Resource Efficiency
Facts and Trends Towards 2050

A report from the IVA project Resource Efficient Business Models – Greater Competitiveness
Changed values in society are altering consumer behaviour and enabling the emergence of new political control mechanisms. The ever-increasing pace of technological development, including digitisation, is affecting these trends and paving the way for the creation of new and powerful business models in Swedish enterprise and industry – business models that exploit the fact that growth and environmental considerations can actually be mutually supportive in the global society of the future. IVA regards resource efficiency as a key factor in making Sweden more competitive, while also recognising that the link between economic growth and increased resource usage can be severed.

Some enterprises have already succeeded in switching to more resource-efficient business models, but more companies can and should follow their example. Companies that change their business models in a resource-efficient direction at an early stage will see significant opportunities for increased profitability and competitiveness. The Government in Sweden should also provide industry and society with tools and control mechanisms to facilitate this transition in the framework of EU cooperation. Contradictions in national and international sustainability policies should be identified and fixed (for example when companies move their production out of the country due to environmental legislation while the emissions impact the environment at the global level.)

It is against this backdrop that in 2014 the Royal Academy of Engineering Sciences (IVA) launched a project called Resource Efficient Business Models – Greater Competitiveness. It has two main focus areas:

• The project will promote new business models with built-in resource efficiency. It will also highlight examples of business models for resource efficiency in different sectors.
• The project will identify control mechanisms that promote the creation of the new business models. The focus will be on both the type and the structure of control mechanisms. The project will also present the private and public sectors with proposals for measures and policy directives.

The vision for the project is that by 2050 Sweden will be regarded as a global role model as a clean and resource-efficient society with the best possible climate in which industry and enterprises can thrive and export resource-efficient solutions while contributing to Sweden’s competitiveness.

One challenge is how Sweden’s efforts will play out at the EU level and in a global context. Sweden becoming resource-efficient will not solve the problem globally. But there are many examples that show how connected the world is; for example, the ban on traditional light bulbs in Europe is affecting light bulb usage in all EU countries as well as their manufacture and use outside the Union. Here, the market can support environmental efforts in a very concrete way. If nothing else, the system’s boundary is made strikingly clear – it is the planet on which we live.

This report, Facts and Trends Towards 2050, describes the short-term supply and demand situation for different resources. The information was gathered through interviews with and consultation between a large number of companies represented in work groups focusing on five sectors: Input Goods, Infrastructure, Consumer Products, Capital Goods/Durables and Food. A Steering Committee has coordinated and supervised the project work, with Björn Stigson as Senior Advisor and Caroline Ankarcrona of IVA as Project Director.

Facts and Trends Towards 2050 addresses the challenges involved in improving resource efficiency, but also the opportunities such as the technological advances that are being made. The problem of balance is also covered; for example, the choice between more efficient resource usage and short-term profitability. The importance of understanding how dynamic today’s business models need to be is also emphasised.

The next phase of the project involves in-depth analysis of a number of resource flows to determine how business models can be adapted for a future resource-conscious society. The importance of cross-sectoral resource efficiency initiatives, including the so-called “value net,” is also highlighted.

The third part of the project describes which control mechanisms may be needed to make Sweden a global leader in resource efficiency, including the potentially important role of the public sector.

My firm hope is that this report, and the project in general, will provide an understanding of what future competitive, resource-efficient business models might look like and how we can make them a reality.

Anders Narvinger
Chairman of the Steering Committee
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- Björn Stigson (Senior Advisor)
- Kenneth Bengtsson (Chairman, Food group)
- Leif Brodén (Chairman, Input Goods group)
- Charlotte Brogren, VINNOVA
- Åke Iverfeldt, Mistra
- Henrik Lampa, H&M (Chairman, Consumer Products group)
- Erik Lautmann, IVA Business Executives Council
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The project defines resource efficiency as “delivering more using less,” so that all environmental resources used in an economy are fundamentally secured for the future and the resources are managed at a level that is below their highest sustainable yield. The term resource efficiency incorporates the notion that waste must be reduced to a level close to zero, damaged ecosystems must be repaired over the long term, and risks at the systemic level for these resources must be identified and mitigated in the future. More productive and sustainable resource usage throughout the life cycle increases the combined economic value and reduces impact on the environment.

The value of raw materials is redefined through analysis of the entire life cycle and the potential value that can be generated. This definition is based on the EU’s Roadmap to a Resource Efficient Europe from 2011.

Improving resource productivity does not necessarily mean more resource savings overall. This report therefore provides several examples of contradictions in the area of resource usage and the challenges they bring.

Sweden currently has a number of national goals which in various ways address the importance of increased resource efficiency in society. The Swedish Environmental Protection Agency’s environmental objective for non-toxic and resource-efficient natural cycles states that “the use of recycled materials must be safe from a health and environmental perspective by, to the greatest extent possible, avoiding the recirculation of harmful substances while aiming for resource efficient natural cycles.” The Agency’s overall “generational goal” stipulates that we should “hand over to the next generation a society in which the major environmental problems have been solved without exacerbating environmental or health problems outside Sweden’s borders.” Models and strategies for resource efficiency in industry are, however, not particularly well developed in our country.

IVA’s project Resource-Efficient Business Models – Greater Competitiveness intends to play a role in a powerful national initiative to improve resource efficiency. The project would like to see the development of several of solutions to increase resource efficiency, including new technical innovations, a more comprehensive systems approach, better control mechanisms, more cooperation and/or thorough analysis and documentation of resource flows. But the most important factor is new business models. The term business model incorporates the following:

- A product or service that also offers a unique experience
- A specific target group for the offering
- Anticipated profitability

Essentially, a business model determines “how, where, when and by what means a company does business.”

The five categories for the project’s work groups are Input Goods, Infrastructure, Capital Goods/Durables, Consumer Products and Food. These categories are to some extent based on internationally accepted definitions of these industries or sectors, but they are based on strict divisions such as business-to-consumer (B2C) versus business-to-business (B2B) to facilitate the necessary cross-sectoral discussions and synergies. To optimise transparency a brief definition of each company category has been included at the beginning of each work group chapter, including a list of the types of companies represented in the group in question.

The lines between sectors are in many cases blurred; for example, the forest and wood sector may often cross over into the packaging industry and consumer sector. Cross-sectoral opportunities and challenges relating to resource efficiency will, however, be examined in more detail in future reports that will include analysis of both the flow of certain raw materials and their usage in different sectoral contexts. Resource efficiency and flow optimisation are complex concepts and the project has consciously chosen to focus primarily on raw material flows. Energy efficiency improvement will therefore be a secondary theme in this report. A number of other IVA projects and reports have addressed energy efficiency in recent years. The service sector (including transport, logistics etc.) is not among the primarily sectors being analysed here either. We do, however, emphasise the fact that solutions to multiple and difficult raw material problems may often come from new smart services (as described in many of the sector chapters under the heading “Dynamic business models”). This will also be explored in future project reports.
The UN predicts that the global population will increase by 30 percent by 2050. The majority of this increase will be in growth nations. The population in these countries will make up a full 85 percent of all people on the planet by 2050.

The situation in Sweden looks brighter, however, and many people today believe that Sweden is about to sever the connection between growth and emissions. One of the ways this is happening is through an increase in the emergence of services – a Skype call, for example, only contributes marginally to emissions. But this is a highly simplified model for Sweden’s success that does not take into account things like the “carbon leakage” that occurs when production is moved from Sweden to other countries.

Forecasts show that the growth nations’ economies will make up 60 percent of global GDP by 2025. There is therefore a risk of a significant increase in pressure on resources, the environment and society.

At the same time, this enormous challenge will not be made any easier by the fact that today’s global controlling bodies, such as the UN and the WTO, are not equipped for the task. Although there is broad political consensus on addressing climate change and the depletion of biodiversity, what is also needed – as pointed out by the International Resource Panel – is a holistic approach to resource management. Without this, we will never be able to fully identify the global shortcomings and connections in resource efficiency. Scientific assessments, such as the Millennium Ecosystem Assessment, Global Environmental Outlook and the fourth evaluation report from the UN Climate Panel, make it increasingly clear that the world cannot achieve sustainable economic growth without significant innovation on both the supply side (production) and the demand side (consumption) of the market. The need to sever the connection between economic growth/resource usage and environmental degradation will require changes in design, production and processes. Consumer behaviour will also need to be altered, and this is where there is significant potential for new business models.

