

BioRefine

NEWS

| THE BIOREFINE PROGRAMME REVIEW | 2/2011 |

**Finnish companies are
shifting towards bioeconomy**

Sustainability and biofuels

**Partnership of biomass
and water**

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The BioRefine programme doubles the total value

When the five-year BioRefine – New biomass products programme was launched by Tekes in 2007, it was estimated that the volume would total EUR 135 million. However this level was achieved in the first three years alone, because the programme attracted many challenging biorefinery research and industrial projects.

As of September 2011 the total value of the programme has reached EUR 232 million. When the programme closes at the end of 2012, the total value is expected to be close to EUR 250 million, which is almost double the estimated value. Approximately half of the total volume is funded by the participating industrial companies.

The programme is co-operating closely with Forestcluster Ltd, which is owned by major forest-related companies and institutes. Forestcluster has launched a second phase of its Future Biorefinery (FuBio) programme.

One of the main goals of the BioRefine programme has been to bring together multidisciplinary research and development competencies and different business areas for creating sustainable and commercially viable biorefinery concepts. In the future bioeconomy will bring these different competences and business areas into close co-operation for creating new solutions based on non-fossil raw materials.

The BioRefine programme yearbook 2011 is available in the web, www.tekes.fi/biorefine → Documents. •

A bioeconomy needs interdisciplinary skills and flexibility



Markku Karlsson
UPM

Shifting operations based on fossil materials towards the utilisation of natural resources involves systemic change. Recycling, renewable energy and resource scarcity are important components. A bioeconomy requires companies to adopt new forms of operation and create new business models.

“**A**t UPM we are strongly focused on moving towards the bioeconomy. Biofuels, fibril cellulose, biochemicals and wood-based composites are at the forefront of our product development,” says **Markku Karlsson**, Senior Vice President, Technology.

“We are heading to an interdisciplinary, networked world, where we will manage a biomass-based value chain from start to finish. We’ve rebuilt our basic skills, partly

by specialized training for existing staff, partly by recruitment.”

Networking for broader competencies

Acquiring new competencies means more than just training and recruitment. A major role is played by networking between experts in different fields.

“For example, in biofuels we need to understand the whole refinery chain, stretching back from the engine technology. We are going into an entirely dif-

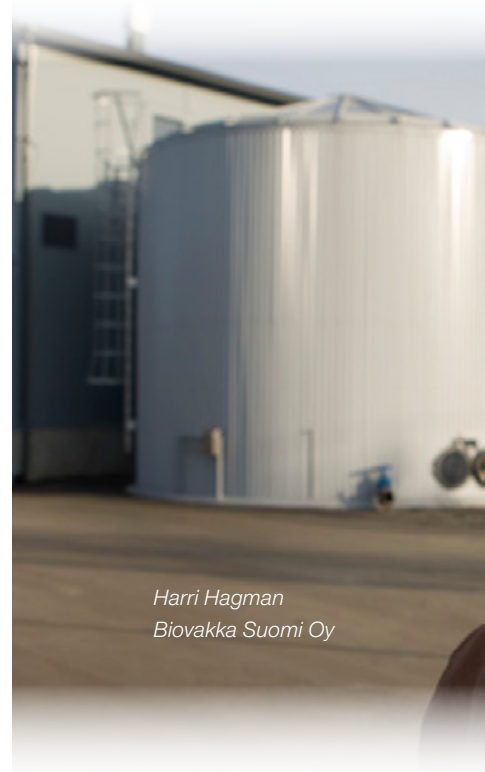
ferent area of skills from those needed by a traditional papermaker.”

The bioeconomy is taking the forest products industry towards the consumer interface, where trends and regulations have to be considered. Consumer-orientation requires flexible and agile operations.

“Alliances with SMEs speed up the commercialisation of the new products and give greater agility even to a large corporation.”



