Hitotsubashi Journal of Commerce and Management 44 (2010), pp.1-11. © Hitotsubashi University

ENTREPRENEURIAL WAY TO COOL THE EARTH

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I. *Introduction*

This paper examines how we can tackle global climate change problems. There are two main approaches, one is based on government regulations and the other is based on innovations by the private sector. The G8 Summit and the Conference of the Parties to the UN Framework Convention on Climate Change (COP) regularly discuss the regulatory approach. This paper, however, discusses the importance of the entrepreneurial approach.

On July 8-10, 2009, the 35th G8 Summit held in L'Aquila, Italy, agreed to an 80% reduction of greenhouse gas in advanced countries by 2050. This "advanced nations 80% reduction plan" is closely connected with the "global 50% cut concept" called the "Cool Earth 50" Plan.

On May 24, 2007, then Japanese Prime Minister Shinzo Abe announced the "Cool Earth 50 Plan" at an international conference titled "Asian Future." The plan presented a long-term strategy to cope with global warming issues, and upheld the following two purposes:

(1) Cutting global greenhouse gas emissions to half the current level by 2050, and
(2) Presenting a long-term vision for developing innovative technologies and building a low-carbon society.

The Cool Earth 50 Plan also proposed three principles for establishing a post-2013 (i.e. post Kyoto Protocol) framework, as follows.

(a) All major emitters must participate, thus moving beyond the Kyoto Protocol, to achieve a global reduction of emissions;
(b) The framework must be flexible and diverse, taking into consideration the circumstances of each country; and
(c) The framework must achieve compatibility between environmental protection and economic growth by utilizing energy conservation and other technologies.

Despite changes in prime ministers, the Japanese Government holds fast to the two purposes and three principles of the Cool Earth 50 Plan. This paper focuses on the following two points:

(i) How environmental protection and economic growth can be compatible, and
(ii) How entrepreneurship should contribute to "Cool Earth" on a long-term basis.

In regard to point (i), this paper clarifies the validity of energy conservation and technological innovation in Sections II and III. One of the most important innovations is

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Carbon Dioxide Capture and Storage (CCS) / Enhanced Oil Recovery (EOR) technology.

In regard to point (ii), this paper introduces two unique Japanese methods for cutting global greenhouse gases, the “Top Runner Program” and the “Sector-by-Sector Approach,” in Sections IV and V. The former is effective in the residential, commercial, and transportation sectors, and the latter is valid in the industrial sectors. In both of them, the “Top Runner Program” and the “Sector-by-sector Approach,” entrepreneurship in the private sector plays an essential role.

II. *Energy Conservation*

Addressing global warming requires a clear vision. The vision should be founded on a good balance between “affluence” and “global salvation,” which may be achieved by promoting energy conservation.

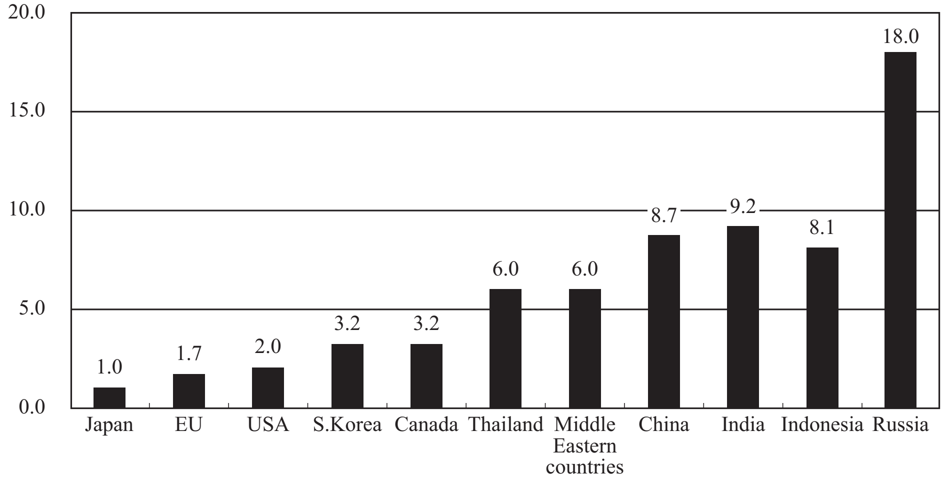
The greatest issue in implementing global warming countermeasures is to avoid initiatives that may conflict with people’s desire to attain affluence. Such initiatives create a “tradeoff” between affluence and global salvation. Unless this tradeoff mechanism is eliminated, global warming countermeasures cannot be expected to make any progress. Developing countries such as China and India did not participate in the framework for establishing country-specific greenhouse gas emission reduction targets under the Kyoto Protocol because they feared that the establishment of such a target may interfere with efforts to realize affluence in their countries.

