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Learning from Japan's Experience in Energy Conservation

Taishi Sugiyama*

Central Research Institute of Electric Power Industry

Abstract:

Japan has achieved the highest level of energy conservation in the world. Every indicator of energy efficiency shows that Japan is positioned in a leading group. Then, how has Japan achieved such energy conservation? In this paper, we will learn lessons from this valuable experience, and discuss how the domestic global warming mitigation policies for the future should be.

* Corresponding author. [e-mail: sugiyama@criepi.denken.or.jp]

This paper is organized as follows.

First, we will review establishing pollution control measures, that is to say a formative experience for Japan that made huge impacts on the country's later efforts on environmental problems.

Second, we will present "theories of energy conservation policies" in detail. "Theories" of environmental taxes and emission trading systems are relatively known to many people, but the "theories of energy conservation policies" are known to few people. However, since we shouldn't develop future global warming mitigation policies without understanding these theories, we will fully explain them.

Third, we will confirm the proven results of the energy conservation policies.

Finally, we will mention that other policy instruments besides regulations have also played important roles. Technological development policies will be discussed elsewhere.

1. Proven results of pollution control measures

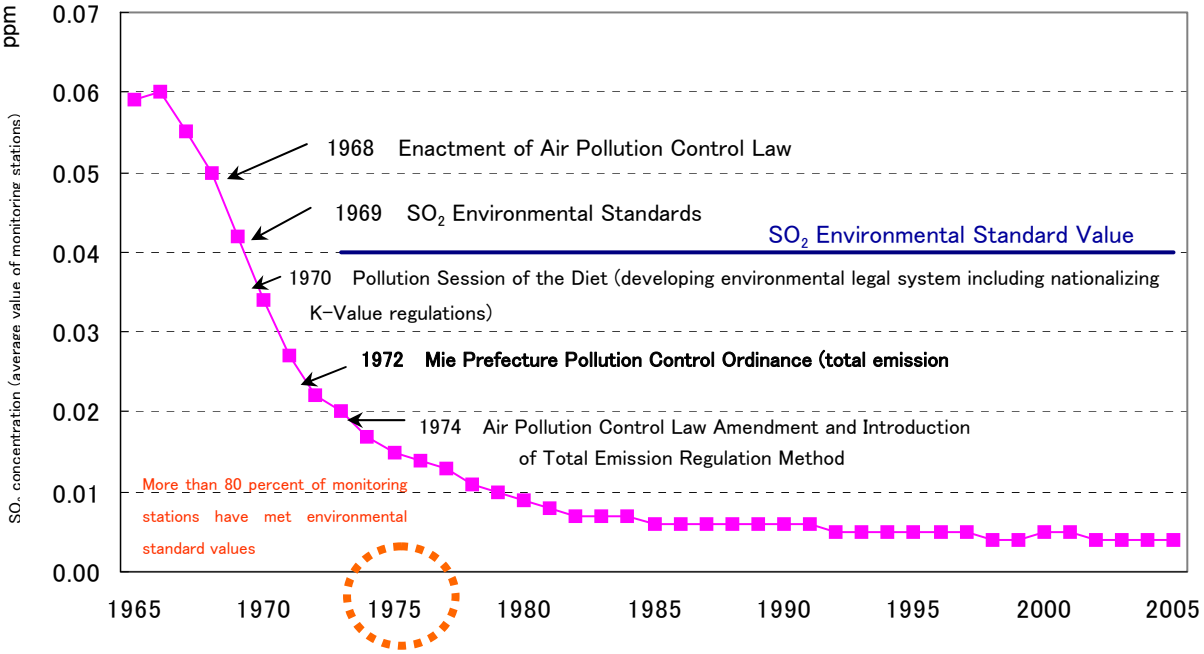
A feature of Japanese environmental policies is that they have been implemented using frameworks of industry policies and achieved great results.

This experience has been taken over by later energy conservation policies, and it is still alive as a frame of current global warming mitigation policies.

Let us take up air pollution control measures below, focusing on ones against SO_2 emissions, as an example of pollution control measures which are deeply related to global warming issues.

As a result of large-scale industrial complex construction projects and energy conversion from coal to oil during 1950s and early 1960s, SO_2 air pollution occurred, being accompanied by serious public health damage. To tackle the problems, various measures had been taken since late 1960s, with the result that considerable reduction in SO_2 emissions and improvement of environmental quality level was brought in short-term.

Figure 1 shows that average SO_2 concentration in the air started decreasing dramatically since late 1960s, and by the middle of 1970s, the environmental standards had been achieved at more than 80 percent of monitoring stations throughout the country. Since then, up to date, the achievement rate of environmental standards has remained at an excellent level of almost 100 percent.



Source: Ministry of the Environment, "About the Status of Air Pollution"

Fig. 1 Changes in SOx Air Pollution Improvement

● Fine-turned policies

What made this immediate environmental quality improvement possible?

It was because a wide range of policies had been implemented to promote development and diffusion of pollution control technologies (Figure 2).

With pollution problems becoming serious, the control measures were planned upon comprehensively considering the cost and feasibility through opinion exchange with experts and related industries, at Task Force for Low-Sulfurization that was established in a governmental advisory agency, Advisory Committee for Energy.

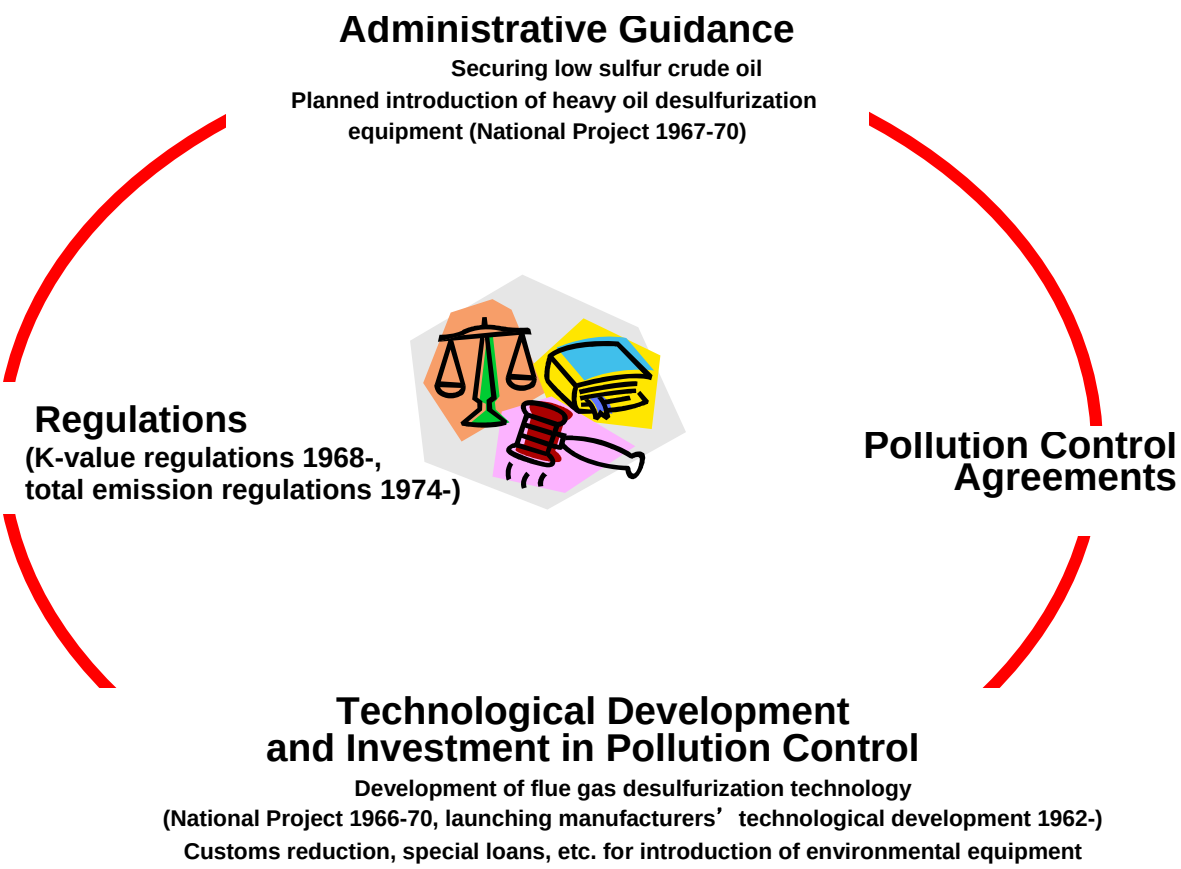


Fig. 2　Fine-tuned Air Pollution Control Policies

At this time, regarding the development and diffusion of control technologies, full discussion was made on certain factors including which technologies would be effective and which technologies could be introduced. Concretely, these technologies included ① lowering sulfur content of fuels (promoting import of low-sulfur crude oil, crude oil burning, and expanding use of LNG), ② desulfurization of heavy oil, and ③ flue gas desulfurization technology.

According to a judgment based on the circumstances surrounding these technologies at the time, it would never be easy for each measure's goal to be achieved. However, eventually, a decision was made that the levels of these goals were attainable if the every measure would be taken. And then, detailed plans based on the long-term view were developed to achieve the goals.

Policy instruments that were adopted then included technological development, tax breaks, regulations, and agreements.

First of all, development of flue gas desulfurization equipment started as a national technological development program. Also, financial measures including customs reduction and special loans by development banks were taken for private companies' installation of equipment for desulfurization of heavy oil, flue gas desulfurization, and desulfurization by gasification process to promote the

measure of installing such equipment.

Regarding regulations, under Air Pollution Control Act, K-value regulations were introduced and sliding-scale-type strengthening of regulations was attempted. In 1974, for large emission sources including large plants, total emission standards that would apply to individual plants came into effect, and for small emission sources including small plants that were exempted from total emission regulations, fuel utilization standards that would be complied with at individual factories took effect.

