

# Technology and Climate Change CLIMTECH 1999–2002

Technology Programme Report 14/2002

Final Report



**TEKES**

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Final Report

Sampo Soimakallio,  
Ilkka Savolainen (eds.)



**TEKES**

National Technology Agency

**Technology Programme Report 14/2002**  
Helsinki 2002

## **Tekes – your contact for Finnish technology**

Tekes, the National Technology Agency, is the main financing organisation for applied and industrial R&D in Finland. Funding is granted from the state budget.

Tekes' primary objective is to promote the competitiveness of Finnish industry and the service sector by technological means. Activities are aimed at diversifying production structures, increasing productivity and exports and creating a foundation for employment and social well-being. Tekes finances applied and industrial R&D in Finland to the extent of nearly 400 million euros annually. The Tekes network in Finland and overseas offers excellent channels for cooperation with Finnish companies, universities and research institutes.

## **Technology programmes – part of the innovation chain**

The technology programmes are an essential part of the Finnish innovation system. These programmes have proved to be an effective form of cooperation and networking for companies and the research sector for developing innovative products and processes. Technology programmes promote development in specific sectors of technology or industry, and the results of the research work are passed on to business systematically. The programmes also serve as excellent frameworks for international R&D cooperation. Currently, 45 extensive technology programmes are under way.

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# Foreword

Climate change has been identified as one of the largest environmental challenges to the mankind. Very significant reductions of greenhouse gas emissions are needed in order to slow down the global warming. Technological development is one of the key issues both in solving the problem and in reducing the costs of mitigation of climate change to national economy. The demand of new technologies in global markets will grow strongly due to the restriction of greenhouse gas emissions. Finland is already leading the way in many technologies that can be used for reducing global greenhouse gas emissions. The export possibilities are expected to grow strongly in the nearby future.

After the climate negotiations in Kyoto in 1997 there was a large demand for a technology programme that would help Finnish companies in forthcoming strategic decisions in changing operational environment. Against this background Tekes, the National Technology Agency of Finland started the Technology and Climate Change programme, Climtech, in 1999. The main task of the Climtech programme has been to create an overall picture of the mitigation of climate change and to identify the most significant technological development fields in Finland. Mitigation of climate change is a long-term issue and therefore the time scale for the technologies studied extends to about 2030.

Climtech has been quite a small technology programme. The projects have been focusing mostly on collecting and analysing information and practical technology development has been done in many other technology programmes and R&D projects of Tekes. On the other hand, the Climtech programme has had a very communicative role. Large efforts have been put on spreading the results of the projects and general information about the mitigation of climate change.

The Climtech programme has analysed the development needs and possibilities of many technologies, which can be applied to control greenhouse gas emissions. This information can be used in companies and in administration in the selection of long term strategies for technology development for domestic and export markets.

The operational form of this programme has been quite different from usual technology programme of Tekes. There have been no open applications for research grants. The steering group and the management team have identified the most important research subjects and have chosen the best researchers to implement the projects. The Climtech programme has also a supervisory group which has been responsible for strategic management and supervision of the programme. Correspondingly, the steering group has been responsible for operational management of the programme and supervision of the projects.

The Climtech programme achieved success because of the tremendous efforts of many people. Tekes would like to express their thanks to the steering group and to the supervisory group chaired by Vice President Heikki Niininen of Fortum for their efforts in supervising the programme and to Programme Manager Ilkka Savolainen and Research Scientist Mikael Ohlström of VTT Processes for their effective management of the programme and its operations. We are also grateful to research organisations and companies for successful implementation of the goals of the Climtech programme and to Motiva Oy for first-class dissemination of the results to the media.

In Helsinki, in December 2002

Tekes, the National Technology Agency of Finland

# Summary

Climtech, the Technology and Climate Change Programme (1999–2002) funded by Tekes has investigated the development needs and possibilities of the technologies, which can be applied to control greenhouse gas emissions and climate change.

