PUBLICATIONS OF THE ACADEMY OF FINLAND 4/12

RESEARCH PROGRAMME ON SUSTAINABLE PRODUCTION AND PRODUCTS (KETJU) 2006–2010

EVALUATION REPORT

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Members of the Evaluation Panel

James Clark

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Lars Gädda

ACADEMY OF FINLAND

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CONTENTS

DESCRIPTION

<table>
<tr><td>Publisher</td><td>Academy of Finland</td><td>Date
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<tr><td>Author(s)</td><td colspan="2">Evaluation panel</td></tr>
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Evaluation Report</td></tr>
<tr><td>Abstract</td><td colspan="2">In 2006, the Academy of Finland launched a new four-year Research Programme on Sustainable Production and Products (KETJU) for 2006–2010. The general aim of the KETJU programme was to meet the major future challenges in basic research of chemical industries and process and productions engineering. The programme placed significant emphasis on interdisciplinary research and international cooperation in the areas of: 1) Industrial ecology; 2) Green chemistry and engineering; 3) Chemicals in industrial production; testing and regulation. To help achieve these aims the Academy appointed an in-house Programme Coordinator for the programme. The KETJU programme announced two joint calls in 2008 and in 2009 with the French National Research Agency (ANR) and altogether five projects were funded. In 2010, the KETJU programme announced a joint call with the Indian Department of Science and Technology (DST). Resulting from this call, five projects were funded, and the KETJU programme was extended until 2014.
In 2012, the Academy of Finland invited a panel of international experts to evaluate how the programme had succeeded in reaching its ambitious goals. The panel consisted of the following scientists:
• James Clark, Professor of Industrial and Applied Chemistry and Director Biorenewables Development Centre, University of York, UK (Panel Chair)
• Rubens Maciel Filho, Professor of Chemical Engineering, and Head of Laboratory of Innovation in Biofuels, State University of Campinas, Brazil
• Pirkko Suominen, Director, Cargill Biotechnology Development Center, USA
• Lars Gädda, Director R&D, Forestcluster Ltd, Finland

According to the evaluation panel, the programme successfully implemented the goals and objectives as laid out in the programme memorandum. It was felt that the programme made a real contribution to strengthening basic research in process engineering and chemistry, which created new areas of application and new competitiveness. The programme established numerous highly successful cross-disciplinary collaborations. A good number of projects within the programme demonstrated significant promise for exploitation by industry. However, it was felt that projects within the programme needed to have a greater level of industrial interaction, and this should be further promoted through training on how to engage with industry in future programmes of the Academy. The overall assessment reveals that the programme was well conceived, timely, well organised and coordinated. The projects within the programme were of exceptional quality and truly multidisciplinary.</td></tr>
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KUVAILULEHTI

Julkaisija	Suomen Akatemia	Päivämäärä Elokuu 2012
Tekijä(t)	Arviointipaneeli	
Julkaisun nimi	Research Programme on Sustainable Production and Products (KETJU) 2006–2010. Evaluation Report	
Tiivistelmä	Suomen Akatemia käynnisti vuonna 2006 neljävuotisen tutkimusohjelman Kestävä tuotanto ja tuotteet (KETJU). KETJUn päätavoitteena oli kohdata perustutkimuksen haasteet kemian teollisuuden ja prosessien ja tuotannon tekniikkojen tulevaisuudessa. Ohjelma tähtäsi päättäväisesti monitieteisyyteen ja kansainvälisyyteen. Ohjelman teemat olivat: 1) teollinen ekologia, 2) vihreä kemia ja tekniikka, 3) kemikaalit teollisessa tuotannossa, testaus ja säännökset. Tavoitteiden saavuttamiseksi Akatemia nimitti ohjelmapäällikön talon sisältä. KETJU-ohjelmalla oli kaksi yhteishakua vuosina 2008 ja 2009 ranskalaisen French National Research Agencyn (ANR) kanssa ja niissä rahoitettiin viisi hanketta. Vuonna 2010 KETJU toteutti yhteishaun intialaisen Indian Department of Science and Technologyn (DST) kanssa. Viisi hanketta rahoitettiin ja KETJU-ohjelma piteni vuoteen 2014. Vuonna 2012 Suomen Akatemia kutsui kansainvälisen arviointipaneelin arvioimaan, miten KETJU-ohjelma oli onnistunut saavuttamaan tavoitteensa. Paneelin jäsenet olivat: • Professori James Clark, University of York, Iso-Britannia (paneelin puheenjohtaja) • Professori Rubens Maciel Filho, State University of Campinas, Brasilia • Johtaja Pirkko Suominen, Cargill Biotechnology Development Center, USA • T&K-johtaja Lars Gädda, Metsäklusteri, Suomi Arviointipaneelin mukaan ohjelma saavutti onnistuneesti tavoitteet, jotka oli ohjelmamuistioon kirjattu. Tutkimusohjelma onnistui vahvistamaan prosessi-tekniikan ja kemian perustutkimusta, ja sen ansiosta kyettiin luomaan uusia sovellusalueita ja uutta kilpailukykyä alalle. Ohjelmassa oli paljon eri tieteiden välistä onnistunutta yhteistyötä. Useissa projekteissa syntyi merkittäviä tuloksia teollisuuteen hyödynnettäviksi. Paneelin mukaan perustutkimuksen projekteilla olisi kuitenkin pitänyt olla ohjelman aikana enemmän vuorovaikutusta teollisuuden kanssa. Arvioitsijat suosittelevatkin, että jatkossa uusissa ohjelmissa koulutetaan tutkijoita siihen, miten lähestyä teollisuutta. Kokonaisuudessaan tutkimusohjelma arvioitiin erittäin ajankohtaiseksi, hyvin organisoiduksi ja koordinoiduksi. Ohjelman hankkeet olivat myös poikkeuksellisen laadukkaita ja aidosti monitieteisiä.	
Asiasanat	Tutkimusohjelma, arviointi, kestävä tuotanto ja tuotteet, vihreä kemia, teollinen ekologia	
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PRESENTATIONSBLAD

Utgivare	Finlands Akademi	Datum Augusti 2012
Författare	Utvärderingspanel	
Publikationens namn	Research Programme on Sustainable Production and Products (KETJU) 2006–2010. Evaluation Report	
Sammandrag	Finlands Akademi inledde 2006 det fyraåriga forskningsprogrammet Hållbar produktion, hållbara produkter (KETJU). Programmets främsta mål var att möta grundforskningens framtida utmaningar inom den kemiska industrin samt inom processer och produktionsteknik. Programmet tog beslutsamt sikte på mångvetenskaplighet och internationellt samarbete. Dess teman var: 1) industriell ekologi, 2) grön kemi och teknik, 3) kemikalierna i den industriella produktionen, testning och föreskrifter. Akademin utnämnde en programchef inom huset. KETJU ordnade två gemensamma utlysningar tillsammans med franska French National Research Agency (ANR) åren 2008 och 2009. I utlysningarna finansierades fem projekt. År 2010 genomförde KETJU en gemensam utlysning tillsammans med indiska Indian Department of Science and Technology (DST). Inom samarbetet finansierades fem projekt, och forskningsprogrammet förlängdes till år 2014. År 2012 inbjöd Finlands Akademi en internationell panel för att utvärdera forskningsprogrammet. Panelens medlemmar var: • Professor James Clark, University of York, Storbritannien (ordförande) • Professor Rubens Maciel Filho, State University of Campinas, Brasilien • Direktör Pirkko Suominen, Cargill Biotechnology Development Center, USA • FoU-direktör Lars Gädda, Skogsklustret, Finland Enligt utvärderingspanelen lyckades forskningsprogrammet uppnå sina mål. Programmet lyckade också förstärka grundforskningen inom processteknik och kemi och resulterade i nya tillämpningsområden och ny konkurrenskraft inom denna sektor. I programmet ingick rikligt med lyckat tvärvetenskapligt samarbete. Många projekt åstadkom betydande resultat som kan nyttiggöras av industrin. Panelen ansåg dock att grundforskningsprojekten borde ha haft ett närmare samarbete med industrin under programmets lopp. Därför rekommenderade den att man i framtida program ger forskarna skolning i hur de kan närma sig industrin. Panelen ansåg att programmet i sin stora helhet var mycket aktuellt, välorganiserat och effektivt koordinerat. Programmets projekt var exceptionellt högklassiga och genuint mångvetenskapliga.	
Nyckelord	forskningsprogram, utvärdering, hållbar produktion och hållbara produkter, grön kemi, industriell ekologi	
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PREFACE

In 2006, the Academy of Finland launched the four-year Research Programme on Sustainable Production and Products (KETJU) for 2006–2010. In 2010, the KETJU programme announced a joint call with the Indian Department of Science and Technology (DST). As a result of this call, five projects were funded and the KETJU programme was extended until 2014. The general aim of KETJU was to meet the major future challenges in basic research of chemical industries and process and production engineering.

