased that Jan-Eric Sundgren has accepted the position of Chair of the working group.

The group's tasks are:

- to describe the challenges facing society in this area, and the political (and policy) processes that are under way in Sweden and the rest of the EU to tackle these challenges
- to provide an overview of where the research frontline is located and the status of Swedish research in the area in an international perspective
- to propose in detail the orientation of a new research program (draft text for the call for funding applications).

A final report must be submitted to Mistra not later than 1 August 2014.

# 2 Introduction

The last more than 100 years of the industrialized society have been dominated by basically 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. This applies to input goods and raw materials, especially those that are not renewable. In international terms, land and water are also limited resources. While energy is not necessarily a limited resource per se, the use of fossil fuels needs to be radically reduced, due particularly to emissions of greenhouse gases from its production and use. Biofuels may also be viewed as a limited resource, when taking into account the land and water that are utilised to produce them. Furthermore, energy is used not only when goods are produced but often also when they are used and in their end-of-life phase

The quest for a substantial improvement in resource utilization and performance has led society – including business – to seek for 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, not only during the production phase but also throughout the whole life cycle, are as energy-saving and resource-efficient as possible. How long a product can be used before its useful service life ends and the scope that exists to maintain and repair it are further factors affecting resource consumption. The ways in which consumers choose to use the product and the incentives and impediments that exist in society also affect resource use.

What is needed is a circular economy, i.e. a system that is restorative or regenerative by intention and design. To quote the introduction paper to the EU Green Week conference 2014: *"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 higher than ever before. In a report from the Ellen MacArthur Foundation in 2012 "Towards a Circular Economy: Economic and Business Rationale for an Accelerated Transition" it is estimated that 65 billion tonnes of raw materials entered the economic system in 2010 and that this figure is expected to increase to around 82 billion tonnes in 2020. In 2010 the world population was approximately 7 billion, implying that approximately 9 tonnes of raw material entered the system per person living on this planet!! From a business perspective this is of course associated with an increased risk for notably higher prices, plus high volatility and severe supply disruptions. From a planet point-of-view the risk is that we accelerate depletion of resources leading to lack of resilience in many natural systems.

At the same time that there are severe risks associated with neglecting a move away from a linear model towards a circular model, there are also large opportunities of gradually shifting the economic model for society. Undoubtedly this will drive innovation and value creation both for individual companies as well as for

society at large. Only the materials-saving potential should be very large. While the possibility to create new jobs is very hard to estimate, it is not unreasonable to guess that e.g. new innovations will create new industries and that advances in research will make the remanufacturing and re-use industries grow considerably.

In September 2011, the European Commission presented a roadmap for a resource-efficient Europe.[1] In order to both foster the growth required to generate job opportunities and prosperity for the population, on the one hand, and to guarantee a sustainable future on the other, fundamental changes are needed in our economy and society. The roadmap raises such issues as the need for improved products and modified consumption patterns, plus how waste should be handled as a resource; it furthermore points to the need for scientific breakthroughs and innovative solutions. There is also a European panel on resource efficiency, whose purpose is to advise the European Commission, the EU member states and private stakeholders. Furthermore, in the beginning of July this year the commission adopted proposals to turn Europe into a more circular economy and boost recycling in the Member States. Achieving the new waste targets would create 580,000 new jobs compared to today's performance, while making Europe more competitive and reducing demand for costly scarce resources. The proposals also mean lower environmental impacts and reduced greenhouse gas emissions. Keeping materials in productive use for longer, reusing them, and improving their efficiency would also improve EU competitiveness on the global stage. This approach is described in a communication which explains how innovation in markets for recycled materials, new business models, eco-design and industrial symbiosis can move us towards a zero-waste economy and society[2].

European provision of input goods, including raw materials, is also discussed in the European Innovation Partnership. There, representatives of the business sector, research and politics are included in a high-level group. Sweden takes part in this cooperation and a strategic implementation plan listing proposed measures has been drawn up[3].

While there are many actors in Sweden, both in the business sector and the academic sectors, which are active in the broad field of resource efficiency, there is still no coherent program that looks upon the issue from a broad perspective. It is also obvious that the field spans over several academic disciplines, implying that a multidisciplinary approach involving several disciplines and stakeholders is needed. For example, engineering research on remanufacturing, research how to design new products that are optimized for maintenance, remanufacturing and reuse, the interplay between services and products and the understanding of new business models and economical aspects of those, both on macro and micro levels, should be dealt with in the same program. Taking into account the huge dependence of the Swedish economy on the industrial sector and the long and fruitful cooperation between business and academia, we believe that the proposed program is needed, has the potential to deliver, and can make a strong contribution to the advancement of the field internationally.