The tradeoff between affluence and global salvation can only be resolved by promoting energy conservation. The figure illustrates this point.

It shows a comparison of primary energy consumption per gross domestic product (GDP) in the world’s major countries and regions, based on data compiled by the International Energy Agency (IEA) in 2006. More specifically, the oil equivalent of primary energy consumption in each country and region was divided by GDP converted to US dollars, to achieve a numerical value for that country/region when Japan is given a value of 1. The smaller the value, the more advanced the energy conservation is in the relevant country/region. However, even in the European Union (EU), where energy conservation is generally assumed to be quite advanced, 1.7 times more energy is used to achieve the same level of GDP as Japan. In regard to other countries, the United States consumes 2.0 times more energy, South Korea and Canada 3.2 times, Thailand and the Middle Eastern countries 6.0 times, and Indonesia, China, and India, approximately 8 - 9 times more energy. When it comes to Russia, the country uses 18.0 times more energy compared to Japan.

The figure shows that energy consumption can be reduced considerably (and in effect, achieve considerable reduction in greenhouse effect gas emissions) while maintaining and expanding affluence, if all countries/regions in the world achieve the same level of energy conservation as that in Japan. Promoting energy conservation is the sole solution to resolving the tradeoff between affluence and global salvation.

Fig. 1 Comparison of Primary Energy Consumption per GDP in Each Country/Region



Note: Figures have been obtained by dividing primary energy consumption (equivalent to tons of oil) by GDP (converted to US dollars) and adjusting them in reference to Japan as represented by a value of 1.
Source: Agency of Natural Resources and Energy, Energy Efficiency and Conservation Division, Report on Energy Conservation Measures (2007).
Original material: International Energy Agency (IEA) Energy Balance 2006.

III. *Technological Innovation*

In order to achieve the long-term target of reducing global greenhouse gas emissions by half by 2050, it is crucial to develop innovative energy technologies that are not merely an extension of conventional technologies. On March 5, 2008, the Japanese Government announced the "Cool Earth—Innovative Energy Technology Program," which identified 21 technologies to be prioritized, as follows:

1. High-efficiency natural gas-fired power generation,
2. High-efficiency coal-fired power generation,
3. Carbon dioxide capture and storage (CCS),
4. Innovative photovoltaic power generation,
5. Advanced nuclear power generation,
6. High-efficiency superconducting power transmission,
7. Intelligent transport systems,
8. Fuel cell vehicles,
9. Plug-in hybrid vehicles/ Electric vehicles,
10. Production of transport bio-fuel,
11. Innovative materials production/processing,
12. Innovative iron and steel making process,
13. High-efficiency houses and buildings,

14. Next-generation efficiency lighting,
15. Stationary fuel cells,
16. Ultra high-efficiency heat pumps,
17. High-efficiency information devices and systems,
18. House/building/local-level energy management systems,
19. High-performance power storage,
20. Power electronics, and
21. Hydrogen production, transport and storage.

In these fields, Japan is a global leader, boasting the world's top level energy technologies.

