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On the Cluster Approach to Environmental Research and Development
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Foreword

The Finnish cluster research programmes that started in 1997 were based on cooperation between producers and users of knowledge. These programmes form a set of public programmes that were organised under several different ministries.

In this presentation an overall picture is given of one of the cluster programmes, The Environmental Cluster Research Programme. This programme aims at raising the level of environmental know-how, improving the state of the environment and creating favourable preconditions for entrepreneurship. The cluster approach links goals of environmental policy and innovation policy closely together by creating a new knowledge base for both sectors and companies. It is also an example of a new type of co-operation in the field of environmental research.

About the authors, Antero Honkasalo has acted as the chairman of the steering group of the programme and Erkki Alasaarela as its scientific co-ordinator.
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Environmental protection has in various ways been connected to the development and advancement of technology and innovations. The development and application of technology has both caused environmental problems and made their prevention possible. However, today’s new technology is usually more environmentally friendly than its predecessors. Among others, the following items can be listed as reasons for this phenomenon:

1) The increasingly effective usage of material and energy
2) More accurate management and adjusting of processes, due to the development of information technology
3) Increase in knowledge about the environment
4) Taking into account environmental protection in all areas of company action

Simply, the effects of costs drive companies towards effective use of materials and energy. Still, many forms of material and energy flow directed towards the environment were earlier overlooked. The reason was they were not regarded as threats to the carrying capacity of the ecological systems, or because the harmful environmental impacts were regarded as relatively low in comparison with the benefits achieved.

Today, in the design of the production and products, environmental viewpoints get more consideration because of increasing knowledge both in the society and among engineers, regulations and pressure from the markets. New technological solutions are designed to make it easier to determine the possible environmental hazards and problems. At the same time, attention is paid to the environmental impacts during the life-span of the product. This is something new in engineering and will have long-term effects. In fact, the issue concerns the opening of the systems borders of engineering and diverse use of its methods. Simultaneously, sustainable development brings into consideration the needs of future generations in the designing of technology.

The advancement of environmental innovations has become an important goal. Obviously, people need new types of technological solutions and practical applications in order to achieve the objectives of sustainable development. Environmental questions are also rising in importance in international competitiveness.

Environmental technology can be divided into two types of products: environmental products and environmentally friendly products. The main purpose of the usage of environmental products, such as various end-of-pipe technologies and measuring instruments and services, is to decrease and control environmental impacts. Environmentally friendly products are all those products that represent a high standard of environmental protection. The latter can therefore include any field of technology.

The boundaries between environmental technology and other technology can be set quite easily when talking about environmental products. The line is less clear with environmentally friendly products. The problem is with how we define “high level of environmental protection”. Also, environmentally friendly technology may lose its importance when (due to development) such technology becomes a normal technological practice. This kind of environmental technology is also dependent on
the spatial and temporal aspects of its target of application. Technology in Finland that is no longer regarded as having high standards of environmental protection, may be regarded as such under conditions prevailing in developing countries.

Environmental impacts are also linked with strong social valuations, which affect the ways in which we understand what constitutes a significant environmental impact and what problems we should direct resources to and, also, what kind of technological solutions are socially acceptable.

More important, however, than focusing on the one-sided definitions of environmental technology, is recognizing that a special characteristic of environmental technology is its various and wide range of applications. Another special feature is the link between application and development of environmental technology to that of the implementation of environmental policy. Environmental policy and the implementation and enforcement of it opens new markets for environmental technology and advances the practical application of such technology.

The main aim of environmental policy is, of course, to decrease and prevent environmental hazards. In order for this to be possible, all the potentialities of technology must be applied to decrease emissions and waste and to save energy. Also, provisions must be made for innovations. This is especially important for companies because preventing environmental hazards by developing new technology is usually far more profitable than making changes in the already existing processes and instruments. The development and application of environmental technology also create new business opportunities for companies. In Finland, permit conditions are based on a level that can be reached by the best available technology (BAT) and, therefore, companies must meet common environmental requirements. This leads to a reduction of competitiveness distortions in companies within the same field.

On the other hand, it has been demonstrated that with the help of standards and regulations the development of already existing environmentally friendly processes and products can be effectively advanced, but that such types that are new and radically different from the contemporary technical solutions need other means. These are, first of all, such creative and flexible management practices that enable long-term development co-operation between companies and authorities and that lead to a learning process on both sides. The exchange of knowledge is also important. Added to this, ambitious goals need to be set, commitment is needed to fulfil them, and political and development actions need to be continuously followed (Kemp 2000).
Cluster approach in industry and technology policies

Industrial clusters have been a major focus of Finnish industry and the technology policy in the 1990s. The Ministry of Trade and Industry published its strategy for industrial policy in 1993. According to the strategy, the role of industrial policy is changing: control and subsidies are being replaced by long-term promotion of overall preconditions for the development of Finnish industry and enterprise for example, promotion of research and development, education, competition and well-functioning financial markets. In this context, the development of a national innovation system is thus crucial for industrial policy (Ministry of Trade and Industry 1993).

The strategy was accompanied by a cluster analysis which dispenses with the traditional industrial classification into branches, and instead focuses on manufacturing industries’ potential by aid of interwined and partly overlapping industrial development blocks, or corporate clusters. These clusters are networks of enterprises and other organisations with shared interests in which participants seek benefits from collaboration. Clustering helps companies to improve their operation potential and competitive capacity, and create new know-how and products through co-operation and synergistic relationships. The key agents in the clusters are the producers and users of the new knowledge and know-how produced—these are enterprises, the public and private service sectors, the authorities and research and educational organisations. The underlying foundation of clusters is a strategic network created through co-operation, where knowledge and expertise are developed effectively and combined in innovative ways. Thus, the cluster approach is better for studying and understanding the development of industry and its competitive capacity than is the traditional approach with a sector-based structure.

The main clusters of the Finnish industry have been forest, basic metals and energy clusters, which are capital and material intensive. During the 1990s, the telecommunication cluster developed extremely rapidly and it now plays a leading role among the exporting clusters. However, it is not only in the modern electronics industry, but also in material- and energy-intensive clusters that success seems to depend more and more on enterprises being able to apply information and communications technology in production.