On the international level, the UN Environment Programme (UNEP) has established its International Resource Panel in 2007 to provide independent, coherent and authoritative scientific assessment on the sustainable use of natural resources and the environmental impacts of resource use over the full life cycle[4].

By providing up-to-date information and best science available, the International Resource Panel contributes to a better understanding of how to decouple human

1 *Roadmap to a Resource Efficient Europe*, Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, COM(2011) 571 final.

2 *http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52014DC0398*

3 Strategic Implementation Plan for the European Innovation Partnership on Raw Materials, Parts I and II, final version, 18/09/2013.

4 *http://www.unep.org/resourcepanel/MembersPartners/tabid/54041/Default.aspx*

development and economic growth from environmental degradation. The information contained in the International Resource Panel's reports is intended to be policy-relevant and support policy-framing, policy-planning and program-planning, and enable evaluation and monitoring of policy effectiveness[5].

In the following we outline the scope of the field, discuss the state-of-the-art and conclude with a recommendation that Mistra should announce funding for a new research program on "Product Design for Resource Efficiency".

5 A new IRP report was launched on 5 June 2014: *Decoupling 2: Technologies, Opportunities, and Policy Options*

# 3 Scope

The focus of a new research program should be on resource efficient design for new products, remanufacturing of existing products, related policy issues and new business models. Several strategies are relevant including reuse, repurpose and redesign. The combination of several strategies is expected. Furthermore, coupling systemic and operational level are desired characteristics for this program. The winning proposal must plan to create concrete cases that give major environmental benefits and which have the ability to be spread. The results are thus expected to be generic in nature and the proposal should include a plan for how to disseminate knowledge in a way that enables several industries as well as public sectors to use the results.

The program should have a holistic view on resource efficient design including various aspects on societal, company and product levels. Developing new business models and innovative ideas including using material and services in new ways are encouraged. However, recycling and the development of new materials are beyond the scope of this program.

The scope of the program should be to support in particular manufacturing companies in the development and implementation of "Product Design for Resource Efficiency". The call does not support the development of solutions for agriculture, forestry, fishing, water supply, sewerage, waste management and remediation.

The program should illuminate policy- social- and environmental issues of resource design and the results should be able to serve as valuable data for policymakers, industry and other stakeholders to support existing and also to create new manufacturing industries of relevance for society and the environment.

Studies of policies, existing as well as new, and their implications for utilization of resource efficient products and processes are interesting. There is also a need to work actively towards an increase of public awareness regarding remanufacturing and resource efficient design and behaviour, both among the general public and also policymakers.

The topics discussed below will enable the development of new skills and new capabilities in trade and commerce, and in scientific disciplines. Understanding and exploiting these will add to competiveness of the Swedish economy as well as creating social opportunities.

Most resources used in production, such as raw materials, energy, chemicals, toxic compounds, and water are scarce, therefore the program should show cases that have major positive environmental impacts by saving these resources.

The results of the program are expected to be generic, in order to allow them to be transferred to several business areas, with the desired output of improving the opportunities for society to get access to high quality products at low cost, while reducing waste and saving resources, preferably at the same time as new job opportunities are created.

To maintain a holistic view and to be able to handle several levels of resource efficient design throughout the program, collaboration between multidisciplinary academic research teams, small- and large companies as well as authorities and/or public organizations are encouraged. Research institutes that connect SMEs may be

included and also proposals that include Original Equipment Manufacturer (OEM) companies are most interesting.

A successful proposal should furthermore consider relevant circumstances in Sweden and the fact that Swedish companies both manufacture and trade products globally.

## Design for new products

It is desirable that the design for new long-life products extends the life time and also maximizes the time before a product needs maintenance and repair. The maintenance and repair procedures should only require small amounts of raw material, energy and labour. The maintenance and repair systems may themselves be designed so that the product is still functioning during maintenance and repair. Furthermore the design should consider resources used while the product is in active, contra passive use, such as energy consumption during sleep mode and user mode.

It is also relevant to study and influence consumer patterns. For example the design of short-life products may influence consumers to use refill systems or enable them to fully use the product with a minimum of waste. For long-life products the design may influence the consumer to completely turn off energy supply when the product is not in use, have an efficient consumer pattern during use, extend the lifetime for the product due to correct handling, etc. Furthermore the design may influence energy consumption during transportation and resources needed for storage and handling at the wholesaler.