With respect to CCS (the third technology in the above list), Japan Oil, Gas and Metals National Corporation (JOGMEC) is pursuing efforts to link the technology to enhanced oil recovery (EOR). JOGMEC has been engaging in the technical development of EOR since the 1980s, and has implemented a feasibility study in Kuwait and Abu Dhabi, on the entire process of recovering carbon dioxide (CO_2) that is released from power stations and injecting it to oil layers to increase crude oil recovery. Based on the results of the study, JOGMEC is presently utilizing the knowledge it has accumulated through the technical development of EOR (CO_2 injection technology, technology for analysis of fluid behavior in underground oil/gas layers, etc.) to implement technical development and surveys on CCS. In addition to CCS, JOGMEC is also pushing forward with technical development and surveys on general environmental conservation issues relating to oil and natural gas development (treatment of oilfield-produced gas and water accompanying oil and natural gas development, etc.).

Not only national corporations like JOGMEC, but also private companies are making efforts for CCS and high-efficiency coal-fired power generation (second technology in the above list). For example, J-POWER is promoting the EAGLE project (Eagle stands for Coal Energy Application for Gas, Liquid, & Electricity). One of the special features in the homepage of J-POWER illustrates the EAGLE project as follows.

> "The EAGLE project is aimed at raising the efficiency of power generation from coal so as to reduce the amount of CO_2 emitted per unit power generated. Using coal gasification and a combination of methods for generating electric power, much higher efficiency is achieved than by the conventional pulverized coal-fired thermal power generation system. Whereas a pulverized-coal-fired plant generates electricity only by steam turbines, an integrated coal gasification combined cycle system (IGCC) uses both steam and gas turbines. Moreover, an integrated coal gasification fuel cell combined cycle system (IGFC) has been developed that uses these two types of turbines plus fuel cells as a third mode of generation. IGFC is the ultimate technology for coal utilization to generate electricity, and the J-POWER Group is the world pioneer in its development. Its commercial implementation could improve generating efficiency by as much as 60 percent, which should reduce CO_2 emissions by around 30 percent compared to existing pulverized coal combustion." (p.15)

The EAGLE project also aims at developing CCS technology. On the same homepage, Kyouhei Nakamura, a member of EAGLE Research & Engineering Group in J-POWER, says "in EAGLE Step II, we are testing CO_2 capture and storage as a way of achieving zero CO_2 emissions in coal-based thermal power generation. The oxygen-blown gasification system adopted in the EAGLE project should be well suited to CO_2 capture and storage because of the low nitrogen content and relatively high CO content of the syngas (synthesis gas). In the CO_2 capture and storage testing, we will attempt to characterize the shift reaction process by which CO in syngas is converted to CO_2 and hydrogen by catalytic reaction with steam. We will also characterize the CO_2 capture and storage process, in which CO_2 is absorbed using an absorbing solution and then CO_2 is desorbed from the absorbing solution." (ibid., p.16)

IV. *"Top Runner Program" and Entrepreneurship*

As a leader in energy conservation, Japan plays a major role in implementing worldwide global warming countermeasures. In fact, the promotion of energy conservation is the single most significant theme among Japan's contribution to the international community in the 21st century.

However, Japan should not remain content with its current level of energy conservation. It is important to remember the historical fact that the ceaseless effort in pursuing technical innovation and institutional reform was the driving force behind the development of Japan into today's leader in energy conservation.

In Japan in the post-oil crisis era, industries began to pursue energy conservation, and advances were made in institutional reforms to promote those efforts. Following the establishment of the "Law concerning Rationalization of Energy Use" (commonly known as the Energy Conservation Law) in 1979, energy conservation guidelines were formulated for plants and buildings, and guidelines on energy consumption efficiency were also compiled for machinery and appliances (automobiles, air conditioners, etc.). The guidelines for machinery and appliances contained advanced concepts that would later lead to the establishment of the "top runner system," which was eventually introduced on a full scale in 1999. Under the top runner system, automotive mileage standards and electrical appliance energy-saving standards are to be set at levels that exceed the performance of the most efficient product on the market at the time, in each product category. The system is presently attracting worldwide attention as a unique energy conservation measure developed by Japan.

A pamphlet titled *Top Runner Program*, issued in January 2008 by Japan's Agency for Natural Resources and Energy, Ministry of Economy, Trade and Industry (METI) and the Energy Conservation Center, Japan (ECCJ), describes the top runner system as follows.

