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Japanese Policy for Environmental Innovation as a Way to Realize Growth

A close-up study on current Japanese measures to nurture and promote environmental technology

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Foreword

Today, when several advanced countries are simultaneously making dire efforts to gain competence and markets shares within the environmental technology sector – the Swedish initiatives must preferably be benchmarked towards others.

This study on a potential future lead market development of environmental innovations is intended to give an understanding of the current development in promotion of environmental technology in Japan. The purpose is to learn and gain experiences for potential future efforts in Sweden to foster prolonged competitive advantages in the environmental technology sector. The findings are further elaborated on within the theoretical underpinning on environment as an economic heave, a key ingredient in today's policy discussions in Japan as well as in Sweden and within the EU.

The report has been written by Åsa Guilamo, analyst on sustainable development in Japan, with assistance from Izumi Tanaka at ITPS Tokyo office on foremost patent data and research strategies included in this report.

Östersund, May 2007

Sture Öberg
General Director

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List of abbreviations

AIST	Institute of Advanced Industrial Science and Technology
ETAP	Environmental Technology Action Plan (EU)
EU	European union
GHG	Green House Gases
LCA	Life Cycle Analysis
MAFF	Ministry of Agriculture, Forestry and Fishery
METI	Ministry of Economy, Trade and Industry
MEXT	Ministry of Education, Culture, Sports, Science and Technology
MLIT	Ministry of Land, Infrastructure and Transport
MoE	Ministry of the Environment
NIES	National Institute for Environmental Studies
NIMS	National Institute for Materials Science
ODA	Official Development Assistance
RITE	Research Institute of Innovative Technology for the Earth
R&D	Research and development
S&T	Science and technology

Summary

The overall aim of this study is to gain an understanding of the current development and promotion of environmental technology in Japan, including governmental measures and, to some extent, new initiatives from the private sector. Policies and research strategies are analyzed from the viewpoint of gaining insight in both the underlying assessments as well as the main aspirations for the future. Three questions are highlighted: What are the current development trends in Japan for governmental R&D, research strategies and patent activity relating to environmental technology? What are the other environmental technology promotion measures of significance? And, finally, what are the current and what future strengths within the field of environmental technology can be expected?

The overall purpose, based on an overview of Japanese success factors and future aspirations, is to learn and gain experiences for potential future efforts in Sweden to foster prolonged competitive advantages in the environmental technology sector. In this regard, the relationship between environmental regulations and innovation, as well as the preconditions for creating lead markets enabling domestic firms to export environmental innovations, are elaborated upon.

To summarize, new visions in Japan's third basic Science & Technology plan include a strengthened focus on biomass & 3R (Reduce, Reuse, Recycle) as well as a more comprehensive view on climate change issues. Ministries and research institutes are currently working on how to mirror and realize the visions of the basic plan into their own strategies. The ministries are highlighting applications of cutting-edge technologies and the need for an Asian perspective. The research institutes to a large extent mirror biomass and the Asian focus. Other key features of the strategies are the emphasis on relating current undertakings to long-term visions and the establishment of follow-up indicators, as done in e.g. the Ministry of Environment's Strategy on promotion of Environmental Research and Technology Development.

According to patent data, Japan's strong competence is currently concentrated to a few key areas: air pollution control equipment, waste disposal and recycling. Weaker areas are water pollution and noise protection. Looking into market sizes the following strong areas appear: Renewable energy plants, Waste treatment and construction, and Instrument for Waste water treatment. Bringing together these results with conclusions from competitiveness indexes and (although limited) export statistics, the main fields of Japanese strengths can be sorted out as:

- Air pollution control equipment
- Waste disposal, treatment & management equipment
- Recycling
- Renewable energy plants

There are also high expectations for future success for so-called environment induced businesses. There are expectations on strong future market growth in following areas: manufacturing of air pollution control equipment and pollution preventing resources (photocatalytic system, catalysts, emissions treatment devices etc.), education, training, information supply (environmental reporting, auditing, consulting for obtaining ISO 14000 etc.),

environmental burden reducing and energy saving technology and processes, and energy saving and energy management (fuel cell cars, new energy etc).

The Eco-Town concept, in spite of the program's limited budget, is considered an effective measure in Japan to promote local economic stimulation through fostering environmental businesses. The Eco Town Program can, to some extent, be compared to the Local Investment Programmes (LIP) and Climate Investment Programmes (KLIMP) in Sweden. As in LIP and KLIMP, local governments/ municipalities are working together with local companies and organisations. However, the Eco-Town program has had a much stronger focus on 3R-related activities (Reduce, Reuse, Recycle), compared to the Swedish programs mainly aiming at reducing the emissions of greenhouse gases. Official development assistance is increasingly being used by Japanese actors as a tool to promote environmental technology abroad, mainly in nearby Asia.

Another innovative policy measure Japan has applied is the environmental technology verification, in place as a pilot project since 2003 and planned as a full-fledged program starting two years from now. The verification has already proven useful for example to obtain knowledge/know-how for providing guidance and information on procurement of environmental technologies. And, as developers were able to learn about features and improvements in technology, these were further stimulated, thanks to publicity from the program.

Reflecting on the Japanese experiences, life cycle analysis (LCA) seems to be an increasingly important complementary tool to regulations for adjusting the imbalances of today's price and cost structures. Since LCA measures are also a part of Swedish environmental policy, the Japanese experiences as a lead market in this regard may contribute to valuable learning. In addition to LCA advancements, Japan will provide a favorable ground for development of environmental innovations on e.g. it's demographic situation, high degree of competition and close monitoring activities from other countries; all important so-called demand factors for national markets to become lead markets.

1 Introduction

At the dawn of the 21st century, development and promotion of environmental technology becomes more and more important in order to cope with severe environmental problems. Many countries all over the world are currently working intensively to meet up to the increasing needs. Measures to develop and promote environmental technology are simultaneously viewed as a way to strengthen their competitiveness on the global market. The world market, including only traditional environmental technology amounts to SEK 4000 billions a year, equivalent to the total yearly production in the Nordic countries per year. Growth has been estimated to 5–20 percent per year. Today, the US dominates the environmental technology market and Japan has approximately 20 percent of the world market. (SOU 2004:84)

To strengthen the country's competitiveness, the Swedish government is investing in the environmental technology sector through a number of initiatives, e.g. the "Sustainable City" project and the new governmental-related organization SWENTEC. Policy measures are also strengthened on the EU arena, taking off from the EU Environmental Technology Action Plan (ETAP), adopted in 2004. At the same time, the process of globalisation is constantly changing the arena for environmental business and policy making.

In today's world, where several advanced countries are simultaneously making dire efforts to gain competence and markets shares within the environmental technology sector – the Swedish initiatives must preferably be benchmarked towards others. Japan constitutes an interesting case of point since the country is aggressively aiming at becoming the world's environmental technology leader, as well as pursuing environmental policy development in a quite different context.

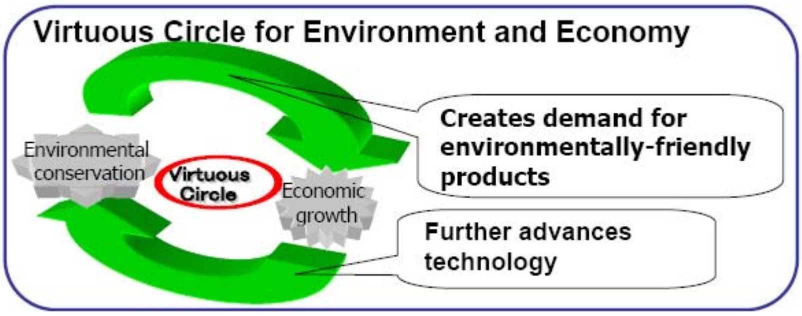
Furthermore, Japan wants to stress itself as "a nation of creative science and technology", and has a high acknowledgement of science and technology as an "investment for tomorrow". The S&T policy is considered one basic pillar for balancing environmental protection with economic growth, reflected in the third five-year phase of Japan's basic S&T plan, which began in April 2006. The plan addresses Japan's most pressing problems, and sets out a potential substantial increase of funding to the environmental field. Ministries and research institutes are currently working on how to mirror and realize the visions of the basic plan into their own strategies. Altogether, this creates an appropriate timing to grasp the current research visions and efforts at different levels in Japan, laying out the ground for the environmental technology successes of the future.

1.1 Growth models based on virtuous circles for environment and economy

After a prolonged period of stagnation and deflation, Japan's economy is currently undergoing a recovery. GDP growth has been climbing since 2002 and reached 2.8 percent last year (2005), with expectations of a similar rate for 2006. (Global Watch, 2006) At the same time, environmentally advanced products and technologies from Japanese companies are gaining attention as well as increased benefits from being highly competitive on the global market. Japanese companies have for example dominant positions in today's world market of e.g. hybrid cars and solar cells. At the World exhibition of 2005 in Aichi, Japan, visitors were surrounded by technologies designed to improve the environment in different ways. In fact, the whole exposition was dedicated to the theme of "Nature's wisdom", with parts of the sight powered by the latest solar cells and shuttle buses used were equipped with fuel cells. (EXPO, 2005)

The possibility to change the flow of goods and capital and to revolutionize industrial activities through consumer behaviour, can according to the Ministry of Environment in Japan (MoE) give rise to what they call the “Environmental Revolution”, following the footsteps of the “Industrial Revolution” and the “IT Revolution” (MoE, 2004). By demonstrating a growth model based on a virtuous circle for environment and economy, the goal is to lead the world as an environmentally advanced nation (MoE, 2005). Also, the powerful Japanese Ministry of Economy, Trade and Industry expresses views on how grappling with environmental problems leads to the creation of new businesses and strengthens international industrial competitiveness (METI, 2006).

Figure 1 Virtuous circle for environment and economy. (Koike, 2005)



Similar views on the environment as an economic heave, are expressed in e.g. the EU Environmental Technology Action Plan, stating that environment is a driver for growth. Also, in the Swedish government’s road map for growth and employment 2006–2008, the environmental challenges are announced as ”economic heaves and of central importance” for the abilities to develop Sweden as a whole (own translation) (Skr. 2006/07:23).

1.2 Environment as an economic heave: policy, theory and empirical evidence

Environment as an economic heave and driver for growth, is a core argument often derived from the Porter hypothesis, stating that regulation that aims at improving the environment might also be beneficial to the affected firms and potentially to the entire economy. An example of the arguments deriving from the Porter hypothesis in policy debates, are e.g. the efforts made by the network of Heads of European Environment Protection Agencies, to promote their common view that environmental policy would not only stay out of way of economic progress, but also that” good environmental regulation in Europe can support a clean, competitive economy and a healthy environment in which to work and live” (Prague declaration, 2005). An important discussion for environmental policy is also whether environmental regulations are capable of creating lead markets enabling domestic firms to export environmental innovations, considering that price and cost structures for environmental innovations to a large part are dependent on regulations.

Before discussing the Porter hypothesis further in foremost chapter 3, it should first of all be noted that there exists a consensus on that it’s from a long term perspective is beneficial for the society to apply a sustainability perspective to consider environmental costs, by internalizing the external effects and thereby visualizing win-win situations between well designed environmental regulations and productivity and growth. (Alfredsson, 2006) Consequently, when the traditional productivity measurement is being adjusted to also include the environmental costs, environmental regulations result in higher productivity. However, the Porter hypothesis in it's assumption of a win-win situation for companies and nations stemming from environmental regulations, uses the traditional productivity measurement.

1.3 Aim and purpose

The overall aim of this study is to gain an understanding of the current development and promotion of environmental technology in Japan, including governmental measures and, to some extent, new initiatives from the private sector. Policies and research strategies are analyzed from the viewpoint of gaining insight in both the underlying assessments as well as the main aspirations for the future. The analysis is aimed to serve as an inspiration for future efforts relating to environmental technology in Sweden. The following three questions are to be highlighted:

- What are the current development trends in Japan for governmental R&D, research strategies and patent activity relating to environmental technology?
- What are the other environmental technology promotion measures of significance?
- What are the current and what future strengths within the field of environmental technology can be expected?

The overall purpose is to, based on analysis of Japanese success factors and future aspirations, learn and gain experiences for potential future efforts in Sweden to foster prolonged competitive advantages in the environmental technology sector.

In addition to present an update of current and up-coming trends in Japan in the field of environmental technology, the purpose is also to relate and compare these findings with a theoretical framework to grasp a deeper understanding on the following key issues:

- What is the relationship between environmental regulations and innovation?
- What are the preconditions for creating lead markets enabling domestic firms to export environmental innovations?

1.4 Definitions & limitations

The environmental industry suffers on a global scale from a lack of clear identity and poor representation as a sector of its own right. Japan has, along with e.g. Canada and the U.S. adopted broad definitions of the environment industry.

According to the OECD classification, environmental businesses include waste treatment, development of equipment for preventing air pollution, development of equipment for preventing air pollution, and provision for education, training as well as information services. The EU environmental technology action plan, ETAP, includes all technologies whose use is less environmentally harmful than relevant alternatives – and encompass technologies and processes to manage pollution (e.g. air pollution control, waste management), less polluting and less resource-intensive products and services and ways to manage resources more efficiently (e.g. water supply, energy-saving technologies). (ETAP, 2004)

Japan has since long applied a broad definition of environmental technology, naturally incorporating businesses in which environmentally conscious consumer behavior bring about demand for environmentally-friendly equipment and services, such as energy saving home appliances and low energy and fuel efficient vehicles. This broad definition of environmental technology is also widely adopted by different key actors in society, such as business leaders, government and academia. Hence, the scope of this study of Japan is not limited to traditional (i.e. collection, filtering, concentration, degradation and measurement) environmental technology but instead quite wide, as illustrated by the analysis on drivers for developing e.g. hybrid cars and solar cell. It can also be noted that in Japan the term Kankyou (Environment) Gijutsu (Technology) is used, rather than Clean Tech (the current buzzword in foremost the US).

For defining environmental innovation, this study takes its starting point in the above-mentioned definition of environmental technology, together with OECD:s definition of Technological Innovation in the Oslo Manual (1995) as "technological product and process (TPP) innovations comprise implemented technologically new products and processes and significant technological improvements in products and processes. A TPP innovation has been implemented if it has been introduced on the market (product innovation) or used within a production process (process innovation). TPP innovations involve a series of scientific, technological, organizational, financial and commercial activities. (Wikipedia, 2006b)

Furthermore, this study is limited to governmental R&D, as laid out in chapter 5, and does not cover R&D activities in the private sector. It should also be noted that this study does not make the attempt to cover the broad spectra of measures for commercialization of R&D, but rather a range of examples from current activities in Japan.

1.5 Method and outlay

The study is based on interviews with central actors within the subject area, foremost representatives from ministries and research institutes, academics with key influence on the environmental policy process and representatives from companies with a competitive environmental edge[1]. The selection among of national institutes conducting R&D relating to environmental technology was made through guidance from key academics relating to the interests expressed from the Swedish side. The interview material was complemented by a throughout study of new policy and strategy documents, both in English and Japanese, channeled out mainly through the interviewees. For analyzing special competence areas, patent and export statistics have been used, and comments on their applicability are elaborated in respective sections in the main text.

Following this introduction chapter, a general theoretical overview of the Porter hypothesis and the lead market approach is given in chapter 3. Thereafter, the Japanese environmental market is elaborated on with special attention given to the most important drivers for the eco-business market, e.g. the role of voluntary actions plans. In chapter five, the governmental R&D structure and current content is presented, laying out the main points of the ministries strategies as well as comments on the key research institutes current environmental R&D focus. In the following patent data chapter, the strong fields of the environmental industry in Japan are analyzed and compared with other strong regions. Promotion efforts for environmental technologies, including official development assistance, are presented in chapter seven. In the last chapter the main conclusions of this study are summarized and suggestions for future studies being laid out.

