EnYm-SHOK

Energy and Environment Strategic Centre for Science, Technology and Innovation (EnYm-SHOK)

Strategic Research Agenda (SRA)

29.4.2008

The Federation of Finnish Technology Industries

0 Executive summary

Mission

EnYm-SHOK is an essential means to leverage the Finnish competitiveness to top international level in global energy and environmental markets through common, long-term and networked strategic research and development.

Vision

In 2050, energy and environmental industry is a leading industry in Finland and a global market leader in selected business areas. The turnover of this industry has increased in 2020 from the present 32 milliard € level (2007) to 100 milliard €.

Based on its superior know-how and innovative production systems, the energy-intensive and environmentally sound industry in Finland has a remarkable global competitive advantage.

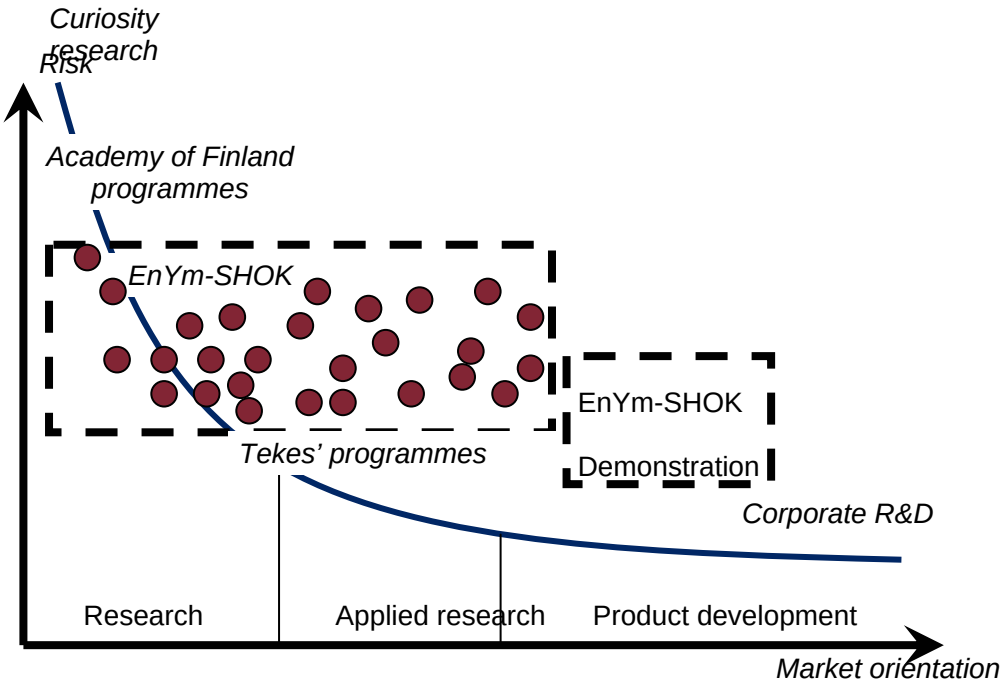
In 2020, Finland is well on its way to the sustainable society of 2050. All the energy policy targets will be reached ahead of time.

The joint research and development has increased from 70 M€/a in 2010 to 120 M€/a in 2015 and 160 M€/a in 2020.

Organisation

EnYm-SHOK is a completely new way to organise the energy and environmental research in Finland. It is designed to bring focus and industry lead to the research. Therefore it is expected that the efficiency of research and use of research resources will increase considerably. Expected benefits are that the development of world leading know-how will be ensured, the best talent will be attracted and the international cooperation will be easier to accomplish. The industry, research institutes and universities working together, the joint project planning and the new joint research programmes will considerably facilitate the development of the whole innovation chain and the development of globally competitive technology and service products.

EnYm-SHOK will organise its research in the form of large research programs of long duration. It will also include closer to the market projects participated by a smaller number of companies operating in a joint value chain. Universities and research organisations will play a significant role in performing the actual research work. Industry will take over when the activities are closed to the products. Also the possibility for demonstrations is included into the EnYm-SHOK activities. The positioning of the EnYm-SHOK activities is illustrated in the following figure.



The research agenda is covering those areas which are necessary for the development of technology and services for fulfilling the requirements stated in the vision. That is solving the problems related to energy security, avoidance of global warming and efficient use of recourses. There is a strong emphasis on developing selected strategic technologies in which Finnish companies can be global leaders.

The research agenda includes the following main areas:

- Carbon neutral energy production
- Distributed energy systems
- Sustainable fuels
- Energy market and smart grids
- Efficient energy use
- Resource Efficient Production Technologies and Services
- Recycling of materials and waste management
- Measurement, monitoring and assessment of environmental efficiency

Across these main application themes, a few cross cutting common activities are proposed as examples of large generic research topics. The possibility for demonstrations is also included as a speciality for EnYm-SHOK.

Research themes

The proposed research topics of the different main areas are the following.

Carbon neutral energy production

- Large scale heat and power from biofuels and wastes
- Heat and Power at Pulp Mills
- Wind energy
- Zero emission fossil power production
- Nuclear power technology

Distributed energy systems

- House heating and other small scale applications
- Municipal and industrial plants, CHP and district heating
- Transportation of merchandise and powering of ships
- Waste to energy

Sustainable fuels

- Solid biofuel production, fuel chains
- Biofuels for transport
- Hydrogen production for fuel cells

Energy market and smart grids

- Future infrastructure of energy systems
- Intelligent management and operation of smart grids
- Customer gateway
- Energy and emission services

Efficient energy use

- Decrease of energy intensity in products and services
- Improvement of energy efficiency in industrial processes
- Development of the components or sub processes
- Energy management

Resource efficient production technologies and services

- Process and product optimisation
- Efficient water purification systems
- Resource efficiency
- External purification methods

Recycling of materials and waste management

- Advanced solutions for recycling of complex and new materials
- Refining concepts for wastes
- Decentralized waste management and recycling
- Innovative technology - service concepts
- Service as an activity

Measurement, monitoring and assessment of environmental efficiency

- Development of assessment methodologies (including life cycle models)
- Assessment of the environmental effectiveness
- Development of on-line monitoring technologies
- Service and business models

International cooperation

In the international context Finland is a small country with moderate resources. Therefore only a small fraction of research results are created in Finland. One of the central requirements for creation of the centre is the build up of international cooperation. Until now the international cooperation is built up between institutes and individual research groups. However, the EnYm-SHOK will become a mayor player in research, even in the global context. It will have considerable human resources as well as facilities comparable with any other organisation in

the world. Its ability to attract the leading research groups in Finland will give it a strong status everywhere in the world. Therefore EnYm-SHOK as an organisation should develop the international research cooperation attracting world leading research groups into joint research projects. In this activity the vast contacts of the Finnish industry and research groups should be utilised. The international cooperation has ton developed in an active way based on decisions which capabilities should be built in Finland and in which areas we will depend on international cooperation.

EU is the central area because the instruments for cooperation are well developed and it is easy to join in. Therefore the EnYm- SHOK will build a strong position in the relevant European Technology Platforms and Joint Technology Initiatives. However, many other countries outside the EU are very strong on research. Such are especially Japan and the USA, but also several other countries like Canada, South Korea and China are emerging. EnYm-SHOK will actively build up its cooperation with industries, research organisations and universities when ever felt appropriate.

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1. Introduction

At present the world is facing a number of threats endangering our present life style and quality of life. The basis for most threats is the fast growth of the world population but also the way in which the developed world uses the limited global resources. The growing Asian population is rapidly adapting the Western world's wasteful way of utilising raw materials. We are threatened by global warming and global pollution which endangers the society. We are also threatened by the extinction of clean water, raw materials and energy resources.

As a consequence of this we need to do something to save the world. The energy intensity of all parts of the society needs to be decreased. This is valid for production of goods and services, housing and real estate as well as transport and logistics. The efficient use of resources requires new processes and total recycling of raw materials and water. A total stop to final deposition of waste materials is also required. The pollution of the earth trough emissions to the air, water or land should be minimised. All this requires a change of lifestyle, but also new energy- and environmental technology. New technology is what this EnYm-SHOK is about.

In more detail the situation is as follows. The energy- and environmental technology cluster is undergoing drastic changes during the coming years. The drivers for those are

- Energy security is under peril because of the decreasing availability of fossil fuels
- The climate change compels a drastic decrease in CO2 emissions
- The availability of raw materials is in peril because of the wasteful ways in which they are consumed

As a consequence the whole energy system needs to be improved as follows

- The energy intensity of all human activities need to be decreased drastically
- New, preferably renewable energy sources need to be employed
- When fossil fuels are used CO2 capture and CO2 disposal is necessary
- The efficiency of all stages of energy production and use need to be increased
- On long term the dependency of imported fuels need to be decreased drastically
- Completely new renewable energy technologies or technologies based on carbon free and abundant fuels need to be developed

The globally continuously increasing human activities in energy production and industrial activities combined with the ever increasing human population increases the risk of catastrophic and long term environmental hazards. As a consequence

- These endanger the health and well being of the whole humanity
- The lack of clean water is threatening not only the southern developing countries, but also many European countries as well as the USA, to mention some
- Transport and industrial activities are increasingly polluting many areas in the world, especially large cities
- The ever increasing amounts of human waste not only threatens human beings in developing countries but are a problem for developed countries as well

As a consequence technologies and processes need to be developed to

- Decrease the overall need for water by the industry and clean the water released to drinkable quality
- Develop the technology used in transport and industrial processes to decrease emissions of harmful substances to a minimum
- Minimise the waste to be deposited by reduction of material use and re-use of all waste fractions possible

The complete change in energy use and production, transport and industrial processes will cost a lot of money. But it is also a possibility for the industry. The problem is a global one. The requirement over the world will be harmonised. The legislation and agreements will span the world. This will results in global markets for the technologies. Therefore those industrial companies which are the first to introduce the new technologies to the world market will also be the successful ones. They will take over the global market with economical success as a consequence. They will also be the ones which creates the new well paid jobs in the respective countries. Therefore it is in the interest of the public sector to encourage the industry to develop the new technology. This happens by building the required infrastructure for research, development and demonstration. The public sector should also use other means for support, like direct financial support and tax incentives.

In order to ensure that the Finnish industrial companies are among those which will succeed in the future, a new organisation will be created. This new EnYm-SHOK organisation will be a private –public partnership which will benefit all the participants. The resources will be increased by additional funding and vide networking of research, academia and industry.

2. Mission and vision of EnYm-SHOK

Mission

EnYm-SHOK is an essential means to leverage the Finnish competitiveness to top international level in global energy and environmental markets through common, long-term and networked strategic research and development.

Vision

In 2050, energy and environmental industry is a leading industry in Finland and a global market leader in selected business areas. The turnover of this industry has increased in 2020 from the present 32 milliard € level (2007) to 100 milliard €.

Based on its superior know-how and innovative production systems, the energy-intensive and environmentally sound industry in Finland has a remarkable global competitive advantage.

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3. The position of EnYm-SHOK in the Finnish innovation system

The total turnover of energy and environment industries in Finland was 32 B€ in 2006 representing 25 % of the overall industrial output of the country. The value of export was 12 B€. The number of employees is 65 000 persons. In addition to this he value of investment is huge. The replacement value of electricity production and distribution facilities alone is 50 milliards. Hence, the industry's impact on Finnish national economy is significant.

EnYm-SHOK is established to strengthen the technology and knowledge base of the industry and the research society to a level which makes it possible to reach the vision of 2020 and the requirements of 2050. By a private- public partnership the funding of joint research is increased to a level twice that of the level of 2007. The objective is that the research funding will be at least 70 M€ per annum in 2010 when the EnYm-SHOK has started properly. This is done by increasing the total funding in a focused way in selected strategic areas. Especially it is expected that the industry will increase its funding for joint research considerably from the level of today.

The EnYm-SHOK will possess research resources which will be comparable with the largest research organisations in the world. The participating industries are the most important ones in their field in Finland and most of them are internationally renowned. They cover well the research topics included in this research agenda. The EnYM-SHOK will attract the best research groups in Finland, including universities and research organisation. Tens of research groups and hundreds of researchers will participate in the research.

The EnYm-SHOK will benefit the industry by

- Making their innovation process faster and more efficient
- Defining the research plan according to their own interests
- Utilising a large network of resources according to need
- Obtaining a longer term and larger share of public research funding than before
- Attracting the most talented personnel for production, research and development

The research partners for industry will continue to be the public research organisations, universities and other public schools. They will also benefit by

- Being able to participate in long term strategic research- and development work
- Networking with relevant high level research
- Increasing their contacts with industry
- Enhancing their operational preconditions both qualitatively and quantitatively
- Increasing their attractiveness among students because of their industry contacts
- Getting exploiters for the new knowledge which they create

The program itself will comprise several levels of activities. Long term generic research programmes with a large number of stake holders participating will be devoted to generic research benefiting almost all members of the EnYm-SHOK. Coming closed to the applied research medium term projects realised by clusters of stake holders will be realised. There is also a possibility to include projects close to product development, led and funded by one company together with a public body. In this type of projects several stake holders are participating, but they are funded trough the lead company. Finally also demonstrations can

be included as an activity of the EnYm-SHOK. The different types of activities are illustrated in figures 3.1.1 and 3.1.2.

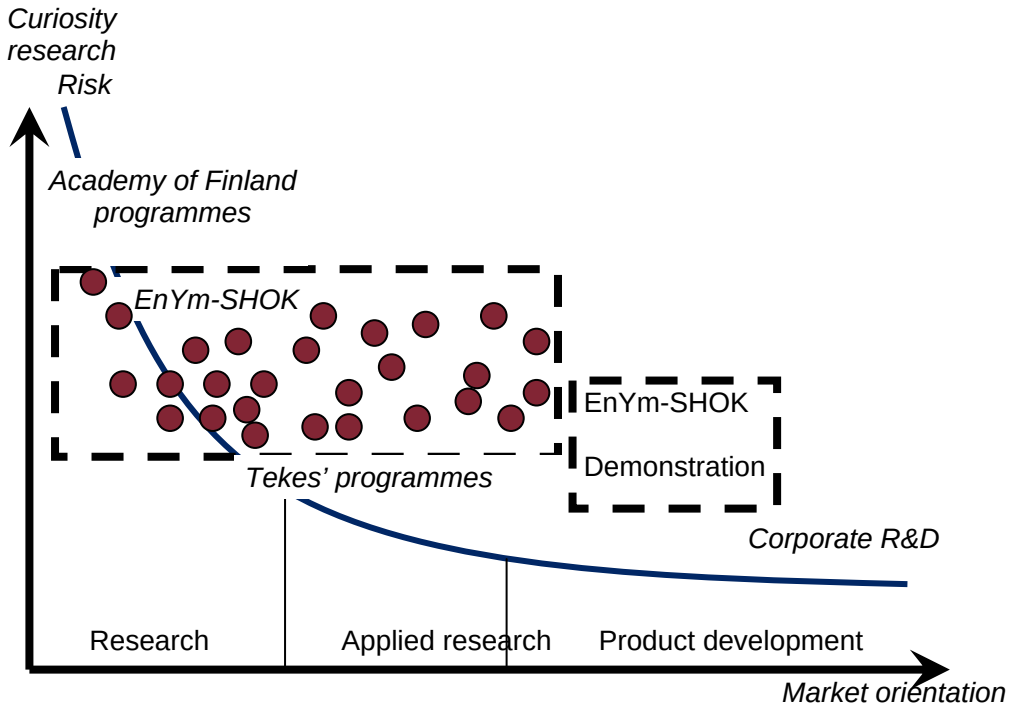

Fig. 3.1.1. Positioning of EnYm-SHOK in the Finnish innovation system

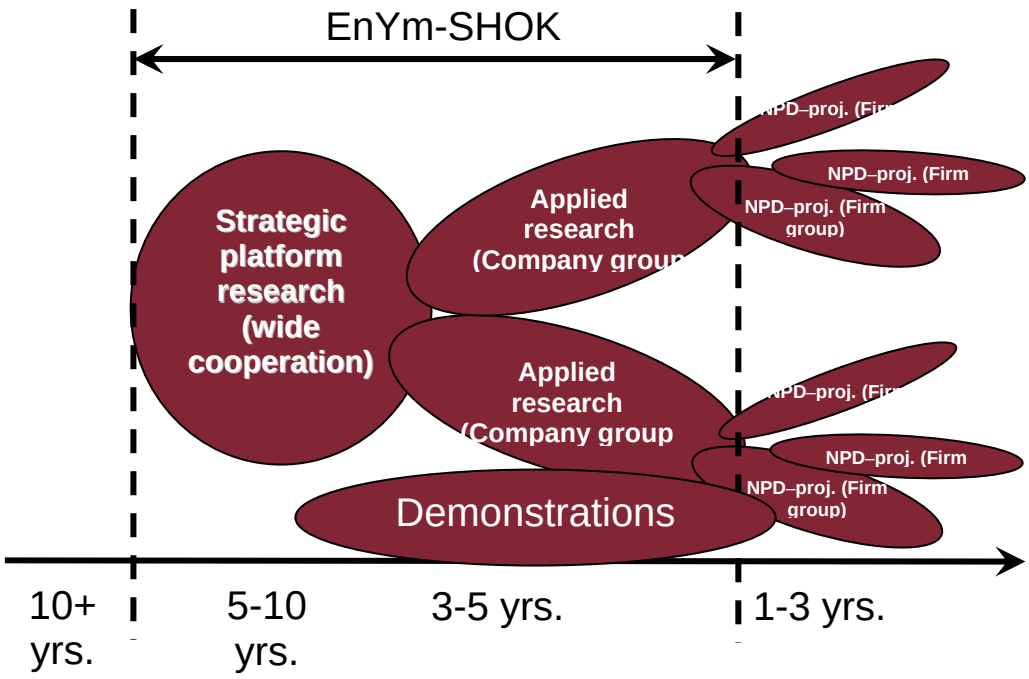

Fig. 3.1.2. Project types in EnYm-SHOK

The goal of the EnYm-SHOK is to support the industry in getting products into the market. The route to this is commonly accepted to include the development chain shown in fig 3.1.3. It is to be noted that in this report a pilot plant is defined as a larger than laboratory scale but smaller than production scale research facility. Demonstration is defined as a production scale production facility. This can be small or large, depending on the application.

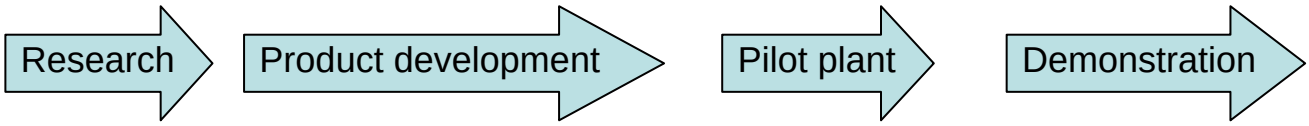

Fig. 3.1.3. Development route from research to market.

The three first steps are commonly funded by the technical funding agencies like EU framework program and Tekes. However, it has been less easy to find funding for the demonstration part, although it is a necessary step in order to get admission to the market. Therefore the present EnYm-SHOK is proposed to include this step also. While the public funding for the first three steps are expected to come from the Academy of Finland and Tekes, the funding for demonstrations are expected to come from the Ministry of Employment and the Economy and EU.

The organisation of the EnYm-SHOK will be determined by the participants when it has been founded. However, it is proposed to be that of a company. The organisation and its officials are shown in fig. 3.1.4.

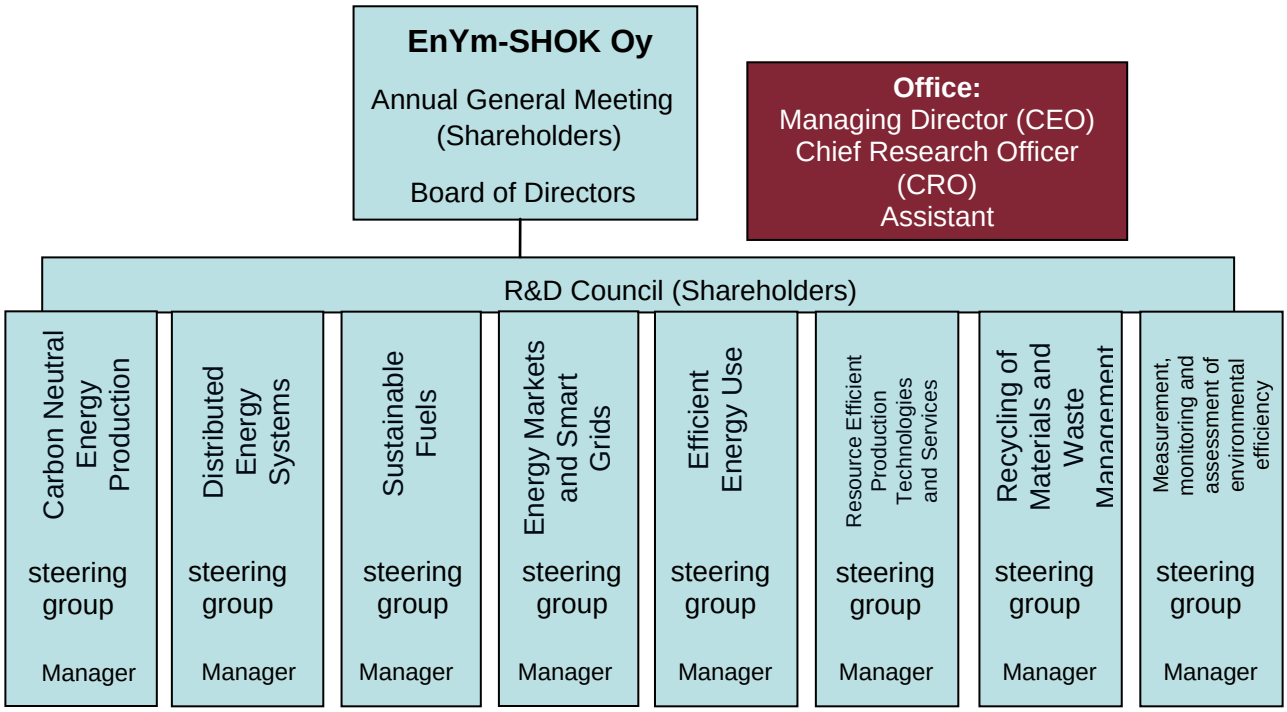

Fig. 3.1.4. Organisation of EnYm-SHOK.

The steering groups led by a manager will do the project planning and the R& D council will make the decisions on programmes and projects included in the EnYm-SHOK activities.

The important thing in the organisation is that all partners will participate in the planning. The industry will set the needs and goals of the research. However, the academia and other research organisations will advice in setting the means how to do the research and development work. They will also provide an important part of the resources, facilities and researches who will perform the work.

One important part of the EnYm-SHOK will be the overall understanding of required resources and infrastructure. The expected considerable increase in research in the chosen selected areas requires build up of new infrastructure. When the program planning is advanced enough so that an understanding of infrastructure needs is available, an analysis has to be done on what new is needed. The EnYm-SHOK needs to provide the required funds to build up the needed infrastructure with its facilities and human resources. However, not everything needs to found in Finland. The international cooperation will be enlarged from the present one. Decisions based on facts have to be made what international resources are used and what is set up in Finland itself.

4. Long-term perspective (Vision and scenarios)(2050)

4.1 Global and EU energy production and use visions

The point of departure for global and regional energy strategies is threefold: combating climate change, promoting economic development, and securing energy supplies. According to the IEA baseline scenario (i.e. business as usual) global energy demand and CO_2 emissions will more than double by 2050 (IEA 2006). Such a high energy demand would also cause high oil and gas prices as well as increased energy-security concerns. The EU has decided to take the lead internationally by commitment to limiting the global temperature increase to 2 degrees Celsius above pre-industrial levels by 2100 (EC 2007). The Intergovernmental Panel on Climate Change (IPCC 2007) has estimated that 2 °C limit would require 50-85% emission reductions by 2050 compared to present emission level. The European Parliament has proposed an EU CO_2 reduction target of 60 to 80% for 2050 as a strategic objective, which means transforming Europe into a highly energy efficient and low CO_2 economy catalysing a *new industrial revolution*.

Figure 4.1.1 shows an example of the primary energy use for the baseline scenario and a policy scenario calculated with global ETSAP TIAM energy system model (see Koljonen et al. 2008). In the policy scenario the commitment to limiting the global temperature increase to 2 degrees Celsius above pre-industrial levels by 2100 was assumed. In the baseline scenario the conventional oil and gas resources would be largely replaced by unconventional oil and gas resources after 2050 meaning rapidly increasing production costs of fossil fuels. The diminished conventional oil and gas are mainly replaced with coal. . It should be noted that in these scenarios nuclear investments were constrained, especially in the developed countries up to 2050 and on the other hand fusion investments were allowed after 2050. However, the maturity of generation IV reactors for large-scale commercial nuclear energy production is generally considered to be more advanced than fusion technology. Owing to the much more efficient use of uranium in Gen IV plants, long-term sustainability of fuel resources is ensured

also for fission power plants. Therefore, the relative shares of fission and fusion can evolve differently than predicted by the scenarios in Figs. 4.1.1 – 4.1.3.

In the policy scenario the calculated CO_2 emissions would decrease below 20 Gt level as the share of renewables from primary energy consumption more than triples by 2050, while coal consumption decreases. Figure 4.1.2 shows that the share of renewables increases especially in electricity production. According to the policy scenario, by 2050 most of the fossil fuel fired power plants would also be equipped with carbon capture and storage (CCS).

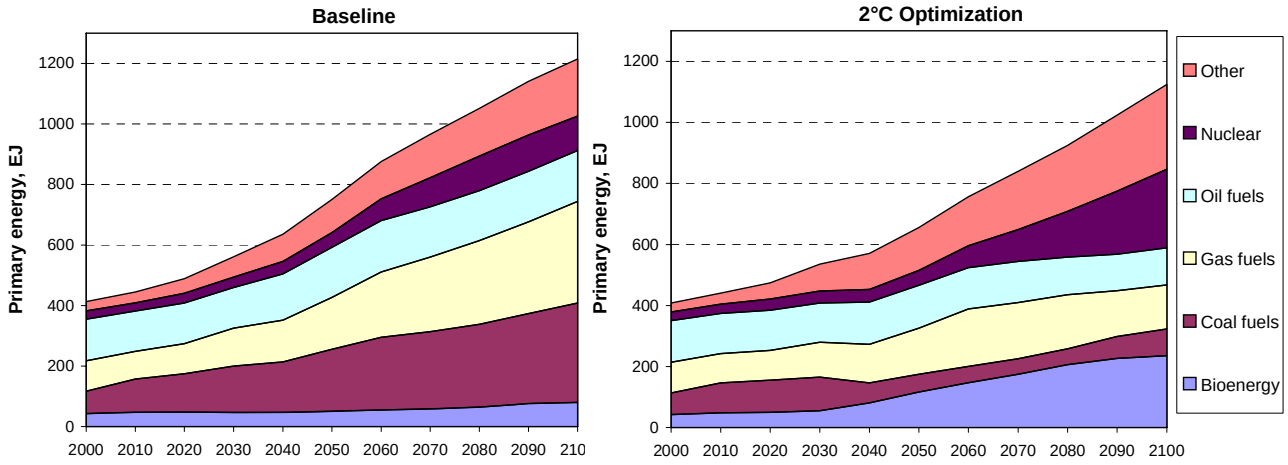

Figure 4.1.1. Global primary energy use in the baseline scenario and policy scenario with maximum 2 C temperature increase and global emissions trading. Source: Koljonen et al.

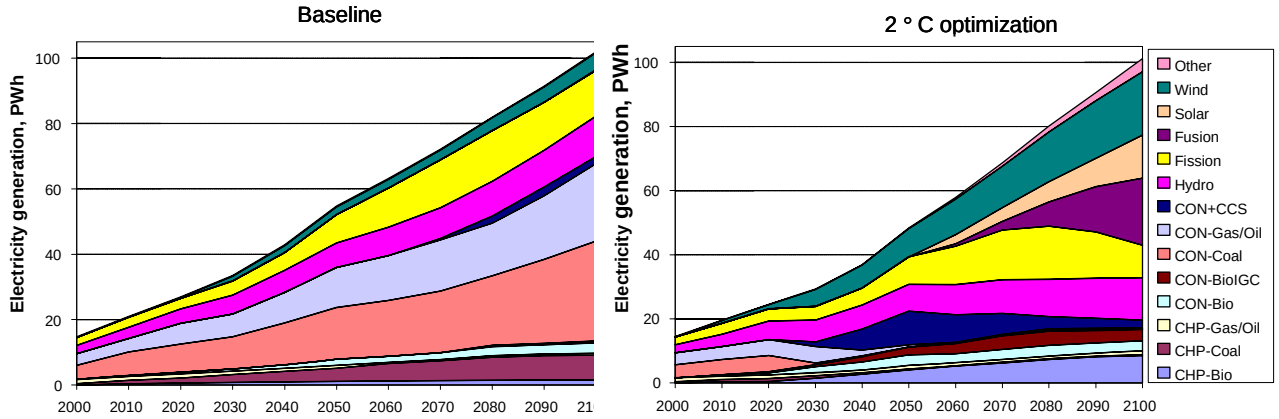

Figure 4.1.2. Global electricity production in the baseline scenario and policy scenario with maximum 2 C temperature increase and global emissions trading. Source: Koljonen et al.