Although Finland’s production structure has become diversified and the significance of the electronics industry will continue to increase, the traditional energy- and material-intensive sectors will also increase their output.

In its report Finland: A Knowledge-based Society, the Science and Technology Policy Council (1996) considers that one important future challenge is to develop co-operation between environmental policy and science and technology policy. Sustainable development and environmental protection have various effects on the operation of an innovation system. Innovation also creates new opportunities for promoting sustainable development.

In addition, the Eco-export Committee (Ministry of Trade and Industry 1995) analysed the state of the Finnish eco-business and environmental technology. Its conclusions were that Finland has good facilities for taking advantage of the opportunities that growing international environmental markets offer. However, networking and co-operation must be used to find solutions which help to implement environmental objectives in research and development work carried out by industry, in public technology programmes and more widely in the whole innovation system.
During the 1980s and 1990s, environmental know-how increased rapidly and environmental protection yielded good results in a number of sectors. Because the main Finnish industrial clusters have been material and energy intensive and thus have earlier caused severe local and regional pollution problems, the control of these industries’ emissions, discharges and environmental impacts has been one of the main concerns of the environmental administration. Emissions have primarily been controlled by means of environmental permitting and regulations. These environmental policy measures and voluntary action by business and industry have contributed to significantly reduced emissions and discharges and to a high level of environmental protection, especially as regards the following factors:

- sulphur dioxide emissions;
- discharges into waters from industry and communities;
- use of biomass for energy;
- efficient energy utilisation;
- efficient handling of hazardous waste;
- recovery of recycled paper; and
- environmental management.

Acidifying emissions and discharges, especially those containing sulphur, have decreased to a great extent in the 1980s and 1990s. Even at the beginning of the 1970s, increased production in the forest industry was accompanied by a corresponding increase in discharges to waters. Since then, however, discharges have continued to diminish, while production has continued to increase. Finland can boast the highest energy use of biomass in all European Union countries. In 2001, 31 percent of all electricity came from combined generation of electricity and heat (Statistics Finland 2002). Together with Sweden and Denmark, Finland was among the leading countries in the world as regards introduction of environmental management systems (the ISO 14001 standard).

The environmental permit system has particularly contributed to the introduction of the best available technology, and it has also promoted indirectly the rise of innovations (Hilden et al. 2002). Additionally, the environmental permit system has been developed so that the environment is considered as one entity, and this is taken into account in the permit conditions. These, again, are based on the level which can be achieved through use of the best available technology.

Bearing in mind the environmental policy instruments now in use, as well as the approved plans and programmes, the main future challenges lie in mastering the climate change, diminishing the volume of waste, and curbing the risks ensuing from the increased use of dangerous substances.
Eco-business

According to Statistics Finland (Saarnilehto 2000), the environmental business sector is well developed. In 1998 it was on a par with the basic metal industry (3.5 million euros). At least half of the production was exported, and much business was done abroad, too. The industry’s impact on employment amounted to approximately 24 000 person years in 1998. Environmental business is seen as one of the new developing clusters in the Finnish economy (Hernesniemi et al. 1995).

The specialised branches of the environment industry accounted for 38 percent of the studied total turnover of the environment industry’s core areas. Approximately one-half (53%) of the total turnover was generated by the environmental business activities of enterprises within other industries, and especially the environmental business activities dispersed within the manufacturing industry. However, as providers of jobs, the specialised branches of the environment industry were almost as important as the environmental business activities within other industries. Two-thirds of the enterprises practising environmental business activity outside the specialised branches of the environment industry expected the markets to expand in the next two years.

In environmental technology export, those sectors that can demonstrate considerable domestic reductions in emissions and discharges have an advantage. Thus, our national environmental policy has created new opportunities not only for solving environmental problems but also for environmental business.

Environmental business exports can be broken down as follows:

- renewable energy and energy savings (37%);
- curbing air pollution (19.8%);
- wastewater management, raw water purification and water distribution (18.2%);
- recycling and waste management (23.3%).

In all these fields, Finland can offer high-level environmental technology, products and expert services, including research. However, the know-how is largely concentrated on cleaning technology and process changes. Only a few products can claim to be successful because of their environmental characteristics. One important example is low-emission traffic fuels.
Cluster research programmes

In Finland, a systematic effort has been made for a number of years to build a national innovation system based on co-operation between producers and users of knowledge (Ministry of Trade and Industry 1997; Science and Technology Policy Council 2003). The public sector has had an important role in the Finnish innovation system, that is, to give support to the co-operation between enterprises and research experts, and the further development of this role is crucial to the Finnish innovation policy (Hämäläinen and Schienstock 2000).

The cluster programmes started in 1997 are an example of this development work. These programmes form a set of public programmes that were organised under several different ministries.

The cluster programmes consisted of research and development projects undertaken collaboratively across political sectors in an effort to integrate the objectives of research, technology and employment policies with sectoral policies, including research and development projects conducted within companies and in the public and private service sector. In the beginning, eight programmes were scheduled for the period 1997-1999 under five ministries. While the overall aim was to support R&D which strengthens industrial clusters, the areas that were chosen appear to be those where the maximum potential for public-private leverage exits rather than the maximum industrial activity (Prihti et al. 2000).

One important goal of the programmes was to break down barriers that hindered industry from benefitting from the knowledge and visions that authorities had in their fields of expertise; thereby, enabling industry to tap new sources of innovation. Co-operative projects were also important for consolidating contacts between researchers and the clients of research institutes and for promoting co-operation between the public providers of funding.

The cluster programmes were launched in the transport, forestry, foodstuff, welfare and environmental sectors. In addition, a working-life development programme and a networking programme for small and medium-sized enterprises (SMEs) have been established. Most of the programmes rely significantly on modern information technology.

The programmes were quite diverse, ranging from fundamental research through applied research to product development and promotion of technology diffusion. A similar variety exists in their size and structure. The programmes incorporated more than 300 projects during 1997-1999, and the projects were implemented by over 400 organisations. More than 23 million euros have been invested in the programmes.