[1] *As identified key academics and policy makers within the environmental field as of July 2006*

2 Theory

2.1 The Porter hypothesis

The Porter hypothesis was first published in an article in Scientific American in 1991, and then further developed by Porter & van der Linde in the Journal of Economic Perspectives in 1995. The hypothesis states that stringent well-designed environmental regulations not only lead to social benefits thanks to an improved environmental quality, but may *very often* also result in increased competitiveness for the regulated companies. The benefits lies within the effects well-designed environmental regulations may have in stimulating innovation, leading to private benefits for regulated companies by increasing productivity or product value. (Ambec & Barla, 2005)

Arguments derived from the Porter hypothesis has, as stated in the introduction of this report, become popular among policy makers, but often been criticized by economists. The different arguments have been centered on the Porter use of “very often”, and if the success stories of cases where environmental regulations have improved polluting firm’s profit is the norm or not. (Ambec & Barla, 2005) Porter and van der Linde do not conduct any empirical test of their hypothesis, instead they present a number of case studies to confirm it. The hypothesis is not one proposition, but rather a broad set of ideas, and difficult to spell out in precise terms. Moreover, the hypothesis does not state the time horizon of the asserted adjustments, making it difficult to evaluate the claim that environmental regulations can increase profits. (Levinson et.al, 2006) Several attempts have been made to review the empirical evidence so far in the economic literature. Also, ITPS has recently made a review, summarizing the theoretical and empirical evidence for the Porter effect, showing that in single cases there exists results that partly supports the hypothesis but that there are also studies falsifying it. One conclusion was that of a lack of support of general positive effects on the competitiveness of a nation’s industry by applying stricter environmental regulations than the rest of the world. (Alfredsson, 2006)

From other reviews, similar conclusions have been drawn, i.e. that there is only scanty, weak evidence to date showing that environmental regulations stimulate innovation activity. However, it has also been pointed out that it still would be unreasonable to, at this stage, simply reject the hypothesis, since the existing empirical research efforts are tainted with several weaknesses. For example, most studies made are stated to examine the impact of traditional command and control regulations, while theoretical research findings suggest that innovation activities are more likely to results from incentive-based regulations. (Ambec & Barla, 2005) There is also a complexity of the processes realizing technological innovation and increased productivity, including various peripheral factors other than environmental regulations, e.g. competitions between firms, demand conditions and governmental economic support measures. From the empirical point of view, an environment in which several factors are complexly intertwined, provides a great challenge. Lack of accurate data on the direct effects of environmental regulations and the difficulty of identifying effects of specific economic support are two of the most important obstacles. (Tanikawa, 2003)

In a research project indirectly commissioned by the Ministry of Economy, Trade and Industry of Japan, several case studies and examinations are pursued on what types of policies (regulations and other measures) can achieve technological innovation. From the research conducted in this research group, the conclusion was that the relationship between environmental regulations and technological innovation or productivity improvement is far from simple. As an example, a research group representative refers to the Japanese automakers as being prompt to produce hybrid vehicles gaining attention in recent years. Hybrids were not necessarily developed in response to specific individual regulations, but instead in order to achieve favorable competitive market place positions, given a consensus on a trend to a general and long term strengthening of regulations. (Tanikawa, 2003)

The research group also observed an increased tendency on more businesses actively proceeding with environmental measures on their own, whether by implementing measures in the absence of environmental regulations, or- when possible- attempting to achieve levels of environmental protection exceeding the required level. Risk management efforts stimulated by the implementation of pollution control measures were pointed out as an important driver of this development. Also, changes in business management concepts reflecting an increased environmental awareness of consumers and capital markets were marked as important incentives. (Ibid.)

2.1.1 Porter from a Japanese perspective

Hamamoto (1998, 2006) analyzes how Japanese industries have overcome environmental constraints and improved total factor productivity, showing that although environmental policies for pollution reduction decreased the final output in the short term, they encouraged various R&D activities for relevant technologies. These R&D activities ultimately improved the overall productivity of the economy. (Nakada, 2002)

Consequently, even though pollution abatement is often considered to be an additional financial burden for production, they are nevertheless likely to encourage R&D activities that contribute to the overall productivity in the medium to log run. (Nakada, 2002) Hamamoto's results do not imply that the Japanese environmental regulations in the 1960s and 1970s were perfectly designed, in the sense that they encouraged firms to pursue innovative activities. However, according to Hamamoto, the command and control approach adopted in Japan, could to a certain extent provide incentives because performance standards, rather than technology-based standards, were set. In addition to Hamamoto, Arimura et.al (2005) has, according to an empirical analysis of environmental innovation in the Japanese economy with focus on private firms in manufacturing sector, made the finding that stringent environmental policy increases the probability of firms' conducting environmental R&D. (Arimura, 2005) Some studies have also shown, not only that regulatory stringency has a significant positive effect on R&D expenditures, but also a small but positive impact of pollution control expenditures on the number of successful environmental patent applications (Brunnermeier and Cohen (2003) in Hamamoto (2006).

2.2 The lead market approach

Differences in export success between firms based in different countries, have often been possible to explain by relative levels of technological sophistication. Supply factors influencing the technological capabilities for environmental innovations can e.g. be efforts in respect of environmental R&D (for example when a country on the national level develops centers of excellence and innovations clusters, or when companies develop cleaner products), or in the implementation of environmental management systems as a supporting factor. According to Rennings & Ziegler (2006) several studies have found empirical evidence that both environmental R&D and management systems have significant impacts. However, other factors such as demand and market conditions leading to early adoption of innovations, has proven important to determine international competitiveness.

The success of new products, creating new markets, is of paramount importance for innovation and an approach with the focus on competition between different innovation designs, early adoption and global diffusion is the ”lead markets” concepts.

Countries that are first in adopting an internationally successful innovation can be referred to as ”lead markets”, and countries following the lead as ”lag markets” (Belsie, 2001). Examples of innovation design and lead markets are e.g. the cellular phones first widely adopted in the Nordic countries and the facsimile machine adopted in Japan before becoming the globally preferred design for text-based telecommunication. In the leading country, the penetration rate tends to be higher for an extended time period, supplying firms with markets knowledge enabling them to constantly improve innovation and retain their lead. (Rennings & Ziegler, 2006)

Main factors for national markets to become lead markets are:

- They are in advance of a global trend (in income structure, demographic trend, regulations, liability rules, standards, etc.)
- They demonstrate a high degree of competition and therefore are likely to experiment and to react to market needs
- They have gained a high reputation concerning problem solving innovations in the past and are therefore intensively studied by other countries

In Besie and Rennings (2005) the lead markets approach is applied to environmental innovations, stating the important role of regulations in enabling innovations as well as the international diffusion of environmental technologies. While environmental innovations are still largely driven by regulations, they will however be accepted in the long run only if the market conditions are favorable and there is sufficient customer demand. Furthermore, lead markets are not necessarily the countries that developed a new technology, since other countries may adopt it first due to specific conditions in e.g. price and cost structure. (Rennings & Ziegler, 2006)

3 Market size and drivers for eco business in Japan

The year of 2006 marks the 50th year since the government of Japan officially acknowledged Minamata disease, one of the so-called "four major pollution triggered diseases", erupted in 1950 to the 1960s. The attention paid by the general public to the environmental problems and health effects back then, constituted the starting point of a process towards the establishment of the first set or environmental regulations in Japan.

Manny of today's policy measures and trends for environmental technology and environmental business development are quite similar to those in Sweden and Europe. Some examples are the increased attention to stimulate sustainable production and consumption patterns by e.g. extended producer responsibility, green procurement, new legislation on waste management and recycling, as well as the enforcement of the Kyoto protocol. The driving forces behind Japanese policy measures can to a large extent be found in international agreements and a firm view on advanced environmental technology as a competitive factor of increasing importance.[2]

There are overall a vast number of Japanese companies that consider environmentally conscious considerations and/or social responsibility as one of their core business strategies. These companies' commitments on the environmental arena are therefore not limited to observance of the law, but driven by other factors. Due to a large number of Japanese companies, making the national competition fierce, the in-house standards are also often found to be more progressive than national environmental legislation. (Ahlner, 2006)

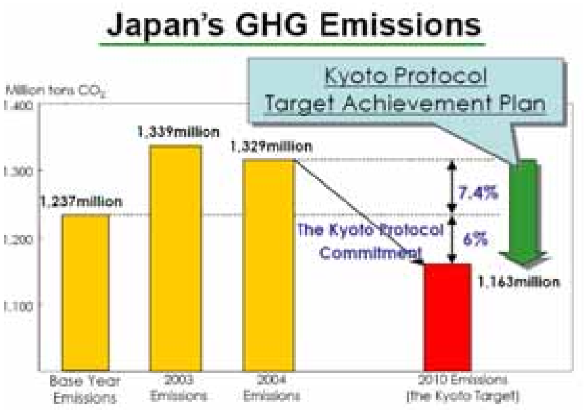
Other factors stimulating the development even further, than compared to e.g. Sweden, are Japan's high population density and its strong dependence on imported energy sources. Currently, Japan imports nearly 90 percent of its oil from the Middle East, making the need to create technologies for new energy to replace oil an urgent matter. Also, Japan's population is aging more rapidly than any other country's and began to shrink last year.

3.1 Kyoto Protocol into force and the new target achievement plan

Under the Kyoto Protocol, Japan has committed to reduce greenhouse gas emissions in the first commitment period by 6 percent below 1990's base year level. The current state of Japan's emissions of greenhouse gases, show that emissions in 2004 stood at approximately 1.33 billion tons, a figure representing a 7.4 percent increase over base year level. (MoE, 2005) and the actual decrease mandated is therefore a total of approximately 13–14 percent compared with today's levels, see below.

[2] *For a comprehensive examination of drivers for environmentally driven technology and business development in Japan, please refer to Ahlner & Tanaka, 2003.*

Figure 2 Japan's emissions of green house gases since base year 1990 and future reductions for the target year. (Koike, 2005)



The Kyoto Protocol came into force in February 2005. Later in 2005, in order to implement policies and measures to achieve the Kyoto target, the Japanese government formulated the "Kyoto Protocol Target Achievement Plan", adopted by the parliament in April 2005.

According to Kyoto Protocol Target Achievement Plan, policies and measures are based on two major key points for ensuring the achievement of the reduction commitment. One is a national campaign to encourage every citizen and business entity to take part in the actions to combat global warming. Another is the dissemination of low emission technologies such as clean energy vehicles, photovoltaic power generations and light-emitting diodes (LED:s).

The basic concepts of the plan are:

- Environment/economy: Win/Win approach
- Promotion of Technological Innovation
- Involvement of stake holders
- Policy mix
- Annual Review and evaluation
- International collaboration

Furthermore, the plan proposed an emission trading system (ETS) and environmental tax as economic instruments. There has been some experimental work conducted on the development of domestic ETS.

An environmental tax on fossil fuels has been discussed intensively the last two years, but has not been able to reach consensus in the government yet (as of October 2006). It is viewed as a key measure to achieve the Kyoto target by MoE and the Ministry of Agriculture, Forestry and Fisheries (MAFF), aiming at making Japan a fore-runner in the field of environmental technology by applying the revenues from the tax to the development of new technologies in areas such as energy conservation. The ministries have though faced strong opposition from industrial circles, which believe an environmental tax would cause a rise in prices and weaken the industries´ international competitiveness.

Japans new domestic, voluntary ETS is mentioned as a way to gain experience and knowledge about cost-effective emission reductions and trade. The plan states that the effects of ETS should be carefully studied, and also be compared with the efficiency of other methods when it comes to effects on industrial activities and the country's competitiveness. (Government of Japan, 2005)

3.2 Energy dependency a rising concern

Japan relies almost completely on imports for its supply of fossil fuels; oil, coal and natural gas, and stands out as one of the few OECD members that possess almost no domestic primary energy resources. Moreover, the transportation of these imports brings about both high costs and instability of supply since Japan is not connected by land to its neighboring countries and quite distant from regions with abundant natural resources, e.g. the Middle East. Therefore, the question of how to acquire a cheap and stable supply of energy is the most critical challenge that Japan faces in the formulation of its national energy strategies.

The recent increase in energy prices and the development at the international energy markets, has spurred the government to set out a new, national energy strategy. The new strategy shifts focus from deregulation, highlighted in the strategy from the 1990s, to national security. Moreover, the new strategy highlights solutions on energy related environmental concerns and how Japan can contribute to increased international collaboration on energy issues.

Five specific goals to be achieved in 2030:

1 Reduce oil dependence (from 50 % to 40 %)

2 Reduce oil dependence in the transport sector (from 98 % to 80 %)

3 Larger share of nuclear power (from 29 % to 30–40 %)

4 Improved energy efficiency by 30 %

5 Larger share of oil produced by Japanese corporations (from 15 % to 40% of the import)

Japan has so far been late coming in implementation of bio-fuels. Nevertheless, an important part of the strategy consists of measures within the transport sector, and the strategy sets out a goal on increasing the maximum portion of bio ethanol in gas from 3 percent to 10 percent and the government is planning to enact a new law within a few years to mandate all newly produced cars to be able to run on a mixture of 10 percent bio ethanol. Today's level for new cars is a mixture of 3 percent, but the supply is still very limited. (METI, 2006c) An important part of the energy policy is the actions to promote new energy technology.

3.3 Eco-business market

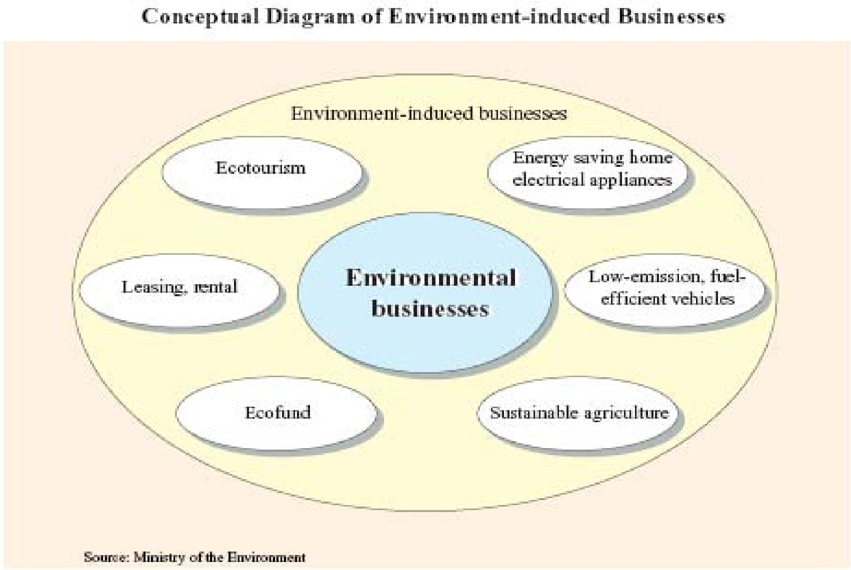
The environmental market in Japan has been rapidly expanding since the second half of the 1990s, partly due to the advancement of environmental laws. In particular, services such as pollution control, waste disposal & recycling, soil improvement and environmental consulting are in an expansionary phase- and it its thought that the size of the market and workforce of environmental industries will continue to expand further.

Statistics on current size (as of year 2000) and future forecast of the environmental businesses has been reported by the Japanese Ministry of Environment, in the format of OECD/Eurostat classifications of the environment industry (MoE, 2005). The market size based on the OECD classifications[3] was approximately 30 trillion yen in year 2000 (2 trillion SEK[4]), and the expected expansion was estimated to approximately 47 trillion yen (3.1 trillion SEK) in year 2010 and approximately 58 trillion yen (3.9 trillion SEK) in year 2020. In this calculation, the environmental business market was defined as the provision of products and services that measure, prevent, reduce, minimize or improve negative impacts on the environment including water, air, soil and problems related to waste, noise and eco-systems. (MoE, 2003 in JETRO, 2006b) The large-scale sales were stated in the areas of:

- Waste treatment services and the manufacture/construction of waste treatment facilities
- Resource recovery and recycling

The environment-related businesses also have continuously increased in recent years, and among these businesses in which environmentally conscious consumer behavior bring about demand for environmentally-friendly equipment and services- covering a broad range of businesses, including the environmentally businesses classified by the OECD. The ministry has named these businesses “environmentally-induced businesses” and predicted their market size and employment potential. (MoE, 2004)

Figure 3 Conceptual diagram of Environment-induced Businesses. (MoE, 2005)



A forecast of the “environmentally-induced businesses”, including environmental businesses, shows that the market size would increase from approximately 41 trillion yen (2.7 trillion SEK) in 2000 to 103 trillion yen (6.9 trillion SEK) in 2025 and the size of employment would increase from approximately 1,06 million people in 2000 to 2,22 million people in 2025. (MoE, 2005)

[3] Please refer to table below “Current and future forecast of market of eco-business in Japan”
[4] All calculations are made with an exchange rate of 1 SEK= 15 yen

Table 1 Estimates of the current and future market size and employment potential of environmentally-induced businesses. (MoE, 2005)

	Market Size (trillion SEK)		Workforce (people)	
	2000	2025	2000	2025
Environmentally-Induced Business	2.7	6.9	1060000	2220000

Sectors predicted to enjoy sizable growth in market size and employment numbers are the consulting sector, the photo-catalytic system sector and the fuel cell battery sector. These and the following sectors are also expected to experience market growth: (JETRO, 2004)

- Manufacturing of air pollution control equipment and pollution preventing resources (photo-catalytic system, catalysts, emissions treatment devices etc.)
- Education, training, information supply (environmental reporting, auditing, consulting for obtaining ISO 14000 etc.)
- Environmental burden reducing and energy saving technology and processes
- Energy saving and energy management (fuel cell cars, new energy etc)

Reflections upon the size of markets and employment in the environmental industry can to some extent be compared with the Swedish experiences as reported by a study within the IVA project Environmental Foresight, *Swedish Strengths in the Environmental Industry*, which uses similar classifications from OECD/Eurostat statistics as the data from Japan. Some general conclusions, laid out in the referred study on Swedish strengths, are that the number of workplaces are divided quite evenly between the two groups pollution management and resource management, but the turnover is greater for the latter due to high value-adding especially for renewable energy plants, belonging to the resource management category.