The programme placed significant emphasis on interdisciplinary research and international cooperation in the following areas:

- industrial ecology
- green chemistry and engineering
- chemicals in industrial production, testing and regulation.

To help achieve these aims, the Academy appointed an in-house programme manager for the programme.

In 2012, the Academy invited a panel of international experts to evaluate how the original programme had succeeded in reaching its ambitious goals. The panel consisted of the following scientists:

- James Clark, Chair, Professor of Industrial and Applied Chemistry, Director of the Biorenewables Development Centre, University of York, UK (Panel Chair)
- Rubens Maciel Filho, Professor of Chemical Engineering, Head of the Laboratory of Innovation in Biofuels, State University of Campinas, Brazil
- Pirkko Suominen, Director, Cargill Biotechnology Development Center, USA
- Lars Gädda, Director of R&D, Forestcluster Ltd, Finland.

Dr Andrew Hunt from the University of York (UK) served as an expert secretary for the evaluation panel. The panel met in Helsinki on 28–30 March 2012.

The principal investigators of the funded projects provided their final reports and completed a self-evaluation. The panel was also provided with data on the applications, reports and outcomes of the funded projects. During its visit, the panel interviewed key individuals at the Academy of Finland involved in planning and implementation of the programme and scientists who had participated in the programme.

This report presents the results of the evaluation and some recommendations by the evaluation panel.

INTRODUCTION

Background

The KETJU programme acknowledged that both manufacturing processes and their resulting products affect the environment throughout their life cycle: from product design through raw material acquisition, production, distribution and use to disposal. The draining of natural resources and increasing deterioration in the state of the environment can directly affect the economic development and especially the livelihood of local communities. A challenge for the KETJU programme was to increase scientific knowledge and know-how in order to maintain the Finnish processing industry's competitiveness and ability to regenerate. A threat is posed by the transfer of industry into foreign ownership and further abroad, and also the possible transfer of research activity abroad. Maintaining the industry's competitiveness and ability to regenerate requires innovative expertise and, inevitably, establishment of international networks.

The KETJU programme placed significant emphasis on interdisciplinary research and international cooperation in the following areas:

Industrial ecology

- Industrial ecology refers to systems formed between industry, academia and NGOs in which the aim is to minimise the consumption of external raw materials and energy as well as the generation of emissions and waste. The aim is to combine material and energy flows by mimicking nature. Implementing industrial ecology requires new tools and decision-making models in order to understand the environmental impacts of different design alternatives and material flows. Industrial ecology is aimed at regional and global sustainable development and prolonging product life cycles.

Green chemistry and engineering

- Green chemistry refers to the design, production, use and disposal of products where raw materials and products are sustainable and have little environmental impact. Green engineering is about planning, commercialising, and utilising processes or products that not only cause as little pollution and health risks as possible but are also economically feasible and make use of renewable resources. It is important to consider the impacts on health and the environment as early as possible in the planning and design of production and products.

Chemicals in industrial production, testing and regulation

- While chemicals are useful, their production, use and disposal may be hazardous to health and the environment. Chemicals refer to substances (elements and their compounds) and chemical compounds. The amendment of EU chemicals legislation is fuelled by a concern about the environmental and health impacts of the tens of thousands of chemicals that are produced and used everywhere on a daily basis. The information currently available on the environmental and health impacts of approximately 90 per cent of the most commonly used chemicals is insufficient.

Objectives

The main aim of the Sustainable Production and Products Research Programme (KETJU) was to strengthen basic research in process engineering and chemistry to boost future R&D in Finnish industries to find, in approximately 20 years' time, new areas of application and new competitiveness.

The objectives of the programme were:
- to produce new and innovative scientific knowledge in the identification, assessment and management of detrimental substances and their risks, the optimal recycling of raw materials, the minimising of waste production and new products and productions concepts making good use of innovations;
- to provide a sound platform for the development of eco-efficient processes and products with innovations based on expertise in environmental protection and chemicals safety and process and chemical engineering;
- to strengthen scientific knowledge and expertise and develop research environments in areas that promote sustainable production and products.

Further aims included:
- to create new multidisciplinary research teams and national and international cooperation networks;
- to increase the mobility of doctoral students and researchers;
- to improve the international competitiveness of the research and industry;
- to create visible social impact.

To maintain the chemical industry's competitiveness and ability to regenerate, Finland must cooperate with the rest of Europe, USA and Asia. Further goals are: to train multidisciplinary experts in interaction with experts in other fields; to create structurally balanced research groups; to increase the share of postdoctoral researchers in research groups in particular; and to increase cooperation and information between scientific communities, business companies and authorities.

Evaluation procedure

The aim of the evaluation of the KETJU programme was to estimate the extent to which the programme had succeeded in fulfilling its original objectives set in the programme memorandum. In addition, the evaluation panel was to provide recommendations for the future, including a justification for the recommendations to the Academy regarding its activities in organising and funding research programmes.

The purpose of this report is not to be a scientific evaluation of the programme but to assess how the coordinated programme succeeded in giving added value to the study of sustainable production and products; how the programme was exposed in the media; whether it stimulated discussion; and how the researchers themselves experienced the programme. This report will be utilised as a strategic tool, which the Academy (the Programme Unit, the Research Councils, the Academy Board) can use in its development work regarding research programmes and science policy.

The panel is expected to assess the programme as a whole, not any individual project, and to reflect especially on the following issues:
1. Planning of the research programme
   - Was the scientific focus chosen properly?

2. Success of the implementation of the programme goals and objectives (as laid out in the programme memorandum)
   - Strengthen basic research in process engineering and chemistry
   - Boost future R&D in Finnish industries to find, in approx. 20 years' time, new areas of application and new competitiveness
3. Collaboration and networking within the programme and internationally
4. New viewpoints to be utilised now or later
5. Applicability of research and importance to end-users (policy-makers, media, NGOs, citizens etc.)
6. Mobility of researchers
7. Societal impact
8. Recommendations for the future

The evaluation process took place before the international collaborations with India were completed. The evaluation panel mainly focused on completed projects, but some consideration was given to ongoing projects that have made significant progress. The quality, innovativeness and efficiency of the research were compared with international standards.

Assessing the project documentation included an examination of the supplied material, including:

- **Programme memorandum:** detailed information on the background, objectives and themes of the programme and the call procedure
- **Programme summary 2003–2011:** summary of the programme lifespan and the coordination activities
- **Summary of outcomes:** summary drafted on the basis of the research reports (national call 2006)
- **Consortium end reports:** summary of research and outcomes (by consortium) during the programme
- **Best publications in KETJU:** received from the consortia themselves
- **Summary of project leader (Form 1) and researcher (Form 2) self-evaluation reports:** summary of the self-evaluation questionnaire (partial) filled in by the project leaders (26 people) and the researchers (29 people) **Applications, research plans** (incl. international calls) and **abstracts** (national call 2006) submitted to the programmes in 2006 and to the international calls
- **Examples of previous evaluation reports:** for your information, three latest evaluation reports of Academy research programmes
- **General information on the Academy and KETJU**
  - All applications for second round: list of projects accepted to the second round in 2006
  - Call texts for national and international calls
  - Coordination budget: KETJU coordination budget 2006–2011
  - Evaluation panellists 2006
  - Funded projects (all calls)
  - Funding list for international calls with ANR and DST
  - KETJU research programme brochure
  - KETJU steering groups and committees 2006–2011
  - KETJU media coverage
- **Final reports of the projects:** detailed information on the outputs of each project

SCIENTIFIC QUALITY

a. Innovation

Many of the projects showed high levels of innovation and some reported breakthrough results. Some of the highlights are briefly described below.

