

# A 3E Vision for a Sustainable Global Society in the 21st Century

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*In seeking a basic solution to global environmental problems, efforts to reduce greenhouse gas emissions must occur in conjunction with an expansion of the "3 Es": energy security, environmental protection, and economic efficiency and sustainable economic growth. A steady supply of energy and the maintenance of the environment must be combined to form two sides of the same coin. Achieving such a balance is the key to realizing sustainable economic growth on both a domestic and a global scale. Japan's high-end energy-saving and environmentally friendly technologies could contribute much toward solving these problems throughout Asia, where energy consumption is increasing. In fact, regional revitalization is currently underway in Japan, which has effectively begun to construct a recycling-oriented society that thrives on natural energy. Mitsubishi Heavy Industries, Ltd. (MHI) is actively engaged in developing technologies that transform and use energy in harmony with the environment and that facilitate environmental conservation, restoration, and creation through an expansion of the 3E approach for creating a sustainable global society.*

## 1. Introduction

Behind the global society of the 21st century lies a multi-polar world economy whose energy consumption is expected to increase rapidly. In particular, the growing economies of Brazil, Russia, India, and China, as well as of other developing countries in Asia, create a major problem for sustainable development. These economies demand restricted energy resources, such as petroleum and water, in large quantities, and they may resist conventional environmental restrictions that could otherwise prevent further global warming. To solve these problems, a social infrastructure must be built that simultaneously realizes the components of the 3E vision: energy security, environmental protection, and economic efficiency and sustainable economic growth. In addition, this infrastructure must expand the 3E program through the diffusion of energy-efficient and environmentally friendly technologies.

This paper discusses the potential for a partnership between Japan and China, which is expected to become the center of economic growth. In so doing, it clarifies how 3E expansion could be achieved for the purpose of regional revitalization through the construction of a recycling-oriented society in Japan and through the promotion of the technologies and product groups through which MHI currently contributes to the realization of a sustainable society.

## 2. Realizing the 3E concept: A major 21st century challenge

### 2.1 The status of measures that combat global warming

When the Russian Federation ratified the Kyoto Protocol in February 2005, international efforts began in earnest to reduce greenhouse gas emission so that the level specified for 2008 might be reached. The United States, which is the world's largest energy consumer, and countries like China and India, in which energy consumption is expected to increase sharply, are exempt from reducing their output

of these gases. In consequence, reaching a global accord for the second-term commitment, which is scheduled to begin in 2013, is expected to be extremely difficult. Having already realized the highest level of energy-savings in the world, Japan is required to reduce its greenhouse gas emission by about 6% of its level in 1990. Achieving such a reduction should likewise prove difficult.

The Kyoto mechanism for transacting emission rights is promoted through the effective use of market mechanisms. However, the clean development mechanism (CDM), which promises to be the most effective of the transaction mechanisms, is an institutional morass whose energy-saving effects and economic performance do not contribute to emission rights approval. In 2010, CO<sub>2</sub> emissions in India and China are expected to reach 29 times the annual reduction of 0.11 billion t-C required of Japan. Such an increase would make it difficult to attain the worldwide reduction target, if only Japan makes efforts to reduce emission levels.

### 2.2 High petroleum prices result from a strained energy supply

The 21st century has brought sharply rising oil prices, primarily because of an increased demand for liquid fuels. This increase in demand has followed from the improved access to transportation brought about by higher living standards in countries with large populations, such as China. The topic of "energy security" thus arises also as a global social issue.

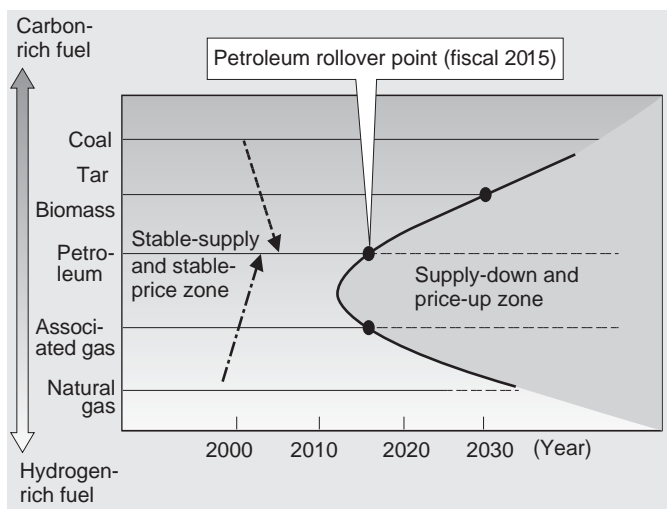
Energy security calls first for an effective use of petroleum and for a shift to high-performance natural gas, followed by energy diversification through the effective use of large coal reserves, the development of unconventional petroleum resources, and the promotion of nuclear power and renewable energy sources. Since oil prices can only be expected to rise, fuel competition is expected to be high, particularly for hydrocarbon fuels during the shift from petroleum to other fuels (Fig. 1).