Figure 4.1.3 shows the corresponding scenarios for electricity production in the Westen Europe. Compared to global average, the share of renewables is clearly higher. The sensitivity of the available wind and bioenergy resources was simulated by reducing the potentials by 40%. Especially wind potentials seem to be a critical factor in the long term. The investments in new nuclear capacities were constrained based on the existing policies, and on the other

hand, no legal obstacles for the CCS were assumed. Without the above constraints, the investments on nuclear capacities would be higher in the Western Europe.

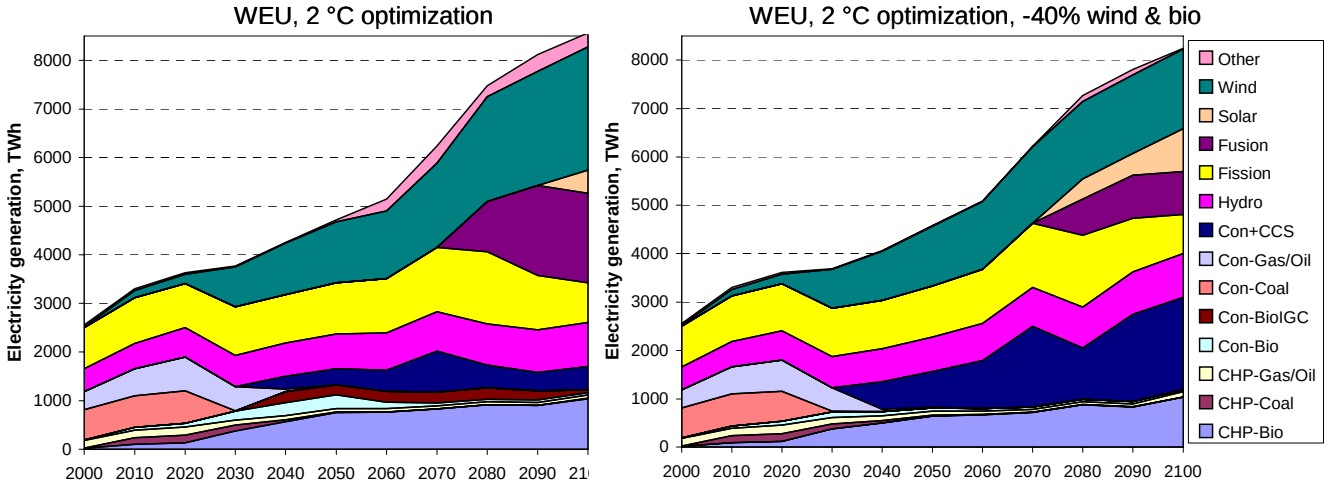

Figure 4.1.1. Electricity production in the Western Europe in the baseline scenario and policy scenario with maximum 2 C temperature increase and global emissions trading. -40% wind and bio: -40% lower resource assumptions for windenergy and bioenergy potentials.

4.2. Global and EU environmental visions

As a consequence of growth of population and the economical growth in developing countries consumption of natural resources is growing rapidly. It has been estimated that the consumption of several natural minerals, such as Cu, Pb, Zn, Ni, Au and Sn, will overrun the amount of reserve base by the year 2050, and consumption of many other minerals will be close to reserve (Halada 2007). Wastage of natural resources combined to substitution of minerals and fossil fuels with renewable resources and increasing food production may lead to new environmental problems. Shortage and increasing competition on biobased resources is already in sight. Erosion is also becoming an ever more widespread problem due to more intensive land use.

This means that by 2050 there will be an enormous change in market of technologies, goods and services. Environmental technologies have to expand from traditional emission control and remediation technologies into the prevention of environmental damage through savings in energy and materials, the choice of non polluting production methods, the sustainable use of renewable energy sources and the development of closed material circulation systems. The shift to material and energy efficient zero-emission technologies and closed cycles is gradually going on. Because of the urgent need for improved air quality, water supply, sewerage and waste management especially in developing countries, the share of emission control technologies is still over 90 % of environmental technology market and will continue to be considerable throughout the next decade. After 2020 zero-emission will be the most intense growth area.

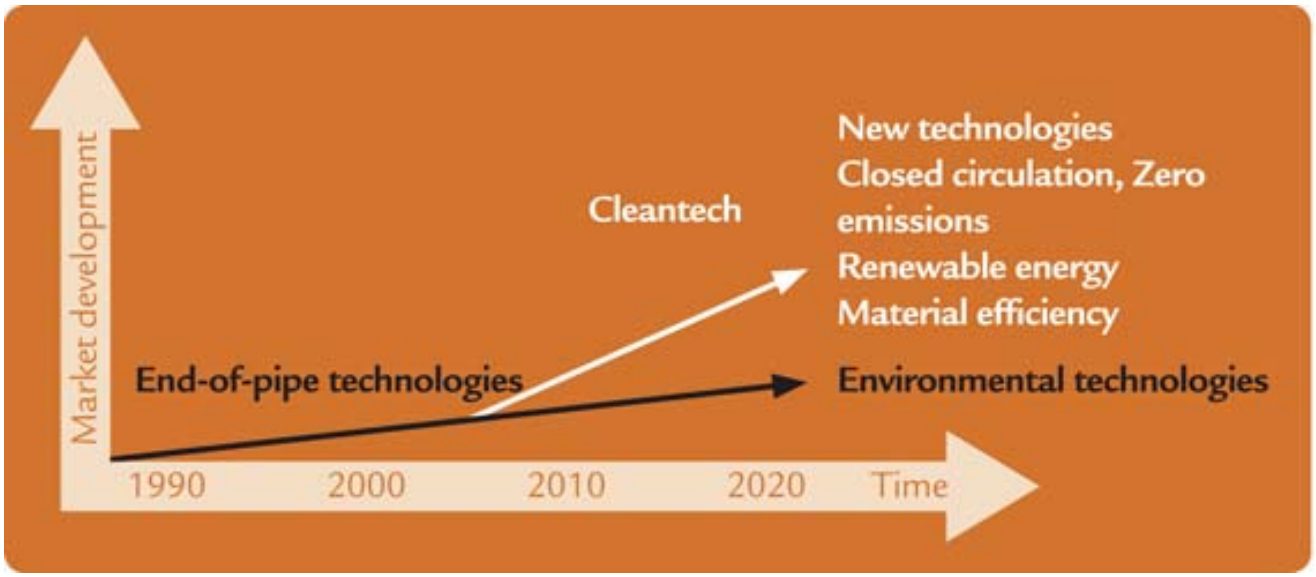

Figure 4.2.1. SITRA 2007: Clean technologies are the fastest growing environmental sector

5. Mid-term perspective (Visions and scenarios) (2020)

5.1 Global and EU visions and scenarios for energy

According to the IEA scenarios (IEA 2007), world primary energy demand in the Reference Scenario (i.e. business as usual scenario) is projected to grow by more than half between 2005 and 2030, at an average annual rate of 1,8%. At the same time, the global energy intensity falls by 1,8% per year. Even in the alternative policy scenario, which includes policies and measures under consideration to rein in the growth of energy demand, the primary energy demand grows by 1,3% per year. Oil is expected to remain the dominant source of primary energy, though its share slightly falls. Coal sees the biggest increase in demand in absolute terms, while natural gas increases more modestly. According to the IEA, it is very uncertain whether the expected oil-production capacity additions from greenfield projects over the next five years will be sufficient to compensate the decline in output at existing fields. Therefore, a supply-side shortage in the period to 2015, involving a high volatility of oil prices, cannot be ruled out.

In the UNFCCC meeting in December 2007 held in Bali was agreed to start the negotiations of the new climate agreement. The EU has decided to implement its own climate strategy even though post-Kyoto agreement would not come into force; that the EU should reduce greenhouse gas emissions from its energy consumption by 20% by 2020. To achieve this objective, the Commission has proposed to focus on a number of energy related measures (EU 2007):

- improving energy efficiency by 20% by 2020;
- raising the share of renewable energy to 20% from energy consumption by 2020, including the target to increase renewables to 10% in transport sector;
- a renewed focus on nuclear safety;
- a proposal to promote sustainable power generation from fossil fuels.

5.2 Global and EU visions and scenarios for environment

Development of the European environmental technology market environment is steered by the Action programmes (6th Action Programme 2002 – 2012), which set out the framework for environmental policy-making in the European Union, and the thematic strategies (air, waste prevention and recycling, soil, natural resources, marine environment and urban environment). These strategies steer the legislative actions. Environmental Technology Action Plan (2004) complements the regulatory approaches.

In the EU the new way of thinking is presented in the revision of the European waste management directive which aims to reduce waste production by promoting more efficient use of resources. This will be done by incorporating life cycle environmental, cost and social impact management to the waste management[1]. The present legislation already aims in minimisation of the amount of waste, especially biodegradable waste, disposed to landfills or even to a total stop of the landfill disposal by 2020, as in Germany.

European and international recycling regulations (such as on WEEE, automobiles, batteries, C&D waste and packaging) enhance the recycling of relevant products and materials. The revision of waste directive aims to further improve the requisites of waste recovery and recycling, e.g. by defining the end-of waste procedure.

Several EU directives have placed stringent demands for monitoring and reporting of atmospheric emissions. The air thematic strategy emphasises the reduction of fine particle emissions from energy production, transport, etc., and the reduction of VOC emissions.

At the 2002 World Summit for Sustainable Development in Johannesburg (WSSD), the EU launched a Water Initiative (EUWI). EU committed to halve by 2015 the proportion of people who are unable to reach or afford safe drinking water and the proportion of people who do not have access to adequate sanitation. Deficit of water resources is a challenge even in many developed countries. In Europe the aim of the 2000 Water Framework Directive (WFD) is to achieve by 2015 good water quality for all waters across the European Union.

6 Energy technology and environmental technology and services market

6.1 Energy technology market in Europe and Globally

According to the IEA scenarios (IEA 2007) the projected cumulative investment need for energy supply infrastructure will be around $US 20-24 trillion (in year-2006 dollars) for the period 2006-2030. More than half of the energy-supply investments, including the expand of energy supply capacity and replacements of phasing out facilities, will be required for the power sector. Especially in the developing countries the investment needs in power sector are the most dominant. Most of the investments in electricity industry are needed for transmission and distribution networks. In contrast, most of the investments in the oil and gas sectors will

1 Proposal for a Directive of the European Parliament and the Council on Waste COM(2005) 667 final

be required for upstream developments and to replace capacity that will become obsolete over the projection period. Both gas and oil investments are projected to be one-quarter of the total (i.e $ 5-6 trillion for oil and $ 4-5 trillion for gas). Investment for bio-refineries is projected to total $ 188 milliard for the period 2006-2030, most of which will occur in OECD Europe, Latin America and OECD North America. About half of global energy investment goes to developing countries, where energy demand increases most. China alone needs to invest about 17% ($ 3,7 trillion) of the world total and more than all other developing Asian countries put together. India's investment needs are more than $ 1,2 trillion, and most of it goes to power sector. OECD countries will account for almost 40% of global investment and OECD Europe alone $ 2,4 trillion.

In figure 6.1.1 are shown projections for energy investment in the 2 °C policy scenarios presented in the section 2.1. In the climate policy scenarios the investments in renewables, CCS and energy saving measures would be rapidly increased, especially after 2020. In these scenarios, the nuclear capacities were expected to more than double by 2050 even though investments in nuclear power were constrained in the OECD countries. Like in the IEA scenarios, more than half of the investments would go to the developing countries.

It is obvious that aggressive climate policies together with growing energy consumption and need to replace the old capacities would create extremely large markets for energy. Focused efforts to promote and demonstrate clean and efficient technologies could give strong position in the future global markets.

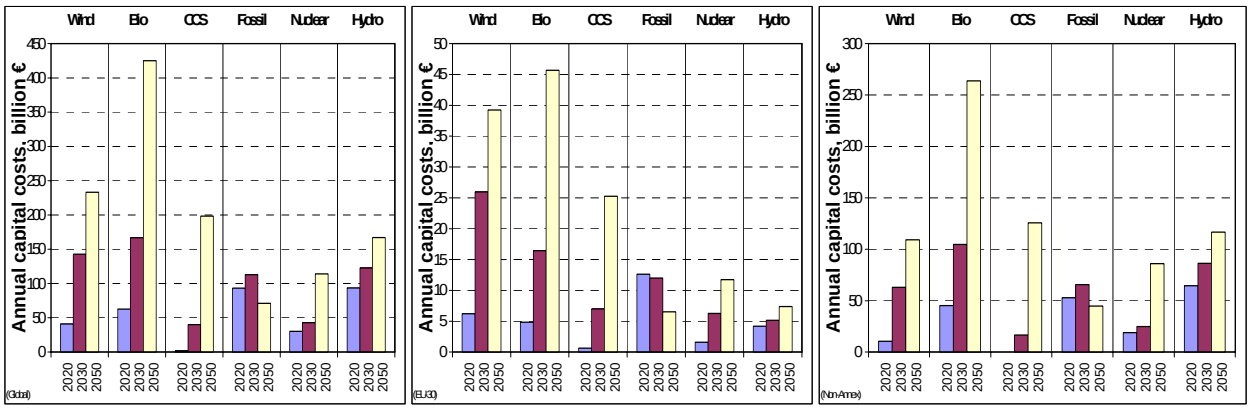

Figure 6.1.1. Annualized capital expenditure for power and heat generation globally, in the EU-30 area, and in developing countries (Kyoto non-Annex-1 countries) in policy scenario with maximum temperature increase limited to 2 °C (source: Koljonen et al. 2008).

6.2 Environmental technology market

The global market of environmentally sound technologies (environmental technologies and clean energy) is roughly estimated to amount to 600 milliard euros, with Europe accounting for around one third of this sum (SITRA 2007). Environmentally sound technologies include products, services, processes and systems whose use results in less harmful impacts on the environment than their alternatives. Examples include clean energy and industrial processes, energy efficiency, material efficiency, the recycling of used materials, closed water cycles,

technologies for environmental monitoring and for remediation of contaminated environment. Clean technologies may include know-how, procedures, goods and services, and equipment as well as organizational and managerial procedures.

Helmut Kaiser Consultancy (2007) estimates that the market of all the environmental technologies will grow significantly by the year 2020. The largest growth segments are environmental monitoring and data collection (nine-fold increase compared to the year 2006), recycling (7 –fold increase), soil and landscape protection and restoration (6-fold-increase and clean energy production (5-fold increase). The segments with highest market share in 2020 will be water and waste water, clean processes, recycling, waste management and clean energy. The market of noise abatement will be steady during this decade, but it will take substantial progress after the year 2015.

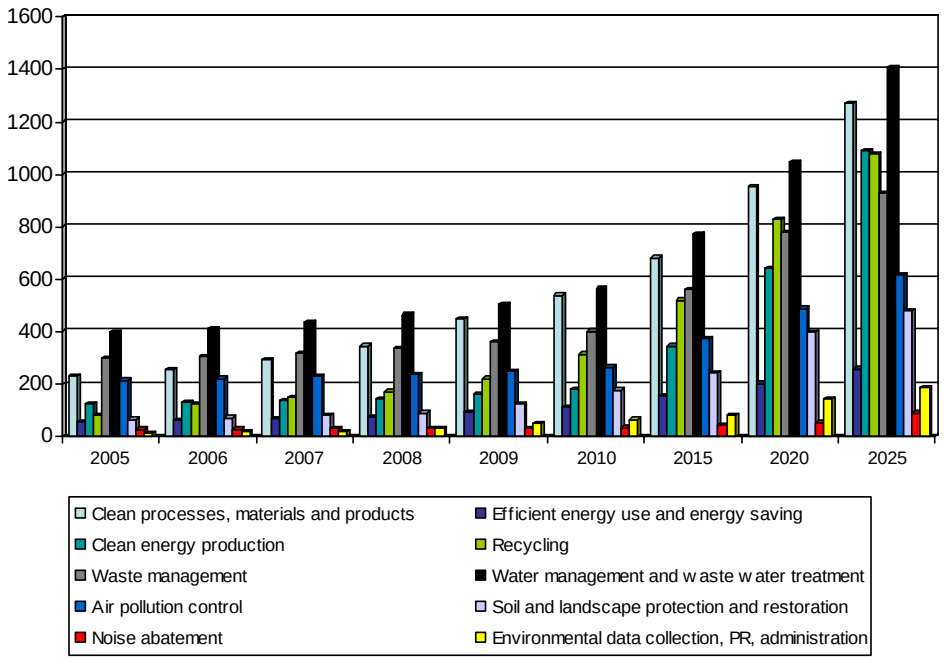

Figure 6.2.1. Markets for Sustainable and Environmental Technology/Renewable Energy 2005-2025 in US$ Bn. In total value chain worldwide (1 USD = 0,75 EUR) (Market Survey, Commissioned by Sitra, Helmut Kaiser Consultancy, Tubingen 2007)

Although Europe, North America and Japan are still most significant market areas (over 90 % in 2004) of clean technologies, the largest growth potential is in developing countries, such as China and other Asian countries, South America and Africa and non-EU countries of the Eastern Bloc[2].

7. Research strategy (2008-2015)

The EnYm-SHOK have chosen eight main research areas to be developed. The topics are chosen so that the technologies needed for the fulfilment of the vision of the EnYm-SHOK are

[2] DEFRA, November 2006. Study of emerging markets in the environmental industries sector. Executive Summary.

developed in the research program. These areas are described in the following chapters 7.1-7.8. In addition to these R&D areas, a few cross cutting subjects have been chosen as examples for possible generic research programmes which could be realised together by a significant number of companies. These are listed in chapter 7.9.

A speciality of the EnYm-SHOK is the possibility to include demonstrations in the research and development chain.

7.1 Carbon neutral energy production

This area covers all heat and power generation in large scale. The following sub-topics are considered important: Heat and power from biofuels and waste derived fuels, Heat and power at pulp mills, wind power, zero emission power from fossil fuels and nuclear power technology.

Large scale heat and power from biofuels and wastes

Finland is a leading country in the use of biofuels in large scale heat and power production. In the last 15 years more than 50 new boilers with a total thermal capacity of around 6000 MWth.have been built in Finland. Most of these are fluidized bed boilers using simultaneously different biofuels, peat, and also waste derived fuels of various kinds. Most are manufactured by manufacturing companies operating in Finland. Also the international market for large scale boilers for biomass fuels is increasing rapidly. Previous strong, long-term research and development efforts in clean combustion and fludized bed technology have made Finnish know-how and companies operating in Finland strong players internationally.

Fluidized bed technology is continuously developing. The strong research and development work in Finland has Present challenges include:

- Improved capability to handle more difficult fuels, such as various unknown woody biomasses, annual plants, waste derived fuels etc. There is a strong need for advanced fuel characterization techniques.
- Clean and safe operation of fuel mixtures. Fuelsoften interact with each other when burned simultaneously in fluidized beds thus causing operational problems, bed sintering, fouling, or unexpected flue gas emissions.
- Increase of power production efficiency. Biofuels often contain impurities (alkalies, chlorine) which make the flue gases corrosive, thus leading to low superheated steam temperatures and lower power production efficiences. Promising research is going on to find ways to advance in the steam data in biofuel based fluidized beds.

Combustion of municipal waste is planned to significantly increase in Finland. A number of new waste combustion plants are under planning. Most of these plants will be burning municipal waste alone and probably based on grate firing. It is obvious that these projects will activate new research and development work in the area of waste incineration and flue gas cleaning. There are good opportunities to widen the good Finnish know-how to benefit the new waste incineration business in the country.

Heat and Power at Pulp Mills

Kraft pulping is (still) the dominating chemical pulping technology in the world. A number of state-of-the art new green-field Kraft pulp mills have been started up in recent years in South-America and East-Asia. In Finland practically all chemical pulp mills are Kraft mills. Finnish pulp mill equipment manufacturing companies are strong players on the global market place, and a large part of the components in the new mill investments is delivered by companies operating in Finland.

In spite of the strong position of the Kraft pulping a variety of new pulping processes are under development, particularly for annual plants. Annual plants give additional challenges for the pulping processed due to their impurities, such as silica and chlorides. Handling the environmental emissions and optimizing the energy economy in these kinds of plants require significant research and development.

The Kraft pulping and chemicals recovery technology is mature, but still continuously improving. The size of the equipment has increased dramatically in recent years. The largest black liquor recovery boilers have a capacity of more than 6000 tons liquor solids per day (Figure 7.1.1). The increased size is a result of advanced research and development - especially in Finland. In particular, mathematical models based on computational fluid dynamics (CFD) have become essential tools in evaluating the air and liquor supply system and furnace designs in this new generation of very large recovery boilers. The models are under further developed and will in the future be increasingly effective and accurate and also able to capture more and more advanced chemical details in the furnace processes.

There is a great interest in the increase of the power production from the pulp mills. Power production is closely connected to the steam temperature in the black liquor recovery boiler and the bark and biofuel boiler. Both boilers are normally operate at significantly lower steam temperatures than for instance modern coal fired steam boilers. This is due to increased high temperature corrosion risks of the superheater tubes in bark and black liquor boiler flue gases. However, promising developments are underway to increase the steam temperature and power output from the pulp mills. These include new design and placement of the superheaters, new superheater materials, control of the chemical environment in the flue gases etc.

Gasification technologies are seen as promising new process units for the pulp mills. Both solid biofuels (bark etc) and the black liquor may be gasified to yield a gas mixture containing large amounts of carbon monoxide and hydrogen . A number of gasification concepts and reactor designs have been suggested. These include oxygen blown entrained flow gasification of black liquor, and fluidized bed gasification of bark and other solid biomass. The former process is actively developed in Sweden, the latter in Finland.

Gasification process product gases may be used as a gaseous fuel to replace fossil fuels in the lime kiln, or to generate electricity in a gas turbine – steam turbine process. They may also be used in synthesis of hydrocarbons or other organic base chemicals thus giving the pulp mills additional new valuable products. Gasification based novel processes are under intense development, and several demonstrations are announced to take place in the next five years. Gasification based processes will dramatically change the pulp mill processes, and before their commercialization significant research and development work is needed.

Also other processes besides gasification based synthesis gas production have become focus of recent serious research. Extraction of the wood raw materials (bark and wood) before pulping can yield valuable organic chemicals, some of which are bioactive and may find use as health promoting food supplements or even pharmaceuticals. Hemicelluloses from the wood can be extracted and used to produce other chemicals including ethanol. Lignin in black liquor can be separated and used as a clean fuel.

The processes described above, gasification based synthesis of hydrocarbons, extraction of valuable chemicals, are examples of concepts connected with the term forest biorefinery. Forest biorefinery is a relatively new term describing future mills where the wood raw material is used to produce a variety of products besides the pulp. The term has become widely used and a number of conferences and meetings are organized under the topic area of biorefinery.

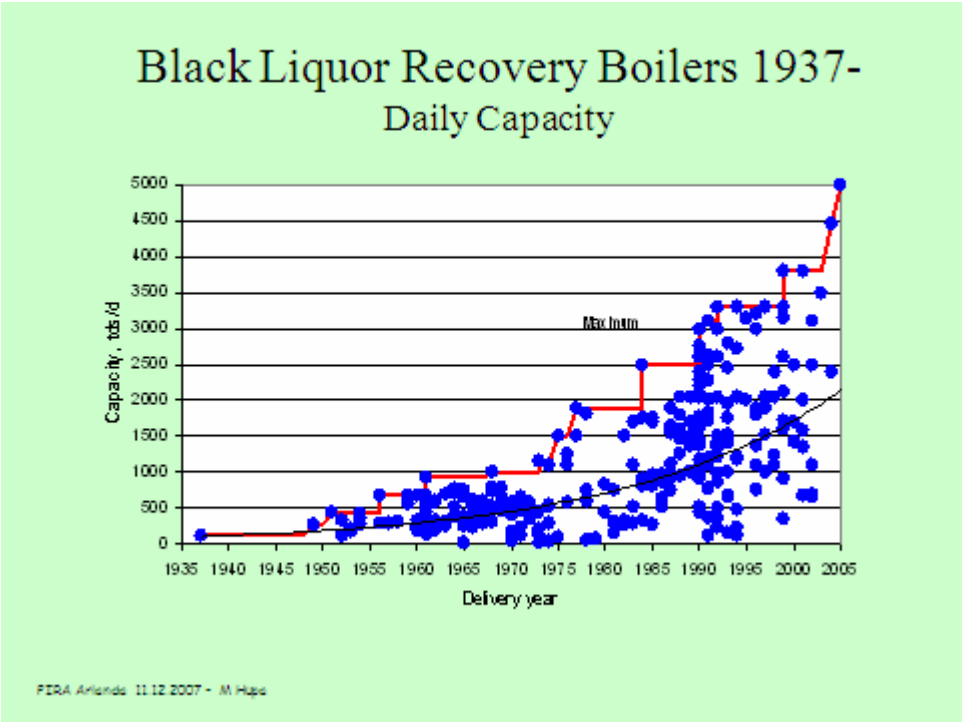

Figure 7.1.1. The daily capacity of black liquor recovery boilers have steeply increased in recent years. Each blue dot represents a boiler being built. Boiler manufacturing industry in Finland is leading the development.

Wind energy

Background

The high growth rate of wind power is anticipated to continue globally, and wind power in Finland is anticipated to grow substantially in future. This growth in manufacturing capacity will coincide with increasing requirements for technology, increasing size of turbines and applications for sites with new environmental conditions (for example offshore, cold and icing conditions).

Investments to wind power in Finland with current investment cost level will be 2–4.5 mrd euros by year 2020, assuming 1500 – 3000 MW of wind power. One of the prerequisites to reach this target, and a substantial share of Finland's target for increasing renewables, is to lower the production costs of wind power through technology development.

The global technology market in 2007 was about 25 mrd euros, of which Finnish industries had a market share of roughly 2 %. The market is still growth rate is still 20 – 30 % annually which means the installed capacity will double every 3 - 4 years. Competitive strength in technology exports are efficient supply chains, reliable and cost competitive technologies and solutions in 3 – 6 MW turbines as well as mastering special conditions.

Research goal

Improving the cost effectiveness of wind power produced electricity

Improving the competitive strength of Finnish wind power technology

Research topics

- Ensuring and enabling investment prerequisites, adapting technology to Finnish conditions and improving the cost effectiveness of wind power :
- using the updated wind atlas in regional planning, modelling and measuring techniques supporting wind power development, improving and developing know-how
- foundation technologies for offshore wind power taking into account icing and winter conditions, finding solutions for challenges in offshore wind power
- cold climate applications and solutions for 3-6 MW turbines
- developing wind energy forecasting techniques, integration of large scale wind power in Finnish power system

Developing technology for export markets and increasing market shares :

- technologies for reliability over lifetime and cost effective solutions for 3-6 MW turbines, managing special conditions. Drive train, generator technologies, composite structures and materials, large steel structures
- developing supply chains, developing technology and modeling/simulation know how and application to R6D processes of the companies
- cold climate solutions for 3-6 MW turbines

Zero emission fossil power production

Background

Carbon capture and storage technologies are given a high priority within EU today, because the CO_2 emission reduction potential of these technologies is quite significant, more than 50% CO_2 emission reduction within EU by 2050 [EU TP documents, several, e.g. SRA].

The purpose of CO_2 capture is to produce a concentrated gas stream that can be easily transported to a CO_2 storage site, e.g. a deep underground geological formation. CO_2 capture applies mainly to large power plants fired with hard coal, lignite and natural gas. It can also be applied to large, single point emission processes such as refineries, cement, chemical and steel plants. It can even be applied to biomass-fuelled plants, paving the way for net negative emissions, because biomass also draws CO_2 down from the atmosphere whilst it is growing.