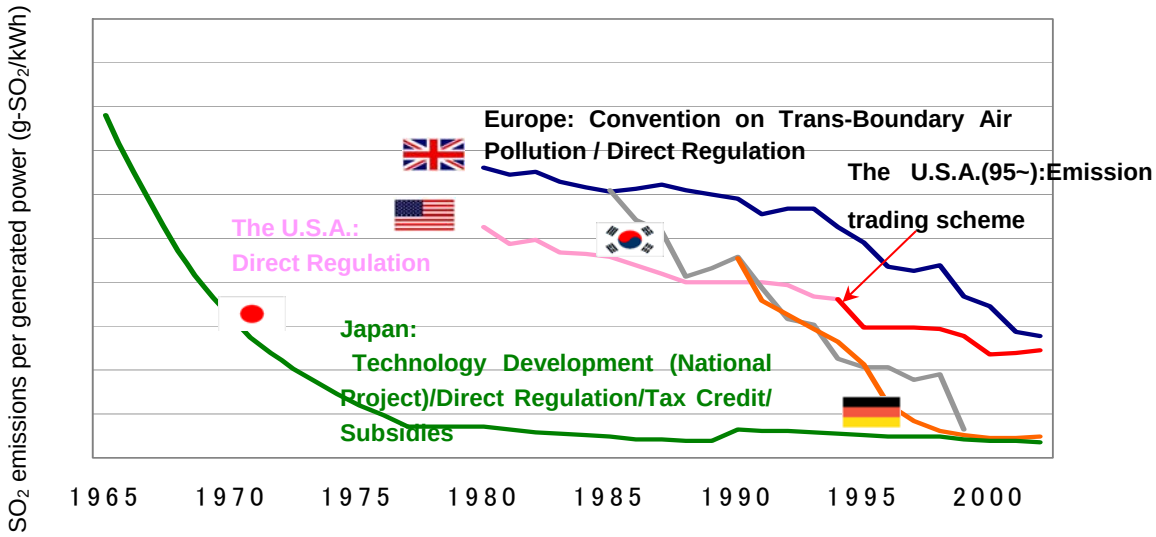
With regard to the approach of total emission regulations, it allowed business flexibility in how they would address the regulations, by providing an approach that establishes a cap on total amount of pollutants emitted from every target facility of a business entity and does not regulate emissions from individual facilities of the entity.

In addition, large-scale business entities began to voluntarily sign pollution control agreements with local municipalities and implement pollution control measures at much higher levels than ones the laws provided.

● Great results

As a result of a series of policies mentioned above, Japan has achieved great results (Figure 3). International comparison on SO_2 emission intensity (SO_2 emissions per kWh of power generation) at coal- and oil-fired power stations shows that Japan has succeeded in significant emission reductions in advance of other countries. Other countries were much behind in improvement of emission intensity, and, for example, in South Korea and Germany, it occurred twenty years later. As for emission intensity in the U.S.A., which introduced emission trading systems, it can not be said that the emissions have been reduced since 1995 in comparison with trend of emissions before then. Moreover, regarding technologies, the U.S. has merely utilized existing ones which had already turned into practical use in other countries such as Japan.

Japan has achieved the highest level of emission control in advance of other countries.



Source: Reference 2

Fig. 3 International Comparison of SO_x emissions

Japan's fine-turned policy instruments have realized ambitious emission reductions ahead of the rest of the world, and have become a superior precedent to other countries.

2. Theories of energy conservation policies

Next, we will discuss on energy conservation policies. We will present data of results later, and we will explain about the theories first.

To make the explanation organized, we will start by talking about the stage of diffusion of existing technologies, followed by discussion on the stage of research and development of new technologies.

Now, to begin with, why are some policies necessary in promoting energy savings (Figure 4) ?

Could energy conservation improvement be pursued without government intervention for the reason that it would lead to cost reductions?

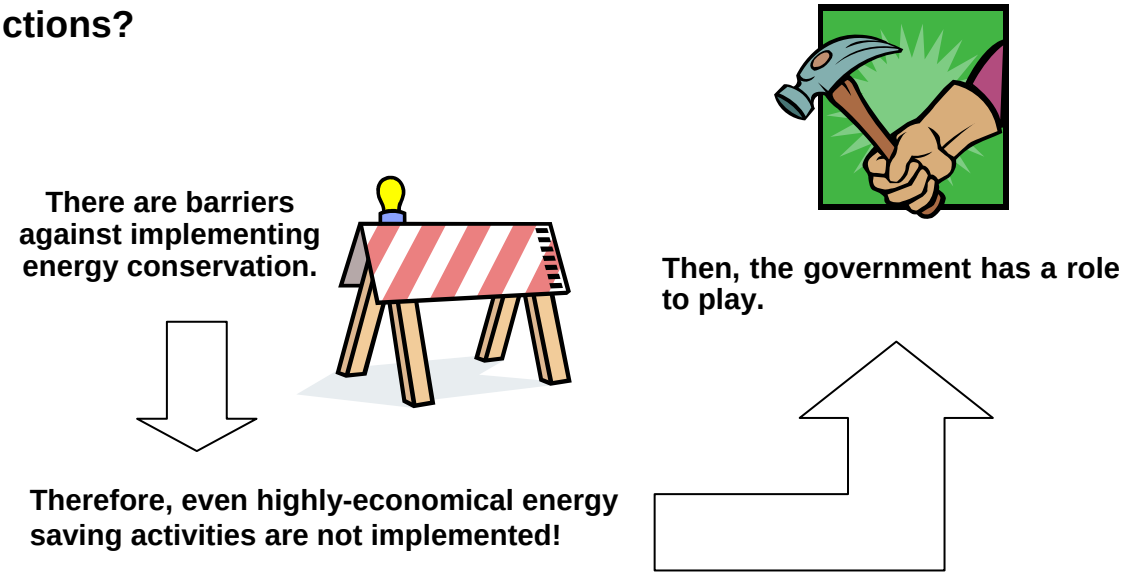


Fig. 4 Why "Energy Conservation Policies" Are Necessary?

Some argue that government doesn't have to do anything because, in many cases, energy conservation will lead to energy cost reductions.

However, it is not true. The fact is that even energy conservation measures which are assumed to be fully cost-effective have not been implemented by various reasons. Then, governments' policies are required.

● **"What are barriers to impede energy conservation?"**

To help you understand this fact, we will explain, with concrete examples, the barriers that prevent investments in energy conservation and consumption of energy-efficient products from being realized (Fig. 5).

- Priority on other purposes
- Preference of consumers
- Lack of information
- Practices of industries
- Distortion in energy price structure
- Instability of macro-market

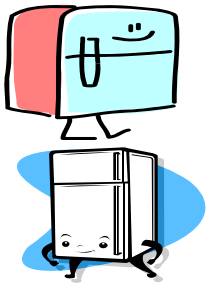


Fig.5 Barriers which prevent investment in energy conservation and consumption of energy-efficient equipment from being realized

For instance, let us imagine that, when we're going to buy a refrigerator, there're two candidate products. One is expensive and its energy efficiency is high, and the other is cheap and its energy efficiency is low.

Consumers may just not be interested in how much energy these products will consume, and they may select one of them according to their preference of color, design, performance, or actresses who are advertising the products. In this way, "precedence of other purposes" and "preference of consumers" are considered as barriers from a viewpoint of encouraging energy conservation.

Next, imaging when information on difference of effectiveness of energy savings between these two refrigerators, such as electricity charges and energy efficiency, is not available at stores, energy-efficient products won't be selected. This barrier is called "lack of information."

Also, in case of building construction, various businesses including designers, constructors, owners, and tenants are involved in one project. Although all of the stakeholders should work together to construct highly energy-efficient buildings, in the actual industry practices, on the contrary, energy conservation tends to be given secondary importance. For instance, people engaged in building design and people engaged in selecting air conditioners rarely have opportunities to exchange their opinions. In this way, "industry practices" is another barrier to impede energy conservation.

With regards to the fifth barrier indicated in Fig. 5, when subsidies for electricity charges are excessive and don't reflect actual cost of power supply, the number of people who would like to buy energy-efficient products will decrease. This is a barrier which is called "energy price distortion," a phenomenon which is often seen in developing countries.

Furthermore, though refrigerator manufacturers need stable macroeconomic conditions so that they could invest in production lines of more refined and more energy-efficient refrigerators, there are some cases in which such conditions are not met. This is as well one of the barriers which is often seen particularly in developing countries.

An actual state is that the progress of energy conservation has been very slow because of the existence of these barriers as mentioned above.

● "What is payback period?"

In this book, payback period means, "the years required to recover the necessary amount of the investment by saved energy cost in case of certain investment in energy conservation."

We will illustrate it using Fig. 6. Installing insulation at a building costs you one million yen. When this measure can save electricity and heating expenses by 500,000 yen per year, the payback period is two years, as a result of a calculation of dividing one million yen by 500,000 yen.

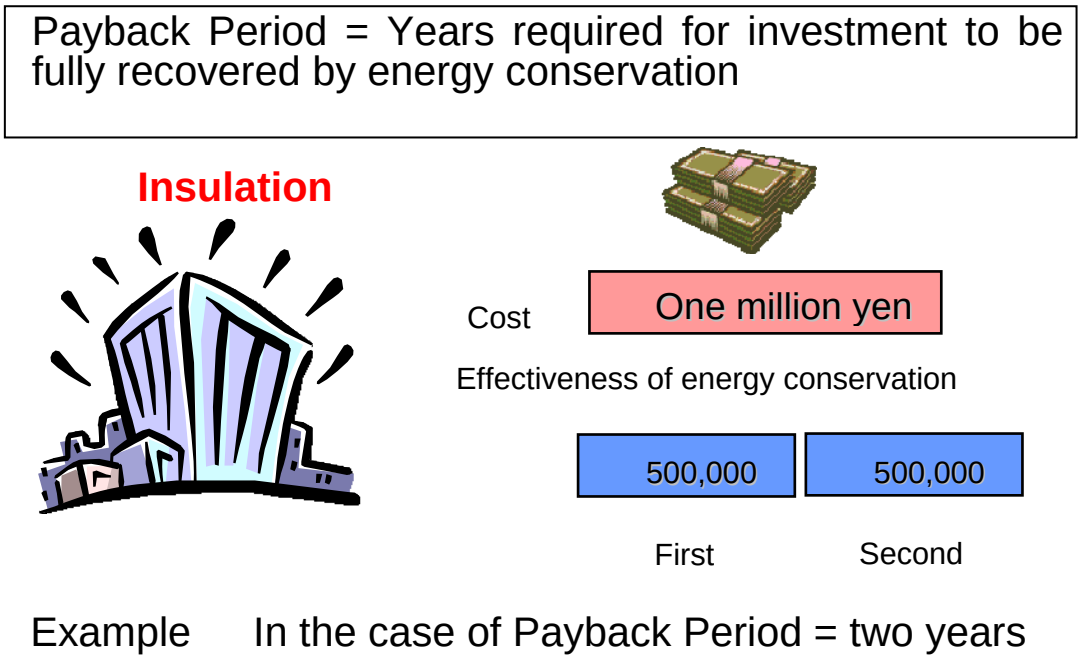


Fig. 6 What Is Payback Period

The payback period can be measured when the information on the necessary cost for investment in energy efficiency improvement and the amount of energy actually saved by the investment is obtained through observing actual economic activities or surveying companies with questionnaires.