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### 2.3 The need for a 3E expansion

As the global market economy advances into the 21st century, regional disparities can be expected to grow in advanced and developing nations. Therefore, a discussion of the effects and limitations of market mechanisms is increasingly important.

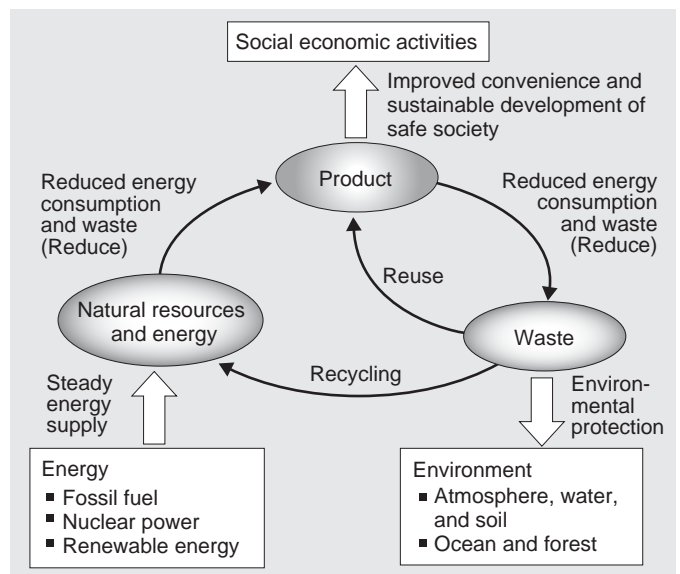
Unilateral attempts to solve problems related to the environment, energy, and the economy cannot be expected to succeed. Rather, the relationship between the health of the environment and energy use must be clearly viewed as two sides of a single coin (Fig. 2), which involves both the efficient use of diversified energy resources and the containment of the environmental load. Energy security, environmental protection, and sustainable economic growth must be achieved in a balanced way through an expansion of the 3E concept (Fig. 3).



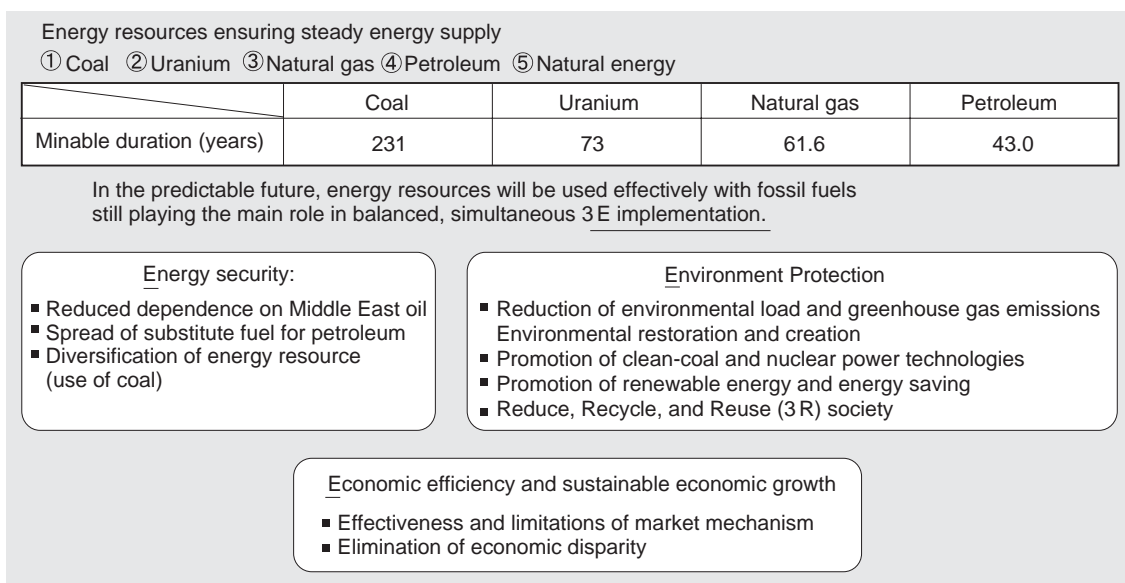
**Fig. 1 Supply-demand balance of diversified hydrocarbon fuels**  
A steep price increase occurs as the supply-demand balance of fuel is lost at the rollover point, where fuel meets the line in the figure; at this juncture, hydrocarbon fuel is replaced by other fuels promoting higher economic performance.