When comparing these results with the statistics from Japan using OECD/Eurostat classifications, it can be concluded that high-value-adding within the category of renewable energy plants, is valid also for the Japanese environmental industry, especially compared to the employment and market scale of waste treatment. Apart from renewable energy plants, other important groups of today’s environmental industry in Japan are those of provision of service for waste treatment and construction and installation for waste water treatment, see below.

Table 2 Current and future forecast of market of eco-business in Japan. (MoE, 2005)

Eco-business	Market scale (100 million Yen)			Employment scale (person		
	2000	2010	2020	2000	2010	2020
A. Prevention of environmental pollution	95,936	179,432	237,064	296,570	460,479	522,201
Manufacturing of equipment and pollution prevention material for:	20,030	54,606	73,168	27,785	61,501	68,684
1. Air pollution preventing	5,798	31,660	51,694	8,154	39,306	53,579
2. Waste water treatment	7,297	14,627	14,728	9,607	13,562	9,696
3. Waste treatment	6,514	7,037	5,329	8,751	6,676	3,646
4. Soil and water purification (incl ground water)	95	856	855	124	785	551
5. Prevention of noise and vibration	94	100	100	166	122	86
6. Environment measurement, analysis and assessment	232	327	462	981	1,050	1,124
7. Others	-	-	-	-	-	-
Provision of service for:	39,513	87,841	126,911	238,989	374,439	433,406
8. Air pollution prevention	-	-	-	-	-	-
9. Waste water treatment	6,792	7,747	7,747	21,970	25,059	25,059
10. Waste treatment	29,134	69,981	105,586	202,607	323,059	374,186
11. Soil and water purification (incl ground water)	753	4,973	5,918	1,856	4,218	4,169
12. Prevention of noise and vibration	-	-	-	-	-	-
13. Environmental research and development	-	-	-	-	-	-
14. Environmental Engineering	-	-	-	-	-	-
15. Analysis, data collection, measurement and assessment	2,566	3,280	4,371	10,960	14,068	17,617
16. Education, training and providing info	218	1,341	2,303	1,264	5,548	8,894
17. Others	50	519	987	332	2,497	3,491
Construction and installation for:	36,393	36,985	36,985	29,796	24,539	20,111
18. Air pollution prevention	625	0	0	817	0	0
19. Waste water treatment	34,093	35,837	35,837	27,522	23,732	19,469
20. Waste treatment	490	340	340	501	271	203
21. Soil and water purification	-	-	-	-	-	-
22. Noise and vibration prevention	1,185	809	809	956	536	439
23. Environment measurement, analysis and assessment	-	-	-	-	-	-
24. Others	-	-	-	-	-	-
B: Technology and products for reduction of environmental burden (Manufacturing equipment and providing technology, material and services)	1,742	4,530	6,095	3,108	10,821	13,340
1. Technology of abating environmental burden and resource conservation technology and process	83	1,380	2,677	552	6,762	9,667
2. Technology of abating environmental burden and resource conservation products	1,659	3,150	3,408	2,556	4,059	3,673
C. Efficient use of resources	201,765	288,304	340,613	468,917	648,043	700,898
(Manufacturing equipment, provision of technology, material, services, construction and installation of equipment)						
1. Prevention of indoor air pollution	5,665	4,600	4,600	28,890	23,461	23,461
2. Water supply	475	946	1,250	1,040	2,329	2,439
3. Renewable energy facility	78,778	87,437	94,039	201,091	211,939	219,001
4. renewable energy facility	1,637	9,293	9,293	5,799	30,449	28,581
5. Energy saving and energy management	7,274	46,829	78,684	13,061	160,806	231,701
6. Sustainable agriculture and fishery	-	-	-	-	-	-
7. Sustainable forestry	-	-	-	-	-	-
8. Prevention of natural disaster	-	-	-	-	-	-
9. Eco.tourism	-	-	-	-	-	-
10.Others	107,940	137,201	152,474	218,436	219,059	195,655
Repairing machinery and furniture	19,612	31,827	31,827	93,512	90,805	66,915
Renovation and repair of house	73,374	89,700	104,542	59,233	59,403	56,794
Urban greening etc	14,056	15,674	16,370	65,601	68,851	71,046
TOTAL	299,444	472,266	583,762	768,595	1.119,343	1.236,439

Note 1. "-" indicates there is no number due to lack of suffient data
2. Date of the market scale 2000 is used for some of the market scale of 1999 etc
3. Total of the market scale may not add up due to rounding

3.3.1 Regulations & voluntary agreements as driving forces

The enforcement of environmental regulations upon business enterprises, set in place because of increasing concerns over serious health effects of industrial pollution, spurred the entrance of the first eco-business in Japan in the form of sales of air and water pollution control equipment. In fact, after the so-called Pollution Diet of the 1960s and the end of 1970s, Japan had among the world's most stringent package of environmental regulations. Furthermore, local governments' pollution control agreements with local industries, often set a higher standard compared to the local level and where effectively implemented.

These types of administrative guidance have, together with voluntary agreements, been a key pillar of environmental policy making in Japan. (Schreurs, 2002)

As laid out, the environmental market in Japan has rapidly expanded since the second half of the 1990s, much due to the government's advancement of environmental laws, and a large number of environmentally-friendly products and services are currently being distributed in response to the increasing environmental awareness. Continuous growth in market size and employment is expected in several sectors, but in particular for waste treatment services, resource recovery and recycling, consulting, photo-catalytic system and the fuel cell battery sector. Estimations calculate that the market size for so-called environmentally induced businesses by the year of 2025 would increase by 150 percent and the number of employment by 110 percent, compared to year 2000.

The recent regulations that have driven the eco business market are e.g. recycling laws and stronger standards on dioxin and soil contamination. Another important law is the green public purchasing law, resulting in a substantial increase of environmental products not only by governments purchased but also the put a match to efforts in the corporate sector. The new set or laws are often grounded or influenced by international agreements and frameworks. The Kyoto protocol is of course important, and becoming more and more so as the commitment period gets closer and since the emission trends in Japan look pessimistic. Last year (2005) the GHG emissions increased by 8,1 percent, implying Japan today has to decrease emissions by roughly 14 percent compare to 1990´s level to reach their target.

Furthermore, the environmental policy making in Japan has since long been giving high importance to administrative guidance, voluntary agreements and a mix of incentives and penalties. The voluntary approach is increasingly being regarded, both in Japan and abroad, as an effective means of achieving the emissions targets set by the Kyoto protocol.

In Japan, the government defines voluntary initiatives as "actions that firms take voluntarily, in which they establish non-binding targets as a means of implementing environmental conservation measures" and the government's Basic Environmental Plan has characterized them as a tool for actively working on issues such as preserving the global environmen and treatment of industrial waste and chemical substances. According to a survey, the Japanese governments interest in voluntary agreements can mainly be attributed to the following: 1) it takes tremendous time to reach consensus on the implementation of economic measures such as regulations and environmental taxes, and 2) Voluntary approaches give firms flexibility and assist in the reduction of costs incurred when reducing their environmental impacts. (Hibiki & Arimura, 2003) For a comprehensive understanding it is however essential to keep in mind this broad policy mix and not least, that "voluntary" actions have a quite different interpretation than in the Swedish/European context.

3.3.2 Keidanren's voluntary action plan on the environment

In June 1997, Keidanren business federation[5] adopted their" Voluntary Action Plan on the Environment", a commitment to strive to reduce the emissions of carbon dioxide by 2010 to a level lower of that of year 1990. By the year of 2005, a total number of 35 industries

[5] *Keidanren, Japan Federation of Economic Organizations, is the by far most influential business federation in Japan, organizing 1,636 members, among them 1,314 companies (including 95 foreign-owned), 129 industry groups and 47 regional economic organizations (as of July 2004).*

were engaged to apply measures toward these goals (altogether representing 45 percent of Japan's total CO2- emissions in 1990). A follow-up has shown that CO2- emissions for 2004 were 0,5 percent lower than 1990, and the reduction target has been achieved every year since 2000. (Nippon Keidanren, Nov 2005)

The plan includes four sections: Global Warming Measures, Waste Disposal Measures, Environmental Management and Environmental Conservation in Overseas Business Activities. Specific targets have been set for Global Warming Measures and Waste Disposal Measures. The goals are set by the sectors themselves and can be expressed as absolute numbers, emission intensity, energy use or energy intensity. Within the sectors, emission trading is possible.

In the government's Kyoto Protocol Target Achievement Plan (KPTAP)[6], the Voluntary Action Plan plays an important role to reduce CO2 emission from industrial & energy-converting sectors. Voluntary actions are supposed to achieve 4,8 percent of emissions reduction.

In Japan, there is a long tradition of problem solving by voluntary agreements between powerful actors in society. Considering a culture intertwined with concepts such as responsibility, consensus and honor, the non-mandatory way forward seem to be quite capable of achieving considerable emission reductions. However, "voluntary" is a concept interpreted in different ways in different countries, and in the Japanese context it is vital to keep in mind the nature of voluntary acts in a societal system characterized by close ties between the bureaucracy and industry.

For example, for design and follow-up procedures of the voluntary agreements within Keidanren's action plan the Ministry of Economy, Trade and Industry (METI) has a central role, surveying each sectors' ability to reach the targets on a regular basis. In the case a sector easily can achieve its commitments, demands are strengthened. In the case a sector faces difficulties, the government can refer the sector to compensate for the shortage to achieve targets. (Srinivasan, 2006) To name Keidanren's and the 35 industrial sectors plans for emission reductions voluntary, is therefore somewhat misleading. In fact, the agreements are "quasi-mandatory", and according to a ministry representative, the concept of voluntary originates from the very start when the plan had more of a non-binding character. (Sakamoto, 2006)

[6] *As mentioned in the introduction in this report, Japan has committed under the Kyoto Protocol to reduce greenhouse gas emissions in the first commitment period by 6 percent below 1990's base year level. The current state of Japan's emissions of greenhouse gases, show that emissions in 2004 stood at approximately 1.33 billion tons, a figure representing a 7.4 percent increase over base year level.*

4 Governmental R&D in the environmental field

The R&D intensity in Japan is the third highest in the OECD area, and in 2005/06, total R&D spending in Japan (industry and public sector) was 21 trillion yen, with a R&D/gross domestic product (GDP) ratio at 3.1 percent (OECD, 2006). Government R&D investments account for approximately a fifth of total national investments, with Japanese industry accounting for most of the remainder.

The Governmental R&D-funding excluding institutional funds to universities and some competitive funds in environmental field for FY 2005 was 149.3 billion yen (9.95 billion SEK), representing a share of 7,5 percent of the total budget. Compared to fiscal year 2001, the budget increased by 63 percent, an exceptional increase also compared to the other so-called primary prioritized areas, as illustrated in figures 4 and 5 below.

Council for Science & Technology (CSTP) was established in the beginning of the new century established in the cabinet office, and has since then been serving as the control tower responsible for coordinating S&T policy from a government-wide perspective. Still, the actual financial contribution within the environmental field (as for others) stems from several ministries, whom continue to draw up own strategies and roadmaps as guidelines and for input to CSTP.

In this chapter, the central changes of directions set out in the government's plans, both the central one from CSTP as well as the content and implementation of the strategies from ministries and key research institutes related to the ministries, is being laid out. The purpose is to analyze Japan's new research strategies and experiences gained this far, both from a perspective of receiving important influences from a somewhat different system, as well as to map out Japan's current and future standings in the environmental research field. The following questions are to be highlighted:

1 The visions in the new 3rd basic plan for Science & Technology; what are the areas of attention within the environmental field, including new changes of directions and how is environment approached in other priority areas?

2 What strategies do the ministries' set out for environmental technology, and how are these related to the S&T Basic Plan?

3 In what way do the strategies of the research institutes put emphasis on environmental technology and what are the recent changes of direction in this regard?

Figure 4 Budget figures for CSTP. (CSTP,2005)

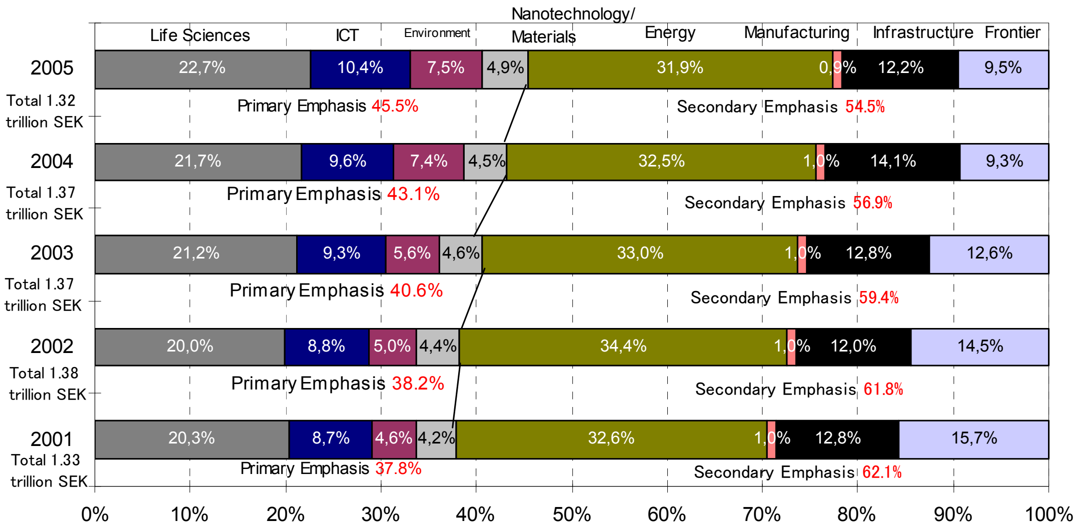
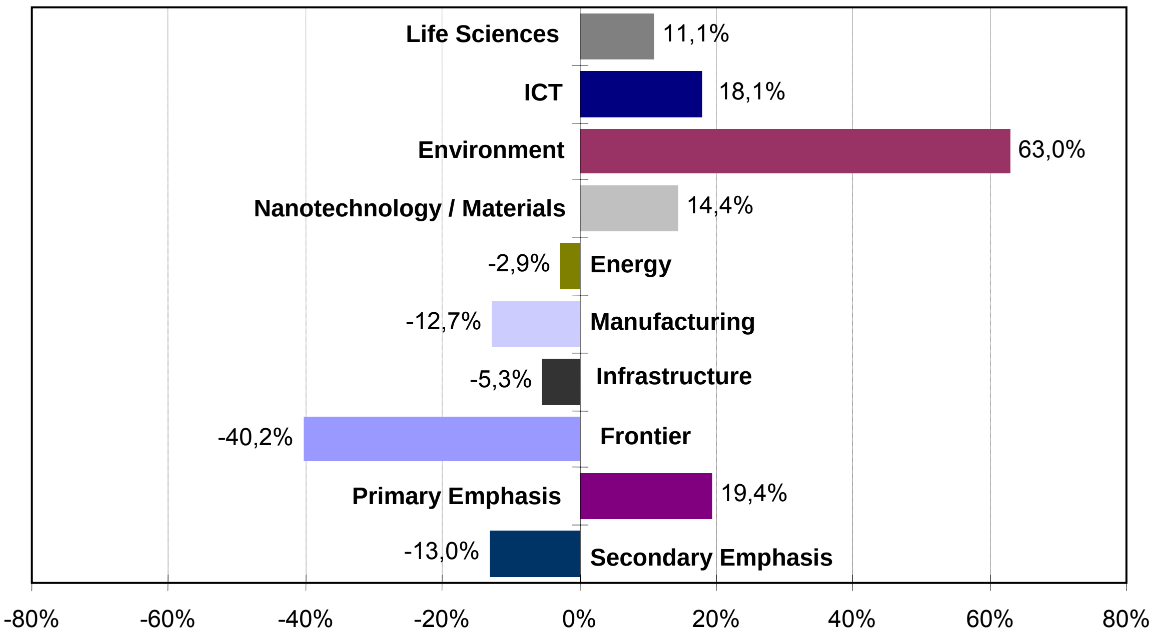


Figure 5 Budget figures for CSTP. (CSTP,2005)



4.1 Research funding system

As in Sweden, the financial contribution to research in the environmental field comes from a number of different governmental sources. In Japan, the main ministries involved are MoE, MEXT, METI, MAFF and MLIT.