The results of the measurement on the obtained information indicate that many opportunities for energy conservation have not been realized in any countries.

In the case of ordinary factories, the payback period of investment in energy conservation will be short and it is around one to three years. In the case of electric home appliances, the payback period is much shorter, and in some cases, it is only six months (Figure 7).

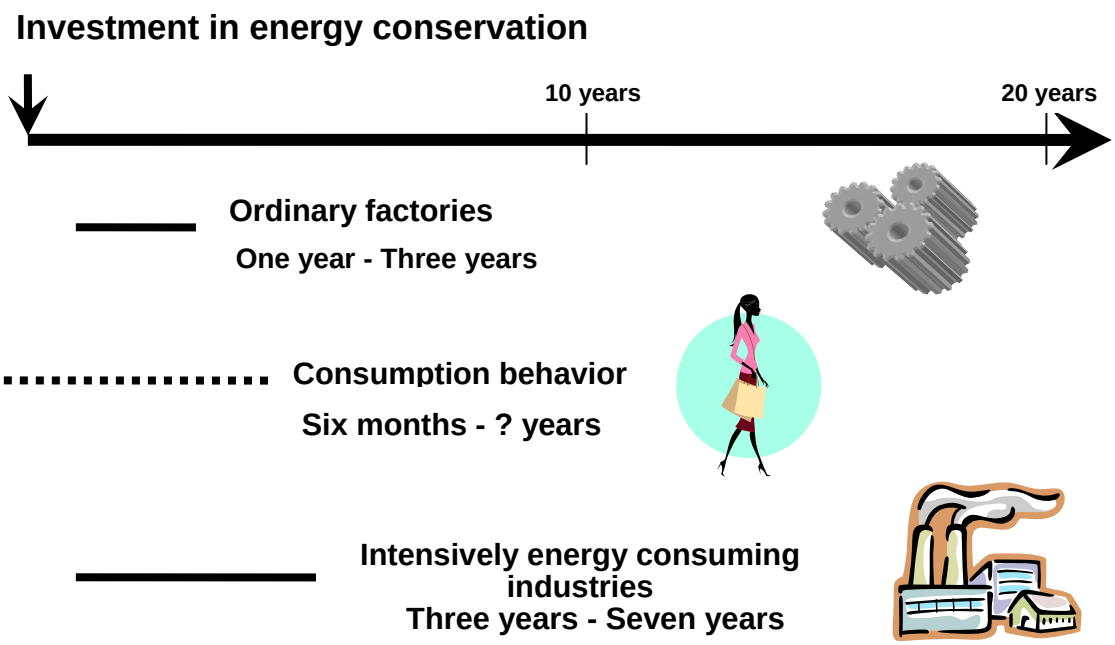


Fig. 7 Without Policies, Energy Conservation Doesn't Easily Advance

Probably, you have experienced selecting a product of which price without tax is cheap, rather than "an energy-saving appliance" at a store, not paying attention to its energy consumption. Of course, though some people will buy energy-saving products "in which investment will require 30 years to be fully recovered," such cases are probably rare.

On the other hand, the payback period is longer in some industries such as power companies whose main business is energy production, or steel making, cement, and petrochemical industries in which energy costs account for a large part of production costs. Even in these industries, the period is about three to seven years.

Thus, an actual state is that even the investment in energy-saving products, in which the investment could be recovered in just a few years, has not been implemented.

● **"The role of energy conservation policies"**

Then, the time has come for government to play its role (Figure 8).

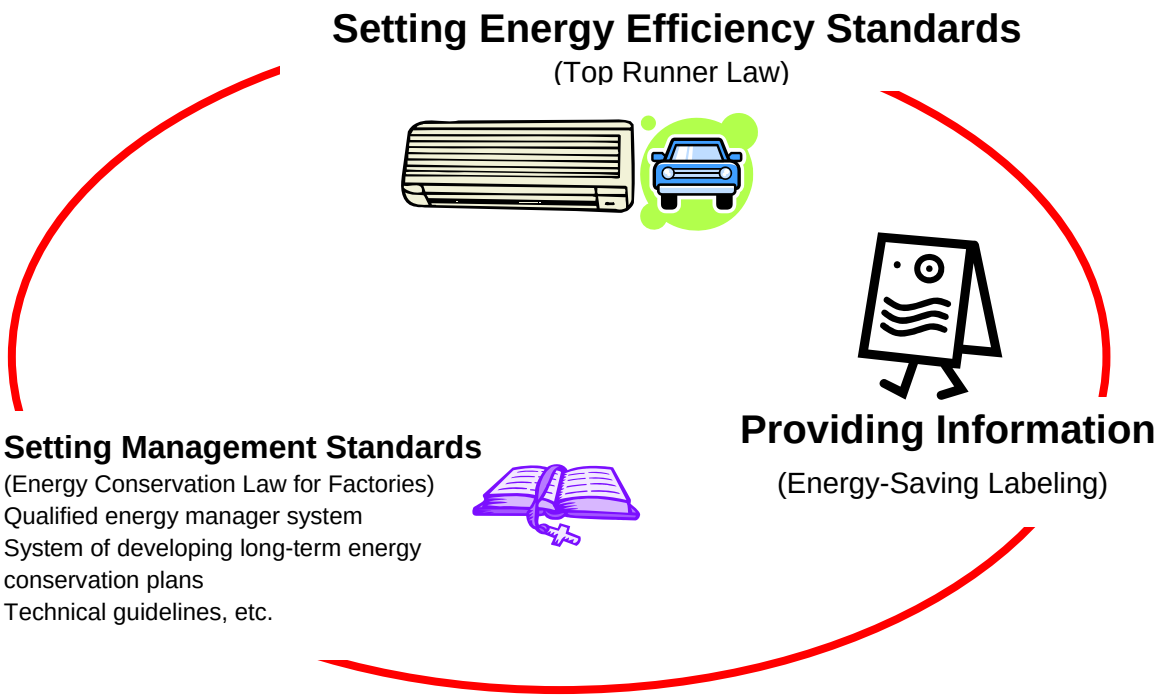


Fig. 8 Energy Conservation Policies by Government

The government will provide information on estimated electricity and heating expenses through establishing energy efficiency standards and an energy-saving labeling program for electric home appliances and automobiles. Consequently, poor quality products with high energy cost will be removed from the market, and companies and consumers who would like to purchase products will be able to select ones taking account of the total costs including electricity and heating expenses.

Also, regarding factories, the government will address the problems by establishing a qualified energy manager system, a system of developing long-term energy conservation plans, and management standards including technical guidelines.

Factories larger than a certain scale will be required to be staffed with employees who have qualification as a manager having expertise on energy and to ensure that employees who are responsible for promoting energy conservation will be available all the time.

Also, developing long-term energy conservation plans will provide opportunities to consider what potential the factories will have for energy conservation.

Moreover, specific technical guidelines including one on temperature management for the equipment important for energy saving such as boilers are prepared in order to routinize tasks of qualified energy managers, opportunities to promote energy saving will not be missed.

● **Promoting technological development**

In the above, we have discussed on the stage of diffusing technologies.

On the other hand, the government has its role to play in promoting technological development as well (Figure 9).

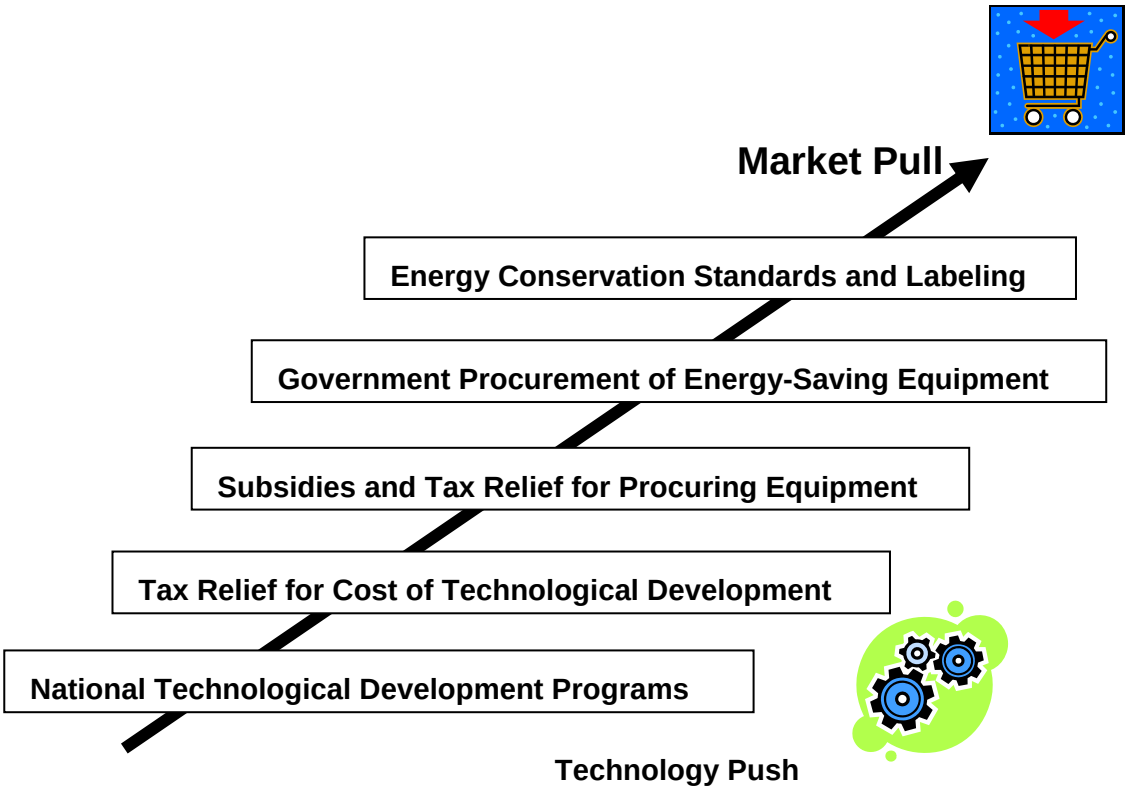


Fig. 9 Technological Development Promotion by Government

Various policies promote development of technologies. They are generally categorized into two approaches; one is a method of "pulling" technological development by creating a market for energy-saving equipment, and the other is a method of "technology push" which facilitates technological development activities themselves.