> "Expectations regarding the role of energy conservation are increasing due to mounting global environmental problems. As a result, demands that machinery and equipment's energy consumption efficiency be increased to the greatest extent possible are now a reality. The Top Runner Program has come into existence in light of this situation. This Top Runner Program uses, as a base value, the value of the product with the highest energy consumption efficiency on the market at the time of the standard establishment process, and sets standard values by considering potential technological improvements added as efficiency improvements. Naturally, target standard values are extremely high. For achievement evaluation, manufacturers can achieve target values by exceeding target values by weighted average values using shipment volume, the same as the average standard value system. The implication of using weighted average values is the same as

the average standard value system, that is, the system is meant to give manufacturers incentives for developing more energy-efficient equipment. Above all, deliberation studies during the value establishment process in this system can proceed smoothly in a shorter period from the start to the final standard determination. While this system gives manufacturers substantial technological and economic burdens, the industry should conduct substantial prior negotiations on the possibility of achieving standard values and adopt sales promotion measures for products that have achieved target values." (pp. 6-7)

Since the introduction of the top runner system in Japan, a number of product categories have reached their target achievement year. The table below shows a summary of the results of the top runner system for those product categories. It is evident from the table that the top runner system has contributed significantly to improving energy consumption efficiency in each product category.

Here, the important factors for the success of the "Top Runner Program" are not only guidance regulations by the government, but also plentiful entrepreneurship within private electrical machine makers and car makers, which enabled many technical innovations. For example, in the case of top runner refrigerators The Japan Electrical Manufacturer's Association (JEMA) states "in connection with the enactment of the Energy Saving Law refrigerators were designated to a specified device and the targets of the years 1984 and 2004 were achieved by improving the energy-saving performance. In 2006 the target values and measuring methods were reviewed, and new target values for the year 2010 were set: power consumption (compared to 2005) should be improved by approx. 21% for electric refrigerators, and by approx. 13% for electric freezers. Companies had to promote the development of energy-saving technology further." (JEMA, *Electrical Industries in Japan 2008*, p. 8) Guidance and entrepreneurship are inseparable in the "Top Runner Program"[1].

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[1] *Top Runner Program* (2008) describes conditions to enable the "Top Runner Program" to work well as follows.

"The Top Runner Program is the requirement imposed on manufacturers of machinery and equipment. Thus, as long as manufacturers make an effort to meet these requirements, energy conservation will advance through replacement of machinery and equipment by consumers. However, as a result of new technological developments that accompany manufacturers' attempts to exceed standard values, the prices of products that exceed standard values are inevitably higher than earlier products. The introduction of this system will yield no results until these high-priced products appear on the market. In this case, the system only places burdens on the manufacturers and the system itself may become a failure. Acknowledging current conditions in Japan, technical progress has been substantial for targeted machinery and equipment and consumers are interested in equipment functionality. Thus, there is currently steady progress being made in the shift to products with higher efficiency. To hasten this shift, plans for promoting replacement purchases of products that achieve standards will be needed. This can be done by demonstrating the significance of highly efficient products through a comparison of the overall costs of highly efficient products and earlier products. The overall product cost is the sum of the purchase price at the time of the replacement product purchase (initial cost) and subsequent energy consumption costs (running costs). Furthermore, as measures to facilitate retailers' energy-efficient activities, rewarding retailers who promote sales of energy efficient products will be effective and important.