### 2.4 Two 3E expansion models

Potential expansion via the 3Es can be broadly divided into two classes. On the one hand, 3E expansion could occur in advanced and developing countries in which energy consumption and the environmental load are expected to increase. On the other hand, interregional 3E expansion could occur among countries like Japan that have aging populations, mature societies, and a declining birthrate, and in which energy consumption remains fairly constant. These latter countries require a steady energy supply, environmental protection, stable employment, and improved economic efficiency. From the perspective of Japan, the former type of 3E expansion would involve the developing countries in Asia, and especially China, whereas the latter type would involve both urban and rural areas in Japan. These scenarios are discussed below.



**Fig. 2 Environment and energy: two sides of the same coin supporting social economic activity.**



**Fig. 3 Simultaneous realization of the 3Es: an important goal for 21st Century global society**

### 3. 3E expansion through partnerships in Asia

#### 3.1 The status of 3E expansion and related problems in Japan

In Japan, the dependence on petroleum dropped from 77% to 55% after the "oil shocks" that occurred during the latter part of the 20th century. However, the dependence of Japan on the Middle East for the oil that it continues to consume rose from 71% in 1980 to 88% in 2003. The combined oil dependence of Japan, China, and South Korea on the Middle East is expected to rise steeply, from 58% in 2003 to 71% in 2020, as a consequence of rapid increases in the oil imports of China. As a nation with an aging population, a mature society, and a declining birthrate, Japan faces the possibility of stagnant economic growth, which may cause a decrease in environment-related investment. If Japan is to become the world's most energy-efficient society while also reducing greenhouse gas emissions, the benefits from such action must outweigh the costs.

#### 3.2 The status of 3E expansion and related problems in China

China has maintained a high annual economic growth rate of 9.7% since 1980, and it is strongly expected to maintain economic growth at an annual rate of 7%. To maintain such growth, it must solve the 3E problem common to all societies that have high economic growth. A variety of energy issues, including power shortages caused by improved living standards, liquid fuel shortages resulting from the now widespread use of automobiles, coal-based energy production, low energy efficiency, and other uncontrolled conditions, make the problem particularly serious in China. The key for China lies in securing liquid fuels and using coal with maximum efficiency. Related environmental and economic issues include regional environmental problems, such as air pollution, water contamination, soil contami-

nation, and waste produced by the delay of environmental protection measures and the advent of rapid urbanization. These problems, in turn, have created serious and wide-reaching environmental problems, such as a dramatic increase in greenhouse gas emissions, acid rain, deforestation, desertification, water shortages, and marine pollution. The expanding economic disparity between urban (coastal) and rural (inland) areas is a growing social problem.

#### 3.3 A 3E cycle between Japan and China

The 3E problems faced by Japan and China could be effectively and mutually solved through the introduction of a 3E cycle (Fig. 4). Such a 3E cycle would consist of the following three points:

- (1) Joint Japanese-Chinese ventures would manufacture liquid fuels and chemical products from coal in China, and these manufactured products would be used domestically in China and would be imported to Japan.
- (2) Joint ventures would be set up in China to promote the dissemination and effective use of Japanese technologies designed for high-level energy use and environmental protection.
- (3) Imports and exports related to joint-venture business would be facilitated through a partnership between the two countries.

The benefits that could be expected from the implementation of such a 3E cycle are as follows:

- (1) Benefits in energy security

The use of liquid fuels manufactured from coal in China would ease world supply constraints by reducing the demand for petroleum. China could make effective use of its own natural resource (coal), the dependence of both Japan and China on Middle Eastern oil would decline, and energy security in North Asia would increase as a result of the economic interdependence of the two countries.