Due to their unsustainable structure, societies are usually characterised in terms of linear flows – we obtain various raw materials, manufacture products and then throw them away. In terms of food alone, the UN FAO estimates that we throw away enough food to satisfy the 800 million chronically hungry and undernourished people around the globe four times over. Different business models could help break this harmful pattern. Consulting firm Accenture has identified five such business models:

- **Circular supplies**, such as renewable energy, bio-based or fully recyclable input goods to replace materials that only last for one life cycle.
- **Resource recycling**: Re-using resources from discarded products or by-products.
- **Prolonging the life cycle** of products and components by repairing, upgrading or reselling them.
- **Sharing platforms** – to increase the utilisation rate of products through shared use and ownership.
- **Products as a service** – a system where someone can offer a product for use by others while retaining ownership of it.
Today, increased resource efficiency is becoming very much a national strategic issue with a significant impact on a country’s competitiveness in relation to other countries. The country with the most resource and energy-efficient solutions will be the winner. The government of the Netherlands has produced a report on the potential of a circular economy. The UK has imposed a tax on the extraction of virgin natural resources. The EU has adopted resource efficiency as one of its flagship initiatives for EU 2020 and expects the proposed measures to provide net savings for companies in the EU of up to EUR 600 billion. The project wants to facilitate the introduction of an effective control mechanism system for resource efficiency at both the Swedish and the EU level.

Many European countries are currently experiencing slowing growth and are losing market share to growth nations. The same applies to the USA which, even though it is the world’s most innovative economy, is suffering from an internal political deadlock which could send investors to other markets. Successful efforts to increase resource efficiency should therefore include the growth and profitability aspects. In light of this, in 2015 the EU started reviewing its previously announced initiatives on the circular economy and has analysed how alternative proposals for this area could be more clearly linked to growth and jobs.

Strong growth in Asia in recent decades has also had a very significant impact on business models and control mechanisms on that continent. South Korea, for example, has introduced a series of commendable initiatives such as a tax deduction for SMEs that clean or recycle waste. China taxes mineral extraction at the same time as the country allows companies that manufacture products made from recycled materials to claim extensive VAT deductions. Japan imposes extensive legal requirements relating to life cycles and corporate responsibility for waste. The race towards a more resource-efficient economy in the future will, in other words, change the political and economic map.

In industry there is also a race under way to see who will succeed in producing the most resource-efficient goods and services. The company Airbnb, which has a multinational network of private individuals, is renting out rooms in what has become one of the world’s absolute largest “hotel chains” – without having to build a single hotel room. The Dutch consulting firm Turntoo is offering circular solutions whereby people rent their washing machine as a service from a company that owns and supplies the machines. Food giant Unilever’s sustainable strategy called Sustainable Living Plan was one of the reasons CEO Paul Polman won the Gothenburg Award for Sustainable Development in the autumn, and French company Michelin leases tires to the US military among others.

Many exciting and important initiatives are already being implemented in Sweden. The Swedish Foundation for Strategic Environmental Research (Mistra) has issued calls for funding proposals under the headings “Product design for resource efficiency: Towards a circular economy” and “Mistra Financial Systems.” The foundation is also launching the Mistra Center for Sustainable Markets (MISUM) at the Stockholm School of Economics. Lena Ek, Former Minister for the Environment, initiated the ambitious international project entitled New Climate Economy. In the private sector, Swedish Humble Brush is playing a part by producing fully biodegradable toothbrushes, Nudie Jeans is turning discarded jeans into rag-mats and Merox is recycling materials from SSAB’s steel manufacturing. Some of IVA’s projects, such as Attractiveness for Sustainable Growth and Electricity Crossroads, are highlighting the consequences for society of various options in economic and energy policy.

Its innovative capacity, strong economy, well-developed social systems and sustainability foresight all put Sweden in a very strong position to contribute to the resource-efficient economy of the future. Our country can deliver climate and environmentally-sound solutions, while also optimising productivity, profitability and competitiveness. In other words, a lot is happening on the resource efficiency front in both the private and public sectors. Still, we need to pick up the pace and increase the number of initiatives.
Synthesis

The new values held today by conscious consumers and businesses have opened the door for new behaviours in the market and control mechanisms that support this development. But due to the shortage of or uncertainty about some raw materials and the new environmental and climate challenges, “business as usual” is no longer beneficial or advisable. Instead there is now a need and an opportunity for building new and dynamic business models for the Swedish economy of the future. There may also be a disconnect between what is offered and what people actually want; some industries offer plenty of resource-efficient products, but find it hard to attract customers. In other cases the opposite is true. This new situation and the needs of the future have been discussed at length by the project’s work groups and are summarised under the different headings below.

Growth, development and demand for resources
Several sectors are experiencing significant fluctuation in the price of their key materials – sometimes with a prolonged upwards trend. And for the most part there are no strategies in place to handle a real shortage. Although specific raw materials can be substituted for others in certain sectors and for some products, this is not always possible. The infrastructure sector often uses local materials, e.g. at construction sites, and the sector may therefore not be prioritising reducing raw material usage.

At the global level, the supply of some primary resources – such as water and land – is threatened by increased competition for the resources, depletion and inadequate restoration, as well as the greenhouse effect. According to some experts, raw materials in the next link of the chain, such as phosphorus and certain minerals, are expected to be in short supply in the not too distant future.

Compared with many other countries Sweden is still in a privileged position in terms or access to resources, which may of course make us more competitive than other EU countries and the rest of the world. Sweden still has an abundance of many input goods such as forest products and iron ore. But we are experiencing the secondary effects of shortages of some imported raw materials. Competition may also arise for the raw materials that are in good supply domestically in terms of which areas to prioritise (for example, biofuel versus food production versus fibre production).

In most industries today there is insufficient analysis of, and strategies for, how to handle a shortage of the most critical raw materials. Resource efficiency needs to be front and centre on the political agenda as well. The question that needs to be asked is: How can we ensure a robust Swedish society and a dynamic economy now and in global resource usage scenarios of the future? It is also important to more clearly show how Swedish society can benefit from a transition to greater resource efficiency.

Resource usage and impact
Bioplastics, textile fibres, construction materials and carbon sinks are bringing new opportunities to input goods sectors such forest and wood in Sweden. But to realise these opportunities Sweden needs to invest significantly in production efficiency, research and in the development of technical innovation and new technologies and processes. At the same time we need to ensure that our forestry practices are sustainable.

The Swedish steel industry has doubled its metals extraction since 2009. Minerals accounted for 10 percent of Swedish exports in 2013. 90 percent of all steel and aluminium is recycled. One reason for this is a high second-hand value and efficient recycling processes. In other words, the metals have the same good quality after they are recycled. Light-weight steel can provide weight savings of up to 40 percent in some designs, resulting in significant resource gains.

Plastic, on the other hand, is a complex material making it difficult to recycle. Only 10 percent is recycled today and the quality and quantity of recycled plastic is low. Plastic does not last forever and its properties are degraded as it ages.

Plastics account for 45 percent of construction costs in the infrastructure sector. At the same time, the percentage in new construction is small compared to in existing buildings and infrastructure, making better use of existing infrastructure a key issue. The housing and service sectors use 38 percent of Sweden’s energy.

High labour costs in the capital goods industry have resulted in more automation. A similar investment is now needed to improve the industry’s resource efficiency, if nothing else, to ensure a sustainable future for the industry. Raw materials account for about 50 percent of expenditures in Swedish industry, which is a reason to review product design, business models and production processes. Engineering products accounted for 44 percent of Swedish exports in 2013.

The paper industry recycles 70 percent of its
products, while the textile industry hardly recycles anything at all today. The consumer product sector has considerable experience of handling consumer requests, and the industry is noticing that the trend towards sustainability is driven by individual initiatives by companies rather than control mechanisms. The industry needs to conduct local and global analysis to study the annual limits for resource consumption, as well as life cycle perspectives that show the total environmental impact during a product’s life cycle.