Mika Aho
St1 Biofuels Oy



Harri Hagman
Biovakka Suomi Oy

A good base for a bioeconomy

Forest resources give Finland a strong base of a bioeconomy, although Markku Karlsson stresses that wood is not the only component.

“We shouldn’t build a bioeconomy around forest biomass alone. Central Europe, for example, is putting the emphasis on recycled fibre and other raw materials from the industrial sideflows and is building urban biorefineries to exploit it.”

“The alpha and omega for UPM is to create convergence between efficient integrated mills and biorefineries. We cannot continue in our present way of making only paper as efficiently as possible. We have a fundamental grasp of the biomass refinery chain and skilled employees that are ready for change.”

St1 Biofuels make a clean break

St1 Biofuels Oy produces ethanol from food processing residues and household biowaste. It is a field where demand has been boosted by legislation as well as environmental awareness.

“We have none of the structures of long-standing industrial operations to slow down our move to new sectors. The lack of an industrial legacy can be a challenge and even a weakness, but when

you’re building a new future it is an advantage. Both physically and psychologically,” says managing director **Mika Aho**, St1 Biofuels Oy.

“It isn’t easy to shift productive operations in a direction where earnings prospects are uncertain. You could say that things have got under way faster because we started from scratch in developing skills and operational structures.”

First goals achieved

St1 Biofuels drew up its technology and capacity strategies several years ago. Mika Aho says that the first stage is complete and its objectives were achieved although the route taken was not always the one that was planned.

“You need to be flexible when conditions change.”

“In the next stage we will be starting to use new feedstocks, waste and residues containing cellulose or lignocelluloses for producing ethanol. The plan is to build a pilot for testing these feedstocks in the first half of next year.”

By 2020 St1 Biofuels aims to be producing 300 million litres of bioethanol annually. This output would be about 10 percent of total energy content of annual gasoline demand in Finland, which is pre-

dicted to be about two billion litres per year.

“With these quantities we will not be saturating the market. Bioethanol can be used to replace petrol both as low blends, for example E10, E15 or E20 and as a high blend such as E85.

“Our approach is less vulnerable to swings in demand because we build small units. We can respond quickly to demand fluctuations because investment decisions are easier when the plant size is small.”

Biovakka breaks new ground

Biovakka produces biogas and recycled nutrients from organic materials. The company was established in 2002 and its first biogas plant came on line in 2004, so it became part of the bioeconomy before the word was invented.

“Pig farmers were some of the founders of the company and they are still its shareholders. They believed in the business and understood the cycle of nature. Farmers tend to trust in the future and are bold enough to take risks because they’re used to setbacks,” says managing director **Harri Hagman**, Biovacka Suomi Oy.

“The shareholders also had a bold innovative approach. They have been major figures of influence in many arenas. As



a small company we've been active participants in projects of the Tekes BioRefine programme. This year we've started our own project in the programme."

Perseverance for long-term profits

"A lot of capital is required to build a biogas plant, and there are no prospects of quick profits when you are operating in a new sector. You need to take the long-term view and wait for the business to start making money."

Biovakka's model is to construct a biogas plant, to charge for accepting biodegradable waste, and to process it into biogas and recycled nutrients.

"These activities are subject to licensing, so we have to work with various public organisations. Each supervises the part of operations under its ambit."

Biogas plants have to be logistically sited so that transport costs are not excessive. This means optimising the transport of incoming fractions and outgoing products.

Harri Hagman believes the operating concept of a biogas plant could have export prospects, although Biovakka's own model is designed for local operations in the Finnish market. •



IEA Bioenergy Workshop: Focus on future biomass-based transport fuels

The 67th meeting of the IEA Bioenergy Executive Committee was held in Helsinki in May 2011. The meeting was hosted by VTT and Tekes. In conjunction with the meeting, a workshop on Future Biomass-based Transport Fuels was organized.