The following will further provide information on an energy-saving labeling program and a governmental procurement program on energy-saving equipment among these various policies.

● **Energy-saving labeling program**

First, we will see the labeling, which shows information on energy-saving performance of equipment at retail stores (Figure 10).

【Multi-stage rating system】
・Energy-saving performance is indicated in 5 stages, from 1 to 5 stars, from low to high performance of products offered on the market.
・In order to clarify the compliance level with the Top Runner standards, arrows are placed under the stars showing achievement and non-achievement.

【Energy-saving labeling system】
・ Products which achieved the Top Runner standards carry a green "e" logo, while others carry an orange "e" logo.
・Achievement level of the standards and energy consumption efficiency (including annual electricity consumption) are also indicated

【Estimated annual electricity charges】
・The estimated annual electricity charges are indicated to clearly show the energy consumption efficiency (including annual electricity consumption).

Fig. 10　Uniform Energy-Saving Label

On the label, the following three kinds of information are provided about the electric home appliances including refrigerators and air conditioners;

1. Multi-stage rating system: it indicates energy-saving performance of the appliances in five stages, from one star (☆) to five stars (☆☆☆☆☆).

2. Energy-saving labeling system: it consists of two kinds of energy-saving logos, a green colored one with a white cutout letter "e" or an orange colored one with the "e" letter. The green logo with a white "e" means that the appliance has already met the top runner standards before its target deadline year.

3. Estimated annual electricity charges: it provides consumers with information of energy-saving performance of individual appliances. Consumers will refer to the information when they are going to buy the products.

● **Procurement of energy-saving products by government**

Next, let us talk about government procurement of energy-saving products.

The government's choice on what equipment to buy is very important. In every country,

government procurement accounts for 10 to 20 percent of its GDP, and therefore, if the government purchases energy-saving equipment, it will considerably contribute to energy conservation throughout the county.

Figure 11 shows the roles the government plays in energy-saving procurement, comparing its effectiveness with that of the top runner program.

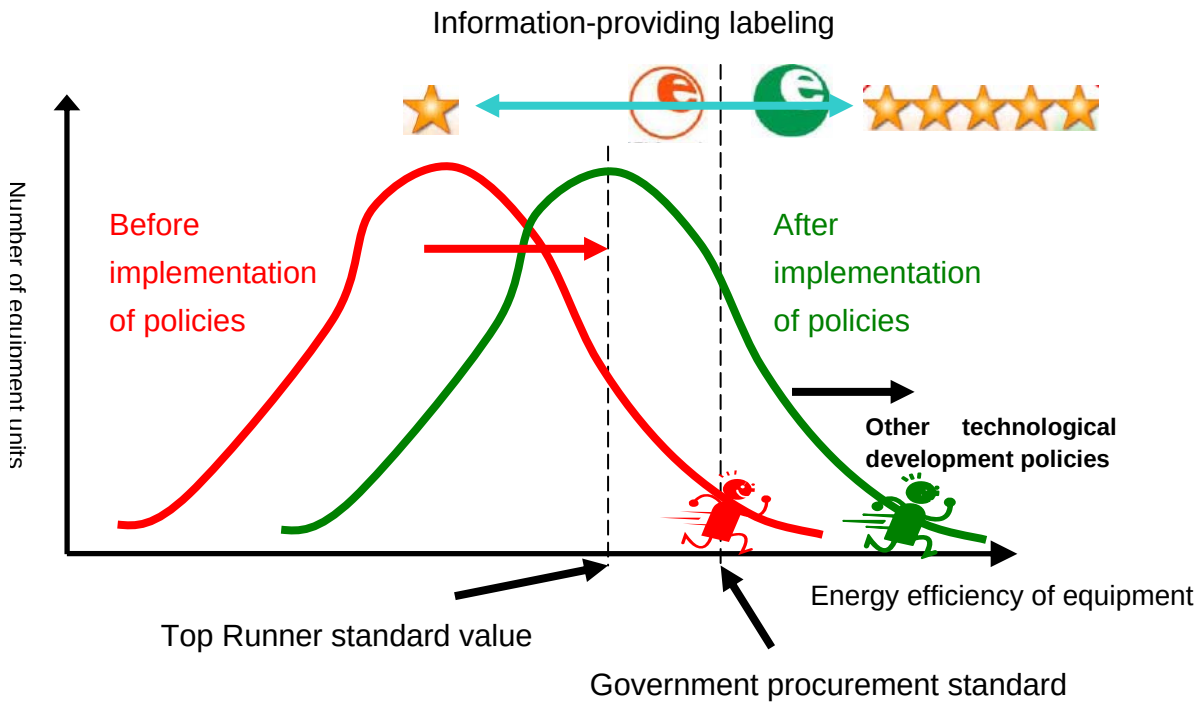


Fig. 11 Technological Innovation Driven by Government Procurement

In the Figure, a red line curve shows distribution of equipment before introduction of both of top runner program and government procurement system, and a solid curve shows distribution after their introduction. A vertical line shows sales of equipment (for example, air conditioners), and a horizontal line shows energy efficiency of the equipment.

Under the top runner program, a top runner standard value is set up just behind the top runner product (a gray colored person in the Figure). Since manufacturers have to ensure that the average energy efficiency value of the equipment they sell will exceed the standard value, the distribution of the products in the target year will be like that shown with the solid curve.

At this time, if the government sets a procurement standard value that is higher than the top runner standard value or will likely front-load the target year, government procurement opportunities will be awarded to a tiptop group among top runners.

In developing the guidelines for such government procurement, the labels with stars and energy-

saving “e” logos are utilized.

The government procurement creates markets for cutting edge energy-efficient products and likely accelerates technological development.

In addition, if governmental departments establish longer payback period than that established in private sectors, it will lead to reductions in governmental expenditure.

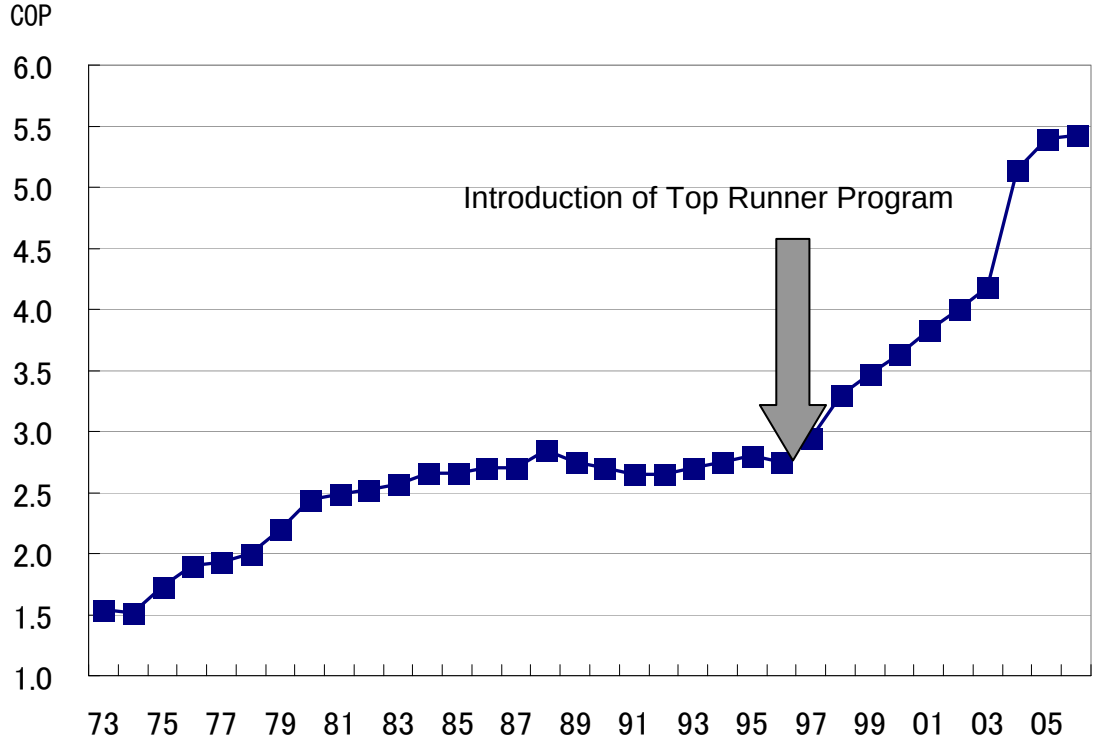
Of course, it is essential that the standards and labeling programs are properly set or developed and the technical capabilities are assured upon full consideration so that such government procurement can work well. Regarding the technical capabilities, technical consideration on individual equipment must be done respectively and concretely.

3. Proven results of energy conservation

Now, upon your understanding the theories of energy conservation policies, let us look at data which show what results has been seen.

● **Energy saving improvement of electric home appliances**

First, we will explain about the changes of energy efficiency of room air conditioners, as a successful example of the top runner program (Figure 12).



Source: Prepared from materials of Association for Electric Home Appliances and Jyukankyo Research Institute Inc. (2.8kW class)

Fig.12 Energy Saving Improvement of Equipment

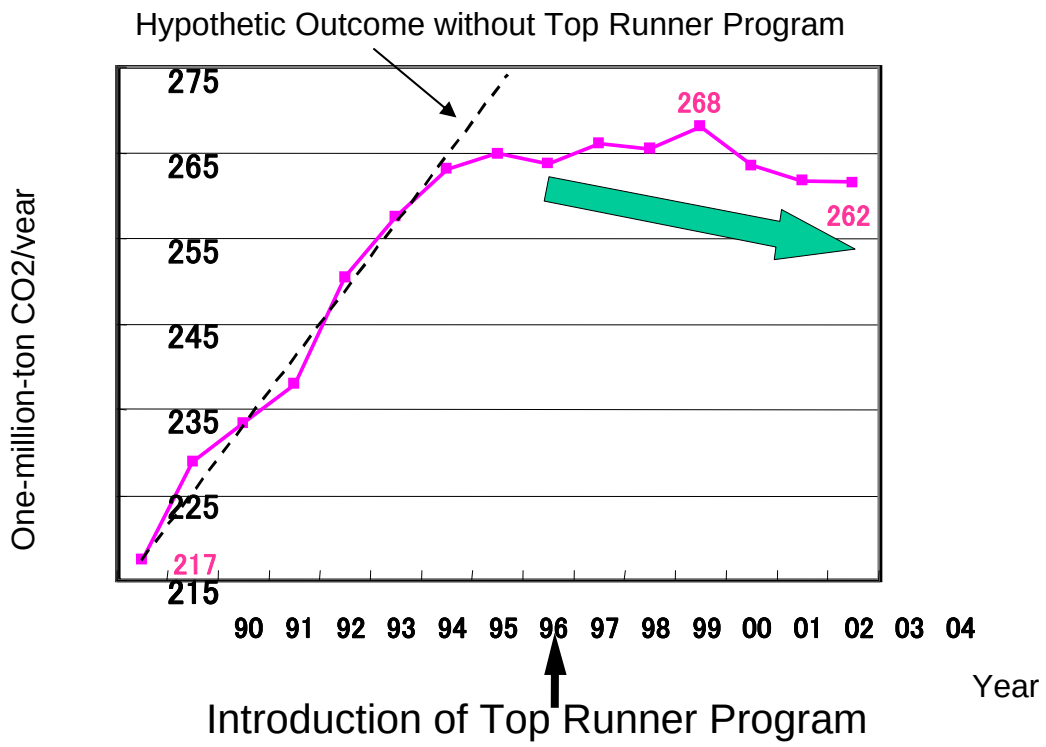
Currently, average Coefficient of Performance (COP) of room air conditioners is around 5.5.