The objective of the Climtech programme has been, by contributing to technological choices, research, development, commercialisation and implementation, to support the mitigation of climate change and the attainment of the national climate change mitigation objectives. Climtech has aimed at serving and guiding other Finnish technology development relevant to reductions of greenhouse gas emissions and improvements of energy efficiency. The technologies are analysed against an overall picture of emissions limitation, and the technical and economic potentials are evaluated.

The Climtech programme has consisted of altogether 27 projects where seven research institutes and universities and eight companies took part. Six main subject areas have been concerned, including 1) renewable energy sources and distributed energy production, 2) energy efficiency and industry, 3) non-CO<sub>2</sub> greenhouse gases, 4) capture and utilisation of CO<sub>2</sub>, 5) development of models and systems, and 6) commercialisation. The projects and their main results are described in this report.

Communication and dissemination of information had more important roles in Climtech than typically in other technology programmes. The programme arranged ten seminars, and numerous reports, articles and brochures have been produced on project and on programme results. More information can be found on the internet pages ([akseli.tekes.fi](http://akseli.tekes.fi) or [www.climtech.vtt.fi](http://www.climtech.vtt.fi)) of the programme.

The Finnish energy technology is relatively advanced, and the exports are expected to grow largely due to requirements for more efficient and less polluting energy technology. The use of technologies and systems developed and applied in Finland brings the possibility of limiting emissions when applied in other parts of the world. Examples of such technologies are e.g. technologies related to wind power, bioenergy, and to small-scale co-production of heat and power.

Especially, Climtech has contributed to dissemination of information on the mitigation opportunities of climate change, and bringing the viewpoint of greenhouse gas emissions reduction to the agenda of the technology development. The information that future energy technology markets are to a large extent guided by emission reduction requirements can be used in the strategic planning in companies.

# Tiivistelmä

Teknologian kehittämisskeskus Tekes on rahoittanut kolmivuotisen teknologiaohjelman (1999–2002) ”Teknologia ja ilmastonmuutos (Climtech)”. Ohjelman tavoitteena on ollut tukea ilmastonmuutoksen hillitsemistä ja kansallisten päästövelvoitteiden saavuttamista vaikuttamalla teknologisiin valintoihin, teknologiaan liittyvään tutkimukseen ja kehitykseen sekä kaupallistamiseen ja käyttöönottoon. Tarkastelun aikajänne ulottuu yli Kioton pöytäkirjan ensimmäisen velvoitejakson, noin vuoteen 2030.

Ohjelma on toteutettu VTT Prosessien koordinoimana ja sen tehtävänä on ollut palvella ja ohjata suomalaista teknologian kehittämistä energiatehokkuuden parantamisessa ja kasvihuonekaasujen päästöjen vähentämisessä. Teknologioita on analysoitu päästöjen rajoittamisen kokonaiskuvan avulla.

Ohjelmassa on ollut yhteensä 27 hanketta, joiden toteuttamiseen on osallistunut seitsemän tutkimuslaitosta ja korkeakoulua sekä kahdeksan yritystä. Hankkeet on jaettu kuuteen alueeseen, jotka ovat 1) uusiutuvat energialähteet ja hajautettu energiantuotanto, 2) energiatehokkuus ja teollisuus, 3) muut kasvihuonekaasut kuin CO<sub>2</sub>, 4) CO<sub>2</sub>:n erotus ja hyötykäyttö, 5) mallit ja järjestelmät ja 6) kaupallistaminen. Hankkeet ja niiden keskeiset tulokset on esitetty tässä raportissa.