1. Flame retardants

This project has contributed to a major breakthrough in seeking alternatives to brominated flame retardants (which are persistent and bioaccumulative and under increasing pressure to be reduced in the EU and elsewhere) by supportive basic research. The project has demonstrated good collaboration with industry and has great publicity value.

2. CO2 utilisation (CO2UTIL)

The greatest achievement in this project has been to obtain the highest ever reported carbon dioxide conversion – an outstanding result based on innovative but quite practical chemical processing modifications. The achievement for such a relatively small grant makes it especially impressive.

3. Iron-based catalysts (NADREDOX)

This project has produced several significant research successes including metal-free oxidations (increasingly important due to both metal scarcity and concerns about metal contamination of products), new iron-oxidation catalysis and non-transition metal-based hydrogen activation for reduction reactions. All of these have real value in chemical synthesis and processing, including pharmaceutical process chemistry. The project involved collaboration within a narrower community than some of the other projects but still relied on effective interactions between different research groups.

4. Fast, selective and ecological ion-exchange materials for hydrometallurgy (FSE_IX)

The sustainable selective extraction of metals is an extremely important goal in sustainable chemistry and this project has made a significant step in this direction. Waste is utilised and metals are trapped and separated in very practical processes. The success and originality of the research is witnessed by its excellent publication record.

5. Forest growth simulator (SUSWOOD)

This project has led to a novel single-tree-level forest simulator including a map-based user interface. Remarkably, it can be successfully used to simulate tree populations with billions of trees. This revolutionary approach is publicly available on a website, which has been accessed many times.

6. Chemical testing – possible breakthrough in the testing and assessment of toxicity and endocrine disruption activity

The development of alternative testing methods for chemical toxicity is a highly topical subject in the light of REACH legislation and is especially appropriate for Finland given the location of the Competent European Authority in the area (ECA). This project has successfully led to alternative methods for the assessment of toxicity and endocrine disruptive activity in chemicals and the environment. The test is simple and requires no specific expertise, training or instrumentation. This could be a breakthrough in chemicals testing.

b. Results

i. Publications

The programme has produced a good number of publications across the range including refereed scientific and professional journals, conference proceedings and contributions to books. The total number of measurable outputs is about 250. The balance between these varied across projects, but all projects had measurable publication outputs and in some cases these were outstanding (up to 16 scientific articles in a single project).

ii. Publicity

There was significant opportunity for publicity based on the successes of the various projects, but little evidence of this opportunity being taken. There was some evidence of press releases (e.g. in the project IFEE) and a public website (in the project SUSWOOD). Given the importance of some of the results obtained, including a good match with some current European priority areas (substitution of hazardous chemicals, use of renewable feedstocks, biobased products, chemicals testing, etc.), there would seem to be a good possibility of increasing the publicity and media value of the research.

iii. Patents

Only one project reported patenting (alternative flame retardants). Given the relatively fundamental nature of Academy-funded research, this need not be a major concern. However, some academics clearly see patents as obstructive to publications (due to delays while patents are prepared and filed) and do not believe they have good support for this in their institutions so that patent preparation becomes a responsibility of the academic and without apparent benefit. There was also evidence that some academics did not know how to engage industry. This suggests that some patent opportunities might have been ignored and that better support for patenting and better information on the benefits of patents, as well as support for industrial liaison, would be helpful. Without this, there is a concern that academics do not know how to follow up on commercialisation opportunities or do not believe it is worthwhile.

iv. Other points

A number of projects gained a good knowledge base and opened doors for future breakthrough discoveries (e.g. BIOCAT, IFEE, FUNMAN, PEGRES, ISSB PENTOVAL and SUSWOOD):

1. The IFEE project led to the formation of a new group in industrial ecology and new undergraduate training opportunities.
2. ISSB created an industrial ecosystem balance scorecard and addressed the importance of system boundaries (a key feature of integrated biorefineries).
3. PEGRES improved the Finnish understanding of biorefineries.
4. SUSWOOD led to simulation methods for regional analysis with application value in others industries (and could also be applicable to the ISSB).
5. VTT xylose project has led to improvements in basic understanding of biomass conversion technologies.

Recommendation

- The panel recommends that the Academy run a seminar at the beginning of programmes such as KETJU on the importance of intellectual property and the commercialisation of science as part of the education and cooperation with industry.

IMPLEMENTATION

Multidisciplinary nature of KETJU

Multidisciplinary programmes such as KETJU may significantly benefit many areas of research and can be viewed as a natural way to face many existing and also foreseen problems. The unique mix of skill that such a programme brings together can not only propose innovative solutions but also catalyse the development of new research areas.

Although sustainable products and production are viewed as worldwide issues with many possible approaches, there is no consensus on how to attack the problem with a unique solution. Research programmes focused on sustainability, especially those concerned with production and products, need to take into account the availability of design, raw material, logistics, environmental impacts of processes (incl. air, soil, water and population – quality of life) and process development that covers a very broad range of knowledge. This will certainly involve basic sciences, the humanities, engineering and economics, among other areas. Bearing in mind that the aims of the KETJU programme primarily included to produce new and innovative basic scientific knowledge into waste minimising production methods as well as new products and production concepts, the research should have been focused on the development of environmentally friendly and sustainable solutions, which requires a huge effort to bring together many areas of knowledge.

In this context, the KETJU programme successfully brought together an extensive range of projects involving many disciplines including chemistry, chemical engineering, biology, law, physics, social sciences, biochemistry, environmental sciences, design, textiles, material science, industrial ecology, genetics, modelling, process technology, forestry, economics, information technology, geography and architecture. Many of these disciplines may be considered well established and follow well-known international curricula (almost universal). In addition to these defined and established disciplines, some subjects are very broad (e.g. environmental sciences, industrial ecology and modelling). The challenging aspect of the KETJU programme was to integrate the knowledge of several disciplines to generate a multidisciplinary approach to the many problems that require it. This is typically the case for green chemistry, which deals with the use of renewable feedstock of different species and conditions. A crucial aspect to be considered is the logistics (transportation of forestry residues) that certainly will have a significant impact on the final cost of the product. This fact appears to have been well addressed in the projects.

The overall view of the panel is that the KETJU programme successfully brought together a wide variety of inter-science and intra-science disciplines to successfully achieve highly complex and important projects in the area of sustainable research. The wide nature of the programme was required to address the aims of the research call. The advantages are the clear need for multidisciplinary approaches to be developed for collaborative projects among different departments and institutions. One such project that should be applauded for bringing together different disciplines

was SUMAC. The main disadvantage of such breadth is that all required aspects were not covered and some subjects still need to be reinforced. This may be due to a lack of either researchers or interest to cover some topics. This is true for KETJU research in the Chemicals in industrial production area: testing and regulation was undertaken in only one project and the KETJU programme would have benefited from additional research in this area.

As the area of Chemistry in industrial processing naturally has a need for process development with alternative feedstocks, there is an even greater need to have more activities in this topic.

Recommendation

- Webinars may help with long-distance communication as well as with a more intense interchange of students.

COLLABORATION

The coordination of the programme was of high quality and the visits by the Academy of Finland and the annual meetings were of great value to the participants of the programme. Tekes' representation on the KETJU steering group and the Academy itself facilitated links to Tekes.

The panel views collaboration as an important point since it allows for a quick exchange of ideas and a possible way to enlarge the project scope. In general, the interaction between researchers of the individual projects was good. The annual programme meeting and also the projects themselves arranged regular meetings, workshops and seminars. These served to bring together researchers, thus enabling the sharing of ideas and research results.