Research goals

There are three main capture technology options under development:

- Post-combustion systems separate CO2 from the flue gases produced by combustion of a primary fuel (coal, natural gas, oil or biomass) in air. Can be retrofitted to existing power plants, as well as included in new builds.
- Pre-combustion systems process the primary fuel (natural gas or synthetic gas from coal) in a shift reaction to produce streams of CO_2 and hydrogen which can be separated. The hydrogen can then be used for either electricity or as a fuel - accelerating the transition to a hydrogen economy.
- Oxy-fuel combustion systems use oxygen instead of air for combustion, producing a flue gas that is mainly H2O and CO2, which can be easily captured after the water vapour is condensed. [EU Zero Em Technology platform SRA]

The EU Commission is currently promoting fast deployment of CCS technologies in Europe by putting together a flagship program of some 10 large-scale CCS demonstration projects, to be started by 2015.

Finnish power companies have expressed their intention to pursue one such large-scale demonstration project in Finland. The SHOK should act as the natural forum for linking Finnish activities in this area to the EU Technology Platform and the flagship demonstration program. Joint research could take place most appropriately around the infrastructure, transport and storage solutions that would be possible in Finnish CCS projects, whereas capture technology development is an area of intense competition between various boiler or other technology manufacturers.

However, excellence in fluidized bed based combustion technologies among the Finnish manufacturers and scientific community offers a solid basis for extending the development towards CCS ready power plant systems. Currently the Finnish technology providers are already on the edge of commercializing high efficiency power generation facilities in large utility scale in Europe. Thus, CCS compatible power generation offers huge international

business opportunities for boiler or other technology manufacturers. An issue of specific interest to Finland is also the potential of CCS to be applied to large bio-CHP plants.

Cleaner fossil energy production can also most importantly be achieved through increased plant efficiencies. Advanced emission control (e.g. with regards to Sox-, NOx-, and particle emissions) is also a development topic of high importance to Finnish coal-fired plants.

Research topics

The detailed research topics of the SHOK in this internationally very active area should be focussed on carefully selected topics where Finland has a possibility to contribute.

Nuclear power technology

Background

At present nuclear R&D in Finland can be divided into two broad categories. In the future a third one should be created in between them. On the one hand, R&D is a precondition for continuing reliable and safe operation of existing reactors. The utilities and safety authorities together with research organizations engage in research and development on reactor safety, which may eventually result in retrofits of existing plants for improved reactor safety. Significant research is ongoing in order to ensure safe spent nuclear fuel management and geological disposal. Plant life management is also an important nuclear R&D field, in order to extend the time for which existing plants can be operated safely and economically. Finland has a strong track record in all these aspects related to the employment of nuclear energy. .

On the other hand, nuclear technology development aims for new and improved plant concepts to be built in the future. A further step into the longer term future is the so called Generation IV plants, a family of advanced nuclear designs including:

- thermal neutron spectrum systems (Very-High-Temperature Reactor (VHTR) and Supercritical-Water-Cooled Reactor (SCWR)) with coolants and temperatures that enable hydrogen or electricity production with high efficiency
- fast neutron spectrum systems (Gas-Cooled (GFR), Lead-Cooled (LFR), and Sodium-Cooled (SFR) fast reactors) that will enable more effective management of actinides through recycling of most components in the discharged fuel; hundred times more energy could be acquired from uranium and also the more abundant thorium could be utilized thus extending the fission fuel resources for thousands of years
- molten salt reactor (MSR).

Research goals

The “nuclear generations” for fission reactors are depicted in Fig 7.1.2. Development of fusion technology is a huge international effort, as e.g. in the ITER experimental fusion reactor project. ITER is a joint international research and development project that aims to demonstrate the scientific and technical feasibility of fusion power. ITER is being constructed in Europe, at Cadarache in France. A new material test reactor will also be built in Europe, the so called Jules Horowitz Reactor (JHR).

Nuclear R&D of both categories (for existing plants and longer term future concepts, respectively) is carried out in Finland today. The power companies have their own development activities ongoing with regards to safety, plant life management and waste management. The national SAFIR 2010 and KYT 2010 research programs are managed by the Ministry of Employment and the Economy and funded jointly by the nuclear utilities and VTT. The Academy of Finland has launched the SUSEN program, funding one project related to Generation IV activities in Finland. There is also ongoing technology development for ITER in Finland, and VTT together with Finnish power companies participate in the Jules Horowitz project.

However, the applied research for near term future reactors, advanced light water reactors has recently been sparse in Finland. The plant currently under construction in Finland (OL3) is not radically different from existing plants, but several new features especially with regards to severe accident management have been incorporated into its design. The know-how on the new construction project as well as on the plant modernisation projects of the operating plants in Finland are valuable starting points for R&D in this area. Also the research institutes and universities have living contacts with the plant vendors and nuclear safety authorities abroad regarding the licensing of new advanced reactors.

Research topics

The SHOK could focus on the following nuclear R&D areas:

- Strengthening of Finnish know-how and technology development in advanced reactor technologies for new reactors, whereas the needs of the currently operating reactors are to be covered by the ongoing national nuclear R&D programs, especially regarding safety matters.
- However, there is a potential to create new business based on the Finnish knowhow in nuclear waste management, and the SHOK should enable this.
- Strengthening of the capabilities of Finnish companies and research organizations to contribute to the large international development programs both on Generation IV and fusion technology. The know-how and capabilities improved by the SHOK should be available also for operating Generation II reactors and for new Generation III reactor projects.
- Strengthening of the ability of Finnish industry to participate in the next reactor projects in Finland (and elsewhere). Numerous countries are going for expansion of their nuclear production capacity, which will result in significant new business opportunities for this industry, which has been strongly consolidated during previous decades.

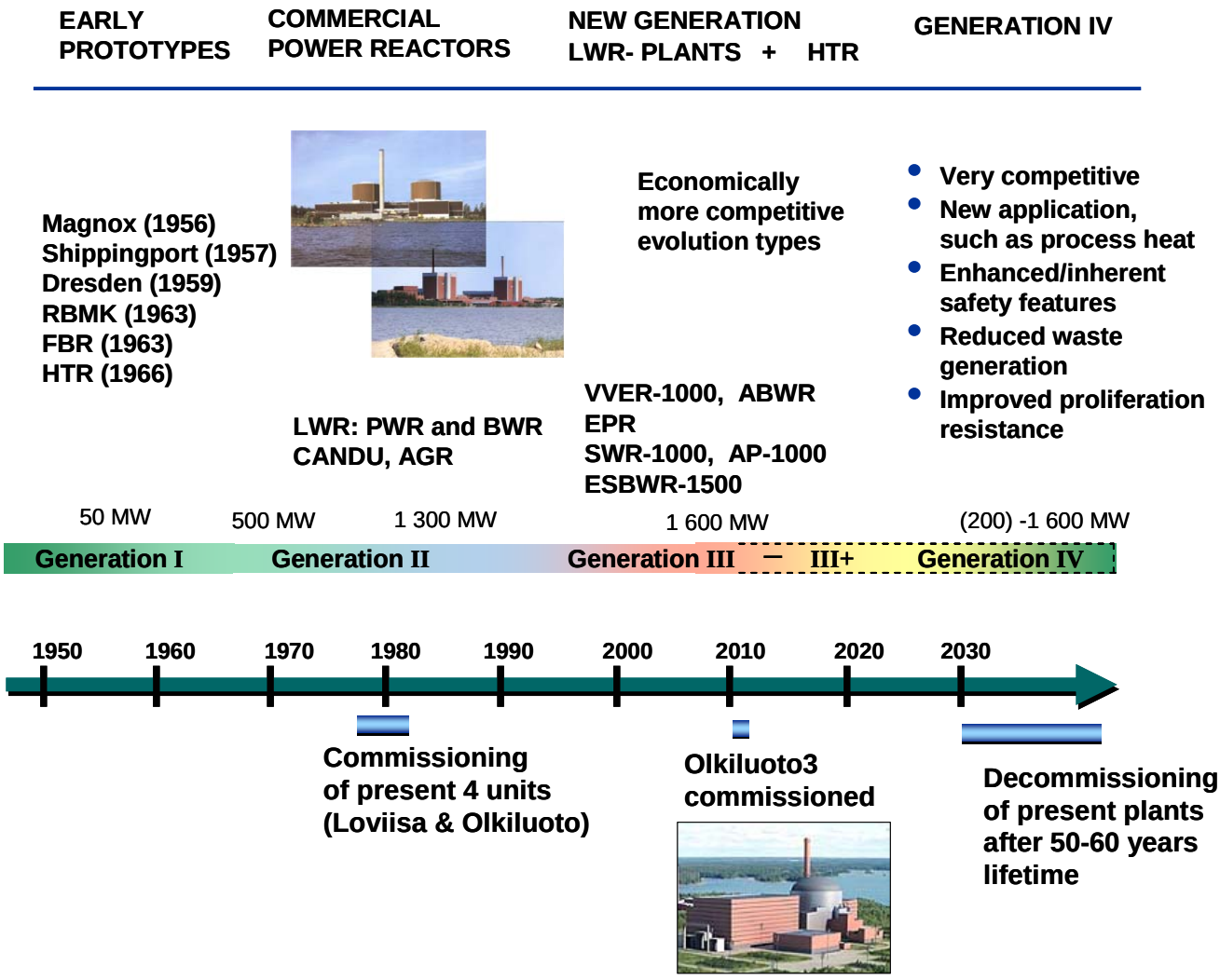

Fig 7.1.2. The evolution of nuclear power

7.2 Distributed energy production

Fossil oil is still dominating the house and small scale heating, however local fuels are replacing oil and gas. Biomass currently accounts for approximately 14% of the world's final energy consumption. About 25% of its usage is in industrialised countries, while the other 75% is used in developing countries. At present, the use of biomass as a traditional fuel is about 38 ± 10 EJ/a, and as modern energy, such as fuel and electricity, about 7 EJ/a.

In Finland, the use of bioenergy can be increased from the present share of 21 % and peat 6 % by 20-50 % by 2020, depending on price levels of fossil fuels and future incentives on renewable energy.

House heating and other small scale applications

Background and trends

In Finland, about 1 Mtoe of light fuel oil is still used for heating of single-family houses and other buildings. It could be replaced by renewable energy sources, such as bioenergy, solar energy and ambient energy using heat pumps.

Research goals and topics

Small scale use of bioenergy for cooking and heating at households has its traditional equipment in every part of the world. The efficiency of those can be improved significantly, and emissions can be further reduced. Heating systems are being automatised to decrease operation and maintenance work and reduce emissions. Highest efficiencies and lowest emissions are reached with homogenous and dry fuel – like pellets or chips – or with several types of bio-oils and continuous operation of equipment. In the future, flue gas cleaning with particle separation and catalysts will be equipped in smaller and smaller units in densely populated areas to reach air quality requirements, concerning especially fine particles.

Development needs

- New types of entrepreneurship: heat as a service product for customer
- Production and logistic systems of new type of biomass-based fuels (solid, liquid, gaseous). Ambitious targets have been set e.g. by Finnish Oil and Gas Federation, 10 % bio oil share of heating oils by 2016.
- Automatic heat production with low emissions in stoves and boilers for main and auxiliary heating purposes

Municipal and industrial plants, CHP and district heating

Background

Nearly one third of electricity is produced in Finland using CHP plants, half of them in industry and another half in municipalities. Various power plant technologies with high fuel flexibility are on the market. Increased use of biomass can replace the use of fossil fuels in CHP plants partially or totally.

The global growth of the world economy causes growing need for energy generation and transportation of merchandise. In particular, the growth is strong in the rapidly industrialising developing countries, which creates an increasing need for distributed energy generation. The increasing price and uncertainty in availability of energy favour reliable high efficiency solutions that are versatile in ability to utilise different fuels. An IC engine offers the efficient basis for highly developed decentralized power generation for fossil and bio mass based fuels.

For decentralised land based energy generation using IC engines, the technology strategy is in particular a strategy of exploiting different fuels. The key issue currently, and in the future, is locating new environmentally sound fuel options and developing the engine technology for

their utilisation. Distributed generation (DG) is typically understood as relatively small plant size, typical range 30kW – 15MW (…100MW), however this is not a strict definition. Usually DG is connected to the utility (grid), which means that normal operating mode is to run in parallel with the utility. A so called island mode operation is sometimes applied in special conditions to provide higher reliability for the consumer. The power generated close to the load gives certain advantages:

- Eliminates voltage step-up and step-down losses (best case, generation at same voltage as consumption)
- Eliminates transmission and distribution losses
- Enables efficient use of heat for various processes; heating and cooling networks

The fuel cell research focuses in developing and commercializing fuel cell power units for distributed land based power generation and for marine auxiliary power. The commercialisation fuel cell technology is expected to realize during the mid term. Solid oxide fuel cells (SOFC) are seen as very potential technology. Fuel cells can also be used for powering land based speciality vehicles. In this case PEFC (PEM) fuel cells would be the technology to use. The research focus is on the design and engineering of the fuel cell system. System integration and application know-how are the key areas.

Objectives

Internal combustion engine power plants RTDD focus on fuel flexibility, efficiency improvements and emission control parallel to reduction of investment and operational cost by various integrated steps. Sustainable power generation requires high electrical efficiency, because the share of electricity in energy consumption is increasing. An IC engine power plant delivers an unrivalled electrical efficiency in its size class, while extremely high total efficiency can be reached by combined heat and power generation. The focus in plant design is on development of modular units with high total efficiency of produced electricity, mechanical power and heat. Process simulation and modelling together with experimental engine research are the essential elements for reaching these goals. The diesel or gas engine is required to have an efficient combustion process, combined with low NOx, smoke and particulate emissions.

The improvement of power-to-heat ratios in CHP plants using biomass is based on the increase in the superheated steam temperature and pressure of steam boilers. The largest plants are designed for 165 bar/545 °C and supercritical values will be introduced in the near future in fluidised bed boilers. The annual fuel consumption of large CHP plants is several TWh (or 10 – 20 PJ) which, in most cases, requires the co-firing of biomass and fossil fuels. The ratio of electricity output to heat output depends on the chosen cycle. The highest power-to-heat ratios – about 1 – are gained with combined cycles and internal combustion engines and in the future even higher ratios are expected with fuel cells.

Research goals and topics

In small scale (under 25 MW_e electricity) combustion technology, and the fuel cell development the main options for electricity and combined heat and electricity are:

- Internal combustion engine development, fuel flexibility and emission control

- Utilisation of coal mine ventilation gas and oil field associated gas
- Natural gas, for base load power, power islands, grid stability services and compressor drives; for IC engines and SOFC fuel cells.
- Advanced technologies for use of light fuel oil, heavy fuel oil and crude oil in power plants, power islands,and ship's power, as base load, stand by and emergency use
- Use of fuel water emulsions, oil sands, Venezuela bitumen, and oil refinery power based on process residue.
- Steam boiler and steam use in steam turbines or steam engines
- Gasification gas combustion in a gas boiler and steam utilisation in steam turbines
- Gasification gas utilisation in a diesel or gas engines and gas turbines
- Use of bio oil, including crude vegetable oil, in diesel engines or gas turbines; conversation technologies for the fuel
- Use of solid biomass for grate based combustion technology
- Stirling engine and ORC process
- Landfill gas or anaerobic reactor gas utilisation in gas engines
- Fuel cells using gaseous biomass or liquid products
- system integration of various energy production, control and end use modules
- Significant increase of overall energy efficiency in the systems
- Fuel processing for fuel cells to enable the use of different fuels
- System efficiencyof fuel cellsS
- System cost for fuel cells by system component development
- Fuel cell system automation
- Thermal integration and thermal components in fuel cell systems
- Development of electrical systems
- Materials development.

In medium scale, the use of low quality biomass with high steam parameters and thus high power-to-heat ratio in CHP plants using fluidised bed boilers or gasifiers is the major future challenge. The new CHP concepts, based pressurised gasification or combustion, have to be demonstrated in full scale. Integration of fuel drying or flue gas condensing to the plants will improve the total efficiency significantly. Multifuel operations will become more important for reliable fuel supply and for filtering the price volatility. Waste to energy applications will be integrated to the power and heat and power generation.

Transportation of merchandise and powering of ships:

Background

Global transportation of merchandise is currently experiencing a strong growth. It can be expected to remain at high level during the medium term and most probably also in the long term. Due to large volumes of the transportable loads shipping is the most efficient and environmentally sound solution for the transportation. An IC engine, operated by liquid or gas fuel, will remain the main prime mover for large container ships, bulkers and tankers.

Research goals

The tightening legislation and competition of market shares drive to further improve the efficiency and environmental aspects in power generation of the vessels. Considerable research efforts are required for lowering emissions as well as for increasing the overall efficiency of the propulsion power, electricity and heat generation. The increasing price of energy enables more complex, sophisticated and expensive solutions in ships to be commercially profitable. The use of gas and gas engines is expected to grow in the mid term, and consequently the R&D efforts in gas engine technology will be increased.

Research topics

The primary research areas in large IC engine technology, whether used as land based, offshore, or ship power plants are:

- Advanced combustion concepts, increased efficiency and controllability
- Fuel injection and (gas) supply into the engine, ability to use multiple fuels
- Ever increasing extreme values of an IC engine
- Overall power plant efficiency, waste heat recovery utilising combined cycle systems
- Development of engine control and monitoring systems
- Development of after treatment methods for exhaust gas cleaning
- Low cost and environmental burden for the engine entire lifecycle

Waste to energy

Background

The Landfill Directive will call for drastic changes in waste management policy. By 2016 only 35 % of biodegrable material can be landfilled compared to the level of 1994. Several countries have already a ban for landfilling any combustible material or biodegrable material. More than 100 waste to energy plans should be built till 2020 to reach the target of waste recycling and energy recovery. In Finland several new waste to energy plants are under planning and licensing phase, typical technologies are mixed waste grate combustion and solid recovered fuels co-firing and co-gasification in fluid bed boilers and gasification. Dedicated systems are coming to demonstration phase, transportation fuels production, ethanol and biogas, in urban biorefineries. In Europe forest, agriculture and urban and industrial wastes are estimated to offer equal volume of additional energy sources for bioenergy. The waste hierarchy provides reduce waste volumes, increase material and energy recovery and reduce landfilling tot the minimum. WtE investments will have significant effect on reduction of green house gas emissions. Waste to energy units are not included in emission trading sector, however the units connected to district heating network are included. Typically municipal solid waste includes 50 % biodegradable material of the net energy value.

Research goals

The countries which still are landfilling large volumes of industrial and municipal wastes, must invest within the next ten years to modern waste to energy plants which can be integrated to

the existing energy, CHP and district heating systems. Due to low quality of mixed waste, the steam values in grate boilers are low. Typical efficiency of electricity generation is 20 – 28 % and power to heat ratio is low in CHP. In Finland like many other countries the challenge is to integrate WtE units to municipal or industrial CHP with various combustion and gasification technologies. The waste incineration directive set limits for emissions and by-products as well as operational regulations. Various WtE energy concepts and technologies are available and will be developed, the driving force is reduced operational cost and improved profit of investments. Technically the target is to increase the overall efficiency to electricity, process heat, district heat and transportation fuels in large urban scale and distributed systems for middle scale cities. In Finland about 5-10 new large WtE units should be built, additionally in small scale applications and niche markets in industry offers favored demonstration investment potential. Small scale investments in agriculture for biogas and integrated systems offer large duplication potential, although with increasing competition of coming from foreign plant suppliers.

Research topics

RTD targets are focused on system approach, integrated material and energy recovery concepts, solid recovered fuels production and quality control, co-combustion, gasification and pyrolysis techniques, emission and by-products control, boiler tube materials. There has been several research programmes, the target should be more on integrating the RTD activities to demonstration or construction of commercial units in order to get the result implemented on the market. On top of component development it is crucial to integrate larger concepts and systems to new investments in order to meet in time the targets set by the EU Landfill directive in 2016. The RTD and technology activities must be integrated also non technical barriers in order to get new solutions on the market, a convincing value chain in most development projects are needed.

7.3 Sustainable fuels

Solid biofuel production and fuel chains

Background

The potential biomass resources from agriculture, forests and industrial processes are ample, but the costs and reliable fuel supply of biomass at plant are hindering the increase of the use of biomass. The efficiency of the procurement system of biomass is highly dependent on the environment and infrastructure in which it is operating. In addition, economic, social, ecological, industrial and educational factors, as well as local traditions, have an effect on efficiency. Every link in the production chain has to be optimised to improve profitability without compromising quality and supply security.

Research goals

The procurement system of biomass consists of a sequence of individual operations performed to process biomass into commercial fuel and to transport it from source to plant.

The typical phases of procurement are purchase, cutting, off-road transport from forests or fields to roadside, chipping, measurement, secondary transportation from roadside to the plant, and receiving and handling at the plant. The system needs the organisation, logistics and tools to control the process.

Research topics

- Resource assessment forecasts in relation to spatial distribution, availability factors and climate.
- Develop biomass cost- supply curves in relation to availability factors, costs and life cycle analysis.
- Develop plant/ tree varieties (crop breeding and physiology) and optimise associated management practices (propagation, cropping systems, etc.) to meet conversion requirements.
- Improve knowledge of breeding tools and apply existing biochemistry techniques to selected energy crop species.
- Develop harvesting and collection systems (new equipment, new chains) to maximise supply by minimizing costs per unit.
- Develop physical and chemical pre-processing methods (including blending and fractionation), systems and strategies to provide homogeneous feedstock for large scale applications thus meeting the quality requirements of the conversion technologies.
- Advanced peat production technologies and environmental impacts
- Safety and standardisation issues covering the full supply chain.

New production chains need to be demonstrated in full-scale.

Biofuels for transport

Background

The EU Biofuels directive set a target of 5.75 % by 2010 and the new proposal a mandatory 10 % by 2020 from the energy used in road traffic. The Biofuels for transport industrial technology platform set a vision of 25 % by 2030. The primary energy demand is enormous, e.g. 10 % target by 2020 represents about 35 Mtoe/a, and if a typical conversion efficiency from solid biomass to biodiesel and gasoline is 50 %, the generic raw material demand is 70 Mtoe/a. In 2005 total Bioenergy consumption in Europe was in order of 60 Mtoe/a ~ 2.2 EJ/a. Today about 2.5 % of biofuels are used in Europe. More than 3 % in US, where the target for 2030 is 20 % share of biofuels. Ethanol from cereals and sugar cane and biodiesel-RME from rape seed and soy are dominating the first generation biofuels production. Major concern has raised due to minimal savings in net green house gas reduction and energy economy, sustainability aspects of raw material production and high additional cost compared to fossil motor fuels. The dominating biofuels implementation strategy is to use low blends, 5 vol-%, of biogasoline or biodiesel, and ethers like ETBE in order to reach large volumes. Dedicated systems like E85 in flexible fuel vehicles, FFV and biogas driven gas vehicles are introduced

in fleet operations in some countries. Various national implementation policies have been seen, next ten years will need crucial investments in order to meet the set targets. For example if a 100 000 toe/a synthetic biodiesel plan has an investment of 300 million euro, and in Europe more than 100 are needed till 2020, the total demand is 30 milliard euro.

Objectives

The second generation biofuels are offering significant improvements in green house gas balance, overall efficiency of production from lignocelluloses materials, additional cost are reduced and tail pipe emissions can be reduced significantly. Dominating production technologies are synthetic biodiesel, alcohols and ethers production by gasification to synthesis gas and Fisher-Tropsch synthesis or similar processes and alcohol fermentation of lignocelluloses materials. Several new concepts and processes are under research and development phase, next 5-10 years will need enormous RTDD investments. Major focus is the biofuels production technologies including the reliable, sustainable raw material supply. Biofuels are mainly used in gasoline and diesel blends up to 10 vol-%, however the products e.g. FT-diesel qualities can be blended even up to 50 % or more. Dedicated vehicle techniques will be developed like FFV with reduced tail pipe emissions, biogas or methane vehicles. Global oil and automotive industry is looking major strategies for multifuel operations like FT-diesel, gasoline, jet fuels and heating oil production from synthesis gas produces from coal, natural gas, tar sand and biomass. Biofuels production integrated to global forest industry operation is a key focus in Finland, also combining the joint interest of energy and forest industry with equipment manufacturers.

Development needs

- thermochemical conversion processes to biofuels like gasification, pyrolysis, catalysis and synthesis technologies
- biotechnical conversion processes, fermentation to alcohols, biogas and other products
- process and system integration to CHP, forest and food industry and agriculture
- sustainable and reliable raw material supply, LCA
- transportation fuels qualities, fuel standardization and regulations
- engine and vehicle development for biofuels, emission reduction, drivability
- laboratory, process development units, pilot infrastructure, significant demonstration investments
- modelling, simulation, new business concepts for international trade
- biorefinery integration when significant cost reduction can be seen
- long term options to sustainable hydrogen economy.

Hydrogen production for fuel cells

Large RTDD activities are focused on fuel cell development and the fuel conversion technologies to hydrogen. Natural gas is a typical fuel, by a reforming step it can be feeded to various types of fuel cells. Large scale stationary applications will need a total new type of sustainable hydrogen production technologies, storage and logistics solutions. Various

primary energy sources will be used; nuclear, renewable energy sources, natural ga and oil products.

7.4 Energy market and smart grids

A smart grid (energy system, especially an electricity system) is a customer-driven marketplace for distributed generation and consumers. Smart grids provide cost-efficient grid and market connection for consumers and distributed generation, enable efficient operation of centralised and distributed generation, offer services to promote consumer-level energy efficiency and energy saving, and guarantee uninterrupted and high-quality supply of energy.

Background and trends

Energy market has been opened up for competition worldwide during the past 10–15 years. The energy market includes three main business areas: energy production, energy transmission and distribution, and energy suppliers. In the future, services offered to energy users and small-scale power producers will play an important role also in the business. The Nordic countries have a long-term experience of the opened energy (electricity) markets, which gives us a competitive advantage when developing new products and services for the global market.

The power grid (transmission and distribution) is a common marketplace for consumers and producers. The European vision is to have one common electricity market area with a high penetration of distributed power generation.

The future electricity market will be more or less a customer- and small-scale power producer-driven market. This calls, for instance, for intelligent demand response actions based on market price and energy saving goals. The traditional centralised power balance (production = demand) control systems will be integrated with customer-based actions.

The two-way on-line communication between a customer and the market (gateway) will be the key for the rapid development of market functions. Already at present, the development of AMM (automated meter management), telecommunication and information systems makes it possible to provide a cost-efficient and real-time connection to each consumer and producer.

In parallel with the market development, the requirements for security and quality of supply will be more and more critical. Questions concerning sufficient energy and power production capacity, adequate power transmission capacity, reliable distribution networks and stable operation of wide-area power grids including a lot of distributed generation are more difficult to solve in an open energy market.

Furthermore, the renovation of the old infrastructure of energy systems is a major challenge. However, the renovation is also a great chance. In the renovation process, it is possible to apply the modern technology with intelligent information systems.

In addition to the above, a high penetration of plug-in hybrid and electric cars having a grid connection will have significant impacts on the market and infrastructure.

The increased complexity of energy systems and impacts of the climate change (storms) are threats to the continuous energy-dependent society. This sets more critical requirements for the reliability of energy grids.

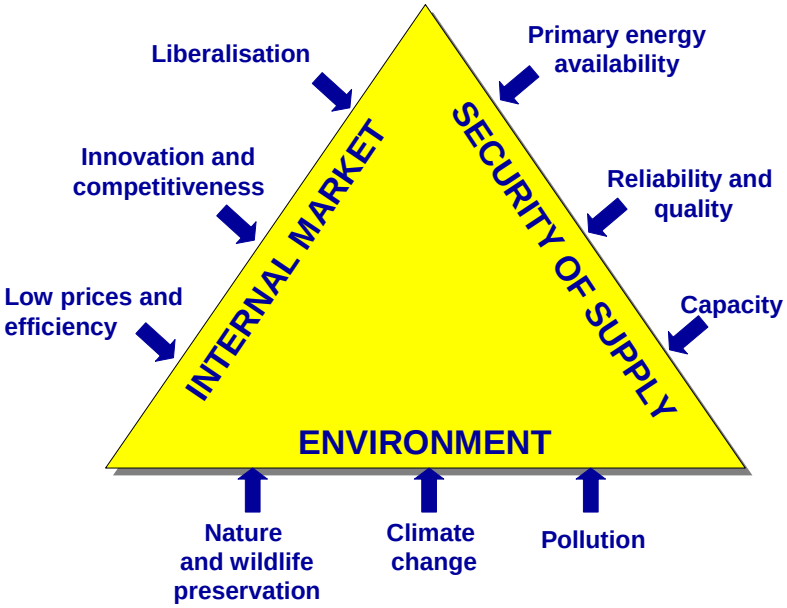

Fig. 7.4.1. Enablers and drivers of the energy market /SmartGrid Technology Platform, EU/

Based on the characteristics of smart grids, it is possible to reach energy infrastructures and systems having a lower total capacity and emissions compared with the structures based on the existing technology and systems, Figure 7.4.2.