Tiedonvaihto muiden tutkimusohjelmien kanssa sekä kansallisella että kansainvälisellä tasolla samoin kuin yhteydet yrityksiin ovat olleet keskeisiä. Myös tiedon levittäminen kansallisella tasolla on ollut ohjelmassa tärkeää. Ohjelma on järjestänyt kymmenen seminaaria, joista yhden YK:n ilmastopöytäkirjan neuvottelujen yhteydessä (COP-8) New Delhissä Intiassa. Ohjelmassa ja sen hankkeissa on tuotettu lukuisia raportteja, artikkeleita ja esitteitä. Lisää tietoa on saatavissa ohjelman internet-sivuilta ([akseli.tekes.fi](http://akseli.tekes.fi) tai [www.climtech.vtt.fi](http://www.climtech.vtt.fi)). Ohjelmassa on myös julkaistu kolme laaja-alaista raporttia tai kirjaa teknologioiden mahdollisuuksista ilmastonmuutoksen hillinnässä.

Uuden teknologian kysynnän odotetaan kasvavan, kun kasvihuonekaasujen päästöjen rajoituksia tullaan vaatimaan. Suomalainen energiatekniikka on suhteellisen edistynyt ja kysynnän kasvun arvioidaan osaksi kohdistuvan juuri siihen. Suomessa kehitettyä teknologiaa voidaan käyttää päästöjen rajoittamiseen myös muualla maailmassa. Esimerkkejä tällaisista teknologioista ovat mm. tuuli- ja bioenergiaan sekä pienen mittakaavan sähkön ja lämmön yhteistuotantoon liittyvät teknologiat.

Ohjelman kautta kasvihuonekaasupäästöjen rajoittaminen on otettu aiempaa selvemmin mukaan teknologian kehittämistyöhön. Kasvihuonekaasujen päästöjen rajoittaminen ohjanee suurelta osalta tulevaisuuden teknologiamarkkinoita. Tätä tietoa voidaan käyttää yritysten strategisessa suunnittelussa.

## To the Reader

This report gives descriptions and main results of the projects of the Technology and Climate Change (Climtech) programme as articles by projects. The articles are given according to the six subject areas of the programme. Each article includes a summary in English and in Finnish. The reports and other publications of the projects are listed at the end of each article.



# Contents

**Foreword**

**Summary**

**Tiivistelmä**

**To the Reader**

<b>Overview of the Climtech Programme . . . . .</b>	<b>1</b>
<b>Renewable Energy Sources and Distributed Energy Production . . . . .</b>	<b>5</b>
Wind Power in Finland – Export Prospects and Emission Reductions . . . . .	5
<i>Hannele Holttinen, Esa Peltola, Sami Tuhkanen</i>	
Road-Map for Solar Energy Technology and Markets in Finland . . . . .	17
<i>Heidrun Faninger-Lund</i>	
The Possibilities of Bioenergy in Reducing Greenhouse Gas Emissions . . . . .	28
<i>Satu Helynen, Martti Flyktman, Tuula Mäkinen, Kai Sipilä, Pirkko Vesterinen</i>	
Distributed Energy Production: Technology, Fuels, Markets, and CO <sub>2</sub> Emissions . . . . .	38
<i>Eero Vartiainen, Päivi Luoma, Jari Hiltunen, Juha Vanhanen</i>	
Future Possibilities of Hydrogen Technologies . . . . .	47
<i>Tero Hottinen, Klaus Mäki-Petäys, Peter Lund</i>	
<b>Energy Efficiency and Industry. . . . .</b>	<b>59</b>
Electricity Saving Possibilities in Household and Office Appliances . . . . .	59
<i>Liisa Sillanpää, Anne Korhonen, Hannu Pihala, Aulis Ranne, Veikko Ahponen</i>	
Generating CO <sub>2</sub> Emission Reductions through Energy Service Companies (ESCOs) . . . . .	69
<i>Harri Laurikka, Katri Kuusinen, Kari Hämekoski, Aleksi Lumijärvi, Sari Siitonen, Pertti Koski, Peter Anton, Tomas Otterström</i>	
Development Scenarios of High-Efficiency Power Plant Technologies in Centralised Electricity and Heat Production and their Impacts on Greenhouse Gas Emissions . . . . .	77
<i>Antti Harmoinen, Jouko Heikkilä, Katri Nyberg, Markku Raiko, Jouko Hepola, Esa Kurkela</i>	
The Impact of IT on Greenhouse Gas Emissions in the Forest Cluster. . . . .	90
<i>Petri Vasara, Laura Peuhkuri, Karina Hänninen</i>	
Environmental and Energy-Related Benefits of Biotechnology in Mechanical Pulping . . . . .	100
<i>Anne Kallioinen, Jaakko Pere, Matti Siika-aho, Liisa Viikari, Helena Mälkki, Antti Lehtilä, Sanna Syri, Rabbe Thun</i>	
Industrial Ecology and the Reduction of Greenhouse Gas Emissions. . . . .	114
<i>Hanne Siikavirta, Pekka Järvinen, Lassi Linnanen</i>	

