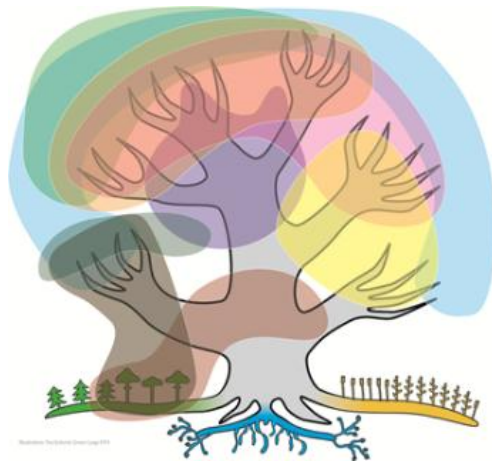


A Bio-based Economy

A strategic research and innovation agenda for new businesses
focusing on renewable resources



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This agenda is the result of cooperation between ten agendas in the area of “The bio-based economy.” The agendas are summarised in the appendix.

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Vision

Sweden makes the conversion to a bio-based economy in the first half of the twenty-first century.

Long-term sustainable development requires a transition to a bio-based economy. This entails a conversion from an economy that is largely based on fossil raw materials to a more resource-efficient economy that extensively utilises renewable resources. The development of primarily forest-based materials¹, products and services based on renewable resources is fundamental to such a conversion.

In the society of the future, many additional products will be efficiently manufactured with regard to the environment and energy, and made of materials based on renewable resources. Materials and products have also been developed for a range of new functions and services that we are completely unaware of today. Old and new manufacturing processes have been improved. Eco-friendly and resource-efficient concepts are a matter of course and Swedish technological know-how is generating new export revenues. Reuse and recycling processes are adapted to maximise the capacity of materials to store carbon dioxide and energy. Developed business models have resulted in in-depth cooperation between large and small companies, which have obscured and shifted the boundaries between earlier industries such as forestry, chemical, textile and energy.

The vision also entails that the materials' function and attractiveness are so compelling that they have become the first choice of consumers. It describes a future in which the green sector – primarily the forest and agriculture sectors – will provide industries with resources that are processed into materials and services.

A bio-based economy

In 2011, the Swedish Government commissioned Formas, VINNOVA and the Swedish Energy Agency to create a national strategy for the development of a bio-based economy to support sustainable development. The conversion to a bio-based economy entails switching from an economy largely based on fossil resources to a more resource-efficient economy based on renewable resources that are produced through the use of sustainable soil- and water-based ecosystem services.

Formas, VINNOVA and the Swedish Energy Agency have defined a bio-based economy as an economy that is based on the sustainable production of biomass with the aim of reducing climate impact and the usage of fossil-based resources. A bio-based economy is further defined by an increase in the processing value of biomass, while energy utilisation is minimised and end products capitalise on industry and energy. The aim is to optimise the value of ecosystem services and contribute to the economy.

Analyses by government agencies indicate that in relation to many other countries Sweden has conditions conducive to the conversion to a bio-based economy. While the conversion from fossil-based to renewable raw materials could lead to competition for resources, it could also create new

¹Materials also pertain to chemicals and energy

opportunities for supplementing traditional products with new products and services, with the aim of supporting and increasing Sweden's competitiveness. In addition to the potential within sectors that have long been agriculture-based industries, the development of a bio-based economy will create excellent opportunities for increasing the usage of biomass raw materials in other industrial sectors, such as the transport sector, the automotive industry, construction sector textile and chemical industry.

Government agencies have identified the following needs for research and development:

- Replacement of fossil-based resources with bio-based resources
- Smarter products and smarter resource usage
- Changed consumer habits and attitudes
- Priority and choice of measures

Research and development has to be complemented with innovative efforts and measures that, in particular, take on the challenges of a bio-economy. The nature and scope of the challenges require extensive cooperation between the players and the sectors must work together to manage the complex issues and the solutions needed for the challenges.

This entails offering incentives for collaboration on cross-industry research and innovation in order to develop and implement solutions that will contribute to a growing bio-based economy. Academic and research institutions have a pivotal role in linking such collaborations, but public- and private-sector players also have key roles. It is also important to stimulate the growth of environments for research and innovation, which will help in the compilation of relevant knowledge and create conditions conducive to innovations within the area.

There is a need to accelerate the development, verification and commercialisation of new bio-based solutions and to continue supporting the demonstration of products, systems and services that are not fuel-based and energy-technology solutions. There is also a need to support small and midsize companies in the commercialisation of new technologies throughout the supply chain. This especially applies to cooperation between major companies, if development and innovation are to be accelerated.

Areas of strength

Sweden has an advantage in terms of knowledge about and access to forest raw materials and their processing. Forestry is one of our greatest export industries. The industry's annual processing value is in the magnitude of SEK 50 billion and the annual production value is approximately SEK 200 billion (2009). The industry's export value was nearly SEK 130 billion (2010), which corresponds to more than 10% of Sweden's exports, and the industry collectively employs nearly 200,000 people, including forest-industry contractors and subcontractors. In many parts of Sweden, the forest industry is essential to employment and economic well-being. If the industry shall maintain its importance for the country a continuous forest and other biomass extraction at a minimum of current-day levels is needed, thus providing the basis for profitability throughout the supply chains. This strategic research and innovation agenda for bio-based materials and products proceeds on the basis of existing opportunities in the forest industry and its significance in Sweden, and aims to create additional areas of strength for Sweden through increased collaboration between various industry sectors and fields of knowledge. Although the forest is the basis for this area of strength, in the long term, renewable resources from other farming will further strengthen this area and Sweden's opportunities.

The forest industry believes in the favourable development of the forest-industry cluster, based on efficiency, knowledge and competency, research, development and innovations. Consequently,

a vision has been formulated, calling for the processing value of the Swedish forest-industry cluster to be doubled by 2035. Half of the growth will come from new products (Products from the forest – a sustainable choice, the Swedish Forest Industries Federation paper on sustainability, 2008-2009).