This means that when the units consume 100W of electricity, 550W of cooling and heating capacity will be produced.

Efficiency can virtually exceed 100, because a room air conditioner is a system that takes unused heat in the air into a room.

After the top runner program was introduced, energy efficiency of the products has been sharply improved. Many experts agree that such improvement couldn't have been achieved without the top runner program.

In addition, the top runner program improved vehicle fuel efficiency, and it also stopped the trend that an annual total amount of CO_2 emissions from cars had been increasing (Figure 13).

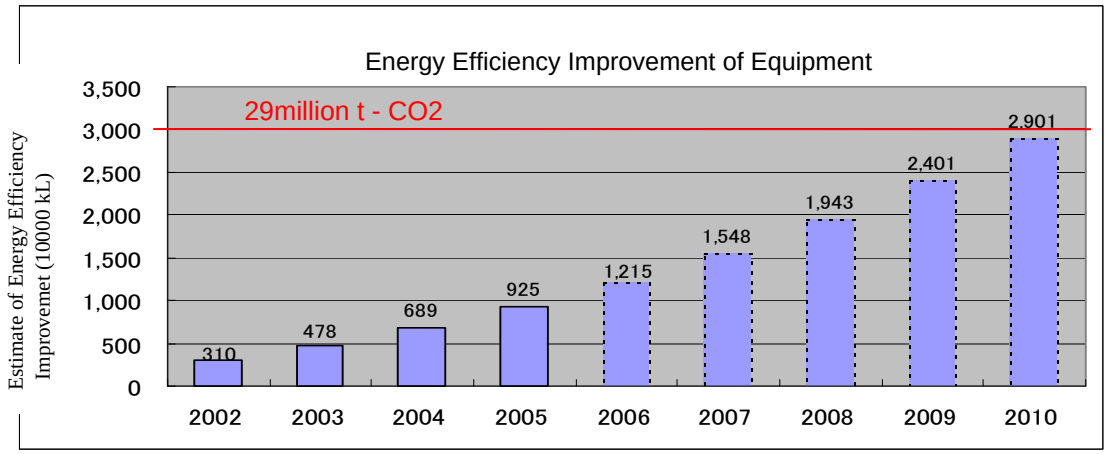


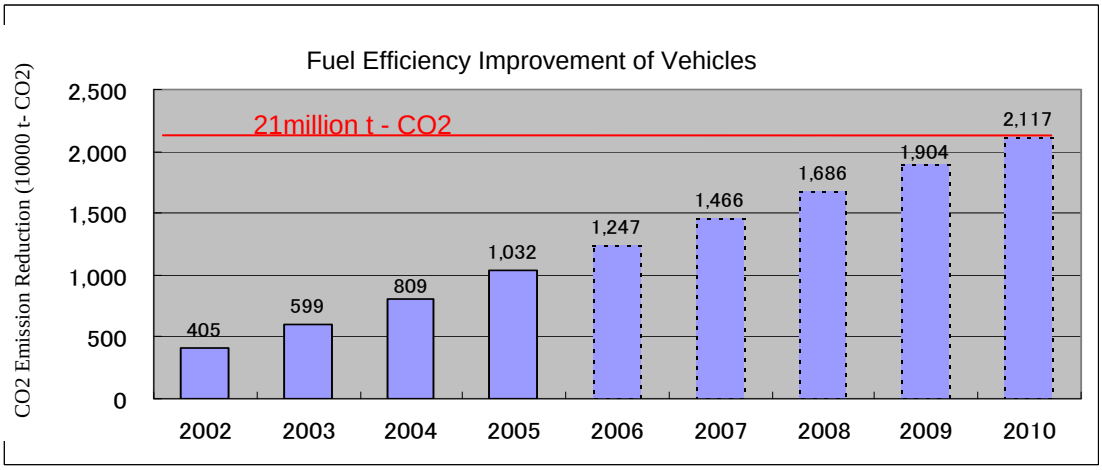
Source: Prepared from materials of Japan Business Federation

Fig. 13 CO_2 emissions from vehicles

Moreover, as for many other electric home appliances covered by the program, a significant improvement of energy efficiency has been realized.

The Figure 14 shows an estimate of reduction in CO_2 emissions achieved by the top runner program.



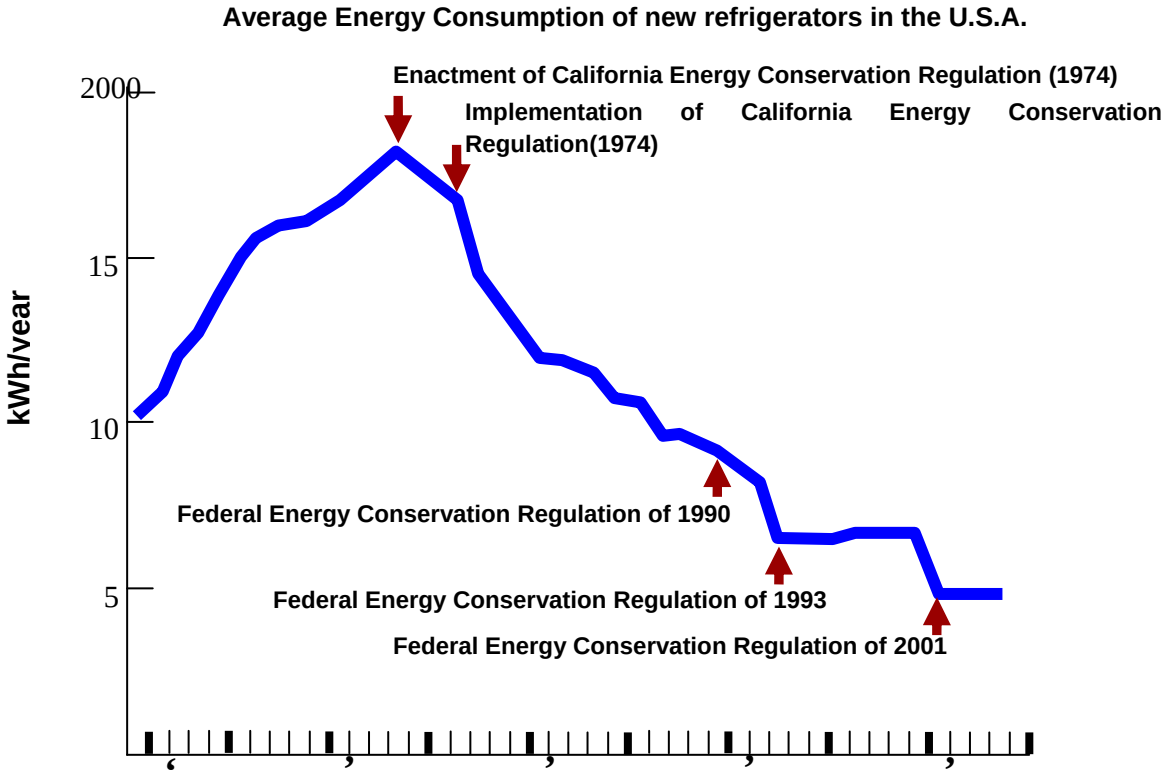


Source: Prepared from materials of Agency for Natural Resources and Energy

Fig. 14 CO_2 Emission Reductions by Top Runner Program

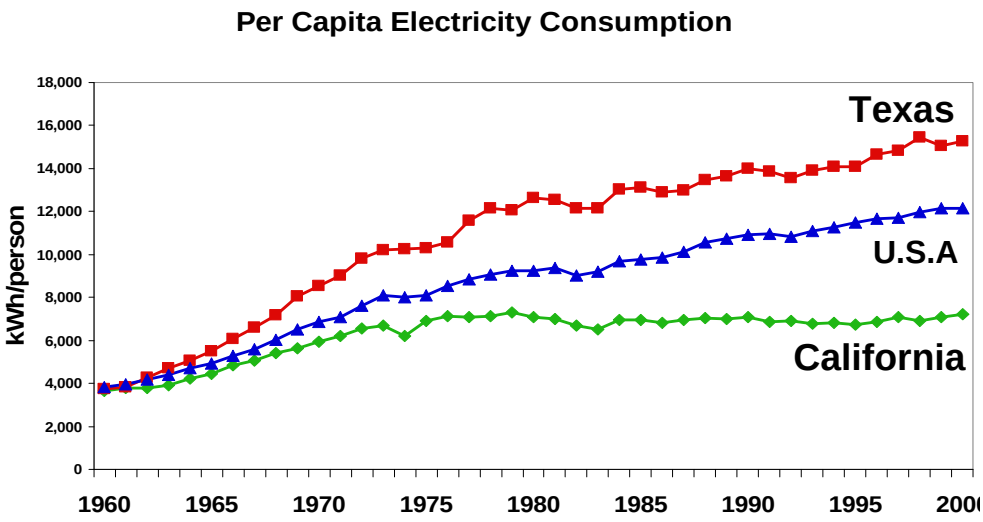
Of course, not every regulation was proper, and some of them need to be reviewed. However, the results have proved that the method of establishing appliance-specific energy efficiency standards was effective as a measure for energy conservation as well as global warming mitigation.