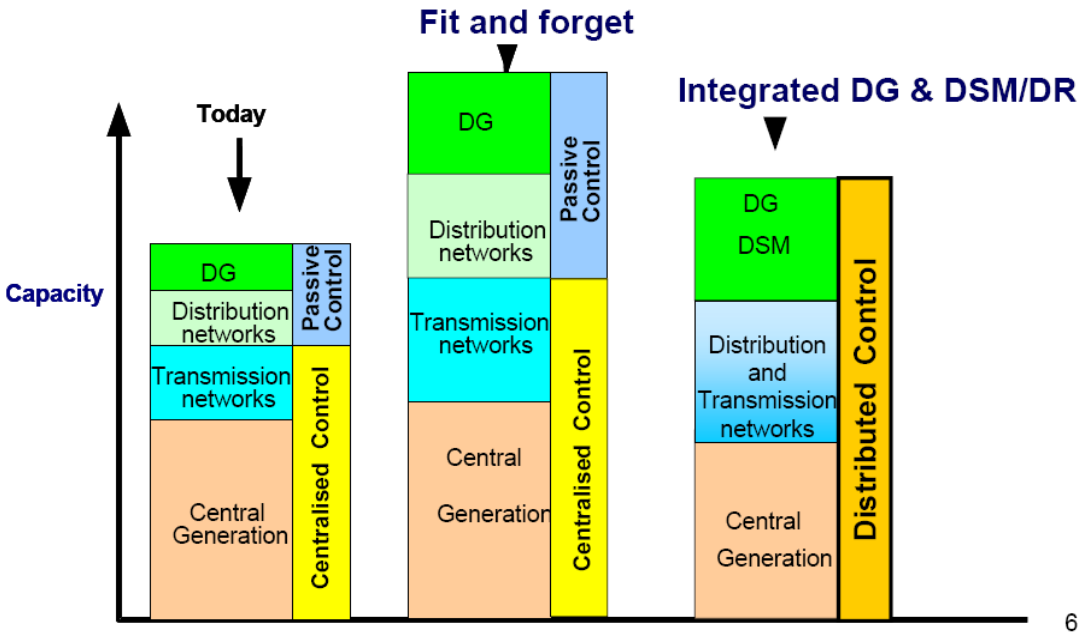

Fig. 7.3.2 Impact of a smart grid on the need for energy system capacity

Research goal

There are two main goals for the research to be conducted in Finland. The first goal is to generate new scientific knowledge, information and technology for physical products, information systems and services to be applied in the global energy market. The second goal is to provide solutions for the domestic energy policy and energy grid renovation process.

The main areas of research will be: a foresight of the global energy market, market structures, grid infrastructures, intelligence of grids, characteristics of customer- and DG-driven energy market, services and business models.

Research topics

The following research topics presented are mainly determined based on the existing and estimated future competencies and strengths in Finland.

The main research topics in the field of energy market.

Market development

- development of the global energy market (Europe, Russia, the USA, Asia)
  - market development; scenarios, enablers and barriers
  - regulation, legislation
- scenarios for the operational environment
  - technology, regulation, environment, customer needs

Market mechanisms

- market principles for electricity and emissions trading and their impacts
- principles for the European-level opened retail market
- integration of the European and Russian energy market
- methods for identifying the main characteristics of well- or poorly functioning energy markets
- regulation principles for long-term opened energy markets

Energy Politics

- impacts of global and national energy politics and policies; customer, society, energy companies

The main research topics in the field of smart grids.

Future infrastructure of energy systems

- new architectures and technology for energy networks with active interfaces to consumers (including a high penetration of plug-in hybrid and electric cars) and distributed generation
- transition strategies from the existing system to new architectures

Intelligent management and operation of smart grids

- management concepts, operation methods and information systems for two-direction energy flow networks having a large DG penetration, energy storages and customer demand response actions

Customer gateway

- concepts, methods and technology for active customer/producer interface enabling
  - demand response, on-line market (price)-oriented load and DG control
  - frequency-based load control during local or system-level loads and generation unbalance situations
  - services for customer-based energy efficiency and saving actions

Energy and emission services

- concepts, information systems, and business models for end-user energy efficiency and energy-saving actions
- concepts, information systems, and business models for management, operation and maintenance of small-scale power production

Demonstrations: In parallel with the research projects, there will be wide-scale demonstrations of future smart grids. The demonstrations will be realised in Finland in co-operation with international partners.

In addition to the above research topics, there will be some interesting long-term research areas. Revolutionary innovations and a breakthrough in these fields can dramatically change the whole energy infrastructure. The most interesting topics are:

- superconductivity (superconductors, energy storages)
- ubiquitous energy production (fuel cells, solar, wind, etc.)
- ubiquitous energy storages (batteries, etc.)

Participating industry and business opportunities

The results of the above research topics improve the existing strengths of the Finnish energy industry. The results will also give a strong basis for totally new business areas and products. Examples of the areas, where the Finnish industry may be in a leading role in year 2020, are:

Physical products

- components for smart electricity networks;
  - automation devices
  - power-electronics-based switchgear
- interactive customer interface (gateway)
  - physical network connection including power electronics
  - intelligent metering devices and systems
  - connection of plug-in vehicles
  - balance settling devices
- building automation integrated with a customer interface
- energy storage systems

Operation and planning information systems

- network planning and simulation software
- decision-making systems for asset management
- energy management systems
- VPP (virtual power plant) operation systems
- distribution management systems

- management of micro grids
- metering databases
- on-line management of loads, balanced settlement
- plug-in vehicle balance settlement systems
- house control systems

Services

- metering data (energy, quality, alarms, etc.) warehouse
- VPP management
- energy (energy efficiency, energy saving) services
- planning of energy systems
- comprehensive asset management services
- consulting

The main players and stakeholders will include energy companies, energy industry, ICT companies, service providers, consulting firms, and energy-intensive industry.

7.5 Efficient energy use

Background

According to the IEA Energy Outlook 2006, the global energy demand increases about 50 % and electricity demand about 100 % by 2030 with the present policy (Reference Scenario) meaning also huge investments into energy infrastructure. CO2 release would increase totally by more than 50 % in energy sector and 60 % in electricity. The Alternative Policy Scenario analyses how the global energy market could evolve if countries were to adopt all of the policies they are currently considering related to energy security and energy-related CO2 emissions. In this scenario energy demand is about 10 % less and CO2 release 16 % less than in the reference scenario. Policies encouraging more efficient production and use of energy contribute almost 80% of the avoided CO2 emissions in 2030 (Fiq. 7.5.1)

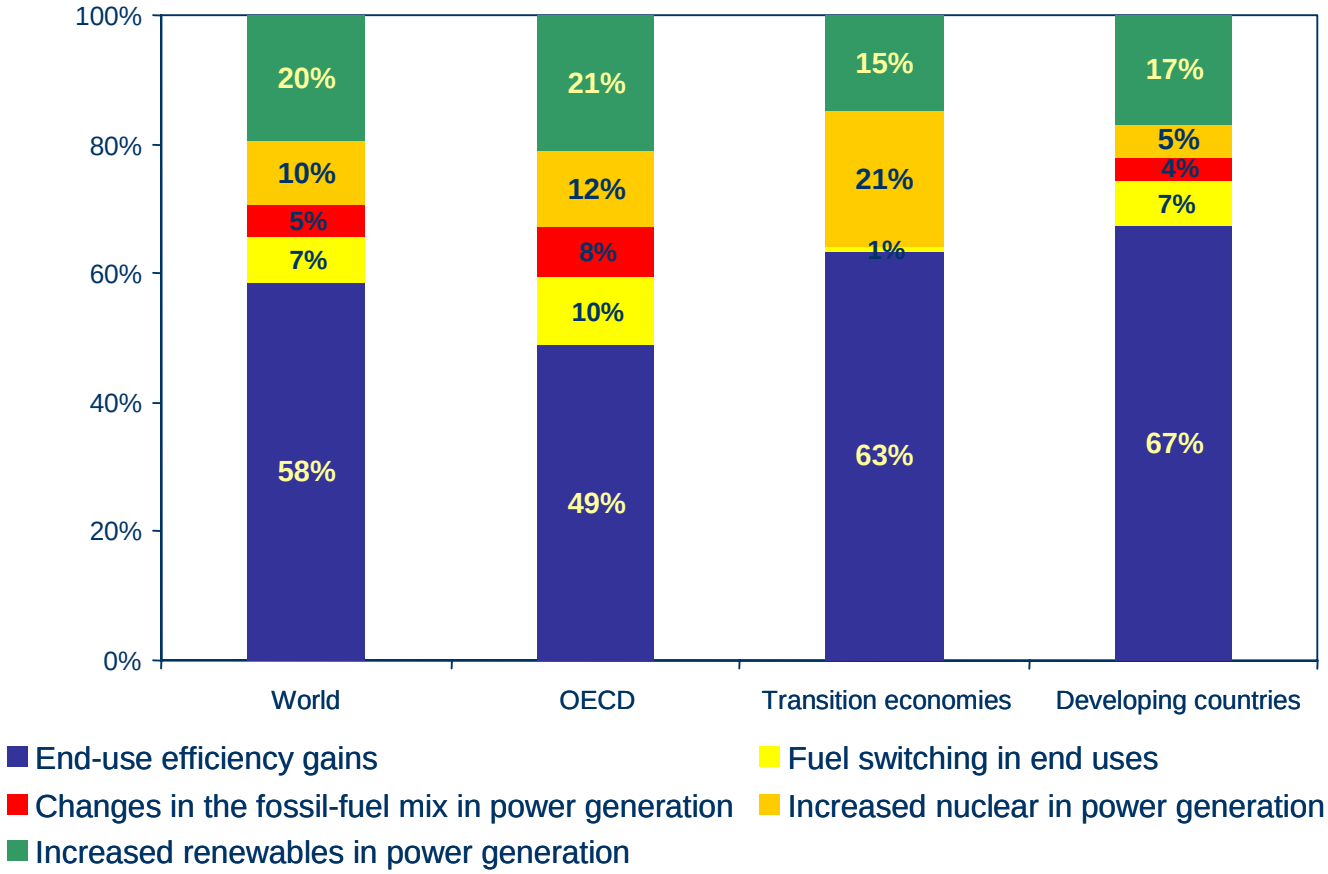

Fig. 7.5.1. Improvements in end-use efficiency contribute for more than half of decrease in emissions, and renewables use for 20% up to 2030

This means additional investments into energy efficiency and less in energy supply: additional investment in electricity end-use are about 950 Bilj.$ and 2360 Bilj.$ totally. The share of industrial sector from these additional energy efficiency investments is about 15 %, transport 45 % and residential and service sector about 40 %.

EC is accordingly aiming to 20 % target in the energy efficiency improvements by 2020. Directive on energy end-use efficiency and energy services is targeting to 9 % savings by 2017 in sectors outside emission trading sectors.

Thus there are several driving forces behind the energy efficiency improvements like environmental, economical and energy security related aspects (lower energy consumption decreases dependence from imported energy). In general, the cost-effectiveness of energy saving investments is good: IEA estimates that 1 $ invested into end-use decrease investments in supply side by 2 $. The increase of energy prices still improves the situation. Technology development supported by the intensified R&D accelerates the development. Important factor is also the increased awareness of end-user on the energy efficiency and environment.

In addition to end-use efficiency it's important to study the whole efficiency along the energy chain. There are many possibilities to improve the efficiency in distribution and transmission,

in energy conversion process and in primary energy production and transport. Figure 7.5.2 illustrates the improvement potential in each stage of energy chain.

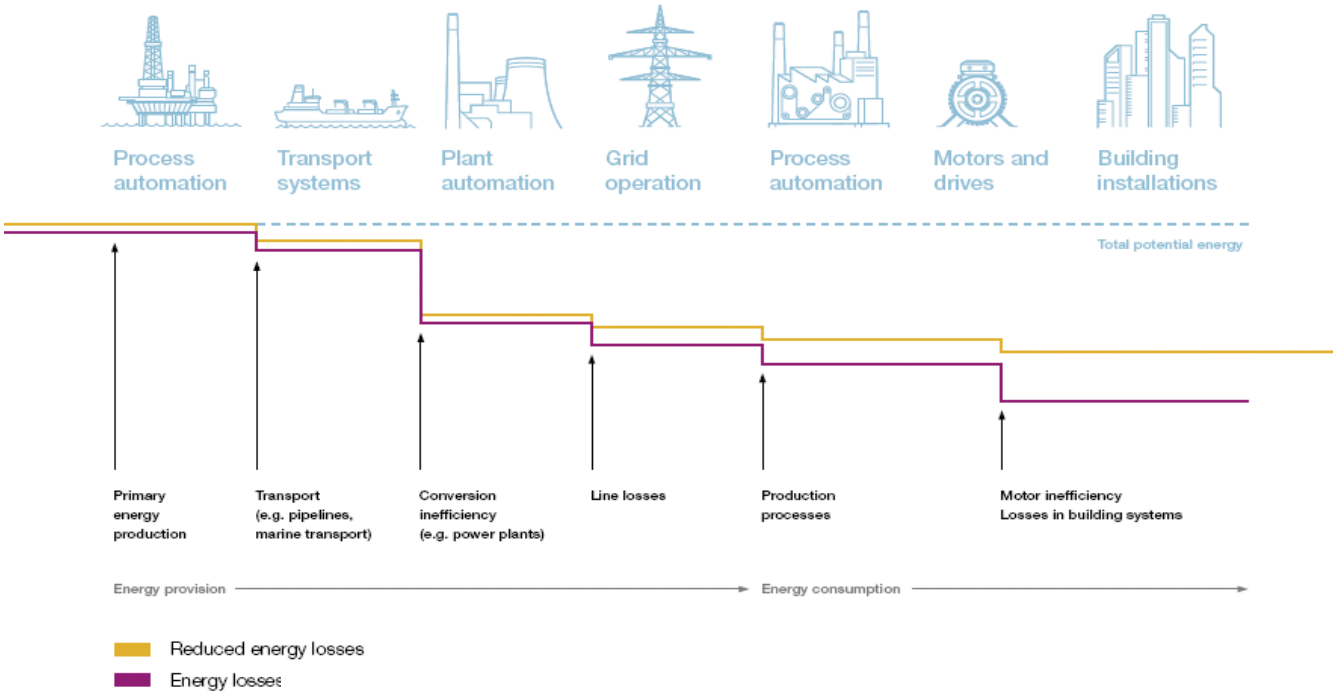

Fig. 7.5.2. Energy efficiency improvement potential in each stage of energy chain.

In Finland the energy efficiency is considered to be quite high in some sectors like in power generation due to high share of CHP, in space heating and in certain industrial processes. However, the global and EU framework still requires considerable improvements also in the energy efficiency inside Finland. This implies the further needs for the development of new technologies and gives possibilities to demonstrate these in Finland.

The development of energy efficiency inside Finland is resulted in the development of knowledge and industry which in certain sectors already is in global market. On the other hand, as can be seen from the above scenarios the global energy efficiency market is increasing rapidly which gives the high potential for the export of the industrial products, knowledge and services. It has been estimated that energy efficiency market are over 100 mrd.€ in 2020 and the share of Finland could be 15 %. If this share can be kept also in rapidly increasing market, the turnover in 2030 could be 40 mrd.€

To achieve and keep this market share in global energy efficiency market presumes considerable investments into R&D work as well as demonstrations inside Finland.

Research goals

Energy use and efficiency improvements can be considered at different levels including the whole energy chain from the fuels to different end-uses and material chains from raw materials to final products to customers. In this connection the focus is in the direct use of energy at different sectors and in the indirect use of energy in products and services to

customers. Actually major part of indirect energy use is coming from the manufacturing industry and its processes and can also be defined as an energy use in industry: in addition to that is energy used in the raw material production, in transportation and logistics of the delivery of products and in the recycling and waste management of products.

It seems that a systematic analysis on the status and potential of energy efficiency is needed covering the whole energy, product and services chains where potential of energy efficiency improvements and technologies both at component, sub-process and process integration level are analysed (see Fig 7.5.3). This analysis gives a good background for the long term research and for the business opportunities and at the same time shows how the national goals for the energy efficiency can be achieved cost-efficiently.

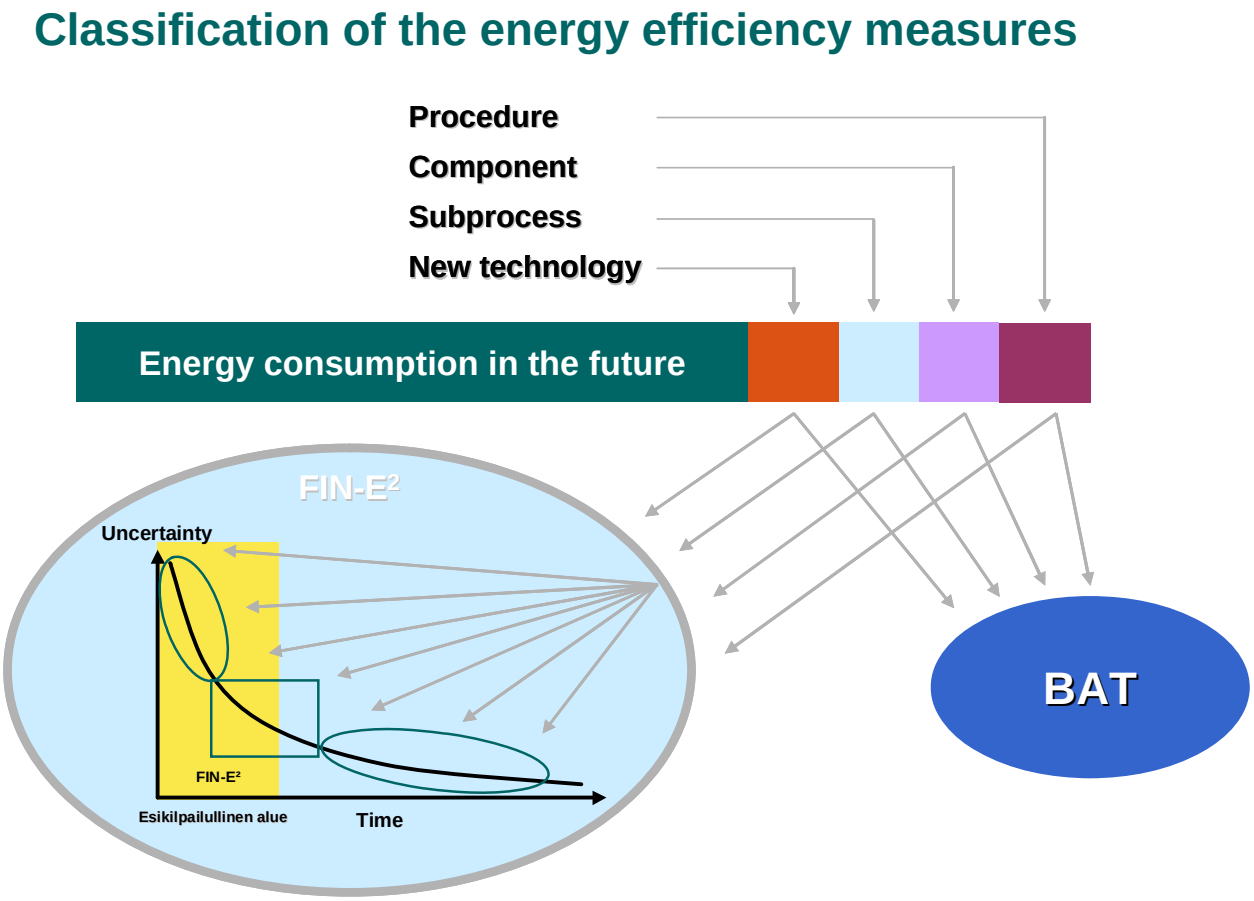

Figure 7.5.3. Assessment of the energy efficiency measures. BAT= Best Available Techniques.

At the same time the focused research can be started at different sectors of energy use including

- energy use in the manufacturing of products and delivering services
- Energy use at community level
- energy use in households and buildings
- energy use transport and logistics
- energy use at leisure time and in related services

Research Topics

Starting point could be the abovementioned comprehensive analysis of whole energy efficiency chains and at the same time to concentrate to some selected specific sectors.

The following list describes the main topics based on the discussions with industry and it also gives some examples on the items below the main headings:

The decrease of the energy intensity in products and services

- The improvement of the energy efficiency in end-uses at different kind of end-users
- The optimisation of the product characteristics on the basis the efficient use of energy and raw materials (total optimisation)
- The development of new products and services resulting from the global warming

The improvement of energy efficiency in industrial processes

This is dealing with the manufacturing of products and services to the industry and end-users. Different types of energy conversions are considered like electricity – mechanical motion, electricity – heat, electricity – light, heat recovery from the low temperature/waste heat to working temperature:

- Mapping of the energy saving possibilities in processes/ Total optimisation of processes including energy, raw materials, environmental effects etc. (measurements, modelling, simulation)
- Development of more efficient processes/manufacturing methods (taking into account the optimised product characteristics
- Increased automation
- Development of the human behaviour in the operation of processes and systems
- Development of new concepts for the efficiency improvement (business models)

Development of the components or subprocesses

- Development of methods and principles for the dimensioning, simulation and modelling
- Automation
    - regulation anf control technology
    - Power electronics
    - control of electrical drives
- New materials
    - Super conductors
    - Carbon nanotubes
    - Materials of power electronics
    - Hard magnetic materials
    - Soft magnetic materials
    - Insulating materials
    - Structural materials
- Integrated concepts with automation-motors/generators- working machines
    - Material efficiency
    - Minimisation of losses
    - Improvement of reliability
    - Maintenance

  - Life cycle assessment
  - ie. new consepts for wind power plants, electrical propulsion systems
- Recovery and utilisation methods of waste energy
- Energy storage

Energy management

a. integration of energy and process management

Demonstrations

Demonstrations depend on the selected research topics. Domestic demonstrations as a part of the improvement of energy efficiency in Finland will give a strong basis also for the export.

7.6 Ressource Efficient Production Technologies and Services

Background and trends

Environmental concern has increased the pressure to reduce material intensity of production and to minimize emissions from process industry. Efficient production technologies, which also take care of environmental issues, mean high material efficiency with low pollution to environment. There have been many driving forces behind this development, for example growing concern over the environment, increasing price of raw materials, tighter legislation and a better understanding of how to control emissions during the processing of various raw materials.

The environmental load consists of air emissions, effluents and solid wastes, Figure 7.6.1. In addition, noise and vibrations as well as heat are considered to be a part of the environmental load; they cannot be calculated in the same way as other impacts, however.

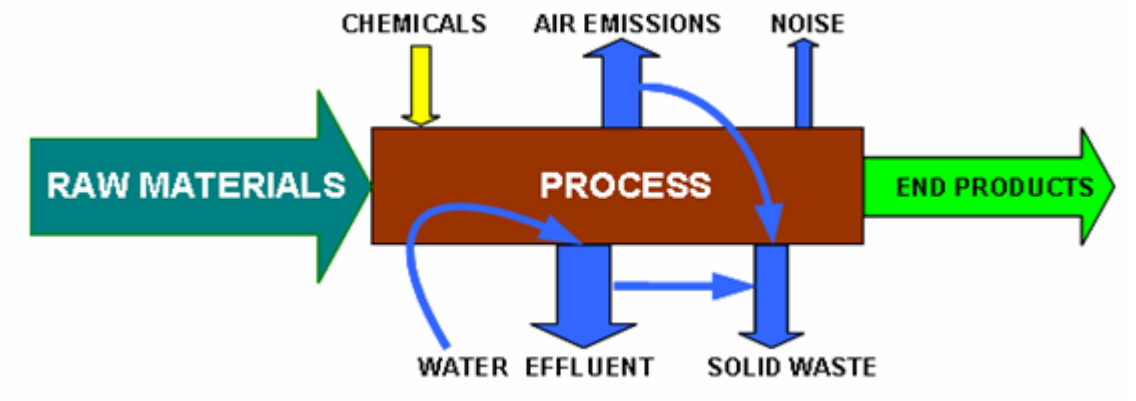

Figure 7.6.1. A schematic flow diagram of the environmental load from process industry

Put simply, it can be claimed that the best way to decrease the environmental load discharged to air, water and soil from a particular process industry is to increase the process yield, reduce its resource- and energy-intensity or utilizes those waste streams that are unavoidable. The qualitative and partly quantity aspects of the environmental load are greatly dependent on the following:

- Raw material: quality of raw material, other additives and raw water used in the process
- Optimisation of process or unit processes: optimal temperature, control of chemical, physical and biological phenomena to maximized resource- and energy-efficiency, process control and automation
- Effectiveness of external and internal purification of air emissions and effluents, recovery and recirculation or utilization of valuable components, heat and energy
- Reduction of noise, vibration, odour emissions and safety risks.

As discussed above the environmental efficient production technologies forms a very complicated area, where care should be taken of special properties of each branch of industry. Since the trend in process industry nowadays is to focus on core competencies (producing main product), environmental efficient production gives new business opportunities for many special companies. Some companies have already outsourced the handling of fresh water, effluent and solid wastes and this development will increase in the near future.

Research goal

The aim is minimise the environmental load from process industry increasing also the material efficiency of the processes. The ultimate goal will be clean and waste free industrial processes.

Research needs

The first need is to design innovative products and processes, and to optimize the existing processes so that resource use and the environmental load are reduced while delivering the same service or achieving the same or better yield of main products (internal approach).

The second need is to improve the resource efficiency of industry by thriving at the recovery of valuable compounds from gaseous, liquid and solid by-product and waste streams as a part of the process and thence develop multi product systems.

The third need (external approach) is how to offer competitive services for companies which produce significant environmental load as a form of effluent, sludge and solid waste.

The fourth need (external approach) is to improve the utilization of unavoidable solid wastes in an environmentally effective way to avoid expensive land filling.

Selected research topics

- Process and product optimization for reduced resource use and less environmental load (air emission, effluent and solid waste)
    - Thermodynamic modelling (high temperature processes and low temperature processes in water phase)
    - Efficient pre-treatment methods for decreasing the amount of harmful compounds in raw materials before introduced in main process
        - Physical
        - Chemical

        - Biological
    - Development of internal process water treatment methods and increasing the recycling rate of process water
    - Development of modular easily replaceable technologies and components with better serviceability and better adaptation to future changes of the operational environment

- Efficient fresh water and effluent purification system with genius sludge handling systems
    - Advanced, energy efficient water treatment technologies and concepts, and combinations of technologies
        - Potable and raw water treatment
        - Disinfection
        - Biological / chemical effluent treatment
        - Oxidative waste water treatment
        - Continuous odour removal from waste water treatment and sludge handling
    - Technologies for specific separation of micro impurities
    - Smart, self-adaptive water treatment technologies
    - Green water chemicals
    - Advanced methods for separation of new products or raw materials from waste water diminishing various types of sludges in effluent purification process
        - Primary sludges
        - Biological sludges
        - Tertiary sludges
    - Energy efficient dewatering of sludges
    - Safety aspects, including risks of new materials and chemicals in water environment

- Resource efficiency
    - Development of multi-product systems reducing the amount of wastes and effluents leaving the process
        - recovery of gaseous compounds from process emissions
        - effluent treatment and recovery/recirculation of valuable compounds within the process
    - Recovery of waste heat and energy
- Solid waste (including sludges) handling in a way which promotes waste utilisation and decreases the need of land filling (see 5.7)

- External purification technologies
    - Technologies for removal of small particles and organic compounds from air
    - Continuous odor removal methods
    - Noise abatement

7.7 Recycling of materials and waste management

Background

The strengths of the Finnish waste management industry include metal recycling, mechanical recycling technologies, waste collection and recycling concepts, as well as engineering and consulting services on waste collection, logistics and planning. As a sparsely inhabited country Finland has developed cost effective technologies and concepts for waste collection and source separation. The utilization of bulk waste from industries and other activities, such as slags, ashes and construction waste, is on a good level. Decentralized small-scale utilization concepts, especially for biofuel or biogas production are on their pathway to larger market.

The larger companies have already established their position in Finland, and they have also expanded or are expanding to international market. In addition, new smaller companies with innovative waste recovery and utilization technologies and concepts have been introduced to market. The integration of waste management to the material and energy chains of the society has brought new actors to the value chain, e.g. waste producers (so called producer responsibility principle) and users of recovered materials.