The FAO has determined that food production needs to increase by 60 percent by 2050. We also need to reduce greenhouse gas emissions, lower the pressure on natural resources and use pesticides and fertilisers more efficiently. The future will bring significant challenges and the Swedish food industry is not prepared for a shortage of resources. Furthermore, one third of all food produced is thrown away. According to the FAO about USD 1 billion dollars is being wasted, which is almost equivalent to all food produced in the EU. New business models and new technology, such as precision technology in agriculture, logistics and packaging, are important.

**Dynamic business models and technical development**

Business models are about having a better understanding of customer needs and how customers use a product. Some companies participating in the project believe that customers in many consumer sectors are environmentally aware, but still frequently put price before the environment. Companies are also noticing that consumers who buy more ecolabelled products trust the company to deliver sustainable goods and services. Here, market pressure is the driver, with competition between companies and customer perception of status and availability. In B2B sectors, on the other hand, it is difficult to charge for a product’s resource efficiency. Here the regulations control the behaviour of companies in a different way.

Individual products can help improve resource efficiency in the user part of the chain. A transaction often develops from a discussion with the customers on raw materials use and the position in the value chain. The use of raw materials between these chains – so-called “value net” – is, however, rarely highlighted. This is otherwise an important factor in optimising flows in a circular resource system.
New technologies that can lead to a technology shift in resource usage are key. But innovation is needed to achieve this. Both product development and development of new processes and business models will be needed. Models based on sharing are already being developed today for vehicles (carpools etc.), offices (renting turnkey offices, used furniture etc.) and even in the clothing industry (renting a wardrobe etc.). Digitisation can shorten lead times and improve product information (e.g. for an individual product’s maintenance requirements).

Future resource usage

Resource scarcity is in general not experienced as urgent today by Swedish companies (especially not by input goods suppliers). Most sectors are not looking as far ahead as 2050. What is clear is that sectors close to the point of consumption are more aware of the problem and have come further in understanding the need for resource-efficient business models. In these sectors, resource efficiency is considered a competitive advantage.

But these sectors are also the least used to relying on control mechanisms to change the conditions and are instead often focusing on making the transition themselves. B2B sectors that are distanced from consumer influence are more likely to need control mechanisms to guide them. Industries that are optimistic about the resource supply and that do not see any imminent shortage need to be motivated by things other than scarcity to take charge of their resource management (such as profitability improvement opportunities, other environmental considerations etc.). Control mechanisms are needed in areas where resource efficiency would not be profitable from a commercial standpoint or where no price has been placed on the negative effects.

There are, however, sectors that are aware of the lack of strategies to handle resource shortages and that have identified this as a real threat. Certain industries are highly fragmented and the various players are only responsible for a small part of the value chain. In this situation it is important to find ways to take joint responsibility for the entire value chain as well as the end product.

Much of the resource efficiency work has up to now been carried out by individual companies. But there are also many opportunities ahead for improved efficiency across businesses and sectors. Success requires a systematic approach and concrete partnerships. These could, for example, be achieved by a number of players coming together to identify common future challenges.

Conflicting objectives are often cited as an obstacle to resource efficiency. Everything from species protection, workplace safety rules, democratic processes in planning and building legislation or rules relating to waste can stand in the way of resource-efficient solutions. Conflicting objectives may be difficult to manage but they may also result in important and far-sighted technology shifts. One important question to ask before proceeding with resource efficiency work is how to optimise resource efficiency for the sustainable development of society. The project will shed light many times on the issue of conflicting objectives, through industry examples in this report and in future publications.

Conclusion

In the Resource Efficient Business Models – Greater Competitiveness project, IVA’s objective is to contribute to a forward-looking dialogue with the community about a vision for Sweden’s role in managing technical and biological resources. This report reflects the current situation for the 45 or so companies that are participating in the work groups, as well as their opinions on the resource issue and how to manage it.

The Steering Committee has determined that Sweden has an important role to play to improve resource management capacity in the society of the future through innovation, cooperation, control mechanisms and other methods. The Committee also believes that this could be done in a way that makes Sweden more competitive globally and puts Swedish industry in a leading position moving forward.

The conclusions drawn here by the work groups will inform the project work to be done in the future. In future phases, the project will focus on providing examples of business models and system changes that can lead to better resource efficiency, profitability and, hopefully, competitiveness as well. The project will identify alternative paths towards a resource-efficient economy by 2050 and how to make the journey successful.

The third and final stage of the project will address how we can realise these desirable paths and determine which control mechanisms are needed.

It will be a demanding and arduous journey for the companies as they strive for smarter ways to manage raw materials and input goods. But the rewards in the form of improved profitability and stronger competitiveness, as well as a sustainable society, will be worth the effort.
Control mechanisms

In addition to the project sector work groups (Input Goods, Capital Goods/Durables, Consumer Products and Food), a group has been formed to analyse control mechanisms.

The premise for the project is that the market economy is the general resource allocation system. In a “perfect market” resource allocation would be done through price mechanisms, where the producer/owner of the resource sells what consumers demand at a given price level. But as we know there are many policy and behavioural aspects that come into play and as a result, the market economy does not always work as well as it should. Distribution is, for example, often a very important factor – we are very concerned with the distribution of costs and revenues between different players in the economy. Also in the “perfect market’s” textbook world there is no public sector, but in the real world in Sweden the public sector is a very significant part of society with responsibility for socially critical functions at the national, regional and local levels.

The public sector’s mission includes managing environmental issues and other areas where the market economy does not work. In Sweden we are working towards the “generation goal” (see fact box), as well as the “16 million goal.”

- Reduced Climate Impact
- Clean Air
- Natural Acidification Only
- A Non-Toxic Environment
- A Protective Ozone Layer
- A Safe Radiation Environment
- Zero Eutrophication
- Flourishing Lakes and Streams
- Good Quality Groundwater
- A Balanced Marine Environment, Flourishing Coastal Areas and Archipelagos
- Thriving Wetlands
- Sustainable Forests
- A Varied Agricultural Landscape
- A Magnificent Mountain Landscape
- A Good Built Environment
- A Rich Diversity of Plant and Animal Life

Control mechanisms can be introduced when a market failure is noticed or resource inefficiency is identified. It is, however, important to analyse the fundamental reasons for the market’s failure, because only then can a control mechanism be introduced.

During the course of the project the need for different control mechanisms will be discussed by the work groups. When the final phase of Resource Efficient Business Models – Greater Competitiveness approaches, the control mechanism issue will be substantially concretized and reports will be produced to describe which control mechanisms will promote resource-efficient business models.

“The overall environmental policy goal is to be able to hand over to the next generation a society in which the major environmental problems have been solved without exacerbating environmental and health problems outside Sweden’s borders.”

Parliament’s definition of the generation goal
Input Goods

Input goods are resources that are used to produce other goods. The project has focused on wood, steel, plastics and chemicals. The companies in this work group are from the metals sector (extraction and production), minerals sector, forest and wood sector, oil and chemicals sector, and the recycling sector (recycling of input goods).

Growth, development and demand for resources

Companies that supply input goods are often the “first link in the value chain” in the production process. Global demand for these resources is so great today that it has led to significant price fluctuation and an upward trend on the raw materials markets (see graphs). The supply of resources globally is becoming increasingly uncertain and this is making it difficult to produce robust business strategies. Environmental considerations and issues of fairness are adding to the need for resource efficiency with respect to input goods.

Many raw materials such as forest materials or iron ore are plentiful in Sweden. But the demand for forest raw materials may increase significantly because many sectors, for climate impact reasons etc., are now demanding more biomaterials. Sweden’s economy is still heavily raw materials-based and tied to input goods (see chart). In this context, our country is not only dependent on Swedish raw materials, but imported ones as well.

IVA has identified an increase in competition for resources due to tough international competition and higher raw materials prices. This may, however, create new opportunities and increased profitability for basic and recycling industries. Many companies are generally quite confident in the market’s ability to handle shortages through clear price signals. They also believe in the plentiful supply of mineral resources in the earth’s crust, net growth in forests and a greater supply of materials in the recycling system.