Alongside with the ExCo members, a group of Finnish bioenergy experts were attending the workshop where presentations were given by twelve invited speakers from all over the world. The workshop consisted of four sessions, such as Strategic Views; Biomass for Road Transport Fuels; Biofuels for Air and Maritime Transport - what's happening now; and Biofuels in first full-scale applications: the Finnish way.

After the workshop the attendees participated in a demonstration of vehicles dedicated to biofuels including features such as FFV (Flexible Fuel Vehicle) with E85 in cold climate; plug-in hybrids with biofuels and FFV; trucks with ethanol and biomethane; and models from Think EV.

The members of the ExCo67 concluded the meeting with a study tour to the Helsingin Bussiliikenne Oy bus company and a St1 biofuel ethanol plant.

International collaboration in bioenergy

IEA Bioenergy is an organization set up in 1978 by the International Energy Agen-

cy (IEA) with the aim of improving cooperation and information exchange between countries that have national programmes in bioenergy research, development and deployment.

Altogether 23 countries plus the European Commission participate in the IEA Bioenergy activities.

The Executive Committee is made up of one representative from each participating country.

The work of IEA Bioenergy is structured in a number of projects called Tasks. The scope of the work covers the whole chain from biomass resources and supply systems to conversion and end-products. Currently there are 12 ongoing Tasks, of which Finnish organizations participate in nine Tasks. •

For more information on IEA Bioenergy and the presentations of the Helsinki meeting, please see www.ieabioenergy.com



Examining sustainability in biofuel use

The Subichoe project as part of the BioRefine programme studied and assessed sustainability of the utilisation of biofuels. The work and its results are meant to help authorities and companies in planning to manage their biomass use as sustainably as possible.

Today almost all products are expected to be sustainable, but how sustainability is measured and monitored gets less attention. Furthermore, sustainability is a concept with many dimensions and can be influenced by environmental, economic, social and cultural matters.

As the use of biomass has increased, so has criticism for the environmental impacts and social problems related to its use. Sustainability criteria for biofuels were examined in 2007 in the Biovaiku project, which was also part of the BioRefine programme.

“In the Subichoe project, which ended in September, we went deeper and looked at new perspectives of sustainability,” says Senior Researcher **Riina Antikainen** of the Finnish Environment Institute SYKE. “Among the things we’ve examined are indirect effects such as land use.”

Alongside SYKE in the project were VTT Technical Research Centre, which acted as the coordinator, plus MTT Agrifood Research, the Forest Research Institute (Metla) and the Government Institute for Economic Research (VATT).

“We’ve used mostly existing material

and have brought together the expertise in Finnish research institutes.”

Global and multidimensional question

“The sustainable use of biomass is very complex because it concerns not merely biofuels but also sectors such as pulp and paper, the mechanical forest industry and food production. This is to say nothing of the strong interests in nature preservation, which have played their own part in evaluating sustainability. There is no single correct alternative for sustainable utilisation.

Moreover it's not enough that things are done properly in Finland if they are handled in an unsustainable way elsewhere. This is why global agreements, to which everyone is committed, are needed," says Riina Antikainen.

"The Finns can influence on sustainable development in the EU. National legislation has to conform to the EU's Renewable Energy Directive, which defines sustainability criteria for biofuels. Government ministries have used our expertise when drafting laws and the results can be used when the directive is applied to national legislation and sustainability criteria are developed."

Antikainen talks of the importance of recognising linkages and the effect on everything else if changes are made.

"Long-term effects are another relevant aspect. A good example is the extraction of tree roots during forest harvesting, to obtain more biomass. It has been done increasingly in recent years but we still don't know what are the total effects it will have in the long run."

She agrees that climatic questions are important but points to the danger of ignoring other environmental effects, for example on natural diversity. "And there are still no detailed criteria for socio-economics questions."

Standards being created

The European Committee for Standardisation CEN is preparing European sustainability standards for biofuels and the International Organisation for Standardisation ISO has initiated its own global project for defining sustainability for bioenergy.