In future, the predicted shortage of natural minerals and increasing energy prices make the material recycling both necessary and economically highly viable. The rapid growth of recycling and waste management market creates new market opportunities to companies that are ready to answer the new global challenges.

The challenges of recycling include amelioration of the quality of recycled fluxes as well as development of cost-effective recycling technologies for new material flows. The technologies have to lead to a better energy and environmental efficiency as well as better material recovery rates. This is emphasised by new European waste legislation which incorporates the life cycle management perspective to the recycling and waste management.

New or improved technologies for the sorting of environmentally and economically important waste material flows (e.g. metals, WEEEs, plastics, automotive shredder residues, etc.) are needed. They include improved automatic identification units, as well as sensors and measuring technologies for the quality assessment of sorted or unsorted fractions. Technologies for effective recovery of the most precious metals which exist in small amounts e.g. in electronic waste, and other low-grade materials are also needed. In addition to mechanical technologies, the opportunities of chemical, thermal and biological technologies should be exploited. One challenge is recycling of new materials, such as composites, nanomaterials, electronic waste and carbon fibers.

Technologies for production of biofuels or biogas from organic waste, plastics, etc. are developing rapidly. More energy efficient technologies are still needed as well as technologies using lower level wastes, such as household biowaste. The utilisation or the energy potential of waste as Solid Recovered Fuel (SRF) is growing. Finland is in forefront of developing the concept of material recovery and co-combustion of SRF. The R&D needs of SRF concept relate in adjusting and modifying the concept into various market conditions.

Stringent objectives for waste and material recycling generate also need of smart logistics systems based on modelling, automatic identification technologies and data transfer methods, and integrated waste collection and source separation solutions. The integration of waste management into the material and energy recovery chains creates new markets for comprehensive and environmentally effective technology + service -concepts.

Research goal

The goal is to develop new material recycling and recovery technologies, concepts and services which result in high-quality recycled materials, fuels and products. In 2015 the Finnish companies will be internationally well-known from life-cycle optimised energy and material effective recycling solutions and environmentally sound and cost-effective integrated waste management services. They are well established in international markets both as product and process suppliers and service providers.

Research topics

The research focuses to:

- Advanced solutions for recycling of complex and new materials, and for recovery of valuable substances from low-grade materials
  The legal, technical and environmental requirements as well as the shortage and growing prices of raw materials steer to increased material recycling, whilst the advanced technologies produce more and more complex materials, and the variety of materials in products is increasing. This leads to the growing need for the recovery of high-quality materials from low-grade and complex materials, using material and energy efficient recycling solutions.
  - Competitive, material- and energy-efficient technological solutions for recycling of new and complex materials (metals, electronic scrap, composites, plastics, low-grade materials, nanomaterials), including new or improved automatic identification units, and advanced mechanical, chemical, thermal or biological technologies.
  - Development of process control
  - Optimisation of the recycling chain, life-cycle assessment of the recycling solutions.

- Refining concepts for industrial wastes and residues (ashes, slags, construction and demolition wastes, mine waste, tyres, biowaste, etc.)
  The objective is to develop cost-effective solutions for treatment and refining of bulk wastes to technologically and environmentally applicable products. In addition to present applications, the aim is to find more competitive “higher-quality” applications.
  - Solutions and technologies for environmentally and cost-effective production of more competitive materials or products, such as building and construction materials, raw materials of industrial processes, materials for environmental technology solutions, and production of fuels and chemicals. Recovery of environmentally hazardous compounds may form a part of these solutions.
  - Modification of production processes or raw materials to produce better quality by-products (process optimisation)
  - Efficient sludge and biowaste treatment processes producing energy, fuels and soil enrichment materials

- Creating the material “market place” where the essential properties and quantity of industrial based solid waste (mainly inorganic material) is introduced for all industry fields as a potential raw material

- Decentralized waste management and recycling
  As a sparsely inhabited country, Finland is an optimal development base for small, modular recycling solutions. They may be more cost-effective and reduce environmental impacts compared to centralised solutions. The market potential of this kind of technical solutions and service concepts in developing countries, and sparsely inhabited areas is significant.
  The research topics include:
  - optimisation of recycling chain including collection, treatment stages, and product distribution
  - development of optimal waste collection systems
  - development of more effective small-scale treatment and pretreatment technologies for example for organic and biodegradable wastes.

- Innovative technology - service concepts
  Service business is an important part of waste management, and innovative life-cycle optimized technology –service concepts is a cross-cutting theme (has synergies with) in all the above-mentioned focus-areas.

  There are basically two different approaches to look at service business: Service as an activity and service as business logic. The idea of service as business logic is to integrate products and service activities into an integrated customer relationship based service business. This approach is well described in MeKO-SHOK research agenda and it is very similar to those EnYm-SHOK participants which provide technology, processes and devices to their customers globally. The target is to get sustainable competitive advantage by integrating service logic to ordinary process and product sales.

  “Service as an activity” approach is very typical to environmental services like waste management and recycling. There one does not supply only a plant or process but may take care of servicing an entire area or city including all logistics and processing needed to accomplish a task. Customers may be not only a single partner like city council but thousands or tens of thousands of companies and properties which produce waste. Domestic service concepts are a good base to offer integrated waste management and recycling services abroad. Because of differences of waste composition, people awareness, readiness to utilize modern technology and affordability to pay for services provided there is much to do to adjust and modify concepts to suit to the needs of different markets.

7.8 Monitoring, measurement and assessment of environmental efficiency

Background

In the past, environmental monitoring has been mainly a regulatory burden and of interest to authorities. The need of target specific environmental information and use of data for control of various industrial and operational processes is, however, rapidly growing. Environmental legislation, international treaties and increased environmental consciousness of citizens set new requirements for environmental monitoring and data management. Adequate monitoring and process control systems are an essential prerequisite of closing of the cycles, production of high-quality recycled materials and confidence to the quality of recycled water. Early warning systems and identification of risks (e.g. risks of extreme weather events, hygienic risks, accidental risks, terrorism) are based on measurement and monitoring methods.

The development needs in the field of measurement technologies are various, including new on-line monitoring technologies for quality control of recycling processes and recycled products, hygienic quality of water, new water impurities, and simple but reliable indicators for identification of accidental emissions, operation control of small treatment plants, etc. The growing amount of information makes production of target specific data from large data masses, data mining, as well as data transmission systems a necessity. In future the shift is from the production of measurement data to processing of data and to service production.

The Finnish actors on the field of environmental monitoring include a few large companies, numerous smaller companies and several public research institutes. The most significant expertise areas are monitoring devices and systems, analysis services as well as models and software for monitoring data processing. The field is fragmented and the role of public institutes in production, processing and distribution of environmental monitoring data is significant, which has lead to small amount of enterprises, especially on service sector. Combination of monitoring and ICT/data processing expertise for control of processes and operations is one of the Finnish strengths, which we should exploit in development of our future environmental technology base.

The need of resource saving by developing sustainable, energy and material effective solutions is commonly recognized. Life-cycle thinking will also be integrated into European environmental legislation. Although there is already a jungle of various assessment methods, reliable and internationally accepted assessment of the environmental efficiency of technologies, processes, products and services is often a difficult task. International cooperation in further development of methods and indicators combined with testing and utilisation of methodologies in Finland is needed. In Finland the principal actors in this field include consulting companies offering environmental efficiency services, research institutes, and public energy and material efficiency centre MOTIVA.

In the changing business and operational environment forecasting of the future needs will be more and more important, especially in planning and acquisition of large scale infra (water systems, waste treatment plants).

Research goal

The objectives are:

- To develop and to bring into use/apply, in cooperation with Finnish and international parties, reliable methods and indicators for monitoring of the environmental efficiency of Finnish technologies, products and services. In 2015 there is a network of qualified service providers using these methods and environmental effectiveness is actively monitored and life cycle models used in product design and decision making by the Finnish actors developing material and energy efficient solutions. This has contributed to their success in international and domestic market.
- To focus the development of Finnish measurement technologies to a few focus areas of EnYm-SHOK, and to develop world-class measurement technologies on these selected segments.
- Service concepts (data management systems, process control)
  In future, the emphasis will shift from data production to processing of data, which will be an important growth area.

Research topics

- Development, testing and application of environmental efficiency indicators and monitoring methods for better understanding of the environmental efficiency of products, processes, services and value chains, including:
  - Finnish and international networking and cooperation in development of assessment methodologies (including life cycle models) and indicators, as well as in large-scale system and technology assessments to ensure the international acceptance of the methodologies used, the Finnish contribution to the international development and the recognition of Finnish expertise in the area.
  - Application of the methodologies in domestic projects and analyses of value chains, e.g. in assessment of the environmental effectiveness of recycling and waste management systems and services, design for environment, as well as case studies including whole the value chain.
  - Integration of the environmental efficiency monitoring to the monitoring and data management systems of companies and organisations (internal data needs, needs and views of the customers, use of the information in marketing)
  - Service and business models

    Short term tasks include:

    - State-of-the art, especially on EnYm-SHOK focus areas
    - Networking: Active participation into European and international projects and networks
    - Needs and views of the customers: which kind of information is needed, how to increase the value of products and services using the environmental efficiency data, how to promote environmentally efficient products, forecasting of the future needs.

- Development of online monitoring technologies

Water and soil monitoring and controlling industrial processes (incl. bioprocesses like waste water treatment) is based mainly on chemical and physical analysis of samples. In order to benefit this monitoring information more effectively, it is vital to know exactly, when and where changes of monitored parameters comes up. This creates a need for fast, accurate and high throughput analytical methods. Off-line methods do not usually meet these demands - they are time consuming and prone to errors. Therefore, various online analytical methods have become more and more popular in environmental monitoring.

Air quality monitoring is based on conventional technique, which has been well tested and approved for many years. The serious concern of respiratory health effects caused by fine particles from traffic and small scale wood burning will rapidly result a high demand of on measurement technique for online fine particle sizing equipment. For the same reason there will an increasing need to develop measurement technique for vehicle exhaust particles (incl. purification efficiency function).
The development needs include also new on-line monitoring technologies for quality control of recycling processes and recycled products, hygienic quality of water, new water impurities, and simple but reliable indicators (e.g. printed indicators) for identification of accidental emissions and for operation control of small treatment plants,

- Service concepts
  Different organizations produce nowadays environmental monitoring data mainly for their own purposes. In the future, the data and information could be shared more easily to improve monitoring activities, and to create new business in environmental monitoring. It has been suggested that a common market place or places for sharing monitoring data could help the coordination and give birth to new business. The future market place concept enables data collecting, data refinement, data distribution and use of data. It also supports coordination of activities within environmental monitoring, enables data sharing between organizations that do not share data today and creates new ways to share, sell, buy and deliver environmental data. Cooperation with ICT – SHOK (flexible services –program).

7.9 Cross cutting activities

In chapters 7.1 to 7.8 a number of applications and their research and development needs have been outlined. Among those proposed subjects it is possible to define projects specific for the groups of companies only interested in one or two of the research areas.

However it is also possible to define research topics which could be realised together by industry groups from two or more of the research areas.

It is also possible to identify generic subjects which in principle could be realised by several or even all participants. A few examples of such subjects are given here. It is to be noted that these are only examples and more of this type could easily be found.

Follow-up and prediction of the development of societies. Forecasting energy and environmental policies and how technologies are developing. Assessment and evaluation methods for new technologies.

Methods for development of new business models.

Understanding of combustion processes by modeling and experimental work.

New materials for power plants and components, modelling and characterisation.

New measurement technologies for emissions and process control.

Generic tools for simulation, modelling, process optimisation

Tools for life cycle assessment, LCA services and LCA of processes. Development of evaluation methods for impacts on health and ecosystems.

Condition monitoring, maintenance, remote diagnostics & control.

Multi process optimisation / Integrated processes. Process monitoring and data analysis (measurement/sensors, data analysis) supporting process optimisation.

8. The national network

The national network expected to participate in the research activities of the EnYm-SHOK comprises a large number of industrial enterprises, practically all universities and a number of research institutions. Many of them will also become shareholders of EnYm-SHOK. However, it is to be noted that the research programmes and projects are also open for participants who are not shareholders. In chapters 8.1 and 8.2 are listed the organisations which participated in the whole process of creating this SRA document.

8.1 The industry

The industrial companies which participated in creating this SRA are listed here. A short description of each one is given in Annex 3.

ABB Oy
BMH Technology Oy
Ecocat Oy
Ekokem Oy Ab
Fortum Oyj
Foster Wheeler Energia Oy
Helsingin Energia
Kemira Oyj
Kuusakoski Oy
Lahden tiede- ja yrityspuisto Oy
Lassila & Tikanoja Oyj
Merinova Oy
Metso Power Oy
Motiva Oy
Neste Oil Oyj
Oilon Oy
Outokumpu Oyj
Outotec Oyj
Pohjolan Voima Oy
Prizztech Oy
Pöyry Energy Oy
Rautaruukki Oyj
The Switch Oy
Teollisuuden Voima Oyj
UPM-Kymmene Oyj
Vaisala Oyj
Vapo Oy
Wärtsilä Oyj
ÅF-Enprima Oy

8.2 Research organisations.

The following research organisation and universities participated in the SRA work.

Helsinki University of Technology
Lappeenranta University of Technology
VTT Technical Research Centre of Finland
Åbo Akademi University

9. International cooperation

In the international context Finland is a small country with moderate resources. Therefore only a small fraction of research results are created in Finland. One of the central requirements for creation of the centre is the build up of international cooperation. Until now the international cooperation is built up between institutes and individual research groups. However, the EnYm-SHOK will become a mayor player in research, even in the global context. It will have considerable human resources as well as facilities comparable with any other organisation in the world. Its ability to attract the leading research groups in Finland will give it a strong status everywhere in the world. Therefore EnYm-SHOK as an organisation should develop the international research cooperation attracting world leading research groups into joint research projects. In this activity the vast contacts of the Finnish industry and research groups should be utilised.

EU is the central area because the instruments for cooperation are well developed and it is easy to join in. However, many other countries outside the EU are very strong on research. Such are especially Japan and the USA, but also several other countries like Canada, South Korea and China are emerging. In the following the main mechanisms for international cooperation are described.

9.1 EU

The European Union has had its well established procedures with framework programmes and project calls, evaluations and grants. However, in resent years the involvement of the different stake holders, especially the industry, has been increased by the creation of technology platforms. These platforms work out their own strategies and programmes in cooperation between the commission, industry, the research society and the member states. Some of these platforms are further developed into Joint Technology Initiatives (JTI) which give still more influence to the member state stakeholders. The active participation in the work of these platforms enhances the opportunity of stake holders to influence the contents of the calls. It is also helpful in finding partners for participation in projects. . It is of essence that the EnYm-SHOK as an organisation joins these technology platforms and joint technology initiatives. The relevant technology platforms and JTI:s are the following:

- European Biofuels Technology Platform
- The European Wind Energy Technology Platform TPWIND
- The Fuel Cell and Hydrogen Joint Technology Initiative
- European Technology Platform for Zero Emission Fossil Fuel Power Plants (ZEP)
- Sustainable Nuclear Energy Technology Platform (SNE-TP)
- European Forest-Based Sector Technology Platform (FTP)
- European Technology Platform, SmartGrids
- Water supply and sanitation technology platform (WSSTP)

A more detailed description can be found in Annex 2.

The commission is continuously trying to increase the effectiveness of the energy research. The new European Strategic Energy Technology Plan (SET-PLAN) described earlier proposes a number of new ways of increasing the member states cooperation by joint strategic planning, European Industrial Initiatives, the creation of a European Energy Research Alliance and European energy infrastructure networks and system transition planning. The idea is to create additional financial resources for research but also for investments. It is important that the EnYm-SHOK participates actively in these organisations, either trough own representatives, or through close contacts to the Finnish partners and officials participating in these organisations.

9.2 Other countries

The industry has traditionally contacts and cooperation with other enterprises over borders. For publicly funded research some cooperative contracts exist between funding organisations in different countries. The Finnish Funding Agency for Technology and Innovation (TEKES) has such contracts, for instance with the US Department of Energy and others. VTT and most universities have their own research agreements all over the world. It is out of scope of this report to go into details. Important countries outside Europe are especially Asia, Japan, China and South Korea, Canada and USA. Russia and Eastern European countries are increasingly important and new contacts are being created.

9.3 Main international research partners

Bilateral contacts between universities and research organisation all over the world have been a norm as long as universities have existed. Finnish research groups have a good repute and good contacts all over the world with a large number of research organisations. Examples of important international research partners in the area of energy and environment with which Finnish research organisations already have working contacts are listed bellow. The list is just an example. It is not a preference list and some important partners might have been omitted by mistake.

New research partners will be included during the work of SHOK.

- Arsenal Research, Austria. Smartgrids, DG
- BRGM – France. The Bureau de Recherches Géologiques et Minières (BRGM), Mineral resources, ground water, environmental risks, treatment of waste, polluted soils, waters and sludge's and environmental monitoring.
- Brigham Young University, Provo, Utah, USA. Bioenergy and gasification
- CEA (French Atomic Energy Commission), France. Nuclear and distributed energy research
- CESI Ricerca, Italy. Smartgids
- Chalmers University of Technology, Gothenburg. Bioenergy and gasification
- CLN Centrale Laboratorium Naftowe, Poland. Bioenergy
- CRIEPI (Central Research Insititute of Electric Power Indusrty), Japan. Energy research
- Denmark's Technical University, Lyngby, Bioenergy and gasification
- DHI Water & Environment – Denmark. Water and environmental health issues. Waste water- and process technology, water recources, water building and hydrodynamics.
- DTU /Risoe National Laboratory, Denmark, Environmnetal and energy research, wind
- EA Technology, UK. Smartgrids
- EAWAG – Sveitsi. Water treatment
- ECN (Energy Research Centre of Netherlands,The Netherlands Bio- and other distributed energy research
- EMPA, Switzerland, Energy reserach
- EPRI (Electric Power Research Institute), USA. Energy research.
- Forschungszentrum Karlsruhe – Germany. Structure of Matter, Earth and Environment, Health, Energy, and Key Technologies. Environmental and materials research. Water treatment, recycling of waste, energy from waste
- Fraunhofer Institute for Environmental, Safety, and Energy Technology UMSICHT, Germany. Energy- and environmental research.
- FZJ (Research Centre Jülich), Germany. Nuclear and distributed energy research
- IGES (Institute for Global Environmental Strategies), Japan. Strategic policy research to support sustainable development in the Asia-Pacific region
- IIASA (The International Institute for Applied Systems Analysis), Austria. Studies on environmental, economic, technological, and social issues in the context of human dimensions of global change
- IIE-UPV, Spain. Smartgrids, DG, energy efficiency
- Imperial College, London. Bioenergy and gasification
- International Flame Research Foundation, Pisa, Italy. . Bioenergy and gasification
- ISET Kassel, Germany. Wind energy
- KEMA, The Netherlands. Energy research
- Kiwa Water Research - Holland. Clean- and waste water treatment, including environmental effects of waste water.
  DHI Water & Environment – Denmark. Water and environmental health issues. Waste water- and process technology, water recources, water building and hydrodynamics.
- Korea Institute of Energy Research (KIER) , Korea, Energy research
- Korea Institute of Science and Technology (KIST) , Korea, Energy research
- Labein, Spain. Smartgrids

- Lawrence Berkely National Lab. Environmental and energy research.
- National Institute of Advanced Industrial Science and Technology (AIST), Japan. Energy research
- National Renewable Energy Laboratory, USA. Energy including wind
- National Technical University of Athens, Greece. Wind energy, DG
- Niiagata University, Japan. Combustion
- Pacific Northwest National Laboratory (PNNL). Energy research
- Paul Scherrer Institute (PSI), Switzerland. Energy research
- Royal Institute of Technology, Stockholm. Bioenergy and gasification, smartgrids
- Sintef Energy, Norway. Energy and environmental research
- Technical University of Munich. Bioenergy and gasification
- Technical University of Tallinn. Bioenergy and gasification
- The Swedish Environmental Research Institute IVL – Sweden. Sustainable development and the environment. Environmental technology, waste treatment, water technologies, clean technologiers and optimisation of processes.
- TNO – Holland. Research, testing and sertfication. Public safety, Defence, Healthy living, Food, Dealing with a changing society, Work participation and ageing, Accessibility, Construction and spatial development, Living with water, Energy (management), Natural and built environment, High-tech systems, processes and materials
- TUDelft, The Netherlands. Wind energy.
- UK Energy Reserch Institute, UK. Energy reserach
- UK.Georgia Tech, Atlanta, USA. . Bioenergy and gasification
- University of Adelaide, . Bioenergy and gasification
- University of Aston, UK. Bioenergy
- University of California, Berkeley, USA. Environmental engineering, environmental sciences, environmental policy and management,
- University of Lund, Sweden. Bioenergy
- University of Stuttgard. . Bioenergy and gasification
- University of Toronto, Pulp and Paper Centre. Bioenergy and gasification
- University of Waterloo- Canada. Water, global warming, green energy, ecotoxicology, environmental pollution and environmental systems
- USDOE national laboratories (NREL, Sandia, Oak Ridge, NETL, PNNL), USA. All kinds of energy research, fuel cells
- VITO – Belgium, Flemish Institute for environmental technology. Energy, materials technology, environmental monitoring, separation technologies, waste water- and waste treatment, smartgrids

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Annex 1. Long- and mid term perspective (Vision and scenarios)(2050), mid-term perspective (Visions and scenarios) (2020) and energy technology and environmental technology and services market

1. Long-term perspective (Vision and scenarios)(2050)

1.1 Global and EU energy production and use visions

The point of departure for global and regional energy strategies is threefold: combating climate change, promoting economic development, and securing energy supplies. The challenge is huge as the growth of population and economies will drive the global energy demand and greenhouse gas emissions without new policies. According to the IEA baseline scenario (i.e. business as usual) global energy demand and CO_2 emissions will more than double by 2050 (IEA 2006). Such a high energy demand would also cause high oil and gas prices as well as increased energy-security concerns due to diminishing oil and gas resources and increased import dependency from politically unstable areas. Urgent action to tackle climate change is required and the EU has decided to take the lead internationally by commitment to limiting the global temperature increase to 2 degrees Celsius above pre-industrial levels by 2100 (EC 2007). The Intergovernmental Panel on Climate Change (IPCC 2007) has estimated that 2 °C limit would require 50-85% emission reductions by 2050 compared to present emission level. The European Parliament has proposed an EU CO_2 reduction target of 60 to 80% for 2050 as a strategic objective, which means transforming Europe into a highly energy efficient and low CO_2 economy catalysing a *new industrial revolution*.

According to the 2006 Revision of the United Nations population projections (UN 2007) the global population will expand from the current 6,7 milliard to almost 9,2 milliard in 2050. This increase will be absorbed mostly by the less developed regions, whose population is projected to rise from 5,4 milliard in 2007 to 7,9 milliard in 2050. By 2025, the population of India is projected to surpass that of China and the two will account then for about 36% of the world population. At the same time the global GDP is expected to grow in all regions with the fastest growth in China, India and other Asian countries. According to the IEA's estimates (IEA 2006), the global growth is the fastest before 2030 with the annual average growth rate 3,2% and slowing to 2,6% in 2030 to 2050. However, the above figures are based on the "business as usual" scenario assumptions and do not take into account the impacts of climate change nor the impacts of the policies to tackle the climate change. According to the widely cited Stern review (Stern 2006) the costs of inaction would account from 5 to 20 % of global GDP before 2050. These costs are not only economic, but also social and environmental and will especially fall on the poor, in both developing and developed countries. A failure to act will also have serious local and global security implications. On the other hand, the 4th Assessment Report of IPCC (IPCC 2007) indicate that early action would result in a less than 5,5 % decrease of global GDP in 2050, which corresponds to slowing average annual GDP growth by less than 0,12 percentage points.

Figure *2* shows the primary energy use for the baseline scenario and a policy scenario calculated with global ETSAP TIAM energy system model (see Koljonen et al. 2008). In the policy scenario the commitment to limiting the global temperature increase to 2 degrees Celsius above pre-industrial levels by 2100 was assumed. In the baseline

scenario the conventional oil and gas resources would be largely replaced by unconventional oil and gas resources after 2050 meaning rapidly increasing production costs of fossil fuels. The diminished conventional oil and gas are mainly replaced with coal, leading to increased carbon intensity of the world economy. As a result, in the baseline scenario CO_2 emissions double form the present 30 Gt level to nearly 60 Gt level. In the policy scenario, the path to the low carbon economy is evident. The calculated CO_2 emissions would decrease below 20 Gt level as the share of renewables from primary energy consumption more than triples by 2050, while coal consumption decreases. Figure 4.1.2 shows that the share of renewables increases especially in electricity production. According to the policy scenario, by 2050 most of the fossil fuel fired power plants would also be equipped with carbon capture and storage (CCS). Also some industrial installations, like steel production, would be equipped with CCS. In these scenarios fusion was assumed to available in 2050, but the costs were set to very high level.

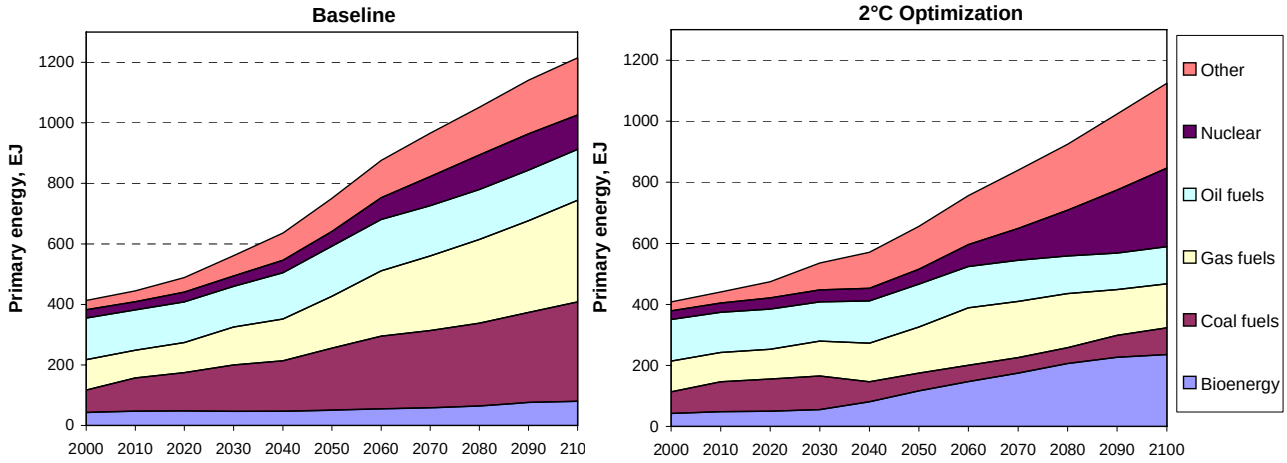

Figure 2. Global primary energy use in the baseline scenario and policy scenario with maximum 2 C temperature increase and global emissions trading. Source: Koljonen et al.

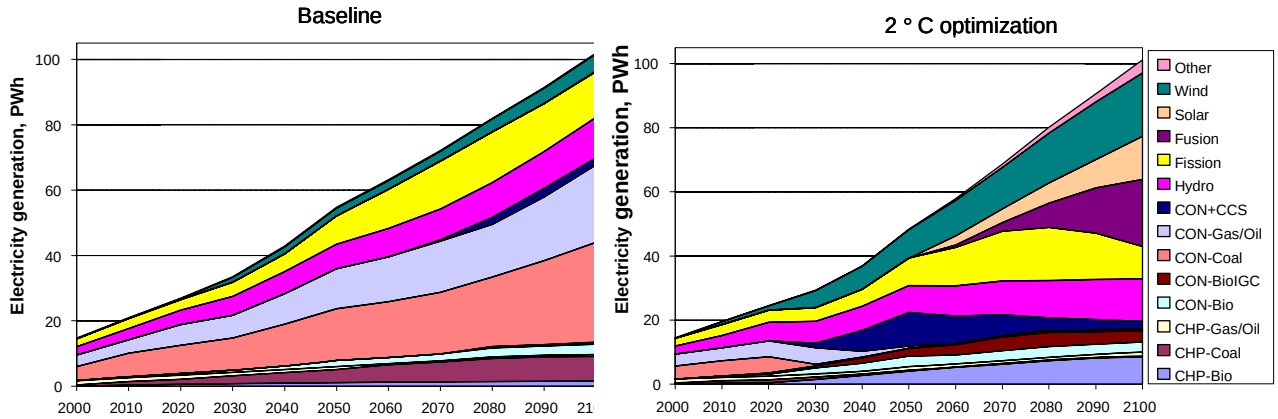

Figure 3. Global electricity production in the baseline scenario and policy scenario with maximum 2 C temperature increase and global emissions trading. Source: Koljonen et al.