By developing more materials that sequester carbon from renewable biomass, the emission of greenhouse gases can be reduced. For the construction industry, this entails finding replacements for resource- and energy-intensive construction materials such as concrete and other mineral-based materials, as well as fossil-based plastics. The capacity of bio-based materials to lower carbon dioxide and reduce emissions through material substitution can be maximised by using them in the products that have the longest service life and which are materials-intensive, namely buildings. Examples are insulation material that can be developed from fibre materials, as well as barrier materials for damp protection, which can be manufactured from biopolymers.

Several other types of material can be developed on an ever-increasing scale: bio-based plastics and composites, carbon fibre, chemicals and energy products. Another example is cellulose-based textiles, which are an excellent alternative to fossil-based fabrics as well as chemical- and water-intensive cotton products. By utilising smart packaging that enables new logistical solutions as well as lighter transportation (lower energy consumption), food can be stored more efficiently (less wastage), and food and medicine can be distributed more safely and be less exposed to the spread of infection.

The wood products industry has great potential for significantly higher growth. It is important to develop new wood-based, functional and innovative products that are technically suited to efficient production flows. The industrial processes have great potential.

For all this to be possible, production systems must be renewed and developed. The forest industry's suppliers of technology and systems – mainly small and midsize companies such as equipment and component manufacturers, software suppliers – have a significant role to play. Consequently, highly innovative collaborations with manufacturer clusters are the key to success.

There are already a considerable number of developed products within these areas that are close to the market. Ekoportal2035 (www.ekoportal2035.se) was created to inspire entrepreneurs, companies, researchers and investors – research financiers from both the private and the public-sector.

The portal is a vision of the future centred on bio-based renewable materials and is an attempt to visualise an environment that to the greatest extent possible is based on materials and products from renewable resources. The product concepts – which were reviewed for feasibility by researchers – require extensive and long-term research, development and demonstration (RDD) to be implemented and translated into innovations.

Research agenda

The new research agenda, NRA 2020 (www.nra-sweden.se), is the collective assessment of Swedish forest-based industries regarding research, development and demonstration, which is necessary for the sector to be able to contribute to achieving the vision of a bio-based society. The research agenda was jointly prepared by the forest industry, the scientific community and public research financiers, and coordinated by NRA Sweden (the Swedish National Support Group) under the leadership of the NRA Council. A large number of people and organisations submitted expert contributions by participating in workshops, reference groups and surveys. NRA 2020 was also inspired by the new European Strategic Research Agenda (SRA), which was created on the Forest-based Sector Technology Platform (FTP, www.forestplatform.org). The detailed connection between

the NRA 2020 and this strategic research and innovation agenda is reported under the concluding section, “priorities within the NRA area.”

NRA 2020 is based on 19 national strategic themes that describe the objectives, anticipated results up until 2020 and prioritised Research and Innovation activities. The strategic themes are divided into four strategic target areas, namely Bio-economy, Raw Materials, Processes and Products.

BIO-ECONOMY – The forest-based sector in the bio-based economy

Research requirements in this area focus on phenomena and processes beyond the actual forest-industry sector, which are nevertheless of considerable importance to the sector’s development. There is a need for further knowledge on how the forest-based sector can facilitate the reduction of carbon emissions and how our forests can be adapted to a changed climate. Future surveys and global market analyses are of strategic importance, as are scientifically based consequence analyses of political decisions that affect the forest industry.

RAW MATERIALS – Utilisation of forest resources

This area deals with the structure and function of ecosystems. Key issues are biomass production, the supply of raw materials and the recovery and reuse of wood and fibre. Well-balanced utilisation of limited resources – land, wood, fibre and biofuel raw materials – is critical to the transition toward a bio-based society. Research into the significance of the forest for uses other than the production of biomass must ultimately be prioritised. There is a need for new forestry models that minimise environmental impact and are adapted to climate changes. Within EU an expanded collaboration in the project SPIRE (Sustainable Process Industry through Resource and Energy) is planned.

PROCESSES – Industrial leadership

Efficient new energy- and water-saving production processes are of critical importance to the industry’s profitability. New business concepts for products and services have to be developed, including services that are based on the soft values of the forest will gain increasing significance. Perhaps, the most exciting and challenging area of research is the new concept for bio-refineries and the products that they could generate. Within EU an expanded collaboration in the project BRIDGE (Bio-based and Renewable Industries for Development and Growth in Europe) is planned.

PRODUCTS – Consumer needs

The focus is on product development, such as new concepts for wood building, furniture and interior design. New products and materials, of which several are yet to leave the laboratory environment, will gain a prominent role in future research. There is also major potential for development among several traditional product groups such as packaging, printed products and hygiene products.

Innovation agenda

Conversion will not be possible without new knowledge garnered from research and development, but such knowledge must also be transformed into a large number of innovations. IVA has issued a clearly defined, shared definition of “innovation”:

“Innovation refers to the transformation of knowledge into new values. It deals with the development of products, services and organisations in both private and public operations. It may concern everything from industrial robots, payment systems and energy optimisation to leadership, business models and healthcare.”²

² IVA, *Innovation for growth*, IVA-M 423, ISSN: 1102-8254, ISBN: 978-91-7082-834-8; www.iva.se

Innovations may be market driven or concept driven, meaning that researchers, inventors and/or entrepreneurs may have a market requirement as their driving force or that a new discovery/idea requires commercialisation in some manner. The creation of radical innovations requires an atmosphere conducive to innovation. Although such environments can be created by society, we do not exist in a vacuum, and market-based motivations are also required. Society must create the conditions for industries and individuals to research and develop new products, processes and services, which are concurrently adapted to market demands.

The farming industry needs to develop its competencies and infrastructure to compete with currently established materials, processes and products. Consequently, a more long-term-oriented strategy is required for the introduction of new materials and products, in which the focus is changed from “*technology push*” to “*market pull*” – In particular, new business models must be developed.