Developing and implementing tools such as Life Cycle Assessment (LCA), ISO-systems, eco-design etc. that pinpoint and enable a systematic resource efficient design of new products in the perspective of raw material consumption, energy and labour during construction, usage (both at end-consumer and in wholesale) and at the end of product life is also within the scope of this program. In many cases the tools already exist, but their usability needs to be improved so that they are implemented and used successfully in a mature way. Understanding the use of ecodesign and related tools and methodology in a company context – including the trade-offs that such tools inevitably give rise to – is an important aspect to take into consideration.

A successful resource efficient design also leaves open options if the product should be remanufactured or used for new purposes at the end of its (first, second, third) life cycle. Robust design and refitting may be valuable possibilities in future business models. Creating products with a robust design that tolerates refitting of remanufactured and new components (different age) to prolong the product life is interesting to this program. Design for remanufacture, -remote monitoring, -upgrade, -reuse, -disassembly, etc. are potentially relevant design strategies to follow when designing for resource efficiency.

## Remanufacturing and technology updating

Remanufacturing of old and new mechanical equipment such as aeronautic, automotive, production and building equipment, rolling stock, pumps, robots, bearings, medical equipment, electronic and electrical products or systems, involves several challenges that are within the scope of this program. It includes social behaviour and how to improve the public awareness of the possibilities and quality of remanufactured goods. To promote the usage of remanufactured goods by influencing policy strategies including public procurement, develop new business models and find new value chains are also interesting.

Strategies for analysing when it is useful to remanufacture at all, considering that some old products may have a more negative impact on the environment than new products, implementation of analytic tools such as LCA, which reveal the gains and losses with remanufactured goods, are also included.

There are several interesting practical issues on how to improve existing remanufacturing processes and how to create new ones. These include, for example, how to tackle the problem of predicting the condition and the amount of incoming goods, to develop new mechanical tools, to optimize the assembly/disassembly processes (if you go efficient in one end you get it more complicated in the other), to improve cleaning processes, and so on.

A recent international workshop series[6] between remanufacturing industrialists and academics has identified the following five challenges, all of which are relevant to the scope of this call:

*New Technologies for Remanufacture*: How can processes be made faster and their costs reduced? For example to automate manual processes for measuring wear and material condition, develop new material addition techniques etc.

- *Information and Tools*: How is remanufacture data managed and analysed?
- *Environmental Assessment*: When is remanufacturing worthwhile?
- *Standards and Regulation:* How can legislation and standards promote the national good?
- *Electronics remanufacture*: Since electronics use is accelerating and now constitutes our largest and most rapidly growing waste stream, remanufacturing of specific electronics has also been identified as one major challenge.

## New Business Models

Developing and identifying new business models are in the scope of this program. New business models with accompanying product-, service- and remanufacturing systems may for instance focus on solutions and performance rather than on the product itself. The built up competence will be important for the possibility to create new markets.

Examples of where business models would promote enhanced resource efficiency include business models that promote and ensure use-intensity of products and systems, reducing redundancy whilst at the same time providing attractive usage solutions to the user (e.g. removing maintenance burden and increasing variety of solutions). For such strategies of so-called product/service-systems to be successful, both the product and the business model need to be designed in a way, such as to allow for the full potential to be realized. In addition, it will be relevant and necessary in some cases to ensure that policy and legislation does not hinder resource efficient solutions that break the current linear economic model of product consumption (e.g. taxes, product liability).

## Policy

There are several issues regarding policy, which are within the scope of this program. For instance, standards and regulation can in many cases promote innovative solutions but it is important to understand how these influence opportunities and limitations on the societal uptake of new resource efficient products and processes. Therefore activities to pinpoint and present knowledge to policymakers, industry and other stakeholders to improve legislation and guidelines in order to promote, or at least to prevent barriers for new innovative solutions are within the

6 Future Remanufacturing Workshop: http://www.remanufacturing-conference.com

scope of this call. Part of these activities may be to look into international trade policy, such as the Technical Barriers to Trade Agreement. One interesting example is how to improve reverse logistics, important to remanufacturing companies. Regulations may also motivate companies to keep the whole production chain, from raw material to the final product, locally and in-house to avoid declaration of goods/raw materials. This is in contrast to the lean business model of manufacturing, where the components are delivered by sub-contractors that need to be trusted to handle and declare raw materials and goods in an appropriate way. It would be valuable to look into these relations in a strategic way.