"The standards will make it easier to evaluate sustainability and, even if they are voluntary for companies, they will play a major role. We can expect them to be fairly general, because they are global and concern all bioenergy feedstocks, but standardisation work can bring about progress even if the standards aren't perfect first time out."

She regards the process as a positive thing because it opens a discussion channel between officials, civic organisations and companies.

Foreseeing the risks

"Companies see a lot of potential and business opportunities in biomass refining and these certainly exist, but there are also risks. Policy lines may change, for example. This is why it would be unwise to convert a whole production process or product range to use one raw material. Alternatives need to be sought. The processes being developed should be able to use a range of feedstocks."

Timo Heikka, Director, Stora Enso, Biorefinery:

“Stora Enso applies the same environmental and social aspects covering quality management systems which are in place in ordinary industrial roundwood production also when procuring wood-based biomass for energy and biorefinery purposes.

Third party audited management systems ensure focusing on most crucial issues, both in biomass procurement and supply as well as in production units' activities. The systems enable and in many cases require open dialogue with stakeholders.

In addition, Stora Enso's Wood Supply is committed in developing and applying forest certification, the certification of forest management and wood production. Raw-material is not procured from cuttings, which do not fill requirements of laws, from protected areas or areas which are subject to an official set-aside process. Outside protected areas are high environmental, cultural, biodiversity and landscape conservation values notified through forest management planning and forest certification. These values are based on definitions by the international High Conservation Value Network and interpreted in a balanced stakeholder process.

In Finland and Sweden, timberland management companies partly owned by Stora Enso utilise long term landscape ecological planning. It is based in describing and recognising large forest areas' ecological features on a landscape level.

"In many cases we can obtain greater reductions in greenhouse gas emissions by reducing energy consumption than by replacing fossil fuels with biofuels. And by developing great energy efficiency, for example in vehicles that use less fuel, we can fairly easily eliminate a large proportion of emissions." •

Southern tree plantations have to be established and managed with a holistic view on the surrounding reality. Plantations are planned as a part of the local land-use. Converting natural forests into plantations is forbidden. The legitimate rights of the indigenous people with regard to traditional land-use will be recognised.

When increasing the volume of biorefinery activities the need to enhance resource efficiency gets stronger. Biomass itself or its value as products and chemicals may not be wasted. As a first thing, before increasing procurement of primary raw material from forests, will utilisation of production side-streams, residues and waste be further enhanced.

In Finland, when raw material for forest chips, i.e. branches and tops, is harvested are "good silviculture recommendations for growing and harvesting energy wood" followed. These are established in a process steered by a broad-based stakeholder group consisting of representatives of wood producers, industry, environmental organisations and research institutions. According to these recommendations it is not allowed to collect tops and branches from dry mineral soils poor on nutrients.

So far Stora Enso and the above mentioned timberland management companies have been collecting stumps only in a limited scale. Stumps, however, contain volume-wise much energy. In addition, high contents of valuable molecules have been identified in them. Research and technical development work will allow certain share of this resource to be sustainably utilised.

Both in combustion and gasification ash

will be produced. In the Finnish statutory order on fertiliser products, the recycling of wood-based ash will become possible in a practical scale, enabling desired fertilisation effect on a single hectare to be reached. The ecological sustainability of biomass usage will be enhanced when valuable ash is not dumped, but returned to forest for keeping the nutrient balance of the soil.”

Simo Honkanen, Vice President, Neste Oil:

“Sustainability is in the core of Neste Oil’s cleaner traffic strategy. For decades, the company has been developing a range of fuels that have a lower level of impact on the environment.

Neste Oil’s sustainability procedures regarding biofuels are based on a thorough understanding of the impact of its products over their entire lifecycle: from feedstock production to the end use of the fuel. For example, the company’s NExBTL renewable diesel has been proven to reduce greenhouse gas (GHG) emissions by 40–80 percent over the product’s entire life cycle when compared to fossil diesel.