On the other hand, due to rapid technical advances in machinery and equipment, there may be cases in which products, not targeted at the time of the standards establishment process because they were not on the market or only on the market in extremely limited numbers, crowd out the conventional products and take a large market share. Therefore, evaluating the changes in shipment volume etc., it is necessary to deal with such cases appropriately." (p.8)

TABLE 1. THE RESULTS OF THE TOP RUNNER SYSTEM BY PRODUCT CATEGORIES

Product category	Energy efficiency improvement	Period
TV sets using CRTs	25.7%	FY1997～2003
VCRs	73.6%	FY1997～2003
Air conditioners*	67.8%	FY1997～2004
Electric refrigerators	55.2%	FY1998～2004
Electric freezers	29.6%	FY1998～2004
Gasoline passenger vehicles*	22.8%	FY1995～2005
Diesel freight vehicles*	21.7%	FY1995～2005
Vending machines	37.3%	FY2000～2005
Computers	99.1%	FY1997～2005
Magnetic disk units	98.2%	FY1997～2005
Fluorescent lights*	35.6%	FY1997～2005

Note: For product categories marked with *, energy efficiency standard values are defined by energy consumption efficiency (e.g. km/l), while those without * are defined by the amount of energy consumption (e.g. kWh/year). In the above table, values for “Energy efficiency improvement” indicate the rate of improvement calculated based on each standard. (Example: If 10 km/l is developed to be 15 km/l, the improvement rate indicated is 50% [It is not calculated as the improvement of fuel consumption by 33% from 10 liters to 6.7 liters for a 100 km drive]; and if 10 kWh/year is developed to be 5 kWh/year, the improvement rate is 50%.)

Source: op. cit., *TOP RUNNER PROGRAM*, 2008.

V. *“Sector-by-sector Approach” and Entrepreneurship*

It is clear that the Cool Earth 50 Plan cannot be achieved simply by utilizing market mechanisms. To reduce the world’s greenhouse gas emissions by half by 2050, breakthrough technical innovations must occur that dramatically promote energy conservation and the use of new energy sources, while using nuclear power generation and other “existing tools” to buy time.

A framework that has begun to attract attention in recent years as a key to achieving breakthrough technical innovations is the “sector-by-sector approach.” The approach aims to reduce greenhouse gas emissions considerably, by making drastic, trans-boundary efforts to improve energy efficiency in each sector (industry, field) that emits significant amounts of greenhouse gases. The Japanese government is encouraging all countries of the world to adopt this sector-by-sector approach.

The advantage of the sector-by-sector approach is that it can make up for the pitfalls in the framework of the Kyoto Protocol, which establishes reduction obligations of greenhouse gas emissions for each country. There would have been no pitfalls, had all major greenhouse gas emitters participated in the Kyoto Protocol framework, but that was not to be.

China (the largest greenhouse gas emission country in the world), India (the 4th largest emission country) and other newly developing countries did not participate in the framework for establishing country-specific greenhouse gas emission reduction obligations under the Kyoto Protocol, for fear that doing so would interfere with efforts to realize affluence in their countries. At the same time, the United States (the 2nd largest emission country in the world) withdrew from the Kyoto Protocol framework, claiming “unfairness” of nonparticipation by the newly developing countries. As a result, the countries that agreed to the imposition of reduction obligations under the Kyoto Protocol only accounted for a little over 30% of total worldwide emissions (calculated based on 2004 data).

The participation of only some major greenhouse gas emitters in the framework for establishing country-specific emission reduction obligations under the Kyoto Protocol increased the possibility of “carbon leakage.” Carbon dioxide accounts for the largest proportion of greenhouse gases. When countries that have emission reduction obligations exist alongside countries that do not, as under the Kyoto Protocol framework, the transfer of large energy-consuming industries and sectors from the former to the latter may in effect increase worldwide CO_2 emissions. This issue is referred to as carbon leakage. It occurs because large energy-consuming industries and sectors in emigrant countries obligated to reduce greenhouse gas emissions generally have higher energy efficiency than immigrant countries that have no reduction obligations. This carbon leakage issue is a serious pitfall of the Kyoto Protocol framework.

As opposed to the above framework, the sector-by-sector approach would not cause carbon leakage, because it aims to reduce CO_2 and other greenhouse gas emissions per sector, instead of per country. Under this approach, large energy-consuming industries/sectors would remain in energy-efficient countries (countries with obligations to reduce emissions), but could also contribute to increasing energy efficiency in their respective industries and sectors in less energy-efficient countries (countries with no emission reduction obligations) through technical transfers. It is important that large energy-consuming industries/sectors remain in energy-efficient countries, not only to better control worldwide CO_2 emissions in the foreseeable future, but also to insure high probability of technical innovations that could further increase energy efficiency in the further future[2].