To encourage co-operation and mutual adjustments between the cluster programmes, their coordinators have regularly met under the chairmanship of a representative of the Science and Technology Council. Some joint projects have also been launched, and seminars and workshops have been arranged.
The Environmental Cluster programme

The goal of the Environmental Cluster Research Programme is to enhance eco-efficiency, thereby improving the state of the environment, and to promote innovation. The programme also aims to create new opportunities in environmental entrepreneurship. In accordance with the cluster approach, a further objective is to promote co-operation between researchers, the business sector, public authorities and funding organizations in order to integrate environmental issues even more closely into the Finnish system of innovation (Honkasalo 2000).

6.1 The First Phase (1997-1999)

The following topics were covered by the first phase of the environmental cluster research programme (1997-1999):

- Material flows and life-cycle assessment
- Eco-efficiency in production processes and products
- Environmentally friendly infrastructure
- Management of environmental knowledge and information
- Promotion of environmental business, eco-exports and marketing
- Evaluation of environmental policy

The programme also included projects on climate change policies.

The Finnish Ministry of the Environment was responsible for the administration of the programme. Certain aspects of implementation and funding were also undertaken by the Ministry of Trade and Industry, the Ministry of Agriculture and Forestry, the Ministry of Labour, TEKES (National Technology Agency of Finland) and the Academy of Finland. Funding of the first phase of the programme totalled 14 million euros. The research units themselves, industry and other financial institutions than the ministries contributed approximately half of the total amount.

The initial call for applications was arranged in 1997. In 1998, three extra-targeted calls for applications were made by the Academy of Finland (“Material flows and re-use of materials”), by TEKES (“Environmental know-how and transformation of product ideas into profitable business”), and by the Ministry of Trade and Industry (“Possibilities to develop the Environmental Cluster”).

Funding proposals for individual projects were made by the steering group of the programme, which consisted of representatives of the financing organisations, the Ministry of Transport and Communications and federations of industries. The funding decisions were made in accordance with the formal procedure of each financing organisation.

About 400 applications were received in the first phase of the programme, of which 60 were allocated funding. Major Finnish environmental research institutes, including 180 research units and 70 enterprises, participated in the first phase of the programme.

The extended abstracts of the projects have been published (Inkeröinen 2001).
6.1.1 Eco-efficiency

Eco-efficiency is a key concept of the environmental cluster programme. This concept refers to the development of production and consumption so that the use of natural resources is as economic and ecological as possible, and emissions and discharges continue to be reduced (BCSD 1993). This means that eco-efficiency thinking couples environmental protection with technical and economic efficiency and with input-output thinking. At the same time, the emphasis is transferred from discharges and waste to sparing use of natural resources and energy, and to decreasing and preventing environmental damage throughout the life cycle of products (OECD 1988).

In Finland, the eco-efficiency work committee, appointed by the Ministry of Trade and Industry, in its spring 1998 report described the implementation of eco-efficiency thinking in environmental policy. The committee acknowledged that present trends of sustainable development are generally pointing in the right direction, although, despite the good results attained in many sectors, implementation is still far from reaching the long-term objectives (Ministry of Trade and Industry 1998).

The eco-efficiency concept has more recently been supplemented with the decoupling and factor concepts. Decoupling refers to a development where the relation between production and emissions or consumption of materials and energy is growing (EEA 2002, OECD 2002). When this relation is closely monitored, it provides an illustrative way of studying which direction eco-efficiency is going. If emissions and discharges continue growing, but slower than the increase in production, this is called relative decoupling; if emissions and discharges go down, the decoupling is absolute.

Decoupling ties together the economic and ecological dimensions of sustainable development, as emissions and discharges, as well as other environmental damage, are seen in relation to the increase in the economy and in production. This means that decoupling does not jeopardise economic growth, but instead it indicates the margin conditions for growth. The level of decoupling sought for different emissions, discharges, and substances will vary.

The factor concept, again, is used to indicate a goal level for long-range eco-efficiency goals. In 15-20 years we should achieve an efficiency in the use of natural resources which is four times the present one; in 40-50 years, use efficiency should be ten times greater. These goal levels are called factor 4 and factor 10. They summarise the order of magnitude to be aimed at in improved eco-efficiency for sustainable development to become possible, and for the continuation of economic growth without depleting natural resources to an extent which severely restricts their use. This means that the factor goals should not be seen as absolute limit values. But, since the aims for sustainable development are expressed in a very general manner and rarely quantified, it is important to be able to compare, at least at the level of factor goals, the present situation in relation to the goal levels (Schmidt-Bleek 2000).

There is also reason to stress that eco-efficiency, the factor goals and decoupling illustrate performance capacity with regard to environmental protection. These concepts do not only refer to the state of the environment, but they also reflect the state of the interaction between society and nature. This means that they are dynamic concepts, and in addition to production and the environment they also comprehend the time dimension. This is important insofar as in environmental protection, goals are often connected with the state of the environment, which easily gives the idea that some kind of static goals should be attained. Nevertheless, in the formulation of the desired state of the environment, the goals are set for two dynamic and continuously changing systems, that is, the ecosystem and society.

The management of material flows and life-cycle thinking are special tools that can be used to promote eco-efficiency. They are also central aspects of the first phase of the cluster programme.
Life-cycle projects have been implemented in the following sectors:

- agriculture,
- forest industry,
- basic metal industry,
- electrical and electronic industries,
- construction,
- stone quarrying and processing industries,
- water supply.

These sector-based life-cycle assessments were produced in co-operation with industries.

For example, according to the life-cycle study of agricultural production, it was found that harmful environmental impacts are lower in organic milk production than in conventional production. As for rye bread, organic production is better compared to the conventional production when impacts are expressed per hectare. When impacts are expressed per kilogram of rye bread produced, organic production may cause even more adverse environmental effects than conventional production. The results of a consumer preference survey show that the Finnish consumer values domestic foodstuffs above all, but the production method and environmental impacts of production are also important (Grönroos and Seppälä et al. 2001).

Under the project “Eco-efficient Finland”, statistics on the total material management (TRM) of Finland have been compiled for the first time. The results show that from 1970 to 1999, the total material requirement of Finland increased one and one-half fold, from 300 million tonnes to over 500 million tonnes. The only decreases were recorded after the first oil crisis of the mid-1970s and during the deep economic recession in the Finnish economy in the early 1990s.