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But in order to utilise this, investment is needed to make production processes more efficient and to handle competition from countries with lower production costs.
Resource usage and impact

There is competition today for the use of certain global input goods. The forest is one example: although forest fibre should only be used for energy production in the final phase, it can be used earlier in pulp production, clothes, packaging, food or in building construction. It is important to add all of these to see how large the total demand is and what constitutes the sustainable use of forests. The same applies to sustainable extraction in the mining sector.

Since many of these industries are fuel-intensive there is concern about higher prices in the fossil industry. There is also concern about “input goods for input goods,” such as land and water. The UN Food and Agriculture Organization (FAO) is, for example, expecting a 100-percent increase in demand for water by 2030.\(^{11}\) Competition for – and regulation of – land and water usage, like permits to operate mines, as well as criteria for water-intensive industries, are key issues.

In Sweden, recycling of various input goods has been stable and relatively constant over the past decade, except for a fairly substantial increase in metal extraction since 2009 (see figure).\(^{12}\)

Certain companies are, however, concerned about price fluctuation and an absolute shortage of less critical resource flows. But efficient exchanges exist for a number of raw materials, where prices can be guaranteed through futures and options. The transition to forest raw materials could reduce the effects of fluctuations in the price and supply of the raw materials they replace. Competition for and production of rare earth metals are not expected to impact resource efficiency efforts to any significant degree.

### Contradictions in resource goals

There are some national and global political contradictions that are hampering resource efficiency efforts. Through the “Ironman” project, Swedish companies LKAB and Höganäs AB want to replace climate-harming coal-fuelled iron production in Sweden and elsewhere with more climate-friendly gas-fuelled production in Norway. The gases formed in iron production could be re-used as fuel in plant pre-heaters, and a carbon dioxide separator could remove the carbon dioxide from the gases and pump it away to be stored under the seabed. The world’s most carbon neutral ironworks could become a reality.

The problem, however, has been that there would still be in increase in emissions in Norway compared to if no ironworks were to be built there. The Norwegian government has therefore been opposed to the plant’s construction for some time.

Norwegian and Swedish players have drawn attention to this contradiction, and today a positive and promising dialogue has been initiated to see if the plant can finally be built.

Read more at iva.se/ironman

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**Domestic extraction per material category, Sweden 2000–2012**

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<tr>
<td>Non-chemical minerals</td>
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<td>80</td>
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Source: SCB.\(^{12}\) Note that the data is for Sweden as a whole and is limited to the industries being covered by the work groups.
Dynamic business models and technical development

Many companies lack any specific resource efficiency goals. However, the energy usage and environmental impact goals of many companies are believed to include the resource efficiency aspect. Many companies would like to more clearly define the gains to be made through resource efficiency, including at the society level. In this context the question also arises of how to modify parameters in complex resource systems without sub-optimising resource usage at certain levels.

A transition to forest raw materials, which is now a common practice, is not seen as synonymous with increased resource efficiency because the transportation needs may increase when raw materials with a different energy density and volume are used.

Like in other sectors, the raw materials sector is transitioning towards selling more services and this is helping to improve resource efficiency.

Many input goods processes are based on well-developed and refined technologies. To achieve great efficiency gains – i.e. production value in relation to raw materials used – more innovation is needed. Fibres could be used to a greater extent and metals used in vehicles could be lighter etc. Of particular importance is the issue of developing technologies to separate components in the recycling system (traceability) and composites that can be recycled without any special treatment (necessary for the packaging industry).

During the project it became apparent that many companies in the recycling sector would like users and the authorities to require greater recycling and re-usage. This, however, requires better knowledge of the options that exist, as well as meetingplaces for dialogue on recycling. A number of representatives from the recycling sector have expressed a willingness to take on a greater role by, for example, developing logistics and reproduction solutions.

<table>
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<tr>
<th>Steel production cycle</th>
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<td>An example of a resource-efficient business model is one used by SSAB Merox, a subsidiary of SSAB which was formed in 1973 to optimise SSAB’s by-product, scrap and waste management. Merox recycles materials for SSAB’s metallurgy, processes and sells products externally, and takes care of waste that cannot be recycled. Read more at iva.se/merox</td>
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Future resource usage

Global long-term trends indicate that demand for input goods will increase. This may benefit a country like Sweden which has a good supply of raw materials.

There is uncertainty about which raw materials have passed their maximum expected extraction peak and which ones are about to. There is also concern about the supply of ecosystem resources and about permits being granted. One issue may be the levels for sustainable net extraction from forests and mineral extraction in relation to the natural value around the extraction/mining site.

Demand for certain input goods may decline, such as for printed newspapers and powder steel for conventional car engines (due to the development of electric cars). Plastics and composites as well as carbon fibre and other fossil materials may initially replace some raw materials such as steel and wood, but in the long run bio-based products will become more important.

Many companies have identified a need to develop technologies and processes to meet specific competition from low-cost nations. There is also a desire to
work with other players to further explore a number of issues to create better consensus and understanding of resource efficiency goals, opportunities and obstacles, and to study the gains to be made by leading in this area. Possible profitability gains need to be identified, including other benefits for companies and society – and any contradictions explored. There is also specific competition relating to forest raw materials and it would therefore be wise to determine a sustainable extraction rate for forests and how this resource should be used.

The companies asked are keen to define how much of the flows and value chains are regional or Swedish versus foreign. One issue is what virgin materials exist and are needed, and which political mandates are needed to drive increased resource efficiency.

Today’s resource efficiency partnerships are thought to work better in B2B than in B2C. The reasons for this include that while rational business strategies determine a company’s resource efficiency focus, consumer choices may be based more on emotions and values.
According to the UN World Population Prospects, the global population will increase from just over 7 billion today to 9.3 billion by 2050. Sweden’s population is expected to increase by 18–33 percent by 2050. Urbanisation is also on the rise: The Stockholm Chamber of Commerce expects Stockholm County to grow by around 40,000 people a year up to 2020. This will be accompanied by an increase in goods and passenger transport in Sweden.

The infrastructure sector will be impacted by this, i.e. through an increased demand for homes, roads and railways. Material costs make up a full 45 percent of construction costs and almost 30 percent of the sector’s total production costs. In comparison with salaries, machinery, transport, fuel and electric power, these costs increased the most in the years 1990–2012 by an average of 4 percent a year, according to the Swedish Construction Federation (BI). Material prices are mainly determined by the international market. From a cost perspective, the infrastructure sector therefore already has an incentive to become more resource efficient. From a sustainability and profitability perspective goods and passenger transport needs to be reduced, for example by being condensed and adapted according to the needs in urban and suburban environments. Alternatively, mass transit as a percentage of total passenger transport needs to increase, and greener fuel alternatives must be more widely used. Although energy efficiency in the operation of buildings has improved, the same does not apply to construction processes.
According to the US Energy Information Administration (EIA) the housing and service sectors are responsible for around 30 percent of the world’s energy usage, although this percentage is steadily increasing. According to the Swedish Energy Agency, homes and services in Sweden account for around 38 percent of energy usage. Buildings have become more energy efficient in the usage phase, but not in the actual construction process which, according to IVA and the Swedish Construction Federation (BI) is still energy intensive. This depends, among other things, on the climate impact of heavy concrete shells in multi-dwelling buildings – although alternative material choices may be worse from a life-cycle perspective. Workplace safety, environmental regulations (such as species protection) etc. may result in conflicting objectives with respect to resource efficiency at building sites if requirements are not handled in a structured way by the players involved.

Numerous trends may have a negative impact on the environment and increase costs in the infrastructure industry. For example, more and more international players, such as minor players in this sector, may emerge and this would increase competition but also speed up the pace of innovation. The construction of the New Karolinska Solna Hospital in Stockholm County, which has involved many subcontractors from other countries, is one example of this.