The bio-based economy is in itself an innovation, provided that it finds acceptance among consumers and markets. Today’s economy is based on a concept of supply and demand, in which oil and unlimited growth are key components. Replacing petroleum-based products with bio-based products will not merely entail a decision to switch resources. Large investments have been made by oil producers and the industries built around oil that cannot easily be scrapped. For many consumers, it is also comfortable and good as it is.

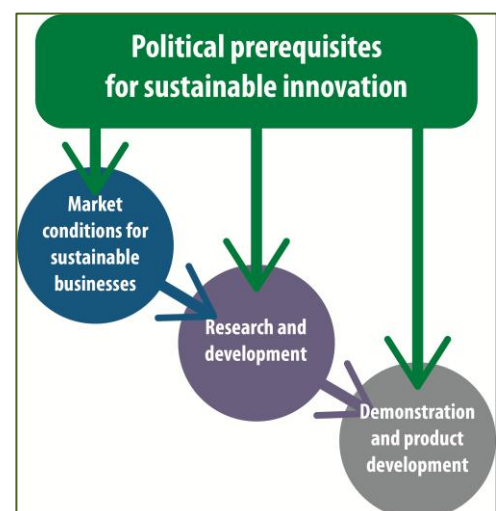
This research and innovation agenda was developed within a network comprising a broad group of stakeholders representing business and research. Supporters of this agenda include leading companies in the forestry, chemical, textile, engineering and automotive industries, as well as universities and research institutions with connections to these industries (refer to appendix from the various completed agenda tasks). Consequently, there is strong collective support from both business and research organisations. Other agenda tasks have also been reconciled, such as design, IT, food production and services.

Implementation of the research and innovation agenda

To implement the agenda, four programme formats are proposed. Projects and activities can be pursued in one or more of the programme formats.

Programme format: Political prerequisites for sustainable innovation

This programme format endeavours to create the conditions for a bio-based economy: what is its current state and what can be done to turn it into a reality from a political and global perspective. It deals with knowledge about the indispensable changes to society required for innovations in the area to succeed, and how the current system must change to support this development. The programme arranges workshops and inquiries that result in basis material for decision makers. Results from the programme’s projects and activities are not only delivered to other programmes, but also especially to political structures with the capacity to influence and remove potential obstacles. Work is conducted in close cooperation with public-sector actors. Deliveries from this programme provide the prerequisites for pursuing further development in the other programme formats.



Questions that must be addressed within this programme format:

- How do control measures influence the development of a bio-based economy? What are the existing control measures? How must they be developed or changed in order to drive sustainable development?
- How should innovations be procured? How should procurements be formulated? What should their impact be?
- Which standards are available? What is the influence of these standards? Is Sweden actively participating in the formulation of standards? Which standards must be infringed upon or changed?
- What is the state of trading conditions in Europe and globally? How should they be changed? What is required? Trade barriers? Can we continue to conform to those with the lowest ambitions?
- What is the impact of laws and regulations? How should they be changed to enable sustainable development on the whole?
- Risk management: which risks are attached to the intended development? How significant are they in relation to the monumental risks in existing developments? How can they be prevented?
- Educational system: what changes would accelerate favourable development? How would these changes accelerate favourable development?
- How can the EU use its influence to provide incentives for a bio-based economy; international experiences?

Participating organisations can be universities, colleges or institutes involving the disciplines of social sciences, economics, natural sciences and the humanities, as well as government agencies and trade and industry. Requirements for industrial co-financing are unclear; this is mainly an issue for the public-sector financiers. Results from activities and projects are linked to the other programmes and are to be openly accessible.

Programme format: Market conditions for sustainable businesses

This programme format is to process new supply chains, produce a specification of requirements for new materials and connect players from various parts of the supply chain. The programme format delivers market essentials and connects potential partners for innovation. Important deliveries to the R&D programme include conceivable business models and knowledge about what is required in terms of performance for new bio-based materials and products, including recycling strategies. The overall aim of the programme is to initiate new supply chains and business constellations through which fertile ground is created for future innovations/businesses. It also deals with identifying and understanding the conservative forces existing in the market. In addition, it deals with building bridges to other industries, new supply chains and new business models. Deliveries of work from this programme format provide prerequisites for further pursuing development in the programmes, "Research and development" and "Demonstration and product development."

The programme format shall primarily create a prototype for the best conceivable business climate in a bio-based economy:

- Connect companies/industries/academia that are yet to contribute to new rallying points through which new opportunities can be explored.
- Comprise a high degree of cross discipline, such as cooperation between academia and business, between various industries, and between business and society.
- Produce ideas for new ecocycles, supply chains and value cycles, services, materials and products and processes.
- Deliver market analyses, potential business models for innovations and specifications of requirements.

- Market and management research to elucidate on the manner in which successful companies and industries operate. What are the driving forces in the successful companies?
- Analyses of standards and trade conditions for the new businesses.

Participating organisations may comprise universities, colleges, institutes and trade/industry. Co-financing of 50% should normally be required from participating companies. Deliveries from activities and projects do not need to be openly available but general discoveries about new markets for bio-based materials should be openly accessible.

Programme format: Research and development

This programme form comprises more traditional research and development of products and processes. New types of material and their manufacturing processes are researched on a smaller scale. To be able to start a project within the programme form the project idea should be based on conditions like market analysis, business model or value chain, i.e. certain material or a certain product with certain characteristics should be defined. This should be produced under the programme “Market conditions for new businesses” before the project may be launched.

The following investment areas/investments fall under this programme format:

- Research and development of a more technical nature, spanning everything from more basic research activities to prototypes on a laboratory scale. Process development for the intended production units can also be developed on a smaller scale and tested and evaluated.
- Preferably cross-disciplinary consortia: chemistry, physics, materials science, design, recycling and sustainability, process engineering and perception and cost-efficient production. Projects should capture all the components required for a reliable result and should be ready for demonstration – they should comprise more than just a recipe for the material or the equivalent. The product’s entire intended lifecycle should be considered.
- Distinct framing of new systems, services, materials and products based on a new playing field.
- Evaluation of the new market conditions at the end of the programme/project.