<b>Non-CO<sub>2</sub> Greenhouse Gases</b> . . . . .	<b>125</b>
Emissions Abatement of Fluorinated Greenhouse Gases . . . . .	125
<i>Sampo Soimakallio, Teemu Oinonen</i>	
The Role of Waste Management in the Reduction of Greenhouse Gas Emissions. . . . .	134
<i>Tarja Turkulainen, Tuula Mäkinen, Kai Sipilä, Sami Tuhkanen, Elina Lohiniva, Allan Johansson</i>	
<b>Capture and Utilisation of CO<sub>2</sub></b> . . . . .	<b>145</b>
CO <sub>2</sub> Capture, Storage and Utilisation in Finland. . . . .	145
<i>Tiina Koljonen, Hanne Siikavirta, Ron Zevenhoven, Jens Kohlman, Arun B. Mukherjee, Liisa Aarikka</i>	
<b>Models and Systems</b> . . . . .	<b>157</b>
Development of Energy System Models for Finland in Co-Operation with the IEA ETSAP Programme . . . . .	157
<i>Antti Lehtilä, Eero Tamminen, Jussi Mäkelä, Pekka Pirilä</i>	
Greenhouse Gas Balances of Biomass and Bioenergy Systems – Participation in an International Collaboration . . . . .	167
<i>Kim Pingoud, Ilkka Savolainen, Sampo Soimakallio</i>	
Carbon Sink of Wood Products. . . . .	173
<i>Kim Pingoud, Anna-Leena Perälä, Ari Pussinen</i>	
Developing and Testing of Renewable Energy Certificate System (RECS). . . . .	184
<i>Nina Elomaa, Jari Hovila, Reima Päivinen</i>	
Information and Communication Technology (ICT) and Energy Economy . . . . .	190
<i>Esa Pursiheimo, Ritva Hirvonen</i>	
Reducing Carbon Dioxide Emissions of Transport in Finland. . . . .	199
<i>Hanna Kalenoja, Jorma Mäntynen, Harri Kallberg, Tuomas Jokipii, Kari Korpela, Mika Kulmala</i>	
The Impact of Climate Change on Energy Management . . . . .	209
<i>Bengt Tammelin, John Forsius, Kirsti Jylhä, Pekka Järvinen, Jarkko Koskela, Heikki Tuomenvirta, Merja A. Turunen, Bertel Vehviläinen, Ari Venäläinen</i>	
Local Means of Livelihood in Mitigating Climate Change – The Case of Southeast Finland . . . . .	218
<i>Sami Lappalainen, Mika Horttanainen, Esa Marttila</i>	
The Impacts of Climate Change Mitigation on Air Pollutant Emissions. . . . .	224
<i>Sanna Syri</i>	
<b>Commercialisation</b> . . . . .	<b>235</b>
Societal Embedding of Innovations Related to Renewable Energies and Energy Saving . . . . .	235
<i>Erja Väyrynen, Sirkku Kivisaari, Raimo Lovio</i>	
Financing of the Commercialisation of Climate-Friendly Energy Technology . . . . .	245
<i>Matti Pulkkinen, Ville Lehtinen</i>	
Markets of New Energy Technologies . . . . .	250
<i>Suvi Monni, Sampo Soimakallio, Mikael Ohlström, Ilkka Savolainen</i>	
<b>Tekes' Technology Programme Reports</b> . . . . .	<b>259</b>

# Overview of the Climtech Programme

Tekes, the National Technology Agency of Finland has funded a three-year technology programme (1999–2002) on Technology and Climate Change (Climtech) to investigate the development needs and possibilities of the technologies, which can be applied to control greenhouse gas emissions and climate change. The programme includes both the control of emissions within Finland as well as supporting the exports of the Finnish technology to limit emissions elsewhere.