NExBTL diesel is currently produced from a wide range of vegetable oils and waste-based feedstock. The company focuses on procuring sidestream and waste-based feedstocks which in 2011 should total some 40 percent of the company’s feedstock base. The feedstock base is continuously being expanded – but only with feedstocks that are verifiably sustainably produced (e.g. certified), fully traceable, and reduce GHG emission for at least 35 percent over their entire life cycle. This is in line with Renewable Energy Directive establishing strict sustainability criteria for the production of these fuels.

Feedstock production is strictly regulated within the EU and other markets, such as in the U.S. Thus Neste Oil procures feedstocks only from suppliers that are committed to international sustainability certification standards, such as ISCC, RTRS, etc. The compliance is verified by independent audits. Neste Oil has also developed its own sustainability verification system and submitted it for review at the European Commission.”

A partnership of biomass and water

Since revising its strategy in 2008, Kemira has focused its research and development on water technology and biomass exploitation. The innovation process involves Kemira’s whole organisation, not merely its R&D functions.

In line with its new business strategy, Kemira is concentrating on customers that operate in water-intensive industries. Meanwhile, a new key field of research is biomass, from which ever-increasing amounts of renewable raw material can be extracted.

“Our focus on water technology was displayed last year when Kemira established the Centre for Water Efficiency Expertise (SWEET) together with VTT Technical Research Centre of Finland. Spending on this 4-year research programme will be €120 million,” says **Heidi Fagerholm**, Executive

Vice President for R&D and Technology at Kemira. “SWEET consists of a network of Finnish and international partners, universities and SMEs. After just the first year, 30 to 40 research projects are underway.”

Tekes is participating in the funding of the SWEET projects.

Fagerholm underlines the important role of strategic partners in Kemira operations, while the company itself concentrates on its core competencies.

“We have created a strong network of partners. The aim is to develop world-class water expertise in Finland and to create new

Heidi Fagerholm
Kemira



business opportunities for the companies in this field.”

Different functions strongly involved

At Kemira, research and development does not take place in isolated divisions but is integrated with marketing, sales, production, product safety and materials procurement.

“All these functions are involved from the very outset when we initiate a product development project. We want to be sure that the research is useful and that there will be demand for the product or service developed,” explains **Kari Saari**, Kemira’s Vice President for Production Technology. “Effective sales and marketing are also needed to commercialise the results of product development. In our view this is one of the strengths of Kemira’s R&D operations.”

The company has four research centres around the world, allowing it meet the special local needs of its customers and quickly make its competencies available globally to different customer segments.

Its research centre in São Paulo, Brazil concentrates on biomass utilisation and processing; large-scale resources make biomass a growth area in South America. The research centres in Atlanta, USA and Shanghai, China complement one in Espoo, Finland, providing global coverage.

“We want to be close to the market and expertise,” Kari Saari says.

A total of about 350 experts work in Kemira’s research and development operations and the annual budget is nearly 2 percent of turnover.

Water chemistry and biomass closely linked

Sustainable development plays a central role in R&D. Kemira believes that sustainable solutions will offer major business opportunities in the future.

“Water chemistry and biomass are tightly bound together. Biomass needs water to grow, bioprocesses have an aqueous phase, and the first stage of most biomass refinement consists of separating water from solids.”

At present most of the water consumed in the world is used in agriculture. In the future, irrigation will increasingly depend on recycling water and purifying wastewater. Both of these require a range of water technologies where Kemira’s strengths lie. Even today, wastewater purification is already largely a biological process, the treatment of biomass.

“In the future micro-organisms and algae are sources of biomass, because they grow rapidly and require little surface area. Algae are extremely water-intensive; solids account for only about one percent of their mass.”