Material consumption at building sites in Sweden has increased by 20 percent since 2000, which is largely due to the fact that we are building more. Materials in demand, such as sand, stone, gravel, wood, etc., are often available locally in a plentiful supply, and if alternatives are sought, it is more likely to be a price issue than a supply shortage issue. Using local materials may, however, lead to environmental protests from people living in the vicinity. All in all, the industry is facing a big challenge to identify and implement business models that involve small inflows and outflows of natural resources. New work processes and digitisation are, however, providing some opportunities.

Natural gravel, often used in concrete, is classified by the Swedish Environmental Protection Agency as a scarce resource in Sweden because it is a finite resource that is important for the supply of drinking water. Control mechanisms to reduce the extraction of natural gravel include the quarry permit requirement, regional materials supply programmes and the natural gravel tax. A construction or procurement entity could, however, reward companies and products that are helping to reduce the use of natural gravel. It is, for example, possible today to produce concrete using crushed stone, although one problem seems to be that customers do not request or value this product.

The construction industry has produced guidelines...
for resource and waste management. According to the Swedish Environmental Protection Agency, the total amount of waste in Sweden in 2012 was 156 million tonnes, of which 123 million came from the mining industry and 7.7 million from the construction sector (see chart).16

The Swedish Environmental Protection Agency points out the importance of limiting construction and demolition waste. In 2012, 900,000 tonnes were classified as hazardous waste and 6.8 million tonnes as non-hazardous, with 3.4 million tonnes being used as construction materials and for refilling and final coverage of landfills. Mud mass (2.1 million tonnes) was dumped into sea. Around 1.6 million tonnes went into landfills (mainly earth mass, concrete and stone). The landfill tax and landfill ban have reduced the dumping of waste in landfills, but the actual quantity of waste has not gone down.16

Dynamic business models and technical development

Infrastructure projects are usually large and costly; they take time to implement but have a long life. Although the market is in a period of rapid transition, the pace of regulatory changes is slower.

A common business model today in terms of local adaptation involves contractors adding a certain percentage to material costs. There is, in other words, no incentive for keeping the quantity of materials or material costs down. If the business model were instead to be based on renting out a turnkey space, there would be other incentives. Today some companies are already renting out complete office furnishings and fittings to customers.

There are also channels for used building supplies, although one problem here is that contractors do not provide guarantees for general contracts when used products are used.

One underlying problem in the construction process is that most players are only involved in a few stages, so that their ability to influence them varies, and no one has a real overview of the situation. If the same company were to handle both the construction and operation phases, it would be better able to choose new materials, such as green asphalt produced at lower temperatures and with a lower climate impact.

Digitisation and a new vision for homes, offices and modes of transport, where ownership and sole rights are not important, could in the future open the way for an advanced “sharing economy.” Offices and other spaces that are only used 50 percent of the time on week days between 8 a.m. and 5 p.m. represent a total capacity utilisation in a 24-hour period of just 13 percent.21

The Public Procurement Act (LoU) is important in the Government’s and the municipal authorities’ construction investments. The ability to influence the construction processes and choice of materials varies depending on the choice of turnkey, general or build & operate contracts. Low cost is often what wins a procurement bid, while after-sales are profitable for consultants/contractors, which is not resource-efficient from a system perspective.

The planning and building permit process and environmental legislation also, of course, play an important role in planning. The process may cause a construction project to take ten years from idea to reality, and it may be difficult to make changes to the design and material choices later on in the process.

Partnerships are often seen as a way to resolve resource issues, even though they may also reduce competition. Public-private partnerships and other collaboration and sharing platforms are examples of interesting models. Agreeing on the challenges and joining forces, as in BASTA or the Ecocycle Council, are also beneficial (see fact box).

The Eurocodes – harmonised rules for calculating the technical specifications of structures – are today enabling multiple construction companies to compete internationally, which will hopefully lead to lower construction prices. But Eurocodes also require more reinforcement in Swedish building construction.

Construction waste becomes swallow’s nest

Infrastructure business models must be able to handle conflicting objectives and increase value by enabling a simultaneous focus on multiple objectives. The Port of Gothenburg has created piles of waste crushed rock where swallows can build nests and lay their eggs, and has created artificial reefs where fish and shellfish can live and play.
The Swedish green certification scheme in the construction sector today does not focus on resource efficiency. The US LEED (Leadership in Energy & Environmental Design) system does, on the other hand, address the choice of materials in an international context. LEED is a certification scheme for green construction that promotes the use of the greenest construction methods. An increase in the application of the UK certification system, CEEQUAL, particularly in the procurement process, would drive resource efficiency work in the sector.

Future resource usage

It is important to make transportation more efficient in this sector in the future by, for example, focusing right from the planning stage on exploiting the potential of used materials around building sites. The large volumes of materials, like crushed rock, produced in the construction process should be seen as an asset. Efficiency in construction routines and methods could be improved by, for example, developing new planning tools to prevent waste, such as materials becoming mouldy before they are used.

Infrastructure of the future will be more resource-efficient mainly due to existing infrastructure having an increased value through better utilisation. The degree of utilisation of offices and other spaces is rarely above 50 percent, although there is a trend towards having fewer square meters and using them more efficiently.

New ways of thinking about what we need, how we live, the use of space etc. are key and are leading to new business models. Players are renting out functions instead of space. Digitisation means that we have our office in our pocket and that we can get realtime information on where to find vacant space.

It is becoming increasingly common to choose used office and building materials. Property company Vasakronan’s own offices are largely furnished with used furniture. The company’s “Smart & Klart” turnkey office concept saves tenants from having to purchase furniture, audio-visual equipment and other technology.21

Today, the democratic process of dialogue between relevant players and citizens can be drawn out and sometimes gets in the way of resource efficiency. This needs to be reversed in the future. Research is becoming a component in business models that emphasise cooperation. In the future new infrastructure projects will be used to increase socioeconomic value, achieve environmental goals and manage conflicting objectives.

The companies interviewed said that by 2050 we will have system solutions where sensors are integrated and interact with each other in real time (Internet of Things) to rationalise the use of premises, places to sleep, as well as roads, transportation and land surface. This should change our approach to living and vehicle ownership. The possibility of using roads more efficiently is being developed in the Drive Me project, where 100 autopi-loot cars will be tested on public roads in Gothenburg starting in 2017.

Digitisation of vehicles fleets will also result in cars that park themselves or even leave their parking space so that someone else can use it. This will free up land for things other than parking.

More advanced signal systems will enable the rail system to be used much more efficiently, provided that railway capacity can be expanded. Also, the material inflows into processes will be reduced and outflows will be lower due to more efficient recycling systems.

**Resource-smart concrete industry**

Thomas Betong (formerly AB Färdig Betong) provides a good example of recycling at its plants where water from washing/rinsing the interior of vehicles is re-used, thus reducing the company’s water consumption. The company also re-uses washed ballast at some of its plants.
Capital Goods/Durables

Capital goods and durables include everything from white goods and vehicles to furniture. Ventilation and climate control equipment is also included. In business-to-business (B2B) this category includes engineering equipment. Companies in all of these sectors were represented in the project’s work group.

Growth, development and demand for resources

The price of capital goods and durables, such as dishwashers or cars, is greatly affected by material costs. This product category uses large quantities of metals, with steel, iron, aluminium and copper as the dominant ones. According to data from McKinsey, an increased demand for metals over the past decade has resulted in higher prices and greater price fluctuation than in the past (see chart).

According to the World Bank in its Commodity Prices Forecast for October 2014, the increase in demand comes mainly from China. However, the World Bank does not believe that metals will become more expensive than today in the period up to 2025. Nor does the EU in its Report on Critical Raw Materials for the EU predict that access to metals such as aluminium, iron and copper will become critical in the future (unike rare earth metals). Fluctuations may, on the other hand, arise due to security policy, epidemics or trade measures, and this is a reason to find ways to save resources.

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Understanding material flows is important, e.g. from a sector competition perspective. Efficient recycling systems exist for some material flows. 90 percent of all steel and aluminium is recycled, according to TCO Development. Steel essentially has a closed cycle in which it is constantly being refined and used for new products. One main reason is the high second-hand value of many metals.