Several seminars were organised during the programme, including a joint international meeting with the French ANR and joint meetings with other programmes of the Academy of Finland, which demonstrated good national and international collaboration among different research units. The level of collaboration and networking within the KETJU programme was generally very high and should be held up as a success of the programme. However, other projects remained isolated from international collaboration and the variation in quality of collaborations was substantial. Within the programme, the collaborations ranged from completely new ones to existing ones. The panel felt that a collaboration approach was a good model for KETJU but that the implementation was not always successful. Some teams were able to take advantage of the multidisciplinary nature of the collaboration, while other projects remained totally isolated within their discipline.

As sustainability was one of the main research objectives, the inclusion of legislators or decision-makers was seen as key for achieving success in the area of industrial ecology. Some projects within the programme had significant influence on international policy. For instance, IFEE successfully investigated aspects of industrial ecology and energy crops such as Jatropha, which influenced national and international energy policy including the discussion of research at the IPCC.

Although significant collaboration took place within the KETJU programme on a national level between academic groups, few research projects had direct interaction with industry. A strong case of industrial success was observed in the project on flame retardants. As a result of poor industrial interaction, the panel made several recommendations for future multidisciplinary programmes for the Academy of Finland.

Recommendations

- training courses on interaction or engagement with industry
- additional speeches from industrialists at annual meetings

International networking at a programme and project level enhances the quality and competitiveness of Finnish research. The KETJU programme had significant variation in the level of international collaboration (Table 1). Some projects were active in international collaboration with exchanges of researchers. CO2UTIL had

successful research with a French research group including student exchanges and specific research tasks carried out with CNRS in France. This project led to additional projects funded by the Academy of Finland and Tekes. The PENTOVAL project was a new collaboration for the research groups involved (in both Finland and France), but it created a lasting collaboration with real involvement between the countries, including PhD students spending time in France. The result of this collaboration led to other collaborations in the EU FP7 Bio-core project.

Table 1. International involvement in KETJU projects (* represents an international collaboration).

Project	International collaboration										
	France	Germany	India	Sweden	USA	Hungary	Czech Republic	UK	Austria	Estonia	Italy
IFEE	-	-	*	-	-	-	-	-	-	-	-
ISSB	-	-	*	*	*	*	-	-	-	-	-
NADREDOX	-	-	*	-	-	-	-	-	-	-	-
BIOCAT	-	*	-	-	-	-	-	-	-	-	-
FUNMAN	-	-	-	-	-	-	-	-	-	-	-
FSE_IX	-	-	-	-	-	-	*	-	-	-	-
SusProc	-	-	-	-	-	-	-	*	-	-	-
PEGRES	-	-	-	-	-	-	-	-	-	-	-
ProDOE	-	-	-	-	-	-	-	-	-	-	-
SUSWOOD	-	-	-	-	-	-	-	-	*	-	-
Xylose	-	-	-	-	-	-	-	-	-	-	-
Chemical testing	-	-	-	-	-	-	*	-	-	*	*
Flame retardants	-	*	-	-	-	-	-	-	-	-	-
SUMAC	-	-	-	-	-	-	-	-	-	-	-
CO2UTIL	*	-	-	-	-	-	-	-	-	-	-
PENTOVAL	*	-	-	-	-	-	-	-	-	-	-

TRAINING

The KETJU programme was very active and highly successful in promoting postgraduate training. At the time of evaluation, the total number of PhD degrees, Licentiate and MSc degrees awarded within the KETJU programme was 40 (summarised in Figure 1). It should be noted that KETJU projects in collaboration with India are still in progress at the time of publication and as such the actual number of successful degrees awarded is likely to be higher.

The evaluation panel viewed the overall KETJU programme as being successful in terms of training provided to researchers and students within the programme. However, specific projects can be highlighted as providing an outstanding contribution to training. These include the IFEE project, which led to new undergraduate training opportunities in the area of industrial ecology, and SUSWOOD, which developed information that can be utilised in graduate education.

The annual two-day KETJU seminar was viewed by those within the programme as highly successful and was able to provide the programme participants with a broad and multidisciplinary outlook on a wide range of topics. Researchers and postgraduate students appreciated the wider community created in the KETJU programme by attending such events. It can be clearly stated that the programme created a new community of researchers and that this provided opportunities for postgraduate studies. However, further collaborations resulting from contacts made at the KETJU annual meeting were limited. The annual event brought together some 60–80 researchers from a wide variety of disciplines. When interviewed, the project leaders and participants strongly emphasised that the annual meeting exposed students to a wide variety of disciplines and topics. This was good in terms of training students to have a greater appreciation for research outside their area of focus. However, the breadth of the

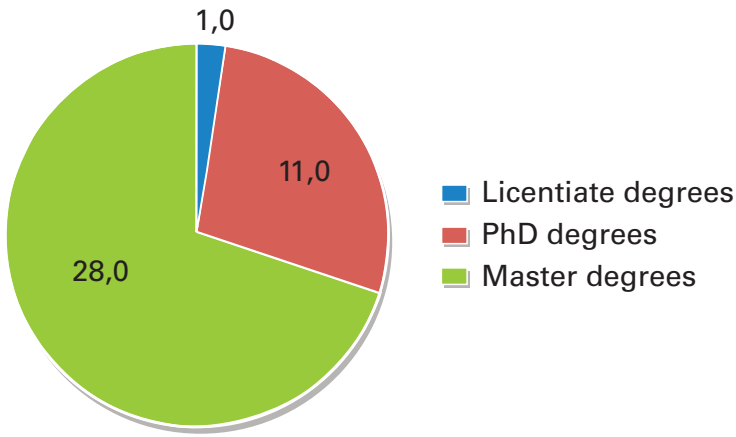

Figure 1. Number of PhD degrees, Licentiate and MSc degrees awarded within the KETJU programme.

research was so large that participants often found it hard to communicate across disciplines. As such, it is recommended that, at the start of any future multidisciplinary programmes, the Academy of Finland organise training for cross-discipline communication in order to encourage interaction and cross-fertilisation of ideas. The evaluation panel also feels that smaller, more focused seminars in addition to the annual meeting would have been of significant benefit to students within the programme.

The level of researcher mobility varied greatly between projects. In general, there was highly active researcher networking, especially at the national level. The programme employed a total of 197 researchers, corresponding to a total of 1,451 FTE months. Several researchers made research visits to universities and research institutions abroad and many of the projects also invited foreign students, researchers or experts for research visits, training or seminars in Finland. However, the number of FTE months utilised in exchange visits or training periods from Finland to other countries was only 40.1. The number of international collaborators travelling to Finland for training or research was even lower, with only 22.5 FTE months employed to bring international collaborators to Finland.

The view of the panel is that no project within the KETJU programme had a significant amount of outreach with schools or the general public. The panel strongly feels that positive interactions between researchers and the next generation are of vital importance to the long-term success of research and development in Finland. As such, the panel recommends that the Academy of Finland's research programmes dedicate a proportion of time to outreach activities.

Recommendations

- In order to promote international collaboration the panel proposes that future multidisciplinary programmes funded by the Academy insist on projects devoting at least 10 per cent of the total budget towards collaborative research with groups outside Finland.
  - This funding should be focused on student or researcher exchange programmes.
  - The amount of funding allocated to international collaboration can thus be reported as a measurable outcome of the programme.
- The panel recommends that the Academy develop training courses to be delivered at the start of multidisciplinary programmes in the areas of:
  - Sustainability (introductory course)
  - Communication across disciplines
- The Academy's research programmes have to dedicate a proportion of time to outreach activities.

IMPACT

The panel considered the initiative well timed as sustainability and the use of renewable resources for the future biosociety are becoming increasingly important in the Nordic and European context.