Let us examine the effectiveness of the sector-by-sector approach in major industries that release greenhouse gases. Of the world's total CO_2 emissions from energy sources, 26.0% are released from coal-fired thermal power plants, 6.3% from iron and steel production, 2.9% from cement production, and 17.1% from road transportation (International Energy Agency, *CO2 Emissions from Energy Origin in the World 1971-2005*, 2007). Below is a close-up look at the effects of the sector-by-sector approach in the electric power and the iron and steel industries.

The Federation of Electric Power Companies of Japan (FEPC)[3], an industrial organization

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[2] The Ministry of Economy, Trade and Industry of the Japanese Government explains the merits of the sector-by-sector approach as follows.

“A fair and comparable ‘yardstick’ will be prepared to encourage all of the major emitting countries to participate in the approach. The Ministry of Economy, Trade and Industry of the Japanese Government explains the merits of the sector-by-sector approach as follows.

In the case of advanced countries: national targets for total reduction are set based on the ‘yardstick’.

In the case of developing countries: reduction actions based on the ‘yardstick’ are being conducted.

The participation of developing countries is encouraged through the diffusion of Japan's superior environmental and energy-saving technologies.” (*FY 2008 Annual Energy Report [Outline]*, p.39)

[3] The homepage of FEPC mentions the sector-by-sector approach as follows.

“As a result of taking various environmental measures at thermal power plants, Japan has achieved the world's top-level energy efficiency. Based on this achievement, the electric power industry in Japan has been making efforts to establish a mechanism for sharing such advanced technologies with electric power industries in other countries.

Through the cooperation between advanced and developing countries, and with the “sectoral approaches” for sector-by-sector improvement of energy efficiency, it will be possible to achieve compatibility between economic growth and global environmental preservation. The electric power industry of Japan has been proposing sectoral boasting a membership of major electric power companies in Japan, has recently estimated the amount of CO_2 emissions that could be reduced in each country and region by 2030, if the electric power industry were to implement the sector-by-sector approach on a global scale. According to the estimation, CO_2 emissions would drop considerably, mainly in China, India, and the United States, by as much as 1.87 billion tons worldwide. Since the world's CO_2 emissions totaled 26.69 billion tons in 2005, implementation of the sector-by-sector approach in the electric power industry would reduce that total by 7%.

The sector-by-sector approach in the electric power industry consists of the following three initiatives:

(1) Operational improvement in existing thermal power stations
(2) Operational improvement in new thermal power stations
(3) Development and introduction of low-carbon technology.

The first point mainly pertains to coal-fired thermal power stations in developing countries, and hinges on a global horizontal expansion of best practices through exchanges among engineers, a practice commonly known as "peer review." The second refers to the introduction of the highest energy efficiency technology at the time, or Best Available Technology (BAT), to thermal power stations that are planned for construction in the near future. This may perhaps be called the "top-runner system" in the power generation sector. As for coal-fired power generation, for example, the application of Japan's highest coal-fired power generation efficiency to other major countries yields a large effect. If it is applied to three major countries, i.e., the U.S., China, and India, there would be the effect of reducing a total of 1.3 billion tons of CO_2 emissions (Agency for Natural Resources and Energy [in the Japanese Government], *Points of FY 2007 Annual Energy Report*, 2008, p.36)[4].

The third point promotes integrated gasification combined cycle (IGCC) and CO_2 capture and storage (CCS) technologies, and promises an extremely large CO_2 emission reduction effect. Electric power companies in Japan are global leaders in regard to the first and second initiatives but are also directing considerable efforts to achieving the third.

Similarly, the Research Institute of Innovative Technology for the Earth (RITE) in Japan has projected the amount of CO_2 emissions that could be reduced by each country at this point in time, if the iron and steel industry in all countries throughout the world achieves the same level of energy efficiency as Japan's iron and steel industry. According to the projection, CO_2 emissions would drop considerably, mainly in China, the United States, and Russia, and as much as 250 million tons of CO_2 emissions could be reduced by the top 10 countries that have

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approaches to the world as a new focus for the post-Kyoto period".