Another material used for capital goods is plastic.
But plastic is a complex material that often contains undesirable chemicals, which makes it difficult to recycle. Its properties also become degraded over time. Research and technical development for clean material flows and efficient collection systems are needed here. Some companies are still investing strategically in sustainable plastic. By 2020, 100 percent of all plastics used in Ikea’s home furnishing products will be recycled or made from renewable raw materials (today that figure is 5 percent). Electrolux is also using recycled plastic, particularly in its vacuum cleaners and irons. Many companies are attempting to make the switch from plastic made from fossil oils to bioplastics.

Resource usage and impact

Companies producing capital goods need, on the one hand, to develop existing products for better resource efficiency, and on other hand to ensure that their products provide better resource efficiency benefits for their customers. It is important for small innovative companies in this sector to reach the market and to grow.

Certain factors also need to be weighed against each other. For example, the benefits of re-using materials need to be weighed against the energy usage throughout the usage phase. Today’s most energy-efficient refrigerators, for example, only use 20 percent of what the average refrigerator on the market at the beginning of the 1990s used – but they last longer. And more than 90 percent of the environmental impact of a lorry is generated during the user phase, hence the emphasis on developing fuel-efficient vehicles. Fossil fuels are still widely used in the industry, and a lot of development money is being invested primarily in refining old technology.

Production waste can be prevented, for example, through increased automation and use of laser technology. The “zero waste” goal is an appropriate challenge here. Virtual production development and simulation can improve efficiency in product lines and production systems for whole factories. Choosing alternative materials like light-weight steel in vehicles also improves energy and resource efficiency. Stronger and more durable steel, for example, can provide weight savings of up to 40 percent in some steel structures.
Dynamic business models and technical development

Resource efficiency should really be addressed at the product design stage. Dismantling tests could, for example, be introduced as part of the product development process to improve efficiency in recycling resources from worn out products by avoiding mixing materials or by using screws instead of adhesives etc.

Selling functions and a “sharing economy” are expected to become more and more common in the capital goods sector. The function of moving people and things will be sold instead of cars as physical products. This requires new business models, tying up capital, distribution of responsibilities and insurance. The product will need to be owned by the customer, the manufacturer or the bank – and this will affect the balance sheet.

One solution is car pools: the customer will still be able to use the car, but more people will be able to use the same car. When more people share capital goods, functionality, efficiency and quality can be improved because the fixed costs are shared by several users. It may also be possible to apply these types of solutions across different spheres between companies and individuals. In the future, for example, it may be possible for a person to drive their car to work and then link up with a taxi service that then uses the car during the day and returns it in time for the drive home.

In order to increase the trend of renting or sharing products in a community instead of individual ownership, the status of renting and sharing will need to be raised. Sustainability awareness among customers is on the rise, which may change consumer behaviour and buying patterns; customers may, for example, avoid products that are made to use and discard. Collection or take-back systems allow people to return their used products, but more financial incentives are needed for this.

Selling used goods is, however, associated with some problems relating to product safety, guarantees etc. More research and control mechanisms are needed to improve the recycling of materials such as plastic to address the problem of chemical traceability and to stimulate collection flows.

Since labour costs in Sweden are high in relation to many other markets, customers often prefer to buy new, reliable products than to service a product they already own. New products may, however, be greener during the operations phase.

When industrial equipment is installed in another country it may be more difficult to have efficient systems for service and product leasing. For certain products it is better to upgrade an entire plant rather than replace parts of it. The product development process needs to address and determine how customers can upgrade the product. One way of handling service and upgrades in a resource-efficient way is through modularisation, i.e. building products from separate modules with standardised interfaces that can be combined to build different versions of a product.

Increasing digitisation and data communication in society may facilitate the emergence of new, resource-efficient business models, such as product sharing within and between companies, between consumers and eventually between products as well. Traditional products will be “connected” and be able to communicate through the Internet of Things/machine-to-machine, and provide information on where the product is located, when it will be available and when it needs to be serviced etc. Lorries and traffic flows could be controlled in this way via GPS and other sensors. Increased digitisation will also facilitate “upgradeability” to prolong the life of products. The Tesla electric car is a modern transport service. All of car’s systems and its performance are controlled by software that users download and then choose the functionality they want.
Resource usage in the capital goods and durables sector is expected to be influenced by a number of trends and technical innovations:

- Less dependence on fossil fuels through future energy optimisation, biofuels and electrification of engines.
- Battery development. Advances are being made, but standardisation will be difficult before the technology matures. The EU’s REACH chemicals directive is seen as an obstacle for the development of battery standards in Europe.
- Development of new and lighter materials in cars etc.
- Digitisation and data communication to optimise transport and resource usage.
- Greater use of recycled materials, including an increase in the use of recycled plastic and bioplastics.
- New ownership models, including shared ownership or selling of functions.
- Changed behaviours and purchasing habits among consumers and companies, with a greater focus on sustainability.
- More focus on modularised design and production to facilitate upgrading.

There is expected to be an increase in the use of virtual methods in the production of products and product system analysis. In addition to recycling, it is predicted that re-manufacturing will also increase, i.e. re-processing rather than replacement of certain products. One example is replacing parts of a ball bearing instead of the whole thing. This is both cost- and resource-efficient.

Business development in relation to policy development is important. The industry could focus more about which players exist and which ones can produce things more efficiently. The relevant legislation could be analysed, including the issue of applicability in other policy areas. There are examples of this today in the WEEE directive (see fact box) and individual producer responsibility, the efficiency of which varies between products.

Global and harmonised incentives and control mechanisms are also needed in the industry. One example of where policies and legislation have merely shifted the natural resources problem outside of Sweden’s borders is chipboard. As a result of the high environmental standards in Swedish legislation, much of Sweden’s chipboard production has been moved to Poland.
Consumer Products

Consumer products can be summarised as products that are broadly and frequently used by consumers on a daily basis. Examples of industry sectors (also included in the product work group) are clothing and fashion, beauty and hygiene, and tools and household utensils.

Growth, development and demand for resources

Consumer goods include items such as textiles (cotton, polyester, hemp, silk, wool, linen, lyocell, viscose), wood fibre (paper, catalogues, packaging), plastics (various products and packaging) and to some extent metals (tools, household utensils, zips, accessories etc.)

Globally, consumer product companies are highly sensitive to short-term fluctuations in the price of materials. The price of cotton, for example, has gone up and has fluctuated increasingly over the past few months. The World Bank expects the price of cotton to continue to go up at least until 2025.9

Due to resource shortages among companies there is an insufficient supply of some new, sustainable materials, certain materials are being substituted for others (e.g. cotton for polyester) and companies are being forced to purchase from another country/region. A real transition is in many cases being delayed – companies are often more inclined to pay more than to make the transition. Many companies believe that the shortage of materials will be clearly felt in 2020 and that they will need to switch to much more resource-efficient management of virgin natural resources by 2050. The capacity for change varies from company to company: a large company is in a stronger negotiating position, while a smaller one can generally make the transition more quickly.

As a result of climate change we can expect to experience more extreme climate conditions. This will affect the harvests for raw materials like cotton and will lead to price increases, but arable land is expected to be used more efficiently through better cultivation methods.30

Parallel to this is an anticipated increase in consumption from a growing middle class. Since consumption and GDP growth are linked, demand for things like fibres is expected to increase (see chart). More land is expected to be used for food production.30

Many companies believe that the cotton supply has now peaked – a theory that is supported by industry reports which indicate that cotton production from 2010 to 2030 will remain constant.30 Much of this production in countries like China is dependent on a sustainable supply of water. However, an increase in synthetics and cellulose is expected. A switch to these materials may present an opportunity for the Swedish textile industry to become more competitive.
Resource usage and impact

Manufacturers of consumer products have opportunities to improve resource efficiency throughout the value chain. Companies say they have the ability to drive resource efficiency without control mechanisms or consumer demand, but Swedish and global control mechanisms could speed up the process (especially as Swedish companies are big exporters to other countries).

The design phase is crucial in laying the foundation for resource efficiency and should therefore incorporate life cycle analysis and impacts.