Figure 4.1.1 shows the corresponding scenarios for electricity production in the Westen Europe. Compared to global average, the share of renewables is clearly higher. The

sensitivity of the available wind and bioenergy resources was simulated by reducing the potentials by 40%. Especially wind potentials seem to be a critical factor in the long term. In these scenarios the investments in new nuclear capacities were constrained based on the existing policies. On the other hand, no legal obstacles for the CCS were assumed.

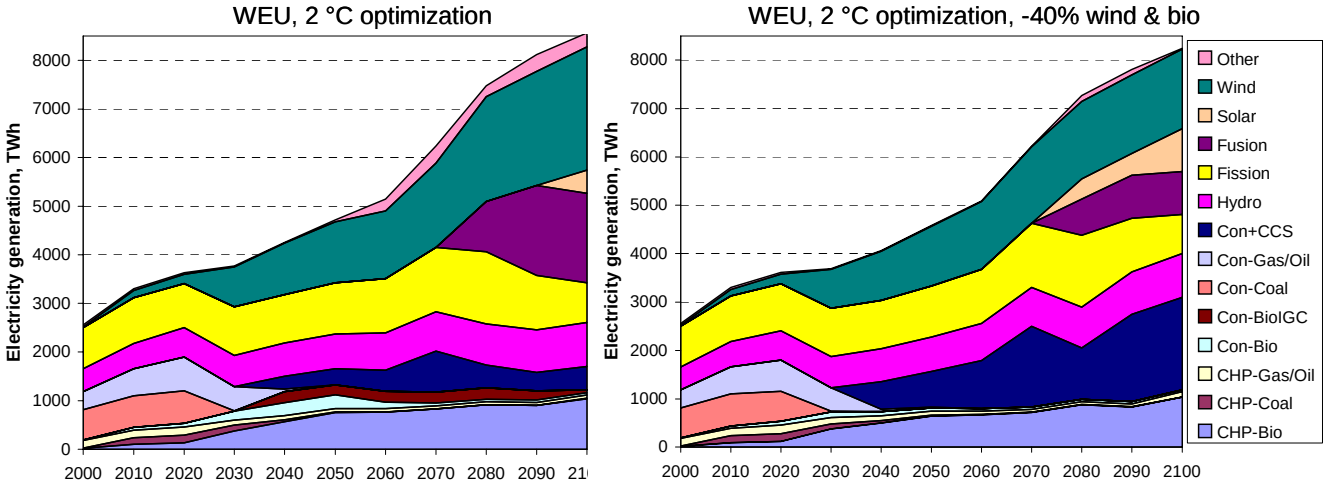

Figure 4. Electricity production in the Western Europe in the baseline scenario and policy scenario with maximum 2 C temperature increase and global emissions trading. -40% wind and bio: -40% lower resource assumptions for windenergy and bioenergy potentials.

According to the IEA scenarios (IEA 2006), about half of the emissions reductions come form energy efficiency improvements by 2050. This is also true in the above figures, but on the other had, decarbonisation can also lead to increased electricity consumption due to investments in plug-in cars, electrical heating, etc. Also, introducing CCS would mean decreased efficiencies in energy production due to energy consumption in carbon capture, transmission and storage.

1.2. Global and EU environmental visions

As a consequence of growth of population and the economical growth in developing countries consumption of natural resources is growing rapidly. It is estimated that the consumption of several natural minerals, such as Cu, Pb, Zn, Ni, Au and Sn, will overrun the amount of reserve base by the year 2050, and consumption of many other minerals will be close to reserve (Halada 200x). Wastage of natural resources combined to substitution of minerals and fossil fuels with renewable resources and increasing food production may lead to new environmental problems. Shortage and increasing competition on biobased resources is already in sight. Erosion is also becoming an ever more widespread problem due to more intensive land use.

This means that by 2050 there will be an enormous change in market of technologies, goods and services. Environmental technologies have to expand from traditional emission control and remediation technologies into the prevention of environmental damage through savings in energy and materials, the choice of non polluting production methods, the sustainable use of renewable energy sources and the development of closed material circulation systems. The shift to material and energy efficient zero-emission technologies and closed cycles is gradually going on. Because of the urgent need for improved air

quality, water supply, sewerage and waste management especially in developing countries, the share of emission control technologies is still over 90 % of environmental technology market and will continue to be considerable throughout the next decade. After 2020 zero-emission will be the most intense growth area.

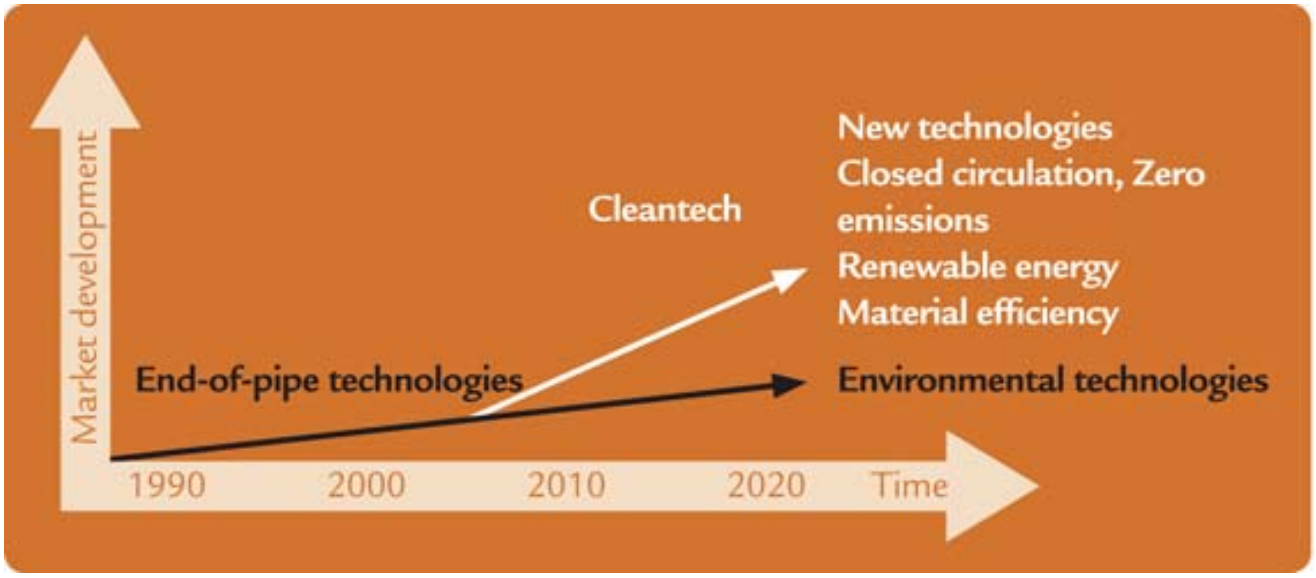

Figure 4. SITRA 2007: Clean technologies are the fastest growing environmental sector

2.3 Energy production and use long- term visions in Finland

The long term challenges for Finland are typical for developed countries. GDP per capita as well as energy intensity (total energy use per unit of GDP) and emissions per capita are high. The percentage of over 60 years old Finnish citizens is expected to grow form the present 25% to over 40% by 2050 (UN 2007). Due to increased social costs the productivity must be continuously increased to maintain the GDP growth. The costs of energy and raw materials would also be critical for Finnish industry's competitiveness operating in Finland because of long transport distances and high labor costs. Finland is currently heavily dependant on energy imports, especially from Russia, so even without climate change, there is every reason to take the steps towards increased share of renewables, nuclear, and increased energy efficiency to limit the Finland's growing exposure to increased volatility and prices for oil and gas. Coal would most obviously be in the future the most secure fossil fuel but by the 2050 coal fired plants should be equipped with CCS to be compatible, and the lack of suitable storage sites in Finland would make this option very costly and uncertain.

Figure 5 shows a scenario of primary energy consumption in Finland with different CO_2 allowance price levels. In these scenarios, 6th nuclear reactor was assumed to be operational in 2030 to compensate the phasing out of old Loviisa reactor. The use of coal is prospected to decrease after the start-up of the 5th nuclear reactor even though the use of coal and coke in metal industry is expected to grow. The use of natural gas is expected to grow in all the scenarios. The use of oil is expected to decrease in the long term, and

the use of peat is dependent on the CO_2 price levels. The use bioenergy is expected to grow considerably in all the scenarios. By 2030 the calculated use of bioenergy was 35-60% (excluding black liquor) higher than in 2002. Also, the use of hydro and especially wind power is expected to grow. The electricity import from Russia dropped to zero after the 6th nuclear reactor had become operational. As a result, the use of indigenous energy sources is increased in all the scenarios. Up to 2015 the greatest potential is in bioenergy and waste fuels but after that also wind power and geothermal heat can increase their role in Finland's energy mix.

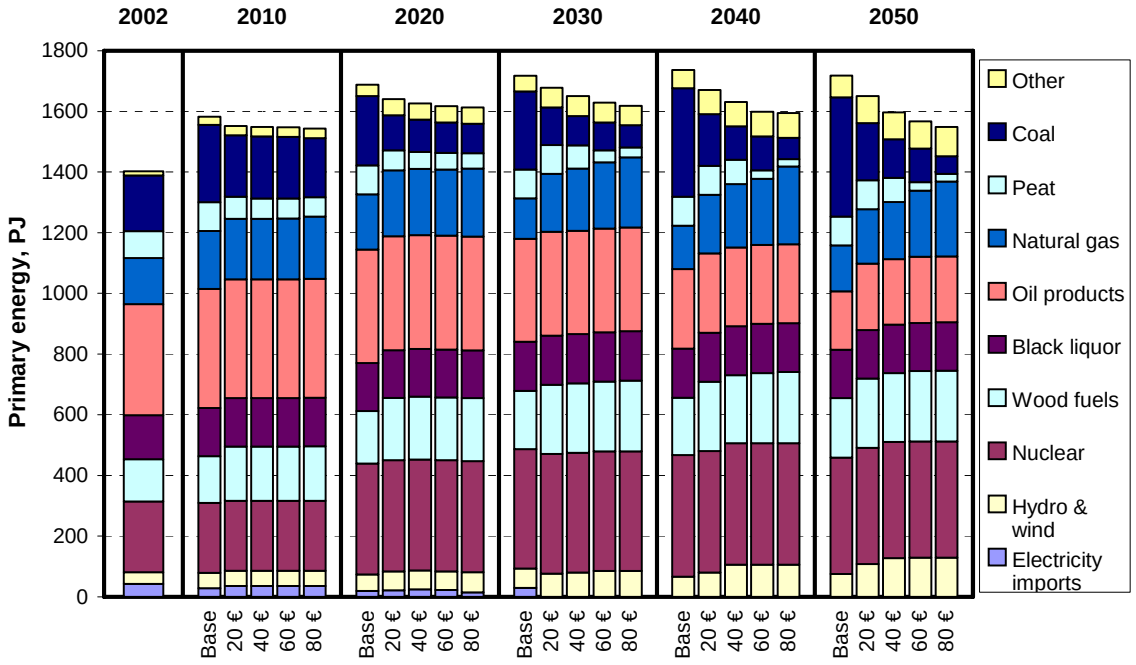

Figure 5. Total primary energy use calculated with Times model for Finland.

The Times scenarios for the development of Finnish electricity sector is presented in Figure Figure 6. The share of CHP is increased in all the scenarios. The new CHP plants are mainly NGCC and fludized bed combustion plants. Solid fuel gasification would become competitive in a small scale gas engine plants in the first place and later in larger scale IGCC. After 2020 also CCS could be an option to decrease CO_2 emissions. In the below scenarios CCS was integrated to steel production at the CO_2 price levels from 40 to 80 €/t CO_2. With the CO_2 price levels from 60 to 80 €/t CO_2 condensing power plants and the largest CHP plants were also equipped with CCS. However, it should be noted that in these calculations no legal obstacles for transport or storage abroad were assumed.

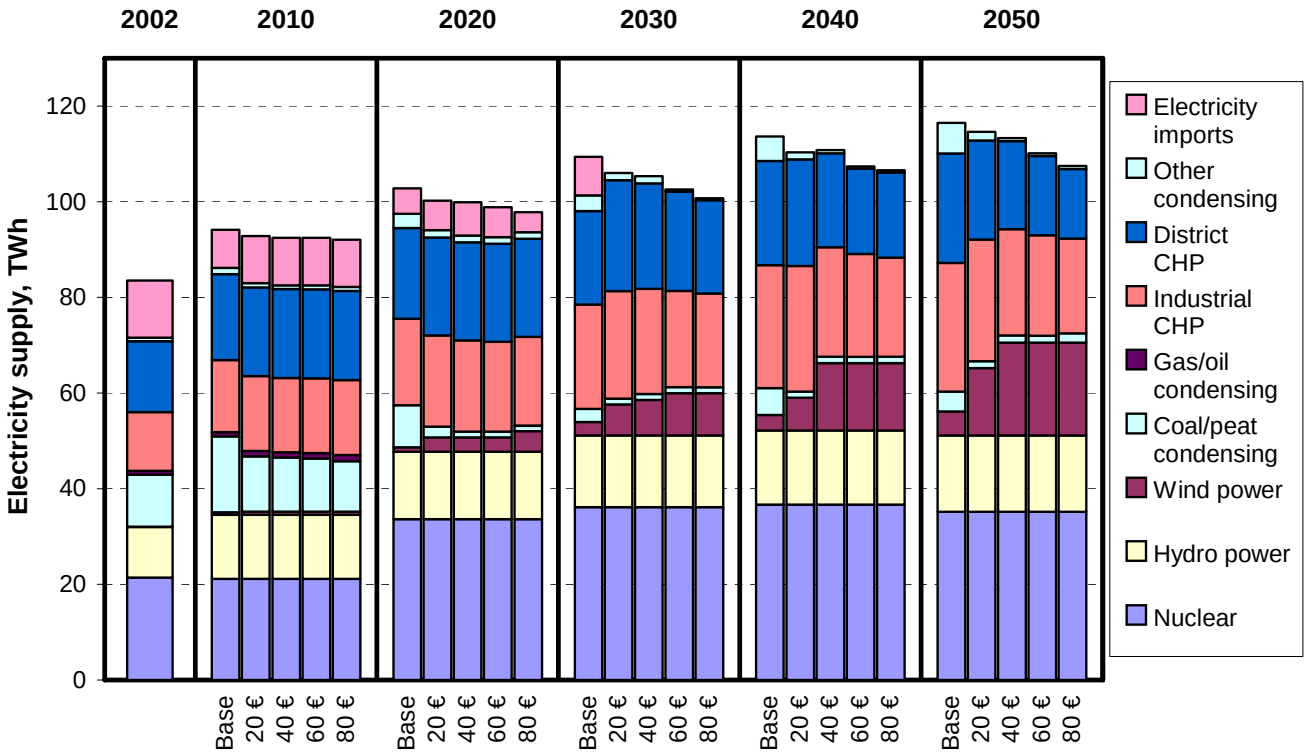

Figure 6. Electricity production and procurement calculated with Times model for Finland.

2. Mid-term perspective (Visions and scenarios) (2020)

2.1 Global and EU visions and scenarios for energy

According to the IEA scenarios (IEA 2007), world primary energy demand in the Reference Scenario (i.e. business as usual scenario) is projected to grow by more than half between 2005 and 2030, at an average annual rate of 1,8%. At the same time, the global energy intensity falls by 1,8% per year. Even in the alternative policy scenario, which includes policies and measures under consideration to rein in the growth of energy demand, the primary energy demand grows by 1,3% per year. Oil is expected to remain the dominant source of primary energy, though its share slightly falls. Coal sees the biggest increase in demand in absolute terms, while natural gas increases more modestly. According to the IEA, it is very uncertain whether the expected oil-production capacity additions from greenfield projects over the next five years will be sufficient to compensate the decline in output at existing fields. Therefore, a supply-side shortage in the period to 2015, involving a high volatility of oil prices, cannot be ruled out.

In the UNFCCC meeting in December 2007 held in Bali was agreed to start the negotiations of the new climate agreement. All the countries under international climate agreement take part in those negotiations. The objective is to finish the negotiations in 2009 so that it can be implemented after the Kyoto period in 2013. The EU has decided to implement its own climate strategy even though post-Kyoto agreement would not come into force. The mainstay of the EU's new policy is a core energy objective for Europe: that the EU should reduce greenhouse gas emissions form its energy consumption by 20% by

2020. This objective will enable the EU to measure progress in re-directing today's energy economy towards one that will fully meet the challenges of sustainability, competitiveness and security of supply. This EU target is seen in the context of the need for international action of developed countries on climate change. Therefore the EU would increase the target to a 30% reduction by 2020, when international commitment exists. To achieve this objective, the Commission has proposed to focus on a number of energy related measures (EU 2007):

- improving energy efficiency by 20% by 2020;
- raising the share of renewable energy to 20% from energy consumption by 2020, including the target to increase renewables to 10% in transport sector;
- new measures to ensure that the benefits of the internal energy market reach everyone;
- reinforcing solidarity among Member States, with a more long term vision for energy technology development;
- a renewed focus on nuclear safety;
- a proposal to promote sustainable power generation from fossil fuels.

The cornerstone of the EU's strategy against climate change is the EU emission trading system (EU ETS). In January 2008 the Commission launched a proposal (EU 2008a) to revise the EU proposal for the period beyond 2012, to strengthen, expand and improve the functioning of the ETS as one of the most important and cost-effective tools for achieving the EU's target for reducing greenhouse gas emissions. This target calls for a reduction in EU emissions of at least 20% by 2020 compared to 1990 levels, and by 30% if a global agreement is committed. The revision sets out a trend line for the emission reductions required by the sectors covered by the ETS. This is done by specifying one EU-wide cap instead of 27 national caps. The annual cap will decrease along a linear trend line, which will continue beyond the end of the third trading period (2013-2020). The linear factor by which the annual amount shall decrease is 1,74% in relation to the phase 2 cap. The emission reductions are divided between ETS and non-ETS sectors to:

- a 21% reduction in EU ETS sector emissions compared to 2005 by 2020;
- a reduction of around 10% compared to 2005 for the non-ETS sectors.

To improve the functioning of the ETS harmonised rules governing free allocation will be introduced. Also, much larger share of allowances will be auctioned. Full auctioning should be the rule from 2013 onwards for the power sector. In other sectors, allowances should be distributed according to later developed EU-wide rules, like bechmarking rules. To expand the ETS, a number of new industries (e.g. aluminium, ammonia and petrochemicals production) and two new gases (nitrous oxide and perfluorocarbons) are included. The aviation sector will be included already in 2011. To strengthen the financial capacity of the low income per capita Member States to invest in climate friendly technologies part of the auction allowances will be redistributed from the high per capita income to low per capita income countries.

The EU Strategic Energy Technology Plan (SET-Plan) has recognized the demonstration of the use of CCS in fossil fuels-based power generation as one of the focus areas of European technology development. The Commission's proposal for CCS Directive aims to resolve all the major CCS-related legislative issues and to provide a comprehensive regulatory framework to ensure the safety of CCS deployment. Furthermore, the Commission confirms that the current ETS can recognize CO_2 captured and safely stored

as not emitted (CCS-projects can opted in for 2008-2012). The Directive examines the implications of making CCS mandatory. After the launch of the CCS Directive, the new build power plants should be *capture ready*. The IEA Greenhouse Gas Programme has proposed that capture ready greenfield plants should reserve space for capture plant, carry out feasibility studies, and identify the potential storage sites and transmission routes to the storage sites.

2.2 Global and EU visions and scenarios for environment

Many environmental challenges have a transboundary or global dimension and therefore require a co-operative global response. The greatest need, and because of the economic growth also the fastest growing market of environmental technologies is in developing countries. Even so, the development of European operational environment is important from the viewpoint of future global markets of environmental technologies. One of the main reasons is that Europe has become a forerunner in environmental legislation. In many aspects, the EU legislation forms the basis of international regulatory approaches. Transmission of the European legislation to various parts of world will also support the export of European technology.

Development of the European environmental technology market environment is steered by the Action programmes (6th Action Programme 2002 – 2012), which set out the framework for environmental policy-making in the European Union, and the thematic strategies (air, waste prevention and recycling, soil, natural resources, marine environment and urban environment). These strategies steer the legislative actions. Environmental Technology Action Plan (2004) complements the regulatory approaches. It covers a spectrum of actions to promote ecoinnovation, and to boost the take-up and implementation of environmental technologies. These include increase of private and public investment to research and, technology platforms, environmental technology verification, and use of financial instruments to commercialisation and implementation of environmental technologies.

A common approach in the European policy as well as in UN and EU strategies is the objective to integrate environmental, social and economic policies within the context of sustainable development in a balanced manner, seeking practical solutions based on life-cycle analysis, cost-benefit analyses and cost-effective policies. Efficient management of resources, decoupling of environmental pressures from economic growth and development of indicators for measuring progress are included into the focus areas of OECD's environmental strategy. Decoupling as well as integrated approaches, cross-cutting environmental themes and linkages between environment media are also emphasised in EU's thematic strategies.

In the EU the new way of thinking is presented in the revision of the European waste management directive which aims to reduce waste production by promoting more efficient use of resources. This will be done by incorporating life cycle environmental, cost and social impact management to the waste management[3]. The present legislation already aims in minimisation of the amount of waste, especially biodegradable waste, disposed to

3 Proposal for a Directive of the European Parliament and the Council on Waste COM(2005) 667 final

landfills or even to a total stop of the landfill disposal by 2020, as in Germany. In short term this has created new markets for waste incineration, especially in those European countries where the municipal waste has mainly been disposed to landfills. The production of energy from waste will grow in developing countries, such as China and India, as well.

European and international recycling regulations (such as on WEEE, automobiles, batteries, C&D waste and packaging) enhance the recycling of relevant products and materials. The revision of waste directive aims to further improve the requisites of waste recovery and recycling, e.g. by defining the end-of waste procedure. At the same time in developing countries, urbanisation creates increasing pressure to recycling and higher value treatment. This means that there will be a growing market for waste collection and source separation services as well as recycling technologies. Because of the present level of waste management in developing countries, and because of the long-term effects of landfills, new high standard landfills as well as after-care of existing landfills are still needed for next decades.

Several EU directives have placed stringent demands for monitoring and reporting of atmospheric emissions. The air thematic strategy emphasises the reduction of fine particle emissions from energy production, transport, etc., and the reduction of VOC emissions. At the same time, increasing use of bioenergy as well as increasing use of nanotechnologies and materials may mean more fine particle emissions. Reduction and segregation of CO_2 emissions . In addition to energy production and use, the global greenhouse gas reduction strategies and treaties will in next years cover all the industrial and municipal activities.

At the 2002 World Summit for Sustainable Development in Johannesburg (WSSD), the EU launched a Water Initiative (EUWI). EU committed to halve by 2015 the proportion of people who are unable to reach or afford safe drinking water and the proportion of people who do not have access to adequate sanitation. The attainment of these goals seems still to be far away. On the contrary, increasing urbanization and higher standard of life means that demand for clean water is increasing steadily, whilst the water resources and economical resources of the world are unbalanced. Irrigation already takes about 70 per cent of available water. By 2025, water use is predicted to have risen by 50 per cent in developing countries and by 18 per cent in the developed world. In addition, water quality is declining. The worst-case scenarios predict massive droughts, water-related wars, threats to water security, etc.

Deficit of water resources is a challenge even in many developed countries. In Europe the aim of the 2000 Water Framework Directive (WFD) is to achieve by 2015 good water quality for all waters across the European Union. This objective is supported by several other directives that form basis of the European Union's policy on water: the directives on bathing water, groundwater, and drinking water, and forthcoming directives on the marine environment and flood management.

3 Energy technology and environmental technology and services market

3.1 Energy technology market in Europe and Globally

According to the IEA scenarios (IEA 2007) the projected cumulative investment need for energy supply infrastructure will be around $US 20-24 trillion (in year-2006 dollars) for the period 2006-2030. More than half of the energy-supply investments, including the expand of energy supply capacity and replacements of phasing out facilities, will be required for the power sector. Especially in the developing countries the investment needs in power sector are the most dominant. Most of the investments in electricity industry are needed for transmission and distribution networks. In contrast, most of the investments in the oil and gas sectors will be required for upstream developments and to replace capacity that will become obsolete over the projection period. Both gas and oil investments are projected to be one-quarter of the total (i.e $ 5-6 trillion for oil and $ 4-5 trillion for gas). Investment for bio-refineries is projected to total $ 188 milliard for the period 2006-2030, most of which will occur in OECD Europe, Latin America and OECD North America. About half of global energy investment goes to developing countries, where energy demand increases most. China alone needs to invest about 17% ($ 3,7 trillion) of the world total and more than all other developing Asian countries put together. India's investment needs are more than $ 1,2 trillion, and most of it goes to power sector. OECD countries will account for almost 40% of global investment and OECD Europe alone $ 2,4 trillion.

In Figure 7 is shown projections for energy investment in the 2 °C policy scenarios presented in the section 2.1. In the climate policy scenarios the investments in renewables, CCS and energy saving measures would be rapidly increased, especially after 2020. In these scenarios, the nuclear capacities were expected to more than double by 2050 even though investments in nuclear power were constrained in the OECD countries. Like in the IEA scenarios, more than half of the investments would go to the developing countries.

It is obvious that aggressive climate policies together with growing energy consumption and need to replace the old capacities would create extremely large markets for energy. Focused efforts to promote and demonstrate clean and efficient technologies could give strong position in the future global markets.

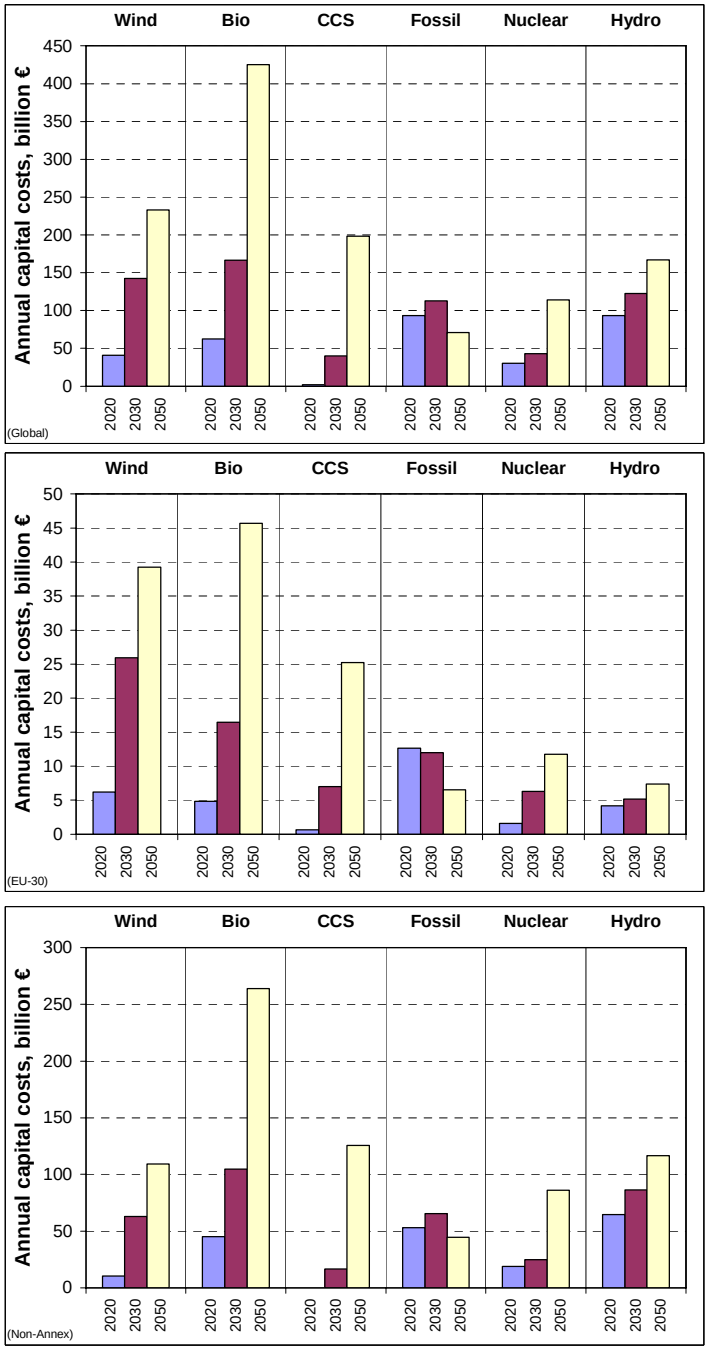

Figure 7. Annualized capital expenditure for power and heat generation globally, in the EU-30 area, and in developing countries (Kyoto non-Annex-1 countries) in policy scenario with maximum temperature increase limited to 2 °C (source: Koljonen et al. 2008).