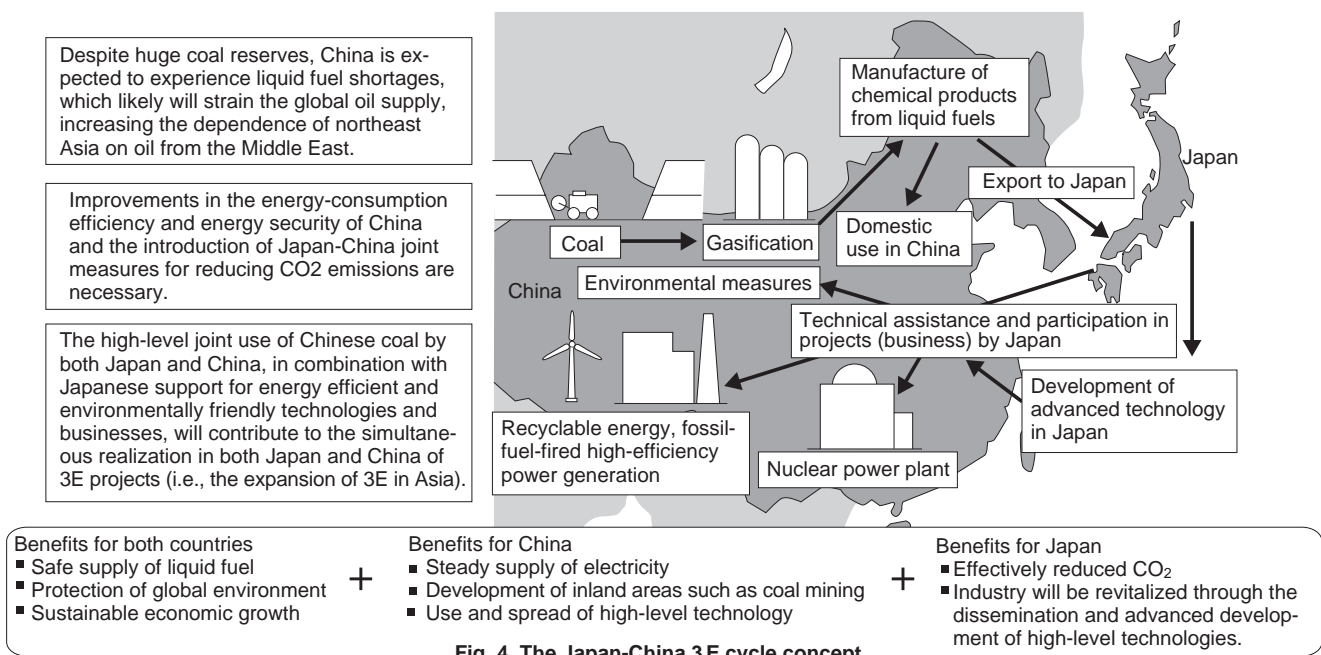


Fig. 4 The Japan-China 3E cycle concept

Introducing and disseminating Japanese clean-coal and nuclear power technologies would ease the discrepancy between power supply and demand, ensuring diversification and clean, high-efficiency energy use. The dissemination of Japan's cutting-edge, energy-saving technology would reduce energy consumption.

(2) Benefits in environmental protection

In China, where CO<sub>2</sub> emissions are increasing several times faster than in Japan, introducing and dispersing Japanese nuclear power and clean-coal technologies, environmentally friendly renewable energy technologies, water and air pollution-prevention technologies, and waste-disposal technologies for the disposal of municipal and industrial wastes and hazardous substances would make environmental preservation and protection measures more effective.

Promoting the manufacture of liquid fuels from coal would increase the use of liquid fuels containing less sulfur oxide and soot, thus reducing air pollution.

(3) Benefits in economic efficiency and sustainable economic growth

A stable energy supply would enable China to enjoy sustainable economic growth. Since coal-mining areas in China are located mostly inland, where economic growth lags, promoting high-level coal use could reduce economic disparities. Since foreign currency otherwise used to import oil from the Middle East would be diverted in part for the purpose of importing liquid fuels from China, Japanese energy and environmental technologies could advance, and Japanese energy and environmental industries could be revitalized. Such progress would ensure the maintenance and growth of domestic industrial competitiveness and technical prowess.

**3.4 An estimation of the effects of a Japan-China 3E cycle**

Working with the Institute of Energy Economics (IEE) in Japan, MHI predicted 3E activity in China for 2020 by using a macroeconomic dynamic measurement model to estimate Japan-China 3E cycle effects. The scenario was simple. The annual average growth rate in the gross domestic product (GDP) of China through 2020 was assumed to be 7.2%. It was also estimated that newly added coal-fired thermal power accounted for 78% of electric power for each ministry. This new coal-fired thermal power was assumed to have an efficiency of 39%, the highest level achieved in China. New power plants built after 2010 would be replaced by nuclear power plants, integrated coal gasification combined cycle plants, and similar plants, with support from Japan. As a result, the output of liquid fuels manufactured from coal equivalent to the additional investment that would be needed for building the new plants was calculated to be equivalent to the imports for Japan.