There is also a need to work actively towards an increase of public awareness regarding remanufacturing and resource efficient design and behaviour both among the general public and policy makers. This may be done by introducing product labels or other tools. With labels on the market it would also be easier to promote public procurement of resource efficient products.

# 4 State-of-the-art, including research challenges

Current knowledge on the topic of product design for resource efficiency predominantly exists on a product and a company level. It is of proprietary nature and is therefore out of reach for research and educational purposes. In examples of companies or industry types, where remanufacturing is most often practiced (e.g. railways, airlines, armed forces), much of the knowledge resides with fleet managers or real estate managers, neither of which have the role of thinking remanufacturing or remanufacturability into their products and systems. There is therefore a large need for research on a macro-economic level, in order to understand, for instance, the impacts on job creation, resource efficiency and the environment. An acceleration of the activities described in the following paragraphs would become possible by a knowledge exchange between fleet managers and universities, training the students as future knowledgeable employees in the economy.

## Design for new products

The current state-of-the-art in the area of design for resource efficiency shows a number of initiatives, predominantly from EU (as described in the next paragraph), but relatively little existing research. A number of private companies have been and are active in this area, but the information and results achieved in these contexts are most often proprietary in nature. One of the first companies to apply an integrated Design for Environment strategy to its products since the early 1990s has been Xerox, with a strict component standardisation (the commonality principle) and a marketing strategy of selling customer satisfaction (leasing with a pay-per-copy pricing), which it also imposed on its Japanese branch Ricoh.

The research that has been carried out and the active research groups in this area are largely Eurocentric and the projects and results produced can be characterized as largely tools-based and focused on single-issue "Design for X (DfX)" tasks (DfDissasembly, DfRecycling, DfPackaging, DfWaste Minimisation, etc.). The language used when discussing resource efficiency rotates around few cases (Caterpillar, Jeep, etc.) but otherwise around a number of anecdotes. Until now research efforts in the field of resource efficiency and design for such tend to be mono-disciplinary (usually mechanical/production engineering) and therefore highly (and purely) technical in nature. There are, for example, no studies of holistic design, anthropology, sociotechnical, or business-oriented elements of resource efficiency. Finally, current resource efficiency research tends to be remedial in nature (i.e. fixing problems and coping with current stock), as opposed to innovative (i.e. designing up-front for resource efficiency and planning business models around such).

## Remanufacturing

The barriers to widespread adoption of remanufacturing are both technical and non-technical, however none are insurmountable. Technical barriers comprise primarily a lack of specific expertise in the small to medium size enterprises (SME) typical of the sector. New tools and techniques are required – particularly for the SMEs which currently dominate the market, yet lack the resources and expertise to develop such tools. Non-technical barriers comprise primarily a lack of knowledge and awareness of what is already available. There remains ambiguity in the definition of remanufacturing and its opportunities for profitability and environmental compliance. Equally, customer (and public) perceptions of remanufacturing are currently poor, with remanufacturing perceived as 'second class' and inferior to newly manufactured products. Policy and regulation issues also present barriers to remanufacture; prohibitive laws and regulations can hinder adoption of remanufacturing, and there are currently few pro-remanufacture policies and standards.

Remanufacturing research has the potential to be very multidisciplinary and is currently being undertaken in many universities worldwide, but typically by researchers in isolated disciplines and most often by small groups of researchers – or even individuals. However, internationally there are three major remanufacture research centres: The National Key Laboratory for Remanufacturing (NKLR), Beijing, China, the Remanufacturing, Resource Recovery (C3R) at Rochester Institute of Technology, USA and the Advanced Remanufacturing and Technology Centre of Singapore (ARTC). Other critical masses of remanufacturing researchers include in Europe, the Remanufacturing research Group at the University of Strathclyde (UK), Bayreuth University (Germany), Linköping University (Sweden) and Politecnico Milano (Italy).

Past research has been high-level and qualitative, with the aim of gaining understanding of the subject; research topics were mainly limited to product and process design. There has been some quantitative work, but this was theoretical and generally not appropriate for operational managers; only seldom were real-world problems addressed. Due to the above-mentioned dispersion of the research effort, projects tended to be piecemeal rather than coordinated. The exception to this rule has been the research undertaken by large wealthy remanufacturers, which constitute less than 5% of the industry. However, in recent years there has been an increasing global interest regarding remanufacturing, for example in the USA, Japan and Europe. This is also seen in new European opportunities within Horizon 2020 (appendix 2) and in that a new journal, Journal of Remanufacturing, was established in 2011.