Participating organisations may comprise universities, colleges and institutes as well as trade and industry to a certain extent. The requirement for industrial co-financing should be set at a 40-60 per cent ratio depending on the focus of the investment. Purely basic research should be financeable by a research council. Deliveries from projects do not need to be openly accessible, but general discoveries about new markets for bio-based materials should be openly accessible.

Programme format: Demonstration and product development

If the research shows promising results and matches market conditions, the work is further pursued under this programme format, through which prototypes, an upscaling of processes and basis material for investment decisions will be produced.

This programme format creates the accessibility of demonstration facilities and delivers a decision-making base for investments. In the event that demonstration facilities are not available, the programme format should be able to contribute to investments.

The following investment areas/investments fall under this programme format:

- Projects are to be based on clear R&D findings and market analyses. Only potentially successful results from earlier studies may submit an application to the programme format. The results are to comprise sustainable and functional materials or products with the intended feasible production processes from an economics viewpoint and distinct market potential.
- Projects are to focus on scaling up to full-scale processes and delivering basis material for decisions on coming investments.
- Evaluation of economic performance is to be implemented during the projects. A comparison is to be made between the existing economy and the new playing field.
- The production of prototypes is to be implemented under this programme format.
- This programme format constitutes the step before commercialisation.

Participating organisations may comprise universities, colleges and institutes as well as trade and industry to some extent. Industrial co-financing should definitely be a requirement and, depending on the closeness to market, business financing is expected to be considerably higher than 50%. The size of projects may vary considerably. A demonstration project may comprise everything from the demonstration of a materials test that is adapted to a certain application, to a full-scale process demonstration.

Shared by all programme formats

All projects are to be pursued or verified through the four programme formats. Each project is to have the capacity to ascertain whether political conditions have first been studied and followed by a study of market conditions, before projects may be launched for research, development and demonstration. Accordingly, projects must comprise all the programme formats, either under the project itself, or through collaboration with other projects.

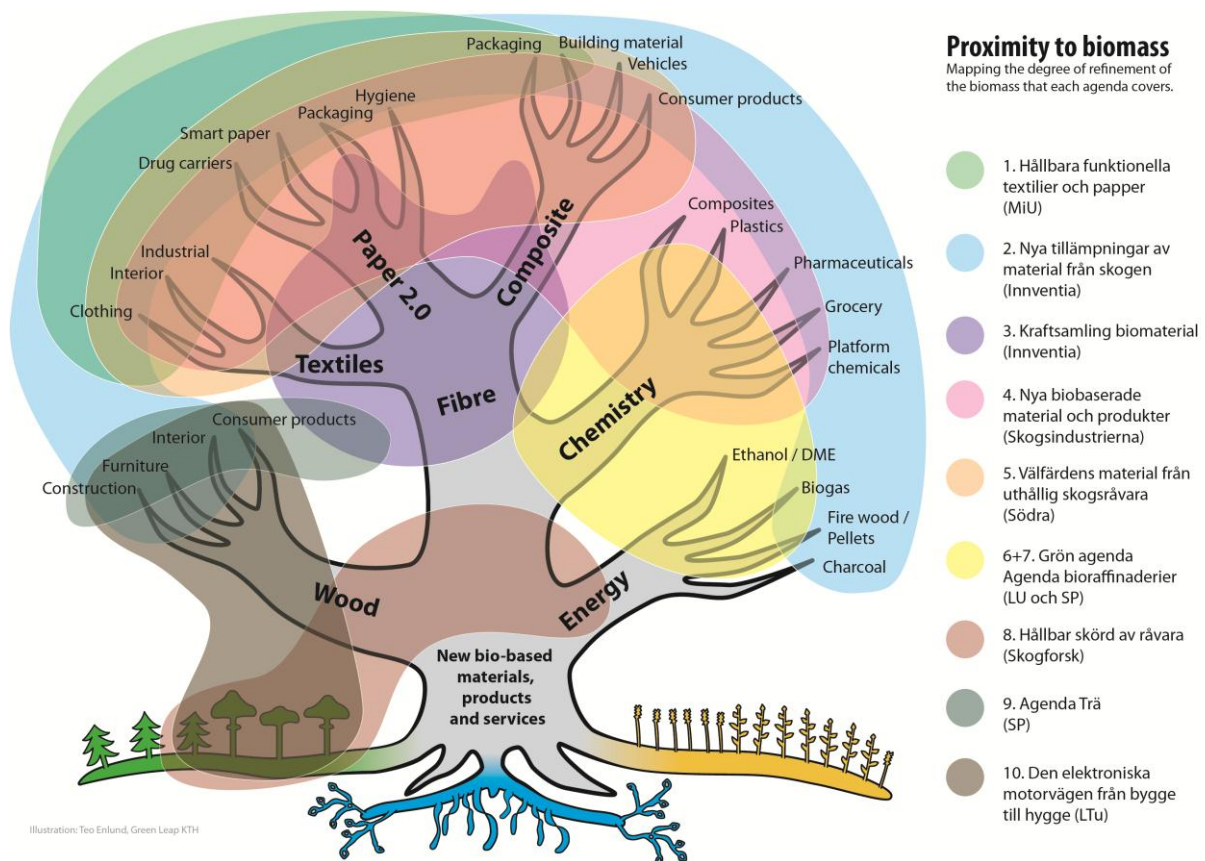
Cooperation between the agendas under VINNOVA's announcement 2012

In spring 2012, VINNOVA made an announcement under the theme: "Strategic research and innovation agendas." A total of 73 agenda initiatives in various areas were granted. This agenda is the result of cooperation between ten of these agendas, all in the area of "The bio-based economy."