The evaluation panel assessed the impact of the KETJU programme from several different perspectives:

- Firstly, the broad impact of the programme was assessed in terms of the visibility of the programme and the dissemination of its results. Some of the projects had created their own websites, but this opportunity to reach a wider public was not fully utilised. Some projects had made special efforts to get their results into practical use. The best example was found in the SUSWOOD project, where the developed information and simulation software was disseminated to the wider society freely via a university website. The projects' visibility towards the scientific community was of good quality thanks to a good number of scientific articles and presentations within the projects. One untapped opportunity for stronger impact was the lack of outreach to schools in Finland. The topic of sustainability and products and processes based on renewable materials is important and is, according to the panel, an opportunity for getting younger people interested and involved in topics related to a sustainable future.
- Secondly, national-level impact was considered from the point of view of science and innovation policy. The panel compliments the initiators of the KETJU programme on the excellent timing of planning and establishment of the programme. This timing was good from two different viewpoints: early start in an area that is becoming increasingly important for Finland and the EU, establishing new and unproven research consortia initiated a new research cooperation model, which could be strengthened in the research programmes established by the Strategic Centres for Science, Technology and Innovation (Forestcluster Ltd and CLEEN Ltd) and from which the centres could benefit.
- The panel also considered the international viewpoint and recognised internationally important contributions from some of the projects. For instance, IFEE projects were presented at the IPCC and thus affected international policy. The ProDOE project, in turn, led to four national seminars and also international sustainability seminars, including one event in collaboration with industry. Projects in the KETJU programme focused on industrial ecology generated thus clear, visible and measurable international impacts. Results from projects in the other two focus areas, Green chemistry and engineering and Chemicals in industrial production, will become more evident later as many good and visible scientific breakthroughs will be obtained.

However, the projects focused on basic science and the application of results should emerge in the coming years in follow-up projects.

Recommendations

- All future projects must have an active website.
- The Academy of Finland should actively look for programme openings similar to KETJU, important from science and societal perspectives, and supporting the move towards a more sustainable future.
- Many of the KETJU projects obtained breakthrough results and opportunities. However, there is not a systematic approach in Finland to secure funding for the next development phases, as in Tekes-funded projects, for example.

ADDED VALUE

A wide variety of scientific disciplines were brought together under the umbrella of the KETJU programme. At first glance, one might ask what a chemist and an economist, for example, would find in common in the same programme. However, it seems that the Academy of Finland wanted to take a comprehensive approach to sustainable production and products and include all relevant scientific disciplines. This left the programme manager with a challenge and opportunity to bring the academics from different disciplines together to add value that would not have been possible in a narrower programme.

The programme manager did a good job in bringing the project teams together at annual seminars. Attendance was high, and most participants found the seminars a very useful forum. Scientists enjoyed meeting others within their discipline as well as getting to know scientists from other disciplines interested in sustainable technologies. Some commented that it was hard to understand chemistry or ecology if you were not in that field. Overall, people liked the opportunity to see the broad picture in one common seminar and interact with scientists across disciplines. Young scientists in particular found this very beneficial.

The fact that most of the projects were asked to operate as consortia was observed as a significant benefit for KETJU, project partners and students involved. Ultimately, being part of the KETJU programme and getting to know the other groups in the programme could lead to a new community in Finland around sustainable products and processes. The broad community has not yet been achieved, but many lasting collaborations between both Finnish and international partners, and between academics from very different disciplines, have been established.

A good example of wide domestic and international collaboration is the IFEE consortium. The partners knew each other before the programme started, but KETJU allowed a comprehensive effort between the teams from the University of Helsinki, Turku School of Economics, Åbo Akademi University and VTT. A new collaboration with a group in India was established and one of the scientists spent several months there. This collaboration will continue even after KETJU. The consortia organised a workshop in Sweden. The KETJU project allowed this line of research to be started at the University of Helsinki and Master's students to be trained in the project. After being established in this programme, this line of research and training will continue at the University.

In 2008, a joint call with KETJU and the French National Research Agency (ANR) was announced. One of the funded projects was PENTOVAL. This funding enabled collaboration between the Finnish and the French group. The groups knew each other before, but this was their first common project. A PhD student from Toulouse spent 18 months at VTT and a PhD student from VTT a year in Toulouse, ensuring that the groups learned from each other and shared their expertise.

For the group from Åbo Akademi University, developing flame retardants, collaboration between organic and inorganic chemists was a result of being funded from KETJU. This group also got a new company, Kiilto Oy, interested in applying their research out of the publicity they got through KETJU.

OVERALL RECOMMENDATIONS

Going forward

The panel feels a number of recommendations could be applied to the KETJU programme or future inter-disciplinary programmes funded by the Academy of Finland:

- *Further funding.* The great success of the KETJU programme should be highlighted in terms of collaboration and high-quality science. As such, the panel would strongly recommend that the Academy of Finland launch more programmes based on the KETJU style in areas such as sustainability, green chemistry, biorefineries, bio-derived chemicals and bioenergy.
- *Future international collaborations.* Brazil has vast quantities of renewable feedstock and the country is also developing green chemistry and biorefinery activities. It is the panel's view that Brazil would be a good strategic fit for collaboration with Finland especially in areas related to renewable resources, biomass and biorefineries. Other countries that the Academy should look to collaborate with in terms of green chemistry include Mexico, Chile and the Republic of Korea. All of these countries have rapidly expanding green chemistry programmes or centres, which could be a good fit with the expertise developed within KETJU. Many of these countries, including Brazil and Chile, have significant research efforts towards the use of forest residues as raw material for green chemistry. Because of its close geographical relationship with Finland, Russia is another country that the Academy could form strategic partnerships with to further exploit the knowledge gained within the KETJU programme.
- *Training.* The funding for projects should be set at four years to be consistent with the length of a PhD (except in special cases).
- *Meetings* within interdisciplinary programmes. The Academy should organise more focused meetings to complement the annual meetings that were viewed as a success within the KETJU programme. The panel recommends that the Academy promote the use of webinars in collaborative projects with the intension to stimulate long-distance communication as well as more intense interchange of students.
- International collaboration is an important aspect of keeping Finland at the forefront of research. As such, the panel feels that future multidisciplinary programmes should insist that projects devote at least 10 per cent of their total budget towards international collaborative research and researcher mobility.
- It would be of benefit if the Academy could run a one-day course at the start of multidisciplinary programmes covering topics such as:
  - intellectual property and commercialisation of science
  - interaction or industrial engagement
  - sustainability
  - communication across disciplines.
- The Academy's research programmes have to dedicate a proportion of time to outreach activities.

New perspectives

The panel made a number of recommendations in terms of future viewpoints for the Academy of Finland:

- Programmes should not try to cover all areas but should concentrate on areas of excellence.
- A greater degree of research symbiosis is needed between projects.
- The Academy of Finland should reinvent Nordic collaboration between Finland, Sweden, Norway, Denmark and Estonia in common areas of excellence such as biorefineries, and also provide complementarities between expertise.
- Russia could benefit from Finland's biorefinery knowledge, and future collaborations should be promoted between the countries.

Future projections

The panel's recommendations in terms of important areas for future focus are:

- Biorefineries. Finland is ideally suited to become a world-leading country in this area thanks to the country's expertise, availability of forest-based raw material, quality of researchers, new multidisciplinary teams and industrial opportunities.
- Sustainable mining and freshwater research. This is an important emerging area in terms of resource security and efficiency.
- Renewable energy in collaboration with Brazil. This would be an area of strategic interest to Finland in terms of international collaboration and energy security.

CONCLUSIONS

The panel considered a wide range of documents, conducted interviews and followed the Academy of Finland's instructions for the production of this evaluation report.

The panel feels that the KETJU programme successfully implemented the goals and objectives as laid out in the programme memorandum. The KETJU programme made a real contribution to strengthening basic research in process engineering and chemistry, which created new areas of application and new competitiveness. The programme established numerous highly successful cross-disciplinary collaborations. A good number of projects within the KETJU programme demonstrated significant promise for exploitation by industry. However, the panel feels that some projects within the programme needed to have a greater level of industrial interaction (even if just at a preliminary stage for Academy-funded fundamental research projects) and that this should be further promoted in the Academy's future programmes through training on how to engage with industry.

The programme generated a significant number of high-quality peer-reviewed publications and a number of projects within the programme aided in influencing both national and international policy.

The overall assessment reveals that the programme was well conceived, timely, well organised and coordinated. The projects within the programme were of exceptional quality and truly multidisciplinary. The collaborative approach was a good model for KETJU, but the implementation within individual projects was not always successful. Some teams were able to take advantage of the multidisciplinary nature of the collaboration, while others remained totally isolated within their discipline and their level of collaboration was limited.