In the Figure 15, we will find that even overseas, energy efficiency standards have achieved a great result in energy saving in private and transportation sectors.



Source: Prepared from materials of Lawrence Berkeley National Laboratory

Fig. 15 Energy Efficiency Standards Have Leaded to Success In Energy Savings Even Overseas



Source: Prepared from materials of Lawrence Berkeley National Laboratory

Fig. 16 Electricity Consumption per Capita

The Figure 16 clearly shows that California which proactively introduced energy efficiency regulations has succeeded in stabilizing electricity consumption per person. Such trend in California outstandingly contrasts with that in the entire U.S. or Texas.

● Energy conservation of factory

We have discussed on energy saving of electric home appliances and vehicle, and now, we will look at the energy conservation of factory.

In the Figure 17, which shows the changes of energy consumption per Index of Industrial Production (IIP), we will see a remarkable improvement has been realized in energy intensive industries after the oil crises.

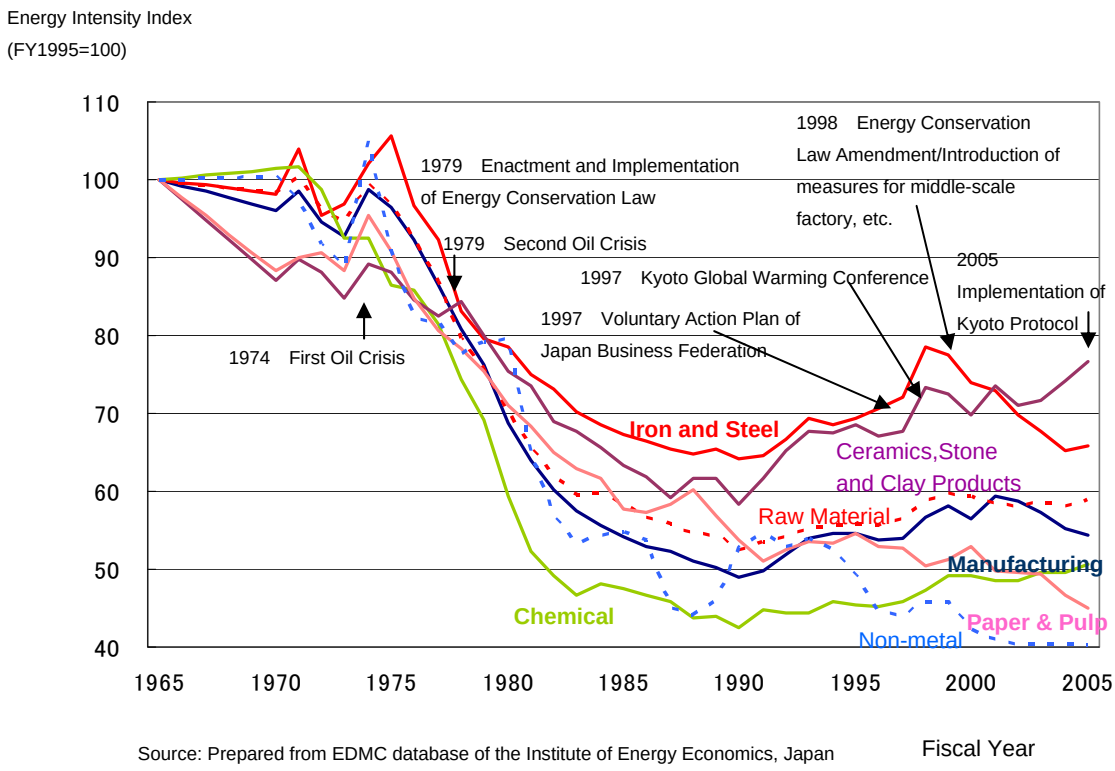
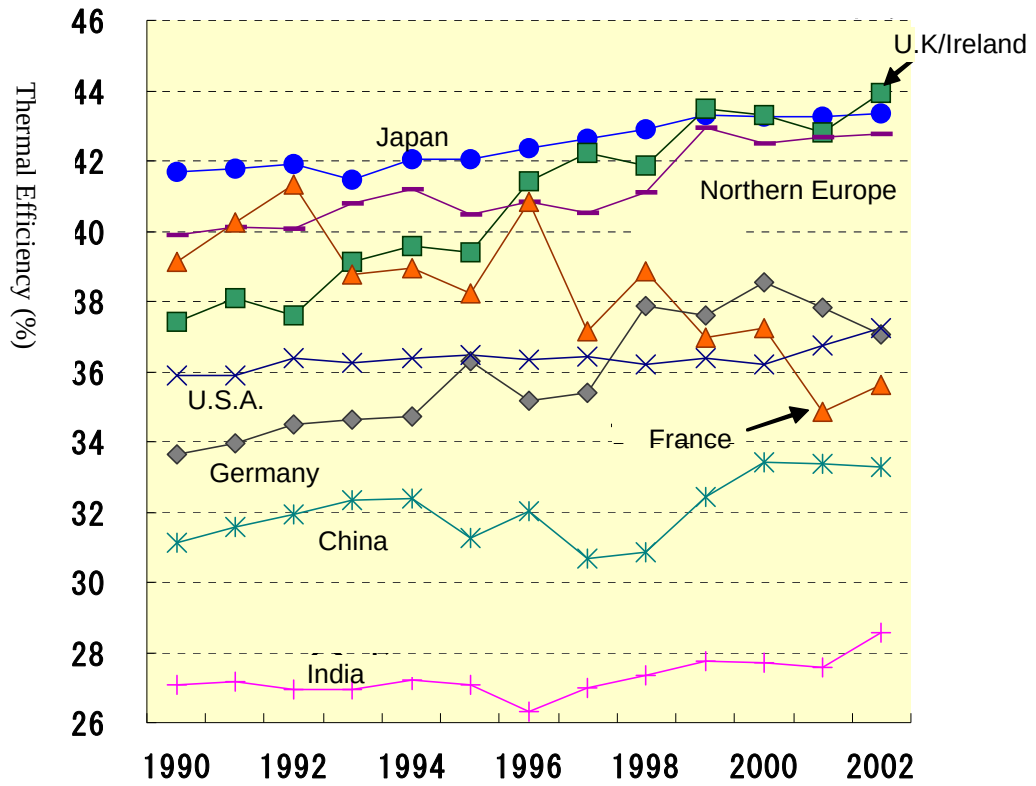


Fig. 17 Energy Consumption per Index of Industrial Production (IPP)

Today, energy efficiency in the power sector of Japan has been at the top level of the world (Figure 18). Also, in other sectors of Japan, the energy efficiency has reached to the highest level (Figure 19 and Figure 20).



Source: ECOFYS; The Federation of Electric Power Companies of Japan

Fig. 18 International Comparison about Efficiency at Thermal Power Plant

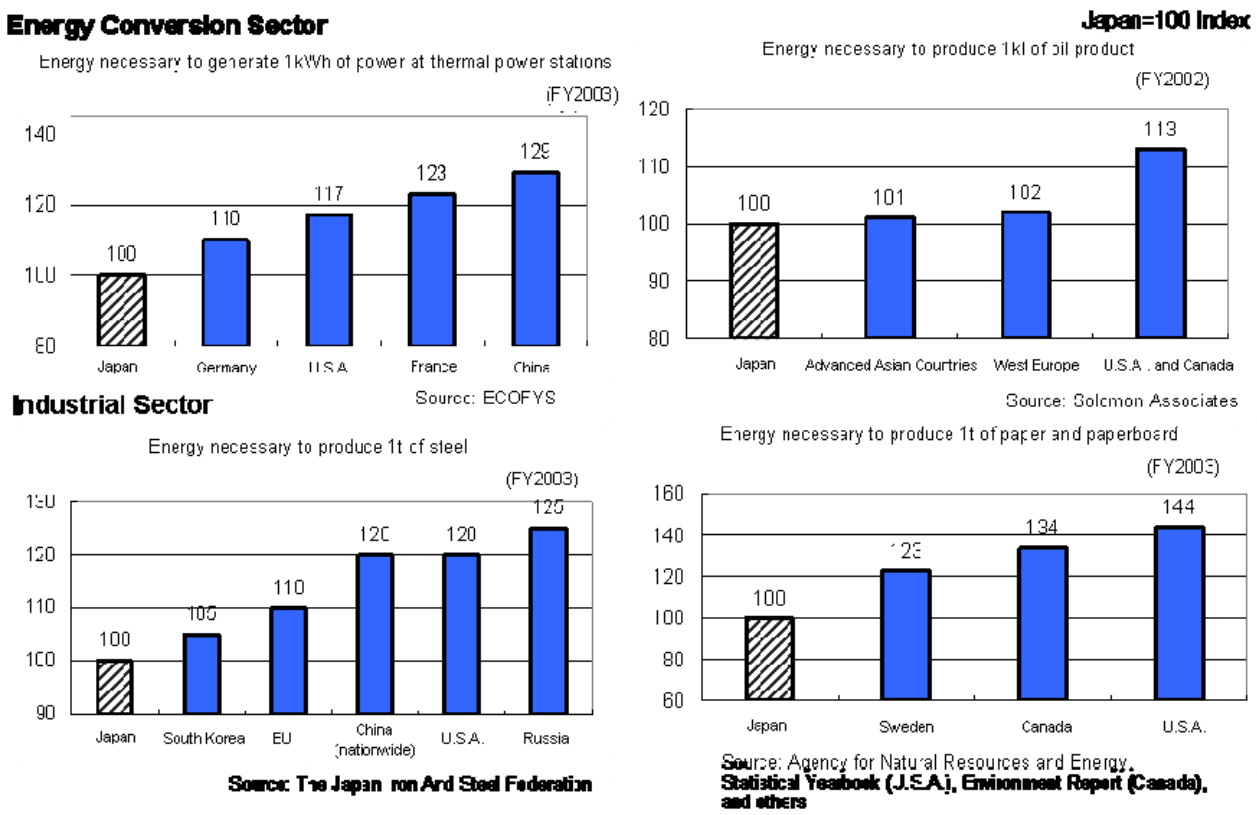


Fig. 19 Comparison of Energy Efficiency in Manufacturing Industry (1)