Many smaller companies are already experiencing a shortage of new, more sustainable materials available for purchase, such as organic cotton, mulesing-free merino wool, and CRAiLAR (see fact box). When new materials become available on the market they are often bought up by large suppliers and smaller companies are unable to compete. The price trends for new materials are currently controlled by production capacity limitations rather than a lack of resources. (Note that the emphasis here is analysing the shortage of materials such as organic cotton, rather than presenting a resource efficiency comparison of these materials with others).

The efficiency of production processes is constantly being improved through technological development, although harmful chemicals are still used in many production processes. Technology exists for the re-use of water in some production processes, but it should be more widely available. Transport in all parts of the chain should be more efficient. Resource efficiency improvement is already widespread today, often in the form of partnerships/networks and horizontally.

Today’s consumers are often knowledgeable about sustainability, but only a small group act on this knowledge and purchase sustainable products. Further information and transparency may be important tools to drive this trend among consumers and perhaps even to get customers to pay more for sustainable products in the future. The question is how to do it.

There is great potential for recycling of consumer products. But we also need access to high-quality materials and product design that is optimised for recycling. We need to build up an aftermarket with high product safety and quality, as well as standards for recycling.

**Mulesing-free and CRAiLAR**

New types of wool have recently entered the market. Mulesing is a procedure that involves cutting away flaps of skin from around the tail and breech area of sheep to prevent flystrike and myiasis. Critics believe, however, that mulesing constitutes cruelty to animals. A number of large clothing chains and wool suppliers have now distanced themselves from the practice and have introduced mulesing-free wool. Canadian technology company CRAiLAR manufactures textile fibres from industrial hemp and other bast fibres. The purpose is to achieve a highly environmentally sound material for clothing manufacturing. It is also hoped that CRAiLAR will be able to be used in the pulp and paper industry etc.

**Resource efficiency right from the beginning**

Houdini Sportswear has succeeded in cutting its total material consumption by 57 percent. The company has implemented resource efficiency at the design stage, including using a checklist for the design team:

- Does this product deserve to be developed?
- Will it last long enough?
- Is it sufficiently multifunctional?
- Will it age well?
- Is the product free from unnecessary additives?
- Can it be repaired?
- Is there an effective end-of-life solution?
Dynamic business models and technical development

On the development side, many of the companies in the work groups are cooperating on a variety of projects. The goal is to develop new sustainable materials and products that use less materials, energy, water etc. in production and can be re-used.

With respect to product development innovation, there is a trend towards biomimetics, where a company’s products mimic nature more and more to improve sustainability. Compostable or even edible packaging is one example of this.

Experts predict that companies will become more technology-oriented, and that many enterprises will own the ideas rather than the production, and sell specialised expertise of, for example, unique designers. Production and consumption will become increasingly digitised with customers paying fewer visits to physical shops. Technical solutions will enable consumers to purchase, rent, borrow and re-use products regardless of geographical location.

Extending the life of products in this way or promoting cycles of use may result in more expensive products. Some companies will find it easier to get their customers to pay a higher price for sustainable products, while companies with products in the low-price segment will face a bigger challenge. Second-hand sales are expected to increase. The Filippa K clothing company has, for example, been operating profitable second-hand shops since 2008. Services such as renting, repairs and assembling spare parts should also see a sharp increase. On websites like Hyrahyra, consumers can rent out their products to generate extra income.

There are not enough recycling partnerships in the sector and this makes it challenging for consumer product companies to operate in a circular and resource-efficient way. Who will take responsibility for making these partnerships happen? It may seem difficult to induce a sustainability mentality among customers, but it could be encouraged if producers take more responsibility. Today H&M is offering its customers the option of returning their worn out products to its stores for recycling. This is not a profitable business for H&M today, but the company is keen to increase customer awareness, get access to recycled fabric and prepare for future resource shortages.

Uniforms for the Dedicated has a packaging solution where products are delivered to customers in a bag that can be turned inside out. The customer can then place old items in the bag (the Rag Bag) and send it to Stadsmissionen (a non-profit working with the homeless and vulnerable).

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3D and 4D technology in clothing production

The work group predicts that we will use more 3D printing in production processes to cut some of the steps in production and transport. Weaving fabric, dying and sewing could be done by a 3D printer. MIT in the USA has developed what they call a 4D printer, where synthetic fibres assemble themselves using DNA technology – a technology that could enable even more steps in the production process to take place in one geographical location. This could regenerate the Swedish textile industry. 3D technology and self-sewing technology could also enable customers to produce materials themselves or re-use their own materials using their own printers.

Read more at iva.se/4d-printer
Future resource usage

Sustainable products will become commonplace in the market by 2050. Today there are several circular networks in Sweden and internationally, and additional partnerships should be established internationally and nationally in technology and process development.

The biggest challenge for companies in this sector is how to close the cycle, i.e. close the recycling loopholes. Today the challenge is that some materials cannot be recycled or re-used and that the recycling industry needs to be developed. Many companies believe and hope that by 2050 we will have a high percentage of materials that are 100-percent recyclable.

Standardisation of input goods and production will make it possible to increase recycling. One possibility is for producers to label products with an EAN code listing the product’s contents. Alternatively, near infrared technology (NIR) could be used to scan the content of products in connection with recycling. The system of returning bottles and cans for cash could also be developed.

Another trend is where customers and users are participants in future resource efficiency work. Future generations will probably prioritise mobility and personal freedom over consumption and ownership. Before they travel they will, for example, be able to arrange their wardrobe for the trip on their phone through a rental service that delivers the clothes to their destination. Consumers may also join sharing networks; for example, individually-owned power drills will be replaced by housing cooperatives purchasing one for everyone to use. Companies will be able to rent out products with related services such as repairs and maintenance to customers.

Different sectors could be integrated vertically for product development and recycling. Amazon could, for example, have a business model where they take back clothes for recycling when they deliver books.

To achieve savings and an effective aftermarket for the recycling system, more cooperation between sectors is needed.

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**Brilliant use of technology**

Near infrared technology (NIR) looks at radiation close to the infrared area of the electromagnetic spectrum (from around 800 nm to 2,500 nm). Transmitting NIR radiation through fabric and similar materials reveals the intrinsic material’s porosity, thickness, moisture content, fibre and dyes. It is hoped that this technology will be able to be used in separating and sorting materials in the recycling industry.
Globally, food consumption has increased steadily in recent decades. The same is true for prices (see graph). Today, according to the FAO, five billion tonnes of food are produced in the world every year. But food production of the future will face a major challenge. The World Resources Institute estimates that to handle the population growth in the years up to 2050, global food production will need to increase by 60 percent compared to the 2007 level. Up to now increasingly industrialised and large-scale agriculture and fishing have managed to increase global production of food raw materials. For the first time in history this must now happen at the same time as the impact on the planet must be reduced, i.e. by lowering greenhouse gas emissions, reducing the depletion of natural resources and limiting the use of pesticides and fertilisers.

In Sweden food consumption has increased steadily over the past 15 years. Sales per capita rose by almost 25 percent between 2000 and 2013. According to the SCB, we purchased food and non-alcoholic beverages in 2013 for SEK 25,039 per person and year. Swedish imports of food and agricultural produce have also increased – from just under SEK 60 billion in 2004 to SEK 102 billion in 2012. Exports have increased as well, but not at the same rate (SEK 58 billion in 2012). The trade deficit in this segment has therefore grown (see graph). Food prices in Sweden have increased in general over the past 15 years, but relative to wages, food has never been cheaper in Sweden than it is today (12 percent of the average income per person).

The food industry is one of the most competitive industries in the world. It is also one of the industries with the lowest profit margins, although it is often less sensitive to economic fluctuation than many other industries.

On the production side, Swedish agriculture has become less profitable over the past 15 years and is now below a level that is sustainable in the long term. The competitiveness of Sweden and Europe in the global agricultural produce market has also been steadily declining over the past 30 years (see chart), largely due to an increase in production in the rest of the world.
Resource usage and impact

In Sweden the basic conditions for food production are very good. But our food production has for a long time been heavily dependent on raw material imports from countries where shortages of various kinds affect us. Our meat and dairy production, for example, needs soy for concentrated feed, and soy is usually imported.