The ten agendas are:

- The electronic highway from construction to clearing site
- Welfare materials from sustainable forest resources
- New bio-based materials and products
- National mobilisation of resources for new applications of forest materials
- Biorefinery agenda / Green agenda
- Sustainable harvesting of forest raw material
- Wood agenda
- Made in Sweden – Future Textiles and Paper
- Mobilisation of resources around new processes for bio-based materials

The agendas are aimed at various areas in which innovation-promoting measures help to achieve the vision of a bio-based economy. We have chosen to illustrate the manner in which the agendas are linked to each other in a stylised tree where the outermost branches relate to products and the trunk of the tree is formed by the various bio-resources.

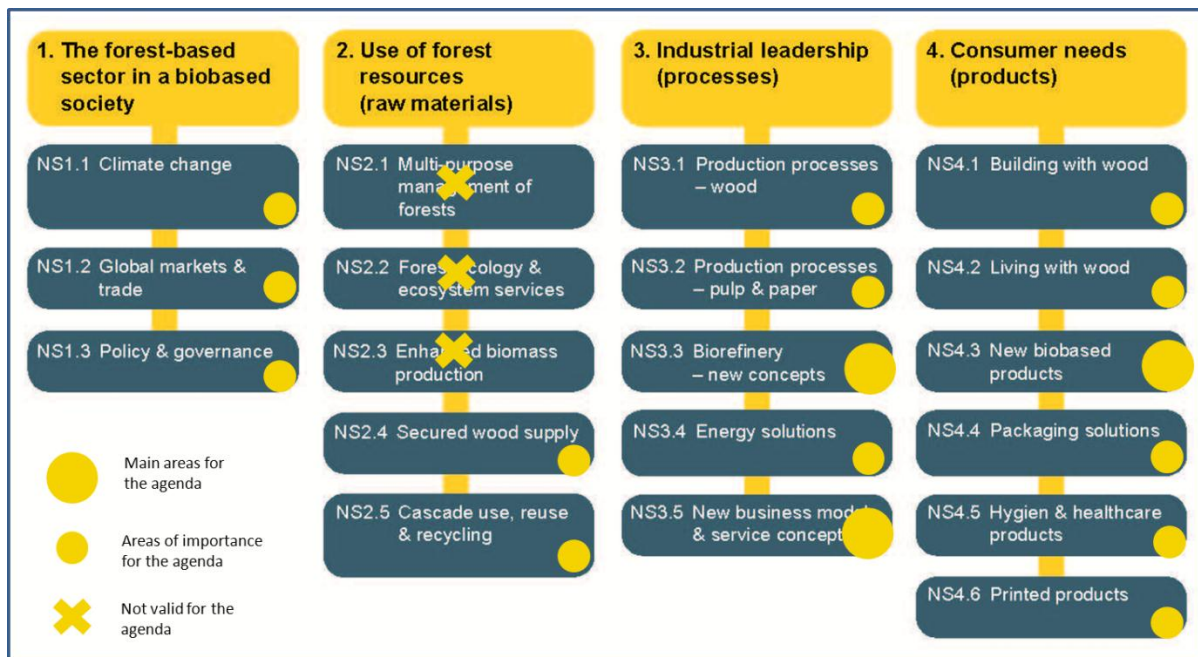


Priorities in the NRA area

This strategic research and innovation agenda is aimed at new products from renewable resources. The manufacture of these products requires the development of new materials, which in turn require new adapted processes. Ultimately, it is also essential that resources can be efficiently delivered at the right time to the right place (bio-refinery). The supply chain is to generate profitability for all the participants involved. Work on the agenda proceeds on the basis of NRA 2020. Consequently, the innovation content will also be concentrated on the areas that concern these issues under NRA 2020.

The groupings that interacted in this shared strategic research and innovation agenda are all strongly connected to NRA 2020 and the research agenda's National Focus areas. The work carried out in these different agendas has involved three main approaches. The first is to further detail the description and content in one or several nearby National Focus areas. The second main approach is to broaden an National Focus area to encompass the issues that are usually handled by other supply chains or areas. The third approach is to clarify and analyse the cooperation between various National Focus areas, primarily the technology area's cooperation with areas that handle business systems. In most of the agenda work, several of these approaches are combined.

The figure below schematically marks the overall connection of the agendas to NRA 2020. It is worth noting that in principle; three areas – National Focus area 2.1, 2.2 and 2.3 – fall beyond the shared interest in this context. These are dealt with under traditional research areas with traditional research funding. The agenda's approach towards new materials, products and services is clearly noticeable.



The road forward

Continued focus on research and innovation is essential if Sweden is to preserve and develop its position in the global market. Companies, universities, colleges and the research institutes research is world class in several areas, but competition is increasing from new biomass-producing industrial countries.

For Sweden, this entails demands for renewal in terms of research, development and innovation. The areas in which such investments have the greatest potential to succeed are being identified through the national research agenda. The agenda is focusing not only on increasing value growth in the existing product areas, but also on creating completely new business opportunities.

Considerable work has been performed under this agenda to coordinate and exemplify the various innovation efforts required for proceeding on the road to a bio-based economy. These innovations comprise different, well-integrated subareas, which in turn have many interconnections. Some examples of the innovation areas that have been identified are:

- Customized products and production to operate in a global market:**
 In order to increase the Swedish wood products industry worldwide an increase in exports outside Europe is required. Increasing exports outside Europe also requires increased knowledge and experience on how to act on the global market, but also new knowledge about product development, needs, culture and business logic of the specific markets. Agile companies will most likely be the winner of this development.
- Developed value chains in the timber industry:**
 Many of the innovations will be developed within the framework of different companies that are suppliers to the timber industry, e.g. ICT companies and suppliers of additives for wood products. This will increase the international competitiveness of the timber industry and the industry's sub-contractors.