In the early 1970s the material intensity of the Finnish economy declined sharply, but the trend has slowed down noticeably since then. At the same time, the impact of the Finnish economy on the material requirements of other countries has been growing strongly. In three decades, the direct impacts from imports almost doubled and the hidden flows (the materials that are transferred and converted, but do not enter the production process as a direct input) from imports more than trebled. In the 1990s over one-half of total material requirements went to producing export goods, and were thereby eventually directed to consumption abroad (Mäenpää et al. 2000, Statistics Finland 2002).

The environmental cluster programme also funded and initiated a book on eco-efficiency (Rissa 2001). This book gives an overall view of the eco-efficiency approach and uses as examples the results of cluster projects and industrial case studies. Its main aim is to introduce the results of the environmental cluster programme to a wider audience.

### 6.1.2 Integrated control of emissions and environmental impacts

The aim of these programme projects was to develop methods for an integrated assessment and control of environmental and economic effects of emissions, and of energy and resource use at the plant level in the context of environmental permitting. The focus was on a holistic and integrated approach in accordance with the Integrated Pollution Prevention and Control Directive (IPPC directive) of the European Union. The projects produced practical approaches, methods and tools for permit authorities and plant operators in their pursuit of reliable options in the integrated permit process (Silvo et al. 2002).

Another goal was to make it easier for operators to predict the authorities’ requirements and thus enable them to find the most effective methods in pollution
prevention and control. In this light, permitting is seen as an open and dynamic process between installations, authorities and stakeholders. The outcome of the process should encourage all parties to promote innovations and adopt new ways to tackle environmental problems brought forward by research.

Substantial supporting activities have been established with cluster funding in order to strengthen and enhance the application of the best available technology (BAT) principle in permitting. National industry branch groups have been set up for major BAT reference document (BREF) categories of the European Union in order to improve the use of these documents and to give the Finnish comments and contribution to the EU work. Half of the members of the branch groups are representatives of permitting and enforcement authorities, the other half consists of experts of companies.

National BAT reports and documents were prepared by the branch organisations for: monitoring of emissions, the pulp and paper industry, production of copper, nickel, zinc and ferrochromium, tanneries, intensive livestock farming, wastewater and waste gas treatment, management systems in the chemical sector, and large combustion plants. The reports cover the main Finnish industrial clusters and other branches of industry that have significant environmental impacts. Half of the cost of the national BAT studies was covered by cluster funding and half by industry.

More than 100 environmental experts of industry have been involved in these activities.

Experiences of this kind of new co-operation between authorities and industry have been encouraging. Within the BAT network, permitting and enforcement authorities together with researchers have had an opportunity to discuss BAT issues with industry on the sector level. Earlier, discussions in Finland mainly took place at the level of individual installations. The new forum has provided all parties with an opportunity for deeper understanding of the application of the best available technology and also of emerging new possibilities that the development of technology can offer for reducing emissions.

6.1.3 Product policies and innovations

In international environmental policies the focus is shifting away from emission limits during the production phase to concern for the hazardous impacts of emissions throughout a product’s life cycle. Although many countries have been able to effectively reduce their industrial emissions, the use and disposal of various products appear to cause greater environmental problems than does their manufacturing. One reason is also the globalisation of the world economy and the effects it has on environmental policies. Global raw material sources, primary production and the assembly of mass products are increasingly located in the developing countries. This means that life-cycle thinking extends the assessment and curbing of environmental damage across economic boundaries. The social responsibility of business and industry for the environmental effects of their activities is highlighted with increased environmental awareness and dissemination of information. Multinational companies now encounter increasing demands for responsibility towards the developing countries. On the other hand, because of business networking, both internationally and nationally, it is often difficult to assign responsibility. The global markets bring pressures for unified regulations, standards and codes of behaviour (Ministry of Trade and Industry 2001).

The need for an overriding product policy is also enhanced by problems related to consumption patterns and ways of life. The continued increase in consumption has become an increasingly important environmental policy issue, which can no longer be set aside when the marginal conditions for sustainable development are defined.
Product policy has much in common with eco-efficiency thinking, for example, life-cycle assessments and market orientation. However, it is more clearly an environmental policy, in which the role of government and of various policy instruments is inevitably underlined. These concepts should not be developed separately from each other; instead, it is important to find ways in which eco-efficiency thinking and its targets can be considered when a product-related environmental policy is developed (Honkasalo 2001).

The Environmental Cluster Research Programme is aimed at providing a solid knowledge base for Finnish product policies. The programme includes, as mentioned above, life-cycle assessments in different sectors of production, and studies on the best available technologies and material flows. The activities will allow us to assess the eco-efficiency potential of different production sectors. Thus, the resulting knowledge base will enable enterprises to focus their product development and authorities to outline environmental policies in such ways that the policies will both support high-level environmental protection and enhance the competitiveness of companies and the national economy.

A study of cluster programme which deals with environmental-related product development consists of five case studies from Finnish industry. In the product development of the case study companies, environmental issues appear to have grown in importance in recent years. Environmental concerns have been integrated, in one way or another, into product development processes. The pressures to incorporate environmental issues into product development have come from customers or through the anticipation or implementation of extended producer responsibility systems and recognition of the environmental advantages in marketing (Kautto et al. 2001).

Another study of cluster programme evaluates product-related environmental management practices in Finnish companies producing electrical and electronic appliances (Kärnä 1999). It analyses challenges and obstacles to environmental improvement of appliances in the market from a product chain perspective. The study argues that, currently, obstacles to environmental improvement of products are more organizational than technical. Key future challenges include improving environmental communication and co-ordination between product chain actors.

**6.1.4 Development of networks for environmental business**

An important feature of the environmental cluster programme is the emphasis on the networking between researchers, funding organisations and the users of research findings. The programme also includes projects that encourage co-operation between enterprises who utilise the natural environment for eco-business and those who seek optimal operation strategies for networking companies specialising in environmental technologies.