MEXT and other ministries promote research and development related to their missions through their national institutes, through institutional funds and grants to universities and contracts with private corporations. The national R&D institutes, attached to the different ministries, are representing a much larger component of research financed by the government compared to research institutes in Sweden.

There are also several independent organizations which are fully funded by several ministries, from where researchers can apply for funds directly. For example, both the Japan Society for the Promotion of Science (JSPS) and the Japan Science and Technology Corporation (JST), funded by MEXT, have significant grant programs. Likewise, the New Energy and Industrial Technology Development Organization (NEDO), which is fully funded by the Ministry of Economy, Trade and Industry (METI), provide grants for research related to energy and new technologies.

The largest share of the government budget for science and technology goes to the Ministry of Education (MEXT), accounting for 63.7 percent of the total budget, followed by that of the Ministry of Economy, Trade and Industry (METI), which accounts for 17 percent. The majority of MEXT's budget is spent on institutional fund for national universities. Primary awardees of funding from the Japan Science and Technology organization (JST), the funding agency under MEXT, continue to be universities and governmental institutions. (OECD, 2006b) [7]

4.2 New administrative structure

In January 2001, there was a major reorganization of the core ministries and agencies. The changes included the establishment of the new "Council for Science and Technology Policy (CSTP)" and the "Council for Economic and Fiscal Policy (CEFP)" in the Cabinet office, as well as a merger of the Ministry of Education, Science, Sports and Culture and the Science and Technology Agency of Japan (STA) to form the Ministry of Education, Culture, Sports, Science and Technology (MEXT), with the aim to unify the responsibilities for science and technology and for promotion of academic activities.

Moreover, 68 national research institutes were reorganized into independent administrative institutions in April 2001 and national universities into corporations in April 2004, and the research institutes then became able to conduct more flexible research management. Compared to their legal status before, the research institutes are now less dependent on the ministries on personal matters and for financial resources.

Since five years back, CSTP conducts planning, drafts, and undertakes comprehensive adjustments of basic science and its fiscal policy. In the annual budget formulation process, the various ministries prepare their annual budget requests with advice and guidance from their external advisory committees, and in consultation with the CSTP and the Ministry of Finance. After these budgets are submitted to the Ministry of Finance, the CSTP may sug-

[7] *For a comprehensive overview and in depth analysis of the research funding system in Japan, please refer to Stenberg, L. (2004) Government Research and Innovation Policies in Japan, ITPS A2004:001*

gest further modifications. Hence, CSTP provides comprehensive coordination of S&T-related policies from a government-wide perspective, giving advice on prioritizing truly important policy areas and striving to eliminate sectionalism among ministries. (CSTP, 2005) Since September 2006, the former Minister of Science and Technology Policy and one of the central players in the formulation of the Science and Technology Plan, Koji Omi, has become the Minister of Finance. This may indicate a bright outlook for science and technology funding the future. (Stenberg, 2006)

4.3 New basic plan for Science &Technology 2006-2010

The basic law for S&T was adopted in 1995 and the following year, the first Science and Technology Basic Plan was launched by the Japanese government, covering the period 1996–2000. A second plan was adopted in 2001, and placed particular priority to four broad fields during the years 2001–2005: Life Science, IT, Environmental Science & technology and Nanotechnology/materials.

The third basic plan for fiscal year[8] 2006–2010, was adopted in December 2005, and gives continued priority of the four fields stated above, including environment.

According to the third plan, government R&D investment should be 1 percent of GDP between fiscal year 2006 and fiscal year 2010, in total about 25 trillion yen (approximately 1.7 trillion SEK), one trillion more than the actual target for the second plan and 6 trillion more compared with the first plan adopted in 1996.

4.3.1 Core standpoints of the 3rd basic plan

The plan includes important system reforms, and shifts emphasis to investing highlighting human resources and exemplifying the principles from “hard” to “soft”, as well as greater significance of individuals at institutions. One important difference in the new plan compared with the second, is the chapter on public confidence and engagement promoting public understanding of S&T. (Takemura, 2006)

Reforms will e.g. introduce schemes to encourage young researchers, increase opportunities for female researchers, to attract outstanding researchers from abroad and provide opportunities for excellent senior researchers. It also sets out that the research environments must be made more competitive, by e.g. increasing general competitive research funds. (Yakushiji, 2006)

Another prominent feature of the plan is to implement a system reform towards world-class excellence in S&T. In order to strengthen development in the sciences and constant innovation, a high priority is to work for further reform of the university system and stronger competitiveness in higher education by setting the goal of creating about 30 world-class centers of excellence. Furthermore, as a base of industry-academia-government collaboration, “advanced research centers on integrated fields for innovation” will be created and supported to provide continuity of assistance from basic research to applied research in the effort of stimulating innovation. One more prominent feature of the 3rd basic plan is to make effort to further develop international co-operation in S&T. In specific terms, this means promoting an early commencement of ministerial meetings among Asian countries to tackle common themes through policy-related information exchange and concrete S&T cooperation. (Matsuda, 2006)

[8] *Fiscal year in Japan runs from April-March the succeeding year*

CSTP has declared three key ideas and six central goals, reflecting the plans basic stances. Among them there is one a goal for "sustainable development- economic growth & environmental protection".

4.3.2 Environmental science continued primary prioritized field

The four prioritized fields, laid out in the second basic plan and still emphasized, are given continuous status as "primary prioritized areas", see below:

The "primary prioritized areas":

- Life science
- Information & Communication technology
- Environmental sciences
- Nanotechnology and material

The "secondary prioritized areas":

- Energy
- Technological craftsmanship (Monodzukuri technologies)
- Infrastructure
- Frontier (outer space and ocean).

In the other primary prioritized areas, apart from environmental science- life science, information & communication technology and nanotechnology and materials, – issues pertaining to and application targeted towards the environment are highlighted. Development of technology in the other fields also are anticipated to contribute to the environmental applications, see below.

Life Science

- Increase in knowledge of metabolism for knowledge of functionality of and increased production of plants
- Environmental technology utilizing biological functions (bio-mimicry)

ICT

- Energy device technology and system such as electrical device with low ultralow voltage and low-power consumption
- Traceability

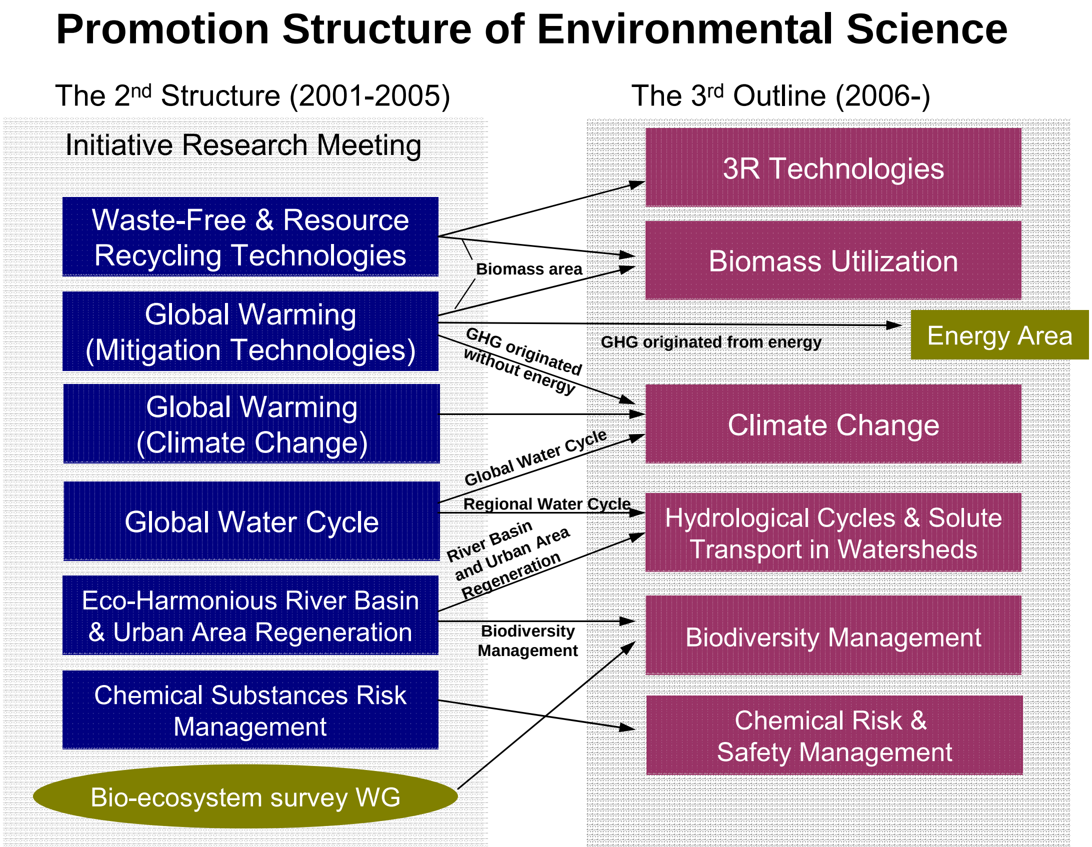
Nanotechnology and materials

- Nanodevice
- Nanodevice to lower energy consumption
- Use in sensor technology for environmental monitoring
- Innovative material to realize high efficient energy – as material for power generation, magnetic material for efficient generators and motors, photovoltaics etc.

- Non-toxic material and technology to detect and remove toxic material
- Alternative material to rare-earth such as indium and precious metals
- New material with low environmental impact for such applications as, high efficient environmental catalyst and bio-degradable plastics. (CSTP, 2006)

To further strengthen the strategic priorities, the 3rd basic plan also makes added efforts in the selection and concentration process within each of the various fields, both in the primary and the secondary prioritized areas. Close investigation in each of the prioritized areas are therefore made to designate *"strategically focused research field"*, to where budget allocation will be emphasized for the next five years. This work, called the **"**field-specific promotion strategy", was finished in the end of March this year (2006).

Figure 6 Promotion structure of environmental sciences in the 3rd S&T Plan (CSTP, 2006)



The promotion strategies for the prioritized area of environmental science include 58 essential R&D issues and 14 strategically focused S&T, see figure above.

The 14 strategically focused S&T for environmental science: (Yakushiji, 2006)

Climate Change research

- Satellite observation of greenhouse gases and earth surface environment
- Climate change prediction for the 21st century by global climate modeling

- Forecast and management of climate change risk with designing carbon free social system in the future

Hydrological Cycles & Solute Transport in Watersheds research

- Basin scale environment observation and building up information infrastructure
- Social scenario design to establish eco-harmonious river basin and city area

Biodiversity Management research

- Multi-scale observation, analysis and evaluation of biodiversity
- Management of ecological service from landscape

Chemical Risk and Safety Management research

- Anticipative approach to assessment and management of new chemical substance
- Chemical risk management technologies to address international cooperation
- Human and social science for chemical risk management

3R (Reduce, Reuse and Recycle) Technology Research

- System analysis, estimation and design technologies for 3R
- Useful material and harmful substance control technologies for international 3R

Biomass Utilization research

- Utilization technologies of grass and wood biomass energies
- Biomass system technologies for a sound material-cycle society

4.3.3 Summarized comments

As initially mentioned, the governmental R&D-funding within the environmental field for FY 2005 saw a substantial budget increase of 63 percent compared to FY 2001, excluding institutional funds to universities and some competitive funds. The priority of environment as a primary prioritized field from the second plan is also confirmed in the new third plan. Thus, continued strengthened research efforts can be expected, especially since the total budget for S&T for the coming period 2006–2010 is set to increase.

The new promotion structure of environmental science in the third basic S&T plan provides a bird-eye view on how the strategic priorities within each of the various fields should be further strengthened. Notable changes of direction in the latest plan within the environmental field is the new focus on Biomass Utilization, a stronger notification on Biodiversity Management and a stronger priority on 3R technologies.

The priorities on 3R and biomass with an up-lifting of utilization technologies of grass and wood biomass energies, as well as biomass system technologies for a sound material-cycle society, is of special interest from an environmental technology perspective. Another interesting feature in the new promotion structure is the concentration of efforts towards combating climate change under one common frame of “climate change”, hereby integrating efforts from three former fields of Global warming and mitigations technologies, Global warming and climate change, and Global water cycle. The amendments mark a change towards a more comprehensive outlook on climate issues. It also marks a step towards clearly targeting climate change issues in other fields, as the research area relating to GHG originating from energy is being regrouped from the environmental to the energy field of the plan's structure.

Energy is one of the basic plan's secondary prioritized areas, and a field that has experienced a small decrease in funding the last period, though energy still stands out as it is representing the by far largest share of the total funding, in FY2005 almost 32 percent. Among the energy priorities, the most relevant themes with environmental technology links among the strategically focused area are, for example, energy saving technologies for urban systems, energy saving technologies for housing and architecture, clean energy vehicle technologies, high performance and low cost photovoltaic technologies, and fuel cell systems and hydrogen storage/transportation technologies. The most prominent field within the energy area is nuclear.

4.4 Ministry of Environment (MoE)

In response to environmental field being selected as one of the priority areas set in the 3rd S&T Basic Plan, Ministry of Environment is now taking initiatives to further promote environmental science and technology by increasing competitive funds for environmental research, by conducting "Environmental Technology Verification Model Project" (see section 7.2) and preparing a strategic plan of environmental S&T (Unisaga, 2005). In the following section, the main outline of the new strategy for funding from MoE, the "Strategy on Promotion of Environmental Research and Technology Development", is presented.

MoE' s new strategy has restructured it's areas of emphasis, building on the new basic plan and set out a targets and suggested indicators for the areas chosen. Of special interest is the included list of cutting-edge technologies identified by the committee to contribute to the areas, stating important applications of cutting-edge technologies seen in areas such as nanotechnology, biotechnology, and ICT in environmental technologies.

For example, in nanotechnology, the prospective for use in environmental monitoring, impact on health and prevention of pollution are strongly stressed. Nano-biotechnology is expected to provide new opportunities for development of sensor which pin-pointed can recognize the hazardous material in the environment. ICT may contribute in many ways, but most prominently for high-precision climate prediction models, on-line monitoring system at global scale, GIS, as well as for traceability of product and material. At the same time, there is an increasing concern of ethical, legal and social issues (ELSI) surrounding the cutting-edge technologies. Research on ELSI, along with the environmental impact of those technologies, is therefore stated as essential.

4.4.1 Strategy on promotion of Environmental Research and Technology Development

This promotion strategy, is the strategic document mainly for National Institute for Environmental Studies, a national research institute with affiliation to MoE, and for research funding conducted by the MoE, i.e. the "Global Environment Research Fund", "Environmental Technology Research and Development Fund," "Waste Management Research Fund," and "Environmental Protection Evaluation Fund."

A similar report on measures for promotion of environmental research and technology development was published based on the "1st Basic S&T (1996–2000)" and the" 2nd Basic Plan on S&T (2001–2005)" and the "Basic Environmental Plan." The report based on the first two plans for S&T were structured based on the society at that time being in economic-recession, hence emphasized the need for innovation and supported close-to-implementation researches, believed to stimulate economic growth.

This current strategic document is formulated based on the 3rd S&T Plan and the renewed Basic Environmental Plan in Fiscal Year 2005 (March 2006). The characteristic of this document differing from the previous two documents are that it promotes both nurturing of the existing researches and at the same time, cultivation of new "seeds."