## Objective

The overall objective of the Climtech programme is, by contributing to technological choices, research, development, commercialisation and implementation, to support the mitigation of climate change and the attainment of the national climate change mitigation objectives. The time scale for the technologies studied extends beyond the first commitment period of the Kyoto Protocol to about 2030. Within this time scale, the emission limits regarding developed countries will most likely be tightened and the emissions for developing countries also be limited.

## Implementation

Climtech was run as a framework programme by VTT Processes to serve and guide other Finnish technology development relevant to energy efficiency improvements and greenhouse gas emission reductions. The technologies are analysed against an overall picture of emissions limitation, and the technical and economic potentials as well as the potential barriers of implementation are evaluated.

The core activities of the Climtech programme were the projects for assessing the potentials of the improved existing and new emerging technologies. The Climtech programme consisted of alto-

gether 27 projects where seven research institutes and universities and eight companies took part. Six main subject areas were concerned, including 1) renewable energy sources and distributed energy production, 2) energy efficiency and industry, 3) non-CO<sub>2</sub> greenhouse gases, 4) capture and utilisation of CO<sub>2</sub>, 5) development of models and systems, and 6) commercialisation. The number of projects involved in these subjects varied between two (themes 3 and 4) and nine (theme 5). The smallest volume of subject area was roughly 140 000 euros (theme 4), whereas the largest was approximately 820 000 euros (theme 5). The projects and their main results are described in this report.

Communication with other research programmes at national and international level, as well as contacts to companies, are of central importance. Dissemination of information at national level is also crucial. The programme arranged ten seminars including one in New Delhi, India during the climate negotiations (COP-8).

## Main results

The demand of new technologies is projected to grow significantly when reductions of the greenhouse gas emissions will be required. The Finnish energy technology is relatively advanced, and the exports are expected to grow largely due to requirements for more efficient and less polluting energy technology. The use of technologies and systems developed and applied in Finland brings forth the possibility of limiting emissions when applied for example, in EU and other parts of the world.

Generally, the relevant technologies are linked to efficient production and use of energy, renewable energy sources, control of industrial process emissions and emissions from waste management. Also technologies advancing the management of material flows are often of importance.

Examples of such technologies are e.g. technologies related to wind power, bioenergy, and to small-scale co-production of heat and power. More detailed examples of technologies are listed below.

Important technologies in the fuel production could be among others integrated production of forest chips, production of biopellets, pyrolysis oil, refuse derived fuels and possibly also production technologies of transportation fuels from natural gas or biomass.

In the electricity production sector the wind power technology (on-shore and off-shore) seems to have an relatively important role. Technologies related to gasification of biomass and co-firing in boilers or gas turbines are assessed to be important also. In the technologies of co-production of heat and power in industry the use of biofuels both in large and small scale would increase. The efficiency of electricity production in recovery boilers would increase. In mechanical pulping process the use of technologies utilizing enzymes or fungi would lower the energy consumption considerably. In the residential sector the biofuelled heating boilers with automatic control and also low energy buildings would be crucial.

The technology development for the near term markets can base on the technologies which already have relatively strong know-how and market shares. However, for the long term technology markets, much wider spectrum of technological alternatives should be covered.

Promoting and advancing implementation and commercialisation of technology is also important. Companies should see the long term opportunities of technologies in order to regard technology development as profitable. A clear long-term political commitment would be here important. This message should also reach the companies and technological development.