For nature-based entrepreneurship the most important further measure was the establishment of an organisation as a centre for environmental entrepreneurship. The aim is an extensive multi-field collaborative organisation that will gain advantages through interaction, effective combining of resources, planning of activities, faster communication of information and the creation of networks between entrepreneurs and researchers. By means of its own data-bank and information network the widely dispersed field could be connected, its image and visibility enhanced, barriers overcome, innovative activities promoted and educational programmes tailored for critical fields (Luostarinen et al. 2002).

In two projects, new market places for environmental products have been created. The first, Ecoport (www.ekoportti.fi), contains free services, citizens’ actions, news, discussion, company descriptions and commerce in organic, biodynamic and ecological products. The second one, Rakennusluuppi (www.rakennusluuppi.fi), is a market place for secondary building materials. However, the use of these websites
has not been wide. It is clear that more emphasis should be based on implementation of these market places.

A study on the impact of the eastward enlargement of the European Union and the EU’s Northern Dimension policy on the environmental business sector was carried out, too. It analyses the demand for eco-industry and for investments in environmental protection in the EU’s applicant countries and in Russia and financing possibilities (Kinnunen 2001).

### 6.1.5 Evaluation of environmental policy instruments

To be able to develop our environmental policy further, we should have a reliable view of the efficacy of the existing instruments, their impacts on the development of environmentally sound technologies and the possible side-effects of their application. This would help us to plan our future environmental policies so as to support the introduction of new environmental technologies and to encourage companies to be innovative in this respect (Loikkanen et al. 1999).

The main result of the evaluation study of the Finnish environmental permit systems in the forest and chemical industries was that it is hard to show that permit conditions have had direct impacts on innovations. However, they have contributed to the distribution of end-of-pipe-technology and to innovations that aim at expanding the market for environmentally better technological solutions. The permit systems have also indirectly contributed to innovations by creating a demand for environmental experts and environmental education. Networks of experts have developed as a consequence of and in response to regulatory instruments (Hilden et al. 2002).

According to the evaluation study of the waste policy, the waste management infrastructure and the recovery of wastes have greatly improved in Finland in the 1990s. In contrast, under the waste policy, waste prevention has not improved, which is the primary objective in the hierarchy defined by the Finnish and EU waste legislation. Thus, new initiatives are needed in waste policy because the amount of waste is still growing. Simultaneously, the scope of policy should be drastically broadened from waste alone to society’s overall cycles of materials and products and to the policy instruments that can influence the whole life span of products (Kautto et al. 2001).

### 6.2 The Second Phase (2000-2002)

The second phase of the environmental cluster programme started in 2000. The following pilot studies were launched to elaborate the plans for further research:

1. *Infrastructure in a sustainable community (EKOINFRA)* (Suunnittelukeskus 1999)
2. *Information society and sustainable development (KESTY)* (Kahilainen 2000)
3. *Environmental effects of hormone-like substances; the need for national research (Nurmi 2000)*

Based on these studies, the second phase focused on numbers 1 and 2 above. The need for further studies on eco-efficiency was also recognised. The third item was considered to be too much outside the scope of the programme that it was left out. However, the pilot research report (Nurmi 2000) naturally can serve other research programmes and activities.
6.2.1 Infrastructure in a sustainable community

The EKOINFRA research programme deals mainly with infrastructure in urban conglomerations. Dispersed settlements are discussed insofar as they either are located on the fringes of urban regions or are surrounded by an urban conglomeration. Natural environments are not included, although green urban environments are.

The themes covered include urban ecology, land use and community infrastructure. This part of the overall research programme worked on environmentally beneficial action models and techniques in communities.

The EKOINFRA programme focused on topical issues such as:

- how to handle entire infrastructure systems
- how to promote and develop co-operation between different sectors
- how to improve the maintenance and care of the infrastructure
- how to make infrastructure more economical without giving up on environmental quality and ecological considerations
- what are the pressing current changes (internal migrations)
- how to make investments and solutions socially and ecologically sustainable

Another main issue was the study of the implementation of legislation and the identification of possible needs for amending environmental legislation. Altogether 41 projects were financed under the EKOINFRA programme. These were divided into six thematic areas, namely:

- The integration of different parts of infrastructure building; future administration models and new praxes
- Future living environments
- Urban ecology
- Combating and repairing environmental damage
- Environmentally beneficial community infrastructure
- Environmentally beneficial traffic and community structure

The first thematic area discusses the integration of various parts of community infrastructure and outlines future administration models and new praxes. Co-operation between environmental actors and sector authorities is often a prerequisite for the creation and use of innovative methods and technologies. Research topics in this field included co-operation between urban regions in land use planning, administrative models for street maintenance, land use planning methods in areas of population loss, the importance of participation and interaction in integrating planning, and using area forums as an instrument in the development of residential areas.

The outlining of the theme “future living environments” was based on the foreseeable strong growth of urban areas in the next few years. The frame of reference for future urban living has, so far, not really been considered in depth: What will future generations expect from their living environment? The Finnish tradition of one-family houses on fairly large plots needs to be supplemented with new forms of housing, where the advantages of individual housing units and the economy of joint infrastructure are combined. Residents’ values and needs should be taken into account when looking for new types of individual housing or small-scale blocks of flats. Under this heading, research was centred on small-scale housing areas with particular attention paid to the views of the residents. Additionally, criteria describing the prerequisites for housing and hard furnishing, the environment, services and infrastructure to make it possible for elderly people to live at home longer were studied.
There is little previous research in Finland on urban ecology, and the few studies are mainly theoretical. The demand for a tighter community structure means less recreational and free areas within the urban agglomeration. Further research is needed on how much and what type of areas in their natural state should be part of the urban structure, and on what an ecological community structure and urban structure means. One issue studied here is the ecological networks in towns of different types, and the relationships between these and the community structure, the urban ecology and the network of green areas. Another main issue deals with trees in an urban environment, with the focus on better management.

With regard to combating and repairing environmental damage, the challenge lies in restoring a polluted or damaged environment, and especially in forestalling environmental damage. Topics studied included restoration of brownfield sites (new uses of industrial areas), reducing emissions and street dust, investigating damage caused by vibrations, and the rebuilding of environmentally damaged areas for residential and recreational use.