In general, it is fair to say that Sweden is not suffering from any absolute shortage of food raw materials today, although certain products may need to be replaced by others to meet a specific demand. The supply of organic chicken or Swedish apples may, for example, be limited, but not the supply of chicken or apples in general.

Certain foods may already be being consumed at a level that will lead to a shortage in the near future. There is a shortage of fish today globally, but according to the FAO, 29 percent of the world’s stock is being overfished, and 61 percent is fished at the limit of what the ecosystem can replenish.37

Both in Sweden and globally there are also some resources that are of fundamental significance for food production and that cannot be replaced, such as water, productive farmland and phosphorous. In Sweden there is in general no shortage of any of these resources. However, we are already dependent on imports from countries where there is a chronic water shortage or that will face one in the fairly near future. Phosphorous, which is mainly extracted from ore and which is a key component in fertiliser, is imported today from just a few countries where production will at worst start to wane as early as 2030.

Notably, most companies in the food chain today lack a strategy or an action plan for possible future shortages.

An important element in future food production is how to economise with the food we actually produce. The FAO estimates that 1.3 billion tonnes – one third of all food produced in the world each year – is thrown away or wasted.38 This, according to the FAO, means that around USD 1,000 million dollars is wasted globally, which is almost as much as all the food produced in the EU.7 This wasted food would be enough to satisfy more than 800 million chronically hungry and undernourished million people four times over. The amount of greenhouse gas emissions from all the wasted food puts it in third place in the emissions ladder, behind China and the USA.39

In the highly industrialised world 40 percent of food waste happens in the retail or consumer part of the chain, while in underdeveloped parts of the world, 40 percent of food waste happens in cultivation and production.38 In 2013 it was estimated that the Swedish food production and consumption chain was responsible for an estimated 1.2 million tonnes of food waste per year, or 127 kg per capita. Households are responsible for the largest share, equivalent to SEK 16–23 billion per year. 35 percent of household food waste is categorized as “unnecessary” food waste. In other sectors waste accounts for an even larger share of what is thrown away.40

Agriculture’s future needs

In 2030, according to the research organisation IIASA, at least 500 million hectares (equivalent to half of China) of new land will be needed to produce enough food and crops for biofuel. But predictions indicate that it will only be possible to find half of that land.
Dynamic business models and technical development

Price is still clearly the dominating factor in food industry business models. Maintaining low raw material and food prices is one of the main reasons why resource wastage is so high, and is therefore the main obstacle in the way of profitability and competitiveness in future food production.

Despite a strong emphasis on price, several other factors have emerged in the Swedish food market over the past 10–15 years: environmental and climate responsibility, health aspects, animal protection and justice have led to multiple certification programmes for today’s food supply. Although several of these have grown quickly in recent years, they still represent a small percentage of the market. According to EkoWeb, in 2014 organic food made up 5.6 percent of all food sold in Sweden. The actual resource efficiency of these product categories (from an environmental and profitability perspective) largely remains to be analysed. In certain cases, conflicting objectives exist between the different factors.

E-commerce has been highlighted as an opportunity for the food industry and is an option that both improves resource efficiency and reduces environmental impact. Online food sales have increased sharply in Sweden over the past five years, with a turnover of SEK 2.2 billion in 2013 (up 38 percent from the year before) according to the HUI research institute. But e-commerce still only accounts for less than one percent of all food sales and only a few players are making a profit.

Using genetically modified crops (GMO) has been presented for a long time as a means of improving efficiency in global food production. Progress has been made in this area, and today the EU has approved around 50 different GMO crops. While GMOs certainly have the potential to improve efficiency in the use of available land and water resources, it is essential that the technology is used wisely.

Meat remains one of the main cut price items in the grocery retail sector, despite low profit margins, poor resource efficiency and high environmental impact. Meanwhile an opinion survey carried out by Demoskop in 2014 shows that the number of vegetarians in Sweden has increased and that one in ten Swedes are now vegetarians.

More and more farms have started selling food directly to consumers to increase their profitability. In most phases of the food chain investments are being made today to develop more resource-efficient technology. Computer support in agriculture and more efficient manufacturing methods are two examples. Investments in smarter packaging in the food industry and grocery retail have also made food last longer and transport more efficient.
Future resource usage

In 2050 three billion more people will have entered the middle class and will start demanding more resource-intensive food such as meat and vegetable oils, according to the World Resources Institute. A report from the FAO and OECD (see graphs) predicts that food prices will fall in general in the period up to 2023. A decline in production linked to climate change may, however, lead to a sharp increase in raw material prices in the period until 2050. The risk is great that the raw material market will be significantly more volatile in the future.

The FAO predicts that by 2050 the world will need to produce 60 percent more calories a year to meet the global food needs. The World Resources Institute has calculated that just over one fifth of these extra calories could be supplied by simply halving the total amount of food we throw away or waste today. International organisations believe that agriculture will need to be more productive and that over 90 percent of the production increase must come from

In Sweden most of the investments in resource efficiency and circular flows have been made by individual enterprises. To reach the future potential, more cooperation is needed between companies, industries and stages in the food chain.

The most serious threat to progress in this area, according to the companies themselves, is that today there is widespread distrust between the different parts of the chain, which is making essential information sharing more difficult.

There is also a lack of the type of systems thinking needed to build circular economies and avoid counterproductive control mechanisms and laws.

There are straightforward infrastructure obstacles to creating circular flows as well. Large quantities of nutrients are being washed down our drains instead of, for example, being recycled back into the fields because many drainage systems are not built to filter out harmful toxins.

Crispy creepy crawlies

In 2013 the FAO produced a book that attracted much attention showing how countries in the West could reduce their environmental impact and farm more productively by replacing beef and pork consumption with insects. There are already two million people on the planet who supplement their diet by eating insects. Insects are everywhere, they reproduce rapidly and have little impact on the environment, according to the FAO. Less than one tenth of the amount of plant biomass is needed to breed and produce one kilo of insects compared to the same amount of meat from livestock.

One challenge is to produce insects that are attractive as food. The UK company Exo produces protein bars containing cricket flour in colourful wrappers and with a high nutritional content. The company has already won prizes for its idea and has been highly praised in the international media.
increasing the yield of existing farmland. Access to potential arable land is, however, expected to increase by 5 percent.

By 2050 there may be a shortage of several resources and raw materials of importance for Swedish food production, such as phosphorus and soy, which are largely imported today. Water may also become in short supply indirectly if we continue to import the same amount of food from countries with unsustainable water usage at their farms. In Sweden and around the world there are currently unutilised areas of fertile farmland where food production could be expanded. These areas are, however, (in many parts of the world) expected to be exposed to tough competition in the future from other sectors in society also in need of more land, e.g. for infrastructure construction or crops to produce biofuel.

Future resource shortages will probably require the creation of new business models in which profitability and growth must be separated from the supply of raw material resources. Investments in organic products, locally produced and fairtrade food prove that it is possible to establish other values than low price, which is the dominant business model today. Connecting services with traditional food selling models could also be an important step. Investment in more ready meals and a stronger link between the grocery and restaurant sectors could be a possibility.

By 2050 a shortage of the resources that drive our food production today may have given rise to entirely new food sources. Experiments are already being conducted today with, for example, large-scale breeding of insects for synthetic meat production.
Appendix – Work group composition

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The **Resource Efficient Business Models – Greater Competitiveness** project is focusing on two main areas:

- Promoting the emergence of new business models with built-in resource efficiency to maximise the value of the resources. The project also aims to highlight examples of business models for resource efficiency in various industries.

- Identifying control mechanisms that promote the creation of these new business models. The focus will be on both the type and structure of control mechanisms. The project will present proposals for measures and policy directives for both the private and public sectors. The objective is for Sweden to be seen as a global role model as a clean and resource-efficient society by 2050.

The project is being run by the Royal Swedish Academy of Engineering Sciences (IVA), an independent academy whose mission is to promote the engineering and economic sciences and the advancement of business and industry for the benefit of society. In cooperation with the business community and academia, IVA initiates and proposes measures to improve Sweden’s expertise and competitiveness. See also www.iva.se

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