3.2 Environmental technology market

The global market of environmentally sound technologies (environmental technologies and clean energy) is roughly estimated to amount to 600 milliard euros, with Europe accounting for around one third of this sum (SITRA 2007). Environmentally sound technologies include products, services, processes and systems whose use results in less harmful impacts on the environment than their alternatives. They protect the environment,

are less polluting, use all resources in a more sustainable manner, recycle more of their wastes and products, and handle residual wastes in a more acceptable manner than the technologies for which they are substitutes (Agenda 21). Examples include clean energy and industrial processes, energy efficiency, material efficiency, the recycling of used materials, closed water cycles, technologies for environmental monitoring and for remediation of contaminated environment. Clean technologies may include know-how, procedures, goods and services, and equipment as well as organizational and managerial procedures.

The market of environmentally sound (clean) technologies will continue to develop rapidly. Environmental legislation has traditionally been the principal driver behind the growth of environmental business. Other common drivers include population growth, climate change, and economic factors such as the prices and availability of energy and raw materials, as well as concern about the state of the environment. Globalisation is forcing rapid changes (migration, urbanization, industrial activities, patterns of food production) leading to dramatic enhancement of energy, water and material consumption. There is a danger of over-exploitation of natural resources, such as metals and minerals, fossil fuels, etc. The shortage of water continues to be a major societal challenge in many developing countries, but also in several developed countries. Considerable part of world population still lives outside water and sanitation infrastructure.

In addition to market growth, the rapid changes in operational environment require new kind of flexibility from environmental technologies. Rapid societal changes as well as introduction of new technologies may result in new environmental risks, and increased emphasis on safety. Market based measures such as emissions trading, and increased awareness of environmental issues among politicians and the public are also becoming more significant drivers of environmental technology. At the same time the need of on target (specific) environmental information grows rapidly.

Helmut Kaiser Consultancy (2007) estimates that the market of all the environmental technologies will grow significantly by the year 2020. The largest growth segments are environmental monitoring and data collection (nine-fold increase compared to the year 2006), recycling (7 –fold increase), soil and landscape protection and restoration (6-fold-increase and clean energy production (5-fold increase). The segments with highest market share in 2020 will be water and waste water, clean processes, recycling, waste management and clean energy. The market of noise abatement will be steady during this decade, but it will take substantial progress after the year 2015.

The recycling industry is becoming a significant part of the global economy today and is estimated to grow to a 472 milliard USD market in 2015 from 62 milliard in 2005[4]. First of all, recycling makes economic sense as it is in many cases highly profitable. This is especially true for metals such as steel and aluminum. Second, high energy prices have driven up the costs of producing materials from virgin material supplies. Also, significant global warming concerns and rising concerns over environmental pollution will also lead to more recycling (Gaia/SITRA).

[4] Helmut Kaiser Consultancy 2007

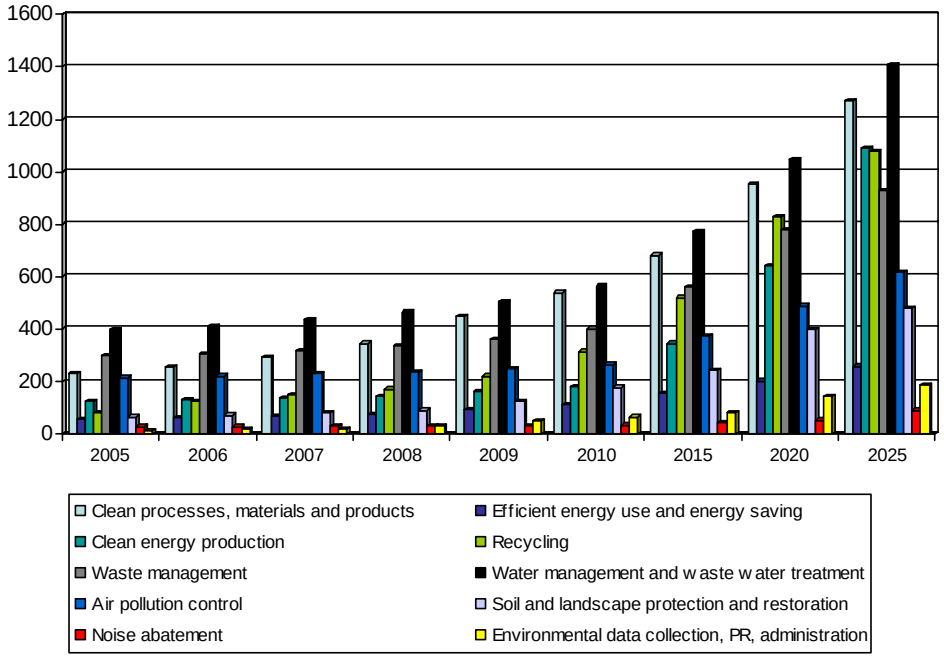

Figure 7. Markets for Sustainable and Environmental Technology/Renewable Energy 2005-2025 in US$ Bn. In total value chain worldwide (1 USD = 0,75 EUR) (Market Survey, Commissioned by Sitra, Helmut Kaiser Consultancy, Tubingen 2007)

Most of the forecasts see great growth (10-13 % per annum) in the area of water treatment and purification. Increasing urbanization and deficit of water resources mean that demand for clean water is increasing steadily. The water scarcity leads to investments in desalination technologies (market growth 15 % per annum) during the past years and advanced water treatment in the form of filtration technologies and water efficiency solutions such as water metering and water recycling. It has been estimated that the amount of recyled water increases from 20 million m^3/d in the year 2005 to 54 million m^3/d year 2015. The market share of membrane technologies, is growing in disinfection, desalination, water recycling and waste water treatment. Membrane biotechnology and ultrafiltration and ceramic membranes are the strongest growth areas. One important trend seems to be toward the integrated treatment systems and methods that combine biological, chemical and physical methods in an optimal way.

The need of cost effective and eco-efficient sludge and concentrate management technologies as well as monitoring, data management and control systems, will increase when water cycles are closed. The reduction of energy consumption is also included into the most significant challenges in the water technology area. There is great potential for innovation, but especially the clean water market is quite conservative. Water is provided by municipal organizations and utilities, which are usually risk averse[5]. The slow evolution is also partially attributable to the lack of financial resources.

The air cleaning market will grow to be worth 290 milliard US dollars by 2015[6]. The main driver is the rapid industrialization of China, India and Southeast Asia. For example, 16 of the 20 most polluted cities in the world are located in China.

[5] Erfan
[6] Helmut Kaiser Consultancy 2007

It is estimated that the role of bio- and nanotechnologies will be dominating in the future development of environmental and clean technology industries. Until now the growth expectations have not been realized, but the forecasts estimate that more technological solutions will be in market after the year 2010, and the market share of nanotechnologies will be several percents from environmental technologies in 2015.

Although Europe, North America and Japan are still most significant market areas (over 90 % in 2004) of clean technologies, the largest growth potential is in developing countries, such as China and other Asian countries, South America and Africa and non-EU countries of the Eastern Bloc[7]. Their economic growth, urbanisation and large scale contamination of environment create new markets for environmental technologies. Many of these markets, including the new EU Member States, will require considerable investment in primary environmental services - clean air, waste management, water supply and soil remediation. Although Europe, USA and Japan will lead the high-tech applications, it is evident that many countries, such as China and India, are already moving beyond basic service demand and are looking to invest in cleaner technologies, renewable energy and more sophisticated approaches to environmental management[3]

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Annex 2. EU Technology platforms and Joint Technology Initiatives

European Biofuels Technology Platform (http://www.biofuelstp.eu/home.html)

The Biofuels platform vision is to provide with biofuels up to 25 percent of road transport energy needs in the year 2030 covered in a cost-competitive, economically viable and sustainable way. The Biofuels Research Advisory Council (BIOFRAC) was created by the EC who invited high-level experts of stakeholders from various sectors with interests in biofuels development, mainly from industry but also from academia and research organizations, to develop a long-term vision for biofuels and determine the need for a European Biofuels Technology Platform (BiofuelsTP). The BIOFRAC group was united in its support of the idea and outlined the structure for such a platform, which was launched in June 2006. The EC formally recognised the TP in April 2007.

Since the start of this millennium the production of biofuels, biodiesel in particular, has significantly increased in the European Union and worldwide. In 2006, the EU biofuel consumption amounted to 5.38 million tons oil equivalent (Mtoe), an increase of 80 % in relation to 2005. 3.85 Mtoe were consumed in form of biodiesel, 0.88 Mtoe as bioethanol and 0.65 Mtoe as other biofuels, such as pure vegetable oils and biogas. This represents 1.8 % of the total EU transport fuel consumption of 296 Mtoe in relation to 1 % in 2005. So far Germany, Sweden and Spain produce the most biofuels for transport, but only Germany and Sweden have met the indicative EU target of 2 % for 2005.

Both strategic fit and sustainability potentials have guided the work of identifying and prioritising key R&D&D efforts needed. Newer technologies will require more integrated R&D&D efforts while more mature technologies work should focus on further development and demonstration of improvements from the very short term. Thus, for the above mentioned critical areas of technology development, the following R&D&D priorities have been identified:

Feedstocks:
Develop availability-cost curves for different sources of biomass (energy crops, forestry and agriculture residues, wastes) and geographical locations.
Develop new high-yield and low-input agricultural and forest systems with breeding of crops and trees optimised for biofuel production.
Develop efficient biomass logistic systems (harvesting/collection/storage) for different conversion concepts at different scales.

Conversion processes:
Improve current conversion processes to their full potential (biodiesel, bioethanol from starch-sugar) for higher GHG reduction, increased flexibility for different raw materials and lower cost.
Develop thermochemical and biochemical conversion processes with feedstock flexibility for different lignocellulosic biomass (BtL, L-C bioethanol).
Develop integrated biorefinery concepts making full use of a variety of biomass feedstocks to obtain diverse high-value bioproducts.
Demonstrate both at pilot and industrial scale reliability and performance of new technologies.

Fuel/engine optimisation:
Establish conditions for compatibility of biofuels and biofuel blends with existing logistics, as well as existing and new powertrains; develop vehicle modifications for neat biofuels and high blends for specific market needs.
Generate engine-fleet test data and set sound quality standards for biofuels.
Develop in-depth understanding of relationship between biofuel quality and engine performance for future fuel/powertrain systems in order to deliver superior combined performance.

Overall system sustainability:
Further develop indicators and coherent methodology to assess and monitor the three dimensions of sustainability: economic, environmental, social.
Generate and collect data required and carry out sustainability assessment of existing and potential promising production chains (land, feedstock, process, fuel use).

In order to develop the European biofuels to its full potential, a number of non-technological deployment measures have to be addressed also under coordinated and target-oriented efforts:
- A coherent, long term and harmonised political and open market framework to secure confidence of investors in capital-intensive innovative technologies.
- Joint public/private financing for R&D and Demonstration of new biofuel production routes and end-use applications. Additional public funding for higher risk large-scale demonstration facilities.
- Biofuel quality standards which are based on sound science while not creating unnecessary barriers for biofuel deployment.
- A simple, coherent and global certification system to assure environmental sustainability of biofuel production chains.
- Social awareness needs to be increased and social acceptance gained by open communication of benefits as well as potential drawbacks of biofuels.

The European Wind Energy Technology Platform TPWIND

Status of TPWID: started in 2006, working groups/first general assembly November, 2007, Strategic research agenda and Market deployment plan will be published in April, 2008.

The main objective of TPWind is to identify areas for increased innovation, new and existing research and development tasks, and to prioritise them, the primary objective being overall (social, environmental and technological) cost reductions**.** TPWind develops a Strategic Research Agenda, addressing technology development issues and a Market Deployment Strategy, addressing issues affecting large-scale deployment of the technology.

Vision: In 2030, wind energy will be a major modern energy source, reliable and cost competitive (cost per kWh). The market context will be driven by concern over the impacts of climate change, oil and gas depletion, high and unpredictable fuel and CO2 allowance prices, and sustainability. The European industry will continue to lead the global market. 21-28% of the EU electricity consumption will be provided by wind (300 GW). It will be supported by an optimal industrial expansion in Europe. The European power markets will

be much better integrated with full ownership separation of transmission and production activities, larger interconnectors, an effective wholesale market and well functioning balancing markets.

Four thematic areas are identified:

1. Wind resource assessment. Goals: reduce the uncertainty of annual power production to <3%, reduce the uncertainty of design wind characteristics to <3%, reduce the uncertainty of short-term forecasting of power production and wind conditions to <3%.
2. Wind turbine technology. The three pillars for decreasing costs are to improve the availability, reliability and accessibility of the turbines.
3. Wind energy integration. The objective is to enable large-scale integration of wind power and high penetration levels while maintaining system reliability, with low or reduced integration costs
4. Offshore deployment and operation. Goals: more than 10% of Europe's electricity demand from offshore wind by 2030, with offshore generating costs competitive with other sources of generation. Technology for sites of water depth up to 50m at any distance from shore which is commercially mature, and technology for sites in deeper water proven through full-scale demonstration.

The Fuel Cell and Hydrogen Joint Technology Initiative

EU has chosen Hydrogen energy carriers and fuel cells as one of the major development areas for CO2 emission reduction in power production and transportation. In order to increase the interest of the industry to participate a public-private partnership was first initiated in the form of a Hydrogen and Fuel Cells Technology Platform (HFP), led by industry and the commission, but strongly supported by the research community. During the years 2004 and 2005 the HFP wrote a Strategic Research Agenda (SRA) and a Deployment Strategy (DS). The preparation for establishing a JTI was started in connection with the preparation for the seventh framework programme (FP7). During the year 2006 an Implementation Plan for the whole duration of FP7 was made. During 2007 and beginning of 2008 preparations were made for the acceptance of the Fuel Cell and Hydrogen JTI in April 2008. In order to be ready for opening a JTI call immediately after the acceptance, an interim JTI organisation was set up in the end of 2007. This is now active in planning the strategy and first project call of the JTI.

The JTI will be governed by a board which comprises 12 members, six of which representing and industry association, industry grouping. Five of the members will be representing the commission. One member will represent an association of research organisations, research grouping called N.ERHGY, which will be established 17 March 2008. From Finland only Wärtsilä Finland is participating in the industry grouping. VTT and TKK are participating in the research grouping.

The main goals of the JTI are

- enabling market breakthrough of fuel cell and hydrogen technologies, thereby enabling commercial market forces to drive the substantial public benefits;
- placing Europe at the forefront of fuel cell and hydrogen technologies worldwide;

- reaching the critical mass of research effort to give confidence to industry, public and private investors, decision-makers and other stakeholders to embark on a long-term programme;
- leveraging further industrial, national and regional investment in research and technological development.

For the FP7 the commission has reserved 450 M€ for the research and demonstration activities to be matched by the same amount from the industry. Thus there is available almost one milliard € for research and demonstration in this area for the period 2008-2015 The industry contribution will be mainly in the form of in kind. In addition to this the industry will invest 5 B€ in industrial product development.

The stationary joint activities comprises R&D on SOFC and MCFC technologies. The subject areas are 1. Cell and stack development, 2. Control and system component development as well as system performance improvement, 3. Durability and robustness improvement, 4. System scalability, alternative applications and modelling for manufacturing, 5. Scaling up of manufacturing, 6. Technology validation and 7. Market entry promotion by demonstrations.

It is planned that there will be several relatively small and focused projects on each subject. The first calls will be opened during the later half of 2008. The demonstrations will start during the later half of the FP7 period.

In principle anybody can participate in the projects and calls. However, those who belong to the JTI organisation have better possibilities to join the most competent consortia and also to influence the contents of the call. Coordinators have to be members. The way to be a member is to join either the industrial grouping or the research grouping. Both are completely open for membership. More information can be found in the following web-addresses:
https://www.hfpeurope.org/
http://www.fchindustry-jti.eu/
https://www.hfpeurope.org/hfp/research-news

European Technology Platform for Zero Emission Fossil Fuel Power Plants (ZEP)

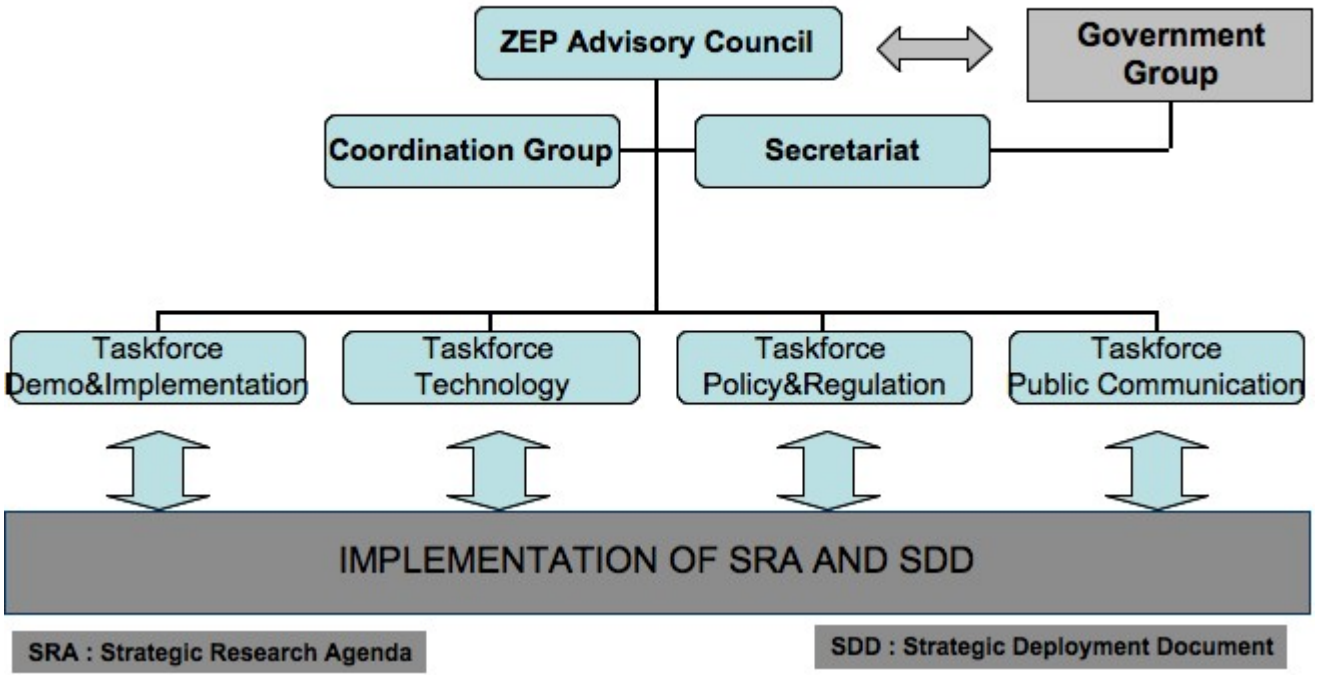
Objectives

Based on the vision of the future it developed, ETP ZEP aims at coordinating the establishment and implementation of a strategic research agenda to meet the needs of European Citizens and industry by 2020. In line with the proposed priority for "Near Zero Emission Power Generation" in FP7, the technology platform will identify and remove the obstacles to the creation of highly efficient power plants with near-zero emissions which will drastically reduce the environmental impact of fossil fuel use, particularly coal. This will include CO_2 capture and storage, as well as clean conversion technologies leading to

substantial improvements in plant efficiency, reliability and costs. The platform is open and accessible, allowing the participation of all interested stakeholders.

Structure

The structure of ETP ZEP is closely linked to its Strategic Research Agenda (SRA) and Strategic Deployment Document (SDD). Elaboration of both documents was successfully done by five Working Groups. Following finalisation of the SRA and SDD end of 2006, focus has shifted to implementation. To better facilitate the prioritisation necessary for this phase, since 2007 the structure is partially reorganised to the current one with four Taskforces, graphically depicted below.



The goal of the ZEP Technology Platform is clear: to enable zero CO2 emissions from European fossil fuelled power plants by 2020. It is an ambitious goal, but perfectly feasible – as long as the process starts now. It means CO2 capture technology must be commercialised, storage locations identified and full-scale demonstration projects implemented without delay. It also means establishing a clear, stable fiscal and regulatory framework. Unless investors are convinced that CCS technology has a secure, long-term future, it will simply not get off the ground. As importantly, Europe needs to commit to a fully coordinated research agenda in order to:

a) Bring current CO2 capture technologies (together with improved power plant efficiency) to commercial readiness by 2020
b) Develop new concepts for implementation beyond this date.

But none of this will be achievable without full public support. Indeed, implementing a comprehensive outreach campaign is a matter of urgency – not only to reassure the public, but convince them of the necessity of deploying CCS as soon as possible. Rising energy demand and the increasingly visible effects of climate change mean that time is not on our side. We will therefore only achieve our goal by adhering strictly to the following roadmap:

Achieving the Vision: zero emission power plants by 2020

Deployment

- Introduce the need for 10-12 CO2 capture and storage demonstration projects in the FP7.
- Engage with regulators and the public in 2007 and carry out an information campaign as soon as possible.
- Establish a legal and long-term regulatory framework by 2007/8, including accreditation of CCS under EU ETS, CDM and JI.
- Identify CO2 point-sources and possible locations for new power plants (and other industrial plants with large CO2 emission) and storage sites in 2007.
- Establish early mover funding mechanisms by 2007.
- Undertake a study on the re-use of existing infrastructure in the North Sea versus new build requirements in 2008.
- Define optimum model for the European CO2 infrastructure linking capture and storage locations by 2009.
- Establish an EU storage programme to develop knowledge, skills and capability for large-scale, deep saline aquifer storage by 2010.

- Start planning for building pipelines that will become part of a European CO2 transport infrastructure in 2010.
- Each power plant has its own plant life cycle. By 2015, all power plants which are due to be replaced, or have increased capacity, should be assessed for CO2 capture.
- Build 4-6 onshore storage sites by 2015 (with a minimum capacity of 2 million tonnes CO2).
- Linking CO2 sources to storage locations through transport systems to continue through 2020.

Research

- Promote R&D activities which enhance the technological assets of the European industry in order to improve competitiveness edge.
- Introduce new options for launching integrated projects, such as public-private-partnerships.
- Define specific roadmaps for launching innovative concepts – even if commercial implementation is long-term, planning has to start now.
- Establish development tools for testing innovative processes or storage facilities. These could include specific sites dedicated to the investigation of innovative technologies, e.g. pilot plants for CO2 capture, leakage laboratories etc.

- Define R&D projects using experimental data from demonstration projects in order to develop and validate new tools (e.g. modelling tools for CO2 storage).
- Support the establishment of networks in key technology and scientific areas (e.g. combustion science, thermodynamics, materials, fluid mechanics, separations, geoscience). Organise meetings and promote knowledge transfer between European research centres and joint access to common tools.
- Develop an information kit for training scientists and engineers in zero emission power plant technology.

Additional information

Home page: http://www.zero-emissionplatform.eu/website/index.html

The European Technology Platform for Zero Emission Fossil Fuel Power Plants (ZEP) has therefore proposed a clear way forward: the Strategic Research Agenda describes a collaborative programme of technology development for reducing the costs and risks; while the Strategic Deployment Document outlines how we can accelerate the market to achieve zero emission power production by 2020. A Strategic Overview summarises the two documents. Brochure summarising SDD and SRA: http://www.zero-emissionplatform.eu/website/docs/ETP%20ZEP/ZEP%20Concepts%20Final%20V2.pdf

ZEP advisory council: http://www.zero-emissionplatform.eu/website/docs/AC/ETP%20ZEP%20AC%20members%20070612.pdf

The Government (formerly Mirror) Group of the member countries is the body representing the relevant political institutions from the Member States. Its role is to proactively advise the Advisory Council of ETP ZEP from a political perspective.
http://www.zero-emissionplatform.eu/website/organisation/gg.html

Taskforces: http://www.zero-emissionplatform.eu/website/docs/Taskforces/TTech/TTech%20members%20070509.pdf

The latest publication: http://www.zero-emissionplatform.eu/website/docs/ETP%20ZEP/CEO-meeting%20letter%20of%20commitment%20industry.pdf

Sustainable Nuclear Energy Technology Platform (SNE-TP)

At European level, the latest Nuclear Illustrative Programme (PINC) from 2007 underlines the need to develop common instruments within the framework of nuclear safety. The European Commission has already launched a number of initiatives in the field of nuclear safety, waste management and decommissioning, such as recommendations on the financing of decommissioning activities, the establishment of a Sustainable Nuclear Energy Technology Platform (SNE-TP) and the establishment of an EU High Level Group composed of national nuclear regulators for the further development of a common understanding and European rules in the field of nuclear safety and waste management.

The Sustainable Nuclear Energy Technology Platform (SNE-TP; www.snetp.eu), launched in September 2007, aims at coordinating Research, Development, Demonstration and Deployment (RDD&D) in the field of nuclear fission energy. It gathers together stakeholders from industry, research organisations including Technical Safety Organisations (TSO), universities and national representatives. Regarding joint infrastructures, the recently launched Jules Horowitz Reactor (JHR) material testing reactor project will, in the short term, support studies on generation II and -III light water reactors on ageing and life extension, safety and fuel performances, and support material and fuel developments for generation-IV reactors. The reactor will be located in Cadarache, France and VTT will be actively involved in the planning and design of this facility.

The Vision Report of this platform reflects a consensus among a large group of stakeholders on research priorities in the field of nuclear fission, addressing the renaissance of nuclear energy with the deployment of generation III reactors, and the development of generation IV systems, both fast neutron reactor systems with fuel multi-recycling for sustainable electricity-generating capability and (Very) High Temperature Reactors for other applications, such as the production of hydrogen or biofuels.

Important issues such as the safety of nuclear installations and the responsible management of waste are also addressed, as well as other issues which are crucial to the success of nuclear energy in the 21st century: education and training, research infrastructures, material research and numerical simulation – and funding. The first significant task of the platform will be to write a Strategic Research Agenda by the end of 2008. The aim will be to define a roadmap for all European nuclear fission research until the year 2040.

Participating organisations and SNE-TP Bodies

Participating organisations (at the date of the launch conference; present status)

Ansaldo, Italy AREVA, France AVN, Belgium CEA, France CIEMAT, Spain CNRS, France Hubert Flocard Director of the PACEN programme EDF, France ENDESA, Spain Pablo ENS E.ON, Germany FORATOM FZD, Germany FZJ, Germany FZK, Germany GRS, Germany IBERDROLA, Spain IRSN, France JRC, EC	JSI, Slovenia KFKI, Hungary Nexia Solutions, UK NRG, the Netherlands NRI, Romania PSI, Switzerland SCK•CEN, Belgium Suez, France Tecnatom, Spain TVO, Finland UJV, the Czech Republic University of Karlsruhe, Germany University of Madrid, Spain Carol University of Rome, Italy Vattenfall, Sweden VTT, Finland

SNE-TP Bodies: (www.snetp.eu/home/liblocal/docs/SNETP_bodies_JAN2008.pdf)

Governing Board: Chair, P. Pradel, CEA, France; Vice Chairs: B. Güthoff, E.ON, Germany and: F. Pazdera, UJV, Czech Republic

Executive Committee: Chair R. Rintamaa, VTT, Finland; Deputy Chairs: T. Lefvert, Vattenfall, Sweden and E. Gonzalez, CIEMAT, Spain

Strategic Research Agenda (SRA): Group leader: H. Ait Abderrahim, SCK-CEN, Belgium

Deployment Strategy:Group leader: P. Morilhat, EDF, France

European Forest-Based Sector Technology Platform (FTP)

In 2004, the European Confederation of Woodworking Industries (BEI-Bois), the Confederation of European Forest Owners (CEPC) and the Confederation of European Paper Industries CEPI took the initiative to set up a Technology Platform for the forest-based sector (FTP). This platform aims at defining and implementing the sector's R&D roadmap for the future and is supported by a wide range of stakeholders. The Forest-Based Sector Technology Platform is an industry-driven process, embedded in industry reality, and supporting the sector's strategy.