A main issue in building an environmentally beneficial infrastructure was the drainage of built-up areas, both as regards existing settlements and with regard to new building. The problems are not only technical but also organisational, economic and legal. Consequently, urban hydrology and the drainage and rainwater in built-up areas form an important research area. Other themes include easily managed roads, the distribution of tasks between landowners and local authorities in road management, and the use of industrial by-products and demolition waste in landscaping.

As regards environmentally beneficial traffic and infrastructure, already existing information was utilised to find means for improving infrastructure and traffic systems in urban regions so as to minimise detrimental impacts on climate and air quality and decrease noise. Public transport and light traffic are the main means for reducing environmentally negative effects of traffic.

Some of the projects under the above themes were development or pilot construction projects. They may have been geographically restricted to a residential area or the streets in a certain locality, or broader, encompassing an entire urban region. The pilot projects were divided into 1) pilot studies for monitoring and assessing already built areas; 2) planning pilot projects based on topical research data and the utilisation thereof; and 3) pilot construction projects for testing and developing new ways of action, methods and technology. Ten of the EKOINFRA projects may be classified as pilot projects.

6.2.2 Information society and sustainable development

The subprogramme on sustainable development and the information society was considered important, because, so far, the main impact of the emerging information society on environmental protection has been the need to recycle and re-use electronic waste. In producing and distributing environmental information, electronic media has become increasingly important. Companies have built up their own environmental data systems, and the environmental administration has developed its own electronic environmental load and control system. The modern information and communications technology, however, provides many other interesting opportunities to promote sustainable development.

The following trends in the development and application of information and communication technology are clearly related to environmental protection (Honkasalo 2001):

1) More efficient treatment of information
Information can be transmitted and handled with much less use of materials and energy. Electronic data processing and storage make it possible to curb paper consumption.

2) Developing steering systems for processes, transports and products
Systems development reduces materials and energy consumption and makes it possible to combat emissions and discharges better. The development of remote control systems enables the manufacturer to use intelligent products and optimise their control. Intelligent products and processes are self-regulating and signal when they need service or when disturbances occur.

3) Transfer of information instead of transport of products, services and people
All the products and services which can be converted to information can, at least in principle, be sent to the client electronically. Virtual schools, teleworking and video conferencing make it possible to curb the need to travel.

4) Electronic trade
Electronic trade will change commercial distribution systems. From an environmental viewpoint this development holds both threats and opportunities. In the worst case, transport and packaging might even increase.

5) Networking
Networking creates new connections, new forms of cooperation, and a basis for innovations. Environmental protection is exceptionally interdisciplinary, and this requires efficient networking and new methods and forms of communication.

6) More efficient information processing and transmission
The Internet and the new networking techniques offer new opportunities so that environmental information can be disseminated throughout the production chain in a form suitable for each recipient.

7) The product as information
The development of information technology will change thought patterns: the product will be seen as objectified information, or just information, instead of as an object. As with eco-efficiency, this directs attention to the service function. However, the connection with the environmental load is not equally clear, and this may easily be overlooked.

Forecasting the extent that the rise of the information society and the potential of computer technology will contribute to reducing materials consumption is difficult. However, many individual products in the information and communicatio sector, for example, base stations for mobile phones (Pesonen 2000) have shown a remarkable increase in eco-efficiency. New base stations are produced with only a fraction of the materials needed for older stations. Services, that is, phone calls, can thus be delivered using considerably fewer national resources.

Heiskanen et al. (2001) summarise their findings on the dematerialization potential of ICT and services as follows:

- Services and ICT do not automatically lead to significant absolute dematerialization.
- ICT and services have three roles in dematerialization: (1) process efficiency, (2) the efficiency of the value chain, and (3) providing an outlet for new consumption activities.
- Services and ICT are necessary, but not sufficient, condition for combining a significant reduction in natural resource use with economic growth.
The future of dematerialization cannot be predicted, but it can be influenced by integrating environmental concerns into early stages in service and technology development.

Eco-efficiency may be an important consideration for some influential actors, but it may not be a sufficient argument to engage all stakeholders. Other meanings and targets, alongside efficiency, need to be developed for resource-conserving solutions. This is a challenge for the social marketing of dematerialization, and of the innovations that are intended to advance it.

The above makes it clear that more information on and an overall view of the direct and indirect effects of information technology on environmental protection are needed. In Finland, it would be especially important for both the environmental and telecommunications clusters if we could also succeed in producing innovations that combine a high level of environmental protection with a high level of ICT expertise.

Before the subprogramme on sustainable development and the information society was started, there was an investigation of related topics and what needed to be researched. The conclusions of the preliminary investigation were as follows (Kahilainen 2000):

- There is a definite need for new research on the links between the information society and sustainable development.
- The core areas of the development of a sustainable information society have already been studied in many places, although the research is not often recognised as such.
- At present, sustainable development and the information society are being promoted both in Finland and elsewhere in the world, but there is a lack of communication.
- Information technology is a natural connecting centre and holds tremendous potential.
- A key issue related to a sustainable information society is immaterialisation.
- The promotion of a sustainable information society is clearly a common project for all actors, and values play a significant role.

The preliminary investigation introduced the concepts of dematerialisation and immaterialisation. The former describes materials savings in production, the latter, replacing material products with immaterial services in consumption (Kahilainen 2000).

In production, dematerialisation continues to progress because in order to save costs, processes are monitored more accurately to save materials and energy. Again, in the field of consumption and lifestyle there are no mechanisms which directly couple environmental considerations and applied information technology or, at least, such couplings are still being developed. Nevertheless, in consumption, the potential savings in materials may even be larger, since in many cases the issue might be actual immaterialisation.

The theme of the environmental cluster research on sustainable development and the information society, for the above-mentioned reasons, is immaterialisation. The Finnish ICT industry has supported the approach taken. From the ICT industry’s point of view, the interface between the products and the society is interesting and important, especially the relationship between people’s way of life, consumer habits and ICT products. A special feature of some ICT products is that consumer habits not only affect the product development, but consumer behaviour can shape and develop the product itself. The Linux operating system is a well-known example of this, but the same principal could be applied to other products, too.