- **An established, sustainable arena for innovation:**
Innovation primarily occurs through meetings between individuals with different perspectives and experiences. A prerequisite for actors in need of new values in the form of new materials, new products and new services from wood to find a way to innovate is a place where one can meet.
- **Energy Storage:**
Extremely cheap paper or textile products. Here, one can imagine a small scale for sensors or RFID, as well as large scale wall papers, banners, bulletin boards or facades.
- **Bio-based composites:**
The development of load-bearing building elements, foam-based lightweight materials and free moldable composites generates immense possibilities. Among many applications the automotive industry is one of the most promising.
- **New products of non-woven:**
Manufacturing of non-woven and textile materials in paper machines can provide an extremely efficient textile production for volume products such as absorbers and insulation, or for relief aid such as blankets and tents.
- **Hygiene and healthcare:** Within healthcare and Life science bio-based products are well suited. Antibacterial surfaces stain or easily washed surfaces and integrated sensors and intelligent features are promising possibilities.
- **Biodegradable packaging:**
Although Recycling is much to be preferred, but unfortunately lots of materials do not end up in the recycling systems available. This has for example generated large belts of plastic debris in our seas, which causes great harm to animals and the environment, and also leads to the fact that environmental toxins enters the food chain and end up in our bodies. This, combined with the fact that all countries do not have well-developed waste management and recycling systems, this means that from an environmental and social perspective there are great opportunities for developing biodegradable packaging.
- **New infrastructure for technology innovation in the forest:**
New intersectoral cooperation in industry and academia is expected to increase the competitiveness of industry and machine manufacturing industries and thus inspire to innovative solutions.
- **Production of new chemicals and materials from waste streams.**
Sewage flows from pulp and paper mills contains overall a large amount of organic material. Today these streams are purified chemically and biologically. There is a great potential to take advantage of this organic material instead of just purifying the sewage.
- **Sustainable harvesting of forest raw material:** New infrastructure for technological innovations in forestry and new cross-sectional cooperation formats within industry and academia. This is expected to lead to increased competitiveness for trade and industry, and machine manufacturing industries, while satisfying the important goals of society.

Appendix: Summaries of the underlying agendas

The Bio-based Economy agenda is the result of collaboration between several agenda works performed during 2012-2013. All of these agendas have delivered separate reports, which all can be found on www.nra-sweden.se. In this appendix summaries of the agendas are presented.

The electronic highway from construction to clearing site

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The Swedish forest-processing industry is facing new challenges. Emerging global economies, with Asia at the forefront, are changing the balance of the world economy at a high pace. Consequently, this is creating new situations subject by stiffer competition in global markets. The earth's natural resources will become increasingly scarce commodities in the future. It is thus a matter of national importance that we refine our raw materials in the most efficient and eco-friendly manner possible.

The vision of this agenda is to nourish and drive a system of research and innovation that will ultimately increase the forest-processing industry's international competitiveness through increased wood processing and product development for new markets. This is one step on the road toward the conversion to a future bio-based society. Our vision includes the creation of a strong national system for wood-technology innovations shared between wood-product industry companies, the forest-processing industry's subcontractors, universities, institutes and society.

The primary means of fulfilling the vision involves a national mobilisation of resources within the framework of the system for wood-technology innovation, to systematically utilise and implement new achievements within the **ICT** area and the materials-technology area developing wood-technology courses at all levels to support the supply of competencies to companies; extended resources for the development of technologies, services and products in cooperation with companies, academia and institutes through demonstration and within the framework of a knowledge-building academy (KBA). These are solid routes towards INNOVATION, in order to capitalise on new opportunities in sensor and computation technology.

Measurable effects until 2030 entail that the value of the forest-processing industry's products will increase by 20% and that the value of the forest-processing industry's subsuppliers of equipment and services will increase by 25%. Export values will increase by 25%. This increase in value will occur without changing the volume of forest raw materials extracted.

Biorefinery agenda / Green agenda

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The vision for this agenda is that in the future, the majority of consumer products, energy and fuel should be produced from renewable raw materials. This will be done in Swedish competitive biorefineries with an efficient utilization of raw materials and minimized environmental impact.

The conversion to a fossil-free society can only take place if existing process industries adapt to a biorefinery concept through which maximised utilisation of available bio-based resources – from forest to agriculture and future marine sources – is the focal point when tomorrow's chemicals, materials and energy are being produced. To succeed in this regard, there is a considerable need for developing new technology platforms and integrating them with each other and existing processes,

as well as adapting innovation processes, defining new supply chains and especially, securing the supply of competencies.

Cross-industry collaboration concerning the biorefinery concept increases the potential for indispensable adaptations to take place in an efficient and integrated manner. For Sweden to be competitive in a bio-based economy, technological and scientific conditions must be developed, in the form of improved and integrated technology platforms based on chemical engineering, separation technology and industrial biotechnology. The development of a new supply chain adapted to bio-based resources also requires a (systems-analytical) holistic perspective that takes into consideration efficient usage of raw materials and increasing competition for resources, initiatives by politicians and decision makers through the creation of social conditions and policies and a development of market conditions.

These areas encompass the biorefinery concept and illustrate that initiatives within all these areas must go hand-in-hand for successful conversion to take place.

Welfare materials from sustainable forest resources

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Our vision is the sustainable production of materials essential to our well-being based on the sustainable production of forest raw materials as a component of the global growth economy. The route to achieving a bioeconomy should be marked as a conversion from fossil-based resources to a sustainable resource base. We are governed by a total appraisal of what is technologically possible, economically feasible, socially and ecologically warranted. We endeavour to create conditions for sustainable solutions to global challenges to society. The major challenges are to make resources last and to create efficient manufacturing processes for innovative products that are adapted to a sustainable society.

“Materials for our well-being from sustainable forest raw materials” is a Research-and-Innovation agenda with the aim of identifying and describing the gaps that must be filled to enable companies to launch new sustainable products. The product areas are textile fibres, packaging for drinks and moist food, as well as personal hygiene products. These represent broad groups of consumer products that are produced by wood polymers and manufactured in large quantities, which are required to make everyday life easier in Sweden, Europe and the rest of the world.