These calculations were used to evaluate the effects of reduced coal consumption, CO<sub>2</sub> emission, and SO<sub>2</sub> emission in China, as well as the extent of the decline in the dependence of Japan on the Middle East for oil (Fig. 5).

As indicated, introducing a Japan-China 3E cycle would reduce coal consumption, CO<sub>2</sub> emission, and SO<sub>2</sub> emission by 2020 in China by 87 million tons (converted to petroleum), 94 million tons (converted to coal), and 7.44 million tons compared to the base scenario. In Japanese terms, the figures for 2000 are equivalent to 2.1 times coal consumption, 0.3 times CO<sub>2</sub> emission, and 8.7 times SO<sub>2</sub> emission. The dependence of Japan on sources of oil in the Middle East would drop from 88% in 2003 to 71.1% by 2020.

**4. 3E expansion for regional revitalization through a recycling-oriented society**

In the European Union (EU), Austria and Germany promote the use of renewable energy resources by enforcing preferential measures that ensure energy security through improvements in energy self-sufficiency and the reduction of greenhouse gas emission. Biomass resources also provide energy and can be used to support agriculture and forestry management, as well as dairy farming, through the creation of jobs. Adoption of such resources can lead to forest protection, as well as to growth and regional development. In the US and Brazil, ethanol from agricultural crops is used to fuel automobiles, this process promotes agricultural and regional development.

Current marketing principles alone cannot ensure the protection and growth of domestic forests or cause primary industries to recycle biomass. Thus, 3E expansion is being seriously considered. Moreover, cities that consume a lot of energy and emit large amounts of greenhouse gases and waste are expected to bear the cost of creating a recycling-oriented society that combines forest protection with growth involving public functions, such as environmental protection, improvements in energy self-sufficiency, and the use of biomass resources and renewable energy (Fig. 6).

	Coal consumed in China	CO <sub>2</sub> emission in China	SO <sub>2</sub> emission in China
2000 (actual)	275 million TOE 	297 million t-c 	8.99 million t 
2020: before 3E cycle introduction	622 million TOE 	671 million t-c 	20.10 million t 
2020: when 3E cycle is introduced	535 million TOE 	577 million t-c 	12.66 million t 
Reduction as a result of 3E cycle introduction	Equivalent to 2.1 times the consumption in Japan in 2000	Equivalent to 0.3 times the emission in Japan in 2000	Equivalent to 8.6 times the emission in Japan in 2000

Fig. 5 The effects of a Japan-China 3E cycle according to the macroeconomic dynamic measurement model

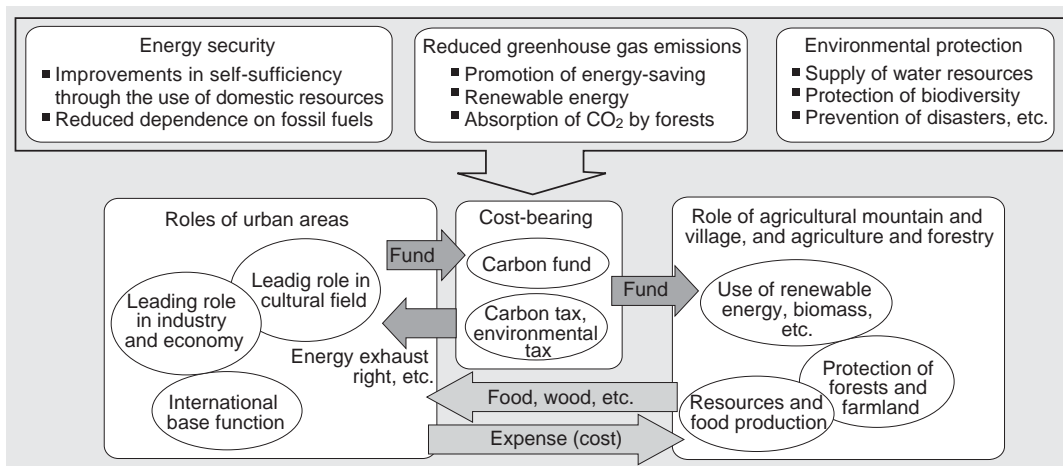


Fig. 6 3E social system concepts for the joint prosperity of urban and rural areas