## Innovative Business models

Business models have been an integral part of economic and trading behaviour for very long but the business model concept has really gained momentum since the advent of the internet in the mid-1990s. Since then the business environment has evolved to one with profoundly more complex industry dynamics and to some extent fading industry boundaries. Technology, especially information and communication technology, has also radically altered the requirements for building and managing a successful business. There are also several examples of where new ground-breaking products/services have needed new innovative business models before becoming commercially successful, as well as examples where existing technology has been used in combination with new business models to create a commercial successful case. In fact, a wrong business model may kill any new idea/product/service before reaching the market.

While the importance of business model innovation is clear, it is equally obvious that academic research on business models lags behind business practice and popular discussion. Even though the number of publications has increased, there are still many unanswered questions. How organizations design and change business models successfully and what influences this from the micro-level of the individual company to the macro-level of regions and countries.

In order to effectively disseminate and utilize new research results, new technologies and methods in the area of product design for resource efficiency it is obvious that there is an increasing demand for the implementation of new business models in parallel, and to ensure that strategic innovation processes include ingredients of a broad value creation and suitable business models. For example, as mentioned in the section on remanufacturing above, the barriers to widespread adoption of remanufacturing are both technical and non-technical. Non-technical barriers comprise primarily a lack of knowledge and awareness of what is already available. A great deal of ambiguity remains in the definition of remanufacturing and its opportunities for profitability and environmental compliance. Equally, customer (and public) perceptions of remanufacturing are currently poor, with remanufacturing perceived as 'second class' and inferior to newly manufactured products. Legally it is also often the case that remanufactured products or components are restricted with respect to their market and business possibilities. New business models for remanufacturing are thus needed and research in this area, due to the present low activities on the academic side, has a potential of gaining international recognition and importantly also helping to bring technology advancements to the market.

## Policy

This proposed program fits well into the emerging and increasing international focus on resource efficiency and will contribute with a Swedish leading edge research effort. By integrating industry, academia, policy considerations and business models into an innovative program it can act as a showcase for other countries in the world. The current international focus on resource efficiency includes a number of initiatives in EU's Horizon 2020 program, including a current open call "Re-use and remanufacturing technologies and equipment for sustainable product life cycle management" and several smaller calls under the "Waste" theme, expected to be launched in 2015. Other Horizon 2020 calls – now closed – "Manufacturing processes for complex structures and geometries with efficient use of material" and "Networking and sharing of best practices in management of new advanced materials through the eco-design of products, eco-innovation, and product life cycle management". Whilst all of these calls (listed in Appendix 2) are directly relevant for and related to this MISTRA proposal, they are all limited in scope to smaller aspects of the resource efficiency and are not holistic in nature.

Furthermore, the EU has funded several research projects on these topics, some of which have Swedish partners (mentioned in Appendix 2).

# 5 Conclusion and recommendation

The working group sees a substantial potential for the Swedish economy. There is already an interest and an environmental awareness in the Swedish society that will be a good starting point to develop a circular economy, including product design for resource efficiency. These concepts are in their starting phases and there is a great need for building new knowledge, developing innovative ideas and new technology. Furthermore we need to have new forms of collaboration between industry and academia, in order to develop and exploit resource efficient product design. Societal wealth is based on managing stocks (natural, human, cultural and financial capital). The circular economy offers to extend this approach of stock management to manufactured capital.

Resource efficiency, with product design as a pillar, is vitally important to maintain and expand global competiveness of existing Swedish industry, as well as to develop new economic sectors.

We strongly recommend Mistra to initiate an interdisciplinary research program with the following characteristics:

- Collaboration between academia, industry and other stakeholders. Focus on resource efficient design for new products, remanufacturing and technological upgrading of goods and components, Innovative Business Models and Policy.
- A holistic approach, coupling systemic and operational levels, plus company and product levels, and including various aspects on societal, environmental and economic impacts.
- Generic results that are broadly disseminated.