To control emissions also promoting the demand of new technology would be needed. Government should create the framework for the markets of

new technologies, but let the markets assess the competitiveness of technological alternatives. New business concepts can also enhance markets.

Co-ordinated action plans and road maps can have central role in the commercialisation of the technologies. Co-operation in technology development and application could be international so that the resources are being used in an efficient way. The Kyoto mechanisms can also be used to promote the application of the efficient new technologies.

## Publications and reports

Numerous reports, articles and brochures have been produced on the project and on programme results. More information can be found on the internet pages ([akseli.tekes.fi](http://akseli.tekes.fi) or [www.climtech.vtt.fi](http://www.climtech.vtt.fi)) of the programme. In addition to the project level reports and brochures, the programme also published three more general studies or books in Finnish on the role of technologies in the mitigation of climate change:

Savolainen, I., Tuhkanen, S., Ohlström, M., Pipatti, R., Pingoud, K., Johansson, A. 2000. Teknologia ja ilmastonmuutos – Lähtökohtia Climtech-ohjelmalle. [*Technology and Climate Change – Starting point for the Climtech technology programme. (In Finnish)*]. Tekes, Helsinki. 65 p. Technology Review: 85/2000.

Savolainen, I., Tuhkanen, S., Lehtilä, A. (eds.). 2001. Teknologia ja kasvihuonekaasupäästöjen rajoittaminen – Taustatyö kansallista ilmasto-ohjelmaa varten. [*Technology and Mitigation of Greenhouse Gas Emissions – Background Study for the Finnish Climate Change Action Plan. (In Finnish)*]. Ministry of Trade and Industry, Publications 1/2001. Edita ltd, 2001. 198 p.

Savolainen, I., Ohlström, M., Kärkkäinen, A. (eds.) 2003. Ilmasto – Haaste teknologialle. Näkemyksiä ja tuloksia Climtech-ohjelmasta [*Climate – Challenge for Technology. Views and Results from the Climtech Programme (In Finnish, with an extended English abstract published in separate volume.)*] Edita, Helsinki 2003. (to be published).

## Benefits due to the programme

Benefits of Climtech are dissemination of information on climate change and its mitigation opportunities, and bringing the viewpoint of greenhouse gas emissions reduction to the agenda of the technology development. Within various sectors of the society, several technologies and solutions are identified and assessed. The information that future energy technology markets are to a large extent guided by emission reductions requirements can be used in the strategic planning in companies.

## Organisation

VTT Processes was responsible for the implementation of the programme. Steering group guided the research work done within the projects. In addition, general directing of research as well as communication between Climtech, industry, other technology programmes and public administration was coordinated by supervisory group.

The following persons participated in meetings of the **Supervisory Group**:

- *Heikki Niininen*, Vice President, Fortum Oyj (Chairman)
- *Mikko Kara*, Executive Director, VTT Processes (Vice Chairman)
- *Martti Äijälä*, Director, Tekes
- *Raija Pikku-Pyhältö*, Chief Technology Adviser, Tekes
- *Sirpa Salo-Asikainen*, Senior Technology Adviser, Tekes
- *Sami Tuhkanen*, Senior Technology Adviser, Tekes (from 1.2.2002)
- *Sirkka Vilkamo*, Industrial Counsellor, Ministry of Trade and Industry
- *Erkki Eskola*, Industrial Counsellor, Ministry of Trade and Industry
- *Pekka Jalkanen*, Director General, Ministry of the Environment
- *Antero Honkasalo*, Director, Environmental Affairs, Ministry of the Environment
- *Juha-Pekka Snäkin*, Senior Adviser, Ministry of the Environment
- *Matti Heikurainen*, Senior Adviser, Ministry of Agriculture and Forestry
- *Raisa Valli*, Senior Adviser, Environmental Affairs, Ministry of Transport and Communications
- *Risto Saari*, Senior Engineer, Ministry of Transport and Communications
- *Lea Kauppi*, Director General, Finnish Environment Institute
- *Matti Melanen*, Research Professor, Finnish Environment Institute
- *Sanna Syri*, Senior Research Scientist, Finnish Environment Institute (until 28.2.2002)
- *Anneli Pauli*, Director of Research, Academy of Finland
- *Jaana Roos*, Scientific Secretary, Academy of Finland
- *Peter Lund*, Professor, Helsinki University of Technology
- *Pertti Haaparanta*, Professor, Helsinki School of Economics and Business Administration
- *Erkki Jatila*, Director General, Finnish Meteorological Institute
- *Mikko Alestalo*, Director of Meteorological Research, Finnish Meteorological Institute
- *Ari Venäläinen*, Senior Researcher, Finnish Meteorological Institute