[4] The above-mentioned special feature of J-POWER describes this point as follows.

"To reduce CO2 emissions it is necessary to lower the ratio of CO2 emissions per unit of production and to reduce the absolute amount of emissions. In generating electricity through fossil fuel combustion, coal results in twice the amount of CO2 emissions compared to natural gas. In Japan, however, coal-fired power stations are generating electricity with higher energy efficiency by raising the temperature and pressure in steam turbines to above the critical point, or to ultra supercritical conditions (USC). This technology is contributing to the reduction of CO2 emissions. If this high performance technology were introduced in the United States, China, and India, the world's big CO2 emitters, it is estimated that CO2 emissions in these three countries could be reduced by around 1.3 billion tons annually, an amount equivalent to Japan's annual total of CO2 emissions and five percent of the world total. It is therefore important to transfer and disseminate these clean coal technologies."

the largest steelworks in the world[5].

In the wake of the oil crisis in the 1970s, Japan's iron and steel industry has achieved the world's highest energy conservation level by abbreviating or merging work processes, recovering and effectively utilizing by-product gases, introducing and reinforcing large-scale waste heat recovery facilities, expanding the usage rate of non-coking or weak-coking coal, and recycling resources. As a result, the energy efficiency (tons of petroleum/tons of crude steel) of Japan's integrated steelworks is a mere 0.59, while that of the United States is 0.74, Canada 0.75, the United Kingdom 0.72, France 0.71, Germany 0.69, Australia 0.79, South Korea 0.63, China 0.76, India 0.78, and Russia 0.80 (2008 survey by RITE). Because of this disparity, a global horizontal expansion of the current level of energy efficiency in Japan's iron and steel industry alone would be able to reduce CO_2 emissions.

Dissemination of existing technologies is not the only reason for implementing the sector-by-sector approach in the iron and steel industry. Other reasons include the development and introduction of breakthrough technologies, such as CO_2 capture and storage (CCS), hydrogen production and utilization, and electric smelting. Japan's iron and steel companies are concentrating on the development of the CCS and hydrogen technologies.

In the case of the sector-by-sector approach, the main engine for its promotion is entrepreneurship within the private sector. Entrepreneurship breaks through limitations of the nation-by-nation approach based on the governmental regulations in each country.

VI. *Concluding Remarks*

This paper focuses on the following two points:

(i) How environmental protection and economic growth can be compatible, and
(ii) How entrepreneurship should contribute to "Cool Earth" on a long-term basis.

In regard to point (i), this paper clarifies the validity of energy conservation and technological innovation. The former applies to short or medium-term efforts, and the latter, to long-term strategy.

In regard to point (ii), this paper introduces two unique Japanese methods for cutting global greenhouse gases, the "Top Runner Program" and the "Sector-by-Sector Approach." The former is effective in the residential, commercial, and transportation sectors, and the latter is valid in the industrial sectors.

There are two ways of realizing the Cool Earth 50 Plan to reduce the world's greenhouse gas emissions by half by 2050; the first is the regulatory way mainly depending on regulations by the government of each country, and the second is the entrepreneurial way based on

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[5] The homepage of The Japan Iron and Steel Federation (JISF) explains its contribution to international energy savings as follows.

"Over the years the Japanese steel industry has amassed a wealth of technologies and expertise regarding measures to save energy and protect the environment. Drawing on this wealth, the steel industry extends technical assistance to its counterparts overseas. Notably, the industry has extended technical cooperation in government-initiated programs such as the Green Aid Plan (GAP), Joint Implementation, etc. The steel industry will continue to participate in JI, Clean Development Mechanism (CDM) and other similar activities as it sets its sights on addressing the issue of global warming."

innovations by the private sector. Finally, it is worth mentioning that both ways are indispensable to achieving the "Cool Earth."

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