We expect the outcome to be:

- An internationally competitive research environment in Sweden
- Projects and collaboration between industry and academia that will result in new products/services and innovative business models
- Involvement of SMEs
- More researchers that will influence education curricula
- New PhD graduates that will transfer skills to industry and academia

Finally, even though there are international calls available that to some extent are close in parts to what the working group recommend, we conclude that a Mistra programme would meet the specific needs for the Swedish industry and academia. A Mistra programme that bring the national actors together, working with a holistic perspective will strongly contribute to the desired outcome stated above that otherwise will be very difficult to obtain. The opportunity to gear international with national funding and vice versa, will furthermore strengthen the Swedish position from an international perspective.

# Appendix 1
# Terms and Definitions

## British Standards Institute

(BSI) -BS 8887-2:2009

**Reconditioning:** The process of returning a used product to a satisfactory working condition that may be inferior to the original specification. Generally, the resultant product has a warranty that is less than that of a newly manufactured equivalent. The warranty applies to all major wearing parts.

**Remanufacturing:** The process of returning a used product to at least OEM original performance specification from the customers' perspective and giving the resultant product a warranty that is at least equal to that of a newly manufactured equivalent.

**Repair:** Repairing is simply the correction of specified faults in a product. When repaired products have warranties, they are less than those of newly manufactured equivalents. Also, the warranty may not cover the whole product but only the component that has been replaced.

**Reuse:** An operation whereby the existing product is recovered and sold with minimum intervention, to another customer requiring a similar product form.

Note that British Standards has also released standards and specifications for end of life processes, for example, BS 8887-220:2010 - Design for manufacture, assembly, disassembly and end-of-life processing (MADE). The terms and definitions are also approved by WRAP and have been used for the work on E-O-L processes by WRAP'S technical advisory board TAG. TDW/004/0-/05 Design for MADE BSI is the part of British standards Institute in charge of definitions for E-O-L processes.

## Other definitions

**Repurpose:** This would include use of the used product for new uses as exemplified by use of mobile phones to operate hospital equipment, the glass cover from washing machines painted and sold as fruit bowls, and washing machine drums altered for use as BBQ kits. It would also include design-remanufacture, for example parts of different vehicle types e.g. cars, motorcycles etc. are reused in the construction a new type of vehicle.

**Reverse Logistics Process:** The most widely accepted definition comes from The European Working group on Reverse Logistics, REVLOG[7] that defines it as: The process of planning, implementing and controlling flows of raw materials, in process inventory, and finished goods, from a manufacturing, distribution or use point to a point of recovery or point of proper disposal.

7 De Brito & Dekker, (2003) "A Framework for Reverse Logistics" Erim Report Series Research in Management, (ERS-2003-045-LIS); Erasmus University Rotterdam, The Netherlands

# Appendix 2
# List of European calls and projects

## Open calls

### Re-use and remanufacturing technologies and equipment for sustainable product lifecycle management

*http://ec.europa.eu/research/participants/portal/desktop/en/opportunities/h2020/topics/2192-fof-13-2015.html*

**Deadline:** 9th December

**Budget:** €3-6 million

There are several calls under the Waste theme that are expected in 2015 (publication in July 2014). See here:
*http://ec.europa.eu/research/participants/portal/doc/call/h2020/common/1597693-part_12_climate_v1.1_en.pdf*
e.g. WASTE-6-2015: Promoting eco-innovative waste management and prevention as part of sustainable urban development1

### SPIRE (Sustainable Process Industry through Resource and Energy Efficiency).

Overview of SPIRE *here*.
Funded through H2020
**Deadline** in December 2014 for *4 calls* in 2015 with a total budget of €77 million

## Closed calls

### Manufacturing processes for complex structures and geometries with efficient use of material

*http://ec.europa.eu/research/participants/portal/desktop/en/opportunities/h2020/topics/2181-fof-02-2014.html*

### Networking and sharing of best practises in management of new advanced materials through the eco-design of products, eco-innovation, and product life cycle management

(Call which EcoSTAR is submitted to)
*http://ec.europa.eu/research/participants/portal/desktop/en/opportunities/h2020/topics/2527-nmp-34-2014.html*

**SPIRE (Sustainable Process Industry through Resource and Energy Efficiency).**

Overview of SPIRE *here*.

**Deadline:** May 2014 for 4 calls

**Total budget:** €60million

## Running projects

**European FP7 SPREE project on Servicizing Policy for Resource Efficient Economy**

*www.spreeproject.com*

One of the partners is Oksana Mont, Professor, International Institute for Industrial Environmental Economics at Lund University

## Other projects and initiatives

*Centre for Remanufacturing and Reuse* (run by Oakdene Hollins in UK)

*The Global Network for Resource Efficient and Cleaner Production* (RECPnet)


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