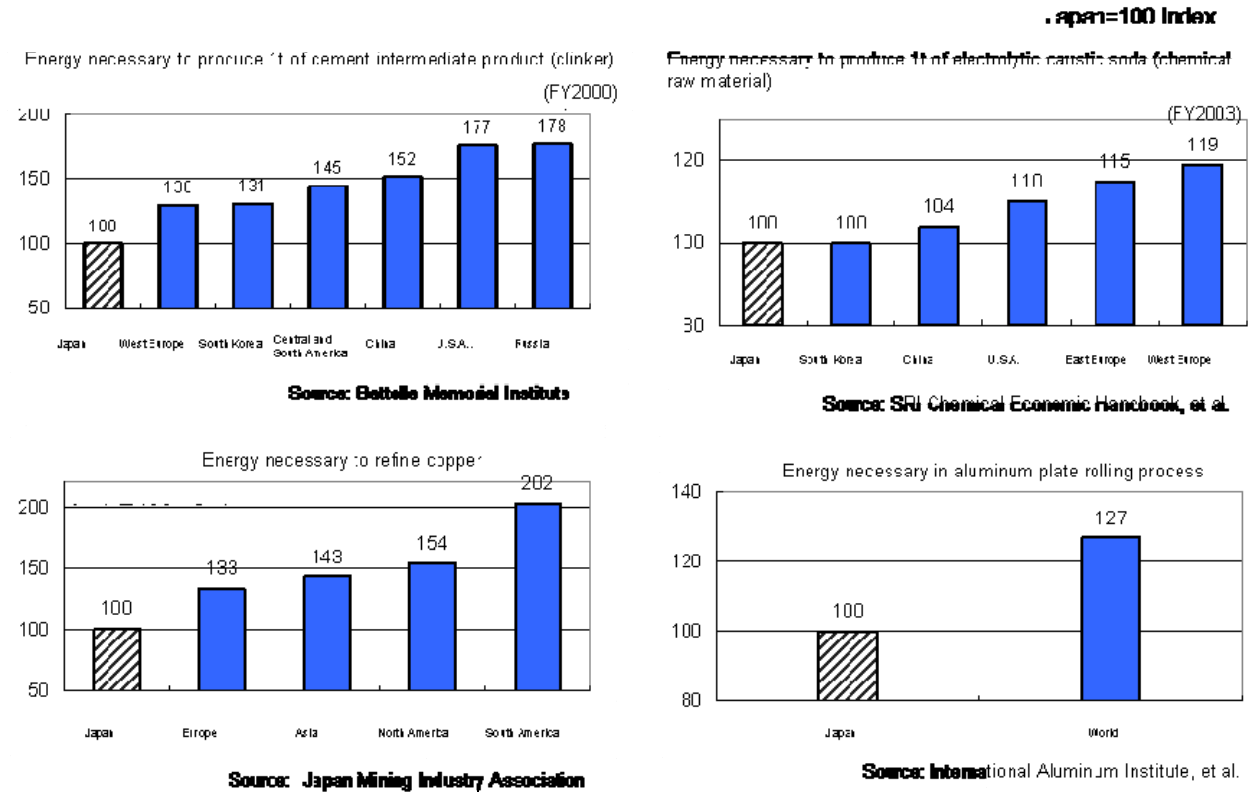


Fig. 20 Comparison of Energy Efficiency in Manufacturing Industry (2)

Since there are some controversies on indexes of this kind of international comparison, Japan can not always take the first place when other indexes are used. However, many experts on energy conservation of factory believe that Japan has made maximum efforts in taking energy saving measures.

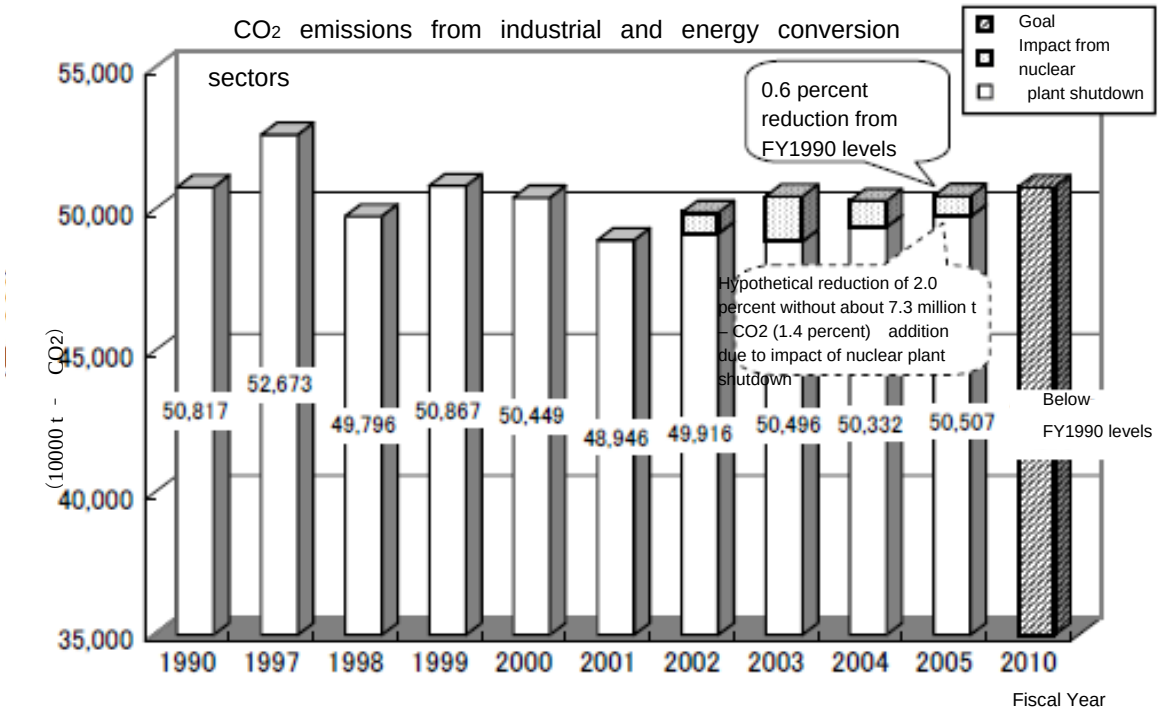
4. Non-regulatory policy instruments

We have discussed on the theories of energy conservation policy so far, and we have also examined data of proved results of energy conservation on both electric home appliances and factory. By the way, not only regulation but also many other factors work on such promotion of energy conservation. In this paper, we will brief on voluntary measures and national technological development programs which have played important roles though they are not so familiar to us.

In factory, since 1997, global warming mitigation measures have been promoted by voluntary approaches of Japan Business Federation, for the reason that energy conservation went around as the results of measures taken after the oil crises and making regulation stricter was deemed improper.

The goal of these approaches is “to reduce CO_2 emissions from industry and energy conversion sectors in 2010 to 1990 level.” A wide range of sectors from manufacturing to service, distribution and transportation participates in these voluntary approaches.

Among the participants, industry and energy conversion sectors account for about 45 percent of the total CO_2 emissions in Japan. In the Fig. 21, we will see the changes of CO_2 emissions from these participant industries. The Figure shows that CO_2 emissions from them had been below the 1990 level for six continuous years since 2000 and thus the goal had been attained. If it had not been for long-term shutdown of nuclear power plants since 2002, more CO_2 emissions could have been reduced.



Source: Japan Business Federation (2006)

Fig. 21 Voluntary Approaches by Japan Business Federation

In the voluntary action plans for the environment, effectiveness of the measures are ensured through a cycle of “Plan,” “Do,” “Check,” and “Act” (PDCA cycle) that works as a review system in industries (Figure 22).

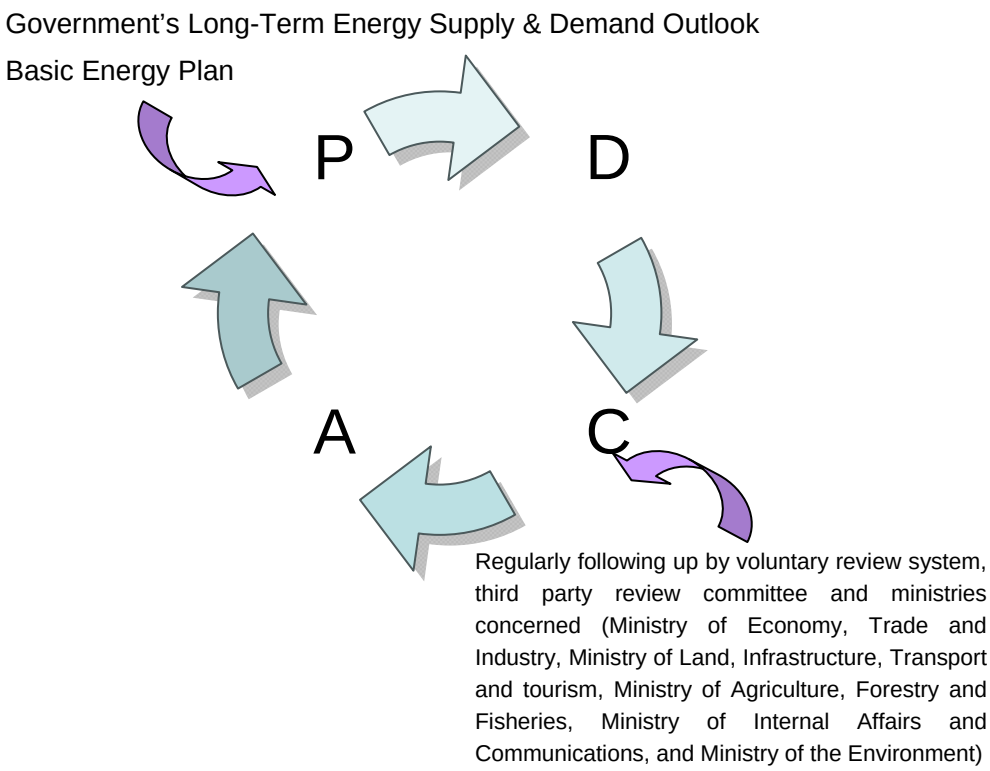


Fig. 22 PDCA Cycle in Voluntary Approaches by Japan Business Federation

In addition, Japan Business Federation itself established a third party review committee in FY2002, and since then, a verification function by third-party has been added to the industries' review system. Moreover, in the system, the measures are also regularly reviewed by a follow-up committee created by related ministries and agencies, and the industries are called for further measures, as appropriate.

A vital feature of the voluntary approaches is that such PDCA cycle has been established. It is assumed important that the PDCA cycle will be expanded to other energy conservation policies.

● **Beyond "outcome without voluntary efforts"**

By the way, as energy conservation is basically an extension of the daily efforts for efficiency improvement of production process, it is not easy for us to answer the question, "how much additive the effectiveness of voluntary energy conservation measures is in comparison with outcome the industries could have attained in the same manner as before without doing their voluntary approaches."