The FTP has as its vision (for the year 2030): *The European forest-based sector plays a key role in a sustainable society. It comprises a competitive, knowledge-based industry that fosters the extended use of renewable resources. It strives to ensure its societal contribution in the context of a bio-based, customer-driven and globally competitive European economy.*

During February 2006 over 700 proposals were condensed into a Strategic Research Agenda (SRA) for the Forest-based Sector Technology Platform (FTP). Stakeholders from all areas including industry, forest owners, researchers and public bodies, have taken an active part in the process of formulating the SRA, with representatives from the European Commission as observers. Sustainability, development and manufacturing of innovative products, resource availability, multiple forest use, biodiversity, the production of bio-energy and energy efficiency are the major topics of the SRA. Biorefinery concept, production of biofuels for transportation sector, and technologies to boost heat and power output are the essential objectives of the SRA.

The National Support Groups have developed and adopted National Research Agendas for the forest-based sector in Denmark, Finland, France, Germany, Ireland, Italy, Latvia, Lithunia, Norway, Russia, Slovenia and Sweden.

European Technology Platform, SmartGrids

Strategic Research Agenda for Europe's Electricity Networks of the Future

The first milestone towards the establishment of a common strategy for the development of Europe's electricity networks was set in April 2006 when the paper 'Vision and Strategy for Europe's Electricity Networks of the Future'1 was published. In this Vision, future electricity markets and networks must provide all consumers with a highly reliable, flexible, accessible and cost-effective power supply, fully exploiting the use of both large centralized generators and smaller distributed power sources across Europe. End users will become significantly more interactive with both markets and grids; electricity will be generated by centralised and dispersed sources; and grid systems will become more inter-operable at a European level to enhance security and cost-effectiveness. This new concept of electricity networks is described as the 'SmartGrids' vision. It will enable a highly effective response to the rising challenges and opportunities, bringing benefi ts to all network users and wider stakeholders.

The European Technology Platform SmartGrids has focused its efforts on the development of this Strategic Research Agenda (SRA). It has contributions from four working groups that represent a wide range of European industrial and academic expertise. Member State governments have also provided valuable advice and comment through the Mirror group. The SRA is a reference document that consolidates the views of stakeholders on research priorities that address the key elements of the Vision document.

The purpose of the SRA is to provide a resource for European and National programmes. It seeks to be non-prescriptive and strategic in nature; it is designed to encourage competitive activity; it is intended to be an inspiration for new thinking in important policy areas. The SRA proposes a framework for a future research programme which can be summarized by the following goals.

- To ensure that Europe's electricity networks develop in such a way that enhances Europe's competitive position while supporting environmental objectives and the commitment to sustainability.
- To capture the benefits of collaboration and co-operation in addressing challenges that are common across all Member States.
- To provide a clear framework, goals and objectives on which the research community can focus, encouraging innovative solutions where this will add value
- To generate the momentum and support necessary to convert good ideas to adopted products and solutions.

A key principle in the development of this SRA is that grid users should be at the focus of developments. To achieve this, the work has taken an integrated approach to technical, commercial and regulatory aspects, seeking delivery of added-value solutions and services to all stakeholders and end customers. It recognizes the complex factors inherent in achieving successful technology transfer from research to deployment, and also the new dimensions created by a liberalized market and its regulatory frameworks.

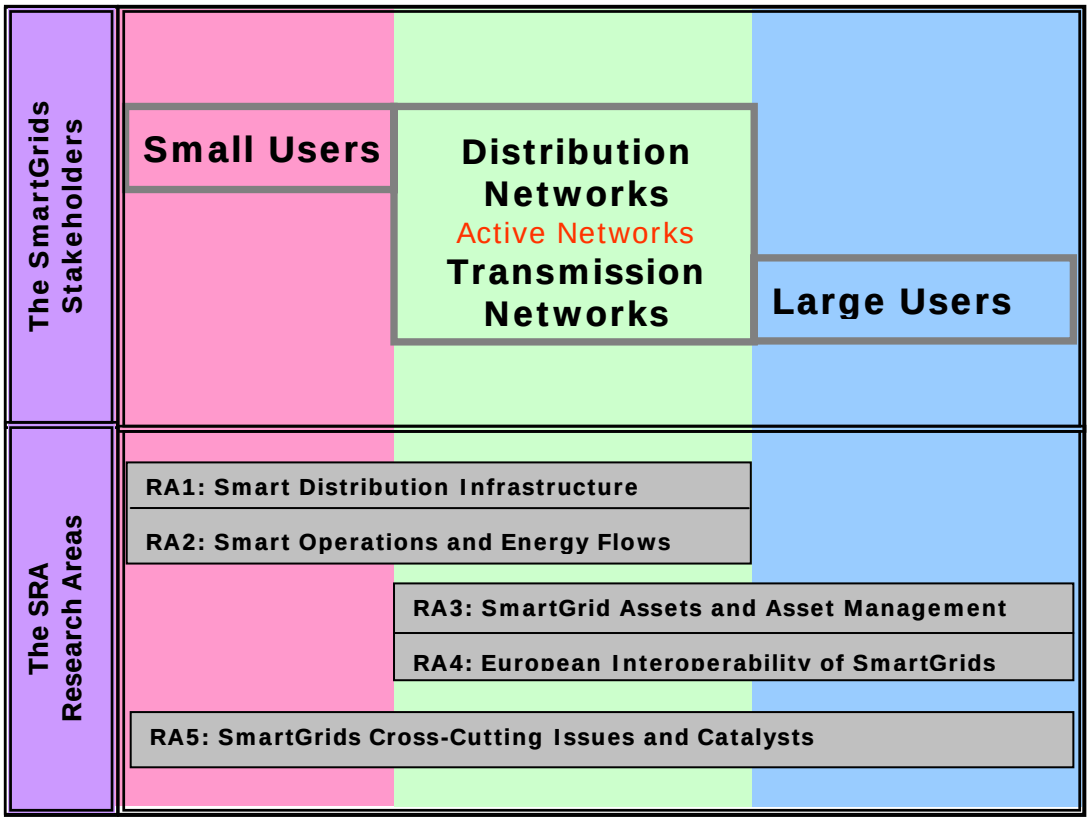
The scale of the challenge for Europe

The IEA World Energy Investment Outlook 2003 states that the electricity sector in the EU has an annual turnover of about €112 milliard and contributes about 1.5% to EU GDP. Investment in the sector is about €22 milliard per year in the EU.

Looking ahead, EU Member States will need to invest in excess of 750 milliard euros in power infrastructure over the next three decades, divided equally between generation and networks (some €90 milliard will be invested in transmission and €300 milliard in distribution networks).

Structure of the SRA

This SRA is presented with a two-tier structure. This structure has five primary Research Areas (RA) which are subdivided into a total of 19 Research Tasks (RT).



Each Research Task is explained using a common format that includes potential projects with expected deliverables; and associated Lighthouse and Catalyst projects.

Catalyst projects are specially targeted at removing commercial or regulatory barriers to ensure rapid take up of innovative solutions. Lighthouse projects seek operational demonstration to bridge the gap between innovation and adoption.

Strategic Research Priorities

The primary objective of a Technology Platform is to boost European industrial competitiveness, and it achieves this by defining research and development priorities. This document is intended as a reference agenda for the lifetime of the EC 7th Framework Programme. It is recognised that steps carried out in the near future will have an impact on the performance of the networks for decades to come. As a consequence, research priorities have been identified by considering the long term strategic value of the expected outputs.

For these reasons, the Advisory Council proposes to work closely with the EC and those states involved in the platform to maintain visibility of research activities at European level, thereby achieving prioritisation and coherence for mutual benefit.

Implementing the SRA

Research identified in this agenda will be facilitated and encouraged by the involved stakeholders. Financial support will come from regular funding schemes for collaborative research within the Framework Programme, using open tendering. However, this is only one potential source of funding. The SRA aims to mobilise a large range of public and private financing sources, including industry, international, national and regional programmes and the financial markets such as the European Investment Bank (EIB). Structural Funds have also been identified as a potential source to support the implementation of SRAs, in particular within new Member States.

Joint Technological Initiatives (JTI) could also be considered as a funding instrument for this SRA where the mobilisation and management of very substantial public and private investment and human resources is needed for a wider European level response.

Innovation opportunities

A few examples of fields for innovation opportunities identified in this SRA:

EXAMPLES of INNOVATION OPPORTUNITIES	
Small Users	Demand Side Participation Enhanced quality and security of supplies
Large Users	Reduced congestion for generation export Access to Europe-wide electricity markets
Distribution Networks	Integration of DER to enhance supply security and quality Achieving asset renewal cost-effectively and securely
Transmission Networks	Reduced congestion for pan European grid energy flows Open access to essential ancillary services across Europe

Water supply and sanitation technology platform (WSSTP)

WSSTP is the European technology platform combining diverse actors involved in European water supply and sanitation. It aims to create synergies between water using sectors, accelerate the implementation of new methods and technologies and to increase the investments into research on defined research areas. WSSTP has produced a common vision document for the whole European water industry, a strategic research agenda and an implementation plan for the short (2010), medium (2020) and long term (2030). According to the WSSTP vision by 2030 the European water sector will be the leading international centre of expertise for providing safe, clean and affordable water services while protecting the environment.

To meet the major challenges of the water sector, the platform has identified the following main research areas:

- Balancing demand and supply by managing demand, exploiting alternative water resources and promoting cleverer use of rainwater.
- Ensuring appropriate quality and security by managing risks of water cycle, better treatment technologies, comprehensive quality monitoring and by inspiring the confidence of public on water governance
- Reducing negative environmental impacts by regarding water as a self-sustained cycle, reducing water-based emissions, making usable products on waste water and sludge, reducing energy consumption and taking local conditions into account.
- Novel approaches to the design, construction and operation of water infrastructure assets by better understanding of all costs, by better materials and technology taking environmental, economic and social impacts into account and by risk analysis based operation, maintenance and replacement of assets.
- Establishment of an enabling framework by developing knowledge on new methods of IWRM/DSS and data management, and risk management, by standardisation of methodology, technology and process, by knowledge on barriers for integrated water solutions implementation, and by using new knowledge transfer and education methods.

The platform also presented six pilot themes. The pilot programme is a structure set up to carry out precisely targeted and prioritized research that is defined by and tested in a number of real-life applications. The pilot actions identified are:

- Mitigation of water stress in coastal zones
- Sustainable water management inside and around large urban areas
- Sustainable water management for agriculture
- Sustainable water management for industry
- Reclamation of degraded water zones (surface water and groundwater)
- Proactive and corrective management of extreme hydro-climatic events.

Annex 3. Industry partners which have participated in the preparation of the SRA

ABB is a global leader in power and automation technologies that enable utility and industry customers to improve their performance while lowering environmental impact. Based on the broad technology base in energy and automation, ABB's products, systems and services help to improve energy efficiency and otherwise the performance of processes in the whole chain from power generation to the distribution and the use of electric power in the customer processes. ABB have activities all over the world working to develop unique technologies that make our customers more competitive. Globally ABB is investing annually over 1 BUSD in R&D, and in 2007 ABB's R&D spending in Finland was 117 MEUR for the work of around one thousand R&D professionals. Collaboration with world-class external R&D partners - like universities and research institutes - has an important role in ABB's technology strategy.

BMH Technology Oy delivers machines and complete material handling systems to power plants that use bio solid fuel or RDF. Another sector is the solid waste processing machines starting from industrial cutting type crushers to different separating machines. The goal is to deliver complete turnkey processing lines.
High industrial standards that are used in Finnish paper industry are introduced in waste processing plants.
The R&D activity of the company was very high in 2002-2004 when new waste processing systems were developed. R&D costs are 1,5 – 5 % of the turnover. The research co-operation with some European manufacturers, VTT and Finnish Technical Universities has long history in BMH Technology Oy

Ecocat Oy is the leading manufacturer of metallic substrate catalysts and has developed unique production processes for metallic substrates and the coating of active elements on them. Ecocat Oy is engaged in the production of catalytic converters for passenger cars, heavy duty vehicles, motorcycles, small engines and industrial applications. In addition to Finland, production sites locate in Italy, India and USA. Local presence is realized by sales offices situated in Brazil, Czech, France, Germany, Italy, Romania, Sweden, United Kingdom and USA.

Development work is done in chemical and mechanical laboratories and in pilot plant located in Finland. Main production plant is located in Finland. Other production plants are Ecocat's turnover 2007 was 93 million euros from European, Asian and American customers. Ecocat has a wide global sales distributor network through its partners, agents and own sales offices. Ecocat employs about 230 people, the major part of which is located in the company headquarters and main factory, Vihtavuori, Finland. The company has its chemical R&D department in Oulu, where it employs 30 people.

Ekokem Oy Ab is the leading Finnish producer of demanding environmental services. Its strengths are high expertise in solving client's individual problems and several state-of-the-art facilities for materials and energy recovery and for waste treatment. Ekokem treats hazardous waste through high-temperature incineration with energy recovery and through six other treatment and materials recycling processes and landfill for the final residue. In a new waste-to-energy plant Ekokem recovers the energy content of a large volume of solid industrial and municipal waste, utilizing it for district heating of two towns and for electricity

production. Through a subsidiary, Ekokem treats contaminated soil, runs demanding landfill and other environmental construction projects and recovers various byproduct streams. Ekokem Group has a turnover of about 90 million euro and a staff of 320 people. The company operates on 10 locations in Finland, with about 20 000 domestic customers and a number of foreign customers in about 30 countries. Ekokem's R&D input is strong and results visible. The shareholders are the state of Finland, municipalities and a large number of industrial companies.

Fortum is a leading energy company in the Nordic countries, other parts of the Baltic Rim area and Russia. Fortum's activities cover the generation, distribution and sale of electricity and heat as well as the operation and maintenance of power plants. In 2007, Fortum's sales totalled EUR 4.5 milliard and operating profit was EUR 1.8 milliard. The company employed approximately 8,300 people. Fortum's shares are quoted on the Helsinki Stock Exchange. Further information: www.fortum.com

Fortum's R&D vision is to enable a CO2-free and sustainable future for Fortum. To achieve this, there are R&D activities in four focus areas: Performance excellence in current operations, growth, climate change mitigation, and the long-term non-emitting energy system. Fortum wants to engage in R&D co-operation with leading external partners and also pursues internal development efforts in selected key areas. The R&D expenditure in 2007 was 21 million €.

Foster Wheeler Energia Oy Group is a specialist in industrial and utility boilers as well as associated service operations. Fluidized bed technology – and circulating fluidized bed (CFB) boilers in particular – lies at the heart of FW´s know-how and product offering. Foster Wheeler has an approximately 40% share of the world market for CFB boilers. Through the experience of supplying over 400 fluidized bed units to industrial and utility customers worldwide, FW has steadily scaled-up and improved the technology. Over 300 of these fluidized bed steam generators have been CFB designs. Foster Wheeler Energia Oy Group is headquartered in Finland, with offices in Varkaus and Espoo and subsidiaries in Germany and Sweden. The group employs some 500 people and has annual net revenues of around 380 million euros. The group is part of global Foster Wheeler Ltd.

Helsingin Energia is a Finnish energy company which provides energy related products and services for customers like industry, communes, real estate and private electricity and district heating customers.

Helsingin Energia has technological know –how which enables the development of new technologies, understanding of their possibilities and the timely application in order to reach the strategic goals of the company. In its business Helsingin Energia strives to use progressive, reliable and environmentally sound technology.

Helsingin Energia performs applied research in order to use new information and own know-how for the development of new products, services, production processes and methods and the improvement of existing products. In addition to the own development work the international development of the technologies are actively followed. The research interest are co-firing biomass in coal dust boilers, biomass logistics and availability, CCS, technology for emission control, use of bio-oils in district heating power plants, of shore and on shore wind energy, energy efficiency.

Kemira is seeking to be a group of global and leading chemical businesses with unique positions in selected customer segments. Kemira's four business areas, Kemira Pulp&Paper, Kemira Water, Kemira Specialty and Kemira Coatings, provide customers with complete solutions, expertise and premium quality products. Kemira serves the pulp and paper industry, water treatment, paint business and chemical industry. New areas of interest are mining and oil (traditional & tar sands).
Main research areas in water treatment include:Potable and raw water treatment, Internal process water treatment & recycling, biological / chemical effluent treatment , oxidative waste water treatment, odour removal, sludge dewatering and management, lab survey and specific analysis.

Kuusakoski Oy is specilaised in recycling of materials. The mission is to recover materials and refine them to products. Several different materials can be recovered by separation, enrichment and refinement to new products. The whole value chain is employed from collecting the materials, transport to the factory and production of new materials. Kuusakoski, together with its research partners, develops new recycling and environmental technology solutions for different materials. Typical materials are scrap metal, old cars, electronics, electrical components, building materials, energy related waste and also municipal waste.

Lahti Science and Business Park Ltd (LSB) is a technology centre focusing on Cleantech business development and is the leader of the Finnish Cleantech Cluster. LSB is the founder and the coordinator of the IASP (International Association of the Science Parks) Enviroparks network focusing on global technology transfer between technology centres.
The main environmental R&D focuses of LSB are 1. constructing of research and pilot environments for Cleantech companies, 2. enhancing of cross-disciplinary research between Finnish universities by facilitating eight professorships in Lahti region and 3. developing of environmental analysis methods.
LSB has constructed, among others, the first pilot-scale facility for soil quality research in Northern Europe and constructs a world class research centre for renewable energy research in 2008. LSB owns 35 % of the leading environmental laboratory in Finland, Ramboll Analytics.

Lassila & Tikanoja specialises in environmental management as well as support services for properties and plants. L&T has business operations in Finland, Sweden, Latvia, Russia, and Norway. Its business is divided into three divisions: Environmental Services, Property and Office Support Services and Industrial Services. L&T’s net sales in 2007 amounted to EUR 554,6 million and it employed 9387 people at the end of the year. The company’s shares are quoted in OMX Nordic Exchange.

The Environmental Services division covers the collection, transportation and processing of recyclable material and waste, as well as the supply of recycled materials and solid recovered fuel (SRF) for reuse. L&T Biowatti Oy – a L&T subsidiary – specialises in procurement, processing and supply of wood-based fuels for customers. Industrial

Services specialises in heavy-duty environmental management and maintenance services with product lines offering to customers hazardous waste services, industrial solutions, damage repair services and wastewater services.

L&T's research and development expenses caused by centralised development projects were EUR 2,4 million in 2007. In addition there is extensive R&D work carried out by business divisions where some 20 people are involved in R&D projects. Main outside partner in R&D is VTT.

Oy Merinova Ab is a technology centre specialised in energy research and development. Merinova is the coordinator of the Energy Technology (Competence) Cluster. In the cluster Merinova is responsible for distributed generation, distribution of electricity and effective use of energy. Merinova participates in several projects related to those technologies. One of the projects is Road-map 2015. In this project there was described the R&D projects needed to achieve the Distribution Networks of the future. At present Merinova is participating in projects like: Power electronics in electricity distribution, Network with lot of Wind Power, New type of MV cable, the EU project: Active distribution network, ADINE and other projects, so that the total number of projects going on is more than 30.

Metso is a global engineering and technology corporation with 2007 net sales of over EUR 6 billion. We are the market leader in pulp and paper technology and in systems for rock and minerals processing and metal recycling. We are also among the leading suppliers of power generation systems, automation and control solutions for the energy and process industry. With approximately 27,000 highly skilled employees, we serve customers in well over 100 countries. We are a global company with operations in more than 50 countries and production in 19 countries and on every continent. Metso's research and development focuses on environmental technology, technology related to the services business and the development of intelligent solutions. In 2007, Metso's R&D expenses totaled EUR 117 million, i.e. 1.9 percent of net sales (EUR 109 million and 2.2%). R&D employed 923 people (839) in 2007. Metso's personnel made almost 850 invention disclosures (710), which led to over 220 patent applications (220). At the end of the year approximately 2,800 Metso inventions were protected by patents (2,500).

Motiva Oy is an impartial and state-owned joint stock company which produces expert services in order to promote efficient energy and material use and renewable energy. Motiva works actively with relevant sector authorities, organizations and companies directly and through networks nationally and internationally. Motiva's mission is to create well-being by promoting the use of energy and materials that are as harmless to the environment and as productive as possible.
The forms of activities include:
* Project management services
* Promotion of energy and material efficiency
* Speeding up introduction of advanced and innovative technology
* Preparation, support and follow-up of energy efficiency agreements and collection of the needs and innovative ideas from the annual reports
* Development and marketing of energy audits and analyses
* Promotion and development of bioenergy business operations

Motiva has participated in several EU-wide and national projects as a coordinator and a partner e.g. in the field of energy efficiency and renewable energy sources.

Neste Oil Corporation is a refining and marketing company focused on premium-quality, clean traffic fuels. The company's strategy is focused on growing its oil refining and biodiesel businesses. Neste Oil's refineries are located at Porvoo and Naantali in Finland, and have a total refining capacity of approx. 260,000 bbl/d. Neste Oil's net sales for 2007 totaled 12,103 million euros. The company employs around 5,100 people and is listed on the Nordic Exchange, Helsinki. For further information, see www.nesteoil.com.
The R&D activities have been concentrated to develop new biofuel production technologies. R&D cost were 28 million euros in 2007. R&D employs 220 people. Technology Centre of Neste Oil is neighboring Porvoo refinery.

Pohjolan Voima develops a concept for multifuel large scale power and heat production. One of the most important benefits of the concept is the fast control in addition to low cost of the produced power and heat. The concept includes fuels like coal, natural gas, peat and biomass. Research is done on CCS strategies suitable for this new concept. The use of biofuels is also promoted by research on biomass production, pre-treatment, logistics and combustion. Wind energy development includes issues on offshore deployment and operation taking into account ice. The development of services dealing with prediction of wind strength and the building of wind power on land are also developed. Hydro power development include increase of power plant efficiency, optimization of river beds and storage of wind electricity.

Outotec is a worldwide technology leader in minerals and metals processing, providing innovative and environmentally sound solutions for a wide variety of customers in minerals processing, iron and steel, aluminum and non-ferrous metals industries. Outotec designs and delivers plants, processes and equipment and provides engineering, project and support services globally. With a global network of sales and service centers, research facilities and more than 2000 experts the company generated annual sales of EUR 1 000 million in 2007.

Outokumpu Group is an international stainless steel company; among the five top producers in the world as ranked by volume. The vision is to be the undisputed number one in stainless steel, with success based on operational excellence, which specifically means value creation through commercial and production excellence.

Stainless steel production uses a lot of energy and materials. Outokumpu ferrochrome technology is a world leader in energy efficiency and the whole Tornio integrate is in the first front. High prices of electrical energy and Climate Change Combat are strong challenges for continual improvements and new concepts. We are making gradual progress in our own research, but bigger, versatile and balanced research programs comprising also the authority aspects are requested.

The decrease of life cycle cost is one driving force for all product and application development. Outokumpu Oyj employs almost 200 specialists in the research and development and also does research with customers, universities and research institutes.

Prizztech Oy is a technology centre specialised in implementation of industrial and research communities energy technology network projects. The company turnover is around 7 MEUR/a employing 50 persons. Prizztech Oy is a leading partner in the Future Basic Energy and Materials Technology, which is a part of Energy Technology Cluster of the National Expertise Programme. The main programmes within the energy technology network are:
- FinnFusion – Industry Network, promoting participation of the Finnish industry and research institutes to the international ITER initiative (1992 -)
- FinNuclear – Finnish Industry Nuclear Road Map, marketing the Finnish technology and services to the nuclear power plant business.
Prizztech Oy has initiated a co-operation between the Industrial Liaison Officers from the European ITER associations. The target is to enhance EU partners joint deliveries to the ITER test fusion reactor to be built in Cadarache France.

Rautaruukki Corporation supplies metal-based components, systems and integrated systems to the construction and engineering industries. The company has a wide selection of metal products and services. The Corporation uses the marketing name Ruukki. Ruukki aims to be the leading supplier of metal-based solutions in Europe to customers in construction and in the lifting, handling and transportation equipment industry. Ruukki is also seeking growth in component and systems deliveries in the energy sector, special products and in parts processing business. Ruukki is also heavily strengthening its special product business. Ruukki's research and development activities are aimed at improving the Group's competitiveness by developing innovative metal-based total deliveries, systems and components, through the development and introduction of new steel products and by developing productivity and production methods.

UPM-Kymmene Oy is one of the world’s leading forest products groups. The Group employs around 26,000 people and in 2007 made sales of EUR 10 billion. UPM’s main products include printing papers, label materials and wood products. The company has production units in 14 countries and its main market areas are Europe and North America. UPM’s shares are listed on the Helsinki stock exchange and the company has an ADR programme on the OTC market in the United States.
In 2007 UPM spent altogether approximately € 50 million (€ 44 million) on research and development projects, or 0.5% (0.4%) of the Group’s sales. UPM’s R&D Centre in Lappeenranta in Finland focuses on fibres and fibre raw materials, papers, coating and printing, as well as customer support, technical services and the environment. UPM’s recycled fibre research is centred in Augsburg, Germany, and support for North American operations in Grand Rapids, Minnesota. UPM opened a new research centre in China in March 2007. The UPM Asia R&D Center is responsible for local fibre raw material research, as well as manufacturing and technical customer service support for UPM’s production units in China and the Asia Pacific Region. UPM has joined as a 20% partner in Forestcluster Ltd, which was established to network top-level research and innovation in the Finnish forest cluster. It coordinates pre-competitive research and development. Its first research programme focusing on intelligent, resource-efficient production technologies started in the beginning of 2008. UPM holds 38,65% of Oy Keskuslaboratorio Ab (KCL), which is the joint pulp and paper research centre for the forest industry in Finland.

Vaisala is a technology company that develops, manufactures and markets products, solutions and services for environmental and industrial measurements. Vaisala's solutions

provide the basis for better quality of life, environmental protection, safety, efficiency and cost savings. Over the past 70 years, Vaisala has evolved into a world leader in many environmental and industrial measurement fields.

Vaisala's main customer groups include meteorological and hydrological institutes, road and rail organizations, defense forces, aviation organizations, private sector with weather-critical operations, system integrators and industry worldwide. The Vaisala Group employs over 1 100 professionals. In 2007, Vaisala achieved net sales of EUR 224 million. Vaisala employs 240 people in R&D, which is 21 % of the total personnel. The key areas in R&D are electronics, sensing materials, RF, digital signal processing and software. A large part of R&D is done together with customers and with world's leading research institutes and universities.

Vapo is the leading supplier of local and renewable fuels, bioelectricity and bioheat, as well as environmental business solutions in the Baltic Sea Region. The Vapo Group consists of the Parent Company Vapo Oy and four business areas: Local Fuels, Heat and Power, Pellets and Garden and Environment. The subsidiary Vapo Timber Oy processes timber. The Finnish State owns 50.1% of the shares in the Parent Company, Vapo Oy, and Metsäliitto Cooperative owns 49.9%. Vapo Group's turnover in 2007 was EUR 660,6 million. The Group had 1 828 employees. Both the individual divisions and the Business Development Department in Vapo conduct research and development activities. Vapo's main product groups are biofuels, bioheat, bioelectricity, growing media and waste treatment. Vapo's research and development activities focus on the above core businesses as defined in Vapo's mission and strategy. Vapo is the world's No. 1 in the area of research and technology in energy and horticultural peat, in pellet production, and in related environmental protection. preparation of bogs for peat harvesting, peat

Wärtsilä is a provider of power generation systems, operating in two main markets. In marine power and propulsion systems Wärtsilä is one of the world's leading providers, and in land based power generation it is the leading provider for diesel engine power plants. Wärtsilä also offers services in both these markets. The business of Wärtsilä's customers is enhanced by providing them with complete lifecycle solutions. Research and development is concentrated in creating more efficient and environmentally sound technologies through innovative products and services. In 2007 R&D expenses totalled EUR 122 million. Wärtsilä's goal is to strengthen the market position of its current main products, and to be a forerunner in the development of new innovative energy generation systems, such as fuel cells.

ÅF-Enprima Ltd's experience on climate and energy related R&D activities lays on long national and international traditions in a.o. Fortum Engineering and Fortum R&D Center. Today ÅF-Enprima is networked through its owner, ÅF Group, to a worldwide expert network both in energy and pulp & paper sectors in order to advise our clients for climate change control and to utilise both inhouse and linked expertises from ouside companies and universities.

SHOK Ltd provides ÅF-Enprima a good means for networking in order to continue and upgrade its operations by

- Providing R&D-Services for all Finnish technology companies and producers
- Developing new climate and energy services concepts for global markets

Annex 4. Principles of budgeting.

It is approximated that when the EnYm-SHOK is in full operation in 2010 the annual research volume will be 70 M€ per annum. This figure is based on a 50% private and 50% public funding of the total research budget. The public funding is expected to come from different sources, the main ones being the National Funding Agency for Technology and Innovation (Tekes), the Academy of Finland and EU framework programmes, mainly FP7.