The research challenges for the industry are:

- New and efficient separation processes for forestry and agriculture raw materials
- Hygiene – Drying of absorbent fibre suspension
- Packaging – Barriers to liquids, oxygen and air. Free-form packaging.
- Textile – Understand the mechanisms that govern dissolution and coagulation of cellulose
- Manufacturing processes and access to pilot plants

The cross-industry challenges are:

- A national strategy with associated objectives for a bio-economy
- New model for trade with IPR
- Investment costing for a bio-economy
- Efficient industry structure for a holistic approach to biomaterials
- Training/education in pace with developments
- Consumer behaviour and materials confidence – how to meet basic needs if today’s products are not available?

New bio-based materials and products

Contact: Jan Lagerström, Skogsindustrierna, jan.lagerstrom@skogsindustrierna.org

This strategic research and innovation agenda describes what must be done for more innovations to be created based on renewable forest materials. The agenda focuses on new materials, products and services.

The vision of the agenda, “Sweden makes the conversion to a bio-based economy in the first half of the twenty-first century” is highly compatible with the vision formulated by FTP (the European forestry platform), the NRA and the Swedish Forest Industries Association. The latter vision entails a doubling of the processing value (approximately SEK 50 billion) of the Swedish forest-industry cluster by 2035. Half of the growth will come from new products, meaning the products that this agenda is concerned with.

The Swedish forest industry has been a strong and important industry for Sweden for many decades. The industry is now facing major challenges. In the mean time, the climate threat is intensifying and a transition to a bio-based economy is necessary. The forest industry has a great opportunity to contribute in this regard. Success with the transition requires not only structural changes, but also higher efficiency in the current supply chain and, first and foremost, the development of new supply chains, with opportunities for a higher processing value of forest raw materials. This agenda is primarily aimed at the latter.

It is based on the recently updated National Research Agenda, NRA 2020. Our agenda does not encompass the parts of the NRA 2020 that deal with forestry, forest growth, energy issues or existing products/processes, but focuses entirely on new values in the form of new materials, new products and new services from forest raw material.

With this agenda, we are thus pursuing the introduction of new solutions for bio-based materials in the market. For this to succeed, the political and structural obstacles that exist today must be identified and remedied. Industries also need to be integrated and to establish new supply chains and business models. In this manner, conditions will be created for developing and demonstrating the new opportunities and to increase the power of innovations. We also aim to clear the path for the increased competitiveness of the Swedish forest industry by increasing the processing value that can be generated in Sweden. This will enable Sweden to lead the development of a sustainable society.

National mobilisation of resources for new applications of forest materials (Forest beyond 2.0)

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The vision is to have a lasting and intense mobilisation of resources on a national level for innovative applications of bio-based materials in an international market. The vision has points of contact with FTP’s vision and the NRA 2020 – a strategic research agenda for forest-based industries in Sweden.

The basis for this agenda is that high-quality research results have been generated from cross-disciplinary environments in several locations in Sweden for many years. However, we do not have the capacity to adequately, and innovatively, expose these to industry participants and industry needs. This agenda is aimed at a fresh start that, in addition to universities/colleges and institutes,

engages a broad spectrum of companies for which forest materials could provide new innovative applications. The agenda also seeks to establish and broaden international networks and alliances.

The long-term objective of agenda is to factor in the structural capital that exists in Sweden, in order to establish internationally competitive resource and competency platforms for the innovative processing and application of forest-based materials. The resources may be national or international.

Work performed for the agenda has proceeded from a broadened set of participants in which the participants are grouped based on several dimensions. One dimension pertains to the location on the supply chain in which the companies operate. For example the following can be named: Forest raw material, Distribution of forest raw material, Processing of forest raw material, Distribution of processed forest raw material, Application of processed forest raw material.

The final category above also encompasses industries in which forest-based materials can find entirely new applications, such as the Fashion industry, Manufacturing industry, Life Science and IT. Existing industries that use wood, such as timber-house industry, can also be renewed with new forest-based materials. Companies in these industries have participated in work for the agenda.

Sustainable harvesting of forest raw material

Contact: Magnus Thor, Skogforsk, magnus.thor@skogforsk.se

This agenda deals with a combination of two internationally strong Swedish fields of knowledge, namely forestry and forest machinery.

Revenues from forestry represent a cornerstone in Sweden's economy. The industry's base is a profitable annual extraction from the forest of approximately 80 million cubic metres of biomass in various forms. Half of the forest land is owned by more than 300,000 private forest owners, whose combined balance sheet totals SEK 700 to 800 billion. Securing and developing Sweden's position requires improved productivity in the supply of raw materials and developed products. The trend of the forest industry's declining productivity in recent years poses a serious threat to the entire industry and tremendous technological-economic challenges. The vision is world-class performance in terms of productivity with the least possible environmental impact, world-leading technologies for mobile processing machinery and a doubling of machinery exports. This is a basic premise for the realisation of the government's vision, The Forest Kingdom of Sweden – value for the world.

The "sustainable harvesting of forest raw material" has two supporting pillars: the establishment of new infrastructure for innovation and the virtual academy, Forest Technology Academy (FTA). There is also considerable support for the initiative from the unified forestry sector, machine manufacturing companies and academia. The objective is for a minimum 35% productivity trend for the forest industry, a doubling of exports of mobile processing machinery, a 90% reduction in soil damage due to machine traffic, a 30% reduction of fuel consumption and a minimum of 50% growth among machine manufacturers, including suppliers and innovators, and a number of test-bed projects to be implemented through new collaborative formats. The virtual FTA is to produce some 20 doctors, courses/projects for a minimum of 3,000 students and hundreds of conferences/seminars.

We propose a new infrastructure for innovations of productive, 'envirogentle' forest-machine technologies. The model aims to radically lower the innovation threshold and thus circumvent some of the deficiencies that have been identified in the current innovation system, such as through intensified cooperation between users, manufacturers and researchers.

The Forest Technology Academy (FTA) is a virtual academy comprising leading universities and institutes with complementary subject profiles, and provides breadth and depth in the field of research and innovation. Subjects include automation, autonomy, simulation technology, operator environments and HMI, hydraulics, hybrid technology, energy optimisation, vehicle fleets, terramechanics and systems development. The FTA and this Research and Innovation agenda bundle together these advance competencies and focuses a considerable portion of them on a clearly defined industrial need of new pioneering solutions.