The strategy is intended to serve as guideline for researchers seeking for research funding, including the social and economic aspects, and set out to cover the next five years, with the next 20–30 years in mind. In the report, "sustainable society" is identified as one of the future visions. Understandably, "sustainable society" includes perspectives other than environment, notably energy supply, food supply and demand, human equality and peace etc. However, in this report, only the environmental aspect was highlighted. (MoE, 2006)

The following six areas of emphasis were previously identified by MoE in 2002, based on the 2nd S&T Plan:

- Global warming research
- Environmental risk evaluation and management of chemical substances
- Clean-up of negative environmental legacy of the last century
- Formulation of resource-circulating (recycling-oriented) society
- Development of technology supporting resource-circulating (recycling-oriented) society
- Basin existing in harmony with nature and renewal of urban areas

In the process of reviewing accomplishment of each above-mentioned areas, areas 2. and 3, as well as, areas 4 and 5 were combined. In the new MoE strategy the areas of emphasis are categorized as follows:

1 Society with no global warming

2 Resource-circulating (recycling-oriented) society

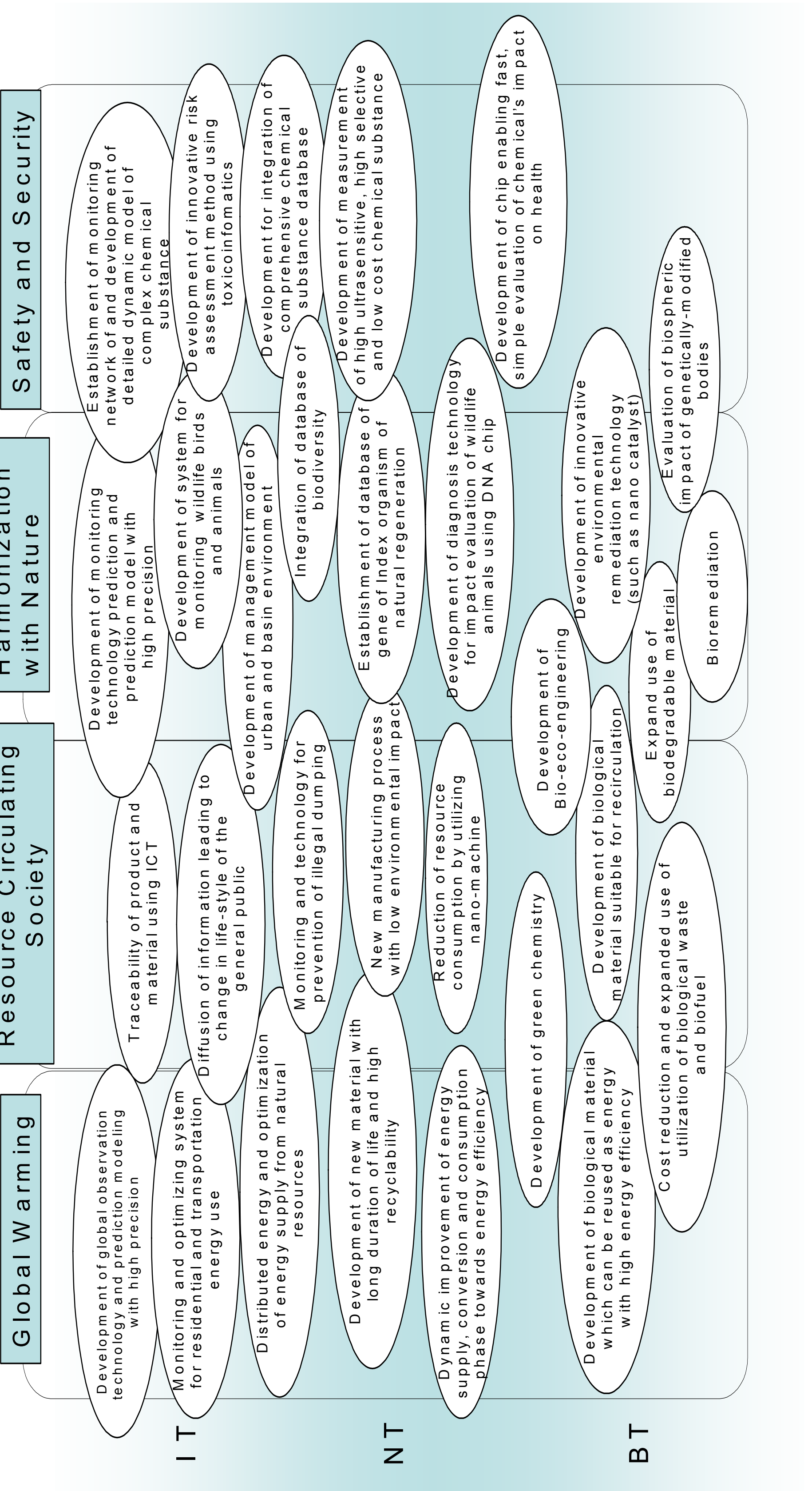
3 Society existing in harmony with nature

4 Safe and secured society with high quality of life

For each of the four areas of emphasis, mid to long term "Policy Objectives" and "Research Issues of Emphasis" and "Issues to emphasize investment" for the next five years have been identified. (See appendix 1 for an example of the first area of emphasis)

Per each area of emphasis, targets are determined. Among suggested mid-term targets are e.g. to strive for a double of the number of domestic patents and international patents in environmental area from fiscal year 2006, and to increase the domestic market size of environmental related technology (environmental industry) (yen per year) a 50 percent increase of predicted size in 2010. Figure 7 below, is a portfolio analysis and presents the cutting-edge technologies identified by MoEs strategy group to contribute to the area of emphasis.

Figure 7


Global Warming
Resource Circulating Society
Harmonization with Nature
Safety and Security
IT
NT
BT
Development of global observation technology and prediction modeling with high precision
Monitoring and optimizing system for residential and transportation energy use
Distributed energy and optimization of energy supply from natural resources
Development of new material with long duration of life and high recyclability
Dynamic improvement of energy supply, conversion and consumption phase towards energy efficiency
Development of green chemistry
Development of biological material which can be reused as energy with high energy efficiency
Cost reduction and expanded use of utilization of biological waste and biofuel
Traceability of product and material using ICT
Diffusion of information leading to change in life-style of the general public
Monitoring and technology for prevention of illegal dumping
New manufacturing process with low environmental impact
Reduction of resource consumption by utilizing nano-machine
Development of biological material suitable for recirculation
Development of Bio-eco-engineering
Expand use of biodegradable material
Development of monitoring technology prediction and prediction model with high precision
Development of system for monitoring wildlife birds and animals
Development of management model of urban and basin environment
Integration of database of biodiversity
Establishment of database of gene of Index organism of natural regeneration
Development of diagnosis technology for impact evaluation of wildlife animals using DNA chip
Development of innovative environmental remediation technology (such as nano catalyst)
Bioremediation
Evaluation of biospheric impact of genetically-modified bodies
Establishment of monitoring network of and development of detailed dynamic model of complex chemical substance
Development of innovative risk assessment method using toxicoinfomatics
Development for integration of comprehensive chemical substance database
Development of measurement of high ultrasensitive, high selective and low cost chemical substance
Development of chip enabling fast, simple evaluation of chemical's impact on health

4.5 Ministry of Economy, Trade and Industry (METI)

METI has developed a governance system through visions and roadmaps for the technology covered by their field of responsibility, foresight exercises that coordinate various actors and sets out common goals for the future.

To realize the visions set out in the New Industrial Structure Report (N Report) published in 2004, METI has formulated Strategic Technology Roadmap (hereafter referred to as STR) in 2005 and revised it in 2006. The aim of STR is to be used as a communications tool between those involved in the projects mentioned in STR and those involved the operation of R&D. (METI, 2005) Additionally, in the New Economic Growth Strategy published in June 2006, the follow-up of the progress and policy to stimulate both demand and supply for nurturing of technology and the market for the seven strategic field, fuel cells, digital consumer electronics, robots, content, health and welfare devices and services, environment and energy device and services, and business support services, is stressed. (METI, 2006a)

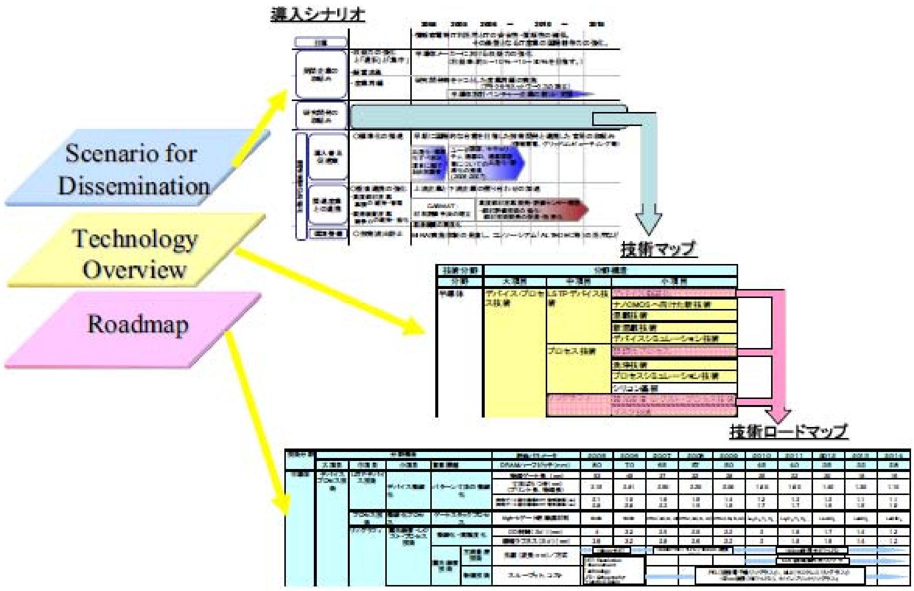
4.5.1 Strategic Technology Roadmap

The METIs STR is established for the following areas:

- Information and Communication
- Life Science
- Environment and Energy
- Manufacturing

For each area of STR, i) Scenario for Introduction, ii) Technology Overview, and iii) Roadmap is formulated, see below.

Figure 8 Structure of STR (METI, 2005)



For the process to establish the STR, task forces were established for each field by New Energy and Industrial Technology Development Organization (NEDO) and by RITE (Research Institute of Innovative Technology for the Earth) for the field of carbon dioxide capture and storage. The task forces consisted of representatives from academia, private enterprises, METI, NEDO, and National Institute of Advanced Industrial Science and Technology (AIST) in order to reflect the expertise of industry, academia, and public institutions. (METI, 2005)

For environment and energy, STR is formulated only for those fields which METI has research and development investment in, namely, carbon dioxide capture and storage, reduction of CFCs/development of CFC substitutes, comprehensive management of chemical substances, the 3Rs (Reduce, Reuse and Recycle), and energy. (METI, 2006b) (Korenaga, 2006)

The STR is comprised of three pillars in the environment and energy area, namely, energy technology, global warming prevention and environmental technology. The technologies mentioned in the STR have objectives of 1) stabilization of energy supply, 2) reduction of carbon dioxide or 3) the realization of environmentally-sound society, which is in line with the area of responsibility of METI. In particular, technologies such as resource development (methane-hydrate), fuel-cell (DME, GTL), clean coal technologies, new energy (fuel cell, biomass, photo voltaic), fluorine substitution and etc. are noted.

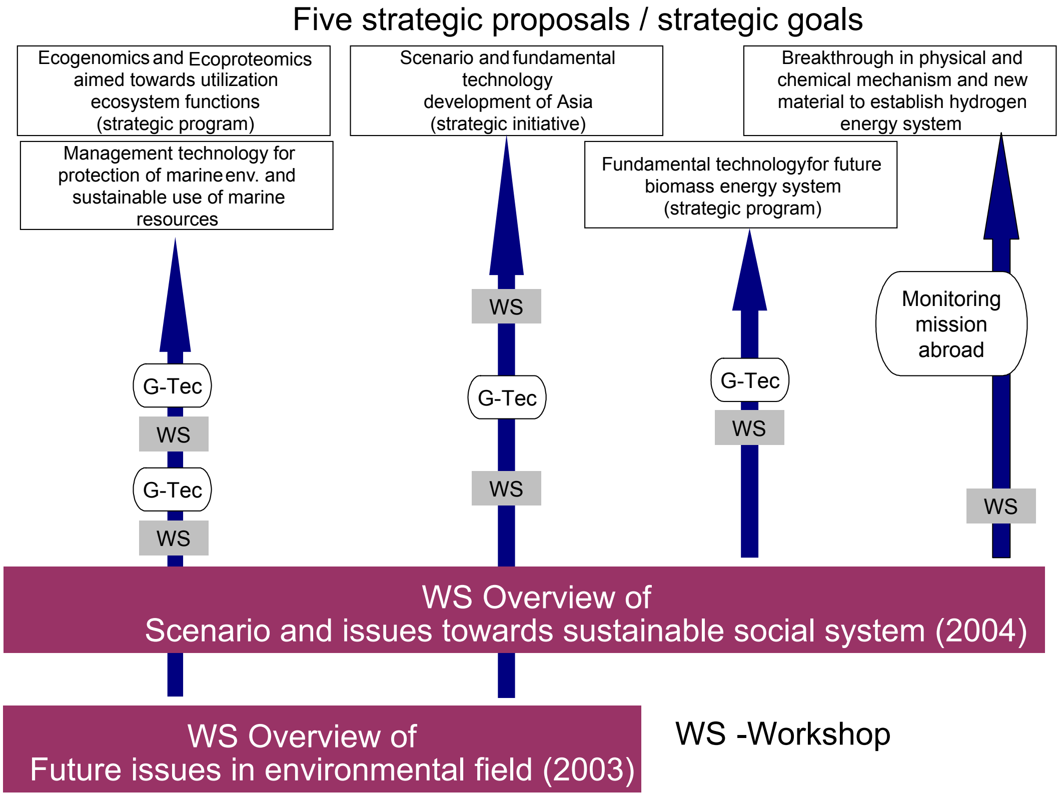
4.6 Center for Research and Development Strategy – affiliated with the Japan Science and Technology Agency under MEXT

MEXT-affiliated Japan Science and Technology Agency (JST) is implementing a broad range of activities in line with the objectives of the Science and Technology Basic Law and Basic Plan. In FY 2003, JST established the Center for Research and Development Strategy (CRDS) in order to strengthen their strategic planning capabilities. The CRDS group core mission is to design effective research and development (R&D) strategies and recommend them to the Government. One, out of in total 4 groups, cover the field of environmental and energy science (Inoue group, named after its principal fellow). (CRDS, 2006)

MEXT strategy work is mainly conducted by JST/CRDS, whose latest strategy proposal for the environmental field highlighted biomass utilization, ecosystem and the Asian perspective. The line of reasoning for a higher priority of biomass is that Japan is currently lagging behind the Kyoto undertakings, in special spotlight since the ratification of the protocol last year. At the same time, solar should be prioritized for stationary use and bio-ethanol and bio-diesel for transport, and co-operation with more resource-endowed Asian neighbours is stressed as vital.