The programme, with a view to sustainable development and the information society, includes projects on: teleworking, goods transports, products culture, agriculture, daily goods trade, Internet-based markets for environmentally sound products and secondary materials, virtual education, youth culture, praxes in daily
life and ICT, environmental awareness and public participation, and environmental evaluation of ICT research. Internet-based markets for environmentally sound products and secondary building materials were already included in the first phase of the cluster programme. Most of these research projects are expected to be completed in year 2003.

6.3 The Third Phase (2003-2005)

The last few years have seen the appearance of a number of environmental policy programmes and programmes for sustainable development. The European Union, the Organisation for Economic Co-operation and Development (OECD), the United Nations Environment Programme (UNEP) and the Nordic countries have been particularly active programme makers. To some extent this drafting of programmes is a response to the necessity of meeting new challenges in a new environment, but we may rest assured that environmental protection itself is also changing. In any case, we can now distinguish a new stage of programme work, which actually reflects both of these trends.

A common characteristic of the trends described is that environmental protection is more closely coupled with the economy. This comes out very clearly in environmental policy documents dealing with production and consumption. The concepts of eco-efficiency, decoupling and product policy highlight the importance of markets and put environmental protection in relation to economic factors and indicators. The same trend comes out in the fact that political programmes tend to place more importance on economic instruments, although in the use of such instruments, progress has been slow. On the other hand, environmental policy is, in the same way as other policy sectors, affected by a certain inertia and an inclination to follow the familiar lines of thinking and acting. However, it is obvious that the dynamic programme-drafting activities as such already indicate a need and a will to renew political thinking.

The weight given to the ecological, economic and social dimensions of sustainable development, seems to be changing. From the outset, environmental policies have been characterised by a strong emphasis on the ecological dimensions and, correspondingly, the links to natural sciences and engineering sciences. As far as economic sciences enter the scene, the emphasis has long been almost exclusively on environmental taxes and charges, on determining the costs for environmental damages, and on cost-benefit analyses relating to environmental policy actions. So far, the social dimension has been the least developed one. Now, there is a stronger stress on the social sciences, but in the development of new instruments, it has only come out in environmental management, improved consumer awareness, and environmental education.

In this connection it must be stated that environmental problems cannot be defined solely on the basis of the natural sciences. Problem definition and identification are always results of social processes. Nevertheless, it still remains unclear to what extent the preponderance of natural and engineering sciences will prevail in the formulation of environmental policy instruments.

A main problem is also that the ecological, economic and social dimensions of sustainable development have been treated separately in political decision-making. The result is that decisions in one sector, however justified and thoroughly worked out, may lead to unforeseen harmful consequences in some other sector (OECD 2001).

6.3.1 Eco-efficient society

In order to be able to meet above mentioned challenges, “An eco-efficient society” was chosen as the overall theme of the third phase of the environmental cluster.
programme. The third phase continues the main ideas and goals of the programme, but, at the same time, expands it towards the social pillar of sustainable development.

A preliminary study was carried out in order to plan the third phase of the programme (Heinonen et al. 2002). According to this study, sustainable use and the conservation of natural resources, a well-functioning societal infrastructure, and ecologically sensitive consumption and production all contribute to an eco-efficient society. Ecosystem services provided by ecosystem processes play a key role not only in supporting the functions of natural systems, but also in the functioning of socio-economic systems. Different urban forms create diverse living environments. The trends in consumption and production impact on the development of the built environment, land-use planning and the societal infrastructure. In order to develop an integrated approach for research activities, a holistic framework should be created that will outline the characteristics of an eco-efficient society and the interactions between natural and socio-economic systems, and that will identify the key cause and effect relationships.

Planning of the third stage of the environment cluster research programme was based on this preliminary study, previous experiences and on the report of the evaluation group. It also took account of discussions during the last decade pertaining to a national innovation system. Additionally, use was made of the impact assessments for projects during the first programme period. The aim is to render the theme eco-efficiency deeper, broader and more varied, so that, in addition to the ecological and economic dimensions of sustainable development, it also encompasses the social dimension. At the same time, the programme was geared to the most important and topical environmental problems.

Life-cycle thinking was divided into three parts, namely:

1) **Nature and natural resources;**

This comprises biological and geological diversity, the functioning of ecosystems, landscape management, outdoor recreation, resource-saving uses, and the transport and accumulation of harmful substances in the environment.

2) **Society and living environments;**

Here, the theme includes housing, improving the quality of communities and the built environment by means of integrating structures, creating prerequisites for a sound and welfare-promoting living environment, and promoting ecological and sound building.

3) **Production and consumption**

The heading covers eco-efficient production and consumer behaviour, lifestyles and social sustainability.

The environmental problems which have priority are:

- Mastering the climate change;
- Preventing waste generation and promoting waste recovery;
- Promoting a sound and healthy living environment; and
- Preserving biological diversity.

With regard to environmental policy, the list was supplemented with:

- Instruments and their impact; and
- Foreseeing environmental technology development.
All the priority areas have one characteristic in common: the means presently in use for achieving policy goals are insufficient, which means that new information is needed both to work on environmental policy and to create innovations and new approaches. The problems are also characterised by the fact that disadvantages cannot be taken away or prevented solely by addressing individual items or sources, but overarching programmes are needed so as to improve eco-efficiency, influence the use of natural resources and energy, safeguard natural systems, and cover all sectors in society.

Mastering the climate change is an area of research which contributes to a better understanding of the greenhouse phenomenon and its consequences. Research is also needed on the social structures and on the behaviour of organisations and consumers in relation to the ways and means of abating the climate change, as well as on adaptation to the climate change.

In waste research, the focus lies on prevention of waste generation.

Policy instruments and environmental technology are closely connected with other priority areas. The use of instruments rests on the social acceptability of environmental policies and on the functioning of natural ecosystems, taking into account the impacts on the environment, ways of life, health, social functioning, economy, employment, income distribution and public participation.

The eco-efficient society programme will be implemented in cooperation and with division of tasks between financiers. In all priority areas, both national and international research is being pursued, and this has been taken into account in planning the programme. In the priority areas now selected, different financiers have recently concluded or are already taking part in ongoing research programmes.