The programme has provided positions for doctoral and postdoctoral researchers and supported the career development of junior scientists. The training of graduate students was highly successful and of exceptional quality. A significant amount of international collaboration and networking took place within the programme, and it is crucial to emphasise the importance of such international links and the benefit of exchange or mobility programmes to the development of younger researchers. The panel feels that the Academy of Finland should promote the use of such schemes in future national and international programmes.

Another important area of focus that was lacking within the KETJU programme was that of *outreach activities to schools and the general public*. Such activities should be made mandatory and would aid in inspiring the next generation of Finnish researchers.

Appendix 1. Terms of Reference

Terms of Reference
FINAL EVALUATION OF THE KETJU PROGRAMME

EVALUATION PANEL MEMBERS:

1. James Clark, Chair, professor of green chemistry and biorefinery, University of York, U.K.
2. Rubens Maciel Filho, Head of Innovation in Biofuels, State Unoiversity of Campinas, Brazil
3. Pirkko Suominen, Director, Cargill BioTDC, USA
4. Lars Gädda, Director R&D, Forstcluster, Finland

Expert Secretary: Dr Andrew Hunt, University of York, UK

RATIONALE:

This will not be a scientific evaluation of the programme. Rather, what we need is to have a report on how the coordinated programme succeeded in giving "added value" to the study of sustainable production and products, how the programme has been seen and treated in media, whether it has stimulated discussion and how the KETJU researchers themselves have experienced the programme.

TASK:

The work of the evaluation panel is to go through the final reports of the projects and the researchers' self-evaluation sheets, as well as other material related to the activities of the programme. At its meeting at the Academy in March, the panel will conduct interviews of key-persons including the programme manager (me), chair/member of the Steering Group, 3-4 project leaders and 3-4 junior researchers.

The panel is expected to assess the programme as a ***whole***, not any individual projects, and to reflect especially on the following issues:

1. Planning of the research programme
    - has the scientific focus been chosen properly
2. Success of the ***implementation*** of the programme goals and objectives (as laid out in the Programme Memorandum)
    - strengthen basic research in process engineering and chemistry
    - boost future R&D in Finnish industries to find, in aprox. 20 years' time, new areas of application and new competitiveness
3. ***Collaboration and networking*** within the programme and internationally
4. ***New viewpoints*** to be utilized now or later
5. ***Applicability*** of research and importance to the users (policy makers, media, NGOs, citizens etc)
6. ***Mobility of the researchers***

7. ***Societal impact***
8. ***Recommendations*** for the future

The quality, innovativeness and efficiency of the research should be compared with international standards.

REPORT

The evaluation report will be written by the panel and edited/finalised by the panel secretary. The result should be a short and concise "strategic tool" that the Academy (Programme Unit, research councils, the Academy Board) can use in its development work regarding research programmes and science policy.

SCHEDULE
Panel days 29.-30.3.2012

CONTACT

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FIN-00531 Helsinki, Finland
www.aka.fi
www.aka.fi/ketjueng

Evaluation material and procedure

Final evaluation is based on the material that has been collected by the Academy of Finland for the purpose of the evaluation. The material consists of essential documents about the programme preparation, the evaluation of the proposals, the funding decisions, the project results and the programme events (see the separate list of documents). The evaluation panel has the possibility to influence on the way of working and it can also, for instance, express wishes regarding the material to be submitted. The evaluation may also include interviews with researchers, programme steering group members etc. These wishes should be communicated with the Academy personnel well in advance to ensure proper arrangements for the panel meeting.

Evaluation report and confidentiality

The results of the evaluation will be collected to a report published by the Academy of Finland. The Panelists will divide the work of writing the report amongst each other. The main responsibility for collecting and compiling text from the panelists is carried by the Chairman of the evaluation panel, who will be assisted by the Expert secretary, who is to edit the report to the final form. Academy of Finland will provide additional assistance if necessary.

The report shall contain statements describing the outcome and impact of the programme and recommendations of the Panel to the responsible funding organizations.

Panel members will be provided certain detailed information which is intended for evaluation purposes only. The panel members are asked to keep such information, knowledge, documents or other matters confidential. The extent to which detailed data of the research projects can be used in the final report must be agreed between the panel and the Academy of Finland. The panel members are also asked to keep the evaluation report confidential before the publication date. Any possible conflicts of interests are also determined and handled based on discussions between the panelists and the Academy of Finland.

Utilization of the evaluation results

The programme steering group shall discuss the issues brought up in the evaluation and draw up an ***after-care plan*** for the programme, including proposals to the Academy and other funding bodies on the implementation of the recommendations insofar as they are considered justified. Proposals will be forwarded as information issues to the research councils involved in the programme. Research councils will take the results of the evaluation into account, at their discretion, in science-policy decision-making and in their action and financial plans.

Evaluations of research programmes are also used as one element in ongoing efforts to identify future research needs and directions.

Appendix 2. Evaluation panel meeting

KETJU research programme 2006–2012

EVALUATION PANEL MEETING

Date: 29–30 March, 2012

Work schedule

Place: Academy of Finland, Helsinki (Hakaniemenranta 6)

Hosts: Programme Manager Dr. Saila Seppo
Ms Elina Sarro

Wednesday 28 March, 2012

18:45 Meeting with programme manager Saila Seppo at the lobby of Hotel Cumulus Hakaniemi (address Siltasaarenkatu 14, 00530 Helsinki), walk to the restaurant

19:00 Get together dinner at Restaurant Graniittilinna (http://www.graniittilinna.com/page.php?page_id=13&language=3)

Thursday 29 March, 2012 (meeting room AHVEN, ground floor)

09:00-10:30 Kick-off of the panel meeting
- Introductions of the panel members and the Academy of Finland staff
- Presentation of the Academy of Finland, research programme KETJU and the evaluation process: Dr *Saila Seppo*, KETJU Programme Manager
- Organization of the panel work: Professor *James Clark*, Chair of the evaluation panel and Dr *Andrew Hunt,* Scientific secretary of the panel
- Interview: programme manager *Saila Seppo*

10:30-11:00 Interview: Chair of the Steering Group, professor *Johanna Buchert*

11:00-11:30 Interview: Member of the Steering Group, Senior Vice President, Technology at UPM-Kymmene and Academy of Finland´s former board member *Markku Karlsson*

11:30-12:00 Interview: French co-operation, Senior Research Scientist *Anu Koivula,* VTT Technical Research Centre of Finland

12:00-13:00 Lunch

13:00-13:30 Interview: Chair of the first steering Group, professor *Riitta Keiski*

13:30-14:00 Interview: Group from Åbo Akademi University: professor *Carl-Eric Wilen, Melanie Aubert, Teija Tirri, Johan Lindholm*

14:00-14:30 Interview: Group SUMAC: *Marja Randelin*, University of Eastern Finland, Päivi Talvenmaa, Tampere University of Technology, *Piia Rytilahti*, University of Lapland

14:30-15:00 Coffee break

15:00-15:30 Interview: Group IFEE: *Jouni Korhonen, Laura Saikku,* University of Helsinki, *Johanna Kirkinen*

15:30-16:00 Interview: Group NADREDOX: *Timo Repo,* University of Helsinki

16:00-> Summary of day one, drafting of the Evaluation Report

Friday 30 March, 2012 (meeting room Virtanen 6073, 6th floor)

09:00-09:30 Interview: professor *Jyri-Pekka Mikkola*, Åbo Akademi University and Umeå University

09:30-12:00 Panel work, writing of the Evaluation Report

12:00-13:00 Lunch

13:00-17:00 Panel work, writing of the Evaluation Report. Summary of the panel and feedback to the Academy of Finland; agree on the delivery of the evaluation report

Appendix 3. Funded projects

National call 2006

BIOCAT (Modular Biocatalyst Platform for Chiral Synthesis of Chemical Compounds by Structure-based Directed Evolution)
Lajunen Marja, University of Oulu, 176 000 €
Neubauer Peter, University of Oulu, 203 440 €
Wierenga Rikkert, University of Oulu, 143 430 €