There are some examples, however, which clearly seem to be results from the voluntary approaches. Let us introduce a few of them.

A voluntary action goal of the iron and steel industry is to reduce energy consumption in steel production process to 10 percent below 1990 level in 2010. Today, since it is not easy for the

industry to achieve the goal, they have been considering additional measures including further efficiency improvement. Moreover, when it will turn out to be hard for industry to attain the goal, they are ready to struggle for securing credits through Kyoto Mechanism, mainly CDM.

The iron and steel industry has also engaged in effective use of waste materials including waste plastic in steelmaking processes such as blast furnace. Though its actual usage of the waste plastic is currently about 450,000 tons, the goal is set at one million tons.

It is considered that all of those measures have been pushed by the existence of framework of voluntary approaches.

Next, we will introduce an example of the electric power industry. The goal of its voluntary approaches is to reduce CO_2 emission intensity by 20 percent below 1990 level in 2010. It was highly ambitious goal-setting which was based on the prospect of high economic growth and the optimistic siting plans for nuclear power stations, both of which were made around in 1997.

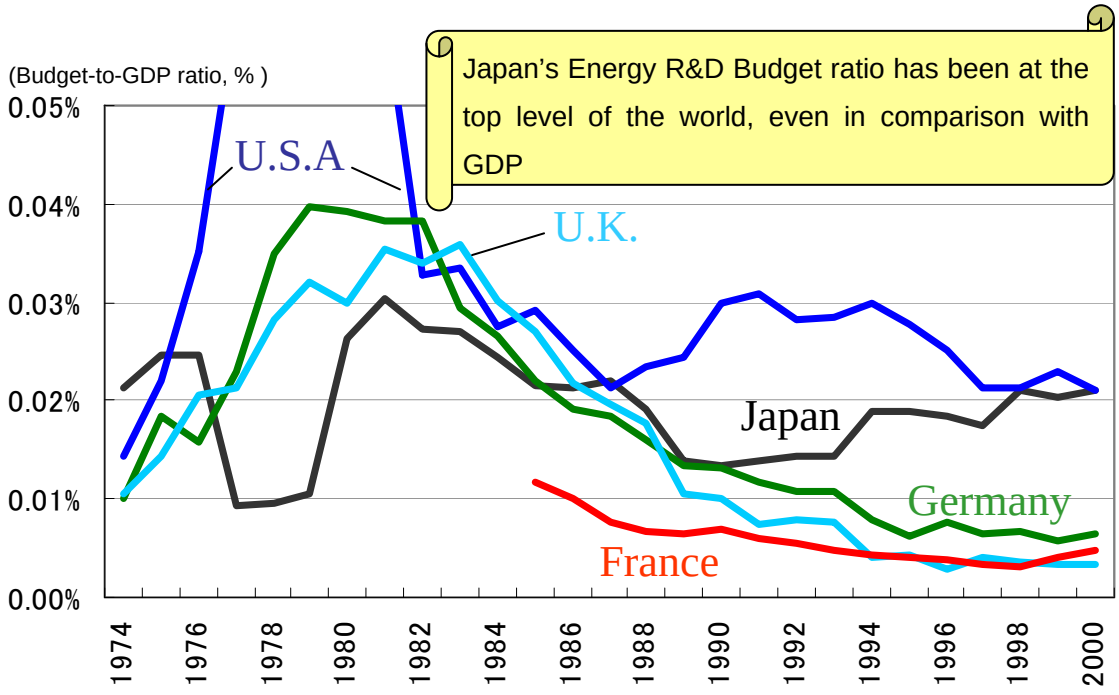
However, contrary to the government's prospect, the economic growth didn't measure up to its expectation, and also the stagnation of power demand significantly delayed the development plans of nuclear power. This raised possibility of falling short of the 20-percent reduction target by about 5 percent. Therefore, the electric power industry has taken additional steps including improvement of capacity utilization rate of nuclear power stations, further enhancement of thermal power generation efficiency, and utilization of Kyoto mechanism, heading toward the goal.

Looking at the entire voluntary action plans, according to the results of a follow-up study on the achievements of FY2005 for 33 industries (25 industry and energy conversion sectors, 3 private business sectors, and 3 non-members of Japan Business Federation) which are under the jurisdiction of the Ministry of Economy, Trade and Industry, 21 industries out of 33 successfully have met their goals, while other 12 industries have failed to attain theirs. Out of 12 non-attainment industries, six industries which are represented by the iron and steel and the electric power are intending to achieve their goals by additional measures, and in the case that they still won't have reached the goals, they intend to acquire credits by using Kyoto mechanism to complement their voluntary approaches. In this way, though the environmental voluntary action plans of Japanese domestic industries are essentially voluntary approaches and they are never regulations, the industries have taken additional measures to achieve their own goals, having contributed to energy efficiency improvement beyond outcome we would have but for their voluntary efforts.

- **National technological development program**

We will change the subject here and talk about the government's national technological development programs. Since the programs will be fully analyzed elsewhere, here we will mention just two points.

First, since the oil crises, government's development budget in areas of new energy and energy conservation has been at the top level of the world in comparison with GDP (Figure 23).



Source: Prepared from IEA "Energy R&D Database"

Fig. 23 Government's Research and Development Budget in the Area of New Energy and Energy Conservation

The total amount of these budgets between 1974 and 2002 reached 1300 billion yen (value in 2002). It was an investment in technological development of which continuousness and largeness of scale were unusual even across the world.

As a result of this investment, some of the technologies, including solar cell, high efficiency gas turbine and heat pump, have come into practical use.

Looking at individual technological development projects, you will find that some of them haven't led to practical use yet. It is partly unavoidable, however, because technological development, inherently, won't always end up in success.

In addition, there are some projects which have led not only to practical use but also to creating new industries. Moreover, even though some projects have failed to come into practical use, the national technological development projects have given impacts on theme setting by private companies and research institutions and have enabled such entities to continue to invest in research and development activities.

Of course, the programs have had much criticism and many problems. However, the achievements as a whole have gotten a passing mark so far, and it seems important to further improve and make use of the programs (Figure 24).

1. 10 out of 23 projects have come into practical use.
2. Effectiveness of energy saving and CO_2 reduction in practical use is generally regarded valid for the entire investment.
3. A number of projects have led to new industries formation.
4. Even though some projects have failed in coming into practical use, the national technological development programs have set the important themes and have made continuous development investment possible.

Fig. 24 Results of National Technology Development Programs

5. Conclusions

We would like to close this paper by summarizing the long talk we have got above (Figure 25).

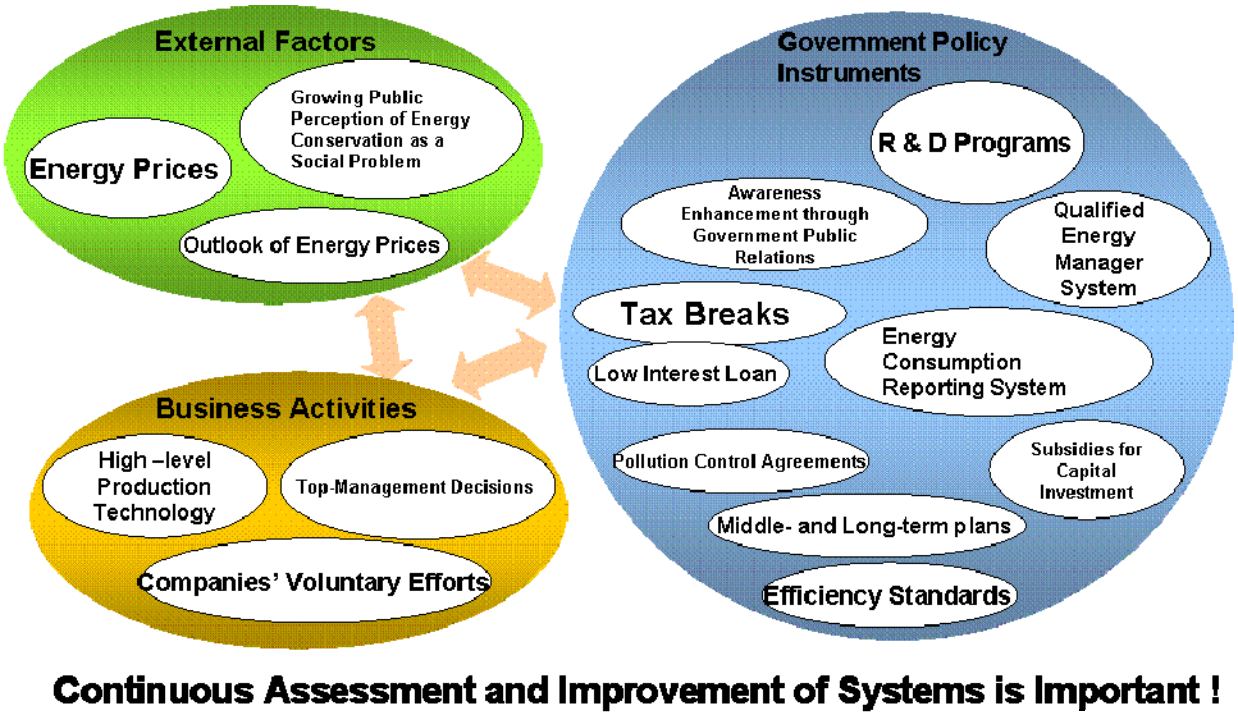


Fig.25 Sector- and technology-specific fine-tuned approaches has realized the highest level of energy efficiency improvement of the world

Japan has implemented fine-turned policy instruments, and as a result, it has realized energy conservation at the highest level in the world.

There are three reasons why the fine-turned policy instruments are necessary.

The first reason is to overcome barriers to energy conservation.

The second reason is to enhance technological development.

The third reason is to prevent business activities from being disturbed. The policies should be taken after their feasibilities are concretely and respectively discussed, and if not, business activities could suffer adverse impact.

Because Japan has achieved a number of results, we should learn that experience more, and with confidence, we should continue to put the experience at the heart of its fine-tuned global warming mitigation measures.

However, unfortunately, little is known about matters including what policies have worked and how much they have worked, or what external factors such as oil price have worked and how they have made impacts on business actions. Since some of existing policy instruments may be out-of-date or out-of-focus, what is important in the future will be steadily continuing assessment and improvement of the policy instruments, that is to say, making PDCA cycle on the instruments work properly.

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