The themes under the eco-efficient society programme may be included into other programmes, and themes under other programmes may also be included in this programme. However, whenever this takes place it is important to clarify what added value is achieved, both for the programmes themselves and for the administration.

A seminar for researchers was organised to present the approaches used in the pilot studies. This was to provide them with a chance to comment on the pilot studies before they were finalised and to discuss the entire research programme and research needs. At the seminar itself, researchers volunteered to try out new types of research cooperation. Their ideas were incorporated into the pilot studies, together with the results of numerous interviews with contact groups.

Applications for the third stage were invited on 17 December 2002. Projects fell into two groups: Pilot studies for the planning and organisation of comprehensive cooperation projects (A); and actual research funding applications (B).

All in all 257 applications were received, which were assessed by awarding points. The members of the steering group and their experts took part in the assessment.

In group A, 6 plans for pre-financing pilot studies for comprehensive studies were approved. From group B, 50 applications were selected, and the applicants were asked for more detailed research plans. Another 50 projects were referred for assessment and possible financing to the National Technology Agency (TEKES). Moreover, three projects were recommended for pre-financing under the European Union Life programme.

When more detailed plans were at hand for group B, altogether 36 projects were approved for financing on June 2002. Another 5 projects were transferred for financing in group A.

The total financing will become clear when the pilot studies are at hand and the final financing has been decided. The Ministry of the Environment will channel about 2 million euro over the programme in 2003-2005. The aim is to engage other financiers and research units so as to achieve a total input of two to three times as much.

The financing seems to fall evenly into the three main areas of the programme.
Assessment of the programme efficacy

The cluster programmes give special attention to the monitoring of the progress of the projects and the evaluation of project results and efficacy. The responsibility for monitoring the supplementary funding was divided between the universities, research institutes, ministries, financing organisations and the State Science and Technology Council. In addition, the Ministries of Trade and Industry and Education appointed an expert committee to evaluate the efficacy of the supplementary funding in the years 1997-1999. The conclusions of this committee concerning the cluster programmes are as follows (Prihti et al. 2000):

"The cluster programmes have made it possible to initiate fruitful cooperation between various sectors and to provide a valuable link between technology and public services. However, it is too early to project any final results. Development needs for these programmes seem evident, especially in giving more focus to the objectives, improving coordination between financiers and reducing multiple reporting requirements. Knowledge of cooperation between different sectors, gained from the cluster programmes, should be developed and extended to new areas. However, the existing clusters need to be more focused."

The external evaluation of the environmental cluster programme was carried out during autumn 2000. The evaluation group comprised representatives of industry, municipalities, universities, consulting bodies and NGOs. Its main results were that co-operation between funding organisations had developed in a positive way. The research institutes have also networked in a significant way. Each cluster project involves about three research units; this figure is certainly higher than the average. However, although 70 industrial companies are involved there are only 14 projects directed by industry. Most of these companies participate through a representative in the steering group of the research project or provide manpower and information to the projects. One reason for this might be that companies are reluctant to involve their R&D projects in a programme whose findings are public and freely accessible to potential users.

The evaluation group also considered it important to continue the environmental cluster programme, but more focus should be given to the role of the scientific community both in the planning and implementation of the programme. Half of the funds should be targeted for open application and half for specific research areas and topics.

A self-evaluation study was also carried out. An e-mail survey was sent to the project researchers and the authorities responsible for supervising the research projects. According to the survey results, no poorly performing projects were found. Most projects were given an evaluation of “good” or “satisfactory” from both parties. However, the authorities were slightly more critical towards the results of the projects and the application of the results in practice than were the researchers.
Conclusions

Environmental know-how in Finland has advanced rapidly during the last decade, and environmental business has become a more and more important and developed industrial cluster. The strengths are mainly concentrated in those sectors of environmental protection where good results have already been obtained in reducing emissions and discharges through national environmental policy. There is, however, a need for new environmental policy measures and new opportunities for eco-businesses, especially with a view to combating climate change, preventing waste generation and reducing the use of harmful chemicals.

The development of technology and especially information technology and its societal applications create a wealth of potential opportunities for improving the state of the environment and introducing environmental innovations. The integration of the social, economic and ecological dimensions of sustainable development can lead to an eco-efficient society, where the use of natural resources and harmful environmental impacts have been reduced to a level that does not exceed the carrying capacity of ecological systems and the whole biosphere. To succeed in these actions however requires a far better, more varied and deeper knowledge, and new ideas and visions of the present trends and future impacts. We also need unprejudiced research and pilot projects combining know-how in environmental and innovation policies. This will require research institutes and industries to work closely together, and, accordingly, an extensive, creative and diversified networking of financiers, researchers, experts and actors utilising and implementing the research results.

The environmental cluster research programme is one example of this new type of research co-operation. The extent, content and goals of the programme and, even more importantly, the cluster approach and the subsequent networking of all the stakeholders involved have made it possible to use this research programme as an instrument of both environmental and innovation policy in a novel way.
**References**


### Title of publication

On the Cluster Approach to Environmental Research and Development

### Abstract

This report presents the environmental cluster research programme. It describes goals, administration and contents. It also discusses relations between the programme and priorities in environmental policy and product policy. These priorities include eco-efficiency, environment-based product policy, integrated control of emissions and discharges, and better prerequisites for environmental businesses. The contents of the programme and the research areas are indicated by research project examples. The outcome of the evaluation of the cluster programmes is also presented.

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Yhdyshenkilö ympäristöministeriössä ympäristöneuvos Antero Honkasalo p. 09-160 39345
Denna rapport presenterar miljöklustrets forskningsprogram och beskriver dess mål, förvaltning och innehåll. Därutöver granskar den relationerna mellan programmet och prioriteringarna inom miljöpolitiken och innovationspolitiken. Prioritetera omfattar ekoeffektivitet, en produktpolitik som bygger på miljöhänsyn, integrerad minskning av utsläppen och bättre förutsättningar för miljörelaterad handel. Programmets innehåll och forskningsområdena blir belyst genom exempel på projekten. Vidare presenterar de huvudsakliga resultaten av utvärderingen av klusterprogrammen.

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