CRDS makes bird's-eye view maps to survey all the R&D areas in each field, revised every year. They also systematically prioritize among these areas and select the most important R&D areas which are then categorized as "strategic initiative", "strategic program" or "strategic project", results recommended to MEXT. (Yokomizo, 2006) (CRDS, 2006)

Figure 9 Flowchart of activities of environment/energy group Derived from presentation made by Inoue, Kotaro (Inoue, 2006)



In the process of selecting important R&D areas, CRDS carry out G-TeC (Global Technology Comparison) investigations, through which they compare Japan's R&D activity level in the selected areas with that of other major countries. (CRDS, 2006) Four G-Tec reports have been published. The following are some examples of research issues highlighted as future issues for Japan in the G-Tec reports. (Inoue, 2006)

Title of G-Tec (published)	**Future research issues for Japan**
Japan-EU-US comparison of third generation biomass technology (May 2005)	- preprocessing and saccharization of hard biomass - parallel production of liquid fuel and material
International research and development on sustain-able exploitation and management of marine bio-resources and ecosystem services (February 2006)	- observation and modeling food chain - bio-resource management based models and modeling - ecosystem based management - marine biotechnology
Japan-Asia research institutes/organizations overviews on development of environmental and energy technology for sustainable development in Asia (January 2006)	- monitoring, prediction, impact evaluation and observation of environmental pollution at global and local ("glocal") level - water and waste management based on cycles and fluctuation estimates in mega-cities
Japan-US comparisons and overviews on terrestrial biodiversity-ecosystem researches (May 2005)	- establishment of research program to challenge complexity and uncertainty in ecosystem - integration of data collected by different entities and utilization in models

The strategic proposals landed in a priority of 13 items, suggested to MEXT. The 5 most important according to CRDS were:

- Ecosystem,
- Renewable energy,
- Hydrogen and Fuel cell,
- Environmental assessment, maintenance & environment in Asia,
- Developing scenarios for Asia

Other items identified were: Global Warming- observation and prediction, Global Warming- Impact Analysis**,** Water cycle observation, prediction and management, Urban environment, Human impacts/toxicology, 3R, Environmentally friendly energy system, and Energy utilization with low emission

4.7 Key research institutes' strategies on environmental technology

In the environmental and energy fields the majority of R&D is carried out at research institutes and directed R&D projects, and only a smaller share goes into institutional funds at the universities. The key national R&D institutes for environmental technology, covered in this study, are the Institute of Advanced Science and Technology (AIST), the Research Institute of Innovative Technology for the Earth (RITE), the National Institute for Materials Science (NIMS) and the National Institute for Environmental Studies (NIES).[9]

The future visions and research fields of AIST's new research strategy are interesting from foremost two angles. First, their future visions that incorporate environmental aspirations clearly lay out connections to the other research fields in addition to environment and en-

[9] For a comprehensive overview of the research institutes' strategies, please refer to the appendix by the author included in Formas and Vinnovas research strategy for environmental technology, to be published in December 2006.

ergy: life science, nanotechnology, and geological survey. Secondly, the selection of focal research subjects is based on a portfolio analysis of both growth of market and the R&D potential of AIST. The result shows us that the fields with the highest potential, made out of these two aspects, are e.g. fuel and solar cells, remediation and green plastics.

Biomass combustion and biomass liquid fuel are also stressed as fields of importance for AIST, even though their current standings have a relatively low rating both for market growth and for the institutes own potential, as compared with the other focal research subjects.

RITE institute currently has a strong focus on CSS, Carbon Sequestration and Storage. Important study targets for RITE in the future will be breed trees as well as R&D on hydrogen and biomass. NIMS activities has, as CSTP has identified nanotechnology and materials as a primary prioritized field, turned more and more focused towards nanotechnology-driven advanced, including functional materials research.

NIES special priorities mirror the MoE strategy closely, since they also narrow down six areas to four, with somewhat different titles but apparently a correlating content. Noticeable are a lower priority given to ozone layer research, a continued focus on climate, and a new Asian focus.

Based on the strategies analyzed in this report, the echoing of CSTP’s priorities seems to be of different importance for different ministries. For example, MoE’s new strategy has a direct reference to CSTP’s 3rd basic plan as the basis for policy, while METI’s roadmap does not include any such reference. Also, the research institutes seems to relate in various extents, e.g. RITE makes main connections to METI’ s roadmap, NIMS relates clearly to CSTP and NIES clearly to Moe’s and CSTP’ s plans.

5 Patents

Environmental technologies are generally of a highly disparate nature and stems from all sections of science, research and development. They also tend to be designed to satisfy requirements of a particular location or to resolve a particular problem, and hence will not necessarily be captured by international patenting. Nevertheless, international patenting is representative of technologies inhibiting most potential. (CIRJE, 2003)

Presented in this chapter are the national patenting activities of mainly Japan, compared to EU and the US. Results from a study on international US patents, are also summarized and analyzed in this chapter.

5.1 Patents as a measure of environmental innovation

Patents within the environmental field are related to the particular intricacy of identifying innovations which can be marked as “environmental” in their character.

This problem of identification is relatively straightforward in the so-called end-of-pipe abatement technologies, but it is much more challenging when the innovations are related to changes in production processes or product characteristics. In the latter, the reasons for undertaking investments might not be clearly “environmental” in nature, but set out for multiples reasons, e.g. reduction of production costs and improvement in environmental performance. This delicate problem also tends to become more acute with time, since changes in production processes and product characteristics are increasingly more prevalent as means of addressing environmental concerns compared to traditional end-of-pipe solutions. (OECD, 2005)

Moreover, different patent offices apply different rules for the “scope” of a patent, and the JPO (Japan Patent Office) in particular often requires multiple patents for a single patent compared with the EPO (European Patent Office) or USPTO (United States Patent and Trademark Office). Consequently, comparisons of patent counts across countries can result in a significant bias. (OECD, 2005)

Another feature to keep in mind is the character of the Japanese innovation system as a “large company-dominated system”. Japanese companies have a tendency to conduct R&D in-house and have a much lower share of R&D in foreign units than other developed countries. (Karlsson et.al., 2006) For example, the top 10 Japanese companies’ R&D expenditures accounts for approx. 40 percent of the total private R&D spending, implying that these large companies have deep pockets and hence are able to carry out all kinds of research in-house: from fundamental to applied. These companies can use their ideas to develop marketable products by themselves, and therefore have different intellectual property management, including applications for patent, than companies with a smaller degree of activities “in-house”. (RIETI, 2006) Sometimes not applying for patents can be argued by Japanese companies as a more effective way of protecting companies in-house inventions.

5.2 Japanese patent system and implications for comparisons

Europe and Japan has adopted the first-to-file system. Within the three years from the filing date, the entry will be checked for formality and if the applicant or a third party requests for examination, examination procedure is started. For the application refused at this point, opportunity for correction and appeal examination is granted. Provided that the applicant pays the patent fee, once the decision to grant a patent has been made the patent right will come into effect as it is entered in the Patent Register. All applications must be filed in Japanese language.

United States patents are based on the first-to-invent principal. Compared to United States practice, Japanese patent practices are aimed at restricting the patent claim's scope as much as possible, including limiting the scope of protection to the specific examples provided in the application. These examples must demonstrate the claims and results, while United States applications include broader claims without examples. For example, in some fields, in Japan, actual physical data is required while the United States accepts theoretical examples. In general, Japanese patenting practice promotes large numbers of incremental inventions, while United States firms tend to apply for fewer, but more radical invention protection.

Figure 10 Features of European, US and Japanese patent systems (OECD, 1997)

Features of system	European PO	US PTO	Japan PO
Basis	first to file	first to invent	first to file
Patents for discoveries?	no	yes	no
Breadth of claims	narrow	broad	narrow
Grace period	none	12 months	6 months*
Speed of processing claim	slow	fast	slow
Filing permitted in any language?	any European language	yes	no
Are patent examinations published?	18 months after filing	no, secret until patent is granted	18 months after filing
Can patent examination be deferred?	yes, for 6 months	no	yes, for 7 years after 18 month publication
Is there an opposition system?	yes, after patent is granted	no, but other parties may request examination	yes, before patent is granted
Patent term	20 years from first filing	17 years from first filing	15 years from date of publication for opposition purposes

The latter-mentioned tendency of providing protection for narrower scope may be a factor in limiting non-Japanese entities, especially that of US, applying for patents in Japan. Additionally, it is a factor to consider in comparing the number of patents. Other factors to be regarded are the length of the process and also the total cost to file for patent. Although the fee charged by the Japan Patent Office is low compared to US or EU system, the total cost is high due to high fees charged by patent attorney, who charges more for foreign applicants, and translation fees.

5.3 Number of patents in environmental and energy technology

The Japan Patent Office (JPO, 2006) conducts annual survey of publicized and registered patents for the four primary and four secondary prioritized areas of science and technology defined by the 2nd Science and Technology Basic Plan, namely, life sciences, ICT, environment, nanotechnology,/materials, energy, manufacturing, infrastructure, frontier sciences. For the field of environment and energy, further analysis is conducted by the following categorization.

Environment:

Global environment, regional environment, environmental risk, biodiversity, resource-circulating social system, fundamental research in environment

Energy:

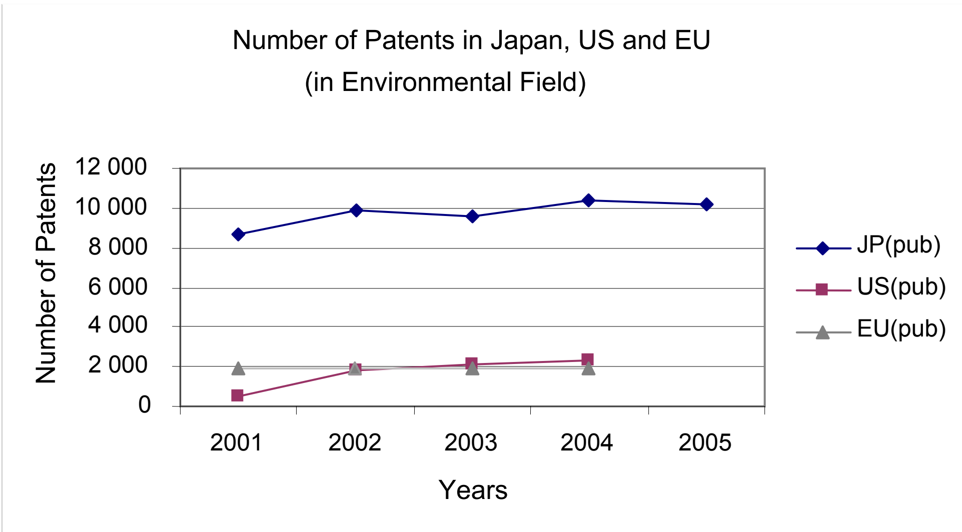
Fossil and processed fuel, nuclear energy, renewable energy, energy conservation energy/ energy utilization technology, minimizing impact to the environment, international cooperation, fundamental research in energy, others in energy

Japan Patent Office (JPO) has been surveying the number of patent applications publicized and number of patents registered using a search engine called PATOLIS-IV. PATOLIS is a privately-owned system, however it's preceding system of patent search was operated by Japan Patent Information Organization (Japio), a public corporation affiliated with the, JPO until 2001. The keywords used to conduct the survey, thus the Japan Patent Office's definition of environmental patents is presented in appendix 1.

Environment

A notable trend in the environment field is an increase in the number of application publicized, which has shown a five-fold increase between 1990 and 2005. In comparison to number of applications publicized in US and EU, the numbers of applications are far greater in Japan. According to JPO this is partly a result of 63 percent increase of governmental R&D spending in this field[10]

Figure 11 Number of patents in environment field for Japan, Us and Europe (Japan Patent Office, 2006)

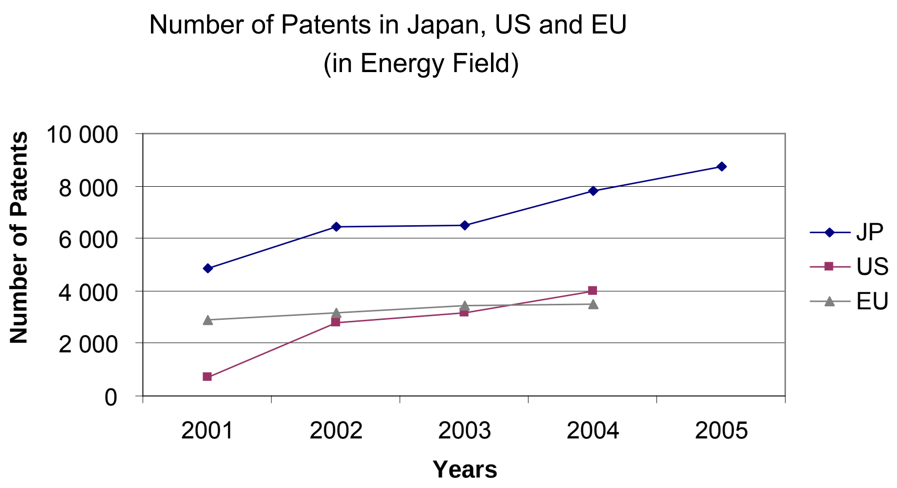


[10] *For more information about governmental R&D-spending in Japan, please refer to ITPS report "A close-up on research strategies for environmental technology in Japan", to be published fall of 2006.*

Energy

Number of applications publicized is greatest in the category of renewable energy. According to JPO this relates to R&D in solar, wind and biomass utilization energies are receiving attention. Following the renewable energies, is R&D in energy conservation and utilization of energy technologies. However, in terms of number of patents registered, energy conservation and utilization of energy technology out-numbers those of renewable energy.

Figure 12 Number of patents in energy field for Japan, US and Europe (Ibid.)



As in the environmental field, the number of applications publicized is more than that of US and EU. Especially since the announcement of the 2nd S&T Basic Plan in 2001, when energy was identified as one of the secondary prioritized areas, the number is on a stead increase.

The JPO survey can however not reveal any particular sectors for grasping environmental technology strengths, other than the fairly wide categorizations used for following up the third basic plan and the JPO's own comments on major areas within these. Still, it gives an overview of total numbers, where Japan shows a much larger total number of patent applications within the environmental field, almost five times as many as for EU and US each, but this might only reflect the differences in the patent requirements. The difference among the three is although not as big for energy patent applications, implying that Japan might be a more important market for environmental technologies than energy technologies compared to EU and the US. Furthermore, for environmental patents steady numbers could be observed 2001–2005, implying a stable situation with perhaps matured technology levels. The category in Japan with the largest share according to the classifications used by JPO was global environment and resource-circulating social systems. Also for energy there was a substantial increase. Japan almost doubled its numbers and the greatest increase was in the category of renewable energy, according to evaluations from JPO (JPO, 2006).

5.4 Shares in EPO patent applications

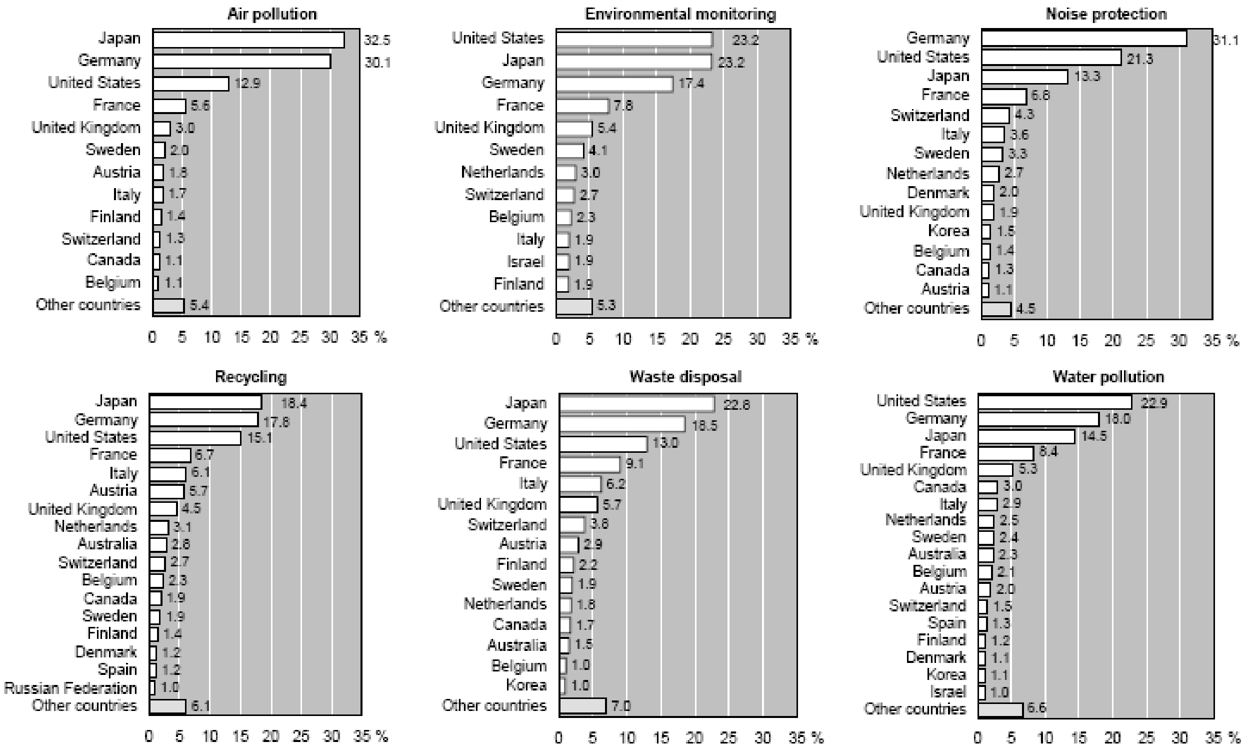
Traditional environmental technology experiencing expansionary phases in Japan today, according to the Japanese policymakers, are services such as air pollution control, waste disposal and treatment & resource recovery and recycling. Other areas predicted to enjoy sizable growth in market size and employment is the consulting sector, the photo-catalytic system sector and the fuel cell battery sector.