“Kemira sees great business potential in utilising biomass and strong opportunities in bioprocesses,” Heidi Fagerholm

says. “We intend to help bioeconomy companies to develop more effective processes, to improve their water cycles and to conserve valuable water.”

In Kari Saari’s words, the sky is the limit as mankind gives up oil and moves to business operations based on renewable raw materials. “Water chemistry and water technology will be the key ingredients.”

Biomass at the hub of BioRefine

The bioeconomy offers business opportunities to other Finnish companies alongside Kemira.

“Participation in the BioRefine programme has given us an insight into what lies ahead and what the development of biorefineries will depend on. It has also helped us to network with different players in this field. And it has supported our own analyses of how we can utilise bioprocesses and develop sustainable technology over the long term,” Kari Saari explains.

Adds Heidi Fagerholm: “The programme is fostering bio competencies in Finland and helping to identify the top experts in the field.”

Kemira’s has placed its own projects in the programme. One of these has ended and two are ongoing.

“We made major advances in the project that has been concluded, with laboratory-scale results that are very promising. We’ve developed a technology for extracting various components, such as acids, from very dilute solutions,” Kari Saari says.

Heidi Fagerholm emphasises that Tekes financing expands a company’s risk propensity in product development projects and thereby facilitates greater advances that any individual company could engage in.

“Tekes networks companies on a broad front, not merely Finnish businesses, research institutes and universities but foreign organisations, too. This also expands opportunities for importing technology that can be further developed here,” Heidi Fagerholm believes. •

Heidi Fagerholm is a member of the board of Tekes and of the steering group of the BioRefine programme.



Kari Saari
Kemira



The research group at Aalto University: standing from left to right, Janne Wallenius, Jouni-Tapio Laaksonen, Shrikant Survase, Matti Viikilä, Evangelos Sklavounos, sitting from left to right, Siiri Viljanen, Minna Yamamoto, Tom Granström ja German Jurgens.

American involvement in the BioRefine programme

The projects led by Aalto University are focused on the production of biochemicals, principally butanol, from renewable feedstock. US participation has reinforced the practical approach and turned the spotlight on cost factors.

“**W**hen we initiated the first BioRefine project in 2008, the production of butanol from lignocellulosics was not high on the list of interesting bioproducts. At that time people were interested in producing ethanol, but the interest in biobutanol came later. It is one of the basic chemicals of industry, used in cosmetics, plastics, car waxes, etc, and is also a substitute for fossil fuels,” says **Tom Granström** of Aalto University.

The BioForest project has been aimed at developing methods for producing biochemicals from wood-based feedstocks, compatible with sustainable development. It is coming to a close at the end of this year but the studies will be continued under the Sewibe project, now starting up. Tom Granström is managing both projects together with **Adriaan van Heiningen**.

“One of the participants we found for BioForest was American Process Inc. (API), which has technology for biomass

fractionation. Professor Adriaan van Heiningen, who arrived in Finland in 2007 as part of the FiDiPro programme, was instrumental in building up international connections.”

Using the API method, wood is cooked to release sugars that are converted into biochemicals like butanol using microbial fermentation.

“The advantage of the process is that it can utilise any wood biomass. Our aim from the outset has been to integrate the

process with pulp production, so as to improve its viability and profitability.”

Using ethanol and sulphur dioxide as fractionation chemicals, feedstock like forest harvesting residues and recycled fibre yield usable sugars that can be fermented into biochemicals such as acetone, butanol and ethanol. The continuous bioreactor that has been developed has good productivity.

Scaling up the process

The BioForest project has obtained promising results at laboratory scale. The next step in implementation is to scale up to the pilot stage, which will be done in the Sewibe project. Participating alongside American Process, UPM and Neste Oil, who were involved in BioForest, are new partners like Stora Enso, ABB and Eastman Chemical. In the BioForest project three more companies were involved: Ruukki Group, St1 Biofuels and Andritz.