- *Tellervo Kylä-Harakka-Ruonala*, Director, Environment and Sustainable Development, The Confederation of Finnish Industry and Employers
- *Jouni Punnonen*, Energy Adviser, The Confederation of Finnish Industry and Employers
- *Juhani Santaholma*, President, Finnish Energy Industries Federation (Finergy)
- *Jukka Leskelä*, R & D Coordinator, Finnish Energy Industries Federation (Finergy)
- *Juhani Reen*, Managing Director, The Finnish Association of Building Owners and Construction Clients (Rakli)
- *Juha Tiuraniemi*, Project Engineer, The Finnish Association of Building Owners and Construction Clients (Rakli)
- *Kari Saviharju*, Director, Technology, Andritz Oy
- *Kari Ebeling*, Senior Scientific Advisor, UPM-Kymmene Corporation
- *Juha Kouki*, Energy Manager, UPM-Kymmene Corporation
- *Jarkko Hukkanen*, Environmental Analyst, UPM-Kymmene Corporation
- *Ilkka Savolainen*, Research Professor, VTT Processes (Secretary)
- *Mikael Ohlström*, Research Scientist, VTT Processes (Secretary)
- *Anja Silvennoinen*, Industrial Counsellor, Ministry of Trade and Industry
- *Erkki Eskola*, Industrial Counsellor, Ministry of Trade and Industry
- *Sirkka Vilkamo*, Industrial Counsellor, Ministry of Trade and Industry
- *Teija Lahti-Nuuttila*, Senior Adviser, Ministry of Trade and Industry
- *Timo Ritonummi*, Senior Adviser, Ministry of Trade and Industry
- *Pirkko Heikinheimo*, Senior Adviser, Ministry of the Environment
- *Risto Kuusisto*, Chief Engineer, Ministry of the Environment
- *Juha-Pekka Snäkin*, Senior Adviser, Ministry of the Environment
- *Teemu Virtanen*, Senior Adviser, Ministry of the Environment
- *Kari Saviharju*, Director, Technology, Andritz Oy
- *Kai Sipilä*, Research Professor, VTT Processes
- *Allan Johansson*, Research Professor, VTT Processes
- *Sanna Syri*, Senior Research Scientist, VTT Processes (from 1.3.2002)
- *Ilkka Savolainen*, Research Professor, VTT Processes (Secretary)
- *Mikael Ohlström*, Research Scientist, VTT Processes (Secretary)

The following persons participated in meetings of the **Steering Group**:

- *Martti Äijälä*, Director, Tekes (Chairperson until 31.12.2000)
- *Raija Pikku-Pyhältö*, Chief Technology Adviser, Tekes (Chairperson from 1.1.2001)
- *Sirpa Salo-Asikainen*, Senior Technology Adviser, Tekes
- *Sami Tuhkanen*, Senior Technology Adviser, Tekes (from 1.2.2002)
- *Kari Komulainen*, Head of Unit, Tekes/Washington

The following persons participated in the **Management Team**:

- *Ilkka Savolainen*, Research Professor, VTT Processes (Programme Manager)
- *Mikael Ohlström*, Research Scientist, VTT Processes
- *Sami Tuhkanen*, Research Scientist, VTT Processes (until 31.1.2002)
- *Riitta Pipatti*, Senior Research Scientist, VTT Processes