OECD has surveyed the trends and shares in EPO patent applications, see graphs below. According to these results, the Japanese shares of EPO patent applications confirm the policy makers views on Japanese strengths, as these areas also represent the categories of traditional environmental technology with a majority of Japanese inventors filing.

The OECD patent search strategy for environmental technology was divided into six sub-groups, essentially covering end-of-pipe solutions (waste disposal, recycling, air cleaning technologies, water cleaning technologies and noise protection).

The most striking numbers for Japan are for air pollution cleaning technologies (32.5%), closely followed by Germany shares, but still Japanese shares here represent the highest number by any other country in any of the categories. Water pollution and noise protection seem to be weaker areas. (OECD, 2006)

Figure 13 Shares of countries in EPO patent applications in environmental technologies (OECD, 2006)



5.5 International ranking based on US patent data

In a paper published at Center for International Research on the Japanese economy (CIRJE) at University of Tokyo, the technological position of the top twelve foreign patenting countries in the US, have been analyzed using patent data[11] relating to environmental technologies between 1975 and 2000, based on the following categories:

[11] *Approach used by CIRJE to identify environmental patents: "a patent is considered to be related to the ecological environment if it's abstract or full text contains words such as "ecology", "ecological", "ecologically" or any other word beginning with "eco-", and "environmentally".*

- Technological specialization index (for national technological priorities),
- Patent share (for global impact),
- Citation rate (for further knowledge development) and
- Rate of assigned patents (for market potential) (CIRJE, 2003)

The empirical findings of this study demonstrate that the expertise and strengths in environmental technologies are concentrated in a relatively small number of countries: Germany, Canada and Japan; all countries showing different priorities being more successful in some technology strength aspects than in others.

As for the number of patents, Japan comes on third place after Germany and Canada, see tables below. Noticeable, when population size is taken into consideration (per million of population in year 2000) Japan drops to seventh place with a patent intensity of 9 (compared with 35 for Sweden). For technological specialization, only 5 out of twelve countries have an index greater than 1, which represents a technological strength at a national level. For Japan, being the largest foreign total patenting country in the US, the score of 0,15 indicates that environment is not an important patenting activity in the US compared to other sectors.

Commercialization appears however to be important for Japanese inventors, since the rate of assigned patents (implying that the legally protected prototype is closer to commercialization) for Japanese environmental technologies is the highest at 0,88. Also, the citation rate (indicating the value of the registered patents for further technological knowledge development), has the highest value for Japan at 5,29, a comparatively high value also for Sweden at 3,16 (mean citation rate: 2,85).

Table 3 Technological strength indicators for US environmental patents by country, 1975-2000 (CIRJE, 2003)

Country	Number of patents	Patent intensity	Technological specialization index	Patent share	Rate of assigned patents	Citation rate
Australia	316	16	1,4	0,81	0,77	1,93
Canada	1260	40	1,34	3,25	0,54	3,96
France	467	8	0,37	1,2	0,57	3,4
Germany	4067	49	1,34	10,48	0,83	3,18
UK	463	8	1,05	1,19	0,58	1,73
Italy	391	7	0,72	1,01	0,65	2,64
Japan	**1147**	**9**	**0,15**	**2,95**	**0,88**	**5,29**
Korea	97	2	0,25	0,25	0,75	1,04
Netherlands	344	22	0,8	0,89	0,66	2,96
Sweden	**308**	**35**	**0,75**	**0,79**	**0,76**	**3,16**
Switzerland	782	108	1,29	2,01	0,55	3,1
Taiwan	111	5	0,17	0,29	0,47	1,84

Note: Data extracted in March 2002

Table 4 Ranking of countries for US environmental patents, 1975-2000 (CIRJE, 2003)

Country	Technological specialisation index	Patent share	Rate of assigned patents	Citation rate	Mean	Mean score rank
Germany	2	1	2	4	2,3	1
Canada	2	2	11	2	4,3	2
Japan	**12**	**3**	**1**	**1**	**4,3**	**2**
Australia	1	9	3	9	5,5	4
Switzerland	4	4	10	6	6	5
Sweden	**7**	**10**	**4**	**5**	**6,5**	**6**
France	9	5	9	3	6,5	6
Netherlands	6	8	6	7	6,8	8
Italy	8	7	7	8	7,5	9
UK	5	6	8	11	7,5	9
Korea	10	12	5	12	9,8	11
Taiwan	11	11	12	10	11	12

Note: Data extracted in March 2002

6 Examples of measures to promote environmental business

Based on recognition that the eco-industrial approach is one important way forward to realize sustainable development, Japanese leaders have launched various types of eco-industrial projects around the country. (Morikawa, 2000) Within the industrial clusters, companies and other entities are organized into multi-sector collaborative "networks."

In Japan, where venture capital is limited compared with the situation in e.g. the U.S., these cluster programs can provide opportunities for critical financial support in high-risk projects. In general, they have played an important role in the promotion of eco-businesses, whom have expanded their domestic and international markets. Among the cluster initiatives in Japan, two programs can be sorted out as of high importance for environmental business development and for gaining experiences from a Swedish perspective; METI's industrial cluster program and METI/MoE:s Eco Town-program.

6.1 Cluster programs – lessons to learn

The Eco-Town concept, although a limited budget for the program, has proven an effective measure in Japan to promote local economic stimulation through fostering environmental businesses. The Eco Town Program can, to some extent, be compared to the Local Investment Programmes (LIP) and Climate Investment Programmes (KLIMP) in Sweden. As in LIP and KLIMP, local governments/ municipalities are working together with local companies and organisations. However, the Eco-Town program has had a much stronger focus on 3R-related activities (Reduce, Reuse, Recycle), compared to the Swedish programs mainly aiming at reducing the emissions of greenhouse gases. In addition to the EcoTown program, Japan targets environmental-related projects within industrial cluster as well as intellectual cluster programmes.

6.1.1 Industrial cluster program

METI has concentrated its efforts on the recovery of economy and industrial revitalization and from this perspective played a role in the promotion of eco-businesses. Aiming at strengthening Japan's international competitiveness and revitalizing regional economies, METI has promoted the Industrial Cluster Project since FY 2001, to create "industrial clusters" that encourage new industries and businesses to be formed at the regional level. A sum of 29.4 billion yen (1.96 billion SEK) was initially allocated to industrial cluster development measures, increased year by year to a current budget level of approximately 80 billion yen (5.3 billion SEK). (METI, 2006)

Today, there are a total of 19 projects within the industrial cluster project nationwide. Targeted industries are mainly biotechnology, ICT, electronics, new manufacturing, new energy, ecology and recycling reflecting the region's own backgrounds. (Mitsui, 2003) Among these projects, about 30 percent have an environmental/energy profile, involving approximately 1000 companies and 90 universities in total.

The city of Kitakyushu (described below) represents one of these industrial cluster projects in the environmental field, the Kyushu Recycle and Environmental Industry Plaza. (Nakagawa, 2004) Kitakyushu is also a part of MEXT Knowledge Cluster Initiative, established in 2003 to create innovative and internationally competitive regional bases that integrate research institutions, R&D industries or universities. In total, 10 regions have been selected, emphasizing partnership between universities and industry. The knowledge cluster initiatives are mainly within the IT and life science field, and Kitakyushu is one of three initiatives within this particular program that focus on environment. (MEXT, 2006)

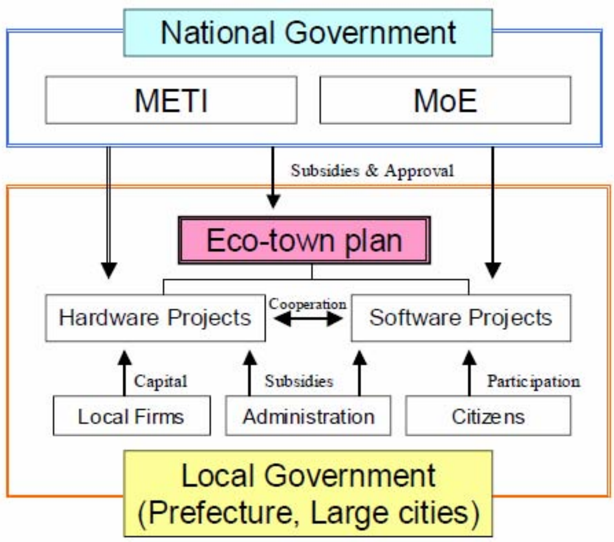
6.2 Eco-Town program

The main objective of the Eco-Town initiative, a policy program for the promotion of eco-industrial development in Japan, is to promote local economic stimulation through fostering environmental businesses that utilize the strengths of local industries. Local governments play a central role in activities under this program, linking local citizens and local industries in order to achieve innovative approaches to urban development that are environmentally friendly. (METI, 2006) The bottom line is that each area develops its plan in the context of region specific characteristics and advantages. For instance, the three cities of Akita, Omuta and Uguisuzawa, are developing areas abandoned after the closing of mines and are now utilizing the technologies in pollution prevention and resource extraction for the development of eco projects as an injection to the local economy. (Morikawa, 2000)

The Eco-Towns originated through a subsidy system established by METI and MoE in 1997. The national government established Eco-Towns to solve garbage problems and assist companies in declining industries such as steel and cement. Kawasaki City, Iida City, Kani City and Kitakyushu City, were approved eco-towns in the first year. Since then 25 cities have been approved eco-towns (by June 2005) and received subsidies.

The national government supports Eco-Towns by establishing the legislative system, and by designing the subsidy system. The local governments initially create an “Eco-Town plan”, taking advantage of the region’s local characteristics. Then, if the basic concept and concrete projects incorporated into the plan are judged by METI and MoE as meeting a certain standard of originality and innovativeness, the two ministries jointly approve the plan. Financial support is then provided for projects to be implemented by the local governments and private organizations to improve physical recycling facilities, and to implement “soft” (institutional/organizational) projects that can contribute to the realization of a sound material-cycle society. (GEC, 2005)

Figure 14 Eco Town Support structure overview (GEC, 2005)



There are two types of subsidy schemes of Eco-Towns: hardware projects subsidy and software projects subsidy. Hardware project subsidies are applied for effective and stable recycle or reuse projects in Eco-Towns and one third of the total cost (half of the cost when a project is particularly innovative) is subsidized. Subsidy amount for a project: 300–500 million yen (20–33 million SEK) and the total amount for hardware projects was 1.43 billion yen (0.1 billion SEK) (2004) and 2.61 billion yen (0.17 billion SEK) (2003). Software projects include Eco-Town planning, regional information projects etc. and the subsidies cover less than half of the total cost. The total amount for software projects was 110 million yen (7.3 million SEK) (2004) and 70 million yen (4.7 million SEK) (2003). The total budget for Eco Town-projects amounted to 1.54 billion yen in 2004 (0.1 billion SEK) (GEC, 2005)

The Eco-Town concept include recycling facilities, and more and more so related to 3R (Reduce, Reuse and Recycle), the building of an economy based on the life cycle-approach. In addition to 3R, the concept of eco-towns also include green procurement, green consumerism, industrial ecology, extended producer responsibility, socially responsible investment, integrated waste management, green labeling, global reporting initiative, corporate social responsibility, EMS and ISO 14001. The eco-town concept, which originally focused on the individual systems related to 3R, has now expanded and become part of the Eco-City concept- to focus on overall urban planning and urban ecosystems, civil society and greening of cities.

Main experiences and key advantages for Eco-Town stakeholders
According to the Global Environment Centre Foundation, a number of lessons have been learnt in the setting up of eco-towns in Japan, and not limited to the specified areas but to the cities as a whole where they are located. Eco-Towns are laboratories where various different eco-concepts can be developed and implemented, and a number of developmental objectives have been simultaneously achieved: eco-towns have helped to dispose waste in an environmentally sound manner and to protect air and water resources, as well as stimulated the local economy and secured employment. (GEC, 2005)

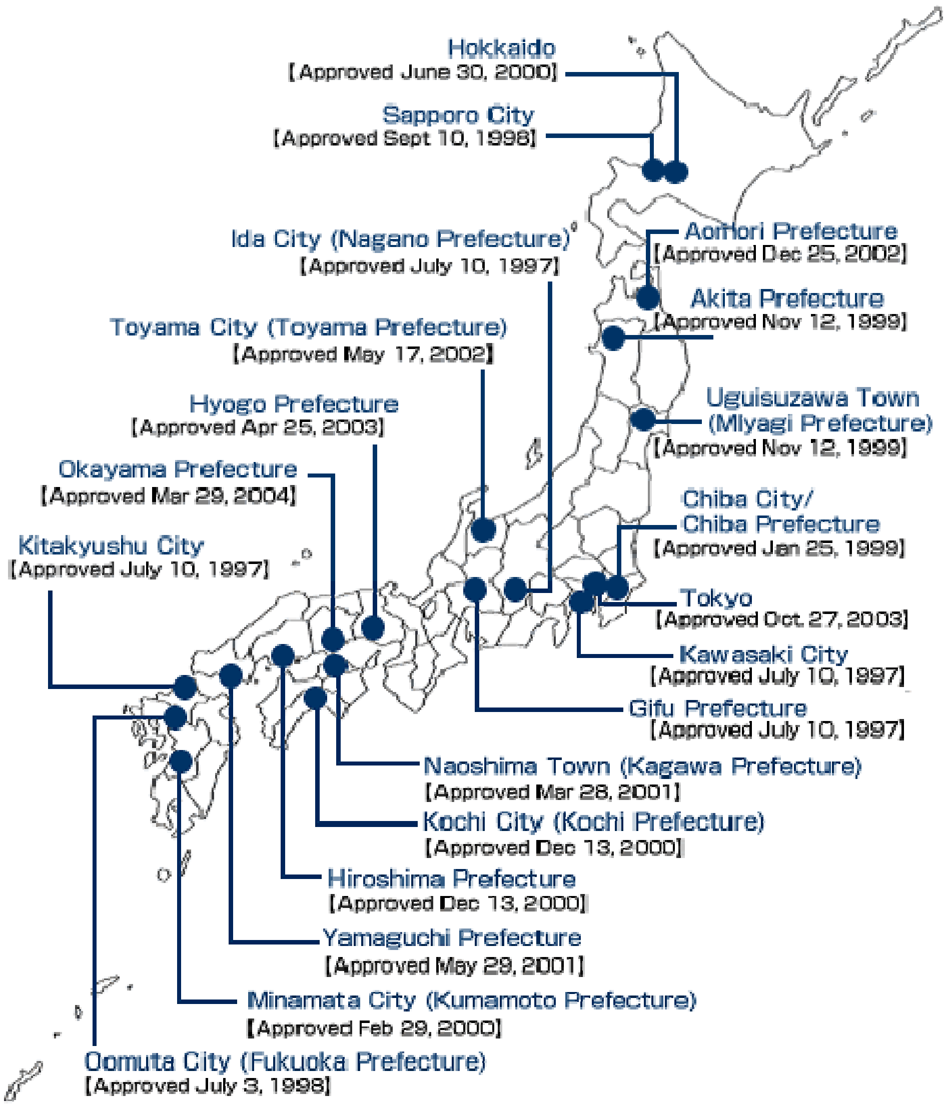
National government Eco-Town Projects have been effective in creating a concrete picture of a sound material-cycle society to the citizens in the late 1990´s. They have also played an important role in the promotion of eco-businesses, which have expanded their domestic and international markets and, finally, for demonstrating Eco-Towns as models of sustainable production and consumption.

Local governments Revitalization of local economy when tax revenue has increased and new employment have been created. Environmental and image improvements have been achieved. Administrative capability enhancement- a "one-stop-service" based on coordination among different local government divisions, which substantially decreases the burden on private companies.

Business The business risk has been reduced by positioning Eco-Town projects as a political measure. Accessibility to information on environmentally-friendly businesses, including CSR.

Citizens Promotion of environmental education, Increasing the transparency and openness.

Figure 15 EcoTown, 20 zones as of April 2004 (METI, 2006)



Kitakyushu Eco-Town

Kitakyushu Eco-Town was the first to be approved in 1997 and today it aims to be "Asia's International Resource-Recycling and Environmental Industry Base City". The city has also promoted development of a special Recycling Area to locate small- and medium sized companies. The city leases land in the area to local SME´s for a long period of time in order to support expansion of SME´s business into the environmental field.