Agenda Wood

Contact: Hans Holmberg, SP, hans.holmberg@sp.se

Sweden's forest industries have a stated vision of converting to a bio-based society by 2050. The vision is that the timber industry will play a major part in this transition.

As a nation, Sweden has a unique position to be proactive in this development with far-reaching integration between forest growth and subsequent processing industries. We see opportunities today for taking a further step in this integration through modern technology that exists or is under development. Activities are increasingly aimed at considering the customer value of the products that are manufactured. A change in attitude, particularly on the part of the customer, is creating opportunities to streamline and adapt the production throughout the supply chain in order to efficiently meet the customer's needs.

Construction-related industries are by far the largest consumers of Swedish timber products, in the form of construction material, interior decoration and furnishings. The international markets for these products are supplied, to ever greater extents, with mineral and fossil-based materials. There is probably considerable potential for Swedish bio-based products to capture major market share from these other material producing sectors internationally.

Through interviews and workshops, the agenda has identified the objectives for 2020, 2030 and the vision for 2050. The focal points of the agenda are several focus areas that require innovation and cooperation between various participants in and beyond the forest-processing industry with the aim of achieving the objectives.

The Swedish forest-processing industry is facing new challenges that will probably differ from those we have seen in the industry's earlier development phases. Technology was previously able to offer solutions for the changes occurring in the market. For example, drying technology was developed as a response to higher demands from the market, automation and optimisation resulted in improved productivity and provided Swedish industries with competitiveness.

The future challenges to the Swedish forest-processing industry are partly about dealing with a global market and competition, and partly about acting on the fast-paced market with business challenges. These challenges must be managed production technically and organizationally in line with new business models

Innovations are built on research. This agenda proceeds from the basis of implementing the research in the areas specified in the National Research Agenda, NRA 2020. In certain cases, focus areas may require supplementary research in addition to the research indicated in NRA 2020, in order to be commercially realisable.

Made in Sweden – Future Textiles and Paper

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Both the Swedish forest industry and the Swedish textile and fashion industry are based on years of tradition and have undergone major changes. The industries represent considerable value and have acclaimed expertise in a broad area. Both industries are classified as basic Swedish industries and form a vital engine for Swedish exports.

The industries are now being challenged by intensifying global competition with products manufactured in low-wage countries by fossil-based raw materials and often with methods involving high environment impact. Consequently, the industries must switch business models and product ranges so as not to lose export value and job opportunities. The conversion requires new business concepts, new participants and new markets, and it must be implemented at a pace that is faster than that of the emerging threats!

This strategic research and innovation agenda deals with anticipating, under controlled forms, urgent industrial conversions based on external factors. With greater awareness of the threats, they can be turned into opportunities that allow Swedish industry the chance to take a proper lead in the conversion to a bio-based economy. Opportunities may then be developed into an international competitive edge with a focus on sustainability, reduced energy usage and positive impact on climate and the environment.

Our vision for the next twenty-year period is for the Swedish forest industry and the textile and fashion industry to become a leading force in Sweden's conversion to a bio-based economy. This development is based on highly developed industry cooperation with considerable knowledge exchange. With limited energy use, Swedish forest raw materials are processed to provide important customer value and significant benefit to society. Through a high pace of innovation in the coming 20 years, the forestry industry has sharply increased the export value using traceable sustainable products, services and functions.

We have identified the conditions for achieving the objectives – conditions in which research and innovation lead to genuine renewal by means of proactive cooperation focused on customer value. We have broken down the ambitions for a number of objectives and provide, in this agenda, a comprehensive description of collaborative formats and initiatives.

Mobilisation of resources around new processes for bio-based materials

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The vision for this agenda is for Sweden to be able to retain its leading position as a forest-industry nation, for the benefit of society, and to enable sustainable social development through increase usage of biomaterials. For this to be possible, new products are required, with increased added value, new processes and new supply chains based on forest raw materials.

There are many examples of new materials and products that have emerged from earlier and ongoing investments, but many of these can only be manufactured on a relatively small scale. Thus, process development is still required for achieving major manufacturing volumes and thereby generating value. The main premise of the agenda is how existing initiatives and resources can be

better utilised and how various research participants and trade and industry can cooperate and function as catalysts for creating real innovation and new supply chains.

The pluralistic approach that is used is a cross-section constellation that was established to identify, develop and prioritise the supply chain that is easiest to take to market. By applying an iterative selection process, the supply chains with major technological and market potential can be identified.

Workshops and individual meetings with key stakeholders, both companies and researchers have generated a number of insights and ideas. Initially the automotive industry was identified as a potential implementer of biomaterials. But after meetings and discussions it has been concluded that there are too many major entry barriers to make vehicle interiors an area for introduction of biomaterials.

Packaging is the product which accounts for by far the largest use of plastic (accounting for 38% of plastic use in the EU, Norway and Switzerland, 2008). With this in mind and the fact that the use of packaging have considerably lower demands on durability than many other uses, the conclusion from the agenda work is that this is the most important and promising area.

Related to this is another important conclusion from the work with the agenda and the discussions held with various actors. The conclusion is the lack of really strong driving forces to create an interest to implement new environmentally friendly materials and that the economic barriers are too great.

Important issue for the packaging area is recycling, renewability and biodegradability. Recycling is much to be preferred, but unfortunately lots of materials do not end up in the recycling systems available. This has for example generated large belts of plastic debris in our seas, which causes great harm to animals and the environment, and also leads to the fact that environmental toxins enters the food chain and end up in our bodies. Furthermore, many countries do not have as well developed waste management and recycling system as in Sweden which means that the need for biodegradable packaging is even larger from a global perspective. Conclusion from the work with the agenda is that there is an environmental and socially need for increased development and progress in the field of biodegradable packaging.