Eastman Chemical, a US company, is a major producer of butanol from fossil feedstock. Like UPM, it strongly believes in the business prospects of extracting chemicals from biomass. Neste Oil and Stora Enso are studying the gasification of biomass but are also interested, on a general level, in fermentation and butanol-related research.

“In the research project now beginning, we aim to raise capacity to the scale of 100 litres. The lab results are important but only experiments at a larger scale will provide the companies with the data to assess whether the process can be profitable.”

Towards an industrial process

“American companies have contributed cost awareness to the project, and the clear objective of implementing the results in industrial processes. They have practical rather than scientific ambitions. Finland is a forerunner in this field and I hope we can retain this position in the future. Foreign partners have widened our research perspectives.”

“We had good timing and also the advantage of finance from the BioRefine programme. It provides an effective framework without a lot of red tape.” •



FiDiPro professor Adriaan van Heiningen together with his students Evangelos Sklavounos and Minna Yamamoto who worked in both projects.

FiDiPro professor opens foreign doors

Adriaan van Heiningen from the University of Maine came to Aalto University under the Finland Distinguished Professor (FiDiPro) programme. His international contacts have networked Finnish and American companies into joint research projects in the Tekes BioRefine programme.

“I came to Finland in 2007 as a FiDiPro professor specifically to start innovative research in the area of biorefining,” **Adriaan van Heiningen** recalls. “It was a five-year position of which I spent a total of about two years in Finland.”

He was born and obtained his chemical engineering degree in the Netherlands, then did his PhD studies in Canada, and became Canadian when he moved to the US. The position in Finland was part-time, and he played an active role, together with Tom Granström, in starting the BioForest and Sewibe projects. Professor van Heiningen has experience in pulp and paper processes while Granström is an expert in bioreactors.

Adriaan van Heiningen says it was relatively easy to get American companies interested in the projects: “API is very keen to commercialize a biorefinery based on SO₂-ethanol-water fractionation technology.”

“It was probably because of contacts with American Process that Eastman Chemical approached me. They had heard about our butanol fermentation work and I believe it is their main interest.”

He points out that the fact that Eastman Chemical would be one of the partners was a big plus to some of the participating Finnish companies.

Professor van Heiningen believes that the strength of biorefinery research in Finland is close collaboration with pulp and paper producers on one hand and the oil industry on the other.

FiDiPro, the Finland Distinguished Professor Programme, enables prominent researchers, both foreigners and expatriates, to team up with the best of the best in Finnish academic research. FiDiPro is financed by the Academy of Finland and Tekes. •



Tekes, the Finnish Funding Agency for Technology and Innovation

Tekes is the main public funding organisation for R&D in Finland. Tekes funds industrial projects as well as projects in research organisations, and especially promotes innovative, risk-intensive projects. Tekes offers partners from abroad a gateway to the key technology players in Finland.

The Tekes Programmes – part of the innovation chain

The Tekes programmes are an essential part of the Finnish innovation system. These programmes have proven to be an effective form of cooperation and networking for companies, universities and research institutes that are developing innovative products, processes and services. The Tekes programmes boost development in specific sectors of technology or industry, and the results of the research work are passed on to business systematically. The programmes also serve as excellent frameworks for international R&D cooperation.

BioRefine, intensive cooperation in biorefinery

The BioRefine Programme launched by Tekes in 2007 promotes cooperation between companies and research organizations in development of business related to novel products, processes or business concepts that utilise biomass in variety of forms.

The existing know-how of Finnish forest and energy companies forms the basis for creating new businesses and new products from biomass. The BioRefine Programme opens up possibilities for networking with Finnish companies and research organisations.

For more information

www.tekes.fi/en/biorefine

Tuula Savola, Programme Manager
tel. +358 10 605 5667
tuula.savola@tekes.fi

Tuula Mäkinen, Programme Coordinator
tel. +358 20 722 6597
tuula.makinen@vtt.fi