The main driving forces for the establishment and development of Kitakyushu Eco-Town were, according to a study conducted by the Global Environment Centre Foundation, administrative and political leadership, survival strategies in heavy industries, and cooperation with research institutes. Private companies in heavy industry apparently played a key role in forming Eco-Town, emerging from stringent circumstances with deteriorating competitiveness and by seeing the situation as a chance to rejuvenate their operations and taking risks to invest in the new industries at that time. (GEC, 2005)

1.1 Verification of environmental technology information – a new initiative

Another innovative policy measure Japan has applied is the environmental technology verification, in place as a pilot project since 2003 and planned as a full-fledged program from two years from now. The verification has already proven useful to e.g. obtain knowledge/know-how for providing guidance and information on procurement of environmental technologies. And, as developers were able to learn about features and improvements in technology, these were further stimulated, thanks to publicity from the program. Support for small and medium enterprises for verification is currently being considered for the full-fledge program.

The Ministry of Environment in Japan has recognized how advanced environmental technologies, even though they are commercial-ready and seem to be useful, have not necessarily been pervasive widely since the users such as local governments, companies and citizens, cannot make selection of those technologies because of the lack in objective assessments, concerning the performance in environmental conservation.

In fiscal year 2003, MoE, therefore launched the Pilot Project of the Environmental Technology Verification (ETV) as a trial implementation of ETV, to verify objectively the performance of the advanced environmental technologies by third parties. (MoE, 2006a) The program is for advanced environmental technologies for which no objective performance data exist. However, it is not a certification program, since the technologies under the J-ETV program are not judged according to a specific standard and the evaluation of data is left up to the users.

The expectations through this project are to increase dissemination of the technologies verified, achieve environmental conservation, stimulate economic activity, and to establish a suitable method and system of ETV. The pilot period for establishing a verification system is from 2003 to 2007. Verification will initially be conducted on a trial basis in representative technological categories. This will lead to Phase 2, at which time vendors will be expected to pay for verification services. Starting in FY08, the technology categories will be expanded, and the verification program will enter into full operation.

During the pilot period, representative environmental technology categories will be selected for: (1) technologies related to major environmental challenges in Japan, and for which the need exists to find ways to encourage the diffusion of those technologies; and (2) technologies for which many companies are requesting verification.

At present, this program does *not* cover the following areas, which are covered under other programs: (1) technologies related to global warming countermeasures, (2) equipment to reduce vehicle emissions, (3) technologies related to waste countermeasures, and (4) installation of greenery on walls and roofs.

Eight technology categories have been selected related to: (1) water quality and chemical substances, and (2) the atmosphere and energy. The five technology categories under water quality and chemical substances are: (1) organic wastewater treatment for small establishments, (2) toilets for mountain areas, (3) simplified monitoring of chemical substances, (4) wastewater treatment technologies for nonmetallic elements (e.g., boron), and (5) water quality improvement of lakes/reservoirs. The three technology categories under the atmosphere and energy area are: (1) ethylene oxide treatment, (2) mitigation of the urban heat-island effect, and (3) volatile organic compounds (VOC) treatment. (Kamita, 2005)

The next step for JETV is to enhance the benefits of verification. A verification logo will be introduced, and use of the logo will be permitted for verified technologies under conditions similar to those used in the United States (i.e., the logo does not imply certification or approval; and unauthorized use is prohibited). After completion of the verification process, the verification results will be published on their program Web sites. In FY06, symposiums will be held to raise awareness of the verification program. For each technology category, other ways, such as using verification data in government procurements, will be sought to stimulate demand for utilization of verified technologies.

The five-year pilot period will end in FY08, followed by full program implementation. After the pilot period, technology categories that have established verification methodologies will shift to a vendor-pay, fee-based system. In principle, fees will cover the actual costs of verification testing. The cost of equipment installation and removal will be covered by the applicant. In some cases, the cost may be too high for small and medium enterprises and some support for small and medium enterprises is therefore being considered. Additional technology categories will be added in FY06. (Kamita, 2005)

6.4 Environmental technology in ODA

Global issues, including environmental issues, have been identified as one of the priority issues in the Japan's Official Development Assistance Charter, enacted in August 2003. Additionally, the policy is enforced based on the Environmental Conservation Initiative for Sustainable Development (EcoISD) and the Kyoto Initiative. (Ministry of Foreign Affairs, 2006) Currently, the key players in enforcing environmental ODA are Ministries of Foreign Affairs and Environment, Japan International Cooperation Agency (JICA) and Japan Bank for International Cooperation (JBIC).

The budget of environmental ODA consisted approximately 33.3 percent of the total budget in 2003. Out of the total expenditure for environmental ODA of 342.6 billion yen (22.8 billion SEK), approximately 7.37 percent or 25.26 billion yen (1.08 billion SEK) was spent on technical cooperation. (Ministry of the Environment, 2005)

Figure 16 Amount spent and percentage of environmental ODA (MoE, 2005)

Through both JICA and the Ministry of the Environment, environmental ODA are enforced in the following areas: Natural Environment Conservation/Environmental Management (Pollution Control)/Water, Disaster Prevention, Electric Power Supply and Renewable Energy and Energy Conservation and Mining. In particular, technical cooperation in the above-mentioned areas include flood control, irrigation, ensuring efficient and sustainable supplies of safe water, air pollution countermeasures, acid rain countermeasures, water pollution prevention measures, and waste disposal, increasing generating capacity, extending electric power coverage, and expanding the use of renewable energy.

JICA assists developing countries by providing the knowledge transfer and training required for environmental analysis and the formulation of environmental countermeasures. Environmental centers are established in the following six countries to contribute to technology transfer and capacity development in the environmental field: Chile, China, Egypt, Indonesia, Mexico, and Thailand. (JICA 2006b)

7 Concluding remarks

Japan has adopted a broad definition of environment technology, naturally incorporating businesses in which environmentally conscious consumer behavior bring about demand for environmentally-friendly equipment and services, such as energy saving home appliances and fuel efficient vehicles. This broad definition of environmental technology is also widely adopted by different key actors in society, such as business leaders, government and academia. Today, the broad definition of environmental technology seems to inspire an open mind to the importance of cutting-edge technologies, as seen in the review of the current undertakings in research strategies.

In Japan there is also a seemingly firmer view, compared to in Sweden, on environmental technology as a competitive factor. The view is probably founded in the oil crises of the 1970s, giving Japanese companies a most welcome competitive edge, since they had been early starters in pursuing efforts in energy saving and energy efficient products. Company forerunner's clearly out-spoken ambitions to go beyond compliance as a key motivation for new innovations is e.g. illustrated by one of the major electronic firm's aspirations of becoming emission neutral, by developing super eco-products.

Comparing the situation in the 1970s with the current one, some similarities are striking. Japan's still strong dependence on imported energy, continues to inspire companies to think and act pro-active today, as illustrated by the development of hybrid technologies. It can also be noted that once companies have experienced successes thanks to an environmental edge, the general understanding of the relationship between environmental products and company reputation and sales deepens. As for the case of a major car manufacturer, environment is now stated as a factor for competitiveness along with "quality" and "cost-reduction".

By demonstrating a growth model based on a virtuous circle for environment and economy, through the "environmental revolution", the government's goal is to lead the world as an environmentally advanced nation. Grappling with environmental problems is expected to lead to the creation of new businesses and strengthen Japan's international industrial competitiveness.

Similar views on environment as an economic heave are expressed in Sweden and within the EU. Nevertheless, the relationship between environmental regulations and technological innovation or productivity improvement is, as the theoretical overview has shown, far from simple. First of all, the theoretical underpinning for the Porter hypothesis on the linkages between environmental regulations and innovation is controversial, and in addition the empirical evidence is weak. There is also a difficulty in empirically testing the importance of regulation (properly designed and implemented) as a driver for competitiveness enhancing innovations, mainly since it is only one of many drivers, including subsidies to R&D, education and skills etc.

However, it seems to be clear that some of the possible innovation offsets, as Porter asserted, will occur only with a time lag. Porter and van der Linde use environmental regulations in Japan and Germany as examples. According to results from Japan, the innovation offset in Porter's argument can be realized as an outcome of technological innovation resulting from R&D efforts by firms, having significant long-term effect on productivity enhancement. Japanese studies have also shown a small but positive impact of pollution control expenditures on the number of successful environmental patent applications.

Differences in export success of firms based in a certain country, have often been explained by lead in technological knowledge. Supply factors influencing the technological capabilities for environmental innovations can e.g be efforts in respect of environmental R&D - a factor currently strongly promoted in Japan. Japan also seems likely to become a lead market for environmental innovation based on its current situation of being advanced in respect of global trends regarding e.g. demographic situation and a high number of certifications for environmental management standards etc. The national Japanese market also demonstrates a high degree of competition and is furthermore intensively watched by other countries, thanks to a high reputation concerning problem solving innovations in the past; all important so-called demand factors for national markets to become lead markets. Moreover, when applying the lead markets approach to environmental innovations the price and cost structures important for encouraging certain types of innovations, are largely dependent on regulations. This study has not explicitly compared country-differences when it comes to stringiness of environmental regulations. It can however be concluded that Japan seems to be a lead market for developing the life cycle approach as a policy tool, potentially leading to the development of a broad set of products and processes with an environmental edge. Reflecting on the Japanese experiences, it seems like life cycle analysis (LCA) is an important complementary tool to regulations for adjusting the imbalances of today's price and cost structures.

Main conclusions and Swedish policy implications:

- Sustainability performance, in Japan as in Sweden, still has the character of risk management in the short term. Internalization of the social costs of environmental damages would provide better incentives for innovations in environmentally friendly directions, by making environmental performance a competitive factor. Getting prices right is a crucial issue for a coordinated environmental and innovation policy, providing a more comprehensive basis for policy making and policy reviews. As e.g. the review of the Porter hypothesis and it's assumption of a win-win situation for companies and nations stemming from environmental regulations has shown, it is apparent how the core arguments in a policy debate on what is economically favorable or not often is diminished as soon as a broader palette of social and environmental costs are being accounted for.

- Today, the life cycle approach is widely adopted in Japan as one constructive way forward for sending out comprehensive cost and price signals. As pointed out in this study, Japanese companies foresee a turning-point for eco-products not yet acquiring a competitive edge coming up in Japan. The success stories also seem to diffuse and motivate others, as illustrated by the achievements of the hybrid vehicle. Still, as mentioned above, sustainability performance is not yet a selling argument of its own. Increased awareness of consumers (and financial markets) is however emerging and life cycle analysis (LCA) is seen as a key instrument. As governmental involvement is not limited to R&D but could also be called for in all phases and include financial support for e.g. dissemination of information, an implication for Swedish policy can be to more actively support LCA-measures. There is much to learn from the Japanese experiences in this regard.

- The Japanese strategies provide several interesting cases in point to consider when forming the Swedish platforms for further development of environmental technology. For strategy formation, the strong emphasis on follow- up on mid-term targets, e.g. to strive for a doubling of the number of domestic patents and international patents, seems sophisticated and could most likely be proven efficient also for the Swedish undertakings. In addition, the broad definition of environmental technology used in Japan has clearly opened up a wide ranging field of possibilities for cross applications; also being reflected in the main policy document. In the Swedish context, these potentials are still to be exploited, and the Japanese ideas of cross-nurturing can be utilized as good quality examples.

- For general policy measures, the Japanese types of targeted programs for e.g. environmental cluster projects, seems to be rather unique from a Swedish standpoint. The cluster projects within e.g. new energy, ecology and recycling would most likely be useful to study more comprehensively, to gain detailed insight on success factors and which components of the program could prove awarding for Sweden to apply. The verification program and the environmental ODA are two other such areas.
- Last but not least, Japan is currently strengthening its Asian connections, an ambition frequently repeated throughout this report when referring to their future research undertakings. Swedish measures targeting Asia can presumably gain from closely monitoring the Japanese actions in this regard, especially for the environmental technology development in connection to China. Also, since Japan is now so actively aspiring to take the lead, research collaboration in the environmental field with Japanese researchers is likely to prove key for future collaborations in the wider Asian region.

7.1 Future studies

Most patent surveys of environmental technologies cover mostly so-called end-of-pipe solutions. These technologies are more easily identifiable compared with identification of innovations related to changes in production processes or product characteristics. Since there seem to be a current general shift from end-of-pipe technologies to more integrated abatement technologies, e.g. declining numbers in recycling patents may be due to measures upstream in the production chain based on life-cycle-analysis. However, despite identification problems and statistics lagging-behind, it is a key issue to try to capture the patent activity also for integrated innovations. Here there is a clear need for further in-depth studies, both to capture today’s trend and to grasp future developments.

More in-depth studies is also needed on well-designed environmental regulations and the empirical results testing Porter on these parameters, since most studies made to this point are stated to examine the impact of traditional command and control regulations, while theoretical research findings suggest that innovation activities are more likely to be driven by incentive-based regulations. Furthermore, an area interesting for a more through benchmarking study is the Japanese/ Swedish LCA-efforts in different sectors on different levels.

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APPENDIX 1

Example of identification - Society with no global warming

Policy Goals

- Meet the First Commitment Period (2012) reduction target [short term goal]
- Establish and meet the post- First Commitment Period reduction target [mid term goal]
- Stabilization of green house gases [long term]

* note the definition of short, mid and long term differs for this area from the other.

Short- approximately five years, Mid- 20-30 years, Long- approximately 100 years

Research Issues of Emphasis

- Establishment of comprehensive green house gas monitoring system*
- Establishment of climate change monitoring and evaluation network of Asia- Pacific region*
- Increasing precision of the climate model and climate change impact prediction and management of risk from climate change*
- Research on design and policy evaluation model for society without global warming *
- Technology development of renewable energy and research on structure to promote diffusion of *
- Technology development and diffusion of new social system such as hydrogen and fuel cell*
- Research on implementation method of low CO_2 emission in Asian countries through CDM and technology transfer
- Development, diffusion and evaluation of green house gas reduction technology (such as free-halogen substance) etc.

APPENDIX 2

List of Technologies

1 Development of global observation technology and prediction modeling with high precision

2 Monitoring and optimizing system for residential and transportation energy use

3 Distributed energy and optimization of energy supply from natural resources

4 Dynamic improvement of energy supply, conversion and consumption phase towards energy efficiency

5 Development of biological material which can be reused as energy with high energy efficiency

6 Traceability of product and material using ICT

7 Diffusion of information leading to change in life-style of the general public

8 Development of new material with long duration of life and high recyclability

9 Development of green chemistry

10 Cost reduction and expanded use of utilization of biological waste and biofuel

11 Monitoring and technology for prevention of illegal dumping

12 New manufacturing process with low environmental impact

13 Reduction of resource consumption by utilizing nano-machine

14 Development of biological material suitable for recirculation

15 Development of monitoring technology prediction and prediction model with high precision

16 Development of system for monitoring wildlife birds and animals

17 Development of management model of urban and basin environment

18 Integration of database of biodiversity

19 Establishment of database of gene of index organism of natural regeration

20 Development of diagnosis technology for impact evaluation of wildlife animals using DNA chip

21 Development of Bio-eco-engineering

22 Expand use of biodegradable material

23 Bioremediation

24 Establishment of monitoring network of and development of detailed dynamic model of complex chemical substance

25 Development of innovative risk assessment method using toxicoinfomatics

26 Development for integration of comprehensive chemical substance database

27 Development of measurement of high ultrasensitive, high selective and low cost chemical substance

28 Development of chip enabling fast, simple evaluation of chemical's impact on health

29 Development of innovative environmental remediation technology (such as nano catalyst)

30 Evaluation of biospheric impact of genetically-modified bodies

The Swedish Institute for Growth Policy Studies (ITPS) is a Government Agency responsible for providing policy intelligence to strengthen growth policy in Sweden. ITPS primarily provides the Government Offices, Members of the Swedish Parliament, other state authorities and agencies with briefings based on statistical material, policy papers and key analyses. Business policy and regional development policy are areas given high priority.
Changes in policy should be based on:

- Statistic data and analyses of the structure and dynamics of industry – to obtain an up-to-date view of future challenges and opportunities.
- Evaluation of results and effects of policy measures and programmes – to provide benchmarks and learn from measures implemented earlier.
- Policy intelligence in order to look outwards and ahead – what issues are likely to come on the growth policy agenda in the future?

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