CO2UTIL (Towards Utilization of Carbon Dioxide as a Green and Versatile Commodity Chemical: Clean Synthesis of Methanol and Dimethyl Carbonate (DMC))
Mikkola Jyri-Pekka, Åbo Akademi University, 192 710 €
Pongracz Eva, University of Oulu, 416 020 €

FSE_IX (Fast, Selective and Ecological Ion-exchange Materials for Hydrometallurgy)
Paatero Erkki, Lappeenranta University of Technology, 228 530 €
Harjula Risto, University of Helsinki, 93 210 €

FunMan (Targeted Functionalization of Spruce Galactoglucomannans with Aid of Galactose Oxidase)
Tenkanen Maija, University of Helsinki, 170 000 €
Willför Stefan, Åbo Akademi University, 84 600 €

IFEE (Indicator Framework for Eco-efficiency)
Kauppi Pekka, University of Helsinki, 147 800 €
Vehmas Jarmo, Turku School of Economics, 214 060 €
Korhonen Jouni, University of Tampere, 275 200 €
Savolainen Ilkka, Technical Research Center of Finland, 105 050 €

ISSB (Industrial Symbiosis System Boundaries)
Korhonen Jouni, Univesrity of Tampere, 202 370 €
Melanen Matti, Finnish Environment Institute, 244 820 €

NADREDOX (Enhanced Organocatalyzed Redox Processes for Sustainable Chemical Synthesis)
Pihko Petri, Teknillinen korkeakoulu, 212 920 €
Repo Timo, Helsingin yliopisto, 212 920 €

PEGRES (Paper, Bioenergy and Green Chemicals from Nonwood Residues by a Novel Biorefinery)
Tanskanen Juha, University of Oulu, 200 140 €
Niinimäki Jouko, University of Oulu, 174 180 €
Manner Hannu, Lappeenranta University of Technology, 213 950 €

ProDOE (Pro-environmental Product Planning in a Dynamic Operational Environment Now and in the Future-Methods and Tools)
Fogelholm Carl-Johan, Helsinki University of Technology, 122 360 €
Härkki Jouko, University of Oulu, 115 040 €

Ekroos Ari, Helsinki University of Technology, 151 050 €
Hukkinen Janne, Helsinki University of Technology, 172 040 €
Heiskanen Kari, Helsinki University of Technology, 108 590 €
Dahl Olli Pekka, Helsinki University of Technology, 100 600 €

SUMAC (Sustainable Innovative Materials in High Tech Applications. An INterdisciplinary Approach to Design, Engineering Technology and Chemistry of Environmentally Sound Products and Production)
Nieminen Eija, Tampere University of Technology, 180 600 €
Uotila Minna, Univesity of Lapland, 191 120 €
Louhevaara Veikko, Univesity of Kuopio, 160 000 €

SusProc (Sustainable Processing of Natural Resources)
Lajunen Marja, Univesity of Oulu, 390 000 e

SUSWOOD (Sustainable and Eco-Friendly Wood Material for Future Industrial Needs)
Tykkyläinen Markku, University of Joensuu, 201 160 €
Kolström Taneli, University of Joensuu, 184 300 €
Westerholm Jan, Åbo Akademi University, 189 450 €

Improvement of Xylose Utilisation for Bioprocesses
Ruohonen Laura, Technical Research Center of Finland, 393 130 €

Chemical Testing by Molecular Biological Methods
Virta Marko, University of Helsinki, 396 600 €

Design of Novel Non-halogenated Flame Retardants
Wilen Carl-Eric, Åbo Akademi, 394 320 €

Joint call of the Academy of Finland and the Agence Nationale de la Recherche (ANR) – June 2008

Carbon dioxide as a green carbon source in transition metal catalyzed syntheses
Matti Haukka, University of Joensuu, 370 300€

SUSE (Sustaining carbonic esters synthesis with carbon dioxide feedstock)
Riitta Keiski, University of Oulu, 171 900€
Jyri-Pekka Mikkola, Åbo Akademi University, 166 530€

PENTOVAL (Biotechnological production of pentanoic acids from sidestreams of biorefineries based on agrobiomass)
Merja Penttilä, Technical Research Center of Finland, 307 440€
Olli Pentikäinen, University of Joensuu, 64 160€

Joint call of the Academy of Finland and the Agence Nationale de la Recherche (ANR) – May 2009

Kristiina Mäkinen, University of Helsinki, (Plant viral particles as nanoscaffolds for controlled positioning of entzymes on solid supports), 248 590 €

Maija Tenkanen, University of Helsinki, (Valorisation of wheat residues to polymeric xylan and cellulose), 349 810 €

Joint call for proposals in the field of Green Chemistry Academy of Finland and Indian Department of Science and Technology, DST 2011

BUSU (Butanol from sustainable sources)
Tommi Aho, Tampere University of Technology, 201 310 €
Matti Karp, Tampere University of Technology, 312 820 €

Sustainable Catalytic Syntheses of Chemicals using Carbon Dioxide as Feedstoc
Riitta Keiski, University of Oulu, 323 930 €

Synthesis of furfural from renewable sources using acid modified Supported Ionic Liquid Catalysts (SILCA) – FUSILCA
Jyri-Pekka Mikkola, Åbo Akademi University, 336 800 €

One pot catalytic valorisation of biomass into fuels and chemicals in aqueous media
Dmitry Murzin, Åbo Akademi University, 196 640 €

Green methods towards pharmaceutically important heterocycles and cyclopentanoids
Petri Pihko, University of Jyväskylä, 239 350 €

Appendix 4. A summary of the KETJU programme lifespan and the coordination activities during the years 2003–2011

YEAR 2003

Preparation of the Research Programme on Sustainable Production and Products was mandated by the Board of the Academy of Finland in December.

YEAR 2004

Science Advisor (Natural Sciences and Engineering Research Unit) Jan Bäckman nominated to take charge of the preparation of the Programme.

The Preparatory Group (PG) was nominated. The group had a representatives from Natural Sciences and Engineering, Biosciences and Environment, and Health research councils. Representatives included also external experts.

YEAR 2005

Programme Manager Saila Seppo was nominated in July to take charge of the preparation and management of the Programme.

The Preparatory Group prepared the first draft of the programme memorandum delineating the goals and themes of the Programme. This draft served as a basis for negotiations with other funding bodies like Tekes (the (Finnish Funding Agency for Technology and Innovation), ministries, private foundations and foreign research funding organizations.

At the national level Tekes was consulted several times to study possibilities for joint funding, but none of their ongoing or beginning initiatives was possible to merge with the KETJU programme. However, the Ministry of Environment welcomed the request to join the KETJU programme as a funding partner, but later refused to fund the programme.

Negotiations with funding organizations within Europe were conducted, and these discussions led to closer contact with French, German and Swedish research funders.

In November the Board of the Academy made the official decision to start the research programme on Sustainable Production and Products. The total Academy allocation for the research grants was EUR 7,5 million.

The KETJU Steering Committee was nominated. The committee had six representatives from the Academy of Finland, and one from the Ministry of Environment. The committee was chaired by Professor Riitta Keiski (AKA), and vice-chaired by Juha Kämäri (AKA). One representative from Tekes was invited as external expert to strengthen the cooperation with Tekes and the scientific expertise, especially in the initial phase of the programme, when the objectives were set and the funding decisions made.

YEAR 2006

The call for proposals was announced in January. The call was national (Finnish) and it was organized in two stages (first letters of intent containing only the research plan, then full proposals). 55 letters of intent were submitted to the KETJU programme comprising 21 individual proposals and 34 consortia. On 9 March the Steering Committee selected 40 research plan proposals for the second stage.

The scientific evaluation panel was organized in Helsinki in June 12-13. The panel was chaired by Professor James Clark from the University of York.

The funding consensus was confirmed by the Steering Committee in October in Helsinki. Altogether 15 projects were approved for funding. Three of the funded projects were conducted by individual teams, 12 were consortiums.

The Academy of Finland continued negotiations with Centre National de la Recherche cientifique CNRS in France and with one German research funder. Unfortunately Academy of Finland couldn´t find funding for these calls, so they didn´t materialize.

YEAR 2007

The KETJU projects started in January.