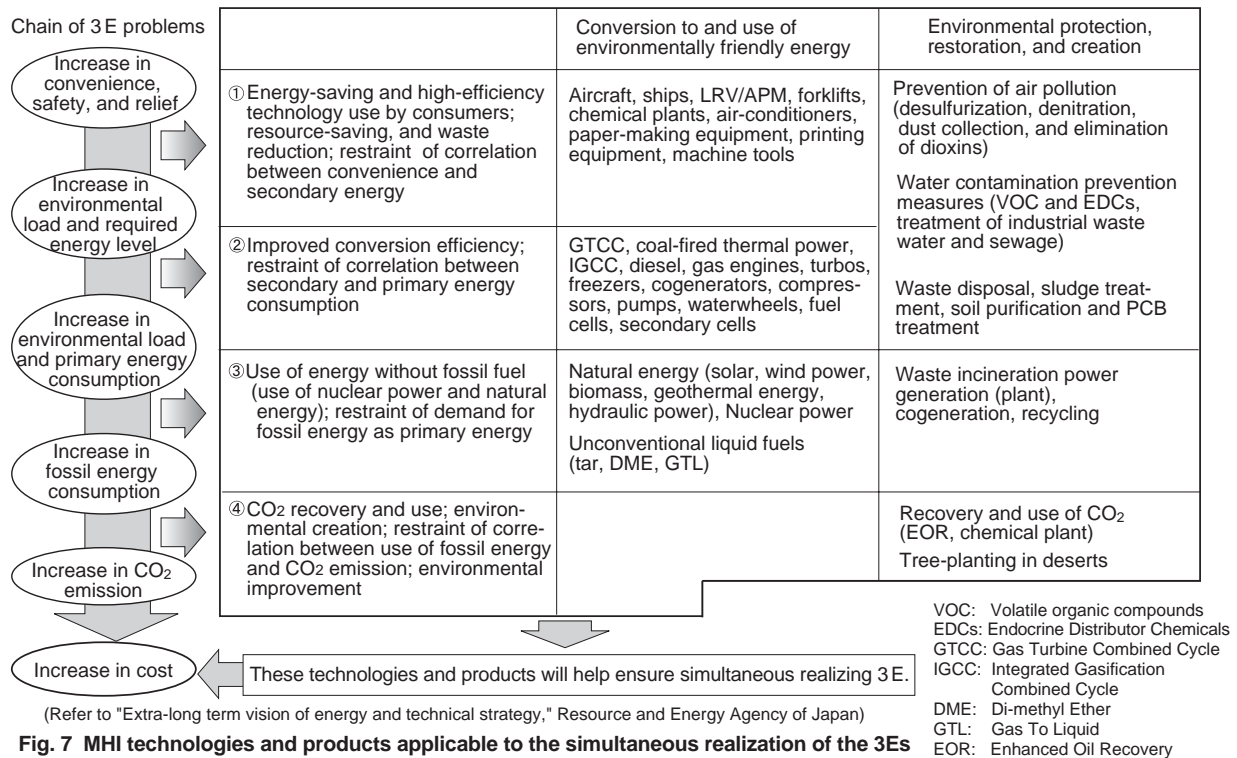


Fig. 7 MHI technologies and products applicable to the simultaneous realization of the 3Es

MHI began working on 3E expansion in April 2004 by setting up the Biomass Power Shizukuishi joint investment program with the town of Shizukuishi, Koikai Farm Ltd., Tohoku Electric Power Engineering & Construction Co., Inc., and Tokyo Sangyo Ltd.

### 5. MHI environmental and energy technologies are applicable to simultaneous 3E expansion.

The simultaneous implementation of 3E concepts requires a conversion to, and the use of, environmentally friendly energy sources, as well as environmental protection and environmental restoration and creation. Social demands for greater convenience, security, and relief generate correlated increases in energy resource requirements, energy consumption, the environmental load and waste, fossil fuel consumption, and CO<sub>2</sub> emission. Technologies are required for the prevention of such correlated move-

ments. MHI provides a wide range of products designed to prevent these problems, and it continues to develop new technologies for this purpose (Fig. 7).

### 6. Conclusions

In response to high economic growth in Asia and the growing needs of Japan's aging, mature society, which faces a decreasing birthrate, MHI is providing products and services to expand 3E development and to promote a sustainable global society while pursuing innovations in technology and business.



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