Opening ceremony and seminar took place in Helsinki in January. The seminar programme introduced the programme in general and highlighted the keynote presentations by industry represantive and by French research partner. About 60 attendees participated in the opening ceremony. All research projects were presented shortly and later presentations were put on the web page of KETJU programme.

Since beginning of 2007 the programme manager visited projects of the programme. The aim of the visits was to hear the wishes and expectations of the Principal Investigators and the researchers towards the programme and to find out how their research has proceeded. The need for seminars and workshops was discussed. The teams did not wish any overwhelming activities, while the annual seminars and more targeted workshops were regarded important for the coherence of the programme.

The French National Research Agency ANR contacted the Academy of Finland in order to start co-operation and open a joint call in a field of KETJU-programme. The memorandum of understanding was prepared and signed and joint-call was opened in December. Academy of Finland allocated 1,2 million euros for this call.

A joint seminar "Chemistry for protection of global environment" with the French ANR-was held in September in Helsinki. The seminar attracted 35 finnish and french researches. The goals of the seminar was to initiate joint research proposals and to discuss about launching an international graduate school on the relevant topic.

All KETJU projects were asked to send an annual report of their work. The reports were put on KETJU web page (http://www.aka.fi/en-GB/A/Research-programmes/Ongoing/KETJU/Annual-Reports/).

Two KETJU projects were presented to press in special seminar, and Academy's paper Appropos introduced one KETJU project.

YEAR 2008

Joint call with the French ANR in the field of sustainable chemistry received ten proposals. Academy and ANR evaluated the applications separately. There was a little confusion about the instructions, which differed a little depending on the country. The programme manager and one steering group member travelled to ANR to decide on the proposals, which will be funded. The final decisions were made in July and three research topics were funded in Finland and in France.

Since the first call with ANR was successful, preparations for next bilateral call started in September. Also Tekes was contacted and asked if they would be interested in joining the call. Unfortunately the call was out of Tekes´s interest area.

A two day annual seminar was arranged in April and it attracted 80 KETJU researches. Keynote speakers were from the Finnish industry and the idea of this seminar was to network industry people with KETJU researches. Unfortunately we didn´t get any participants from the industry. Back to back with KETJU annual seminar Tekes´s Industrial Biotechnology programme SYNBIO started its own seminar and had invited KETJU researches to join.

A two day seminar "Power and Energy" was organized in Helsinki area in June jointly with two other Academy´s research programmes (Sustainable Energy and Power in Finland). At the seminar researchers from different fields discussed on topics like "is there enough of energy?", "who makes energy?" and "who decides on the energy?". The seminar was very interactive and received lot of positive feedback.

The steering group of KETJU programme discussed about opening a joint call with an African country. Since Finland and South Africa already had some existing collaboration in the field of sustainable production, we wanted to further strengthen that area. Unfortunately even after much work and many contacts to South Africa, we were not able to build co-operation, the process just didn´t proceed fast enough.

All KETJU projects were asked to send an annual report of their work. The reports were put on KETJU web page.

YEAR 2009

A bilateral call with themes green chemistry and agrobiomass valorization between Academy of Finland and French ANR was opened in January. Only two applications were received and they both were evaluated in France and in Finland. They received excellent grades and were granted funding in both countries.

KETJU programme arranged a two day annual seminar in February. Keynote speak "Transformational Forest Biorefineries: Opportunities and Challenges" was given by professor Arthur Ragauskas from the Georgia Institute of Technology, USA. KETJU researchers presented their work in parallel session under four titles: "Environmental issues", "Biorefinery", "Green chemistry" and "Green processes and methods".

Two "value-chain" seminars were arranged during the year together with three other Academy´s programmes. The idea was to connect researchers from complete different fields (Sustainable Energy, The Future of Work and Well-being, Finnish Companies and

the Challenges of Globalization and KETJU) and to give them the possibility to interact and learn from each others research.

India is one of the Academy´s priority countries for research co-operation. KETJU steering group saw, that it would be beneficial for the Finnish researches to work with the Indian researches in the field of green chemistry. Therefore negotiations started with the Indian department of science and technology (DST) and concluded with opening a joint research call in December.

All KETJU projects were asked to send an annual report of their work. The reports were put on KETJU web page.

YEAR 2010

Ten research proposals were submitted to the joint call with the Indian DST. The proposals were evaluated separately in both countries and at the end five applications were funded.

The final seminar of the programme was held in September. About 60 researches were present. Academy´s vice president, research opened the seminar and two keynote lectures were given, another about waste as a future feedstock and the other under title " from Academia to Industry: Molding of motivation and need". The other speakers represented Finnish Strategic Centre for Science, Technology, and Innovation, French research partner, and KETJU project leaders.

YEAR 2011

The steering group discussed and planned the evaluation process for KETJU programme.

Appendix 5. KETJU Research Programme Steering Groups and Steering Committees

STEERING GROUPS

Years 2005–2006

Chair:
Professor *Riitta Keiski*, Research Council for Natural Sciences and Engineering

Vice chair:
Professor *Juha Kämäri*, Research Council for Biosciences and Environment

Members:
Professor *Marja-Liisa Hänninen*, Research Council for Health
Counsellor of Agriculture *Leena Hömmö*, Research Council for Biosciences and Environment
Professor *Mikko Kara*, Research Council for Natural Sciences and Engineering
Technology Director *Markku Karlsson*, Academy of Finland´s board member
Development Manager *Auli Keskinen*, Ministry of the Environment

Expert members:
Chief Adviser *Raija Pikku-Pyhältö*, Tekes – the Finnish Funding Agency for Technology and Innovation

Years 2007–2009

Chair:
Research Professor *Johanna Buchert,* Research Council for Natural Sciences and Engineering

Vice chair:
Professor *Juha Kämäri*, Research Council for Biosciences and Environment

Members:
Counsellor of Agriculture *Leena Vestala (former Hömmö)*, Research Council for Biosciences and Environment (until March 2008)
Professor *Jaakko Kangasjärvi,* Research Council for Biosciences and Environment (from March 2008 on)
Professor *Riitta Keiski*, University of Oulu
Technology Director *Markku Karlsson*, UPM-Kymmene Ltd

Expert members:
Chief Adviser *Raija Pikku-Pyhältö*, Tekes – the Finnish Funding Agency for Technology and Innovation

Years 2010–2011

Chair:
Research Professor *Johanna Buchert,* Research Council for Natural Sciences and Engineering

Vice chair:
Professor *Jaakko Kangasjärvi,* Research Council for Biosciences and Environment

Members:
Professor *Reijo Lahti*, Research Council for Biosciences and Environment

Expert members:
Chief Adviser *Raija Pikku-Pyhältö*, Tekes – the Finnish Funding Agency for Technology and Innovation Professor *Riitta Keiski*, University of Oulu

SUB COMMITTEES

Year 2006

Chair:
Professor *Riitta Keiski*, Research Council for Natural Sciences and Engineering

Vice chair:
Professor *Juha Kämäri*, Research Council for Biosciences and Environment

Members:
Professor *Marja-Liisa Hänninen*, Research Council for Health
Technology Director *Markku Karlsson*, Academy of Finland´s board member

Years 2008–2009

Chair:
Professor *Jaakko Kangasjärvi*, Research Council for Biosciences and Environment

Vice chair:
Research Professor *Tuija Pulkkinen*, Research Council for Natural Sciences and Engineering

Member:
Professor *Pirjo Vainiontalo*, Research Council for Natural Sciences and Engineering

In 2006, the Academy of Finland launched the four-year Research Programme on Sustainable Production and Products (KETJU) for 2006–2010. The aim of the KETJU programme was to meet the major future challenges in basic research of chemical industries and process and production engineering. The programme placed significant emphasis on interdisciplinary research and international cooperation in the areas of industrial ecology, green chemistry and engineering, and chemicals in industrial production.

In 2012, the Academy of Finland appointed an international expert panel to evaluate the programme. The panel was asked to assess how the programme had succeeded in reaching its goals and to evaluate the programme as a whole, reflecting on, for example, the future applicability of research and its importance to end-users. This report includes the results of the evaluation and the recommendations of the panel.

ACADEMY OF FINLAND

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